Evidence Review on the Use of Wool in Peatland Restoration

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Abstract

Peatlands are among the most carbon-dense ecosystems globally, storing nearly one-third of terrestrial carbon while covering only around 3% of the Earth's land surface. In addition to their climate regulation function, peatlands play a critical role in water storage and flow regulation, buffering hydrological extremes such as floods and droughts and influencing downstream water quality. In the UK, however, approximately 90% of peatlands are degraded due to historical drainage, burning, grazing, and peat extraction. These disturbances have transformed many peatlands from long-term carbon sinks into net sources of greenhouse gases, dissolved organic carbon, and associated contaminants, while also accelerating erosion and hydrological instability. Among degraded systems, severely eroded bare peat surfaces represent the most challenging restoration context and remain a major bottleneck to achieving national peatland restoration targets.

This literature review examines the emerging use of sheep wool as a biodegradable, low-carbon restoration material for stabilising bare peat surfaces. Conventional stabilisation approaches, such as stone, coir, and synthetic geotextiles, are often associated with high financial costs, substantial embodied carbon, and logistical constraints, particularly in remote upland environments. In contrast, sheep wool is locally abundant in many peatland regions and possesses physical properties, including high moisture retention, structural resilience, and gradual biodegradability, that may support erosion control and vegetation re-establishment. The review synthesises existing evidence on wool's performance in soil and land restoration contexts, drawing on studies of erosion mitigation, hydrological regulation, and plant establishment, while highlighting the limited but growing body of peatland-specific research.

Particular attention is given to identified knowledge gaps, including the magnitude and persistence of wool's effects on peat hydrology and greenhouse gas fluxes, its interactions with peat structure and microbial processes, and potential ecological risks associated with residual veterinary chemicals. By situating sheep wool within the broader context of nature-based solutions and circular-economy approaches to restoration, this review evaluates its potential contribution to climate mitigation, water quality improvement, and sustainable peatland management. The synthesis provides a foundation for future empirical research and offers a critical evidence base to inform best practice and policy development for bare peat restoration.

Introduction

Alongside decarbonisation efforts, international policy has shifted towards utilising natural ecosystems to sequester atmospheric carbon as part of efforts to meet the Paris climate agreement and keep the rising global temperature below 1.5°c. These so-called Nature-based Solutions (NbS) are incorporated into climate mitigation goals, forming part of Net Zero policies and recognised within the framework of the 1997 Kyoto Protocol. Wetland and peatland habitats have been identified as vital NbS candidates for their extensive terrestrial carbon sequestration and storage capacity (Gregg et al., 2021).

Wetlands contain the highest concentration of carbon among all land habitats and are unique in their ability to sequester carbon continuously over time. Though they cover just 3% of the Earth's surface, wetlands—including peatlands—are thought to hold about one-third of the planet's terrestrial carbon (Yu et al., 2010; Page and Baird, 2016).

Peatlands have unique hydro-chemical conditions that allow them to store carbon long-term. As mosses grow, they replace and bury older plant material in waterlogged environments, preventing microbial respiration from releasing carbon back into the atmosphere. Over time, this process leads to the buildup of soil organic and inorganic carbon, forming the characteristic dark, rich layers of peat.

Peatlands cover 10% of the UK land area (Fig. 1) and, when in good condition, can sequester an estimated 0.2 tonnes of carbon per hectare per year (Smith et al., 2007). However, most UK peatlands are degraded, transforming these large carbon sinks into major sources of greenhouse gas (GHG) emissions, including CO_2, NO_2, and CH_4. For instance, degraded peatlands store globally ~80.8 Gt soil C and emit ~1.91 (0.31–3.38) Gt CO_2-eq. a^{-1} (0.52 (0.08–0.92) Gt CO_2-C-eq. a^{-1}) mostly as CO_2 (Leifeld and Menichetti, 2018). The primary causes of this degradation are human activities such as peat excavation for fuel and horticultural use, drainage for agriculture, burning for grouse shooting, and overgrazing (Artz et al., 2019). These activities disrupt the natural hydrology and ecology of peatlands, leading to their physical, chemical, and ecological breakdown. The loss of the surface living layer (acrotelm) and the drying of deeper layers (catotelm) quickly turn peatlands from carbon sinks into significant sources of Carbon emissions, contributing to climate change.

Currently, it is estimated that up to 90% of UK peatlands are in poor or degraded condition, releasing 23 million tonnes of carbon annually into the atmosphere (Evans et al., 2017). The most severely degraded peatlands, where surface vegetation has been completely lost (bare peat), contribute disproportionately to these emissions, as the absence of vegetation worsens the release of greenhouse gases (GHGs). This degradation causes carbon loss through both gaseous and fluvial pathways, accounting for 10% of global annual fossil fuel emissions (Page and Baird, 2016) and 3.5% of the UK's total yearly emissions. (Evans et al., 2017).

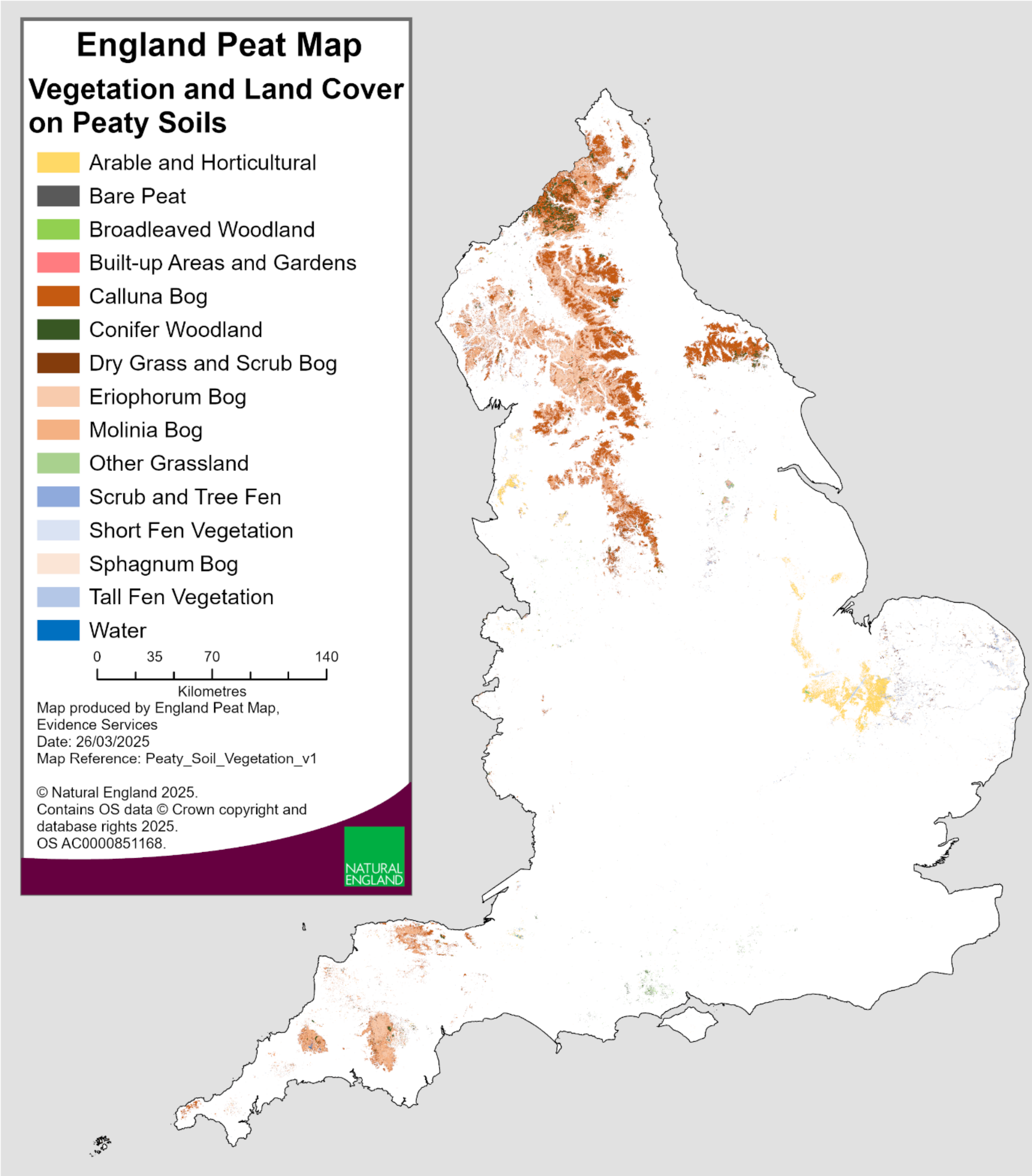

Figure 1: England peat map. Map of England, showing the geographic location and coverage of peaty soils and the respective vegetation type or land use. Image taken from England Peat Map Project Final Report NERR 149, page 20.

Therefore, international, and national commitments to peatland restoration are crucial for both carbon sequestration and the prevention of large carbon emissions. For instance, key international instruments and commitments relevant to peatlands include:

- Ramsar Convention on Wetlands: Recommendations and resolutions emphasising the wise use and management of peatlands (e.g. Recommendation 6.1, Resolution VIII.17).

- IUCN World Conservation Congress: Resolution 043 (Hawaii 2016) calls for action to protect, restore, and sustainably manage peatlands worldwide.

- UN Convention on Biological Diversity (CBD): Aichi Biodiversity Targets (Goal D – Target 15) highlight peatlands' role in mitigating and adapting to climate change, as well as supporting threatened wildlife.

- UN Framework Convention on Climate Change (UNFCCC): Voluntary inclusion of peatlands in national greenhouse gas accounting under the Kyoto Protocol, with IPCC guidance on reporting wetland emissions and sequestration.

- UN Sustainable Development Goals (SDGs): Particularly SDG13 (climate action) and SDG15 (life on land) support peatland restoration as a means of combating climate change and halting biodiversity loss.

- European Union Directives, including:

  - Water Framework Directive (WFD): Peatlands are integral to good ecological status and may be included in programmes of measures for river basin management.

  - Habitats Directive (92/43/EEC): Peatland habitats (Annex 1) and species are protected, requiring favourable conservation status across their natural range.

  - Birds Directive (2009/147/EC): Emphasises habitat creation, re-establishment, and management for protected bird species, many of which rely on peatland ecosystems.

Alongside the context of climate change, several other negative impacts accompany the degradation of peatland habitats, including downstream eutrophication of water bodies, socio-economic consequences, ecological diversity, and the effect on wider ecosystem services (e.g., water purification and regulation, nutrient cycling; Zak and McInnes, 2022).

Peatland degradation has significant effects on water quality, especially by increasing water colour due to higher levels of dissolved organic carbon (DOC). Studies have demonstrated that the breakdown of peatlands leads to the leaching of DOC into nearby water bodies, resulting in a noticeable rise in water colour, which can harm water quality and raise treatment costs for drinking water (Chapman et al., 2010; Parry et al., 2015; Luscombe et al., 2016). In particular, the steady rising trend in raw water colour at the Watchgate Water Treatment Works (WTW) intake from 1990 to 2012 (Fig. 2) is notable, with increased seasonal variability and higher peak levels, especially during autumn when high colour events tend to occur.

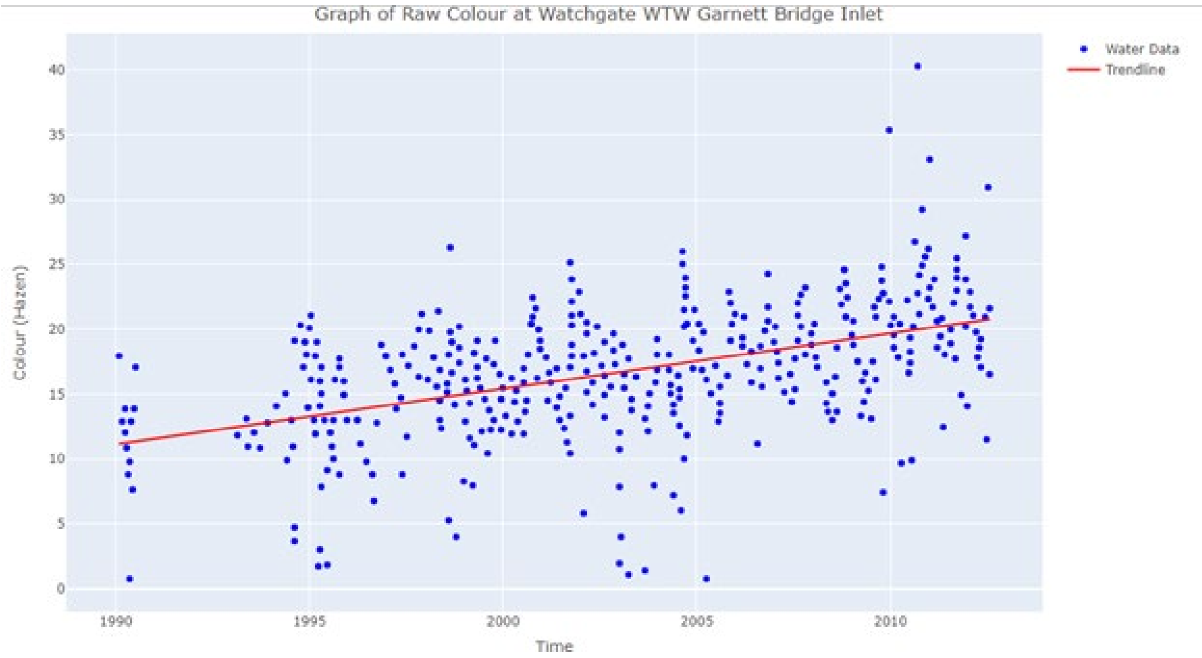

Figure 2: Raw colour at Watchgate WTW Garnett Bridge Inlet. The graph shows changes in water colour between 1990 - 2012.

This is linked to the degradation of upland peat in the Lake District catchments, where deep and shallow peat soils are degraded or completely bare rather than covered by peat-forming sphagnum mosses. The loss of peat-forming vegetation compromises peat hydrology, leading to increased drying in summer and higher weathering in autumn and winter. This results in the release of DOC from eroded peat, while climate change and visitor pressure further contribute to peat loss.

Figure 3: Bare-peat sites in the Lake District. The grid of images shows examples of bare-peat at candidate experimental sites for testing wool as a restoration material. The top row, right-to-left, Rusland, Ulscarf and Ulscarf. Bottom row, right-to-left, shows Bamptom Common, Bolton Fell Moss and Rusland.

Approximately 13% of UK peatlands are classified as bare or eroded, equating to roughly 450,000 hectares that present a major restoration challenge (Artz et al., 2019). The financial implications of restoring such a large area are considerable, particularly given the wide variability in unit costs reported across projects. Recent analysis of Peatland ACTION data indicates that the average restoration cost in Scotland is £1,550 per hectare (2020-£), with a 5th percentile of £191/ha and a 95th percentile of £4,483/ha (Glenk et al., 2020). Scaling this to the UK-wide extent of bare peat suggests a potential cost of ~£2.0 billion at the 95th percentile. However, for severely degraded sites, costs are substantially higher: leading restoration contractors such as Barker & Bland have identified figures of up to £40,000 per hectare for restoring bare peat, often with only a 30–40% success rate due to the difficulty of re-establishing vegetation cover on exposed substrates. At this upper-band estimate, restoring the UK's 450,000 hectares of bare peat would require investment in the order of £18 billion. These figures underline both the scale of the restoration challenge and the need for careful prioritisation of interventions, balancing ecological feasibility with financial sustainability.

Wool has already been applied in restoration projects based on the assumption that its structural, thermal, and hygroscopic properties resemble those of Sphagnum moss. These properties are expected to provide support for re-establishing vegetation on deteriorated peatlands. Wool may contribute to rewetting and revegetating these areas, which are essential strategies for reducing emissions from degraded peatlands and enhancing their capacity to sequester carbon.

Although sheep wool has already been trialled in peatland restoration, evidence of its effectiveness remains limited and anecdotal, with most accounts confined to grey literature or non-scientific sources rather than peer-reviewed studies. For example, the Peatland ACTION Technical Compendium notes that wool can felt together to provide structure and act as a seed source, with early observations suggesting it may support colonisation on bare peat (Peatland ACTION, Restoration – 7 Stabilisation and Revegetation). At the same time, the guidance stresses the need for further monitoring and highlights risks such as potential contamination from sheep-dip chemicals. This lack of systematic testing and rigorous evaluation of risks, efficacy, and optimal application methods reflects a wider issue in peatland restoration, where technical guides (e.g. YPP, NatureScot) are often applied in a dogmatic manner without sufficient consideration of how interventions affect the functional behaviour of the peatland.

This literature review addresses key evidence gaps surrounding the use of sheep wool in peatland restoration. It critically examines the potential of untreated wool as a sustainable, biodegradable, and locally sourced alternative to conventional stabilisation materials such as stone, coir, and geojute, which are frequently associated with high financial costs and substantial embodied carbon. By synthesising findings from peatland restoration studies alongside broader soil stabilisation and erosion control literature, the review evaluates wool's reported capacity to enhance surface stability, moisture retention, and vegetation re-establishment. It also considers uncertainties and potential risks identified in the literature, including the presence of residual veterinary chemicals, nutrient release during decomposition, and implications for water quality. Through this synthesis, the review aims to clarify the conditions under which wool-based interventions may be effective and ecologically appropriate, and to identify priority areas for future research. In doing so, it situates sheep wool within wider nature-based and circular-economy approaches to restoration, assessing its potential contribution to low-carbon outcomes that support climate mitigation, biodiversity recovery, and peatland policy objectives in the UK and beyond

Literature Review

Research on the direct application of sheep wool for restoring bare peatlands is absent from peer-reviewed scientific literature. Although peatland restoration has been examined due to its significance for climate mitigation, biodiversity conservation, and water regulation, most studies concentrate on rewetting, reprofiling, and the use of conventional materials such as coir logs, geotextiles, or stone bunds (Evans et al., 2021; Moors for the Future Partnership, 2020). Research specifically targeting bare peat surfaces is also limited, despite their recognition as one of the most ecologically challenging states of degradation, characterised by severe erosion, hydrological instability, and the absence of vegetation (Parry et al., 2014).

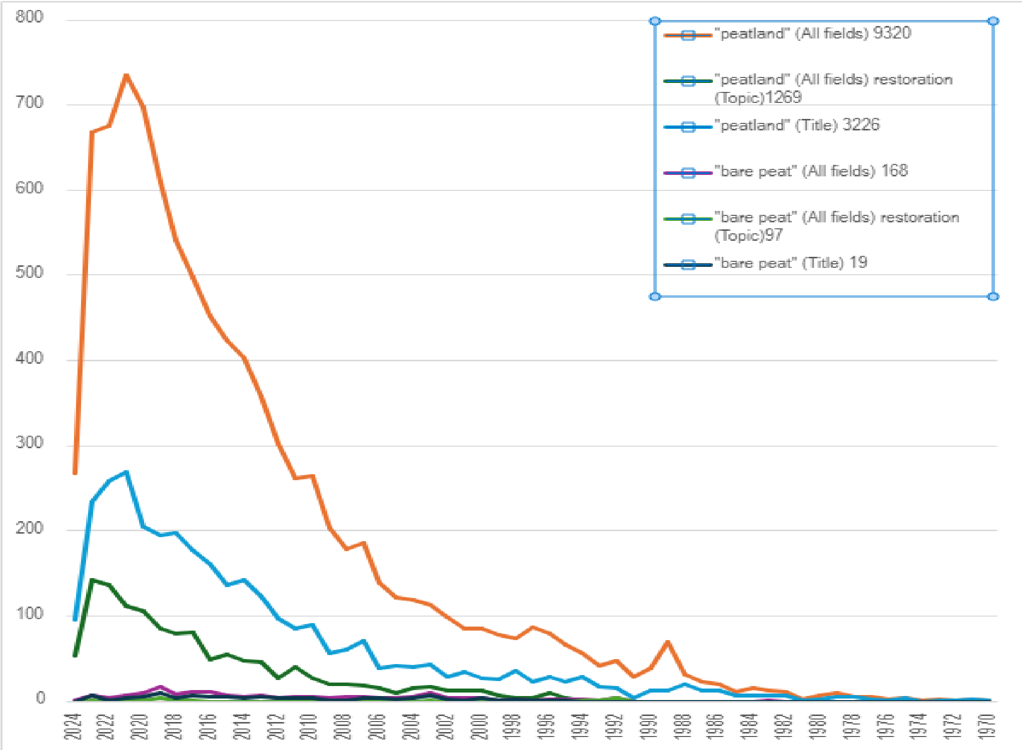

Figure 4 Temporal trends in scientific publications related to peatlands and bare peat (1970–2024). Data represent the number of publications indexed in Scopus by year for different search terms: "peatland" (all fields, 9320 records), "peatland restoration" (topic, 1269), "peatland" (title, 3226), "bare peat" (all fields, 168), "bare peat restoration" (topic, 97), and "bare peat" (title, 19).

Bare peat surfaces pose severe ecological challenges, including high erosion rates, structural instability, and the loss of vegetation and hydrological functions, yet systematic investigations into their restoration dynamics remain limited. Given this lack of evidence, the review adopts an integrative approach by breaking the problem into its fundamental components. Instead of focusing solely on studies concerning wool in peatland restoration—which are entirely absent—this review draws on related fields: (i) wool as a material for soil improvement and land management, (ii) Wool chemistry, biodegradation, and contaminant risks, (iii) grey literature case studies. By framing the discussion around these interconnected themes, this review establishes the scientific context for the current study and highlights the novelty and importance of evaluating wool as a sustainable material for restoring highly degraded peatlands.

Although no studies have examined wool in this specific context, evidence from related fields suggests it could be a promising material (Kovács et al., 2025; Broda, 2023; Camilli et al. 2025). Wool has been investigated as a soil amendment due to its high nitrogen and sulphur content, which derive from its keratin structure. Experimental studies show that when applied as pellets or hydrolysed fibre, wool decomposes slowly, releasing nutrients that can improve plant growth and soil microbial activity (Kovács et al., 2025; Broda, 2023). Camilli et al. (2025) reviewed multiple applications of waste wool and concluded that it can (tab.3) increase soil fertility, enhance moisture retention, and improve microbial community dynamics, thereby functioning as a slow-release organic input. Similarly, Gabryś (2022) demonstrated that mixing wool fibres into potting substrates enhanced water retention and modified root development, findings that highlight wool's potential to influence soil structure as well as fertility.

Table 1 properties of wool for soil improvement

Study	Wool Compound	Observed Effects	Quantitative Results
Correa et al. (2025)	Wool pellets (raw wool)	↑ Soil fertility, ↑ Water retention, ↑ N mineralization	Increased lettuce biomass by 18–35%, depending on soil type. Nitrogen mineralization enhanced over 8 weeks.
Mubarak et al. (2009)	Wool (W) and Hoof (H) mix	↑ Soil fertility in sandy soils	W application increased total nitrogen by 14.3% and organic C by 10.6% over control.
Kroening (2004)	Woolscour waste (grease + fibers)	Slow nitrogen release, ↑ microbial activity	Nitrate-N levels rose steadily over 21 days, indicating sustained release.
Cetin Karaca et al. (2023)	Sheep wool fertilizer	↑ Microbial respiration, ↑ Moisture holding	Soil respiration increased by 22.1%, soil water content by 13.8%
Marczak et al. (2023)	Wool waste	Acts as slow-release N fertilizer	N release curve shows 70% mineralization over 60 days.
Lal 2020	Sheep waste (including wool)	↑ Barley yield, ↑ Soil health	Yield increased by 25–30%, microbial biomass C by 33%.
Zoccola et al. (2015)	Hydrolyzed wool proteins	Organic nitrogen source, water retention	Wool hydrolysate contains ~13% N; slow release over 30–50 days.
Kovács et al. (2025)	Wool pellets	Dependence on microbial activity for N release	Soil with active microbial communities showed 2× higher N release from pellets.

These properties are directly relevant to the restoration of bare peat surfaces, where both structural stability and nutrient availability are limiting factors. The fibrous, three-dimensional structure of wool is likely to act in a similar way to fibre geotextiles, providing temporary protection against erosion while creating microsites for seedling establishment. At the same time, its gradual nutrient release could help overcome the extreme nutrient deficiency of bare peat without the risks associated with sudden nutrient enrichment. Importantly, wool's capacity to retain water (Szczepanik et al., 2025) aligns with the hydrological goals of restoration, where maintaining surface moisture and reducing desiccation are essential for peat stability and vegetation recovery (Fig.5).

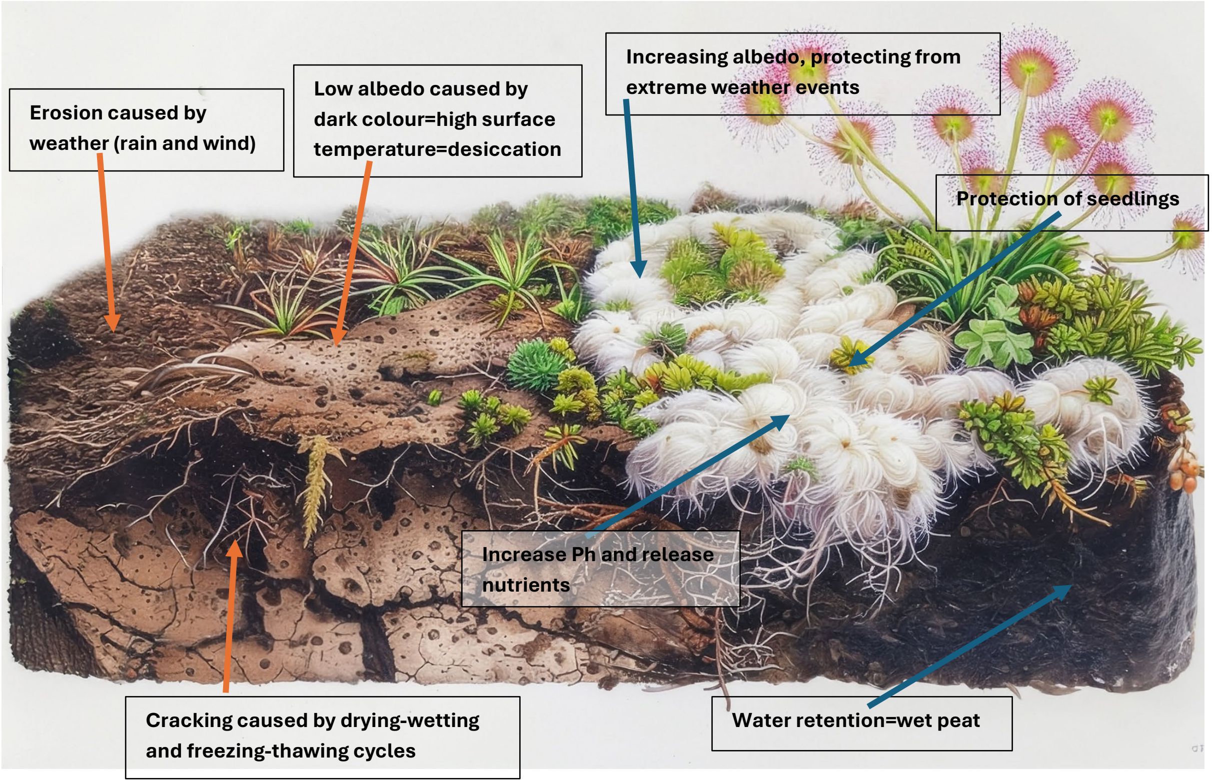

Figure 5 Property of Wool in Bare peat restoration

Nonetheless, there are also risks and uncertainties. One concern is the presence of pesticide residues in raw wool from sheep husbandry, particularly synthetic pyrethroids such as cypermethrin and deltamethrin, which are widely used for blowfly, lice, and tick control. Recent laboratory analysis showed that residues can persist in fleeces for at least two years post-treatment and, under worst-case scenarios, were detected at concentrations several orders of magnitude above aquatic toxicity thresholds (Taylor et al., 2024). This highlights a potentially serious environmental risk if untreated fleeces are deployed directly into saturated peatland systems. Moreover, the report found that fleeces are difficult to trace back to treatment histories, complicating sourcing and risk assessment. While organic or untreated fleeces may reduce this hazard, their availability is limited, and scouring to remove residues is costly and carbon-intensive.

In contrast, conventional peatland restoration continues to rely on imported materials such as coir, which carry their own environmental and logistical challenges. Artz et al. (2018) highlight that bare peat stabilisation remains one of the most costly forms of restoration, requiring repeated applications of lime, seed, and fertiliser, followed by physical coverings. Programmes such as the Moors for the Future Partnership and the Yorkshire Peat Partnership report that aerial delivery of these materials represents a substantial portion of restoration costs and contributes significantly to the carbon footprint of projects. The Crichton Carbon Centre (Taylor et al., 2024) note that sheep's wool could reduce these dependencies, offering a locally available, low-value agricultural by-product with the potential to substitute coir and jute. Early pilot trials of wool bunds and logs in the Pennines, Yorkshire, and the Brecon Beacons suggest the material is biodegradable, locally acceptable, and capable of providing erosion control, although results remain mixed and long-term effectiveness is uncertain.

In summary, while there is no peer-reviewed evidence for the effectiveness of wool in peatland restoration, research from agronomy, soil science, and grey-literature pilot trials indicates several properties—structural reinforcement, water retention, and slow nutrient release—that make wool a plausible candidate for stabilising bare peat. However, uncertainties remain around decomposition rates, sourcing logistics, and pesticide residues, with the latter representing the most significant potential ecological risk (Taylor et al., 2024). Addressing these gaps will require both controlled laboratory trials and carefully monitored field experiments before wool can be recommended at scale as a restoration material.

Table 2 Comparison of wool and conventional fibre materials (coir/jute) for bare peatland restoration.

Criterion	Wool (sheep fleece, raw or processed)	Coir / Jute (imported geotextiles)	References
Source & availability	By-product of UK sheep farming; often low or no commercial value; potentially available locally at restoration sites.	Imported from Asia (mainly India, Sri Lanka); requires international shipping and supply contracts.	Taylor et al., 2024; Artz et al., 2018
Carbon footprint	Low if sourced and used locally; supports circular bioeconomy. Risk of higher footprint if scouring or transport required.	Higher due to cultivation, processing, and long-distance transport; embodied carbon not always reported.	Taylor et al., 2024
Cost & logistics	Low raw material cost; collection and traceability may add expense; potential for farmer co-production.	Higher material cost; long lead-in times can delay projects; aerial delivery adds expense.	Artz et al., 2018; Moors for the Future, 2020
Function in restoration	Provides fibrous structure for erosion control; gradual nutrient and moisture release; may support seedling establishment.	Widely used for erosion control; physically stabilises peat surface but provides no nutrient input.	Kovács et al., 2025; Gabryś, 2022; Evans et al., 2021
Decomposition rate	Biodegradable; >95% mass loss within ~15 weeks under soil burial (though slower in waterlogged peat).	Biodegradable over months to years depending on site conditions; generally slower breakdown.	Hodgson et al., 2023; Taylor et al., 2024
Environmental risks	Potential contamination from pyrethroid residues; persistence >2 years post-dip at ecotoxic concentrations. Risk varies by sourcing and treatment history.	No pesticide risk, but potential biosecurity risks from import (pests, pathogens).	Taylor et al., 2024
Socio-economic context	Supports local farmers, reduces waste wool disposal, encourages innovation in upland communities.	Reliant on overseas supply chains; no local economic benefit.	Taylor et al., 2024

Wool as a material for soil improvement and land management

Wool has long been recognised as a potential agricultural amendment due to its high nitrogen (N) content and slow-release properties. Early research demonstrated that uncomposed wool waste could be used directly as a nutrient source for high-value crops, including basil and chard, resulting in yield increases of two- to five-fold compared to unamended controls (Zheljazkov, 2009). These effects were attributed to both improved nitrogen availability and enhanced root interaction with degrading fibres. Previous studies by the same group also found that wool and hair wastes could serve as valuable soil amendments, providing macronutrients and micronutrients while diverting organic waste from landfill (Zheljazkov, 2005; Zheljazkov et al., 2008a). Other experiments confirm the agronomic potential of wool in different forms. Chereji and Munteanu (2011) tested sheep wool in compost mixtures, reporting improvements in organic matter stability, humus formation, and nutrient availability. Their work emphasises that wool-based composts may improve soil physical structure while gradually releasing N.

Beyond nutrient release, wool has been applied as mulch. Studies in horticultural systems found that wool mulches suppressed weeds, conserved moisture, and reduced nutrient leaching (Hartley & Rahman, 1997; Duppong et al., 2004). Wool fibre mats have also been tested for soil surface stabilisation, combining erosion protection with organic nutrient input (Williamson et al., 2000). These uses suggest that wool could play a multifunctional role in land management by simultaneously addressing soil fertility and physical stability.

A recurring theme in the literature is that wool use in any ecological or agricultural setting offers a sustainable alternative to landfilling. Recycling wool into agricultural amendments not only tackles disposal issues but also supports soil enhancement strategies. As Broda and Gawlowski (2017) suggest, the structural characteristics of wool fibres—especially their keratin content—make them suitable for extended biodegradation processes, ensuring a slow release of nutrients back into the soil.

Together, these findings point to wool as a versatile material for soil improvement and land management. However, most applications to date remain focused on horticultural and agricultural soils, with little direct testing in degraded peatland systems.

Wool chemistry, biodegradation, and contaminant risks

The biodegradation of wool is gradual, driven primarily by keratinolytic microorganisms capable of breaking disulfide bonds. Scanning electron microscopy (SEM) and energy dispersive X-ray (EDX) studies show that while many fibres retain structural integrity over months, others exhibit visible decomposition, with plant roots sometimes growing directly over wool surfaces (Fig. 3) (Zheljazkov, 2009). Broda and Gawlowski (2017) examined the biodegradation of wool fibres in soil and found that microbial activity progressively altered the fibre structure, releasing nutrients in synchrony with plant demand. More recently, Hodgson et al. (2023) demonstrated that under soil burial conditions most wool fabrics, regardless of chemical processing, exhibited very high levels of degradation, with over 95% mass loss recorded within just 15 weeks (in non-peaty soil). In parallel, the decomposition process was shown to release nitrogen and sulphur into the surrounding soil, derived from the breakdown of peptide bonds and cysteine residues within the keratin structure, further underlining wool's fertiliser potential. While concerns have been raised about chemical treatments such as chrome dyeing, which delayed degradation and left up to 40% of material undecomposed, the study found no strong evidence of chromium leaching into the soil, though the authors highlighted that more controlled testing would be needed to confirm this (Hodgson et al., 2023).

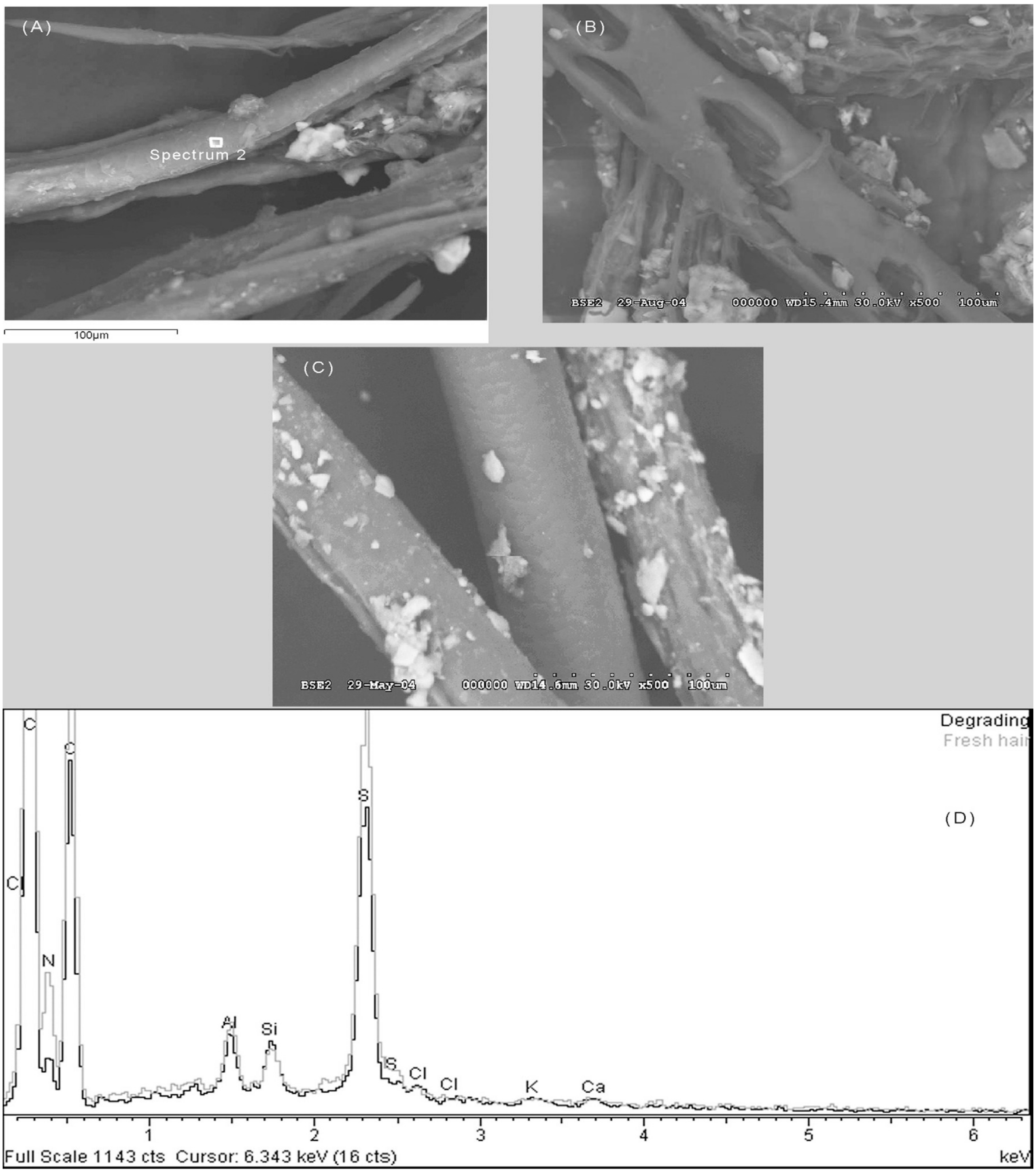

Figure 6 Scanning electron microscope (SEM) and x-ray microanalysis of degrading wool and hair used as soil amendments. (A) SEM back-scattered electron image of degrading wool fibres. (B) SEM back-scattered electron image of decomposing hair from the 40 g hair treatment of valerian at 500× magnification, showing plant root penetration into the hair structure. (C) SEM back-scattered electron image comparing decomposing hair (outer fibers) with a fresh hair strand (center). (D) X-ray microanalysis spectra comparing elemental composition of decomposing and fresh hair shown in (C). Image reproduced from Zheljazkov et al. (2008),

Keratin degradation has also been stimulated through alkaline hydrolysis, producing wool hydrolysates that act as fertilisers and heavy metal binding agents (Evangelou et al., 2008). However, the slow breakdown of untreated wool is generally considered advantageous for agricultural contexts, as it ensures sustained nutrient availability.

Chemical contaminants and ecological risks

Wool presents several properties that could significantly benefit peatland restoration. Both raw and treated wool exhibit thermal insulation and hygroscopic characteristics that enhance microclimatic conditions, supporting moss and plant establishment (Kohara & Toshiniari, 2004; Xu et al., 2006). Its relatively high pH (7.0–7.2) provides buffering capacity in acidic peat environments (typically pH 3.8), creating more favourable conditions for vegetation growth. Wool also contains keratin, a nitrogen-, phosphorus-, potassium-, and sulphur-rich protein essential for plant development (Zheljazkov, 2005; Hustvedt et al., 2016). As it decomposes, wool releases amino acids and peptides, contributing to long-term soil fertility and structural stability (Korniłłowicz-Kowalska & Bohacz, 2011), while its hydrophilic nature helps reduce erosion and enhance hydrological stability—key restoration goals (Zheljazkov, 2005). Additionally, wool fibres can absorb heavy metals, offering co-benefits for remediating contaminated sites (Galán-Marín et al., 2010). However, despite these ecological benefits, wool's use in restoration carries environmental and health concerns. The most prominent issue involves pesticide residues from ectoparasiticides used on sheep, including persistent compounds like synthetic pyrethroids, which accumulate in wool grease and lanolin and may persist long after shearing (Bourdillon et al., 2023; Niell et al., 2011; 2016). These residues can leach into soils and groundwater when wool is applied to land, potentially contaminating aquatic ecosystems and harming soil fauna, with implications for nutrient cycling and biodiversity (Rubino et al., 2021; Hu et al., 2014; Milano & Chèvre, 2019; Lari et al., 2014; Beaumelle et al., 2023; Pelosi et al., 2021; Fritsch et al., 2022). Other contaminants may include organic compounds from wool scour sludge and trace heavy metals absorbed during grazing or processing (Williamson et al., 2000). Furthermore, raw wool may introduce pathogens or non-native seeds if not properly treated, posing additional risks in ecologically fragile peatlands (Zheljazkov, 2009). Thus, while wool has notable potential as a restoration material, further research is essential to fully understand and mitigate its contaminant pathways and long-term ecological risks.

Grey Literature Evidence and Case Studies

The lack of empirical research highlights the urgent need for a systematic approach to gather relevant information, to enable evidence led restoration efforts. To date, only internet sources have been located, and these findings will be summarised in this section.

Site/Location	Project	Purpose	Key Outcomes/Goals	Links
Fleet Moss, Yorkshire Dales	Wool logs for erosion control	Reduce erosion, support vegetation regrowth	Improve water retention, boost plant growth, income for farmers	Yorkshire Dales Project
Dartmoor, Southwest Peatland	Wool-filled felt tubes for erosion control	Slow water flow, support bog plant growth	Stabilize water levels, enhance biodiversity, local wool market	Southwest Peatland Project
North Pennines AONB	Upland sheep wool for erosion control	Alternative to imported materials, reduce erosion, retain carbon	Low carbon, supports local agriculture, compares with coir use	North Pennines Project
Bannau Brycheiniog, Wales	Wool blankets as permeable dams	Slow water flow, prevent erosion, preserve carbon-rich soils	Enhance climate resilience, circular economy with Welsh wool	Beacons National Park
Kilmarie Coastal Path, Isle of Skye	Wool-based "floating path" for path stabilization	Protect peat, improve drainage	Durable, eco-friendly alternative to traditional materials	Isle of Skye Path Project
Lake District	Sheep fleece layered paths	Path erosion control, protect peat, ensure drainage	Collaboration with conservation bodies, adapts to environment	Lake District Project
Isle of Anglesey	'Made with Wool' project for sustainable footpaths	Eco-friendly path foundation, reduce plastic reliance	Wool traceability, monitors ecological impact	Anglesey Project - Floating Wool Path Guide

Table 3 Examples of wool-based applications in UK peatland and upland restoration projects.

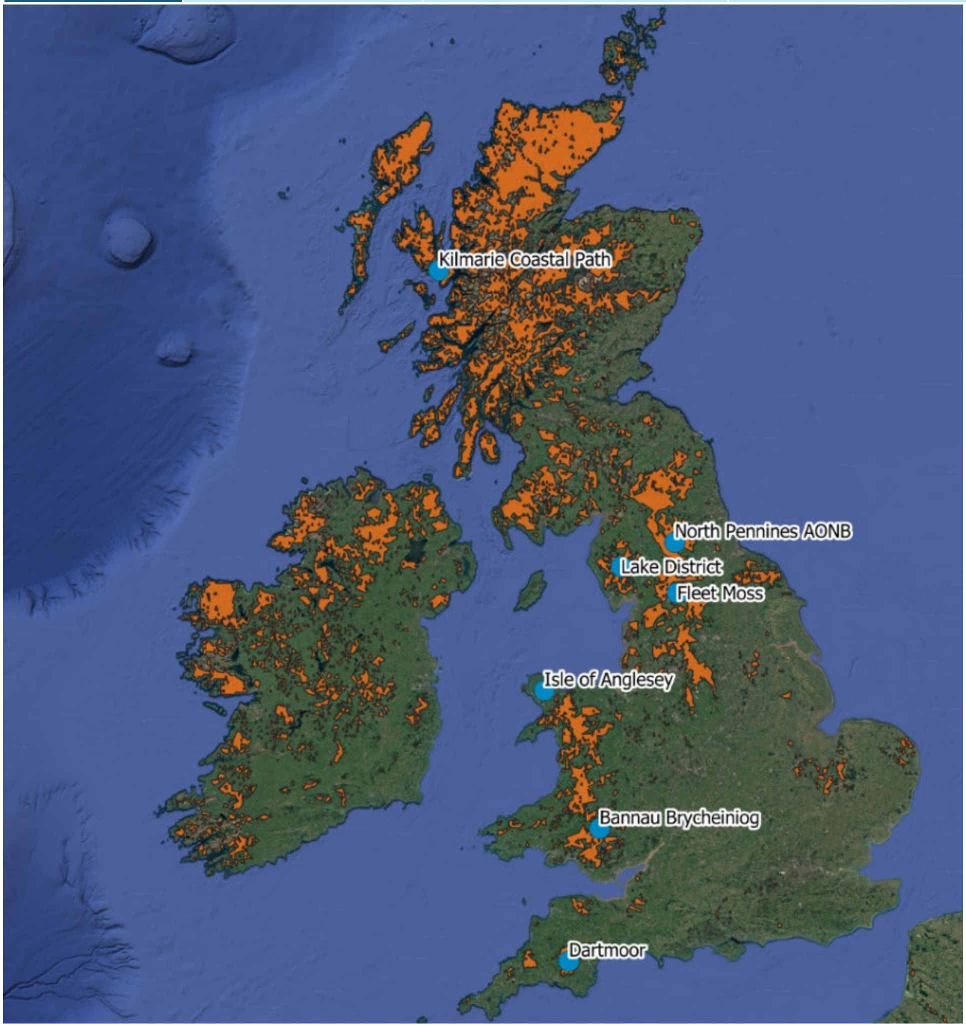

Figure 7 *Orange Areas: Extent of peatlands in the UK and Ireland Peatmap_NWEurope_v0_2). Blue Points: Locations where wool has been trialled for use in peatland restoration.*

Figure 8 A: Wool-filled felt tubes installed on Dartmoor's peatland to slow water flow and support bog plant growth. E: Sheep's wool used in the North Pennines AONB to reduce erosion and retain carbon in peatland restoration 8 F: Wool blankets placed in Welsh peatlands to slow water flow and protect carbon-rich soils, aiding climate resilience C: 9 Wool logs placed across Fleet Moss in the Yorkshire Dales to combat erosion and support peatland restoration. D: Sheep wool used on the Isle of Skye to create a durable, eco-friendly path that protects peat and improves drainage. B: Volunteers with Fix the Fells use sheep fleece to reinforce paths, control erosion, and protect peat in the Lake District G: 10 Welsh wool used to create sustainable footpaths, reducing plastic reliance and promoting eco-friendly infrastructure.

Fleet Moss Trial, Yorkshire Dales National Park

In 2023, the Yorkshire Dales National Park Authority initiated a trial using low-value Swaledale sheep wool logs to reduce erosion and promote vegetation regrowth. Funded by a "Farming in Protected Landscapes" grant, 30 wool logs were placed in erosion channels. Expected outcomes include improved water retention and vegetation recovery, building on previous studies showing positive results with coir logs. This initiative aligns with conservation efforts and provides a potential income stream for local farmers.

Dartmoor Wool Trials, Southwest Peatland Partnership

The Southwest Peatland Partnership is conducting trials on Dartmoor to utilise locally sourced wool for erosion control in degraded peatlands. About 100 wool-filled felt tubes were installed using various techniques to slow water flow and support bog plant growth. The project aims to evaluate wool's effectiveness in stabilising water levels, enhance biodiversity, and create a market for low-value fleece, thus supporting local farmers facing economic challenges.

North Pennines Sheep's Wool Trial

The North Pennines AONB Partnership is testing upland sheep wool as an alternative to imported materials for peatland restoration under the Tees-Swale: Naturally Connected program. The trial involves 150 wool rolls crafted from locally sourced fleece and aims to slow water flow, reduce erosion, and enhance carbon retention. Regular monitoring will compare the effectiveness of wool with traditional coir, promoting a low-carbon solution that benefits local agriculture.

Bannau Brycheiniog Wool Blanket Project

In Bannau Brycheiniog, a peatland restoration project is utilizing locally sourced sheep wool to combat climate change by preserving carbon-rich soils. Wool blankets crafted from local fleece are airlifted to peat sites, serving as permeable dams to slow water flow and prevent erosion. Supported by Natural Resources Wales and the Welsh Government, this initiative highlights the circular economy and aims to enhance the climate resilience of Welsh peatlands.

Kilmarie Coastal Path Project, Isle of Skye

The Kilmarie Coastal Path Project repaired a 100-meter path section using approximately 300 raw fleeces, creating a wool-based "floating path" that protects underlying peat and facilitates drainage. This eco-friendly alternative to traditional materials enhances durability and reflects historical wool usage in construction. The method is considered for other paths managed by the John Muir Trust, supporting farmers by utilizing excess wool.

Lake District Path Repair

In the Lake District, path erosion is addressed through the use of sheep fleece layered with stones to form "floating paths." This technique protects peat while allowing for proper drainage. The National Trust and Lake District National Park Authority employ various methods for path repair, ensuring ecological integrity through collaboration with Natural England and adapting to environmental conditions.

‘Made with Wool’ Project, Isle of Anglesey

The ‘Made with Wool’ project tests untreated sheep wool as a natural foundation for sustainable footpaths on the Isle of Anglesey. Co-funded by LEADER, the initiative sources wool through a traceability scheme and has utilized around 700 fleeces in construction. These paths are monitored for ecological impact compared to traditional plastic alternatives, promoting sustainable practices, and enhancing the market for Welsh wool.

Evidence Gaps and Risks of Sheep Wool Use in Peatlands

Sheep wool has been proposed as a potential amendment in peatland restoration, valued for its ability to provide structure, enhance soil aeration, and support vegetation growth. While initial trials indicate promising outcomes, the application of wool in these sensitive ecosystems requires careful risk assessment to ensure that ecological integrity is not compromised.

A primary concern is the potential contamination from sheep dip chemicals, particularly pyrethroids, which can leach into surrounding watercourses and pose significant risks to aquatic organisms and biodiversity. Evidence from Bloor et al. (in review) suggests that pesticide residues in wool may persist in the environment, highlighting the need for chemical residue analysis prior to field deployment. Additional considerations include the release of nutrients during wool decomposition, possible shifts in peatland pH, and the accumulation of heavy metals. Together, these factors can alter water chemistry and affect ecosystem function.

The Peatland ACTION Technical Compendium emphasises that any use of sheep wool requires prior approval and licensing, underlining that this remains an emerging technique with limited field evidence. Importantly, the aim of risk assessment is not to discourage innovation, but to optimise wool’s application while safeguarding peatland health.

Beyond chemical concerns, wool use must be evaluated within the broader context of peatland restoration practices. Degraded peatlands are sometimes treated as “sacrifice zones,” where interventions are applied under the assumption that little ecological value remains. However, lessons from other restoration contexts—such as monoculture plantations in forestry or sod-laying in grasslands—show that expedient interventions can undermine long-term recovery by reducing biodiversity and altering ecosystem dynamics. Avoiding this mindset is critical, as peatlands play a central role in carbon sequestration and climate regulation. Poorly tested restoration methods risk delaying recovery and exacerbating degradation.

Comparative evidence underscores the importance of adopting a holistic, data-driven restoration model. For peatlands, this requires integrating ecological monitoring with assessments of chemical leaching, soil health, and biodiversity impacts. Recent analyses, including Brennand’s “carbon calculator,” further stress that the environmental costs of restoration methods—such as carbon emissions from material transport—must be weighed against their potential gains.

In conclusion, sheep wool holds potential as a restoration material, but its use must be guided by robust scientific evidence. Comprehensive risk assessments (ecotoxicological studies), long-term monitoring, and site-specific management are essential to ensure that wool contributes positively to peatland recovery rather than perpetuating cycles of degradation. By moving beyond a "sacrifice zone" mentality and aligning with rigorous, sustainable practices, restoration efforts can better support peatland resilience, biodiversity, and carbon neutrality targets.

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