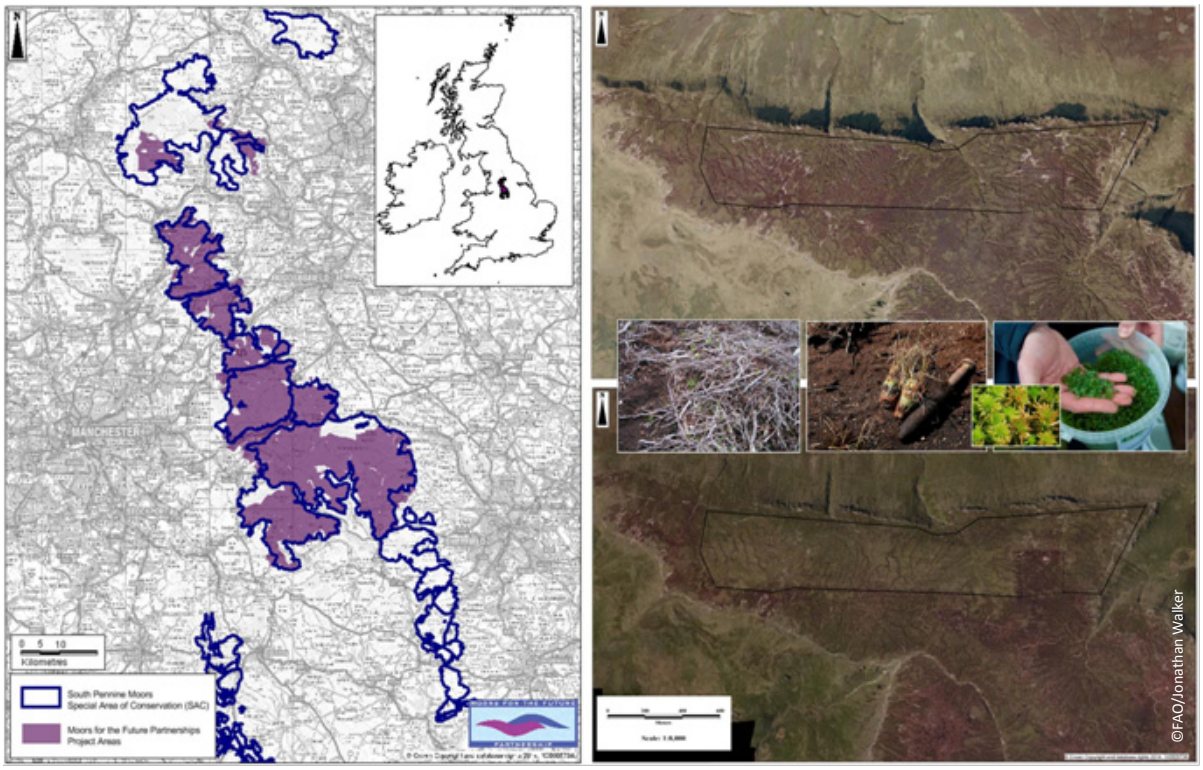
Food and Agriculture Organization of the United Nations

Stabilisation of bare peat, South Pennine Moors

South Pennines, Derbyshire, North, West and South Yorkshire, Lancashire, England, United Kingdom (LON: 01 46 59 W, LAT: 53 27 37 N)

Buckler, M., Fry, C., Maskill, R., Pilkington, M., Proctor, S., Walker, J., S. & Wittram, B.,

Moors for the Future Partnership, Edale, Derbyshire, United Kingdom



Left: Map of Moors for the Future Partnership's project areas covering the South Pennine Moors, UK. Right: Aerial photograph of the 'Making Space for Water' project on Kinder Edge, Peak District, in the United Kingdom, which was funded by the Department for Environment, Food and Rural Affairs (Defra). The photos show the land before the bare peat stabilisation work began in 2009 (top) and after treatment in 2013 (bottom). The solid line depicts the treatment area, which received substrate–stabilizing brash application (middle left) and plug planting (middle centre) in addition to gully–blocking works. Re–introduction of *Sphagnum* moss (middle right) will help regenerate native blanket bog vegetation, strengthen hydrological integrity and promote future peat formation. A control area, receiving no treatment (dashed line), highlights the importance of intervention and lack of natural revegetation.

Summary

The blanket bogs of the United Kingdom's Peak District and South Pennines show evidence of long–term decline caused by a range of natural and human–induced factors. The most significant feature of this decline is the large area of bare and eroding peat and associated damaged vegetation. This degradation has reduced the area's capacity for delivering ecosystems services including: clean drinking water released slowly over a long period following rainfall; storage of carbon from old vegetation in the form of peat; habitat for raising animals (sheep and grouse); and extensive areas for recreation.

There are two main reasons for the formation of these areas of bare peat. Since the start of the industrial revolution, atmospheric pollution has caused the loss of *Sphagnum* mosses, the building blocks of these bogs. These mosses are very sensitive to the sulphur oxides emitted by burning coal. Without these mosses, the bogs start to dry out and become more susceptible to summer wildfire. These fires can remove all vegetation, including the roots and seeds, from the bog and burn the peat itself. Once the bogs start drying out, the peat shrinks, forming cracks, pipes and holes, which furthers dries out the peat. In addition, gullies are created, either from collapsing peat pipes, or through the surface erosion of the drying bare peat, which again dries the bog surface even further.

These conditions are exacerbated by the weather conditions on the summits where blanket bog forms. Blanket bog formation requires high levels of cloud and rainfall. Because of the altitude in the Peak District and South Pennines (approximately 600 m), the bogs there are subjected to regular, sustained periods of freezing and thawing. These factors, together with the summer drying of the peat, cause extensive lamination of the bog surface, which was built up in layers. In combination, these erosive forces also lead to the loss of approximately 2.5 cm of peat from the whole of the bare peat area, a highly mobile surface which is not conducive to the establishment of vegetation. This problem is also made worse by additional factors:

- the atmospheric deposition has lowered the pH to around 3.5, which most plants, even moorland plants, cannot tolerate;
- the areas are extensively grazed, and the vegetation is generally unpalatable and nutrient poor. The most palatable vegetation types are the extending areas of young cottongrass (*Eriophorum* spp.) and the flowering heads of grasses and sedges. Removal of these plants leads to the loss of sources of new vegetation.

To protect the remaining active blanket bog (a nature conservation priority habitat) and to prevent the further loss of peat, the surface of the bog needs to be revegetated. The ideal situation is the establishment of a diverse sward dominated by sphagnum mosses, which reduces the risk of wildfire, the stops the drying out of the peat and reinstates ecosystem services. This requires stabilizing the bog surface, adding the missing plant species and amending the hydrology. The work described below outlines the approach taken by the Moors for the Future Partnership, established in 2003, to achieve those ends.

1. Practice description

Area of the site	65 000 ha in the South Pennine Special Area of Conservation (SAC)	
Current land cover/use	Degraded blanket bog with restricted sheep grazing and grouse moor management.	
Previous land cover/use	Blanket bog (natural peatland) that has been intensively grazed by sheep, managed for grouse shooting and damaged by extensive wildfires.	
Origin of intervention	Individual landowners and managers in the Peak District realized that the problem of moorland erosion could not be tackled by one partnership alone. In February 2003, the Moors for the Future Partnership was formed with funding from the Heritage Lottery Fund (HLF). Partners include local authorities (Peak District National Park Authority, Derbyshire County Council), government organizations (Natural England, Environment Agency, Department for Environment, Food and Rural Affairs), utility companies (United Utilities, Yorkshire Water, Severn Trent Water) and charities (National Trust, Royal Society for the Protection of Birds).	
Types of intervention used in the area	☑ Rewetting ☐ Drainage ☐ Cultivation of crops ☐ Grazing ☐ Forestry ☐ Aquaculture ☐ Fishery ☑ Other: Reducing erosion	
Duration of implementation	11 years (February 2003–Present)	
Main purpose of the practice	The main purpose of our bare peat stabilization works are to prevent further erosion and peat loss; reduce the exposure of bare peat to destructive weather conditions; stabilize the structure of the peat body to reduce erosion and its associated negative impacts on ecosystem services, including water quality and carbon losses; and re–introducing the possibility of future peat formation.	
Level of technical knowledge	☐ Low ☐ Medium ☑ High	
Water table depth from surface	Autumn 2013 mean values: • 0.08 m (intact moorland) • 0.40 m (bare peat site)	
Present active drainage system	Width of channels	0.2–8.0 m
	Distance between channels	4.0–90 m
Subsidence	Before practice	
	During practice	

2. Implementation of activities, inputs and cost

N	Establishment of activities	Input/materials	Duration	Cost
1	Removal of Grazing	Fencing materials	Installation time: 2 weeks per 1 km Life Span: 10 year	£9 per m
2	Bare Peat Stabilisation – Heather Brash	**Materials** Builders dumpy bags Suitable heather moorland for donor site – above 200 m, disease free **Labour/Machinery** Ground truthing of work area Double chop forger harvester Supporting tractors and trailers Helicopter and associated support crew for lifting bags to work area Teams of spreaders to distribute brash Helicopter to remove empty bags **Note**: 1 bag will cover 64 m^2 of bare peat **Materials** Geo-jute netting – open weaved product with a weight of between 500–600 g/m^2 **Labour/Machinery** Ground truthing of work area Helicopter and associated support crew for lifting bags to work area Teams of workers to attach geo–textile **Materials** Granulated Lime fertiliser : 1 000 kg per ha Nurse Crop Seed mix : • 49 kg per ha amenity grass mix • 1 kg per ha Deschampsia Flexuosa • 0.65 kg per ha dwarf shrub mix • 90:10 ratio of Calluna Vulgaris:Erica Tetralix N:P:K fertiliser Initial treatment rate – yr.1 • Nitrogen – 40 kg per ha • Phosphate – 120 kg per ha • Potassium – 60– 120 kg per ha Maintenance treatment – yr.2 and 3 • Nitrogen – 40 kg per ha • Phosphate – 60 kg per ha • Potassium – 60 – 120 kg per ha **Labour/Machinery** Helicopter and associated support crew for aerial application works **Material** Plugs: • Cloudberry (*Rubus chamaemorus*) – 2 % • hare's–tail cotton–grass (*Eriophorum vaginatum*) – 13.5% • common cotton–grass (*E. angustifolium*) – 50 % • bilberry (*Vaccinium myrtillus*) – 14% • crowberry (*Empetrum nigrum*) – 19 % • rross Leaved Heath (*Erica Tetralix*) – 1.5 % **Labour/Machinery** Helicopter and support crew to fly plugs out Team of workers to plant the plugs **Notes**: 1 plug per 4 m^2	**Cutting and delivery**:1 000 bags per week **Flying**: 500 bags per week **Spreading**: 20 bags per person per day **Life Span**: 3 year for brash – heather seeds to establish after 1 year	£65 per bag for supply, fly and spread

3	Gully Blocking	**Material** Stone – 750 kg load Timber – 4 plank dams – two stakes Bales – two bales per dam Plastic dams – 2 m wide **Labour/Machinery** Helicopter to fly material out Team to install dams	**Application rate:** Average 50 dams per day Life Span Life time for all dams	**Supply and Installation:** £150 per dam – average
4	*Sphagnum* Application	**Material** *Sphagnum* beads – 20 beads per m^2 = 33 litres per ha **Labour/Machinery** Helicopter and support crew to fly material out Spreading team to distribute the beads	**Application rate:** 35–50 ha per day hand spread	**Supply**: £20 per litre (£660 per ha) **Flying**: dependent on site and size of works ~£100 per ha **Spreading**: £90 per ha **Total**: £850 per ha

3. Environmental characteristics

Climate	☐ Tropical ☑ Temperate ☐ Boreal			
Average annual rainfall	1 152 (2011) mm			
Altitude	Bleaklow site: 468–633 m a.s.l.			
Slope	0–75 %			
Peat depth (cm)	☐ ≤ 30 ☐ 30–50 ☐ 50–100 ☑ 100–300 ☐ >300			
Peatland type based on the water source	☐ Fen ☑ Bog ☐ Undefined			
Hydrologic network	The peatlands are drained by a network of erosion gullies and streams that flow into upland reservoirs, where a proportion is abstracted through water treatment works, and the rest flows into major river systems, including the Mersey and Humber catchments.			
Main vegetation species	Before practice	No vegetation, bare, eroding peat		
	During practice	During the first three years of work, nurse crop grass species of *Agrostis* sp. and *Deschampsia flexuosa*, bryophyte species such as *Hypnum jutlandicum* dominate the vegetation cover. Once restoration actions are complete, this vegetation cover develops to more typical blanket bog species dominated by *Deschampsia flexuosa, feather mosses, Calluna vulgaris, Vaccinium myrtillus and Eriophorum vaginatum.*		
Water quality	Water pH	3.9		
	Water turbidity	POC loss of 77 tonnes C/km^2/year		
	Dissolved organic carbon content	Surface water	Before practice	28
			During practice	Monitoring in progress

4. Socio-economic dimension

Local stakeholders	• Landowners; (e.g. private shooting interests) industry (e.g. water companies) agricultural businesses, local authorities, conservation organizations (e.g. National Trust), • commoners (both those with grazing rights and those without), • tenant farmers • shooting tenants • shooting rights owners • local residents and neighbours • Access groups, recreational user groups (e.g.British Mountaineering Council, Ramblers association, fishing and sailing clubs) • Government agencies (e.g. Natural England, Environment Agency and Forestry Commission) that initiate, authorize and fund much of the work.
Land tenure	Much of the land is owned privately by water companies, private shooting/ agricultural/forestry interests, charities like the National trust, and by the state/ government through the Forestry Commission, local authority or other means. Also, there are tenancies, (e.g. agricultural and/or shooting rights), there are commons, and some land has shooting rights owned by one party and the land by another. There are also long–term leases, such as the Eastern Moors, owned by the Peak District National Park Authority but on a long lease to the National Trust and Royal Society for the Protection of Birds.
Land, water, and other natural resource access and use rights	• Water companies rely on the land for water supply, which is drained into reservoirs and other catchment features. • Shoots rely on the heather dominated areas to rear grouse and use cover (trees and scrub) for pheasants. • Members of the public enjoy a 'right to roam' over mountain, moorland, common and heath through the CRoW Act 2000. • Some residents rely upon spring fed water supplies, which may have riparian rights extending onto other land beyond their own. • Graziers rely upon the grass and vegetation to feed stock. • Wind turbines and masts are located on numerous upland sites.
Conflicts	• Between those who want to rewet the moors (e.g. Natural England, Environment Agency, water companies, conservation bodies) and those who do not (grouse shooting interests). • Moorland wild fires are sometimes caused deliberately by persons unknown, causing widespread problems for other stakeholders. • Illegal persecution of raptors. • Some walkers and members of the public not respecting the rural landscape (e.g. not closing gates behind them, dropping litter, not controlling dogs).
Conflict resolution mechanism	• Legal redress through police and courts • Partnerships that seek consensus between stakeholders, (e.g. Moors for the Future Partnership, Yorkshire Peat Partnership, Pennine Prospects). • Ranger services • Local forum and groups

Legal framework	Institutions: • Natural England • Environment Agency • Forestry Commission • HSE • Local authorities • Police • Secretary of State, (especially on Commons) • The Water Services Regulation Authority (OFWAT) is the economic regulator of the water and sewerage sectors in England and Wales. Laws: • Countryside and Rights of Way Act 2000 • Wildlife and Countryside Act 1981 • Water Act 2003 • Reservoirs Act 1975 • Health and safety at work Act 1974 • National Parks and Access to the Countryside Act 1949 • EU Habitats Directive
Products derived from the peatland	• Water • Climate change mitigation • Carbon sequestration • Flood reduction • Heather brash for restoration of degraded peatlands (with bare peat) • Access and recreation • Food (beef, lamb and venison) • Timber • Literature and art • Fuel (biomass, wood and peat) • Horticultural peat
Market orientation	Products from these moorlands are marketed at all levels, from the very local to international.

5. Assessment of impacts on ecosystem services

1 highly decreasing/ 2 moderately decreasing/ 3 slightly decreasing/ 4 neutral/ 5 slightly increasing/ 6 moderately increasing/ 7 highly increasing

Provisioning services	Agricultural production	6
	Food security and nutrition	4
	Employment	5
	Income	6
	Non-timber forest products yield	4
	Livelihoods opportunities	5
	Resilience and capacity to adapt to climate change	7
Socio-cultural services	Level of conflicts	4
	Gender equality	–
	Learning and innovation	6
Regulating services	Waterborne carbon (DOC) loss	3
	Fire frequency	–
	Biodiversity	7
	Subsidence rate	2
Off-site benefits	Water quality	1
	Frequency of flooding	2

6. Climate change mitigation potential

1 highly decreasing/ 2 moderately decreasing/ 3 slightly decreasing/ 4 neutral/ 5 slightly increasing/ 6 moderately increasing/ 7 highly increasing

Impact	Rate	Estimate ($t\ ha^{-1}\ year^{-1}$, CO_2-eq)	Remarks
Net GHG emission	1	305 711 (carbon budget after 4 years of restoration)	Unrestored, bare peat sites can have carbon losses as high as 52200 t ha yr^{-1} of carbon. Stabilized sites showed improved carbon budgets over bare peat sites. One stabilized site achieved a carbon budget after 4 years of restoration that was even higher relative to the vegetated controls. The carbon benefit of peatland stabilization is predominantly avoided loss and could be up to 83300 t ha^{-1} yr^{-1} of carbon. See for further information (Worrall *et al*. 2011).
CH_4 emission	4	253	Limited number of measurements (93) (Worrall *et al*. 2011).
CO_2 emission	1	28 100 (bare gullies) – 68 400 (stabilized gullies with geotextile) – 61 400 (stabilized gullies without geotextile)	Bare peat sites (flat / interfluve) were both net sources of CO_2, all other sites (stabilized and intact control) were net sinks of CO_2).
N_2O emission	–		No Information
Carbon sequestration/ storage aboveground s	1		See Net GHG emission box

7. Additional information

Our work can be broken down into the following categories:

- Stock management. We put up fences and walls to manage grazing which allows vegetation to recover and to provide a suitable habitat for moorland birds such as the grouse, curlew and the rare twite or 'Pennine Finch'.
- Stabilising bare peat. We spread heather cuttings to protect the peat and provide a source of seeds. We apply lime to reduce acidity and spread grass seeds and fertiliser that will form an initial crop of grass.
- Increasing diversity. We increase diversity by planting out by hand plugs of cotton grass , heather, crowberry, cloudberry, bilberry.
- Dams. We block erosion gullies (sometimes known as groughs) using stone dams, heather bales or timber planks. This helps prevent the peat from drying out by raising the water table and keeps eroding peat out of the reservoirs downstream.
- Path management. We refurbish footpaths to protect against the effects of erosion by foot traffic. We landscape paths that have become divided over time, lay flagstones over boggy sections and add water management measures so that paths and the surrounding peat isn't washed away in wet periods.

For more information see below and visit:
web: www.moorsforthefuture.org.uk
twitter: @moorsforfuture
facebook: moorsforthefuture

Clay *et al.* .2012. Carbon dioxide fluxes and DOC concentrations of eroding blanket peat gullies. *Earth Surface Processes and Landforms*, 37(5): 562–571.

Dixon, S.D., Qassim, S.M., Rowson, J.G., Worrall, F., Evans, M.G. Boothroyd, I.M. and Bonn, A. 2013.Restoration effects on water table depths and CO_2 fluxes from climatically marginal blanket bog, *Biogeochemistry*

Worrall, F. & Moody, C.S. (in review) The rate of turnover of DOC and POC in streamwater – including diurnal cycling in short–residence time systems.

Worrall, F., Rowson, J.G., Evans, M.G., Pawson, R., Daniels, S. and Bonn, A. 2011. Carbon fluxes from eroding peatlands – the carbon benefit of revegetation following wildfire. *Earth Surface Processes and Landforms* 36(11): 1487–1498.

I4422E/1/02.15