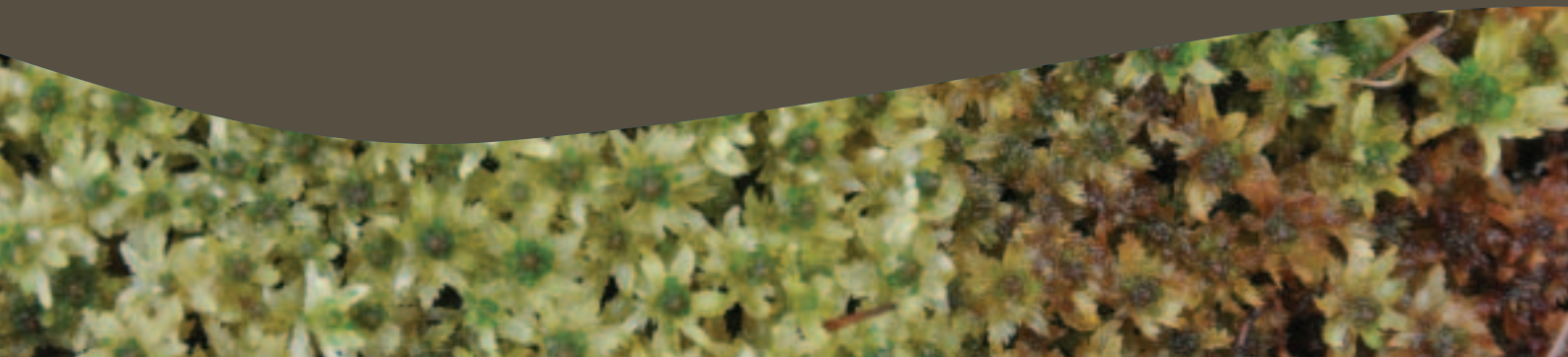
UplandsManagementGroup

MOORS FOR THE FUTURE PARTNERSHIP

BLANKET BOG

Outcomes and improvements

LAND MANAGEMENT GUIDANCE



CONTENTS

Introduction

This guidance for land managers and conservation advisers has been collaboratively produced by representatives of the Uplands Management Group (UMG) in response to a request from the Uplands Stakeholder Forum (USF) for best practice guidance.

It is designed to put into practice the joint voluntary Defra Blanket Bog Restoration Strategy agreed by the Uplands Stakeholder Forum (USF).

This guidance will enable land managers to take steps to improve the vegetation characteristics and hydrological properties of blanket bog, which is defined by a peat depth of over 0.4m, across the uplands of England (see Q1–2).

The five agreed outcomes (see Q5) sought by land managers and conservationists via this approach are:

- the capture and storage of carbon
- improved water quality and flow regulation
- high levels of biodiversity
- a healthy red grouse population
- good quality grazing

The UMG provides practitioner input to the USF, chaired by Defra. The Group seeks to produce guidance for practitioners covering a range of upland management activity. For more information go to: www.uplandsmanagement.co.uk

HOW TO USE THIS PACK

The guidance consists of:

• DECISION MAKING TOOLKIT

Use it out on the hill to agree the starting condition of the blanket bog and to decide on the best management methods to improve it. It is intended to aid the thought process when making these decisions, rather than being a step-by-step guide of what to do.

• OUTCOMES AND IMPROVEMENTS

The booklet details the most likely starting points of deep peat you may find on your moor, as described in the Blanket Bog Restoration Strategy. These pages explain how each state of deep peat meets or detracts from the five agreed key outcomes. Actions and examples of restoration scenarios are suggested to move the peatland towards favourable condition.

• FREQUENTLY ASKED QUESTIONS

Created by practitioners for practitioners. It explains the current evidence base for peatland restoration and the impacts that different management methods may have, depending on local conditions.

Blanket bog toolkit

BLOCK GRIPS, GULLIES AND DRAINS A range of materials and techniques can be used to create dams including peat, stone, timber, plastic sheeting, heather bale and coir roll, as well as reprofiling http://www.moorsforthefuture.org.uk/factsheets

STABILISE BARE PEAT using heather brash or geotextile to halt the erosion of bare peat prior to revegetation.

REVEGETATE BARE PEAT using grass seed, lime and fertiliser to revegetate blanket bog. This grass is a temporary stabilisation treatment, to be replaced by blanket bog species. http://www.moorsforthefuture.org.uk/factsheets

REDUCE HEATHER DOMINANCE and open up the canopy by cutting or restoration burning. Where needed on the driest surfaces, leave heather brash to create humid micro-climate for wet loving species to be introduced. http://www.moorsforthefuture.org.uk/factsheets

REINTRODUCE BLANKET BOG SPECIES using plug plants or seed coated pellets to diversify sward (common cotton grass, hare's tail cotton grass, bilberry, crowberry, cloudberry, cross leaved heath). Where heather is absent it may be added to the mix.

INOCULATE WITH SPHAGNUM A variety of techniques are available including translocation from adjacent moorlands (if there is sufficient supply), cultivated plug plants, pellets coated in plant fragments or spores, and beads or gel containing tiny plants.

REDUCE MOLINIA DOMINANCE by inoculation with moorland species, including sphagnum, cutting to break up tussocks, and raising the water table. In extreme cases spraying and/or burning may be required.

GRAZING Grazing livestock in sustainable farming systems is an integral part of managing moorland environments and can contribute to blanket bog restoration. Grazing management includes the removal of plant material:

- through ingestion and the effects of trampling
- that otherwise may need to be managed by cutting or burning and so reduce the frequency of those activities
- that would contribute to fuel load and wildfire risk

Where stocking rates can be carefully controlled, grazing can be used:

- to help prepare the ground for seeding of bog plant species by creating open or bare ground
- to remove grass growth once vegetation has been re-established on bare peat and create conditions that allow typical bog species to colonise
- with trampling, to break up dense swards of molinia

In more natural or fully restored areas low levels of grazing are sustainable and are consistent with the maintenance of good condition, reducing the need for other forms of management. Because livestock do not graze evenly they can introduce variation in vegetation structure.

MONITOR WATER TABLE It is important to be able to tell if the water table is consistently high. Here are some simple indicators that will help show that the water table is high. Note – always assess after a few days without rain, not immediately after rainfall:

- The surface layer of the peat is moist and sticky, not dry and crumbly – try squeezing it
- The pressure from your feet shows obvious moisture seeping out around the base of the soles
- If you sit or kneel on it your clothes should get wet immediately
- Push a stick into the peat. The top part of the stick comes out clean and moist relative to the lower part
- The surface may feel bouncy to walk across
- Sphagnum mosses are abundant

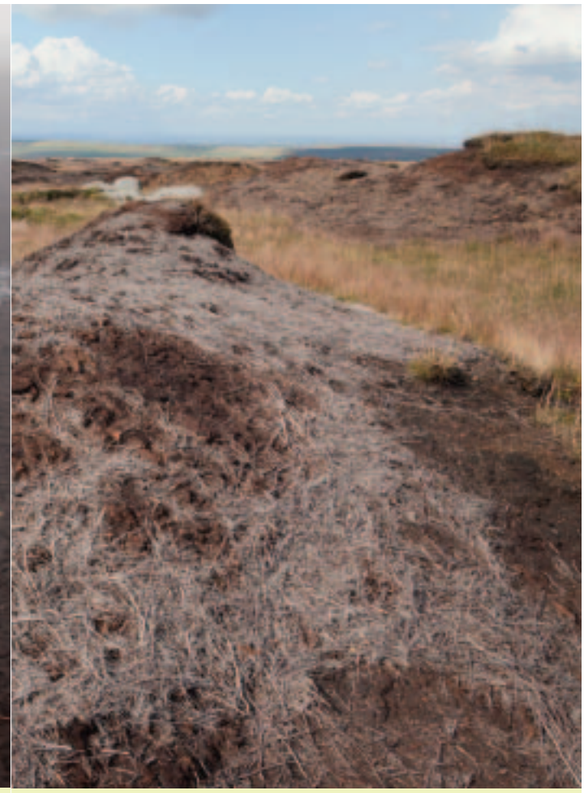
A reliable way of measuring the water table depth and which is repeatable is through using manual dipwells. These can be made simply from 1m lengths of 34mm diameter polypropylene waste pipe with perforation holes drilled in it at 100 mm intervals, with the first perforation holes located 100 mm below the position of the ground surface after installation. The base of each dipwell is sealed with a waterproof tape. The piping is installed by coring out peat, using the same diameter pipe as the dipwell. The dipwell is then pushed into the hole with approximately 100 mm of pipe protruding above the ground surface. The dipwells are normally checked manually, by blowing down a tube which is lowered into the pipe. When the tube reaches water, bubbles are produced and the resulting depth can be measured and recorded.

MONITOR GROUSE NUMBERS and other typical moorland birds, if practical, year on year.

RECORD CHANGES IN VEGETATION over time (especially sphagnum) using fixed point photography. Use a GPS device to fix location or choose an obvious site. Take photos in a certain consistent direction (ideally north so you're not facing into the sun). Photograph the GPS and then photograph the site. Make sure a fifth of the photo is sky for scale and endeavour to keep the height of the camera consistent (eye level). Emerging best practice is to use 3D photography.

Moors for the Future Partnership has produced a number of factsheets relating to tools in this toolkit available here http://www.moorsforthefuture.org.uk/factsheets. Ring 01629 816577 to request printed versions. Factsheets on more of the tools above are planned.

A stone gully block on Kinder Scout



Bare peat that has been spread with heather brash to prevent further erosion

Beads containing tiny sphagnum plants ready to be spread

Blowing into a dipwell to measure water table depth

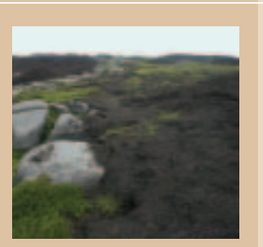
State 2

Bare peat

Little or no vegetation with areas of exposed bare peat and extensive gullying and hagging. Unlikely to support representative peatland communities. Small patches of dwarf shrubs (heather) may exist (inactive).

State 2: Bare peat

How these characteristics affect the five outcomes

Description and range of characteristics	Appearance	Biodiversity	Grouse	Sheep	Carbon	Water	Suggested improvements
Drainage features Water is not held on the moor, and runs off freely • No drainage features present • Drains/gullies present, unblocked, eroding • Drains/gullies present, unblocked, naturally revegetating • Drains/gullies present, blocked • Obvious peat pipes or cracks		Reduced hydrological functionality and presence of blanket bog species (Q8)	Chicks get lost in drains. Fewer invertebrates (Q30)	Limited grazing potential. Risk of loss of sheep in drains (Q35)	Carbon lost, especially from eroding gullies and haggs	Water is focussed into channels, high dissolved (DOC) and particulate carbon (POC). This may lead to siltation in reservoirs and increased treatment costs	• Block any eroding gullies/drains – a variety of techniques are available depending on type and scale of feature including: reprofiling, peat and plastic dams, stone dams, coir rolls, heather bales
Areas of bare peat Areas of bare peat occupy 1000s of square metres and more than 25% of any given area • The area is not naturally revegetating • The area is continuing to erode • Gullies and haggs often present		Bare peat areas support very little biodiversity	No nesting or feeding habitat	No food, may get stuck	Carbon lost, especially from eroding gullies and haggs	Water moves freely across any bare peat surfaces but readily forms channels. High dissolved (DOC) and particulate carbon (POC)	• Stabilise eroding surfaces – a variety of techniques may be required depending on type and scale of feature including: stock exclusion, use of matting, addition of lime and fertiliser, addition of seed, brash or plant plugs • Monitor establishment and repeat as required
Water table Low water table • Even after a wet period the peat surface is dry, friable and crumbly • Sphagnum mosses are sparse or absent		Poorly functioning bog with limited wetland species. Depressed invertebrate numbers	Low invertebrate numbers means there is reduced food for young grouse (Q7)	Diversity of food limited	Carbon lost, especially from eroding gullies and haggs (Q7)	Water table often 0.5m or greater, lower than vegetated surfaces. Hydrophobic surfaces of dry peat make it difficult to rewet	• Block any eroding gullies/drains if present (as above) • Stabilise and revegetate • Diversify vegetation once stabilised with wetland species if not present. A vegetated surface will aid water table re-establishment (Q22) • Monitor changes in water table (Q29)
Vegetation structure Absence of significant vegetation results in poor or no structure • Fragmented vegetation structure that lacks continuity • Vegetation often as islands in large areas of flat bare peat surfaces or on the tops of eroding haggs		Poor nesting habitat, viewing points or shelter. Poor for most moorland birds. Limited diversity in vegetation (Q7)	Poor nesting habitat, viewing points or shelter	Grazing pressure concentrated due to localised vegetation patches. Limited food sources in winter (Q7, Q34)	Limited opportunities for carbon sequestration (Q7)	Water movement not constrained by surface roughness. This may lead to higher surface flow in peak rainfall events (Q7)	• Monitor response to revegetation (Q29) • Supplement with additional wetland species as required (Q22) • Consider future vegetation management requirements, if any (Q10, Q19, Q34)
Vegetation composition Generally species poor • Limited vegetation present • Poor species diversity • Often lacking wetland species • Often acrocarpous mosses (carpet moss) present		Limited diversity in vegetation and range of associated species. Vegetated areas largely support heath or acid grassland species	Limited feeding opportunities due to restricted cover and range of species	Limited feeding opportunities due to restricted cover and range of species (Q34)	Limited opportunities for carbon sequestration (Q7)	Lack of bog vegetation may increase infiltration rates into the peat	• Monitoring response to revegetation (Q29) • Supplement with additional wetland species as required. The process of establishing a range of wetland species will vary but may need a number of interventions as revegetation progresses (Q22)
Susceptibility to wildfire • Extensive dry peat surfaces • Absence of wetland species • High fuel loads nearby		Likelihood of damage from wildfire likely to be variable dependent on location and adjacent vegetation types. These areas may be vulnerable to wildfires starting on adjacent land		Dry peat is combustible and if ignited can burn for significant periods. Wildfire is often responsible for the initial creation of bare peat. Wildfire may undo restoration attempts or make restoration more difficult (Q7)			• Consider risk of wildfire, in particular: Is there a history of wildfire in the area? Is there vegetation with high fuel loads adjacent to the restoration site? (Q39) • Draw up a wildfire management plan • Monitor changing fuel load

Restoration is likely to be progressive and take place over a variable, and significant, time period depending on the existing state and the treatment methods. The below example, starting with a bare peat surface, has gone through a phase of grass domination (usually the simplest vegetation to establish quickly), cotton grass and heather establishing later. This has revegetated the bare surface but restoration is not complete as it lacks diversity of species and sphagnum is absent. However the ground is now in an improved state with reduced carbon losses and can receive more typical moorland species, including sphagnum.

An area of bare peat (2010)

Heather brash has been spread (2011)

A nurse crop of grass is growing (2013)

Some moorland species have established (2014)

Sphagnum can be planted out as plugs healed into open spaces. This makes an immediate impact and the plugs quickly expand

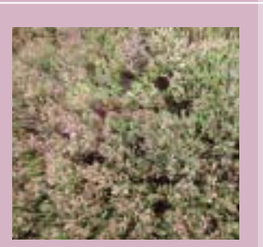
Sphagnum can be added in the form of propagules spread on open areas between the cotton grass and heather. Establishment takes longer but larger areas can be tackled

State 3

Dwarf shrub dominated blanket bog with other species scarce or absent (largely inactive)

Largely inactive, severely modified bogs where dwarf shrub cover exceeds 75% of the canopy and other typical mire species such as bog mosses and even cotton grass are rare or absent. It may have moderate to severe gullying and hagging. Occurs often on 'drier', modified peats and the more easterly moors.

State 3: Dwarf shrub dominated blanket bog

Description and range of characteristics	Appearance	How these characteristics affect the five outcomes: Biodiversity	Grouse	Sheep	Carbon	Water	Suggested improvements
Drainage features Water is not held on the moor and runs off freely. Presence of drainage is variable across this state • No drainage features present • Drains/gullies present, unblocked, eroding • Drains/gullies present, unblocked, naturally revegetating • Low water table • Drains/gullies present, blocked • Obvious peat pipes or cracks		Reduced hydrological functionality leads to reduced presence of blanket bog species (Q8)	Chicks get lost in drains. Fewer invertebrates (especially craneflies) due to dry conditions (Q30)	Sheep get lost in drains. Reduced connectivity for grazing in areas where hagging is prevalent. Haggs and gullies can provide shelter (Q35)	Carbon lost due to eroding peat from gullies and hagg edges	Where gullies exist, water is focussed into channels causing high dissolved and particulate carbon. May lead to siltation in reservoirs and increased treatment costs. Peat pipes may increase flow into watercourses	• Block any gullies or drains – a variety of techniques are available depending on type and scale of feature including: reprofiling, peat and plastic dams, stone dams, coir rolls, heather bales
Areas of bare peat Areas of bare peat less than 25% of any given area (100s of square metres not 1000s) • The area is not naturally revegetating • The area is continuing to erode • Gullies and haggs may be present • Peat surface whilst not exposed may have thick layer of acrocarpous mosses		Limited/no blanket bog vegetation. Bare peat areas support very little biodiversity	Nesting or feeding habitat may be reduced. Small patches of bare, open areas are important for drying wet birds	Reduced foraging area	Carbon lost, especially from eroding gullies and haggs (Q7)	Water moves freely across any bare peat surfaces. High dissolved (DOC) and particulate carbon (POC). May lead to siltation in reservoirs and increased treatment costs	• Stabilise and revegetate any bare peat surfaces. Use the same techniques deployed for the more extensive bare peat areas as required • Monitor establishment and repeat as required (Q29)
Water table Low water table • Even after a wet period the peat surface is dry, friable and crumbly • Sphagnum mosses are generally absent • Peat pipes often associated with dense heather		Poorly functioning bog with few wetland species. Low invertebrate numbers so reduced food availability for birds	Low invertebrate numbers, reduced food for young grouse. Limited drinking water (Q7)	Diversity of food limited. Limited drinking water	Carbon lost, through erosion and oxidation of the peat (Q7)	Water quality poorer due to oxidising surface layer. Average water table 40–60cm below surface. Hydrophobic surfaces of dry peat make it difficult to rewet (Q7)	• Block any eroding gullies or drains if present (as above) • Remove heather canopy and reintroduce wetland species. A diverse vegetated surface will aid water table re-establishment (Q17, Q22) • Consider effects of management on the water table in the peat • Monitor changes in water table (Q29)
Vegetation structure Lacks structure due to single species dominance • Limited variation in the height or structure of the vegetation, often a dense canopy which shades other vegetation • No or limited understorey of mosses		Single-species stands of heather produce conditions that are poor for other plant species due to drying of peat and shading. No variety in habitats for insects or other moorland birds (Q7, Q17)	Visibility reduced, making it more difficult to defend territories and spot predators. Few areas for birds to dry out. Some tall heather provides shelter and a food source during periods of snow (Q7)	Grazing pressure concentrated on the edges due to restricted movement through dense heather stands. Some tall heather provides a food source during periods of snow (Q7, Q34)	Limited opportunities for carbon sequestration as shading and umbrella effect of canopy stops peat forming species from growing. (Rainwater does not reach peat surface to make it moist) (Q7, Q17)	Surface water movement not significantly constrained by surface roughness as shading reduces the number of species able to survive under the heather. Dominant heather can lead to peat pipe formation (Q17)	• Reduce the competitiveness of heather by removing the canopy. This will provide some short-term structural diversity and create conditions for establishment of bog species (Q11, 12, 13, 19, 20) • Monitor response of vegetation (Q29)
Vegetation composition Tends towards single species, heather domination • Heather dominant, can often be 100% cover • Poor species diversity • Dry understorey usually only represented by sparse feather mosses • Often a deep litter layer present		Vegetation takes on the appearance of dry heath and not blanket bog. Wetland species generally sparse or absent. Vegetation does not support diverse moorland fauna (Q17)	Dense heather provides less diverse food sources (e.g. limited/no cotton grasses in the spring) and may be too dry to provide abundant insects for young chicks	Poor variety of food choices, especially a lack of cotton grass, an important food supply in the spring and other grass and sedge species (Q34)	Carbon will be released from dry peat soils under heather and capture will be limited due to the absence of significant peat-forming species. Peat piping and increased porosity of the peat will increase losses of dissolved (DOC) and particulate carbon (POC) (Q7, Q17)	Water movement not significantly constrained by surface roughness provided by a more diverse range of wet-loving species. Water draining these areas is likely to be high in dissolved (DOC) and particulate carbon (POC)	• Reduce the competitiveness of heather through canopy removal. On dry surfaces where practical, cutting can be used to leave the mulch to increase surface humidity and create micro-environments for wet-loving species to grow (Q11, 12, 13, 17, 19, 20) • Inoculate with a range of wetland species (exact mixes to be determined on a site by site basis). The ultimate aim is to establish sphagnum mosses (Q22, 25, 26) • Monitor response of vegetation (Q29)
Susceptibility to wildfire • High fuel load of heather • Low water table so surface peat prone to damage • Low resilience		Damage from wildfire likely to be extreme. Heather dominated swards have high fuel loadings and ignite readily. Dry peat is combustible and if ignited can burn for significant periods. The highest risk of long-term damage occurs in this state		Often this state will have developed because the peat has dried out due to several factors sometimes in combination including: previous wildfire damage, drainage, loss of mosses due to atmospheric pollution and frequent managed burning favouring heather dominance. Further wildfire incidents will make restoration more difficult. Wildfire is detrimental to all outcomes (Q7)			• Undertake a wildfire risk assessment (Q39) • Produce a wildfire management plan • Implement recommendations from wildfire management plan • Monitor changing fuel load

Examples of restoration scenarios:

Impact of burning Rotational burning of heather dominated stands perpetuates heather growth and vigour and exacerbates the drying out of the peat. Restoration burning with follow up inoculation, and/or with raised water table may break the drying cycle (Q11, Q13)

Cutting As an alternative cutting can slow the re-growth of heather, allowing more time for sensitive species to regenerate naturally and for inoculations to establish before the heather canopy becomes dominant (Q18)

Brash Leaving brash in place if cutting will provide increased humidity at the surface and provide a micro-environment for other species to colonise (Q19)

Blocking drainage features Blocking drainage features (here using plastic sheeting) helps to raise the water table and prevent further erosion

State 4

Grass and/or sedge dominated blanket bog (potentially active)

May be active or have potential to become so. Vegetation is dominated by graminoids such as purple moor grass, cotton grass or deer grass with sphagnum bog mosses scarce or absent. This state does not include the post-burn grass or sedge dominated areas of modified bogs of State 5.

State 4: Grass and/or sedge dominated blanket bog

How these characteristics affect the five outcomes

Description and range of characteristics	Appearance	Biodiversity	Grouse	Sheep	Carbon	Water	Suggested improvements
Drainage features Presence of drainage is variable across this state • No drainage features present • Drains/gullies present, unblocked, eroding • Drains/gullies present, unblocked, naturally revegetating • Low water table • Drains/gullies present, blocked		Where drains are absent, wetland vegetation species may be present, though sphagnum absent or sparse (Q8)	Vegetation does not support grouse. Risk of loss of chicks in drains, where present. Wet areas potentially have more invertebrates and provide feeding areas for chicks if present (Q30)	Risk of loss of sheep in drains, where present (Q35)	Where peat is vegetated loss of carbon through DOC and POC is reduced but methane emission may be high. Overall effects on carbon balance uncertain	Water flow rates affected by drainage and/or surface vegetation roughness. Reduced levels of dissolved (DOC) and particulate carbon (POC)	• Block any eroding gullies/drains – a variety of techniques are available depending on type and scale of feature including: reprofiling, peat and plastic dams, stone dams, coir rolls, heather bales
Areas of bare peat Areas of bare peat less than 10% of any given area (10s of square metres) • Extensive areas of bare peat generally absent • Any bare areas likely to be naturally revegetating • Little sign of active erosion		Biodiversity generally unaffected by the presence of small areas of bare peat	Small patches of bare, open ground are important for drying wet birds	If present may reduce foraging area	Carbon will be lost where there is sparse vegetation cover. However this is likely to be of limited extent in this peatland state	Only limited impact on water as a result of the restricted extent of bare peat	• Stabilise and revegetate any bare peat surfaces. Use the same techniques deployed for the more extensive bare peat areas as required • Monitor establishment and repeat as required (Q29)
Water table High water table • Unless subject to drainage water tables are generally high • The peat surface may feel wet • Small pools of water may exist in hollows • Sphagnum mosses are sparse or absent		Good conditions for wetland species, and high potential for sphagnum inoculation. Abundant invertebrates, though diversity may be limited (Q7)	Vegetation does not support significant numbers of grouse. Abundant invertebrate numbers providing food for young grouse. Presence of drinking water (Q7)	Presence of moist vegetation and drinking water. After rainfall grass dominated areas may be very wet (Q7)	Possibility of carbon being sequestered in areas with high water table (Q7)	Improved water quality as reduced levels of dissolved and particulate carbon with a high water table (average 10–30cm from surface and often at surface in winter) (Q7)	• Consider sphagnum, heather seed and cotton grass inoculation where sparse or absent. A diverse vegetated surface with abundant peat-forming species will aid water table re-establishment (Q22) • Monitor changes in water table (Q29)
Vegetation structure • Not much variation in the height or structure of the vegetation due to single species dominance • In ungrazed or lightly grazed situations the structure may be very tussocky • In heavily grazed areas surface structure is lacking • Shrubs generally absent		Tall, dense vegetation may be important for invertebrates, reptiles or amphibians due to stable microclimate. Limited habitat diversity for moorland birds (Q7)	Grouse generally avoid areas where heather is completely absent as there is no food source. There are fewer areas for nesting and shelter	Area accessible for sheep providing the ground is not too wet or tussocky (Q7, Q34)	Carbon may be sequestered where cotton grass and/or purple moor grass are present. Generally a dense cover in grassy swards leads to limited surface oxidation of peat (Q7)	Water movement may be constrained by some surface roughness, particularly in tussocky swards, less so in heavily grazed swards (Q7)	• Consider management to diversify vegetation (Q18) • Consider cutting to break up large tussocks (burning is likely to encourage tussock formation) (Q19) • In extreme cases herbicide treatment on extensive areas of purple moor grass followed by burning may be required. On large stands progressively treat the area • Consider future grazing requirements (Q34) • Monitor changes in vegetation (Q29)
Vegetation composition • Vegetation dominated by grasses and sedges • Shrubs generally absent • Some mosses may be present but largely feather mosses • Sphagnum absent or sparse		The peat, with a high water table is able to support wetland species. However grass dominated swards tend to have limited diversity (Q7)	Diversity of food sources required by grouse are restricted. Cotton grass may be present but heather absent. May be abundant insects for young chicks (Q7)	Cotton grass provides good forage for sheep especially in spring. Purple moor grass areas poor for sheep. Grass areas favoured in the summer (Q7)	Carbon capture limited due to absence of significant sphagnum cover (Q7)	A more diverse sward, particularly with sphagnum will improve surface roughness (Q7)	• Follow above treatments to open up sward • Diversify vegetation structure through reseeding/ inoculation/translocation with a range of wetland species (especially sphagnum but exact mixes to be determined on a site by site basis) (Q18, Q22, Q26) • Monitor changes in vegetation (Q29)
Susceptibility to wildfire • Fuel load highly variable • Ungrazed swards can be highly flammable, particularly purple moor grass in the spring as leaves die back to leave a straw type mat • Grazed cotton grass, mat grass and heath rush swards present low wildfire risk		Purple moor grass dominated swards ignite readily and so there is some risk from wildfire, especially in the spring before new growth appears. However the swards do not have high fuel loads and fire is likely to pass through quickly. As there are high water tables the peat surface is generally damp or wet and unlikely to ignite	Environmental danger comes if there are adjacent habitats with high fuel loads which have potential to ignite. Socio-economic damage can be caused if wildfire is close to infrastructure e.g. roads, buildings and the cost of containment is high. Wildfire is detrimental to all outcomes. Causes of wildfire need to be addressed (Q7)				• Undertake a wildfire risk assessment (Q39) • Produce a wildfire management plan • Implement recommendations from wildfire management plan • Monitor changing fuel loads

Grass and sedge dominated deep peats can vary considerably dependent on management regimes. They are often not subject to drainage and in these situations water tables can still be high. They can also be active to varying degrees dependent on the vegetation mix; those with cotton grass are most active, purple moor grass less so and those with heath rush and mat grass generally inactive. Sphagnum however is generally sparse or absent.

Heavily grazed, cotton grass dominated deep peat

Heavily grazed deep peat with heath rush, mat grass and cotton grass

In no grazing situations tussocks of either cotton grass or purple moor grass can develop. These may have some mosses associated with them, particularly feather mosses

Lightly grazed purple moor grass swards can often dominate landscapes

With high water tables inoculation with sphagnum can be successful, following initial treatments depending on the current state. (Q25, Q26)

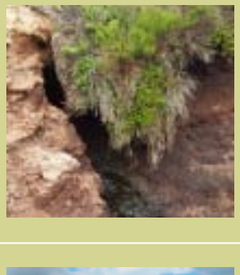
Experimental treatment with various types of sphagnum propagules in the South Pennines. Using plugs gives immediate results. However it is too soon to determine whether these will establish quickly enough to outcompete with the regrowing purple moor grass

State 5

Modified blanket bog with high dwarf shrub cover but with sphagnum and other mire species (active)

Dwarf shrub cover is high, often reaching 50–75%, and sphagnum cover tends to be lower than in intact blanket bogs. Cotton grass is abundant or frequent as an understorey and becomes dominant in the years following fire. Moderately active, with peat formation likely to be slower than in State 6. It may be drained, but usually with few gullies or haggs. Characteristic of much of the Pennines for example.

State 5: Modified blanket bog

Description and range of characteristics	Appearance	How these characteristics affect the five outcomes: Biodiversity	Grouse	Sheep	Carbon	Water	Suggested improvements
Drainage features Often has extensive drainage networks (grips) • Drains/grips/gullies present, unblocked, eroding • Drains/grips/gullies present, unblocked, naturally revegetating • Drains/grips/gullies present, blocked • Peat pipes or cracks may be present • No drainage features (gullies, grips, drains or haggs) present		Reduced hydrological functionality leads to reduced presence of blanket bog species. Vegetation near drains may resemble dry heath (Q8)	Chicks get lost in drains, fewer invertebrates (especially craneflies) (Q30)	Risk of loss of sheep in drains (Q35)	Carbon likely to be lost as dissolved organic carbon and particulate organic carbon due to extensive drainage networks	Where drains exist, water is focussed into channels, high dissolved and particulate carbon. May lead to siltation in reservoirs and increased treatment costs	• Block any eroding gullies/drains – a variety of techniques are available depending on type and scale of feature including: reprofiling, peat and plastic dams, stone dams, coir rolls, heather bales
Areas of bare peat May have small areas (10s of square metres) of bare peat but not extensive (less than 10% of any area) • Isolated areas of bare peat that are small in size, and represent a low proportion of the moor • Some man-induced erosion • Some areas may be naturally recolonising from surrounding vegetation		Mostly a vegetated peat surface though small areas of bare peat can be present especially on the highest ground	Habitat is broken up, but not significantly	May be some reduced foraging area	Carbon will be lost from bare or eroding areas	Water moves freely across any bare peat surfaces, resulting in dissolved and particulate carbon	• Stabilise and revegetate any bare peat surfaces. Use the same techniques deployed for the more extensive bare peat areas as required • Monitor impact on vegetation (Q29)
Water table Water table variable, but can be low due to presence of drains and high heather cover • Extensive drainage networks often present • Peat pipes often associated with abundant heather cover • Sphagnum mosses usually present though not abundant		Poorly functioning bog with limited wetland species though with significant potential from drain blocking. May have reduced invertebrate numbers so reduced food availability for birds (Q7)	Reduced invertebrate numbers, reduced food for young grouse (Q7)	Diversity of food may be more restricted due to drier surface with heather dominance (Q7)	Low water tables will result in loss of carbon (Q7)	Water table on average 10–40 cm below peat surface, sometimes at surface in winter months (Q7)	• Block any eroding gullies/drains if present (as above) • Remove heather canopy and reintroduce wetland species. A diverse vegetated surface will aid water table re-establishment (Q17, Q22) • Consider effects of management on the water table in the peat (Q22) • Monitor changes in water table (Q29)
Vegetation structure Good diversity in vegetation structure • Good variation in the height and structure • Most areas have a shrub canopy with an understorey of mosses • Shrub canopy may shade out sphagnum if it becomes too dominant		Often has good structure though hummock structure characteristic of healthy bog is often absent. Diversity of habitats for moorland birds (Q7)	Good diversity of nesting habitats, as well as viewing points, drying areas and hollows for shelter (Q7)	Variable structure generally good for sheep. Some tall heather provides a food source during periods of snow (Q7, Q34)	Limited opportunities for significant carbon capture, due to dominance of heather and limited sphagnum/cotton grass cover (Q7)	Water movement may be retarded by surface roughness. Water draining these areas is likely to be high in dissolved organic carbon (DOC) and particulate organic carbon (POC) (Q7)	• Remove heather canopy. On large stands progressively treat the area. This will provide some short-term structural diversity (Q12, Q13, Q19, Q20) • Monitor changes in vegetation (Q29)
Vegetation composition Heather usually the dominant species • Heather often the dominant species (50–75% cover) • Less diverse than very active bog, usually less than six indicator species • Sphagnum mosses usually present though not abundant		Limited diversity in vegetation, wetland species present but often with low cover frequency. Heather often dominant. May be some areas of better quality bog (Q7)	Provides a variety of food throughout the year though heather dominated stands may be less diverse (eg limited/no cotton grasses in the spring) (Q7)	Whilst food is available throughout the year heather dominance may restrict choice, with limited availability of grass and sedge species (Q7)	Carbon will be released from dry peat soils under heather and capture will be limited due to the absence of significant peat-forming species. Peat piping and increased porosity of the peat will increase losses of dissolved organic carbon and particulate organic carbon (Q7)	Water movement may be retarded by surface roughness provided by a more diverse range of wet-loving species (Q7)	• Reduce the competitiveness of heather through canopy removal (Q12, Q13, Q17, Q19, Q20) If practical, cutting can be used to leave the mulch to be incorporated into the peat, increase surface humidity and create micro-environments for wet-loving species to grow • Inoculate with range of wetland species (Q22, Q25, Q26) Exact mixes to be determined on a site by site basis. If hummock-forming sphagnum mosses are scarce or absent look at ways of reintroducing them through inoculation or translocation • Monitor response of vegetation (Q29) • Monitor occurrence of bog asphodel (Q29, Q36)
Susceptibility to wildfire • High fuel load from heather • Wetland species are present but tend to be sparse and do not provide for significant natural resilience		Damage from wildfire likely to be significant. Heather dominated swards have high fuel loadings and ignite readily. Peat that is not protected by wetland species can ignite and burn for significant periods	Often this state will have developed because the peat has dried out due to several factors sometimes in combination including: previous wildfire damage, drainage, loss of mosses due to atmospheric pollution, frequent managed burning favouring heather dominance. Further incidents will make restoration more difficult. Wildfire is detrimental to all outcomes (Q7)				• Undertake a wildfire risk assessment (Q39) • Produce a wildfire management plan • Implement recommendations from wildfire management plan • Monitor changes to fuel load

The characteristics of modified blanket bog are highly variable. The following show some of the range of types that fall within this peatland state:

Heather dominant bog but with good sphagnum cover. All that may be required in this situation is a reduction in the heather dominance

Heather and cotton grass dominated bog, lacking significant sphagnum cover. All that may be required in this situation is a diversification of the vegetation through the addition of sphagnum

Areas which have been subject to historical hot burns or wildfire often have heather and cotton grass but with a cover of acrocarpous mosses. The moss carpet needs breaking up followed by diversification of the vegetation through the addition of sphagnum and other wetland species

Heather dominated bog with some cotton grass, lacking significant sphagnum cover and other wetland species. All that may be required in this situation is a diversification of the vegetation through the addition of sphagnum and other wetland species

Improvement of these modified bogs is likely to require a full range of management practices. They are however, due to the presence of relatively high water tables, very capable of being restored to a very active state. The following are examples of the range of techniques that can be deployed:

Slowing water movement across bare peat surfaces using heather bales or coir rolls. This helps stabilise the peat by reducing the erosive forces of the water and by capturing particulate peat allowing species like cotton grass to act as initial colonisers. Sphagnum can be added following stabilisation

Blocking drains with plastic dams to rewet heather dominated bog. This may be all that is required but monitoring is required to confirm that a rise in the water table is then controlling heather growth and allowing an expansion of sphagnum

Sphagnum translocated to suitable areas.

This is just one of a number of techniques to supplement or reintroduce sphagnum

Stabilising eroding gullies or peat hagg edges. Stone dams used to slow down water flow and capture particulate peat. Brash including a range of bog species has been spread on the sides and bottom. In extreme cases reprofiling of the gully/hagg sides is required to reduce the slope angle

State 6

Active hummock/hollow/ridge blanket bog (very active)

This is unmodified or little modified, sphagnum-rich blanket bog, which is peat-forming (active) often with hummocks and hollows. There may be basin or valley mire components. Typically neither heather nor cotton grass achieve high abundance and there is usually a good sphagnum understorey. It meets, or is close to meeting favourable condition attributes.

State 6: Active hummock/hollow/ridge blanket bog		How these characteristics affect the five outcomes					
Description and range of characteristics	**Appearance**	**Biodiversity**	**Grouse**	**Sheep**	**Carbon**	**Water**	**Suggested improvements**
Drainage features Few man-made drainage features – any active drains blocked • No active drainage features (grips, gullies or drains) present • Any drains/gullies will have been blocked		Good hydrological functionality (Q8)	Chicks not lost in drains. Wet areas will provide feeding areas for grouse chicks	Sheep and lambs not lost in drains. Drain blocks provide safe crossing points	Carbon will be being sequestered as peat is forming. Little loss of carbon through drains or bare peat	High water tables limit flood attenuation capacity except in dry weather	• No intervention action required
Areas of bare peat Areas of bare peat rare, if present may be naturally occuring, little evidence of man-induced erosion • No/minimal areas of bare peat • Peat mass usually continuous and stable • No man-induced erosion		Natural blanket bog surface	Continuous habitat providing territories	Foraging areas not limited by areas of bare peat	Peat depths may be in excess of 1 metre over large areas, typically storing over 500 tonnes of carbon per hectare with ongoing capture of carbon	Surface flows moderated by understorey of sphagnum. Reduced loss of dissolved and particulate carbon	• No intervention action required
Water table High water table • The peat surface is wet and bouncy • Pools of water exist in hollows • Sphagnum mosses are abundant • Peat pipes may be present but not of any significant consequence		Abundant invertebrates, important food source for nesting moorland birds. Optimal conditions for sphagnum growth and diverse blanket bog vegetation (Q6, Q7)	Abundant invertebrate numbers providing food for young grouse. Presence of drinking water (Q6, Q7)	Drinking water available (Q6, Q7)	Possibility of carbon being sequestered. High water table limits losses of carbon through oxidation (Q6, Q7)	Water table on average 5–10cm from surface and often at surface in winter. Improved water quality as less oxidation of the peat (Q6, Q7)	• No intervention required, blanket bog functioning naturally
Vegetation structure Very variable • Diverse vegetation structure • Moorland vegetation provides both a canopy and understorey • Vegetation is growing at different heights • Hummock and hollows can be seen on surface topography		Natural blanket bog surfaces. Diversity of nesting habitat, hummocks provide viewing points/ drying areas, hollows provide shelter. Generally good for most moorland birds (Q6, Q7)	Diversity of nesting habitat, hummocks provide viewing points/drying areas, hollows provide shelter. Diverse structure helps maintain grouse territories (Q6, Q7)	Good accessibility for sheep, grazing pressure should be dispersed (Q6, Q7)	Hummock-forming sphagnum species best for carbon sequestration (Q6, Q7)	Complex surface topography and high sphagnum cover slows passage of surface water (Q6, Q7)	• This is what 'good' looks like • Ideally no active management of structure is required for any outcome • Monitor vegetation (Q29)
Vegetation composition Diverse, sphagnum-rich and not heather dominated • Diverse vegetation composition (more than six indicator species) • Both dry- and wet-loving species • High cover of sphagnum • Lower cover of heather and grasses • Abundance of hummock-forming sphagnum moss		More natural blanket bog communities with the full range of associated species. Supports stable populations of typical moorland bird species and high populations of invertebrate species. Crane fly larvae are a key bird food source (Q6, Q7)	Heather and sphagnum grow in balance producing abundant young heather shoots. Other important food sources include cotton grass, berries and invertebrates (Q6, Q7)	Provides a variety of food though productivity is low with limited winter grazing potential (Q6, Q7, Q34)	Peat-forming species (sphagnum and cotton grass) abundant. Optimal conditions for carbon sequestration (Q6, Q7)	Abundant sphagnum maintains high water tables (Q6, Q7)	• This is what 'good' looks like (Q6) • No specific management required to change diversity as this peatland state has diverse blanket bog vegetation and is fully functioning for all outcomes • Monitor vegetation (Q29) • Monitor nutritional value of dwarf shrub • Monitor occurrence of bog asphodel (Q29, Q30)
Susceptibility to wildfire Inherently resilient due to wetness and vegetation types • Low fuel load • High water table – surface peat moist • Sphagnum-rich – vegetation retains moisture		Lower likelihood of ignition, or damage in the event of a wildfire (Q7)					• Undertake a wildfire risk assessment (Q39) • Monitor any long-term changes to vegetation structure and composition in relation to wildfire risk

Very active blanket bogs generally require no active restoration management interventions since they are functioning as natural ecosystems. They may however be an important source of material for the restoration of modified blanket bogs and in particular may provide areas where sphagnum can be sustainably harvested for use in restoration elsewhere on the site. If doing this particular care should be taken not to damage the hummock/hollow nature of the bog surface. This type of structure lends itself to hand collection of material rather than mechanical collection. There will be some diversity in the characteristics of this type but generally much less than in the more modified types. Variation is generally reflected by the wetness of the peat which dictates presence of pools and the relative abundance of the different vegetation components. Generally sphagnum is abundant and represented by different forms (carpet and hummock forming) and dwarf shrubs generally grow in balance with the sphagnum providing abundant young heather shoots but soil wetness restricts their competitiveness. The following show some of the variation in this most active state:

Often open pools of water are present

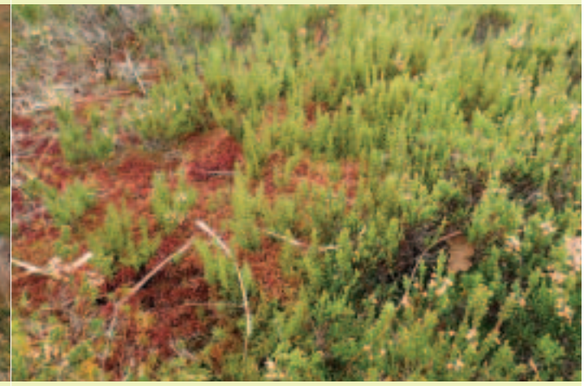
Non-crustose lichens (lichens that don't form a crust) are more likely to be found in drier locations

Very active blanket bogs can be very diverse and contain a range of species not present on more modified types Sphagnum is consistently present throughout and its presence is a good indicator of an active bog. It can be present in a range of forms:

Wet sphagnum lawn, occupies hollows

Sphagnum carpet

Sphagnum hummocks create structure and are features of undisturbed bog



Heather growing in balance with sphagnum, continually forming fresh shoots

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