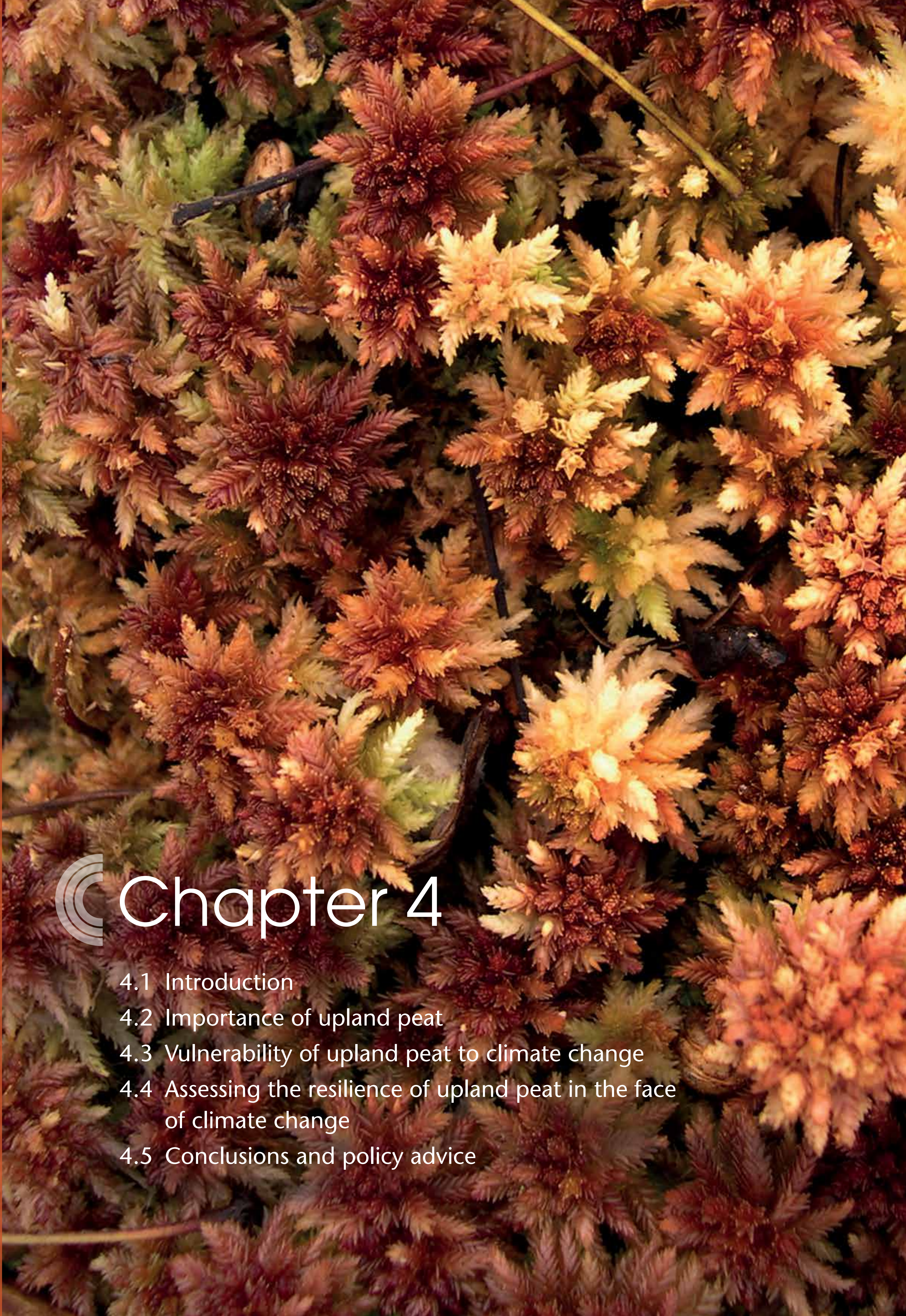


Chapter 4

Chapter 4:
Regulating services – upland peat

Key messages

Peatlands provide a number of services to society.

- They are significant natural carbon stores, with upland deep peats in England holding an estimated 140 million tonnes of carbon, worth billions of pounds.
- Upland peat plays a key role in regulating the supply and quality of drinking water, as the source of a number of major river catchments in England.
- They also provide highly valued cultural services and are internationally important wildlife habitats.

If functioning peatlands are to survive in a changing climate and continue to provide these services, they need to be in a good condition. The peat archive going back over 9,000 years shows that new assemblages of peat-forming mosses that are tolerant of warmer and drier conditions may develop and continue to lay down peat. But in order for new assemblages to be able to develop, peatlands need to retain their water holding capacity.

Climate change strengthens the case for action to protect and restore peatlands. Warmer and drier conditions in the future are likely to increase the rate of carbon losses from degraded peatlands, and reduce the water-holding and filtering capacity of degraded peat. The longer the delay in reversing degradation, the more expensive it will become to deliver.

Potential risks

The majority of upland peat is not in a sufficiently good condition for peat-forming vegetation to persist or colonise in the face of climate change.

- Of the total area of upland deep peat (3,550 km^2), only 160 km^2 (4%) is in a favourable ecological condition where mosses are still actively forming peat. This has declined from 210 km^2 (6%) in 2003.
- Nearly half (1,600 km^2) of the total area of deep peat has been modified to the extent that little, if any, peat-forming vegetation remains. Of this, nearly 1,000 km^2 (30% of the deep peat area) has become more like heathland as a result of regular burning.
- Decades of damaging land management practices and pollution have caused widespread degradation: almost all upland peat has been acidified from atmospheric pollution; some 750 km^2 (21%) has been drained due to attempts in the 19th century and in the 1970s to modify the land for agriculture; a further 500 km^2 (14%) is intersected by deep gullies; some 350 km^2 (10%) is over-grazed as a result of the drive to increase sheep stocking levels since the 1950s.

Many upland peats are losing carbon to the atmosphere and erosion of peat into water courses is increasing. This has implications for the provision of regulating services and is adversely affecting wildlife and the amenity value of upland peats.

Key messages

Options for further action

Over the last decade some efforts have been made to restore degraded peats in the uplands.

- Nearly one-third (1,100 km^2) of upland peat has management plans in place that, if fully implemented, could return protected sites to a favourable condition. In practice, it may take many decades for degraded peats to recover the full range of services provided by undamaged habitats.
- Payments of £27 million to livestock farmers through the Rural Development Programme for England have reduced grazing intensity in over 40% (some 3,000 km^2) of the uplands since 2007.
- Investment of £45 million by water companies between 2005 and 2015, often in partnership with conservation organisations, is funding measures such as re-vegetating bare and gullied peat and blocking drainage channels.

Around two-thirds of degraded peat lack clear plans for restoration. We found limited evidence of reductions in the amount or intensity of burning. Revegetation schemes cover only around one-quarter of bare peat and there has been limited restoration of gullied areas.

In many cases, the benefits of restoration to society outweigh the costs. The case for restoration becomes stronger with climate change. However, some landowners will not experience the full range of benefits from restoration, such as those from reduced carbon emissions and therefore lack incentives to act.

The Government should strengthen the policy framework to enable further restoration effort across the uplands. Specifically, it should:

- **Set a clear policy signal on the urgent need to increase restoration.** An explicit policy goal would help to drive forward the concerted action required.
- **Review the enforcement of existing regulations for protecting and enhancing peat sites.** Damaging practices on many protected sites are continuing, despite regulations being in place that require active measures to prevent site deterioration.
- **Improve incentives for land-owners to invest in restoration.** In some cases, restoration can require a high upfront capital outlay and result in reduced revenues from current activities. It is therefore important to explore ways to manage peatlands that deliver multiple benefits both to society and to landowners. In this regard, effective price and market mechanisms that fully value the services from well-managed peatlands will be required to stimulate further restoration effort.

4.1 Introduction

This chapter assesses the resilience of upland deep peat in England in the face of climate change. We focus on upland peats because it:

- provides a wide range of ecosystem services that are particularly important from a climate change perspective, including carbon storage and water purification;
- is sensitive to changes in climate, particularly reduced water availability and the increased risk of wildfire; and
- has been subject to decades of pollution and modification by land uses, which have increased their vulnerability to the impacts of climate change.

The chapter assesses how climate change may impact on upland peat; reviews how historic and current land uses are likely to have affected its vulnerability; and analyses the types of restoration available and the scale of uptake to date. The chapter concludes with analysis of the costs and benefits of restoration to provide an insight on the appropriateness of current effort.

4.2 Importance of upland peat

Peatlands are freshwater habitats that, when in good condition, are effectively waterlogged for most of the time. This inhibits the aerobic decomposition of organic matter, which form organic rich peat layers. Over thousands of years of accumulation, these layers can reach depths of many metres. Intact upland peats provide a range of services to society (Box 4.1).

Box 4.1: Ecosystem services provided by intact upland peats

The UK is among the top ten nations of the world in terms of its total peatland area. England has some 6,700 km^2 of deep peat[1] soils making up 5% of land cover.[2] Just over half of deep peats in England (3,550 km^2) are located in the uplands.

The main type of semi-natural habitat associated with deep peat in the uplands is 'blanket bog', so called because it literally blankets upland plateaus. As their water is sourced solely from rainfall, snow and mist, these habitats only occur where rainfall is very frequent.

The UK is home to 13% of the world's blanket bog habitat, which is a notified Priority Habitat.[3] The main locations in England are Dartmoor, the Peak District, the Lake District and the Pennines, as well as to a lesser extent in the North York Moors and Exmoor.

Regulating services

Climate regulation through carbon storage

- In an active, peat-forming state, deep peat represents net sinks of carbon dioxide, accumulating between 3 and 7 tonnes of carbon per hectare each year.[4] In the UK, many peatland areas have been accumulating carbon since the retreat of the last glaciers 10,000 years ago.
- An estimated 140 million tonnes of carbon is stored in England's upland deep peats.[5] If, over time, this were all to be lost to the atmosphere, it would equate to around 500 million tonnes of of carbon dioxide with a value of billions of pounds based on the price of carbon.
- Due to their waterlogged nature, intact peatlands can also be sources of methane.[6] Even though methane has a higher global warming potential than carbon dioxide, it has a shorter lifetime in the atmosphere, meaning that over the long term the amount of carbon sequestered outweighs the amount of methane emitted.[7]

Water quality regulation (waste detoxification)

- The plant-soil systems of deep peats intercept and retain various atmospheric pollutants, such as sulphur, nitrogen and heavy metals, that would otherwise contaminate drinking waters. These pollutants do, however, contribute to degradation of the peat.

Flood hazard regulation

- As undamaged peatlands are waterlogged, they have very little ability to store additional water during heavy rainfall events.[8] Consequently, upland catchments with a high proportion of blanket bog habitat often exhibit a rapid runoff response, so that stream flow rises quickly during rainstorms and returns rapidly afterwards to low-flow conditions.
- The creation of drainage channels accelerates the rate at which water leaves a peatland. Run-off may also be accelerated by the loss of vegetation, where areas of bare peat can become so dry that water will no longer infiltrate.

1 Defined as being at least 25 cm in depth.
2 Additionally, shallow peaty soils and soils with peaty pockets make up a further 5% of England's land (5,270 km^2 and 2,100 km^2 respectively). Natural England (2010).
3 Over 50 Priority Habitats of principal conservation importance have been notified by Natural England under the Natural Environment and Rural Communities Act 2006. See Chapter 3 for more detail.
4 Billett et al. (2010); Worrall et al. (2010).
5 Natural England (2010).
6 Gorham (1991).
7 Bain et al. (2011).
8 Holden et al. (2007).

Box 4.1: Ecosystem services provided by intact upland peats

Provisioning services

Water supply

- Peatlands are the headwaters for some of England's major water supply catchments that supply drinking water reservoirs across the uplands. For example, there are 55 reservoirs in the Peak District that provide water to the major surrounding conurbations of Sheffield and Manchester.
- Water derived from functioning peatlands is naturally of very high quality, being relatively pure due to limited human impacts, low weathering rates and widespread overland flow.[9]

Cultural services

Landscape/amenity

- Peatlands are a highly significant part of England's natural heritage. As they generally form relatively large tracts of semi-natural habitat, they can provide a strong 'sense of place' and 'wilderness', which is rare within the heavily modified landscapes typical of England.

Archaeology

- Peat soils are of considerable archaeological importance as they can preserve records of species, environment, climate and land use for 10,000 years or more.[10] Such records provide insights into past environment and culture, including historic climate changes and land management regimes.[11]

Biodiversity

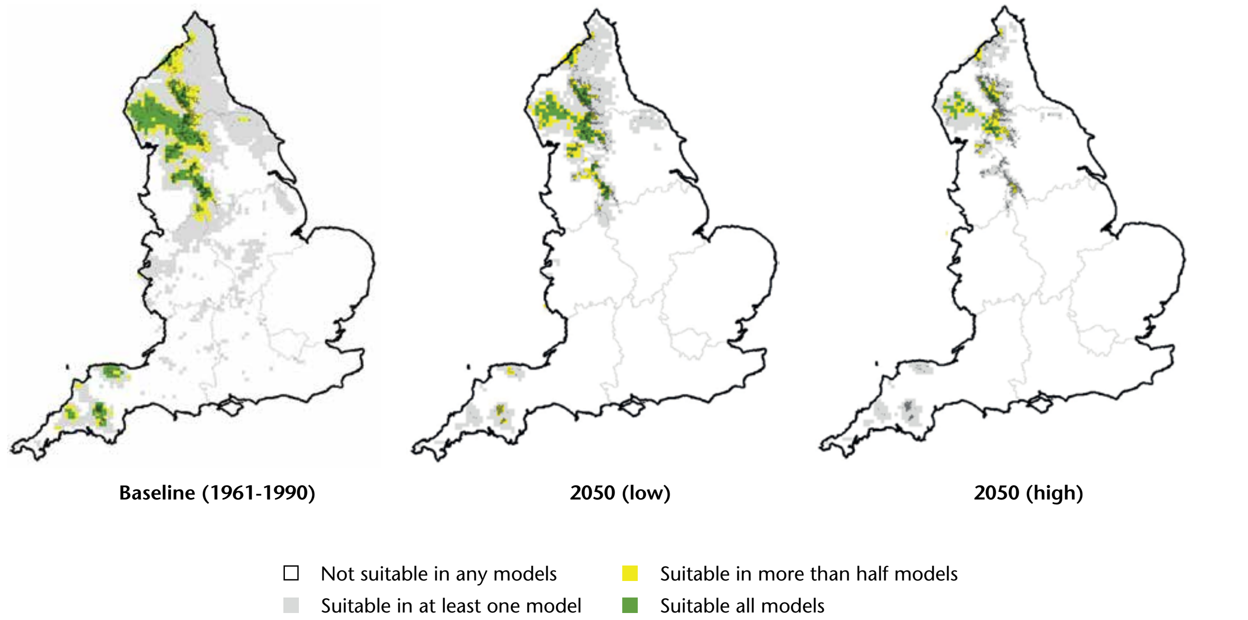
- In England, around 1,300 km^2 (nearly 40% of all upland deep peat) are designated as Sites of Special Scientific Interest (SSSI), reflecting their national importance for biodiversity.
- Blanket bog habitats make up one-fifth of all Special Conservation Areas (SACs) in England, highlighting the importance of this habitat under the EU Habitats Directive.
- Some *Sphagnum* mosses are priority species for conservation. Unusual and rare invertebrates are supported on bog habitats, including the most diverse range of dragonfly assemblages of any British habitat. For birds, blanket bog is an important nesting or feeding habitat for upland breeding species, especially golden plover and dunlin.

4.3 Vulnerability of upland peat to climate change

Modelling suggests that warmer and drier conditions could increase the vulnerability of vegetation communities that currently dominate upland blanket bogs. The area of suitable climate for current assemblages of peat forming vegetation is projected to decline in extent by between one-half and two-thirds by the 2050s. (Figure 4.1).[12] However, some care is needed when interpreting such models as they do not account for non-climatic factors that affect suitability, such as underlying geology, topography and drainage. Neither do they account for the condition of blanket bog or its current management.

9 UK National Ecosystem Assessment (2011b), Chapter 5: Mountain, Moors & Heaths.
10 Brunning (2001); Blackford et al. (2006); Yeloff et al. (2007).
11 UK National Ecosystem Assessment (2011b), Chapter 5: Mountain, Moors & Heaths.
12 Clark et al. (2010). Between 1,320 km^2 and 720 km^2 of blanket bog on deep peat will retain climate suitability by 2050 under low and high climate scenarios respectively.

Figure 4.1: Projected changes in climatic suitability for upland blanket bog in England for the 2050s



Source: Environmental Change Institute et al. (2013) for the Adaptation Sub-Committee, based on Clark et al. (2010).
Notes: Clark et al. (2010) used an ensemble of eight statistical bioclimatic models to identify the vulnerability of blanket bog habitats to climate change. These models vary in complexity and include simple thresholds based on precipitation or potential evaporation/transpiration, general linear models based on temperature, and classification trees and generalised additive models. The modelling is only based on climatic variables and does not account for other factors that influence the formation of blanket bog, including underlying geology, topography and drainage conditions. This explains why some models identify suitability in areas where blanket bog is not currently located. However, over half of the models correctly identify 94% of existing habitat as being within climatically suitable areas. The bioclimatic models do not account for the condition of blanket bog or their ability to continue to function with different assemblages of *Sphagnum* species.

New assemblages of peat-forming vegetation that can tolerate warmer and drier conditions may develop. Paleo-ecological evidence stretching back over 9,000 years show that drier conditions give rise to a shift in the assemblage of *Sphagnum* mosses, from species typical of wet conditions to those more typical of drier conditions.[13] *Sphagnum* species more tolerant of dry conditions are better at forming peat than *Sphagnum* species typical of hollows and pools, as they tend to form raised hummocks. This explains why the deepest bogs in England are generally found at the southernmost limit of bog formation.[14]

***Sphagnum* mosses require a high water table to have the best chance of persisting or new species developing.** If the water table is consistently lower than the surface, peat-forming mosses will tend to dry out and shrink. As a result, the stored carbon reacts with oxygen, decomposes and is released as carbon dioxide to the atmosphere and as dissolved organic carbon (DOC) to water courses. A dried out peatland will also be colonised by non-peat forming species (such as scrub, heather and grasses), which maintain a low water table. If the majority of peatlands were in a good condition, then it would be more likely that future compositions of *Sphagnum* would be able to develop and continue to form peat in the future, even with a warmer and drier climate.

13 Barber (1981). See also Dise (2009), Lindsay (2010), Belyea and Clmyo (1998) and Belyea and Clymo (2001).
14 Swanson (2007).

4.4 Assessing the resilience of upland peat in the face of climate change

We have used indicators to assess trends in the condition of the 3,550 km² of upland deep peat in England and on the uptake of restoration effort.

Condition of upland deep peats

Nearly half (some 1,600 km²) of upland deep peat has been modified to the extent that little, if any, peat-forming vegetation remains (Figure 4.2).

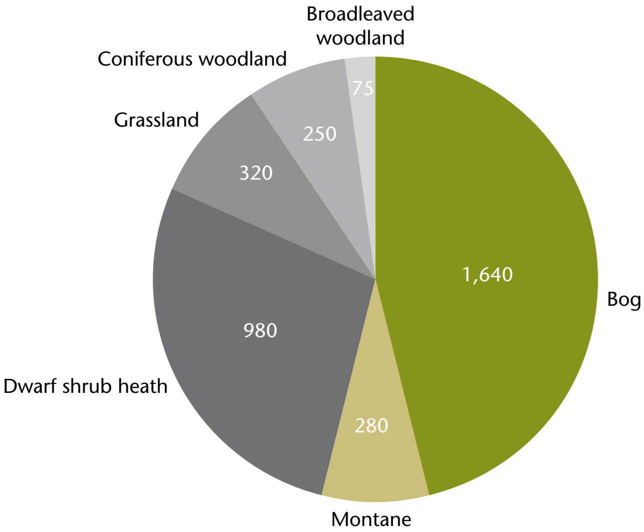
- *980 km² has become more like heathland.* In these areas, decades of drainage and regular burning has resulted in the deep peat now being dominated by heather. Although heather is a characteristic component of blanket bog vegetation, if it becomes dominant it can displace peat-forming *Sphagnum* mosses. Heather is the preferred habitat for red grouse, the primary game bird used for shooting. There are approximately 140 shooting estates in the English uplands with an average size of 20 km².[15] The sport is becoming increasingly popular, with both the number of recorded shooting days and the number of gamekeepers employed increasing between 2000 and 2009.[16]
- *320 km² is now dominated by grasses.* Drainage and decades of relatively intensive livestock grazing has caused a change in vegetation cover from *Sphagnum* species to grasses such as Purple Moor Grass, which is less likely to be peat-forming.
- *325 km² is wooded, mostly by coniferous plantation forestry.* The early and mid-20th century saw a concerted programme of afforestation, mostly using fast-growing conifer species. Land that was marginal for agriculture was targeted, which often meant deep peat in the uplands. To enable tree growth, deep peats as ploughed and drained, resulting in the complete loss of *Sphagnum*.[17] The encroachment of scrub and broadleaved woodland also dries out the peat. While some of these areas have high value for wildlife, many are associated with peat drainage and invasive scrub species, such as Rhododendron.

Detailed surveys show that the majority of upland peat is physically degraded and virtually all is affected by historic and on-going atmospheric pollution (Figure 4.3).[18]

- Almost all (98%) of the total area of deep peat in England suffers from a legacy of acidification and heavy metal contamination from centuries of industrial air pollution. It continues to be adversely impacted by ammonia emissions from lowland agricultural production and oxidised nitrogen pollution from fossil fuel burning. These acidify the peat and raise nutrient levels, which cause peat-forming vegetation to be replaced by nutrient-demanding species such as grasses.

15 Olivier and Van de Noort 2002; Simmons 2003.
16 Number of recorded shooting days increased from 1,560 in 2000 to 1,898 in 2009. The number of gamekeepers employed rose from 196 to 253 in the same period. Natural England (2013b).
17 Natural England (2010).
18 *Ibid.*

Figure 4.2: Estimated land cover of the 3,550 km² of upland deep peat classed as mainly peat-forming (green shades) and non-peat forming (grey shades) (2007)

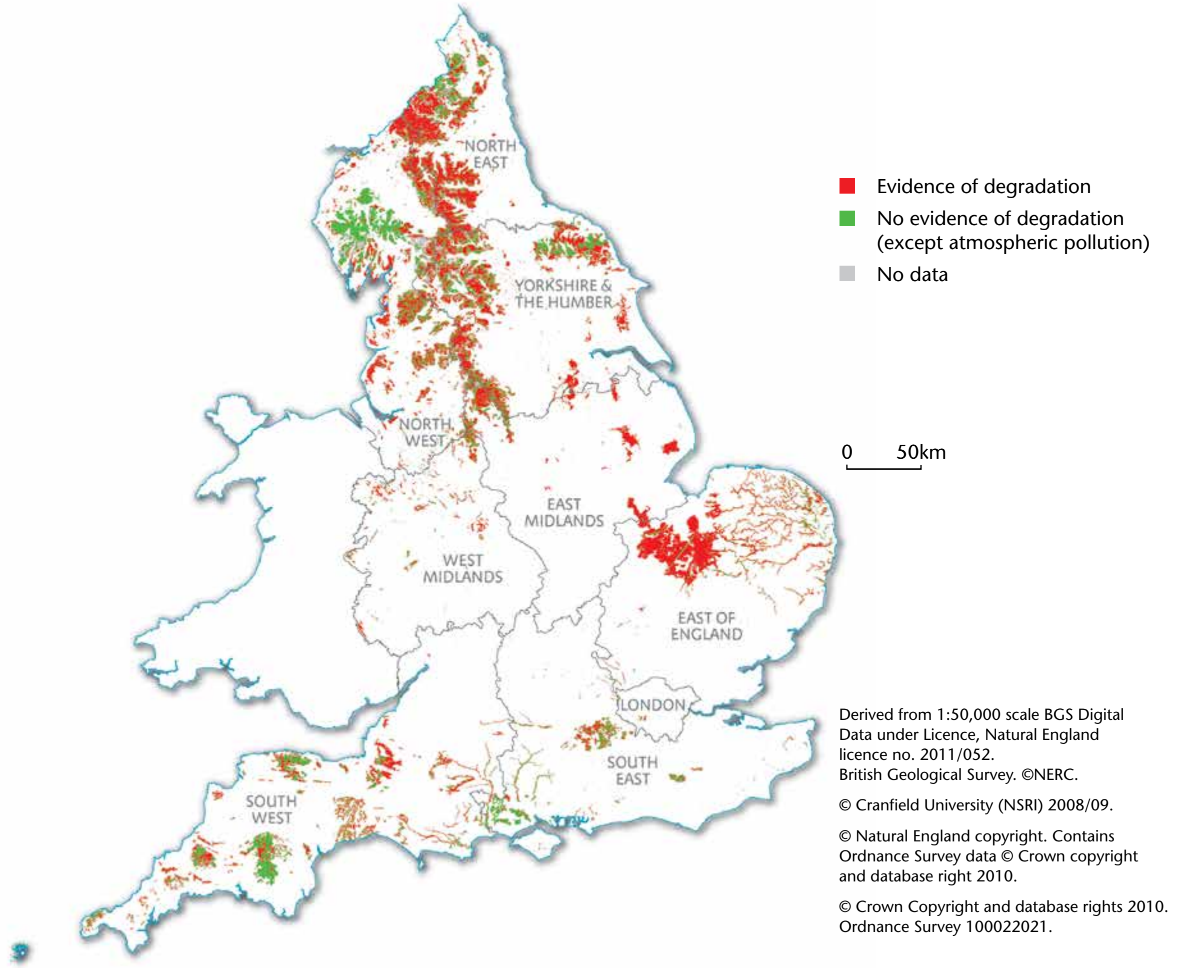


Source: Environmental Change Institute et al. (2013) for the Adaptation Sub-Committee.
Notes: Natural England's deep peat map was used to identify the total area of deep peat in England covering a total area of 6,700 km². To identify the proportion of deep peat located in the uplands we referred to Natural England (2010). This identified that 3,550 km² of deep peat as either currently or previously blanket bog, which is exclusively an upland habitat. We estimated the current land cover of the upland deep peat area by overlaying the deep peat map with the Land Cover Map 2007 (Morton, 2011) and referring to the Natural England Priority Habitat Inventories for blanket bog, fen and raised bog. From this, we identified:
– 1,700 km² of bog over deep peat, of which 90 km² is in fen and/or raised bog. We assumed that the remaining area of bog (1,640 km²) is over upland deep peat.
– 290 km² of montane over deep peat, of which 10 km² is in fen. We assumed that the remaining area (280 km²) is over upland deep peat.
– 1,025 km² of dwarf shrub heath over deep peat, of which 50 km² is in fen. We assumed that the remaining 980 km² is over upland deep peat.
– 335 km² of coniferous woodland over deep peat. We assumed that 7% of the upland peat area (250 km²) is under this land cover (based on Natural England 2009).
– 195 km² of broadleaved woodland over deep peat. We assumed that 3% of the upland peat area (75 km²) is under this land cover (based on Natural England 2009).
– 850 km² of extensive grassland over deep peat, of which 60 km² is on fen. We assumed that the remaining area (320 km²) of upland deep peat is under this land cover.

- Around one-fifth (750 km²) has been drained through the cutting of shallow ditches (known as 'grips'). This was the result of grants to land managers to drain moorland for agricultural improvement in the post-war period. Gripped peats drain water more quickly away from the mossy surface, which thins or disappears completely.
- Nearly 500 km² (14%) is gullied; these are branched erosion features that extend into the peat mass to form a network of channels. These often erode down to the mineral layer under the peat and lose peat material from their bare sides.
- The uplands support around 3 million sheep (45% of the national stock) with stocking levels increasing from the 1950s onwards in response to targeted payments.[19] Farmers were encouraged to stock hardy breeds that could withstand longer periods on the moors. This led to many areas becoming overgrazed. Although stocking levels have declined over the last decade or so,[20] around 300 km² of deep peat (9%) continue to suffer from the impacts of overgrazing.

19 The headage based Sheep Annual Premium Scheme (SAPS) was introduced in 1981. As a result the breeding flock expanded throughout the 1980s (Defra Agricultural Observatory, 2011.)
20 Overall numbers have reduced during the 2000s, with the most recent figures showing that the national breeding flock fell by 0.5% in 2010 (Defra Agricultural Observatory, 2011).

Figure 4.3: Scale of degradation of peat soils in England (2010)



Source: Natural England (2010).
Notes: Using data from the National Soils Map, Priority Habitat Inventory and the British Geological Survey and field assessment, Natural England (2010) collated and mapped evidence on the condition of peat soils. These include deep peats (areas covered with a majority of peat >40cm deep), shallow peaty soils (areas with a majority of soils with peat 10-40cm deep) and soils with peaty pockets. Overall, Natural England (2010) report that 74% of deep peats show visible signs of degradation or are subject to damaging land management practices (red areas in the above map). 96% of deep peat is affected by atmospheric pollution.

- Erosion at the sides of haggs and gullies can eventually undermine the remaining vegetation and leave a landscape of bare peat. This can also occur as a result of severe wildfires that burn into the peat. Around 40 km^2 (1%) of deep peat is completely bare of vegetation. Bare peat is constantly being eroded by rain splash, frost heave and wind as well as becoming very hot and dry in warm weather. Much of the eroded peat is carried into rivers and reservoirs.
- An estimated 10 km^2 of upland peat has been lost to development, primarily for mineral extraction, landfill sites and wind turbines.

Only around 160 km^2 (4% of deep peat) is in a sufficiently good condition to still be actively forming peat.[21] This has declined from 210 km^2 in 2003 (Figure 4.4). As noted in Chapter 3, a lower proportion of blanket bogs SSSIs are in a favourable ecological condition

21 This is the area of blanket bog SSSI currently assessed as being in a favourable ecological condition. Favourable condition means that the features for which the site was notified are present and that the management regime in place is likely to retain those features. For blanket bog SSSIs, the key features will include peat-forming *Sphagnum* mosses, as well as other species representative of this habitat type. See Chapter 3 for more detail on SSSI condition.

than most other types of SSSI habitats. On the positive side, the majority (83%) of blanket bog SSSI is now classed as being in an 'unfavourable recovering' condition, compared to 16% in 2003. The unfavourable recovering classification means that a management plan is in place that, if fully implemented, should result in the site returning to a favourable condition in time. We assess what this means in practice for the scale of restoration effort later in this chapter.

The majority of upland peat is losing carbon to the atmosphere. An estimated 350,000 tonnes of carbon dioxide each year is emitted from upland peat in England, the majority of which is from areas that are being rotationally burnt (260,000 tonnes carbon dioxide). Less than 20,000 tonnes of carbon dioxide a year are sequestered by undamaged blanket bogs.[22]

Increasing amounts of carbon are being lost into water bodies.

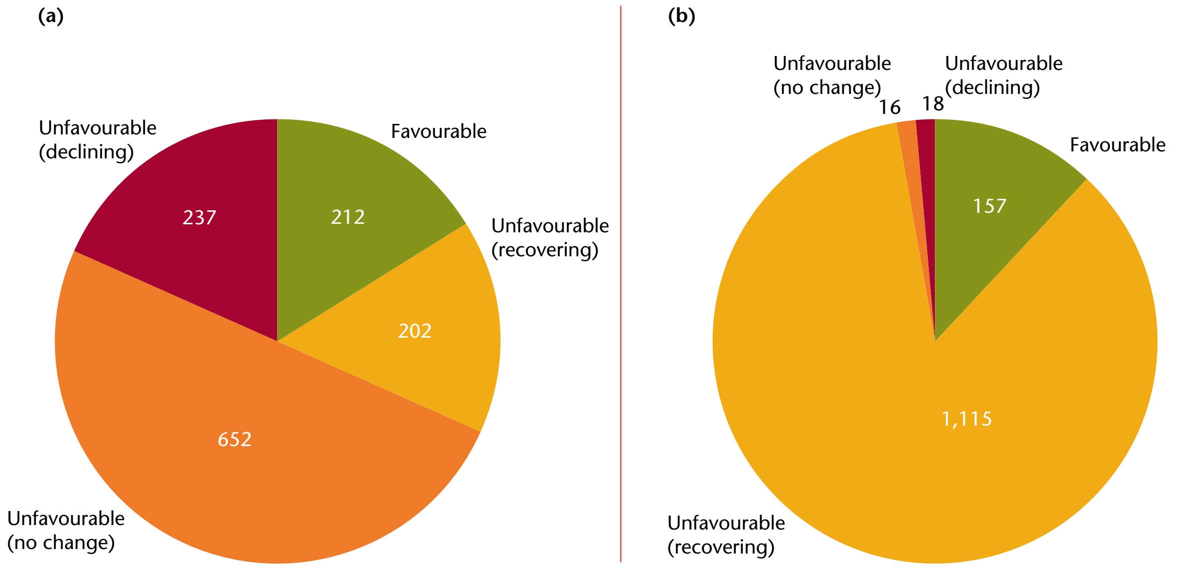
- Levels of dissolved organic carbon (DOC) in water courses have doubled over the last 30 years, with the associated discolouration of water.[23] This has been responsible for the single largest change in upland water quality.[24] The increase in DOC levels may be in part due to recovery from the long-term effects of acid rain,[25] however it is also likely to be caused at least in part by managed burning.[26]
- Erosion of upland peats is resulting in the release into river systems of airborne contaminants that were previously locked in the peat.[27]
- The transportation of particulate organic carbon (POC) into reservoirs is reducing water storage capacity in many parts of the uplands.[28]

These pressures represent a significant long-term challenge for water companies in the uplands, particularly given the requirements under the Water Framework Directive to reduce the levels of purification treatment.[29]

Climate change could result in a three-fold increase in the rate of carbon loss over the next few decades unless current levels of degradation are reduced. The rate of carbon loss is dependent on a number of factors, such as soil temperature, vegetation cover, microbial activity and peat chemical characteristics. Studies estimate that for every one degree increase in temperature, there is likely to be a 30% increase in CO_2 emissions from degraded peats.[30,31]

22 Natural England (2010).
23 Carbon losses into water courses are in the form of Dissolved Organic Carbon (DOC), which turns water brown, and Particulate Organic Carbon (POC), both of which incur water treatment costs.
24 UK National Ecosystem Assessment (2011b), Chapter 5: Mountain, Moors & Heaths.
25 *Ibid.*
26 Natural England (2013b) found strong evidence that burning results in increased water colouration and/or DOC in peatland watercourses.
27 Rothwell et al. (2007); Nizzetto et al. (2010).
28 For example, average losses of 260 tonnes per km^2 per year have been recorded in the heavily eroded peatlands of the Peak District. UK National Ecosystem Assessment (2011b), Chapter 5: Mountain, Moors & Heaths.
29 Article 7: "Member States shall ensure the necessary protection for all bodies of water identified with the aim of avoiding deterioration in their quality in order to reduce the level of purification treatment required in the production of drinking water".
30 Blodau (2002).
31 Graves and Morris (2013) for the Adaptation Sub-Committee.

Figure 4.4: Condition of SSSI blanket bog on deep peat in England, 2003 and 2013 (km^2)



Source: Environmental Change Institute et al. (2013) for the Adaptation Sub-Committee.
Notes: Nationally important SSSIs are designated with the aim of conserving specific biological or geological features. The condition of these features is assessed on a rolling programme against agreed standards. 'Favourable' condition status indicates that the SSSI meets the agreed standards for the features of interest. 'Unfavourable recovering' condition status indicates that the SSSI fails to meet the standards, but has appropriate management in place that will achieve those standards . Sites with inappropriate or no suitable management are Unfavourable. 'No change' or 'Declining'. UK-wide Common Standards Monitoring programme is undertaken by the statutory conservation agencies to assess the effectiveness of management of the features for which protected areas have been designated. Favourable Condition Target(s) have been set for each site. The monitoring tests whether these targets have been met. These results are the condition assessments for Blanket Bog SSSI's located on deep peat.

Effectiveness of peatland restoration

Restoration of degraded deep peats is technically and ecologically possible. However, unlike for some other habitats, the cessation of damaging activities is not generally sufficient to allow a degraded peatland to recover key functions, such as carbon sequestration.

Generally, restoration involves raising the water table nearer to the surface in order to re-establish peat-forming vegetation. The types of action required to deliver this can be divided into three broad categories, although in many cases one or more of these types of restoration will be required in the same location (Table 4.1).[32]

If undertaken properly, restoration is anticipated to recover at least some of the original ecosystem functionality over a period of time.[33] There are, however, some uncertainties.

- **Timescale**: the time it will take for a restored site to revert to an undamaged state will vary between sites. Although re-establishment of peat-forming vegetation within a period of five to ten years is widely reported, changes to ecological condition, greenhouse gas balances, water quality and hydrological functionality are harder to discern conclusively or consistently. In many cases it may take decades for peatland functionality to recover and be observable.[34]

32 Lunt et al. (2010), Natural England (2013b).
33 *Ibid.*
34 Lucchesea et al. (2010); Mills et al. (2010); JNCC (2011); Grand-Clement et al. (2013).

- **Methane spike**: although re-wetting a drained peatland will usually reduce carbon dioxide emissions, it is also likely to cause a temporary methane 'spike'. As a result, net greenhouse gas emissions may increase after re-wetting, before decreasing subsequently.[35] However, there is evidence that post-restoration methane emissions can be managed to some extent, for example, by controlling the abundance of plants that act as methane shunts and re-establishing bog mosses that will break the methane down.[36]

Table 4.1: Summary of peatland restoration measures and their effectiveness

Restoration measure	Degradation type	Approach	Evidence of effectiveness
Re-vegetation	Bare	Usually dwarf shrub and nurse grass seeds mixes are used to re-establish a covering of vegetation. Severely eroded and sloping sites firstly require stabilisation with heather brash or geo-jute[37] in order to allow re-vegetation.	Major reductions in particulate organic carbon (POC) release occur when bare peat is re-vegetated. Surface re-vegetation, especially with *Sphagnum*, slows down the flow of water. Recent modelling and field work suggests that re-vegetation could have a larger effect than blocking drains on downstream flood risk.
Water management ('re-wetting')	Drained	Drainage ditches ('grips') and gullies are blocked at regular intervals using peat scooped up from adjacent areas and packed as a plug into the ditch. Plastic, wood, heather bales and plywood have also been used.	Water tables rise in the first two years after blocking. However, there is a longer time-lag (>10 years) before water tables start to operate similarly to those in intact peatlands. Thus it is expected that the full extent of dissolved organic carbon (DOC) and colour reductions from grip blocking might not be realised for at least 10 years. Major reductions in POC release occur following gully blocking. Benefits of gully blocking mainly come from reduced sediment loss (and associated heavy metals) rather than reduced DOC.
Vegetation management	Rotationally burnt Overgrazed	Reducing the intensity and/or rotations of controlled burns, or completely ceasing burning regimes altogether. Reducing stocking rates or complete removal of any grazing.	Vegetation cover is a key driver of DOC concentrations. *Sphagnum* seems to be associated with low concentrations while heather is associated with higher concentrations of DOC. The evidence base is increasing that burning increases colour production. Abandonment of burning should lead to water quality improvements over a 10-20 year timescale.

Source: Bain et al. (2011) and Holden et al. (2012).

35 Natural England (2010).
36 *Ibid.*
37 Fibrous mesh webs that disintegrate over time leaving stabilised peat surfaces.

Current scale of restoration

The last decade has seen effort to restore around one-third of upland peat. A key driver has been the target of getting 95% of SSSIs into either a favourable or unfavourable recovering condition by 2010.[38] As a result, 1,100 km^2 of blanket bog SSSI (31% of the total area of deep peat) is now classed as being in a recovering condition, compared to only 200 km^2 in 2003 (Figure 4.4). As highlighted in Chapter 3, this means that a management plan is in place that, if implemented, should result in the SSSI eventually reverting to favourable condition in time. There have been two main mechanisms for delivering restoration:

- **Environmental Stewardship scheme**. Some £27 million has been paid to farmers and landowners who have taken up moorland restoration options under the Higher Level Scheme (HLS) since 2007. These options now cover some 3,500 km^2 of the uplands, of which 2,000 km^2 are on deep peat.[39] The main type of restoration supported by HLS is a reduction in grazing,[40] although payments can also be made for grip blocking.[41] This would suggest that the main contribution to restoration from the scheme has been to reduce stocking levels across a large area of upland peat. On this basis, it is likely that the 300 km^2 of deep peat classed as being over-grazed is being restored and that any SSSIs that were in an unfavourable condition due to over-grazing are now recovering.
- **Catchment-scale restoration to improve water quality.** Some £45 million will be invested by water companies in partnership with land-owning charities (such as RSPB and the National Trust) between 2010 and 2015, much of which is on SSSI sites (Box 4.2). We estimate that some 600 km^2 of upland peat is being restored by these partnerships, which are mostly delivering hydrological restoration (namely grip and gully blocking). As such, it is likely that a relatively high proportion of the 750 km^2 of gripped peat and a proportion of the 500 km^2 of gullied peat is in the process of being restored. The partnerships have also been re-vegetating around one-quarter of the 40 km^2 of bare peat. Many, if not all, of these partnerships have accessed HLS funding to also reduce overgrazing pressure.

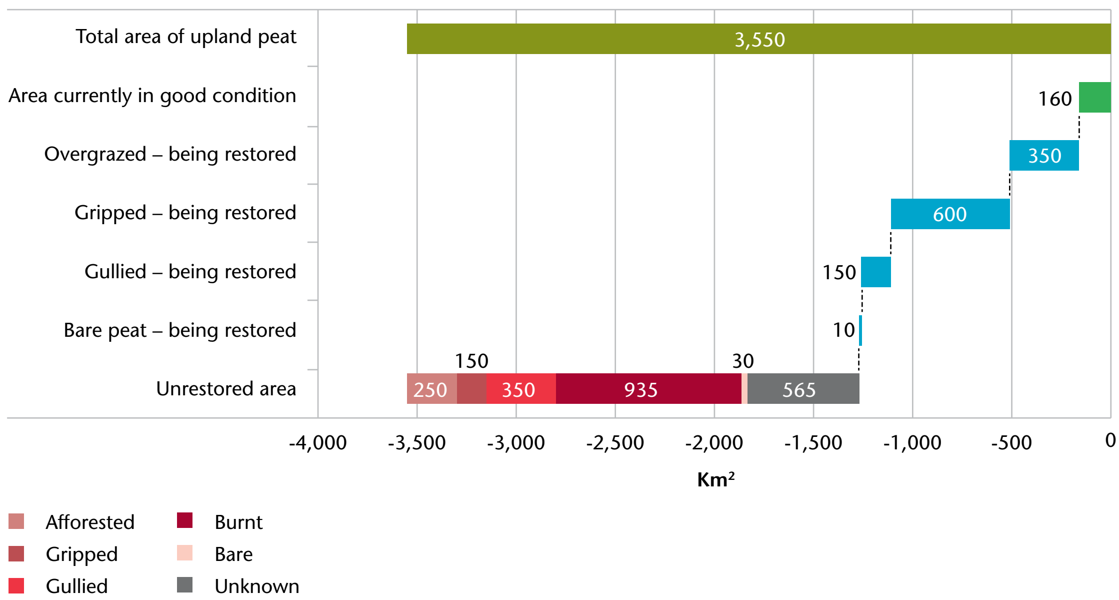
It is not clear whether all of the SSSI area classed as recovering is currently being restored. Our analysis suggests that catchment scale partnerships only cover around half of the 1,100 km^2 classed as recovering. Although uptake of HLS restoration options is much wider, these are unlikely to be delivering more costly hydrological restoration or revegetation. It is also not clear how the remaining 35 km^2 of SSSI classed as being in a declining condition is being restored.

38 See Chapter 3 for more detail on this target and how it was delivered for all SSSIs.
39 Natural England data provided at the request of the ASC. See Environmental Change Institute et al. (2013) for Adaptation Sub-Committee.
40 By following an agreed stocking calendar and funding for temporary fencing.
41 Data on the amount of grip-blocking supported through this option are not available, but anecdotal evidence suggests it is a low proportion due to the up-front capital costs.

We found limited evidence of clear plans to restore the two-thirds of peat (Figure 4.5). We have not found evidence of any reductions in burning and there remain areas of both bare and gullied peat that are not being restored.

It appears that restoration to date has generally been focused on SSSIs that are in quasi-public ownership such as land owned by water companies and voluntary organisations. There has been much lower uptake of restoration on privately owned land.

Figure 4.5: Estimated areas (km²) of total, restored and unrestored upland deep peat in England



Source: Based on Environmental Change Institute et al. (2013) for the Adaptation Sub-Committee.
Notes: The total area of deep peat is the estimate from Natural England (2010). The area in good condition is the proportion of SSSI blanket bog assessed as being in favourable condition in 2013 (Figure 4.4). The area of overgrazed land being restored has been estimated based on the area of deep peat covered by the HLS Moorland Restoration option (approximately 1,900 km²). This suggests that the 350 km² identified by Natural England (2010) as being over-grazed is likely to be under restoration. The areas of gripped, gullied and bare peat under restoration are based on estimates from various projects described in Box 4.2. The remaining area is deep peat under the different land cover types estimated by Natural England (2010) for which we have not found evidence of restoration.

Box 4.2: Summary of catchment-scale peat restoration projects in English uplands

At the 2009 price review, the water regulator (Ofwat) supported water companies' proposals to spend some £60 million on 100 catchment management schemes and investigations over the period 2010-2015, with the aim of helping to address deteriorating water quality in the natural environment. Nearly two-thirds of this expenditure (£45 million) is for work that United Utilities, South West Water and Yorkshire Water are carrying out to restore degraded upland water catchments.

Many of these catchment schemes are being delivered through innovative multi-agency partnerships. Alongside the water industry, National Park Authorities and Areas of Outstanding Natural Beauty (AONBs) bodies play key roles in co-ordinating a number of these partnerships, which have also benefited from funding and advice from the statutory environmental bodies (Natural England, the Environment Agency and Forestry Commission) including through agri-environment payments. Non-governmental organisations, such as the National Trust, RSPB and the Wildlife Trusts, have also made key contributions to these partnerships.

- **Sustainable Catchment Management Programme (SCaMP):** United Utilities pioneered catchment-scale management in the North-West uplands, in partnership with the RSPB. The project aims to have restored around 205 km^2 by 2015. In the first phase of the project between 2005 and 2010, some 55 km^2 has been re-wetted through grip blocking and 5 km^2 of bare peat has been re-vegetated.
- **Yorkshire Peat Partnership:** managed by the Yorkshire Wildlife Trust in partnership with Yorkshire Water, two National Park Authorities (Yorkshire Dales and North York Moors) and the National Trust. The partnership aims to restore 425 km^2 of degraded blanket bog across the county by 2017. Since 2009, over 30 km^2 has been brought into restoration, with over 300 km of grips blocked and 40 km of eroding gullies re-vegetated. Yorkshire Water has also been funding research and monitoring, including an Ecosystem Valuation of the restoration carried out on Keighley Moor. This demonstrated that for every £1 spent in the catchment, society would benefit by £1.31. Conversely, for every £1 not spent on restoration in the catchment, society stands to lose £2.03.[42]
- **Moors for the Future**: a ten year partnership between the Peak District National Park Authority, Natural England, Environment Agency, Severn Trent Water, United Utilities, Yorkshire Water, National Trust, Derbyshire County Council and the RSPB to restore bare peat in the Peak District and South Pennines. Since 2003, nearly 500 km^2 of the South Pennines Special Area of Conservation has been brought into restoration management, including stabilising around 8 km^2 of bare and eroding peat. The programme is also being funded by Yorkshire Water to improve the condition of 100 km^2 of upland SSSI sites owned by the company across the county. Pioneering work has been developed by the partnership to re-introduce *Sphagnum* on a landscape-scale.
- **North Pennines AONB Partnership's Peatland Programme:** the AONB has almost 30% of England's blanket bog, a large proportion of which has been drained. Since 2006, effort has focussed primarily on blocking nearly 7000 km of drainage channels, restoring an area of around 70 km^2. More recently, the project has begun to restore the 25 km^2 of bare peat within the AONB, with around 1 km^2 re-vegetated to date.
- **Exmoor and Dartmoor Mires on the Moors project:** began in 2010 with significant financial support from South West Water as part of its *Upstream Thinking* initiative. In Exmoor, the project aims to restore 20 km^2 of blanket bog and by 2010 had blocked 50 km of ditches, covering nearly 4 km^2 of moorland. On Dartmoor, a pilot project has also recently been started with the National Park Authority, the Duchy of Cornwall and Dartmoor Commoners Council.

42 Harlow et al. (2012).

Assessing the scope for additional restoration

Understanding the economics of restoration can help to establish whether or not there is a case for wider restoration effort than is currently being delivered. This section presents results of our analysis on the costs and benefits of restoration.[43] The economic case is based on the scale of benefits derived from restored peatlands, relative to the costs of restoration as summarised in Box 4.3.[44]

Box 4.3: Economics of upland peat restoration as an adaptive response to climate change

Our analysis estimates the net benefits, namely benefits minus operating and opportunity costs but excluding capital costs, of restoring degraded peatlands.[45] The value of net benefits is compared to the capital costs of restoration. Restoration projects that deliver net benefits above the capital investments required can be justified on economic grounds, while projects where net benefits are below the capital cost cannot. Net benefits are expressed as a discounted present value of future costs and benefits over 80 years, while the capital costs are one-off (upfront) costs.

Benefits of restoration

Restoration of degraded peatlands can recover a number of ecosystem services associated with undamaged peatlands. A key benefit is improved carbon storage, because restoration reduces carbon losses due to degradation and can eventually re-start carbon sequestration. Restoration also improves the condition of habitats for wildlife, as well as delivering water regulation services provided by functioning peatlands.

Our analysis models the benefits of reduced carbon losses as the difference in net carbon emissions between restored and degraded sites, which we estimate to be between 1 and 4 tonnes of CO_2 equivalent per hectare per year. These are based on a range of emission factors estimated by Natural England (2010), Artz et al. (2012) and Smyth (2013). The range of emission factors reflects the degree of uncertainty in these estimates, as well as a debate as to whether or not restored sites ever reach the same carbon sequestration levels as undamaged sites.[46]

Emission savings are valued using DECC central (non-traded) carbon prices which increase from £58 per tonne of CO_2 equivalent in 2014 to £284 per tonne of CO_2 equivalent in 2100. We account for a short term increase in methane emissions of 2.5 tonnes of CO_2 equivalent each year for the first 10 years due to re-wetting and the length of time it takes to re-start peat formation.

Our analysis includes a value of £152 per hectare per year to cover the non-market value of the biodiversity and ecosystem services (other than carbon storage) provided by peatlands.[47] While this value is only indicative, other valuations are generally of a similar magnitude.[48]

Climate change increases the benefits of restoration because warmer temperatures are likely to accelerate carbon losses from degraded peatlands.[49] In our analysis we account for the effects of climate change based on a low emissions p10 probability scenario and a high emissions p90 probability scenario from UKCP09. In our model, we assume climate change increases the difference in emission savings between a restored and a degraded site by 0.5% per year under a low climate change scenario, and by 1.5% under a high climate change scenario. This is based on the assumption that emissions from degraded peats increase by 30% for each degree increase in temperature.[50]

43 Scotland's Rural College (2013) for the Adaptation Sub-Committee.
44 A full description of the assumptions is included in the report produced by Scotland's Rural College (2013) for the Adaptation Sub-Committee.
45 Here the term `net benefits' is used in an unconventional sense, to refer to benefits net of all costs with the exception of capital costs. This approach allows easy identification of what levels of capital investment are likely to be merited by restoration under a range of benefit scenarios.
46 Lucchesea et al., (2010); Mills et al., (2010); Joint Nature Conservancy Council, (2011); Grand-Clement et al., (2013).
47 Our use of £152 per hectare per year is based on an even split of the marginal valuation of £304 per hectare per year for the biodiversity benefits provided by UK inland wetlands (from UK National Ecosystem Assessment 2011b, Chapter 22). This is to account for optimism bias (following Harlow et al. 2012).
48 For example, Christie et al. (2011) provide estimates of £136 per hectare per year.
49 See Orr et al., (2008); Acreman et al., (2009); Clark et al., (2010); Gallego-Sala et al., (2012); Essl et al., (2012).
50 Graves and Morris (2013) for the Adaptation Sub-Committee. Graves & Morris (2013) estimate per hectare emissions in 2020, 2050 and 2080 for different peatland categories under low and high climate change scenarios. This is based on a relationship described by Blodau (2002) that every one degree increase in temperature results in approximately 30% increase in CO_2 emissions. The difference between reported baseline and 2080 emissions per hectare are approximated here by applying a linear annual increase in per hectare emissions of 0.5% and 1.5% for the low and high change scenarios respectively. This is a simplification, not least since the time profile is more likely to be non-linear, but is adequate to illustrate the relative effect of different climate change scenarios.

Box 4.3: Economics of upland peat restoration as an adaptive response to climate change

Ongoing costs of restoration

Restoration incurs ongoing management and monitoring costs such as replacement of dams, and management of vegetation cover. In addition, restoration may impose opportunity costs[51] in cases where it displaces current land use activities such as farming and grouse shooting.[52] Evidence on the scale of opportunity costs is mixed, given uncertainty over both the physical displacement of activities and the net value of such activities. Our analysis assumes opportunity costs ranging from zero (such as in the case of revegetation of bare peat, which has no productive value) to £100 per hectare per year for restoration measures that result in partial to complete displacement of grouse shooting activities.[53] Our analysis assumes low and high estimates of £100 per hectare per year and £400 per hectare per year for these ongoing and opportunity costs. This is more pessimistic than actual restoration experience, as shown in Table B4.3.

Capital costs of restoration

Capital costs include upfront costs such as dams for blocking drainage grips and gullies, geo-jute for stabilising bare peat and fencing for stock control. Table B4.3 provides a range of capital costs observed in actual restoration projects.

Table B4.3: Estimated range of costs for five restoration options.

Restoration options	Capital costs (£/ha)		Ongoing costs (including opportunity costs) (£/ha/yr)	
	Low	High	Low	High
Re-vegetation of bare beat	200	7,000	25	100
Grip blocking	150	600	25	200*
Gully blocking	1,000	4,000	25	100
Reduced burning	0	300**	25	200*
Reduced livestock intensity	0	3,000	25	150*

Source: Capital cost estimates are derived from Holden et al. (2008); Estimates of opportunity costs for livestock farming and grouse shooting are based on the Farm Business Survey (Scott & Harvey) and Fraser of Allander Institute (2010) respectively.
Notes: Estimates of capital costs are based on a limited number of observations and are not normalised to account for differences in site conditions/project objectives so may not be representative of all sites. Here we assume that ongoing costs are uniform across restoration types and range between £25 and £100.
* represents restoration options that incur positive opportunity costs.
** high-end estimate of the capital cost for reduced burning is due to the fact that reduced burning often occurs in tandem with grip blocking.

Our analysis demonstrates that in many cases if a value is placed on the benefits from restoration, they will outweigh the costs. The benefits from restoration become even stronger with climate change. Figure 4.6 presents a range of estimates of net benefits (excluding capital costs) based on two benefit and costs scenarios:

- *High net benefit scenario:* high carbon savings (4 tCO_2e per hectare per year) and low ongoing and opportunity costs (£100 per hectare per year).
- *Low net benefit scenario:* low carbon savings (1 tCO_2e per hectare per year) and high ongoing and opportunity costs (£400 per hectare per year).

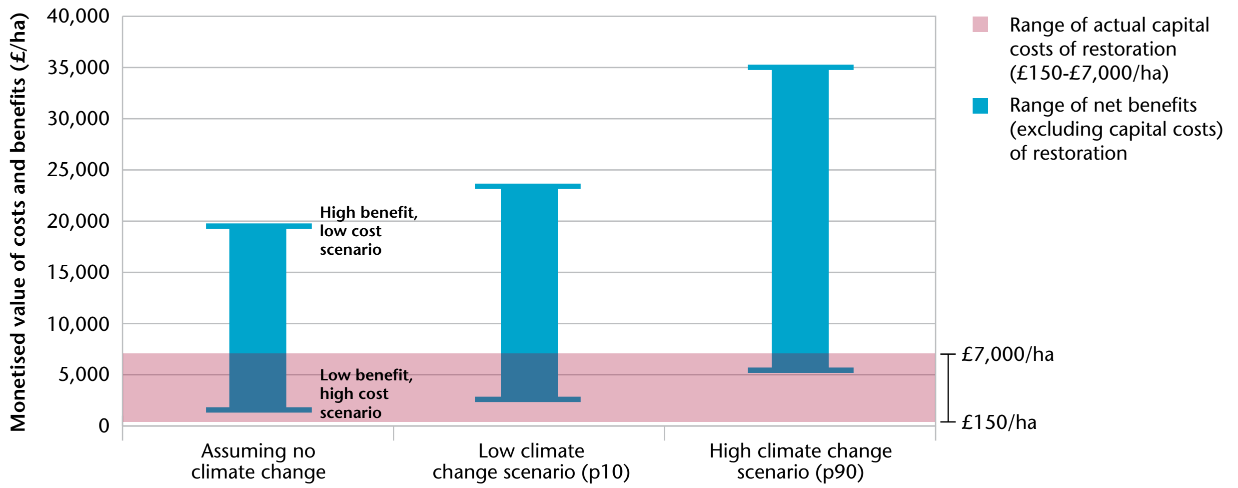
51 Opportunity costs refer to the economic activity a restored peatland replaces.
52 There are other land uses which may impose higher opportunity costs. For example, forestry where early clear felling of standing timber will impose significant costs in terms of income foregone.
53 Based on Fraser of Allander Institute (2010).

The wide range in the estimated net benefits (as reflected in the height of the blue bars in Figure 4.6) highlights the uncertainty around these estimates and the fact that the balance of costs and benefits will be site-specific in nature. Restoration projects yield net benefits that lie anywhere in between the two net benefit scenarios. These benefits generally lie above the actual range of capital costs of restoration.

Once climate change is factored in, the net benefits from restoration are sufficient to merit capital investments that are generally higher than the range of actual capital costs reported for typical restoration activities.

- *No climate change:* restoration projects deliver net benefits of up to £20,000 per hectare in present value terms under a high net benefit scenario. This is well above the range of capital costs observed in practice of £150 to £7,000 per hectare.[54] Even in the low scenario, net benefits of around £1,000 are realised, making many restoration projects cost-effective.
- *With climate change:* restoration projects deliver net benefits (excluding capital costs) of up to £24,000 (under a low p10 climate) and £35,000 per hectare (under a high p90 climate) under a high net benefit scenario. Even in the low net benefit scenario, projects deliver benefits of over £5,000 per hectare under a p90 climate.

Figure 4.6: Assessing the costs and benefits of upland peat restoration as an adaptive response to climate change



Source: Based on Scotland's Rural College (2013) and Graves and Morris (2013) for the Adaptation Sub-Committee.
Notes: Figure shows the net benefits (blue bars) over an 80-year period and actual range of capital costs (pink shaded region) of restoring peatlands. The bottom and top of the blue bars represent low and high net benefit scenarios respectively. Net benefits are expressed as a discounted present value (of stream of future ongoing costs and opportunity costs and benefits), while the capital costs are one-off (upfront) costs. The low net benefit scenario represents a low emission differential of 1 tonne of CO_2 equivalent per hectare per year and a high ongoing and opportunity cost) of £400 per hectare per year; and the high net benefit scenario represents a high emission differential of 4 tonnes of CO_2 equivalent per hectare per year, and a low ongoing cost (and opportunity cost) of £100 per hectare per year. We include a Willingness To Pay value of £152 per hectare per year for the non-market value of the biodiversity and ecosystem services (other than carbon storage) provided by peatlands. The analysis also includes a methane spike of 2.5 tonnes of CO_2 equivalent per year for the first 10 years following restoration. We account for the impact of climate change on degradation rates by assuming that climate change increases the difference in emission savings between a restored and a degraded site by 0.5% per year under a low climate change scenario (p10) and by 1.5% under a high climate change scenario (p90).

54 Refer to Table B4.3 in Box 4.3.

The analysis suggests there is potential for a wider uptake of upland peat restoration than is being delivered at present. Additional uptake would potentially yield large net benefits even under conservative assumptions about emission savings and allowing for high-end capital and ongoing costs. Further restoration effort in areas that meet these conditions could be justified. The public nature of benefits and the private nature of costs suggest that engagement with land managers will be important in identifying appropriate policy structures to align incentives between private land owners and society. Key to this will be developing approaches to managing peatlands in ways that allow landowners to run their businesses, while also delivering benefits to society through protecting and enhancing the supply of regulating services.

4.5 Conclusions and policy advice

Our analysis has highlighted that upland peat in England is generally in a degraded condition due to a combination of land use and management practices, and pollution. Without further action, it is likely that the current level of degradation will increase with climate change. Instead of providing important and valued services, peatlands will increasingly cause costly problems to society that may become irreversible. At the same time, their international importance to biodiversity will continue to decline.

There is a need for additional restoration effort if peatlands are going to have any chance of continuing to provide key regulation services in a changing climate. The longer the delay, the more expensive it will become to reverse the scale of degradation from increasing losses of carbon to the atmosphere and into water supplies. If further action is not taken soon on the two-thirds of upland peats that do not have clear plans for restoration, then it is feasible that the level of degradation could be effectively irreversible by the middle of the century with climate change.

There is a case to strengthen the policy framework to enable additional restoration effort across the uplands. There are already regulations and incentives in place that go some way to protecting upland peats. As highlighted earlier in this chapter, these have had a measure of success in facilitating restoration schemes. There are, however, questions as to whether or not the current policy framework will enable the scale of additional restoration effort required (summarised in Table 4.2). Furthermore, there is no explicit policy goal driving forward additional restoration effort.

To strengthen the policy framework, the Government should:

- **Set a clear policy signal on the need to increase restoration effort.** The Government has a generic policy of managing all of England's soils sustainably by 2030.[55] In 2013, the Government provided a Statement of Intent to "protect and enhance the natural capital provided by peatlands in the UK".[56] This statement noted that there is "a strong case for improving the condition of our peatlands" due to their importance for regulating

55 HM Government (2011). The only specific provision on peat in the White Paper is the policy goal of making the transition to peat-free alternatives for horticultural uses. This is not relevant to upland blanket bog, as the extraction of peat for horticultural uses in England is only from lowland raised bogs.
56 Joint Ministerial letter to the IUCN Peatland Programme: *Securing Benefits from UK Peatlands* (February 2013). The statement outlined the actions and intentions of Defra, the Scottish Government, the Welsh Government and the Northern Ireland Executive to enhance UK Peatlands.

water quality and mitigating climate change . However, the statement did not recognise that climate change accentuates the need for additional action on restoration. Nor did it make any explicit commitment to ensure that a specified proportion of degraded peatlands are restored within an agreed timescale. The goal in the England Biodiversity Strategy of restoring 15% of 'degraded ecosystems' by 2020 for climate change mitigation and adaptation benefits is clearly relevant in this regard. However, it is not yet clear how this policy ambition is being defined or how it will be delivered.[57]

- **Review the enforcement of existing regulations for protecting and enhancing peat sites.** Our analysis has highlighted that there has been action taken over the last decade to put in place management agreements to improve the condition of protected sites. Despite this, it is also clear that damaging practices are continuing on some protected sites. For example, there is no difference between the rate of managed burning on SSSI and non-SSSI sites.[58] A review of the enforcement regime would highlight the extent to which current regulations are being effectively implemented and thus leading to protection and enhancement of upland peat sites. A key issue the review should explore is how much of the protected site network is being regularly burnt and whether such burning is causing damage to the biodiversity interest for which the site was designated or to the supply of regulating services.

- **Improve incentives for land owners to invest in restoration.** A major barrier to the wider uptake of restoration measures is the lack of adequate financial incentives for landowners, both to underpin the capital outlay and to help address reduced revenue from current activities. There is also uncertainty on the future of some existing incentives, particularly agri-environment payments and water company investment in catchment-scale action to improve water quality. It will be important that the Government pushes forward with its plans to develop effective market mechanisms that deliver additional investment for appropriate management of the natural environment.[59] A key priority is the development of a Peatland Carbon Code, which could facilitate private investment in restoration. The value of the benefits could be sold on the voluntary carbon market via the Corporate Social Responsibility (CSR) route, or potentially through companies' meeting their requirements to report on their corporate greenhouse gas emissions. There are many practical challenges to overcome in developing such a scheme, but if successful, this could unlock additional restoration investment.

57 It is currently not clear how this goal is being defined in terms of the types of 'degraded ecosystems' that will be included, or the baseline that will be used by which to assess if the 15% ambition has been met by 2020.
58 Natural England (2013b).
59 Defra have recently published an action plan for developing the potential for Payments for Ecosystem Services (Defra 2013a). This highlights schemes that aim to improve water quality and restore peatlands, following on from the recommendations of the recent Ecosystem Markets Taskforce report.

Table 4.2: Current policy mechanisms for protecting and restoring upland peat

Current regulations	Effectiveness
SSSI designation Entails a legal requirement to avoid damaging practices.	Low proportion of blanket bog SSSI in favourable condition raises questions as to whether damaging practices are being avoided.
EU Habitats Directive Article 6(2) requires appropriate steps to avoid the deterioration of Special Areas for Conservation (SACs).	As with SSSIs, low proportion of SACs in favourable condition suggests that appropriate steps are not being taken.
Heather and Grass Burning Regulations Limits the size and duration of controlled burns.	Does not preclude burning on sensitive bog habitats.
Cross-compliance All claimants of the Single Farm Payment must keep their land in Good Agricultural and Ecological Condition (GAEC). In the uplands, measures include avoiding burning on blanket bog and preventing overgrazing.	Important for protecting and maintaining blanket bog, but does not actively deliver restoration.
Environmental Impact Assessment Regulations Requires projects that aim to increase agricultural productivity of more than 2 hectares of semi-natural land to assess the scale of environmental effects and identify mitigation options. Where significant impacts are identified that cannot be mitigated, consent for the proposal will not be given.	Safeguards remaining semi-natural blanket bog from agricultural intensification, although this is not currently a major pressure in the uplands. Does not apply to non-agricultural projects, such as drainage for grouse moor management.
Water Framework Directive The Environment Agency has statutory powers under Article 7 to notify Drinking Water Protected Areas (DrWPAs). Where DrWPAs are 'at risk' of not meeting their objectives, the Environment Agency establishes Safeguard Zones where a voluntary action plan is produced in partnership with relevant landowners to identify where and what measures are needed to protect and improve drinking water quality. Should voluntary measures not be effective, the EA can look to other regulatory approaches, including Water Protection Zones (WPZs). These require changes to land practices that are having a demonstrably adverse effect on drinking water quality.	Currently there are 53 'at risk' DrWPAs due to DOC (discolouration) in England. The EA has established Safeguard Zones in these catchments and will review if they are effective in delivering measures to improve water quality. The EA has only notified one WPZ in England to date.

Table 4.2: Current policy mechanisms for protecting and restoring upland peat	
Current incentives	**Effectiveness**
Environmental Stewardship Upland Entry Level Scheme provides payments for the implementation of a range of land management practices, including a number of moorland maintenance requirements such as avoiding overgrazing by maintaining a minimum stocking rate and not maintaining existing grips or drains. The Higher Level Scheme includes a range of moorland restoration options, primarily concerned with reducing stocking levels.	UELS is similar to cross-compliance as an important mechanism for maintaining blanket bog, but not actively restoring them. HLS restoration has widespread uptake and plays key role in reducing over-grazing pressure, but has been less effective in other types of restoration. There is some uncertainty on the future of these schemes following reforms to the Common Agricultural Policy post-2016.
UK Forestry Standard and Open Habitat Policy The Forestry Commission publishes guidelines that promote specific management practices that protect peat soils from a number of potentially damaging forestry operations, including planting, felling and drainage. They also state that new planting should not occur on deep peat soils. Government policy in place on the conversion of some woodland to open habitat restoration of unimproved grasslands, heaths and moors, marshlands, fens and bogs.	Important mechanism for protecting remaining blanket bog through avoiding future planting. Since publication of the Open Habitat Policy in 2010, there has been targeted open habitat restoration although the majority has been on lowland heath sites and not upland blanket bog. The Forestry Commission will be publishing an Open Habitat Strategy for the Public Forest Estate in England in July 2013, which is likely to include more detailed plans on the scale of restoration planned.
Heather and Grass Burning Code A voluntary code that describes minimum standards for environmental good practice in burning. Advises against burning in sensitive areas, including on blanket bog and within five metres of watercourses.	Important addition to Burning Regulations that should be reducing frequency and intensity of burning in sensitive areas, although not clear if widely taken up.
Water company investment Water companies can fund improvement in areas of a catchment that is important for water quality, for example, in a Safeguard Zone. Ofwat allowed three water companies (United Utilities, South West Water and Yorkshire Water) to invest around £45 million in upland catchment-scale restoration schemes.	Has been an important driver for water companies to invest in catchment-scale restoration during current price review period (2005 to 2015). Ofwat will decide in 2014 if water companies will be able to continue to invest in catchment-scale restoration projects in the next price review period (2015-2025). Ofwat has made clear that water companies will need to build the evidence base to demonstrate the effectiveness and benefits of catchment-scale approaches for meeting water quality objectives.