HEATHER FUTURES

The Heather Trust
championing our magnificent moorlands

Change in the Extent of Moorland Habitat in the UK between 1990 – 2023

FOREWORD

Lord Douglas Miller was Parliamentary Under Secretary of State at the Department for Environment, Food and Rural Affairs. He has long worked on conservation projects and was awarded an OBE for services to wildlife conservation in Scotland.

“This report quantifies current and historical loss of heather moorlands, and the results are stark - we are rapidly losing moorland habitats from across the upland areas of the UK. It is essential reading for all those with an interest in our moorlands, including those connected with moorland management, groups who influence and shape policy and land use options as well as the relevant departments in the UK Governments.

The report highlights the challenges facing policy-makers in balancing the different objectives related to upland land management, and provides an evidence base for them to assess future threats to moorland habitats. The survival of many of our cherished, red-listed bird species depends on well-managed sustainable, resilient moorland habitats which also deliver a suite of societal objectives related to biodiversity, economic return, climate and recreation.

I sincerely hope that this report will bring about a broad consensus across a range of stakeholders on the importance of conserving moorland habitats, such that future generations can still experience the beauty of the Curlew call over the moor or wonder at the purple vista in late summer.

Lord Robbie Douglas-Miller OBE
Member of the House of Lords

EXECUTIVE SUMMARY

BACKGROUND

1. Moorland habitats in the UK have been shaped by climatic conditions, acidic peat soils, and historic land use practices. Much of the UK’s moorland has been managed specifically for sheep farming, deer stalking and grouse shooting, with suitable conditions for these activities maintained by active grazing, the control of predator species and prescribed burning.

2. UK Moorlands have been recognised as being of international ecological importance for their plant and bird communities, in particular many species of red-listed ground-nesting birds that are absent or declining away from managed moorland habitats.

3. The extent of moorland in the UK has likely been declining since the nineteenth century with afforestation, over-grazing and agricultural reclamation key drivers of moorland habitat loss. In recent decades subsidies for woodland creation and increasing private investment and public support for rewilding initiatives, as well as increased legislation of moorland management techniques have increased the pressure on moorland habitats.

4. To gain a better understanding of the large-scale processes affecting moorland habitats in recent decades and to inform land use policy, in this report we assess moorland habitat loss between 1990 and 2023 using land cover maps. We quantified moorland habitat loss by region and assessed which habitats were most prominent in replacing moorland.

KEY FINDINGS

5. Estimated total losses of moorland between 1990 and 2023 were 609 km² in England, 6,696 km² in Scotland, 349km² in Wales, and 498 km² in Northern Ireland. This represents 21% (Northern Ireland), 15% (Scotland), 7% (Wales) and 7% (England) of the 1990 extent of moorland lost over 33 years. Across the UK, this equates to an area of moorland the size of Birmingham being lost each year.

6. Moorland was primarily converted to improved grassland (55%), coniferous woodland (34%) and broadleaved woodland (6%), though there was significant regional variation with coniferous woodland a more significant threat than improved grassland in many regions of Scotland.

7. Current targets for woodland expansion across the UK are 30,000 Ha per year, and annual planting rates are currently much lower than this. 88% of new coniferous planting (1990 – 2023) took place on moorland habitats, so there is likely to be significant further pressure on moorland habitat from continued expansion of coniferous woodland.

IMPLICATIONS

8. Current land use policies have resulted in the loss and fragmentation of open moorland habitats with limited large-scale spatial strategy, and in many cases this has resulted in the creation of unconnected blocks of woodland which have detrimental effects on open ground species and offer limited positive biodiversity value.

9. Many red-listed open-ground bird species of conservation importance are in rapid decline as habitat is fragmented and managed moorland and the extent of effective predator control declines. In the last thirty years we have observed severe declines of open-ground species and species that benefit from moorland management such as eurasian curlew (*Numenius arquata)*, northern lapwing (*Vanellus vanellus)*, golden plover (*Pluvialis apricaria)*, and black grouse (*Lyrurus tetrix)*.

10. To maintain the benefits of moorland habitats, there is an urgent need to move towards more coherent, integrated, spatially targeted policies in the uplands that balance the benefits of maintaining large areas of contiguous, open moorland habitat with the important benefits associated with the restoration of large-scale native woodlands.

THE HEATHER FUTURES PROJECT

For many years, moorlands have been lost or degraded due to overgrazing, undergrazing and commercial afforestation. Despite this, there is limited available evidence on changes in the extent and quality of moorland habitats in the UK.

Heather Futures addresses this evidence gap by identifying the best available datasets on current and historical moorland extent across the UK and produced regional and national estimates of moorland extent and historical moorland loss. This report is a direct result of the culmination of the first phase of the Heather Futrures research project. We hope it will engage policy-makers and alert stakeholders to the pace at which moorland habitats are being lost and encourage more coherent land use policy in the uplands.

BEHIND THIS REPORT

The Heather Trust
championing our magnificent moorlands

Originally established in the 1980s to reconcile grouse and sheep farming interests on moorland, The Heather Trust has since broadened its goals to ensure every moorland is managed sustainably, effectively and sensitively. In recognising and understanding the many economic, social and environmental interests, we strive for moorlands to be managed for everyone's wellbeing.


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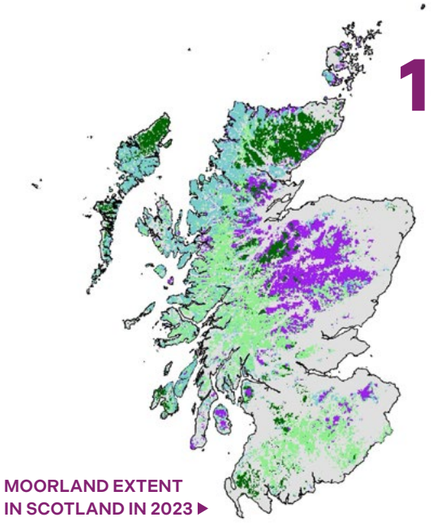


MOORLAND EXTENT IN SCOTLAND IN 2023 ▶

1 BACKGROUND

> More recent threats to the extent of moorland are driven by government subsidies for afforestation (Westaway *et al*. 2023), private individuals or businesses buying land for afforestation in the expectation that profits can be generated from carbon markets (McMorran *et al.* 2022) and growing public support for 'rewilding' as a land management objective (Sandom *et al.* 2019).

1.1 HISTORY OF MOORLAND IN THE UK

Moorland habitats have been shaped by a combination of temperate oceanic climatic conditions, acidic peaty soils and historic land use practices (Thompson *et al.* 1995). Much of the UK's moorland has been managed with sheep or cattle grazing (Simmons 2003) and fire events playing an important role in the ecology of the UK uplands for millennia, with charcoal and pollen counts often showing frequent fire episodes and high heather cover (Chambers *et al.*, 2017; Webb *et al.*, 2022). Since the nineteenth century, much of the UK's moorland has been managed specifically for deer stalking and grouse shooting, with sheep or cattle grazing and prescribed burning used to maintain suitable conditions for red grouse (*Lagopus lagopus scotica*) and red deer (*Cervus elaphus*). Moorland in the UK has been recognised as being of international ecological importance for its plant and bird communities, with high densities of species of conservation significance (Thompson *et al.* 1995, Stroud *et al.* 2001). However, the extent of moorland habitats in the UK has likely been declining since at least the nineteenth century (Stevenson & Thompson 1993), with afforestation, over-grazing due to increased sheep numbers, and agricultural reclamation key drivers of moorland loss from the second half of the twentieth century onwards (Thompson *et al.* 1988, 1995, Bardgett *et al.* 1995, Robertson *et al.* 2001). In recent years, traditional land management practises on UK moorland have also come under increased scrutiny (Carver 2016, Hodgson *et al.* 2018, Shewring *et al.* 2024) with more attention on the environmental costs and benefits of traditional approaches to moorland management (Werrity *et al.* 2019), growing public support for rewilding (Thomas 2022), and government subsidies for the conversion of moorland habitat to commercial forestry or native woodland (Westaway *et al.* 2023).

1.2 WHAT DO WE MEAN BY MOORLAND? ▸

The term moorland can be used to refer to a broad range of open habitats including i) open areas where heather (*Calluna vulgaris*) is dominant and other dwarf shrubs such as bilberry (*Vaccinium myrtillus*) and crowberry (*Empetrum nigrum*) are present; ii) wetter areas of raised bog or blanket bog where sphagnum mosses and cotton-grasses may be dominant; iii) acid grassland areas where purple moor-grass Molinia caerulea is dominant - these may be

▲ Management for Red Grouse shooting is common in UK moorland habitats.
Photo by Caroline Legg

CHARACTERISTICS USED TO DEFINE *MOORLAND* IN THIS REPORT:

▲ open areas where heather is dominant and other dwarf shrubs such as bilberry and crowberry are present;

▲ wetter areas of raised bog or blanket bog where sphagnum mosses and cotton-grasses may be dominant;
Photo by TineWelli

▲ acid grassland areas where purple moor-grass *Molinia caerulea* is dominant;
Photo by Marathon, CC BY-SA 2.0

areas where over-grazing has reduced heather and dwarf shrub cover; iv) areas with heather in the understorey of scattered trees or shrubs like rowan (*Sorbus aucuparia*), birch (*Betula pubescens*), scots pine (*Pinus sylvestris*) and juniper (*Juniperus communis*) - this may include transitional habitats and areas on the fringes of woodland; v) in southern Britain, areas of heathland on sandy soils dominated by heather, cross-leaved heath (*Erica tetralix*) and gorse (*Ulex europaeus*), and vi) areas of coastal heathland where thin soils and high levels of exposure prevent vegetation succession, and coastal specialists like thrift (*Armeria maritima*) and sea campion (*Silene uniflora*) complement typical heathland vegetation. The definition of moorland used in this project is thus similar to other working definitions of "moorland" that have been used in a UK conservation context (Holden *et al.* 2007).

▲ areas with heather in the understorey of scattered trees or shrubs like rowan, birch, scots pine and juniper;

▲ in southern Britain, areas of heathland on sandy soils dominated by heather, cross-leaved heath and gorse;
Photo by David Martin

▲ areas of coastal heathland where thin soils and high levels of exposure prevent vegetation succession.
Photo by Tony Atkin

Native breeds of cattle can maintain and enhance the botanical diversity of moorland habitats.
Photo by John Eveson

1.3 MANAGEMENT OF MOORLAND HABITATS

Many areas of moorland, particularly those in eastern areas, are managed for grouse shooting. Management for grouse shooting includes i) the prescribed burning or cutting of heather-dominated vegetation patches to create a mosaic of different age structures, which provides a good mix of nesting and feeding habitats for grouse; ii) the lethal control of foxes, mustelids and corvids to increase the breeding productivity of grouse and other ground-nesting birds; iii) the use and management of herbivores to maintain sward height and diversity, prevent over-grazing, and reduce the tick-burden on grouse by 'mopping' up ticks onto dipped/treated herbivores. Management for grouse shooting has been shown to be more effective than other land uses at preventing heather loss, due to the importance of heather for grouse (Robertson *et al.* 2001).

There are differing perspectives within the scientific and conservation community on the environmental impacts of many aspects of management for grouse shooting and wider moorland management techniques (Thompson *et al.* 2016, Ludwig *et al.* 2019, Werrity *et al.* 2019, Newton 2021). There is conflicting evidence on the impacts of heather burning on carbon sequestration and hydrology (e.g. Davies *et al.* 2016, Douglas *et al.* 2016, Heinemeyer *et al.* 2018) and also on the benefits and costs of alternatives such as heather cutting / mowing (Heinemeyer & Ashby, 2023). The conflicting evidence likely reflects the importance of site-specific parameters (e.g. rainfall) and confounding factors (e.g. drainage) affecting hydrological conditions (Ashby & Heinemeyer, 2021), and fundamentally, the absence of long-term, multi-site studies which cover at least an entire cycle of burning or cutting and vegetation regrowth (Harper *et al.* 2018; Heinemeyer *et al.* 2023). The public debate is often intense yet over-simplified (Davies *et al.* 2016), with strongly-held opinions amongst public commentators reinforcing polarised positions amongst stakeholders and the public (Hodgson *et al.* 2018), and information from relevant NGOs not always fully reflecting the state of the peer-reviewed evidence (Ashby & Heinmeyer, 2021).

The lethal control of foxes, corvids and mustelids is also a key component of moorland managed for grouse shooting. In this case, the scientific evidence unambiguously shows that predator control associated with grouse moor management is associated with higher densities and higher breeding productivity of a suite of conservation priority ground-nesting bird species (Fletcher *et al.* 2010, Douglas *et al.* 2014, Baines *et al.* 2022), including eurasian curlew (*Numenius Arquata*), which has been described as the UK's most pressing terrestrial conservation obligation. However, the illegal killing of raptors to increase grouse productivity has locally reduced densities of some raptor species (Newton 2021). Following strong evidence of the persecution of golden eagles on grouse moors obtained from satellite tagged birds (Whitfield & Fielding 2017), the Scottish Government commissioned the Werrity Review into Grouse Moor Management (Werrity *et al.* 2019), which recommended grouse moor licencing with the intention of reducing raptor persecution.

In western Britain and northern Scotland there are large areas of blanket and other bog types used primarily for deer stalking and sheep farming that are now primarily valued for carbon storage, with an estimated 3.2 billion tonnes of carbon stored in UK peatlands, approximately 20 times more than in the UK's forest biomass (Bain *et al.* 2011). Due to much peatland degradation (mainly resulting from drainage), there are public subsidies available for peatland restoration involving blocking drainage channels and eroded gullies, and re-vegetating areas of bare peat.

Southern heathland areas are principally managed for conservation and recreation value, with grazing, scrub clearance and burning to prevent succession towards woodland (Bullock & Pakeman 1997).

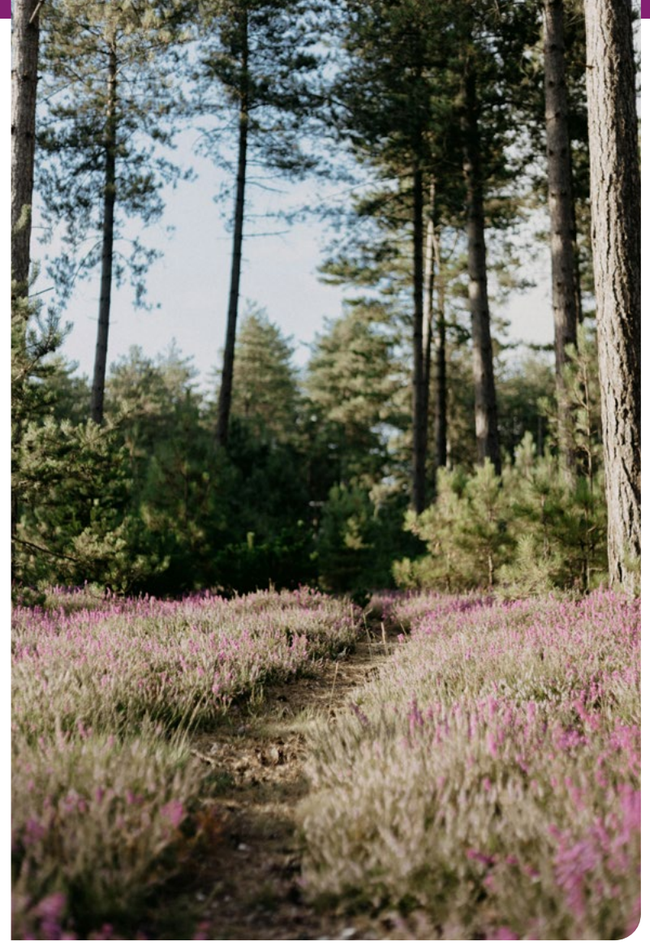
1.4
CONSERVATION SIGNIFICANCE

> *The upland moors in Great Britain (GB) have a high conservation value of international significance with six moorland plant communities virtually confined to the British Isles*
>
> *Harris et al. 2011.*

The principal conservation importance of UK moorland habitats in a global context is the high densities of ground-nesting birds supported on heather moorland and rough grassland on the moorland fringe (Pearce-Higgins *et al.* 2009). Many of these bird species are becoming increasingly dependent on the predator control which is carried out on moorland managed for grouse (Fletcher *et al.* 2010, Douglas *et al.* 2014, Baines *et al.* 2022). Many of the birds supported by UK moorland habitats are rapidly declining in areas without predator-control such as lapwing (*Vanellus vanellus*) (-51% , 1995–2022 UK wide breeding abundance trend), oystercatcher (*Haematopus ostralegus*) (-21%), curlew (*Numenius arquata*) (-50%) golden plover (*Pluvialis apricaria*) (-10%) with black grouse range and abundance also declining substantially in recent years (Baines & Hudson 1995, Pearce-Higgins *et al.* 2009) and ring ouzel (*Turdus torquatus*) in steep decline (Wotton *et al.* 2012). Extensive areas of blanket bog in north-west Britain and the Western Isles support high densities of greenshank (*Tringa nebularia*) and dunlin (*Calidris alpina*). Moorland habitats also support high densities of short-eared owl (*Asio flammeus*), hen harrier (*Circus cyaneus*), merlin (*Falco columbarius*), golden eagle (*Aquila Chrysaetos*) (Amar *et al.* 2008) although as discussed above populations of golden eagle and hen harrier are suppressed by raptor persecution (Newton 2021), although there has recently been a partial recovery in the English Hen Harrier population, a likely consequence of the Hen Harrier Action Plan (Natural England, 2016). Upland moorland also supports a suite of rare plant communities, some of which are confined to the UK (Harris *et al.* 2011) including six moorland plant communities that are confined to the British Isles (Thompson *et al.* 1998). The UK holds approximately 20% of the lowland heathland of north-west Europe (UK Biodiversity Steering Group, 1995). This habitat is confined to southern and southwestern Britain, and it holds nationally significant populations of nightjar (*Caprimulgus europaeus*), dartford warbler (*Sylvia undata*, woodlark (*Lullula arborea* as well as high densities of eurasian skylark (*Alauda arvensis*), meadow pipit (*Anthus pratensis*), whinchat (*Saxicola rubetra*), european stonechat (*Saxicola rubicola*) (Sim *et al.* 2016) as well as adders (*Vipera Berus*), and localised populations of smooth snakes (*Coronella austriaca*), sand lizards (*Lacerta agilis*) and natterjack toads (*Epidalea calamita*) (McInerny & Minting, 2016).

> *Upland birds provide a valued cultural and recreational ecosystem service. The assemblage includes top-level predators, as well as a wide range of invertebrate feeders and a few species that are largely herbivorous. The maintenance of viable upland bird populations from across a range of trophic levels may therefore provide a useful indicator of environmental change in upland areas at a range of scales, from local management-driven alteration to large-scale climatic changes.*
>
> *Pearce-Higgins et al. 2009*

▼ *GROUND-NESTING BIRDS ARE RAPIDLY DECLINING IN AREAS WITHOUT PREDATOR-CONTROL*



1.5
HISTORIC DECLINE IN THE EXTENT OF MOORLAND HABITATS

The extent of moorland habitat in the UK is known to have declined significantly across the twentieth century, with various analyses describing this process:

i.) Heather coverage may have been declining in the uplands locally for 200 years or more, evidenced by pollen analysis of sediment cores (Stevenson & Thompson 1993), although there is palaeoecological evidence for periodic shifts between heather-dominated and grass-dominated moors (Chambers *et al.* 1999);

ii.) The increased sheep population from the 1750s onwards associated with the highland clearances resulted in a decline in heather coverage and a greening of hill ground in Scotland (Dodgshon & Olsson 2006);

iii.) Between 1940 and 1995 around 20% of upland heather moorland in England and Wales was estimated to be lost to afforestation and agricultural reclamation supported by government subsidy (Thompson *et al.* 1995);

iv.) In Scotland from the 1940s to the 1970s there was loss of approximately 18% of heather moorland driven by similar pressures as above (ibid.);

v.) In the northern Peak District, 36% of moorland was lost between 1913 and 1981 largely associated with increased sheep numbers and conversion to grassland (Anderson & Yalden 1981). At high densities, ungulates directly impact moorland, blanket bog and montane habitats through over-grazing, trampling and dung, leading to succession from heath to grassland. Indeed, this process has been observed in many upland areas, with increases in domestic sheep numbers together with a decline in cattle in upland areas reducing the extent of heather coverage (Fuller & Gough 1999). However, there is also evidence that removing sheep from moorland areas can lead to an increase in deer numbers, with a consequent loss of heather coverage (DeGabriel *et al.* 2011).

vi.) The increased grazing pressure together with the drainage of moorland through the 1950s to the 1980s resulted in the enclosure and subsequent conversion to permanent pasture of many moorland areas (Miller *et al.* 1984).

vii.) Afforestation of moorland and unenclosed rough grassland in Southern Scotland was estimated to have resulted in the loss of 5,000 pairs of breeding Curlew by the end of the 1980s (Ratcliffe 2007);

viii.) In Scotland, 103 active grouse moors in the 1940s, grouse shooting had ceased on 46 and continued on 57 by the 1990s with 24% heather loss on sites where grouse shooting continued, 41% heather loss on sites where shooting had ceased by the 1990s (Robertson *et al.* 2001).

ix.) A significant proportion of moorland habitat in Wales and South-West England was assessed as in poor condition in the mid-1990s, with 24% and 38% of moorland in England and Wales respectively showing signs of over-grazing by sheep (Bardgett *et al.*, 1995).

1.6
COMPETING LAND MANAGEMENT OBJECTIVES

More recent threats to the extent of moorland are driven by government subsidies for afforestation (Westaway *et al.* 2023), private individuals or businesses buying land for afforestation in the expectation that profits can be generated from carbon markets (McMorran *et al.* 2022) and growing public support for 'rewilding' as a land management objective (Sandom *et al.* 2019). There are ambitious national targets for 30,000 ha of new woodland per year at the UK level (Beauchamp & Jenkins 2020), and ambitious regional targets for the expansion of woodland cover into moorland habitat (Cairngorms National Park Authority 2022, for example). Each nation of the UK has individual targets, with the Scottish Government aiming to increase woodland cover from 17% to 21% by 2032 (Scottish Government 2009, WEAG 2012) and a shorter-term objective to increase cover by 18,000 ha per year from 2024 (Scottish Government 2017).

The rationale for these targets are i) the UK is a net importer of timber (Forest Research 2024); ii) the low level of woodland cover in the UK compared to other similar countries in western Europe (Marston *et al.* 2023); iii) the expected biodiversity benefits of increased woodland cover (FitzGerald *et al.* 2021) and iv) the expectation that woodland sequesters more carbon than open landscapes (ibid.). While in many contexts in the UK the benefits of native woodland expansion are unequivocal (Burton *et al.* 2018), recent research has indicated that planting trees on moorland (i.e., peaty) soils is unlikely to result in net carbon benefits in decadal timescales due to increased soil carbon losses via disturbance caused by the initial planting and roots stimulating organic matter decomposition (Friggens *et al.* 2020, Warner *et al.* 2022). The expansion of scrub and woodland cover in former moorland habitat has resulted in large increases in the populations of many woodland favouring species in northern Britain (e.g. Martay *et al.* 2023), with positive trends for many common species (Heywood *et al.* 2024). Native Scottish pinewoods are the westernmost extent of the Fennoscandian boreal forest, and are much reduced from their post-glacial extent (Kinloch *et al.* 1986, Salmela *et al.* 2010). Many remaining fragments of Scottish pinewoods are within moorland habitats (Mason *et al.* 2024), and the natural regeneration and expansion of these fragments is a conservation objective with potential long-term benefits for species of conservation concern (Gullett *et al.* 2023). However, much of the expansion of woodland cover in Britain since the early twentieth century has been non-native coniferous plantations that have offer limited biodiversity benefits and often have detrimental impacts on biodiversity (Wilson *et al.* 2014). Indeed, a recent report which examined the societal, biodiversity and climate-related benefits and costs of afforestation in Scotland recommended the discontinuation of subsidies for planting non-native conifer species (The Royal Society of Edinburgh 2024).

Woodland expansion into moorland habitats has i) reduced the open ground available to waders and other open-ground species (Wilson *et al.* 2014); ii) provided increased habitat for generalist predators meaning the predator control effort needed to deliver sustainable populations of waders increases (Douglas *et al.* 2014) and iii) directly reduced predator control effort because tree planting effectively means the cessation of management for grouse. Finding the balance between open ground and woodland species requires an in-depth understanding of the conservation significance of different species and the suitability of environmental and habitat conditions at specific sites for target species (Calladine *et al.* 2022). In a broader context, across the moorland, peatland and tundra habitats of northern Europe, afforestation is a significant threat to moorland and tundra biodiversity (Wilson *et al.* 2014, Pálsdóttir *et al.* 2022). This is associated both with tree planting (often for the purpose of carbon sequestration), and the northwards spread of tree species into tundra habitats driven by global warming (Mekonnen *et al.* 2021, Speed *et al.* 2021) and increased abundance of generalist predators in northerly moorland or tundra landscapes associated with shifts in the severity of winter, habitat structure and food availability (Ims *et al.* 2019).

1.7
OBJECTIVES

In the context of 1.1 – 1.6, the objectives of this report are:

i.) to carry out a broad-scale assessment using nationally available datasets from recent decades to estimate the current rate of moorland habitat loss;

ii.) To assess which habitats and land uses are most prominent in replacing moorland;

iii.) to provide regional data on moorland habitat loss to better inform regional conservation decision-making;

iv.) To consider the likely consequences of continued moorland habitat loss.

> Afforestation of moorland reduces the habitat available for open-ground species.

Photo by Michal Klajban

2 METHODS

METHODS OVERVIEW

Data Sources

UK Centre for Ecology & Hydrology

Land Cover Map (LCM) Datasets from the CEH;

and **manual reviews** of:

- known areas of planted and regenerating young woodland on moorland
- proportion of new coniferous and broadleaved woodland planting that is planted on moorland habitats.

Spacial Extent

- England
- Scotland
- Wales

Temporal Extent

Changes between 1990 to 2023

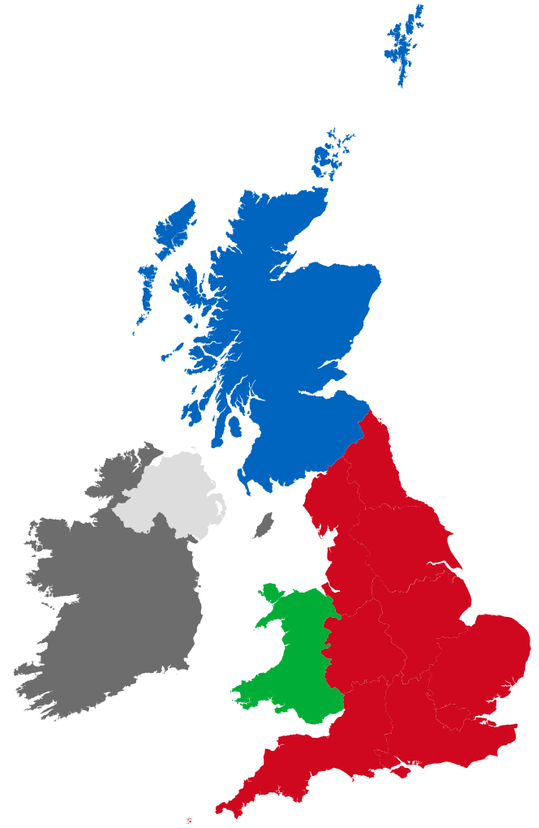


TABLE 1.
ALL THE LANDCOVER CLASSES IN THE CEH LAND COVER MAPS.

1	Deciduous woodland
2	Coniferous woodland
3	Arable
4	Improved grassland
5	Neutral grassland
6	Calcareous grassland
7	Acid grassland
8	Fen
9	Heather
10	Heather grassland
11	Bog
12	Inland rock
13	Saltwater
14	Freshwater
15	Supralittoral rock
16	Supralittoral sediment
17	Littoral rock
18	Littoral sediment
19	Saltmarsh
20	Urban
21	Suburban

▲ Highlighted classes are considered to be 'moorland' in analyses in this report

To investigate change in the extent of moorland habitats across the UK from 1990 to 2023, we used the Land Cover Map (LCM) datasets produced by the Centre for Ecology & Hydrology (Marston et al. 2023). We considered four land cover classes within the LCM to be consistent with our working definition of moorland (Section 1.2): 'heather moorland': 'acid grassland', 'heather grassland', and 'bog' (Table 1). For England, Wales and Scotland we compared the extent of these habitat categories in 1990 to the extent of these habitats in 2023 (the most recently available dataset). We produced maps showing the location of losses and gains of moorland for each country, and provided regional analyses of land cover change, specifically identifying the extent of moorland lost in each region and identifying land cover types replacing moorland. We also manually reviewed known areas of planted and regenerating young woodland on moorland to assess the extent to which areas of new woodland will still be classified as moorland in the dataset. To better understand future trajectories, we also investigate the proportion of new coniferous and broadleaved woodland planting that is planted on moorland habitats. All analyses were carried out in the R statistical software package (R Core Team, 2024).

3 RESULTS

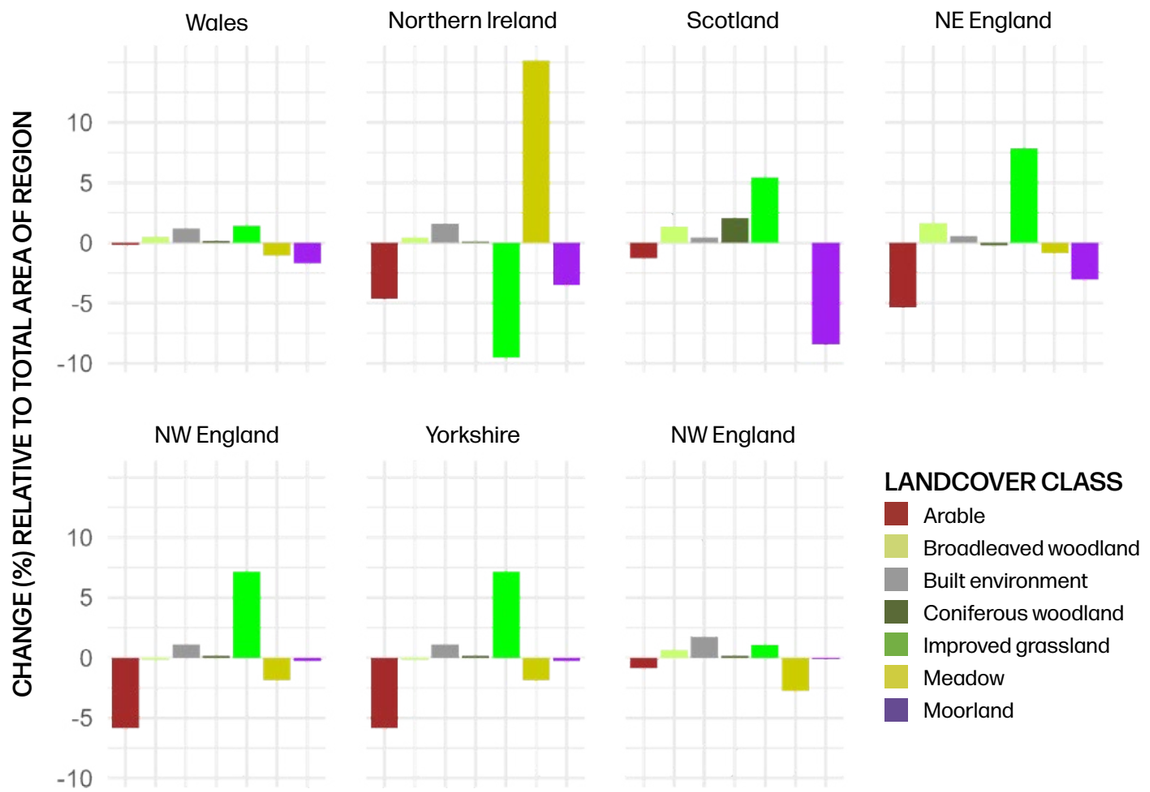
Moorland, arable and meadow habitats are declining across most areas of the UK with big increases in the extent of improved grassland and both coniferous and deciduous woodland (Figure 1). The decrease in the extent of moorland habitat is greatest in Scotland, with improved grassland, coniferous woodland and broadleaved woodland increasing in contrast.

Estimated losses of moorland habitat between 1990 and 2023 are 609 km² in England (Table 2), 6,696 km² in Scotland (Table 3), 349km² in Wales (Table 4), and 498 km² in Northern Ireland (Table 5). This represents 21% (Northern Ireland), 15% (Scotland), 7% (Wales) and 7% (England) of the 1990 extent of moorland lost in 33 years.

8,152 km²

of moorland habitat has been estimated to be lost between 1990 and 2023 in the UK. Expansion of improved grassland and coniferous woodland were the two landcover types most prominent in replacing moorland.

FIGURE 1. SUMMARY OF LAND COVER CHANGE BY REGION 1990 - 2023



In Scotland, heather moorland is dominant in the east of the country with acid grassland dominant in the west and large areas of blanket bog in northern Scotland and the Western Isles and Shetland (Figures 5 and 6). Moorland has been lost across all areas of Scotland (Table 3 and Figure 7) but regional hotspots of moorland loss in Scotland are Skye, Caithness, Kintyre and much of Southern Scotland (Figure 7). In Wales, the dominant moorland habitat class is acid grassland, with heather loss across much of the moorland in south Wales and the Cambrian mountains associated with over-grazing (Bardgett *et al.* 1995). England, the majority of the moorland losses are in the north-east and the north-west (Table 2 and Figure 4), with Yorkshire and the south-west showing small losses.

TABLE 2.
ENGLAND REGIONAL LAND COVER CHANGE 1990 – 2023.

LANDCOVER	1990 EXTENT (KM²)	2023 EXTENT (KM²)	CHANGE (KM²)	% CHANGE
NORTH-EAST ENGLAND				
Improved grassland	2505	3180	675	27
Broadleaved woodland	399	542	142	36
Built environment	666	715	49	7
Coniferous woodland	649	631	-18	-3
Meadow	86	7	-79	-92
Moorland	2024	1763	-261	-13
Arable	2141	1680	-462	-22
NORTH-WEST ENGLAND				
Meadow	183	387	204	111
Built environment	1532	1706	173	11
Improved grassland	6329	6411	83	1
Broadleaved woodland	851	836	-15	-2
Coniferous woodland	311	288	-24	-8
Arable	1530	1434	-95	-6
Moorland	2976	2738	-237	-8
YORKSHIRE				
Improved grassland	3616	4725	1109	31
Built environment	1222	1399	176	14
Coniferous woodland	264	288	24	9
Broadleaved woodland	812	787	-24	-3
Moorland	2253	2203	-49	-2
Meadow	599	307	-292	-49
Arable	6465	5565	-900	-14
SOUTH-WEST ENGLAND				
Built environment	1290	1699	409	32
Improved grassland	12472	12724	251	2
Broadleaved woodland	1828	1993	164	9
Coniferous woodland	392	434	42	11
Moorland	1002	969	-33	-3
Arable	5406	5207	-199	-4
Meadow	1160	499	-661	-57
ENGLAND TOTALS				
Improved grassland	44812	50814	6002	13
Built environment	11603	13774	2171	19
Broadleaved woodland	8779	9382	602	7
Coniferous woodland	2626	2638	12	0
Moorland	9228	8620	-609	-7
Meadow	3519	1829	-1689	-48
Arable	47795	41539	-6255	-13

TABLE 3.
SCOTLAND REGIONAL LAND COVER CHANGE 1990 – 2023.

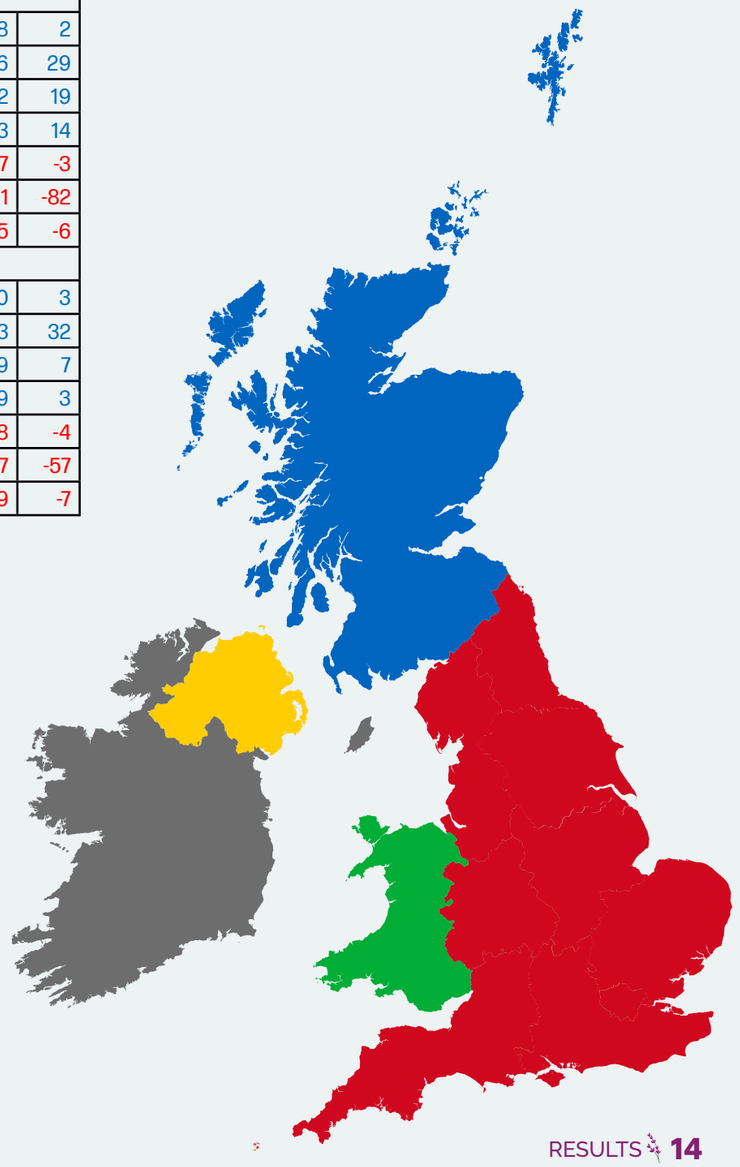
LAND COVER	1990 EXTENT (KM²)	2023 EXTENT (KM²)	CHANGE (KM²)	% CHANGE
NORTH-EAST SCOTLAND				
Broadleaved woodland	208	379	170	82
Coniferous woodland	588	687	99	17
Improved grassland	1698	1763	64	4
Built environment	111	173	63	57
Arable	1850	1700	-150	-8
Moorland	1914	1628	-286	-15
HIGHLANDS				
Improved grassland	4197	7015	2817	67
Coniferous woodland	3299	4098	799	24
Broadleaved woodland	1096	1617	521	48
Built environment	122	235	114	93
Arable	822	903	80	10
Moorland	29505	24809	-4697	-16
EAST SCOTLAND				
Improved grassland	2014	2818	804	40
Coniferous woodland	798	999	202	25
Broadleaved woodland	816	982	166	20
Built environment	514	601	87	17
Moorland	5632	5023	-609	-11
Arable	3221	2557	-665	-21
WEST SCOTLAND				
Broadleaved woodland	166	205	39	23
Coniferous woodland	76	111	35	45
Improved grassland	619	651	32	5
Built environment	361	366	5	1
Arable	133	76	-57	-43
Moorland	537	476	-60	-11
SOUTHERN SCOTLAND				
Improved grassland	5278	5871	593	11
Coniferous woodland	2175	2666	492	23
Broadleaved woodland	684	874	190	28
Built environment	267	341	74	28
Arable	1487	1258	-230	-15
Moorland	5729	4666	-1063	-19
SCOTLAND TOTALS				
Improved grassland	13791	18095	4305	31
Coniferous woodland	6933	8559	1626	23
Broadleaved woodland	2966	4053	1087	37
Built environment	1371	1712	341	25
Arable	7512	6492	-1020	-14
Moorland	43277	36581	-6696	-15

TABLE 4.
WALES REGIONAL LAND COVER CHANGE 1990 – 2023.

LAND COVER	1990 EXTENT (KM²)	2023 EXTENT (KM²)	CHANGE (KM²)	% CHANGE
WEST WALES				
Improved grassland	6313	6525	212	3
Built environment	499	668	168	34
Broadleaved woodland	1084	1210	125	12
Coniferous woodland	869	845	-24	-3
Meadow	232	136	-96	-41
Arable	683	573	-110	-16
Moorland	3018	2805	-214	-7
EAST WALES				
Improved grassland	3616	3695	78	2
Built environment	264	339	76	29
Arable	385	457	72	19
Coniferous woodland	456	519	63	14
Broadleaved woodland	523	506	-17	-3
Meadow	147	26	-121	-82
Moorland	2189	2054	-135	-6
WALES TOTALS				
Improved grassland	9926	10216	290	3
Built environment	762	1006	243	32
Broadleaved woodland	1605	1714	109	7
Coniferous woodland	1324	1363	39	3
Arable	1068	1029	-38	-4
Meadow	379	162	-217	-57
Moorland	5200	4852	-349	-7

TABLE 5.
NORTHERN IRELAND REGIONAL LAND COVER CHANGE 1990 – 2023.

LANDCOVER	1990 EXTENT (KM²)	2023 EXTENT (KM²)	CHANGE (KM²)	% CHANGE
NORTHERN IRELAND TOTALS				
Improved grassland	8081	6717	-1364	-17
Built environment	450	673	223	50
Broadleaved woodland	648	713	65	10
Coniferous woodland	514	528	14	3
Moorland	2429	1931	-498	-21
Meadow	89	2257	2168	2436
Arable	1259	590	-669	-53



ENGLAND MOORLAND EXTENT

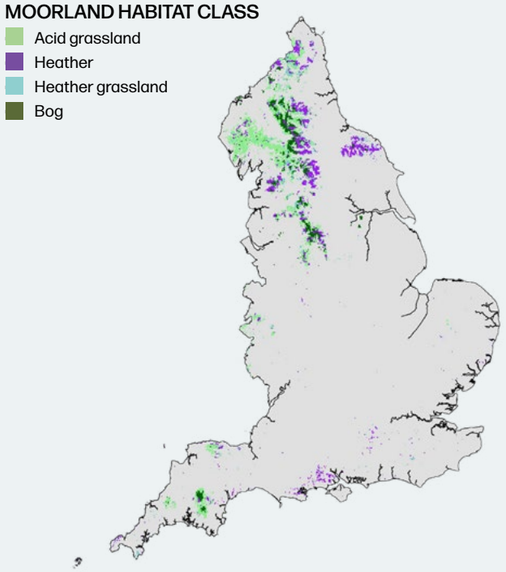


FIGURE 2.
ENGLAND MOORLAND EXTENT IN ENGLAND IN 1990.

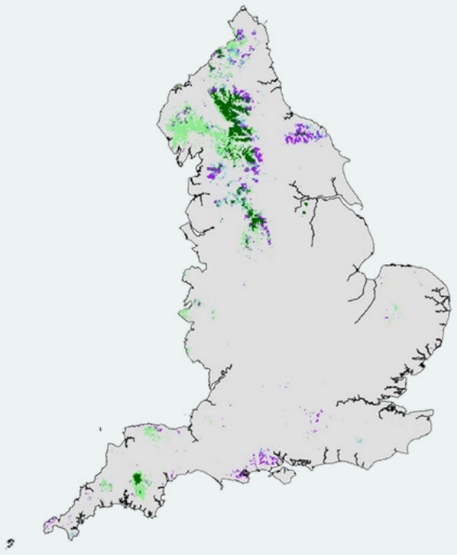
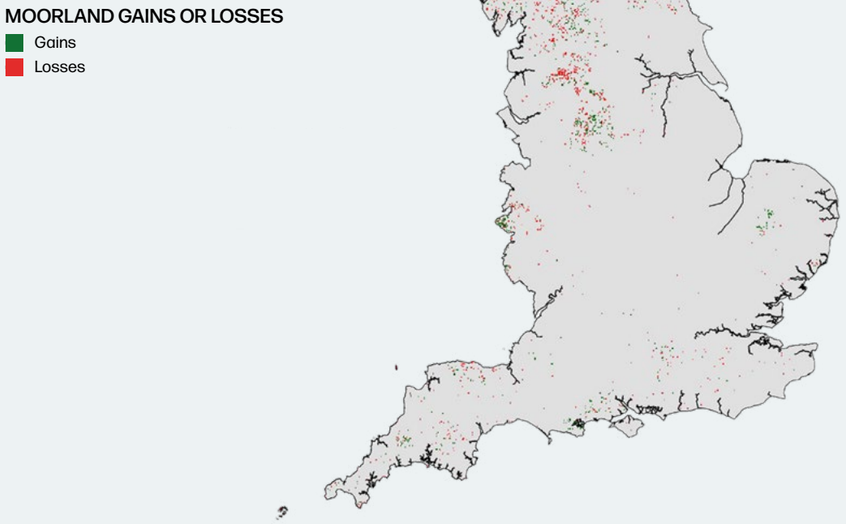


FIGURE 3.
ENGLAND MOORLAND EXTENT IN ENGLAND IN 2023.

1990 2023

FIGURE 4.
CHANGE IN THE EXTENT OF MOORLAND HABITAT IN ENGLAND BETWEEN 1990 AND 2023



SCOTLAND MOORLAND EXTENT

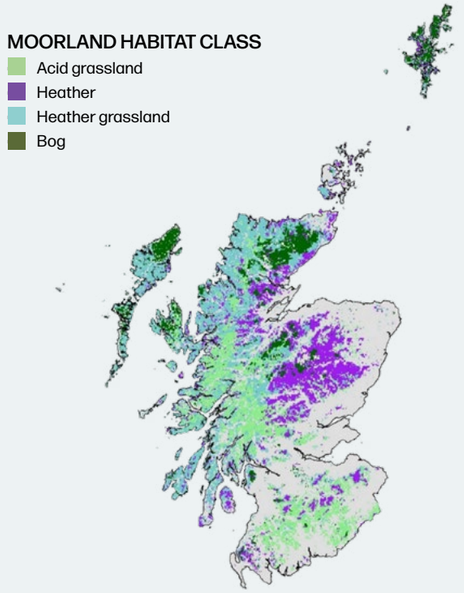


FIGURE 5.
ENGLAND MOORLAND EXTENT IN SCOTLAND IN 1990.

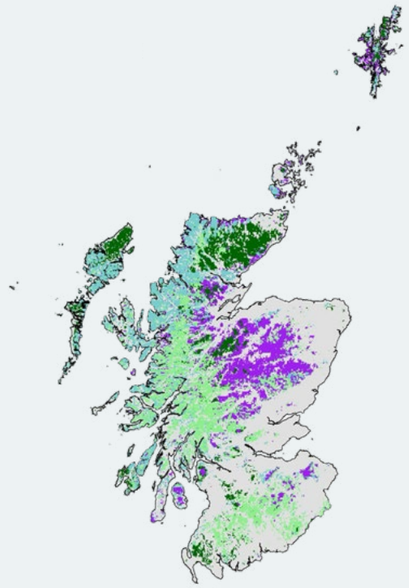
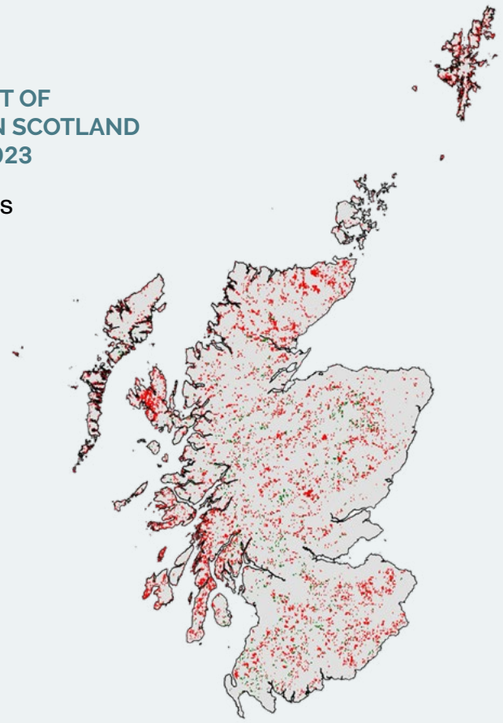


FIGURE 6.
ENGLAND MOORLAND EXTENT IN SCOTLAND IN 2023.

1990 2023

FIGURE 7.
CHANGE IN THE EXTENT OF MOORLAND HABITAT IN SCOTLAND BETWEEN 1990 AND 2023



WALES MOORLAND EXTENT

MOORLAND HABITAT CLASS
- Acid grassland
- Heather
- Heather grassland
- Bog

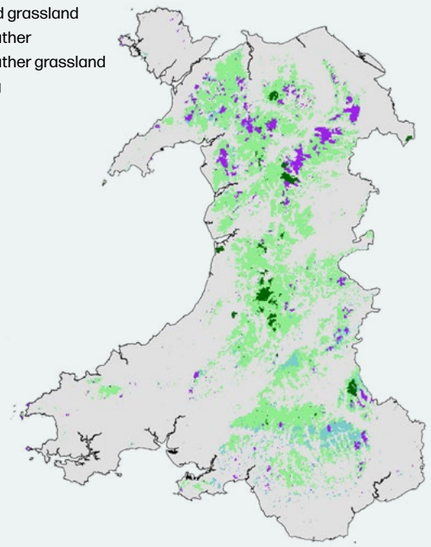


FIGURE 8.
ENGLAND MOORLAND EXTENT IN WALES IN 1990.

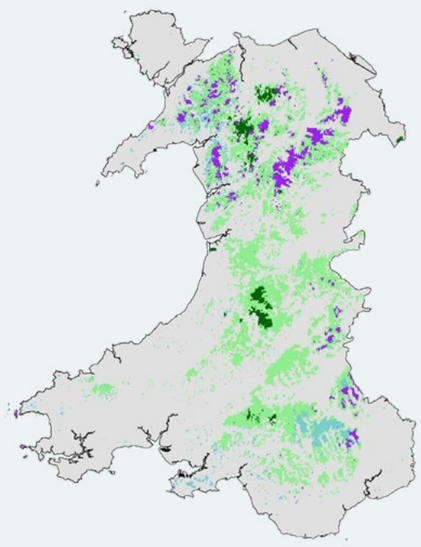


FIGURE 9.
ENGLAND MOORLAND EXTENT IN WALES IN 2023.

1990 2023

FIGURE 10.
CHANGE IN THE EXTENT OF MOORLAND HABITAT IN WALES BETWEEN 1990 AND 2023

MOORLAND GAINS OR LOSSES
- Gains
- Losses

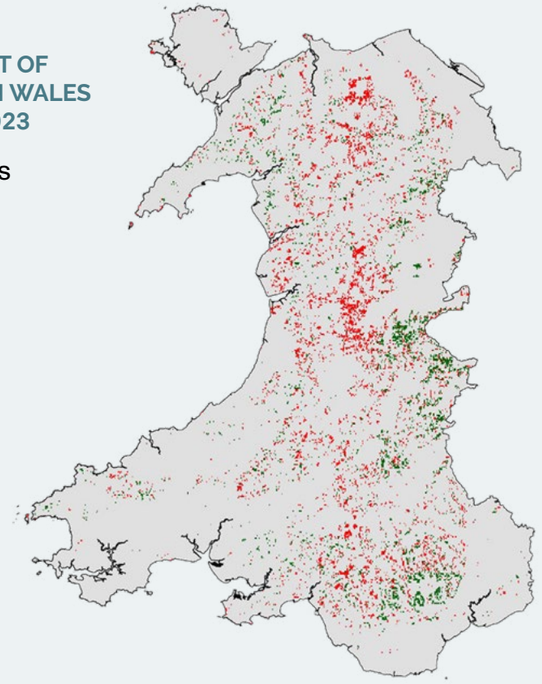
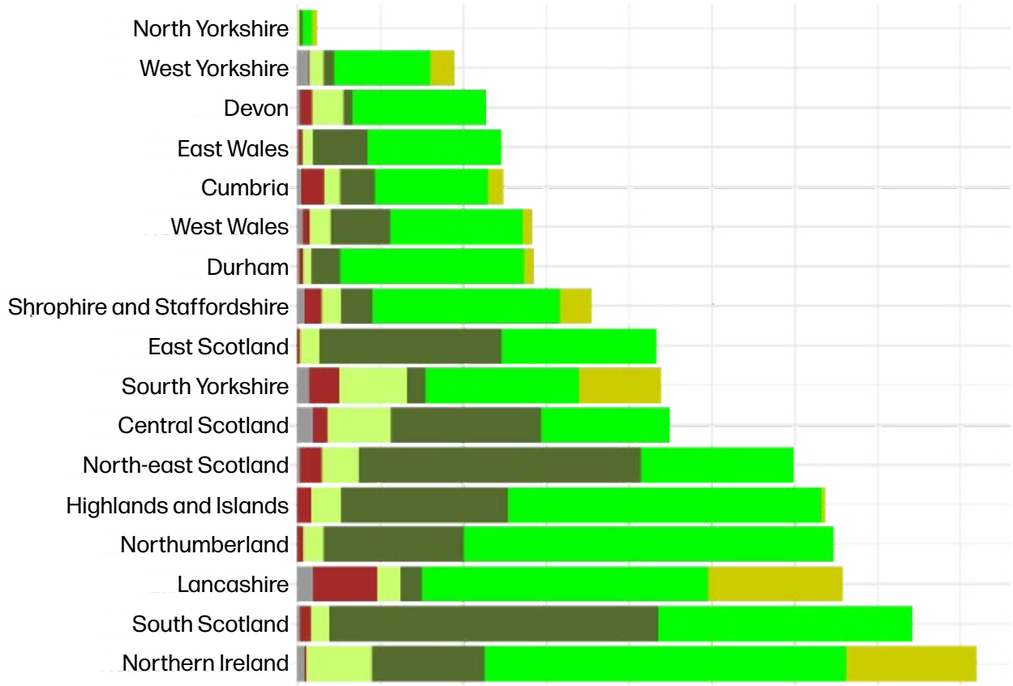


FIGURE 11.
LAND COVER THAT DIRECTLY REPLACED MOORLAND BETWEEN 1990 – 2023.

MOORLAND HABITAT LOSS 1990-2023



LANDCOVER REPLACING MOORLAND
- Meadow
- Improved grassland
- Coniferous woodland
- Broadleaved woodland
- Arable
- Built environment

Sites with planted or regenerating woodland <10 years old are likely to be classified as moorland, so the rate of moorland habitat loss in recent years is likely to be under-estimated.

Photo by Neil Theasby, CC BY-SA 2.0

Expansion of improved grassland and coniferous woodland were the two landcover types most prominent in replacing moorland in the UK, although there is significant regional variation (Figure 11). Coniferous woodland expansion was the most significant landcover replacing moorland in North-east Scotland (57% of lost moorland replaced with coniferous woodland), South Scotland (53%), East Scotland (51%) and Central Scotland (40%). The proportion of improved grassland in replacing moorland was highest in Durham (78%), Devon (71%), Northumberland (69%). Across England as a whole, improved grassland (60%) was the most common habitat replacing moorland, with coniferous woodland (14%) and broadleaved woodland (9%) the next most common. In Scotland improved grassland (53%) was also the most common habitat replacing moorland, but coniferous woodland (39%) was far more significant, but broadleaved woodland (5%) less so. Indeed, in Scotland and Wales, 92% of new coniferous woodland was planted on moorland, while the equivalent figure in England was 48%. For Broadleaved woodland, 40% of new habitat in Scotland was formerly moorland, while the equivalent figure for England was only 6%.

TABLE 6.
PRE-EXISTING LAND COVER WHERE CONVERSION TO CONIFEROUS WOODLAND TOOK PLACE 1990 – 2023.

	CONIFER PLANTING ON ACID GRASSLAND (KM²)	CONIFER PLANTING ON HEATHER GRASSLAND (KM²)	CONIFER PLANTING ON HEATHER (KM²)	CONIFER PLANTING ON BOG (KM²)	CONIFER PLANTING ON ALL MOORLAND HABITATS (KM²)	CONIFER PLANTING IN OTHER HABITATS (KM²)
ENGLAND	69 (24%)	57 (20%)	7 (2%)	6 (2%)	139 (48%)	151 (52%)
WALES	147 (59%)	35 (14%)	43 (17%)	5 (2%)	230 (92%)	21 (8%)
SCOTLAND	828 (27%)	1050 (35%)	739 (25%)	167 (5%)	2784 (92%)	234 (8%)
NORTHERN IRELAND	19 (12%)	63 (42%)	11 (7%)	35 (23%)	128 (84%)	25 (16%)
UK	1063 (32%)	1205 (37%)	800 (24%)	213 (6%)	2850 (88%)	431 (13%)

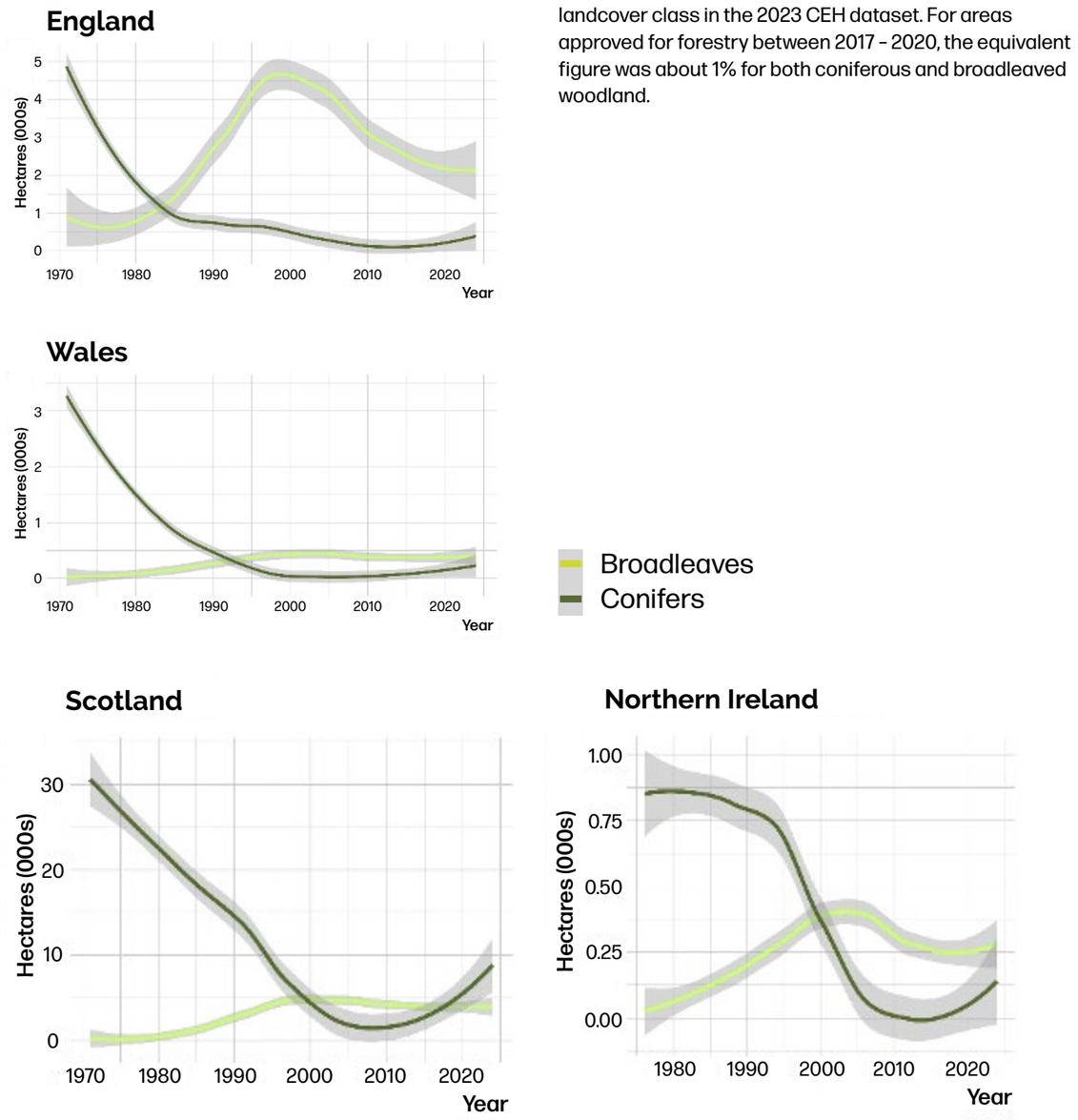
▲ Acid grassland, heather grassland, heather, and bog are the four land cover classes we considered to be 'moorland'. The proportion of new coniferous woodland in each category is shown in brackets.

TABLE 7.
PRE-EXISTING LAND COVER WHERE CONVERSION TO BROADLEAVED WOODLAND TOOK PLACE 1990 – 2023.

	BROADLEAVED PLANTING ON ACID GRASSLAND (KM²)	BROADLEAVED PLANTING ON HEATHER GRASSLAND (KM²)	BROADLEAVED PLANTING ON HEATHER (KM²)	BROADLEAVED PLANTING ON BOG (KM²)	BROADLEAVED PLANTING IN OTHER HABITATS	PROPORTION ON MOORLAND
ENGLAND	33 (2%)	35 (2%)	39 (2%)	7 (<1%)	114 (6%)	1885 (94%)
WALES	41 (12%)	14 (4%)	7 (2%)	0 (0%)	62 (19%)	272 (81%)
SCOTLAND	98 (10%)	208 (21%)	75 (8%)	14 (1%)	395 (40%)	586 (60%)
NORTHERN IRELAND	2 (<1%)	36 (11%)	14 (4%)	14 (4%)	66 (20%)	265 (80%)
UK	174 (5%)	293 (8%)	135 (4%)	35 (1%)	637 (17%)	3008 (83%)

▲ Acid grassland, heather grassland, heather, and bog are the four land cover classes we considered to be 'moorland'. The proportion of new broadleaved woodland habitat in each category is shown in brackets.

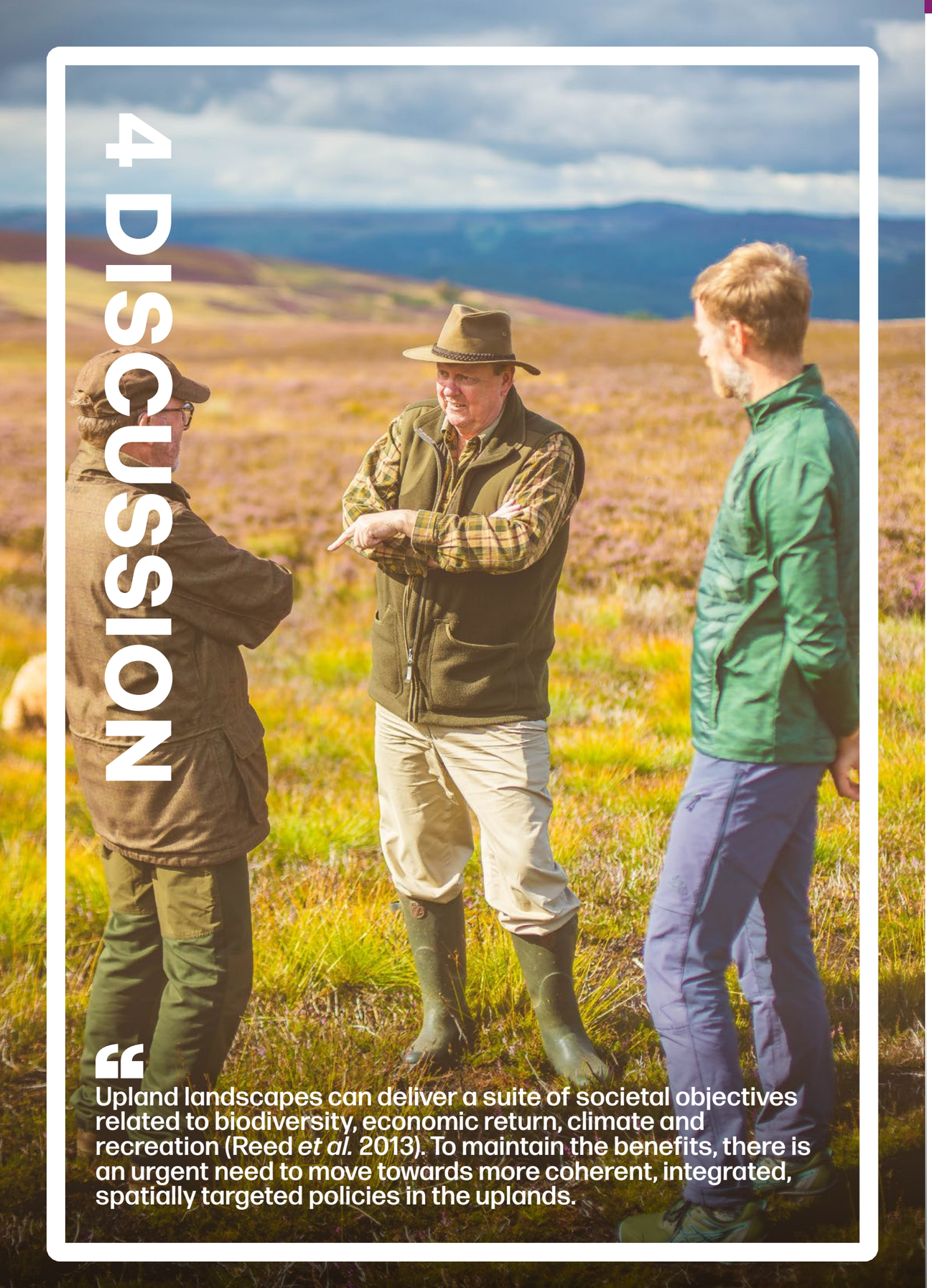
FIGURE 12.
SMOOTHED TRENDS IN ANNUAL TREE PLANTING RATES BY NATION.



Data taken from UK Government website - *Forestry Commission Key Performance Indicators (www.gov.uk/environment/forests-and-woodland#research_and_statistics)*

In Scotland and Northern Ireland, there have been increases in woodland planting in the last decade (Figure 12), the majority of which will not have been included in these datasets: of areas approved for forestry grants in 2015 and 2016 only 12.4% of coniferous woodland and 2.6% of broadleaved woodland was identified as a woodland landcover class in the 2023 CEH dataset. For areas approved for forestry between 2017 – 2020, the equivalent figure was about 1% for both coniferous and broadleaved woodland.

4 DISCUSSION



> Upland landscapes can deliver a suite of societal objectives related to biodiversity, economic return, climate and recreation (Reed *et al.* 2013). To maintain the benefits, there is an urgent need to move towards more coherent, integrated, spatially targeted policies in the uplands.

> **The extent of moorland habitat in the UK is declining rapidly, equivalent to an area approximately the size of the city of Birmingham being lost every year.**

The analysis in this report provides clear evidence that the extent of moorland habitat in the UK has is declining rapidly. At a UK level, the reduction in the extent of moorland habitat between 1990 to 2023 was 8,152 km². This is equivalent to an area of moorland approximately the size of the city of Birmingham being lost every year. Scotland (6,696 km²) lost the most moorland habitat, followed by England (609 km²), Northern Ireland (498 km²), and Wales (349 km²). Moorland was primarily converted to improved grassland (55%), coniferous woodland (34%) and broadleaved woodland (6%). These findings show a consistent trend with earlier studies assessing moorland habitat loss (Stevenson & Thompson 1993, Robertson *et al.* 2001), with the continuing importance of agricultural improvement relative to afforestation in driving moorland habitat loss notable in this current analysis. The limitations of the dataset and the analysis are discussed in Section 4.1, then in Section 4.2 the key threats to moorland habitat are considered, and the implications of moorland habitat loss (4.3) are discussed.

4.1 DATA LIMITATIONS

While the CEH land cover dataset is the most suitable dataset to assess temporal land cover change, the dataset has various limitations. The dataset is created through the supervised classification of satellite images, with a combination of methods used to train a model to identify each of the 21 habitat classes used in the land cover map. Validation testing of the 2021 land cover map against a ground-truthed dataset of 35,182 points showed that the landcover map had overall accuracy of 82.6%, though this varied between classes – arable land had the highest accuracy at 96%, and heather grassland lowest at 43% (these errors are overwhelmingly the misclassification of heather grassland as heather or acid grassland). Because there is overlap between heather grassland, heather, bog and acid grassland, the dataset cannot reliably be used to investigate transitions between these classes (e.g. to investigate the depletion of heather cover in moorland).

Where land transitions from moorland to woodland, either as a result of planting or natural regeneration, sites will still be classified as moorland in the dataset for some years as the trees establish, because in terms of the automatic classification of satellite images, a site will retain most of the characteristics of moorland as young trees establish, even though habitat transition to woodland is underway. Of woodland grants approved from 2015 onwards (including conifers, native, and natural regeneration) only a very small proportion are classed as woodland in the 2023 landcover dataset. While these areas retain many of the characteristics of moorland habitat, the site has de facto been lost as an open moorland habitat. This means that more recent tree planting is excluded from the data, and in the case where tree planting rates have been increasing in recent years (as is the case in most of the UK), the pace of land use change (from moorland to forestry) is likely to be significantly under-estimated.

4.2
KEY THREATS TO MOORLAND HABITAT

4.2.1
OVERGRAZING AND CONVERSION TO IMPROVED GRASSLAND

Conversion to improved grassland has been the most significant factor driving the loss of moorland habitat in the UK in the period covered by the CEH Landcover maps (1990 – 2023), with 55% of lost moorland habitat being converted to improved grassland. While in the 1950s / 1960s there were agricultural subsidies available for agricultural improvement of unenclosed moorland, conversion of moorland to improved pasture is not currently supported by agri-environment funding. Grazing pressure from wild ungulates is also likely to be increasing in the uplands, with red deer (133% increase), fallow deer (245%) and roe deer (129%) all at least doubling in population size across the UK since 1995 (Heywood *et al.* 2024). The resultant increased grazing pressure will be contributing to the loss of heather and land transitioning from heather dominated moorland to grassland. However, sheep and cattle numbers have declined significantly in recent years from their peaks in the 1990s (DEFRA 2024), suggesting that conversion to improved grassland to produce silage for grazing animals may not be such an important driver of moorland habitat loss in the future.

4.2.2
CONIFEROUS PLANTATIONS

Coniferous woodland is the second most important factor identified in the analysis, with 34% of lost moorland replaced with coniferous woodland. However, it is clear from the lags involved in the landcover maps identifying areas as such after planting (see 4.1) and the relative increase in planting rates in recent years that coniferous plantations are likely to be a more important contributor to current declines in moorland extent than the data would suggest. In some regions of Scotland coniferous plantations are the biggest cause of moorland habitat loss, with 92% of new coniferous plantations in Scotland replacing moorland habitat (Table 6). For Wales (92%) and Northern Ireland (88%) the figure was also high, but in England it was much lower, reflecting more restrictive policies regarding large-scale afforestation in the uplands.

Planting on blanket bog is a very low proportion of new planted areas due to better regulation of the sector since the widespread planting of coniferous plantations on blanket bog in northern Scotland in the 1980s. Only 5% of new planting between 1990 – 2023 was on blanket bog habitat in Scotland (Table 6). For England (2%) and Wales (2%), the figure was very low, but in Northern Ireland the figure was much higher (30%).

Current targets for woodland expansion across the UK are 30,000 ha per year, with national targets of 18,000 (Scotland), 2,000 (Wales), and 7,500 (England). The majority of this will be coniferous woodland, and annual planting rates are currently much lower than this (Figure 12) meaning that there is considerable momentum to increase planting rates. Given the proportion of new coniferous planting that has taken place on moorland habitat (88% across the UK), there is likely to be significant further pressure on moorland habitat from continued expansion of coniferous woodland. An additional threat is the considerable spreading potential of self-seeded sitka spruce onto moorland habitats, which is already being anecdotally recorded in lots of contexts.

▼ 34% of lost moorland replaced with coniferous woodland. However, they are likely to be a more important contributor to current declines in moorland extent than the data would suggest.

▲ Broadleaved woodland in the uplands can also support species of conservation concern.
Photo by Peter Moore, CC BY-SA 2.0

4.2.3
BROADLEAVED WOODLAND

Only 6% of the moorland lost between 1990 – 2023 was replaced with broadleaved woodland, reflecting the lower proportion of broadleaved woodland being planted relative to coniferous woodland. Additionally, a much lower proportion of all new broadleaved woodland was on moorland, with the figure highest in Scotland at 40%, and lower across the other nations (Table 7). However, there has been much recent support for the rewilding of moorland habitats, with many large estates having recently been bought with the purpose of reducing moorland management interventions and grazing intensity to allow habitats to transition to more shrub and woodland cover. Habitat change at upland sites where natural regeneration is encouraged will be slow, and sites may retain the characteristics of moorland for decades. However, where traditional moorland management techniques such as grazing, muirburn and predator control have ceased, the species composition of the moorland may change, and there are likely to be declines of ground-nesting birds associated with the recovery of predator populations and vegetation succession.

4.3
BROADER CONSEQUENCES AND POLICY IMPLICATIONS

Upland landscapes can deliver a suite of societal objectives related to biodiversity, economic return, climate and recreation (Reed *et al.* 2013). A diverse and resilient suite of upland habitats would include large areas of contiguous moorland with a range of management approaches, as well as a mix of broadleaved and coniferous woodland with both commercial harvesting and areas actively managed for conservation, and areas with limited intervention (Burton *et al.* 2018). However, current policy offers large subsidies for land cover change from open ground to woodland, together with ambitious national targets for woodland cover, but no equivalent targets related to moorland and open ground species. This has resulted in the piecemeal fragmentation of open landscapes, and caused rapid declines in open ground species including curlew, which has been identified as one of the UK's most pressing terrestrial conservation obligations (Brown *et al.* 2015). The absence of any over-arching spatial strategy related to woodland creation has also resulted in the creation of unconnected blocks of woodland with limited biodiversity value which fragment open ground habitats. Additionally, as the amount of woodland in a landscape increases, the predator control effort required to maintain stable populations of ground-nesting birds on adjacent open ground increases (Douglas *et al.* 2014), but tree planting is almost always associated with a cessation of predator control. As such, the most obvious and pressing risk associated with the current policy approach is that regional tipping points are passed, beyond which management for open-ground species and continued moorland management becomes financially and ecologically untenable. This would have dire consequences for those species like curlew and black grouse for which the majority of the population are dependent on managed moorland and the associated predator control.

To maintain the benefits of managed moorland from upland landscapes, there is an urgent need to move towards more coherent, integrated, spatially targeted policies in the uplands. Land use policy needs to be cognisant of the value of maintaining large areas of contiguous, open moorland habitat together with management designed to support ground-nesting birds, as well as acknowledging the important benefits associated with the restoration of large-scale native woodlands.

▼ Short-eared owl (Asio flammeus) are among the open-ground nesting birds that are likely to benefit from managed moorland and the associated predator control.

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TABLES AND FIGURES

TABLES

FIGURES

The Heather Trust
championing our magnificent moorlands

THE HEATHER FUTURES PROJECT

For many years, it has been understood that moorlands have been lost or degraded due to overgrazing, undergrazing and commercial afforestation. Despite this, there was limited available evidence on changes in the extent and quality of moorland habitats in the UK.

Heather Futures addresses this evidence gap by identifying the best available datasets and producing regional and national estimates of moorland extent and historical moorland loss. This report is the result of the culmination of the first phase of the Heather Futures research project. We hope it will engage policy-makers and alert stakeholders to the pace at which moorland habitats are being lost and encourage more coherent land use policy in the uplands to ensure these special habitats remain sustainable and resilient for generations to come.

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