

Environmental Change in the Scottish Uplands

An introduction to the Scottish uplands

The Scottish uplands are generally defined as the land above the level of agricultural enclosure, which is typically 300-400m above sea level (ASL) but often lower, especially in the far north. The uplands may be divided into the montane and sub-montane zones, the former beginning at the theoretical tree-line (up to 600-700m ASL, and descending as one moves north). Natural tree-lines are rare in Scotland, but can still be seen, for example at around 640m ASL on Creag Fhialcach in the north-east.

Whilst renowned and revered for their wildness, Scotland's uplands have borne the footprints of human activity for millennia. Low-intensity arable and livestock agriculture, arguably coupled with natural herbivore grazing, created an open landscape with very little woodland cover by 1700 AD.

The next century saw the introduction of hardy sheep breeds able to withstand year-round exposure to upland weather conditions, and a subsequent step-increase in grazing intensity. In the nineteenth century, highland sporting pursuits gained popular favour, further influencing the landscape by promoting high densities of deer and grouse for shooting.

A major change followed the First World War, when subsidies were made available to encourage planting of commercial conifer forests in the uplands, and livestock grazing was favoured by payments for extensive drainage after the second war. Intensification of grazing reached a peak in the last decades of the twentieth century when European funding, via the [Common Agricultural Policy](#) (CAP), solely rewarded production as the key agricultural output.

In the twenty-first century, subsidies have begun to favour wider aspects of land management, such as water quality, biodiversity and carbon storage, whilst management for game shooting is arguably declining. Grazing pressures are decreasing, heather is being replaced by rough grass and conifers, and renewable energy has become a key economic activity in the upland environment. Upland land use is currently dominated by the three principal activities of livestock farming, commercial forestry and fieldsports (grouse shooting and deer stalking).

This long history of human activity means that only the high altitude montane zone can be considered natural or near-natural, and in this respect is the most extensive habitat of its kind in the British Isles. Montane vegetation comprises a diverse assemblage of bryophytes (liverworts and mosses), lichens¹ and prostrate (low-growing) vascular plants², whilst the sub-montane region is characterised by heather, acid grassland and, increasingly, commercial conifer plantations.

Changes in the size of upland bird populations are not as well monitored as those for other major UK habitats, due to relatively low numbers of human observers in these areas. However, various single-species surveys have revealed declines in certain upland species including black grouse, ring ouzel, wheatear, twite, curlew and dunlin.

¹ Lichens are not plants, but composite organisms formed from a symbiosis (mutually beneficial joining) between a fungus and either a green alga or a cyanobacterium.

² Vascular plants are those with strengthened tissues called xylem for conducting water and minerals. Bryophytes are examples of non-vascular plants.

The impact of land use change

1. Livestock/Grazing

Livestock have been grazed in the Scottish uplands for centuries, but their numbers have risen dramatically since the 18th century. There are now approximately 2.3 million sheep in the Scottish uplands, and they outnumber red deer by 8:1 and cattle by 14:1.

In simple terms, an increase in grazing pressure from negligible to intense tends to result in vegetation sequentially dominated by tree/scrub, then dwarf shrub (e.g. heather), then grass. High densities of grazing animals generally cause depletion of vegetation diversity, prevent tree regeneration and promote soil erosion. Grazing by herbivores also affects other animal species, either directly (e.g. trampling of birds' nests, and provision of carrion for scavengers) or indirectly, via altered vegetation (which may mean changes in the extent of food, shelter and/or predation).

However, not all change is bad, and low-to-moderate levels of grazing may be of benefit to biodiversity in the uplands. Grazed heather moorland contains more grass than ungrazed moorland, boosting numbers of meadow pipits, and low levels of grazing also prevent high densities of field voles, which cause damage to sapling trees.

2. Sporting management

Management of the Scottish uplands for sporting interests reached its zenith in the mid-to-late 19th century, following Queen Victoria's purchase of the Balmoral estate in 1852. In the interest of maintaining high densities of red grouse, extensive heather-burning and the sustained and indiscriminate control of predators were employed; the legacy of the latter is still seen in the restricted distributions of several birds of prey, as well as the Scottish Wildcat, Britain's only native feline.

In general terms, management for grouse encourages the growth of heather, whilst deer and livestock reduce heather cover and prohibit the regeneration of forest; this combination of management practices leads to the heather-grassland mosaic seen across much of the Scottish uplands, though heather cover has decreased by around 20% since the 1940s (due to increases in both grass and commercial forestry)³.

Changes in the extent of grouse moor management have implications for upland birds, perhaps most significantly via the control of nest predators such as corvids, foxes and mustelids⁴. Predator control (legal and illegal) on the former benefits ground-nesting birds such as waders yet often has a negative impact on raptors, whilst the practice of rotational burning of heather in order to provide a mosaic of feeding areas and shelter for grouse may suppress numbers of passerines⁵ such as meadow pipits.

³ A degree of grass cover on heather moorland is beneficial for biodiversity, but dominance of grass is generally seen to be negative. Heather moorland is common in Scotland but very rare internationally.

⁴ Mustelids are the family of small carnivores that includes stoats, weasels, martens, otters and badgers.

⁵ Passerines (also called 'perching birds') are an order of birds that includes larks, pipits, tits, thrushes, warblers, swallows, crows and many other similar groups.

3. *Forestry*

Commercial forestry planting in Britain started in earnest with the formation of the [Forestry Commission](#) under the government Forestry Act of 1919. The extent of Scottish commercial forestry rose from 1267km² in the 1940s to 9131km² in the 1980s, an increase of 620%.

Afforestation is one of the key causes of loss of heather and blanket bog. In the early stages of growth, conifer plantations may benefit open-country species such as hen harrier and short-eared owl, by providing opportunities for nesting and foraging; indeed, it is likely that the expansion of forestry in the 1970s was in large part responsible for the recovery of the hen harrier in Scotland. However, both species begin to avoid forestry as trees grow.

Plantations displace moorland specialists such as golden plover, dunlin and greenshank. As they mature, their bird communities will gradually change from those associated with scrub habitats (e.g. whinchat and willow warbler) to those typical of coniferous woodland (e.g. crossbills, crested tit, coal tit, siskin, goldcrest and capercaillie).

4. *Erosion, Drainage, drain-blocking and burning*

Drainage of moorland and blanket bog increased substantially after the Second World War, when government subsidies were allocated for cutting of ditches to promote livestock farming, and the practice continues today on grouse moors, despite very limited evidence for its effectiveness.

The environmental costs of extensive drainage of the uplands are well documented, however, and include altered rainfall-runoff regimes (and hence flood frequency), subsidence and erosion, nutrient loss, carbon release and loss of flora and fauna. There is more carbon stored in UK peatlands than in the forests of the UK and France combined, and most of it is found in the uplands.

5. *Wind energy and hydro-electric*

A relatively new form of land use in the uplands (and elsewhere) is renewable energy installation, principally related to wind and hydroelectric power. The Scottish government has outlined various targets for renewable energy capacity for 2020, including the provision of 100% of electricity demand (currently 25%) and 11% of heat-energy demand (currently 2.8%), meaning that renewable energy installations – and their associated impacts – are set to become increasingly visible in the uplands.

The potential impacts of wind turbines on wildlife are numerous and include direct habitat loss, effective habitat loss via disturbance, increased energetic costs due to avoidance activity, and mortality through collisions with structural components such as towers, blades and powerlines.

Wind farms may also require considerable disturbance to habitats in which they are situated, including the drainage and/or removal of peat for the installation of turbines, sub-stations and access roads, and the felling of forests in order to manipulate wind movements over the site. These practices have the additional impact of elevating greenhouse gas emissions, meaning that poorly-sited windfarms have the potential to cause a net release of carbon.

A number of studies have assessed the potential impacts of wind turbines on birds and bats, and while the results are quite variable, there is undoubtedly potential for windfarms to cause significant

local-level mortality, which could theoretically accumulate into regional- or national-level effects as the numbers of windfarms increase.

Approximately 10% of Scotland's current energy generation already comes from hydropower, equivalent to 1.3GW, and there was an SNP manifesto commitment to provide a rapid expansion of renewable energy production by Scottish Water. In 2009 it was estimated that there was capacity for a further 1.2GW in Scotland, across 7,043 schemes, 63% of which (14% in terms of energy output) were below 100kW.

The known impacts of hydro-electric schemes are diverse, and go beyond the simple removal of habitat associated with the creation of the reservoir. They include greenhouse gas emission from the reservoir, evaporative water loss, reduced downstream water flow (altering stream dynamics and sediment transport, for example) and obstruction of fish migration.

Despite this, the environmental impacts of 'micro-hydro' (<100kW) installations tend to be viewed as negligible; the British Hydropower Association's current literature describes micro-hydro installations as "environmentally benign". However, there is little evidence that the impact of hydroelectric schemes, per-watt, decreases with scale. Reductions in flow rate and oxygenation downstream (with concomitant impacts on habitat quality), obstruction of aquatic wildlife migration and dispersal, and pollution from chemicals used in site maintenance, are still likely to occur with micro-hydro power. Crucially, scientific studies on the effects of micro-hydro installations on river habitats are extremely rare.

The impact of climate change

Climate affects ecosystems and habitats by dictating the conditions in which organisms grow, survive and reproduce; changes in climate therefore lead to changes in the composition of plant and animal communities. Since 1914, average temperatures in Scotland have increased by 0.5°C, though the changes are least pronounced in the north, where the only significant seasonal increases have been in the spring. Over the same period, precipitation has increased the west in spring, and decreased in the east in summer.

According to the [UK Climate Impacts Programme \(UKCIP\)](#), by the 2080s, the UK is likely to experience average temperatures between 2 °C and 3.5°C warmer than the present, though these increases will be less pronounced in Scotland than the south. A predicted general trend is for summers to be drier and winters to be wetter.

Future rises in temperature are likely to result in three major, interconnected changes in Scottish upland vegetation:

- (1) **An increase overall plant growth**, with changes in species composition. Warmer conditions combine with increased air-borne nitrate pollution to make a formerly harsh environment relatively mild, which means that the specialist upland species no longer have an advantage over the commoner species from lower altitudes. The result is a homogenisation of plant communities in montane areas.

The emission of nitrous compounds from industrial processes peaked in the 1980s, and has since dropped to around half of peak levels. High levels of nitrogen deposition not only cause increased competition, they may also – together with sulphur dioxide, another industrial pollutant - directly reduce growth and cover of lichens and bryophytes by damaging plant tissues.

(2) **A shift in the timing of leafing, flowering and budding.** Changes in the timing of seasonal events such as spring flowering can have important consequences if species that rely on these events are not able to change the timings of their own lifecycles at the same rate. For example, birds such as blue tits, that rely on caterpillars for feeding chicks, may find that their food supply is no longer available at the right time if caterpillars have hatched early in order to coincide with earlier leaf emergence.

(3) **Range shifts.** Permanent movements of a variety of plant and animal species in response to climate change have already been observed, and more are predicted. As the climate changes, the areas of land that are suitable for each species also change, in part because all species are dependent upon 'primary producers' such as plants and algae, which are sensitive to temperature and sunlight.

For northerly species and those living at high altitude, this change in suitable land area typically equates to a reduction, since a warming climate pushes them northwards and uphill, respectively, and land area decreases with altitude and latitude. In practice, almost all range shifts represent reductions in range, since all species are limited to greater or lesser extents in their ability to move in response to climate.

Looking to the future

Predicting the future of land use is both important and difficult; important because decisions made in one sphere (e.g. species conservation) should ideally be made with consideration of the likely future socio-environmental context (e.g. agricultural policy, tourism, climate), and difficult because the drivers of change are numerous and inter-linked.

Many of the economic activities that shape the upland landscape, such as farming and shooting, rely upon subsidies and are now arguably operating at the limits of viability. Grouse shooting is an industry reliant to a significant extent upon a financial elite, making it especially vulnerable to economic fluctuations. A trend for economic migration of human workers out of the uplands could feasibly result either in agricultural abandonment and hence benefits to wildlife and biodiversity, or, conversely, a greater prevalence of low-input but locally damaging ventures such as commercial forestry and windfarms.

Low-input management in the absence of subsidy or economic return (e.g. forestry) is unlikely to result in heather moorland in the uplands, given the nature of vegetation succession. Allowing the loss of heather in favour of rough grassland and birch scrub will certainly be of benefit to some species, and might arguably be more 'natural' than swathes of heather, but the latter is the rarer habitat globally; the majority of the world's heather moorland is in the UK.

Agricultural subsidies are likely to continue to play a role in dictating the upland landscape. The CAP, which linked subsidies to economic production and arguably lead to much upland erosion and homogenisation, was partly replaced in 2005 by the [Single-Farm Payment Scheme \(SFP\)](#), which was 'decoupled' from production in an attempt to address the damage done by intensive land management. The SFP provides more opportunity for the economic survival of farms in marginal areas, but is only guaranteed until 2013.

The economic value of land is likely to be increasingly measured by reference to ecosystem services rather than more obviously tangible outputs such as crops, livestock or recreation opportunities. Put from an alternative perspective, the value of the natural environment is likely to be increasingly

measured by reference to economics, rather than to intrinsic or aesthetic worth⁶. The upland environment, for example, provides three key services: (1) climate regulation (via carbon sequestration and storage), (2) flood regulation, and (3) water purification; it is likely, therefore, that subsidies in the future may promote protection of peat, and avoidance of erosion and drainage. Such 'cross-compliance' subsidies would likely result in lower densities of sheep, and increased prevalence of management for grouse shooting.

An alternative scenario is that subsidies will be completely removed from the unproductive uplands, inducing a process of 're-wilding'. Effects on upland fauna would depend then upon the extent to which conservation management could be funded; lack of management is likely to result in the growth of scrub and woodland, prompting a gradual change in the suite of species inhabiting the uplands.

Some commentators believe that tourism and recreation could fund the maintenance of healthy habitats for wildlife in the uplands, though it is a notoriously fickle industry, heavily reliant on uncontrollable factors such as the weather. Furthermore, ventures such as the Abernethy estate (where a switch from traditional sporting management to conservation-based tourism in 1977 resulted in an increase from one full-time employee to twenty) are unlikely to be widely copied; the success of this estate's atypical enterprise is strongly reliant upon its rarity, so it might be unfeasible for anything but a small proportion of estates to sustain themselves in this manner.

⁶ Although though this might sound cynical, it is not necessarily bad news.