RESTORING THE SCOTTISH UPLANDS

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SUMMARY

The prevailing view of the Scottish Uplands is that they are 'naturally' low in productivity. However, there is compelling evidence that land use practices stretching back six millennia have led to significant declines in productivity, biodiversity and ecosystem service provision. These continue to this day with high levels of grazing by sheep and deer, extensive muirburn and planting with exotic conifers. South West Norway provides a good example of the positive economic and ecological effects of reductions in grazing and muirburn over the last one hundred years. With appropriate measures this could also be achieved in Scotland to the benefit of all rural sectors.

INTRODUCTION

The Uplands are defined as all areas lying above the upper limit of enclosed farmland so, in some parts of Scotland, especially in the west, the Uplands come down to the shoreline. Covering around 70% of the land surface, the Scottish Uplands are an important resource. They are generally of low productivity with poor soils, high rainfall and high exposure. As a result, most upland areas are used for low-input, low-output activities that support relatively few people: hill sheep farming, grouse shooting, deer stalking or conifer-based forestry. Many people believe that the open landscapes, and low productivity, of the Scottish Uplands are 'natural': shaped by the forces of nature, rather than by the hand of man. In this paper we present an overview of current thinking on the impact of humans on the Scottish Uplands, describe their current state and discuss the benefits of an ecologically restored upland region for Scotland's economy and ecology.

LAND USE HISTORY

Oosthoek (2013) summarised current understanding of the changes in land use and in woodland cover that have occurred in Scotland since the last ice age ended 11,400 years ago. The landscape at that time was treeless tundra dominated by low shrubs and herbs. Temperatures rose within a few decades and trees gradually colonised across the land bridge from Europe and Ireland. The first people arrived around 8,000 BC. They may have used fire to burn patches of woodland and would probably have felled trees locally but, overall, they had little impact on the woodland until after the change in climate. The woodland reached its greatest extent at around 60% land cover between 4,000 and 3,000 BC. Between 3000 and 2400 BC the climate became colder and wetter and Scots pine woodland disappeared from flat, boggy upland areas, especially in the Highlands. Total woodland cover would, however, still have been high. At this time clearings became larger and more permanent. By the time the

Romans arrived in Scotland in 80 AD, woodland cover is thought to have declined to around 25%, with the Highlands having been less affected than the Lowlands, the Southern Uplands and the Western and Northern Isles. Over the next millennium woodland cover gradually declined until it reached an all-time low of about 6% in 1900. This decline was entirely due to human impacts. Clearing of land for agriculture continued for many centuries. Then, from about 1200 onwards, felling of woodland for commercial timber started. Between 1600 and 1900 charcoal and tanbark were produced from western oakwoods. This probably helped to conserve these woodlands although their species composition and structure is likely to have changed considerably. Most other land uses resulted in an increasing loss of woodland cover. From 1750 cattle were replaced by sheep and there were huge increases in sheep numbers, first in the Southern Uplands and later in the Highlands. From the mid-1800's red deer numbers also started to increase as the number of stalking estates increased. Burning was used to provide new vegetation growth for sheep and a patchwork of heather for red grouse. Timber extraction, muirburning and grazing by sheep and deer reduced woodland cover further and prevented woodland from regenerating for the next 150 years.

The 20th and early 21st Centuries have seen an increase in total woodland cover. This has largely been due to commercial planting of exotic conifers but, helped by grant aid from the 1980s onwards, there has also been planting of new native woodlands (2,600 ha of new native woodland has been planted by the Forestry Commission alone since 2006; J Fletcher pers. com). In 1998 only around 4% of Scotland's land area was semi-natural woodland (MacKenzie, 1999). Although that figure will be higher now, there are still virtually no examples of tree-line woodland or high altitude scrub. Even including commercial plantations, Scotland is still one of the least afforested countries in Europe with a total woodland cover of around 17% of the land area.

To establish new woodlands, fences are normally needed since natural woodland regeneration is prevented in most of the Uplands by the predominant open hill land uses of deer stalking, grouse shooting and sheep grazing. Sheep numbers have fallen since the subsidy system changed in 2005 from a headage payment to an area payment but, where sheep have been taken off the land, deer have often come in (Thomson *et al*., 2011). Between them, grazing and burning prevent trees and shrubs from regenerating and maintain a vegetation that is uniformly short.

UNINTENDED CONSEQUENCES

What have been the ecological consequences of the historic loss of tree cover and the continuing heavy grazing and burning of the Uplands? Fraser Darling (1955) was the first to point out the impact of these practices when he reviewed the state of the West Highlands of Scotland. He concluded that "the bald, unpalatable fact is that the Highlands and Islands are largely a devastated terrain". He proposed that, without tree or scrub cover, Scotland's heavy rainfall had leached nutrients from the soil making it less productive and more acidic. As well as intercepting rainfall, the roots of trees bring essential minerals and nutrients from deeper in the soil and deposit them on the surface when the leaves fall. The acid soils that resulted from the removal of trees encouraged the spread of acid-loving plants such as heather and rough grasses. These, in turn, produced litter that was slow to decompose and further acidified the soil. In very wet areas, iron and aluminium precipitated out lower down the soil profile and formed a hard 'iron pan' that prevented the infiltration of water and led to water-logging and

peat formation. Without trees intercepting rainfall and moving large amounts of water from the soil to the atmosphere through evapo-transpiration, runoff and soil waterlogging increased. The loss of woodland and scrub cover had thus led to acidification of soils and a reduction in their nutrient content as well as increased water-logging and peat formation. Fraser Darling proposed that, far from being 'natural', the low productivity of Scotland's upland soils was largely due to millennia of human (mis-) use of the land.

The loss of woodland has had other unintended consequences including:

Increased soil erosion and landslides. Tree and scrub roots go deeper than those of grasses and herbs so bind the soil and help to prevent soil movement.
Silting up of lochs and reservoirs due to increased soil erosion (Nisbet *et al.*, 2011).
Reduced carbon sequestration. On peat soils, the carbon stored in peat may be greater than that which would be stored in a woodland but, on non-peat soils, the reverse is likely to be true.
Flooding. Woodlands store water better than do open vegetation types. They thus even out the flow of water into streams and rivers (Nisbet *et al*., 2011). Furthermore, muirburn, as well as heavy grazing, have compacted the surface soil so that rain-water runs off very quickly resulting in increased flooding on lower lying land.
Drying out of soils. The shade provided by trees and scrub helps to reduce evaporation and therefore drying out of soils during dry periods.
Loss of salmon spawning grounds. Overhanging trees shade streams and prevent temperatures building to the point where salmon can no longer survive (Nisbet *et al.* 2011). The leaves of deciduous trees also provide an input of nutrients to streams.
Loss of shelter for deer and domestic stock. Red deer are a woodland species in most of their range. In Scotland most red deer live on the open hill and, as a result of the poor forage and lack of shelter, they are smaller than red deer in any other European country. Similarly, only the hardiest, smallest and least productive breeds of domestic stock can survive on the open hill.

Unfortunately, although commercial afforestation with exotic conifers can help to alleviate many of these issues (soil erosion, siltation, flooding, drying out of soils, carbon sequestration, shelter), it does not address soil degradation since the needle litter is slow to decompose and acidifies the soil and the water runoff (Hornung, 1985). It therefore does not reverse podsolisation nor improve soil nutrient status.

The loss of woodland has also led to a loss of biodiversity (Shaw and Thompson, 2006) and a reduction in habitat condition. Commercial plantations of exotic conifers generally have little ground flora and thus there is little food for ground layer invertebrates and small mammals. The uniformly short vegetation and simplified structure that results from heavy grazing and burning also supports few small mammals that, in turn, would support predators. Heavy grazing prevents grasses and herbs from flowering and setting seed and thereby providing a food source for invertebrates. The loss of woodland and scrub has removed whole habitats from the Scottish Uplands. There is, for example, an almost complete absence of treeline woodland and high altitude shrub habitat. Condition monitoring of Scottish designated sites in 2010 showed that >40% of woodland features, >60% of upland grassland and heathland features and >80% of montane habitats were in unfavourable condition, all largely due to overgrazing by sheep and deer (Scottish Natural Heritage, 2010). Woodland habitats have mostly failed to recruit any young trees into their canopies for at least 150 years, the understorey and shrub layers have been eliminated and selective grazing has resulted in many

of the more palatable plant species disappearing from woodland floor communities (Scottish Natural Heritage, 2010).

As a result of these impacts, biological productivity and biodiversity are probably at an all time low. Re-instating open woodland and woodland/open habitat mosaics does, however, hold the potential to reverse these impacts (Carnol and Bazgir, 2013; Miles, 1988; Mitchell *et al*., 2007; Nielsen *et al*., 1987).

LESSONS FROM SOUTH WEST NORWAY

Norway today is well wooded, and it is often assumed that it always has been so. However, 100 years ago "it was commonly believed that our forests would soon no longer exist, and initiatives were implemented to counteract the deforestation" (Statistics Norway Introduction to Forestry Statistics 2011).

Today, Norway, especially the coastal SW, is in the middle stages of an unprecedented period of forest regeneration and expansion. Early stages were mostly aided by forestry management for conifers; but increases in forest cover since the 1950s have been dominated by natural regeneration, both deciduous and coniferous. The forested area of Norway almost doubled from 69,113 km^2 in 1907 to 123,800 km^2 in 2007 (Bryn *et al*., 2013). The volume of standing deciduous timber, almost all naturally regenerated (deciduous timber is not cultivated commercially) has nearly doubled in the last 20 years alone (Statistics Norway, 2013a). The area of non-commercial woodland in coastal SW Norway (Rogaland, Hordaland, Sogn and Fjordane, and More and Romsdal; total area 62,043 km^2), all naturally regenerated, increased by 1,000 km^2 in the 8 years 2005-2012. It now comprises 12% of the region's land area (Statistics Norway, 2013a) and is predicted to increase greatly in extent (Bryn *et al*., 2013).

In the early 20th Century, deforestation was almost total in many parts of coastal South West Norway. This is an area of mild, oceanic climate closely similar to Highland Scotland in both climate and landforms. It also had similar land use patterns until the late 19th century when management for deer and grouse became prominent in Scotland. Blom (2007) describes this area as: " 'the treeless coastal rim', where the landscape has been deforested for many centuries as a result of heather moor husbandry's effects through burning and grazing….represents the most pronounced oceanic landscape we have, the 'hyperoceanic' section" (quotation marks in original). Peat was commonly cut for fuel until recent decades because of the lack of fuel wood, continuing in some areas into the 1980s (E. Lie Dahl, pers. comm.). This region is the same area where natural forest regeneration has been most rapid and extensive in recent decades, and where the potential for future expansion is greatest (Bryn *et al*., 2013). In particular, Rogaland in the extreme South West, formerly the most deforested province in all Norway, is on the same latitude as northern Scotland. It has closely similar landforms and geology, and a mild hyperoceanic climate with temperature and precipitation patterns closely similar to those of Highland Scotland. Woodland, already 2,400 km^2 in extent today (26% of the land area), has the capacity to reach c. 4,000 km^2 (52%) through continued natural regeneration, most of which is predicted to occur (Bryn *et al*., 2011; 2013). Satellite images of Rogaland and Wester Ross in the Scottish Highlands clearly show the difference in the extent of woodland between the two areas (Figure 1).

Figure 1: Satellite images of Rogaland, Norway and Wester Ross, Scotland. Dark green areas are woodland

This is almost entirely due to a steep decline in the intensity of domestic stock grazing[1] and associated human activities such as muirburn (Bryn, 2008; Bryn and Debella-Gilo, 2011; Bryn *et al*., 2013; Hofgaard *et al*., 2010; Rekdal, 2010a; 2010b; Speed *et al*., 2008): "Much of our rough grazing/moorland (*utmark*) has been deforested. This is now returning to forest ... around 15% of the total land area (of Norway) may be re-wooded, mostly in montane and coastal areas" (Rekdal, 2010b); Norway has "been deforested by various forms of land use lasting for millennia, whereas natural forest regeneration and afforestation in recent decades have evidently shown the ecological potential for forests in semi-natural heaths and meadows throughout Norway ... Similar findings have been reported from local studies in the European Alps and many other mountain regions (Sitzia *et al*., 2010), so the process of deforestation is probably more or less the same for populated mountain regions worldwide" (Bryn *et al*., 2013).

This indicates that an exceptionalist view of upland Scotland, in which the lack of woodland is asserted to result from causes other than a long post-Mesolithic history of anthropogenic influence, is untenable. Changes similar to those in South West Norway would result in a similar pattern of woodland regeneration; considerably more quickly if managed to that end. The rapid re-establishment of woodland in many places where grazing pressure/muirburn has been reduced locally, such as inadvertently on the central reservation of the dualled sections of the A9 at Drumochter in Scotland, is indicative of this.

[1] Red deer, roe deer and moose have all increased from being rare or extinct in Norway to being common over the period of woodland expansion, and especially since the 1950s (Statistics Norway, 2013b; 2013c; 2013d). All three species are now common in Rogaland, but have stabilised at densities which do not prevent woodland regeneration and expansion.

In Norway, this woodland, though not managed primarily for timber, is exploited in many ways. Some timber is extracted, and it is the main source of fuel wood, a renewable energy industry with a declared income (much - perhaps most - is in the 'informal' sector) of £37 million in 2009, or 816 kg per Norwegian household and increasing by 9% annually (Statistics Norway). Sheep and cattle are grazed at modest intensities and find shelter in inclement weather. It is very important for game shooting: a large proportion of red and roe deer, moose, and black grouse are hunted there, as are the vast majority of willow (red) grouse (in higher-lying open montane birch and willow woodland). Non-hunting recreational value is also high. It is the main location for cabins, a major source of income for the rural economy in sales, and in service industries (Rekdal, 2010a). It is a major habitat for wildlife, increasingly so as it matures (Blom, 2007), and has beneficial effects for soil conservation and development, and for reducing erosion.

THE POTENTIAL FOR SCOTLAND

As we have seen, Scotland's Uplands have not always been treeless, and would be largely wooded in the absence of human influences. It makes very little sense for Scotland's Uplands to remain treeless given the increasing pressure on natural resources around the globe. When coupled with the decline in global productivity that is likely to result from climate change, Scotland would surely benefit from becoming more productive over the coming decades. Scotland's Uplands are performing well below their ecological and economic potential. It should therefore be a high priority for Scotland to address the condition and productivity of the Uplands so that they can make a significant contribution to the country's resilience and ability to produce food and other goods in an uncertain future.

How might Scotland's Uplands look following a period of reduced grazing and burning and woodland restoration? At present, all that typically remains of semi-natural woodland in the Uplands are fragments mainly confined to river valleys, steep slopes and inaccessible ground; the places that have been too difficult to cultivate or manage, or are inaccessible to grazing animals. This lack of semi-natural woodland is illustrated in Figure 2(a) for Kinloch Laggan in the Central Highlands. By contrast, Figure 2(b) shows that virtually all of this upland area is capable of supporting woodland of some description; up to an altitude of 900 m. Kinloch Laggan is typical of much of upland Scotland, which suggests that much of the Uplands of Scotland, with the exception of the summits of higher mountains, is capable of supporting woodland or scrub, sometimes in a natural mosaic with open habitats.

The Scottish Forestry Strategy (Forestry Commission Scotland, 2006) reaffirmed the Scottish Government's commitment to an increase in woodland cover from the current 17% to around 25% in the second half of the century. This would involve the creation of some 650,000 ha of new woodland to add to the current resource of 1,334,000 ha. The justification for the target is the wide range of benefits likely to ensue. These include:

- Helping to offset greenhouse gas emissions through carbon sequestration.
- Restoring lost habitats that will help to mitigate the effects of climate change through regulating water flow and shading.
- Ecosystem services such as: flood reduction and protection of soil and water resources.
- Underpinning a sustainable forest products industry.
- Supporting rural development by increasing the range of potential economic outputs.

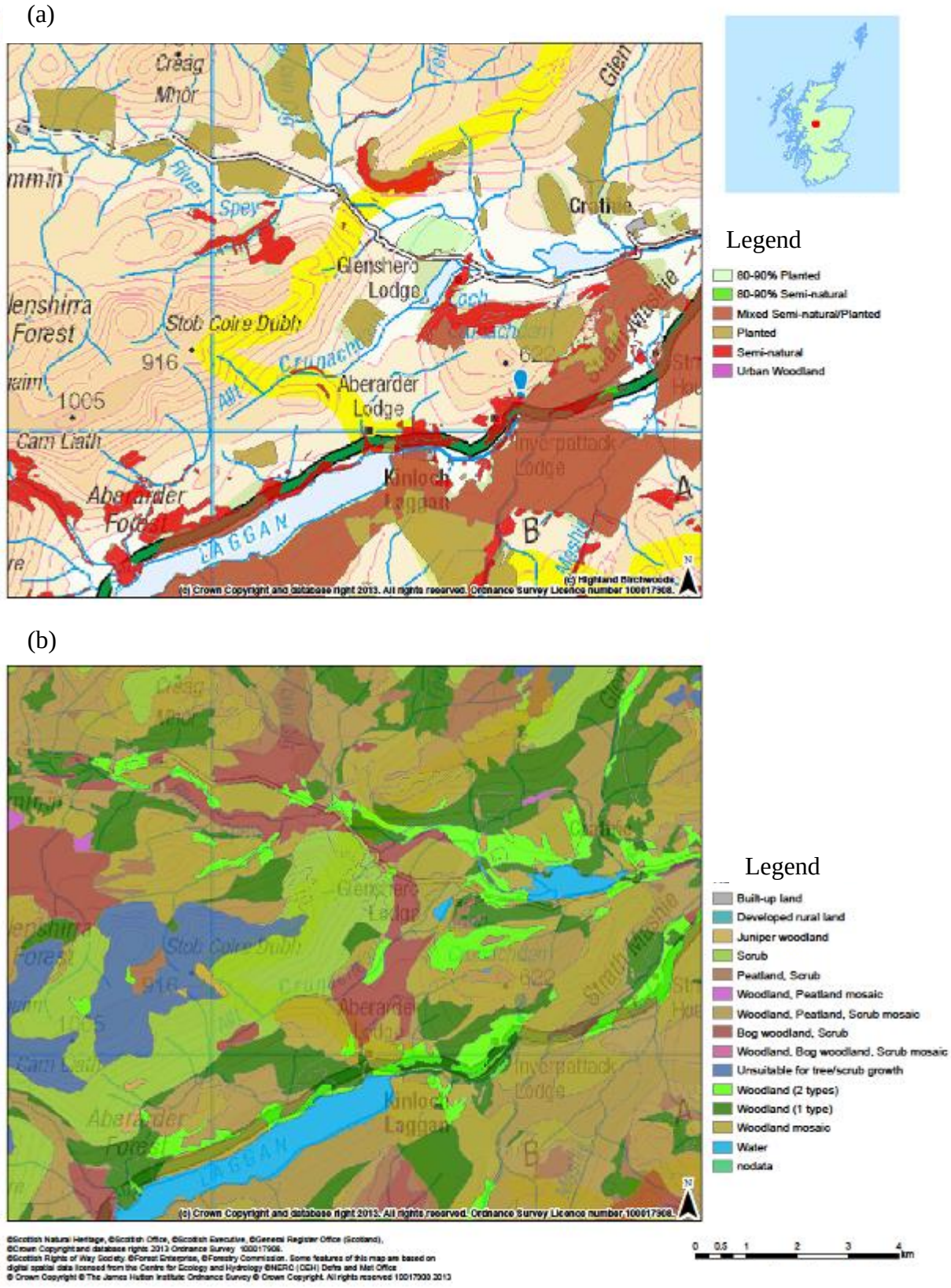

Figure 2: Kinloch Laggan showing (a) existing woodland cover (Highland Birchwoods, 2001); (b) potential native woodland cover as predicted by the native woodland model (Hester *et al*., 2003)

Research has shown that the vision of 25% forest cover in Scotland is achievable (Forestry Commission Scotland, 2006), and the Scottish Government is encouraging local authorities to prepare indicative forestry strategies to identify preferred and potential areas for woodland creation (The Scottish Government, 1999). Progress towards this target will, however, be piecemeal and expensive, with deer browsing needing to be controlled locally, either through culling or through fencing of each new woodland, unless grazing and burning are reduced generally across the Uplands. If this could be achieved, large areas of woodland and scrub would spontaneously regenerate in many parts of the Uplands, as has occurred in southern Norway.

Reversing the historic, and continuing, degradation of the Scottish Uplands through the re-instatement of woodland and scrub would deliver a more productive and biodiverse landscape. It would also provide enhanced ecosystem services as well as having the potential to provide the wide range of economic outputs that are now enjoyed by the people of South West Norway. A variety of woodland structures, from closed canopy through wood pastures to montane scrub, would provide the ecological and structural diversity necessary to support a wide range of integrated land-uses. The resulting landscape, through its diversity of species, habitats and land uses, would be resilient to future changes and would be capable of underpinning the sort of productive rural economy that will be so important for Scotland in the coming decades and centuries.

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