THE LANDSCAPE ECOLOGICAL IMPACT OF AFFORESTATION ON THE BRITISH UPLANDS AND SOME INITIATIVES TO RESTORE NATIVE WOODLAND COVER

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ABSTRACT

The majority of forest cover in the British Uplands had been lost by the beginning of the Nineteenth Century, because of felling followed by overgrazing by sheep and deer. The situation remained unchanged until a government policy of afforestation, mainly by exotic conifers, after the First World War up to the present day. This paper analyses the distribution of these predominantly coniferous plantations, and shows how they occupy specific parts of upland landscapes in different zones throughout Britain. Whilst some landscapes are dominated by these new forests, elsewhere the blocks of trees are more localised. Although these forests virtually eliminate native ground vegetation, except in rides and unplanted land, the major negative impacts are at the landscape level. For example, drainage systems are altered and ancient cultural landscape patterns are destroyed. These impacts are summarised and possible ways of amelioration are discussed. By contrast, in recent years, a series of projects have been set up to restore native forest cover, as opposed to the extensive plantations of exotic species. Accordingly, the paper then provides three examples of such initiatives designed to restore native forests to otherwise bare landscapes, as well as setting them into a policy context. Whilst such projects cover a limited proportion of the British Uplands they nevertheless restore forest to landscapes at a local level.

Key words: plantation trends, exotic conifers, landscape pattern, biodiversity loss, native woodland restoration

INTRODUCTION

The paper originated in a visit to the College Valley, described below, when the idea arose to compare the limited restoration of native forest with the widespread afforestation by exotic conifers in the British Uplands. Accordingly, a paper with the present content was prepared and presented at the International Association of Landscape Ecology (UK) meeting in Edinburgh in September 2012. The current text was derived from this paper with additional comments from an anonymous referee.

The first part of the paper therefore tracks the expansion of forestry in the British Uplands after the First World War until the present day. Before that time, the forest cover in the British Uplands had stabilised at a low level, following the activities of man initially by felling and then by over-grazing by sheep and deer, as well as by burning, in previous centuries (Darling, 1947). In some regions, such as the Southern Uplands of Scotland, the forest had been completely removed centuries before as described by Smout et al. (2005). However, following the last Ice Age, the landscape was mainly covered with forest to quite high altitudes in England and Wales and, at progressively lower elevations, further north in Scotland, as indicated by Ashmole (2006) and McVean and Ratcliffe (1962). In more exposed sites, montane scrub was present, mainly of juniper (*Juniperus communis*) *(nomenclature according to Stace 1997)* and dwarf species of willow (*Salix spp.),* as described by Ashmole (2006). Because of centuries of intense human pressure only fragments of these habitats remain, for example, the patches of woodland in Wester Ross, Northern Scotland and montane scrub above Abernethy in the Cairngorms in the Central Highlands of Scotland.

Information on the original distribution of forests in the uplands is provided by texts such as McVean and Ratcliffe (1962) and an impression of the likely appearance of Scottish valleys can be gained by comparison with relatively complete forest landscapes in Norway; which are in the same Atlantic North Environmental Zone as defined by Metzger et al. (2005). Virtually no landscapes in Europe are unmarked by agricultural influences and it is only areas such as the American National Parks, for example Yosemite, that can be considered ‘pristine’ and undisturbed (Nash, 2014; Runte, 1997). The desire to return at least some areas to a relatively natural state provides the motivation for the projects described in the second half of the paper.

Apart from isolated relics in North Wales and Northern England, most of the remaining native woodland fragments occur in the uplands of Scotland, because of the rugged terrain, on rocky slopes and stream sides. In such locations only small groups of silver or downy birch (*Betula pendula* or *B. pubescens*) and rowan *(Sorbus aucuparia)* remain and provide potential nuclei for possible expansion if grazing were to be reduced.

The objective of returning degraded habitats and landscapes to their original natural state started in the 1990s with the introduction of the term ‘rewilding’ by David Foreman. This term first appeared in print in 1990 (Foote, 1990) and was later expanded by Soule and Noss (1998) and is now widely used in expressing the desire to return landscapes without tree cover to a more natural balance. It has however been used by writers such as Monbiot (2013) to stimulate a wider discussion about the future of agriculture in the uplands. It is not the objective of the present paper to enter this discussion, but rather only to contrast the composition of the new native woodlands from three case studies with that of existing exotic plantations.

An additional relevant point is that the scientific literature reflects a growing interest in the ecology of plantations, as shown in Table 1. In order to derive the figures presented in this

Table, the Web of Knowledge (Thomson-Reuters, 2013) was interrogated for the keywords listed. The Table shows that before 1990 there were only three papers published on afforestation in the uplands. Interest in conifer planting continues to increase, but papers on the uplands have declined using this measure. In general, as measured by the number of papers on this topic, the literature is surprisingly limited compared with other ecological subjects.

The present paper first provides figures for the current area and composition of forest cover in the British Uplands and then examines the landscape ecological impacts of the forests which have mainly been planted since the First World War. Three case studies of new initiatives to restore native woodland cover in Britain are then described and set in their policy context in two separate sections. These case studies are representative of the 44 projects in Scotland alone (Forestry Commission Scotland, 2014a) that include some elements of encouraging the return of native forests. These projects include a range of different objectives but cover a relatively small proportion of the country. An example of an entire estate where woodland is being restored is Glen Feshie in the Cairngorms, northern Scotland.

Table 1: Results of the literature search of key words in the Web of Knowledge 1980-2012 (Thomson-Reuters, 2013)

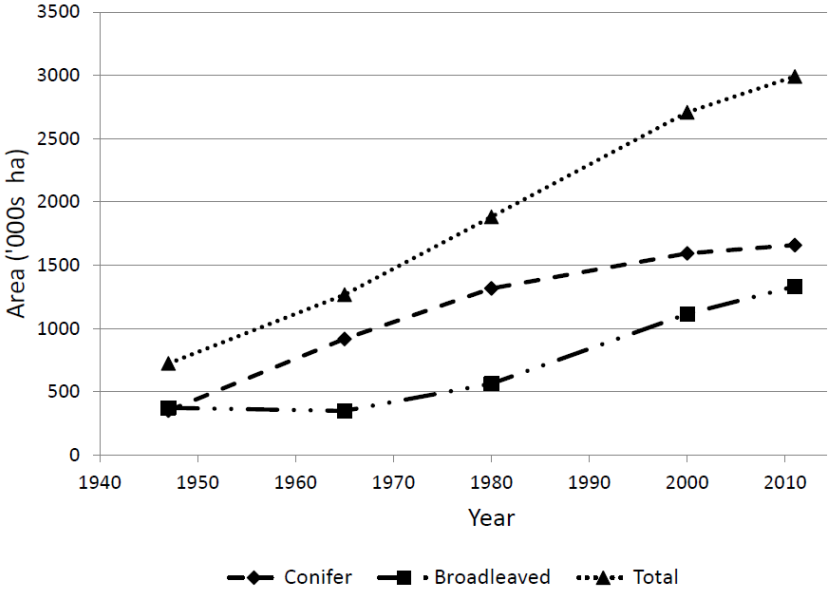
Keyword 1	Keyword 2	1980-90	1990-2000	2000-2010
Afforestation	Conifer	1	8	11
Afforestation	Broadleaved	0	2	3
Afforestation	Upland	3	14	5
Afforestation	Ecology	5	23	8
Conifer	Ecology	19	46	36
Oak wood	Ecology	11	15	5
Woodland	Ecology	46	133	204

THE HISTORY OF AFFORESTATION

Since World War I, British Government policy has supported forestry in order to build up a strategic reserve of timber. The resultant afforestation has led to the largest land use change in Europe involving a shift from agriculture to forestry, mainly in the uplands (Forestry Commission, 1952, 1970, 1984, 2003, 2013). Afforestation in the uplands has largely been carried out by the Forestry Commission, which also administers grants to private landowners (refer to Aldhous, 1997 for examples). Initially, the policy of the Commission was dominated by planting exotic conifers, but recently their policy has changed to a more balanced view; as described in the UK Forestry Standard Guidelines (Forestry Commission, 2011) and epitomised by the removal of exotic conifers in native pinewoods, as described by Bain (2013). Until recently, the expansion has largely ignored biodiversity and landscape ecological issues, although the visual landscape was considered from the 1930s onwards, as mentioned by Bell and Apostol (2008). Bell (personal communication, February 19, 2014) has pointed out that the improvements to forest policy, not only in visual terms but also in ecological factors, have occurred since the 1970s. Biodiversity has now become a major policy issue, as described later in this paper, and as reflected in the Biodiversity Action Plan

for Woodlands (BAP, 1994). Forest cover in the UK had increased significantly before 1947 (Aldhous, 1997) but almost doubled between 1948 and 1995 (Mason, 2007). The pattern of distribution changed from the lowlands of England and Scotland to the uplands, especially in Scotland. The balance also shifted from native broadleaves to exotic conifers, as expressed by the present dominance of Sitka spruce *(Picea sitchensis*). Trends of forest cover change were extracted from Forestry Commission Reports (Forestry Commission, 1952, 1970, 1984, 2013) and are shown in Figure 1. These indicate that the overall increase in woodland area after 1948 was almost linear until the mid-1990s when the rate of increase in conifer area slowed down. In contrast, broad leaved cover only increased from 1980 onwards. Nevertheless, the conifer area still continued to increase after this date (Forestry Commission, 2013).

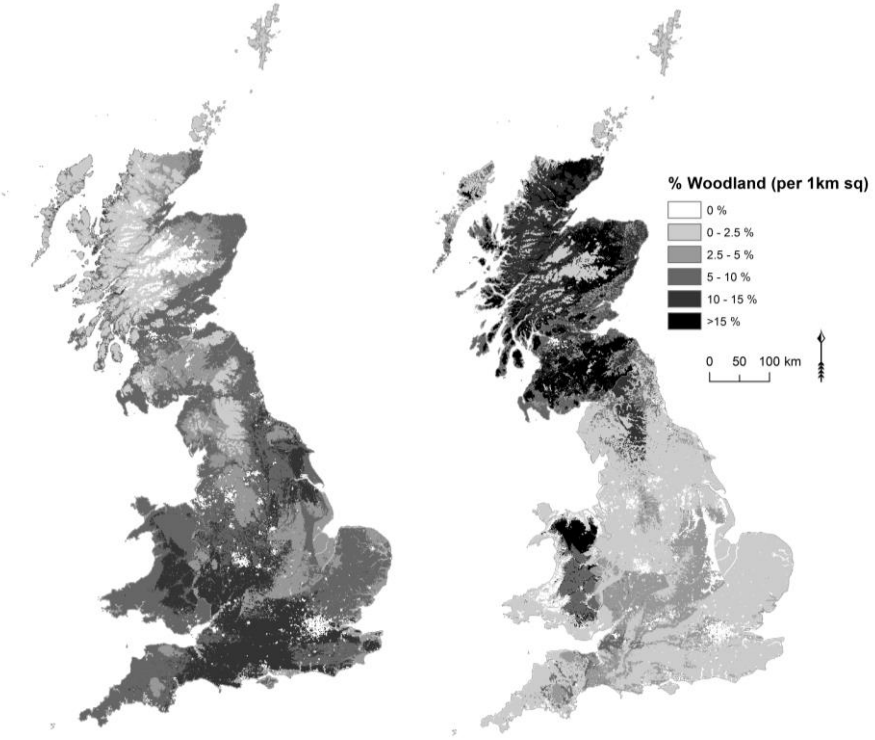
Fig. 1: Areas of woodland and forest in Britain between 1947 and 2011, extracted from Forestry Commission statistical sources



In 1948 there was marginally more broadleaf than conifer but by 1965 the situation had reversed. Conifer cover has increased by almost 300% since 1947. In addition, conifers were mainly planted on open moorland whereas the core of broadleaves has remained much the same, although supplemented by recent planting in the lowlands. In the period after World War II, there was much conversion of broadleaves to conifers, although this has recently been reversed.

Table 2 and Figure 2 show the distribution patterns of woodland by Environmental Zones in Britain as reported by the UK Countryside Survey (Carey et al., 2008). The England Lowland Zones have more broadleaved woodland than all the other Zones together. Apart from this statistic, the other Zones have a relatively even distribution. Although the English Lowland Zone is dominated by broadleaves, it still has a significant area of conifers because of localised plantations, mainly of Corsican pine (*Pinus nigra*), on former heathland in South-West England and East Anglia.

Fig. 2: Maps showing distribution of woodland cover across British Environmental Zones derived from the Countryside Survey in 2007



Broadleaved *Coniferous*

Table 2: Areas of total woodland cover in the Environmental Zones of Great Britain described by Carey et al. (2008) extracted from the Countryside Survey database ('000s ha)

Country	Environmental Zone	Broadleaf	Conifer	Area of Zone	% Zone Broadleaf	% Zone Conifer
England	Easterly Lowlands	519	81	6275	8%	1%
	Westerly Lowlands	422	104	4885	9%	2%
	Uplands	40	72	1569	3%	5%
Scotland	Lowlands	131	181	2227	6%	8%
	Intermediate upland and islands	63	293	2555	2%	11%
	True uplands	57	481	3203	2%	15%
Wales	Lowlands	84	4	1083	8%	0%
	Uplands	90	102	1026	9%	10%

Table 3: The altitudinal range of broadleaved/mixed and conifer plantations in the Environmental Zones described in Carey et al. (2008) extracted from the Countryside Survey database

Country	Environmental Zone	Woodland Type	Mean Altitude (m)	Min. Altitude (m)	Max. Altitude (m)
England	Easterly Lowlands	Broadleaved and mixed woodland	86	1	244
		Coniferous woodland	115	15	239
	Westerly Lowlands	Broadleaved and mixed woodland	94	0	269
		Coniferous woodland	127	12	274
	Uplands	Broadleaved and mixed woodland	243	106	427
		Coniferous woodland	293	112	466
Scotland	Lowlands	Broadleaved and mixed woodland	87	2	250
		Coniferous woodland	139	6	289
	Intermediate upland and islands	Broadleaved and mixed woodland	74	2	310
		Coniferous woodland	201	13	462
	True uplands	Broadleaved and mixed woodland	200	17	367
		Coniferous woodland	335	144	527
Wales	Lowlands	Broadleaved and mixed woodland	91	2	241
		Coniferous woodland	197	21	291
	Uplands	Broadleaved and mixed woodland	261	124	482
		Coniferous woodland	361	152	520

In the Lowland England Zones, the conifer plantations, although extensive, are localised as described above and do not differ greatly in altitudinal range from broadleaved woodland. By contrast, in the Upland England Zone, the conifer woodland is on average over 50m higher than broadleaved woodland because it was planted on land formerly grazed by sheep. In Scotland, the contrast is even greater. Because of the shelter effect of the high mountains, the highest level of planting is in the Scottish Upland Zone, compared with the exposed Marginal Lowland Zone. Broadleaved woodland reaches its maximum altitude in Wales, although individual sites in England are also high. Figure 3 shows a picture of a typical landscape in the British uplands, with the summits unplanted and the valleys still being used for agriculture.

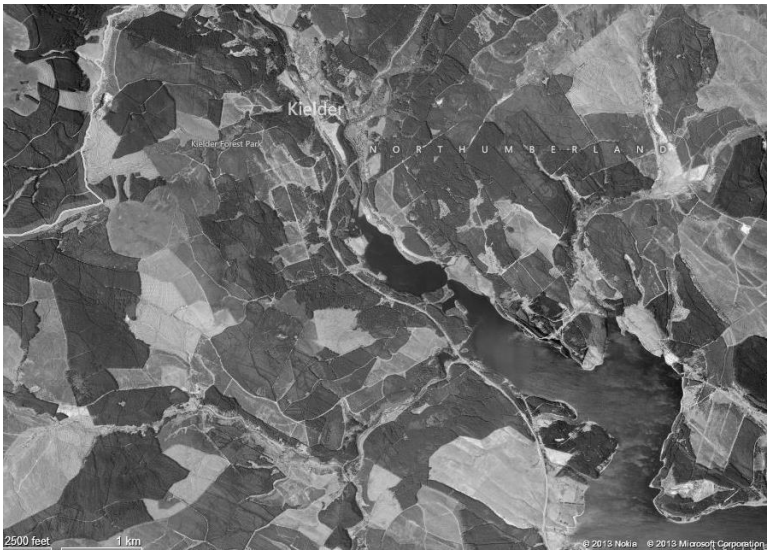
The species that are planted also differ between Zones and altitudes. However, throughout the north and west of Britain, Sitka spruce is the dominant species; although there was a trend in the 1970s for lodgepole pine to be planted at high altitudes and in exposed situations in the north. In sheltered valleys in Wales and south-west England, Douglas fir (*Pseudotsuga*

menziesii) is locally important. In the English and Scottish Lowland Zones, the major conifers are various species of pines (*Pinus sp*.) and larches (*Larix sp.)* (Mason, 2007).

Apart from the general patterns described above, there are particular regions in the uplands where entire landscapes are dominated by coniferous plantations.

Fig. 3: Example of a typical valley in the British Uplands showing location of plantations on the mid slopes with summits and valleys unplanted (© CEH - Countryside Survey)

Fig. 4: Satellite image of Kielder forest in Northumberland, North-East England showing an example of a landscape where little unplanted land remains ((Google, 2013) ©2013 Nokia ©2013 Microsoft Corporation)



An example of these is shown in Figure 4 which consists of a satellite image of Kielder Forest. The principal examples of such landscapes as defined by the Environmental Zones of the Countryside Survey (Carey et al., 2008) are listed below:

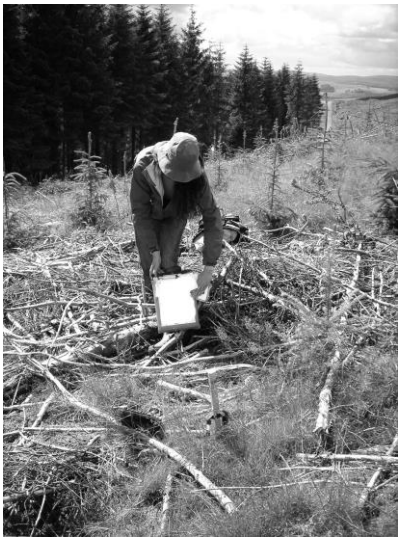
- Wales (Upland): Betwys-y-Coed and reservoir catchments such as Vyrnwy
- England (Upland): Spadeadam, and Kielder in North-East England
- Scotland (Lowland): the Trossachs, Central Scotland and Moray/Nairn in North-East Scotland
- Scotland (Upland): the Southern Uplands and Rannoch Moor in the Highlands
- Scotland (Marginal Upland): Dumfries/Galloway and the Flow Country in Northern Scotland

IMPACTS OF CONIFEROUS AFFORESTATION ON VEGETATION

The impact on the ground vegetation of dense plantations of species such as Sitka spruce is very pronounced, with virtually no herbaceous cover able to survive, as shown by Carey et al. (2008). Some bryophytes are able to colonise the ground in more mature stands in the Uplands where wind blow has occurred or where thinning has been undertaken, and ferns such as *Dryopteris dilatata* are also able to establish a field layer (Hill, 1979). Otherwise vegetation cover only remains in rides, by tracks, and above the highest planted trees. Eycott et al. (2006) have shown that the species that do survive are those from the vegetation present before the trees were planted that are shade tolerant; this applies to most plantations in the uplands.

In areas with difficult access for modern timber extraction methods, there has often been local wind blow and some vegetation cover of species such as *Carex echinata* has returned, largely originating from the seed bank. The same process occurs where felling has taken place without replanting; for example, in Glen Affric where Sitka spruce has been cleared on land adjacent to the native pinewood.

Fig. 5: Example of a felled area with vegetation cover recovering (© CEH - Countryside Survey)



In terms of the wider impact of loss of native habitats in the uplands, the vegetation outside plantations is the product of several centuries of over-grazing. However, it does consist of native species with strong oceanic affinities but these occur widely elsewhere in the landscape. In terms of habitats, the most widespread are species-poor *Nardus stricta* grassland and heathland dominated by *Calluna vulgaris* (Carey et al., 2008). The exception is where afforestation has taken place on active blanket bogs, which are a Priority Habitat under the European Habitats Directive (European Commission, 1992).

Impacts of afforestation on landscape ecology

Apart from the impact on vegetation, the majority of changes take place at the landscape scale, because they influence entire catenas and include many effects well away from the plantations themselves. These may be summarised as follows:

1. On the majority of gleyed and peat soils, deep ploughing is carried out before planting to improve drainage and facilitate tree growth. As a result, the run-off of water is more rapid and the response time of stream flow after rainfall is reduced. Apart from the drying out of the soils this has the effect of rapid changes in water level and flooding of land and urban areas down-stream (Robinson, 1986).
2. Following afforestation there is destruction of the original drainage patterns that have developed over centuries and the hydrology of whole catchments is altered in extreme cases, as summarised by Robinson et al. (1998). Small streams are destroyed, together with their flora and fauna. As the forest cover progressively develops, other changes take place, such as the loss of springs, with their associated wetland vegetation (Bunce, personal observation). In addition, the transpiration of the forest when it reaches canopy closure reduces the flow of water to the main streams or reservoirs by 30% (Robinson et al., 1998).
3. The water balance and hydrology of bog systems is highly modified after drainage. Sensitive plant species are lost and, in the Flow Country in Northern Scotland, the dunlin (*Calidris alpina schinzii*) is now threatened (Lavers & Haines-Young, 1997). The active blanket bogs of Western Britain are unique in Europe, as recognised by their status as a priority habitat in the Habitats Directive.
4. The plantations do contribute to carbon sequestration. However, the oxidization of peat following drainage probably balances the gain in carbon held in the timber (Byrne & Milne, 2006).
5. Rainfall which passes through the canopy of Sitka spruce is acidified and causes acid run-off. In the 1990s it was established that such acidification caused loss of fish populations and modified the invertebrate composition of the rivers (Maitland et al., 1990). Lower sulphur deposition levels have reduced this impact.
6. When felling takes place, there is a major loss of nutrients because of the removal of canopy, exposure of the soil, and disturbance by machinery during extraction (Titus & Malcolm, 1991). Run-off is now even more pronounced because of the large scale of modern forestry operations. The majority of land is replanted so the area of forest remains relatively stable.
7. In some areas, the entire mid-slopes of valleys are planted. In these situations, the vegetation on the mountain summits is isolated. Such isolation effects the movement of birds and larger mammals, as well as invertebrates such as butterflies.

Potential amelioration measures

1. In the 1980s, a policy of encouraging broadleaved belts by streams to reduce acidification was introduced, but is not often seen. However, with the recent changes in forest policy, planting of broadleaf belts beside streams could become more widespread.

2. The addition of broadleaved compartments within existing forests would also provide a range of ecological benefits. A limitation however, is that there are few broadleaf species suitable for planting on wet acidic soils.
3. Diversification of plantation age structure through thinning regimes would enable a ground layer to develop. However, modern forestry requires extraction on a large scale, and precludes the labour intensive procedure of thinning.
4. The introduction of belts of broadleaves adjacent to conifer plantations would be beneficial and has already taken place locally.
5. Felling of exotic conifer plantations adjacent to native woodlands could enable these stands to regenerate. For example, felling around stands of native Scots Pine (*Pinus sylvestris*) in Glen Affric and the Cairngorms has already taken place. A problem remains in the recovery of ground vegetation and tree seedling establishment after felling.
6. Incorporation of landscape design principles so that the plantations fit better the natural patterns in the landscape, as outlined by Bell & Apostol (2008).

INITIATIVES TO RESTORE BETTER BALANCE TO LANDSCAPES

As discussed in the Introduction, the planting and encouragement of new tree cover to restore the original forest cover to open landscapes is now taking place in several practical exercises. Therefore, some examples are described below, as well as a description of relevant native woodland policy in the uplands.

Linking environment and society in Wild Ennerdale

Ennerdale is a remote valley situated on the western fringes of the Lake District National Park. It is a spectacular mountain landscape with steep ridges and exposed rock outcrops, extensive mixed woodland and forest, dynamic natural rivers, a glacial lake and highly valued flora and fauna. Established in 2002, Wild Ennerdale is a partnership of people and organisations led by the principal landowners in the valley: the Forestry Commission, National Trust and United Utilities, with additional support from Natural England. The area of land covered by the partnership extends to 4,711ha.

Before this partnership was formed and began its stimulating work, Ennerdale had suffered a disappointing environmental history since the 1930s. The problem was that the Forestry Commission acquired the valley and commenced planting all the mid slopes with conifers. The outcry that followed led to the agreement by the Commission not to proceed with planting the core of the Lake District. Unfortunately, this was too late for Ennerdale. The valley became synonymous with dark plantation forest throughout the remainder of the last century and only started to emerge from this period in the 1990s as policy changed and the forest matured.

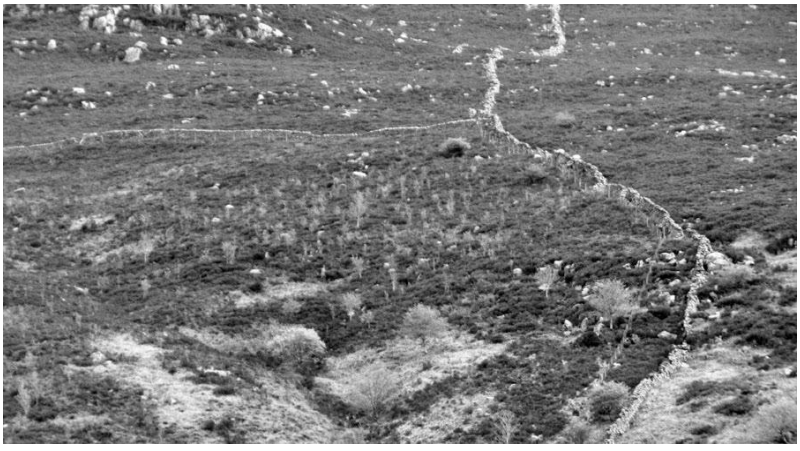
The changes to Ennerdale started in 1979 (S. Bell, personal communication, February 18, 2014) and were initiated by Duncan Campbell. “Forest design planning” was then implemented by Oliver Lucas and Simon Bell. The landscape architect who subsequently worked in Ennerdale was Elizabeth Mackintosh, who modified the plan to incorporate more broadleaves, open spaces and further diversification.

Fig. 6: The valley of Ennerdale showing a return to a relatively natural balanced landscape

Over the last ten years, the Wild Ennerdale Partners have been exploring how to allow the whole valley to develop as a wilder place, whilst also delivering benefits to people and business.

The partners' vision is to "allow the evolution of Ennerdale as a wild valley for the benefit of people, relying more on natural processes to shape its landscape and ecology". Wild land is a relatively new concept in the UK, as discussed in the Introduction, and involves giving natural processes greater freedom to develop future landscapes. Nature conservation in England is generally focused on small-scale interventions. Wild Ennerdale is one of the largest wild land initiatives in England, allowing ecosystems throughout the valley to evolve with greater freedom. Ennerdale is highly significant for its rich legacy of archaeological remains and has been described as the one of the best remaining examples of a settled medieval valley in the Lake District. It is also home to diverse habitats including significant resources of flora and fauna, which range from regional to international importance. Over 40% of the area is designated as a "Site of Special Scientific Interest "and "Special Area of Conservation". The continuous transition of vegetation types from the shore of the lake, through woodlands to open heathland, up to mountain summits, is spectacular.

Fig. 7: Picture of natural regeneration within fenced land in Ennerdale



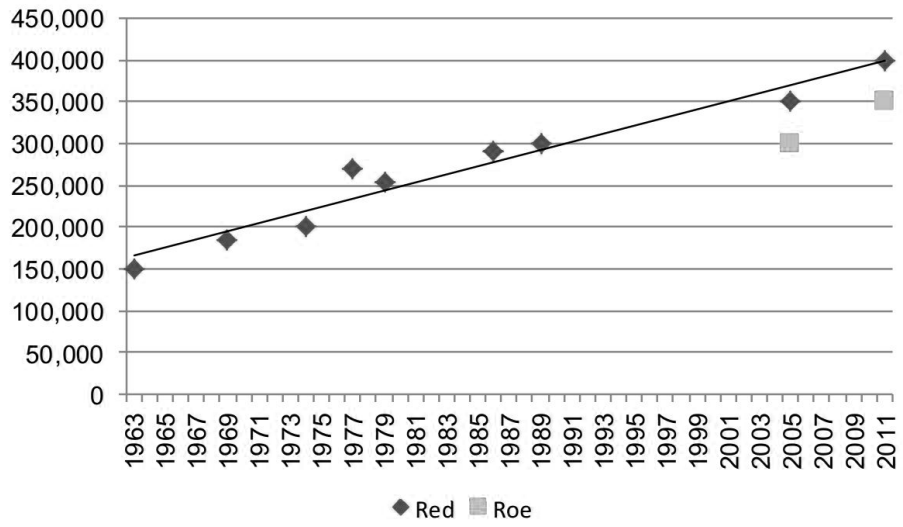
Community involvement is an essential part of the process of change towards a wilder valley, both to guide and inform the Partnership, and to ensure that the benefits of Wild Ennerdale reach beyond the geographical 'valley boundary'. The partnership approach recognises that people are a significant part of a 'wild' landscape and that the extent to which people can interact, and indeed become part of a natural process, is dependent upon appropriate levels of access and types of activities permitted. Without some intervention to regulate access however, there is a danger of destroying the very qualities that the public consider necessary in a 'wild' place – that is untamed nature, solitude, adventure and the quiet enjoyment of spectacular landscapes. Wild Ennerdale has just celebrated its tenth anniversary and has demonstrated an increasing desire to blur the boundaries between traditional farming, forestry and conservation. The Partners are aiming towards a future natural destination where natural processes and a sense of wilderness are key drivers and outputs.

WOODLANDS, WILD LAND AND LIVING LANDSCAPES

It is proposed that the isolated fragments of protected areas in the UK provided by national and European statutory habitat and species designations are inadequate for conservation or ecological enhancement, hence the policy to increase Scottish woodland cover (Scottish Executive, 2006). National Parks and National Scenic Areas are at a landscape scale but are not currently set up to deliver policies for ecological restoration. As an alternative, conservation non-governmental organisations, such as the John Muir Trust, are leading large scale ecological restoration projects, termed 'living landscapes', across the UK. The aim of these projects is to encourage natural processes to operate, and to increase ecological robustness in the face of climate change. In many of these areas, the climax vegetation, as well as being an overall indicator of habitat health, is forest. Therefore, the focus of these projects is often therefore woodland restoration. Such projects have the potential to be beneficial for both the environment and for local rural communities. Safeguarding and enhancing habitats should also generate truly sustainable economic development, whilst protecting the natural capital on which ecosystem services that are essential to wildlife and valued by people depend. However, to achieve this objective, major ecological restoration projects face many challenges. The current deer management framework, essentially a voluntary system controlled by private owners with an interest in high numbers for hunting, has allowed most red deer populations to increase steadily since data collection began (Figure 8). Previously, Darling (1955) described how deer populations were at their highest level since the Nineteenth Century. Whilst regional and overall population estimates must be treated with caution, it is probable that the total population has risen from around 150,000 red deer (*Cervus elaphus*) in 1960 to around 400,000 in 2004 (Clutton-Brock et al., 2004). Current deer densities in much of upland Scotland are generally too high to allow natural regeneration. The density of deer per kilometre square that will allow regeneration is between four and seven. It is even lower on poor soils and in exposed situations (Gill, 1992; Scottish Wildlife Trust, 2012), and currently the densities are often over ten and can reach 30 (Scottish Natural Heritage, 2010). Forestry Commission Scotland (2014b) also report that sustained browsing by deer prevents woodland regeneration and is currently the most widespread threat to the condition of designated woodland features. Fuller & Gill (2001) discuss the ecological impacts of increasing deer numbers and consider that community structure is strongly modified by increasing deer numbers.

Native woodland has been squeezed into isolated pockets and maintained at a low level because of the overall high grazing pressure. Montane scrub (consisting of low-growing shrubs such as dwarf birch (*Betula nana*), Juniper (*Juniperus communis*) and several species of montane willows (*Salix spp.*) is almost extinct in Scotland, and there is less than two kilometres of natural tree line in the entire country (LINK Deer Task Force, 2013). Tackling ecological restoration under the current deer management regime generates significant costs and conflict with private estates, where deer stalking is the primary objective. It is suggested that a statutory system of deer management is the only way to ensure that public objectives; including landscape scale restoration involving woodland; are achieved.

Fig. 8: Estimates of numbers of red deer (*Cervus elaphus*) (1963-2011) and roe deer (*Capreolus capreolus*) (2005-2011) in Scotland (John Muir Trust)



Carrifran Wildwood

As described in the introduction, the Southern Uplands of Scotland, together with most of upland Britain, have been denuded of their natural vegetation by a millennium or more of grazing by domestic sheep, goats and cattle, as well as by fire and felling. In 1993, a group of local people had the idea of acquiring an entire catchment in order to restore native woodland and moorland ecosystems. They located Carrifran, an outstanding 650 ha site in Dumfriesshire with an altitudinal range of 160 to 820 m. The group raised £400,000 (80% from private individuals) enabling Borders Forest Trust (BFT) to purchase the valley in 2000 without the use of public money. A key feature of the project is its grass-roots base. The project has been conceived, planned and brought to fruition largely by dedicated volunteers from diverse backgrounds, with free assistance from ecologists, foresters and other specialists. Management decisions are taken by the Wildwood Group, a volunteer element within BFT. However, a part-time professional project officer has managed grant-aided contracts for fencing, tree planting and deer control, as well as supporting volunteers on site. Trees are funded by a benefactor and donations from private individuals play a fundamental role (Ashmole, 2011). Over 15 years, more than 550,000 native trees and shrubs have been planted, about one fifth of them by volunteers, who have also collected all the seeds. About 300 ha of deciduous forest, interspersed with open grassland and moorland habitats, are now

established in the main glen and in a hanging valley between 600 and 750 m. In the latter, the aim is to restore tree-line woodland and scrub, in which dwarf juniper and *Salix* species are well represented (Chalmers & Ashmole, 2007). The range of biodiversity in Carrifran is increasing through natural colonisation by mobile animals, plants and fungi, while translocation of missing woodland herbs is commencing. Large predators are absent, so culling of deer is necessary, together with maintenance of a perimeter stock fence, but other human intervention is declining as the ecosystem matures. The instigators of the Wildwood intend the project to be exemplary, demonstrating the power of individuals, harnessing public support, to enhance their local environment. Carrifran already offers a rare opportunity to enjoy a place where nature is re-asserting control.

Late in 2013 Borders Forest Trust was able to purchase an additional 1800 ha (4500 acres) of denuded land at Talla and Gameshope, contiguous with Carrifran. With the inclusion of the nearby land at Corehead, BFT now owns 31 square kilometres of the wildest part of the Southern Uplands. Restoration work will be carried out at Talla and Gameshope over many years, probably mainly by volunteers. This will ensure that it will always be possible for residents and visitors to Southern Scotland to see and walk through an extensive area of wild land, with vegetation comparable to what was present before the influence of people and their domestic animals became dominant.

Fig. 9a.: Bare landscape at Carrifran before planting (2004) and 9b. Young plantations in Carrifran showing return to forest cover (2013)

College Valley

Management is also changing in the College Valley Estate; which consists of some 5250 ha of land, extending from the valley floor to the summit of The Cheviot in North-East England. The estate was acquired in 1953 and, since that date, management has principally revolved around upland sheep farming and forestry. The latter consists mainly of exotic plantation, established in the 1960s and 70s. The principal vegetative cover on the southern, higher part of the Valley (some 2225 ha) has been upland pastures grazed year round by hefted sheep, heather managed for grouse shooting, commercial forestry and some sub-arctic vegetation on the exposed summits and on cliffs. A large proportion of this area is in a botanical SSSI, repeatedly classified by Natural England over the last two decades as in 'unfavourable' condition.

The Estate would like to see a recovery of the sensitive, vascular botany on this land and, more subjectively, an 'improvement' in its landscape value. Accordingly, the estate took advantage of a tenancy break clause to bring the land back into their management control in 2012, and have replaced the resident hefted sheep with seasonal summer grazing by a combination of sheep and cattle. At the same time, some 50% of conifer plantations are being replaced by native woodlands after harvesting, using natural regeneration where possible. In addition, stock has been excluded completely from much of the lower, riparian pastures to allow regeneration of tree and shrub species along some 73 ha of the lower valley. These changes in management are being accompanied by a rigorous monitoring programme in order to ensure objectives are met. The results will be used to formulate the detail of the summer grazing pattern as well as the intensity. The whole programme involves the active cooperation of the estate, Natural England, the National Park, external monitors, graziers, forestry managers and consultants.

Forest ecosystem restoration in the Scottish Uplands - a review of the current situation with respect to upland woodland

Scottish upland forests are fragmented, overgrazed and in poor condition, despite efforts over the last 50 years to create new plantations. With around 12% forest cover, the UK remains one of the least afforested countries in Europe (EU average 37%) (FAO, 2010). Limited natural tree regeneration has occurred in Scotland in the past 200 years. The decline in woodland cover since then has been attributed to clearances to facilitate farming, grazing pressure from various types of livestock, and to a certain extent, climate change (Smout, 2000). Overgrazing, particularly by deer, has been the biggest factor in halting woodland regeneration (Smout, 2000, Watson, 1983). Although sheep numbers have declined to some degree since the decoupling of subsidies (Silcock et al., 2012), deer numbers have continued to increase in recent years, as described above. A comparison of Ordnance Survey (the UK national mapping agency) map editions since the early Nineteenth Century shows that woodland remnants have become smaller, due to the death of trees and the lack of regeneration. Scottish Natural Heritage considers that about a third of protected woodlands are in unfavourable condition (Scottish Natural Heritage, 2014a).

The Native Woodland Model of SNH (Scottish Natural Heritage, 2014b) suggests that 50% of Scotland's land area could support woodland, yet only 4% is currently covered by semi-natural woodland. Expansion targets within the UK Biodiversity Action Plan, and development of Forest Habitat Networks, are priorities in the Scottish Forestry Strategy (Scottish Executive, 2006), but unsustainably high numbers of herbivores in the Scottish uplands makes delivery of these targets difficult (Scottish Wildlife Trust, 2012). During winter, deer usually shelter in woodlands, and the high deer densities preclude tree regeneration and ecosystem restoration (Gill, 1992; Gill & Morgan, 2010; Palmer & Truscott, 2003). Experience from elsewhere in Europe suggests that herbivores need to be strictly controlled to enable tree regeneration to occur (Gill, 1992; Hester et al., 2000). A second possibility is to protect regeneration by fences (Kamler et al., 2010, Palmer and Truscott, 2003), as has been carried out in nature reserves such as Rassal ashwood (Scottish Natural Heritage, 2014c). Ecosystem services associated with woodland restoration include flood mitigation, soil restoration and erosion control, and carbon sequestration.

Outwith the areas of the Scottish uplands which are intensively managed mainly for deer and grouse, the Single Farm Payment system of the EU supports existing land use, principally sheep grazing, which is on a large scale compared with mountain landscapes in the Pyrenees and Carpathians.The long history of overgrazing - discussed as long ago as 1947 by Darling (1947), which greatly increased after Britain joined the European Union

(Silcock et al., 2012) has led to a major decline in ecosystem health at a landscape scale. The balancing duties of SNH present difficult challenges to resolve these conflicting economic and ecological demands in the uplands. The challenge is urgent however, because restoration of ecosystem health through reducing herbivore impacts is critical to a resilient natural resource base supporting the ecosystem services increasingly needed in a climate challenged future. However, the recent Common Agricultural Policy negotiations and discussions in the press concerning opposition to any changes in the status quo, suggest that the situation is unlikely to change in the immediate future.

DISCUSSION

Many landscapes throughout Europe now have higher tree cover than in recent centuries. For example, in Norway (Potthoff, 2004), large areas are now being re-colonised by forest, because of the decline in summer farms, and therefore grazing in the mountains. The same process is also happening elsewhere in the mountains of Europe as well as on poorer soils in Eastern Europe, because of land abandonment (Benayas et al., 2007). The major difference from Britain in all these situations is that the expanding tree cover is of native species derived from natural regeneration of local trees and does not consist of planted exotics. Whilst the literature on Ancient Woodland Indicators, for example Hermy et al. (1999), shows that the ground vegetation of such new forests will be different from that present in old growth forests, there is no doubt that the environmental impacts are much lower than that described for plantations in Britain. However, in Spain and Portugal, plantations of *Eucalyptus* species dominate entire landscapes in regions such as Galicia and the Algarve. These plantations have comparable ecological impacts to upland forests in the UK, for example on soil organic matter as described by Madeira et al. (1989). Favoured species for timber are also often planted outside their natural range, for example Scots pine in the lowlands of Scotland and Norway spruce (*Picea abies*) in Switzerland.

In the majority of these continental landscapes, enough trees remain for the return of tree cover to take place with natural regeneration and, whilst the new forests are different from the original cover, the destruction had not proceeded to the same extent as in British uplands where tree cover is absent in many regions, as discussed above. The new approaches in Britain described in the present paper therefore often require active planting, as well as fencing, to restore tree cover although as shown in figure 5, natural regeneration can occur. The widely discussed possibility of a decline in hill sheep farming because of lack of profitability (Clother & Finch, 2010) also needs to be taken into consideration. However, a decline in sheep grazing will often not lead to forest regeneration in the UK because of the lack of seed trees and the expansion of aggressive competitive species such as *Nardus stricta*, *Molinia caerulea* and *Pteridium aquilinum* when grazing is removed. The numbers of deer in Scotland, described above, will also restrict regeneration in Scotland (Forestry Commission Scotland, 2014b). The pro-active projects described in the present paper therefore represent a major step forward and indicate the potential for the restoration of better balanced landscapes in the British uplands. However, under current economic conditions, such projects are only likely to cover a relatively small proportion of the British Uplands although the numbers of such projects are significant, as mentioned above. Nevertheless, at a local level they restore balance to landscapes where the majority of woodland cover had been lost. In addition, as the Carrifran wildwood project shows, other groups of organisms such as birds also return. The public support for this project also indicates the popularity of such initiatives,

as does the policies of government agencies such as the Forestry Commission in restoring native pinewoods (see Forestry Commission Scotland, 2014a).

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