THE ROLE OF GRAZING ANIMALS AND AGRICULTURE IN THE CAMBRIAN MOUNTAINS:

recognising key environmental and economic benefits delivered by agriculture in Wales' uplands

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Executive Summary

This report examines the benefits derived from the natural environment of the Cambrian Mountains, how this environment has been influenced by grazing livestock and the condition of the natural environment in the area. The report then assesses the factors currently causing changes to the Cambrian Mountains environment and discusses how to maintain the benefits derived from this environment in the future.

Key findings:

- The Cambrian Mountains are one of Wales' most important areas for nature, with 17% of the land designated as a Site of Special Scientific Interest (SSSI). They are home to and often a remaining stronghold of a range of species and habitats of principal importance for the conservation of biological diversity with many of these species and habitats distributed outside the formally designated areas.
- The natural environment is critical to the economy of the Cambrian Mountains: agriculture, forestry, tourism, water supply and renewable energy form the backbone of the local economy. A range of non-market ecosystem services such as carbon storage and water regulation provide additional benefit to wider society.
- Documentary evidence shows the Cambrian Mountains have been managed with extensively grazed livestock for at least 800 years, while the pollen record and archaeological evidence suggest this way of managing the land has been important in the area since the Bronze Age. This management is inextricably linked to the habitats that are now found across most of the area.
- The area is not immune from changes to the natural environment: areas of concern include loss of habitat diversity, the spread of *Molinia caerulea* (purple moor grass, gwellt y bwla) and a decline in upland bird species.
- While there are localised concerns about overgrazing, for example on montane habitats, at the landscape scale overgrazing by sheep is not currently a primary driver of habitat change in the Cambrian Mountains.
- The spread of *Molinia* across a large proportion of the peat and peaty soils of the Cambrian Mountains suggests that undergrazing is now an issue in some areas.
- The decline of upland bird species has complex causes. However, there is a need to increase grazing pressure in some places to improve breeding success.
- For many upland bird species the importance of maintaining an appropriate mosaic of habitats within the landscape is acute.
- A decline in traditional farming techniques has reduced habitat diversity and is likely to have had a deleterious impact on bird populations.
- Since the late 1980s, the delivery of agri-environment scheme prescriptions by farmers has generally had positive effects for habitats and a range of plant communities. However, there are concerns relating to the appropriateness and impact of certain grazing regimes on some habitats and species. Given the key role that such schemes play in determining management systems across three quarters of the eligible area in the Cambrian Mountains it is critical that the management prescriptions applied through these schemes deliver both for nature and for the farmers that apply them.
- Further work should be undertaken in order to identify what impacts, if any, changes in predator numbers are having on species in the Cambrian Mountains, in particular ground-nesting birds

The report concludes that:

- Extensive livestock production has proved its value as a sustainable system for managing the Cambrian Mountains over the long term and is a good template for managing the area in the future.

- The continuation and reinvigoration of the traditional, extensive farming systems of the area will help to ensure the natural environment of the Cambrian Mountains thrives in the face of a changing climate and other pressures.

1. Introduction

The Cambrian Mountains[1] occupy around 10% of Wales and are one of the most sparsely populated areas in England and Wales. They are known for their desolate, historic landscape and for the nature that is found in the high-altitude but temperate, oceanic climate. The environment in the Cambrian Mountains has been shaped over millennia by humans, with the landscape, terrain and climate well suited to extensive livestock production, particularly grazing ruminants. These animals are still traditionally and extensively managed in the area.

Many of the habitats and species found on the Cambrian Mountains are considered to be of European importance. Indeed, 17% of the Cambrian Mountains are designated as a Site of Special Scientific Interest (SSSI), with nearly 90% of the SSSI area also designated under the European Habitats Directive as a Special Area of Conservation (SAC) or a Special Protection Area (SPA) or both. At the same time, the Cambrian Mountains are home to (and often a remaining stronghold of) a range of species and habitats of principal importance for the conservation of biological diversity (Welsh Government Section 42 list), with many of these species and habitats also distributed outside the formally designated areas. Furthermore, the Cambrian Mountains are home to a number of internationally recognised Important Plant Areas (See Annex 1 for more details of the species and habitats of importance for nature conservation in the Cambrian Mountains).

The Cambrian Mountains also provide water for large areas of Wales and the English Midlands and considerable quantities of carbon are sequestered and stored in the peat soils and vegetation. A number of major rivers including the Severn, Wye, Tywi and Teifi find their source in the Cambrian Mountains and so the peat soils are also important for water regulation, protecting downstream communities from flooding during wet periods and from low river levels during drought. The open landscape provides a range of recreational opportunities that have proved attractive for tourists, bolstering the local economy.

This report examines the benefits derived from the natural environment of the Cambrian Mountains (Section 2), before going on to look at how this environment has been influenced by grazing livestock and the people who keep them (Sections 3 and 4). The report then considers the current condition of the natural environment in the area and factors affecting this condition in Sections 5 to 7, before concluding with an assessment of how to maintain the benefits derived from the Cambrian Mountains in the future (Sections 8 and 9).

[1] Although the Cambrian Mountains have no statutory or other legal boundaries and span three local authority areas, the region does have a clear and distinct geography and history. Over the years, initiatives and schemes such as the Cambrian Mountains ESA, the Cambrian Mountains Initiative and the Cambrian Mountains National Park application, as well as local authority data have all used different but largely overlapping boundaries for their purposes. Since the overlap between areas is so large, for this report we use data compiled using a number of these different boundaries. The principal areas considered to be within the Cambrian Mountains stretch from Pumlumon and associated hills in the North, southwards across the Elenydd and the Tregaron upland plateau, and south again to the hills between Llandovery and Lampeter.

2. The importance of agriculture and the natural environment in the Cambrian Mountains to the local and wider economy

Within the Cambrian Mountains the economy is highly dependent upon agriculture and forestry with 19% of the population employed in these sectors in 2001 as opposed to an average of 8% in the three local authorities of which they form a part. Agriculture provides the greatest income stream for the area at £47.5m, while also important to the economy is tourism, which despite being considered to be relatively underdeveloped contributes an annual income of £32.6m from around 870,000 visits annually (Cambrian Mountains Initiative, 2008). Much of the tourism of the region is dependent upon the quality of the Cambrian Mountains environment: for example, tourists are drawn to the quality of the landscape, nature watching, outdoor pursuits, the quality of the food, the distinctive culture and cultural heritage, and the remoteness.

Renewable energy from water and wind are a significant and increasing income stream in the Cambrian Mountains, and drinking water supply principally from the Elan Valley and Llyn Brianne generates around £9 million per annum (Cambrian Mountains Initiative, 2008).

Image A. Llyn Brianne, located in the headwaters of the River Tywi, Southern Cambrian Mountains. *The reservoir enables water flow into the Tywi to be regulated for later abstraction at Nantgaredig, Carmarthenshire. Photo: Hugh Gillings, Dinefwr Photographic Society.*

Other services from the environment of the Cambrian Mountains such as flood regulation, and carbon storage and sequestration are more difficult to value because they are provided within a non-market system. However, the parallels with landscape and nature provision are strong: the benefits of an attractive landscape with a wealth of nature *stem* from those managing the land but *accrue* to tourist enterprises and the health and wellbeing of those partaking of them. Similarly, the benefits of flood regulation, carbon storage, and clean water *stem* from land managers but *accrue* to the insurance industry (flood regulation), the water industry, and society more widely.

Based on data from the National Ecosystem Assessment a recent paper suggests that an additional £8.3 million per annum could be generated from the Cambrian Mountains through investment in carbon storage and sequestration, water regulation (reduced flooding), and increased drinking water quality and quantity (A. Davies, NRW, pers. comm.). It should be noted that this figure does not take into account the full cost of losing the services that are currently provided.

A recent study (Mabis, 2007) examining the value of wildlife-based activity in Wales estimated the annual value of this activity to be £1.9 billion, which included a 55.4% contribution from agriculture,

fishing and forestry-related activities, 8.2% from tourism, 8.7% from energy and water-related industries and 26.8% from public and third sector conservation activities (including agri-environment payments). Although there are no Cambrian Mountains specific data, the study estimated the indirect value of these activities at 26.4% of the total contribution, highlighting the multiplier effect that these sectors have on the wider economy. A comparable indirect contribution would be anticipated within the Cambrian Mountains area.

3. A Brief History of the Cambrian Mountains

The Cambrian Mountains were heavily modified by glacial activity during the last Ice Age, leaving an upland plateau dissected by steep-sided valleys. As the climate warmed, the tundra environment gave way to birch forest, open montane grassland and juniper scrub (Moore & Chater, 1969). Through the Mesolithic period (7,700 – 5,500 BC), pollen evidence suggests there was mixed woodland in the area, except on the open habitats of the higher land, with species such as pine, oak, elm, hazel and alder. Charcoal fragments indicate that woodland clearance through burning was the first human impact on the area around 7500 BC (Wiltshire & Moore, 1983) with a subsequent transition to the more widespread open conditions, typified by grass, heather and sedge, which persist to the present day. Species indicative of cultivation and grazing in the pollen record, as well as the large numbers of cairns, individual megaliths, stone rows and stone circles point to the exploitation of upland pastures during the Bronze Age, 5500-3500 years ago (see Image B). Extensive peat bog formation began in the region around 3,000 BC (Moore & Chater, 1969).

Image B. Bronze age flint arrowhead. *Found in eroding peat near Bugeilyn, North Cambrian Mountains. Photo: John Mason.*

By the medieval period, extensive use was being made of the upland pastures and in the late 12th century large parts of the Cambrian Mountains formed part of the lands granted to the Cistercian abbeys of Strata Florida and Strata Marcella. The principal resource of these monastic lands was the cattle and sheep grazed upland pastures. Livestock were managed by the monastic granges themselves and by those with holdings within its boundaries. Considerable wealth was derived from the wool trade, with the monks of Strata Florida, for example, being granted a licence by King John in 1212 to export their wool free of duty to France and Flanders. The existence of sunken storage facilities across parts of the Cambrian Mountains also point to dairying activity at upland sites during this period (Hall & Sambrook, 2009), although whether these were for milk from cows or ewes is unclear. Many upland settlements originated in the medieval period as dwellings (hafodydd), occupied during the summer months, in order to exploit upland pastures at some distance from the home farms in the lowlands (hendrefi). Studies of Cistercian lands in northwest Wales, suggest that sheep were the principal livestock kept on these monastic lands (Elfyn Hughes, Dale, Ellis Williams, & Rees, 1973). Given the importance of the wool trade to the Cistercian economy, it seems likely that sheep were also the major component of the livestock kept in the Cambrian Mountains during the mediaeval period.

The 16th century was a time of some change in the Cambrian Mountains with the dissolution and break-up of the monasteries, an increase in the population of the area and the growth of landed

estates. In terms of vegetation it is interesting to note that in 1524, John Leland described the '*bare*' treeless hills of the area (Hearne, 1770).

Evidence for the continuation of the shepherding tradition is found on the 1744 Lewis Morris map of the Manor of Perfedd, an area including much of the Cambrian Mountains area around Pumlumon. On the map many lluestau (simple shepherds huts with few outbuildings) are identified. The common belief recorded by Morris following interviews with local inhabitants was that the lluestau had originally been seasonally occupied hafodydd, but had with time (and certainly by the 1700s), become permanent shepherding dwellings. Documentary evidence from the time refers to lluestau being attached to their own areas of upland pasture known as sheepwalks, implying that sheep were the principal grazers (Hall & Sambrook, 2007). Interestingly, the term *sheepwalk* is retained to this day to describe different sections of hill onto which sheep are hefted and gathered, with, in many cases the same boundaries being retained from at least the 1800s (source: Elan Valley Estate records).

By the beginning of the 19th century considerable enclosure of previously open lands was taking place across Wales: in 1795 0.7 million hectares in Wales were unenclosed 'waste' but this had declined to 0.2 million hectares in 1843 (see Moore-Colyer, 1976). Although there was an increasing tendency towards enclosure within the lower lying reaches of the Cambrian Mountains at the time (Davies, 1814), great swathes of the area were left as unenclosed land and survive as such to the present day. Similarly, 19th century attempts at agricultural improvement in the Cambrian Mountains did not reach the levels seen in other areas, although innovators such as Thomas Johnes of the 4000 hectare Hafod Estate near Cwmystwyth, in the central Cambrian Mountains, were to be found. Johnes established an experimental farm at Pwllpeiran (some 200 years before it became an Experimental Husbandry Farm) and tested various methods for agriculturally improving hill swards (Moore-Colyer, 1992).

Depopulation of the farming communities and amalgamation of farming units was a feature from the late 1800s. An illustration of this is given by Jones, (1967). In the upper reaches of Cwm Ceulan and Cwm Tynant near Talybont, in north Ceredigion, some 29 smallholdings (tyddynod) and 14 farms were occupied in 1880; by 1920 a mere 4 tyddynod were occupied and 9 farms. On neighbouring Pumlumon the data are starker: in 1880 there were 150 residents on 20 farms living to the north and east of Pumlumon; by 1967 there were no occupied farms left.

Image C. Sheep shearing at Dinas, Ponterwyd 1896.
Reproduced with permission from Howells, 2005.

4. Land management in the Cambrian Mountains from the 20th century to the present day

A period of afforestation and land improvement. Agricultural improvement of the Cambrian Mountains reached its peak in the post-Second World War period. However, the roots of the modern era of land improvement in the Cambrian Mountains are to be found in the Cahn Hill Improvement Scheme centred on Pwllpeiran (later to become an experimental husbandry farm) and established by Sir George Stapledon of the Welsh Plant Breeding Station in the 1930s. Pioneering farmers such as Captain George Bennett-Evans, of Manod, Llangurig took up the challenge of improving hill land using lime and a range of reseeding techniques. Following the Second World War, a further phase of land improvement was initiated based on the need to increase self-sufficiency in food production and stimulated by the 1947 Agriculture Act and land improvement grants. Despite these inducements the the proportion of the Cambrian Mountains under improved farmland increased from 16% in 1948 to only 20% in 1983, around a third of this increase being the re-improvement of land that had been improved in the 1930s but had since reverted to rough grazing (Parry & Sinclair, 1985). It is interesting to note in this context the wry comments of Walter Davies who said of the Cambrian Mountains that '*men of some opulence have occasionally done wonders in temporarily improving alpine tracts…and their farms, too hastily reported to be permanently improved, have reverted to the state of nature'* (Davies, 1814).

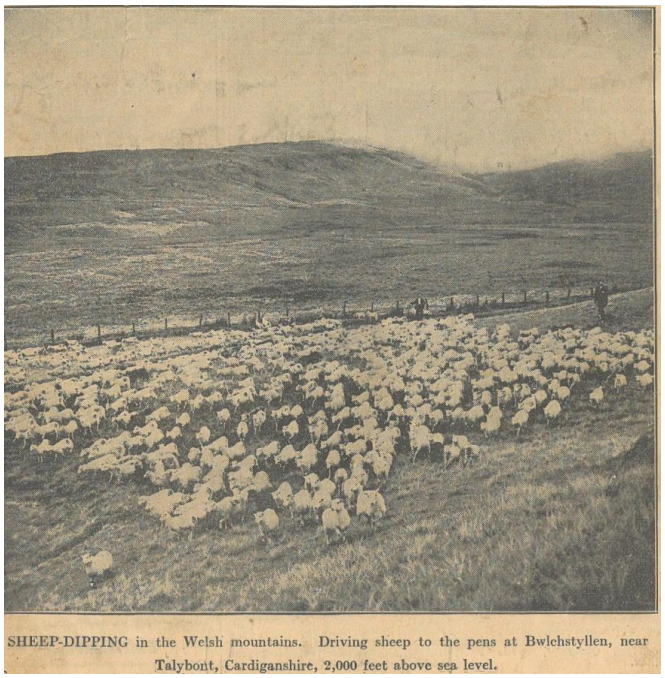
SHEEP-DIPPING in the Welsh mountains. Driving sheep to the pens at Bwlchstyllen, near Talybont, Cardiganshire, 2,000 feet above sea level.

Image D. Sheep gathering for dipping at Bwlchstyllen, near Talybont, 1938. Clipping believed to be from Cambrian News. With thanks to E. Howells.

A far greater impact on the semi-natural habitats of the Cambrian Mountains after the Second World War came from the objective to increase self-sufficiency in timber, leading to widespread afforestation with conifers, largely under the auspices of the Forestry Commission. Following the severe winter of 1947 in particular, with stock numbers decimated, many Cambrian Mountains farmers sold blocks of land to the Commission for tree-planting. The scale of the changes was considerable: in 1948 just 3% of the area was under conifers, by 1983 this figure had reached 21% with the bulk of this planting prior to 1963 (Parry & Sinclair, 1985). The nature of conifer plantations is such that little semi-natural habitat remains following canopy closure and so there is no doubt that loss of habitat on this scale represented a severe loss for upland species assemblages. A further consequence of the extensive afforestation of the period was the acidification and aluminium pollution of soils and freshwater

streams (Ormerod et al., 1989) leading to a loss of invertebrates and freshwater bird species (Ormerod and Durance, 2008; Tyler and Ormerod, 1992).

Current land use in the Cambrian Mountains. The tradition of extensive livestock farming in the Cambrian Mountains continues to the present day, with the area retaining its status as a significant livestock producing area. The predominant sheep breeds grazing the Cambrian Mountains are the Welsh Mountain, the Hill Speckle and the Beulah. Crossbreds of these breeds (predominantly Mules) are highly valued for their maternal traits and are widely used as the foundation breeding stock in lowland sheep farming in Wales and across the border in England. Purebred ewes drafted from the hill are also valued for their ease of management and low maintenance costs in lowland systems, and male lambs are frequently sold as stores for finishing on richer pastures in the lowlands. There are therefore strong economic links between farms in the Cambrian Mountains and elsewhere, with Cambrian Mountains sheep contributing to the production efficiency of farming systems in other localities.

Image E. Farmstead with range of traditional and modern farm buildings in the Cambrian Mountains, 2013. Photo: John Mason.

Largely because of the retention of extensive livestock farming, and excluding the area taken over with conifer plantation, the land cover of the Cambrian Mountains continues to be dominated by moor and heath, blanket bog and mire, and semi-natural grassland (see Table 1), with only around 30% of the land classified as enclosed farmland.

Table 1. Land cover of the Cambrian Mountains by habitat. *Based on the UKNEA categories using CCW Phase 1 habitat survey. Source: Cambrian Mountains Initiative.*

Land cover	Hectares
Moor and heath	19081
Semi-natural grassland	44878
Wetland – bog and mire	21854
Woodland	49637
Enclosed farmland	56586
Other	3800

The introduction of agri-environment schemes. The development of agri-environment schemes has had a considerable impact on agriculture and land management in the Cambrian Mountains. The first such scheme in the area was the Cambrian Mountains ESA which started in 1986. At a similar time the use of Section 15 and Section 16 management agreements under the Wildlife and Countryside Act 1981 became more widespread. Since then, Cambrian Mountains farmers have been able to apply to enter the Tir Gofal, Tir Cynnal and most recently Glastir agri-environment schemes. At the present time at least 58.1% of the total area is covered by an agri-environment scheme (Table 2) with coverage of around 77% of all eligible land (excluding conifer plantations, water bodies, grey infrastructure). These data underestimate the coverage of agri-environment agreements because they do not include areas with Section 15 management agreements on SSSI or Section 16 management agreements on nature reserves (1496 hectares on 1/1/2013; data supplied by CCW). Section 15 / 16 data were not included in the analysis because it was not possible to calculate the percentage of this area that is also covered by a Tir Gofal or Glastir agreement. The area under Section 15 and Section 16 agreements has dropped from a peak of 6235 hectares in 1995 typically to prevent double-funding issues when land has been entered into other schemes.

A clear objective of all agri-environment schemes in the Cambrian Mountains is to prescribe a grazing level on the semi-natural areas of farms to maintain these habitats in good ecological condition, with additional options available for reverting agriculturally improved areas to semi-natural habitats. While farmers can benefit from these schemes to the extent that payments are based on a calculation of income foregone by undertaking the variety of actions available under each scheme, public benefit is seen through safeguarding and improving semi-natural habitats, landscape and a variety of other ecosystem services.

Table 2. Coverage of agri-environment schemes in the Cambrian Mountains at 1st April 2013. *Data were compiled for this report by Welsh Government using the Cambrian Mountains ESA boundary. Note this boundary encompasses a 22% smaller area than the boundary used in Table 1. Around 25% of the area is not eligible for entry to agri-environment schemes.*

Agri-environment scheme	Hectares	% of area
Tir Gofal	52519	34.2
Glastir Entry	18751	12.2
Glastir Commons	12762	8.3
Tir Cynnal	5229	3.4
Total	89261	58.1

5. Exploring the relationship between nature and grazing livestock in the Cambrian Mountains

Across the majority of habitats found in the Cambrians, low to moderate grazing levels typically lead to habitats being maintained in a stable condition in the absence of other factors such as burning and atmospheric pollution. Heavier stocking favours grass species at the expense of woody and herbaceous species. However, the exact outcome of high grazing impacts depend upon a range of factors across all habitat types: Soil type is of considerable importance – for instance, the outcome of heavy sheep grazing on dwarf shrub heaths is usually a shift towards grassland composed of unpalatable grasses, especially Matgrass (*Nardus stricta*) and purple moor grass (*Molinia caerulea; gwellt y bwla)* on damper soils (Welch 1986), while on better drained soils the vegetation may tend towards *Agrostis-Festuca* swards (Miles 1988). Other factors affecting the pathways and rates of vegetation change under high grazing pressure include: seasonality of grazing, the age and vigour of heather, existing species composition of the vegetation, supplementary feeding and shepherding practices, and the type of species grazing. Evidence from studies comparing the impacts of cattle versus sheep suggests that their different grazing habits affect the composition of habitats, with the greater selectivity of sheep reducing the herb components of habitats and increasing the prevalence of *N. stricta* in comparison to cattle (Hodgson & Grant).

Image F. Dry heath and acid grassland mosaic. *Ystumtuen, Northwestern Cambrian Mountains. Spring, 2013. Photo: John Mason.*

Reductions in grazing pressure from moderate levels can also have a range of impacts depending on soil type, existing vegetation and other management and external factors. On damp soils and peat, heather (*Calluna vulgaris*) or *Molinia* can become overly dominant under light grazing (Rawes & Hobbs, 1979; Jones, 1967). Over time, very low grazing pressure can allow tree establishment with the species which become established largely depending on seed availability. Mountain ash is a common pioneer because seeds are readily spread by birds, with goat willow often found on damper soils. Conifers, often sitka spruce, can also self-seed and frequently establish on the borders of

plantations and even more distantly - such as those growing above Llyn Llygad Rheidol on Pumlumon some 2.5km from the nearest Sitka plantation.

A highly valued feature of upland habitats is the breeding bird assemblage typically associated with them. Bird species characteristic of the Cambrian Mountains include red grouse, golden plover, curlew, ring ouzel, wheatear, skylark, redshank, common sandpiper, whinchat, stonechat, dunlin, merlin, and hen harrier. The nesting and feeding needs of these species can vary markedly, but all have traditionally found suitable sites within the Cambrian Mountains area. The preferred nesting and feeding habitats are shown in Table 3. All these species are dependent upon an appropriate degree of grazing to maintain the heath, acid grassland and blanket bog feeding and nesting habitats. Typically, each species requires a mosaic of habitats and vegetation structures often to include areas of more heavily grazed, invertebrate-rich, acid grassland. Other upland bird species that are dependent upon water, either pools and lakes or fast-flowing streams, include teal, common sandpiper, dipper, and goosander.

One of the features of the Cambrian Mountains in terms of the provision of non-market ecosystem services is the large proportion of the area that is covered by peat and peaty soils which act as large carbon stores (see page 20 of Vanguelova, Broadmeadow, & Anderson (2012) http://www.forestry.gov.uk/pdf/Peatland_Wales_Report_2012.pdf/$file/Peatland_Wales_Report_2012.pdf). Management of bogs to maintain or increase bog mosses as part of the overlying vegetation contributes to further peat development. This also serves to increases the habitat's capacity to store water, helping to ameliorate the impacts of periods of high and low rainfall on river and reservoir levels. The history of management of the Cambrian Mountains suggests that in this area such vegetation is attained under conditions of low grazing pressure to achieve some control of *Molinia* and invasive scrub, while allowing mosses and other components of bog communities to flourish. Indeed, in areas of the Cambrian Mountains where stock have been excluded, there is evidence that *Molinia* can become overly dominant (see for example Image G). However, uncertainty around the best management systems to maximise carbon sequestration has made this a subject of current scientific research.

***Image G. Stock exclosure on Claerwen National Nature Reserve on the Elan Valley Estate**. Showing overgrowth of Molinia (lighter coloured senescent vegetation). Image taken in spring, 2013. This exclosure was erected around 20 years ago. The area outside the exclosure is subject to a Section 16 agreement to maintain light sheep grazing. Photo: I. Joyce*

Table 3. Typical upland bird species found in the Cambrian Mountains showing preferred nesting and feeding habitats and the grazing pressure required to maintain this habitat. *Compiled from Fuller (1996) and Lamacraft, Vanstone, & Thorpe (2010).*

Species	Nesting habitat	Feeding habitat	Grazing pressure
Red grouse	Dry heath	Dry heath with varied age structure, some flush / mire	Low to moderate
Black grouse	Woodland edge, heather	Heather, blanket bog	Low
Golden plover	Damp mosaic of short and long vegetation	Short grassland, blanket bog	Moderate
Dunlin	Blanket bog	Blanket bog with mosaic of short and long vegetation	Low to moderate
Curlew	Damp, often short vegetation	Mix of long and short grass; Juncus; damp pasture	Moderate
Short-eared owl	Rank grass, heath	Rank vegetation with high vole numbers	Low
Skylark	Unimproved grassland	Unimproved grassland	Moderate
Wheatear	Short acid grassland	Short acid grassland	High
Snipe	Open, boggy ground	Mosaic of long and short boggy pasture and shallow margins of standing water	Low to moderate
Ring ouzel	Steep slopes, rocks, heath	Mosaic of short acid grassland and heath including bilberry / crowberry	Moderate
Redshank	Tussocky, damp pasture	Damp pasture	Moderate
Hen harrier	Mature heather	Heather : grass mosaic	Low to moderate
Merlin	Mature heather, scattered trees	Heather, wet flush and grassland mosaic with varied structure	Low to moderate

6. The current condition of nature in the Cambrian Mountains

As discussed above, at the broad scale the natural environment of the Cambrian Mountains is in good health, with around 50% of the area occupied by habitats of great value for nature: moor and heath, blanket bog and mire, and semi-natural grasslands (Table 1). The most serious impact on these habitats has been through afforestation with conifers in the post-Second World War period, with an additional but relatively limited impact of agricultural improvement (increasing from 16% of the area in 1948 to 20% in 1983) and some loss in the area of heathland. However, this reduction in heathland cover is probably best characterised as localised. For example, a study using aerial photography to compare heathland cover on 10,000 ha around Pumlumon showed a 5% reduction in the number of hectares classified as heathland between the 1940s and 1992 (Norris, Radford, & Stevens, 1997).

Finer scale vegetation surveys show a mixed picture with regard to habitat condition, with some, but not all, habitat areas in good condition ecologically (see Annex 2). Possibly of greatest conservation concern are areas of montane habitat found on summit ridges. Here, plants like dwarf willow (*Salix herbacea*) and the sedge *Carex bigelowii* are at the southern end of their distribution range and are in a precarious ecological position: there are only two known specimens of dwarf willow on Pumlumon for example, and only small patches of *C. bigelowii*. Another plant species of conservation concern on Pumlumon is mossy saxifrage (*Saxifraga hypnoides*) which is now only found on the northern slope of Pumlumon (pers. comm. R Jones and K Heppingstall, NRW), while in the Elennydd SSSI the moss *Sphagnum magellanicum* is also only found in one location (Ardeshir, 2003).

Of concern across the wider landscape is the spread of *Molinia* (see Annex 2), with many areas now dominated by this grass species. Scientific evidence suggests that the species has increased in dominance across large areas of the Cambrian Mountains starting from around the beginning of the 20th century and continuing through the 1960s (Chambers, Mauquoy, Cloutman, Daniell, & Jones, 2007), with rank overgrowth of *Molinia* now dominating large swathes of open moorland across the Cambrian Mountains (Image H). The spread of *Molinia* is important because it can shade out a range of herb species. Furthermore, it is a grass of low palatability for livestock and the deciduous and tussocky nature of *Molinia* makes overdominance of the species a fire risk in dry springs and a considerable obstacle to recreational hillwalking.

Image H. View across the upland plateau of the Elenydd, Spring 2013. *While darker areas of vegetation are formed by heather, the lighter colouration of senescent Molinia is evident across much of this landscape. Photo: I. Joyce.*

Another important recent development in the condition of nature in the Cambrian Mountains has been the large decline in many of the bird species characteristic of the Cambrian Mountains (see Table 4). These declines in upland breeding bird populations are particularly important because the Cambrian Mountains have traditionally been considered a key area for these populations as well as a last Welsh refuge for species such as the golden plover. In Section 7 drivers of change within the Cambrian Mountains that may have impacted on bird numbers are reviewed. However, given that most of these species are migratory it also needs to be borne in mind that factors outside the Cambrian Mountains may also be playing a role.

Table 4. Recent changes in breeding bird numbers on Pumlumon SSSI and Elenydd SSSI.

Species	% change	Location	Dates	Reference
Golden plover	-92	Pumlumon	1984 to 2011	Crump and Green, (2012)
Golden plover	-90	Elenydd	1982 to 2007	Johnstone et al., (2008)
Dunlin	-59	Elenydd	1982 to 2007	Johnstone et al., (2008)
Redshank	-100	Elenydd	Since 1994	Lamacraft et al., (2010)
Stonechat	-100	Elenydd	Since 1994	Lamacraft et al., (2010)
Ring ouzel	-100	Pumlumon	1984 to 2011	Crump and Green, (2012)
Curlew	-100	Pumlumon	1984 to 2011	Crump and Green, (2012)
Teal	-100	Pumlumon	1984 to 2011	Crump and Green, (2012)
Redstart	-100	Pumlumon	1984 to 2011	Crump and Green, (2012)
Red grouse	-48	Pumlumon	1984 to 2011	Crump and Green, (2012)
Common sandpiper	-90	Pumlumon	1984 to 2011	Crump and Green, (2012)
Skylark	-53	Pumlumon	1984 to 2011	Crump and Green, (2012)
Whinchat	-81	Pumlumon	1984 to 2011	Crump and Green, (2012)
Wheatear	-67	Pumlumon	1984 to 2011	Crump and Green, (2012)

7. Drivers of change in the natural environment of the Cambrian Mountains

Given the evidence from Section 6 that concerns exist over aspects of the Cambrian Mountains natural environment, possible drivers of change to this environment are reviewed below. In the first instance, given the importance of farming to the maintenance of the habitats of the area, evidence of changes in farm practice are addressed, before considering the impact of factors external to farming.

The key messages that emerge from the review are that:

- there is little evidence that there has been an increase in stocking rate over the long term; indeed, stocking rates are currently at very low levels by historic standards;
- the loss of a number of traditional farm management practices is likely to have impacted negatively on the natural environment by reducing diversity within and between habitats;
- external drivers of change, notably through pollution, are likely to be having a range of deleterious impacts on habitat condition;
- a combination of the above is likely to be responsible for two of the major concerns in the natural environment of the Cambrian Mountains: the spread of *Molinia* and the serious decline in the populations of a range of upland breeding bird species;
- the widespread uptake of agri-environment schemes means that prescriptions under these schemes need to be carefully tailored to the needs of the Cambrian Mountains, with adequate monitoring used to ensure that unexpected deleterious impacts are spotted early and rectified.

Changes in grazing livestock numbers. Sheep numbers have increased considerably across Wales since 1867, and particularly in the post-war period (Neil, 2012). Evidence for a long-term, overall increase in sheep numbers in the Cambrian Mountains is, however, not clear cut. Data collated for this report on stocking levels on the Elan Valley Estate and on Pumlumon (Figures 1 and 2) indicate that despite considerable periodic fluctuations there has been no long-term upward trend in sheep numbers on the farms studied, with an average stocking rate of 1.85 mature sheep per hectare on the Elan Valley holdings, and 2.17 mature sheep per hectare on the Pumlumon holdings over the period shown. Average stocking rates on farms in both areas have dipped well below the long term average in recent years. Data from the parish of Llangwyryfon, Ceredigion (Figure 3), a lowland area near to the Cambrian Mountains, are also presented here to illustrate the marked difference between hill and lowland areas of mid-Wales in terms of the change in livestock numbers. The data show a 9-fold increase in sheep numbers in Llangwyrfon parish between 1890 and 1967 reflecting a reduction in the proportion of land used to cultivate crops, as well as an increase in output per hectare.

Overall, the data from Figures 1 and 2 do not suggest that an increase in grazing pressure due to sheep is a recent cause of deleterious changes in the natural environment of the Cambrian Mountains.

The other important livestock in the Cambrian Mountains are cattle. However, there are currently around 25 times the number of breeding sheep as suckler cows in the area, which given the greater appetite of cattle equates to around four times the grazing impact. While, there is little doubt that sheep have increased proportionately to cattle in Wales over the last century, with a slight reversal of this position in recent years, the situation in the Cambrian Mountains is not clear. Local knowledge in the Elan Valley area indicates that only a handful of farms have maintained cattle herds during the last 50 years (A. Baker, pers. comm.). Around Pumlumon a few herds of cattle are to be found, normally on in-bye fields. However, during the early part of the twentieth century the number of herds was considerably greater (E. Howells, pers.comm). These herds were small (1 to 10 cattle) and associated with the numerous lluestau and tyddynod. The cattle were typically kept on in-bye fields for most of the year, with grazing on the open hill during the summer months to allow hay and oat crops to mature.

Although the available evidence suggests that in living memory at least, the grazing impact of sheep has been considerably higher than that of cattle in the Cambrian Mountains, this is not to downplay the impact of cattle keeping across the landscape. Firstly, it needs to be borne in mind that there were many more holdings keeping cattle (see Section 3); and secondly, the diversity of management needed to maintain cattle is likely to have had important benefits for the mosaic of habitats found in the area. Not only are cattle themselves less selective grazers than sheep, they also require greater resources for overwintering – for example, hay from traditionally managed upland hay meadows, rhos hay and the cultivation of oats were all associated with cattle keeping in the hills (E. Howells, pers. comm.). The farm management practices used to produce these resources would have generated a significant source of additional habitat diversity, helping to support a range of plant and animal species.

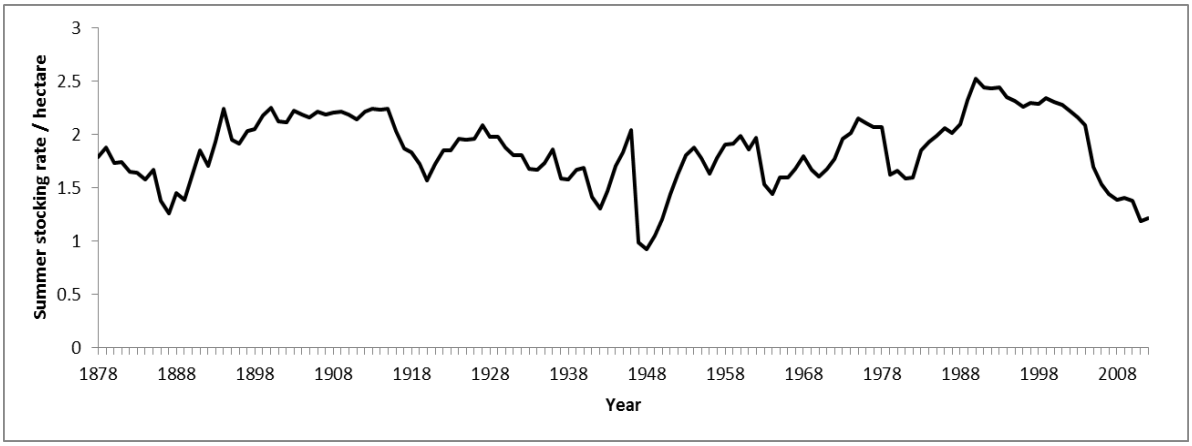

Figure 1. Summer stocking rate of mature sheep on the Elan Valley Estate 1878-2012. *Stocking rates are compiled from ewe and wether numbers on eight holdings that cover 5397 hectares of the estate. Data from 1878-1892 are for two of the eight holdings (1392 hectares) and from 1990 onwards cover five of these eight holdings (3757 hectares). Of these five from 1990 onwards, two use actual figures, and three use data inferred from maximum stocking rates allowed under agri-environment and tenancy agreements on the holdings. Note the dips in sheep numbers associated with social and economic upheaval caused by the two world wars, as well as the impact of severe winters such as those of 1947, 1962 and 1979. Sheep numbers peaked in 1989 and 1990, driven by headage payments, before the impact of the introduction of the Cambrian Mountains Environmentally Sensitive Area (ESA) was felt with a stabilisation and then decline in numbers. Successive generations of agri-environment schemes (ESA Phase 2 and then Tir Gofal), have resulted in further reductions in stock numbers. On some holdings it is evident that the poor profitability of sheep production has encouraged farmers to stock below the maximum allowed stocking rates on these schemes. Data were compiled from records held by the Elan Valley Trust.*

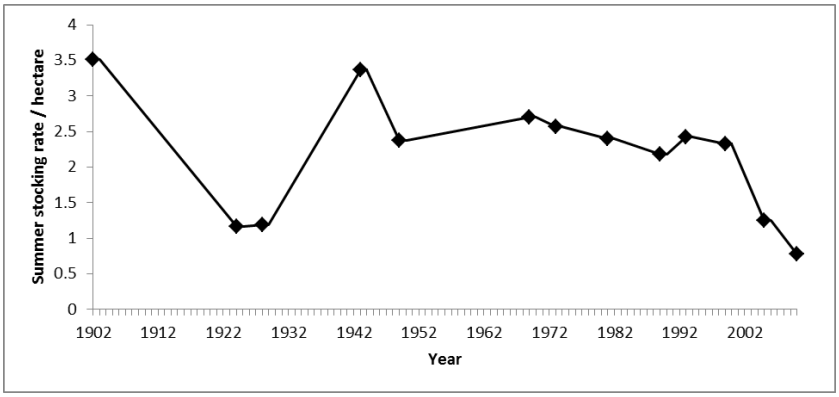

Figure 2. Summer stocking rate of mature sheep on Pumlumon 1902-2010. *Stocking rates are compiled from ewe and wether numbers on five sheepwalks over 1220 hectares of Pumlumon. Data from 1902-1928 are for two of the five sheepwalks only (485 hectares) Although the available data are not so fine-grained there are clear fluctuations in stock numbers over time, but little evidence of an increase in stock numbers driven by headage payments in the 1980s. Again, the influence of agri-environment schemes can be seen during the latter period with land under ESA and then Tir Gofal schemes. It is worth noting that in the last few years nearly all stock have been removed from some of the Pumlumon sheepwalks. Data were compiled from records held by Chris Evans (pers. comm. and from agri-environment maximum stocking rates).*

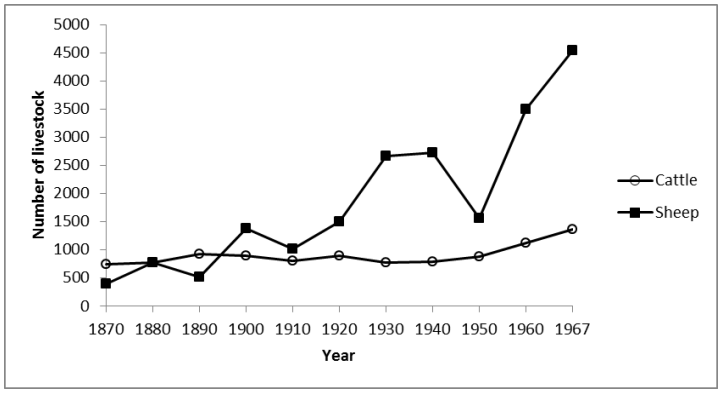

Figure 3. Stock numbers in the parish of Llangwyryfon, Ceredigion 1870-1967. *The data illustrate the dramatic increase in sheep production in lowland West Wales during the time period in contrast to the situation in the Cambrian Mountains. Note the reduction in sheep numbers following the 1947 winter. Records held in the National Archives, Kew.*

Changes in farm practice: Wethers. A feature of flock management in the 19th century that declined during the twentieth century was the importance of wethers (castrated rams) grazing on the hill all year until drafted for sale as 4-year-olds. Until the end of the 19th century, wether sheep typically formed around 40% of the adult sheep on Welsh hills and were valued for their ability to lead sheep to sheltered areas during bad weather, act as the 'policemen' of unenclosed sheepwalks, and for the additional weight (and therefore value) of their fleeces. On parts of Pumlumon the practice of keeping wethers died out during the first half of the 20th century. For example, on Nantllyn sheepwalk approximately half the mature sheep sold were as wethers in 1902, but by 1943 fewer than 1% were wethers. On the nearby Henhafod sheepwalk in 1943 fewer than 10% of the mature sheep were

wethers, with none left by 1950 (C. Evans, pers. comm.). The practice of keeping wethers on the Elan Valley Estate was maintained for somewhat longer (Figure 4), possibly because of restrictive clauses in tenancy agreements and the unenclosed nature of the Estate.

There is little doubt that there are behavioural differences between wethers and ewes. For example, wethers show a stronger territorial instinct and hence display a different foraging behaviour to ewes. In addition, some authors have speculated that ewes show a stronger preference for nutrient rich, more readily digestible herbage than wethers (Roberts, 1959; Hester, 1996). Although Hester (1996) suggested that the loss of wethers may have led to an increase in *Molinia*, rush and mat grass, little scientific analysis of the impact of this change on the plant communities of the Cambrian Mountains has been attempted, and hence the impact of this change in management on the natural environment is hard to quantify.

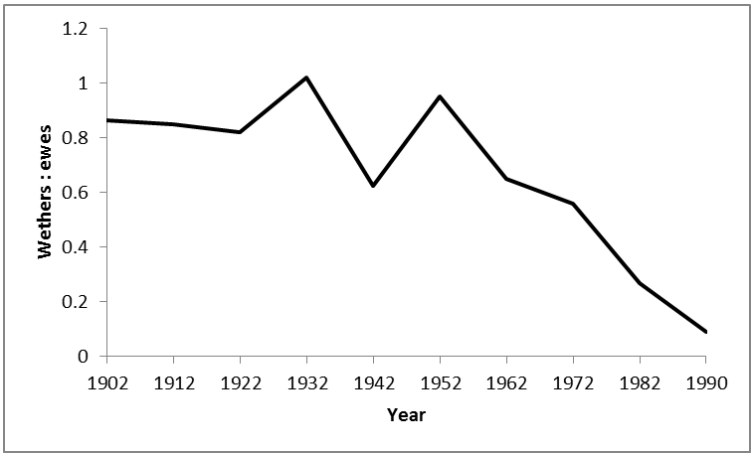

Figure 4. Ratio of wethers to ewes kept on three holdings on the Elan Estate from 1902 to 1990. *Data were compiled from records held by the Elan Valley Trust.*

Changes in farm practice: Shepherding. Another change in farming practice over this time was the reduction in the traditional shepherding management of sheep in the Cambrian Mountains. Such shepherding typically entailed the regular movement of sheep away from areas being conserved for use later in the year, for cattle or for rhos hay production. Sheep were typically shepherded up the hill towards grazing that would otherwise be underutilised such as dense stands of *Molinia*. The practice was sufficiently important that specialist sheepdogs (cwn cwrsio) were maintained for the purpose of driving sheep in this way (Howells, 2005). Although difficult to quantify, the loss of such regular shepherding will have exacerbated the overgrowth and increasing dominance of *Molinia*. Since sheep favour grasses which are more palatable and easier to access, the lack of shepherding has also contributed to both under and overgrazing within single extensive units of land.

Changes in farm practice: Burning. There is considerable evidence that well managed burns, particularly on heath can improve the mosaic of habitat by maintaining a diverse age structure of the woody heath species. This diversity is particularly important for upland breeding birds such as curlew, golden plover, hen harrier and merlin (Whittingham, Percival, & Brown, 2000; Tharme, Green, Baines, Bainbridge, & O'Brien, 2001; Thompson, MacDonald, Marsden, & Galbraith, 1995) and for a range of invertebrates (Ushera & Thompson, 1993). Burning has been seen as an important management tool by hill farmers in the Cambrian Mountains for its ability to remove senescent vegetation and generate a flush of more palatable new growth. However, negative aspects of burns are apparent in some situations. For example on deep peat, burning risks setting fire to the underlying peat, has been correlated with the production of considerable water discolouration (Yallop, Clutterbuck, & Thacker,

2008), can be deleterious to habitat integrity favouring overgrowth of *Molinia* (Hobbs, 1984), and reduces peat formation by damaging sphagnum (Lindsay, 2010).

Anecdotal evidence points to a considerable reduction in the number of burns on the Cambrian Mountains in recent times, with farmers and landowners often citing the difficulty of complying with the stringent regulations now associated with the practice, the risk of cross-compliance breaches, and the short window of opportunity that exists for burning under favourable weather conditions. In recent years, there has been a reduction in the area of exposed, eroding peat on parts of the Cambrian Mountains (A. Baker pers. comm. and Ardeshir, 2003) and it seems likely that this has occurred at least in part because of the reduction in burning frequency. This is certainly of benefit for water quality and carbon storage and is likely to reduce the spread of *Molinia*. However, where fires are started accidentally, or otherwise, there is a heightened risk they will occur at inappropriate times of the year, such as during the nesting season, and be more damaging because of the greater fuel load available. Furthermore, many areas of heath are no longer managed with fire, even where this would be beneficial to the mosaic of heathland vegetation.

Changes in farm practice: Rhos hay. Known locally as *gwair cwta*, rhos hay was once commonly made for winter fodder, particularly for overwintering cattle. The hay was made from forage on the open hill, typically from *Molinia*-dominant swards and often cut on one day and carted the next depending on weather conditions. Sometimes the hay was stacked on the open hill and protected from livestock with hurdles prior to winter feeding. Nowadays, the practice of making rhos hay has virtually disappeared from the Cambrian Mountains although on one or two holdings such as Henfron in the Elan Valley the tradition has been retained. Typically, rhos hay is of poorer nutritional quality than meadow hay (Hayes & Spiridonova, 2012) and was often scattered with rocksalt or molasses to improve palatability.

The loss of this tradition has reduced the range of management activities undertaken in the Cambrian Mountains and thereby both reduced diversity in habitats and contributed to the overdominance of *Molinia* in previously harvested areas.

Agri-environment schemes: stock reduction. As noted in Section 4 the Cambrian Mountains ESA scheme was launched in 1986, followed by Tir Gofal and Tir Cynnal, and latterly Glastir. Over three quarters of the eligible land area is now covered by an agri-environment scheme. Prescriptions under these schemes have typically stipulated a maximum stocking rate and this has contributed to a sustained reduction in the number of grazing sheep across much of the Cambrian Mountains. On many farms, stocking levels are now similar to, or below, levels seen at other historically low points such as following the severe winters of 1947, 1963 and 1979. In addition to a reduction in total sheep numbers there has also been an additional reduction in winter stocking: While traditionally, many holdings have maintained a settled flock throughout the year, the ESA and subsequent schemes have typically required winter stocking rates to be half those of summer stocking rates on the hill. Indeed, on some farms, heather regeneration options have stipulated no winter grazing.

The reduced grazing levels prescribed under agri-environment have been aimed at improving the ecological condition of a range of plant communities and habitats. However, there is concern that the reduction in grazing intensity has also favoured the spread of *Molinia* on damp soils and that the ranker vegetation resulting from lower grazing pressure has reduced breeding success for a number of bird species, including golden plover (Johnstone & Dyda, 2010). Indeed, the CCW have identified the need for management prescriptions that generate a mix of vegetation heights including many short-cropped areas in an effort to halt the decline in upland bird species (Lamacraft, Vanstone, & Thorpe, 2010) and the RSPB have noted that in upland habitats '*undergrazing and loss of vegetation structure is now occurring in some areas, with adverse impacts for some species such as golden plover and other waders.'* (Silcock, Brunyee, & Pring, 2012).

Agri-environment schemes: Other measures. In addition to prescribing stocking rates, agri-environment schemes have also included a range of habitat and other options such as those targeted at maintaining upland hay meadows, and measures for maintaining traditional field boundaries. There is little doubt that the farmers implementing these options have brought considerable biodiversity and landscape benefits.

External drivers of change: Atmospheric nitrogen pollution. The Cambrian Mountains are subject to some of the highest levels of nitrogen deposition in the UK (see http://pollutantdeposition.defra.gov.uk/node/88) with the majority of the area receiving at least 19 kg nitrogen / hectare / year, and typically over 24 kg nitrogen / hectare / year. For comparison, the average nitrogen application to grassland in the UK last year was 55 kg nitrogen / ha (Holmes, 2013). Although little atmospheric nitrogen pollution originates in the Cambrian Mountains area, the high rainfall of the area leads to a high level of 'wet' deposition of dissolved nitrogen in the rain. Transport (33%), power stations (37%), and industry (16%) are the principal emitters of atmospheric nitrous oxide (NOx) pollution in Wales (MacCarthy, Thistlethwaite, Salisbury, & Pang, 2012). Agricultural atmospheric nitrogen pollution is typically in the form of ammonia with deposition from this source tending to be focused locally around intensive agricultural units (Dragosits, et al., 2002), of which there are few in the Cambrian Mountains. Nitrogen deposition is of particular concern in the Cambrian Mountains because of the impact of excess nitrogen in driving vegetation change across a range of upland habitats. For example, current rates of deposition are thought to be in excess of those that cause conversion of heathland to grassland (Bobbink, Boxman, Hornung, & Roelofs, 1998). Nitrogen deposition can have particularly serious impacts on blanket bog because of the high nitrogen retention capacity of bog mosses and closed nitrogen cycling (Bobbink, Boxman, Hornung, & Roelofs, 1998). Furthermore, *Molinia* is particularly well adapted to the shift in the nitrogen : phosphorus balance that results from nitrogen deposition (Kirkham, 2001) and has been shown to be favoured by high rates of nitrogen deposition (Tomassen, Smolders, Lamers, & Roeloefs, 2003). It seems likely that high levels of atmospheric nitrogen deposition are therefore having a range of negative impacts on the natural environment of the Cambrian Mountains including playing a role in the spread of *Molinia*.

External drivers of change: Acidification. Acidification caused by dissolved atmospheric nitrogen and sulphur pollution (acid rain) is also a cause for some concern in the Cambrian Mountains where the soil type is particularly poor at buffering the acidifying effects of these pollutants and afforestation with conifers has exacerbated the impact (Ormerod et al., 1989). In recent years, the acidifying effects of sulphur pollution have been reduced dramatically, with consequent improvements in the water chemistry of Welsh streams (Reynolds, Stevens, Brittain, Norris, Hughes, & Woods, 2004). However, conifer forest streams at Llyn Brianne in the south of the Cambrian Mountains remain too acid for sensitive invertebrates, while moorland streams are still at risk from acid events (Ormerod and Durance, 2009). The impact on vegetation is also difficult to assess given that typical species found in the Cambrian Mountains are adapted to acidic soils. Calcicolous plants such as those living in some more alkaline flushes are likely to have been negatively affected however (R.A. Jones, pers. comm.)

Image I. Clear felling sitka spruce, Cambrian Mountains, Spring 2013. *Photo: John Mason.*

Other drivers of change: Predators. A recent report by the RSPB has reviewed the impact of predators on wild birds in the UK. The report concluded that the impact of predation, particularly on ground-nesting birds such as curlew, red grouse, and golden plover, can be significant (Gibbons, et al., 2007). For example, an RSPB study of curlew breeding success in Northern Ireland found that 82–95% of breeding attempts failed at the nesting stage, with predation accounting for about 90% of nest failures. The primary predators implicated in these studies and that are of relevance to the Cambrian Mountains are foxes and crows (Grant, et al., 1999; Harding, Green, & Summers, 1994). While crow numbers are reported to have remained static in Wales since 1995 (Johnstone, Thorpe, Taylor, & Lamacraft, 2012), there appear to be no similar reliable data for fox numbers. However, in upland Britain as a whole, fox numbers have increased in response to the expansion of commercial forestry plantations, which provide shelter and sites for breeding (Chadwick, Hodge, & Ratcliffe, 1997). Anecdotal evidence from farmers within the Cambrian Mountains suggests that this increase has resulted in additional predation on livestock, while Summers et al., (2004) and Baines, Moss, & Dugan (2004) have associated the increase with predation of upland birds. Local anecdotal evidence has also implicated the badger as an important predator of ground-nesting birds following the colonisation of many areas of the Cambrian Mountains during the last 40 years. Indeed, badger setts are now known at heights up to 550 metres and 5 km from the nearest woodland in the Cambrian Mountains in areas close to the traditional breeding sites of ground-nesting birds such as the golden plover and dunlin (A. Baker, pers. comm.). Scientific evidence remains inconclusive in terms of the overall likely impact of badgers on ground-nesting species from other geographical areas (FERA, 2011), but some have concluded that the wide and opportunistic nature of the badgers diet means that they may impact on nest survival on a localised basis (Hounsome & Delahay, 2005).

8. Maximising future socio-economic benefits from the environment of the Cambrian Mountains

Evidence presented in this report shows that extensive livestock production has proved its value as a sustainable system for managing the Cambrian Mountains over the long term. Such management has not only enabled humans to produce high quality food but has led to the development of internationally important semi-natural ecosystems. These ecosystems provide a high value of additional benefits from the natural environment in the form of carbon sequestration and storage, flood regulation, clean water, and a high quality landscape for recreational access and tourism. Given these factors, it is reasonable to suggest that the systems that have been used to manage the area in the past represent a good template for the future.

However, as has been shown, the area has not been immune from changes to the natural environment. Furthermore, the future challenges of climate change and economic pressures to intensify agricultural production to satisfy the demands of a growing world population will increase the prospects of other deleterious changes occurring.

Increasingly, land management activities are being viewed through the prism of the ecosystem services that such activities provide. As has been noted, past management has ensured that the Cambrian Mountains deliver an array of non-market ecosystem services of benefit to society, where land managers do not see the benefit of their actions. Market failure of this kind typically leads to a reduction in the provision of non-market services. Such an analysis suggests that in the Cambrian Mountains an intensification of agriculture that goes beyond the traditional extensive farming systems may in the future come to reduce the ecosystems services currently derived from the natural environment of the area.

One solution is for those who benefit from the provision of services from the natural environment of the Cambrian Mountains, for example the insurance and water industries, to have greater involvement in financially supporting appropriate land management that secures and even increases the benefits they currently receive. However, a long term partnership is needed between farmers and those who benefit from land management actions if such a vision is to succeed. The Welsh Government has a role to play in enabling this process, underpinned by a scientific evidence base that allows decisions to be made based on an understanding of the ecosystem service benefits of particular habitat management actions.

9. Conclusions

- The Cambrian Mountains are an important place for nature. Land cover continues to be dominated by a mix of blanket bog, heath and semi-natural grassland, and a high proportion of the area is recognised to be of European importance for nature conservation. The area is home to a range of rare and highly-valued species.
- Maintaining an appropriate level of grazing is critical to maintaining the key habitats of nature conservation interest. While there are localised concerns about overgrazing, for example on montane habitats, at the landscape scale overgrazing by sheep is not currently a primary driver of habitat change in the Cambrian Mountains.
- The spread of *Molinia* across a large proportion of the peat soils of the Cambrian Mountains suggests that undergrazing is now an issue in some areas.
- The decline of upland bird species is of considerable conservation concern with complex causes. There is a need to increase grazing pressure in some places to improve breeding success.
- For many upland bird species the importance of maintaining an appropriate mosaic of habitats within the landscape is acute. A decline in traditional farming techniques has reduced habitat diversity and is likely to have had a deleterious impact on bird populations.
- Since the late 1980s, the delivery of agri-environment scheme prescriptions by farmers has generally had positive effects for habitats and a range of plant communities. However, there are concerns relating to the appropriateness and impact of certain grazing regimes on some habitats and species. Given the key role that such schemes play in determining management systems across three quarters of the eligible area in the Cambrian Mountains it is critical that the management prescriptions applied through these schemes deliver both for nature and for the farmers that apply them.
- Further work should be undertaken in order to identify what impacts, if any, changes in predator numbers are having on species in the Cambrian Mountains, in particular ground-nesting birds
- Management of the Cambrian Mountains that maintains the natural environment using extensively grazed livestock will ensure that the area continues to deliver economic benefits from food production and a range of ecosystem services. Indeed, there is scope to increase agricultural output while enhancing these other services.

The common thread that runs through the report is that of the key role of extensively grazed livestock, managed by farmers and shepherds, in maintaining the benefits society derives from the natural environment of the Cambrian Mountains. In many ways, the narrative is one of balance: of farming in balance with nature, which allows food to be produced in a sustainable way while also enabling nature to flourish and society to benefit more widely from a range of other services provided by the natural environment. For the future, the continuation and reinvigoration of the traditional, extensive farming systems of the area will help to ensure the natural environment of the Cambrian Mountains thrives in the face of a changing climate and other pressures.

Contributions. The interpretation of the evidence used in compiling this report is the responsibility of the author alone. However, the author would like to thank a number of people for their willingness to share information and offer advice towards the compilation of the report:

Ken Perry, NRW; Chris Evans, farmer; Erwyd Howells, shepherd; Alec Baker, Elan Valley Trust; Karen Heppingstall, NRW; R. Andy Jones, NRW; Alex Turner, NRW; Alun Davies, NRW; Joe Daggett, NT; Nick Fenwick, FUW**.**

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Annex 1

Detailed in Annex 1 are the European Habitats Regulation Natura 2000 Sites (SAC and SPA) and the Sites of Special Scientific Interest in the Cambrian Mountains. Although many SAC are notified principally for their habitats on land, a number of SAC listed here have been designated within and outwith the Cambrian Mountains for habitats and species dependent on water. In these SAC the nature conservation features are critically dependent upon the land management practices used in the Cambrian Mountains for the provision of high quality water and include riparian / river SACs where the headwaters of the rivers are to be found in the Cambrian Mountains. The Section 42 list of species and habitats of principal importance for nature conservation in Wales is extensive and covers a range of species across the plant, animal and fungi kingdoms. For this reason, and since there is a more complete and up-to-date data set on birds than on other Section 42 taxa, only Section 42 bird species typical of the Cambrian Mountains are listed in Annex 1.

Special Areas of Conservation (SAC):

Elenydd SAC. Habitat features of European importance: blanket bogs, calaminarian grasslands; dry heath; and oligotrophic to mesotrophic standing waters with vegetation of the Littorelletea uniflorae and/or of the Isoëto-Nanojuncetea.

Coetiroedd Cwm Elan/ Elan Valley Woodlands SAC. Habitat features of European importance: old sessile oak woods with Ilex and Blechnum; dry heath; Tilio-Acerion forests of slopes, screes and ravines

Cwm Doethie – Mynydd Mallaen SAC. Habitat features of European importance: old sessile oak woods with Ilex and Blechnum; dry heath.

River Wye/ Afon Gwy SAC. Habitat features of European importance: water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation; Transition mires and quaking bogs. Species features of European importance: White-clawed (or Atlantic stream) crayfish; Sea lamprey; Brook lamprey; River lamprey; Twaite shad; Atlantic salmon; Bullhead; Otter; Allis shad.

Afon Tywi/ River Tywi SAC. Species features of European importance: twaite shad; otter; sea lamprey; brook lamprey; river lamprey; allis shad; bullhead.

Afon Teifi/ River Teifi SAC. Habitat features of European importance: Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation. Species features of European importance: brook lamprey; river lamprey; atlantic salmon; bullhead; otter; floating water-plantain; sea lamprey.

Cors Caron SAC. Habitat features of European importance: active raised bogs; degraded raised bogs still capable of natural regeneration; transition mires and quaking bogs; depressions on peat substrates of the Rhynchosporion; bog woodland. Species features of European importance: otter.

For more information on Welsh SACs please see:
http://jncc.defra.gov.uk/ProtectedSites/SACselection/SAC_list.asp?Country=W

The Special Protection Area to be found in the Cambrian Mountains is the Elenydd – Mallaen SPA which has been designated for its important breeding populations of merlin, a species dependent on heath and scrub habitats for its prey, and red kite. For a fuller picture of the importance of the area for birdlife please see the information on Section 42 species below.

The key areas of SSSI land not designated as an SAC / SPA include:

Pumlumon SSSI: A mountain range site that supports a variety of upland habitats and distinctive plants and animals. Of particular importance are the extensive areas of blanket bog, dry heath and high altitude grassland, as well as mountain lakes, rare plants, including stiff sedge, spring quillwort, dwarf willow and starry saxifrage, rare and scarce mosses and liverworts, and the exceptional variety of upland breeding birds.

Elan Valley Grasslands: A suite of 12 SSSIs particularly noted for their upland fringe hay meadow habitats. They form a key habitat for the Section 42 plant species *Vicia orobus*, and are a Wales Biodiversity Partnership Priority Grassland and Heathland Habitat. The Elan Valley supports some of the richest examples of neutral grassland in Wales, accompanied by equally species-rich acid grassland.

Section 42 bird species breeding in the Cambrian Mountains:

curlew, golden plover, skylark, hen harrier, red grouse, black grouse, ring ouzel.

Annex 2

Recent vegetation survey results from the Cambrian Mountains.

1. Jerram, R. (2005). *Pumlumon SSSI. Survey of National Vegetation Communities and Vegetation Condition.* CCW West Region Report .

This survey was undertaken on Pumlumon SSSI vegetation in 2005. The northern area of the SSSI was dominated by dry heath in generally favourable condition but with locally dominant areas of western gorse (*Ulex galii*). In central areas the mix of blanket bog and dry heath was found to be in favourable condition, with some areas of bog in poorer condition due to dominance of *Molinia* or heather. In the south of Pumlumon SSSI, are semi-natural acid grasslands with some blanket bog and dry heath, and small areas of montane habitat on the summit ridges. Here, the dry heath and montane habitat were found to be in unfavourable condition as was some of the blanket bog.

2. Ardeshir, D. (2003). *Resurvey of fixed plots at Claerwen National Nature Reserve.* ADAS Wales.

This survey compared vegetation plots between 1993 and 2003. The survey found a reduction in the area of bare peat, an increase in brophytes including sphagnum papillosum, and little change in heather (*Calluna vulgaris*) and *Molinia*.

3. Luxton, K.-J., & Facey, R. (2006). *The state of commonland in Wales - an indicative study.*

This survey used CCW monitoring standards methodology and was undertaken on Abergwesyn Common in north Breconshire. On this common, the principal conservation interest was identified as being in the areas of blanket bog. In the areas of bog surveyed the habitat was found to have a restricted species compliment compared to blanket bog in good condition and was described as severely degraded. At the site level the area was described as being dominated by fairly rank *Molinia* with suppressed heath and areas of eroding and drying peat hags.

4. Chambers, F., Mauquoy, D., Cloutman, E., Daniell, J., & Jones, P. (2007). Recent vegetation history of Drygarn Fawr (Elenydd SSSI), Cambrian Mountains, Wales: implications forconservation management of degraded blanket mires. *Biodivers. Conserv.* , 16:2821–2846.

A site survey around Drygarn Fawr in the southern Elennydd area. For the 1-km square in the sampling site the vegetation was described as largely blanket bog (86.5%), represented by an impoverished form of the *Molinia*–Potentilla erecta mire community that is now dominated by *Molinia*.

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