UK National Ecosystems Assessment

2nd Draft Economics group report

Mountains, Moorlands and Heaths

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Executive Summary

1. Mountain, Moorlands and Heaths (MMH) habitats cover much of the uplands of the UK. The specific habitats covered by this report are *Bracken; Dwarf shrub heath; Bog; Fen, marsh and swamp; Montane* and *Inland rock.* During the last 20 years, MMH is estimated consistently to cover about 18% of the UK. Its distribution is strongly biased towards Scotland where it makes up 43% of the land surface area, against 12% in both Wales and Northern Ireland and only 5% in England. Falls in Dwarf Shrub Heath have been noted for Scotland over the period 1990-2007 from 1,007,000ha to 894,000ha; however, the area of bog increased over this time.

2. Most important recent pressures for change in MMH habitats are livestock grazing, forest planting, air pollution, and grouse moor management. These factors have impacted on both the size of MMH habitats and their ecological quality. Both quality and quantity "matter" from the perspective of ecosystem good provision.

3. The main ecosystem services covered in this economics report are the following:

- Livestock Products
- Game
- Peat
- Drinking Water and Pollution Treatment
- Natural Hazard Mitigation
- Biodiversity
- Landscape values (cultural heritage) and
- Carbon

However, some of these are not covered in much detail, since they are the subject of cross-habitat thematic economics reports; or because of lack of data. Many of these services are, in fact, produced from multiple habitats including those out-with MMH. Good examples include sheep farming (carried our across a range of upland habitats) and red deer (dependent on MMH, grasslands and woodlands). Moreover, all of the ecosystem service flows depend in terms of both quantity and value on how land is managed: for example, on grazing intensity, or the degree of heather burning on grouse moors. Moreover, many MMH habitats are particularly dynamic, and can transition to other habitat types dependent on management.

4. **LIVESTOCK:** the value of sheep and cattle grazing. The uplands have traditionally been used to produce "store" lambs and cattle for sale to lowland farmers who then fatten stock for market. In Scotland, livestock trade from the uplands to lowlands can be documented back to the 12th century. Sheep and cattle production depends on inputs such as grazing from upland landscapes out-with of MMH. Cattle numbers peaked around 1979, sheep numbers peaked around 1988; both are now falling. These changes reflect changes in the CAP. Real prices have fallen since 1949, although there have been some periods of increasing prices, one such increase was seen between 2004 and 2010.Gross margins also fell over the recent past, although rose for sheep last year. The values of livestock in Great Britain for 2004 (latest year for which population data for MMH is held) is found to be in the region of £72 million for cattle and £161 million for sheep. We produce a range of forecasts for future sheep and cattle numbers on "typical" upland farms under a range of scenarios based on the Foresight exercise.

5. **GAME:** Management of MMH for grouse shooting has been very influential in determining the appearance of parts of the UK uplands, and in determining the flow of a range of ecosystem services. Heather burning and raptor control are two management activities which are particularly important. Moorlands have been managed as "sporting estates" since the early 19th century. Data from the national gamebag census show a long term decline in grouse abundance and bag density since the 1930s. Current prices are around £130 for a days driven shooting, and a greater % of estates (43%) make a profit on grouse shooting compared to 2001, due to a real increase in the price per brace. However, many estates are mainly shot by owners, whilst a majority run at a loss. FAI (2010) estimate Gross Value Added for all grouse shooting in Scotland, based on a number of "grossing up" assumptions. For direct spending alone, this amounts to between £5.6 and £12.2 million in 2009. Red deer numbers are uncertain, with somewhere around 50,000-70,000 culled annually. No firm data are available on the annual value of this service flow, but one estimate from 2004 puts it at over £24 million/yr. In addition, culling of hinds and stags by estates (ie shooting undertaken by estate workers for population control purposes) generates around £5 million per annum in revenues.

6. **Peat production.** Peat is extracted from MMH for supply to gardeners and horticulturalists. UK production has fallen from about 1.8 million m^3 in 2001 to 0.94 million m^3 in 2009, with a target set of phasing out production for use in gardening products by 2020. In 2009, the value of peat extracted was around £9.4 million. However, this resulted in the release of about 400,000 tonnes of CO2, which is has an external costs of around £20 million using a carbon price in 2009 of £50/tonne.

7. **Water Quality.** The UK uplands are locations for collection and storage of drinking water supplies. However, it is not clear that the economic value of drinking water can be attributed to MMH habitats in any sensible way. Management of peatlands is, however, related to water colouration issues. Colour problems due to DOC run-off have increased over the last 20-30 years. The practice of moorland gripping may have contributed to this problem. Avoided cost calculations can be made of the benefits of reducing colouration problems by blocking drains. These will vary on a catchment-to-catchment basis. One study showed benefits from avoided costs of treatment were around £5 million over 10 years. MMH habitats also assimilate air pollutants such as SO2 and NOx, but no economic value estimates were found for these services.

8. **Flood risks.** How MMH landscapes are managed can impact on downstream flood risks, although the ability of peatlands to act as buffers in this way is often over-stated. No estimates could be found either for individual catchments or for the whole country of the economic values of changes in flood risks due to changes in management of MMH habitats.

9. **Wild Fire risks.** MMH management also has implications for wild fire risks, for example where cessation of grazing allows scrub vegetation to re-colonise raised bogs or lowland heathland. Changes in fire risks would be site specific and would relate to specific management actions or exogenous factors such as drought. No economic value estimates could be found for MMH.

10. **Carbon.** Carbon sequestration values are being covered by a thematic economics report. The Science Group report for MMH shows how important MMH habitats are for the UK in terms of carbon storage: around 40% of UK soil carbon is found within MMH. Changes in carbon flux over time, and changes in future carbon fluxes in MMH, are clearly of great potential significance. However, no figure is available from the science group report for

either the amount of carbon currently stored in MMH alone, or the current amount of net sequestration/emission for MMH.

11. **Cultural heritage values.** As the Science Group report makes clear, upland landscapes have a high degree of cultural importance in the UK. In economics terms, both use and non-use values have been shown to exist for upland landscapes. However, MMH form just part of these landscapes. Recreation (use values) and landscape values are being dealt with in separate thematic economic reports for the NEA. However, we make three points here. First, whilst a range of recreation values exist for upland activities, these are often not specific to MMH habitats. People's perceptions of upland landscapes, and thus their willingness to pay for maintenance of these landscapes, are not unique to MMH either, but may include other components of the upland landscape, such as rough grasslands and woodlands. Second, there is likely to be a high degree of heterogeneity in cultural values for MMH even when these can be identified (some evidence is presented in the main body of this report). Finally, figures for the number of recreation trips specifically to MMH are not available, with the exception of an estimate of 159,888 skier days in Scotland in 2008-9 implying an annual value of around £3.9 million. The number of skier days per year though is very much weather-dependent: unofficial estimates for last winter show an increase to 373,382 skier days, on the back of a long-term decline since the 1990s.

12. **Biodiversity.** Again, biodiversity is being covered by a separate thematic report. However, we note here the great importance of MMH to biodiversity conservation in the UK, and report on a number of simulations of changes in biodiversity related to upland farming within MMH under a range of future scenarios.

13. **Trade-offs and synergies:** There are many examples within MMH of management actions designed to increase the supply of one ecosystem service having either positive or negative impacts on other ecosystem services. The table below, commented on in the main text, summarises these connections.

Trade offs (-) and Synergies (+) between ecosystem service flows from MMH habitats.

Increase in➔	SC	DG	PE	DWQ	CSS	CLT	BIO
Sheep/cattle		-	-	?	?	- or +	- or + dependent on target
Deer/grouse	-		-	?	Reduction in burning, so -	Likely – for grouse	As above
Peat extract.	-	-		-	-	-	-
Drinking water quality	- (possible)	-	-		+	+ or -	?
Flood risk	+	?	-	-	?	?	?
Fire risk	-	-	?	?	-	? but perhaps +	Perhaps +
Carbon store/seq.	- (possible)	-	-	?		+	+
Cultural	+ or -	+ or -	-	+	+		+
biodiversity	Likely – in most cases	Depends on species	-	?	+	+	

14. KEY: SC = sheep/cattle; DG = deer/grouse; PE = peat extraction; DWQ = drinking water quality (colour); FLR = flood risks; FIR = fire risks; CSS = carbon storage or sequestration; CLT = cultural values (landscape aesthetics); BIO = biodiversity as measured by birds. A + for FLR is an increase in flood risks; a – for FIR is a fall in wild fire risks.

1. Introduction, Status, Drivers and Trends

This document aims to identify the economic values associated with ecosystem services for the Mountains, Moorlands and Heaths (MMH) habitats. These habitats are:

Bracken, *Dwarf shrub heath*, *Bog*, F*en, marsh and swamp*, *Montane* and *Inland rock*

During the last 20 years, MMH is estimated consistently to cover about 18% of the UK. Its distribution is strongly biased towards Scotland where it makes up 43% of the land surface area, against 12% in both Wales and Northern Ireland and only 5% in England. Table 4.1 in the Science Group Report shows how the area of each of the different habitat types within the MMH class have changed over time. In 1998, the last year for which consistent data are available, MMH habitats in total covered 25 million hectares of land in the UK.

The report firstly lists the services that are to be valued (as identified by the Science Group Report) then presents some of the issues with identification of values for this landscape. For each service there then follows a section which gives details of the marginal prices, quantities and values associated with the services (or information about data or theoretical issues which have prevented such values from being presented here). In addition each section identifies any risks of double counting of service values and possible future drivers of changes to marginal prices.

MMH habitats are often "produced" by interactions of natural conditions (geology, topology, altitude, climate) with human management actions. This is most obviously the case for heather-dominated moorlands, which have been "produced" with the joint objectives of game and agricultural outputs. Lowland heaths are also the result of intentional management for livestock grazing. Reductions or cessation of grazing of such areas can cause transitions to other habitat types e.g. scrub woodland. Such transitions impose social costs in the form of loss of wildlife species and landscape qualities associated with lowland heaths or upland heather moors.

As the Science Group report on MMH makes clear, MMH areas in the UK are subject to a number of pressures, including forest planting, over- and under-grazing and atmospheric pollution. Box 1 below summarises present, past and future drivers of change. These pressures also impact on the ecological quality of MMH. The Science Group report also contains evidence on changes in MMH extent over time. Losses of MMH speed up after WW2, although this has by no means been a uniform picture, and has slowed down in last 20 years. For example, a rise in dwarf shrub heath is noted for England and Wales 1998-2007, whilst there has been some substitution across habitats within MMH. Scottish Natural Heritage estimate that the extent of heather moorland (falling into both Bog and Dwarf Shrub Heath classifications) in Scotland declined by 15%, from 19% of land area in the 1940s to 15% in the 1980s. Lowland heath has primarily been lost due to development of towns and roads, afforestation and agricultural improvement; the extent today is around 20% of that of 1900.

Box 1: Drivers of Change in MMH

- Livestock numbers – these depend on world market prices for inputs and outputs, on changes in agri-environment and CAP and on world trade agreements
- Acidification/eutrophication from air pollution. Over the past two decades acid deposition in the UK has declined by over 50% (although still have many areas of MMH which exceed critical loadings), whilst N deposition has "not fallen as expected".
- Forest planting. Depends on development of carbon markets, UK forest policy, world timber prices, land prices, alternative rates of return.
- Demand for shooting: this depends on international market forces and the economics of sporting estates. Climatic impacts are also expected on deer/grouse populations.
- Catchment management issues
- Wind farm economics and planning policy

2. What ecosystem services are relevant for MMH?

The Ecosystem Services for MMH habitats which are reviewed in this chapter are:

- Livestock Products
- Game
- Peat
- Drinking Water and Pollution Treatment
- Natural Hazard Mitigation

- Biodiversity
- Landscape values (cultural heritage) and
- Carbon

Unlike many of the ecosystem services derived from other UK landscapes, areas of MMH have significant issues of *driver-service interactions* which somewhat complicates the identification of value. Many of the landscapes are specifically managed for biodiversity, recreation or indeed non-use values such as landscape characteristics. As can be seen in the Science Group Report a large proportion of National Parks, SSSIs and other designated sites are located in MMH or include areas of MMH. However, the public's perceptions of MMH tend to be tied into different landscape categories such as "the hills" which can make it difficult to identify values for the specific habitats which make up MMH, since the value attached to "hill landscapes" incorporates habitats which encompass several NEA groupings. Whilst large sections of society make very limited actual use of these (typically) remote and 'wild' landscapes these landscapes play an important role in the cultural identity of the country. Lowland heaths, in contrast, may attract relatively high use values. Membership of organisations like the John Muir Trust and social action going as far back as the mass trespass on Kinder Scout highlight the importance of the traditional use of areas in and around MMH to the population of the UK. These social movements formed an important basis for the National Park movement in the UK. It is of interest that first national parks to be designated in both England and in Scotland (the Peak District and Loch Lomond and Trossachs National Parks respectively) are located close to major population centres, suggesting the importance of MMH landscapes to the urban population of the UK.

MMH habitats are dynamic. Recent management changes in the uplands of the UK may impact on the areas defined as falling into the MMH type. There has been recent emphasis on "re-wilding" and planting of native forestry, with burning and grazing regimes being changed to allow an increase in the cover of woodland in these landscapes. This implies that the area of MMH may be reduced in the light of these changes, with some areas becoming part of the forestry ecosystems which are considered elsewhere within the NEA. This should be considered in analysis of changes to ecosystem services and their values. Changes in grazing and burning pressures can, over time, change MMH habitats into rough grassland habitats, through the replacement of heather with grass species. What counts as MMH is thus partly a function of current and future land use.

We now proceed to a listing of ecosystem services and values.

2.1 Provisioning Services

2.1.1 Livestock products

The main products or outputs being valued here are cattle and sheep (typically store lamb production). The main recent trends have been a reduction in stocking density of sheep in particular as payments to farmers have been decoupled from livestock numbers. Such reductions have taken place, however, in the context of large increases in sheep numbers over the preceding 50 years (Dallimer et al, 2009). The main drivers in change in marginal values are likely to be world market price fluctuations, whilst future agri-environmental payment schemes and core agricultural support policy in the LFA post-2013 will be key determinants of variations in the volume of output.

Moor and Heathland habitats are semi-natural landscapes with a level of grazing or burning required to prevent the natural transition to woodland habitats. Mountain habitats are often unlikely to see this kind of transition due to geophysical and climate constraints[1]. However, these same constraints see limited use of these habitats for agriculture as they are incapable of supporting livestock in isolation from connected systems e.g. for the supply of winter fodder. Whilst in some moor and heath locations livestock products are pure ecosystem service values (with the management being focussed solely on maximising revenues from agricultural ventures) in other cases they can be considered as a by-product of management for the provision of other services (for example, the maintenance of low intensity cattle grazing in the Burren (Co. Claire, Ireland) to maintain recreational access).

It is common in areas of MMH for agricultural activity to be based on land management by tenant farmers or crofters, with land owners focussing on management for shooting and hunting. However, the rights of tenant farmers and (in particular) crofters[2] have often allowed them to act in ways which the landowners may not have considered to be optimal in maximising Game output

[1] Climate change may lead to some shifts in the altitudinal constraints to certain species assemblages which may see a reduction in the areas of mountain habitats with a gradual transition to moor, heath and forestry.
[2] That is not to say that "farmers" do not own land, most of the agricultural enterprises which graze MMH landscapes will own some of the holding but this tends to be land at lower level in valley bottoms with grazing also taking place on the higher moors and heath land where grazing is rented.

from the landscape. The level of economic interaction in decision making and past over-stocking has been an issue in the hind cast and may continue to be an issue into the future. However, much of this overstocking and overgrazing is likely to have been a by-product of the manner in which subsidy payments were made in Less Favoured Areas under the CAP until recently (headage payments related to stock numbers). Since 2004 a process has been underway to decouple the payments received by upland farmers away from stock numbers and towards management of the landscape. This shift in the payment structure for agriculture has had an impact upon the gross margins from agriculture enterprises and impacts upon stocking densities in these landscapes, as can be seen in Figure 1 for Scotland, and in Table 1 and Table 2 for England.

A recent DEFRA report identified that there has been a fall in grazing livestock numbers since 2004 in LFAs in England (more so than in lowland agricultural habitats): *"Over this period in the LFA, the number of breeding ewes has fallen by 12%, beef cows by 13%, dairy cows and the number of other cattle and calves by 11%" (Defra 2010)*. Obviously this information relates to LFAs generally and not specifically to MMH habitats, although the report also identified impacts had been hardest felt in MMH areas e.g. the North York Moors, South West Moors and parts of the South Pennines. Indeed 99% of MMH land cover has LFA status (Science team report) so such figures are relevant as an indication of what has been happening in MMH areas, although are likely to present an underestimate of the impact (RSE 2008).

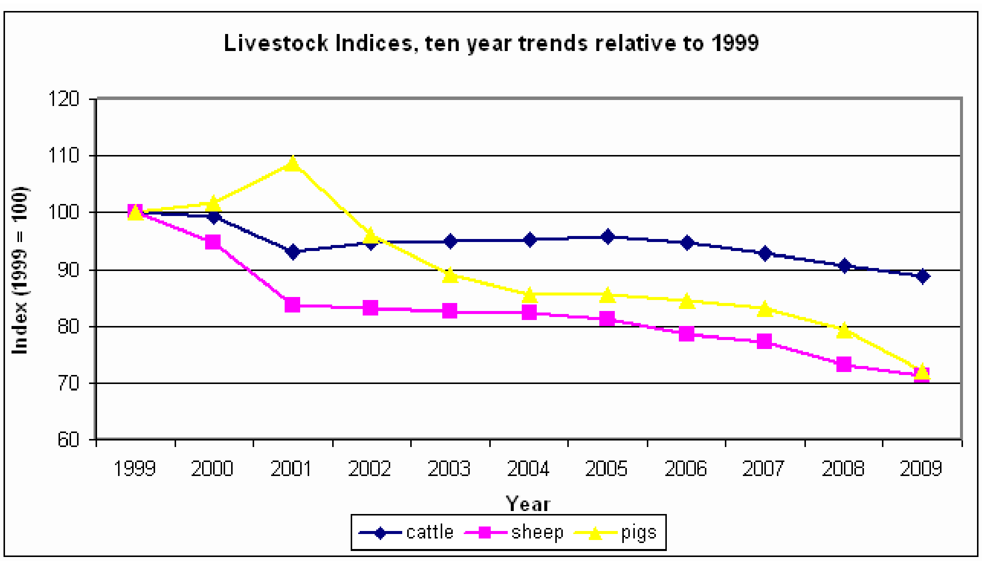


Figure 1 – Livestock numbers over last 10 years in Scotland. Source: Scottish Government

Table 1 Historical trends in the total cattle attributable to MMH by Government Office Region

Total Cattle					
	1969	1979	1988	2000	2004
North East	24923.07	26158.92	23745.25	8441.75	7381.61
NorthWest	44310.79	44238.53	43504.43	21220.97	17295.57
Yorkshire and Humber	47285.83	54066.02	48519.94	21276.34	18310.73
East Midlands	8975.29	9386.16	7855.11	6053.2	5856.62
West Midlands	14767.84	15649.3	13805.97	9422.12	9021.61
Wales	48836.97	48980.15	44520.16	31309.52	27597.13
East	1080.8	1112.72	666.96	211.72	258.7
South East	12085.26	13214.04	8866	5837.4	4592.81
South West	30794.33	34797.61	31668.38	20804.42	18597.12
London	51.98	68.43	53.28	10.57	9.62

Table 2 Historical trends in the total sheep attributable to MMH by Government Office Region

Total Sheep					
	1969	1979	1988	2000	2004
North East	179551	219284.3	300747.7	223537.6	196551.3
NorthWest	259521.6	282168.7	439459.8	348146.7	284354.5
Yorkshire and Humber	211235.5	273186.1	378428.4	263717.8	307331.6
East Midlands	27823.7	38657.36	55602.5	26716.44	40179.29
West Midlands	48830.8	64324.29	83894.88	64724.42	67520.14
Wales	544564.3	680895.9	866029	683804.7	858238.2
East	548.55	554.61	868.47	857.42	636.21
South East	9920.34	13421.7	21787.18	17140.36	14740.95
South West	54596.8	63077	91731.07	61586.48	61626.79
London	0	112.19	157.43	16.43	0.36

Regional variations in trends over time can be seen in Tables 2 and 3.

Figure 2 Trends in cattle numbers by region in MMH habitats

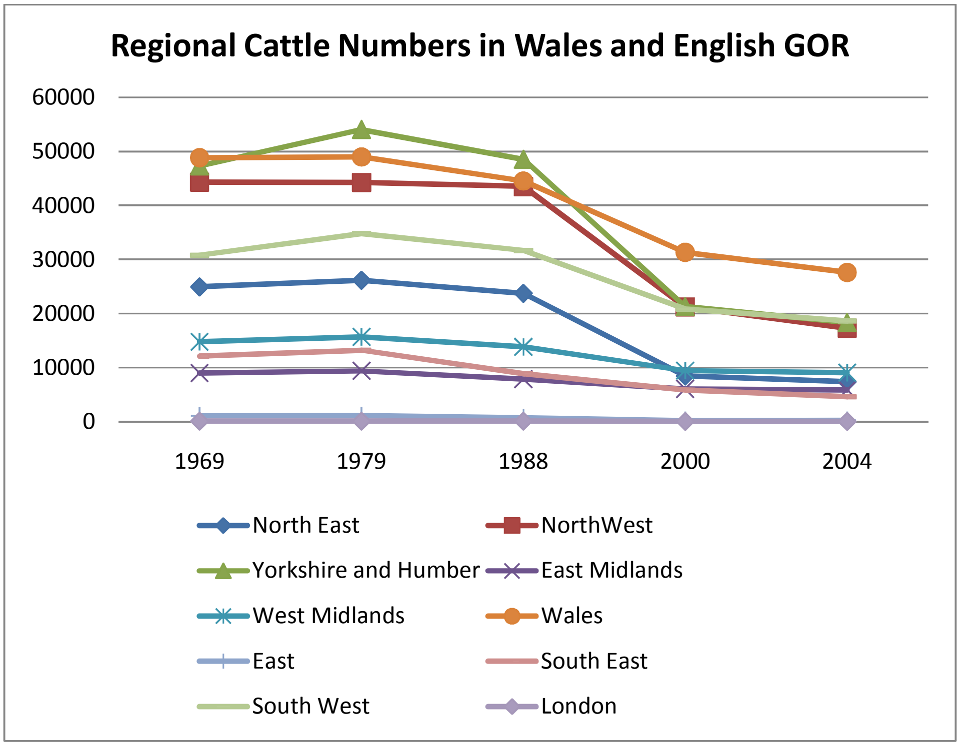
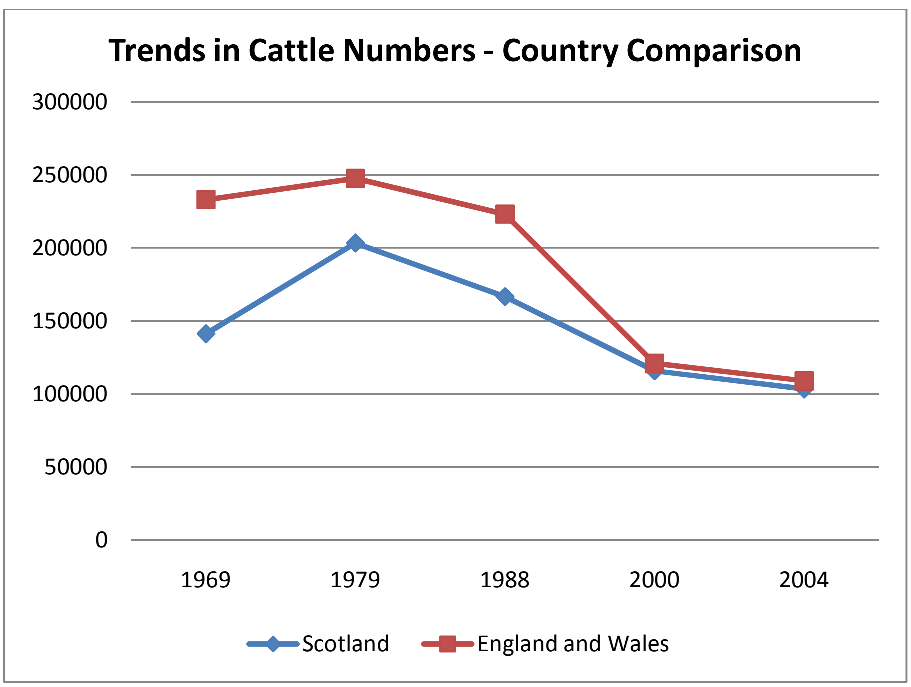


Figure 3 – Trends in Cattle Numbers in MMH



As can be seen a similar trend has been observed in all regions with a decline in the numbers of cattle being reared in recent years (the decline being most pronounced in the North of England: North West, North East and Yorkshire and Humber GOR). Since 2004 the potential of cattle for landscape management has been identified so there is a possibility that in some areas an increase in cattle numbers may have been witnessed, predominantly with native breeds to replace sheep grazing and allow a natural regeneration of landscapes.

Figure 4 – Trends in sheep numbers in MMH (source: Edina)

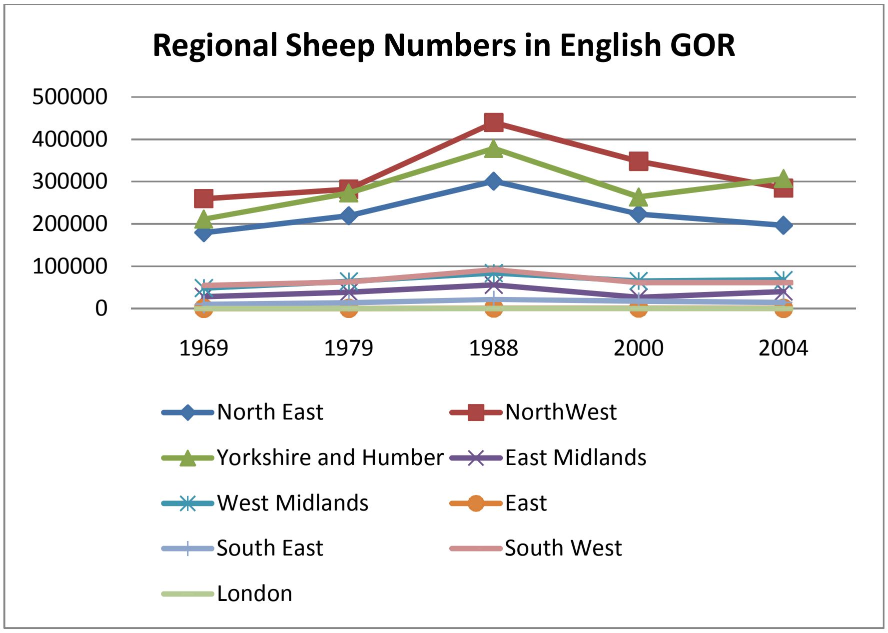
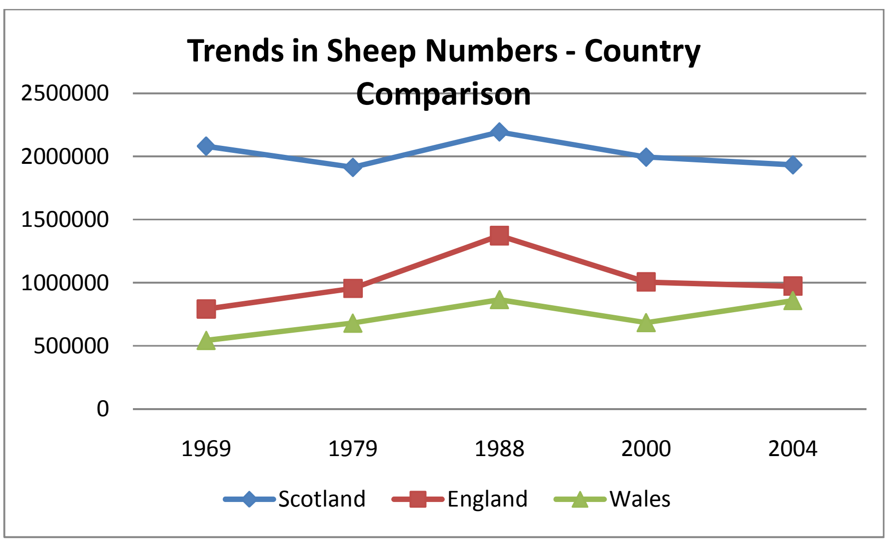


Figure 5 Trends in Sheep numbers



Figures 4 and 5 give similar information for sheep, and identify the importance of the subsidy structure for the stocking levels of sheep in all regions. Again a consistent trend can be seen for all regions and countries with a peak in sheep numbers in the late 1980s and early 1990s. This reflects the 'MacSharry' reforms to the CAP in 1992 which introduced set aside land and payments to reduce stocking densities; in addition these reforms reduced the level of support for beef by 15% which relates to the trends seen in figures 2 and 3 above. In 1999 'Agenda 2000' reforms further reinforced the need to consider the environment in agricultural decision making with the requirement of all EU states to introduce Agri-environment schemes.

Changes in prices and profits

Table 3 gives some recent historical data on changes in Gross Margins (revenues minus variable costs) for sheep and cattle relative to deer, whilst Table 4 shows the variation across sub-types and regions for sheep: geographical factors will often determine which of these types MMH habitats support.

Table 3. Gross Margins 2004 – 2010 (2010 Prices)

	2004 – 2005 Gross Margins without subsidies (FMHB)	2007 -2008 Gross Margins without subsidies (FBS)	2010- 2011 Gross Margins without subsidies FMHB
Sheep*	£153.08 per ha	£54.15-92.06 per ha	£129.51 per ha**
Cattle***	£ 1.19, -5.93, 33.23 per cow Feb-Apr, May-June, Aug-Oct	NA	£90, 175, 257 per cow Feb-Apr, May-June, Aug-Oct
Deer (farmed not hunted)	£297.86 per ha selling calves, £1113.12 per ha finishing stag calves.	NA	NA

*Upland – crossbreed ewes ** Assumed grazing density of 3 head per ha. *** Differences between 2004 and 2010 relate in part to subsidy structure, in 2004 more subsidy was paid related to stocking densities so was factored into calculations (without subsidy) but in 2010 the single farm payments and LFA payments are no longer directly relate to stock levels or gross margins so cannot be factored into gross margins data. The Farm Management Handbook no longer provides data for farmed deer due to variability across enterprises and the Farm Business Survey does not report margins for upland / MMH cattle or deer enterprises.

TABLE 4 Regional analysis for sheep per tupped ewe, Gross Margins Subsidies (2010 prices)

Region	2004-05	2010-11
Blackface NW & W Highlands	£-4.59	£1.37
Blackface Grampian & S Uplands**	£9.36	£24.26
Cheviot North	£7.97	£20.07
Cheviot Borders**	£13.90	£29.84

**Overwintered on farm.

Table 5 Historical trends in prices of sheep and cattle per head values (Taken from Agricultural Statistics for Scotland) (2010 Prices).

	1949	1959	1969	1979	1988	2000	2004
Cattle	£1525.25	£1318.51	£838.24		£868.79	£325.53	£339.52
Sheep	£210.71	£158.82	£78.99	£143.01	£68.51	£29.97	£42.82

Table 5 shows the variation in prices for cattle and sheep across the hindcast with declines in real prices seen up until 2004 although there has been some rise in prices between some periods analysed the overall trend is one of falling prices. Table 3 and 4 look at the more recent past and identify some of the gross margins as reported from agricultural compendiums such as the Farm Management Handbook and Farm Business Survey and show how these margins have changed over the period since 2004. As can be seen 2009 to 2010 has seen higher prices for some livestock products: for example, the gross value of revenues to store livestock production in Scotland rose from £52 million in 2004 to £84.5 million in 2009. Given the changes to the way in which agriculture is funded, the current baseline is an unstable one subject to changes annually, as the structures which promote agricultural activity alter.

Total Value of Livestock in the MMH

The available data allows analysis of the total value of livestock in the MMH but places a constraint, in that population data related to this habitat type is only available up until 2004. The price data used is that presented in table 5 above so the issues inherent in the 2004 data of changes to agri-environmental schemes subsidies should be taken into account in considering the results presented below in Table 6.

Table 6 Total Value of Livestock in MMH landscapes in 2004 (2010 Prices)

Country	Cattle	Sheep
England	£27,611,257	£41,661,338
Scotland	£35,105,068	£82,787,428
Wales	£9,369,778	£36,749,758

Forecasts for the Future

Future changes to agricultural support structures are unclear post 2013. The *Foresight* project has analysed a range of scenarios, the outputs of which have been used to predict changes to management, stocking densities and gross margins for various agricultural outputs on MMH landscapes. To illustrate the effects of possible future changes on the volume and value of livestock output, we use a series of farm management models for the Peak District: further analysis for other areas of MMH would be possible given additional funding. The scenarios outline 4 possible changes world market conditions and prices for inputs and outputs (Hanley et al, 2010a). The "world markets" scenario places emphasis on private consumption with no support from the government for agriculture (or the environmental outcomes from farming). The "Global Sustainability" scenario focuses on social and environmental issues. The "National Enterprise" scenario is similar to the world markets in most regards but allows for greater national protectionism. Finally the "Local Stewardship" scenario places emphasis on social values and conservation of the natural resources and the environment. Table 7 outlines the impacts of the various scenarios on subsidies, input prices and output prices whilst Table 8 identifies the impacts on various types of MMH agricultural enterprises in terms of gross margins, stocking densities and land use / abandonment. In each of these tables a status quo (present) scenario is also presented which reflects the current outputs of livestock services from these landscapes.

Table 7 Relative values associated with policy scenarios.

		Future Scenarios			
	Present	World Market	Global Sustainability	National Enterprise	Local Stewardship
Regulations					
Headage Payments	0	0	0	100	0
Single Farm Payments	100	0	87	0	154
Agri-Environmental Schemes	100	0	100	0	100
Input Prices					
Fertiliser	100	80	151	136	147
Labour (wage)	100	135	147	100	90
Technology	100	73	87	94	94
Feed	100	76	154	96	202
Output Prices					
Meat Prices	100	80	90	111	134

Possibly of most importance to the identification of the ecosystem service value of livestock production in MMH is the World Market scenario given it removes any form of subsidy (transfer payments). In this scenario both types of agricultural enterprise see a reduction in gross margins per ha and a reduction in the land used for agriculture (particularly for sheep). Sheep numbers fall considerably. Abandonment of agricultural use of MMH would result in transition of the landscapes (in the long run potentially to forestry). In contrast, a “National Enterprise” scenario would see increases in both sheep and beef numbers, due to the restoration of headage payments. This makes clear the influence of future policy choice on ecosystem service provision.

Table 8 Moorland farm types: Impacts on Management per ha

Moorland Sheep

			Future Scenarios			
Management Variables	Unit	Present	World Market	Global Sustainability	National Enterprise	Local Stewardship
Total Gross Margin	£/ha	100.38	13.11	78.97	83.73	140.27
Sheep	Nos/ha	1.79	1.10	1.32	2.33	1.79
Beef	Nos/ha	-	-	-	-	-
Dairy	Nos/ha	-	-	-	-	-
Livestock Units	Nos/ha	0.27	0.17	0.20	0.35	0.27
Land Used	ha/ha	1	0.58	0.82	1	1
Land Fallow	ha/ha	0	0.42	0.18	0	0

Moorland Sheep & Beef

			Future Scenarios			
Management Variables	Unit	Present	World Market	Global Sustainability	National Enterprise	Local Stewardship
Total Gross Margin	£/ha	77.56	13.43	58.53	95.28	123.11
Sheep	Nos/ha	1.36	0.04	1.11	1.77	1.73
Beef	Nos/ha	0.04	0.15	0	0.15	0.08
Dairy	Nos/ha	-	-	-	-	-
Livestock Units	Nos/ha	0.23	0.12	0.17	0.38	0.32
Land Used	ha/ha	0.86	0.09	0.68	1	1
Land Fallow	ha/ha	0.14	0.91	0.32	0	0

Double Counting Risks: It should be noted that many of the livestock in the MMH will be over wintered outside of MMH habitats, and require associated inputs from in bye land so not all of the gross margin can be attributed to the MMH landscape. The value will be shared between MMH, Semi Natural Grassland and Agricultural landscape areas as identified in the UKNEA. The exact distribution of values is difficult to identify and there is a risk of double counting of this value which should be taken into account when considering aggregating values across habitats.

Likely drivers of future change in marginal prices: The marginal prices for livestock are likely to be impacted more by the global market prices for livestock than was the case in the hind cast given the current decoupling of agricultural subsidies from livestock numbers. With further changes in the funding of agriculture within the EU likely, issues of abandonment and transition of landscapes may also be relevant. Taking the estimates coming out of the Foresight project we can see that world market prices are expected to fall in a status quo baseline although future policy changes towards local stewardship may lead to local increases in prices in the UK. As discussed above additional feed and overwintering (or fattening) on lowland areas and inputs from in bye land may impact on the gross margins of these agricultural enterprises. Estimation of these impacts is not possible for MMH alone since returns from livestock farming in MMH have always been profoundly impacted by land use in the lowlands.

2.1.2. Game

> **The main products being valued are grouse shooting and deer stalking. Main trends are related to seasonal impacts (and to some extent the life cycle of pest species such as ticks). The marginal prices for these services are typically set in global markets where they compete against other high quality country sports in other countries.**

The maintenance of semi-natural landscapes in MMH is in no small part a function of the management of these areas for shooting and hunting. Many upland estates are mixed use, providing potential for grouse shooting and deer stalking as well as pheasant and partridge shooting and fishing. In 2002 the Countryside Alliance identified that country sports were the fifth most popular leisure and recreation activity in Britain by participation. Total direct expenditure is estimated to exceed £3.8 billion annually although this is dominated by fishing which accounts for almost 2/3 of this expenditure and is being considered by another group within the UKNEA.

Burning of moorland to encourage increased grouse numbers is a critical element of management in large areas of MMH (refer to figure 4.13 in Science Group Paper). The grouse shooting available in the UK is considered to be of international merit with the IEEP and others (2004) identifying that it was likely that grouse shooting in the UK operated in high value international markets competing against significant shoots in other countries rather than from shooting of other bird species in the UK. It does not however hold that such shoots are always profitable, and the same report identified that most grouse moors are unprofitable and require subsidisation by land owners although the situation had improved since a 1996 study. Climatic conditions can also impact on the profitability of hunting estates, 2009's harsh winter led to a need to cull deer on estates which is likely to have limited the potential for stalking this year[3].

Deer stalking is dependent upon a mix of habitats upon which the deer rely, meaning that the value associated with this service is attributable to MMH, Forestry and SNG habitat types as identified in the UKNEA framework. Also the general condition of the estates, i.e. the environment within which country sports takes place, can impact on the value to participants (Bullock, Elston and Chambers, 1998). This may however be partly captured elsewhere in terms of the recreational value of the landscape. There is therefore a risk of double counting of benefits which should be taken into account. A wide range of values exist for a day's hunting in different areas of the country and on different estates. The premium paid on different estates could be used to enable a travel cost or hedonic analysis of the value to participants. Such analyses have been carried out elsewhere, but that analysis was out with the scope of the current research, as it would require primary data collection. Grouse populations and bag sizes have fluctuated over time, as Figure 6 below shows:

[3] Unpublished research based on information from the Glen Tromie Estate in the Cairngorms National Park.

Figure 6 Index of grouse abundance on the basis of the national Gamebag Census. source: Aebischer and Baines (2008).

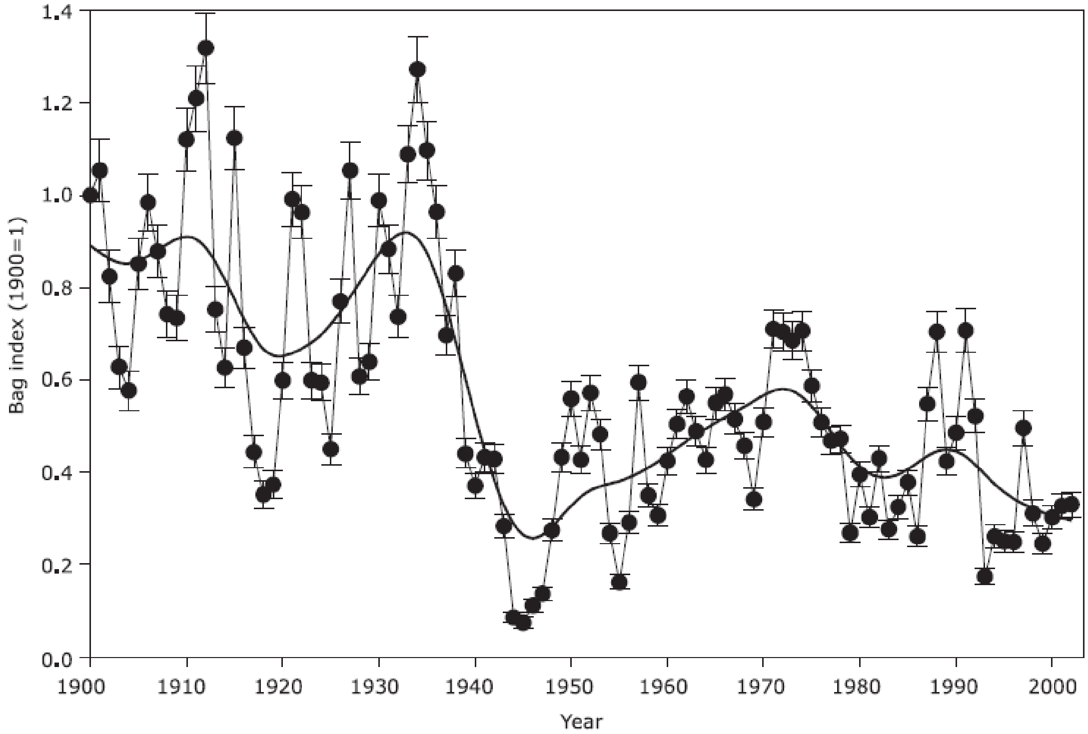
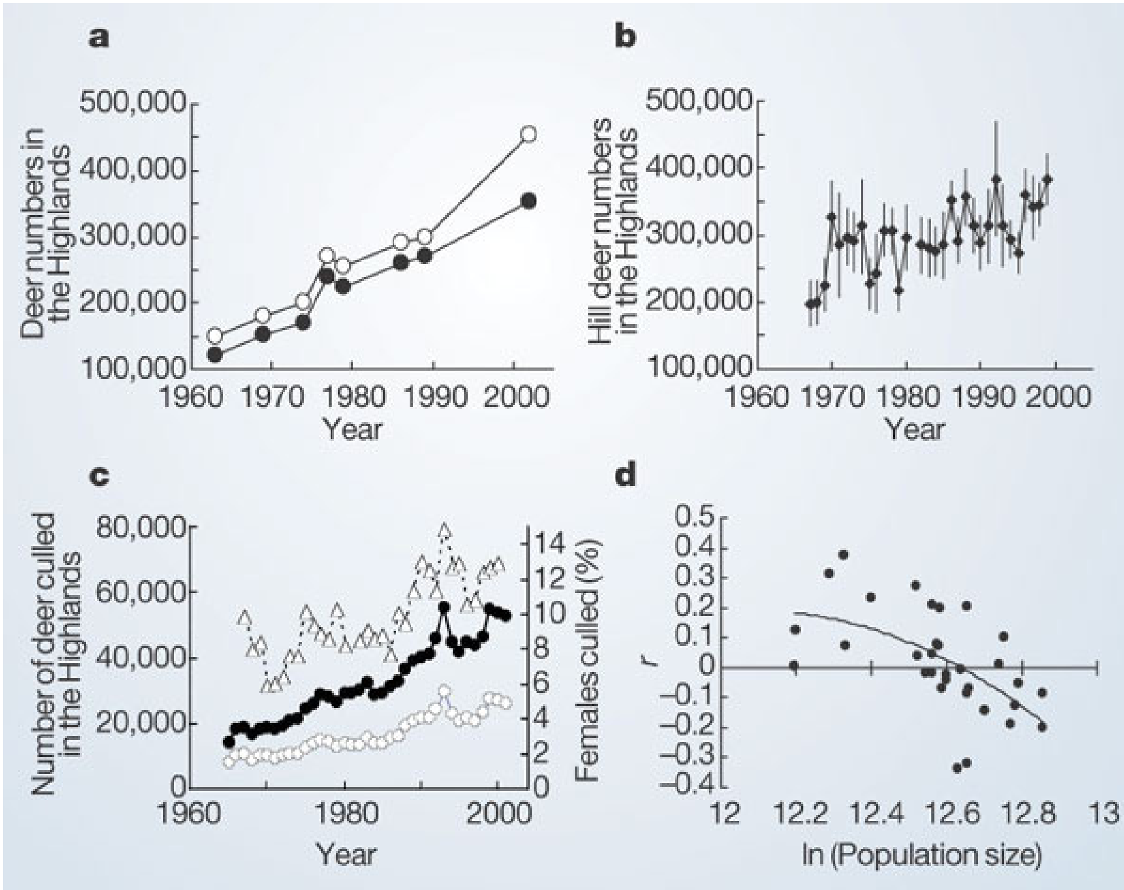


Figure 4. Red Grouse index of bag density from the GWCT's National Gamebag Census, 1900-2002 (data from 495 estates). The thick line represents the long-term trend, while the error bars indicate ± 1 s.e.
Índex de densitat de captures de la Perdiu d'Escòcia a partir de les dades del Cens Nacional de Caça 1900-2002 (dades de 495 finques). La línia gruixuda representa la tendència a llarg termini i les barres indiquen ± 1 e.s .

Figure 7 shows data for deer populations, also taken from the Science Group report.

Figure 7 The number of red deer in the highlands of Scotland: From Clutton-Brock et al. (2004).



WWF/RSPB estimates of total red deer in Scotland[4], including (hollow circles) or excluding (filled circles) an arbitrary increase in the estimated number of woodland deer by 70,000 in 2002 (from ref. 4); **b,** total hill deer numbers estimated from a multiple regression model[6] and corrected for year of count, showing 95% confidence limits; **c,** estimates of annual numbers of adult females (hollow circles) and all deer (filled circles) culled and of the annual culling rate (per cent) of adult females (triangles); **d,** estimates of annual population-growth rate (r) of hill deer, plotted against population size in the following year, using data shown in **b**. The plot indicates that population growth is density-dependent and that r=0 at a population size of 310,000–315,000, given the existing culling regime.

Given the available data, market prices provide the best opportunity for valuing field sports in the MMH. Table 9 gives details.

Table 9: Value of grouse shooting days – taken from FMHB, Advertised Prices and The Economic Study of Grouse Moors (Fraser of Allander Institute, 2010).

Price per brace	Advertised Market Prices 2009 / 2010	Report Sample 2005 -2009	Report Sample Prices 2009	Reported Prices 2000	Reported Prices 1994	Reported Prices 1989
Grouse Driven	£90-120	£105.09	£130.95	£127.91	£107.80	£124.19
Grouse Walked Up	£50-75	£58.50	£71.24	£70.48	£64.68	£55.88
Grouse over pointers	N/A	£18.53	£32.34	£70.48	£72.38	N/A

Grouse bags are reported as having declined by 50% in Scotland since 2000 (FAI, 2010), whilst the real value of a brace shot has increased over the same time period. Comparing 2000 data with 2009 data, FAI (2010) show a substantial increase in the percentage of estates making a profit on grouse, from 17% in 2001 to 43% in 2009.

In 2009 grouse were driven 41% of the time, walked up 33.9% and shot over dogs 11.7% of the time, with 713 total days shooting[4] on surveyed estates and a total bag of 29,096 (85% of which were driven). In 2005-09 an average 35.2% were driven, 43.7% walked up and 9.8% shot over dogs with 576 days and an average bag of 32,654 (71% of which were driven) (FAI 2010). This equates to approximately 1 days shooting per 1000ha of land managed for grouse shooting and a value of £2.38 per ha in 2009 based on bag (£90 - £130 marginal price assumed) and £3.42 per ha averaged from 2005-2009 for driven grouse (although this is based on Scottish Data the per ha values should be approximately representative for shooting in the rest of the UK). However, it should be noted that this may represent an inaccurate estimation of value as 35% of grouse shooting is undertaken wholly by owners, implying that a third of the grouse bag is not marketed. Whether the owners have a relatively higher or lower marginal utility than the people to whom shooting is let may impact upon the actual value for this service. However, it seems an appropriate assumption that prices will be equivalent to the marginal utility for these individuals as the price signal will determine their actions (i.e. whether to shoot more themselves or let more to others). As an aside, the fact that only 45% of grouse estates currently make a profit could be related to a significant

[4] Based upon responses from 81.5% of estates involved in grouse shooting factored up to 100% (totals for those estates surveyed 581 days in 2009 and 470 days average 2005-09). Requires several simplifying assumptions.

proportion of value from this ecosystem service **not** being reflected in market prices, and as such not entering the accounts of the estates.

FAI (2010) estimate Gross Value Added[5] for all grouse shooting in Scotland, based on a number of "grossing up" assumptions. For direct spending alone, this amounts to between £5.6 and £12.2 million in 2009.

Table 10: Other Game Prices

Species	Advertised price
Red Deer	£150 – 1500 per deer
Roe Deer	£50 (unaccompanied) – 150 per deer
Pheasant	£17-29 per bird driven
Partridge	£40-60 per brace driven

The values from shooting deer (roe and red), pheasant and partridge are attributable to forest, agricultural and MMH landscapes. For red deer, stalking or shooting takes place in both MMH and rough grassland habitats, whilst both play important roles in the lifecycles of the species in conjunction with forests. There is a difference between the reported values used by the forestry group and the advertised prices identified above, this suggests that there is a difference in value for stalking in different landscapes and across different regions.

As was discussed above (Figure 7) deer numbers have been seen to rise significantly since the 1920's. There is some uncertainty about the exact populations of deer but recent estimates by the Deer Initiative suggest a population of Red Deer in Scotland of 300,000 with between 50,000 and 70,000 culled annually, and an estimate of 500,000 to 600,000 Roe Deer in Great Britain. There is limited data available about the numbers of deer stalked in the UK and the revenue generated; further work potentially involving primary data collection is required in order to estimate the quantity of this service. The one exception is for the year 2004 where a PACEC (2006) study

[5] Gross Value Added is a measure of the value added to the economy by any economic activity. It is defined as the value produced by the activity itself, less the value of goods and services purchased from other producers, and is equivalent to the activity's contribution to Gross Domestic Product (FAI, 2010).

investigated hunting using questionnaires of providers and participants. The data is not perfect, estimates of gun days in relation to deer vary by a factor of over three depending on whether providers or participant responses are used (200,000 and 680,000 gun days respectively). However, this provides the only available data, with estimates of 120,000 deer taken not as part of a job (that is, where the person shooting is not paid to manage deer). Taking the advertised prices this implies a value of between £24 and £180 million per year. Again there are issues of the numbers of these participants who pay full market price for this activity, only 45% of respondents who stalked deer paid by the day to do so (40% were members of syndicates but these groupings are not mutually exclusive). As with grouse it can be assumed that landowners would rent out more shooting if the marginal benefit to themselves of shooting is lower than the market price. However, in the case of deer, supply of shooting opportunities is likely to outstrip demand significantly.

Venison for consumption

In addition to the value of stalking itself, value is also derived from the sale of venison from both stalking and the general management of deer on upland estates. It should be noted that this is not the same as the farmed venison identified in the livestock products section above but wild venison. Work by Fiona Newcombe of SNH (received in personal correspondence) has aimed to identify the value of this provisioning service.

Approximately 3500 tonnes of venison are produced annually from wild deer (based on Munro 2002 Report on the Deer Industry in Great Britain, 2002). It is estimated that a significant and rising proportion of the venison consumed in the UK is retained from stalking or sold directly to consumers: this is not included in these estimates. This means that much of the prices and therefore value of venison is hidden and cannot be taken into account in the analysis presented here. However, the venison sold to game dealers should give an approximation of the value, albeit one which does not take into account the entire market.

Table 11. Venison Production, Quantity Sold to Game Dealers and Estimated Values

Year	Estimated Total Vol. Venison Cull Returns (Tonnes)	Estimated [Wholesale] Value (£) Cull Returns	Estimated Total Vol. Processed Venison Returns (T)	Est. Wholesale Value Paid to Producers
2002/03	3,196	£3.2m	2,613	£2.6m
2003/04	3,437	£3.4m	2,428	£2.4m
2004/05	3,753	£3.7m	2,919	£2.9m
2005/06	3,549	£3.5m	2,227	£2.2m
2006/07	3,495	£5.2m	2,552	£3.8m
2007/08	3,482	£5.2m	2,235	£3.3m
2008/09	3,438	£5.1m	2,424	£3.6m

SNH report that, in Scotland, the price paid per kilogram dropped in 1995/96 from approx. £2.45 to £1.30 per kilogram on average, it dropped further in 1999/2000 from approx. £1.45 to £1 and then to £0.75 in 2001/2002, before recovering back to £1 and then climbing again to the current average of £1.50 per kilogram (range: £1 - £3)[6]. The data provided to us by Scottish Natural Heritage diverges somewhat from the data presented in the forestry chapter in that they are not reported by SNH to have fallen as low as identified in Macmillan and Phillip 2010, however, trends are consistent between the data sets.

Double Counting: Other than the issues identified above about the attribution of values between forestry and MMH landscapes there are several double counting issues related to hunting and game on the MMH landscape. The presence of deer and grouse may have an impact upon recreational values, whilst associated management of the landscape impacts on the landscape quality. There is recent evidence that public good values for moorland landscapes are inversely related to management intensity (Stewart, 2010). Again, production of this ecosystem service (hunting) is a driver of other ecosystem services; as grouse numbers are pushed up by more intensive management of heather moorlands, there can be impacts on water quality (see the science group report) and other bird species (both positive and negative: see Hanley et al, 2010b).

Changes to marginal prices: Much hunting taking place on UK MMH is based upon an international market which therefore depends upon international demand, and the prices of substitute hunting experiences. Given sustainable management of the resource which may not hold for some of the competition (such as doves in South America) there is the potential for increased revenues should

[6] Note prices not indexed as source did not make clear if prices were in real terms or not.

the competition been reduced. Changes to climate may have a positive or negative impact on attractiveness of the UK as a destination for such activities and also the severity of winters may impact upon the success of estates in the MMH. Also pressure for less intensive use of MMH and for greater access for the general public may mean less grouse in the future. Conflict already exists between landowners, gamekeepers and other users of MMH (Thirgood and Redpath, 2008).

2.1.3.Peat

The main product being valued is peat extraction for horticulture and gardening. Trends in extraction have been downwards with an aim set out by DEFRA that no horticultural peat products are sold in the UK by 2020. Main drivers in change of marginal price are likely to be moves to ban the use of peat. Valuation data suggests that value from peat may be maximised by not extracting it in the UK.

Unlike most of Europe, peat is not extracted commercially in the UK for burning with the exception of some use in the whisky industry for drying barley. It is used as fuel for domestic fires in some remote areas of Scotland, but this is predominantly low intensity and low impact. The value to the households which burn peat is the cost of the alternative fuel forgone. However, as the practice of cutting peat is a time consuming one the marginal costs of time should be taken into account which significantly reduces the values of the service in terms of domestic use of peat for heating (although any increase in oil prices in the future may mean that a higher value is elicited from this service).

Therefore, it is assumed here that the main value of peat extraction from MMH is for horticulture and gardening (domestic gardening accounts for 70% of this usage) where it goes to make up a good proportion of many types of compost (although peat free alternatives are becoming more common). DEFRA have recently called for peat to be phased out of all compost sold to gardeners in the UK by 2020, which will have a major impact on the future value of this service. Targets of a reduction in peat content of composts by 90% by 2010 were also set, but in 2009 42% of growing media was still made up of peat.

In 2001, England accounted for 80% of the UK's peat production (1.5 million m^3) and Scotland 20% (355,000 m^3). By 2009 the UK produced 0.94 million m^3 (again mainly from England– precise proportions are not available but they are assumed to have stayed relatively constant[7]). Between 1999 and 2005 demand for peat in the UK stood relatively constant at 3.4 million m^3, 2007 saw a fall to 3.01 million m^3 and in 2009 2.96 million m^3 were used. The price of peat lies between £5 and £15 per m^3 (lower bound relating to the costs of extraction from a manufacturers own UK supply and the upper bound being delivered peat (www.hdc.org.uk/assets/pdf/40041000/1833.pdf). Further investigation is needed but a value of £10 per m^3 seems appropriate as an approximation of value. This price combined with the levels of production from the UK gives an annual value of £9.4 million pounds (with a range of between £4.7 and £14.1 million) for this (non-renewable, extractive) ecosystem service.

Domestic extraction of peat for horticulture is estimated to release 400 thousand tonnes of CO2 to the atmosphere each year, this value can be used to offset the financial benefits of the extraction but given that carbon services of MMH are not accounted for in this section it is necessary to ensure that this does not result in double counting of the costs of carbon. Taking DECC guideline shadow costs of CO2 of £26.5 in 2009 (increasing at 2% pa) this equates to a carbon cost of extraction of £10.6 million in 2009. This suggests that the extraction of peat in the UK makes a net loss of £1.2 million when accounting for carbon costs (albeit at higher peat prices a benefit of £3.5 million is identified). The additional loss of value associated with biodiversity, water pollution and recreational services are likely to further reduce the value of peat extraction services.

Double counting issues: Peatlands are the single largest carbon reserve in the UK, containing around 3 billion tonnes of carbon (c 150 million tonnes in woodlands). Peatlands in good condition sequester carbon; peatlands in degraded condition emit carbon, and also discolour water supplies (good condition peatlands will also emit coloured water, but at lower levels). There can be offsetting effects for other GHGs, notably methane, which can be emitted more from wet peat in good ecological condition.

Likely drivers of changes in marginal price of peat: The most likely driver of change in the market for peat from MMH will be any ban of the use of peat for horticultural or gardening purposes. If this were to occur only export markets would be available, and given that the UK imports approximately 50% of the total amount of peat used from Ireland and the Baltic states it is

[7] Which ties in with the usage of peat relatively well with 80% used in England, 10% in Scotland and 5% in both Wales and Northern Ireland.

suggested that the world market price (in fact given costs of transport it is likely to be a regional price) would fall significantly. The existence of suitable alternatives, some of which are generated from processes which reduce the amount of landfill generated in a given country further suggests that market prices will fall significantly in the future. Given this fall in price, the relative expense of transporting the products and the additional likelihood that local authorities will not renew or extend any further licenses beyond those which already exist it is not beyond expectation that peat extraction will become uneconomic from UK MMH in the 2020s. The main value of the peat, however, lies in the carbon and biodiversity values of the peat left in situ in the MMH landscape; the public good nature of these goods suggests that they are not considered in the decision to extract peat. However, moves such as the shutting down of Thorne Moors in South Yorkshire, Wedholme Flow in Cumbria and Hatfield Moor peat extraction sites with compensation of £17 million being paid by the government to the producers suggests that the public goods associated with peat in situ are beginning to be identified in policy.

2.2 Regulating Services

2.2.1.Drinking water and Pollution Treatment

The main product being valued is the filtration services of MMH landscapes. The main trends in provision of this service depend in turn on trends in the quality of the MMH landscape. Drivers of change are related to management intensity, whilst values and changes in marginal values depend on the relative costs of treatment. However, monetary values for this service are too spatially distinct to identify general service values without fuller analysis.

MMH provide 70% of drinking water to the UK, due to the high levels of precipitation and potential for capture and storage they provide. They provide a contribution to (drinking) water quality through filtration services and also provide a buffer of supply. However, precipitation itself cannot be attributed to MMH habitats so the value of the water itself is not relevant to the value of the habitats. The value of the water treatment services can be identified for different water authorities, but not on a catchment or river basin level since this is deemed as sensitive information. It is therefore not possible to identify the value of the presence or quality of MMH landscapes to treatment costs in this report.

There is one study that has examined quantified farmers willingness to accept money for adopting water quality protection practices in Nidderdale (Beharry-Borg et al 2010). These values can be used with average costs of treatment for dissolved organic carbon and increased nitrates to help determine the overall value of clean water for this specific catchment.

Generally water in the UK is treated to a common standard for potability (set at the EU level) with fixed doses of chemicals or ultra-violet light – as such, MMH filtration services are unlikely to generate high values in respect of potability. MMH landscapes are functionally related to water colouration, and even habitats in good condition have some colouration associated with them. Those in poor condition can produce significant levels of sediment. MMH in good condition can be seen to have a relative value compared to MMH in poor condition, but may have a negative value in comparison to other landscape types in terms of drinking water colour. This means that there is a significant issue of what a value is being placed relative to, i.e. what baseline is the appropriate one against which to measure the value of these services.

Over the last 20-30 years, the degree of discolouration of surface waters derived from the UK uplands has increased due to a significant increase in dissolved organic carbon (DOC) concentrations (Evans et al., 2006). This increase in DOC has been attributed to a variety of factors including climate change, recovery from acidification and changes in land use and management. While the drivers controlling the long-term trend in DOC continue to be debated (Roulet and Moore, 2007), the spatial variability in DOC concentrations and fluxes are primarily controlled by soil type. Land management is one of the important factors shown to be important in controlling stream water DOC concentrations and hence water colour (Yallop and Clutterbuck, 2009). Other factors include proximity of the peatland to a stream (e.g. Bishop et al., 1994) and other hydrological processes (Dawson et al., 2008).

In the past large areas of upland blanket peat, particularly in the English Pennines, were extensively drained with the purpose of lowering the water table to improve the quality of vegetation for grazing and reduce downstream flood risk by establishing a moisture deficit (Holden et al., 2004). However, there is little evidence that peatland draining fulfils either of these roles and it is now widely believed that they have exacerbated the degradation of peatlands. Consequently many upland drainage networks have been targeted for restoration, which involves blocking the drainage ditches to raise the water table and reinitiate peat forming processes. Wallage et al. (2005)

observed higher concentrations of DOC and water colour in soil water adjacent to drainage ditches than in soil water adjacent to blocked drainage ditches. Thus drain blocking has been widely recommended as a suitable technique to reduce DOC and water discolouration.

Blocking of land can therefore reduce costs of treating parameters such as dissolved organic carbon. Using an example sub-catchment which is 15% gripped and has an annual mean DOC concentration of 14mg/L the projected figure for DOC after 10 years under a 'do nothing' scenario is 21mg/L (Chapman et. al, 2009). Contrastingly, the projected level of DOC if all grips were to be blocked is 13.44 mg/L. At current prices, the estimated associated increase in treatment costs per day is approximately £146 for a typical treatment plant with capacities of 60ML/day. The total average cost of treatment per day exclusive of this increase in DOC treatment costs is £1,316.00. Therefore, based on this scenario the avoided costs of treatment for 10 years for a typical plant is £5.3 million.

Other pollution treatment services are also provided by MMH landscapes. Air pollution which is deposited on these landscapes is assimilated into the environment in a way which reduces the levels of run off of pollutants (NOx and SO2) into the water system compared to alternative land covers such as forestry or grassland (see Science Group report for more detail). Again this relates in real terms to the quality of the water downstream, and although there may be some impacts on biodiversity these are likely to be limited compared to other sources of emissions. No benefit estimates were found for assimilative functions of MMH for NOx and SO2 related to surface water quality.

2.2.2. Natural Hazard Mitigation

Main products being valued are changes in flood risk and wildfire risk. It is not possible to identify trends from existing data, and additional primary data collection is required for this service which will likely have to be applied at a catchment level. The main drivers of change are likely to be climate change and management regimes.

Flood risk

Previous research has shown the significant value of flood risk mitigation, in terms of the benefits of avoided damages. Werrity et al (2007) identify values of c£35,000 for damage to buildings and c£14,000 for damage to contents per property for a typical event, whilst Penning Roswell et al (2005) identify a range of costs of flooding depending on the age and type of building and depth of flood water. Research for the US, has shown a 4% reduction in house values for a 1% reduction in flood risks based upon hedonic analysis. Future work could analyse this relationship for the UK which would allow a more accurate analysis of potential impacts of future flood risks.

Whilst it is relatively easy to find values which are relevant to the analysis of flood risk mitigation, it is extremely difficult to identify quantitative measures of how changes in MMH landscapes relate to changes in the risk of downstream flooding. There are complex hydrological interactions at work which mean that, in any given watershed, MMH landscapes may in fact contribute towards increased flood risks. The Science Group report gives a full over-view of these issues. In order to fully analyse the impacts of flood risk of changes in MMH management a full GIS-based analysis of watershed characteristics throughout the UK would be required to identify whether specified changes to these habitats have positive or negative benefits associated with them given different frequencies of precipitation.

Likely changes to the value of flood risk reduction. It is extremely difficult to estimate the impacts on future values of changes in flooding. Should risk increase there is a chance that insurance premiums would increase and in some areas insurance be removed altogether (note that from 2013 the Association of British Insurers will terminate its formal agreement to provide UK-wide cover for flood risk). Whilst this would not result in an increase in the cost of flooding to society (it matters not whether an insurance company or a household foots the bill) it may have impacts on the distributional impacts of flooding, affecting lower income households most which cannot afford to move away from flood plains. However, the main impact is likely to come from climatic change and any change in extreme weather patterns – in particular high precipitation events. It is possible that MMH landscapes could be managed in the future to mitigate flood risks but this is likely to involve the transition of some areas of watersheds to alternative land cover types (forestry for example) in order to reduce the synchronisation of water release to down stream areas. This would have to take place on a watershed to watershed basis and is therefore extremely difficult to evaluate on a UK wide scale.

Wildfire Risk

Intensive management of MMH leading to bare peat can lead to increased wildfire risk. Conversely, more extensive management leading to a build up of fuel loads can also increase the risks of wildfire. Costs of fighting fires in remote areas of moorland can be extremely high (up to £2m). Upland moor and heath habitats present the largest unbroken areas of habitats in the UK, as such the risk of fires spreading is also high. In the event of large scale wildfires, the services associated with MMH landscapes will alter leading to increased water pollution and colouration, changes to flood risks, loss of value from field sports (controlled burning is of course part of grouse management but the birds also need some cover), high losses of carbon dioxide and other green house gases, increased air pollution and loss of agricultural productivity.

The major impact of time upon the values of this service and the marginal cost will likely relate to changes in the risks of wildfire, and be related to factors such as climatic change and to some extent usage of MMH for recreation. As with flood risk, the identification and pricing of changes in risk is challenging in this setting. Potentially the problem is more complex, indeed, than that for flood risk. The costs of fighting the fires will depend on specific features such as the local geomorphology and isolation so it is not possible to place a value in these terms generic enough for the purposes of this study. The price could be considered to be the loss of other service values from the landscape impacted by fire for a given time period (6 months for example) but this will very much be related to the area which is burnt. But again the issue is that in order to identify a value for this service it is necessary first to identify a quantity with which to interact the price which has not been possible within the timeframe (or indeed expertise) of the NEA exercise. If it were possible to analyse the risk of different severities of wildfire and the associate time frame against which impacts would be felt then the value would simply be the expected value of loss of other services for this period. However, this approach would prevent the summation of services for this landscape and this value should be omitted if summation is required.

2.2.3. Carbon

Carbon sequestration values are being covered by a thematic economics report. The Science Group report for MMH shows how important MMH habitats are for the UK in terms of carbon storage: around 40% of UK soil carbon is found within MMH. Changes in carbon flux over time, and changes in future carbon fluxes in MMH, are clearly of great potential significance. *However, no figure is* *available from the science group report for either the amount of carbon currently stored in MMH, or the current total amount of net sequestration/emission.*

2.3 Landscape (Cultural Heritage) Values

Cultural values for all habitats are being covered by a thematic economics report. Some points are worth noting, however, in the context of this habitat-specific report for MMH. The MMH Science Group report argues that MMH landscapes are particularly important for people as places for rest and contemplation, as well as for active recreation. Significant non-use values would seem likely to be attributable to certain MMH landscapes, along with significant use values linked to recreation (see, for example, Hanley et al (2001) for values associated with mountaineering: the authors give a mean consumers surplus value of £25 per trip for rock climbing in Scotland) . Data are not available on the number of outdoor recreation trips attributable to MMH, with the exception of estimates of total skier days in Scotland (159,888 in 2008-9: given a mean lift pass cost of £25/day, this implies a value of £3.9 million for this recreation activity in 2008-9. Unofficial estimates for 2009-10 are for 373,782 skier days, implying a total value of around £9.3 million). At the same time, one must recognise that many MMH habitats are produced, rather than natural, despite the perceptions of the general public. An obvious example is heather moorland. Recreation is being valued separately in another economics thematic report.

Ample evidence exists in the economics literature of significant values being placed on upland landscapes by the general public; and of how these values vary regionally. For example, Hanley et al (2007) use choice experiments to estimate of relative value of different landscape characteristics of the UK uplands under alternative future scenarios. Table 12 below shows results for Willingness to Pay a marginal change in each landscape attributes, according to which region of the country individuals live:

Table 12. Cultural (heritage) values for upland landscapes in England.

Region / Attribute	North West	Yorks and Humber	West Midlands	South West	South East
HMB	0.23 (0.09 0.41)	0.31 (-0.49 1.05)	0.81 (0.40 1.37)	1.64 (-5.42 11.10)	0.53 (0.26 0.88)
RG	0.09 (-0.44 0.20)	0.67 (-0.76. 2.40)	0.76 (-0.15 1.83)	0.23 (-4.94 11.50)	0.12 (-0.46 0.72)
BMW	0.24 (0.10 0.45)	-0.13 (-1.22 0.47)	0.54 (0.07 1.03)	0.73 (-2.79 6.13)	0.54 (0.27 0.86)
FB	0.02 (0.00 0.03)	0.04 (-0.03 0.13)	0.01 (-0.04 0.06)	-0.01 (-0.32 0.50)	0.03 (0.00 0.06)
CH1	1.69 (0.18 3.24)	5.96 (0.36 18.64)	3.23 (-1.11 9.71)	16.04 (-0.91 21.35)	-0.85 (-3.60 2.16)
CH2	0.49 (-3.14 4.11)	16.73 (0.07 48.57)	23.78 (13.44 41.67)	26.75 (-79.5 134.0)	6.60 (0.18 15.01)

Key: HMB = heather moorland and bog - % increase; RG = rough grassland - % change; BMW – broadleaved and mixed woodland, % change; FB = field boundaries, length conserved; CH1 = cultural heritage no change rather than rapid decline; CH2 – cultural heritage much better conserved rather than rapid decline. All values are UK £ per household per year. Figures in parentheses are the 95% confidence intervals. Values for all regions except South East relate to landscape change in the named regions. For South East, they relate to change in all other regions. Source: Hanley et al, 2007.

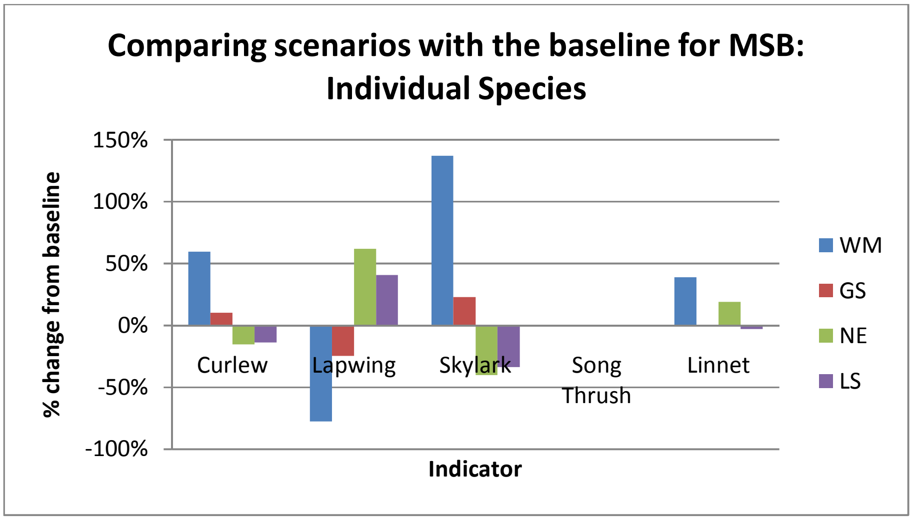
The “HMB” landscape attribute is most relevant to MMH habitat, since it represents a 1% change in heather moorland and bog areas. As may be seen, this is typically valued higher than an equivalent increase in rough grasslands, and in some regions than an equivalent change in woodland. Cultural Heritage values here were defined in terms of “the presence in the landscape of traditional farm buildings, the keeping of traditional livestock breeds, and traditional farming practices such as shepherding with sheep dogs”. Some of these values might also be attributable to MMH habitats, depending on how they are managed. Significant regional variations can be seen in the value of a change in heather moorland and bog: in the West Midlands of England, a 1% increase is valued at

£0.81 per household per year, whereas the equivalent figure for the North West region is £0.23/hsld/year. However, it is not possible to use these values in the context of the scenarios being examined for the NEA, since the landscape attributes used in the Hanley et al study do not map exactly onto those used by the Scenarios group, and they overlap with habitats out-with of MMH.

2.4. Biodiversity

The economic value of changes in biodiversity are being considered principally in the thematic economics report on Biodiversity. However, it is worth making some comments here in the MMH chapter. As the Science Group report makes clear, MMH are important habitats for a range of species in the UK, notably waders and raptors. Drivers which have impacted on species populations within MMH include grazing pressures from sheep, burning, raptor persecution, air pollution and habitat loss. At the same time, land management within MMH can exert positive influences on species, for example through predator control and the "production" of un-evenly aged heather patches. Changes in land management can be expected to lead to changes in different indicators of biodiversity. An illustration for MMH is provided by Acs et al (2010) and Dallimer et al (2009), who estimate models of land management and different avian diversity indicators for farms in the Peak District. Hanley et al (2010) combine these models to investigate the likely effects on avian diversity of a range of future scenarios for agricultural policy and world market prices for inputs and outputs. An illustration of their results is shown below. As may be seen, changes in future policy support and in prices lead to un-even impacts on alternative indicators. Some species gain whilst others loose. However, converting these gains and losses into monetary equivalents is not possible at present, given the available literature on valuing biodiversity change in the UK uplands.

Figure 8: Scenario analysis of possible future changes in upland biodiversity on agricultural land in England.



Note: MSB is Moorland Sheep and Beef Farm type. The scenarios considered are based on the Foresight exercise: see Morris et al, 2007. They are World Markets (WM), Global Sustainability (GS), National Enterprise (NE) and Local Sustainability (LS). Source: Hanley et al, 2010.

2.4 Trade offs and synergies

Management actions can have conflicting impacts on different ecosystem services. For example, managing woodlands to maximise carbon sequestration can lead to reductions in biodiversity (Capparos et al, 2010). Management actions can also produce joint increases in some ecosystem services: for instance, conserving peatland to conserve carbon may also reduce water colouration problems. Below, we set out a qualitative matrix of ecosystem services which illustrates likely trade-offs or synergies. However, the size of these effects will be habitat and management-action specific. In some cases, sign reversals may also occur. Information to populate this matrix is taken from the Science Group report.

Table 12: trade offs (-) and synergies (+) between some ecosystem service flows from MMH habitats.

Increase in➔	SC	DG	PE	DWQ	CSS	CLT	BIO
Sheep/cattle		-	-	?	?	- or +	- or + dependent on target
Deer/grouse	-		-	?	Reduction in burning, so -	Likely – for grouse	As above
Peat extract.	-	-		-	-	-	-
Drinking water quality	- (possible)	-	-		+	+ or -	?
Flood risk	+	?	-	-	?	?	?
Fire risk	-	-	?	?	-	? but perhaps +	Perhaps +
Carbon store/seq.	- (possible)	-	-	?		+	+
Cultural	+ or -	+ or -	-	+	+		+
biodiversity	Likely – in most cases	Depends on species	-	?	+	+	

KEY: SC = sheep/cattle; DG = deer/grouse; PE = peat extraction; DWQ = drinking water quality (colour); FLR = flood risks; FIR = fire risks; CSS = carbon storage or sequestration; CLT = cultural values (landscape aesthetics); BIO = biodiversity as measured by birds. A + for FLR is an increase in flood risks; a – for FIR is a fall in wild fire risks.

Comments: *increased sheep and cattle production* may well reduce bird abundance or species diversity, but this depends on the starting point, and which species one focuses on. The ratio of sheep to cattle may also matter (Evans et al, 2006). For plant diversity, a u-shape relationship between grazing intensity and diversity may also hold. For *increased grouse and deer numbers*, drinking water quality may be impaired by a higher burning frequency. Carbon losses will increase due to burning; cultural values may rise or fall depending on the baseline, whilst impacts on birds will vary across species e.g. positive for waders and negative for some raptors (Thirgood and Redpath, 2008). Increased *peat extraction* would seem to reduce supply of most other ecosystem services. Managing catchments specifically to reduce water colouration problems would likely lead to lower levels of erosion, which might increase cultural values. No information is available on how MMH habitats should be managed to reduce flood risks downstream, so this column is omitted; similarly, it is highly unlikely that MMH habitats would mainly be managed for wild fire risk reduction. Managing for *improved carbon storage or uptake* would necessitate cessation of peat extraction; it would potentially also involve re-wetting of moorland to encourage *sphagnum* regeneration, which might have benefits in terms of reducing wildfire risks and reducing DOC run-off. Managing for carbon would also mean a lower intensity of moorland burning which would reduce grouse numbers.

Managing for *cultural services* (non-use values of landscape)might mean a fall in stocking densities if these are currently high, but could equally involve payments for maintaining or increasing stocking rates (Tinch et al, 2010). Some evidence from a recent choice experiment suggests a preference for less-intensively managed grouse moors, so management for cultural services might imply less intensive moorland management – although there are trade-offs here with rural employment on sporting estates, which people also care about. Peat extraction would likely fall in such a scenario, but fire risks might increase if people are in favour of scrub woodland being allowed to develop. Biodiversity might gain under this management regime, although again this would be species-specific. Finally, the effects on other ecosystem services of managing for *biodiversity* are very hard to generalise about, since this depends on what specific biodiversity targets are adopted. For example, certain bird species might benefit from the re-introduction of cattle into upland areas from where they have recently been lost.

2.5 Near-term options for sustainable management

2.5.1 reform of agri-environment and agricultural support schemes

Most recent reforms of the CAP saw a de-coupling of support from production decisions. The Single Farm Payment, introduced in 2005, has become an important part of farm incomes for hill farmers in the UK. Loss of this payment post-2013 might see large changes in both the management of upland farmland, and in the number of farmers and the amount of land devoted to livestock farming. The implications for the supply of ecosystem services from MMH from such changes is unknown. Since 1987, agri-environment schemes have become an increasingly important component of agricultural support spending, rewarding farmers for undertaking management actions which are thought to increase the supply of certain public goods. There is mixed evidence on the environmental performance of current agri-environment schemes within the EU (Kleijn and Sutherland, 2003; Whittingham, 2007). Reform of agri-environment schemes to reward the supply of a wider range of ecosystem services in MMH would be desirable in the future.

2.5.2 Livestock as management tools

Livestock in MMH habitats can be considered as management tools for the provision of service rather than services themselves (Pykala, 2003). Native breeds which are increasingly being used for management in the MMH due to their better weight and grazing patterns may have a premium associated with the meat. For example the Wild Ennerdale Partnership are attempting to market meat from native breeds in order to encourage local farmers to adopt this livestock. However, this is again an example of the use of livestock management as a means for providing services other than simply livestock production. Livestock have additional value beyond their market prices within the MMH landscape (e.g. see Hanley et al, 2007), and these should be included the Cultural Services and Recreation activities being valued separately.

2.5.3 Changing the intensity of grouse moor management

Red Grouse management has both positive and negative impacts on ecosystem services in the UK uplands. Benefits include the maintenance of internationally important habitats and associated biodiversity, provision of local employment and increased income to rural communities. However, the costs include the continued illegal killing of protected birds of prey and the impact of management on water quality and carbon storage (Bonn et al. 2009). Partly as a results of the conflicts arising from the negative consequences of grouse management there is currently considerable debate over the most appropriate form of red grouse management with opinions varying from re-wilding with minimum management to continued intensive management. There is an urgent need to understand the environmental and socio-economic consequences of different forms of management, the processes that lead to the implementation of these alternatives and the likelihood of these different forms of management occurring under different future scenarios. Alternatives to the main management method in use today (intensive driven shooting) would include walked-up shooting with less intensive use of burning and lower levels of raptor control. However, the means by which estates could be encouraged to switch to less intensive management methods are not clear.

2.5.4 Red Deer Management

With increasing populations of Deer in the MMH the need for management is also increasing. Overpopulation of deer (optimal densities suggested by some estates are about 1 deer per ha whereas 10 per ha is relatively common across the MMH) leads to overgrazing[8], damage to crops and damage to trees and other plants as well as increased road accidents and issues with diseases transmission (to livestock, pets and humans) (see Forestry Section and Science Group Report).

The sustainable management of deer is likely to become more of a problem in the future. The recent cull of deer in Richmond Park sparked some concern amongst some sections of society but the need to cull will increase in the future (short of an outbreak of disease or other natural restriction to population). One suggestion in some sectors has been the reintroduction of natural predators, however, there may be limited public support for such reintroductions. Indeed the Alladale Estate in Sutherland, which at one point aimed to reintroduce wolves, has dropped this species from a recent planning application due to public concerns.

Natural England produced a Sustainable Deer Management Plan in 2004 (see www.naturalengland.org.uk/Images/deeractionplan_tcm6-4123.pdf). In August (2010) the Deer Commission for Scotland was merged with SNH who now have responsibility for deer management in Scotland. Whilst policies exist in both countries setting out deer management aims and

[8] Although overgrazing from sheep is seen to be the major issue in the uplands and management of sheep grazing is likely to be significantly easier and cheaper than managing wild populations of deer.

objectives the control of deer remains the responsibility of land owners. Local factors may impact upon perceptions of optimal deer management and policy has aimed to take local factors into account (through local deer management groups). Policies include changes to seasons and the method of deer culling aimed at making deer management easier. Going forward, sustainable management of deer must be further supported and promoted taking into account the public benefits of deer in the environment and the potential reduction of ecosystem services from overpopulation.

Policies to promote management through public education to increase the demand for venison may not achieve the goals they set out as they are likely to promote farming of deer. The cost of management can be extremely high in terms of paying individuals to cull deer and fencing[9] to prevent damage from deer to given habitats (or to reduce risks of road accidents and disease transmission). Further financial support may be required in order to achieve the goals of deer management plans.

2.5.5 Reduction of Peat Extraction

The extraction of peat leads to loss of ecosystem service values; that is there are carbon, other environmental and social costs of peat extraction. These losses of services outweigh the financial benefits of extraction. The suggestion for sustainable management is that peat extraction be reduced, this has already entered policy with plans to stop all extraction for compost by 2020, but the failure to meet 2010 targets suggests that further promotion or policing of this policy may be required.

[9] Deer fencing can have other impacts on wildlife in particular bird strike can be an issue with fences being related to fatalities in Black Grouse and Capercaillie, both protected species.

2.6 .Research Gaps

Given additional funding and time it would obviously have been possible to improve the estimates of value for the ecosystem services of MMH landscapes. The following section identifies some of the ways in which the research could be extended

Livestock

- Extension of analysis of gross margins and stocking density, and how this relates to the provision of other ecosystem services. Likely future trends in gross margins (output prices and input costs).
- Fuller analysis and identification of native breed price premiums and outputs from native breed herds and flocks. The science group have identified this as an important aspect of future management in the MMH landscape and this may have an impact on the values from this service.

Game

- Additional primary data collection is required in order to identify the level of paid stalking in the UK and the number of deer taken and their relative values.
- Some form of hedonic or travel cost analysis in order to identify features which add value to a stalking experience would allow a more accurate representation of the potential value of this service, and how this might change under alternative land management options.
- Fuller data is required for grouse shooting in England and Wales to ensure data comparability.
- Information on how the economic value of a day's grouse shooting depends on how moorland is managed, for instance in terms of management intensity (this work will be undertaken as part of the Framework 7 project *Hunting for Sustainability*).

Water Quality

- Catchment level analysis of costs of treatment and likely runoff and colouration.

Natural Hazard Mitigation

- Hedonic analysis of house prices and flood risk to identify value specific to the UK.

- Catchment (or river basin district) level analysis of risks based upon peak flow analysis.
- Assessment of costs of fighting fires and the risk of fires under different management scenarios and in different locations across the UK.

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