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Valuing Ecosystem Services: Case Studies from Lowland England

Annex 6 - Reconnecting the Culm project: Devon

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Valuing Ecosystem Services: Case Studies from Lowland England

Culm grasslands

Preface

This report has been commissioned by Natural England under the contract reference number of 23092.

The work aims to present how a combined ecosystem services and economic valuation approach can be used to understand the implications of different environmental conservation plans. Guidance from Defra on ecosystem services and value transfer is followed (Defra, 2007, eftec, 2010). The approach is used to assess and, where possible, value the likely changes in ecosystem services resulting from an intervention.

The information thus generated can be incorporated into decision-making or support tools such as cost benefit analysis. This information could also inform the way in which the management and conservation projects are designed to maximise the ecosystem service generation.

This is one of the six case study reports prepared to illustrate the application of the ecosystem services – economic valuation approach.

The work has benefited greatly from the ideas, knowledge, data and critique provided by numerous individuals in Natural England, Devon Wildlife Trust and other organisations. These include:

Stewart Clarke, Julian Harlow, John Hopkins, Ruth Waters Mark Elliott, Peter Burgess, Diane Burgess and Andrew Thompson.

We know that some others have provided advice or data to those who helped us and though we cannot list these people here, our sincere thanks go to them too. And our sincere apologies to anyone inadvertently omitted from the list above. Needless to say, any remaining errors are the fault of the authors alone.

Dr Robert Tinch, Adam Dutton, Laurence Mathieu (authors) and Ece Ozdemiroglu (internal reviewer).

24 November 2011

Contents

1. The Decision Context

This case study uses value transfer to assess the costs and benefits of possible changes in ecosystem services of a project to restore the Culm grasslands of Devon and Cornwall. It provides a rapid assessment of the relative benefits and costs of the Working Wetlands Project which aims to achieve this goal. Working Wetlands is the name of the agri-environmental project between Exmoor and Dartmoor. The project aims to enhance conservation by providing targeted help with agri-environment scheme applications aimed at protecting and expanding the coverage of Culm grasslands. Key stakeholders in the project include The Devon Wildlife Trust (DWT) (the lead), Butterfly Conservation, The Environment Agency for England and Wales, Natural England, GrantScape and Devon County Council.

The Culm is characterized by unimproved wet grassland and part of a widespread but scarce habitat type known as 'Rhôs Pasture' (Welsh name for Culm habitat), forming part of the national priority Biodiversity Action Plan habitat, 'Purple Moor Grass and Rush Pasture'. The most common grassland found in the area is the fen-meadow where swards are dominated by purple-moor grass interspersed with sedge species and herbs. Wetter lands support tall-herb fens and swamps. Above the valleys are wet-heaths.

The total Culm National Character Area (NCA) covers 280,000 ha. Culm Grasslands are arguably Devon's most important habitat as a refuge for a diverse set of flora and fauna and biodiversity is the most prominent ecosystem service provided by this project. Notably the Culm is home to nationally important populations of butterflies and moths including the marsh fritillary (*Euphydryas aurinia*), small pearl-bordered fritillary (*Boloria selene**)***, wood white (*Leptidea sinapis**)*** and brown hairstreak (*Thecla betulae**)***. De-fragmenting these habitats will play an important role in the protection of Devon's biodiversity.

The project area has a number of designations reflecting the importance of the resource: Biosphere Reserve (UNESCO), UK Biodiversity Action Plan (BAP) priority habitat, Site of Special Scientific Interest (SSSIs) and Special Area of Conservation (SAC).

Nevertheless, the Culm is not a 'natural' habitat but rather the result of centuries of farming practices. These grasslands and the associated farming practices are part of the cultural heritage of the area, as well as being important from a biodiversity / nature conservation perspective.

Despite their importance, there have been significant losses of Culm grassland in the last hundred years. Over 50% was lost during the late 1980s and early 1990s due to the effects of poorly targeted farm subsidies which indirectly encouraged farmers to plough these grasslands to plant crops including flax. Only 10% of the resource present in 1900 still survives. Remaining Culm grassland is still being lost as farmers diversify their business into, for instance, tourism and 'abandonment' such as leaving marginal farmland un-grazed.

The project provides targeted help with agri-environment scheme applications, with the aim of protecting and expanding the coverage of Culm grasslands. It runs from 2008 until 2014 across three sites between Exmoor and Dartmoor (see Figure 1):

- Knowstone and Witheridge;
- Hollow Moor; and
- Torridge and Tamar headwaters.

The total area of the project is 65,000ha, just under a quarter of the total Culm NCA. Within this area, approximately 8,000 ha are to be brought into improved management via HLS agreements (see Table 2 below), including 2,040 ha returned to wet grassland in favourable condition.

source: http://www.devonwildlifetrust.org/working-wetlands/

Figure 1: Location of the Culm project areas (Project areas are highlighted in light blue)

2. The Ecosystem Services and Affected Population

2.1 Ecosystem services

The key ecosystem service that will benefit from the Working Wetlands project is biodiversity / habitats.

The project is centred on assisting landowners in securing Environmental Stewardship Grant agreements. These agreements ensure that environmental features found on the farm are managed sensitively and that landowners are financially rewarded for this additional work. The grants are available regardless of the Working Wetlands project. In essence the project does not increase direct funding of conservation activity but rather reduces the costs and information barriers that prevent farmers from applying for and accessing funds. However alongside this support with securing funding, there are a number of subsidiary elements. The project supports land owners through:

- Whole farm, farming and wildlife advice;
- Administering a small grant award;
- Free training events;
- Free advice on and submission of applications for Entry Level and Higher Level Stewardship;
- Access to machinery such as mobile stocking facilities; and
- Help with finding graziers or land to rent for grazing with our Grazing Links initiative.

In addition there is some direct funding for interventions under the GrantScape component of the project. The £400,000 project has been focusing primarily on half a dozen sites including DWT's flagship National Nature Reserve, Dunsdon. The money has been spent on a wide range of habitat improvements such as scrub clearance, hedge restoration, soil stripping, fencing along with some land purchase as a means to make DWT's Culm holdings more robust and secure.

2.2 Affected population

The work is largely carried out in the Culm of Devon with some overlap into Cornwall. Table 1 presents the populations of Devon and Cornwall along with the populations of the district councils in which the project is being carried out in Devon.

Table 1: Human populations in 2001 (County Wide), 2009 (District) around the Culm project area

Area	Population
Cornwall	231,241
Devon	747,400
Torridge	65,300
West Devon	52,700
North Devon	91,500
Mid Devon	76,000

Sources, National Statistics - Neighbourhood database (county wide, accessed July 2011) and Harris, 2010 (district).

Devon is also an important tourist destination, attracting 28-29 million visits per year (Research Department, 2010; 2009); 32% of which come from within the south west. The Devon Wildlife Trust receives 50,000 visits to its wildlife reserves in this area each year.

3. Ecosystem Service Changes

Here we summarise the likely effects the Working Wetlands project may have on the ecosystem services provided in the area (as reported in Section 2.1). The changes are the difference between what is provided now and will be provided in the future without the project, i.e. the baseline (Section 3.1) and what is likely to be provided when the project is implemented (Section 3.2). The discussion of the likely impacts is presented in Section 3.2. The quantitative assessment is presented in the spider diagram at the end of that sub-section and Tables 2 and 3.

3.1 Assessing the baseline

The baseline management option is 'business as usual' resulting in ongoing decline in the Culm grasslands. This has implications for a range of ecosystem services, but in particular for biodiversity, since declining levels of Culm not only reduce the total area of habitat available for a range of Culm-dependent species, but also fragment the remaining habitats and populations, increasing their vulnerability. There is some ambiguity over the impact of 'business as usual' as two divergent impacts will occur. On the one hand, some marginal lands may be abandoned and turn to scrub as farmers diversify into non farming businesses. Simultaneously other lands will be brought into more intensive livestock farming practices to improve profits. We therefore restrict estimates of impacts on food and fibre to stewardship payments.

3.2 Qualitative and quantitative assessment of the change

Food and fibre: There is some uncertainty over the impact upon agricultural production. If we assume that farmers are moving from more intensive to extensive practices then the productivity per hectare will drop; but if the impact of the payments is to dissuade abandonment / non-agricultural diversification, the reverse may be true.

The project managers do not have estimates for what area was being farmed in what manner before they intervened. Thus, we have no estimate of the area of dairy, cattle or sheep farm either moved out of cultivation or towards lower stocking densities. Given this lack of data the next best indicator can be found in the agri-environmental (High Level Stewardship) payments to farmers.

HLS payments for the first three years of the scheme were used to estimate the trajectory of increase in the cost of HLS payments over the period of the program. It was assumed that 2011 would see the highest increase rate and it would slow from 2012 onwards mirroring the yearly increase. The cost for 2011 was estimated by multiplying the costs from January and February by six to make 12 months. Table 2 **Error! Reference source not found.**describes the changes in land under management with a projected trajectory.

Table 2: Annual change in area under management

Increase in land under agreement	2008	2009	2010	2011	2012	2013	2014
Yearly change (ha)	140.17	289.99	1810.28	*3600*	*1810.28*	*289.99*	*140.17*
total (ha)	140.17	430.16	2240.44	*5840.44*	*7650.72*	*7940.71*	*8080.88*

(Italicised numbers indicate the estimated/projected values).

Timber: To date 90 hectares of Sitka spruce plantation has been removed to restore Culm. This represents roughly 3% of the land to be brought into favourable condition.

Renewable energy: Not affected by the project.

Fresh water quality: Wet grasslands filter the water that passes through them as well as reducing the fertilisers required by the grasses and so nitrogen loads. Quantitative estimates of water quality impacts would require a thorough scientific assessment which is not available in this study. This is also subject to the same uncertainties over food production as where land is kept in production which might otherwise be abandoned the impact of the project would be negative.

Water flow regulation: Wet grasslands are likely to impact upon flood management and water quality in downstream catchments. They can help store flood waters in heavy rains. Quantitative estimates of flood defence impacts would require a thorough scientific assessment which is not available in this study.

Soil and erosion control: Lower stocking ratios and wetter conditions may help maintain higher vegetation cover and reduce erosion, and over time wet grassland may aid soil formation. These impacts are not likely to be very significant, and would require further detailed analysis to specify.

Climate regulation: Carbon sequestration impacts are uncertain as it depends upon the baseline decisions of individual landowners. In some instances loss of Culm is incurred as farmers diversify into (for instance) tourism and leave marginal lands. If farmers are largely leaving land to go to scrub then it is uncertain whether the wetland would be a relative sink or source of GHG emissions. If instead the farmers move towards intensive livestock farming then the Culm grassland management would reduce emissions per hectare. Wetlands are also better able to sequester green house gasses in the soil. The impact of removing tree cover from 90ha to restore Culm could be negative. In this instance the change from pasture to wet pasture is likely to have a benefit but any estimate for a relatively slight change in land use may be wide off the mark.

If we were more certain of the land use change we might apply values from Cantarello et al. (2011), or NE (2010) to estimate the yearly changes in sequestration. However, the estimation process here is more complicated because Culm Grasslands are not simply a single kind of wetland. They are a complex mosaic

of fen, mire, wet heath and swamp all of which will have significantly different carbon sequestration values and the relative levels of which we have no data for.

However, in order to illustrate the calculation, we first assume that the baseline is for the 2,040 ha to be in the natural grassland/pasture class. Areas that change to the inland marsh category would yield a benefit of 27.2 tonnes of carbon per hectare. However, areas changing to the moor and heath category would result in losses of 13.8 tonnes of carbon per hectare. Applying these figures to the whole area gives a range from **loss** of 28,000 tonnes to **gain** of 55,000 tonnes, with the "true" figure somewhere in between: a simple average would be 13,500 tonnes of carbon, or approximately 50,000 tonnes of CO_2 equivalent. These are total figures for the carbon stored in the ecosystem, not estimates of sequestration rates: it would take many years for the soil carbon to adjust following change of system management: we do not know exactly how long this would take, but using 50 years as an approximation along with the simple average suggests very approximately 1,000 tonnes per year for this simple average, rising to 4,000 tonnes per year for the most optimistic case (considering the full 2,040 ha to be converted from 'grassland' to 'marsh').

There is some uncertainty, as noted, about the baseline: a partial agricultural abandonment scenario might result in a landscape characterised as 'transitional woodand/scrub' or 'agriculture with significant areas of natural vegetation': these types are classed identically in Cantarello et al and contain less carbon on average than natural grasslands: more in vegetation, but less in the soils. It is also important to recognise that there is substantial variation in the amount of carbon recorded within each land-cover class in the Cantarello et al study: applying these broad averages to specific cases gives only a very rough approximation. Because of the very high uncertainty about this figure, we do not include it in the main analysis, but return to this in the sensitivity analysis.

The production of CO_2 equivalent per tonne of dead weight produced was estimated using the Cranfield model (Williams, 2006). Using stocking rates from Redman (2011) the production of CO_2 equivalents at high and low levels of stocking densities were then estimated per hectare per year. If we assume that the project leads to these farms moving from high to low stocking densities we can estimate that approximately 15 tonnes of CO_2 emissions are saved per hectare per year on beef farms and 1.5 tonnes on sheep farms. Given that 2,340 ha of grassland will be protected we might estimate that between 2,283 and 23,388 tonnes of CO_2 might be saved each year.

For the calculation we use the sheep estimates as these are the lower of the two and so conservative (but remain significant). But we assume that the farms are moving from the highest density / ha to conservation grazing density. Once all of the land is converted there is a gain of 2,283 tonnes per year. The area covered is estimated based on existing grassland in favourable condition at the time of valuation and an extrapolation towards the total aimed for at the end of the project as in Table 2.

Air quality: Impacts on air quality are unlikely to be significant.

Recreation: The DWT suggests that the wet Culm is not as attractive for walkers or recreational use as drier sites might be (Peter Burgess- Devon Wildlife Trust pers. comm. 2011). The value of the area for recreation is also limited by the easy reach of popular substitute sites, with Exmoor and Dartmoor standing either side of the area. So the recreational benefits of this area are likely to be less significant than in other cases. The change in aesthetic quality of the area may influence recreation values for local residents but the impact is likely to be minor.

Education and knowledge: Educational provision will increase as farmers have signed up for Higher Level Scheme educational payments (16 trips per year currently). The trips encouraged by these payments may not present a net gain as alternative school trip destinations may be available (in the absence of the payments). The farms may however provide more local destinations for a farm trip which schools may not otherwise have had. The marginal benefit of gaining a stronger understanding of agriculture over other educational trips and the value of providing this extra choice are difficult to value.

Similarly to the estimates used above for increases in HLS sign up we have had to estimate the increase in the number of classes per year that will add to the initial 16. We essentially assumed that since in the first 3 years an extra 16 joined that the rate would continue with roughly 5 new classes per year. Thus, the total number of classes visiting increases to 21 in the first year, then 26 and then 37 classes per year. We then assume that there are only 37 classes running each year into perpetuity.

Cultural and spiritual: Culm grassland and traditional agricultural practices have cultural heritage values that will be significantly enhanced under the project and further eroded without it.

Landscape and aesthetics: The aesthetic appeal of the Culm grasslands will be enhanced by the project, with more traditional, low-intensity grazing landscapes and increased wildlife presence. Hedgerow restoration and improved condition of watercourses contribute to this.

Biodiversity/habitat: The primary improvement in ecosystem services provided by the project will be biodiversity. The Culm Grassland is important for a range of species, including the following:

- Plants: three-lobed water crowfoot (*Ranunculus tripartitus*); wavy St. Johns Wort (*Hypericum undulatum*), whorled caraway (*Carum verticillatum*), lesser butterfly orchid (*Platanthera bifolia*),
- Mammals: otter (*Lutra lutra*), dormouse (*Muscardinus avellanarius),* harvest mouse (*Micromys minutus*), brown hare (*Lepus europaeus*), bats (Vespertilionidae spp. and Rhinolophidae spp.)
- Butterflies and moths: marsh fritillary (*Euphydryas aurinia*), small pearl-bordered fritillary (*Boloria selene*), wood white (*Leptidea sinapis*) and brown hairstreak (*Thecla betulae*), dingy skipper *(Erynnis tages*), narrow-bordered

bee-hawk moth (*Hemaris tityus*), double line (*Mythimna turca*), ruddy highflyer (*Hydriomena ruberata*) and dingy mocha (*Cyclophora pendularia*).

- Birds: reed bunting (*Emberiza schoeniclus*), curlew (*Numenius arquata)*, snipe (*Gallinago gallinago*), tree pipit (*Anthus trivialis*), willow tit (*Poecile montanus*), grasshopper warbler (*Locustella naevia*), barn owl (*Tyto alba)*.

The project aims to create 96ha of Culm from arable and forestry, and to shift 2040ha of Culm into favourable status.

Figure 2 provides an overview of the relative changes in ecosystem services which we might expect from this project. This is eftec's assessment based on the responses provided by the Devon Wildlife Trust. It compares the services provided in the baseline and the Working Wetlands project. A scale of 0 to 5 is used where 0 means the service is not provided and 5 means the service is provided and is considered optimal for the site.

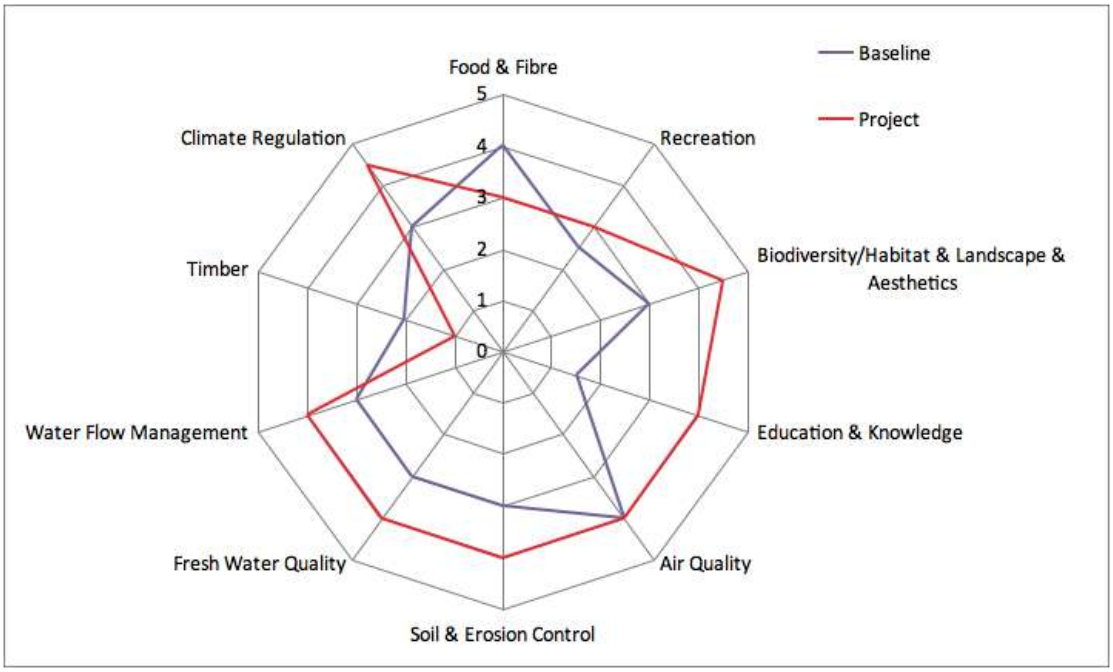

Figure 1: Ecosystem service changes in the two baselines and with the Culm project (eftec's assessment)

Tables 3 and 4 provide an overview of the physical changes valued by the project.

Table 3: Habitat changes under policy scenario for the Culm

Habitat type	Area	Quality to Be Achieved	Changes under project	Timing
Wet Grassland	2040ha	Favourable condition	Sympathetic management has been achieved on 480 hectares of high quality grassland. The creation of 96 hectares of Culm habitat from arable land and forestry plantation. By the end of the project they hope to have an extra 2040 ha of wet grassland in favourable condition.	Project started in 2008 ends 2014 but the newly created habitat will exist into the foreseeable future. Over the first 3 years of the project 440ha of land were converted to favourable status. Conversion is therefore relatively fast and in terms of years rather than decades.
Dry Grassland	300 ha	Favourable Condition		
Hedges	300 km	Favourable Condition	Hedges are recorded when positive management has been restored either through AG /ENV or advice.	
Watercourses	255km	Favourable Condition	Watercourses are recorded when land management is positively influenced on adjacent land.	

Table 4: Remaining Physical Changes to be Valued

Ecosystem service	Value	Source
Educational visits under the HLS scheme	16 classes per year	Total classes agreed to date projected forward
Estimated CO_2 changes	From agricultural intensity change: approximately 2,283 tonnes/year From change in land cover: uncertain, could be in the order of 1,000 tonnes/year for 50 years.	Estimated from Williams (2006) and Redman (2011) based on assumed changes in stocking. Estimated from Cantarello et al (2011) and assumed habitat changes.

4. Appropriate Monetary Valuation Evidence

Here we report the process of review and selection of the unit economic value estimate that is appropriate to the case study. The value evidence includes market prices, estimated premia where relevant and estimates of willingness to pay (WTP) or willingness to accept compensation (WTA) for non-market goods and services.

The appropriateness is determined by similarities between the context on which the estimate is based and the context of the case study. The key factors that define this context are decision making context, place, ecosystem services and population affected. The estimates also need to be robust or at least variations explainable.

Table 5 shows the unit value estimates that are selected for further analysis. The same estimates are presented in bold throughout the text.

Table 5: Unit economic value estimates used in the analysis

Ecosystem Service	Value	Reference	Key reason for selection
Food and fibre			
Higher Level Stewardship payments	Beginning at £35,000 per year and rising to £1.2 million for food	Higher Level Stewardship Scheme costs provided by Natural England for the site currently under agreement and extrapolated into the future	The cost of HLS payment is used as a proxy for the benefit the stewardship actions generate.
Climate Regulation			
Non-traded carbon price	£51.70 per tonne in 2010 to £268 in 2100	DECC, 2010	The mid price non-traded value is used (DECC, 2010)
Education and research			
The cost of an educational trip to a farm	£725/class trip	Estimated using HLS scheme costs and (Mourato et al., 2011)	Cost of providing educational trips – min measure for benefit
Cultural and spiritual & Landscape and aesthetics & Biodiversity and habitat			
Willingness to pay to increase Culm grass by 10% in the project area	Local residents £17.53/household/year Tourists £11.84/trip/household	Burgess et al., 2004	Recent stated preferences study that is about Culm grass and in the project area

Food and fibre: Values for food production can be based on agricultural returns, corrected to remove agricultural subsidies that are a transfer payment. This can be carried out using a detailed assessment of changes in production of specific foods (in this case, livestock) or, approximately, through consideration of the value of land taken out of agriculture. In the case of land lost to agriculture due to coastal changes or repeated flooding, suggest using market prices, but adjusting to 65% of the prevailing land price, in order to correct for agricultural subsidies (Penning-Rowsell, 2005). This approximate rule of thumb is suitable for general use.

However, in this case, we are missing information on the areas removed from production or subject to changed grazing regimes. As a proxy, we can consider the Higher Level Stewardship Scheme (HLS) payments. The payments through the HLS are designed to both pay for the costs of managing the land and the opportunity costs of moving to less intensive practices. As such they can provide a proxy for opportunity cost, but this is not directly a measure of the physical change in production. In this specific case, the management costs are minor and most of the HLS payment can be considered as opportunity cost.

Further, we do not separately account for management costs, so the management costs included in the HLS measurement are not over-counted, but rather simply 'mis-filed' as opportunity costs under the food and fibre category, instead of as costs of management.

Table 6 displays the estimated yearly costs of the HLS as the project progresses to its final year. The costs up to February 2011 were provided by Natural England for all farms that are under agreement thanks to the project. The rate of new uptakes for the remainder of 2011 was assumed to be the same for the subsequent months. We then assume that uptake declines towards the final year mirroring the uptake up to 2011. What is presented is the cumulative growth in payments which will continue for the 10 year agreement. However we are using these as opportunity costs and so use them as perpetual costs. Further detail on this calculation can be found in Section 5.

Table 6: Higher Level Stewardship Payments

Year	Aggregate
2008	£35,672
2009	£54,641
2010	£191,471
2011	£1,046,110
2012	£1,182,940
2013	£1,201,910
2014	£1,237,582

Timber: (eftec, 2010) reports information from public forestry in the UK suggesting the following average timber values:

- Conifers and Plantations on Ancient Woodland Sites (PAWS): £120 per ha year;
- Ancient Semi-Natural Woodland (ASNW) and restored PAWS: £15 per ha year, and
- Other broadleaved: £30 per ha year.

However the same source cites costs of forest management that are slightly greater than these benefits, suggesting that the net value of this service would be negligible and hence is excluded from the analysis.

Climate regulation: Can be valued using DECC guidance figures for carbon values. In this case, the relevant figures are those for non-traded carbon. **The mid-range values rise from £51.70 per tonne in 2010 to £268 in 2100.**

Education and knowledge: In principle education services could be valued using willingness to pay methods, but for practical reasons this is difficult. An alternative proxy is to use the costs of engaging in education activities. Mourato et al. (2011) value educational trips made by schools to the London Wetland Centre and the Hanningfield Reservoir in 2009 and bird watching activities for the RSPB-organised Big School Birdwatch.

The value of educational trips is the sum of transport costs, value of teachers' time, value of student time based on the cost to government of keeping students in education and (if applicable) the cost of HLS payments to the farmers who receive education trips.

Mourato et al (2011) estimate the above (with the exception of the cost to farmers) as follows:

- Transport costs: The average cost to parents of a primary and secondary school day trip in the UK was used to value transport costs = between £7.75 and £16.18 per child per trip.

- Teachers' in-vehicle travel time: was valued using 'wage rate' – 125% of their wage (estimated at £35,000 per annum, to reflect the cost of their time and labour overheads).

- Student time: was valued at the cost to government of students in education (about £5,140 per student per year).

- Time spent travelling in the vehicle was calculated using GIS from the postcode locations of each school. The 'excess time' - time spent waiting or walking to and from school buses - was valued at 200% of in-vehicle travel time costs, following standard procedures in transport analysis.

The final values were £628 per educational trip or £19 per child for the London Wetland Centre, and £839 per educational trip or £30 per child for the Hanningfield Reservoir.

For this case study, the landowner costs can be estimated using agri-environment Higher Level Scheme payments (Natural England 2010). These come as a base payment (£500 for a minimum of 4 visits) per year and a per trip payment (£100) which is equivalent to £8.55 per child (assuming a class size of 26.3).

Thus, the value of an educational trip in this case study based on the student and school costs (£19) and farmer income (£8.55) is **£27.55 per child per trip** or just under **£725 per trip** (assuming a class size of 26.3).

Cultural and spiritual & Landscape and aesthetics & Biodiversity and habitat: Although these ecosystem services can be separated out at a conceptual level, it is often the case that valuation instruments combine them in an overall appraisal of changes to a resource. For this study in particular, a combined analysis is the most appropriate since there is already a stated preference study (Burgess et al, 2004) undertaken specifically for Culm grasslands in the area.

The stated preference survey was carried out in 2002 and estimated the willingness to pay for a 10% increase in the current range of the Culm. The study presents the area of Culm in Devon as 4047ha and in Cornwall as 349ha. A 10% increase would therefore correspond to creation of approximately 440ha of Culm. **Willingness to pay for visitors was £11.84 per trip whilst for local people it was £17.53 per year** (Burgess et al., 2004). The original valuation was for payments over a 10 year period and so yearly benefits are *only* included for the first 10 years.

5. Transfer Evidence and Estimate Monetary Value

Having selected (or assumed) the appropriate unit value estimate, here we aggregate this to the affected ecosystem service and/or population. In many cases, this is a simple multiplication of the unit of change (from Section 3) and the unit economic value (from Section 4).

Table 7 summarises the results and the rest of this section explains the process behind these. The unit estimates from different years are converted to 2010 £ using the Retail Price Index and Consumer Price Index (Note the Consumer Price Index only began in 1996).

Table 7: Summary of Values for Likely Ecosystem Service Changes

Ecosystem service	Environmental Change	Economic Value	Value £ /year
An opportunity cost based on agri-environmental payments	Value is taken directly from the HLS payments Table 5	Rises to £1,237,582 in 2014	£1,237,582 in 2014
Climate regulation			
Carbon sequestration with the project	2,283 tonnes/year	Yearly carbon price as in DECC (2010) guidance	~£125,000/year once all land is converted, rising over time
Education and research			
School visits to farms	16 classes rising to 37	£725/class	Reaches ~£27,000
Cultural and spiritual & Landscape and aesthetics & Biodiversity/habitat			
Based on a valuation for the Culm Grasslands	2040 hectares of Culm grassland in favourable condition	£13.11/household –locals £9.95/visit -tourists	~£33 million

Food and fibre: The HLS values used are taken directly from Section 4 (Table 6). Beyond 2014 we assume a perpetual opportunity cost of £1,237,582 which is the maximum the yearly payments reached in our estimate.

Climate regulation: The change in emissions per hectare of land moved from high to low stocking is used here. The total area brought into favourable condition was assumed to have changed stock densities from high to low and so the size of this area was multiplied by the per hectare emissions/year change estimate. The estimated total emissions per year are multiplied by the non-traded carbon price

provided by DECC (2010) for each year and discounted for future years[1]. Given uncertainty over the forms of farming used in these sites we present prices based upon sheep farming and cattle farming (See Section 3).

Education and knowledge: The number of classes per year agreed to in the Higher Level Scheme agreements (16) is multiplied by the cost estimates for a single class (£725) in the first year and this rises by roughly 5 each year up to a maximum of 37.

Cultural and spiritual & Landscape and aesthetics & Biodiversity/habitat: The project aims to create 96ha of Culm from arable and forestry, and to shift 2040ha of Culm into favourable status. We assume that Burgess et al (2004) estimate still applies even though the scale of change is different. The affected population to aggregate the WTP estimate is the same as in the Burgess et al (2004): 747,400 Devon households and around 2.4 million households visiting from outside Devon each year. The WTP estimates for each group are multiplied with the group population. The original valuation was for payments over a 10 year period and so yearly benefits are only included for the first 10 years.

[1] (High Stocking Rate – Low Stocking Rate) x CO_2/dead weight produced x dead weight/head of livestock

6. Aggregation

Table 8 summarises present value estimates for the costs and benefits of the Working Wetlands project. The results are reported over 10, 50 and 100 year time frames, and with a changing discount rate according to Government guidance (HM Treasury, 2003): 3.5% for years 1-30; 3.0% for years 31-75; and 2.5% for years 76-125.

The costs of the activity are in terms of the running costs of the project and the loss of food and fibre. Food and fibre costs were estimated based upon Higher Level Stewardship costs and so include some of the costs of implementing the physical land management.

Table 8: Present value estimates of costs and benefits for the ecosystem services associated with the project (million £)

Ecosystem Services	Present Value			Notes
	10 years	50 years	100 years	
Administration of the project	-£0.12m	-£0.12m	-£0.12m	
Running costs of the project	-£3.15m	-£4.83m	-£5.52m	These are the costs of running the wildlife trust work helping farmers into the scheme.
Food and fibre	-£7.08m	-£27.94m	-£36.38m	Likely to be an overestimate of these costs since it includes the costs of implementing the work (but those do need to be counted).
Climate regulation	£0.806m	£4.76m	£8.18m	These figures assume that the farms are moving from the most polluting practices / ha to the least but for sheep farming. If it is cattle the change would be 10x larger. The area covered is estimated based on existing grassland in favourable condition at the time of valuation and an extrapolation towards the total aimed for at the end of the project. It does not include values associated with change in carbon contained in soil and vegetation.
Education and research	£0.15m	£0.60m	£0.79m	Assuming that the farm visits set up in the HLS scheme continue in perpetuity. The prices here are costs and so represent the minimum value of the educational benefits.
Cultural and spiritual; Landscape and aesthetics; Biodiversity/habitat	£293m	£293m	£293m	Mean WTP estimates for all tourists and households in Devon.
NET PRESENT VALUE	£282m	£266m	£260m	

7. Sensitivity Analysis

It is difficult to define the baseline for this case study beyond the fact that the Culm grasslands themselves would remain fragmented across an increasingly small area. Whether this loss would come from a lack of farming or intensive farming is less certain and this significantly impacts upon our ability to estimate some impacts such as impacts on food or GHG emissions.

For the **climate regulation** benefits we assumed that displaced livestock production relates to sheep. If, instead, displacement is cattle, the climate regulation benefits could be greater (see Table 9). In addition, we did not use estimates of the change in carbon contained in soil and vegetation. The estimates for this are too uncertain. The most 'optimistic' view of the change would involve conversion of 2040ha of 'grassland' land cover category to 'marsh', resulting in sequestration of 4000 tonnes per year, with a present value of £8.3m over 50 years. However the true value is likely to be substantially less than this.

Table 9: Sensitivity to type of livestock – climate regulation (£m)

GHG reduction benefits if the change is from	**Present Value**		
	10 years	**50 years**	**100 years**
Sheep (central estimate)	£0.806m	£4.763m	£8.18m
Cattle (high estimate)	£8.06m	£47.6m	£81.8m

For the **Cultural and spiritual; Landscape and aesthetics; Biodiversity/habitat** services, the WTP results were presented using the mean from the survey, applied to estimates of the Devon population and annual visitor numbers (see Table 10).

Table 10: Sensitivity to WTP estimate – Cultural and spiritual; Landscape and aesthetics; Biodiversity/habitat (£millions, Present Values over 50 years)

	Number	Mean value	Low	High
			(95% confidence interval)	
Residents	747,000	£84m	£47m	£121m
Visitors	2.4 million	£208m	£46m	£370m
Total		£292.5m	£93m	£491m
Net Project Value		£282m	£66m	£464m

The results are robust to these changes: although the total value changes substantially, it remains positive.

The aggregate WTP results also rely upon estimates of the size of the relevant user/non-user populations. Given the relative size of the benefits to the costs, it is unlikely that a reduction in the estimated population would significantly affect the result. However, if we adopt a more conservative approach and look at only the population of the areas around the Culm project sites – Torridge, West Devon, North Devon and Mid Devon (285,500 households) and consider only visitors to Devon

Wildlife Trust sites (knowing that the Culm is not particularly attractive to general visitors), the resulting benefit estimates are presented in Table 11.

Table 11: Sensitivity to stated preference value: low population estimates (£millions, Present Values over 10 years)

	Number	Mean value	Low	High
			(95% confidence interval)	
Residents	285,500	£18m	£10m	£26m
Visitors	50,000	£4m	£1m	£8m
Total		£22m	£11m	£34m
Net Project Value		£11m	£0m	£23m

Even with these more conservative estimates, the NPV remains positive in most scenarios, dropping to zero with the lowest value and population estimates.

8. Reporting

Flood risk and water quality impacts may be significant but we were unable to measure them appropriately. Effort was made to include carbon sequestration via the effects of livestock. However the estimates do not include soil sequestration which may be significant for wet grasslands but may also be negative depending on the specifics of the project.

The other benefits valued may be underestimates, in particular education. Education values were based upon costs and did not present the value of these trips. Moreover our inability to estimate the relative value over alternative educational trips (which may well be zero) means that this value is at best uncertain.

The total costs estimated come to (in present values): £10 million (10 years), £33 million (50 years) and £42 million (100 years). The WTP estimate for cultural and spiritual; landscape and aesthetics and biodiversity/habitat services from the contingent valuation results were all gained in the first 10 years of the project but were significant and robust in sensitivity analysis.

Summary

The Culm Grasslands are arguably Devon's most important habitat and home to nationally important butterflies and moths. A project led by the Devon Wildlife Trust has targeted three areas of Devon in which they are encouraging and helping farmers to sign up for Higher Level Stewardship schemes. With the help of an economic valuation study implemented in Devon for Culm grasslands (Burgess et al., 2004), Cultural and spiritual; Landscape and aesthetics and Biodiversity/habitat services were possible to estimate. And on the basis of this valuation alone, the project is likely to generate net public benefits of hundreds of millions of pounds over ten years.

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