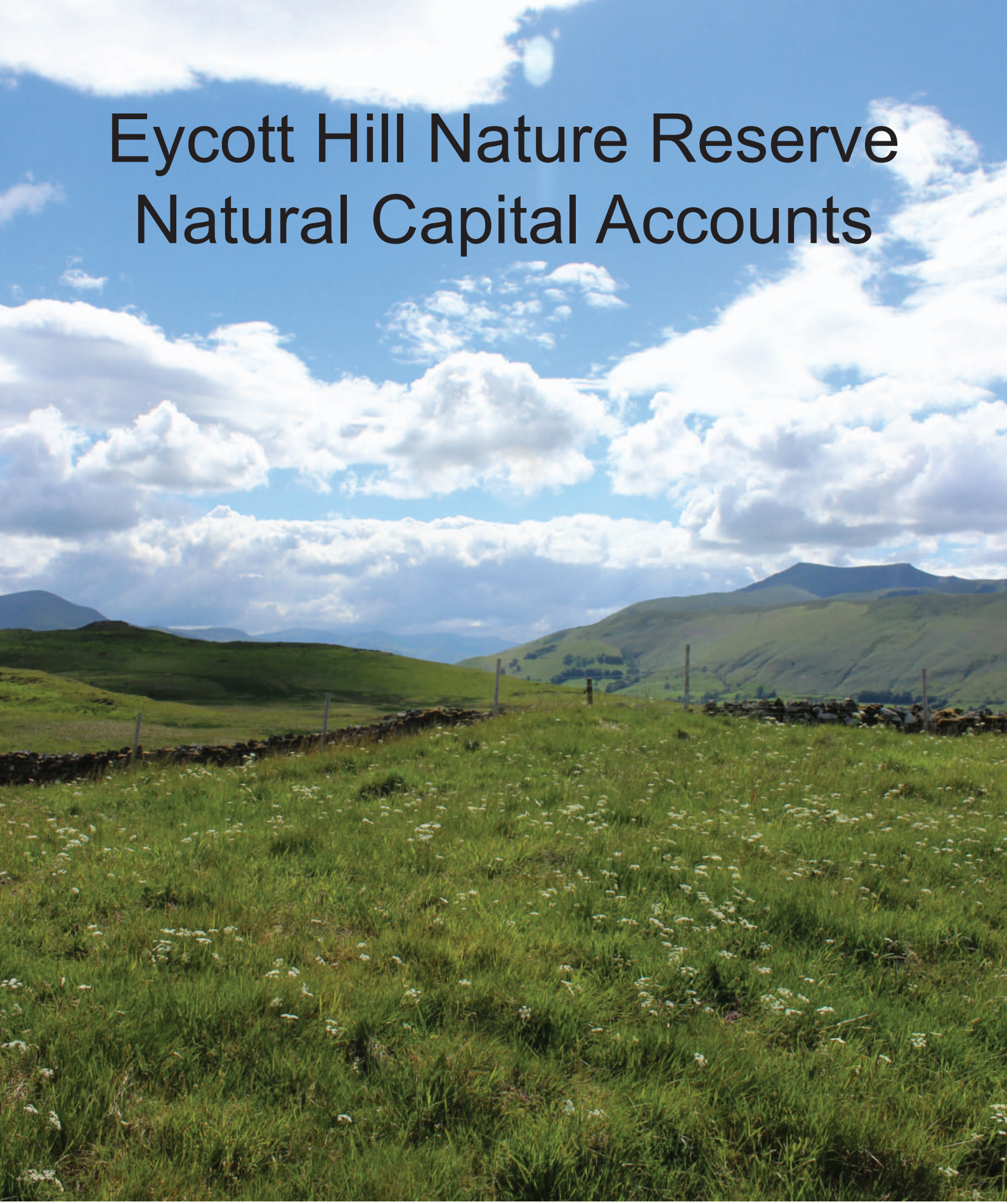
Eycott Hill Nature Reserve
Natural Capital Accounts



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Eycott Hill nature reserve natural capital accounts

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Executive summary

This report presents a natural capital assessment of the Eycott Hill nature reserve in two time periods, T1 when the site was managed as an upland livestock farm (2011), and T2 the current state of the reserve (2017). The work was commissioned by Cumbria Wildlife Trust who own and manage the nature reserve. Using a natural capital accounting framework, the assessments aimed to identify and assess existing natural capital assets (asset register), the flow of ecosystem services from them (physical flow account), and the monetary value of the resultant benefits (monetary flow account). The net ecosystem service benefits were then established for T1 and T2, taking into account the costs of maintaining the natural capital assets (natural capital balance sheet). The assessments of the two time periods were then compared. As part of the assessment we also compared the state of biodiversity in T1 and T2, and took a more in depth look at the social benefits that were not possible to quantify as part of the accounting approach. We also briefly analyse the pros and cons associated with out-wintering the cattle that currently graze the reserve.

Eycott Hill (217 hectares) consists of upland habitats, with half of the site forming the Eycott Hill SSSI, designated in 1988. In T1 the asset register shows the site consisted of valley mire and swamp, species poor acid grassland on higher elevations, with patches of dwarf shrub heath and bog vegetation. The lower lying areas of the site supports neutral grasslands. The north-eastern area of the site was managed as improved grassland. The whole site was grazed mainly by sheep, but also by some cattle. It experienced a grazing level of c.0.3 Livestock Units (LU) per hectare between 2002 and 2011 (although historically this was much higher with up to 800 sheep in total). The distinctiveness and condition of these habitats in T1 provided a total of 2015 biodiversity units, as measured by the Defra biodiversity metric. A qualitative assessment of ecosystem services shows a relatively broad range of services in the provisioning and regulating categories, with agricultural production being provided at the highest level, followed by water regulation and purification services. There is a low level of provision of the cultural services in T1. The physical and monetary accounts show that the service of greatest value in T1 is air quality regulation (although this is still quite low), through removal of an estimated 0.25 tonnes of PM_{10} per year with an associated value of £5,002 (Present Value (PV) £127,651 over 50 years). This is followed by physical health services saving society £2,560 per annum (PV £94,625), and recreational opportunities to the value of £2,002 per annum (PV £51,094). Due to there being few trees at the site, carbon sequestration and timber/woodfuel production are low. Agricultural production at the site delivers an annual deficit of £15,344 (PV £391,600) once subsidies are stripped out. Although most of the land is rough grazing, with zero emissions, the livestock at the site produce Green House Gas (GHG) emissions that cost society £3,649 per annum (PV £93,130). The overall GHG balance in T1 results in a net carbon loss, a cost to society of £3,649 in 2018. The total cost associated with running the Eycott Hill as a farm is estimated to be £127,300 (PV 3.25M). The maintenance costs are high, resulting in a net natural capital asset value of £0.48M of external ecosystem service benefits (this includes agricultural subsidies).

In T2, after just over 2 years of managing the site as a reserve and practicing low intensity livestock farming, the asset register shows the range of habitats is the same. However, the area of neutral grassland has been increased, with the improved grassland area being managed as species-rich grassland; hedges and trees have been planted at the site (broadleaved and juniper), and heathland is being restored. These changes have led to an increase in biodiversity units at the site (2066), as measured by the Defra biodiversity metric. A qualitative assessment of ecosystem services shows a broader range of services provided by the site, notable here are the cultural ones that score a high provision across all services. All regulating services are likely to increase in their provision, with agricultural production seeing a significant drop in intensity. The physical and monetary accounts show that the services of greatest value are physical health, which is estimated to deliver £44,741 savings to the NHS per year (PV £1,653,984), and recreation estimated at £34,789 per annum (PV £887,864). This is because the site is now promoted as a Wildlife Trust reserve. Other services have increased in their provision and value, for example air quality regulation, carbon sequestration and timber/woodfuel production. In T2, agricultural production has decreased but still shows a deficit of £7,907 (PV £201,797 deficit), although GHG emissions have reduced. The overall GHG balance in T2 shows that the site moves from being a net emitter to net sequestration of 160.62 tCO_2e per annum, valued at £10,615 (£2018). Maintaining Eycott Hill as a nature reserve is estimated to cost less than in T1 at approximately £60,954 per annum (PV £1.56M), with HLF funding covering all the site management costs. The total net natural capital asset value in T2 is £3.13M.

The management of Eycott Hill as a nature reserve provides other social benefits. For example, educational activities engage university, college and school students, with the site providing the basis for learning about flora, fauna, land management and agricultural practices. Outreach activities such as art workshops and guided walks engage a wide range of groups, including disadvantaged individuals. The reserve also creates opportunities for volunteering, that increases experience, self-esteem, improves health and personal development. The low-intensity farming at the site provides an opportunity for producing ‘conservation grade’ beef, which could potentially double the farm gate price, if sold directly to the consumer. Out-wintering of the calves (at present they over-winter in a barn and are grain fed) is likely to be less impactful environmentally, with cost savings of c.£200 per head.

The account for T1 shows how management for intensive agriculture has limited the ability of the natural capital assets to produce ecosystem services to any high level across the provisioning, regulatory and cultural categories. As a result the net value of the natural capital assets was low, due to agricultural production and related GHG emissions. However, in T2 the natural capital benefits are much higher, due to the move away from improved grassland, and the planting of more trees at the site, despite it still being early on in the conversion process. The net value of the assets in T2 is 6.5 times higher than in T1. It must be noted that the site is still likely to be important for water flow and quality regulation and pollination. Due to the complexities of quantifying and valuing these services they could not be included in the account. If they were able to be included, net asset value in T2 would be higher.

The natural capital assessments and accounts at Eycott Hill has successfully shown how changes in site management can have a positive effect on the provision of public benefits, and that public money can be used to enhance these benefits. This study can be used to demonstrate best practice to roll out a natural capital approach more widely, and to communicate and showcase the added value of nature reserve management and a move to low intensity agriculture.

Contents

1. Background

1.1 Aims

Natural Capital Solutions were commissioned by Cumbria Wildlife Trust to undertake a natural capital assessment of the Eycott Hill nature reserve near Penrith. The assessments were taken at two time points, the first (T1, 2011) before the site was established as a nature reserve, and the second assesses the natural capital as it is now (T2, 2017). We identify and assess the existing natural capital stocks, the flow of services derived from this natural capital, and their value to society at T1 and T2. These benefits are then compared to the maintenance costs at T1 and T2 within a natural capital accounting framework. Using this account we demonstrate the natural capital gains (and losses) that managing the site as a nature has brought about.

1.2 The natural capital approach

The natural environment underpins our well-being and economic prosperity, providing multiple benefits to society, and yet it is consistently undervalued in decision-making. Natural capital is defined as "*..elements of nature that directly or indirectly produce value or benefits to people, including ecosystems, species, freshwater, land, minerals, the air and oceans, as well as natural processes and functions"* (Natural Capital Committee 2014). These benefits (often referred to as ecosystem services) include food production, regulation of flooding and climate, pollination of crops, and cultural benefits such as aesthetic value and recreational opportunities (Figure 1).

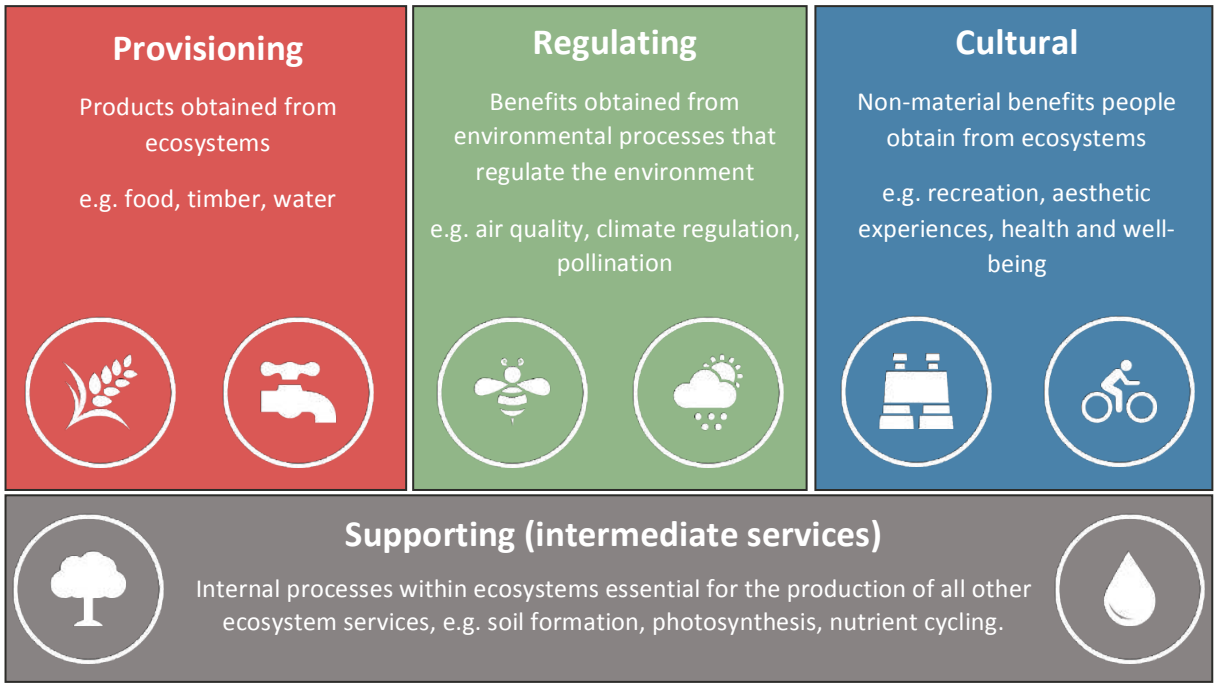

Figure 1: Key types of ecosystem services (based on MA 2005)

The concept of natural capital and its associated approaches can be used to understand the natural capital assets of an area or organisation. Through a natural capital assessment, it is possible to understand the extent and condition of those assets, so the number and the flow of ecosystem service benefits from those assets can be established. These benefits can then be valued. Information on the condition and benefits derived from an asset enables better informed land management decisions to be made because of the transparency gained by recognising an asset's full, long term value. It provides an understanding of the consequences of land management change (whether that be a change from one type of natural habitat to another, or from natural habitats to, for example, hard engineering or housing developments) on the range of benefits that can be provided by a landscape. It can also highlight how specific changes can be tailored to enhance certain services or values, and how environmental change (e.g. climate change) may affect natural capital assets, their benefits and values. It can reveal the value of both public and private benefits that come from managing landscapes, and it is key to identifying trade-offs and synergies between different ecosystem services.

By taking a natural capital approach, Cumbria Wildlife Trust will be able to more accurately demonstrate the value of the natural environment and their management of it, highlight critical assets that require protection or restoration, enable natural capital to be taken in to account more fully in decision making, and start to monitor losses and gains over time.

1.3 Natural Capital Accounting

A natural capital account measures and values the natural capital assets of an area, based on the flow of ecosystem services and associated benefits from those assets. The benefits are then compared to the costs (capital and operational expenditure), in the form of a balance sheet. General principles and methodology have been developed, such as the Principles of Natural Capital Accounting background paper (ONS 2017) and Corporate Natural Capital Counting Guidelines (Eftec RSPB & PWC 2015). According to ONS (2017): "*natural capital accounts are a series of interconnected accounts that provide a structured set of information relating to the stocks of natural capital and flows of services supplied by them*". A natural capital account is comprised of a number of different components, outlined below and illustrated in Figure 2:

- An extent and condition account (asset register) – the area, type and condition of natural capital assets.
- Physical flow account – the biophysical annual flow of ecosystem services from the natural capital assets.
- Monetary flow account – the monetary value of these benefits calculated per annum, together with the overall value of the asset over its lifetime (usually calculated over 50 years)
- Maintenance cost account – the cost of current and future natural capital maintenance activities

- Natural capital balance sheet – the value of the benefits derived from the natural capital assets are compared to the costs of maintaining those assets. Valuations are referred to as 'asset values' and the maintenance requirements as 'liabilities', following standard accounting terminology. In addition, two components of asset value are recognised: private value (benefits to the landowner or organisation) and external value (wider benefits to society).

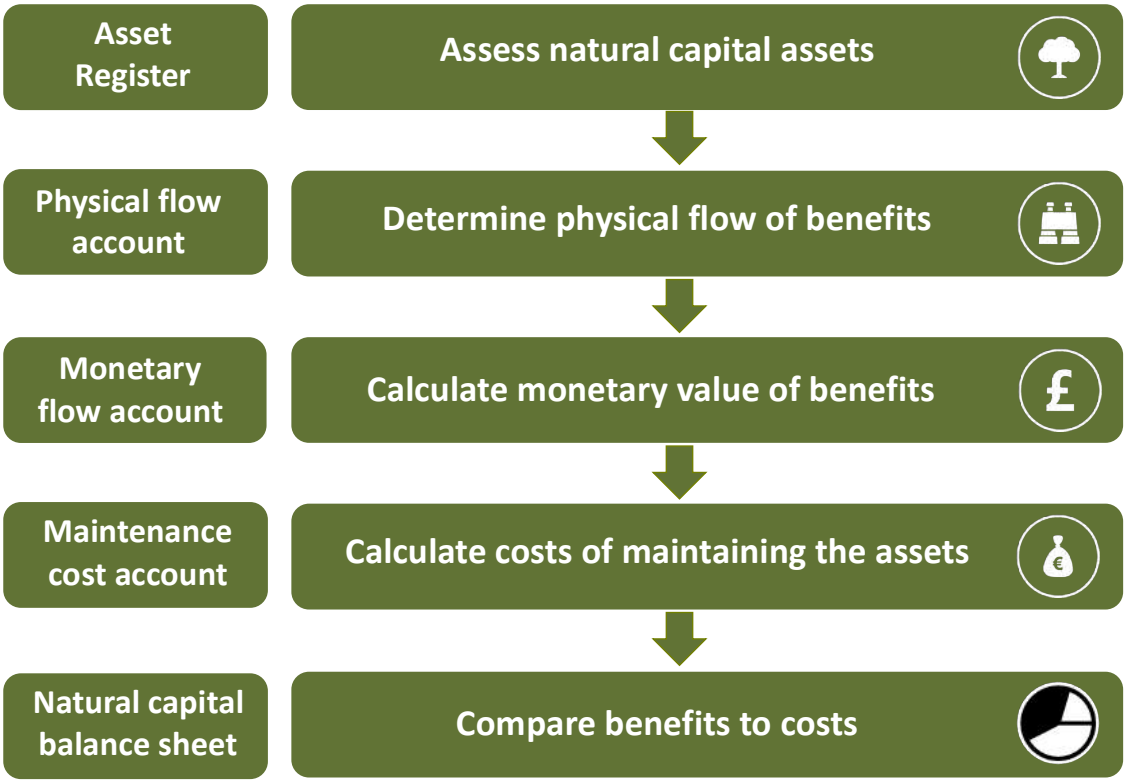

Figure 2: Outline of the assessment approach.

Natural capital accounts can be used to compare the benefits derived from existing natural capital assets with the costs required to maintain them. Once set up it can also be used to examine change over time from a baseline year, or can be used to determine the potential impact of a proposal or new investment.

2. Outline of methodological approach

Full details of the methodology are provided in Annex 1, with a brief outline of the approach described here. We use the framework for corporate natural capital accounting (CNCA) developed by Eftec et al. (2015) for the Natural Capital Committee, and the ONS (2017) Principles of Natural Capital Accounting. The approach used, therefore, draws on the concepts of natural capital and economic valuation[1]. It also follows the broad approach to natural capital assessment outlined in "*How to do it: a natural capital workbook"* published by the Natural Capital Committee (2017).

The natural capital assets of the site at T1 and T2 were first described and mapped (Figure 3 & 4). The condition of the habitats was determined in T1 using an existing ecological survey (O'Reilly 2014), and at T2 by surveying in the field. These were converted into the Defra condition scale for use in the biodiversity metric (Defra 2012) calculation at T1 and T2. The Defra biodiversity metric is a relatively crude measure that captures the condition and distinctiveness of habitats at a site, and converts it into biodiversity units per hectare (see Annex A1.1). More distinctive habitats and those in better condition yield higher biodiversity units. Calculating the biodiversity units at T1 and T2 allows us to assess whether biodiversity has increased since habitats have been restored as part of the nature management. Large changes in restored / created habitats have been included (e.g. newly planted woodland), but less obvious changes, for example, through blocking ditches, have not been included as it is not clear how much the condition of the habitat has increased.

The natural capital assets identified at each site deliver a range of ecosystem services, which provide benefits to people. Those that can be quantified and valued were assessed in the physical and monetary flow accounts (below). However, there are still a number of ecosystem services that cannot be assessed in this way, hence a quantitative assessment (and a natural capital account) may not capture all the benefits provided by the site. A qualitative assessment was, therefore, conducted and is useful both as a summary, and to provide a more comprehensive overview of the benefits provided by the natural resources in each area. It is also useful at drawing attention to key services and highlighting those that should be the focus of more detailed assessments. To do this, each ecosystem service was simply scored on a scale from 0-3, based on an expert assessment of the provision of each service at the site, determined using general principles and any data available. Note that these scores were separate to, and not used in, the calculation of the physical flows and monetised benefits of services used in the natural capital account.

Next, indicators were used to measure the physical flow and monetary value of a number of ecosystem services. The services assessed are summarised in Table 1 and discussed in more detail in Annex 1. Annual values were calculated for each service, as well as the present value (PV) of each service, which calculates the value of the flow of benefits over a 50-year period, using discount rates from the HM Treasury (2018), and the ONS (2014). All prices

[1] Economic valuation quantifies the benefits that people gain as a result of the consumption of goods and services. It is based on welfare or well-being concepts where policy aims to maximise the welfare of society. The economic value of ecosystem services can be measured within the framework of 'total economic value' (TEV) (Defra 2007).

used are for 2018, or converted to 2018 prices using the latest HM Treasury GDP deflator series, to allow the comparison of annual flows. The estimated value of the benefits provided by the sites and the costs of maintaining them in present value terms were calculated and are summarised in a natural capital balance sheet giving the total net natural capital asset value.

A range of assumptions have been made in assessing the physical flows of ecosystem services, in the valuation of those flows, as well as when using discounting and calculating present values. These assumptions are outlined when describing the methodology for the assessment and valuation of each ecosystem service.

Table 1. Units of measurement of the physical flow and monetary value of the ecosystem services.

Ecosystem service	Physical flow	Valuation
Carbon sequestration	Quantity of CO_2 sequestered	£/tonne of CO_2
Timber/woodfuel production	m^3/ha	£/m^3/year
Air quality regulation	Tonnes of PM_{10} and SO_2 absorbed	£/tonne of PM_{10} and SO_2/year
Agricultural production	Ha	£/ha/year
Greenhouse gas emissions from agriculture	GHG/ha	£/ha/year
Recreation	Number of visits	Recreational value/visit/year
Health & well-being (QALYs)	Active visits	£/QALY/year

3. Natural capital account for Eycott Hill

3.1 Site overview, natural capital asset registers and biodiversity

Eycott Hill is a nature reserve situated near Berrier, just inside the north-east boundary of the Lake District National Park and World Heritage Site. The 217 ha site consists of upland habitats, with half of the site forming the Eycott Hill SSSI, designated in 1988 based on biological and geological interest. There are a variety of habitats at the site including, valley mire and swamp containing rich and intact vegetation communities supporting a number of locally and nationally rare plants, species poor acid grassland on higher elevations, with patches of suppressed heath vegetation. The lower lying areas of the site support a range of wetland communities bisected by a number of artificial drains and ditches.

Before being purchased by Cumbria Wildlife Trust in 2015 the site was managed for agriculture and was grazed mainly by sheep, but also some cattle. From 2002-2012 there was an ESA agreement to stock the land at 0.3 Livestock Units (LU) per hectare. An organic HLS agreement was drafted in 2012 to graze the designated half of the site at a reduced stocking rate (0.25 LU per ha), and the other half of the site was used to maximise agricultural output. However, these conditions were not met. Previous to 2002, the site had seen much higher stocking levels, with up to 800 sheep across the site. During this time the SSSI was managed unfavourably, with attempts by previous land owners to drain the swamps. Eight percent of the site was considered as 'unfavourable – declining' in 2007, although the rest of the site was considered to be in 'favourable' condition.

Since Eycott Hill was purchased and managed as a nature reserve, the aim has been to make it an exemplar of good upland management, including conservation farming. The site conversion is a 5 year Heritage Lottery Funded (HLF) project. Activities have been centred around restoring a mosaic of valuable wildlife habitats including upland heathland, blanket bog, valley mires, upland hay meadow, upland oak wood and juniper scrub, native hedges, ghyll and alder woodland. Wetland habitats have been restored through the blocking of artificial drains and ditches, new woodland and hedges have been planted and the main areas of intensive agriculture (improved grassland) are being restored to species-rich grassland. The whole site is grazed by 25 Luing cattle all year round. The calves graze from May to November, and over winter in a barn where they are grain fed. The cattle are bred to produce beef for consumption on the open market.

A breakdown of the main habitat types found at Eycott Hill in T1 and T2 is provided in the natural capital asset registers (Table 2 & 3), including the area and condition of each habitat. The site map shows the location of these habitats (Figures 3 & 4).

This site is important for biodiversity as well as ecosystem services. In order to quantify how the site has improved in terms of biodiversity from when it was managed to maximise agricultural output, to being managed as a nature reserve with low intensity conservation grazing and meat production, we have used the Defra biodiversity metric. The results show (Table 4) that there has been an increase from T1 to T2 of 51.34 biodiversity units.

Table 2. Natural capital asset register for Eycott Hill T1 (2011).

Habitat	Area (ha)	Area (%)	Condition
Fen, marsh and swamp	**110.17**	**50.75**	
	5.72		Poor
	97.31		Moderate
	7.14		Good
Acid grassland	**67.49**	**31.10**	
	5.73		Poor
	61.78		Moderate
Neutral grassland	**25.04**	**11.53**	
	21.14		Poor
	3.9		Moderate
Improved grassland	**6.16**	**2.84**	Poor
Bracken	**3.95**	**1.82**	Poor
Dwarf shrub heath	**1.48**	**0.68**	Moderate
Weedy vegetation	**1.44**	**0.66**	Poor
Inland rock	**0.65**	**0.30**	Moderate
Calcareous grassland	**0.3**	**0.14**	Moderate
Broad-leaved mixed and yew woodland	**0.28**	**0.13**	Poor
Bog	**0.13**	**0.06**	Good

Table 3. Natural capital asset register for Eycott Hill T2 (2017).

Habitat	Area (ha)	Area (%)	Condition
Fen, marsh and swamp	**92.55**	**42.63**	
	5.72		Poor
	79.69		Moderate
	7.14		Good
Acid grassland	**57.87**	**26.66**	
	5.73		Poor
	52.15		Moderate
Neutral grassland	**33.61**	**15.48**	
	21.14		Poor
	12.47		Moderate
Broad-leaved mixed and yew woodland	**21.87**	**10.07**	
	0.28		Poor
	21.59		Moderate
Bracken	**3.95**	**1.82**	Poor
Dwarf shrub heath	**6.28**	**2.89**	
	1.48		Moderate
	4.8		Poor
Inland rock	**0.65**	**0.30**	Moderate
Calcareous grassland	**0.18**	**0.08**	Moderate
Bog	**0.13**	**0.06**	Good

Table 4. Biodiversity units for Eycott Hill T1 and T2.

Habitat	Biodiversity units	
	T1	T2
Acid grassland	517.16	440.12
Neutral grassland	115.76	184.32
Fen, marsh and swamp	34.32	34.32
Dwarf shrub heath	17.76	46.56
Improved grassland	12.32	0
Bracken	7.88	1.68
Calcareous grassland	3.6	2.16
Weedy vegetation	2.88	0
Inland rock	2.6	2.6
Bog	2.34	2.34
Broad-leaved mixed and yew woodland	1.68	259.08
Total	**2014.54**	**2065.88**

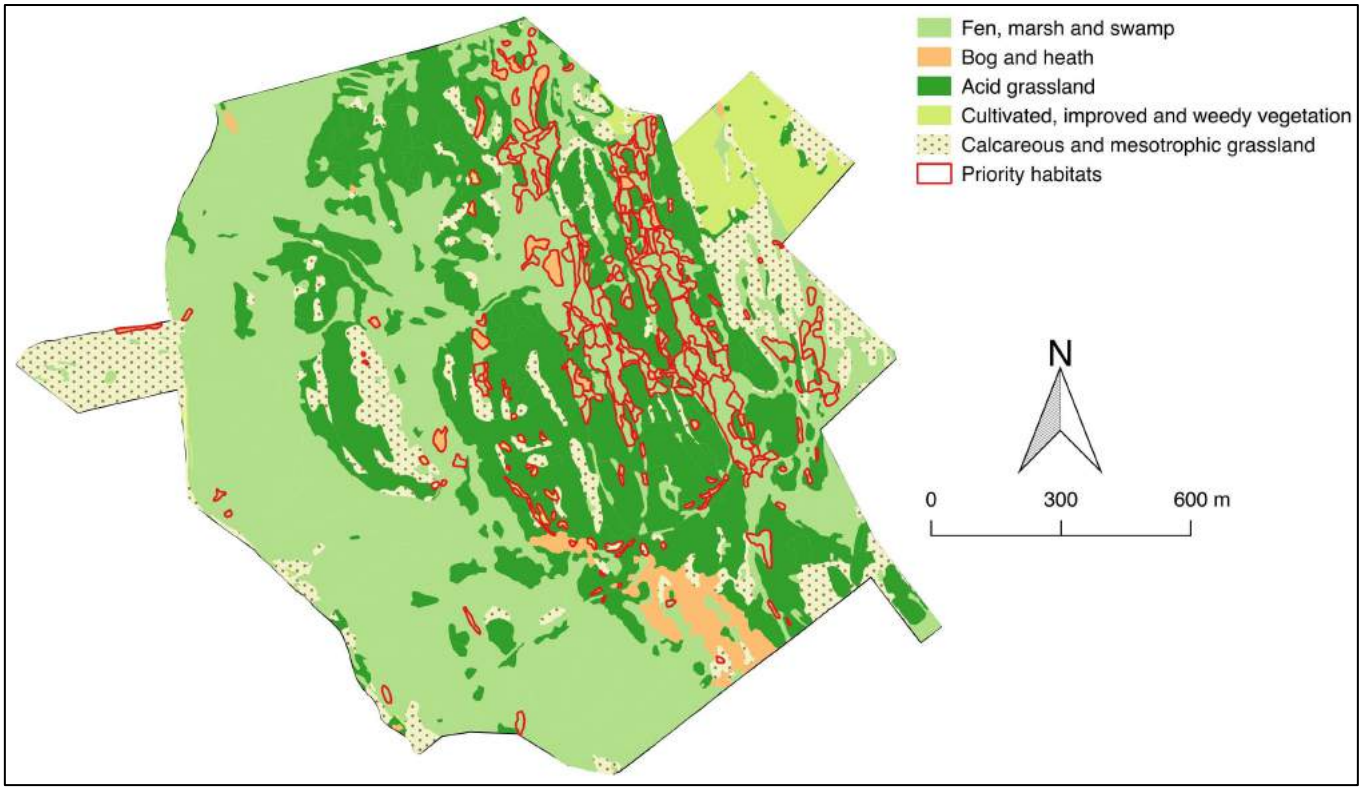

Figure 3. Key habitats present at Eycott Hill T1.

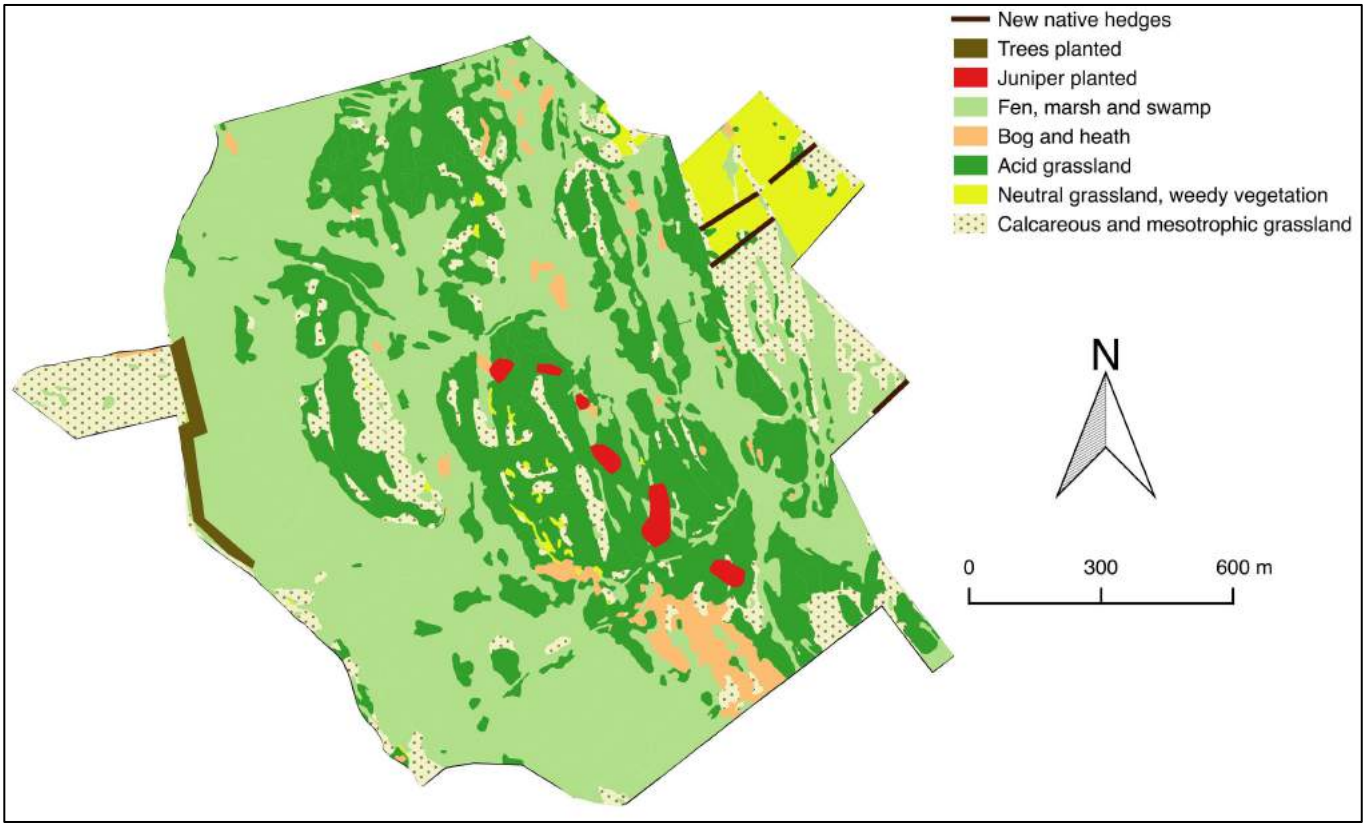

Figure 4. Key habitats present at Eycott Hill T2.

3.2 Qualitative assessment of ecosystem service flows

The qualitative assessments of ecosystem services currently provided by Eycott Hill at T1 and T2 are presented in Table 5. In general the level of provisioning services drops from T1 to T2. In T1 the area was significant for provisioning services due to the emphasis on maximising agricultural production through sheep and cattle farming. The delivery of this service drops in T2, as there is a much less intense level of agriculture at the site. As the area of woodland and juniper scrub increases in T2 the site scores higher for the provisioning of fibre and fuel. In contrast to the provisioning services, and the levels of regulating and cultural services increase from T1 to T2.

Due to the increase in woodland, shrub and hedges, the carbon sequestration and storage* and air quality regulation capacity is likely to increase. The blocking of 4000 metres of peat drainage ditches to restore the degraded mire habitat in T2, will also increase carbon sequestration and storage. Water quality and flow regulation is likely to improve at the site with the blocking of ditches, and the improvement of the wetland habitats, erosion is likely to be reduced through increased tree cover and a reduction in grazing pressure. The improved condition of habitats due to reduction of grazing, and intensive agriculture will increase pollinators and pest and disease control, allow greater soil quality regulation and has increased biodiversity (see Table 4).

* Carbon storage was not quantified in the Physical and Monetary Flow Accounts as it is a natural capital stock rather than an ecosystem service flow.

Table 5. Estimated ecosystem service provision scores for Eycott Hill in T1 and T2: 0 - no delivery; 0.5 - some delivery but not significant, 1 - delivery, 2 -significant delivery, 3 - very significant delivery. List of ecosystem services adapted from CICES v5.1.

Ecosystem service category	Ecosystem service	Estimated provision	
		T1	T2
Provisioning	Food: crop and livestock production	3	1
	Fibre and fuel (e.g. timber, woodfuel, wool, peat etc.)	0.5	1
	Water (includes for drinking, agriculture and industry)	1	0.5
Regulating	Carbon sequestration and storage	1	2
	Local climate regulation	2	3
	Air quality regulation	1	2
	Water quality regulation and erosion control	2	3
	Water flow regulation	2	3
	Pollination	2	3
	Pest and disease control	1	3
	Noise attenuation	0	0
	Soil quality regulation	2	3
	Habitat and population maintenance (biodiversity)	1	3
Cultural	Aesthetic experiences	1	3
	Education, training and scientific investigation	1	3
	Recreation and tourism	0.5	2
	Health and well-being	0.5	2
	Characteristics and features of biodiversity that are valued (existence, option, bequest)	1	3
	Spiritual and cultural experiences	1	3

There is a significant increase in the provision of cultural services at the site from T1 to T2. The site before the nature reserve was created although privately owned, had a permissive access route onto the open fell. The site was not widely known for the aesthetics of its landscape or recreation, therefore the provision of these services were low. Since the nature reserve was established it has been promoted to the public, with recreational activities such as walking, courses and workshops about the flora, fauna and the farming approach being run, allowing the site to function for educational and scientific purposes. The management has increased the biodiversity value of the site, allowing people to appreciate the landscape and to experience being in nature. Increased promotion and recreational opporunities in turn will have increased health and well-being of those who visit the site.

3.3 Physical and monetary flow accounts

The estimated physical and monetary flows of ecosystem services from Eycott Hill in T1 and T2 are outlined in Tables 6 & 7, and full methods are provided in Annex 1. The service of greatest value in **T1** is **air quality regulation**, through removal of an estimated 0.25 tonnes of PM_{10} per year with an associated value of £5,002 (Present Value (PV) £127,651 over 50

years). Though the site also contributes to SO_2 pollution amelioration, the concentration of SO_2 near the site was very low and so the economic impact of this service is negligible

Table 6. Annual physical and monetary flows, and present values of ecosystem services from Eycott Hill in T1. All valuations use 2018 prices.

Ecosystem service	Annual physical flow	Annual monetary value (£ 2018)	Present value (£)
Carbon sequestration (tCO_2)	2.61	172	9,726
Timber/woodfuel production (m^3)	2.24	35	903
Air quality regulation (t)			
PM_{10}	0.25	5,002	127,651
SO_2	0.007	16	410
Agricultural production (ha)	217	-15,344	-391,600
Greenhouse gas emissions from agriculture (tCO_2e)	55.22	- 3,649	- 93,130
Recreation (number of visits)	350	2,002	51,094
Physical health (visitors that meet activity guidelines)	3.75	2,560	94,625
TOTAL		**-9,206**	**-200,321**

Table 7. Annual physical and monetary flows, and present values of ecosystem services from Eycott Hill in T2. All valuations use 2018 prices.

Ecosystem service	Annual physical flow	Annual monetary value (£ 2018)	Present value (£)
Carbon sequestration (tCO_2)	205.68	13,593	346,900
Timber/woodfuel production (m^3)	177.44	2,895	73,886
Air quality regulation (t)			
PM_{10}	0.86	17,384	443,652
SO_2	0.016	35	906
Agricultural production (ha)	217	-7,907	-201,797
Greenhouse gas emissions from agriculture (tCO_2e)	42.28	- 2,794	-71,307
Recreation (number of visits)	6082	34,789	887,864
Physical health (visitors that meet activity guidelines)	65.58	44,741	1,653,984
TOTAL		**102,736**	**3,134,088**

(PV £410). Given the rural location of Eycott Hill, it is unlikely that the service is in any great demand.

There is provision of **recreational and physical health** opportunities at Eycott Hill in T1, as the site has always been open access. However, it has only been known to the local community so the flow of these services is low. There are an estimated 3.75 visitors that meet activity guidelines per year. These active visits are associated with an estimated 0.13 Quality Adjusted Life Years (QALYs). This is projected to deliver £2,560 of savings to the NHS per year (PV £94,625). The recreational value of the site is estimated at £2,002 per annum (PV £51,094).

The site is also estimated to **sequester** (capture) 2.61 tonnes of **CO_2** per annum worth £172 per year (PV 9,726). The **timber/woodfuel production** for T1 is relatively low, totalling 2.24m^3 per annum. This has an estimated annual value of £35 (PV £903).

The total area of the site (217 ha) was under **agricultural production** in T1 and grazed by sheep and beef cattle under a grazing agreement with Natural England. Agricultural production of the site based on **net** farm income for Less Favoured Area (LFA) farms is estimated to deliver an annual **deficit** of £15,344 (PV £391,600 deficit), once farm payments have been stripped out (i.e. it is only profitable when income support for farmers is included). **Greenhouse gas emissions** from the small area of improved grassland (the rest of the site is rough grazing and therefore 0 emissions) and the livestock at the site is estimated at 55.22 tCO_2e per annum. This is an emission, hence represents a cost to society of £3,649 per annum (PV £93,130). The amount of carbon emitted from the site due to agricultural production is considerably higher than the amount of carbon sequestered, and the balance between the two will result in a net carbon loss of 52.61 tCO_2e per annum, valued as a **cost to society** of £3,477 in 2018.

The results are very different in **T2**. As a Wildlife Trust nature reserve the Eycott Hill site had much greater visibility and draws in more people from a wider area. This has led to an increased provision of cultural services at the site. The service of greatest value in **T2** is **physical health**, with an estimated 65.58 visitors that meet activity guidelines. These active visits are associated with an estimated 2.24 Quality Adjusted Life Years (QALYs). This is projected to deliver £44,741 savings to the NHS per year (PV £1,653,984).

The **recreational value** of the site is also considerable and is estimated at £34,789 per annum (PV £887,864). This is based on 6,082 visits to the site each year, as measured by tally counters at the entrance.

The **air quality regulation** service increases in T2 with the removal of an estimated 0.86 tonnes of PM_{10} per year with an associated value of £17,384 (PV £443,652). The site also contributes to an increase in SO_2 pollution amelioration at 0.02 tonnes of SO_2 with an associated value of £35 (PV £906).

The site in T2 also shows an increase in **carbon sequestration** with the take up of 205.68 tonnes of **CO_2** per annum worth £13,593 per year (PV 346,900). The **timber/woodfuel production** for T2 totals 177 m^3 per annum. This has an estimated annual value of £2,895

(PV £73,886). This reflects the value of the woodland resource should it be used for this purpose, but there is no intention of doing so at Eycott Hill.

Agricultural production is focused on conservation grazing of 25 Luing cattle, which are bred for beef. This production shows a decreased **deficit** in comparison to T1 of £7,907 (PV £201,797 deficit), once the HLS cattle grazing subsidy has been subtracted from the net income (it is only profitable when income support for farmers is included). **Greenhouse gas emissions** also decrease with 0 emissions from the rough grazing and an overall reduction of livestock at the site totalling 42.28 tCO_2e per annum (a 40 tCO_2e reduction from T1). This emission represents a **cost** to society of £2,794 per annum (PV £71,307). The amount of carbon emitted from the site due to agricultural production in T2 is lower than the amount of carbon sequestered, and the balance between the two will result in a **net carbon sequestration** of 160.62 tCO_2e per annum, valued at £10,615 in 2018.

3.4 Maintenance costs account

The total cost associated with running Eycott Hill as a farm is estimated to be £127,300 per annum (PV 3.25M) (see Table 8 for a breakdown of these costs). These figures are derived from the average fixed and variable costs across Less Favoured Area (LFA) hill farms in England.

Maintaining Eycott Hill as a nature reserve in T2 is estimated to cost less, at approximately £60,954 per annum (PV £ 1.56M) (see Table 9 for a breakdown of these costs). These costs are quite high and reflect that this is an HLF funded project converting the site from a farm into a nature reserve with wildlife as a priority. Once the project ends (2020) and the site is managed as a regular nature reserve, the maintenance costs will decrease. The maximum likely reserve maintenance costs in any year have been estimated as being £4,100 (based on the costs associated with nature reserves similar in size and situation to Eycott Hill). Costs may be this high once every 5 years.

Table 8. Approximate breakdown of annual maintenance costs for Eycott Hill T1 (averages from 2015 presented in 2018 prices).

Expense	Cost (£)
Farm business variable costs	39,600
Farm business fixed costs	49,100
Imputed rent	11,700
Loss from sale of machinery, glasshouses and permanent crops	200
Unpaid manual labour	26,700
TOTAL	**127,300**

Table 9. Approximate breakdown of annual maintenance costs for Eycott Hill T2 (year 2016/17 in 2018 prices).

Expense	Cost (£)
Repair and conservation	34,898
Building work	1,008
Access and interpretation	3041
Livestock (including haymaking)	22,007
TOTAL	**60,954**

The maintenance costs are partially covered by the basic farm payment subsidy in T1 (£26,500, PV 0.68M), and are fully covered in T2 by grant funds from the HLF. These are included in the private asset baseline value and the maintenance costs (as liabilities) are deducted from this baseline value in the natural capital balance sheets of T1 and T2 (see below).

3.5 Natural capital balance sheet for Eycott Hill T1

The natural capital balance sheet for Eycott Hill in T1 & T2 is given in Tables 10 & 11 below. The total value of the natural capital assets of Eycott Hill are quantified, together with the total liabilities (both reported in **present value** terms) with the net value of the natural capital assets of the site outlined. Agricultural production and timber are considered to generate private value, as this value would be retained by the CWT. The other ecosystem services are considered to generate external value. These have been placed in the corresponding columns on the balance sheet.

The net natural capital asset value in T1 is £0.48M. The inclusion of the agricultural subsidies, included under private value, ensures that the net value is positive rather than negative. Overall the maintenance costs of the conventional farming system in T1, are higher than those in T2. Due to increased ecosystem service provision in T2, the net asset value at the site is higher at £3.13M. The value of natural capital benefits has increased from T1 to T2 by £2.65M. This is a large increase in natural capital benefits brought about by converting the Eycott Hill site from intensive agriculture, to a nature reserve with low intensity livestock farming. The grant income (included under private value) that has enabled this conversion has cancelled out the maintenance costs and increased the overall net asset value.

Net natural capital benefits in T2 do not capture all the natural capital benefits provided by the site. Three notable benefits not included are water quality and flow regulation, and pollination. As the qualitative assessment of ecosystem services in T1 and T2 shows (Table 5), these services are likely to increase as a result of the management of the site as a nature reserve, that includes High Nature Value farming. If it was possible to quantify these services (which it is, but only with a more complex modelling approach), the net natural capital asset value is likely to be higher. The non-monetised benefits from the natural capital also show

an increase in T1 and T2. Managing for wildlife and low intensity farming even at this early stage of the conversion of the site has resulted in an increase in habitat for biodiversity. This is also an important public benefit.

Table 10. Eycott Hill T1 natural capital balance sheet (2018).

	Private value (PV £M)	External value (PV £M)	Total value (PV £M)
Asset values (£)			
Baseline value	0.29	0.19	0.48
Cumulative gains/ (losses)	-	-	
Additions/ (disposals or consumption)	-	-	
Revaluations and adjustments	-	-	
Gross asset value	0.29	0.19	0.48
Liabilities			
Legal provisions	-	-	
Other maintenance provisions	(0.00)[(i)]	-	(0.00)
Total net maintenance provisions			
Total net natural capital assets	0.29	0.19	**0.48**

Asset values (non-monetised)	**Biodiversity units**	
Defra metric	2015	**2015**

(i) The maintenance costs are 0 because our calculation of agricultural production (private value) uses net farm income (costs already stripped out), therefore the maintenance costs in Table 8 have already been accounted for.

Table 11. Eycott Hill T2 natural capital balance sheet (2018).

	Private value (PV £M)	External value (PV £M)	Total value (PV £M)
Assets values (£)			
Baseline value	1.43	3.26	4.69
Cumulative gains/ (losses)	-	-	
Additions/ (disposals or consumption)	-	-	
Revaluations and adjustments	-	-	
Gross asset value	1.43	3.26	4.69
Liabilities			
Legal provisions	-	-	
Other maintenance provisions	(1.56)[ii]	-	(1.56)
Total net maintenance provisions		-	
Total net natural capital assets	(0.13)	3.26	**3.13**

Asset values (non-monetised)	**Biodiversity units**	
Defra metric	2066	**2066**

(ii) The maintenance costs are not 0 as in the natural capital balance sheet for T1 (Table 10), because in T2 there are also costs associated with wider reserve natural capital management (Table 9).

4. Benefits of out-wintering cattle

Eycott Hill is home to a small (25) herd of Luing cattle. The cattle grazing is an important element of the conversion from intensive agriculture to a nature reserve with conservation grazing. The adult cattle graze the area all year round, with the calves grazing between May and November, after which time they overwinter in a barn and are grain fed. The aspiration of the CWT is to graze the Luing cattle outside all year round, including for calving. We briefly reveal some of the welfare, environmental and financial pros and cons associated with converting to all year round grazing. We are unable to produce figures for the environmental impacts as these are highly variable in the literature, and depend upon finding studies on similar systems of livestock management. This would be a major research undertaking.

The advantages of out-wintering are reduced costs of straw bedding and supplementary feed (e.g. hay, silage or concentrate), less use of machinery, no need to build or maintain housing, increased health status of cattle, even efficient and low cost distribution of manure, contented cattle, less labour time. Estimates are that grazing Luing cattle outside in winter can create a cost saving of £200 per head.

There are both cost and environmental implications associated with the use of bought feed for cattle overwintering inside. Silage or grain may have been grown in intensively managed arable systems, which results in environmental impacts from the application of pesticides,

fertilizers used to grow the grain, and the GHG emissions associated with the growing, harvesting, and transportation process. Ideally, hay cut from the Eycott Hill site would be used to feed the cattle over winter. There are also impacts from the materials used in the housing infrastructure and space used for overwintering. These impacts, that potentially can be felt at multiple scales, and extra costs can be avoided by out-wintering the cattle. The added impacts of out-wintering will be largely local.

The possible impacts of out-wintering livestock are being researched by Natural England in a number of nationally funded projects. Provisional results show that light damage to topsoil and vegetation from treading can encourage increased botanical diversity and provide improved habitat for some birds. Winter grazing may have negative implications to floristic diversity if the site doesn't have adequate forage and supplementary feed is required (e.g. poaching around feeders). Out-wintering is not likely to be suitable for calves and store cattle in the uplands of the north of England, as the winters will not be mild enough. Whilst overall it may increase health of the cattle to be outside all year, there is an increased risk of liver fluke from extended grazing. Pregnant cows may need to be monitored to ensure access to feed and if the ground is soft. Access to the fields must be possible in adverse weather.

There is potential to make more from the sale of the beef from these cattle. At present the beef is sold into the standard meat market. It would be possible to market and sell the beef as a 'conservation grade' product. The Pumlumon Project run by Montgomeryshire Wildlife Trust state that beef produced through conservation grazing can be twice as profitable as conventional beef production. Figures on the overall levels of return available to producers who invest in securing 'added value' to their product have come from the Natural England Avon Grazing Project (2011). Figures are based on a well-finished native breed beast weighing 500kg live weight and with an R3 grading. A value added product sold through a specialist processor guaranteeing a premium is likely to fetch a higher price. For example, organic beef can attain a 9% increase in price per head deadweight. This report concurs with the Pumlomon project in that a doubling of the farm gate price per head could be achieved, however, this is if the meat is sold directly to the final customer. This would require significant additional costs, but would leave a reasonable profit.

5. Social benefits

There are important additional social benefits that flow from the management of natural capital at Eycott Hill in T2, that we are not able to quantify in a manner that can be included in the natural capital account. As we highlight in the qualitative ecosystem service section (Table 5), education and training, improving people's access to places that have high biodiversity, which contribute to aesthetic, cultural and spiritual value are also very important benefits that flow from the natural capital assets of the Eycott Hill site. This is not to say that there are no benefits of this nature at T1, as can be seen in Table 5. However, they are likely to be low where they do occur, and we do not have the relevant data.

5.1 Educational value

There is a considerably higher educational value in T2 than in T1. Cumbria Wildlife Trust allow the site to be used for educational and training purposes, as well as outreach activities that spans University, college and school levels. The nature with its low intensity agriculture is managed by CWT in association with Newton Rigg College, and is used as a case study for educating students learning about land-based management systems. It is also used for school level land-based science learning. It is a site used by people participating in the John Muir award. The nature reserve hosts students from Newton Rigg (**288** in 2017), University placements (**1** in 2017), and developing skills (**116** participants over **9** courses in 2017) and recording training courses (**15** participants over **2** courses in 2017).

Other outreach events include art workshops and exhibitions. These have benefited local children as well as disadvantaged groups, for example the elderly suffering with dementia, disadvantaged children and adults with learning disabilities (**661** participants across **33** workshops in 2017). General and specialist guided walks (the former achieved **186** participants over **17** walks in 2017) and family discovery events are also run from the site.

Many interest groups use the site for orienteering and geological exploration. The site also supports youth group visits. The site is important in allowing people to share in the public benefits that flow from the natural capital assets of the site in T2, that are managed by the CWT.

5.2 Engaging with the local community: volunteers

Volunteers of the CWT that work at the Eycott Hill site in T2 are engaged in a wide range of activities from conservation work (e.g. tree planting, maintenance, fencing, vegetation management), checking livestock, survey work, and running events. Whilst this is a non-market service, its value can be quantified by calculating the FTE equivalent positions that would have to be funded to complete the same amount of work. The number of volunteer days at Eycott Hill in 2017 totalled 333.5. This is equivalent to **2,334.5** volunteer hours (assuming full-time), which is in turn equivalent to **1.22 FTE** positions in that year. We have estimated that volunteers would be earning on average c. £18,000 across these activities. In which case the value of the volunteer's work is **£21,960**. Whilst we have revealed the value of volunteering in T2, the participants also derive personal benefits from volunteering. These include enhanced self-esteem, personal development, occupational experience, improved health, education and learning.

6. Conclusions and recommendations

6.1 Key findings

Natural Capital Accounting has been successfully applied to two time periods and management approaches at Eycott Hill. The account for T1 shows how management for intensive agriculture has limited the ability for the natural capital assets to produce ecosystem services to a high level across the provisioning, regulatory and cultural categories. The gross value of the natural capital assets was positive (PV £0.48M), but only

when including agricultural subsidies as a private value. However, the maintenance costs are significantly higher than the value of the natural capital assets in this system (£127,300 per annum, PV £3.25M), leading to a net natural capital asset value of just £0.48M. However, in T2 the natural capital benefits are much higher, due to the restoration of woodland, hedgerows, neutral grassland and heather habitats, even though it is still early on in the conversion process. The net value of the assets in T2 is £3.13M, which is 6.5 times higher than in T1. As outlined above, if we were able to quantify other services that are provided by the assets at Eycott Hill, this would increase the net natural capital asset value of the nature reserve further.

At T2 the value of recreation and physical health vastly outweighs all other benefits. Air quality regulation and carbon sequestration are also important, but are much less valuable than the cultural services. This is a common finding in natural capital valuation and accounting studies. It demonstrates the importance of accessible natural greenspaces for society and the economy, where the impact on health and well-being is substantial. The additional social impacts of the management of Eycott Hill at T2 are also important, providing volunteering opportunities and workshops, that in turn have well-being benefits, and using natural capital to provide training and education.

The development of the accounts at Eycott Hill has shown that there is enough data available to produce meaningful accounts that can demonstrate how changes in site management, here specifically to conservation and low intensity livestock agriculture, can have a positive effect on the provision of public goods. It also shows how largely public money can be used to generate these public benefits, an aspiration of post-Brexit agricultural policy. It is hoped that they can be used to demonstrate best practice to roll out the approach more widely and to communicate and showcase the added value of nature reserve management. The accounts can also be used as a baseline against which gains and losses can be calculated in the future.

It should be noted that it is also important for water quality regulation and water flow regulation. These could not be included in the accounts (see below), although the values are likely to be much smaller than the recreation and health values. It highlights the importance of carrying out an initial qualitative assessment of all ecosystem services that flow from a site, so that a wider range of benefits can be captured and taken into account.

6.2 Data gaps, assumptions and limitations

Work is progressing rapidly on the calculation of physical and monetary flows of ecosystem services from natural capital assets, but it remains a developing area. A number of ecosystem services remain difficult to quantify and value. Some are highly location specific, for example water flow and flood risk. This can be quantified and valued by running detailed hydrological and flood risk modelling, but it is difficult to generalise to other sites. Others, such as water quality can be modelled, but are very difficult to value, while many of the cultural services, such as aesthetic experiences, cultural heritage, and spiritual experience and sense of place are difficult to even quantify. It should, therefore, be borne in mind that

the natural capital accounts presented in this report place values on several key benefits, but these are necessarily incomplete.

For the services that have been included in the accounts, a range of assumptions have been made, and these are outlined when describing the methodology (See Annex 1). For most ecosystem services these assumptions are minimal, as established production functions exist, linking natural capital to ecosystem service production, and levels of production to monetary value. For some services, despite fast developing research in relevant areas, broad assumptions have to be made because these links are not clear. This is particularly the case for physical health, and this estimate should, therefore, be used with care.

Valuation of ecosystem services is appropriate at indicating the magnitude of benefits, and has allowed these to be compared across a broad suite of services. It was important to demonstrate the range of benefits that the natural environment can provide. However, these results need to be interpreted with care, and in the knowledge that whilst the highest quality and most readily available data were used, there are limitations and assumptions that need to be kept in mind.

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Annex 1: Methodology

This annex provides detailed information regarding the methods used to develop the Natural Capital Accounts for Eycott Hill in T1 and T2, including sources of data and assumptions made. The methods used to determine physical and monetary flows for each ecosystem service are described in turn.

A1.1 Biodiversity metric

We use a biodiversity metric here to provide a measure of the quality of the habitats present at the site in T1, and to assess whether it has improved in T2. The metric is based on habitats rather than species. Habitats can be assessed much more easily and gives an indication of overall quality for biodiversity. This forms the basis of the Defra biodiversity metric, now being used frequently in assessments to determine ecological impact, including biodiversity net gain and offsetting.

Having habitats that support rich biodiversity is important in its own right, but also as biodiversity fundamentally underpins many of the ecosystem services from which we gain benefit. There is increasing evidence that areas richer in biodiversity support higher levels of ecosystem service provision for a whole range of services.

For T1 and T2 all habitats are scored by multiplying together two factors:

Habitat distinctiveness – is scored as low (2), medium (4) or high (6). Distinctiveness includes parameters such as species richness, diversity, rarity and the degree to which a habitat supports species rarely found in other habitats. In general, intensive agricultural habitats are scored as low, semi-natural habitats score medium, and priority habitats score high.

Habitat condition – is scored as poor (1), moderate (2) or good (3) and is based on standard condition assessment criteria applied to the specific habitat at the site.

This score assumes that each new habitat is properly established and has been created successfully. This fits with the other ecosystem services calculations we use here, which all assume that any new habitats are fully and successfully established.

However, to fully apply the Defra biodiversity metric two additional constraints need to be considered. An initial score is calculated as above, based on the intended habitat, but this is then downweighted by dividing by two additional factors:

Difficulty of creation / restoration – a standard score given to each habitat type, scored as low (1), medium (1.5), high (3) and very high (10).

Years to target condition – a sliding scale from 5 years (1.2) up to a maximum of over 30 years (3) is applied based on the length of time it takes to establish each new habitat in the target condition.

A1.2 Carbon sequestration

Carbon sequestration from woodland areas were calculated following the UK Woodland Carbon Code methodology and look-up tables (Woodland Carbon Code 2012a,b). Values for hedgerows and scrub were calculated at 50% of the storage capacity of broadleaf woodland. The sequestration rates were averaged over a 60 year period for coniferous tree species (in this case juniper) and 100 years for deciduous species (these being the time periods after which they are typically harvested). The average annual sequestration rates were then multiplied by the area of each woodland type and added together to give the total sequestration estimate for woodland at the site.

Monetary flows were calculated using the government's non-traded central carbon price (£66 per tonne) in 2018 prices (BEIS 2017). We use the non-traded carbon price because it is a better reflection of the 'real' value of carbon sequestration if it were to be exchanged, than market prices. Using the latter reflects the current institutional set up of carbon markets, rather than the true value of carbon sequestration.

The present value (PV) of the ability of the woodland to sequester carbon into the future was calculated over a 50 year period, using the discount rates suggested in HM Treasury (2018), and the formula within ONS (2016). We used the predicted carbon prices for the next 50 years to account for change over time in the value of this service and assumed that the area of woodland remains static.

A1.3 Timber/woodfuel production

Annual physical flows of timber/woodfuel production were calculated in terms of overall yield, by multiplying the yield class of the different species by the area of each woodland type. Where yield classes were not known, the average yield class for the species of interest was used. The monetary flows for the woodland areas were calculated by multiplying the yield by the standing price of timber or woodfuel. The average price for softwood in 2017 was taken from the Forestry Commissions Coniferous Standing Sales Price Index (Forestry Commission 2017) and inflated to 2018 prices (£20.17). The price for broadleaved timber in 2015 ranged from £15 to high quality timber reaching £250 per m^3 standing (ABC 2015). As the sites are not being managed as commercial forestry, we have assumed that most output would be in the form of fuelwood and hence use the lower price inflated to 2018 value (£15.80). The present/asset value of the ability of the woodland created to provide timber into the future was calculated over a 50 year period, as outlined in Section A1.1 above. It was assumed that the management and extraction rate does not change over time and that the area of woodland remains static. The unit price is also assumed to be constant.

A1.4 Air quality regulation

We measured the ability of the vegetation at the sites to absorb two key pollutants, particulate matter ≤10µm in diameter (PM_{10}) and sulphur dioxide (SO_2). Quantifying the physical flow of the air quality regulation service provided by the woodland and grassland was based on the absorption calculation in Powe & Willis (2004) and the method in ONS

(2016). Scrub and hedgerow were calculated as having half the absorption capacity of deciduous woodland. The deposition rates for PM_{10} and SO_2 in coniferous woodland, deciduous woodland and grassland were taken from Powe & Willis (2004). Average background pollution concentrations for PM_{10} and SO_2 were calculated using Defra data (Modelling of Ambient Air Quality 2018 and 2001).

The surface area index of coniferous and deciduous woodlands in on-leaf and off-leaf periods was taken from Powe & Willis (2004). The proportion of dry days in 2018 (rainfall <1mm) for north-west England was estimated using MET office regional value data (http://www.metoffice.gov.uk/climate/uk/summaries/datasets). The proportion of on-leaf relative to off-leaf days was estimated at the UK level using the average number of bare leaf days for five of the most common broadleaf tree species (ash, beech, horse chestnut, oak, silver birch) in the UK using the Woodland Trust data averages tool (http://www.naturescalendar.org.uk/findings/dataaverages.htm).

The air quality regulation service was valued using guidance from Defra that provides estimates of the damage costs per tonne of emissions across the UK (Defra 2015). These are social damage costs based on avoided mortality and morbidity. Therefore, it was assumed that the value of each tonne of absorbed pollutant by the tree stock was equal to the average damage cost of that pollutant. The average damage cost for SO_2 across all locations was £2,190 (2018 prices). The PM_{10} damage cost estimates depend on the location (urban size or rural) and source of pollution. Eycott Hill is considered rural so the central damage cost used was £20,177 (2018 prices). When calculating the present / asset value over 50 years, the absorption rate was assumed to be constant. However, the damage cost of PM_{10} and SO_2 was adjusted to reflect inflation up to 2018, and the value was also subject to an uplift of 2% per annum to reflect the assumption that willingness to pay for health will rise in line with economic growth, as recommended by Defra (2011).

A1.5 Agricultural production

The physical annual flow of agricultural production at the site was measured as the area of land used for grazing. The monetary value of agricultural production was calculated based on Net Farm Income minus the income received from subsidies. Net Farm Income (NFI), the return to farm operators once all expenses have been deducted, were obtained from the Defra Farm Accounts England (2018) data for Less Favoured Area (LFA) farms. This takes into account farm gate prices, to give gross output, and subtracts typical variable costs (e.g. fertilizers, husbandry, feed and forage costs) and fixed costs (labour, machinery, fuel, buildings). Annual NFI estimates were obtained for 2017 and were then adjusted to remove the effects of Basic Farm Payments (income support). This gives a return to the land resource itself after deducting all costs associated with production and excluding income support subsidies. In T2 the area of production was the same, but was based on the accounts associated with the low intensity grazing of 25 Luing cattle in 2017, that were supplied by Cumbria Wildlife Trust. In this case, the annual NFI were adjusted to remove the effect of the Higher Level Stewardship cattle grazing subsidy.

A1.6 Greenhouse gas emissions from agriculture

Agricultural activities release CO_2 and other greenhouse gasses such as methane and NO_2 into the atmosphere, with emissions highly variable depending on the type of farming practices employed. These emissions can therefore negate the benefits obtained through carbon sequestration of habitats within a site.

The greenhouse gas emissions of the sites were calculated by multiplying area (i.e. grazing type e.g. rough grazing/permanent pasture) and numbers of livestock by emissions figures for each grassland and livestock type in Bateman et al. (2013). These emission figures are based on three types of agricultural emissions:

1. Emissions from typical farming practices (e.g. tillage, sowing, spraying, harvesting, and the production, storage and transportation of fertilizers and pesticides)
2. Emissions of N_2O from fertilizers
3. Emissions of N_2O and methane from livestock, caused by enteric fermentation and the production of manure

Eycott Hill was classed as rough grazing in T2 (associated with zero greenhouse gas emissions) and permanent grassland in T1 (emissions of 1.24 tCO_2e/ha). The total physical flow of greenhouse gas emissions was calculated by adding these emissions associated with maintaining the grazed habitat and livestock emissions (in tCO2e). These were monetised using the BEIS (2017) non-traded central carbon price (£66 £2018), as described for carbon sequestration in Section A1.1.

A1.7 Recreation

The importance of access to the natural environment is being increasingly recognised. Visits to natural areas have been shown to enhance physical and mental health and well-being, increase social cohesion and contribute greatly to the local economy. There are various methods for calculating the recreational value of a site including, for example, using visitor spend and contribution to the local economy. Given the limited opportunities for spending at Eycott Hill we instead used recreational value derived by Sen et al. (2014) from a meta-analysis of just under 300 previous assessments of the value of outdoor recreational visits to different habitat types in Great Britain. The physical flow of the recreation service to the site in T1 was an informed estimate by Cumbria Wildlife Trust, in T2 it was calculated as the estimated number of visits from site counter data. The annual monetary flow for recreation was estimated by multiplying the number of visits by the per person per trip recreational value for mountains, moors and heathlands (£5.72 2018) from Sen et al. (2014).

A1.8 Health and well-being

There is now a growing body of evidence to show the positive effect that the natural environment can have on human health and well-being. Monetising these benefits remains a challenge with mental health in particular lacking a generic measure that is commonly applied, making it very difficult to value at present (Binner et al. 2017). Physical health is more commonly valued, although methods are still being refined. We measured the physical

flow of health benefits delivered by the sites, using an approach developed by White et al. (2016) who analysed the implications of recreational physical activity in the natural environment on health in England. The method relies on estimates of visitors to natural environments who meet recommended activity guidelines (based on both duration and intensity of physical activities). These can be translated into Quality Adjusted Life Years (QALYs) scores, with 30 minutes of moderate to intense physical activity (if taken 52 weeks a year) being equal to 0.0107 of a QALY. QALY scores have an associated monetary value through estimated savings in health care costs. We are, therefore, able to value this physical health benefit by calculating the total number of QALYs from active visits to sites that meet guidelines, and multiplying this by the QALY value. The social value of one QALY has been estimated to be worth £20,000 (White et al. 2016). Note, however, that the HM Treasury has recently (March 2018) published an update to the Green Book (the Government's key guidance document on appraisal and evaluation), in which the value associated with one QALY has been increased to £60,000 (HM Treasury 2018). Given the large monetary benefit that would be assigned if using the higher QALY figure and the large number of assumptions involved in calculating this value, we have taken a conservative approach and used the lower estimate of £20,000, as has been used in previous natural capital assessments. But note, therefore, that the estimates for the value of physical health presented here could be considered to be much higher.

The first step in these calculations was to convert the number of visits to the sites into numbers of visitors (thereby accounting for repeat visits by the same individuals). We followed the DEFRA/EA (2004) guidance, treating Eycott Hill in T1 as a local site of fair importance with a predicted 17.1 visits per adult per year. In T2 the site was considered a honeypot site of mid importance with a predicted 17 visits per adult per year. The total number of visits to each site was divided by the visit rate to give the total number of visitors.

The next step is to determine the number of these visitors who met physical activity guidelines at the site. We subsequently used the proportions of active visits that met physical activity guidelines based on Monitoring Engagement with the Natural Environment data for England (thus across all habitats), to work out estimated number of QALYs and associated monetary value.

The present value (PV) of the ability of sites to deliver physical health benefits into the future was calculated over a 50 year period, using the discount rates suggested in HM Treasury (2018) and the formula within ONS (2016). Discount rates for QALY effects are recommended at 1.5%, declining to 1.29% after 30 years (differing from the 3.5% declining to 3% rates recommended for other service indicators).

A number of assumptions are used in these calculations and the results should therefore be interpreted with caution; it is the ecosystem service with the greatest degree of uncertainty out of all those assessed here.