Environment and Rural Affairs Monitoring & Modelling Programme (ERAMMP)

ERAMMP Report-28A: Welsh Mountain, Moor and Heath (MMH) Monetary Account

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Approved by James Skates
Bridget Emmett

Abbreviations Used in this Report

ABS	Annual Business Survey
APS	Annual Population Survey
BEIS	Department for Business, Energy & Industrial Strategy (UK Government)
Defra	Department for Environment, Food and Rural Affairs
EW-MFA	Economy-wide Material Flow Accounts
ERAMMP	Environment and Rural Affairs Monitoring & Modelling Programme
ETS	Emissions Trading System
EMEP4UK	European Monitoring and Evaluation Program Unified Model for the UK
GDP	Gross Domestic Product
LCM2015	UKCEH 2015 Land Cover Map
LULUCF	Land Use, Land Use Change and Forestry
MAC	Marginal Abatement Cost
MENE	Monitoring Engagement with the Natural Environment
MMH	Mountain, Moor and Heath
NAEI	National Statistics and National Atmospheric Emissions Inventory
NC	Natural Capital
NCAI	Scottish Natural Heritage's Natural Capital Asset Index
NPV	Net Present Value
NSW	National Survey for Wales
ONS	Office for National Statistics
SDA	Severely Disadvantaged Area
SEEA	System of Environmental Economic Accounting
SNA	System of National Accounts
UKCEH	UK Centre for Ecology & Hydrology
USEPA	United States Environmental Protection Agency
UN	United Nations
WORS	Welsh Outdoor Recreation Survey
WTA	Willingness to Accept
WTP	Willingness to Pay

Abbreviations and some of the technical terms used in this report are expanded on in the programme glossaries: https://erammp.wales/en/glossary (English) and https://erammp.cymru/geirfa (Welsh)

Contents

1 Key Points

I. The asset value of ecosystem services for which we can estimate monetary values in Welsh Mountains Moorland and Heath stands at approximately £3 billion in 2018.

II. Between 2003 and 2018 renewable electricity production in Welsh Mountains Moorlands and Heath increased by 721%.

III. Day trips to Welsh Mountains Moorlands and Heath peaked at 111 million hours in 2015 (not including holidays).

IV. The overall asset value – while variable – appears relatively stable over the time period for which we have enough data (2009-2018).

2 Summary and Introduction

This report looks at natural capital assets and the flows and values of services. These are terms that help us think logically about how to measure our complex natural world and its impact upon people.

Natural capital assets are environmental resources that persist long-term, such as mountains, woodlands, or a fish population. From these assets, people receive a flow of services, such as mountain hikes and fish captured for consumption. We can value the benefit to society of those services by estimating what the hikers spent to enable them to walk over the mountain or any profit from bringing the fish into the market. Applying this logic consistently across assets and services enables us to start building accounts of Welsh Mountains Moorlands and Heath (MMH).

The habitats included in this report's definition of MMH are:

- bracken
- dwarf shrub heath
- inland rock
- montane
- upland bog
- acid grassland

Fen marsh and swamp above the moorland line would be included but none were found in Wales. Upland forests and enclosed farmland are specifically excluded since they reside in their own habitat accounts. Upland acid grassland could reside in both agricultural, semi-natural grasslands and MMH accounts and given the importance of grassland in the Welsh uplands it seems distortive to exclude it.

We believe an approach to habitat accounts which, includes everything one might expect it to and in so doing includes overlaps between accounts, produces results which are more readily interpretable and useful for policy. The only downside to our approach is that the individual habitat accounts cannot be added to one another to produce the whole but this seems a small penalty since national accounts can be estimated separately.

UKCEH 2015 Land Cover Map (LCM2015) does not map these habitat types directly with montane essentially defined as all upland areas, bracken folded into acid grassland and dwarf shrub heath split into heather and heather grassland.

Table 2.1 provides the areas under each habitat from the LCM2015.

Table 2.1: Welsh Mountains Moorlands and Heath as defined in the 2015 Land Cover Map from UKCEH.

Habitat	km^2	% of Wales
dwarf shrub heath	664	3.2%
inland rock	71	0.3%
upland bog	262	1.3%
acid grassland	2629 (4153*)	19.9%

** All Welsh Acid Grassland. The figure outside of brackets represents the acid grassland above the moorland line.*

All monetary valuations are given in 2018 prices deflated using the HM Treasury June 2019 gross domestic product (GDP) deflators[1]

Office for National Statistics produced Natural Capital accounts remain experimental and future publications will be subject to methodological improvements.

Monetary ecosystem service valuations offer comparative analysis across services whereas physical flows provide information about the changes over time independent of price changes. The services are presented by type, which include provisioning, regulating and cultural. Types of service are defined at the beginning of each section.

Many ecosystem services are not being measured in this article, such as flood mitigation and tourism, so the monetary accounts should be interpreted as a partial or minimum value of Welsh MMH natural capital.

2.1 Collaboration

This article was produced for the Welsh Government by the Office for National Statistics with UKCEH. Office for National Statistics natural capital accounts are produced in partnership with the Department for Environment, Food and Rural Affairs (Defra). Further details about the natural capital accounting project[2] are also available.

2.2 What are ecosystem services?

This article uses the term “ecosystem service” throughout, which generally refers to a flow of benefits to humanity from living (biotic) components of the Earth. However, non-living (abiotic) components, such as oil and gas or wind used for energy, can also be included in ONS Natural Capital Accounts. A summary of the main trends is presented in this article, but more information can be found in the datasets accompanying this release. This article presents 5 service accounts, containing estimates of the quantity and value of services being supplied by Welsh MMH Natural Capital.

[1] www.gov.uk/government/statistics/gdp-deflators-at-market-prices-and-money-gdp-june-2019-quarterly-national-accounts
[2] www.ons.gov.uk/economy/environmentalaccounts/methodologies/naturalcapital

3 Provisioning Services

Provisioning ecosystem services create products that include food, water and materials. These are produced by nature and then consumed by society.

The agricultural biomass provisioning service has been included in this account, due to the inclusion of the acid grassland habitat within the definition of Welsh MMH, although it wasn't included in the 2019 UK MMH accounts.

3.1 Agricultural biomass

Agricultural biomass is the value of crops, fodder and grazing, which supports agricultural production. We attempt to exclude farmed animals from these estimates as they are considered to be produced rather than natural assets. The food eaten by farmed animals, such as grass and feed, is included.

In 2015, according to the UKCEH Land Cover Map, there was an estimated 328,329 hectares of grassland in Welsh MMH. There are no data on how much of this area is farmed and so we assume that all grassland areas in Welsh MMH are farmed. Stocking rates across Severely Disadvantaged Areas and Disadvantaged areas in 2017 would indicate 9.9 sheep and 0.8 cattle per hectare[3]. On that basis that amount of land would support 264,000 cattle and approximately 3.2 million sheep grazing.

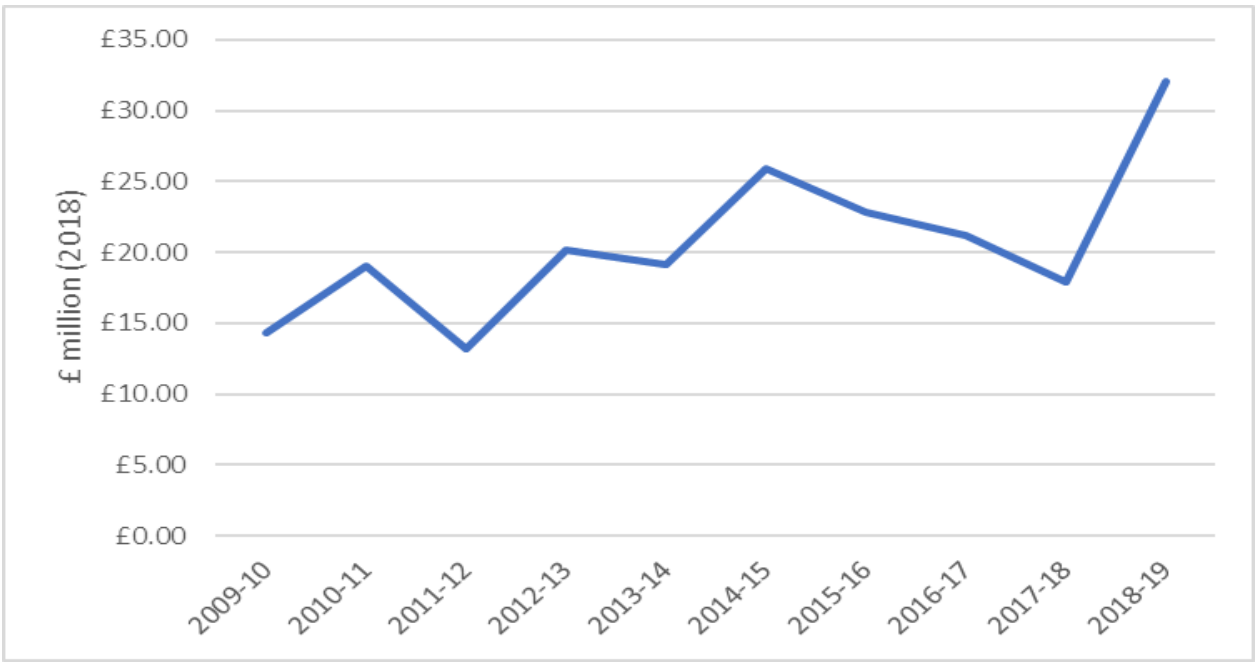
At the scale of the UK we would use the total livestock to estimate roughage requirements figures. Normally we would subtract from that the net consumption of animal feed in the UK to estimate the total roughage consumed from the land.

We cannot know how much feed is used by upland farms with any accuracy. In the related data tables, we do present the total yearly roughage requirements estimate for these cattle and sheep at approximately 2.8 million tonnes.

The annual valuation for agricultural biomass within Welsh MMH has used a farm rent approach. Farm rent is an imputed estimate of total rental costs for agricultural land. In the UK publication valuation methods included a resource rent approach, aggregated whole farm income and a farm rent approach. Not all of these are readily reproducible at habitat or national scales. Resource rent relies on national accounts data that aren't reproduced for Wales alone. Whole farm income approaches may be possible in the future with more development.

[3] www.gov.wales/survey-agriculture-and-horticulture-june-2017

Real farm rents have increased over time



Source: Farm Business Survey

Figure 3.1: Real terms annual farm rental value in Welsh MMH

The agricultural biomass provisioning service, for all types of agreements in Less Favoured Areas, in Welsh MMH show a high of £32 million in 2018-19 and a low of £13 million in 2011-12.

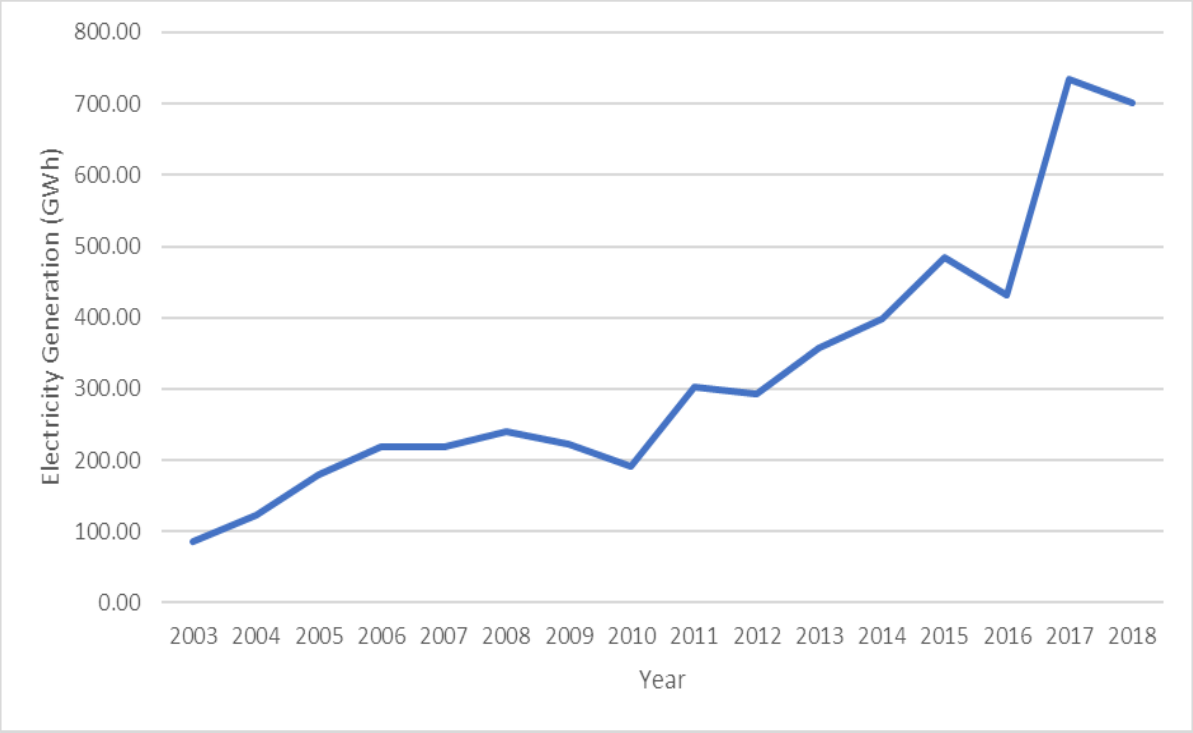
3.2 Renewable energy – wind power

Estimated electricity generation from wind power in Welsh MMH has increased significantly, since 2003. By 2018, electricity generation by wind power was over eight times higher than in 2003. This increased from approximately 85 GWh to 702 GWh, as shown in figure 3.2.

For most years, there have been increases in the amount of electricity generated by Welsh MMH wind power. Drops in production occur in 2010, 2012 and 2016. We attribute the 2016 decrease to a reduction in average wind speeds, as mentioned in the UK MMH Natural Capital accounts[4]. This is also reflected by the wind generation load factor, a measure of generation efficiency. Between 2015 and 2016, it decreased from 29.3% to 23.6%.

[4] www.ons.gov.uk/economy/environmentalaccounts/bulletins/uknaturalcapital/mountainsmoorlandandheathaccounts

In 2018, wind power generation in Welsh MMH was over eight times higher than in 2003



Source: Office for National Statistics and Department for Business, Energy and Industrial Strategy (BEIS)

Figure 3.2: Welsh wind power electricity generation in mountain, moor and heath areas, 2003 to 2018

Our monetary values are based on apportioning profits from the overall energy generation and distribution industry of the UK by total power produced. There are issues with this approach – notably that it doesn't directly reflect the economics of wind power but of the overall electricity market. The annual value of wind energy provisioning in Welsh MMH increased 84% between 2009 and 2017. In 2017 the annual value of renewable wind energy was £3 million. We estimate the asset value of renewable wind energy was £57 million in 2017. However the value fell back down to around £1.7 million in 2018 as the increases in 2017 are likely largely driven by the cost of investment in that year and wider issues with the electricity market. It is therefore worth paying most attention to the physical installed capacity increases.

3.3 Comparison with UK MMH Accounts

For UK MMH the increase in value over the same period was over 24 times larger. However, Welsh and UK figures are not directly comparable for two reasons: First, acid grassland is included in Welsh MMH and not in UK MMH. Second, we used a new methodology to extract the number of wind turbines within MMH areas.

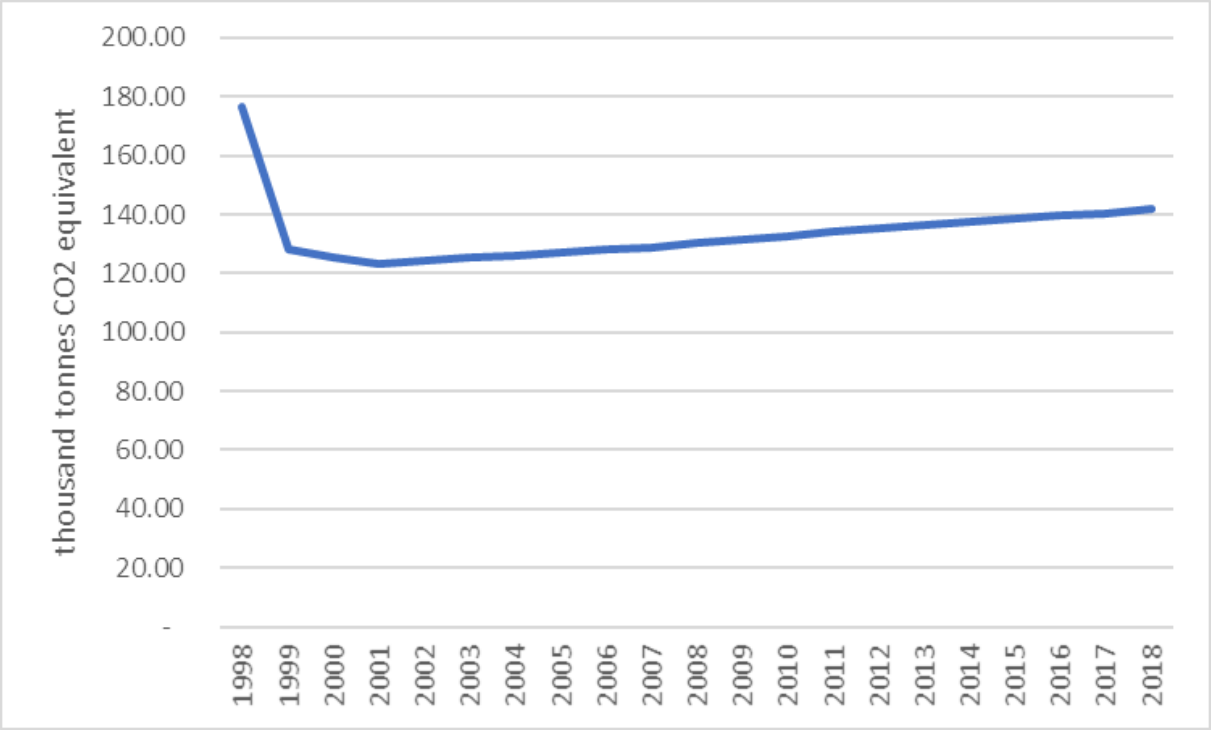
4 Regulating Services

As well as provisioning services, natural assets provide several less visible services known as regulating services. A regulating service is usually one that helps to maintain a more comfortable environment by for instance removing pollution. Regulating services include cleaning the air, sequestering carbon and regulating water flows to prevent flooding.

4.1 Carbon sequestration

Carbon sequestration covers the removal of green house gases (largely CO_2) from the air. Overall estimated carbon sequestration in MMH in Wales decreased by approximately 22% from 0.18 million tonnes of carbon dioxide equivalent (MtCO2e) in 1998 to 0.14 MtCO2e in 2017, as shown in Figure 4.1. Over the period 1998 to 2017, estimated carbon sequestration was lowest in 2001 (0.12 MtCO2e) and highest in 1998 (0.18 MtCO2e).

Carbon sequestration in Welsh MMH has been gradually increasing since 1999



Source: Office for National Statistics and National Atmospheric Emissions Inventory (NAEI)

Figure 4.1: Gross Carbon sequestration in Welsh MMH 1998 to 2018

Between 1998 and 2018, carbon sequestration occurred entirely in the grassland use change category. Meanwhile, the wetlands land use change category emitted more carbon than it sequestered. It is important to note that we exclude both upland forests and wetlands from this report. Forests because they sit more properly in the woodland accounts and wetlands because the current aim of natural capital accounts is to capture benefits from nature.

Projected annual carbon sequestration estimates, from 2018, show a gradual decrease in overall carbon sequestration, at an average rate of around 0.2% annually, to 0.13 MtCO2e in 2050. The consistent decrease over this time period is entirely attributed to the grassland land use change category.

Estimated annual valuations of carbon sequestration show an overall positive trend from 1999 to 2017, increasing from approximately £7 million to £9 million. Alongside decreasing carbon sequestration, we project the annual value to increase to £31 million in 2050, for Welsh MMH. This trend is driven by increases in the non-traded price of carbon[5].

The asset value of the carbon sequestration regulating service utilises future annual valuation projections. This increased between 1998 and 2018, from £482 million to £725 million.

4.1.1 Comparison with UK MMH Accounts

Welsh MMH contributed approximately 13% in 1998 and 9% in 2017, to the total rate of carbon sequestration in UK MMH. However, Welsh and UK figures are not directly comparable. This is due to the sub-habitat acid grassland being included in Welsh MMH and not in UK MMH.

4.2 Air pollution removal

Vegetation in mountain, moorland and heath in Wales aids in removing pollution from the atmosphere. The benefits of this to people are measured in avoided health costs of not breathing air pollutants

The pollutants covered in pollution removal are:

- PM2.5 & PM10 (PM2.5 is a component of PM10).
- Nitrogen dioxide (NO2)
- Ground-level ozone (O3)
- Ammonia (NH3)
- Sulphur dioxide (SO2)

Air pollutant removal has been modelled for 2007, 2011, 2015 and 2030. Between these years a linear interpolation has been used and adjusted for real pollution levels as an estimation of pollution removal (please see Methodology section for more information).

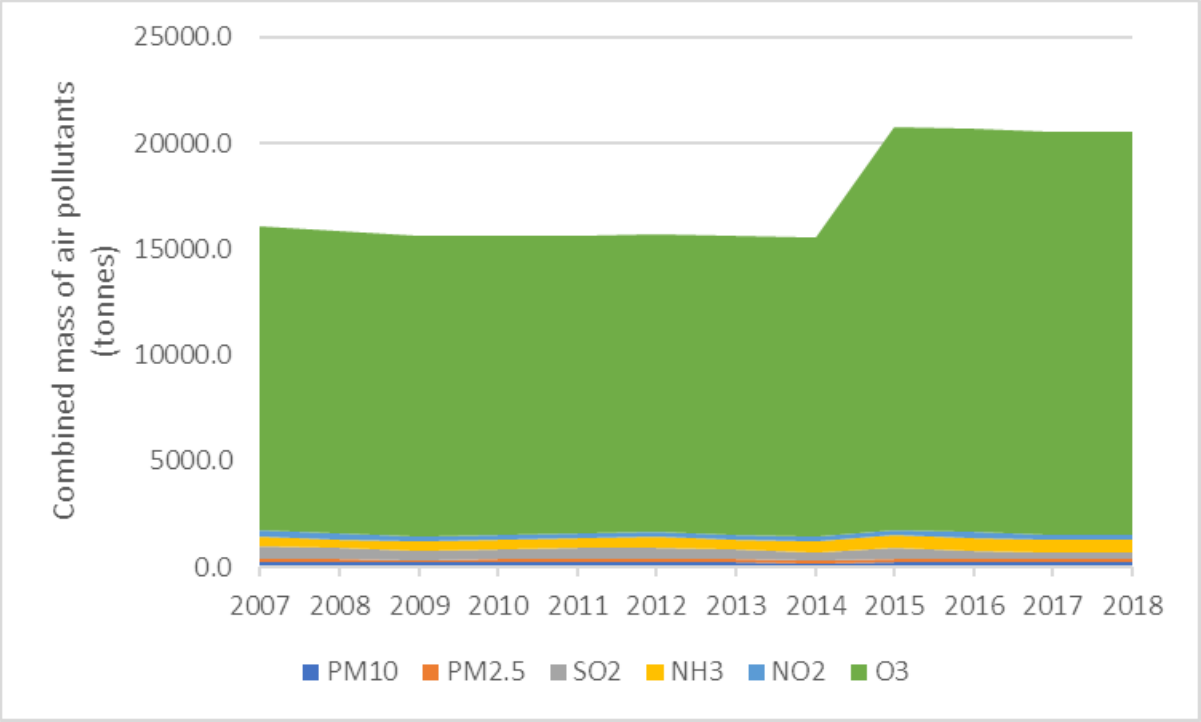
Air pollution is valued in natural capital accounts as the saved the health costs from avoided respiratory and cardiovascular diseases in the local population.

The amount of pollution that Welsh MMH removed from 2007 to 2018 fluctuated, but has increased overall by approximately 28%, from 15.9 thousand tonnes in 2007 to 20.3 thousand tonnes in 2018, as seen in Figure 4.3. Beyond 2018, pollution removal by Welsh MMH areas is projected to decrease slightly to 20 thousand tonnes in 2030; possibly as a result of less pollution being emitted into the atmosphere and therefore not being removed.

The increase in the physical flows, from 2014 to 2015 derives from using a different data source to apportion Welsh semi-natural grassland air pollution removal. Please see methodology section for more detail.

[5] www.gov.uk/government/collections/carbon-valuation--2

Pollution removal from Welsh MMH has increased by 28%, from 2007



Source: UK Centre of Ecology and Hydrology and Office for National Statistics

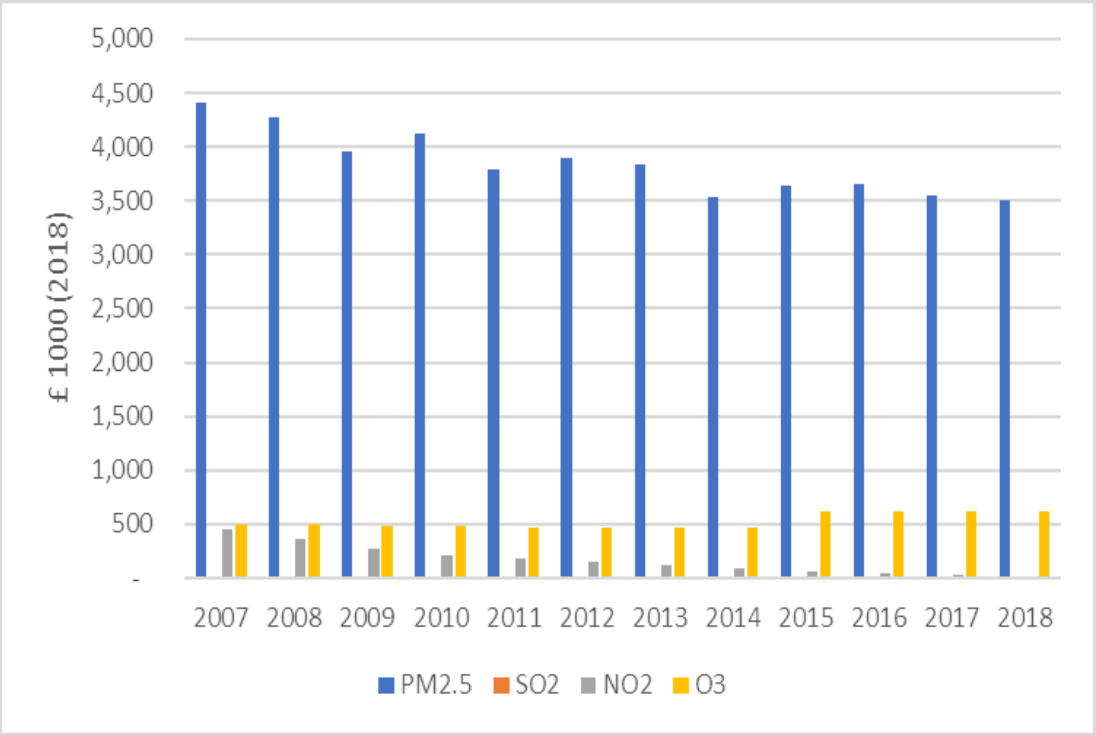
Figure 3.2: Pollution removal physical flow, broken down by pollutants, Welsh MMH, 2007 to 2017

***Notes**: PM2.5 is a subset of PM10. PM2.5, a component of PM10, is a fine particulate matter with a diameter of less than 2.5 micrometres, or 3% of the diameter of a human hair. Ground-level ozone (O3) represented the majority of total pollution (by mass) removal (93%) in 2017, as shown in Figure 4.3. Welsh MMH removed approximately 17% of the total air pollution in UK MMH during 2018.*

In 2018, it is estimated that the avoided health costs in the form of: avoided deaths, avoided life years lost, fewer respiratory hospital admissions and fewer cardiovascular hospital admissions, amounted to £4.2 million for Welsh MMH.

Although the removal of PM2.5 represents less than 1% of total pollution removed, approximately 84% of the avoided health impacts were as a result of reductions in PM2.5 concentrations, as shown in Figure 4.2.

Reductions in PM2.5 concentrations represent approximately 84% of the avoided health impacts



Source: UK Centre of Ecology and Hydrology and Office for National Statistics

Figure 4.3: Pollution removal annual value, broken down by pollutants, Welsh MMH, 2007 to 2018

Annual valuation for MMH air pollution removal declined by 22% from approximately £5.4 million in 2007 to £4.2 million in 2018 and the asset valuation of the pollution removal regulating service for Welsh MMH was £143 million in 2018.

Without the inclusion of acid grassland within the definition of MMH, overall air pollution removal in Welsh MMH is lower and consistently decreases overtime, from 5.8 thousand tonnes in 2007 to 5.5 thousand tonnes in 2018, compared with an increase when including acid grassland, to 20.4 thousand tonnes in 2018. Similarly, without the inclusion of acid grassland, both the annual and asset values are considerably lower, at an estimated value of £1.1 million and £39 million, respectively, in 2018, compared with £4.1 million and £143 million when including acid grassland.

4.2.1 Comparison with UK accounts

Welsh MMH pollution removal (without acid grassland) consistently accounts for approximately 5% of total UK MMH pollution removal, per year.

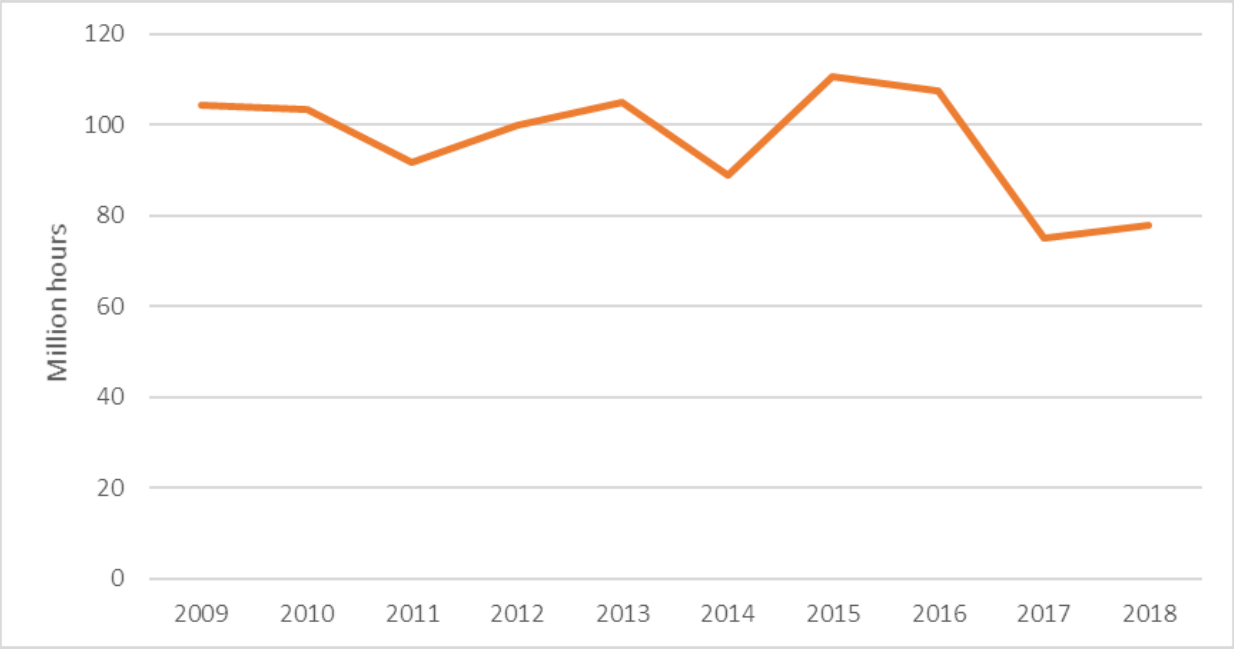
5 Cultural Services

Cultural services capture the non-material uses and experiences people have in the natural environment. They include recreation, education, art, sense of place and spirituality.

5.1 Recreation

People in Wales spent less time in mountains, moorlands and hills (MMH)[1] during 2017, than previously seen. There was a small recovery in 2018. The fall was driven by falling visit rates since 2015. These figures differ from older National Natural Capital Accounts as a result of using additional data from the National Survey for Wales. The use of additional data has allowed us to form a more representative view of visit rates in Wales, as they are less influenced by the index on Monitoring Engagement with the Natural Environment (MENE) outputs, an English survey which we use to fill data gaps. Please see the Quality and Methodology section for more details. Between 2015 and 2017, estimated visits dropped by around 30% (from 47 million to 33 million). Meanwhile, time spent dropped by around 32% (from 111 million to 75 million hours).

Flow of outdoor recreation in mountains, moorlands and hills, Wales, 2009 to 2018

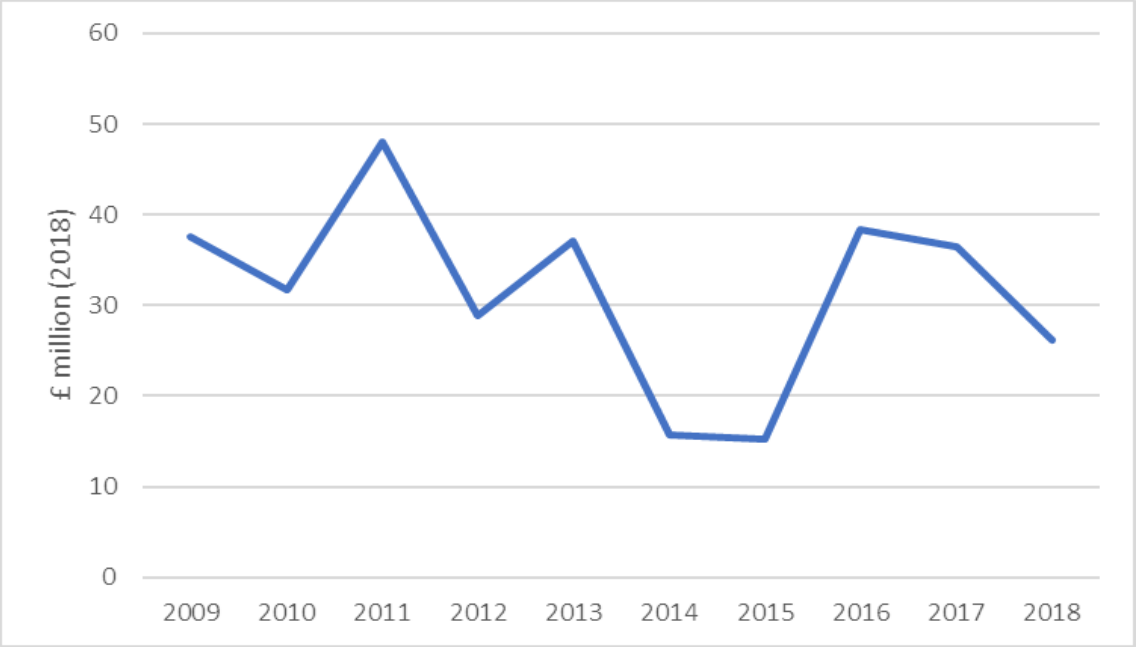


Source: Office for National Statistics, Monitor of Engagement with the Natural Environment (MENE) survey, National Survey for Wales (NSW)

Figure 5.1: Time spent in Welsh mountains, moorland and hills fell to their lowest levels in 2017

Between 2009 and 2018, the average length of an outdoor recreation visit to MMH in Wales was two hours and 26 minutes. One hour and 56 minutes were spent at the visit destination and 27 minutes were spent on travelling to and from the visit destination. For some visitors travel time could be part of their enjoyment from nature, which is shown in their choice of route or travel method. For others it may represent a willingness to pay or a cost of accessing outdoor recreation.

Spending in Welsh mountains, moorlands and hills decreased by 40% between 2009 and 2018



Source: Office for National Statistics, Monitor of Engagement with the Natural Environment (MENE) survey, National Survey for Wales (NSW)

Figure 5.2: Outdoor recreation value for mountains, moorlands and hills, Wales, 2009 to 2018

In 2018, Welsh MMH natural capital provided outdoor recreation valued at £26 million. Between 20011 and 2018, the value of Welsh MMH recreation decreased by 45% (from £48 million). In addition to falling visit rates, Welsh people are also opting for cheaper visits to MMH habitats. Average spend per visit to MMH in Wales decreased from £1.18 in 2009 to £0.88 in 2018**.** Time spent on outdoor recreation has many additional benefits beyond expenditure, such as health and well-being. The value of these benefits is not currently captured in the recreation account.

Notes**:** *The MMH classification for the outdoor recreational surveys used are for "mountain, moorland or hill", in contrast to "mountain, moorland or heath" for other ecosystem services. One reason for this could be that survey respondents find it more challenging to identify whether 'heath' is associated with their most recent outdoor visit destination.*

5.1.1 Comparison with UK MMH Accounts:

Time spent on Welsh outdoor recreation in MMH contributed to around 11% of the UK MMH total (708 million hours) in 2018, despite Wales having an estimated population 5% of the UK's. Welsh people took around 15 visits to MMH habitats in 2018, which were 13 more visits than the UK average of two visits. In the same year, UK MMH natural capital provided outdoor recreation valued at £1,152 million. Wales represented 2% of this (approximately £26 million), with the average Welsh person spending around £14 on visiting MMH, higher than the UK average of approximately £10.

6 Asset Valuation

Here we present the asset values of Welsh MMH natural capital by service. These values are estimated by capitalising the annual flow of services from the natural resource that are expected to take place over a projected period, known as the asset life. The annual environmental service flows provide the basis for the projected flows. This is a method known as net present valuation (NPV), which is explained in more detail in the methodology section.

Recreation is by far the largest service by value (40% in 2018) but it is also highly variable – likely due to the lack of a good yearly dataset as much as actual variation. In 2016 and 2017 the asset value topped £3 billion. Figure 6.1 shows the total asset value over time broken down and an approximate figure of £3 billion would be a reasonable general estimate for the value of the services we can estimate.

This is a relatively small figure – but it underlines how cheaply the products of the environment are rather than how important they are. The price is an important signal of levels of trade. If we are to decouple economic production and growth from environmental impact then the raw price ought to remain low with most value added upstream in the supply chain. If we were to look at the final consumer value of products from Welsh upland agriculture, it would be significantly higher.

While highly variable the overall asset value appears relatively stable and may be increasing over this time period

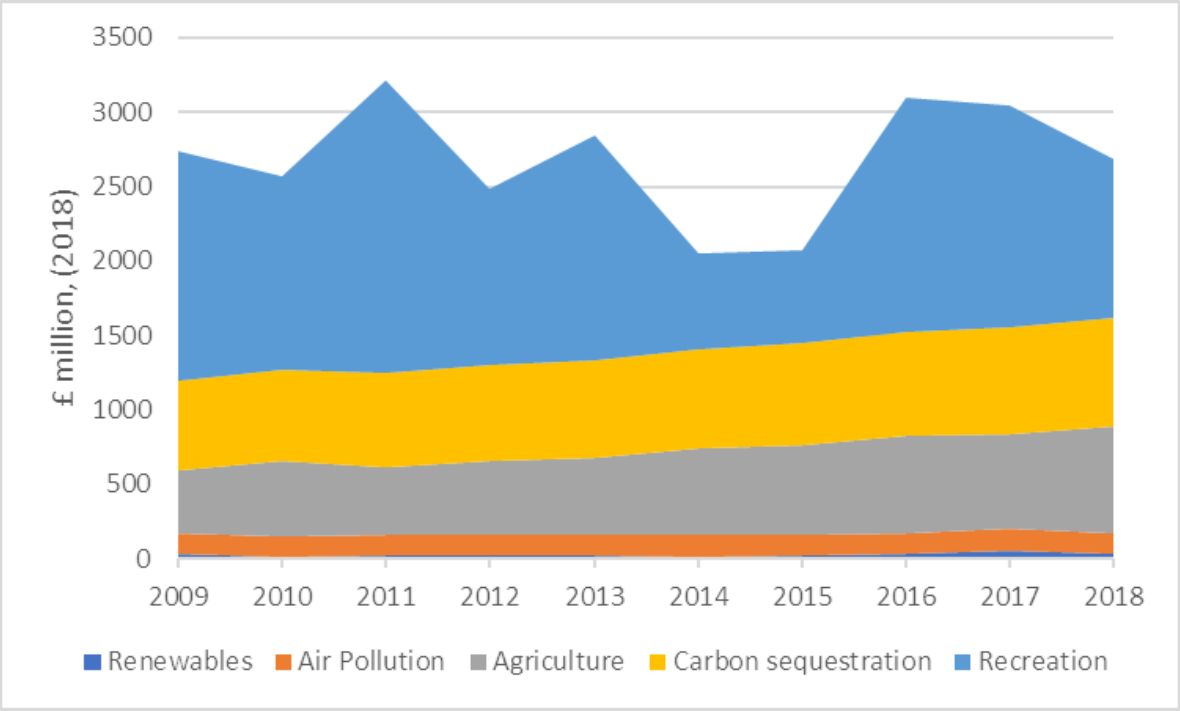


Figure 6.1: Stacked chart of Welsh MMH asset values over time by service

Figure 6.1 clearly shows that the value of the regulating services has been increasing over time. These are largely modelled services and public goods which explains the lower variability. Their prices are not set by markets but by government and so change more predictably and generally increase with costs. Renewables have been steadily increasing as the installed capacity gradually increases and its prices are driven by the wider electricity

market. If we were able to see the changing cost basis more directly the increases may be sharper as we know costs have been plummeting and yearly variability would be greater.

Agriculture and recreation on the other hand are directly observed actions linked to prices. Yearly shifts in average rental prices and travel costs reveal a lot of variability. On the whole these services appear to have fallen, or at a least dipped but over time these may start to look like a relatively stable time-series with a degree of variability.

The relative variability of the observed services (agriculture and recreation) is clear relative to the services that are largely modelled

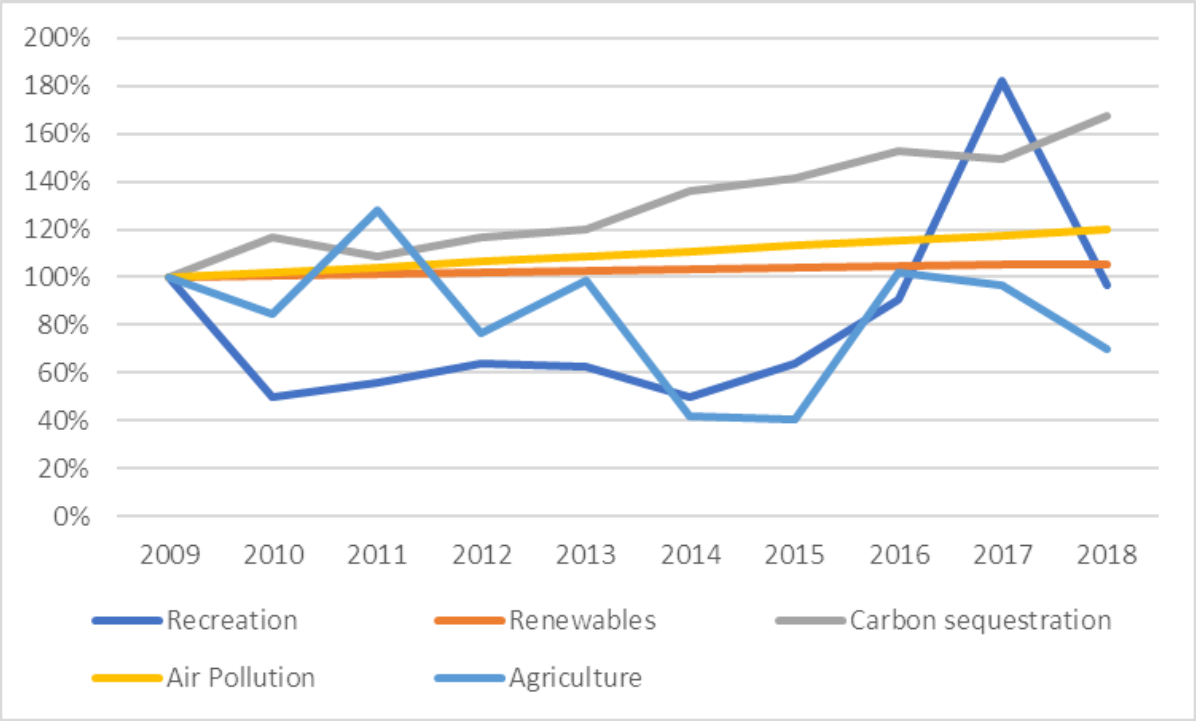


Figure 6.2: Line chart of Welsh MMH asset values indices over time by service (2009 = 100%)

7 Quality and Methodology

The methodology used to develop these estimates remains under development; the estimates follow those reported in UK natural capital accounts: 2019[6]. The estimates presented are experimental and should be interpreted in this context.

Experimental Statistics[7] are those that are in the testing phase, are not yet fully developed and have not been submitted for assessment to the UK Statistics Authority. Experimental Statistics are published to involve customers and stakeholders in their development and as a means of building in quality at an early stage.

This article describes the methodology used to develop natural capital ecosystem service accounts. The broad approach to valuation and the overarching assumptions made are explained in this article. This is followed by a more detailed description of the specific methodologies used to value the individual components of natural capital and physical and monetary data sources.

We have used a wide variety of sources for estimates of UK natural capital, which have been compiled in line with the guidelines recommended by the United Nations (UN) System of Environmental-Economic Accounting Central Framework and System of Environmental-Economic Accounting Experimental Ecosystem Accounting principles, which are in turn part of the wider framework of the System of National Accounts (SNA).

As the UN guidance is still under development, the Office for National Statistics (ONS) and the Department for Environment, Food and Rural Affairs (Defra) published a summary of the principles underlying the accounts[8].

An alternative appraisal of Scottish natural capital is available through Scottish Natural Heritage's Natural Capital Asset Index (NCAI)[9]. The NCAI is a composite index, which analyses nature's potential contribution to the well-being of Scotland's citizens.

7.1 Annual ecosystem service flow valuation

Broadly, two approaches are used to value the annual service flows. For fish capture, timber, carbon sequestration, pollution removal, noise mitigation, urban cooling, and recreation, an estimate of physical quantity is multiplied by a price. This price is not a market price but satisfies two accounting conditions:

- identifying a price that relates, as closely as possible, to contributions provided by the ecosystem to the economy
- where no market exists, imputing a price that an ecosystem could charge for its services in a theoretical market

[6] www.ons.gov.uk/economy/environmentalaccounts/bulletins/uknaturalcapitalaccounts/2019
[7] www.ons.gov.uk/methodology/methodologytopicsandstatisticalconcepts/guidetoexperimentalstatistics
[8] www.ons.gov.uk/economy/environmentalaccounts/methodologies/principlesofnaturalcapitalaccounting
[9] www.nature.scot/professional-advice/planning-and-development/valuing-our-environment/natural-capital-asset-index

These conditions are necessary to integrate and align ecosystem services to services elsewhere in the national accounts, for example, in the accounts woodland timber is an input to the timber sector.

For agricultural biomass, water abstraction, minerals, fossil fuels, renewable, and electricity generation a “residual value” resource rent approach is used. Before detailed data source and methodology is described, the resource rent approach is defined.

7.2 Renewables

We used the resource rent approach to estimate the apportioned value of Welsh MMH renewables. The resource rent can be interpreted as the annual return stemming directly from the natural capital asset itself. This is the surplus value accruing to the extractor or user of a natural capital asset calculated after all costs and normal returns have been considered.

The steps involved in calculating the resource rent are given in Table 7.2. Variations of this approach are applied depending on the category of natural capital under assessment; the variations are explained in the individual ecosystem service methodology.

Table 7.2 Derivation of resource rent

Output	
Less	Operating costs
	Intermediate consumption
	Compensation of employees
	Other taxes on production PLUS other subsidies on production
Equals	Gross operating surplus – SNA basis
Less	Specific subsidies on extraction
Plus	Specific taxes on extraction
Equals	Gross operating surplus – resource rent derivation
Less	User costs of produced assets (consumption of fixed capital and return to produced assets)
Equals	Resource rent

Source: Office for National Statistics

Return to produced asset estimates are calculated using apportioned industry-based net capital stocks[10] and the nominal 10-year government bond yield[11] published by the Bank of England, then deflated using the gross domestic product (GDP) deflator to produce the real yield. This rate is relatively conservative compared with those expected in certain markets and could overstate the resulting resource rent estimates.

Technical guidance on SEEA Experimental Ecosystems Accounting[12] acknowledges that the use of the method may result in very small or even negative resource rents. Obst et al. (2015) conclude that:

"resource rent type approaches are inappropriate in cases where market structures do not permit the observed market price to incorporate a reasonable exchange value for the relevant ecosystem service. Under these circumstances, alternative approaches, for example, replacement cost approaches, may need to be considered".

7.2.1 Apportioning

We apportioned the UK wide resource rent value for Electricity supply and distribution by first using the Annual Business Survey ratio of turnover for the sector in Wales to turnover in the UK. That first step gave us the value of energy production in Wales. We then used data from BEIS to estimate the ratio of the yearly generation from wind power in Wales against the yearly generation of all electricity in Wales. Finally we estimated the ration of the number of turbines in MMH against all turbines in Wales. This was done by mapping wind turbine positions against a shapefile of Welsh MMH areas. Multiplying the resource rent value by each of these ratios in turn provided our final value.

7.3 Recreation

The recreation estimates are adapted from the "simple travel cost" method developed by Ricardo-AEA in the methodological report Reviewing cultural services valuation methodology for inclusion in aggregate UK natural capital estimate[13]. This method was originally created for use on the Monitor of Engagement with the Natural Environment (MENE) Survey[14], which covers recreational visits by respondents in England.

[10] www.ons.gov.uk/economy/nationalaccounts/uksectoraccounts/datasets/capitalstocksconsumptionoffixedcapital
[11] http://www.bankofengland.co.uk/boeapps/iadb/index.asp?Filter=Y&Travel=NIxIRx&levels=1&XNotes=Y&C=DUS&G0Xtop.x=51&G0Xtop.y=7&XNotes2=Y&Nodes=X41514X41515X41516X41517X55047X76909X4051X4052X4128X33880X4053X4058&SectionRequired=I&HideNums=-1&ExtraInfo=true
[12] www.seea.un.org/sites/seea.un.org/files/Presentations/Training_China_2017/seea_eea_tech_rec_final_v3.2_16oct2017.pdf
[13] www.ons.gov.uk/file?uri=/economy/environmentalaccounts/methodologies/naturalcapital/reviewingculturalservices.pdf
[14] www.gov.uk/government/collections/monitor-of-engagement-with-the-natural-environment-survey-purpose-and-results

The method looks at the expenditure incurred to travel to the natural environment and some expenditure incurred during the visit. This expenditure method considers the market goods consumed as part of making the recreational visit (that is, fuel, public transport costs, admission charges and parking fees). This expenditure is currently assumed as a proxy for a marginal price for accessing the site.

Estimates for the UK MMH cultural service of outdoor recreation in this publication use survey data across five surveys covering England, Wales, and Scotland. Combined Great Britain outputs are scaled up to UK level using population estimates[15] for people aged 16 years and over.

The questions used from these surveys can be broadly summarised as:

- How many visits to the outdoors for leisure and recreation have you made in the last four weeks?
- On the last visit to the outdoors, what type of habitat did you go to?
- What was the main means of transport used on this last visit?
- How far did you travel to get to and from the main destination of this visit?
- How long was the visit, in terms of time (including travel time)?
- How much did you spend on [spending category]?

For estimates of outdoor recreation in England, the Monitor of Engagement with the Natural Environment (MENE) Survey[16] is used. The survey collects detailed information on people's use and enjoyment of the natural environment during visits. This report relates to the full ten years of surveying from March 2009 to February 2019. MENE samples around 47,000 respondents, containing around 20,000 visit takers, annually.

Previously we used the Welsh Outdoor Recreation Survey (WORS 2014)[17] in combination with England's MENE survey to produce outdoor recreation estimates for Wales. However, since obtaining 2016 and 2018 data from the National Survey for Wales (NSW)[17],all Welsh estimates are calculated using NSW (in combination with MENE) only, as NSW provides improved sampling and comparability between WORS and NSW is not advisable. Estimates of outdoor recreation in Wales for 2017 and prior to 2015 are based on an index of MENE outputs. Because of this, we multiply estimates of total expenditure by the proportion spent on each expenditure type in the most recent year we have data available. This allows the different expenditure types to sum to total expenditure, despite some years being based on an index of MENE outputs.

First, the absence of a question relating to the transport method affects our ability to estimate overall running costs and travel time, given that we do not know how respondents travel to their visit destination. We address this by calculating the proportion of total

[15] www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/datasets/populationestimatesforukenglandandwalesscotlandandnorthernireland
[16] www.gov.uk/government/collections/monitor-of-engagement-with-the-natural-environment-survey-purpose-and-results
[17] www.naturalresources.wales/evidence-and-data/research-and-reports/national-survey-for-wales/?lang=en

distance travelled to MMH habitats by different methods of transport in the MENE survey for the years of 2016 and 2017. These are used as proxy variables for NSW and the years of 2016 and 2018 respectively. We multiply the proxy variables by the total distance travelled in NSW to produce estimates for distance travelled by different methods of transport, which are used in our running costs calculations.

Second, there is not a breakdown available for expenditure type, for instance, how much money a respondent spends on food and drink, fuel or admissions. Instead, an overall amount is collected in the 'VisitMoney' variable of the NSW[18].

This affects our ability to calculate annual expenditure values as we replace reported fuel costs with our calculated running costs, while also subtracting money spent on food and drink. We address this by calculating the proportion of total expenditure spent on different types of expenditure in the MENE survey for the years of 2016 and 2017. Again, these are used as proxy variables for NSW and the years of 2016 and 2018 respectively. We multiply the proxy variables by the total expenditure reported in NSW, to produce estimates for the amount spent on food and drink and fuel, the former removed, and the latter replaced by our calculated running costs.

Estimates of outdoor recreation focuses on short day trips from home. This misses out potentially large amounts of spending on outdoor activity from domestic tourism, which future reports will aim to include. In 2014, research conducted on behalf of Visit Wales[19] showed that outdoor activity tourism contributed £481 million to economic activity: £236 million from domestic overnight visitors, £220 million from day trippers and £24 million from international overnight visitors.

Habitat descriptions differ between surveys. Table 7.3 describes these differences by country for MMH.

Table 7.3: MMH habitat classifications by country

Broad habitat	**England survey habitats**	**Scotland survey habitats**	**Wales survey habitats**
Mountain, moorland and hill	mountain, hill or moorland	Mountain/moorland	Hills, mountains or moorland
		Mountain/hill	
		Moorland	
		Wildlife area	

Source: Office for National Statistics

[18] www.gov.wales/sites/default/files/statistics-and-research/2019-02/national-survey-wales-questionnaire-2018-19.pdf

[19]www.outdoorrecreationni.com/wp-content/uploads/2015/11/The-Economic-Impact-of-Outdoor-Activity-Tourism-in-Wales-Visit-Wales-March-2014.pdf

Notes:

1. England refers to Monitor of Engagement with the Natural Environment Survey habitats.
2. Scotland refers to Scottish Recreation Survey and Scotland's People and Nature Survey habitats.
3. Wales refers to National Survey for Wales habitats.
4. "Wildlife area" habitats in Scotland are apportioned across various broad habitats.

For the asset valuation of outdoor recreation, projected population growth calculated from ONS population statistics[20] and an income uplift assumption, were implemented into the estimation. The income uplift assumptions are 1%, declining to 0.75% after 30 years and 0.5% after a further 45 years. These assumptions project the annual value to increase over the 100 years.

It is acknowledged that the expenditure-based method provides an underestimation of the value provided by visits to the natural environment. Primarily, this is because there are several benefits that are not accounted for including scientific and educational interactions, health benefits and aesthetic interactions. Currently, there is no method in use that incorporates these considerations. Additionally, the time spent by people in the natural environment is not itself directly valued because of the accounting and methodological challenges involved.

A significant number of outdoor recreation visits have no expenditure as people take local visits, such as walking to a local park.

7.4 Agricultural biomass

Agricultural biomass relates to the value of crops, fodder and grazed biomass provided to support agricultural production. Agricultural statistics[21] are published by the Department for Environment, Food and Rural Affairs (Defra). Grazed biomass calculations are based upon livestock numbers and livestock annual roughage requirements provided in the Eurostat Economy-wide Material Flow Accounts (EW-MFA) questionnaire[22]. This approach is also used in the UK Material Flows Accounts[23].

Estimating the proportion of agricultural production, which can be attributed to nature rather than modern intensive farming practices, is challenging. Modern farmers heavily manage and interact with the natural services supplied on their land. For example, sowing, irrigation, fertiliser spreading, pesticide use, and livestock management are all industrial practices applied to the land. Very intensive farming may even take place entirely indoors without soil

[20] www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/datasets/tablea11principalprojectionuksummary
[21] www.gov.uk/government/statistical-data-sets/agriculture-in-the-united-kingdom
[22] www.ec.europa.eu/eurostat/documents/3859598/9117556/KS-GQ-18-006-EN-N.pdf/b621b8ce-2792-47ff-9d10-067d2b8aac4b
[23] www.ons.gov.uk/economy/environmentalaccounts/datasets/ukenvironmentalaccountsmaterialflowsaccountunitedkingdom

or natural light. At the other extreme, livestock may be allowed to roam freely over semi-natural grassland with very limited human intervention.

As with the principles applied to the UK natural capital accounts, we draw the line between the farmland ecosystem and the economy at the point at which vegetable biomass is extracted (Principles of natural capital accounting, Principle 5.3)[24]. This means farmed animals are not included in these estimates as they are considered as produced rather than natural assets. Instead the grass and feed that livestock eat are regarded as ecosystem services and so are included. This is also consistent with the boundary between the environment and the economy used in the material flows accounts.

For the primary valuation of agricultural biomass, a farm rental approach was used[25]. Total farm rental was estimating by applying an imputed rental cost to all agricultural land. Average "SDA mixed livestock" Farm Business Tenancies costs in Wales from the Farm Business Survey[26] was multiplied by our estimate of total upland grassland in Wales.

In practice, farm rental represents a table annual valuation of the natural asset, with future low-level disaggregation potential, which could be linked with indicators of condition. However, further work is needed to consider if rental prices are materially inflated by tax breaks or development potential.

7.5 Carbon sequestration

Estimates relate to the removal of carbon dioxide equivalent (CO2e) from the atmosphere by habitats in the UK. However, because of a lack of data we are unable to include the marine habitat, including those intertidal areas such as saltmarsh. Furthermore, peatlands are only partially covered. The UK Centre for Ecology and Hydrology[27], estimates that degraded peatland emits 23 million tonnes of CO2e across the UK. This is more than the natural environment removes.

The carbon sequestration data come from the UK National Atmospheric Emission Inventory (NAEI), which reports current and future projections of carbon removal for the Land Use, Land Use Change and Forestry (LULUCF) sector.

LULUCF sector breakdown identifies net carbon sequestration activities in the following subcategories:

- forest land remaining forest land
- land converted to forest land
- grassland remaining grassland
- land converted to grassland

[24] www.ons.gov.uk/economy/environmentalaccounts/methodologies/principlesofnaturalcapitalaccounting
[25] www.ons.gov.uk/economy/environmentalaccounts/bulletins/uknaturalcapitalaccounts/2019#provisioning-services
[26] www.farmbusinesssurvey.co.uk/DataBuilder/Default.aspx?Menu=Menu&Module=Instructions
[27] www.naei.beis.gov.uk/reports/reports?report_id=980

- cropland remaining cropland
- land converted to cropland
- wetlands remaining wetlands
- land converted to wetlands

For the years 1990 to 2018, estimates of carbon sequestration are sourced from the Greenhouse gas inventory[28]. In the asset valuation, projections of carbon sequestration are provided for the years 2017 to 2050 using the central values. This is produced by the National Atmospheric Emission Inventory (NAEI) in the LULUCF emission projections[29]. For years used in the projections beyond 2050, the carbon sequestration rate is assumed to be constant as at 2050 levels.

A presentation of natural capital accounts based on the impacts from nature acting naturally would include sequestration from ancient woodland but might exclude plantation forests. Emissions from damaged green spaces would not be included, as this is essentially a form of human-driven pollution, but emissions from a volcano would.

Another view of natural capital would state that all natural habitats are somewhat modified. Usually human intervention is required to capture value and so the possibility of valuing many natural services (notably renewable energy) as if they were separate from human action is impossible. Under a combined nature and human approach, greenhouse gas emissions from poorly managed peatland should be included.

This is an area of research to consider further as our accounts develop. In this article we continue to use gross carbon sequestration as the asset value but present analysis of the net value to provide a rounded picture.

The Royal Society estimate that a further 30 million tonnes of carbon could be sequestered per year through land use change[30]. This would more than double current estimated natural sequestration: 15 million tonnes would come from expanding woodland by 1.2 million hectares; 10 million tonnes would be sequestered in soils following changes in agricultural processes; and the other 5 million tonnes is driven by habitat restoration.

To work out the annual value, we multiply the physical flow by the carbon price. The carbon price used in calculations is based on the projected non-traded price of carbon[31] schedule. This is contained within the Data table 3 of the Green Book supplementary guidance. Carbon prices are available from 2010 to 2100. Prices beyond 2100 are constant at 2100 levels.

The non-traded carbon prices are used in appraising policies[32] influencing emissions in sectors not covered by the EU Emissions Trading System (ETS) (the non-traded sector). This is based on estimates of the marginal abatement cost (MAC) required to meet a specific emission reduction target. Beyond 2030, with the (expected) development of a

[28] www.naei.beis.gov.uk/reports/reports?report_id=958
[29] www.naei.beis.gov.uk/reports/reports?report_id=927
[30] www.royalsociety.org/-/media/policy/projects/greenhouse-gas-removal/royal-society-greenhouse-gas-removal-report-2018.pdf
[31] www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal
[32] www.gov.uk/government/publications/carbon-valuation-in-uk-policy-appraisal-a-revised-approach

more comprehensive global carbon market, the traded and non-traded prices of carbon are assumed to converge into a single traded price of carbon.

7.5.1 Apportioning to Welsh MMH

Apportioning is done in a relatively crude manner. We aggregate gross change by the categories listed above: forestland, grassland, cropland and wetland. In our definition of MMH grassland is the only area of interest since wetlands emit carbon (and we only report gross change currently) and the others are not included at all. We then take the area of grassland in Welsh MMH as a ratio of that for the whole UK and use that to adjust the overall values down.

7.6 Air pollution removal by vegetation

Air quality regulation estimates have been supplied in consultation with the UK Centre for Ecology and Hydrology (UKCEH). A very brief overview of the methodology will be explained here. A more detailed explanation can be found in the full methodology report (Jones et al. 2017).

Calculation of the physical flow account uses the European Monitoring and Evaluation Program Unified Model for the UK (EMEP4UK) atmospheric chemistry and transport model, which generates pollutant concentrations directly from emissions and dynamically calculates pollutant transport and deposition, considering meteorology and pollutant interactions.

Air pollution data removal by UK vegetation has been modelled for the years 2007, 2011, 2015 and then scaled to create values in 2030. Between these years a linear interpolation has been used and adjusted for real pollution levels as an estimation of air pollution removal.

The health benefits were calculated from the change in pollutant exposure from the EMEP4UK scenario comparisons, that is, the change in pollutant concentration to which people are exposed. Damage costs per unit exposure were then applied to the benefiting population at the local authority level for a range of avoided health outcomes:

- respiratory hospital admissions
- cardiovascular hospital admissions
- loss of life years (long-term exposure effects from PM2.5 and nitrogen dioxide (NO2))
- deaths (short-term exposure effects from ozone (O3))

The damage costs were updated in February 2019. For a method of how the damage costs are calculated please see the Air Quality damage cost update 2019 report published by Defra[33].

Future flow projections used for asset valuation incorporate an average population growth rate and an assumed 2% increase in income per year (declining to 1.5% increase after 30

[33] www.uk-air.defra.gov.uk/assets/documents/reports/cat09/1902271109_Damage_cost_update_2018_FINAL_Issue_2_publication.pdf

years and 1% after 75 years). Income elasticity is assumed to be one. Annual forecasts are discounted to 2018 present values using a 3.5% discount rate, reducing appropriately as per the Green Book methodology. More work is being conducted in this area.

7.6.1 Apportioning to Welsh MMH

Apportioning was relatively simple as the standard models already break up the results by broad habitat and nation. As such we could easily add our basic estimate of MMH lands. The only complication was the addition of acid grassland. This was done by taking our estimate of total acid grassland in Welsh MMH as a proportion of all Welsh grassland to add an appropriate portion of all grassland habitat.

7.7 Asset valuation

The net present value (NPV) approach is recommended by the System of Environmental-Economic Accounts (SEEA) and is applied for all ecosystem services to estimate the asset value. The NPV approach estimates the stream of services that are expected to be generated over the life of the asset. These values are then discounted back to the present accounting period. This provides an estimate of the capital value of the asset relating to that service at a given point in time. There are three main aspects of the NPV method:

- pattern of expected future flows of values
- asset life – time period over which the flows of values are expected to be generated
- choice of discount rate

7.7.1 Pattern of expected future flows of services

An important factor in the valuation of natural capital is determining the expected pattern of future flows of services. These paths are not observed and hence assumptions concerning the flows must be made, generally as a projection of the latest trends.

A more basic way to estimate the expected flows is to assume that the current flow (averaged over recent years) is constant over the asset life, but this might not be the case. In some cases, more information is available on future expected levels of services in non-monetary terms or future unit prices. Where there are readily available official projections these have been considered but otherwise the default assumption in these estimates is that the value of the services is constant over time.

This article assumes constant service values throughout the asset life, except for the estimates for carbon sequestration and air pollutant removal by vegetation, where further projections are used.

Where the pattern of expected service values is assumed to be constant, it is based on averages over the latest five years of data, up to and including the reference year in question.

7.7.2 Asset life

The asset life is the expected time over which the services from a natural resource are expected to be provided. An estimate of the asset life is an important component in the NPV model because it determines the expected term over which the service flows from an asset should be discounted.

Following the ONS and Defra principles paper[34], this article takes one of three approaches when determining the life of a natural capital asset.

Non-renewable natural capital assets: where a sufficient level of information on the expected asset lives is available this asset life is applied in the calculations. Where a sufficient level of information on their respective asset lives is not available a 25-year asset life is assumed.

Renewable natural capital assets: a 100-year asset life is applied to all assets that fall within this category of natural capital.

7.7.3 Choice of discount rate

A discount rate is required to convert the expected stream of service flows into a current period estimate of the overall value. A discount rate expresses a time preference – the preference for the owner of an asset to receive income now rather than in the future. It also reflects the owner's attitude to risk. The use of discount rates in NPV calculations can be interpreted as an expected rate of return on the environmental assets.

Based on an extensive review by external consultants[35], the ONS and Defra use the social discount rate set out in the HM Treasury Green Book (2003, page 100). In line with guidance set out in the document, estimates presented in this article assume a 3.5% discount rate for flows projected out to 30 years, declining to 3.0% thereafter and 2.5% after 75 years. The rationale for this approach is discussed further in the ONS and Defra principles paper[34].

[34] www.ons.gov.uk/economy/environmentalaccounts/methodologies/principlesofnaturalcapitalaccounting
[35] www.ons.gov.uk/economy/environmentalaccounts/methodologies/naturalcapital

8 References

Jones, Laurence; Vieno, Massimo; Morton, Dan; Hall, Jane; Carnell, Ed; Nemitz, Eiko; Beck, Rachel; Reis, Stefan; Pritchard, Neil; Hayes, Felicity; Mills, Gina; Cryle, Philip; Dickie, Ian; Koshy, Adam; Holland, Michael. (2017) *Developing estimates for the valuation of air pollution removal in ecosystem accounts.* Final report for Office of National Statistics. Wallingford, NERC/Centre for Ecology & Hydrology, 75pp. (CEH Project no. C06156)

Obst, C., Hein, L. & Edens, B. *National Accounting and the Valuation of Ecosystem Assets and Their Services*. Environ Resource Econ 64, 1–23 (2016). https://doi.org/10.1007/s10640-015-9921-1

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