Office for National Statistics

Woodland natural capital accounts methodology guide, UK: 2020

How the natural capital ecosystem service accounts are measured for the woodland habitat.

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Release date:
28 February 2020

Next release:
To be announced

Table of contents

1 . Introduction

The methodology used to develop these estimates remains under development; the estimates reported in Woodland natural capital accounts, UK: 2020 are experimental and should be interpreted in this context.

Experimental statistics 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, including our approach to valuation and the overarching assumptions. This is followed by a more detailed description of the specific methodologies we use to value the individual components of natural capital as well as our physical and monetary data sources.

We have used a wide variety of sources for estimates of UK woodlands natural capital. These have been compiled in line with the guidelines recommended by the UN System of Environmental-Economic Accounting (SEEA) Central Framework and SEEA Experimental Ecosystem Accounting principles, which are part of the wider framework of the system of national accounts.

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.

We welcome discussion regarding any of the approaches presented.

2 . Methodology by service

This section explains the data sources and methods used in each service.

Timber and bio fuels

The method used to value the provisioning services related to timber supply requires two inputs: the stumpage price and the physical amount of timber removed. Annual flow values are then generated by multiplying the two factors together.

In our valuations of timber provisioning service assets, we used Forestry Commission forecasts of timber availability to estimate the pattern of expected future flows of the service over the asset lifetime.

Removals estimates are taken from Forestry Commission Timber statistics and converted from green tonnes to metres cubed (m^3) overbark standing, using a conversion factor of 1.222 for softwood and 1.111 for hardwood.

The stumpage price is the price paid per standing tree, including the bark and before felling, from a given land area. Stumpage prices are sourced from the Forestry Commission Coniferous Standing Sales Price Index in the 2018 Timber Price Indices. The Coniferous Standing Sales Price Index monitors changes in the average price received per cubic metre (overbark) for timber that the Forestry Commission or Natural Resources Wales sold standing, where the purchaser is responsible for harvesting.

To apportion the timber into timber sales and timber used for biofuels, data from Forestry Statistics 2019 on deliveries of UK grown softwood and hardwood deliveries were used to calculate the percentage of timber sales that are used for biofuels.

Carbon sequestration

Estimates relate to the removal of carbon dioxide equivalent (CO2e) from the atmosphere by woodland in the UK. A CO2e is a metric measure used to compare the emissions from various greenhouse gases on the basis of their global-warming potential (GWP), by converting amounts of other gases to the equivalent amount of carbon dioxide with the same GWP.

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

The LULUCF sector breakdown identifies net carbon sequestration activities into two subcategories: forest land remaining forest land and land converted to forest land.

For the years 1990 to 2017, estimates of carbon sequestration are sourced from the Greenhouse Gas Inventories . 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 NAEI in the LULUCF sector emissions projections. For years used in the projections beyond 2050, the carbon sequestration rate is assumed to be constant at 2050 levels.

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 schedule. This is contained within the data table 3 (Excel, 7.84MB) 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 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 more comprehensive global carbon market, the traded and non-traded prices of carbon are assumed to converge into a single traded price of carbon.

Air pollution removal by vegetation

Air quality regulation estimates have been supplied in consultation with the Centre for Ecology and Hydrology. A very brief overview of the methodology will be explained here. A more detailed explanation can be found in the full methodology report published in July 2017.

Air pollution levels are produced by the European Monitoring and Evaluation Program Unified Model for the UK (EMEP4UK) atmospheric chemistry and transport model. EMEP4UK uses emissions data and models to calculate pollutant transport and deposition, considering meteorology and pollutant interactions.

Air pollution data removal by UK vegetation has been modelled for the years 2007, 2011 and 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 of exposure were then applied to the benefiting population at the local authority level for a range of avoided health outcomes, including:

- 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, see the report published by the Department for Environment, Food and Rural Affairs (Defra).

The economic value is attributed to the UK National Ecosystem Assessment (UKNEA) broad habitats at a UK level, by allocating the total economic value of pollutant removal at the UK level by the proportion of pollutant removed by each vegetation type. This physical estimate was calculated for the UKNEA broad habitats at the grid-square level by first disaggregating the quantity of pollutant removed by each Centre for Ecology and Hydrology landcover class and then re-aggregating these estimates up to the UKNEA broad habitats.

Future flow projections used for asset valuation incorporate an average population growth rate and an assumed 2% increase in income per year (declining to a 1.5% increase after 30 years and a 1% increase after 75 years). Income elasticity is assumed to be one, meaning that if income rises by 1% then demand for health care also increases by 1%. 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.

Temperature regulation

A brief overview of the methodology of urban cooling will be provided here, but for a more detailed description please see the Economics for the Environment Consultancy (EFTEC) and others' 2018 report, Scoping UK Urban Natural Capital Accounts: Extension to develop temperature regulation estimates (PDF, 834KB). To calculate the physical flow of local climate regulation services for urban woodland, EFTEC and others calculated the proportional impact on city-level temperatures caused by the urban cooling effect of woodland and their buffers using the cooling values from various sources.

EFTEC and others estimated the cooling benefit provided by woodland in urban environments for 11 city regions in the UK. EFTEC and others (PDF, 834KB) created a set of regions that comprised the main 11 city regions in Great Britain. Some city regions encompass large urban conglomerations (for example, Greater Manchester City Region), while others include considerable rural areas as well (for example, North East City Region). All spatial calculations were made within these boundaries. For a map of the city regions, see page 21 in the scoping study (PDF, 834KB). They calculated the overall benefit by applying cooling effects discovered in academic literature (Table 1) to the urban area within the cooled areas beside green or blue spaces.

Table 1: Width of buffers and temperature differentials applied for urban blue and green space

	Width of buffer to apply (m)	**Temperature differential (degree Celsius)**	
Asset		**Green or blue infrastructure**	**Buffer**
Urban green space			
Woodland (200 < x < 30,000m²)	0	-3.5	n/a
Woodland (> 30,000 m²)	100	-3.5	-0.52

Source: Eftec and others (2018)

The monetary account measures the value of the cooling effect in pounds. The cooling effect is monetised through the estimated cost savings from air conditioning and the benefit from improved labour productivity. The benefit from improved labour productivity makes up most of the value, with avoided air conditioning energy costs only accounting for a small fraction.

This is assessed by non-financial business sectors, based on averaging temperature mitigation across urban areas and applying temperature–output loss functions to estimate the gross value added (GVA) that would have been lost owing to heat in the absence of the cooling effect, accounting for adaptation behaviours. These estimates represent exchange values as they are directly based on avoided losses in economic output and expenditure. Welfare values would be included if the valuation covered the non-market benefits to the general public of urban cooling (for example, the value of tree shading). In principle, some of these non-market benefits may be captured within the recreational account, to the extent that the cooling and shading features of green and blue space generate more recreational visits to such sites on hot days.

These adaptation behaviours consider the averted loss of labour productivity from air conditioning and behaviour change. For the purposes of this analysis, a 40% reduction is applied to the estimated additional avoided productivity loss from urban cooling to more labour-intensive or non-office-based sectors for averted losses owing to behavioural change (that is, mining and utilities and manufacturing). An 85% reduction is also applied for less labour-intensive or office-based sectors for averted losses owing to air conditioning (that is, information and communication and real estate activities).

Additionally, avoided air conditioning energy costs are based on estimates in London and extrapolated to other city regions. To extrapolate to other city regions, data on the relative air-conditioned office space and percentage green space in other regions are used. This figure is more tentative. The value of the service will fluctuate year to year reflecting the number of hot days (defined as over 28 degrees Celsius) experienced.

The monetary account of the future provision of the ecosystem service, or future benefit stream, accounts for the benefits received over a specified time period, in this case 100 years. The account incorporates a projection for an annual increase in working day productivity losses owing to climate change, which increases the value of urban cooling over time. The assessment of future climate impact relies on a broad estimation of the number and degree of hot days in the future across Great Britain. As well as including climate change impacts, an annual uplift is applied to the monetary values to account for year on year increases in GVA over the 100-year assessment period. For the first 30 years, this uplift is 2% annually, decreasing to 1.5% for years 31 to 75 and 1% for years 76 to 100.

Further work is needed to measure this ecosystem more accurately (for example, adoption of a more granular, bottom-up approach to physical account modelling). For a full list of all the recommendations to update this service, see the Scoping UK Urban Natural Capital Accounts: Extension to develop temperature regulation estimates (PDF, 834KB).

Noise mitigation by vegetation

There is a detailed methodology note on how noise mitigation was produced; please see the methodology report published by Defra.

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 (PDF, 1.22MB). This method was originally created for use on the Monitor of Engagement with the Natural Environment (MENE) survey, which covers recreational visits by respondents in England.

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 cultural service of outdoor recreation in this publication use survey data across four surveys covering England, Wales and Scotland. Combined Great Britain outputs are scaled up to UK level using population estimates 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, we use the MENE survey. The survey collects detailed information on people's use and enjoyment of the natural environment during visits. This report relates to the full 10 years of surveying from March 2009 to February 2019. The MENE survey samples around 47,000 respondents, containing around 20,000 visit takers, annually.

In Scotland, data from two surveys are used to produce estimates of outdoor recreation. From 2003 to 2012, data from the Scottish Recreation Survey (ScRS) were used. The ScRS was undertaken through the inclusion of a series of questions in every monthly wave of the TNS Omnibus survey, the Scottish Opinion Survey (SOS). In every month of the SOS, around 1,000 face-to-face interviews are undertaken with adults in Scotland aged 16 years and over.

Replacing the ScRS, Scottish Natural Heritage commissioned the Scotland's People and Nature Survey (SPANS) for the first time in 2013 to 2014, then again in 2017 to 2018. Unlike the ScRS, SPANS excludes questions relating to respondent expenditure during their last outdoor recreation visit. To produce estimates of Scottish outdoor recreation expenditure beyond 2012, we created a statistical model. Using comparable MENE survey and ScRS data, this model examined the relationship between English and Scottish per visit expenditure on a habitat basis. Linear interpolation was used to produce estimates of Scottish recreation from 2014 to 2016.

In Wales, estimates of the outdoor recreation cultural service are based on data from the 2014 Welsh Outdoor Recreation Survey (WORS). A total of 5,995 interviews were achieved in the 2014 WORS, containing 4,941 visit takers. Estimates of outdoor recreation in Wales before and after 2014 are based on an index of MENE survey outputs. These surveys focus on short day trips from home and miss out potentially large amounts of spending on outdoor activity from domestic tourism, which future reports will aim to include.

Habitat disaggregated estimations of expenditure and time spent may not sum to overall time spent. This is because habitat estimates may be based on a different sample: those answering a question on habitats visited.

For the asset valuation of outdoor recreation, we implemented projected population growth calculated from Office for National Statistics (ONS) population statistics and an income uplift assumption 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 next 100 years.

We acknowledge 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. The value of local recreation and the aesthetic benefit from living near green and blue spaces is estimated through house prices. The recreational value for spending time in woodland fluctuates throughout the time series. This is because when we spilt our surveys down into different types of habitats, the sample size reduces significantly for woodlands. Furthermore, many of the visitors did not spend any money on admissions when visiting the woodland. In the time series, the average number of people who answered the admissions question but spent no money on the trip was 98%, but those that do often have a large impact on the national value.

Scientific research

Data on publicly funded research grants were sourced from the [UK Research and Innovation (UKRI) gateway](). First, we searched project titles for relevant keywords, while also excluding irrelevant keywords. We included the keywords: “woodland”, “tree”, “timber” and “forest”. Meanwhile, we excluded keywords related to: regions outside of the UK, concepts from other academic disciplines such as mathematics and computer science such as “tree graph”, and false positive results such as “street”.

Second, we manually sifted the abstracts to determine whether each grant included any fieldwork in UK woodlands. We provided justifications for including or removing each grant. We also consulted different members of the natural capital team. We excluded studies that focus on environmental models and studies where all research was undertaken in the lab.

Once selected for inclusion, we divided research amounts by project length to provide an estimate for cost per day. We then multiplied by the amount of days a project operated during each year. This provides estimates of how much is spent on UK woodland every year between 2006 and 2019, as of 17 December 2019.

3 . Asset value

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 – this is the time period over which the flows of values are expected to be generated
- choice of discount rate

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 therefore 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.

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 Office for National Statistics (ONS) and Department for Environment, Food and Rural Affairs (Defra) principles paper, this article takes the renewable asset approach. For renewable natural capital assets, a 100-year asset life is applied to all assets that fall within this category of natural capital. In addition, 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 (PDF, 453KB) by external consultants, 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% between 30 and 75 years and 2.5% after 75 years. The rationale for this approach is discussed further in the ONS and Defra principles paper.