Woodland natural capital accounts methodology guide, UK: 2024

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

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1 . Introduction to developments

The methodology we use to develop these estimates remains under development. The estimates reported in our Woodland natural capital accounts, UK: 2024 bulletin are labelled as official statistics in development and should be interpreted in this context. Until September 2023, these were called experimental statistics. Read more about the change in our guide to official statistics in development. We publish official statistics in development to involve customers and stakeholders in their development and as a means of building in quality.

Our efforts to find new and more accurate methodological approaches are ongoing. As a result, there are some changes which mean data in the 2024 woodland accounts cannot be directly compared with data in the previous 2022 woodland accounts.

We use a wide variety of data sources to produce the woodland natural capital accounts bulletin. We compile these sources in line with the guidelines recommended by the United Nations (UN) System of Environmental-Economic Accounting (SEEA) Central Framework and the UN SEEA Ecosystem Accounting. We recently published our Principles of UK natural capital accounting: 2023 methodology, which summarises the principles we apply when interpreting guidance and developing practical methodologies in the UK.

We welcome feedback on any of our approaches. To get in contact, please email natural.capital.team@ons.gov.uk .

Our woodland natural capital accounts bulletin presents data for the:

- size of the woodland habitat (extent)
- condition of the woodland habitat
- quantity and value of services supplied from the ecosystem services (annual physical and monetary ecosystem service flow accounts)
- value of the ecosystem services as an asset, which represents the stream of services expected to be provided over the lifetime of the asset (monetary asset account)

2 . Woodland extent

We use the broad habitat classifications from the 2011 UK National Ecosystem Assessment to categorise habitats. According to this classification system, woodland includes both managed plantations and ancient, semi-natural woodlands. Both coniferous and deciduous (broadleaves) are included.

To show the area of woodland in these accounts, data are sourced from Forest Research's Forestry statistics for 2023, which includes data from the Department of Agriculture, Environment and Rural Affairs (DAERA) woodland register for Northern Ireland. Great Britain data are from the National Forest Inventory (NFI). The woodland register data contain all woodland over 0.1 hectare. The NFI is woodland that is over 0.5 hectares in extent and greater than 20 metres in width. This includes areas recently felled and expected to be replanted, and open space within woodland.

3 . Woodland condition indicators

Ecosystem condition accounts provide a structured approach to recording and aggregating data describing the characteristics of ecosystem assets and how they have changed.

The United Nation's (UN's) System of Environmental-Economic Accounting–Ecosystem Accounting (SEEA EA) (PDF, 5.3MB) is a spatially-based, integrated statistical framework.

The first step is to define and select ecosystem characteristics and associated variables. To assess condition, this means looking at characteristics that can show a directional change over consecutive accounting periods in a scientifically robust manner. We also need to collect data on stable characteristics.

Ecosystem condition typology

The ecosystem condition typology (ECT) is a hierarchical typology for organising data on the condition characteristics.

Abiotic (physical) ecosystem characteristics:

- physical state characteristics – including soil structure, water availability
- chemical state characteristics – including soil nutrient levels, water quality, air pollutant concentrations

Biotic ecosystem characteristics:

- compositional state characteristics – including species-based indicators
- structural state characteristics – including vegetation, biomass, food chains
- functional state characteristics – including ecosystem processes, disturbance regimes

Landscape-level characteristics:

- landscape and seascape characteristics – including landscape diversity, connectivity, fragmentation, embedded semi-natural elements in farmland

Environmental pressure indicators

Some environmental pressure indicators, for example, wildfires and access provide a broad measure of potential effects on the condition of ecosystems. However, as they do not provide direct measures of condition for individual ecosystem assets, they are used as a proxy measure where no other data are available.

Indicators of protection status (for example, Sites of Special Scientific Interest (SSSI) and Special Areas of Conservation (SACs)) are classed as ancillary indicators as they can be used as proxy measures for condition in cases where no other information is available. Protected sites information could be thought of as a rough proxy for reduced environmental pressures, especially reduced overexploitation (for example, indicating lower management intensities).

Physical state indicators for woodland

Soil

Soil is important for providing many essential ecosystem services, such as food production, water purification and greenhouse gas regulation. Monitoring trends in specific soil indicators over time provides a suitable physical state condition indicator.

Soil data are taken from the UK Centre for Ecology and Hydrology (UKCEH) Countryside Survey from 1978, 1998 and 2007. Since then, the UKCEH survey has been monitoring soil samples in a rolling five-year survey to understand the state of topsoil (up to 15 centimetres depth).

Compositional indicators for woodland

Bats

Bats depend on a range of habitats, and in the UK are reliant on insect prey. They are sensitive to changes in land use, habitat fragmentation, climate, and site management.

The National Bat Monitoring Programme (NBMP), run by the Bat Conservation Trust (BCT), coordinates annual bat surveys. Volunteers monitor bats at survey points and along walks by listening for their vocalisations using specialised equipment. The monitoring sites and walks have been mapped against habitat maps to enable us to break it down by broad habitat.

The detection distance of bats means that the bats recorded may not be at the exact location of the recording point. A "buffer" is placed around each recording point based on the approximate maximum detection distance for each species. These are:

- Daubenton's bat – 10 metres (m)
- common pipistrelle and soprano pipistrelle – 25m
- noctule – 100m

Indices for each species are based on spots or walks where at least 50% of the buffer area was of the relevant habitat.

Generalised Additive Models (GAM) are used to fit a smoothed line to each bat dataset, with full details on the statistical methods used in the NBMP's annual report.

Bees

Bees provide a range of ecosystem services as well as being useful indicators of wider ecological health. In particular, bees are one of the main groups of insects responsible for pollination of wildflowers, berries, orchards, and crops. Because a third of all UK crops are pollinator dependent, this is a particularly important service. Habitat loss and degradation is related to declines in bee populations, so is a useful indicator of long-term changes in the condition and health of the environment.

The Bumblebee Conservation Trust runs the BeeWalk Survey Scheme. This uses citizen volunteers to monitor the number of bumblebees on a monthly walk from March to October, along a set route of approximately one mile. This identifies worker bees (the most common), drones (fertile males), and queens (the sole fertile female in any colony). The number of bees per kilometre is counted and reported over time. The total number of bees per kilometre per BeeWalk is an indicator of the condition of woodland habitats.

Birds

Bird populations measured by the Join Nature Conservation Committee (JNCC) provide a useful indicator of the state of UK nature, as they occupy a wide range of habitats and respond to environmental pressures.

Many of the habitat-based bird population indices are official statistics and produced by the Royal Society for the Protection of Birds (RSPB) and British Trust for Ornithology (BTO).

Species are selected for the index if they have a population of at least 300 breeding pairs and are a native species. To find out more about how bird populations are counted, please visit the British Trust for Ornithology's (BTO's) breeding bird survey web page.

Butterflies

The UK Butterfly Monitoring Scheme states that butterflies are good indicators of environmental change because they have short life cycles and react quickly to weather and climate change.

Moths

Moths hold vital roles in the ecosystems, with more than 2,500 moth species present in Britain in a range of habitats, according to the Butterfly Conservation website. Moths and caterpillars are important for feeding bird chicks, so declines could have major knock-on effects for bird species. They also have an important role in pollinating crops and wildflowers.

According to the Butterfly Conservation, more than 50 individual species became extinct in the 20th century. Data is supplied to us from the Rothamsted Research Insect Survey for moth counts.

National Forest Inventory

Changes in land use practices, woodland management, and effects from climate change affect the ecological condition of woodlands.

The National Forest Inventory (NFI) survey is based on data collected between 2009 and 2015 in Great Britain. More than 15,000 one hectare squares were sampled, recording data for 15 woodland ecological condition indicators at each survey site, recorded in NFI's woodland ecological condition in Great Britain methodology (PDF, 3.1MB). These are then classed as favourable, intermediate, or unfavourable. For full details, see Forest Research's NFI survey methods.

NFI indicators used in this publication include:

- tree health
- invasive species
- regeneration at component group level
- number of native trees and shrub species
- deadwood volume (metres cubed per hectare)
- vertical structure
- veteran trees
- age distribution of trees
- proportion of open space

A variety of ages of trees in woodlands benefits biodiversity, because they provide different ecological habitats. To be classified as favourable, woodlands need to have young, intermediate, and old trees present. The NFI defines a veteran tree as a tree that is of interest biologically, culturally, or aesthetically because of its age, size, or condition.

The vertical structure is defined as the number of "storeys" in the tree canopy. Woodlands with greater structural diversity (more storeys) provide a wider range of microhabitats and conditions.

Regeneration is an assessment of seedlings, saplings, and young trees. It is an important indicator of biodiversity for predicting the future health of woodlands. To be classed as favourable, the woodland needs to have trees with four to seven centimetres diameter, as well as having saplings and seedlings present.

Tree diseases and pests have a negative impact on woodland biodiversity. Dead and decaying wood enable light to reach the forest floor, which is an important micro-habitat. The rapid and widespread death of trees can harm ecological health.

Areas of open space within, and adjacent to, woodlands provide increased light for some shade-intolerant species, improving environmental and structural heterogeneity. The UK Forestry Standard required for woodlands to have a minimum of 10% open ground.

Statutory Plant Health Notices

Statutory Plant Health Notices (SPHN) are instructions to take action, such as felling, when trees on a site are found to be infected with pests or disease. Different bodies are responsible for issuing these notices in each country. Forest Research's forestry statistics (PDF, 862KB) publishes data on the number of sites issued with SPHNs and the number of fellings carried out as the result of a SPHN.

Landscape-level indicators for woodland

Habitat connectivity

Habitat connectivity measures the ease of different species' movement between landscape habitats. One definition is "the degree to which the landscape facilitates or impedes movement among resource patches", from 'Connectivity is a vital element of landscape structure', published by Oikos, which we have used here.

Connectivity can be structural – about the distribution of patches of habitat across a landscape, or functional – about the ability of species to move around different habitat patches. For example, birds might functionally move across a naturally structurally fragmented set of habitats many miles or even thousands of miles apart, while some terrestrial mammals may struggle if a single road crosses their habitat.

According to the JNCC, the method used for connectivity involves calculating functional connectivity, which is the ability of species to move between resource patches in the landscape. The indicator uses a measure of population synchrony of 33 butterfly and 29 woodland bird species in the UK.

Woodland on farmland

Data are collected by the Department for Environment, Food and Rural Affairs (DEFRA) on the size and structure of the agricultural industry in the UK, including the area of woodland on farmland (see Agriculture in the UK (PDF, 3.5MB) for more information).

Environmental pressure indicators

Pressure indicators are defined here as damage inflicted on the landscape by humans.

Wildfires

Wildfires can be a pressure indicator. Most are anthropogenic in origin, with or without intent. There are two main sources of wildfire data: reports and satellite data. Reported fires include wildfires of all sizes attended by Fire and Rescue Services but may miss some remote fires that are addressed by land managers. Satellite data capture fires in both built-up and remote places but can miss smaller fires under 30 hectares.

England

The England wildfire statistics were collected from the Home Office's Incident Recording System, recorded in the Fire statistics incident level datasets on GOV.UK.

Scotland

Wildfire data for Scotland use statistics from the Incident Recording System and only represent wildfires responded to by the Scottish Fire and Rescue Service. These exclude wildfires extinguished by landowners alone.

Wales

The Welsh Government reports annually on wildfires with data from the three Fire and Rescue Services in Wales.

Protected sites

There are several formal designations, including Special Areas of Conservation (SACs) in the UK, a Site of Special Scientific Interest (SSSIs) in Scotland, Wales and England, or Areas of Special Scientific Interest (ASSIs) in Northern Ireland. The rare fauna or flora present, or important geological or physiological features, make it an area of interest to science.

The England and Wales data were recorded by habitat. The Scottish data were recorded by feature category and, therefore, sites were only included if they had the habitat as the feature. For example, if the site had been recorded as a feature for birds, invertebrates, or earth sciences, we were not able to assign it to a habitat.

The sites are classified according to their condition as either favourable, recovering, unfavourable or destroyed.

Certified woodland area

Certified woodland in the UK has been independently audited against the UK Woodland Assurance Standard which promotes good forest practice. They offer product labels that demonstrate that wood or wood products come from well-managed forests. See Forest Research's data downloads page for more information.

Access to woodland

This was recorded by the Woodland Trust in their State of the UK's woods and trees 2021 report (PDF, 27.6MB). The report analysis uses accessible woodland data, along with data on overall woodland cover and population census data.

4 . Ecosystem services

Timber and woodfuel provisioning

Removals estimates are taken from Forest Research timber statistics and converted from green tonnes to cubic metres (m3) 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 Forest Research Coniferous Standing Sales Price Index in the Timber Price Indices. Annual flow values are then generated by multiplying the stumpage price and the physical amount of timber removed.

Asset valuations use Forest Research forecasts of timber availability to estimate the pattern of expected future flows of the service over the asset lifetime.

The timber data contain all uses of timber including woodfuel. To separate out woodfuel provisioning, data are sourced from Forest Research UK roundwood deliveries (XLS, 94KB) and deducted from the timber value, to ensure no double counting occurs. Data for woodfuel are only available from 1994, so prior to this date, timber estimates include some woodfuel provisioning.

Air pollution regulating

Air pollution regulation estimates have been supplied in consultation with the UK Centre for Ecology and Hydrology (UKCEH), with a full methodology available in the report published in July 2017.

Physical flows use the European Monitoring and Evaluation Program Unified Model for the UK (EMEP4UK) atmospheric chemistry and transport model to generate pollutant concentrations directly from emissions. They also dynamically calculate pollutant transport and deposition, considering meteorology and pollutant interactions.

Air pollution removal by UK vegetation has been modelled for the years 2007, 2015 and 2019 and then scaled based on previous modelling to create values for 2030. For the remaining years, where government concentration data are available through the UK's Automatic Urban and Rural Network (AURN), figures are fed into the model to generate estimates for changes in air pollutant concentrations caused by vegetation. When no pollution concentration data are available, we assume concentrations fall by a constant rate until they reach 2030 values.

Health benefits are calculated from the change in pollutant concentration to which people are exposed. Damage costs per unit exposure are then applied to the benefiting population at the local authority level for the following avoided health outcomes:

- respiratory hospital admissions
- cardiovascular hospital admissions
- loss of life years, in terms of long-term exposure effects from particulate matter 2.5 (PM2.5) and nitrogen dioxide (NO2)
- deaths, in terms of short-term exposure effects from ozone (O3)

For the method of how damage costs are calculated, please see the Department for Environment, Food and Rural Affairs's (DEFRA's) Air Quality damage cost update 2019 report (PDF, 1.13MB).

Estimates are attributed to habitats based on the rates of deposition for different habitat types.

Greenhouse gas regulating

Greenhouse gas regulating estimates the value of the removal of greenhouse gases, in carbon dioxide equivalent (CO2e), from the atmosphere by habitats in the UK. Estimates presented represent net values and so our greenhouse gas regulating reflects both storage and removal of greenhouse gases as a single service. Full details about what is measured in the service, and why, can be found in Section 5: Physical accounts of our Principles of natural capital accounting: 2023 methodology.

Physical data come from the UK National Atmospheric Emission Inventory's (NAEI) Greenhouse Gas Inventories report. This report contains data relating to carbon exchange in the Land Use, Land Use Change and Forestry (LULUCF) sector. The woodland account includes data which pertains to both the "forest land" and "harvested woodland products" land categories. We also aim to estimate the gross carbon sequestration benefits of nature, but this is not possible with current inventory data.

The capacity for habitats to remove greenhouse gas from the air depends upon the habitat type and extent. Local greenhouse gas regulating estimates are produced through local authority modelling of national estimates and are not specific to the land management of each authority.

To estimate the annual value, we multiply the physical flow by a carbon price. The carbon price used in calculations is based on the projected non-traded price of carbon schedule. For further details, see Table 3 of GOV.UK's Green Book supplementary guidance. Carbon prices are available from 2020 to 2050. Prices prior to 2020 and beyond 2050 are deflated or inflated respectively by 1.5% annually, based on advice from the Department for Energy Security and Net Zero (DESNZ).

Flood regulating

To capture the flood regulating service for woodland in Great Britain, Forest Research examined how much it would cost to have flood water storage (reservoirs) in an area where there was no woodland. They looked at the substitution costs of having no woodland. For Northern Ireland, Forest Research estimated the annual and asset values.

Noise regulating

Noise regulating estimates the value of vegetation that acts as a buffer against noise pollution, such as road traffic.

DEFRA's noise mapping study is used alongside spatial population data and a UKCEH Land Cover Map (LCM) to determine the number of buildings located near vegetation that would provide a reduction in the volume of noise. The health impacts and nuisance associated with noise are used alongside the number of buildings to create an annual value.

A single year of data from 2014 are carried forward to create a time series. This value is deflated to match the latest price year.

DEFRA's Scoping UK Urban Natural Capital Account – Extending noise regulation estimates – NR0170 methodology details how noise mitigation estimates were produced. Further work is required to develop this methodology.

For these accounts, the estimates are attributed to woodland, as urban woodland habitats provide the vegetation, which acts as a buffer.

Urban heat regulating

Urban heat regulating estimates the value of green (for example, parks) and blue (for example, lakes) spaces that can cool urban environments on hot days. The benefits of this include limiting loss of labour productivity and reducing air conditioning use.

Data are available for 11 city regions, with coverage across England, Scotland and Wales. These do not create a full picture of the UK urban heat regulation.

The cooling effect of green and blue spaces reduces the loss of productivity because of heat, which is determined per industry type, and by the extent of green and blue space per city region. To create an annual value, for each city region the number of hot days (28 degrees Celsius and above) are multiplied by the productivity saved and the gross value added of each industry. Projected increases in hot days over the next 71 years are included in the asset valuation.

DEFRA's Scoping UK Urban Natural Capital Accounts – Extension to develop temperature regulation estimates – NR0172 methodology details how urban heat regulating estimates were produced.

For our Woodland natural capital accounts bulletin, estimates are attributed to the woodland habitat because it provides a cooling affect.

The Impacts of hot days on productivity in Great Britain, published on 15 May 2024, improves the linkage to updated local area industry data which will improve urban heat estimates in the future. This is a working methodology and not used in our Woodland natural capital accounts, UK: 2024 estimates of ecosystem services.

Recreation and tourism (expenditure)

Recreation and tourism (expenditure) estimates the amount spent to enable visits to the natural environment, such as transport, car parking and admission costs. In the absence of a ticket to access a public beach, buying a bus ticket represents the cost of the trip, and this is assumed as a proxy for the value of accessing the site.

Recreation and tourism (expenditure) estimates combine separate estimates of nature-based tourism and outdoor recreation. Tourism estimates include day visits longer than three hours in duration, overnight trips and visits from international travellers visiting the UK. To avoid double counting, estimates of recreation include only day visits three hours or shorter in duration.

Estimates for the cultural service of outdoor recreation in this publication use survey data across multiple surveys covering England, Scotland, Wales, and Northern Ireland. 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)?

Recreation data for England are taken annually from Natural England's Monitor of Engagement with the Natural Environment (MENE) survey between 2009 and 2018, and the People and Nature Survey (PaNS) between 2020 and 2022. Because of differences in the level of reported expenditure between the two surveys, the Living Cost and Food Survey (LCF) was used as a proxy series to join the surveys without a step change. This involved linking LCF spend items to PaNS expenditure items and using the LCF growth rates between 2019 and 2020 to impute a 2020 expenditure value for PaNS. PaNS data are applied as growth rates to the imputed 2020 value, generating a consistent timeseries.

Non-expenditure data do not feature a step change. However, changes to survey design have reduced the comparability of MENE and PaNS across all variables.

In Scotland, data from two surveys are used to produce estimates of outdoor recreation, where:

- from 2003 to 2012, the Scottish Recreation Survey (ScRS) is used
- for 2013 to 2014, 2017 to 2018, and 2019 to 2020, Scotland's People and Nature Survey (SPANS) is used

Unlike 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 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 2019. Data from PaNS are used as a proxy series to impute missing years from 2020 onwards.

In Wales, data from the Welsh Outdoor Recreation Survey (WORS) were used in 2014 to 2015, followed by recreation-based questions asked in the National Survey for Wales (NSW) in 2016 to 2017, and 2018 to 2019. In Northern Ireland, estimates of outdoor recreation have been compiled from the People in the Outdoors Monitor for Northern Ireland (POMNI). This survey ran for the first time in 2020 to 2021. For both nations, data from MENE and PaNS are used as a proxy series to impute missing years and generate a full timeseries from 2009 onwards.

Four surveys are used to generate estimates of nature-based tourism. This includes Visit Britain's Great Britain Day Visits Survey (GBDVS) and Great Britain Tourism Survey (GBTS). Both surveys collect annual data from 2011 to present, with a pause in 2020. The LCF is used as a proxy series to impute expenditure estimates in 2020. We also use the International Passenger Survey (IPS), which collects data annually for international visitors, as well as Northern Ireland annual tourism statistics.

A limitation of the GBDVS data we use to generate tourism expenditure estimates is that we need to make some assumptions on how to correctly apportion spend between activities. This is because respondents' spending is attributed to all types of activities they have completed, leading to a multiplication of expenditure.

We apportion by using data from ad hoc questions added to a single round of the GBDVS, which asked respondents about the importance of different activities within broader visit categories. We apply these one-off proportions to avoid the multiplication and double counting of spend between activity types.

Changes made to the GBDVS between 2019 and 2021 has led to a reduction in the amount of this double counting within their estimates. As our proportions are unchanged, the survey data are being subject to more double-counting removal than they now require, leading to lower estimates.

As a result of this, there is more uncertainty around our estimates from 2021 onwards, and these may be an underestimate of tourism expenditure in nature. We are looking to update our tourism methodology to adapt the approach to apportioning to activities in future, to more accurately reflect the categories present within updated surveys.

For a detailed methodology on how tourism estimates were produced, see the DEFRA's Tourism values for Natural Capital Accounts – NR0176 and our UK natural capital accounts: Tourism – methodology.

Estimates are equally attributed to habitats based on the types of natural places visited by respondents within their survey responses. Habitat disaggregated estimations may not sum to overall totals. This is because the question on habitat visited may be asked less frequently compared with other questions, resulting in smaller sample sizes. Estimations can differ depending on sample sizes.

For broad habitat classifications by country, please see the Habitats section in Section 2: Methods used of our Health benefits from recreation methodology, natural capital, UK methodology.

For the asset valuation of outdoor recreation, projected population growth calculated from population statistics in our Principal projection – UK summary dataset were implemented into the estimation. These assumptions project the annual value to increase over the 100-year asset lifetime.

A number of outdoor recreation visits have no expenditure as people take local visits, such as walking to a local park. Therefore, it is acknowledged that the expenditure-based method provides an underestimation of the value provided by visits to the natural environment. Other services, recreation (house prices) and recreation (health benefits) aim to capture some of this additional value.

Recreation (health benefits)

The number of people gaining these benefits are calculated using the recreation-based surveys discussed in recreation and tourism (expenditure). The monetary value of health benefits from recreation have been used in accordance with the description from the work of Claxon and others (2015) in their article Karl Claxon's Methods for the estimation of the National Institute for Health and Care Excellence cost-effectiveness threshold article. This cost-saving approach concluded that £13,000 of NHS resources adds one Quality-Adjusted Life Year (QALY) to the lives of NHS patients (2008 prices).

The methodology underpinning the health benefits gained from recreation can be found in Section 2: Exposure to nature of our Health benefits from recreation, natural capital, UK methodology. Since this methodology, further work has been undertaken to implement the "exposure to nature" approach.

Estimates are equally attributed to habitats based on the types of natural places visited by respondents within their survey responses.

5 . Cite this methodology

Office for National Statistics (ONS), released 15 May 2024, ONS website, methodology, Woodland natural capital accounts methodology guide, UK: 2024