Office for National Statistics

UK natural capital accounts methodology guide: 2023

Methods to calculate natural capital ecosystem service accounts that estimate habitat extent, ecosystem services and asset value in the UK.

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1 . Introduction

The methodology we use to develop these estimates remains under development. The estimates reported are experimental and should be interpreted in this context. We publish experimental statistics to involve customers and stakeholders in their development and as a means of building in quality.

This methodology describes how the UK's natural capital ecosystem service accounts are developed. It explains the broad approach to valuation and the overarching assumptions involved. It also includes a more detailed description of the specific methodologies used to value the individual components of natural capital, and physical and monetary data sources.

We use a wide variety of data sources to produce the UK's natural capital accounts. 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 UK natural capital accounts present data for the:

- size of the seven broad terrestrial habitats (extent)
- 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 . Habitat extent

We use the broad habitat classifications from the 2011 UK National Ecosystem Assessment to categorise habitats. The mapping data for these habitats are from the Land Cover Maps produced by the UK Centre for Ecology and Hydrology (UKCEH).

Each of the 21 Land Cover Map habitat classes are assigned to eight broad habitat classes.

Enclosed farmland

This includes the categories of arable, horticulture and improved grassland. Annual crops, perennial crops such as berries and orchards, freshly ploughed land, and higher productivity grasslands.

Woodland

This includes managed plantations as well as ancient, semi-natural woodlands and includes both coniferous and broadleaf (deciduous) woodland.

Mountains, moorland, and heath

This includes heather, heather grassland and inland rock. These are mountainous, open and rugged habitats.

Semi-natural grassland

This includes acid grassland, calcareous grassland (where the geology below is composed of calcium carbonate), and neutral grassland. These are acidic, alkaline, and neutral habitats, respectively, with low levels of plant species diversity.

Urban

This includes suburban and urban habitats, consisting of built structures and other infrastructure.

Freshwater, wetlands, and floodplains

This includes fen, bog and freshwater. Freshwater bogs are partly drained habitats, including ericaceous (acidic composition) and herbaceous mosses that form over peat rich soils.

Coastal margins

This includes saltmarsh, littoral rock, littoral sediment, supralittoral rock, and supralittoral sediment. Littoral areas are on the shoreline with supralittoral areas being the splash zone above the high-tide mark.

Marine

This broad habitat is saltwater. In this UK account, we only show the total extent of the remaining seven broad terrestrial habitats. Marine is included to show the change of habitats between 1990 and 2021 where a terrestrial habitat has become marine or vice versa.

3 . Annual ecosystem service flow valuation

Ecosystem services estimate the contribution of natural assets in the UK to the economy and society. To do this, annual service flows are calculated using a physical measure of its output in units appropriate to the good or service, and a valuation is then applied. An estimate of physical quantity is multiplied by a price for:

- fish and timber provisioning
- greenhouse gas, air pollution, noise and urban heat regulating
- recreation (health benefits), and recreation and tourism (expenditure)

The price we use satisfies two accounting conditions:

1. Identifying a price that relates, as closely as possible, to contributions provided by the ecosystem to the economy.
2. Where no market exists, imputing a price that an ecosystem could charge for its services in a theoretical market.

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

For agricultural biomass, water, minerals and metals, oil and gas, coal, and renewable electricity provisioning, we use a residual value resource rent approach.

For the first time in the 2023 accounts, we assign the value of each ecosystem service to the habitat where the value is derived.

This is described in detail for each service in Section 6: Methodology by service.

4 . Resource rent definition and assumptions

The resource rent can be interpreted as the annual return stemming directly from a natural capital asset. This is the surplus value accruing to the extractor or user of a natural capital asset calculated after all costs, including opportunity costs, have been considered.

We explain how variations of this approach are applied depending on the category of natural capital under assessment.

Resource rent is calculated by applying the following steps:

1. Gross operating surplus (System of National Accounts basis) is calculated as output minus operating costs (intermediate consumption plus compensation of employees plus other taxes on production) plus other subsidies on production.

2. Gross operating surplus (resource rent derivation) is calculated as gross operating surplus (System of National Accounts basis) minus specific subsidies on extraction plus specific taxes on extraction.

3. Resource rent is then calculated as gross operating surplus (resource rent derivation) minus user costs of produced assets (consumption of fixed capital and return to produced assets).

For the UK, we get these data from the supply and use tables. Return to produced asset estimates are calculated using industry-based net capital stocks from our Capital stocks and fixed capital consumption, UK: 2021 bulletin, and the Bank of England's 10-year government bond yield. These are deflated using the gross domestic product (GDP) deflator to produce the real yield. The government bond yield is relatively conservative compared with rates expected in certain markets and could therefore overstate the resulting resource rent estimates.

Scottish estimates of gross operating surplus and taxes less subsidies are sourced from the Scottish Government's Supply, Use and Input-Output Tables. As these tables run a year behind the UK input-output supply and use tables, we have used data from Scotland's Quarterly GDP to produce estimates to the same timeframe. The estimates for the latest years are therefore subject to greater uncertainty than those for which we have balanced supply and use tables.

As capital stocks are not produced for Scotland, the ratio of intermediate consumption, from supply and use tables for Scotland to UK values, is applied to UK values to derive the net capital stock and consumption of fixed capital.

For England, Wales and Northern Ireland, complete supply and use tables are not available. To provide estimates for these nations, we use data from our Non-financial business economy, UK and regional (Annual Business Survey) bulletin. To enable us to apportion by country using the best data available, estimates for Scotland are deducted from the UK total, and the remainder is split across England, Wales, and Northern Ireland according to proportions of gross operating surplus.

5 . Asset valuation

Natural capital asset values measure the stock, or the stream of services of that natural resource, in terms of future expected supply and use over a reasonably predictable time horizon.

The net present value (NPV) approach is recommended by the United Nations System of Environmental-Economic Accounting – Ecosystem Accounting (SEEA EA) (PDF, 5.33MB) 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, which are:

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

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. When the pattern of future flows is not available, assumptions concerning the flows must be made, generally as a projection of the latest trends.

In some cases, information is available on future expected levels of services in physical terms or future unit prices. Where these official projections are readily available, they have been used in calculations. Otherwise, our default assumption is that the current value of the service is constant over the asset lifetime. This is based on averages over the latest five years of data, up to and including the reference year in question. For the reference year itself, the value is known and so an average is not applied.

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.

For non-renewable natural capital assets, a 25-year asset life is assumed unless a sufficient level of information on the expected asset lives is available, in which case this is applied in the calculations.

Renewable natural capital assets are assumed to have a 100-year asset life.

Choice of discount rate

A discount rate is required to convert the expected stream of monetary 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.

The Discounting for Environmental Accounts Report November 2016 (PDF, 453KB) for the Office for National Statistics (ONS) by external consultants from Chantry Educational Services and the Department for Environment, Food and Rural Affairs (Defra) uses the social discount rate set out in the HM Treasury's Green Book (PDF 1,489 KB). In line with the guidance, estimates presented assume a 3.5% discount rate for flows projected out to 30 years, then declining to 3.0%, then further to 2.5% after 75 years. The rationale for this approach is discussed further in our Principles of natural capital accounting methodology.

The discount rates applied to air pollution regulation, noise regulation and recreation (health benefits) employ the health discount rates as detailed in HM Treasury's Green Book. This is because of the health-based nature of these ecosystem services and because the future utility benefits associated with these service provisions are unlikely to be characterised by high rates of diminishing marginal utility.

6 . Methodology by service

This section provides an explanation of the data sources and methods used to calculate the physical and monetary values for each ecosystem service.

Agricultural biomass provisioning

Agricultural biomass estimates the value of crops, fodder and grazed biomass provided to support agricultural production. In theory, cultivated biological resources should be excluded from the UK natural capital accounts (for more details, see Principle D2 in our Principles of UK natural capital accounting methodology). Farmed animals are considered produced rather than natural assets, but we are unable to exclude them from our monetary estimates because of limitations in the granularity of industry data.

The Department for Environment, Food and Rural Affairs (Defra) publish Agricultural statistics. Grazed biomass calculations are based on livestock numbers and livestock annual roughage requirements provided in the Eurostat Economy-wide material flow accounts (EW-MFA) questionnaire (PDF, 3,0334KB). Regional physical flows are taken from Defra's cereal and oil seed rape production and are only included for barley, oats, oilseed rape and wheat.

Input-output supply and use tables for the UK and Scotland are used for the gross operating surplus and taxes less subsides variables in the resource rent calculations. For Scotland, the UK net capital stock for Standard Industrial Classification (SIC) 01 was apportioned based on the ratio of consumption of fixed capital between the UK and Scotland, using data from Scottish Government's Total Income from Farming Estimates and Defra's Total income from farming in the UK. Agricultural accounts for each nation are used to apportion the remainder of the resource rent, once Scotland had been deducted, based on the gross operating surplus.

Estimates have been assigned to the habitat of enclosed farmland. There may be some value that can be attributed to semi-natural grassland, but we currently do not have data available to separate this.

Coal provisioning

Coal production statistics are available from the Department for Energy Security and Net Zero (DESNZ), in the Digest of UK Energy Statistics (DUKES). Northern Ireland stopped coal production in 1970 so has no value for this service.

For the valuation, a residual value resource rent approach is used based on our Input-output supply and use tables and capital stocks data for the SIC division: Mining of coal and lignite (SIC 05). Because of the small size of this industry across the UK, the proportions from the Annual Business Survey are too volatile to use here. Instead, we use total production to apportion the remaining UK data across England and Wales once Scotland has been deducted.

Estimates are attributed to the habitat of mountains, moorland, and heath. Inland rock is included in mountains, moorland, and heath as one of the UK Centre for Ecology and Hydrology (UKCEH) Land Cover Map (LCM) classifications. As we do not have a subterranean habitat class, the assumption is that mountains, moorland, and heath cover the locations of most extraction sites.

Fish provisioning

Fish provisioning estimates the value of marine fish taken from mainland UK waters. Aquaculture or farmed fish are removed from estimates as farmed fish are viewed as a produced asset rather than a natural asset (see Principle D2 of our Principles of UK natural capital accounting: 2023 methodology).

Physical data on marine fish capture (live weight) are sourced from the rectangle-level landings data published annually in the Marine Management Organisation's (MMO) UK Sea Fisheries Statistics and the EU Commission's Joint Research Centre Scientific, Technical and Economic Committee for Fisheries as part of the Fisheries landings and effort data call. Live weight is the weight of a product when removed from the water.

To calculate marine fish capture from UK waters, exclusive economic zone (EEZ) MMO statistical rectangle factors were used. For more detail on how fish capture in UK waters is estimated, see GOV.UK's UK commercial sea fisheries landings by Exclusive Economic Zone of capture report 2019.

Valuations are calculated by multiplying annual net profit per tonne (landed weight) by tonnes of fish captured (live weight) for a specific species. Net profit per tonne (landed) estimates for marine species by marine areas, provided by Seafish, are calculated using Seafish's economic estimates for fleet segments and MMO data on landings by stocks (landed value and landed weight), and landings by stocks and species (in cases where species are not managed by total allowable catches). Landed weight is the weight of a product at the time of landing, regardless of the state in which it has been landed. Landed fish may be whole, gutted and headed, or filleted.

The data are aggregated for overall annual valuations of fish provisioning from the four nations and the UK EEZ. A notable limitation of the fish capture provisioning valuation methodology is that landed weight net profits were multiplied by live weight fish capture. Based on MMO data on live and landed weights of UK vessel landings into the UK, aggregate landed weight is around 7% less than live weight. Additionally, the economic data are based on UK fleet data, which we also apply to EU vessels that may face different costs and prices.

Furthermore, net profit per tonne is not available for all fish species so not all of the physical flow is valued. We can estimate a net profit valuation for 85% of the fish capture tonnage on average between 2016 and 2021. The valuation of fish capture from UK waters is therefore likely to be an underestimate.

For all of the fish species across UK waters, we estimate the sustainability of fishing using the International Council for the Exploration of the Sea's stock assessments. These do not include wider externalities from fishing, such as plastic pollution.

For each stock, we check that fishing pressure is at or below levels capable of producing maximum sustainable yield. We also check if each stock's spawning biomass is at or above the level capable of producing the maximum sustainable yield. In 2021, we were able to estimate the stock sustainability status for 74% of the fish capture tonnage, leaving 26% as unknown. Those species estimated to be sustainable are valued using an asset lifetime of 100 years, while those estimated to be unsustainable or unknown are valued over 25 years.

We can determine if the level of fishing for a specific stock is sustainable, but this approach does not consider the knock-on effects of unsustainable fishing to the wider ecosystem. For instance, if a fish species that forms a substantial part of other fish species' diets is managed unsustainably, it risks affecting the sustainability of other fish stocks higher up the food chain.

Fish provisioning estimates are attributed to the marine habitat.

Minerals and metals provisioning

Physical estimates of mineral extraction are provided by the British Geological Survey (BGS). Up to and including 2014, mineral extraction is based on the annual minerals raised inquiry, but since 2015 BGS have attempted to obtain data from alternative sources, including Mineral Products Association and the British Ceramics Confederation. Estimates for the four nations will not always sum to UK totals because of data limitations.

Estimates are grouped into:

- construction minerals: sand and gravel, silica sand, gypsum, slate, chalk, igneous rock, limestone, dolomite, and sandstone
- clay minerals: fireclay, china clay, ball clay, talc, and clay and shale
- fertiliser minerals: barytes, fluorspar, and polyhalite
- salts: salts and potash
- metals: tin, tungsten, lead, gold, and silver

Monetary estimates are based on the residual value resource rent approach calculated from the SIC subdivision class: Other mining and quarrying (SIC 08) and Mining of metal ores (SIC 07). Other mining and quarrying includes extraction from a mine or quarry, but also dredging of alluvial deposits, rock crushing and the use of salt marshes. The products are used most notably in construction, such as stone and aggregates, manufacture of materials, such as clay and gypsum, and manufacture of chemicals.

This SIC division excludes some aspects of the processing of the minerals extracted. However, crushing, grinding, cutting, cleaning, drying, sorting, and mixing are not excluded. This may inflate the resource rents associated with the pure natural provisioning service.

One of the main limitations of the resource rent approach is the inability to account for different profits and costs across the types of minerals and metals. As a result, we have been unable to assign monetary values across habitats, and all the monetary value has been assigned to mountains, moorland, and heath.

Physical estimates can be attributed to both marine habitats and mountains, moorland, and heath habitats. Inland rock is included in mountains, moorland, and heath as one of the UKCEH Land Cover Map (LCM) classifications. As we do not have a subterranean habitat class, the assumption is that mountains, moorland, and heath cover the locations of most extraction sites.

Oil and gas provisioning

Physical estimates of oil and gas production are available from the North Sea Transition Authority (NSTA) website.

Monetary estimates follow a residual value resource rent approach calculated from the NSTA's income and expenditure data on UK upstream oil and gas exploration, operating and decommissioning activities, published by the NSTA, and net capital stock and consumption of fixed capital data for SIC subdivision class: Extraction of crude petroleum and natural gas (SIC 06) from our capital stock data.

Scottish oil and gas provisioning is estimated using the Scottish Government's oil and gas statistics, comparable with the UK NSTA's data. Consumption of fixed capital and cost of capital is estimated through an apportionment of our capital stocks data for SIC 06, using relative operating expenditure reported by the NSTA and Scottish Government, respectively.

For Wales and Northern Ireland, oil and gas provisioning are assumed to be zero. The estimate for England is therefore calculated to be the remainder once the value for Scotland has been deducted from the UK total.

Infrastructure for the extraction of oil and gas must be decommissioned and the costs are incurred at the end of an asset's lifetime. This distortion of the cost profile has a downward impact on the resource rents in later years. We have therefore adjusted decommissioning costs, so they vary according to total income generated in each year, while maintaining the total value of the costs. The distribution of these costs mirrors total income as it changes over time and results in a smoother time series.

For the asset valuation, we use NSTA's annual production and expenditure projections data. For Scottish and English estimates, the UK projections were apportioned based upon the relative five-year average of oil and gas production from 2017 to 2021. Annual five-year averages of "unit resource rent" (average resource rent divided by average production) are applied to production projections.

Estimates are attributed to the marine habitat.

Renewable electricity provisioning

Electricity generated by renewable sources is published in DESNZ's Digest of UK Energy Statistics. Bioenergy is excluded to avoid valuation double counting with timber removals and agricultural biomass.

Monetary estimates begin with SIC 35.1: Electricity power generation, transmission, and distribution. These data are apportioned using turnover from our Annual Business Survey (ABS) to derive SIC 35.11: Production of electricity.

For Scotland, the ratio of Scotland and the UK's total installed capacity is used to apportion the UK's net capital stock and the resource rent for Scotland's SIC 35.1 is calculated, before being apportioned to SIC 35.11 using turnover from the regional ABS.

For England, Wales and Northern Ireland, the value for Scotland for SIC 35.11 is deducted from the value for the UK and the remainder is apportioned across the nations using the gross operating surplus for SIC 35.11 from the regional ABS.

Values for the four nations are then further apportioned using the percentage of electricity generation that comes from renewable sources from GOV.UK's Energy Trends: Electricity generation and supply article. This provides a final estimate for the value of the production of electricity from renewable sources.

One of the main limitations is the lack of data reflecting the profits and cost for electricity generation from renewable sources, as opposed to other electricity generation.

The UK valuation for this service is calculated by summing the estimates for the four nations to accurately reflect the value derived from renewable energy provision across the UK.

Estimates for renewable energy provisioning are attributed to habitats based on technology:

- Hydroelectric to freshwater, wetlands, and floodplains
- Solar photovoltaic (PV) to enclosed farmland; semi-natural grassland; mountains, moorland, and heath; and urban, using mapping data from the DESNZ's Renewable Energy Planning Data and UKCEH 2021 Land Cover Maps
- Wave and tidal to marine
- Offshore wind to marine
- Onshore wind to enclosed farmland; mountains, moorland, and heath; and semi-natural grassland, using data from the DESNZ's Renewable Energy Planning Data and the UKCEH 2021 Land Cover Maps

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 publication (2021). 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.

Estimates for timber and woodfuel provisioning are attributed to the woodland habitat.

Water provisioning

The service of water provisioning estimates the value of public water supply. This maintains UK-wide consistency, as industry data are not available for Scotland, and avoids double counting of the valuation of hydropower.

Physical data for water provisioning are sourced from Scottish Water, the Drinking Water Inspectorate, Natural Resources Wales, and Northern Ireland Water.

Monetary estimates are based on the residual value resource rents calculated for the SIC subdivision class: Water collection, treatment and supply (SIC 36). A limitation of this approach is that the calculated resource rent is not purely related to water supply, but also includes the process of treating the water and rents made in industrial applications.

Further methodological development would be required to more accurately estimate the value purely related to water supply. Further work could also look to value the services relating to other uses of the water provisioning services, and to explore the roles of different ecosystem types in providing clean water.

Estimates are attributed to the freshwater, wetlands, and floodplains habitat.

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 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. 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 DESNZ.

Data are available for distinct habitat types, which are mapped to the eight broad habitats. Because of a current lack of data, we are unable to include the marine habitat, including those intertidal areas such as saltmarsh, coastal margins and mountains, moorland, and heath.

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.

Estimates are attributed to the urban habitat. However, these estimates could also be 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, Wales and Scotland. 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.

Estimates are attributed to the urban habitat. However, these estimates could also be attributed to the habitats that provide a cooling affect, such as woodlands or freshwater, wetlands, and floodplains.

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, Wales, Scotland, 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 Department for Environment, Food and Rural Affairs' 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.

Recreation and aesthetic (house prices)

Recreation and aesthetic values for house prices include the additional expenditure on houses that are near to green (land) and blue (water) spaces, enabling people to make free trips to the natural environment, as well as the value added to a property by a view of a green or blue space. Using current data and modelling approaches, the effect of green space proximity and visual amenity cannot be separated. Estimates relate to urban properties only, defined as built-up areas with a population of 5,000 or greater.

Data from the Valuation Office Agency, HM Land Registry and Ordnance Survey are used to estimate the effect of proximity to public green space on house prices. A unique house-level dataset is produced by linking data, and machine learning techniques are then applied to flexibly model house prices. To get an estimate of the average effect of green and blue spaces on house price, we estimate the difference between the predicted price based on the real data and the predicted price if there were no green and blue spaces. This value is extended to cover all houses, not just those that have sold, to produce an asset value.

To simulate a no-nature scenario, we set the area of private gardens and functional green space, other natural land, and blue space within a 500-metre radius to zero. We also set the distance to functional green space to a minimum of 1,000 metres, and the distance to the sea to a capped maximum value of 2,000 metres. These are combined to give an aggregated "effect of nature". The effect of private gardens and public nature are also estimated.

The annual value in house prices is based on the average percentage increase in house prices from nature multiplied by imputed rental data from the Office for National Statistics (ONS).

A limitation of this method is that HM Land Registry data are only available for England and Wales. Figures for the UK, Scotland, and Northern Ireland are estimated using property transaction data between 2011 and 2020 in England and Wales. A future development would be to extend this modelling to include data from Scotland's Land Information Service.

Data for 2021 are currently an average of the effect on house prices between 2011 and 2020. We intend to update the data source for future accounts.

Our estimates are attributed to the urban habitat.

7 . Cite this methodology

Office for National Statistics (ONS), released 27 November 2023, ONS website, methodology, UK natural capital accounts methodology guide: 2023