Urban natural capital accounts methodology guide, UK

Methods to calculate natural capital accounts that estimate habitat extent, condition indicators, ecosystem services and asset value of urban areas in the UK.

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1 . Overview

The methodology used to develop these estimates remains under development; the estimates reported in our Urban natural capital accounts, UK: 2023 bulletin 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. For more information, please see our Guide to experimental statistics.

Experimental Statistics are published to involve customers and stakeholders in their development and as a means of building in quality at an early stage. Ongoing efforts are made to find new and more accurate methodological approaches to improve the quality and reliability of the data. As a result, there are some changes that mean data in the 2023 urban bulletin cannot be directly compared with data in our 2019 UK natural capital: urban accounts bulletin.

This article describes the methodology used to develop Natural Capital Ecosystem Service Accounts. The broad approach to valuation and the overarching assumptions made are explained in this article.

Reflecting our Urban natural capital accounts, UK: 2023, this methodology guide firstly covers the definition of extent of UK urban areas, addresses the various condition indicators used, and finally includes the methods used in assessing urban ecosystem services.

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

2 . Urban extent

To estimate the area of the urban habitat in the UK, or "urban extent", in 2021 we followed the methodology created by Economics for the Environment Consultancy (eftec) and others (2017). This methodology uses a variable buffer to create a periphery around urban sites, where high levels of interaction between people and nature are also expected. This extent for Great Britain uses the Office for National Statistics (ONS) Built-Up Areas (2021) dataset, using the prototype conglomerates product. For Northern Ireland, we applied the Settlement Development Units (2015) product.

To calculate the different habitats within the ONS defined urban area, we used the 2021 Land Cover Map from the UK Centre of Ecology and Hydrology to estimate the extent of the eight ONS broad habitats. The ONS uses the broad habitat classifications from the UK National Ecosystem Assessment (PDF, 2.09MB). Using the same defined urban area and using the Ordnance Survey Open Greenspace map, we estimated the extent of green and blue spaces, including the extent of allotments. We use a range of external data sources to estimate the ecosystem services and they have differing methods of defining urban extent.

Accessibility of green space

Accessibility to nearest greenspace was calculated at a Unique Property Reference Number (UPRN) level for all urban residential properties in mainland Great Britain. Residential properties were identified using residential Address Base Premium Classification Codes, excluding garages and car parking spaces. Urban properties were identified using the 2021 Built-Up Areas (BUA) dataset, for this purpose UPRNs were considered urban if they were in a BUA containing at least 2,500 residential UPRNs. The Ordnance Survey Open Greenspace map data were used to estimate each UPRNs haversine (as the crow flies) distance to access points by greenspace type. Data were also captured on the area of the nearest greenspace and the total area of greenspace within a 500m radius of each UPRN. These data were then aggregated for different countries.

The greenspace functions covered are:

- allotments or community growing spaces
- bowling green
- cemetery
- religious grounds
- golf course
- other sports facility
- play space
- playing field
- public park or garden
- tennis court

Further detail on these functions is provided in the Ordnance Survey's Open Greenspace technical documentation.

3 . Urban 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 Nations System of Environmental-Economic Accounting - Ecosystem Accounting (SEEA EA) (PDF, 5.33MB) 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 way. 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 fly-tipping, 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).

Compositional indicators for urban areas

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 them 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 NBMP's Annual Report. The urban index is a composite of three bat species trends, including:

- common pipistrelle
- soprano pipistrelle
- noctule

Bees

Bees provide a range of ecosystem services as well as being useful indicators of wider ecological health. Bees are one of the main groups of insects responsible for pollination of wildflowers, berries, orchards, and crops. As 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 urban habitats.

Birds

As they occupy a wide range of habitats and respond to environmental pressures, bird populations (as shown on the Joint Nature Conservation Committee (JNCC) website), provide a useful indicator of the state of UK nature.

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

These are not available for all habitats, so we build new indices for those by using earlier papers on potential species. These indices are presented as experimental statistics for information and should not be confused with the official indexes.

Species included in the urban index are swift, robin, magpie, blue tit, kestrel, woodpigeon, house sparrow, house martin, herring gull, goldfinch and carrion crow.

Trends for 2020 should be treated with caution because of monitoring issues during the coronavirus (COVID-19) pandemic. See the BTO website for further details.

Moths

Moths hold vital roles in ecosystems with more than 2,500 moth species present in Britain (as shown on the Butterfly Conservation website) in a range of habitats. 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.

More than 60 individual species became extinct in the 20th century, according to Butterfly Conservation. Data for moth counts are supplied to the Office for National Statistics (ONS) from the Rothamsted Research Insect Survey.

Mammals

The Living with Mammals Survey (LwM) started in 2003, with the aim of producing effort-based indices of mammal abundance across the built environment and has run annually ever since. It is a citizen science project run by the People's Trust for Endangered Species and it records sightings in urban and suburban gardens, common ground, recreational spaces, cemeteries and other urban green spaces.

Count data used by the LwM Survey indicates whether the number of mammals observed has increased or decreased, implying a change in the underling population. However, caution must be implemented to avoid over-interpreting these figures. Even if count data are proportional to the population, we cannot see the functional relationship and alternative factors can drive visibility of species. Additionally, count data do not indicate the overall population or species richness of mammals.

The combined index of the most commonly recorded mammal species in Great Britain's urban areas includes hedgehogs, foxes, badgers, bats, grey squirrels, rabbits and brown rats. It is noteworthy that the sample size has struggled to recover immediately after the coronavirus (COVID-19) pandemic, leading to wider confidence intervals in the most recent years.

Landscape-level indicators for urban areas

Hedgerows

A hedgerow, or hedge, is a line of woody or shrubby vegetation, which is managed to alter its natural shape. Hedgerows:

- provide windbreaks, which prevent soil erosion and protect crops
- provide habitats for wildlife, especially pollinators such as bumblebees, butterflies and insects, which need hedge banks
- provide shelter for wildlife, such as birds
- reduce flooding
- improve air quality; a hectare of hedgerows between 3.5 metres (m) and 6 m wide could sequester as much as 131.5 tonnes of carbon per year

The Woodland Trust's 2014 newsletter (PDF, 2.3MB) reports estimates that half of all hedgerows were lost from the countryside during the 20th century.

Hedgerows are very important to birds and there are 21 priority Biodiversity Action Plan (BAP) bird species, with 10 species using them as a primary habitat.

Forest Research provide hedgerow data for urban and rural areas in their National Forest Inventory - tree cover outside woodland in Great Britain. They define hedgerows as boundary lines of trees and shrubs over 20 metres long and less than 3 metres in height having a mean width of less than 4 metres at the base.

Hedge species, like hawthorn, dog rose and English yew, can help provide environmental benefits, such as noise reduction and cooling in urban areas and garden spaces, as explained in this publication from the Royal Horticultural Society (PDF, 592KB).

Urban Trees

Forest Research define trees outside of woodland as follows:

- small woods are wooded features exceeding 0.1 hectare, and less than 0.5 hectare in extent or less than 20 metres in width
- groups of trees are clusters less than 0.1 hectare
- lone trees are single trees 2 metres or more in height whose crowns have no contact with the crowns of any other tree crown
- hedgerow trees are single trees of 3 metres or more in height located within hedgerows, whose crowns have no contact with the crown of any other tree

For further details, see their report, Tree cover outside Woodland in Great Britain (2017).

Environmental pressure indicators

Some environmental pressure indicators, for example, wildfires and fly-tipping, provide a broad measure of potential effects on the condition of ecosystems. As they do not provide direct measures of condition, the System of Environmental Economic Accounting classes these as ancillary or proxy indicators.

Wildfires

Wildfires can be a pressure indicator. Most are anthropogenic in origin (meaning that they are started by human activity), with or without intent.

England

The England wildfire statistics were collected from the Home Office's Incident Recording System.

Scotland

The wildfire data for Scotland are compiled by the Scottish Government using data 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.

Fly-tipping and litter

Official statistics are used to record the number and type of incidents of fly-tipping in England (shown on GOV.UK) and of fly-tipping in Wales (shown on the Stats Wales website).

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 (animals) or flora (plants) present, or important geological or physiological features, make it an area of interest to science.

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

4 . Annual ecosystem service flow valuation

Broadly, two approaches are used to value the annual service flows. For carbon sequestration, pollution removal, noise mitigation, urban cooling, recreation, and tourism, an estimate of physical quantity is multiplied by a price. This price 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 elsewhere in the national accounts.

For renewable electricity generation, a residual value resource rent approach is used. For further details, see our UK natural capital accounts methodology guide: 2022.

5 . Asset valuation

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

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

For further details, see our UK natural capital accounts methodology guide: 2022.

6 . Methodology by service

Food production

Allotments and community growing spaces

Using data from Ordnance Survey, we estimated the area of allotments and community gardens within the urban area. See Section 2: Urban extent, for how we define the urban area.

Edmondson and others (2020), in their Feeding a City case study, combined citizen science data for self-provisioning crop yields with field-mapping and GIS-based analysis of allotments in Leicester, UK, to provide estimates of food production at a city scale. They reported a current estimate of about 1.6 kilograms of produce per square metre of total allotment land area (including unused plots and uncultivated areas within plots), and a potential estimate of 1.8 kilograms of produce per square metre, if currently unused plots were cultivated to the average of 51.5% of their area.

We multiplied their current estimate of 1.6 kilograms of produce per square metre by the area of allotments and community garden spaces, to estimate the amount of food produced in urban areas annually.

In May 2016, Capital Growth estimated that the value of produce per metre square was £4.06 in 2013 and £3.97 in 2014, giving a value of £4.01 per metre square when averaging out the two years. All values are updated to 2021 prices. We multiplied the average value per metre square by the area of allotments and community garden spaces, to estimate the total value of urban food production.

To calculate the asset value, we multiplied the annual value by the sum of all discount factors over 100 years taken from the Green Book guidance published on GOV.UK. This simple approach cannot be applied to all ecosystem services but was used for this service as there are no future projections involved.

Renewables

Domestic solar Photovoltaics (PV)

Domestic solar PV data refers to solar PV systems installed in residential properties. Largely, these systems will be small scale, 0 to 4 kW in capacity, although there has been a surge in 4 to 10 kW systems in recent times. As there are more residential properties in urban areas than rural areas, it is assumed that the majority of these systems are installed in urban areas.

Energy generated by renewable sources is published by the Department for Energy Security and Net Zero (DESNZ) in the Digest of UK Energy Statistics, published on GOV.UK. Domestic solar PV generation was calculated as a proportion of total solar PV generation using domestic solar PV scheme data provided directly by DESNZ. By using this method, we are assuming that commercial and domestic systems have similar efficiency levels. Using these values, we apportioned monetary estimates published in our UK natural capital accounts: 2022 bulletin. For further information, see the UK natural capital accounts methodology guide: 2022. We calculated each UK country's portion of domestic solar installations from the UK total number of installations. These percentages were then applied to domestic solar PV generation and monetary estimates to provide a breakdown of values by UK country.

Air pollution

Air quality regulation estimates have been supplied in consultation with the UK Centre for Ecology and Hydrology (UKCEH). A very brief overview of the methodology will be explained here. A more detailed explanation can be found in the full methodology report published in July 2017 on the National Environment Research Council website.

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

Air pollution data removal by UK vegetation has been modelled for the years 2007, 2015, 2019. We have then scaled this based on previous modelling to create values for 2030. For 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 because of vegetation. Linear interpolation then occurs for future years where no government concentration data are available.

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

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

The damage costs were updated in February 2019. For a method of how the damage costs are calculated, please see the Air Quality damage cost update 2019 report (PDF, 1.13MB) published by Defra.

Carbon sequestration

Estimates relate to the removal of carbon dioxide equivalent (CO_2e) from the atmosphere by woodland and grassland in UK urban areas.

The carbon sequestration data come from the UK National Atmospheric Emission Inventory (NAEI) Greenhouse Gas Inventory. This contains data relating to carbon change in the Land Use, Land Use Change and Forestry (LULUCF) sector. LULUCF is divided into six land use types. However, to estimate values for urban areas we only focus on Forest Land and Settlements.

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

Another view of natural capital would state that all natural habitats are somewhat modified. Usually, human intervention is required to capture value and so the possibility of valuing many natural services (notably renewable energy) as if they were separate from human action is impossible.

We have opted for a combined nature and human approach for urban areas, where greenhouse gas emissions from soil disturbance during construction are included.

This is an area of research we will consider further as our accounts develop. The net carbon sequestration values presented align with the 2019 Greenhouse Gas Inventory for the Land Use, Land-Use Change and Forestry sector. We also aim to estimate the gross carbon sequestration benefits of nature but this is currently not possible with inventory data.

By using data from the National Forestry Inventory, that looks at tree cover outside woodland areas in Great Britain, we calculated the proportion of woodland and tree cover in urban areas for each of the three nations.

Urban woodland makes up around 8% (286,500 hectares) of total woodland in Great Britain, as shown in the National Forest Inventory: tree cover outside woodland in GB statistics on GOV.UK. In England, 11% of the total area of woodland and tree cover outside woodland is in urban areas, with Scotland and Wales recording 2% and 10%, respectively. As the National Forest Inventory covers Great Britain only, we calculated values for Northern Ireland based on the proportion of urban woodland in Great Britain (8%).

Using these percentages, and assuming that they remain constant over time, we were able to apportion the carbon sequestration data for Forest Land. The apportioned Forest Land values were then added to Settlements estimates to calculate physical flows for England, Scotland and Wales.

To estimate 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 Data table 3 of the 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, following guidance from the Department for Energy Security and Net Zero (DESNZ).

Urban cooling

A brief overview of the methodology of urban cooling will be provided here. For a more detailed description, 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 the main 11 city regions in the 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. They calculated the overall benefit by applying cooling effects from academic literature to the urban area within the cooled areas beside green or blue spaces (Table 1).

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

Asset	**Width of buffer to apply (m)**	**Temperature differential (degree Celsius)**	
Urban green space		**Green infrastructure**	**Buffer**
Woodland (200 < x < 30,000m^2)	0	-3.5	n/a
Woodland (> 30,000 m^2)	100	-3.5	-0.52

Source: Economics for the Environment Consultancy (eftec) and others (2018)

The annual value of the cooling effect is estimated from 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 asset value for 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 these ecosystem services 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

Trees can act as a buffer against noise pollution, in particular road traffic noise. The value of noise mitigation was estimated from urban vegetation in terms of improved sleep, less annoyance and health outcomes. The estimated benefits were for the urban road reduction on major roads only. The annual and asset values are estimated based on 167,000 buildings benefiting in 2017. The calculation is based on the avoided loss of quality adjusted life years (QALY) associated with annoyance and lack of sleep and adverse health outcomes owing to noise.

For a detailed methodology paper on how noise mitigation estimates were produced - please see Scoping UK Urban Natural Capital Account - Extending noise regulation estimates - NR0170 published by Defra. The UK Centre for Ecology and Hydrology have recently addressed improvements to the noise reduction methodology. [FA4]

Tourism and recreation

The recreation estimates are adapted from the "simple travel cost" method developed by Ricardo-AEA in the methodology Reviewing cultural services valuation methodology for inclusion in aggregate UK natural capital estimate. 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 during the visit. It 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 the value of accessing the site.

Estimates for the cultural service of outdoor recreation in this publication use survey data across seven surveys covering England, Wales, Scotland and Northern Ireland. The questions used from these surveys can be summarised as:

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

For estimates of outdoor recreation in England, the Monitor of Engagement with the Natural Environment (MENE) Survey is used. The survey collects detailed information on people's use and enjoyment of the natural environment during visits. This report relates to the full ten years of surveying from March 2009 to February 2019. MENE samples around 47,000 respondents, 20,000 of whom make visits 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) was 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 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 2016.

Previously we used the Welsh Outdoor Recreation Survey (WORS 2014) in combination with England's MENE Survey to produce outdoor recreation estimates for Wales. However, since obtaining 2016 and 2018 data from the National Survey for Wales (NSW), all Welsh estimates are calculated using NSW only, as NSW provides improved quality of the sampling approach, therefore comparability between WORS and NSW is not advisable.

Estimates of outdoor recreation in Wales for 2017 and before 2015 are based on an index of MENE outputs. Because of this, we multiply estimates of total expenditure by the proportion spent on each expenditure type in the most recent year for which we have data available. This allows the different expenditure types to sum to total expenditure, despite some years being based on an index of MENE outputs.

The absence of a question relating to the transport method within NSW affects our ability to estimate overall running costs and travel time, given that we do not know how respondents travel to their visit destination. We address this by calculating the proportion of total distance travelled to mountains, moorlands, and heath (MMH) habitats by different methods of transport in the MENE Survey for the years of 2016 and 2017. These are used as proxy variables for NSW and the years of 2016 and 2018, respectively. We multiply the proxy variables by the total distance travelled in NSW to produce estimates for distance travelled by different methods of transport, which are used in our running costs calculations.

The NSW does not include a breakdown of expenditure type, for instance, how much money a respondent spends on food and drink, fuel or admissions. Instead, an overall amount is collected in the "Visit Money" variable of the NSW. This affects our ability to calculate annual expenditure values as we replace reported fuel costs with our calculated running costs, while also subtracting money spent on food and drink.

We address this by calculating the proportions of expenditure on each type of service from MENE in 2016 to 2017. This proxy variable is then multiplied by the total expenditure in NSW to produce a service expenditure breakdown, with food and drink removed and fuel costs replaced with calculated running costs.

Finally, we use the People in the Outdoors Monitor for Northern Ireland (POMNI) in combination with England's MENE Survey to produce outdoor recreation estimates for Northern Ireland. Data from POMNI are only available for 2021. The survey samples around 6,000 respondents, 67% of whom take visits annually. Northern Ireland data before 2021 are based on an index of MENE outputs.

These surveys focus on short day trips from home and miss out potentially large amounts of spending on outdoor activity from domestic tourism. A combined recreation and tourism account has been created to capture this additional spending.

Habitat disaggregated estimations may not sum to equal overall totals. This is because the habitat-visited question 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 of our Health benefits from recreation methodology.

For the asset valuation of outdoor recreation, projected population growth calculated from our Principal projection -- UK summary dataset and an income uplift assumption, were implemented into the estimation. The income uplift assumptions are 1%, declining to 0.75% after 30 years and 0.5% after a further 45 years. These assumptions project the annual value to increase over the 100 years.

It is acknowledged that the expenditure-based method provides an underestimation of the value provided by visits to the natural environment. Primarily, this is because there are several benefits that are not accounted for including scientific, educational 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 substantial number of outdoor recreation visits have no expenditure as people make local visits, such as walking to a local park. Finally, to avoid double counting, the value of local recreation and the aesthetic benefit from living near green and blue spaces is estimated through house prices.

Urban tourism and recreation estimates have been calculated through aggregating values of respondents who visited "built-up areas" and similar habitat types across the various surveys.

Health benefits from recreation

The UK Natural Capital Accounts: 2022 included a new recreation account for the first time. The recreation-based surveys discussed in this section of the report have been further used to generate the number of people gaining health benefits from regular recreation, and the monetary value associated with this. The monetary value of health benefits from recreation have been derived from the work of Claxon and others (2015) in their article: Methods for the estimation of the National Institute for Health and Care Excellence cost-effectiveness threshold. 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 values).

The methodology underpinning the health benefits gained from recreation can be found under Exposure to nature in Section 2, Methods used, of our Health benefits from recreation methodology report. Since this report, additional work has been completed to implement the "exposure to nature" approach into the UK Natural Capital Accounts: 2022. This includes integrating data from the People in the Outdoors Monitor for Northern Ireland Survey to improve estimates for Northern Ireland.

Urban health benefits from recreation estimates have been calculated through aggregating values of respondents who visited "built-up areas" and similar habitat types across the various surveys.

Recreation and aesthetic value in house prices

Recreation house prices estimates the additional value included within house prices associated with proximity to green (land) and blue (water) spaces, enabling people to make "free trips" to the natural environment, while aesthetic house prices estimate the value added to a property by a view of a green or blue space.

After 2016, aesthetic and recreational annual value in house prices is based on the average percentage increase in house prices from living within 500 metres of green or blue space from 2009 to 2016 multiplied by our imputed rental data. Asset values are held as 2016 estimates. For a detailed methodology, see our 2019 House pricing methodology article.

This method is based on Zoopla house price purchase data, which is no longer available. We are exploring the use of Valuation Office Agency and HM Land Registry data for future estimates of the effect of the proximity to public green space on house prices.

7 . Cite this methodology

Office for National Statistics (ONS), released 07 September 2023, ONS website, methodology, Urban natural capital accounts methodology guide, UK