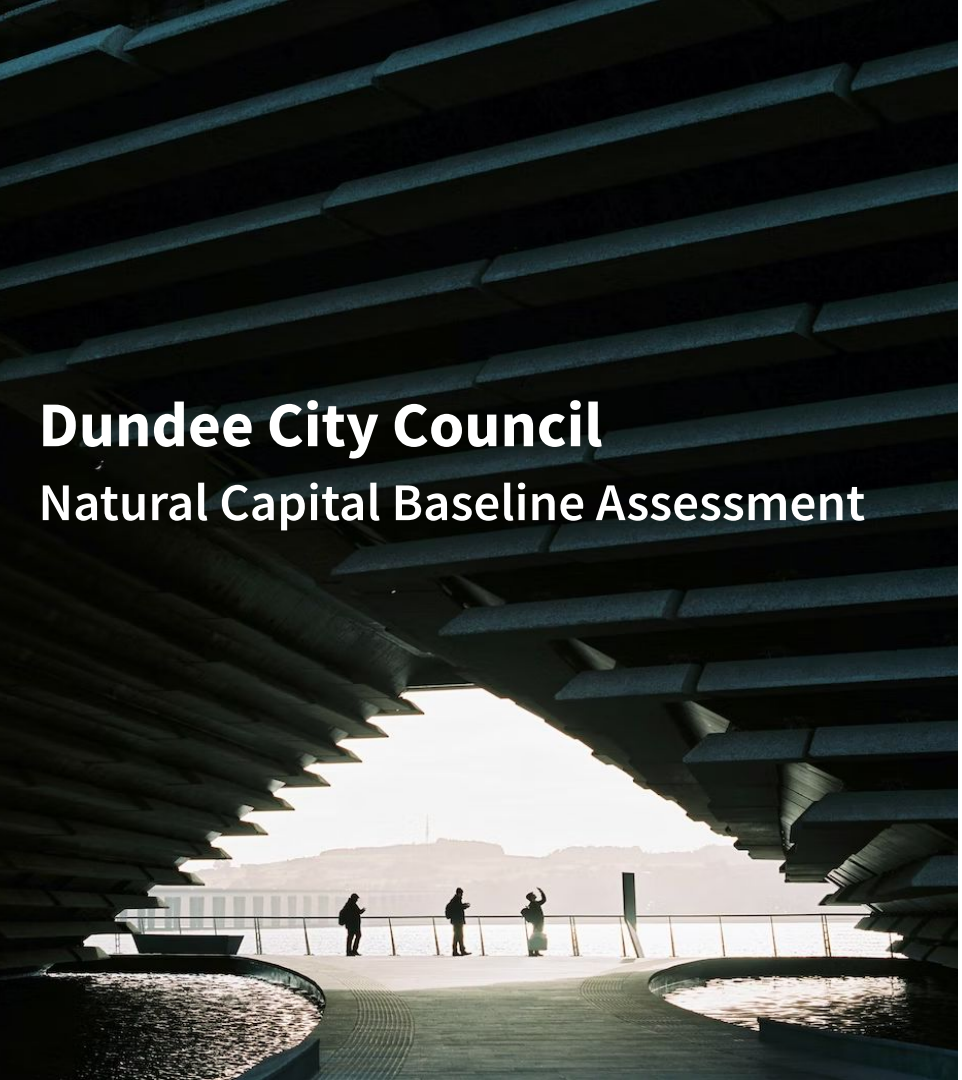


Dundee City Council

Natural Capital Baseline Assessment

natcap research

How to navigate this report

This report details the data used by Natural Capital Research Ltd to calculate the natural capital assets and ecosystem service flows within Dundee City Council. We provide a series of maps and tables to illustrate how the various assets and flows are distributed, and a summary heatmap to help you understand where in in the city multiple overlapping ecosystem services occur.

- Our **introduction** and **key findings** set out **the context** and provide **topline enhancement** considerations for Dundee's focus metrics - carbon and biodiversity.
- Our **detailed findings** then provide information **across all assets and services** within scope.

Introduction

Scope of work

Natcap was asked by Dundee City Council to provide a **baseline assessment** of the following ecosystem services:

- Carbon storage & sequestration;
- Soil erosion prevention;
- Flood risk reduction;
- Important areas for pollinators;
- Important biodiversity habitats and connectivity of woodlands; and
- Enhanced biodiversity metric for Scotland.

Our approach

Natcap's proprietary models are able to ingest data from various sources, remote sensing and field data, to provide this baseline assessment of the **natural assets** and **ecosystem services** within the city of Dundee.

Our approach to the delivering the findings was guided by the following:

- Dundee City Council would like to **further the sophistication** of their climate risk assessment process and ensure the next iteration is **increasingly science-based**.
- The outputs of this assessment will be used to inform both Dundee's **Climate** and **Biodiversity Action Plans**.
- Therefore, while all ecosystem services and assets within scope are included in this report, we emphasise **carbon storage and sequestration** and **biodiversity units** in the key findings.

What does this baseline assessment give you?

The output of this baseline assessment is a starting point. It **sets the baseline**, and provides Dundee City Council with a **science-based** understanding of what is present now, and as such, can **inform future thinking** of where to focus effort and how to measure progress.

1. Baseline assessment

What natural assets and ecosystem services are within the area of interest?

2. Identify opportunities for enhancement

Where should I prioritise enhancement of those assets and services?

3. Set targets

Can we set targets for enhancement against the baseline and within an agreed time horizon?

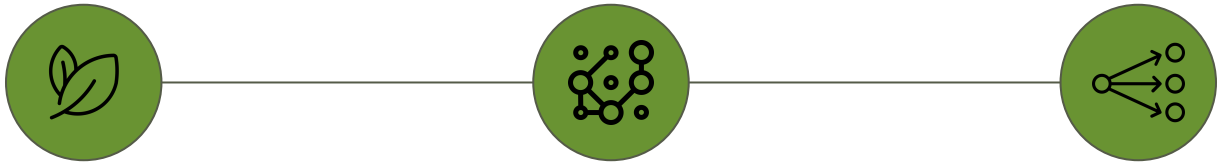
4. Measure progress against those targets

How can we meet these targets and measure our progress?

The work presented in this report is addressed stage 1 of what could be a broader process to set targets, develop a plan to achieve them, and measure progress towards this aim.

A note on concepts

Like all specialisms, this subject area has its own terminology and definitions. Below we clarify three important terms.



Nature
The natural world, with an emphasis on the non-human living components and their interactions with each other.

Biodiversity
This concept describes the diversity of nature. More specifically the diversity present within species, between species, and between ecosystems.

Ecosystem services
The flows of services that are provided by nature that yield a benefit to people. Carbon storage and its benefits for climate mitigation is one example.

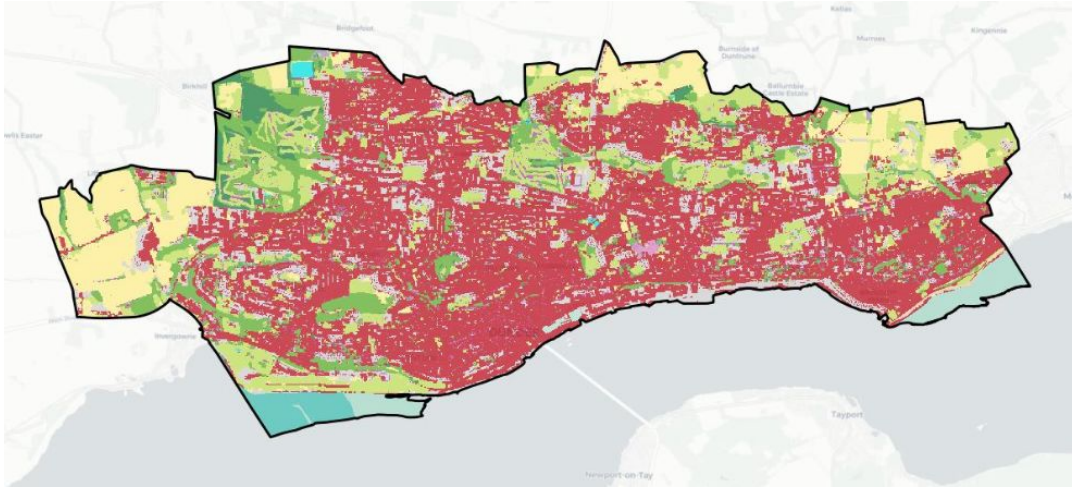
Key findings

What are the natural assets within the City of Dundee, and what ecosystem services do they provide?

Natural assets

What natural assets, or landcover types, are found within the Dundee assessment area?

This map illustrates the main landcover types within the assessment area, alongside a table detailing these categories by hectare.

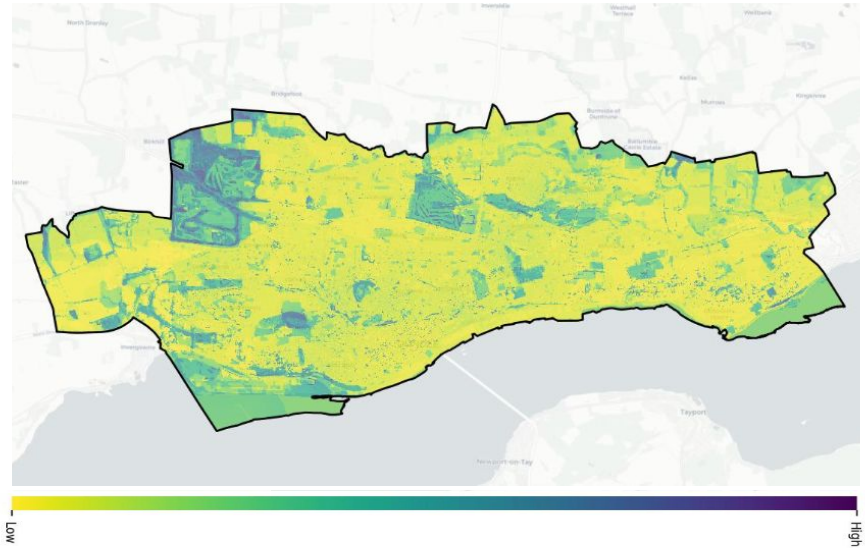


Asset	Quantity	
Landcover		
Neutral grassland	936.9	ha
Arable and horticulture	666.4	ha
Hedgerows and trees outside of woodlands	141.0	ha
Broadleaved mixed and yew woodland	556.8	ha
Coniferous woodland	105.7	ha
Built-up areas and gardens	2,853.0	ha
Sparsely vegetated land	668.4	ha
Dense scrub	33.8	ha
Dwarf shrub heath	6.0	ha
Supralittoral sediment	8.0	ha
Water		
Fen marsh and swamp	92.9	ha
Large rivers and lakes	12.7	ha
Bog	21.0	ha
Littoral sediment	138.3	ha
Topography		
Average elevation	64.8	m
Average slope	5.3	%
Soils		
Loam	211.0	ha
Sandy loam	5,974.9	ha
Organic	36.3	ha

Ecosystem services

How (and where) are dundee's natural assets providing flows of ecosystem services?

The map below is a heatmap showing where you have the largest supplies of multiple ecosystem service flows. Areas that are low across combined ecosystem services (yellow) can be viewed as areas of opportunity to concentrate enhancement efforts, while areas with highest ecosystem service flows should be conserved as part of a natural capital development strategy.



Ecosystem service flow	Total	Average
Carbon storage in vegetation and soils	1,571,001.0 tCO2e	252.0 tCO_2e/ha
Carbon storage in woodlands and forests	91,628.0 tCO_2e	15.0 tCO_2e/ha
Carbon storage in trees and vegetation outside of woodlands	34,203.0 tCO_2e	5.0 tCO_2e/ha
Carbon storage in topsoil	1,445,170.0 tCO_2e	232.0 tCO_2e/ha
Carbon sequestration in vegetation and soils	3,035.0 tCO2e/yr	<1 tCO2e/ha/yr
Carbon sequestration in woodlands and forests	1,938.0 tCO2e/yr	<1 tCO2e/ha/yr
Carbon sequestration in trees and vegetation outside of woodlands	1,097.0 tCO2e/yr	<1 tCO2e/ha/yr
Soil erosion prevention	11,698.0 tonnes soil loss avoided/yr	2.0 tonnes soil loss avoided/yr/ha
Flood risk reduction	1,377,669.2 m^3 runoff avoided/yr	220.8 m^3 runoff avoided/yr/ha
Recreation	28,500.0 number of visits/yr	n/a
Important areas for supporting insect pollinators of crops	3,576.0 ha	n/a
Important biodiversity habitats	555.0 ha	n/a

Ecosystem services

What is the contribution of assets found inside parks managed by Dundee City Council

Below we show the average ecosystem service provision inside city parks for vegetation carbon storage and sequestration, soil carbon storage, and flood risk avoidance. Parks included in this assessment are those managed by Dundee City Council. The full list can be found within the appendix, on slide 38.

Map illustrating parks included within this assessment

	Inside parks (average per ha)	Outside parks (average per ha)
Carbon storage (vegetation)	98.6 tCO2e	11.6 tCO2e
Carbon storage (soil top 30cm)	242.9 tCO2e	230.3 tCO2e
Carbon sequestration (vegetation)	1.9 tCO2e/yr	0.3 tCO2e/yr
Flood risk reduction	543.0 m3/yr	185.4 m3/yr
Soil erosion prevention	4.6 tonnes/yr	1.6 tonnes/yr

Dundee's focus metrics

A deeper dive on carbon and biodiversity

Below we show total quantity, and average per hectare, for key ecosystem services of carbon storage, carbon sequestration, and biodiversity. We expand on our modelling approach for each within the detailed findings, but some key concepts are:

- **Biodiversity units**: this metric is calculated by considering:
  - Distinctiveness, protected species, SSSI condition, and nature connectivity
  - This metric aims to capture the key components of biodiversity, tailored for the Scottish context
  - Note that the average score per hectare across Scotland is ~12
- **Carbon storage**: The quantity of carbon stored in vegetation and soil across the city of Dundee*
- **Carbon sequestration**: The quantity of carbon that is being absorbed on an annual basis by vegetation within Dundee*

	Biodiversity metric	Carbon storage (vegetation)	Carbon storage (soil top 30cm)	Carbon sequestration (vegetation and soil)
Total	65,344 biodiversity units	125,831 tCO2e	1,445,170 tCO2e	3,035 tCO2e/yr
Average per ha	10.4 biodiversity units	20.2 tCO2e	232.0 tCO2e	0.5 tCO2e/yr

*The average includes all land in Dundee, including built up areas.

Dundee's focus metrics

What do these findings mean in context?

Providing metrics beyond the Dundee assessment area remains outside the scope of this baseline assessment, However, to provide some context, we took at a city of similar size and review average figures to provide some point of comparison. Below we provide a view of ecosystem service provision for Aberdeen.

Average per ha	Biodiversity metric	Carbon storage (vegetation)	Carbon storage (soil top 30cm)	Carbon sequestration (vegetation)
Dundee	10.4 biodiversity units	20.2 tCO2e	232.0 tCO2e	0.5 tCO2e/yr
Aberdeen	10.9 biodiversity units	46.3 tCO2e	290.0 tCO2e	<1 tCO2e/yr

What does this mean for Dundee?

- First these comparative figures should be viewed with the understanding that Dundee is more built-up than Aberdeen, where Dundee's assessment area is 46% built-up, compared to 22% of Aberdeen's
- This broadly explains the lower scores of vegetation carbon storage per hectare
- That said, Dundee has some very high scoring areas for biodiversity, with Riverside Nature Park being providing the highest unit value at 82 (this is compared to Aberdeen's highest score of 32)
- In sum, Dundee is in a relatively good position in some areas, but with scope for future improvements

With all of this in mind, how can you approach opportunities for enhancement of these metrics…

Carbon storage and sequestration

A topline view of opportunities for enhancement

Enhancement considerations

To quantify the enhancement opportunities for carbon sequestration in the city, a more detailed analysis is needed than is provided in this baseline. Our initial findings conclude:

- Increasing tree planting in the city will increase carbon storage and sequestration. Opportunities for planting exist within parklands managed by the city council, but also in denser areas of the city through increased planting of street trees.
- Young trees on average sequester more carbon, so this is likely to have near-term benefits for sequestration rates.
- Tree species should be selected that will be suitable under a changing climate, and a variety of species to maximise biodiversity benefits. Guidance can be found in the Forest Research urban tree manual.

Biodiversity units

A topline view of opportunities for enhancement

Enhancement considerations

To quantify the enhancement opportunities for biodiversity in the city, a more detailed analysis is needed than is provided in this baseline. Our initial findings conclude:

- Connecting patches of woodland throughout the city with the largest city parks should be a priority to create ‘bio corridors’ for the movement of species. Currently many small patches of woodland are isolated or fragmented in the heart of the city
- Connectivity would be improved by the addition or urban trees or hedgerows - with shared benefits for carbon storage and sequestration
- Overall, biodiversity units would be improved by the creation of more native broadleaf woodland and species-rich grassland habitats. We note the challenges associated with this in an urban context, but opportunities for habitat improvement may be available in the cities parks and nature reserves.

Our findings in detail

A breakdown of outputs by ecosystem service

Carbon storage in vegetation

What is it?

Carbon storage is the amount of carbon (measured in tonnes of CO2 equivalent) contained in living vegetation within assessment area. This includes aboveground biomass and tree roots.

Why is it important?

Vegetation is able to store significant amounts of carbon, making it a key asset in climate change mitigation.

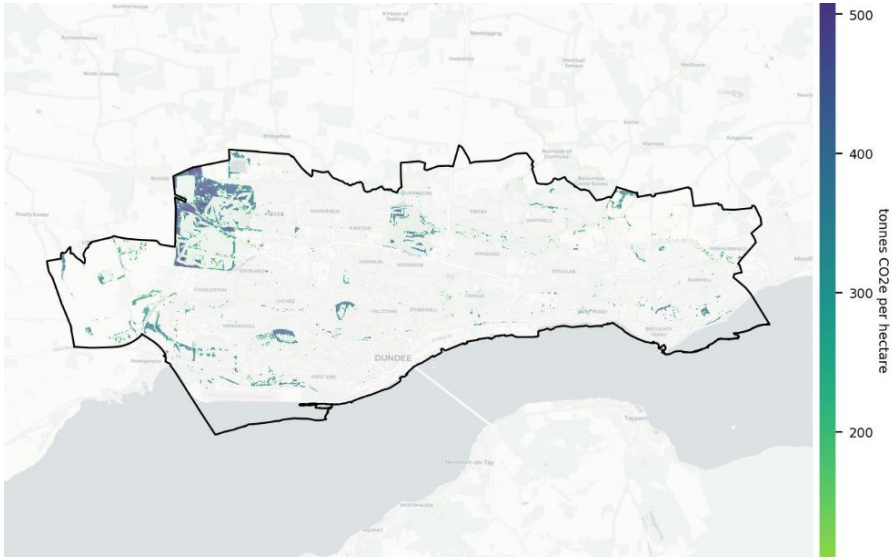
How did we model it?

We combine remote sensing with forest inventory data from more than 120,000 sites to estimate tree age and site productivity. This data is also complemented by climatic, topographic and soil parameters to improve our estimations.

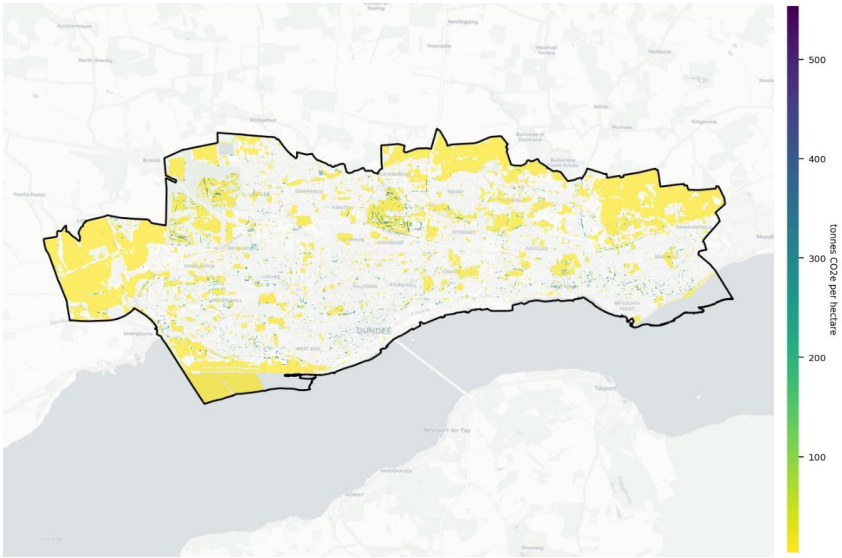
We can use this information to estimate carbon storage for all trees inside and outside forests. Trees outside of forests include parkland and street trees.

Carbon storage in vegetation

Inside and outside of forests and woodlands



Estimated storage of carbon in trees in forests and woodlands (tonnes CO2e per hectare)



Estimated storage of carbon in trees outside of forests and woodlands (tonnes CO2e per hectare)

Carbon storage in vegetation

Inside and outside of forests and woodlands

Ecosystem service flow	Total		Average	
Carbon storage in vegetation	125,831	tCO2e	20.2	tCO₂e/ha
Carbon storage in woodlands and forests	91,628.0	tCO₂e	15.0	tCO₂e/ha
Carbon storage in trees and vegetation outside of woodlands	34,203.0	tCO₂e	5.0	tCO₂e/ha

Carbon storage in trees in woodlands, trees outside woodlands (including street trees) and in vegetation

Landcover	Area (ha)		Total (tCO₂e)	Average (tCO₂e/ha)
Trees in woodlands and forests				
Broadleaved mixed and yew woodland	556.8	ha	64,210.6	115.3
Coniferous woodland	105.7	ha	27,417.5	259.3
Trees and vegetation outside woodlands				
Arable and horticulture	666.4	ha	2,443.6	3.7
Bog	21.0	ha	153.9	7.3
Built-up areas and gardens	2,853.0	ha	0.0	0.0
Dense scrub	33.8	ha	247.7	7.3
Dwarf shrub heath	6.0	ha	43.9	7.3
Fen marsh and swamp	92.9	ha	681.2	7.3
Hedgerows and trees outside of woodlands	141.0	ha	27,286.9	193.6
Large rivers and lakes	12.7	ha	0.0	0.0
Littoral sediment	138.3	ha	0.0	0.0
Neutral grassland	936.9	ha	3,345.8	3.6
Sparsely vegetated land	668.4	ha	0.0	0.0
Supralittoral sediment	8.0	ha	0.0	0.0

A more granular breakdown of the carbon stored in trees in woodlands, trees outside woodlands (including street trees), and in vegetation

Carbon storage in topsoils

What is it?

Carbon storage is the amount of carbon (measured in tonnes of CO2 equivalent) contained in the top 30cm of soils within assessment area.

Why is it important?

Much like vegetation, soil is able to store significant amounts of carbon. A fact that often surprises, is that soils capture more carbon than the world's biomass and atmosphere combined.

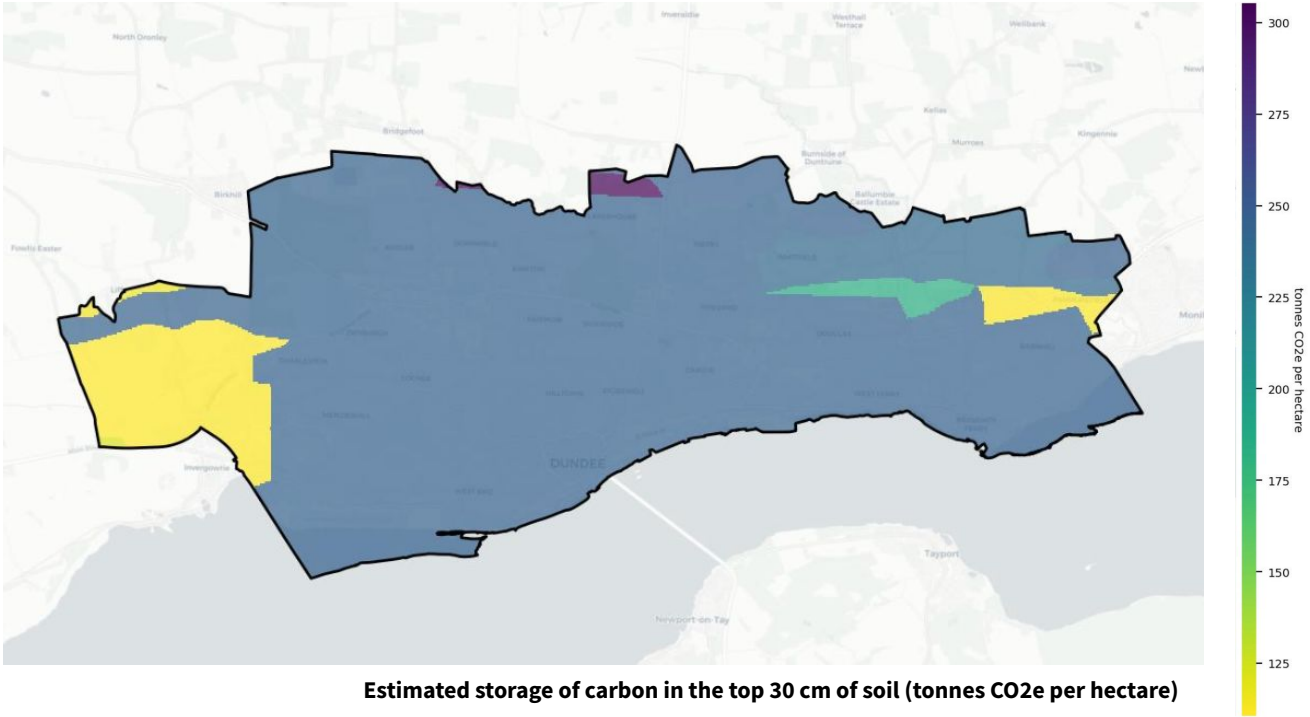
How did we calculate it?

This model takes data from the FAO Global Soil Organic Carbon Map (GSOC), which has been calculated using input data from James Hutton Institute and the national soil map for Scotland.

The resolution (and therefore certainty) of this map is low compared with other data sources in this report, and so the results should be treated with caution at a site level.

Carbon storage in topsoils

	Carbon storage (soil top 30cm)
Sum	1,448,820 tCO2e
Average per ha	232.0



Estimated storage of carbon in the top 30 cm of soil (tonnes CO2e per hectare)

Carbon sequestration

Inside and outside of forests and woodlands

What is it?

Not to be confused with carbon storage, this is the amount of carbon absorbed by vegetation within assessment area each year.

Why is it important?

The benefits of carbon sequestration are very similar to carbon storage, here we're looking at the capacity of vegetation to absorb carbon on an annual basis. A further point of note is that on average, younger trees will sequester carbon at a faster rate than older trees.

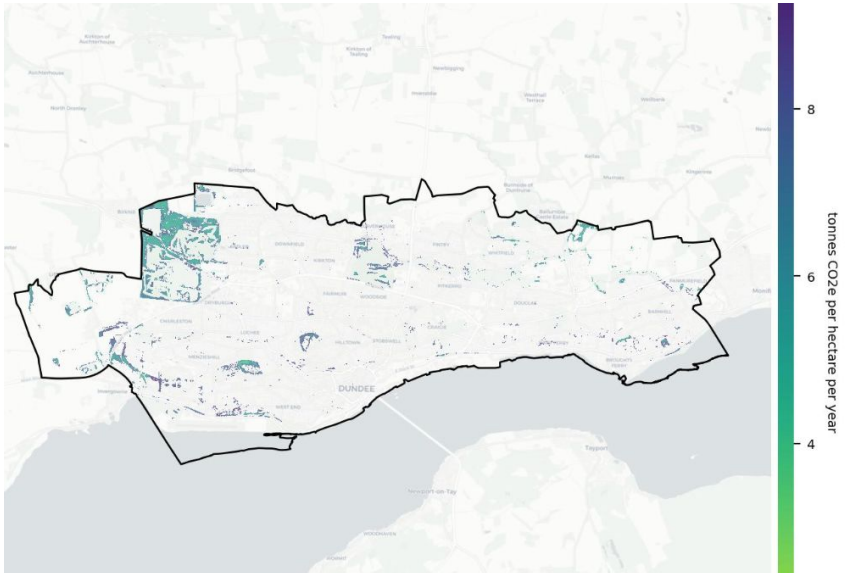
How did we model it?

Our approach to modelling carbon sequestration is coupled with our carbon storage models.

Forest inventory data and remote sensing information are used to estimate tree age and site productivity. This is complemented by other parameters, such as climatic and soil-related, to improve our estimations.

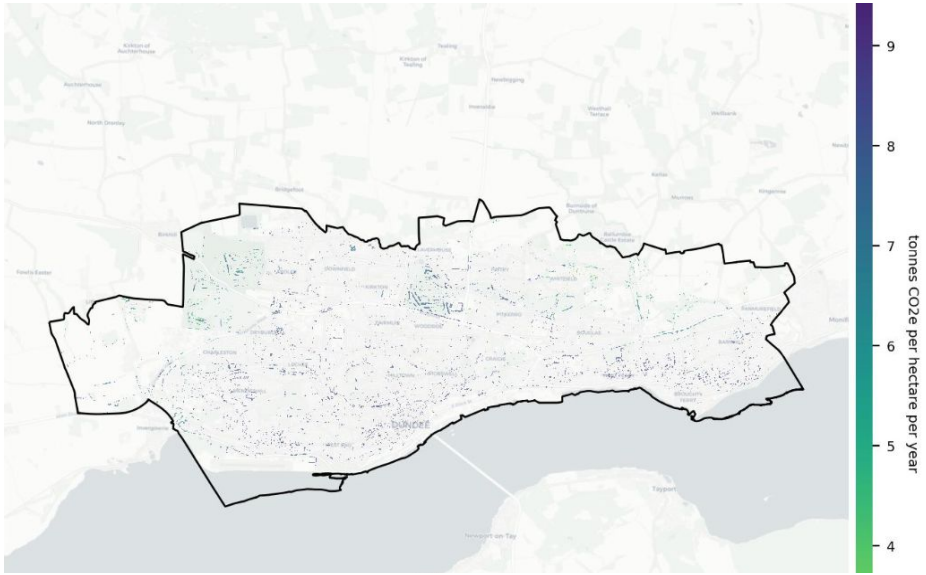
Carbon sequestration

Inside and outside of forests and woodlands



Estimated rate of carbon sequestration by trees within forests and woodlands

Ecosystem service flow	Total		Average	
Carbon sequestration in woodlands and forests	1,938.0	tCO2e/yr	<1	tCO2e/ha/yr



Estimated rate of carbon sequestration by trees outside of forests and woodlands

Ecosystem service flow	Total		Average	
Carbon sequestration in trees and vegetation outside of woodlands	1,097.0	tCO2e/yr	<1	tCO2e/ha/yr

Biodiversity metric

What is it?

What we're aiming to describe here is the diversity within a system (the recognised definition describes diversity within a species, between species and between ecosystems). To measure this, our biodiversity unit considers the distinctiveness of habitats in Scotland, connectivity of broad habitat types, predicted richness of important species for Scotland, and SSSI condition.

Why is it important?

Biodiversity is often thought of as a 'quality' of nature - it underpins many of the services that nature provides, and is vital to the continuing function of an ecosystem.

How did we model it?

We model biodiversity units using four key parameters. Each is given a score, which are then multiplied together, alongside the hectares of assessment area, to provide total biodiversity units.

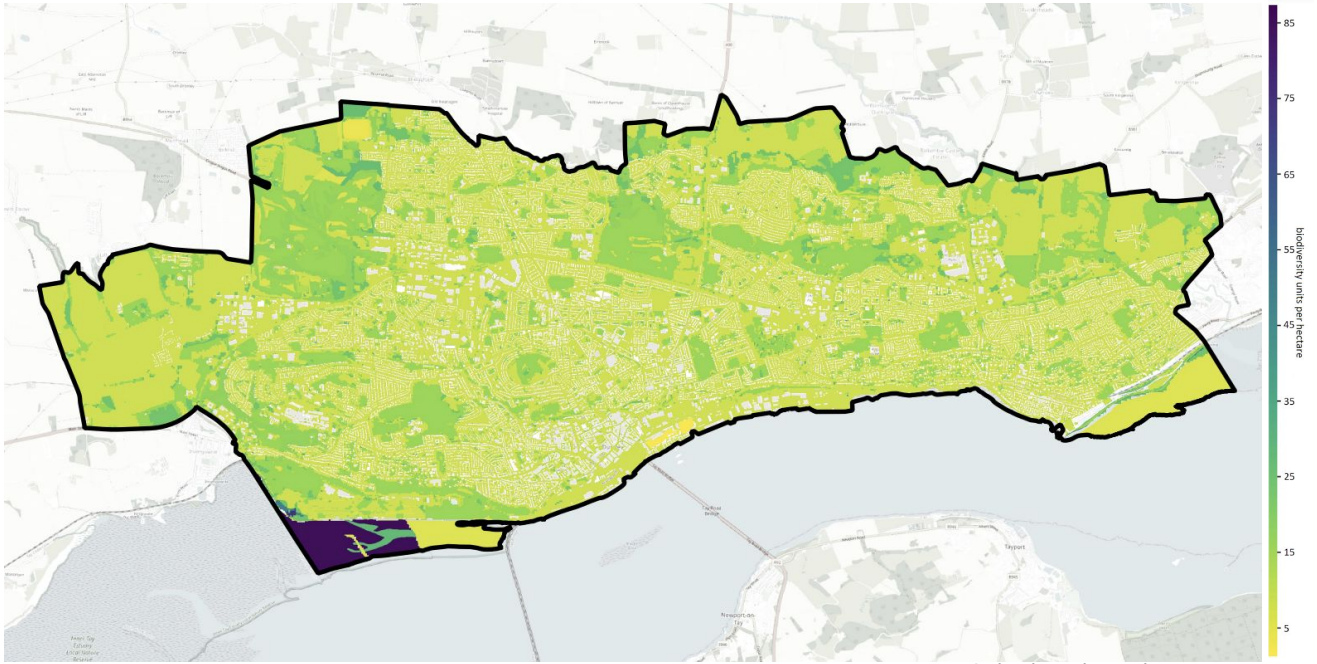
Our four parameters

- Distinctiveness - for instance rarity of habitat in Scotland, and EU Red List Categories
- SSSI condition - taken from NatureScot's national monitoring programme for SSSI condition
- Protected species - score based on the average number of protected species that are predicted to occur in the assessment area
- Connectivity - score based on identifying patches of landcover that may contribute to connectivity

See appendix, slides 36 and 37 for more detail.

Biodiversity metric

	Biodiversity metric
Sum	65,344 biodiversity units
Average per ha	10.4



Number of biodiversity units per ha

Important areas for biodiversity

What is it?

Here we show whether areas are designated for biodiversity protection.

Why is it important?

This allows you to see which areas within the assessment are already designated as protected areas. You can also observe, when comparing this with other maps, how these areas are correlated with the production of ecosystem services, such as pollination or carbon storage.

How did we model it?

Our estimations are determined by combining information on designated protected areas and conservation sites with data for habitats that are recognised as important for biodiversity.

We group these areas by their designation, either as:

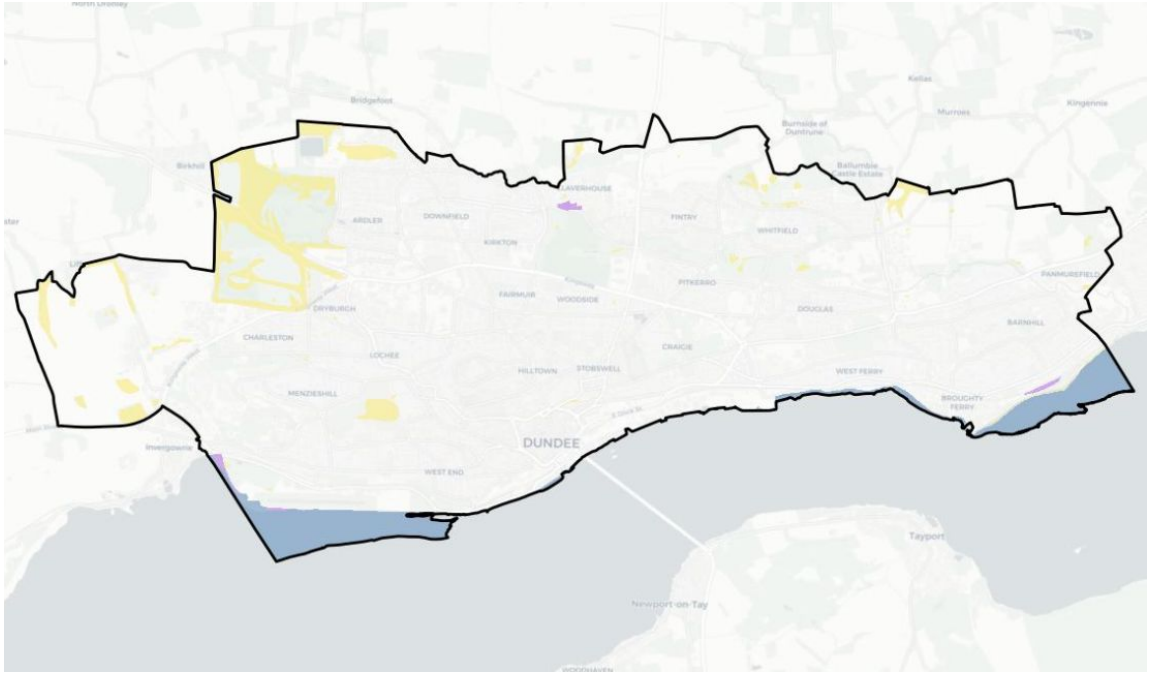
- ‘International Importance
- 'National Importance - Statutory protected’
- ‘National important - non statutory protected’*, ‘Local Importance’

*including ancient woodlands and principle BAP habitats

Important areas for biodiversity

International Importance - Statutory Protected
Local Importance - Statutory Protected
National Importance - Non-Statutory Protected

	Important biodiversity areas
Sum	550 ha



Important habitats for biodiversity

Connectivity of woodlands

What is it?

Connectivity looks at how easy it is for species to move through a landscape, between patches of habitat. This model considers woodland habitats specifically. As such we're aiming to assess the importance of each woodland habitat patch within your assessment area for the movement of species across the wider landscape.

Why is it important?

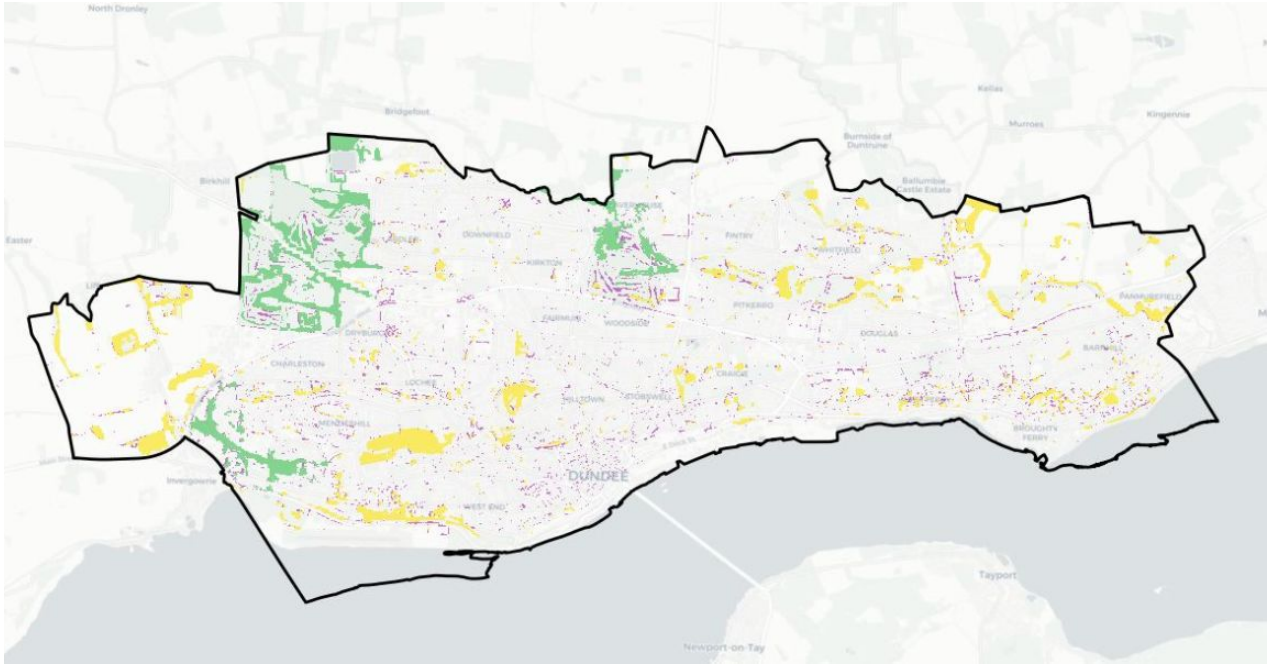
In areas of fragmented habitat, improving connectivity between these patches is a good route to supporting biodiversity within these regions.

How did we model it?

Our connectivity model is grounded in the principles of bigger, better, and more joined up.

As such, it identities patches of habitat and then uses graph theory models to estimate the contribution of each patch to the overall connectivity of the landscape. Patches are scored for their importance as 'high, 'medium' or 'low'. The landscape is defined as OS 100 km grid squares.

Connectivity



Important native woodland patches for the movement of biodiversity across landscapes (metric indicating contribution of patch to overall landscape connectivity, from low to high)

Hedgerows and trees outside of woodlands

Low Importance

Medium Importance

A note on our methodology:
This map also displays hedgerows and trees outside of woodlands. The importance of these trees is not modelled but these are displayed to show the connectivity of the land between woodland patches

Pollination

What is it?

This describes key areas within assessment region that provide suitable habitats for insect pollinators. Importantly, we don't just consider the suitability of the habitat, but the proximity of these areas to pollination dependent crops. Allotments are included in the model as areas that are dependent on pollinators.

Why is it important?

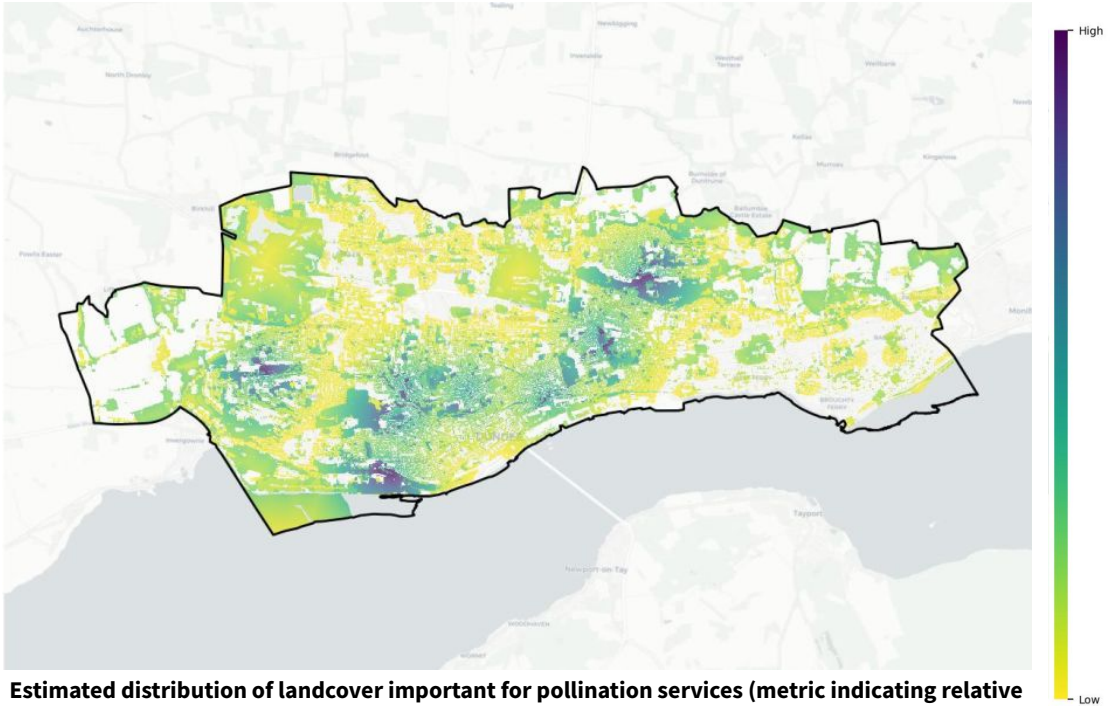
Pollinators allow plants to fruit, set seed, and breed. As such they play an important role in the functioning of our ecosystems and the production of food.

How did we model it?

Our pollination model is built by identifying suitable nesting habitats for pollinators from high resolution landcover data. Demand for this ecosystem service is estimated using a number of parameters. First we must establish which of the crops within the assessment region require pollination for production, and second, the extent to which that provision will impact crop yield. A decay function is applied to estimate the importance of supply location. Demand and supply maps are combined to calculate baseline pollination service provision.

Pollination

	Important pollination areas
Sum	3,567 ha



Estimated distribution of landcover important for pollination services (metric indicating relative importance of landcover in that location, from low to high)

Flood risk reduction

What is it?

This is the role of vegetation in reducing water surface runoff per year.

Why is it important?

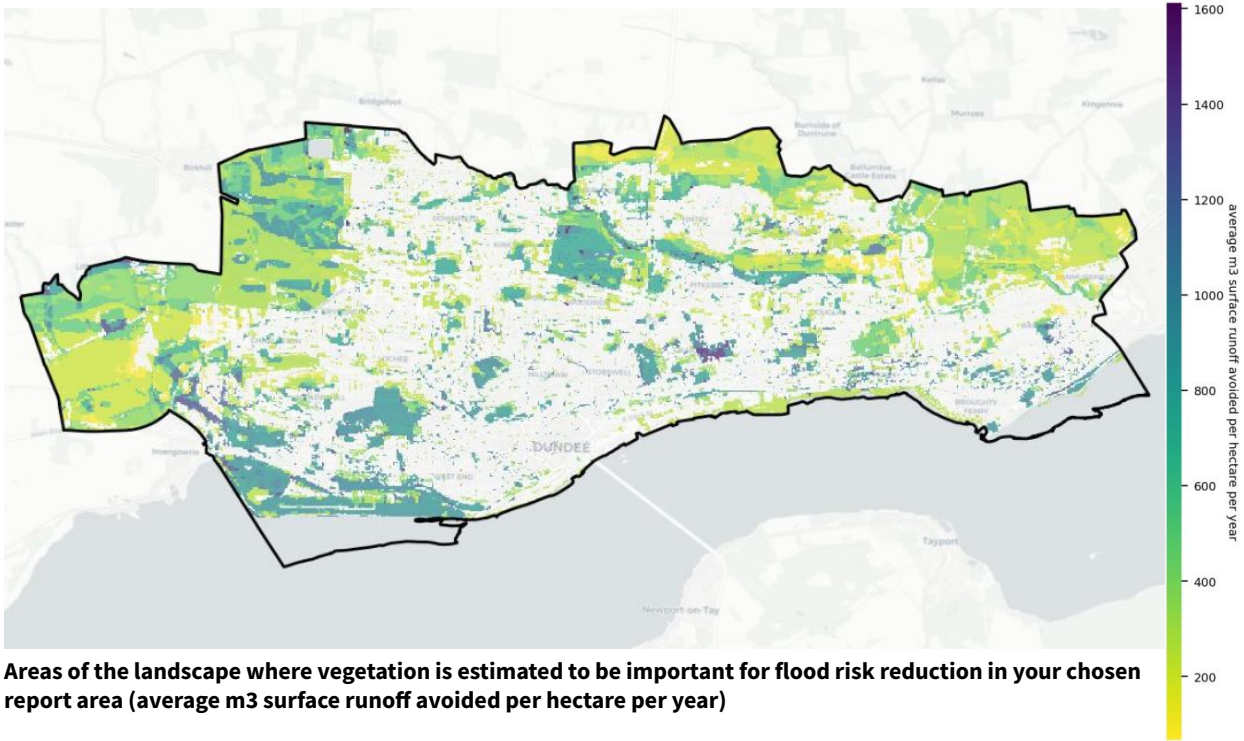
Vegetation is important in reducing surface rainfall-runoff and thus reducing the downstream flood risk during a storm event.

How did we model it?

To model the role of vegetation in reducing flood risk, we utilise a grid-based hydrological model that takes inputs such as soil characteristics, climatic conditions and vegetation data to model the current scenario - i.e. surface runoff with vegetation present. We then run the model simulating what would happen if the vegetation was removed. Taking the difference between the two, we can estimate the quantity of surface runoff avoided.

Flood risk reduction

	Flood risk reduction
Sum	1,377,669 m3 runoff avoided/yr
Average per ha	221 m3 runoff avoided/yr/ha



Areas of the landscape where vegetation is estimated to be important for flood risk reduction in your chosen report area (average m3 surface runoff avoided per hectare per year)

Soil erosion prevention

What is it?

Here we look at the role of vegetation in preventing soil erosion per year.

Why is it important?

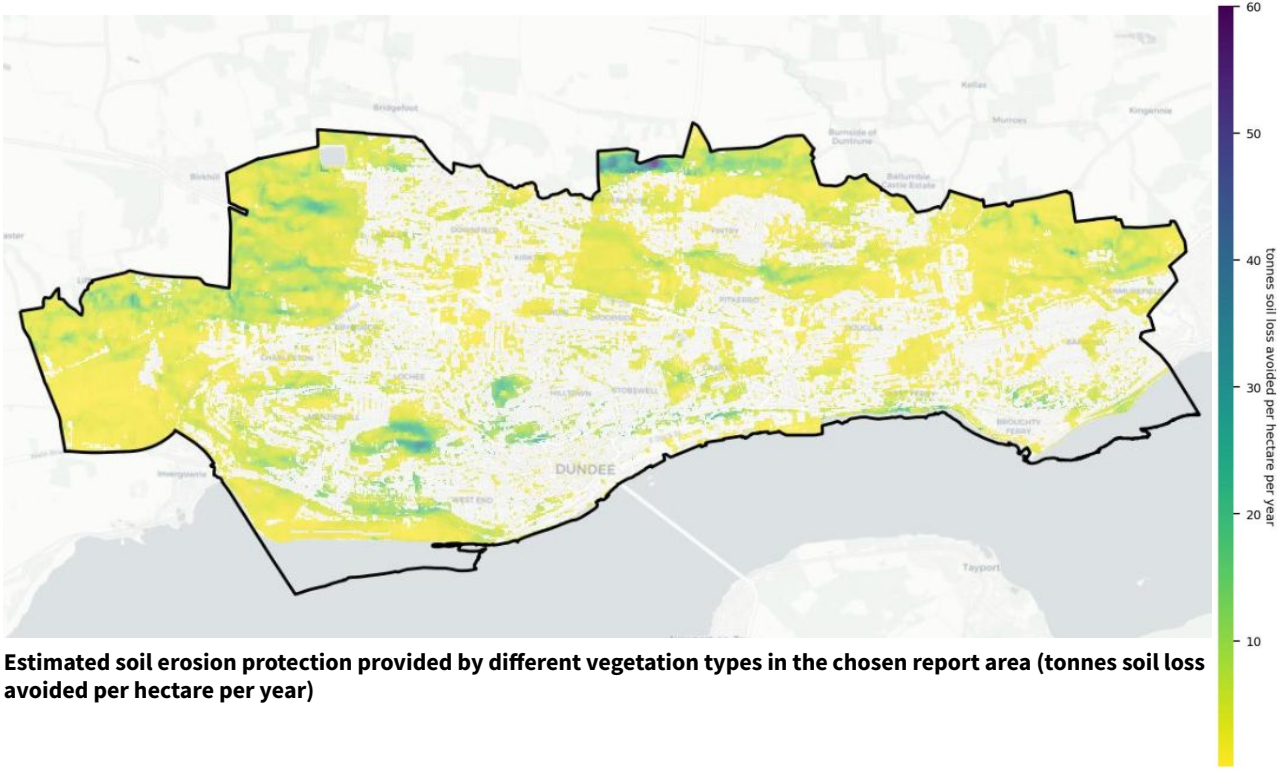
While this is likely to be more important in an agricultural, rather than urban, setting, broadly topsoil is one of the most productive parts of the soil. As such, its loss results in lower yields and higher production costs, as well as contributing to water quality and sedimentation issues downstream.

How did we model it?

This model combines a number of different factors that contribute to soil erosion - for instance rainfall intensity, management and slope length. We take the difference between a hypothetical maximum erosion scenario in which all ground is bare and an estimate of erosion under current landcover to predict how much erosion the current landcover is preventing.

Soil erosion

	Soil erosion prevention
Sum	11,698 tonnes soil loss avoided/yr
Average per ha	2 tonnes soil loss avoided/yr/ha



Estimated soil erosion protection provided by different vegetation types in the chosen report area (tonnes soil loss avoided per hectare per year)

Appendix

Biodiversity metric

Our approach to this metric is to capture the important constituents of biodiversity in a Scottish context, namely:

- **Distinctiveness:** how important is the landscape in terms of rarity and protection?
- **Protected species:** Are protected species predicted to occur in the assessment area?
- **Connectivity:** How important is this area for landscape connectivity?
- **SSSI condition:** Are there SSSIs within the assessment area, and if so, what condition are they in?

These are the four components that make up the calculation of a biodiversity unit. Scores are applied to each, and multiplied by the total hectares of the assessment area. See overleaf for an infographic of this calculation.

To note, that the biodiversity metric when applied to water bodies does not account for connectivity.

Biodiversity metric

Methodology

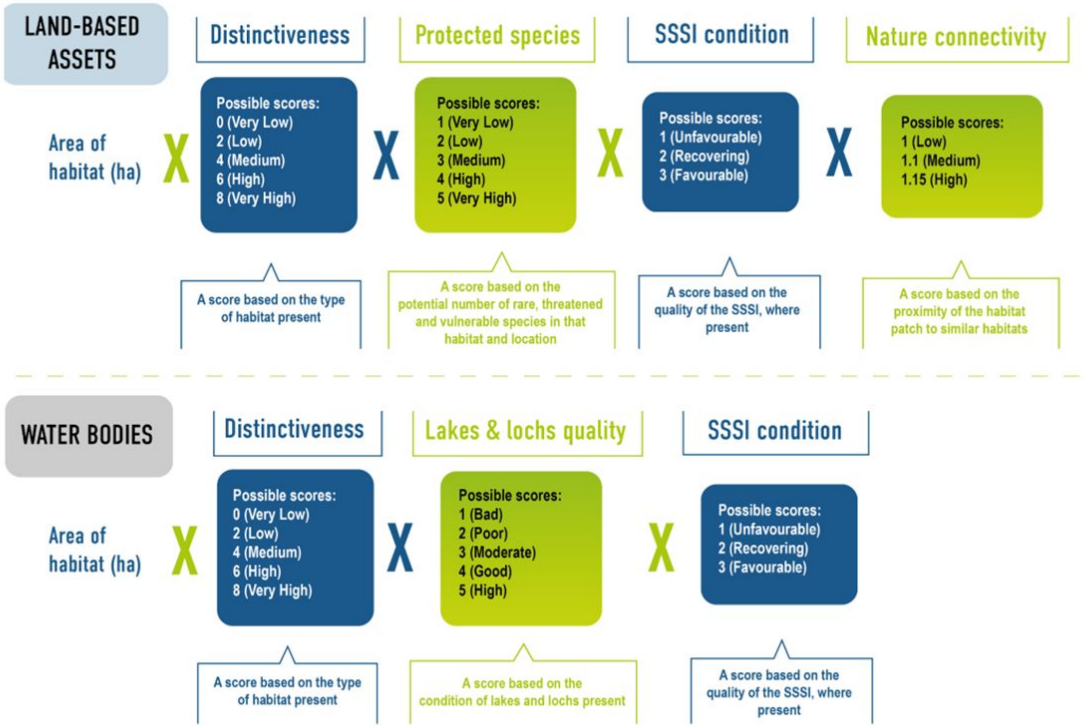
Here you can see the score applied to each of these components.

Each score is multiplied, and this total is then multiplied by the total area of habitat in hectares.

What does this mean

Given the above, how should you think about the biodiversity metric?

Areas that score highly, should be considered as playing an important function for promoting biodiversity in the Scottish context.



Parks analysed

- Balgay, Victoria and Lochee Parks
- Baxter Park
- Broughton Ferry Nature Reserve and Barnhill Rock Garden
- Caird Park
- Camperdown Country Park
- Clatto Park
- Dawson Park
- Drumgeith Park
- Dunhope Park
- Farimuir Park
- Finlathen Park
- Magdalen Green
- Middleton Wood
- Orchard Park
- Reres Hill Park
- Riverside Nature reserve
- Slessor Gardens
- South Road Park
- Stobsmuir Ponds
- Templeton Woods
- The Law
- Trottick Mill Ponds Local Nature Reserve

Data sources: Assets

Input data	Extent	Citation	Licensing
Landcover			
Surface water bodies and reservoirs	GB	OpenStreetMap contributors, 2020	OpenStreetMap® is open data, licensed under the Open Data Commons Open Database License (ODbL) by the OpenStreetMap Foundation (OSMF) and CC BY-SA 2.0. © OpenStreetMap contributors.
Trees crops (orchards, vineyards, allotments)	GB	OpenStreetMap contributors, 2020	OpenStreetMap® is open data, licensed under the Open Data Commons Open Database License (ODbL) by the OpenStreetMap Foundation (OSMF) and CC BY-SA 2.0. © OpenStreetMap contributors.
National Forest Inventory 2018	GB	Forestry Commission, 2018	Any public sector information contained in these data is licenced under the Open Government Licence v.2.0. Contains, or is based on, information supplied by the Forestry Commission. © Crown copyright and database right 2018 Ordnance Survey.
Ancient Woodlands (England)	England	Natural England, 2020	© Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right [2020].Contains public sector information licensed under the Open Government Licence v3.0
Ancient Woodlands (Scotland)	Scotland	Scottish Natural Heritage, 2020	Copyright Scottish Natural Heritage Contains Ordnance Survey data © Crown copyright and database right [2020]. Contains SNH information licensed under the Open Government Licence v3.0.

Input data	Extent	Citation	Licensing
Landcover			
Ancient Woodlands (Wales)	Wales	Natural Resources Wales, 2020	Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number 100019741. Crown Copyright and Database Right.Contains public sector information licensed under the Open Government Licence v3.0.
Priority Habitat Inventory	England	Natural England, 2020	© Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right [2020].Contains public sector information licensed under the Open Government Licence v3.0.
Habitats Map Of Scotland (HabMoS)	Scotland	Scottish Natural Heritage, 2020	Copyright Scottish Natural Heritage Contains Ordnance Survey data © Crown copyright and database right [2020]. Contains SNH information licensed under the Open Government Licence v3.0.
Traditional Orchards	Wales	Natural Resources Wales, 2020	Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number 100019741. Crown Copyright and Database Right.Contains public sector information licensed under the Open Government Licence v3.0.

Data sources: Assets

Input data	Extent	Citation	Licensing
Landcover			
RPA Crop Map of England (CROME)	England	RPA, 2018	This data has been made freely available by Defra and its agencies for your use under the Open Government Licence.Attribution statement: © Rural Payments Agency.
Terrestrial Phase 1 Habitat Survey	Wales	Natural Resources Wales, 2020	Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number 100019741. Crown Copyright and Database Right.Contains public sector information licensed under the Open Government Licence v3.0.
Surface waterbodies	GB	Ordnance Survey Zoomstack, 2020	Contains OS data © Crown copyright and database right 2021. Contains public sector information licensed under the Open Government Licence v3.0.
Scotland Habitat and Landcover map	Scotland	Space Intelligence, 2020	Available under Open Government Licence
Corine Landcover Map	GB	Copernicus, 2018	Open and free access, as established by the Copernicus data and information policy Regulation (EU) No 1159/2013 of 12 July 2013.
Copernicus Sentinel-2 mission. Level 2-A data	GB	European Space Agency (ESA), 2016	European Space Agency - ESA and content produced from ESA remote sensing data. © ESA 2000 - 2020.

Input data	Extent	Citation	Licensing
Landcover			
Woodlands, trees and hedge composition			
National Tree Map (NTM)	England, Wales	BlueSky Ltd, 2020	©Bluesky International Limited.
BlueSky Digital Terrain Map and Digital Surface	Scotland	BlueSky Ltd, 2021	©Bluesky International Limited.
Topography			
European Digital Elevation Model v1.1 (Slope and DEM)	GB	Copernicus, 2016	Open and free access, as established by the Copernicus data and information policy Regulation (EU) No 1159/2013 of 12 July 2013.
Water and wetlands			
Ordnance Survey Zoomstack (surface water bodies and rivers)	GB	Ordnance Survey Zoomstack, 2020	Contains OS data © Crown copyright and database right 2021. Contains public sector information licensed under the Open Government Licence v3.0.
Landcover map (see above)	GB	Mixed	Mixed

Data sources: Assets

Input data	Extent	Citation	Licensing
Landcover			
Soil type			
1:250 000 National soil map of Scotland	Scotland	Soil Survey of Scotland Staff (1981). Soil maps of Scotland at a scale of 1:250000. Macaulay Institute for Soil Research, Aberdeen	Content owned by the EU is licensed under the Creative Commons Attribution 4.0 International (CC BY 4.0) licence. © European Union, 1995-2021.
Topsoil Physical properties for Europe (based on LUCAS topsoil data)	GB	European Soil Data Centre (ESDAC), 2015; Ballabio, Panagos and Montanarell, 2016	Content owned by the EU is licensed under the Creative Commons Attribution 4.0 International (CC BY 4.0) licence. © European Union, 1995-2021.

Data sources: Ecosystem service flows

Input data	Extent	Citation	Licensing
Carbon storage in vegetation and soils			
National Tree Map	England, Wales, Scotland	BlueSky Ltd, 2020	©Bluesky International Limited.
Digital Terrain Model and Digital Surface Model for Scotland	Scotland	BlueSky Ltd, 2021	©Bluesky International Limited.
National Forest Estate England, Scotland and Wales	England, Scotland, Wales	Forestry Commission, 2019	Any public sector information contained in these data is licenced under the Open Government Licence v.2.0. Contains, or is based on, information supplied by the Forestry Commission. © Crown copyright and database right 2018 Ordnance Survey.
Sentinel Satellite Observations (NDVI summer, NDVI winter)	GB	European Space Agency (ESA), 2020	European Space Agency - ESA and content produced from ESA remote sensing data. © ESA 2000 - 2020.
Digital Elevation Model (DEM, EU-DEM v1.1)	GB	Copernicus, 2016	Open and free access, as established by the Copernicus data and information policy. Regulation (EU) No. 1159/2013 of 12 July 2013.

Input data	Extent	Citation	Licensing
Carbon storage in vegetation and soils			
Landcover map	GB	See data inputs in stocks table	See data inputs in stocks table
Woodland Carbon Code Lookup Tables	GB	Accessed from: https://woodlandcarboncode.org.uk/standard-and-guidance/3-carbon-sequestration/3-3-project-carbon-sequestration	Disclaimer: The Woodland Carbon Code Carbon Lookup Tables are distributed 'as is' and without warranties as to performance or merchantability or any other warranties whether expressed or implied. In particular, there is no warranty for the predictions derived from the Carbon Lookup Tables as they are regarded as indicative and not prescriptive.
Forest Research Climate Maps	Scotland	Forest Research 2020	© Crown Copyright 2021
Global Soil Organic Carbon Map (GSOC v1.0)	Global	FAO 2019	Content made available under the Creative Commons CC BY 4.0. Data contributed by Cranfield University and The James Hutton Institute

Data sources: Ecosystem service flows

Input data	Extent	Citation	Licensing
Carbon storage in vegetation and soils			
Topsoil Organic Carbon Content (TOC) Map for Scotland	Scotland	Lilly, A, Baggaley, N and Donnelly, D. 2012. Map of soil organic carbon in top soils of Scotland. Map prepared for EU project GS-SOIL - Assessmentand strategic development of INSPIRE compliant Geodata-Services for European Soil Data. ECP-2008-GEO-318004.	Available under the Open Data licence
1:250 000 National soil map of Scotland	Scotland	Soil Survey of Scotland Staff (1981). Soil maps of Scotland at a scale of 1:250 000. Macaulay Institute for Soil Research, Aberdeen	Available under the Open Data licence

Input data	Extent	Citation	Licensing
Carbon sequestration in vegetation			
National Tree Map	England, Wales	BlueSky Ltd, 2020	©Bluesky International Limited.
Digital Terrain Model and Digital Surface Model for Scotland	Scotland	BlueSky Ltd, 2020	©Bluesky International Limited.
National Forest Estate England, Scotland and Wales	England, Scotland, Wales	Forestry Commission, 2019	Any public sector information contained in these data is licenced under the Open Government Licence v.2.0. Contains, or is based on, information supplied by the Forestry Commission. © Crown copyright and database right 2018 Ordnance Survey.
Woodland Carbon Code Lookup Tables	GB	Accessed from: https://woodlandcarboncode.org.uk/standard-and-guidance/3-carbon-sequestration/3-3-project-carbon-sequestration	Disclaimer: The Woodland Carbon Code Carbon Lookup Tables are distributed 'as is' and without warranties as to performance or merchantability or any other warranties whether expressed or implied. In particular, there is no warranty for the predictions derived from the Carbon Lookup Tables as they are regarded as indicative and not prescriptive.

Data sources: Ecosystem service flows

Input data	Extent	Citation	Licensing
Carbon sequestration in vegetation			
Sentinel Satellite Observations (NDVI summer, NDVI winter)	GB	European Space Agency (ESA)	European Space Agency - ESA and content produced from ESA remote sensing data. © ESA 2000 - 2020.
Landcover map	GB	See data inputs in stocks table	See data inputs in stocks table
Digital Elevation Model (DEM, EU-DEM v1.1)	GB	Copernicus, 2016	Open and free access, as established by the Copernicus data and information policy Regulation (EU) No. 1159/2013 of 12 July 2013.
Forest Research Climate Maps	Scotland	Forest Research 2020	© Crown Copyright 2021

Input data	Extent	Citation	Licensing
Soil erosion prevention			
R factor (used in the RUSLE model)	GB	European Soil Data Centre (ESDAC), 2017	Open and free access. Content owned by the EU is licensed under the Creative Commons Attribution 4.0 International (CC BY 4.0) licence. © European Union, 1995-2021.
K factor (used in the RUSLE model) dervied from LUCAS data	GB	European Soil Data Centre (ESDAC), 2015	Open and free access. Content owned by the EU is licensed under the Creative Commons Attribution 4.0 International (CC BY 4.0) licence. © European Union, 1995-2021.
LS Factor (used in the RUSLE model)	GB	European Soil Data Centre (ESDAC), 2015	Open and free access. Content owned by the EU is licensed under the Creative Commons Attribution 4.0 International (CC BY 4.0) licence. © European Union, 1995-2021.
C factor (used in the RUSLE model) derived from Landcover map	GB	Panagos, et al., 2015	
Landcover map	GB	See data inputs in stocks table	See data inputs in stocks table

Data sources: Ecosystem service flows

Input data	Extent	Citation	Licensing
Soil erosion prevention			
Fractional vegetation cover dervied from Sentinel-2 satellite data	GB	European Space Agency (ESA), 2016	European Space Agency - ESA and content produced from ESA remote sensing data. © ESA 2000 - 2021.

Input data	Extent	Citation	Licensing
Flood risk reduction			
1:250 000 National soil map of Scotland	Scotland	Soil Survey of Scotland Staff (1981). Soil maps of Scotland at a scale of 1:250 000. Macaulay Institute for Soil Research, Aberdeen	Available under Open Government Licence
Rivers and waterways	GB	Ordnance Survey Zoomstack, 2020	Contains OS data © Crown copyright and database right 2020. Contains public sector information licensed under the Open Government Licence v3.0.
European Soil Database v2 Raster Library	GB	European Soil Data Centre (ESDAC), 2015; Panagos, 2006	Content owned by the EU is licensed under the Creative Commons Attribution 4.0 International (CC BY 4.0) licence. © European Union, 1995-2021.
Digital Elevation Model (DEM, EU-DEM v1.1)	GB	Copernicus, 2016	Open and free access, as established by the Copernicus data and information policy Regulation (EU) No 1159/2013 of 12 July 2013.
Landcover map	GB	See data inputs in stocks table	See data inputs in stocks table
Weather data from Climate Forecast System Reanalysis (CFSR)	GB	National Center for Atmospheric Research, 2017	Content owned by the EU is licensed under the Creative Commons Attribution 4.0 International (CC BY 4.0) licence. © European Union, 1995-2021.

Data sources: Ecosystem service flows

Input data	Extent	Citation	Licensing
Important areas for supporting insect pollinators of crops			
Rural Payments Agency (RPA) Crop Map of England (CROME)	England	RPA, 2018	This data has been made freely available by Defra and its agencies for your use under the Open Government Licence.Attribution statement: © Rural Payments Agency.
Corine Landcover 2018 (perennial crops of berries, orchards and vineyards)	GB	Copernicus, 2018	Open and free access, as established by the Copernicus data and information policy Regulation (EU) No 1159/2013 of 12 July 2013.
Open Street Map (Orchards, vineyards)	GB	OpenStreetMap, 2018	OpenStreetMap® is open data, licensed under the Open Data Commons Open Database License (ODbL) by the OpenStreetMap Foundation (OSMF) and CC BY-SA 2.0. © OpenStreetMap contributors.

Input data	Extent	Citation	Licensing
Important areas for supporting insect pollinators of crops			
Traditional orchards (Wales)	Wales	Natural Resources Wales, 2020	Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number 100019741. Crown Copyright and Database Right.Contains public sector information licensed under the Open Government Licence v3.0.
Functional nectar diversity by landcover type	GB	Baude et al., 2016	
Landcover map	GB	See data inputs in stocks table	See data inputs in stocks table

Data sources: Ecosystem service flows

Input data	Extent	Citation	Licensing
Important biodiversity habitats			
NNR, LNR, SSSI, SAC, SPA, Ramsar, Priority Habitat Inventory, Natural Improvement Areas, Environmentally Sensitive Areas, Biosphere reserves	England	Natural England, 2020	© Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right [2020].Contains public sector information licensed under the Open Government Licence v3.0.
NNR, LNR, SSSI, SAC, SPA, Ramsar, Biosphere reserves	Wales	Natural Resources Wales, 2020	Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number 100019741. Crown Copyright and Database Right.Contains public sector information licensed under the Open Government Licence v3.0.
NNR, LNR, SSSI, SAC, SPA, Ramsar, Environmentally Sensitive Areas, Biosphere reserves	Scotland	Scottish Natural Heritage, 2020	Copyright Scottish Natural Heritage Contains Ordnance Survey data © Crown copyright and database right (2020) Contains SNH information licensed under the Open Government Licence v3.0.

Input data	Extent	Citation	Licensing
Important biodiversity habitats			
Ancient Woodlands (England)	England	Natural England, 2020	© Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right [2020].Contains public sector information licensed under the Open Government Licence v3.0.
Ancient Woodlands (Scotland)	Scotland	Scottish Natural Heritage, 2020	Copyright Scottish Natural Heritage Contains Ordnance Survey data © Crown copyright and database right (2020) Contains SNH information licensed under the Open Government Licence v3.0.
Ancient Woodlands (Wales)	Wales	Natural Resources Wales, 2020	Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number 100019741. Crown Copyright and Database Right.Contains public sector information licensed under the Open Government Licence v3.0.

Data sources: Ecosystem service flows

Input data	Extent	Citation	Licensing
Nature networks			
Landcover map	GB	See data inputs in stocks table	See data inputs in stocks table
Recreation			
Flickr records 2020	GB	Flickr API, 2020	Open access.
eBird records 2020	GB	Levatich and Ligocki, 2020; GBIF.org (25 August 2020)	GBIF.org. Licensed under the Creative Commons Attribution 4.0 International (CC BY 4.0) licence or CC0 1.0 Universal (CC0 1.0) Public Domain Dedication
iNaturalist	GB	Ueda, 2020; GBIF.org (25 August 2020)	GBIF.org. Licensed under the Creative Commons Attribution 4.0 International (CC BY 4.0) licence or CC0 1.0 Universal (CC0 1.0) Public Domain Dedication
Digital Elevation Model (DEM, EU-DEM v1.1)	GB	Copernicus, 2016	Open and free access, as established by the Copernicus data and information policy Regulation (EU) No 1159/2013 of 12 July 2013.

Input data	Extent	Citation	Licensing
Recreation			
Surface waterbodies and rivers, waterways Greenspaces, roads, Public Rights of Way (PRoW)	GB	Ordnance Survey Zoomstack, 2020	Contains OS data © Crown copyright and database right 2020. Contains public sector information licensed under the Open Government Licence v3.0.
Protected areas (NNR, LNR, SSSI, SAC, SPA, Ramsar, Priority Habitat Inventory, Natural Improvement Areas, Environmentally Sensitive Areas); Country Parks	England	Natural England, 2020	© Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right [2020].Contains public sector information licensed under the Open Government Licence v3.0.
Protected areas (NNR, LNR, SSSI, SAC, SPA, Ramsar); Country Parks; Wales Coastal Path	Wales	Natural Resources Wales, 2020	Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number 100019741. Crown Copyright and Database Right.Contains public sector information licensed under the Open Government Licence v3.0.

Data sources: Ecosystem service flows

Input data	Extent	Citation	Licensing
Recreation			
Protected areas (NNR, LNR, SSSI, SAC, SPA, Ramsar); Country Parks	Scotland	Scottish Natural Heritage, 2020	Copyright Scottish Natural Heritage Contains Ordnance Survey data © Crown copyright and database right (2020) Contains SNH information licensed under the Open Government Licence v3.0.
Population density 2020	UK	Reid et al., 2017; UK Gridded Population, 2011	Contains data supplied by Natural Environment Research Council. ©NERC (Centre for Ecology and Hydrology). Contains National Statistics data © Crown copyright and database right 2011. Contains public sector information licensed under the Open Government Licence v3.0.
Recreation assets (World Heritage Sites + Registered Parks and Gardens + Registered Battlefields)	England	Historic England, 2018	Contains public sector information licensed under the Open Government Licence v3.0.

Input data	Extent	Citation	Licensing
Recreation			
OpenStreetMap (OSM) paths (extracted from OSM roads), parks, public gardens, accessible areas	GB	OpenStreetMap, 2021	OpenStreetMap® is open data, licensed under the Open Data Commons Open Database License (ODbL) by the OpenStreetMap Foundation (OSMF) and CC BY-SA 2.0. © OpenStreetMap contributors.
National Forest Estates Recreation Areas GB, National Forest Estates Recreation Routes GB	GB	Forestry Commission, 2016	Any public sector information contained in these data is licenced under the Open Government Licence v.2.0. Contains, or is based on, information supplied by the Forestry Commission. © Crown copyright and database right 2018 Ordnance Survey.
National Cycle Network	GB	Sustrans UK, 2020	© Sustrans is a registered charity in England and Wales (number 326550) and Scotland (SC039263). Open Data Commons Open Database License (ODbL) v1.0
Countryside and Rights of Way (CRoW)	England	Natural England, 2020	Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right 2020.

Data sources: Ecosystem service flows

Input data	Extent	Citation	Licensing
Recreation			
Annual Survey of Visits to Visitor Attractions for England	England	VisitBritain, 2020	© VisitBritain/VisitEngland 2021.
All Forests Visitor Survey (Wales)	Wales	Forestry Commission Wales, 2005	© Crown Copyright, courtesy Forestry Commission (2005), licensed under the 2020 Open Government Licence. Contains public sector information licensed under the Open Government Licence v3.0.
All Forests Visitor Survey (Scotland)	Scotland	Forestry Commission Scotland, 2003	© Crown Copyright, courtesy Forestry Commission (2003), licensed under the 2020 Open Government Licence. Contains public sector information licensed under the Open Government Licence v3.0.