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Experimental Statistics

AGRICULTURE, ENVIRONMENT, MARINE AND ECONOMY

Scottish natural capital accounts: 2022

1. Main points

Overview

Natural capital is the world's stock of natural resources. This includes air, water, minerals and all living things. These natural resources underpin our society and economy because they provide a wide range of benefits (for example, pollution removal, carbon sequestration, recreation, etc.). These benefits are often known as "ecosystem services".

The benefits derived from our natural assets can be divided into three categories:

- provisioning services that create products such as food, water, and minerals;
- regulating services such as air pollution removal and carbon sequestration; and
- cultural services such as recreational use of nature.

This publication looks at natural capital assets, including the physical and monetary flows of assets and the values of services that they provide. Considering natural resources in accounting terms helps us to think logically about how to measure aspects of the natural world and better understand their impact on people. Throughout, the benefits resulting from our natural assets are grouped by the types of services that they provide (i.e., provisioning, regulating or cultural).

Scotland's natural capital accounts have been produced by the Office for National Statistics who also produce UK natural capital accounts. Several ecosystem services are not being measured in this article, such as flood mitigation. The monetary accounts should be interpreted as a partial or minimum value of Scottish natural capital.

Overview summary statistics in this report are given for 2018 as this is the last year for which we have figures for all of the services.

Asset valuation

• Scottish natural capital assets that we can currently value were estimated to be £206 billion in 2018. Scotland's total asset value has decreased by 4% from £213 billion in 2017.This decrease is due to a fall in the asset value of fossil fuels.

• The largest part of this asset value came from recreation, which accounted for 30% of the total Scottish assets value in 2018. This was followed by fossil fuels which accounted for 25% and carbon sequestration which accounted for 18%.

Annual valuation

• The total value of annual monetary flows from Scottish natural capital assets in 2018 was £15.6 billion. The largest monetary annual flow was from fossil fuels (£11.6 billion), followed by recreation (£1.06 billion) and carbon sequestration (£804 million).

• The total value of annual monetary flows from Scottish natural capital assets has increased by 417% since 2015, this was largely driven by an increase in fossil fuel prices.

• However, over the longer term there is a move away from fossil fuels with fossil fuel production having declined by 62% between 1999 and 2020. Meanwhile, Scottish renewable energy generation reached 29,626 GWh in 2020, increasing by 784% from 2003, owing largely to rising wind energy provisioning.

Compared to UK

• Scottish natural capital assets accounted for 17% of the UK asset value in 2018. Scottish natural capital assets also account for the majority of the UK assets value for a number of services, including fish capture 88%, fossil fuels 86% renewable energy 58% and timber 61%.

• Annual monetary flows from Scottish natural capital assets accounts for 34% of the total monetary flow from UK natural capital assets in 2018.

2. Things you need to know about this release

This article looks at natural capital assets, including the flows and values of ecosystem services. Any natural resource or process that supports human life, society and the economy form an important part of our natural capital.

From these assets people can receive a flow of services, such as mountain hikes and fish captured for consumption. We can value the benefit to society those services provide by estimating for example, what the hikers spent to enable them to walk over the mountain or any profit from bringing the fish into the market. Applying this logic consistently across assets and services enables us to start building accounts of Scotland's nature.

Where available, estimates are presented between the period from 1998 to 2020 and all monetary valuations are given in 2020 prices. Owing to data coverage constraints, 2018 is the latest year for which we can estimate an overall Scottish natural capital asset value.

The Scottish and UK accounts remain experimental and future publications will be subject to methodological improvements. There have been fewer methodological improvements between the Scottish Natural Capital accounts: 2021 and the current publication than between the 2021 and Scottish natural capital accounts: 2020. However, we still caution against comparison between accounts. Please use the data available alongside this release for time series analysis.

Readers should also be cautious in how they interpret an increase or decrease in value. An increase in asset value does not directly imply an increase in the quality or quantity of an asset. For instance, in the coming year we can expect food prices to increase due to the war in Ukraine since Ukraine is a significant food exporter and Russia is a significant source of fertiliser. Relatedly, farming in Scotland might be more profitable with no actual change in yield. The change in value is still interesting but requires further analysis.

This is equally true of "air pollution removal" which might show a fall in value when in fact it is the total air pollution requiring removal that has fallen. This example would be a positive outcome and is not necessarily a sign that Scottish vegetation's capacity to remove air pollution has degraded.

Several ecosystem services are not being measured in this article, such as flood mitigation and water quality regulation and tourism, so the monetary accounts should be interpreted as a partial or minimum value of Scottish natural capital.

Our asset values are not an absolute "value" of the price we would accept to sell the entire natural world. The natural world supports all life on earth, and its collapse would precipitate our own, implying infinite value.

3. Provisioning services

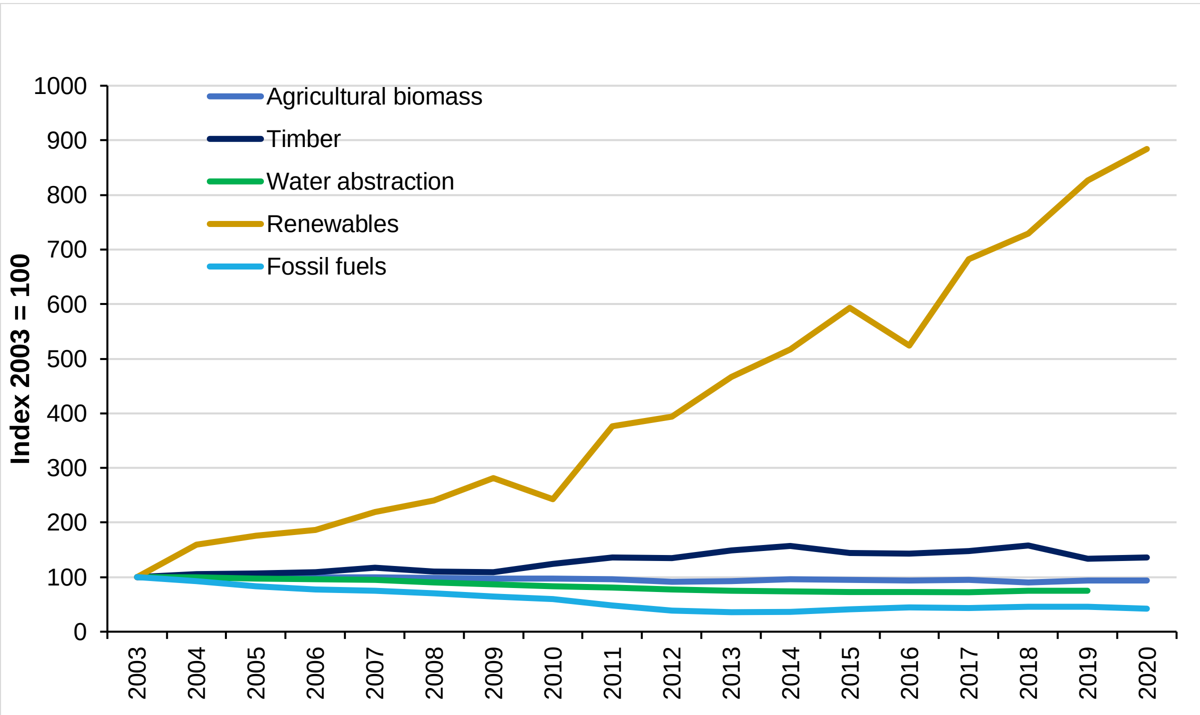
Provisioning ecosystem services create products that include food, water and materials. These are produced by nature, extracted and then used by society to support human life. The values of provisioning services are largely based on existing market prices. This means that the asset values of these services are subject to changes in market conditions, such as price changes. These price changes can often distort how natural assets are valued and therefore a wider view of our interrelated economy must be taken to understand asset value behaviour, including application of a four capitals approach. Using the provisioning services of a natural asset may affect its ability to provide regulating or cultural ecosystem services.

Provisioning services currently included in the Scottish ecosystem accounts are:

- Agricultural biomass
- Fish capture
- Timber
- Water abstraction
- Minerals
- Fossil fuels
- Renewable energy

Figure 1: Renewable energy provisioning was almost nine times larger in 2020 than in 2003

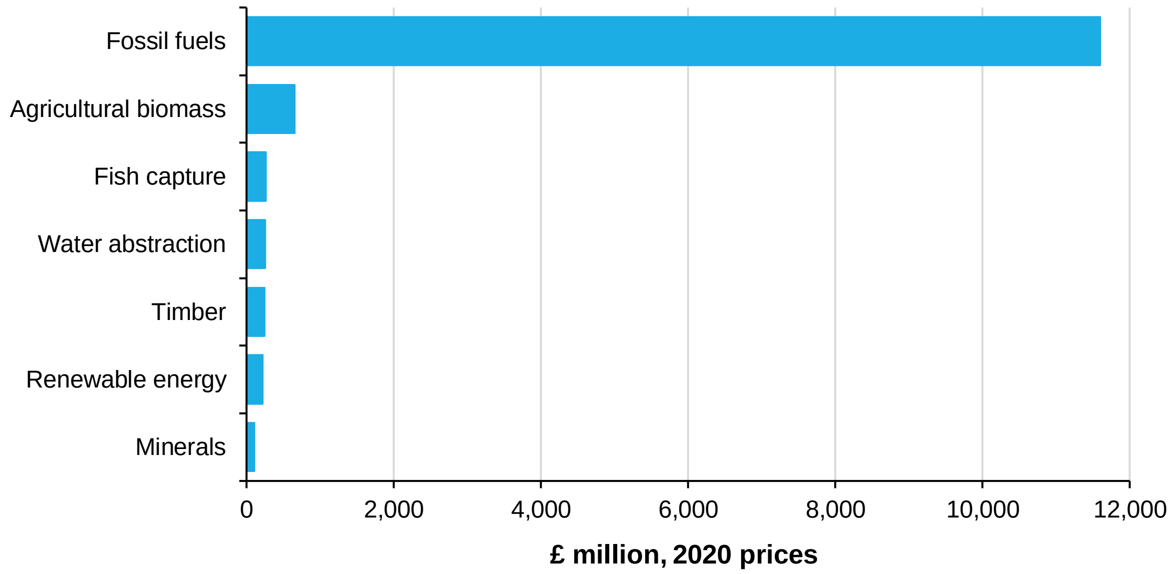
Index of provisioning services physical flow (index 2003 = 100), Scotland, 2003 to 2020



Source: Office for National Statistics, Scottish Government, European Commission: Scientific, Technical and Economic Committee for Fisheries, Forest Research and Scottish Water

Figure 2: Fossil fuels continue to dominate the annual value of the provisioning services, representing 87% of the total value in 2018

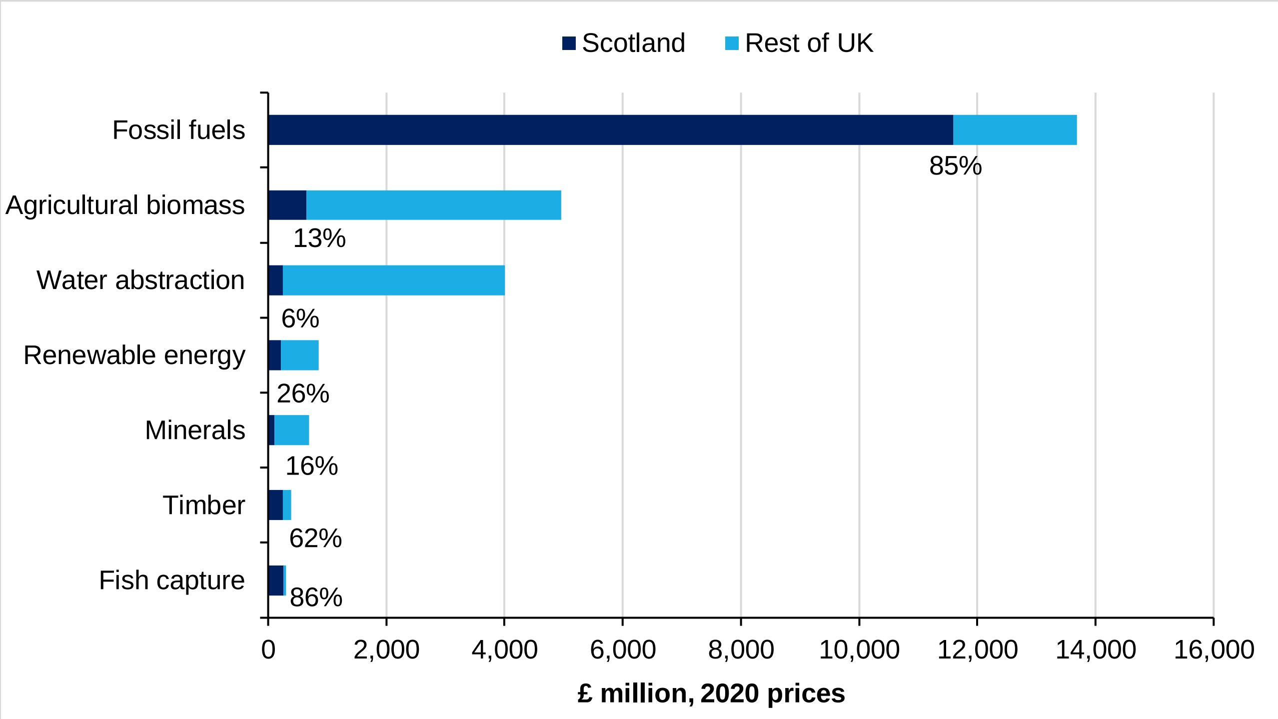
Annual value of provisioning services (£ million, 2020 prices), Scotland, 2018



Source: Office for National Statistics

Figure 3: Scotland represented 54% of the UK's provisioning service value in 2018

Aggregate annual value of provisioning services (£ million, 2020 prices), UK, 2018



Source: Office for National Statistics and Scottish Government

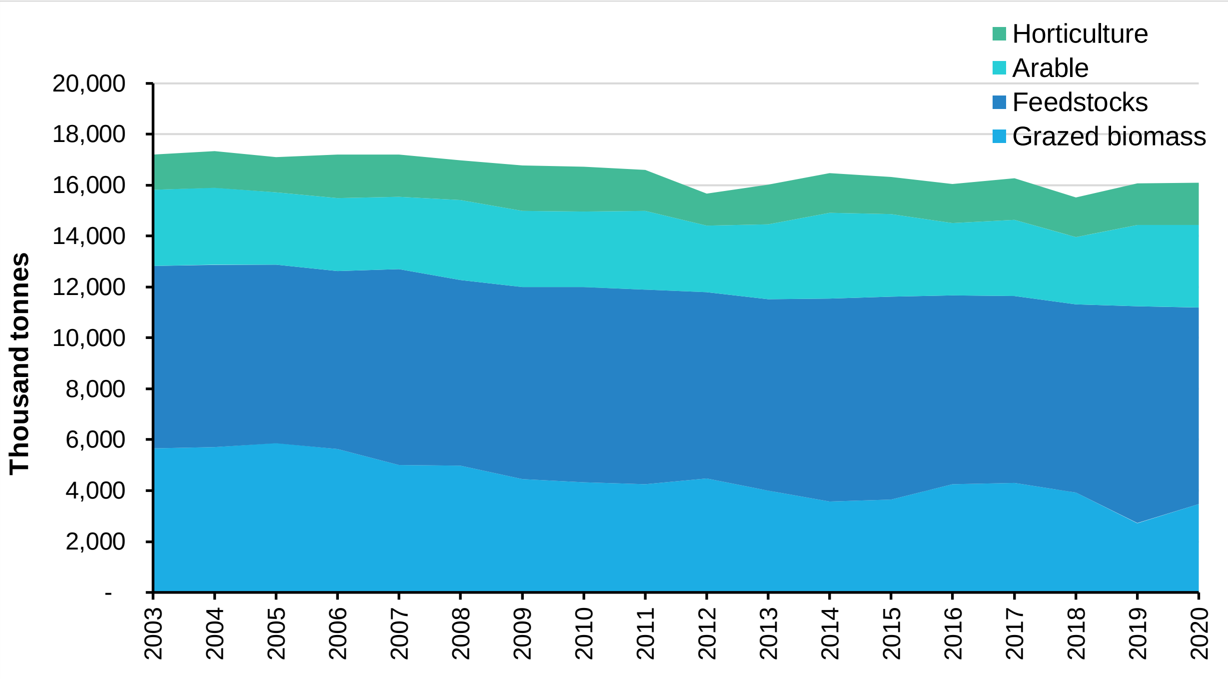
Agricultural biomass

Agricultural biomass refers to the value of crops, fodder and grazing which support Scottish agricultural production. The food eaten by farmed animals is included in this analysis; however, the farmed animals themselves are not. It is assumed that farmed animals are produced assets rather than natural assets.

In 2020, Scottish agricultural biomass rose by 0.2% from 2019, totalling 16.1 million tonnes. Since its lowest value in 2018, the total volume of agricultural biomass in Scotland has increased slightly over the past two years. The 16.1 million tonnes of agricultural biomass produced in Scotland constituted 17% of the UK's total in 2020: its highest proportion since 2007.

Figure 4: Scottish agricultural biomass has increased by 3.8% since 2018

Agricultural biomass production, thousand tonnes, Scotland, 2003 to 2020



Source: Office for National Statistics and Scottish Government

Grazed biomass and feedstocks continue to account for the majority of Scottish agricultural biomass production. Grazed biomass made up 22% of the total Scottish agricultural biomass output while feedstocks comprised of 48% of total tonnage. Although grazed biomass output is up by 27% from its 2019 total at 3.5 million tonnes, feedstocks decreased by 9% from 2019, down from 8.5 million to 7.7 million tonnes.

Arable biomass, which includes the production of wheat and barley, has increased by 1% from 2019 to equal just over 3.2 million tonnes in 2020. [The Scottish Agricultural Census 2020] reports that the area used to grow winter crops fell by 13% from 2019, most likely as the result of wet weather conditions at the start of 2020 making planting and growing difficult. Correspondingly, winter barley and wheat suffered 21% and 14% falls in output, down to 314,000 and 802,000 tonnes, respectively. However, a dry spring resulted in increased spring planting, which saw a resulting 15% increase in spring barley and 19% increase in oats production, up to 1.8 million tonnes and 224,000 tonnes, respectively.

Previous Scottish natural capital accounts have provided resource rent annual valuations using the residual value approach. This is the surplus value to the agricultural industry after all costs have been considered. Estimated at an aggregate scale, it may include non-agricultural aspects of farm businesses. As part of our development, we will look at alternative measures of capturing food production value.

Using the industry residual value, the annual value increased by 15% to £651 million in 2018. The industry residual value for 2018 is the highest since its 2004 peak, at £651 million. Farm rent remains consistent across the time series, with its 2018 value at £246 million.

Fish capture

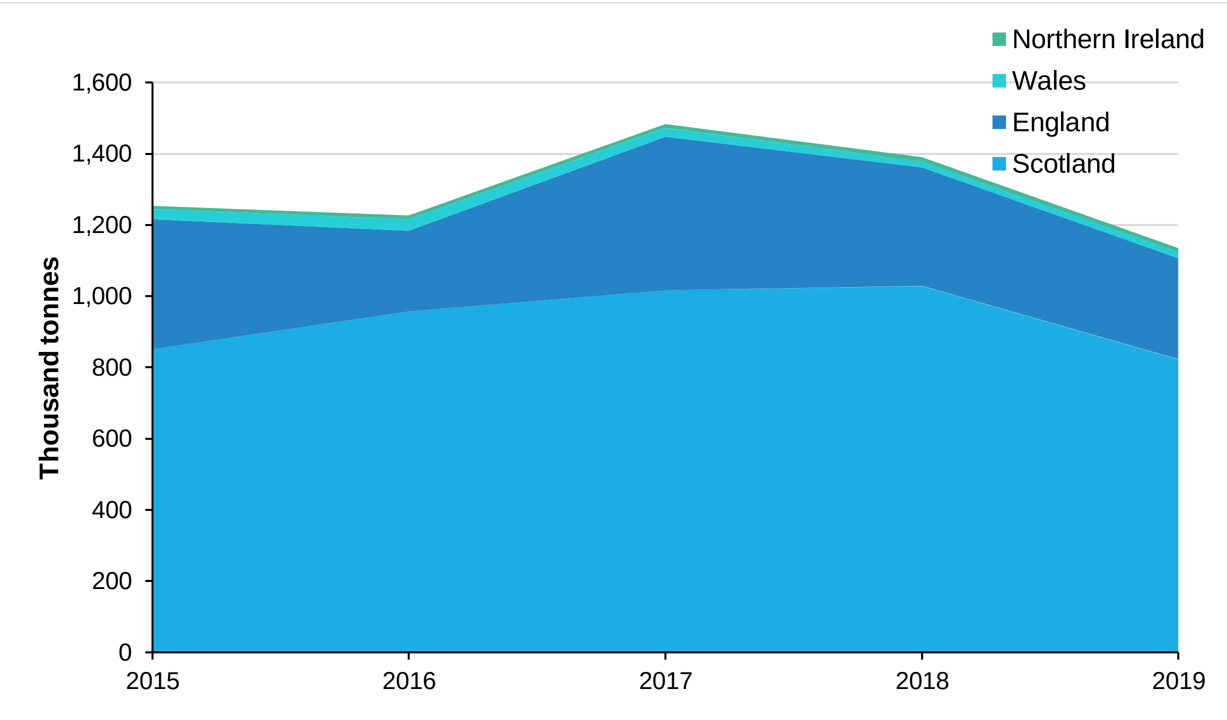
Fish capture includes the value of marine fish taken from Scottish waters. Scottish boundaries do not perfectly align with the geographical areas of fish capture statistics. For more detail on how fish capture across UK waters is estimated, see the Marine Management Organisation Exclusive Economic Zone Analysis and associated publications.

We have been working to improve our fisheries statistics and yet work is needed. We rely on a range of external sources, which all involve known uncertainties. For instance, Norway and Faroese landings are excluded from this analysis. The economic data are based on UK fleet data, which we also apply to foreign vessels that may face different costs and prices.

Aquaculture or farmed fish, like farmed livestock, have been removed from estimates as farmed fish are viewed as a produced asset and not a natural asset. For more information on the method please see the methodology section.

Figure 5: On average, 72% of fish capture tonnage came from Scottish waters between 2015 and 2019

Thousand tonnes of fish capture, UK waters, 2015 to 2019



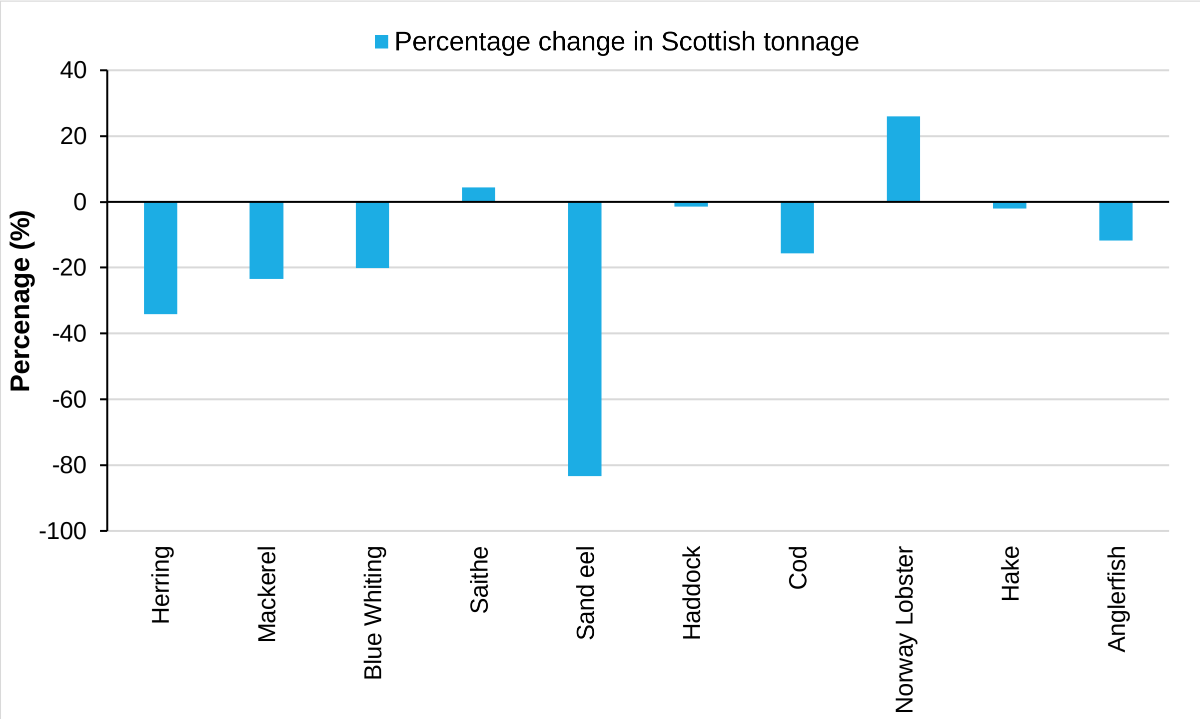
Source: Office for National Statistics, Scientific, Technical and Economic Committee for Fisheries, Seafish, Marine and Management Organisation

Scottish waters represent most of the fish capture from UK waters. The number of fish caught in Scottish waters declined by around 20% from 2018 to 2019. Prior to 2019, Scottish fish capture had not declined as much as other UK waters. However, the decline between 2018 and 2019 in fish captured in Scottish water was greater than the decline in English waters (-15%), Northern Irish waters (-6%) or Welsh waters (6%), which actually saw an increase.

A number of quota species saw a decline in their total allowable catch (TAC) between 2018 and 2019, such as the number of herring that could be caught in the North Sea falling 41%. This along with other market factors could be the reason behind the decline in the overall fish capture between 2018 and 2019.

Figure 6: Most species have seen a decline in tonnage in Scottish waters between 2018 and 2019

Percentage change in capture by species, Scottish waters, between 2018 and 2019 (shows top ten captured species in 2018)



Source: Office for National Statistics, Scientific, Technical and Economic Committee for Fisheries, Seafish, Marine and Management Organisation

Making up 56% of overall catch tonnage in 2019, the two most caught species in Scottish waters (by tonnage) were herring and mackerel. Both mackerel (23%) and herring (34%) have seen a significant decrease in the overall catch between 2018 and 2019 in Scottish and UK waters. Sand eel catches in Scottish waters have declined by over 80% and are no longer one of the 10 highest volume species caught in Scottish waters.

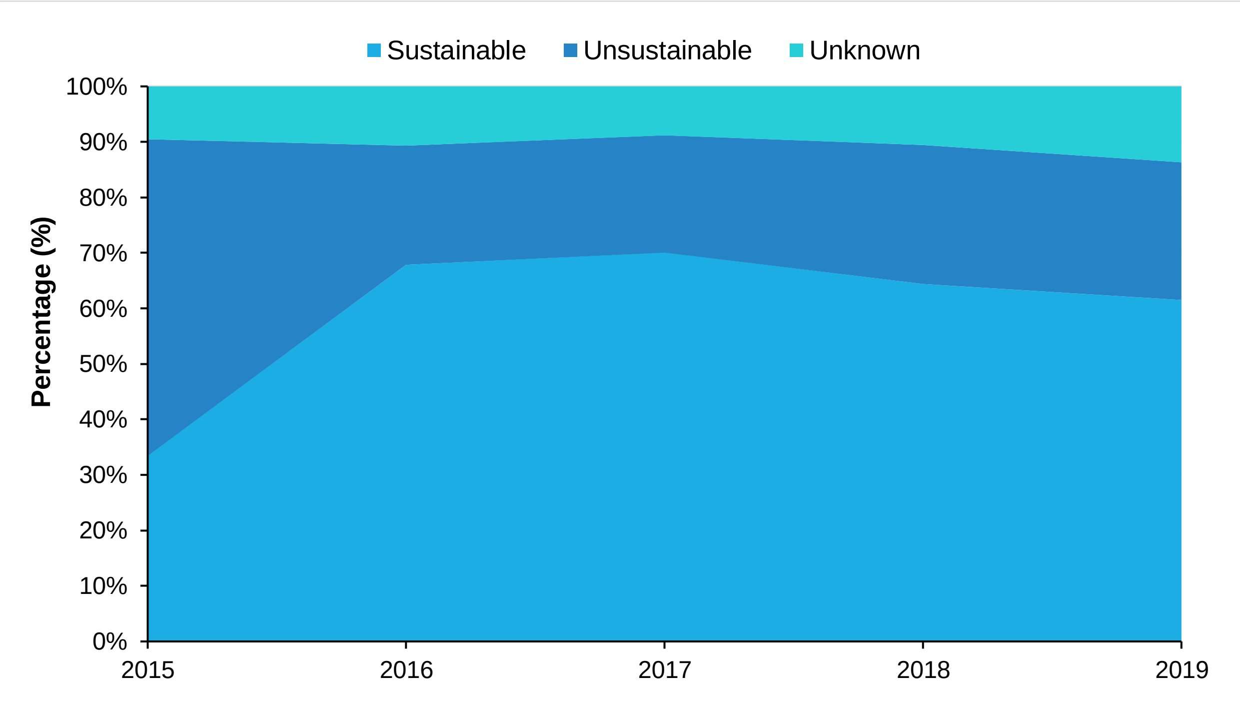
For all fish species across different areas in UK waters, we estimate whether fishing is sustainable using [The International Council for the Exploration of the Sea stock assessments](). This does not include wider externalities from fishing. For each stock we check that fishing pressure is at or below 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 Scotland, we can determine stock sustainability for 86% of the fish capture tonnage, leaving 14% as unknown.

From 2015 to 2019, the percentage of sustainable fish capture increased from 33% to 62%. The percentage of fish caught, where sustainability is unknown, increased from 10% in 2015 to 14% in 2019. Within this time series, the largest year-on-year improvement in sustainable fishing occurred from 2015 to 2016, as a result of mackerel fishing becoming sustainable.

However, there was a fall in the proportion of fish that are sustainably caught in Scottish waters between 2018 and 2019 from 64% to 62%. This is partly due to a fall in the proportion of Norway lobsters that are caught sustainably from almost 100% in 2018 to only 40% in 2019. All mackerel landed and 99% of herrings landed in 2019 were caught sustainably in 2019. However, less than 1% of cod, blue whiting, edible crabs, anglerfish, lobster or saithe were caught sustainably in 2019.

Figure 7: In 2019, 62% of Scottish fish capture was sustainable

Percentage of Scottish fish capture that is sustainable, unsustainable and fish capture where sustainability is unknown, Scotland, 2015 to 2019

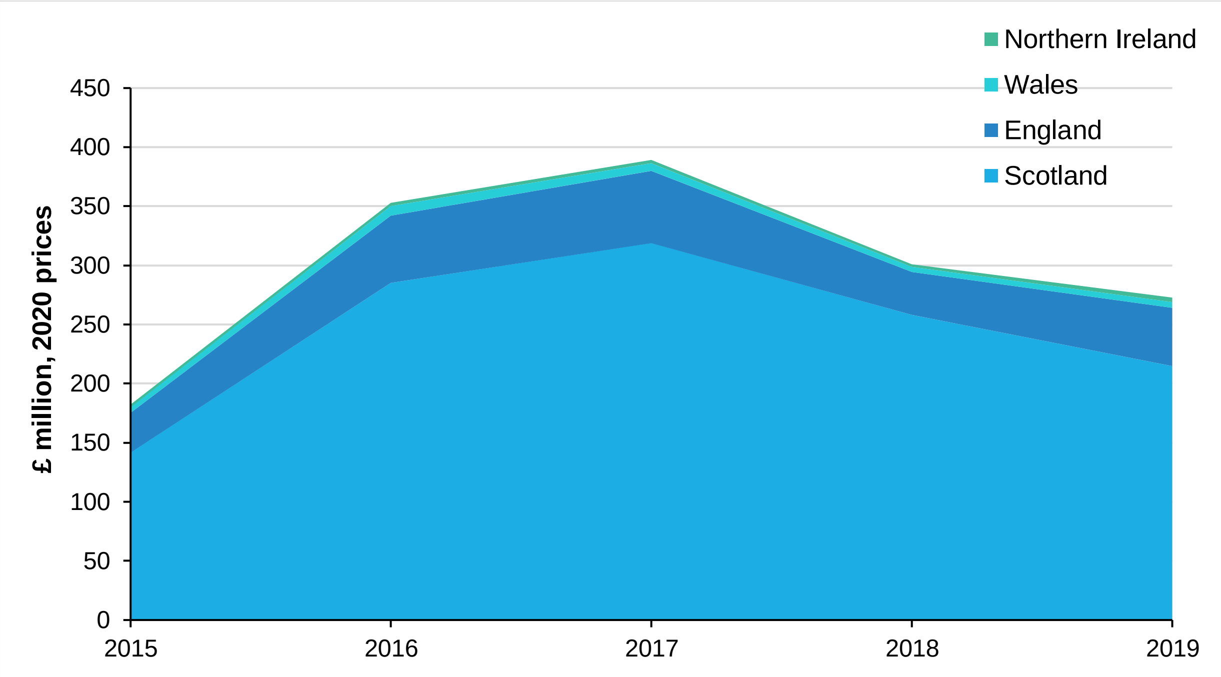


Source: Office for National Statistics, Marine Management Organisation, Seafish, Scientific, Technical and Economic Committee for Fisheries and The International Council for the Exploration of the Sea

The value of fish capture is calculated using net profit per tonne (landed) estimates, provided by Seafish, for different marine species. Across the period 2015 to 2019 an average of 95% of the fish capture by tonnage had profit data.

Figure 8: Scottish fish capture provisioning value dropped 19% from 2017 to 2019, mainly due to a drop in the net profit of herring and mackerel

Net profit from fish capture (£ million, 2020 prices), UK waters, 2015 to 2019



Source: Office for National Statistics, Scientific, Technical and Economic Committee for Fisheries, Seafish, Marine and Management Organisation

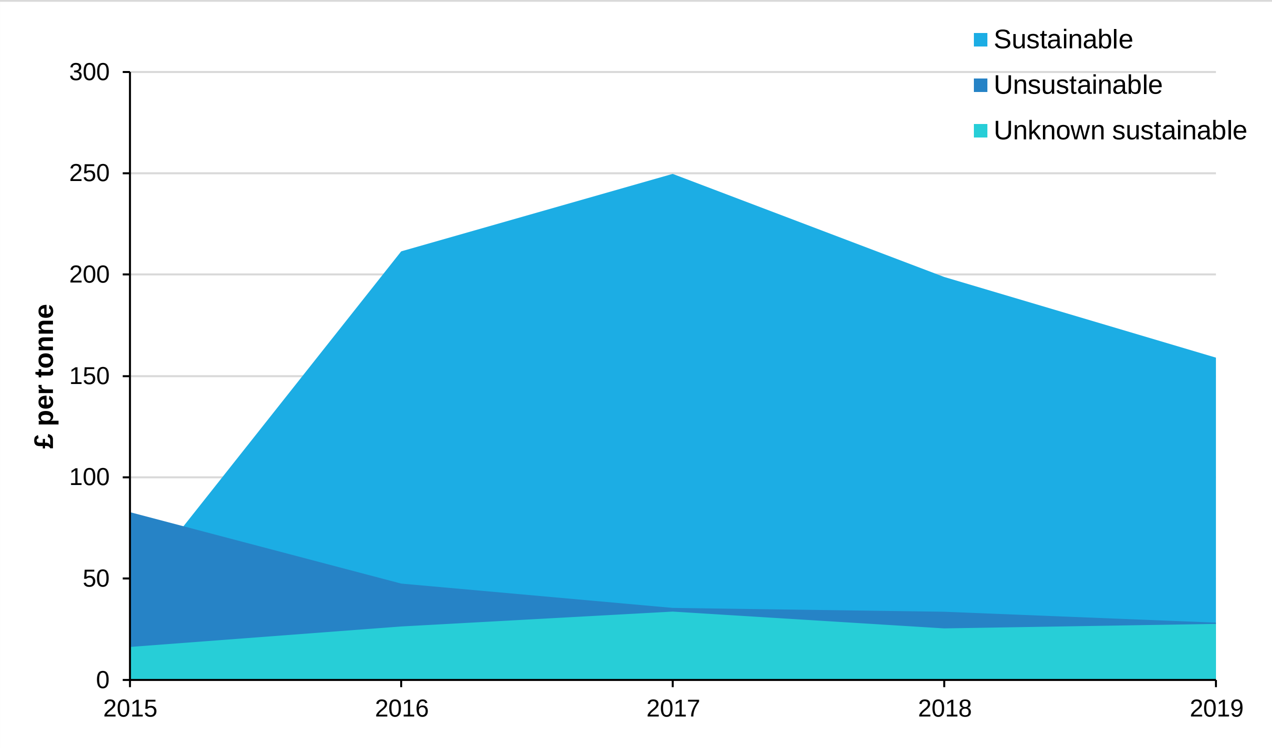
The net profit of both mackerel and herring fell by 24% between 2018 and 2019. However, Scottish waters represent even more of the UK by net profit than by tonnage as fish stocks are on average more profitable per tonne in Scotland (£261) than in the UK (£240). The contribution of Scottish waters toward overall net profit has grown year-on-year between 2015 and 2018 from 75% to 86%. However, the proportion of profitability has dipped in 2019 (79%) compared to 2018 (86%) due to the declining volume of profitable fish in Scottish water such as mackerel and herring.

The value of Scottish fish capture provisioning services was £215 million in 2019, with an asset value of £5.7 billion.

In 2019, 74% of the value of fish capture from the Scottish EEZ was sustainable — around £159 million of £215 million. In 2019, 13% of Scottish landed fish value came from unsustainably sourced fish and 13% came from landed fish where sustainability is not known.

Figure 9: Sustainable fish capture is making up more of the catch value

Value of landed Scottish sustainable fish, unsustainable fish, and fish with unknown sustainability (£ million, 2020 prices), Scotland, 2015 to 2019



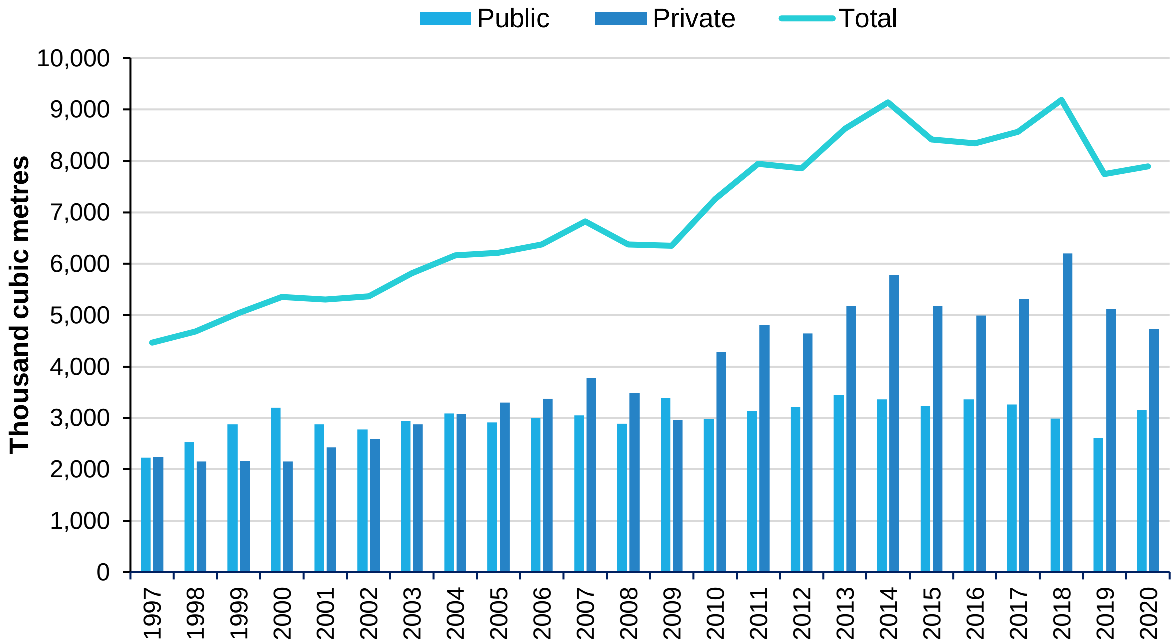
Source: Office for National Statistics, Marine Management Organisation, Seafish, Scientific, Technical and Economic Committee for Fisheries and The International Council for the Exploration of the Sea

Timber

The total volume of timber production in Scotland has increased by 9% from 2010 to 2020. In 2020, nearly two-thirds of Scottish timber were produced by the private sector, increasing from around 40% of timber production 20 years prior. Across the time series, most of the timber production is softwood from coniferous trees such as spruce, pine and larch, which generally grow faster than hardwood species of broadleaved trees such as oak, birch and beech.

Figure 10: Private timber production was 50% greater than public timber production in 2020

Total fellings of overbark in thousand cubic metres, public and private, Scotland, 1997 to 2020

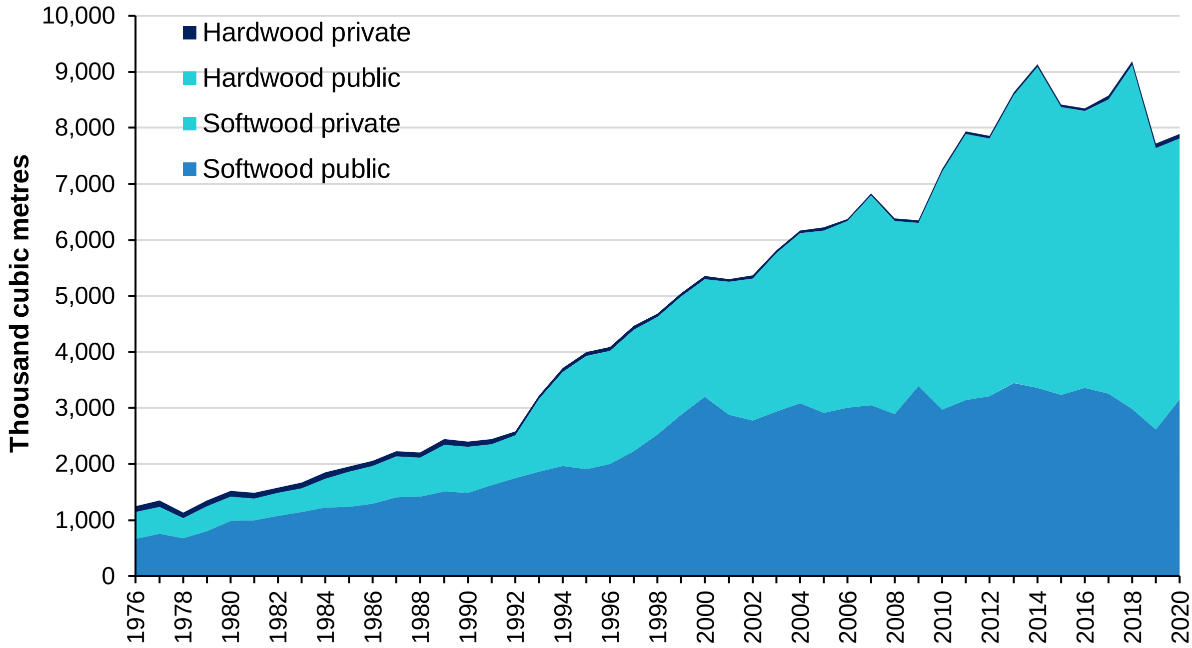


Source: Forest Research

An individual hectare of forest plantation that exclusively produces timber may not continuously provide a full range of additional ecosystem services. For example, once trees are felled, they cease to capture pollutants from the air. Following replanting, the carbon sequestration services provided by younger trees will be lower than for older growth. Some of the fellings store carbon longer term, for instance, in timber used for building material, while other carbon may be released into the atmosphere when wood is burned for heat or energy generation.

Figure 11: Overall hardwood and softwood production increased in 2020

Timber production (thousand cubic metres overbark), Scotland, 1976 to 2020



Source: Forest Research

Notes:

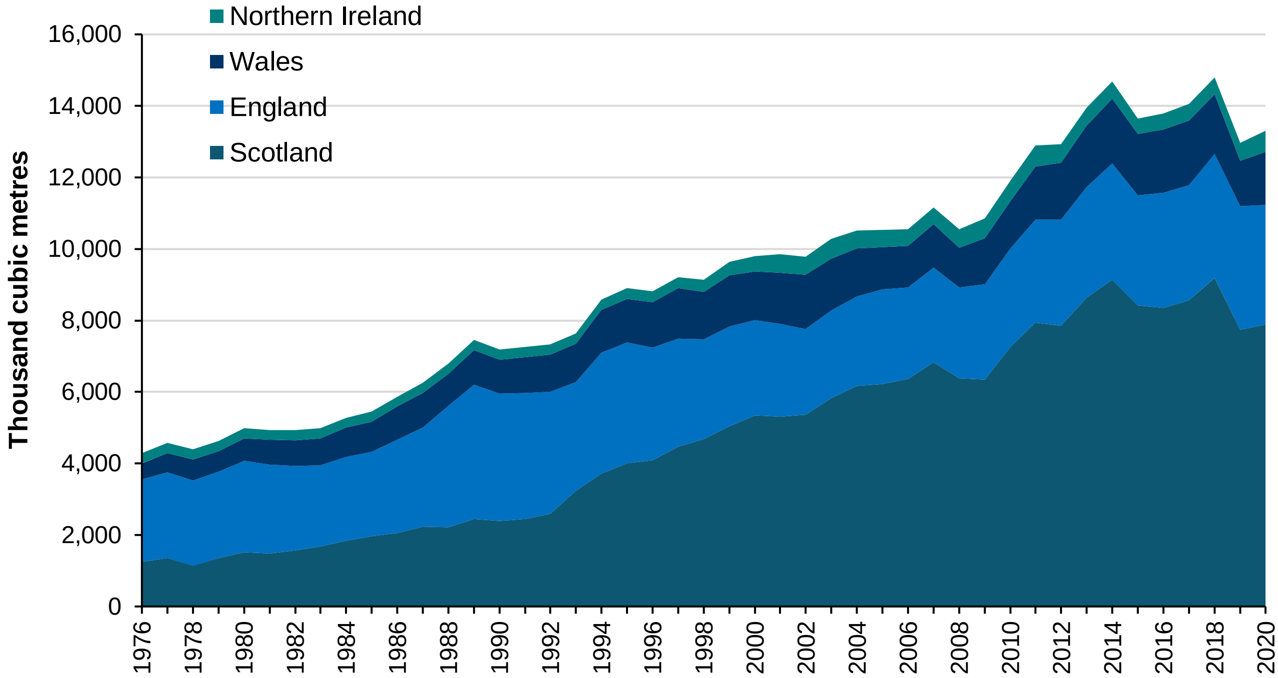
1. Public refers to Forestry and Land Scotland

Softwood production peaked in 2018 at 9,116,000 metres cubed of overbark (m^3) but has since dropped by 14% to 7,815,000 m^3 in 2020. Overall, hardwood production has increased in recent years. However, in 2020 hardwood production dropped marginally by 1% from its highest total in 2019, with 74,437 m^3 produced.

Relative to the rest of the UK, Scotland's timber production has increased substantially in recent decades. Scotland represented 59% of UK timber production in 2020, increasing from 55% in 2000 and 33% in 1990. Scottish forests make up 46% of the woodland area in the UK.

Figure 12: In 2020, all UK countries saw an increase from their 2019 timber production

Timber production (thousand cubic metres overbark), UK, 1976 to 2020



Source: Forest Research

The stumpage price is the price paid per standing tree for the right to harvest timber from a given area and is used to calculate the overall valuation for timber services.

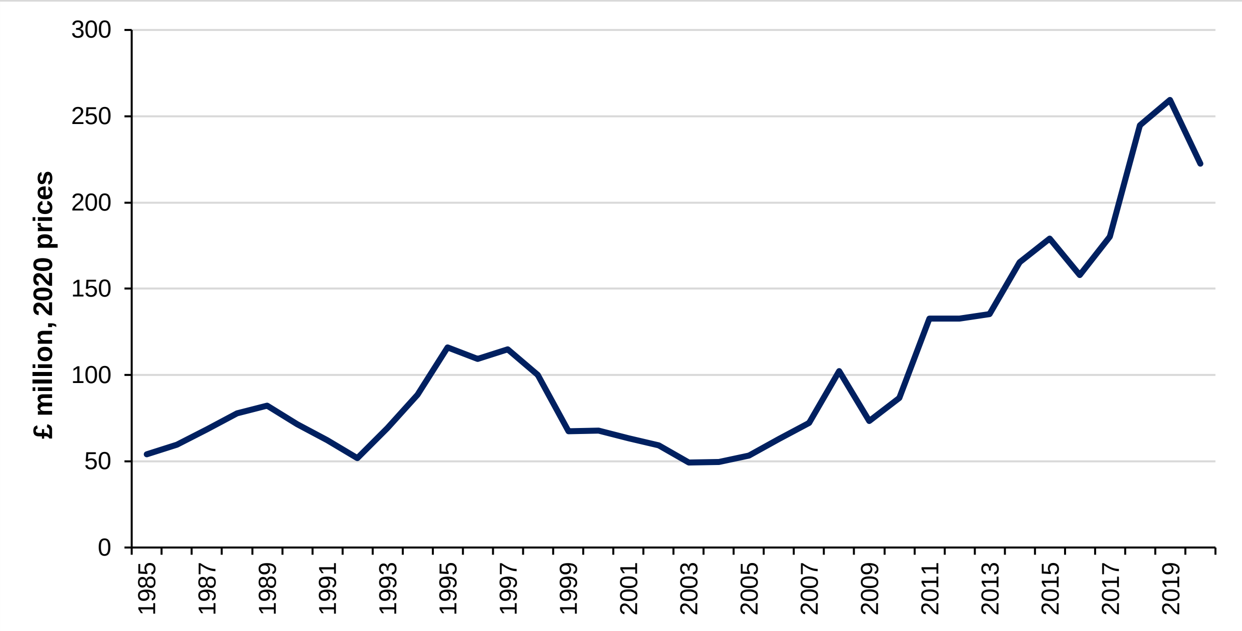
The timber provisioning service valuation has increased by 156% over the last decade, from £87 million in 2010 to £223 million in 2020. The increase in the annual valuation has been driven by a 9% increase in production and a 136% increase in stumpage price for the same period.

Although overall timber production in Scotland increased by 2% in 2020, Figure 13 shows a decline in annual value for the same period. This is due in part to a 16% decrease in stumpage price, down from £33.50 in 2019 to £28.22 in 2020.

However, it is worth pointing out that the September 2021 stumpage price has already recovered to £40.12 per cubic metre (2020 prices); so, while stumpage prices have risen reasonably steadily over the 15 years prior to 2019, prices have fluctuated more dramatically in recent years.

Figure 13: Timber production in 2020 increased from 2019, but a decline in stumpage price has reduced the service's provisioning valuation

Timber provisioning annual value (£ million, 2020 prices), Scotland, 1985 to 2020



Source: Office for National Statistics and Forest Research

Scotland's forestry strategy states that between 2030 and 2050 there will be a decline in softwood availability, mainly due to the uneven age structure of the forest estate following high levels of planting prior to the 1990s. Scotland contributed 80% of the UK's new planting in 2020. Of the 49,500 hectares of new planting in Scotland between 2010 and 2020, 64% of this new planting was softwood (conifers) and 36% was hardwood (broadleaved).

Current and historic planting data informs forecasts of timber production, which we use to estimate the value of the timber provisioning service in the future. In 2020, the asset value of Scottish timber was £8.1 billion, contributing 61% towards the total UK value of £13.1 billion.

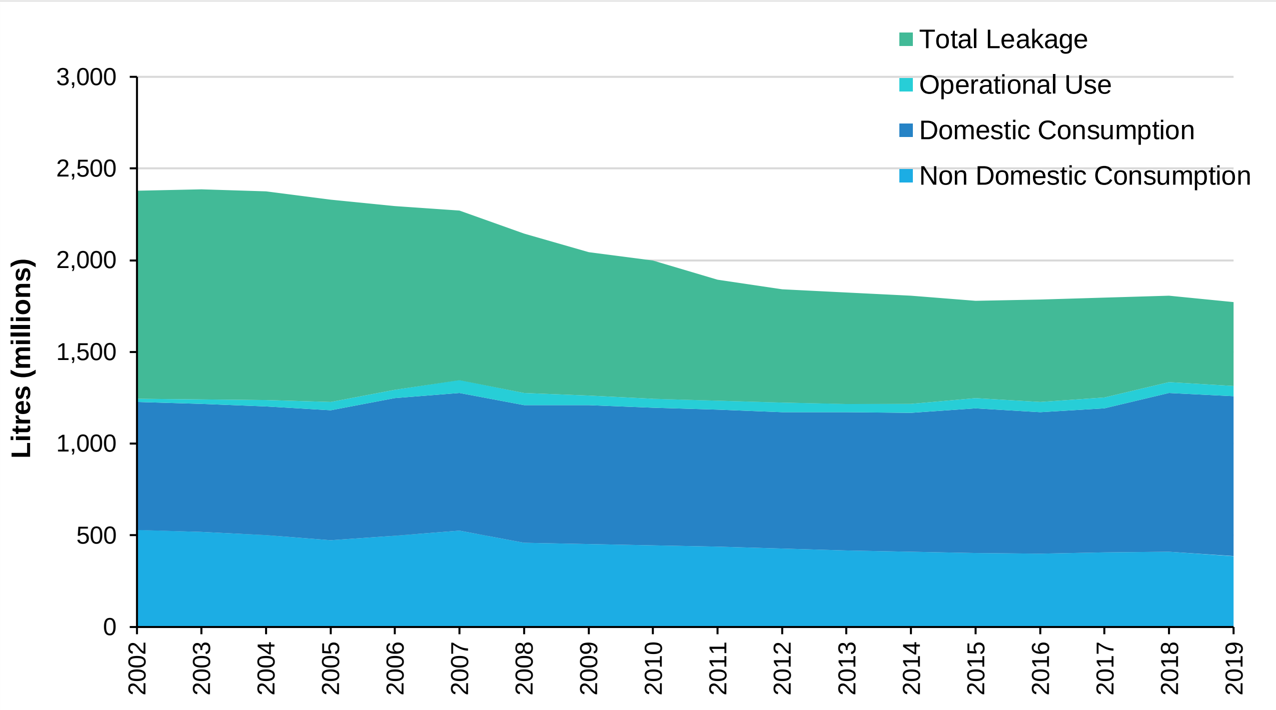
Water abstraction

Water abstraction is the process of taking water from a surface source (such as a river, stream or canal) or from an underground source. Total water abstraction for public water supply between 2002 and 2019 has decreased by 25%, from 912 million to 683 million cubic metres, primarily due to a reduction in demand in water caused by less leakage. Of all water abstracted, on average 96% became treated water.

As illustrated in Figure 14 below, the greatest proportional change of treated water since 2002 has been in water leakage. Whereas water abstracted for domestic consumption, non-domestic consumption and operational use has remained relatively constant, leaked water has decreased substantially by 60% from 1,132 million to 454 million litres in 2019.

Figure 14: Scottish water abstraction has fallen across the time series, due mainly to fewer leakages

Treated water produced, million litres, Scotland, 2002 to 2019

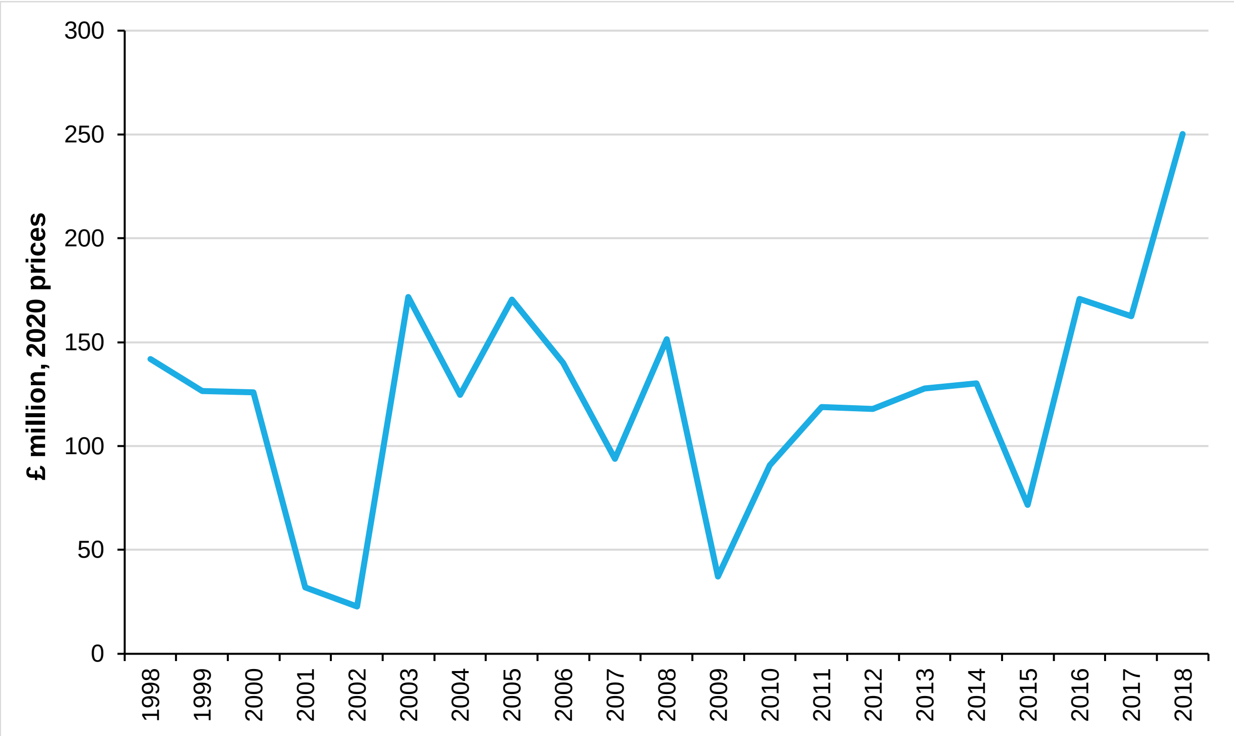


Source: Scottish Water

We derive monetary estimates of the water abstraction provisioning service from industry level data on the collection, treatment, and distribution of water for domestic and industrial needs. This valuation varies year-on-year but was estimated to be £250 million in 2018 (see Figure 15), up 54% from 2017, which is 6% of the UK annual value.

Figure 15: The water abstraction annual value has more than doubled since 2015

Water abstraction annual value (£ million, 2020 prices), Scotland, 1998 to 2018

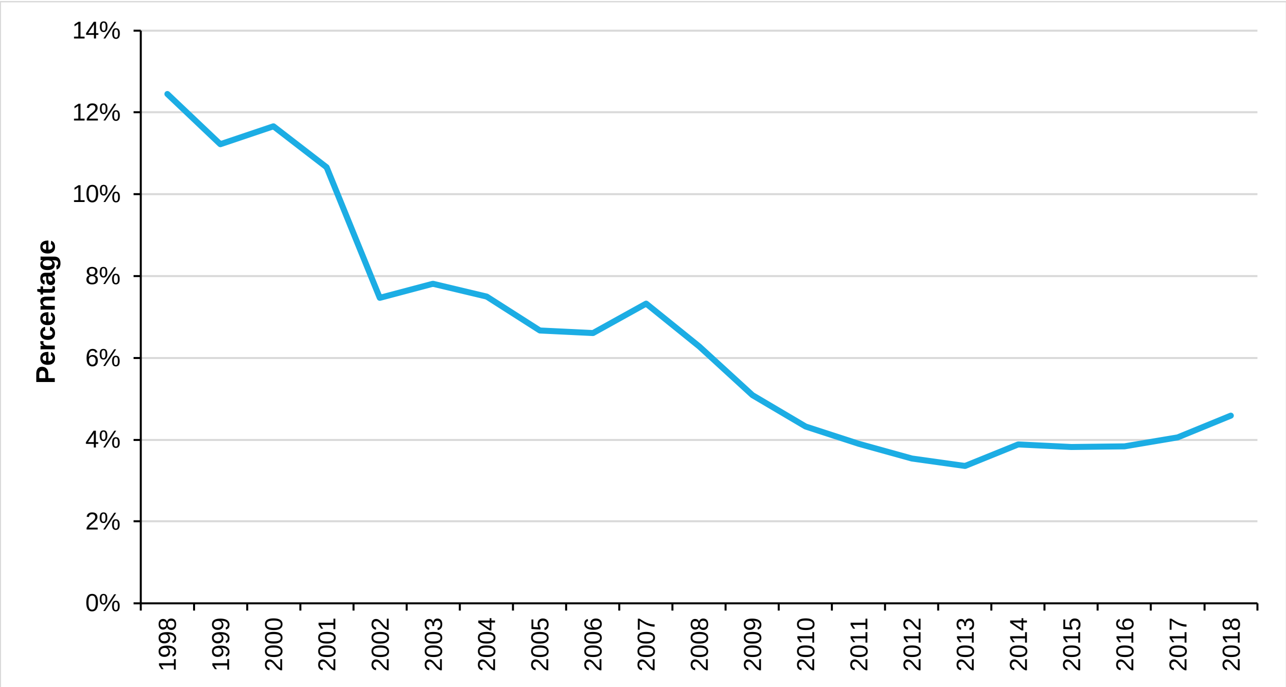


Source: Office for National Statistics and Scottish Water

In 2018, the asset value of Scottish water abstraction was £4.7 billion, representing an 18% increase from 2017. The Scottish contribution to the UK asset value has reduced by 63% since the beginning of the time series. In 1998, Scottish water abstraction made up 12% of the UK asset value but has since fallen to 5% two decades later in 2018. This appears mainly due to Scotland's much larger reduction in leakage than other areas of the UK.

Figure 16: Scottish proportion of UK water abstraction asset value has fallen by nearly two-thirds since 1998

Proportion of UK asset value (%), Scotland, 1998 to 2018



Source: Office for National Statistics

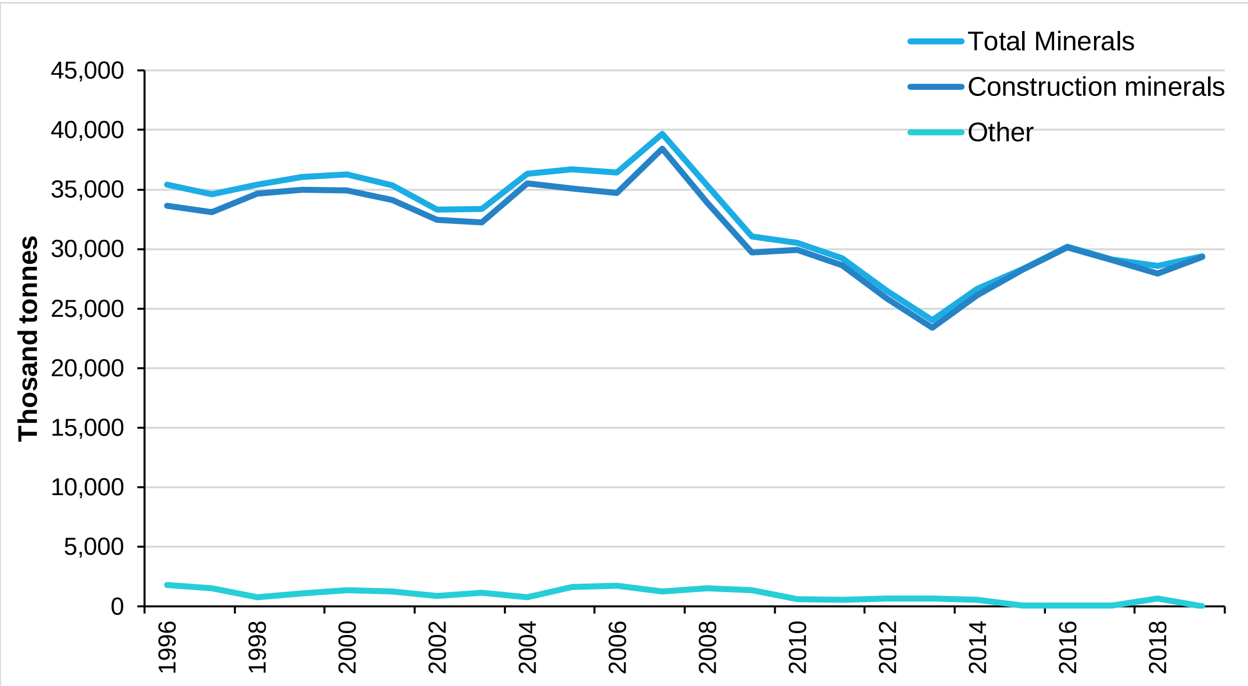
Minerals

Mineral extraction in Scotland in 2019 stood at 29,366 thousand tonnes, this was a 3% increase on the amount extracted in 2018. In 2019, Scotland accounted for 13.9% of all minerals extracted in the UK. The amount of minerals extracted in the UK as a whole actually decreased by 3% between 2018 and 2019.

The vast majority of minerals extracted in Scotland are construction minerals, which accounted for 99.9% of all minerals extracted in 2019. This is slightly more than the UK where 96% of minerals extracted were construction minerals.

Figure 17: Mineral extraction in Scotland is almost completely construction minerals

Construction mineral extraction, Scotland, 1996 to 2019



Source: British Geological Survey

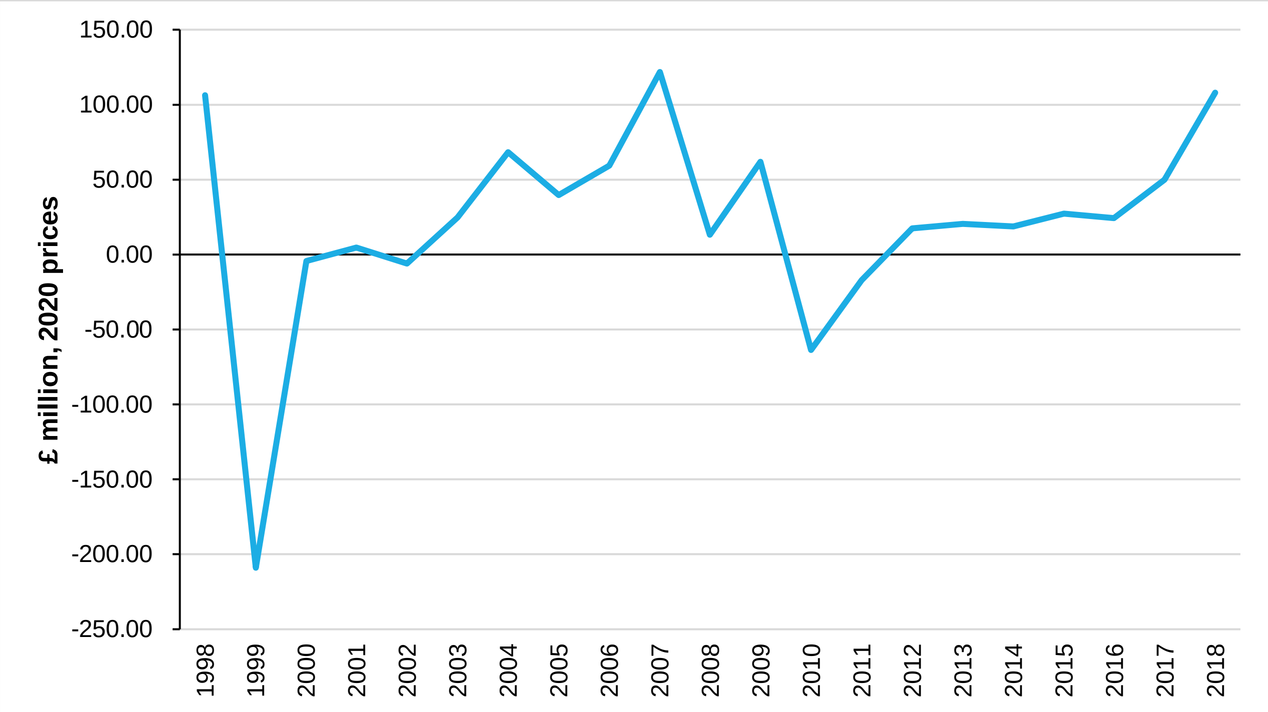
Notes:

1. Construction minerals include sand and gravel, slate, igneous rock, limestone and dolomite, and sandstone.
2. Other minerals include barytes, fireclay, honestone, peat, silica sand, talc, and clay and shale.

Construction materials are used in house building and infrastructure projects. In 2019, the number of houses built in Scotland increased by 10% which accounted for the increase in construction minerals being produced.

Figure 18: Mineral provisioning value increased by £58 million in 2018

Annual value of mineral extraction (£ million, 2020 prices), Scotland, 1998 to 2018



Source: Office for National Statistics

Using the resource rent approach (see Methodology section), the annual value of mineral provisioning fluctuated between 1998 and 2018. There are costs incurred for making use of natural resources, and in 1999 and 2010 these estimated costs outweighed income from the extraction of minerals. In 2018, the annual value increased to £108 million.

Unstable valuations of the mineral production abiotic provisioning service, along with years of negative gross operating surplus for the minerals industry in the UK national accounts, do not lend well to valuation comparisons between the UK and Scotland. Data inputs and methods will be reviewed in future accounts.

Fossil fuels

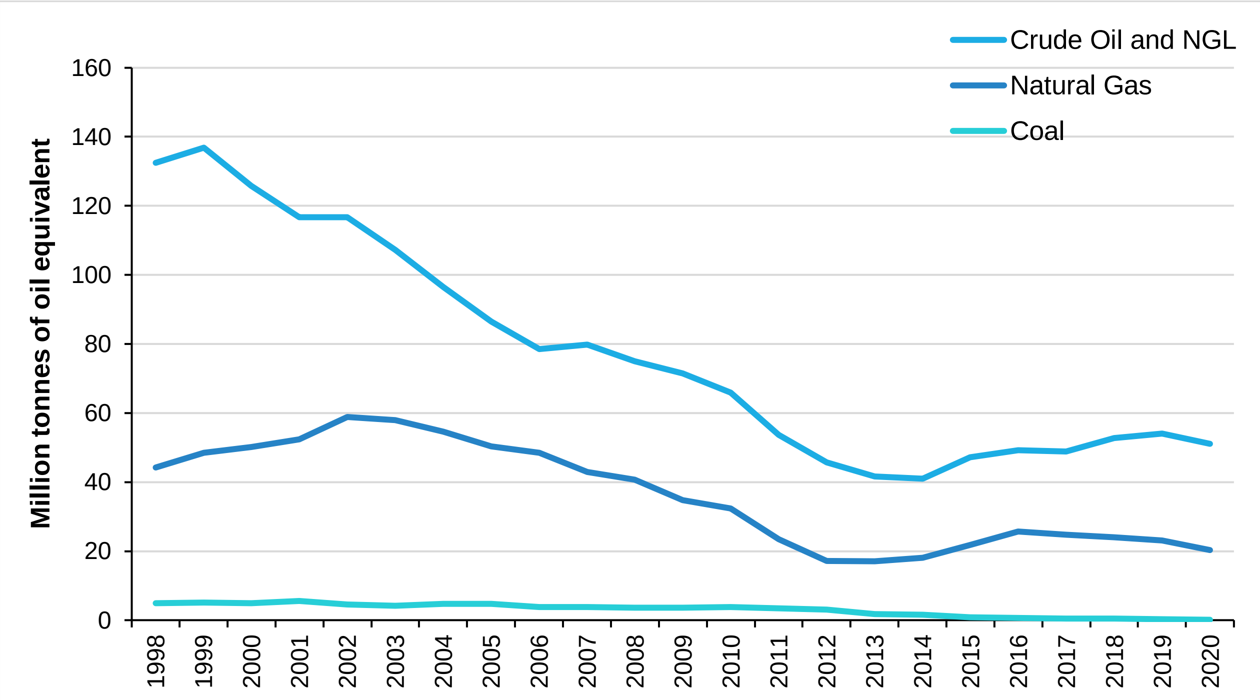
Fossil fuels include crude oil and natural gas liquids (NGL), natural gas and coal. Fossil fuel production has declined by 62% between 1999 and 2020. Crude oil and NGL production have declined by 63%, natural gas production has declined by 58% and coal has declined by 97%.

Scottish production of crude oil and NGL peaked in 1999 with 136.9 million tonnes of oil equivalent, before declining steadily to 41 million tonnes in 2014. It has since rebounded slightly, with production steadily increasing in most years after 2014. However, in 2020 crude oil production fell by 6% compared to 2019.

Natural gas production has declined since 2016 falling by 12% between 2019 and 2020. Coal's significance has declined in the last 20 years from 3% of all fossil fuels produced in 1999 to only 0.2% in 2020. The year 2020 also saw the closure of the last coal mine in Scotland.

Figure 19: Across the time series, crude oil and natural gas liquids production has fallen by 63% and 58%, respectively

Fossil fuel production, million tonnes of oil equivalent, Scotland, 1998 to 2020



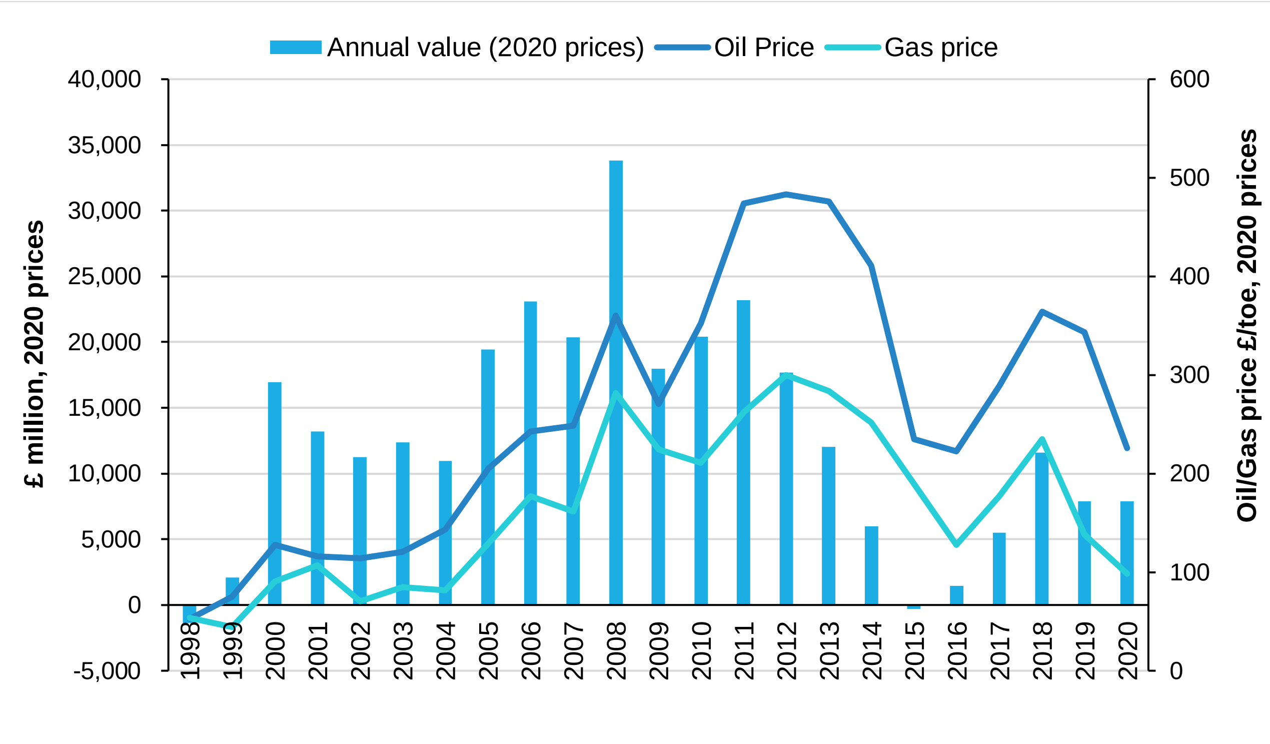
Source: Oil and Gas Authority and Department for Business, Energy, and Industrial Strategy

The majority of the UK production of both crude oil & NGL (97%) and natural gas (61%) comes from Scotland. The crude oil and natural gas proportions have been relatively stable over the last 10 years.

While the general trend shows lasting production shifts, the annual value of fossil fuel abiotic provisioning fluctuates year-on-year, driven largely by oil and gas price changes. The Brent crude oil price was on average 34% lower in 2020 compared to 2019.

Figure 20: Fossil fuels annual value varies with oil and gas prices, reaching a peak in 2008 at £33.8 billion

Fossil fuels' annual value (£ million, 2020 prices), Scotland, 1998 to 2020 and Gas/Oil prices, £/toe, 2019 prices, 1998 to 2020



Source: Oil and Gas Authority and Department for Business, Energy, and Industrial Strategy

The Scottish fossil fuels provisioning service annual value was £7.9 billion in 2020.

This uses a resource rent approach which estimates the residual remaining to the extractor after all costs and normal returns are considered. This is closely related to profitability. The details of the methodology used to estimate the value of fossil fuels can be found in the methodology section.

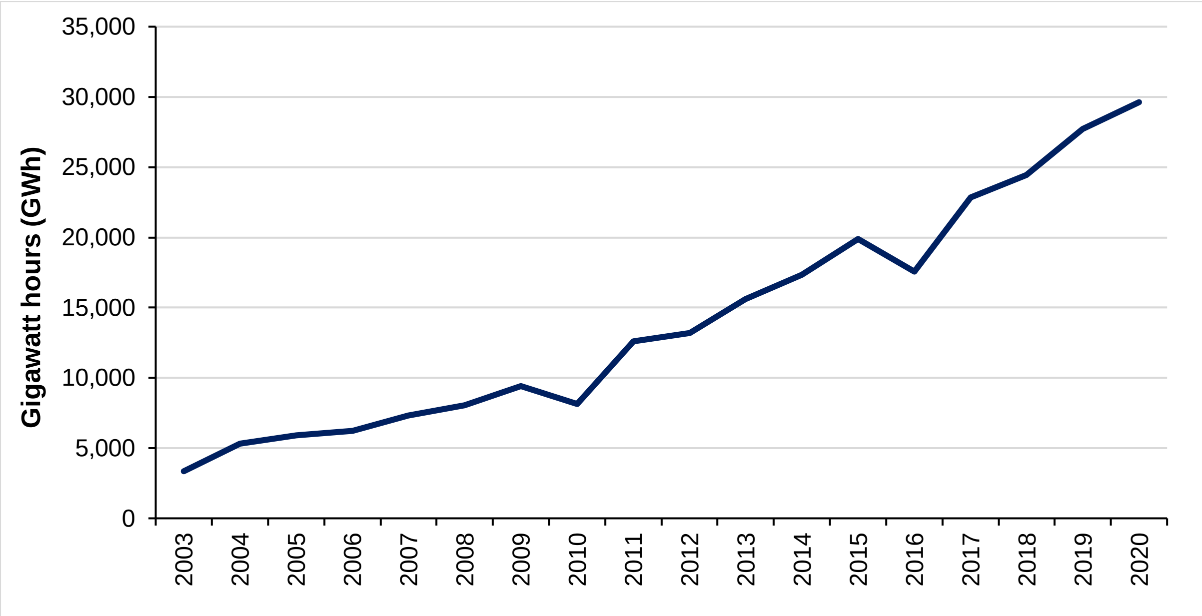
Resource rent is different from an intrinsic measure of value, such as the wholesale price determined by the market or the value it provides to the economy in terms of economic output (i.e., gross value added). Resource rent does not value government receipts, employment, supply chain activity or energy security as benefits.

Renewable electricity generation

Scotland's electricity generation from renewable sources has increased by 7% from 2019 to 2020. Since 2016 where renewables' output dropped by 12% from the previous year, Scottish renewable electricity generation has seen year-on-year growth. Since 2003 Scottish renewables have increased by 784%, up from 3,351 gigawatt hours (GWh) to a record of 29,626 GWh in 2020.

Figure 21: Scottish generation from renewable sources is 8 times larger in 2020

Electricity generated from renewable sources, gigawatt hours, Scotland, 2003 to 2020



Source: Department for Business, Energy and Industrial Strategy

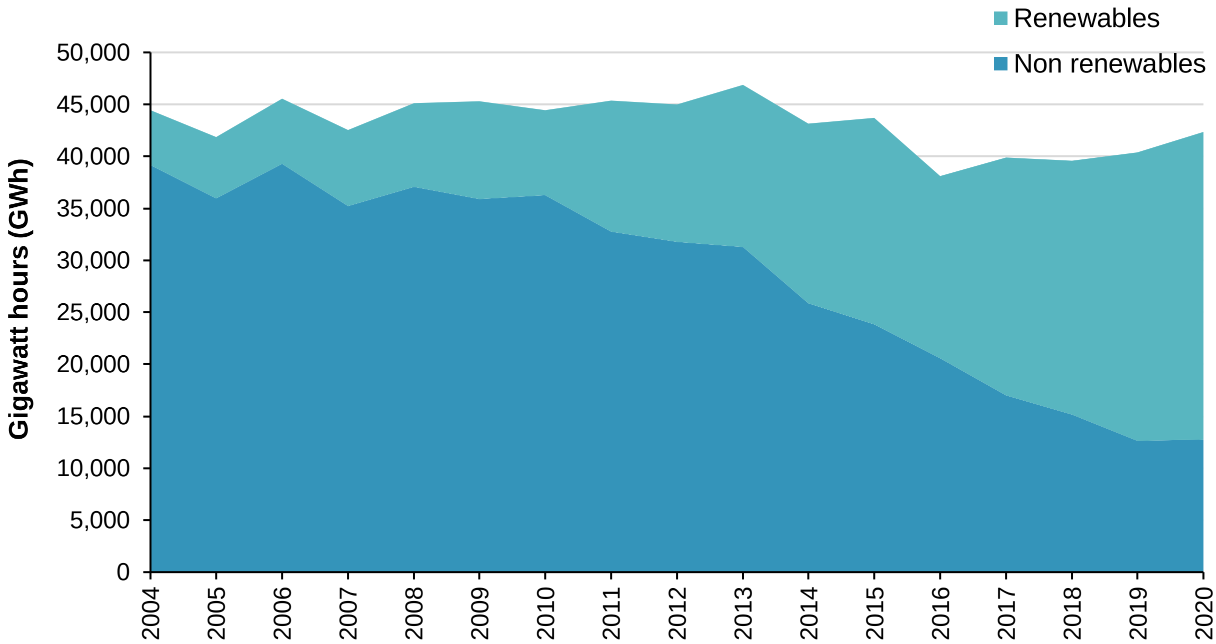
Notes:

1. Renewable electricity generation includes hydro, wind, wave and tidal and solar PV.
2. Generation from "other sites" is not included. "Other sites" are sites that have not been attributed to a region so that data related to individual companies are not disclosed.

Over the time series, although there has been a slight reduction of 5% in the total electricity generation in Scotland, there has been a 457% increase in renewable energy generation. The increase in renewable outputs coincides with a 68% reduction of the contribution on non-renewable sources such as coal, oil and gas (Figure 22).

Figure 22: The proportion of renewable electricity generation continues to increase

Electricity production generation from renewable and non-renewable sources, gigawatt hours, Scotland, 2004 to 2020



Source: Department for Business, Energy and Industrial Strategy

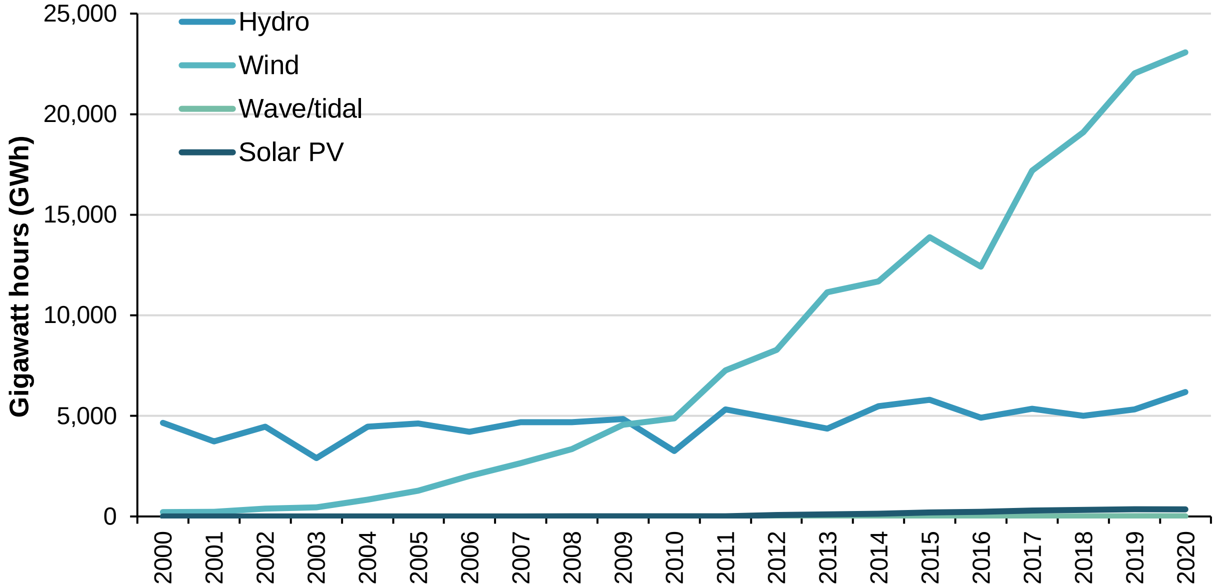
Notes:

1. Renewables include wind, hydro, solar PV and wave and tidal.
2. Non-renewables include coal, oil, gas, nuclear, other thermal, hydro, pumped storage, and non-biodegradable waste combustion.
3. Non-renewable generation only includes generation from Major Power Producers (MPPs).
4. Renewable generation from "other sites" is not included. “Other sites” are sites that have not been attributed to a region so that data related to individual companies are not disclosed.

Scotland’s contribution to UK renewable energy provisioning decreased from 76% in 2003 to 31% in 2020. This is because hydropower, which is largely in Scotland, was historically the largest renewable electricity generation source in the UK. Although its generation has remained stable, with other renewables’ growth it now represents a minority of UK renewable generation.

Figure 23: Wind continues to lead as the greatest contributor to Scottish renewable energy

Electricity generation from renewables, gigawatt hours, Scotland, 2000 to 2020



Source: Scottish Government and Department for Business, Energy and Industrial Strategy (DUKES)

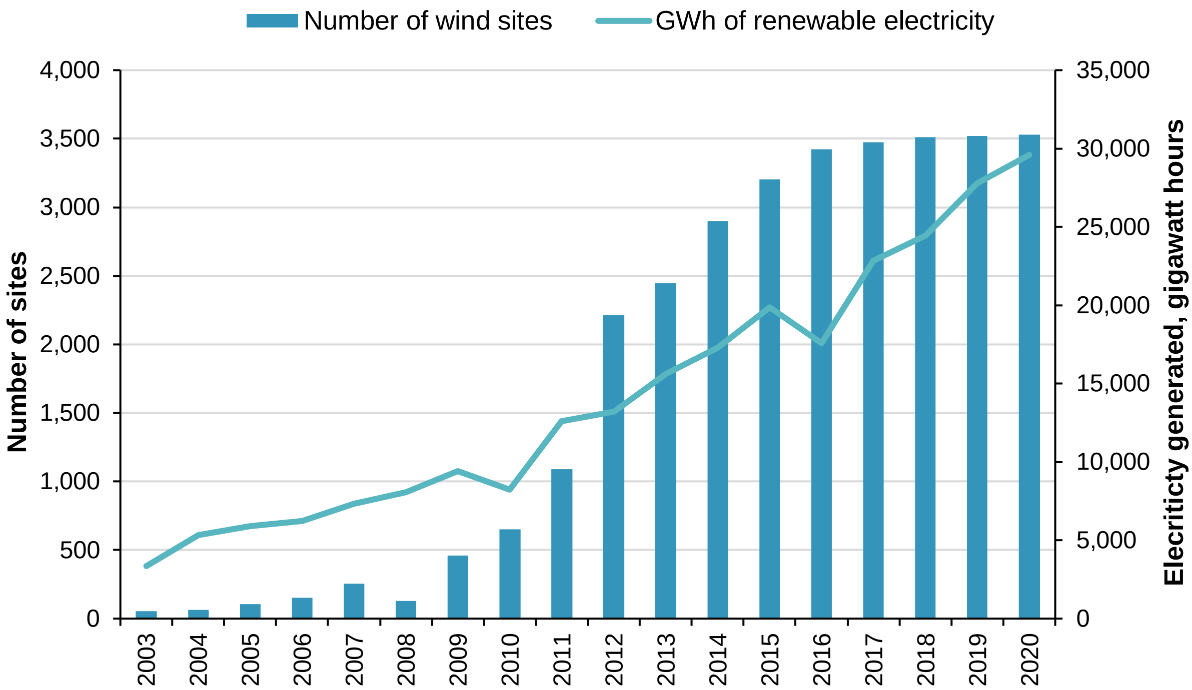
Notes:

1. Electricity generation from renewables excludes landfill and sewage gas, other bioenergy, anaerobic digestion, and biomass and waste.
2. Generation from "other sites" is not included. “Other sites” are sites that have not been attributed to a region so that data related to individual companies are not disclosed.

Of all renewable electricity generation in Scotland, wind contributed more than all other sources at 78% in 2020. Before 2010, Scottish hydropower was the long-running main contributor to electrical output. Since then, however, wind generation has become the largest single contributing renewable electricity source. Currently, there are over 27 times the number of wind electricity generation sites than in 2008, producing 23,075 GWh in 2020.

Figure 24: The number of wind sites and electricity they produce are at their highest levels

Wind generation from renewables and number of wind sites, gigawatt hours, Scotland, 2003 to 2020



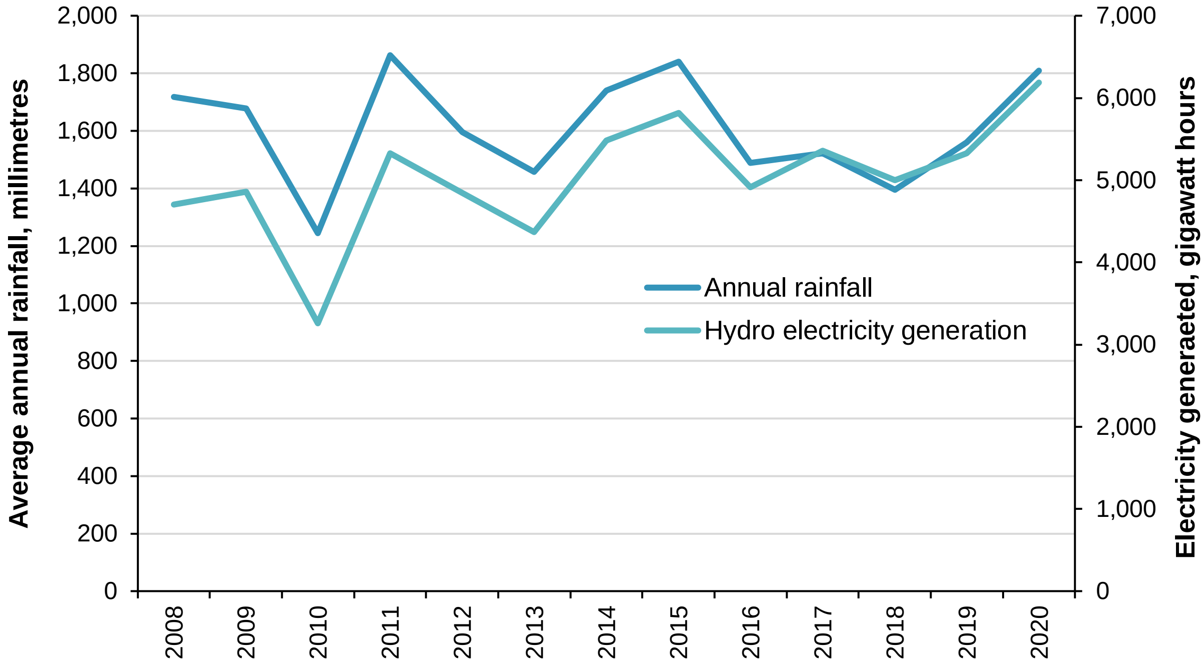
Source: Scottish Government and Department for Business, Energy and Industrial Strategy (DUKES) and Department for Business, Energy and Industrial Strategy (BEIS)

Hydroelectricity generation was the next largest renewable energy source in Scotland in 2020, contributing 6,187 GWh, or 21% of the year's total. This is an increase of 16% from the previous year; the greatest proportional growth of any renewable energy source from their 2019 estimates. This is also the first year that hydroelectric generation has surpassed 6,000 GWh.

Hydroelectricity generation is sensitive to changes in precipitation, as flowing water is needed to spin turbines which generate electricity. As can be seen in Figure 25, the two measures are highly related, with changes in precipitation causing variation in hydroelectric output. The 78% increase in hydropower sites from 2014 to 2018 might have contributed to an increased ability to harness the benefits of rainfall and generate greater electrical output in any given year, relative to precipitation.

Figure 25: Annual rainfall and hydroelectric electricity generation fluctuate similarly across the time series

Average rainfall (millimetres) and hydroelectricity generation (gigawatt hours), Scotland, 2008 to 2020

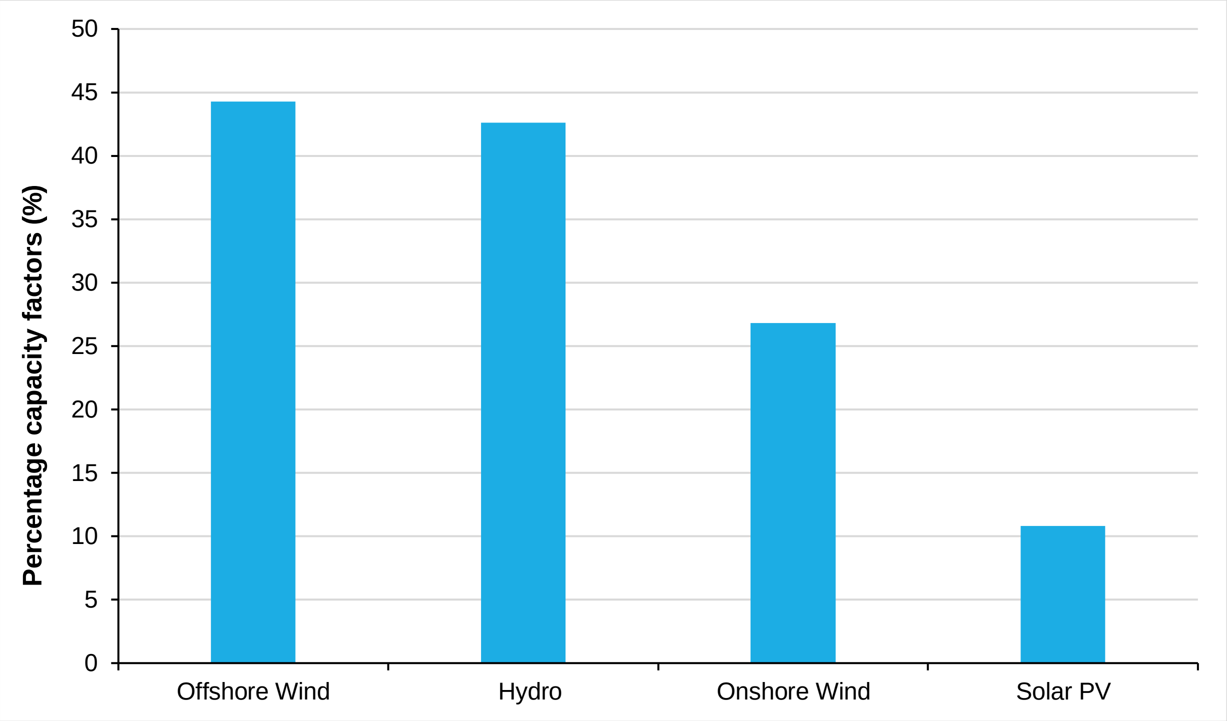


Source: Met Office and Department for Business, Energy, and Industrial Strategy

Capacity factors are a ratio of actual to technical potential total generation capacity. Hydropower capacity factors increased by 15.8% from 36.8% in 2019 to 42.6% in 2020. Capacity factors vary with the weather but can improve with advancements in renewable technologies. In the case of hydropower, it appears that an increase in rainfall has resulted in a greater capacity factor and produced a comparable increase in electrical output.

Figure 26: Scottish offshore wind capacity factor averaged 44.3% in 2020

Load factors of renewable energy technologies (percentage), Scotland, 2020



Source: Department for Business, Energy and Industrial Strategy

The number of solar PV sites has more than doubled since 2012, and since then electricity generated from solar PV has increased 404%. This means that the electricity generated per site has nearly doubled in this same time period. Although the load factors for solar PV are the lowest of all renewable production in Scotland (10.8%), solar PV was responsible for 1.2% of all electricity from renewable sources in 2020.

Scotland’s 2018 annual value of renewables was £221 million, while the asset value was £5.3 billion.

4. Regulating services

As well as provisioning services, natural assets provide several less visible services known as regulating services. A regulating service is an ecosystem benefit which moderates natural phenomena. Regulating services include cleaning the air, sequestering carbon and regulating water flows to prevent flooding.

This section presents four regulating ecosystem services:

1. Carbon sequestration
2. Air pollution removal
3. Noise mitigation
4. Urban cooling

Green and blue spaces in Scotland’s urban areas can help reduce the temperature on hot days, leading to savings in productivity, and can reduce noise disturbance. The annual value of Scottish urban cooling in 2019 was £3.8 million and Scottish noise mitigation equalled £0.7 million in 2019

However, green urban areas can also provide other regulating services, such as carbon sequestration and air pollution removal, which are both carried out by vegetation. Because air pollution is known to lead to respiratory diseases in humans, the risk of those diseases for a population can be estimated from the levels of pollution and the health costs of those diseases. The capacity for vegetation to sequester carbon and remove such air pollution invariably relies on the amount of vegetation present in a particular area.

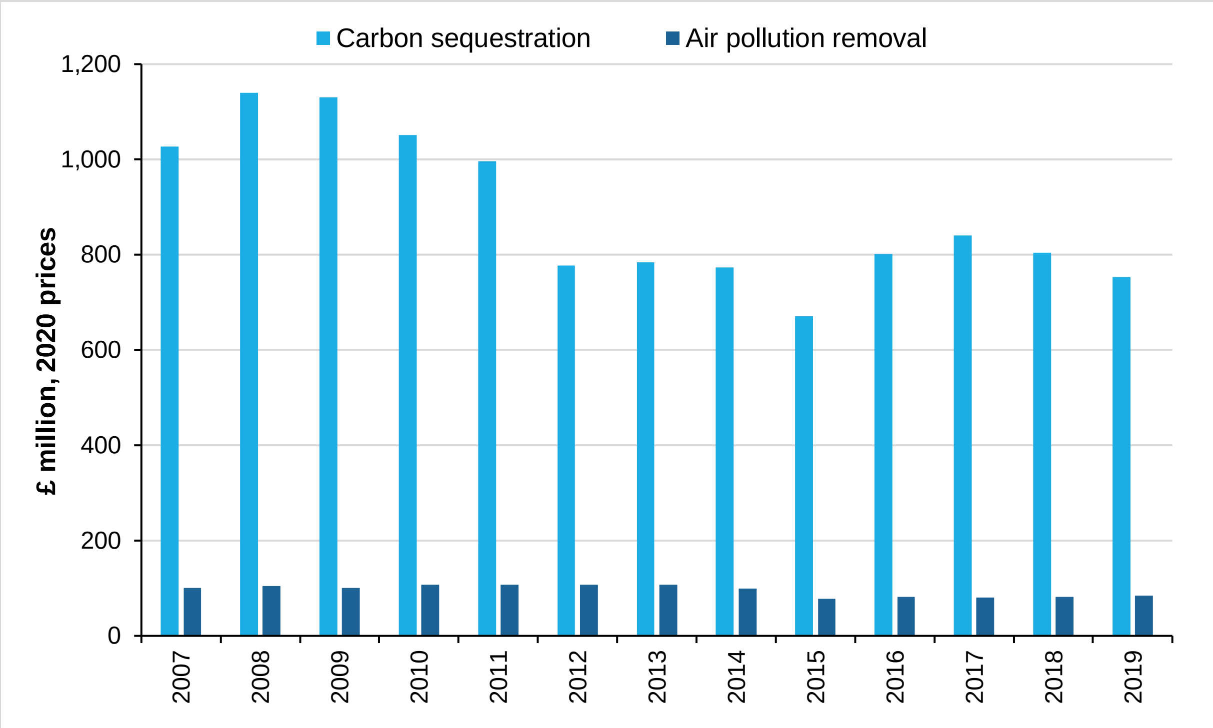
The valuation methods used differ; whereas carbon sequestration is a removal cost, air pollution removal is a societal cost. That is, we measure the value of avoiding damage (for carbon) and the value of treating existing damage (for air pollution). Air pollution removal valuation does not account for the cost of abatement, and carbon sequestration valuation does not consider the global societal impacts of carbon dioxide.

The amount of carbon sequestrated is substantially more than the amount of air pollutants removed by vegetation. However, the value per tonne of air pollutant removed is on average four times higher than a tonne of carbon removed. This is because the avoided health impacts of pollutants, mainly PM2.5, provide significant benefits to society.

In 2019, the annual values for Scottish carbon sequestration and air pollutant removal equalled £753 million and £84.4 million, respectively (2020 prices).

Figure 27: The annual value of carbon sequestration is consistently larger than that of air pollutant removal

Annual value of carbon sequestration and air pollutant removal (£ million, 2020 pries), Scotland, 2007 to 2019



Source: Office for National Statistics, National Atmospheric Emissions Inventory (NAEI), and UK Centre for Ecology and Hydrology

Carbon sequestration

When using this analysis, it is important to note that we do not capture all carbon sequestration. Because of a lack of data, values related to carbon sequestration by marine ecosystems are not included in the current estimates.

An assessment of Scotland's blue carbon resources (2017) estimates the scale of carbon production and storage in Scottish inshore Marine Protected Areas (MPA) and Special Areas of Conservation (equal to around 11,350 km2). Estimates show that stocks of carbon, in inshore MPAs in both living materials and sediment, are estimated to be 9.4 megatons of organic carbon and 47.8 megatons of inorganic carbon.

Annually, the living components of inshore MPA habitats are estimated to emit 248,000 tonnes of organic carbon. MPA sediments sequester 126,000 tonnes of organic carbon. This means that Scotland's MPAs stores around half of the organic carbon it produces. However, most of the sequestrated organic carbon is likely to originate from land rather than the marine environment.

Scottish MPAs production of inorganic carbon is vastly outweighed by the quantity of inorganic carbon it sequesters, by around 950% – while 36,000 tonnes of inorganic carbon are produced, 348,000 tonnes of carbon are stored each year. The major difference between inorganic carbon production and sequestration has several possible explanations. Inorganic carbon production may be underestimated, and inorganic carbon sequestration may be overestimated. Furthermore, Scottish inshore MPAs may sequester inorganic carbon that originates from outside the MPA zone.

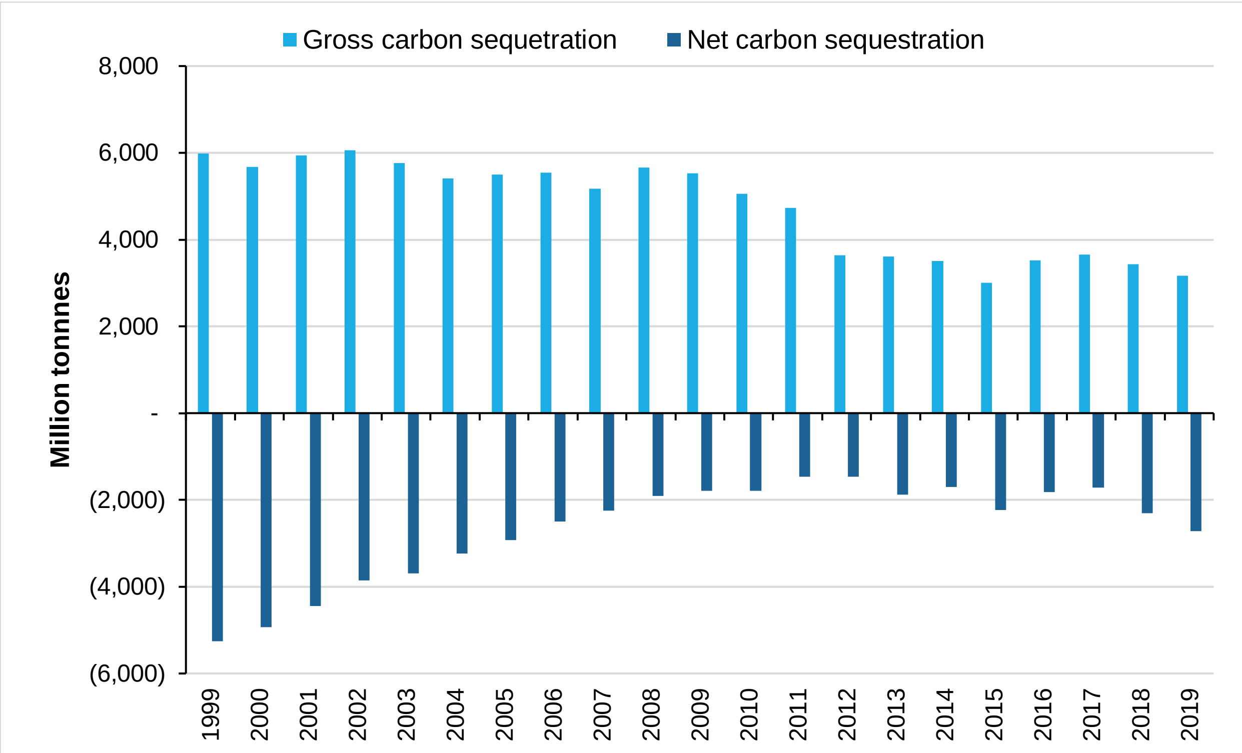
This 2021 report by climate change (Scotland centre of expertise connecting climate change policy and research) gives the latest estimates of peat extent and condition in Scotland. About a quarter of Scotland's area is covered in peat, storing over 3 billion tonnes of carbon. When peat is in a near natural condition, it has a net cooling effect on the climate.

Gross carbon sequestration is defined as the change in living biomass. This value only includes new carbon sequestered from the atmosphere leaving out transfers between habitats. This measure is used within the natural capital accounts as it minimises transfers and ensures a positive overall sequestration figure. Gross carbon sequestrated stood at 3.17 million tonnes of CO2 equivalent in 2019 (Figure 22) between habitats. This represents 36% of the UK total amount sequestered (8.88 million tonnes). The large proportion being sequestered in Scotland, is because Scotland has a high proportion of the UK's forests and woodland. This provides a service worth £0.75 billion yearly and an asset valuation of £38.37 billion. However, this excludes the emission costs related to the management of natural habitats.

Net carbon sequestration provides an overall picture as it includes transfers between different habitats and emissions. In 2019, Scotland's environment as defined as Land Use, Land Use Change and Forestry (LULUCF) emitted a net amount of 2.72 million tonnes of carbon equivalent, this is a reduction compared to 1990 when 9.07 million tonnes of carbon equivalent were emitted. This reduction may be in part due to a 44% fall in the amount of carbon emitted by the cropland habitat and a 35% reduction in the amount emitted by the grassland habitat.

Figure 28: Scottish carbon sequestration stood at 3.17 million tonnes of CO_2 equivalent being sequestered in Scotland in 2019, 36% of the UK total

Million tonnes of CO_2 equivalent of carbon sequestered, Scotland, 1999 to 2019

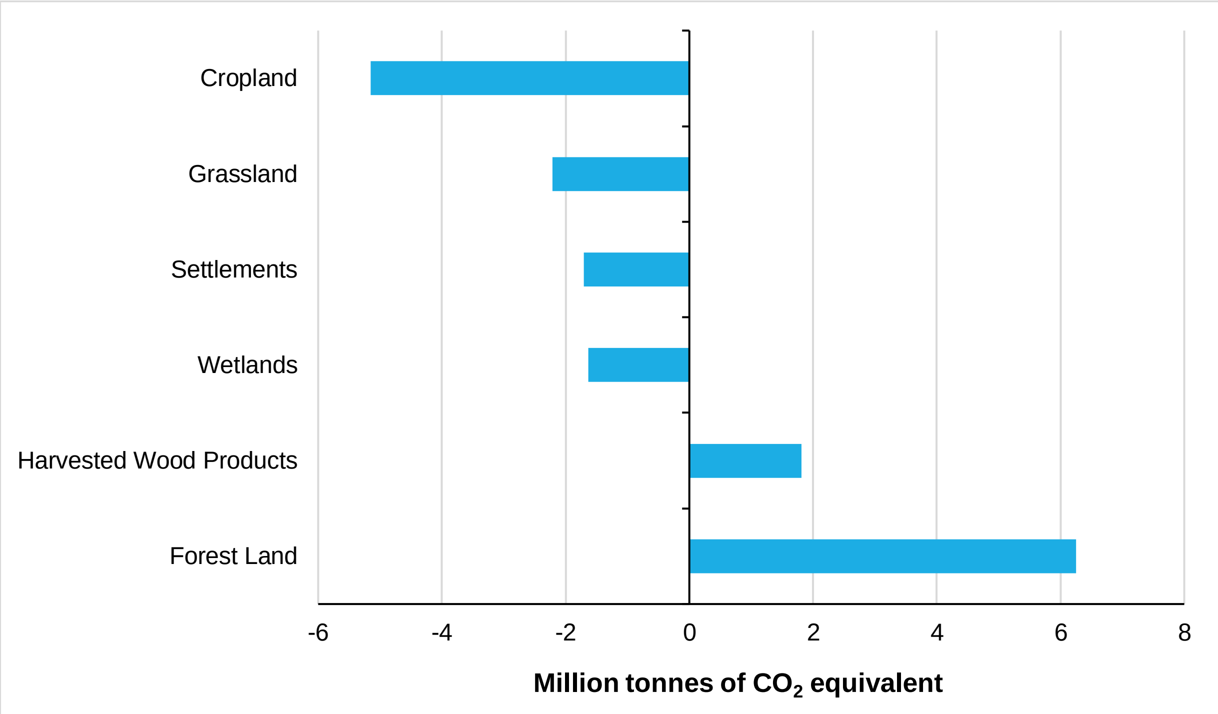


Source: Office for National Statistics and National Atmospheric Emissions Inventory (NAEI)

In 2019, forest land removed 6.25 million tonnes of carbon. In contrast, cropland emitted 5.15 million tonnes, however, this is a decrease compared to 1999 when cropland emitted 8.36 million tonnes. This means Scottish croplands provide negative net carbon sequestration valued at negative £1.22 billion annually. This could be seen as a hidden cost of food production and in principle could be netted off with market-based costs such as fertiliser and fuel within the agricultural biomass account.

Figure 29: Forest land sequestrated the most of any habitat in 2019

Net carbon sequestration by broad habitat, million tonnes of CO2 equivalent, Scotland, 2019



Source: Office for National Statistics and National Atmospheric Emissions Inventory (NAEI)

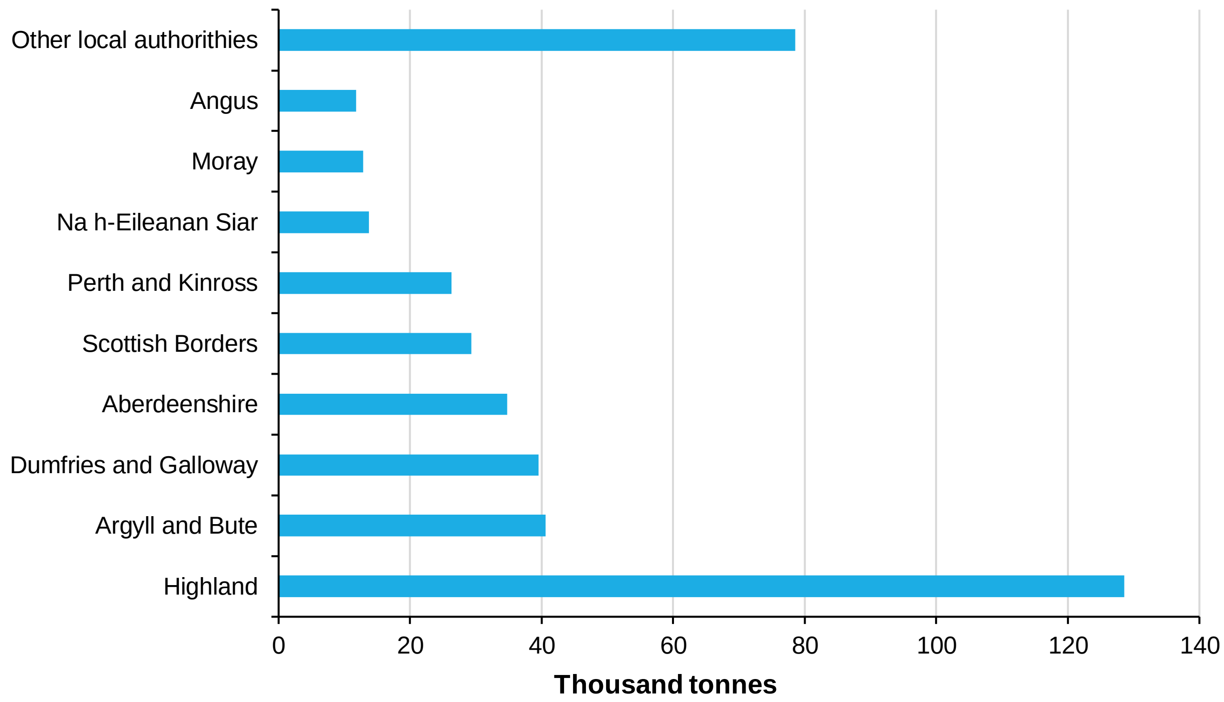
Air pollution removal

Vegetation removes airborne pollutants from the environment. We can measure the benefits of this to humanity by looking at the savings to health costs associated with breathing in air pollutants. The causes of air pollutants we measure are PM10, PM2.5, sulphur dioxide (SO_2), ammonia (NH_3), nitrogen dioxide (NO_2) and ozone (O_3). More information on the type of health costs saved and the method of measuring this benefit can be found in the methodology section.

In 2019, it was estimated that vegetation in Scotland removed 411 thousand tonnes of pollutants, which is a 7.7% increase on the volume of pollutants removed in 2018. This represents 31% of the volume of air pollutants removed across the UK. The habitats that removed the most air pollution in 2019 were woodlands, accounting for just over 28% of all air pollution removals. The Highlands was the local authority that removed the most airborne pollutants in 2019, removing 129 thousand tonnes (30% of total). This may be expected given its large landmass compared to more urban authorities.

Figure 30: The Highlands was the local authority that was responsible for the most airborne pollution remove in 2019 (30%)

Airborne pollutants removed by local authority, Scotland, 2019



Source: Office for National Statistics and UK Centre for Ecology and Hydrology

The main pollutant is ground level ozone. Ozone is not directly emitted but is formed by a complex set of reactions involving other pollutants such as nitrogen oxides in the presence of sunlight. There tends to be more ozone in rural than urban areas, as in a natural environment a balance is formed where sunlight breaks down nitrogen dioxide to form ozone.

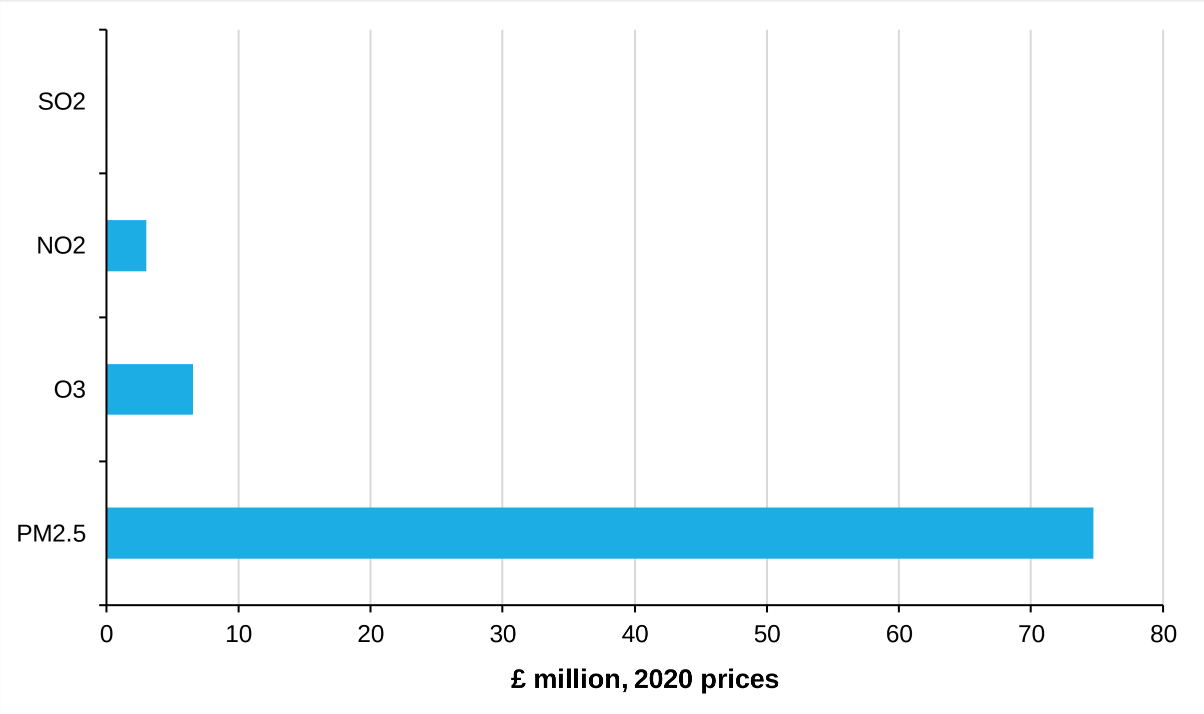
In polluted conditions where the air contains nitric oxide from fuel combustion, the balance is upset. As it is nitric oxide that destroys ozone, ozone concentrations are actually lower next to busy roads. Ozone represented 93% of all pollutants removed in 2018. Ground level ozone has also accounted for over 90% of all air pollution removed in all years going back to 2007.

It is estimated that in 2019, the avoided health costs in the form of avoided deaths, avoided life years lost, fewer respiratory hospital admissions, and fewer cardiovascular hospital admissions, amounted to a substantial £84.4 million.

PM2.5 (fine particulate matter with a diameter of less than 2.5 micrometres, or 3% of the diameter of a human hair), is the most harmful. PM2.5 can bypass the nose and throat to penetrate deep into the lungs, leading to potentially serious health effects and healthcare costs. Although the removal of PM2.5 represents only 1.6% of total pollution removed, 89% of the avoided health impacts are a result of reductions in PM2.5 concentrations.

Figure 31: The removal of PM2.5 resulted in nearly 90% of total avoided health costs in 2019

Avoided health costs from the removal of pollutants, Scotland, 2019

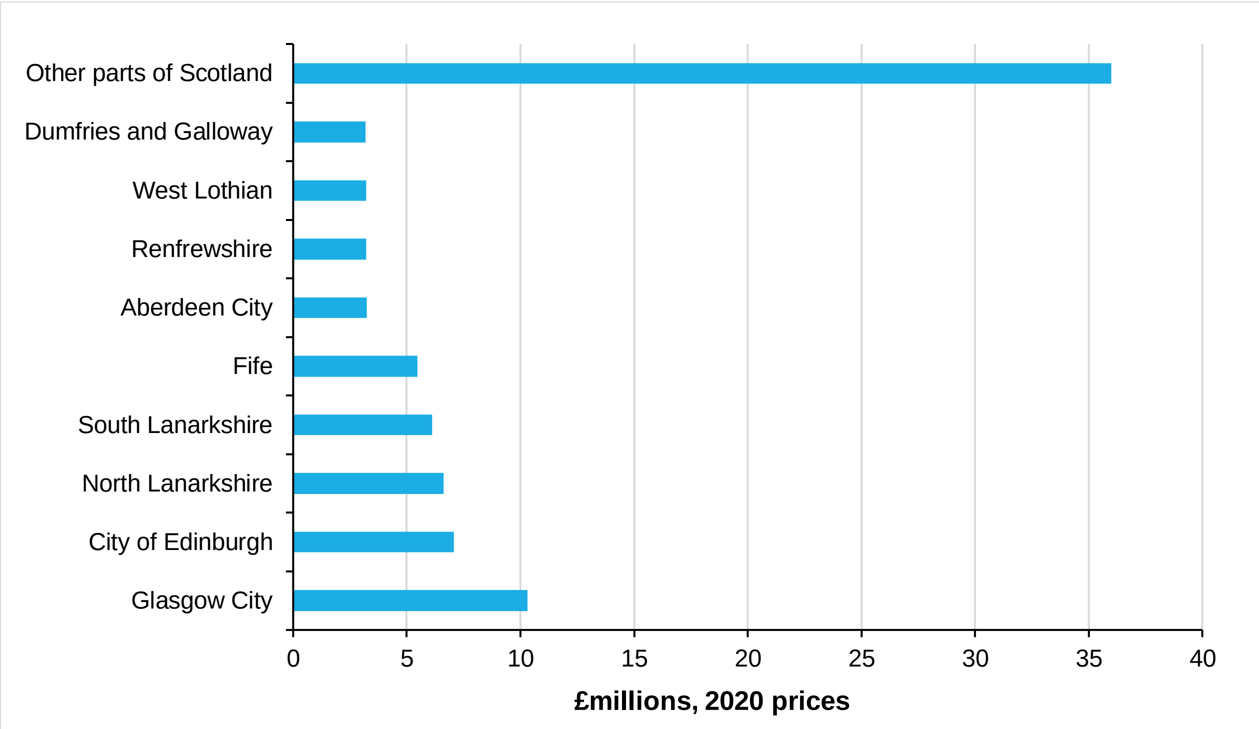


Source: Office for National Statistics and UK Centre for Ecology and Hydrology

While most of the pollution was removed in rural parts of Scotland, the two areas that benefited the most were the bigger cities of Scotland, Glasgow and Edinburgh. This is because the benefits are associated with health savings of lower pollution and the savings will also be greater in areas with larger populations.

Figure 32: Urban local authority benefitted the most from the removal of air pollutants

Avoided health costs from the removal of pollutants, Scottish local government councils (£ million, 2020 prices), 2019

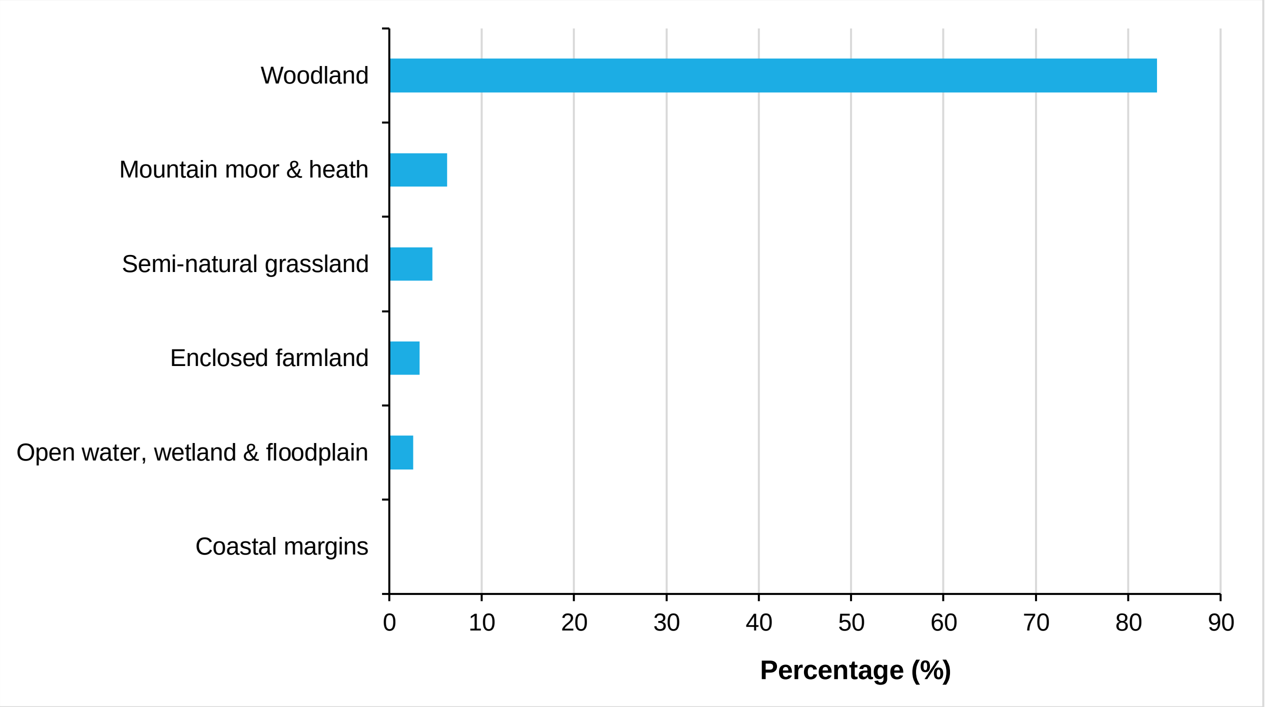


Source: Office for National Statistics and UK Centre for Ecology and Hydrology

Most PM2.5 in Scotland is removed by woodland This accounts for 83% of all PM2.5 removed in 2019. Also, it is the rural authorities that account for most of the removal of this dangerous pollutant, even though they are not the authorities that benefit most from the removal.

Figure 33: 94% of PM2.5 pollutants are removed by woodland, mountain moor and heath or semi natural grassland habitats in 2019

Percentage of PM2.5 removed by habitat, Scotland, 2019



Source: Office for National Statistics and UK Centre for Ecology and Hydrology

Noise mitigation by vegetation

The Scottish Government estimated over one million people in Scotland are exposed to regular noise of 55 decibels or greater, around the volume of normal speech. Vegetation acts as a buffer against noise pollution, for example, in urban areas with road traffic noise. Forest Research found that planting buffers of trees and shrubs can reduce noise by five to ten decibels for every 30 metres width of woodland. Noise pollution causes adverse health outcomes through lack of sleep and annoyance, even hearing loss from prolonged exposure. Eftec and others (2018) have developed initial estimates of the benefits vegetation has in reducing noise.

These estimates are considered minimum values, but further work is needed to develop more refined and robust estimates. The number of buildings receiving mitigation in Scotland is estimated to be 7,000 (Table 1). This is lower than estimates for other countries but could be largely influenced by the different noise metric used. Where these metrics were compared, the metrics used in Scotland covered a smaller area than the metrics used elsewhere. For further methodological information please see the extending noise regulation estimates produced by Eftec and others (2018).

Table 1: 7,000 buildings benefitted from noise reduction resulting from urban vegetation in Scotland

Number of buildings where road noise levels are mitigated by vegetation in Scotland (rounded to the nearest thousand)

Noise band in noise metric by decibel[1]	England	Scotland	Wales	Northern Ireland	UK
More than 80	-	-	-	-	-
75.0-79.9	1,000	-	-	-	-
70.0-74.9	8,000	-	1,000	-	-
65.0-69.9	36,000	1,000	3,000	1,000	-
60.0-64.9	98,000	6,000	8,000	4,000	-
Total	143,000	7,000	12,000	5,000	167,000

Source: Eftec and others

Notes:

1. 5 dBA bands applied along with guidance in Defra's noise pollution: economic analysis published in 2014.
2. Number of dwellings receiving mitigation in Scotland is likely to be lower than the estimates for the other countries because Eftec and others (2018) used the Lden noise metric rather than the LA1018 metric which was not available for Scotland.
3. Urban vegetation includes large woodlands (>3,000m^2) and smaller woodlands (<3,000m^2), but not very small woodlands (<=200m^2).

In 2019, the value of noise reduction in Scotland was £665,000 in avoided loss of quality adjusted life years (QALY) from sleep disturbance and annoyance. Valuations based on QALY are economic welfare values, which investigate how noise reduction affects people's social welfare. The annual avoided loss of quality adjusted life for the UK was worth £14.2 million in 2019.

Table 2: Noise mitigation from natural capital led to a saving of £665,000 in avoided loss of quality adjusted life years associated with a loss of amenity and adverse health outcomes in Scotland, 2019

Annual value of noise mitigation (£ thousand, 2020 prices), UK, 2019

Noise band in noise metric by decibel[1]	England	Scotland	Wales	Northern Ireland	UK
More than 80	2	-	-	-	2
75.0-79.9	160	-	12	3	175
70.0-74.9	1,197	8	115	61	1,381
65.0-69.9	4,368	134	339	153	4,994
60.0-64.9	8,437	522	729	351	10,039
Total	14,164	665	1,196	567	16,591

Source: Eftec and others

Notes:

1. 5 dBA bands applied along with guidance in Defra's noise pollution: economic analysis published in 2014.

The asset value of noise mitigation from vegetation in Scotland was £36 million in 2019. Scotland made up around 4% of the £903 million asset value of noise mitigation across the UK. The asset value for noise reduction in Scotland is based on the estimated future flow of benefits over 100 years.

Many assumptions were made when estimating the future flow of value from noise mitigation by urban vegetation. For example, population affected was held constant and the impact of electric cars was not considered.

Urban cooling

The urban heat island effect means that cities and towns are prone to higher temperatures than the rural environments surrounding them. Green and blue spaces, such as parks and lakes, can cool urban environments through the process of evapotranspiration and shading. This benefits the economy by avoiding labour productivity loss and reducing the use of artificial cooling (air conditioning).

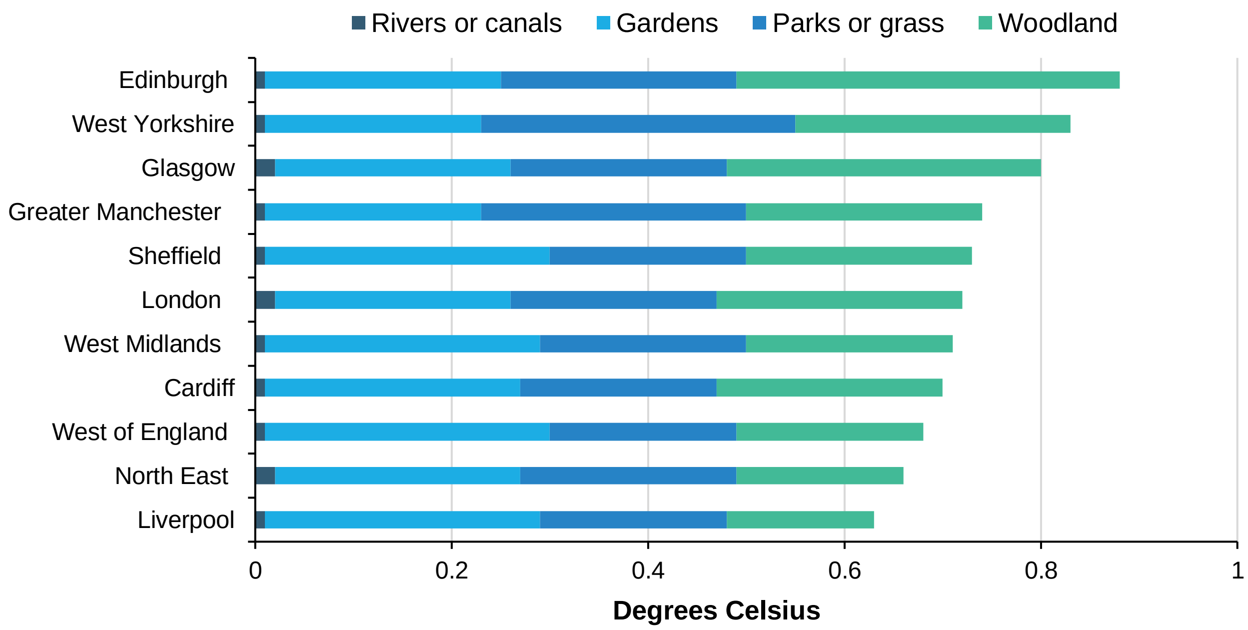
Eftec and others (2018) estimated the [cooling effect provided by natural capital for 11 city regions] across Great Britain, including two Scottish regions – Glasgow and Edinburgh. The cooling effect is based on reducing heat on hot days. “Hot days” refers to any day with a temperature between 28 degrees Celsius and 35 degrees Celsius, as defined by the Eftec and others (2018) report.

As shown in Figure 34, the cooling effect in both Glasgow and Edinburgh is similar, with Edinburgh’s green and blue space providing just 0.08 degrees more cooling. For all areas in the UK, as well as both Scottish cities included here, green spaces (such as parks) provide substantially more cooling than blue spaces (such as lakes).

[Edinburgh has a greater cooling effect than all other city regions] mentioned in Eftec and others (2018), closely followed by Glasgow. Figure 34 shows Edinburgh has a cooling effect 0.14 degrees Celsius greater than the average of the 11 Great British city regions covered. Scottish cities have the highest cooling effects because of the amount of woodland relative to the size of the city region.

Figure 34: Edinburgh city region has the largest area of woodland relative to city area and observed the greatest cooling effect of the 11 cities in Great Britain

Average annual cooling effect of green space and blue space in all Great British regions, degrees Celsius, 2014 to 2018



Source: Eftec and others (2018)

The value of green space in Scotland increased to £3.82 million in 2019 before falling to £0.33 million in 2020 (Table 3). These values are low compared with other Great British city regions such as London, which had the highest avoided costs in both 2019 and 2020 at £360.2 million and £312.1 million, respectively. This is because London, of all regions included here, has the largest economy and highest number of hot days (see Table 4). The total number of hot days across all regions of Britain during 2019 was nearly half of those in 2018.

However, Scottish city regions experienced an overall increase in the number of hot days in 2019, with Edinburgh seeing an extra 0.4 days over 28 degrees Celsius, and Glasgow reporting no change from its 2018 total. This 29% increase in hot days resulted in a 6% increase in avoided costs due to urban cooling effects, up from £3.6 million in 2018 to £3.8 million in 2019 (2020 prices).

Table 3: Total annual value of cooling from green/blue space in each of Great Britain's regions (£ million, 2020 prices)

City Region	2017	2018	2019	2020
Cardiff	5.88	4.75	5.52	10.82
Greater Manchester	1.39	8.79	10.81	16.91
Liverpool	0.80	4.18	6.20	9.91
London	212.02	647.48	360.19	312.07
North East	0.03	0.07	2.41	0.72
Sheffield	3.11	7.93	7.92	7.90
West Midlands	16.33	28.04	36.04	39.25
West of England	12.31	10.38	13.43	21.37
West Yorkshire	2.00	8.36	6.66	13.99
Edinburgh	-	0.38	1.41	0.18
Glasgow	-	3.22	2.40	0.15
Scottish Total	-	3.60	3.82	0.33
Total GB	253.87	723.58	452.99	433.26

Source: Eftec and others (2018) and Met Office

Table 4: Number of hot days in each of the 11 Great British regions

City Region	2017	2018	2019	2020
Cardiff	3.1	4.9	2.3	4.9
Greater Manchester	0.8	4.2	3.0	3.7
Liverpool	1.8	6.3	2.8	3.0
London	7.3	23.2	7.8	13.8
North East	0.0	0.1	0.8	0.5
Sheffield	1.6	5.2	5.5	5.0
West Midlands	4.6	10.3	5.6	8.0
West of England	4.6	8.4	3.6	7.1
West Yorkshire	1.1	3.0	3.6	3.2
Edinburgh	0.0	0.4	0.8	0.1
Glasgow	0.0	1.0	1.0	0.1
Scottish Total	0.0	1.4	1.8	0.2
Total GB	24.8	66.9	36.8	49.5

Source: Eftec and others (2018) and Met Office

Notes:

1. In 2017 there were no days classed as hot days in Edinburgh and Glasgow.

In 2020, while the total number of hot days for all regions in Britain increased by 35% from 36.8 to 49.5, Scottish city regions showed a decrease from 1.8 to 0.2 hot days from 2019. Correspondingly, this has resulted in a 91% decrease in annual value, down to £330,000. As might be expected, the cooling effects provided by green and blue urban spaces are limited in their benefits by the number of hot days. For example, more cold days and fewer hot days will decrease the demand for air conditioning, so the financial benefit of cooling is reduced.

The 2020 asset value of urban cooling for Glasgow and Edinburgh city regions are £133.2 million and £69.5 million, respectively (2020 prices). These are calculated using the average number of hot days over the last five years and projected green space urban cooling increases over the next 100 years. The £202.7 million asset value of urban cooling in Scotland has risen steadily year-on-year and now stands at nearly three times its £51.4 million estimate from 2016.

With climate change projected to continue throughout the century, green and blue urban spaces will come to play an increasingly important role in urban temperature regulation. The Met Office’s derived projections on climate change suggest that, at a global mean warming of 2 degrees Celsius, both Scotland’s hot and cool days in summer could warm by 1 to 1.5 degrees Celsius, with summers as hot as 2018 becoming around 50% more likely. Accordingly, the value of urban green and blue spaces will likely increase as their cooling effects will continue to provide valuable regulating services affecting productivity and avoided artificial cooling costs.

5. Cultural services

Cultural services are the non-material, experiential benefits people obtain from natural capital, such as recreation and aesthetic experience. Nature provides us with several cultural services, the value of which can be understood by measuring engagement with the natural environment.

One part of how we conceptualise this engagement with nature considers visits to green and blue spaces (such as parks and lakes), which are measured through survey responses and are presented as part of our combined recreation and tourism service.

Additionally, cultural services can be conceptualised as the desire to live near to these green or blue spaces or with a view of nature. We therefore present here the value that both features add to house prices. These two conceptualisations of cultural services provided by nature are related in that living closer to green and blue spaces enables people to make "free trips" to the natural environment.

Cultural services like recreation and tourism differ from provisioning and regulating services in that there is no one “asset” that we refer to. Whereas timber provisioning considers trees and carbon sequestration considers the benefits provided by trees for air carbon regulation, the “asset” that makes recreation and tourism services possible is the natural environment in its entirety. ‘Trips to nature’ therefore includes visits to all areas of nature, which can then classified into seven broad habitats.

Recreation and tourism

In line with methodological changes to the way recreation services have been estimated for the 2021 UK natural capital accounts, we now present a combined recreation and tourism account; the first time this has been used in Scottish natural accounts valuations. This method has been applied to all previous years for which data were available.

The combined recreation and tourism service valuations now use survey data to capture both shorter and longer trips taken to nature by visitors in Scotland. Previously, the recreation service was limited to using survey data that considered day trips only. By introducing tourism survey data, we can extend our coverage to include visits to nature over three hours in duration that might have been taken across multiple-day trips. For both recreation and tourism data, expenditure is taken as the amount spent on travelling to the natural environment.

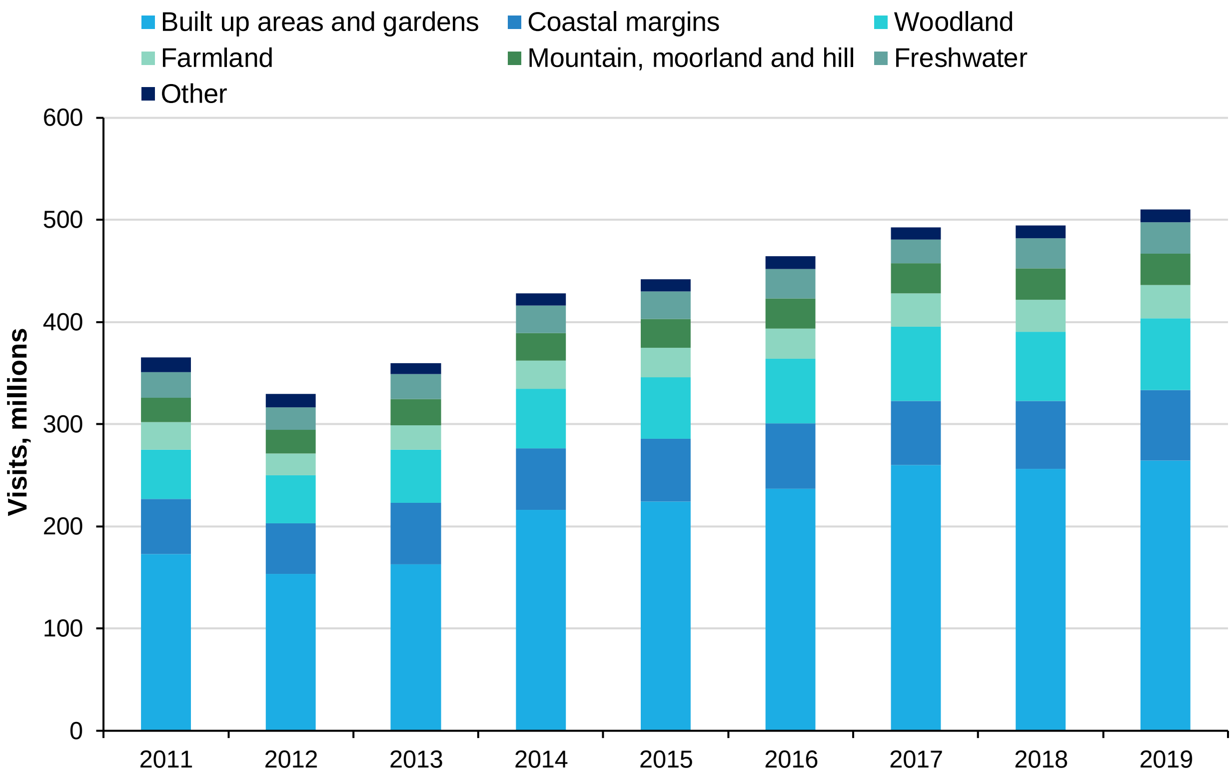
The underlying tourism and recreation survey data for our estimates largely cover all years presented across the time series. However, for years where survey data were not available, we have imputed the missing data using linear forecasting methods.

During 2019, there were an estimated 510 million visits made to Scotland's natural environment. The number of yearly visits made to each Scottish habitat has increased steadily from 2012 to 2019. This has largely been driven by more visits taken to urban green spaces like local parks and gardens, which is responsible for 63% of the increase. In the same period, woodland (13%), coastal margins (11%), farmland (6%), freshwater areas (5%) and mountain, moorland and hills (5%) have all seen more modest increases in yearly recreational visits. This trend is also true for both England and Wales.

In 2019, visits to built-up urban green space areas in Scotland made up the largest proportion of visits to outdoor recreation spaces (52%). Visits to coastal margins and woodland grew by 4% and 3% on their 2018 totals, respectively. Mountain, moorland and hill areas experienced a marginal increase (0.7%) from their 2018 total, while visits to other unlisted areas fell by 2.8% from its 2018 total to constitute just 2.4% of all 2019 visits.

Figure 35: Visits to built-up areas and gardens are the most visited habitat across the time series

Number of visits by habitat (millions), Scotland, 2011 to 2019

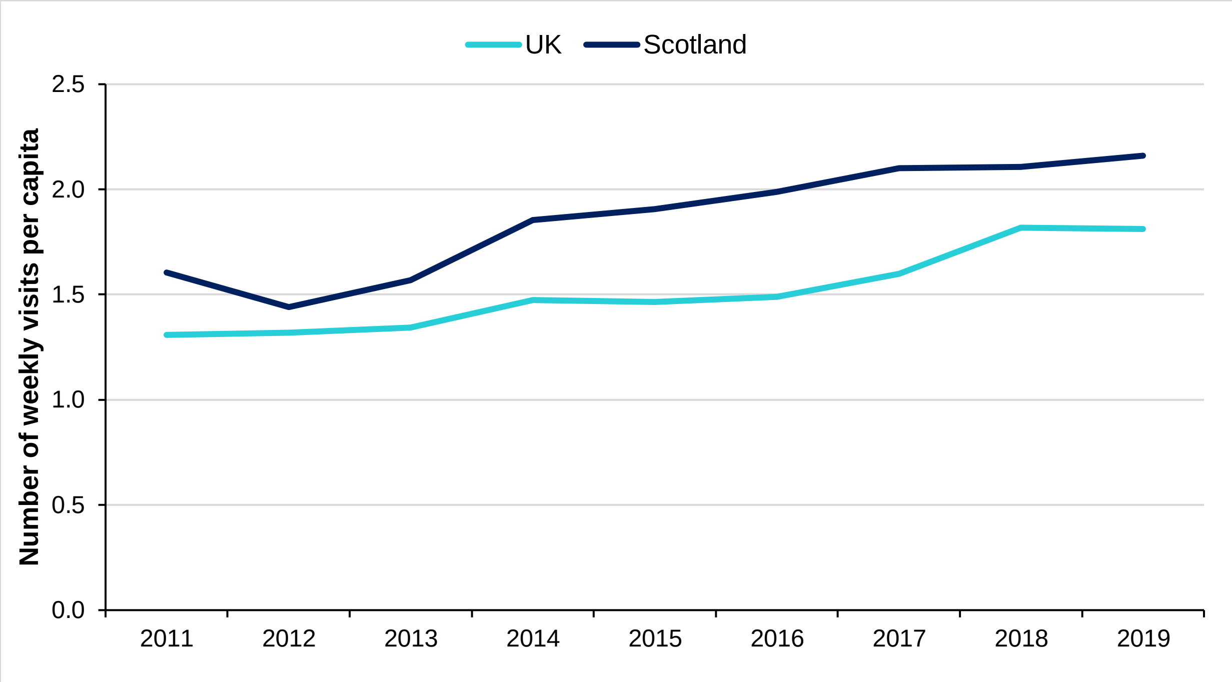


Source: Office for National Statistics, Monitor of Engagement with the Natural Environment (MENE) survey, Scottish Recreation Survey and Scotland's People and Nature Survey, Great Britain Day Visits Survey (GBDVS), Great Britain Tourism Survey (GBTS) and International Passenger Survey (IPS)

Scotland continues to see more weekly visits per person in 2019, 2.2 visits compared with the UK average of 1.8 visits. This is true of all years in the time series (see Figure 36). Additionally, the weekly expenditure each person makes during these trips to nature remains below the UK average; £4.32 for Scotland and £5.26 for the UK. Scotland continues to see the lowest expenditure per visit to nature (£2.00), compared with both England (£2.93) and Wales (£2.12), a trend beginning in 2018.

Figure 36: The average weekly visits to nature per person in Scotland is greater than the UK average across the entire time series

Average per capita visits to nature, UK and Scotland, 2011 to 2019



Source: Office for National Statistics, Monitor of Engagement with the Natural Environment (MENE) survey, Scottish Recreation Survey and Scotland's People and Nature Survey, Great Britain Day Visits Survey (GBDVS), Great Britain Tourism Survey (GBTS) and International Passenger Survey (IPS)

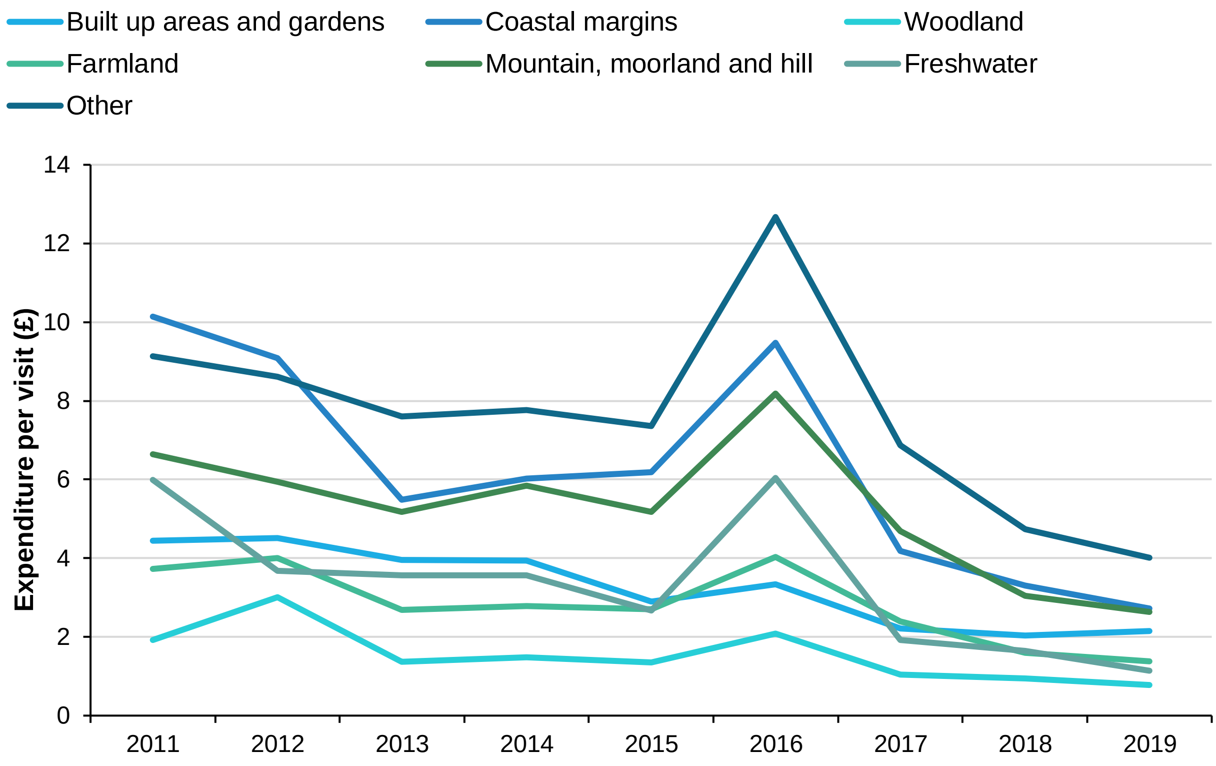
In 2019, UK outdoor recreation had an annual value of £14.8 billion (2020 prices). Scottish visits represented around 7% of this, estimated at £1.0 billion in 2019. This 2019 annual value of Scottish recreation has decreased by 48% from £1.9 billion in 2011, whereas the value of UK recreation grew by 2% in this same period from £14.5 billion in 2011 to £14.8 billion in 2019.

This is a surprising trend considering 39% more visits were made to Scottish habitats in 2019, compared to 2011. The decrease in annual value appears to be explained largely by people spending less money per visit to nature; in particular, making more trips at lower cost to built-up areas and gardens.

Expenditure per visit taken to all Scottish habitats has reduced by 62% across the time series, from £5.33 per visit in 2011 to £2.00 per visit in 2019. Built-up areas and gardens (-52%), coastal margins (-73%) and woodland (-59%), which are consistently the three most visited Scottish habitats, all saw at least a halving in expenditure per visit from 2011 to 2019 (see Figure 37).

Figure 37: Average expenditure to all habitats (except built-up areas) in Scotland fell between 2018 and 2019

Average expenditure per visit (£) to Scotland's habitats, 2011 to 2019



Source: Office for National Statistics, Monitor of Engagement with the Natural Environment (MENE) survey, Scottish Recreation Survey and Scotland's People and Nature Survey, Great Britain Day Visits Survey (GBDVS), Great Britain Tourism Survey (GBTS) and International Passenger Survey (IPS)

Overall, visitors in Scotland reduced their weekly spending to outdoor areas by £4.23 (49%) down from £8.55 in 2011 to £4.32 in 2019, whereas the UK average fell by only £0.16 (3%), from £5.42 to £5.26, in the same period.

The asset value of recreation in Scotland in 2019 was estimated to be £57 million, 9% of the UK value.

Recreation and tourism data trends

It is important that we caveat some trends in the data presented above. This includes the sudden rise in expenditure within 2016, and overall declining trend of expenditure across the time series.

First, the data depicts a sudden rise in expenditure in 2016, followed by a dramatic fall the following year. The rise in expenditure in 2016 appears to be the result of methodological changes within the tourism-based surveys between 2015 and 2016. When responding to the survey, respondents were shown smaller lists of response options, as opposed to one single large list. In some cases, this caused an increase in the number of responses chosen by each respondent.

As data is captured at an activity level, this led to increases in the magnitude of double counting per person and therefore to a greater total expenditure across all visits. Currently, our methodology does account for double counting. However, it does not account for a fluctuation in the magnitude of double counting across the time series.

Consequently, the actual expenditure per visit appears to be multiples higher than we would expect in 2016. Unfortunately, Scotland appears to have been one of regions most affected by this technical issue. Further improvements to our tourism methodology are required to fix this issue.

Second, over the time series, while trips taken to nature have increased by 39%, expenditure has decreased. By using the travel cost method of asset valuation, accordingly, the annual and asset values have also both decreased.

This declining trend is reflected within both the recreation-based and tourism-based surveys. Therefore, we are confident that this trend reflects the reality that people are spending less today on visits to nature in Scotland than in previous years. However, examining the survey data further, this decline is exaggerated by the methodology change within our tourism data.

Other variables captured by recreation survey data, such as the average time spent travelling, car parking expenditure, vehicle running costs and transport fares expenditure all show declining per-trip values in Scotland across the time series.

Furthermore, the number of shorter duration trips has increased, while the number of longer duration trips have decreased consistently between 2011 and 2019. Similarly, the proportion of respondents travelling shorter distances per trip has increased while those reporting travelling longer distances has decreased during this time.

While it is not possible to draw any definitive conclusions from these results, individual indicators appear to point to Scottish visitors making shorter and cheaper trips closer to home, especially to built-up urban areas. This could be because of better access to nature or changing attitudes towards travelling and expenditure. While the estimates of the magnitude of this trend are not as reliable as we intend, the trend itself appears to reflect changing behaviours towards recreational activities in Scotland.

Scottish house prices: Recreation and aesthetic values

The value of green and blue spaces through house prices at the UK level have previously been published. This analysis focuses on estimating the proportions of Scottish house prices that are attributed to access or views to blue and green spaces (such as parks and lakes). Access to, and views of these spaces provide a range of benefits which are reflected through market prices for housing. By implementing a hedonic pricing method, we provide estimates for the value of green and blue spaces, relative to the value of properties within 500 meters of these spaces.

There are two important caveats to note before interpreting the estimates for Scotland. First, we were unable to include data on Scottish schools as Education Scotland only inspect a sample of schools and educational establishments are not given an overall inspection outcome in the same way that Ofsted and Estyn provide. Since there is a strong correlation between house prices and proximity to school, this lack of data will reduce the precision of the Scottish model. Unfortunately, until these data are available, we cannot incorporate these considerations into our house prices model.

Second, it is possible that our sample of urban property prices underestimate actual urban property prices in Scotland. This is because property price data from Zoopla, captures the advertised price rather than the real selling price. Scottish properties, however, are marketed with either a fixed price or “offers over” – the minimum offer accepted by the seller. As bidding for “offers over” houses can drive up the selling price of properties, our data on advertised prices likely underestimates the real selling price.

The hedonic pricing approach analyses a range of variables that affect house prices. This includes the willingness to pay for living close to green and blue spaces. Table 5 shows the variables included in this model. We can use this approach to measure the value of the “free” recreational trips to nearby green spaces, which are missing from the recreation account. The value of these “free” trips are not considered as a total volume but are assumed to be an inherent benefit of living near green and blue spaces.

It is worth noting that some of the differences that we attribute to green or blue spaces may be because of additional characteristics of the property or the local area, which the model is unable to identify.

Table 5: Variables included in the hedonic pricing model

Characteristic vector	Component variables	Sources
Structural	Number of bedrooms	Zoopla
	Property area (square feet)	
	Property type, such as house, bungalow, flat	
	Property attributes based on description (for example, garage, double glazing)	
Neighbourhood	Distance to railway station	Ordnance Survey
	Distance to local labour market	
	Distance to nearest transport infrastructure	
	Distance to nearest retail cluster	
Socio-economic	Scottish Index of Multiple Deprivation, Output Area Classification	Scottish Government
Environmental amenities	Distance to green space	Ordnance Survey
	Distance to blue space	
	Area of Natural Features in 500 metres radius of property (square metres)	
	Area of functional green space in 500 metres radius of property (square metres)	
	Area of blue space in 500 metres radius of property (square metres)	
	Function of green space	
	Area of residential garden (square metres)	
	Distance to railway line	

	View over green or blue space	Zoopla
	Air pollution	Department for Environment, Food and Rural Affairs
	Noise pollution	
	Distance to coast	
	Distance to substation, tower, overhead lines	UK National Grid

Source: Office for National Statistics

Table 6 shows the split of the total stock value by recreational and aesthetic values for the years 2010-2016. The value of recreational services is based on the distance from green and blue spaces and the total area these spaces occupy. Distance and land cover data used in this model are taken from the Ordnance Survey. The value of aesthetic services is based on the view individuals have of green and blue spaces. Recreational values are significantly larger than aesthetic values across this time series.

In 2016, recreational asset value equalled £8.74 billion and aesthetic asset value equalled £0.85 billion. Across the time series, the average value of access and views to green and blue space has fallen by 25% from £4,450 in 2010 to £3,317 in 2016. These substantial decreases in value may be the result of many conditions. One interpretation is that people have a declining need to live next to green and blue spaces as the market tightens across the time series.

Table 6: In 2016, the total stock value of living within 500 metres of green and blue space was estimated to be £9.6 billion

Year	Average value (£)	Average value (%)	Stock value (£billion)	Aesthetic value (£billion)	Recreational value (£billion)	N properties (millions)
2010	4,450	2.41%	13.74	1.49	12.25	2.48
2011	3,456	1.92%	10.51	1.28	9.23	2.49
2012	4,137	2.30%	12.44	1.17	11.27	2.51
2013	4,046	2.24%	12.02	1.14	10.88	2.52
2014	3,754	1.97%	11.02	1.16	9.86	2.53
2015	3,666	1.90%	10.75	0.99	9.76	2.55
2016	3,317	1.77%	9.59	0.85	8.74	2.57

Source: Office for National Statistics

For annual values, we can present an equivalent rental value of living within 500 metres of green or blue space shown in Table 7. "Imputed rent" is a national accounting term for what homeowners would receive if all homes were rented. It can be thought of as the amount that non-renters are willing to pay themselves for the housing services they produce. This must be imputed as homeowners do not receive payment on their property.

Table 7: In 2018, the estimated rental value of living within 500 metres of green and blue space was approximately £305 million

Imputed rental values for green and blue space, £ million (2020 prices), Scotland, 2010-2018

Year	Total (£ million, 2020 prices)
2010	361
2011	294
2012	340
2013	342
2014	298
2015	292
2016	272
2017	316
2018	305

Source: Office for National Statistics

Travel to work areas (TTWA) are geographical areas created to approximate labour market areas. These are designed so that most people live and work within these defined areas, while relatively few people commute between areas. Table 8 presents the average effect of living near green and blue spaces in different TTWA.

Within the 10 most sampled travel to work areas; Edinburgh has the largest average effect with £7,195 of an average property's value being attributed to access to and views of blue and green spaces (2.93% of the average property price).

Table 8: Average effect of living near green and blue spaces in different TTWA, 2020 prices, Scotland, 2009 to 2016

Travel to work area	Average Value (£, 2020 prices)	Average value of property price (%)	N Validation Set	Average distance to green spaces (m)	Average distance to blue spaces (m)
Glasgow	3,234	1.93%	5911	276	334
Edinburgh	7,195	2.93%	2415	254	390
Motherwell and Airdrie	2,174	1.65%	1907	290	473
Falkirk and Stirling	2,454	1.56%	1648	284	281
Livingston	2,660	1.77%	1174	285	350
Kilmarnock and Irvine	1,952	1.71%	1086	331	333
Ayr	1,688	1.09%	729	290	367
Dunfermline and Kirkcaldy	2,353	1.73%	601	315	355
Perth	3,162	1.75%	585	262	345
Inverness	2,626	1.36%	409	309	228

Source: Office for National Statistics

6. Asset valuation

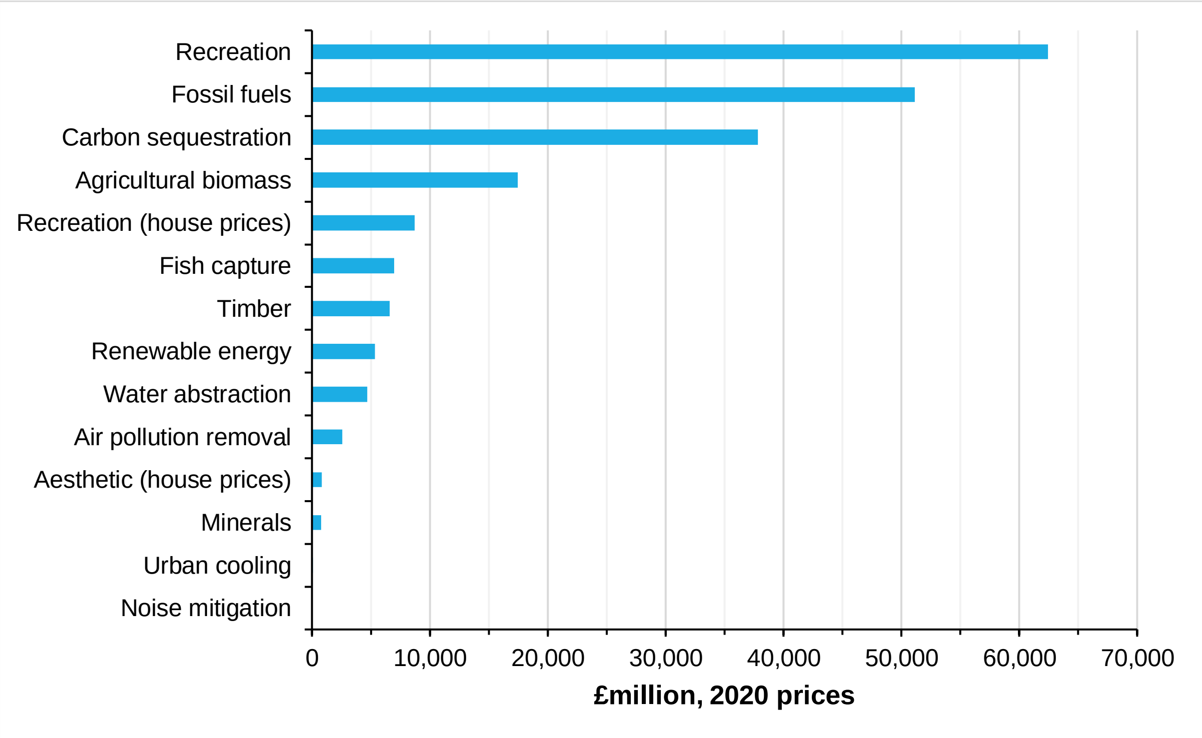
Here we present the asset values of Scottish natural capital by service. These values are estimated by capitalising the total annual flow of services from the natural resource that are expected to take place over a projected period, known as the asset life. The annual environmental service flows provide the basis for these projected flows. This is a method known as Net Present Valuation (NPV), which is explained in more detail in the methodology section.

Some of the environmental services presented in this article are produced from renewable resources whose stock is not exhausted over time, such as Scottish woodland delivering carbon sequestration. For these renewable resources, a 100-year asset life has been assumed. The non-renewable abiotic resources presented in this article are minerals and fossil fuels, which have an assumed asset life of 25 years.

In 2018, outdoor recreation was equivalent to 30% of the value of Scottish natural capital assets, which in total equalled £62 billion. The second and third largest services were fossil fuels, making up 25% of Scottish natural capital assets, and carbon sequestration, making up 18%, respectively. This is the first year since 2015 that fossil fuels did not constitute the single largest service in terms of asset value.

Figure 38: Scottish natural capital assets were valued at £206 billion in 2018

Asset value by service (£ million, 2020 prices), Scotland, 2018



Source: Office for National statistics

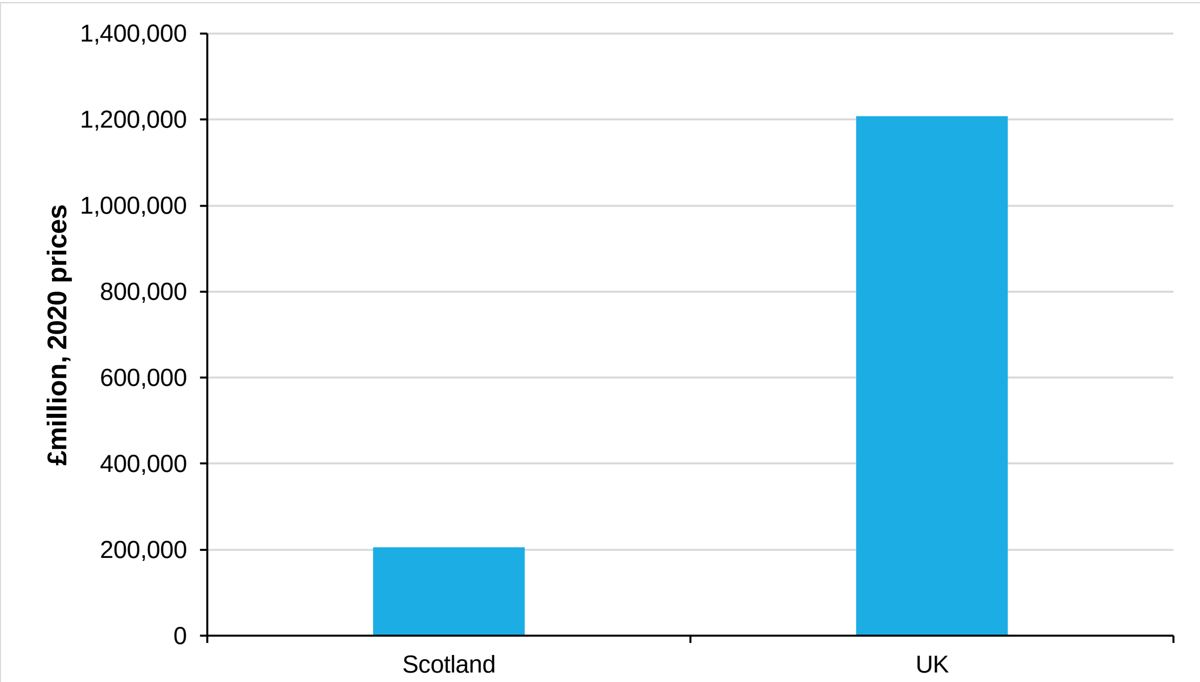
Notes:

1. Values for noise mitigation are from 2018.
2. Values for recreation and aesthetic (house prices) are from 2016.

The asset value of regulating and cultural services amounted to £113 billion in 2018, or 55% of Scotland's total quantified natural asset value.

Figure 39: In 2018, Scotland's natural capital assets equalled 17% of the UK total natural capital asset value

Asset value (£ million, 2020 prices), UK and Scotland, 2018

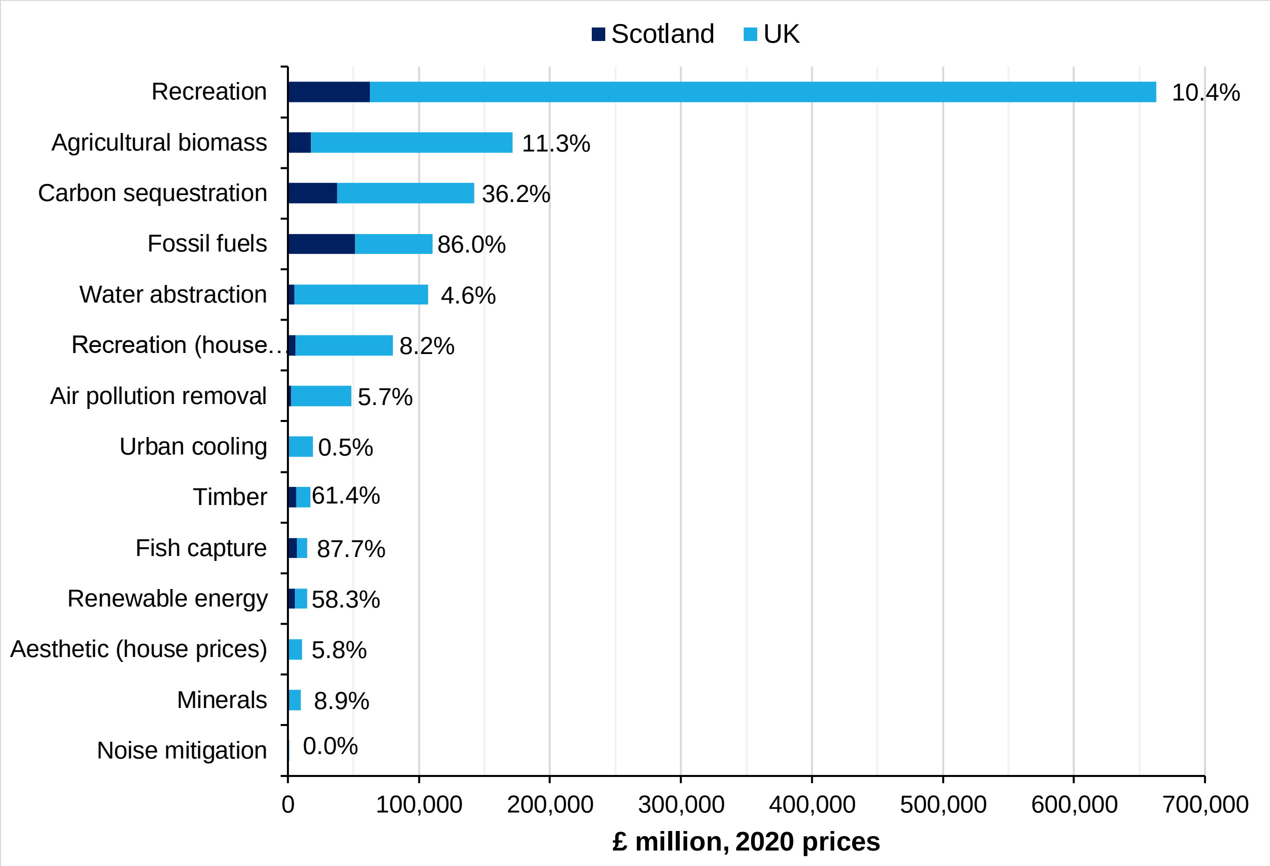


Source: Office for National Statistics

Scotland's contribution to the total UK asset value of each ecosystem service ranges from 0.5% (urban cooling) to 88% (fish capture). Scottish contributions to UK total asset values are particularly large across some provisioning services, with Scotland contributing 88% in fish capture, 86% in fossil fuels, 61% in timber and 58% in renewable energy.

Figure 40: Scotland makes a significant contribution to UK provisioning services

Ecosystem service asset values (£ million, 2020 prices), UK, 2018



Source: Office for National Statistics

7. Methodology

This article was produced for the Scottish Government by the Office for National Statistics. Office for National Statistics natural capital accounts are produced in partnership with the Department for Environment, Food and Rural Affairs (Defra). Further details about the natural capital accounting project are also available.

The methodology used to develop these estimates remains under development; the estimates reported in this article are experimental and should be interpreted in this context. Experimental Statistics are those that are in their testing phase, are not yet fully developed and have not been submitted for assessment to the UK Statistics Authority. Experimental Statistics are published to involve customers and stakeholders in their development and as a means of building in quality at an early stage.

This methodology section provides a detailed summary of the methodology used to develop the natural capital accounts. This summarises the broad approach to valuation and the overarching assumptions made, as well as giving a more detailed description of the methods used to value the individual components of natural capital and physical and monetary data sources.

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

As the UN guidance is currently still under development, the Office for National Statistics (ONS) and the Department for Environment, Food and Rural Affairs (Defra) published a summary of the principles underlying the accounts.

We welcome discussion regarding any of the approaches presented via email at natural.capital.team@ons.gov.uk.

Overview of services

This section provides a high-level overview of the ecosystem services' relative quality and future aims. For detailed information on the methods used please continue to the methodology by service section.

Table 9: Summary of service estimates quality

Service	Sustainability	Coverage	Source data	Granularity	Timeliness	Timespan
Provisioning						
Agricultural biomass	3	2	1	3	2	1
Fish capture	1	2	2	1	2	1
Timber	1	1	1	1	1	1
Water	3	2	1	3	2	1
Minerals	2	1	1	3	2	1
Fossil fuels	1	1	1	3	2	1
Renewable energy	3	3	2	2	2	1
Regulating						
Carbon sequestration	1	3	2	2	2	1
Air pollutant removal	1	1	2	1	3	2
Urban cooling	1	3	3	2	2	2
Noise mitigation	1	2	2	1	3	3
Cultural						
Recreation	1	3	2	1	2	1
Recreation (house prices)	1	2	1	1	3	2
Aesthetic (house prices)	1	2	1	1	3	2

Source: Office for National Statistics

Notes:

1. 1/Green = relatively strong, 2/Amber = could be improved, 3/Red = needs improvement.
2. Suitability: Suitability of method in the valuation of natural capital asset, particularly considering the ability to integrate condition and sustainability measures. A suitable natural capital value has a clear logic chain where the impact of changes can be measured and sustainability influences asset valuation.
3. Coverage: The ability to provide a well-rounded and fair coverage of the full benefits the service provides.
4. Source data: The quality of the underlying data sources for estimating the ecosystem service.

5. Granularity: The ability to disaggregate the service, primarily by geography.
6. Timeliness: The ability to provide full up to date estimates.
7. Timespan: The ability to provide a consistent timeseries going back several years.

Service summary and future aims

Agricultural biomass

Estimates of the provisioning value of agricultural biomass, based on a resource rent residual value of industry national accounts data, does not offer a strong logic chain from extent, condition and flow, through to its final valuation. As a result, it is difficult observe how changes in agriculture impact its natural capital asset valuation. Further development and examination of alternative methods is required. The methodology for the valuation of agricultural biomass is likely to change substantially in the future.

Fish capture

Using net profit estimates of fish capture of individual species in different areas provides a clear logic chain from natural capital asset to valuation. As a result, we can now begin to integrate sustainability measures.

Timber

Estimates of the provisioning value of timber provide a strong logic chain from flow to valuation, using stumpage prices, and manages to integrate future projections of provisioning services. We currently have no development plans for the near future.

Water abstraction

Estimates of the provisioning value of water abstraction, based on a resource rent residual value of industry national accounts data, do not offer a strong logic chain from flow to valuation. As a result, it is difficult to observe how changes in the water industry affect its natural capital asset valuation. The methodology for the valuation of water abstraction is likely to change substantially in the future. Long-term, we hope to net off the costs of any water restrictions to society from overall industry income.

Minerals

Estimates of the provisioning value of mineral extraction, based on a resource rent residual value of industry national accounts data, do not offer a strong logic chain from flow to valuation. As a result, it is difficult to observe how changes in the mineral extraction industry affect its natural capital asset valuation. Data for the minerals industry is relatively sparse. We currently have no development plans for the near future.

Fossil fuels

Estimates of the provisioning value of fossil fuels, based on a wholesale price integrated resource rent residual value adaptation, represent the best available practical approach to the valuation of the fossil fuels asset. There are unlikely to be any significant changes to this methodology in upcoming accounts.

Oil & NGL and natural gas production figures for 2020 were not available in time for this publication. Therefore, we estimated these figures by using the UK production figures and calculating a Scottish figure by using the average proportion of UK production accounted for by Scotland over the last five years.

Renewables

Estimates of the provisioning value of renewable energy, based on a resource rent residual value of industry national accounts data, do not offer a strong logic chain from flow to valuation. As a result, it is difficult to observe how changes in the renewables industry affect its natural capital asset valuation. The methodology for the valuation of renewables is likely to change substantially in the future. We aim to use data on subsidies and levelized costs of operation to estimate the overall income for the renewable providers. The direction of the change is uncertain.

Carbon sequestration

Carbon sequestration largely suffers from coverage issues relating to the extent of land-based emissions (such as from degraded peatland) that are currently not fully covered within the greenhouse gas inventory. Potentially significant sequestration from marine habitats is also not included. There are also issues with the exclusion of 'natural' emissions; if sequestration moved from a gross to a net sequestration basis, the value would fall. The valuation process for carbon sequestration is unlikely to change soon but the coverage of different habitats is likely to improve.

Air pollution removal

We hope to update the models and data to provide more accurate and timely values of air pollutant removal by vegetation. Direction of the change would be uncertain, but it is unlikely to be large.

Urban cooling

Long-term, it is desirable to use remote sensing temperature data to improve our estimates of urban cooling. If we can move from a relatively simple model to a more precise site-specific prediction, we may also switch to a less conservative valuation price.

Noise mitigation

We hope to use other data to provide yearly estimates of noise production. This would allow us to see expected changes between years but should not impact on the scale of the service. There are also likely to be changes in the modelling for noise dispersion which may reduce benefits.

Recreation

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 and educational interactions, health benefits and aesthetic interactions. Currently, there is no method in use that incorporates these considerations. Additionally, the time spent by people in the natural environment is not itself directly valued because of the accounting and methodological challenges involved.

A significant number of outdoor recreation visits have no expenditure as people take local visits, such as walking to a local park. The value of local recreation and the aesthetic benefit from living near green and blue spaces is estimated through house prices. Future work aims to incorporate the value that being in nature provides to individual wellbeing and health.

Recreation (house prices)

The original data source for advertised house prices is no longer readily available. Therefore, we will move to actual recorded sale prices. In addition, we need to make more direct estimates of urban and rural house numbers, but also include the value of recreation outside of formal parks. The overall impacts of these changes are unknown but could be significant.

Aesthetic (house prices)

See Recreation (house prices). However, in addition we would need to change the basis on which a "view" is identified, which again will have an uncertain impact on value.

Annual ecosystem service flow valuation

Broadly, two approaches are used to value the annual service flows. For fish capture, timber, carbon sequestration, pollution removal, noise mitigation, urban cooling, and recreation, an estimate of physical quantity is multiplied by a price. This price is not a market price but satisfies two accounting conditions:

- identifying a price that relates, as closely as possible, to contributions provided by the ecosystem to the economy

- 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 example, in the accounts woodland timber is an input to the timber sector. For agricultural biomass, water abstraction, minerals, fossil fuels, and renewable energy generation a residual value resource rent approach is used.

Resource rent definition and assumptions

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

The steps involved in calculating the resource rent are given in Table 10. Variations of this approach are applied depending on the category of natural capital under assessment; the variations are explained in the individual ecosystem service methodology.

Table 10: Derivation of resource rent

Calculation	Measure
Less	Operating costs
Less	Intermediate consumption
Less	Compensation of employees
Less	Other taxes on production PLUS other subsidies on production
Equals	Gross operating surplus – SNA basis
Less	Specific subsidies on extraction
Plus	Specific taxes on extraction
Equals	Gross operating surplus – resource rent derivation
Less	User costs of produced assets (consumption of fixed capital and return to produced assets)
Equals	Resource rent

Source: Office for National Statistics

Most of the data used in Scottish resource rent calculations are available from the Scottish Government input-output tables (1998 to 2018). Return to produced asset estimates are calculated using apportioned industry-based net capital stocks and the nominal 10-year government bond yield published by the Bank of England, then deflated using the gross domestic product (GDP) deflator to produce the real yield. This rate is relatively conservative compared with those expected in certain markets and could overstate the resulting resource rent estimates.

Technical guidance on SEEA Experimental Ecosystems Accounting (page 193) (PDF, 5.33 MB) acknowledges that the use of the method may result in small or even negative resource rents. Obst, Hein and Edens (2015) conclude that:

> "...resource rent type approaches are inappropriate in cases where market structures do not permit the observed market price to incorporate a reasonable exchange value for the relevant ecosystem service. Under these circumstances, alternative approaches, for example, replacement cost approaches, may need to be considered".

If the residual value approach does not produce plausible estimates for subsoil assets and provisioning services, alternative methods should be explored (Principle 7.7). Finally, where unit resource rents can be satisfactorily derived, care still needs to be taken when applying these at a disaggregated level. Even for abiotic flows, the extraction or economic costs could vary spatially, and hence national unit resource rents could be misleading for specific regions.

Asset valuation

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

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

Pattern of expected future flows of services

A principal factor in the valuation of natural capital is determining the expected pattern of future flows of services. These paths are not observed and so assumptions concerning the flows must be made, generally as a projection of the latest trends.

A more basic way to estimate the expected flows is to assume that the current flow (averaged over recent years) is constant over the asset life, but this might not be the case. In some cases, more information is available on future expected levels of services in non-monetary terms or future unit prices. Where there are readily available official projections these have been considered, but otherwise the default assumption in these estimates is that the value of the services is constant over time.

This article assumes constant service values throughout the asset life, except for the estimates for carbon sequestration and air pollutant removal by vegetation, where further projections are used. Where the pattern of expected service values is assumed to be constant, it is based on averages over the latest five years of data, up to and including the reference year in question.

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 a key component in the NPV model because it determines that the expected term over which the service flows from an asset should be discounted.

Following the ONS and Defra principles of natural capital accounting paper, this article takes one of three approaches when determining the life of a natural capital asset.

Non-renewable natural capital assets: where a sufficient level of information on the expected asset lives is available, this asset life is applied in the calculations. Where a sufficient level of information on their respective asset lives is not available, a 25-year asset life is assumed.

Renewable natural capital assets: a 100-year asset life is applied to all assets that fall within this category of natural capital.

Choice of discount rate

A discount rate is required to convert the expected stream of service flows into a current period estimate of the overall value. A discount rate expresses a time preference – the preference for the owner of an asset to receive income now rather than in the future. It also reflects the owner’s attitude to risk. The use of discount rates in NPV calculations can be interpreted as an expected rate of return on the environmental assets.

Based on an extensive review by external consultants, the ONS and Defra use the social discount rate set out in the HM Treasury Green Book (2020, page 119). In line with guidance set out in the document, estimates presented in this article assume a 3.5% discount rate for flows projected out to 30 years, declining to 3.0% thereafter and 2.5% after 75 years. The rationale for this approach is discussed further in the ONS and Defra principles of natural capital accounting paper.

Methodology by service

The following section provides an explanation of the data sources and methods used in each service.

As well as updated data and a newer price basis, there have been some methodological improvements and underlying data source changes from the previous Scottish natural capital accounts: 2021. Results should not be compared across accounts. Please use the data available in the 2021 release, together with that provided in the current publication, for time series analysis. The scale of these changes varies across different ecosystem services. Table 11 provides a broad explanatory summary of these changes and the impact they have on service valuations.

Table 11: Percentage change in 2018 asset values by service owing to methodological changes between 2020 and 2021 accounts

Service	Percentage change	Explanation
Carbon sequestration	-16%	Updated carbon prices to better reflect the zero-carbon policy. Also changes to how carbon sequestration is mapped.
Recreation and tourism	174%	Inclusion of tourism data to include trips to nature not covered by recreation surveys alone. Large valuation increase is due to more trips to nature captured.
Total	**158%**	

These experimental accounts are being continually revised to produce the best statistics with the available data and methods.

Agricultural biomass

Agricultural biomass relates to the value of crops, fodder and grazed biomass provided to support agricultural production. Agricultural statistics are published by the Scottish Government. Grazed biomass calculations are based upon livestock numbers and livestock annual roughage requirements provided in the Eurostat Economy-wide Material Flow Accounts (PDF, 2.96MB) (EW-MFA) questionnaire. This approach is also used in the UK Material Flows Accounts.

Estimating the proportion of agricultural production, which can be attributed to nature rather than modern intensive farming practices, is challenging. Modern farmers heavily manage and interact with the natural services supplied on their land. For example, sowing, irrigation, fertiliser spreading, pesticide use and livestock management are all industrial practices applied to the land. Very intensive farming may even take place entirely indoors without soil or natural light. At the other extreme, livestock may be allowed to roam freely over semi-natural grassland with limited human intervention.

As with the principles applied to the UK natural capital accounts, we draw the line between the farmland ecosystem and the economy at the point at which vegetable biomass is extracted (Principle 5.3). This means farmed animals are not included in these estimates as they are considered as produced rather than natural assets. Instead, the grass and feed that livestock eat are regarded as ecosystem services and so are included. This is also consistent with the boundary between the environment and the economy used in the material flows accounts.

For the primary valuation of agricultural biomass, a residual value resource rent approach is used. This is based upon data for the Standard Industrial Classification (SIC) subdivision class: crop and animal production, hunting and related service activities (UK SIC 01). The input-output supply and use tables and capital stocks data do not provide further SIC breakdowns so the industry residual value includes animal production. The factor used for apportioning net capital stocks and consumption of fixed capital is the proportional relationship between Scotland and UK aggregate agriculture accounts consumption of fixed capital.

While residual value resource rent approaches should be used for valuing provisioning services in the first instance (Principle 7.5), top-down industry-level estimates present difficulties in establishing clear ecosystem service logic chains and disaggregation. Condition indicators, or even physical flows of agricultural biomass, cannot readily be related to the estimated valuation of the service.

Fish capture

We have been working to improve our fisheries statistics and yet more work is needed. We rely on a range of external sources that all involve known uncertainties. For instance, Norway and Faroese landings are excluded from this analysis. The economic data are based on UK fleet data, which we also apply to foreign vessels that may face different costs and prices.

Aquaculture or farmed fish, like farmed livestock, have been removed from estimates as farmed fish are viewed as a produced asset and not a natural asset.

Physical data on marine fish capture (live weight) is sourced from the rectangle-level landings data published annually by the EU Commission's Joint Research Centre (JRC) Scientific, Technical and Economic Committee for Fisheries (STECF) as part of the Fisheries Dependent Information (FDI) data call (deep sea).

To calculate marine fish capture in the Scottish exclusive economic zone (EEZ), Marine Management Organisation ICES statistical rectangle factors were used. The overall fish capture provisioning service physical flow presented in this article represents landings (tonnage) from UK waters. UK boundaries do not perfectly align with the geographical areas of fish capture statistics. For more detail on how fish capture in UK waters is estimated, see the Marine Management Organisation Exclusive Economic Zone Analysis and associated publications.

Valuations are calculated using net profit per tonne (landed) estimates, provided by Seafish, for different marine species by marine areas. Net profit per tonne is calculated using Seafish economic estimates for fleet segments and Marine Management Organisation 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). Annual net profit per tonne (landed weight) is multiplied by tonnes of fish captured (live weight) for a specific species. The data are aggregated for overall annual valuations of fish provisioning from the UK EEZ.

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. Live weight is the weight of a product, when removed from the water.

A notable limitation of the fish capture provisioning valuation methodology is that landed weight net profits are multiplied by live weight fish capture. Based on Marine Management Organisation data on live and landed weights of UK vessel landings into the UK, aggregate landed weight is around 7% less than live weight.

Net profit per tonne was not available for all fish species so only partial physical flow is valued. Based on available net profit per tonne annual data, 93% of fish provisioning (live tonnes) from Scottish waters was valued in 2018.

For all fish species across in Scottish waters, we estimate whether fishing is sustainable using The International Council for the Exploration of the Sea stock assessments. This does not include wider externalities from fishing. 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 2019 in Scotland, we can determine stock sustainability for 86% of the fish capture tonnage, leaving 14% as unknown.

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 significant part of other fish species' diets is managed unsustainably, it risks affecting the sustainability of other fish stocks higher up the food chain.

Timber

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

Timber provisioning service asset valuations use Forestry Commission forecasts of timber availability to estimate the pattern of expected future flows of the service over the asset lifetime.

Removals estimates are taken from Forest Research Timber Statistics and converted from green tonnes to cubic metres (m^3) overbark standing, using a conversion factor of 1.222 for softwood and 1.111 for hardwood.

The stumpage price is the price paid per standing tree, including the bark and before felling, from a given land area. Stumpage prices are sourced from the Forestry Commission Coniferous Standing Sales Price Index in the Timber Price Indices publication (2021). The Coniferous Standing Sales Price Index monitors changes in the average price received per cubic metre (overbark) for timber that the Forestry

Commission or Natural Resources Wales sold standing, where the purchaser is responsible for harvesting.

Water abstraction

Physical data for water abstraction for public water supply are sourced from Scottish Water.

Monetary estimates are based on resource rents calculated for the Standard Industrial Classification (SIC) subdivision class: Water collection, treatment, and supply (SIC 36). The definition of this industry subdivision states: “the collection, treatment and distribution of water for domestic and industrial needs. Collection of water from various sources, as well as distribution by various means is included.” A limitation of this approach, therefore, is that the calculated resource rent is not purely related to water supply, but also includes the process of treating the water.

In estimating the resource rent for the Scottish water abstraction provisioning service input-output supply and use tables and capital stocks data are used. The factor used for apportioning net capital stocks and consumption of fixed capital is the proportional annual relationship between Scotland and UK water collection, treatment, and supply (SIC 36) intermediate consumption at purchasers' prices.

Further work is required 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.

Minerals

Physical estimates of mineral extraction are provided by the British Geological Survey (BGS) as a country-level breakdown of the United Kingdom Minerals Yearbook. Mineral extractions after 2014 are estimated.

Monetary estimates are based on the residual value resource rent approach calculated from the SIC subdivision class: Other mining and quarrying (SIC 08). This division 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, and manufacture of materials, such as clay and gypsum, and manufacture of chemicals. This division does not include processing (except crushing, grinding, cutting, cleaning, drying, sorting, and mixing) of the minerals extracted.

In estimating the resource rent for the Scottish minerals abiotic provisioning service Scottish input-output tables and source-level apportioning of ONS UK capital stocks is used. The factor used for apportioning net capital stocks and consumption of fixed capital, is the proportional annual relationship between Scotland and UK other mining and quarrying (SIC 08) intermediate consumption at purchasers' prices.

Fossil fuels

Physical estimates of oil and gas production are available from the Scottish Government. Country-level coal production were requested from the Department for Business, Energy, and Industrial Strategy (BEIS) Digest of UK Energy Statistics (DUKES).

Monetary estimates of oil and gas are based on the methodology published by the ONS in June 2013, following a residual value resource rent approach calculated from the SIC subdivision class: Extraction of crude petroleum and natural gas (SIC 06). Production statistics are combined with oil and gas price data supplied by the Oil and Gas Authority (OGA) to calculate income. Deductions are then made for operating expenditure, from the Scottish Government, and user costs of produced assets, from ONS UK capital stocks data. The factor used for apportioning net capital stocks and consumption of fixed capital is the proportional annual relationship between Scotland and UK oil and gas capital expenditure.

For the valuation of coal, a residual value resource rent approach is used. This is based upon supply and use and capital stocks data for the Standard Industrial Classification (SIC) division: Mining of coal and lignite (SIC 05). The factor used for apportioning net capital stocks and consumption of fixed capital, was the proportional annual relationship between Scotland and UK other mining and quarrying (SIC 05) intermediate consumption at purchasers' prices.

For the asset valuation of fossil fuels, an asset life of 25 years has been assumed. Asset valuation uses annual projected UK oil and gas production from the OGA until 2035. Then, following OGA methodology, assumes a further 5% production decline per year (for all years following 2035) to be able to project over the full 25-year asset lifetime. UK production projections are apportioned for Scotland based upon the last five years of Scottish contribution to UK production. To estimate valuations in future years, annual five-year averages of “unit resource rent” (average resource rent divided by average production) are applied to production projections.

As with all services, the methods used will be reviewed for future updates.

Renewable generation

Energy generated by renewable sources is published in the Scottish Government Energy Statistics Database.

Monetary estimates are based on the residual value resource rent approach calculated from the SIC Group 35.1: Electric power generation, transmission, and distribution. UK capital stocks data are apportioned for Scotland based on relative installed capacity. These data are then apportioned using turnover from the ONS Annual Business Survey (ABS) to derive the resource rent of 35.11: Production of electricity. To estimate the renewable provisioning valuation, data are further apportioned using renewables proportion of total energy generation.

Carbon sequestration

Estimates relate to the removal of carbon dioxide equivalent (CO_2e) from the atmosphere by habitats in Scotland. However, because of a lack of data we are unable to include the marine habitat, including those intertidal areas such as salt marsh.

The carbon sequestration data was taken from the UK National Atmospheric Emission Inventory (NAEI), which reports current and future projections of carbon removal for the land use, land use change and forestry (LULUCF) sector. This contains data relating to carbon change in the Land Use, Land Use Change and Forestry (LULUCF) sector from 1990 to 2100. The Department for Business, Energy and Industrial Strategy (BEIS) has provided a further breakdown of these data to enable estimation of carbon stock change in living biomass, which currently represents the "gross" carbon sequestration figure.

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. Under a combined nature and human approach, greenhouse gas emissions from poorly managed peatland should be included.

This is an area of research we will consider further as our accounts develop. In the meantime, we continue to use gross carbon sequestration as the asset value, and annual value data to give a more rounded picture.

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 Business, Energy and Industrial Strategy (BEIS).

Air pollution removal by vegetation

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 developing estimates for the valuation of air pollution removal in the ecosystem accounts report published in July 2017.

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 Scottish vegetation has been modelled for the years 2007, 2011, 2015 and then scaled to create values in 2030. Between these years a linear interpolation has been used and adjusted for real pollution levels as an estimation of air pollution removal.

The health benefits were calculated from the change in pollutant exposure from the EMEP4UK scenario comparisons, that is, the change in pollutant concentration to which people are exposed. Damage costs per unit 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 (NO_2))
- deaths (short-term exposure effects from ozone (O_3))

The damage costs were updated in February 2019. For a method of how the damage costs are calculated (PDF, 1.01MB) please see the report published by Defra.

Future flow projections used for asset valuation incorporate an average population growth rate and an assumed 2% increase in income per year (declining to 1.5% increase after 30 years and 1% after 75 years). Income elasticity is assumed to be one. Annual forecasts are discounted to 2018 present values using a 3.5% discount rate, reducing appropriately as per the Green Book methodology. More work is being conducted in this area.

Noise mitigation by vegetation

Please see the full extending noise regulation estimates paper published by Defra.

Urban cooling

A brief overview of the methodology of urban cooling will be provided here but for a more detailed description, please see Eftec and others (2018). To calculate the physical flow of local climate regulation services for the urban blue and green space assets, Eftec and others (2018) calculated the proportional impact on city-level temperatures, caused by the urban cooling effect of blue and green space features and their buffers, using the cooling values from various sources.

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

This is assessed by non-financial business sectors, based on averaging temperature mitigation across urban areas, and applying temperature-output loss functions to estimate the gross value added (GVA) that would have been lost because of heat in the absence of the cooling effect, accounting for adaptation behaviours.

These adaptation behaviours consider the averted loss of labour productivity from air-conditioning and behaviour change. 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 example, mining, utilities and manufacturing are reduced at 40%. An 85% reduction is applied for less labour-intensive or office-based sectors for averted losses because of air-conditioning (for example, information and communication; real estate activities).

These estimates represent exchange values as they are based on avoided losses in economic output and expenditure. Welfare values would be included if the valuation covered the non-market benefits to the 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 (defined as over 28 degrees Celsius).

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 experienced.

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

Further work is needed to measure this ecosystem more accurately, for example, adopting a more granular, bottom-up approach to physical account modelling. For a full list of all the recommendations to update this service please see Eftec and others (2018).

Recreation

The recreation estimates are adapted from the "simple travel cost" method developed by Ricardo-AEA in the methodological report Reviewing cultural services valuation methodology for inclusion in aggregate UK natural capital estimate. This method was originally created for use on the Monitor of Engagement with the Natural Environment (MENE) Survey, which covers recreational visits by respondents in England.

The method looks at the expenditure incurred to travel to the natural environment and some expenditure incurred during the visit. This expenditure method considers the market goods consumed as part of making the recreational visit (that is, fuel, public transport costs, admission charges and parking fees). This expenditure is currently assumed as a proxy for a marginal price for accessing the site.

Estimates for the cultural service of outdoor recreation in this publication use respondent data from two surveys in Scotland: Scotland's People and Nature Survey and the Scottish Recreation Survey.

From 2003 to 2012, data from the Scottish Recreation Survey (ScRS) were used. The ScRS was undertaken through the inclusion of a series of questions in every monthly wave of the TNS Omnibus Survey, the Scottish Opinion Survey (SOS). In every month of the Scottish Opinion Survey 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 Monitor of Engagement with the Natural Environment (MENE) from Natural England 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.

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

Table 12: Scottish recreation broad habitat classifications

Broad habitat	Scotland survey habitats
Built-up areas and gardens	Village
Built-up areas and gardens	Local park or open space
Built-up areas and gardens	Towns
Built-up areas and gardens	Golf course/football stadium
Built-up areas and gardens	Local urban

Built-up areas and gardens	Local area
Built-up areas and gardens	City
Built-up areas and gardens	Country lanes
Built-up areas and gardens	Castle/historical building
Built-up areas and gardens	Garden/gardening
Built-up areas and gardens	Local show/festival
Built-up areas and gardens	Leisure/sports centre
Built-up areas and gardens	Streets/roads
Coastal margins	Sea/sea loch
Coastal margins	Beach/cliff
Coastal margins	Beach
Coastal margins	Cliff
Coastal margins	Wildlife area
Woodland	Woodland/forest – managed by Forestry Commission/Forest Enterprise
Woodland	Woodland/forest – other type of owner
Woodland	Woodland/forest – do not know owner
Woodland	Wildlife area
Farmland	Farmland – fields with crops
Farmland	Farmland – fields with livestock
Farmland	Farmland – mixed crops and livestock
Farmland	Wildlife area
Farmland	Farmland unspecified
Farmland	Country/countryside
Mountain, moorland and hill	Mountain/moorland
Mountain, moorland and hill	Mountain/hill
Mountain, moorland and hill	Moorland
Mountain, moorland and hill	Wildlife area
Freshwater	Loch
Freshwater	River/canal
Freshwater	River

Freshwater	Canal
Freshwater	Wildlife area
Freshwater	Reservoir
Other	Others
Other	None of these
Other	Do not know/Not stated

Source: Office for National Statistics, Scottish Recreation Survey, Scottish People and Nature Survey

For the asset valuation of outdoor recreation, projected population growth calculated from ONS population statistics 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 and educational interactions, health benefits and aesthetic interactions. Currently, there is no method in use that incorporates these considerations. Additionally, the time spent by people in the natural environment is not itself directly valued because of the accounting and methodological challenges involved.

A significant number of outdoor recreation visits have no expenditure as people take local visits, such as walking to a local park. The value of local recreation and the aesthetic benefit from living near green and blue spaces is estimated through house prices.

Recreation method changes from previous years

There are sizeable differences in this year's recreation estimates compared with previous years, which are the result of broader methodological changes that are being made to the way the UK recreation and tourism accounts are produced.

The 2021 UK Tourism and outdoor leisure natural capital account was produced to improve the estimates within the recreation account. Like the recreation account, the tourism account captures the amount spent on travelling to the natural environment.

Estimates for the cultural service of tourism use data from three surveys: Great Britain Day Visits Survey, Great Britain Tourism Survey and the International Passengers Survey.

The newly introduced tourism account features overlap with our existing recreation account. Double counting would occur if both measures were included in their entirety, in which some of the same expenditure is counted twice. To avoid this, methodological changes have been introduced to the recreation account.

To generate the UK's 2021 combined recreation and tourism account, we have taken the approach of adding the aspect of recreation estimates not already captured within tourism to the tourism estimates. This involves determining recreation estimates for the number of visits and amount spent on day trips less than three hours in duration. These estimates are then added to tourism estimates to produce the full recreation and tourism account.

This method maintains the larger sample size of the tourism-related surveys, while also using the respondent level data of the recreation surveys to generate detailed estimates for trips less than three hours in duration.

This method has also been used to produce this year's Scotland natural capital accounts. For more information about changes in recreation estimates, please see this methodological guide.

Recreation and aesthetic value in house prices

For a detailed methodology note on how the recreation and aesthetic value in house prices was produced for the UK accounts, please see this 2019 House Pricing Methodology paper. Please note that there are two significant differences for consideration when assessing house price values for Scotland.

First, we were unable to include data on Scottish schools as Education Scotland only inspect a sample of schools and educational establishments are not given an overall inspection outcome in the same way that Ofsted and Estyn provide. Since there is a strong correlation between house prices and proximity to school, this lack of data will reduce the precision of the Scottish model. Future work might hope to use alternative data sources on the quality of Scottish schools.

Second, it is possible that our sample of urban property prices are underestimates of actual urban property prices in Scotland. We source property price data from Zoopla, which uses the advertised price rather than the selling price. However, Scottish properties are marketed with either a fixed price or "offers over" the minimum offer accepted by the seller. As bidding for "offers over" houses can drive up the selling price of properties, our data on advertised prices could underestimate the actual selling price.

Annex A: The Natural Capital Asset Index and the Natural Capital Accounts – How Do They Compare?

An alternative appraisal of Scottish natural capital is available through NatureScot's Natural Capital Asset Index (NCAI). The NCAI is a composite index which analyses the relative potential of nature to contribute to the wellbeing of Scotland's citizens. The NCAI and national natural capital accounts provide complimentary information about natural capital in Scotland. This annex provides information on the similarities and differences between the NCAI and the Scottish natural capital accounts.

NatureScot has been producing the NCAI since 2007, and it is now part of the National Performance Framework as an economic indicator. The 2021 NCAI update was published on 26th May 2021. Adapted from the existing UK-wide accounts by the ONS in 2021, the Scottish natural capital accounts presented for the first time estimates of the value of Scotland's natural capital in monetary terms and has subsequently been updated on an annual basis. This will make it easier to incorporate natural capital into decision-making and helps demonstrate the vast contributions that the environment makes to the economy and society in terms that are more comparable to other economic indicators.

The main difference between the NCAI and the accounts is the representation of value; the accounts look to measure nature's contribution to society and the economy through commeasurable monetary terms, whereas the NCAI seeks to demonstrate the contribution of nature to the citizens of Scotland more directly. The accounts are able to demonstrate the contribution of select assets comparatively and in absolute values, which is vital for demonstrating value when compared with other types of capital. The NCAI instead looks at the contributions provided by Scotland's terrestrial ecosystems relative to each other, in doing so it is able to include a wider range of benefits and habitats.

The accounts include some abiotic benefits such as renewable energy, mineral and oil and gas deposits in their valuations; the NCAI focusses instead on living ecosystems and habitats. It is impossible to wholly accurately model the full range of benefits derived from the environment and neither the accounts nor the NCAI claims to be fully successful in doing so. Both models make considerable contributions to our understanding of the total benefits Scotland obtains from the environment and can be seen as complimentary to each other.

How they represent value

The NCAI tracks the changes in the potential of the natural environment to provide benefits to people. The accounts seek to measure these benefits directly through market and hypothetical market values and express them mainly as monetary values.

Many benefits cannot be accounted for or valued because of their intangible nature, even in hypothetical markets, as a result many of these benefits remain unaccounted for in the accounts. As the NCAI does not measure benefits directly and seeks to assess the ability of habitats to provide benefits it is therefore better able to account for more intangible benefits.

There are issues surrounding value with both the NCAI and the accounts. The NCAI has value weightings within it based on academic studies and surveys of the Scottish public. These weightings are not updated annually and don't reflect changing attitudes within the Scottish public to inform valuation. The NCAI outputs are relative to themselves and cannot be directly compared with other forms of capital such as human or produced, meaning that comparison between them is difficult. The accounts use up to date valuation of benefits. However, they often use current value to project expected benefits into the future; future values are also impacted by changing attitudes as well as by market forces which may change (for example, oil prices).

The accounts value the stock of natural capital by forecasting the benefits and use into the future. There are issues here surrounding policy changes (for example, banning sale of petrol/diesel cars and other climate change policies that would affect the projected demand of oil and gas, or increased woodland planting etc.) and how these will affect future value flows.

Abiotic services

The NCAI accounts only for biotic ecosystem services (i.e., those produced by habitats) with the exception of the provision and quality of water which is strongly influenced by ecosystem functions. The accounts on the other hand include many abiotic services, that is, services that are still provided by nature but do not require organic input. These include renewable energy and non-renewable mineral, oil and gas reserves.

The accounts do not include livestock as they consider them to be produced or man-made capital. The NCAI uses livestock numbers as one of its indicators, as a proxy for potential to supply provisioning services (i.e., food).

Biodiversity

Biodiversity can be found at many points along the value chain: it supports the ability of habitats to function effectively, contributes directly to the benefits and is valued as a benefit in itself. As a result it has always been difficult to value within the natural capital concept and complementary indicators are often used to ensure that biodiversity is not overlooked. In 2021, the UK treasury published a global review on the economics of biodiversity, known as ‘The Dasgupta Review’. The review advocated for incorporating natural capital into decision making to improve outcomes for biodiversity.

The review highlighted the benefits in valuing national natural capital for the inclusion in national accounts and in tracking the changes in portfolios of natural capital stocks, as the NCAI does. The NCAI includes some broad biodiversity indicators:

bird and butterfly indicators. The accounts do not currently account for biodiversity either as inputs or outputs.

Timeframes involved

The NCAI tracks changes since the year 2000; the 2021 update provides results up to 2019. A more rudimental version of the NCAI is able to demonstrate trends back to 1950 although detailed data becomes less reliable prior to 2000. The accounts, where available, provide monetary estimates of ecosystem service flows between 1997 and 2020. Historical values are deflated using the HM Treasury June 2021 GDP deflators.

What is covered

The NCAI only accounts for terrestrial habitats and assets (to the high-water mark). While marine habitats were considered during the initial development of the NCAI, a lack of data meant it was not possible to include marine habitats. A recent feasibility study suggested a marine version of the NCAI is possible but may still be limited by data availability. The accounts include terrestrial and some marine assets in the form of fish capture from the sea.

Ecosystem disservices / costs

The Scottish natural capital accounts account only for benefits flowing from different habitats; they currently do not account for disbenefits arising from changes in the environment. While the NCAI does not measure these disbenefits, it does use stress indicators to highlight negative changes to habitats (for example, increases in fertiliser and pesticide use) which can be attributed to losses of habitats and places pressure on assets to provide benefits into the future.

An Experimental Official Statistics publication for Scotland

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How to access background or source data

The data collected for this statistical bulletin may be made available on request, subject to consideration of legal and ethical factors. Please contact natural.capital.team@ons.gov.uk for further information.

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