Office for National Statistics

Article

Scottish natural capital accounts: 2020

The Scottish natural capital ecosystem service accounts, highlighting the relative importance of services provided by Scottish natural assets. Natural capital refers to physical and natural resources and the benefits these provide.

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Table of contents

1 . Main points

- In 2016, the partial asset value of Scottish natural capital was £196 billion, 20% of the UK asset valuation.
- 37% of the asset value was attributable to non-material benefits not directly captured in gross domestic product.
- Living near publicly accessible green and blue spaces added on average £2,393 to property prices in Scottish urban areas.
- Because of the cooling effects of urban green spaces, Edinburgh and Glasgow avoided £3.15 million in productivity losses during 2018.
- Fossil fuel extraction has more than halved between 1998 and 2018.
- In 2018, renewables made up the majority (55%) of Scottish electricity generation, up from 18% in 2008.
- In 2016, nearly four-fifths of total UK waters fish capture was caught in Scottish waters.
- Timber production in Scotland has doubled between 1997 and 2018.
- Our model suggests the equivalent to 1,549 years of life were saved through Scottish vegetation removing air pollution in 2017.
- In 2017, Scotland represented 39% of UK net carbon sequestration.
- During 2017, over 1 billion hours were spent on visits for outdoor recreation in Scotland.

2 . Things you need to know about this release

This article looks at natural capital assets, the flows and values of services – terms that help us think logically about how to measure aspects of the natural world and their impact upon people. Natural capital assets are environmental resources that persist long-term, such as mountains, woodlands, or a fish population.

From these assets, people receive a flow of services, such as mountain hikes and fish captured for consumption. We can value the benefit to society of those services by estimating 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 1997 to 2018 and all monetary valuations are given in 2018 prices deflated using the HM Treasury June 2019 gross domestic product (GDP) deflators. Because of data coverage constraints, 2016 is the latest year we can estimate an overall Scottish natural capital asset value.

It is recognised that the Scottish and UK accounts remain experimental and future publications will be subject to methodological improvements. There have been significant methodological improvements from the previous Scottish natural capital accounts: 2019 so results should not be compared across accounts. Please use the data available alongside this release for time series analysis.

For context the £291 billion (2017 prices) asset value of natural capital for 2015 in the 2019 accounts is now 18% lower (£239 billion) based upon the methodological improvements in this publication. In addition to the decrease caused by the methodological improvements, there has been a further 22% drop as a result of changes to the valuation of services between 2015 and 2016.

Monetary ecosystem service valuations offer comparative analysis across services whereas physical flows provide information about the changes over time independent of price changes. The services are presented by type, which include provisioning, regulating and cultural. Types of service are defined at the beginning of each section.

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

3 . Collaboration

This article was produced for the Scottish Government by the Office for National Statistics. The article is available from both the Office for National Statistics and the Scottish Government. 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.

4 . Overview of Scottish ecosystem services

This article uses the term "ecosystem service" throughout, which generally refers to a flow of benefits to humanity from living (biotic) components of the Earth. However, non-living (abiotic) components, such as oil and gas used for energy, are also included in this release. A summary of the main trends is presented in this article, but more information can be found in the datasets accompanying this release.

This article presents 13 service accounts, containing estimates of the quantity and value of services being supplied by Scottish natural capital.

Table 1: Scottish ecosystem services asset valuation
£ million, 2018 prices

	£	£	Percentage change
Services	**2015**	**2016**	**2015 to 2016**
Provisioning			
Agricultural biomass	14,411	15,239	6
Fish capture	3,233	5,251	62
Fossil fuels	147,137	89,432	-39
Minerals	1,263	1,484	18
Timber	5,062	5,221	3
Water abstraction	2,870	3,003	5
Renewables generation	2,248	3,400	51
Regulating			
Carbon sequestration	40,484	41,114	2
Air pollutant removal	2,255	2,262	0
Urban cooling*		60	-
Noise mitigation*			-
Cultural			
Recreation	24,117	23,376	-3
Aesthetic (house prices)*	616	545	-12
Recreation (house prices)*	6,085	5,598	-8
Total	249,843	196,019	-22

Source: Office for National Statistics

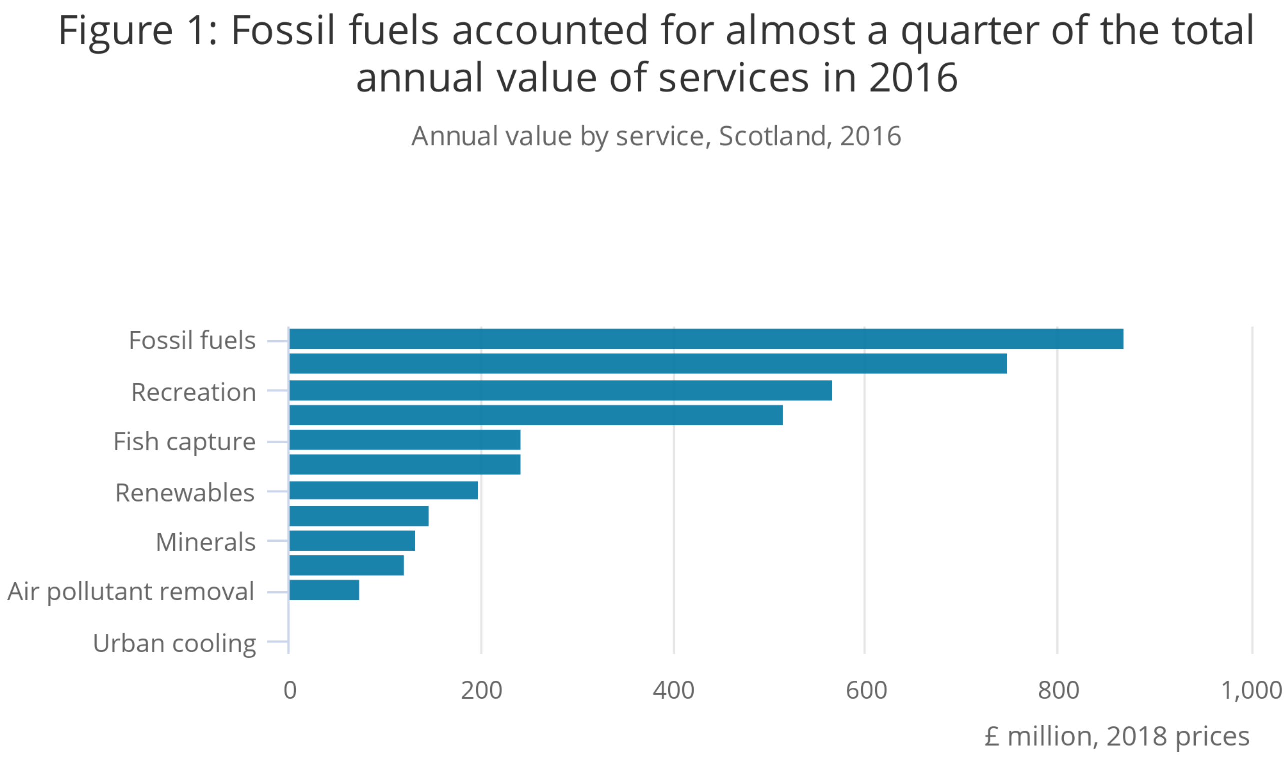
Notes

1. * Services marked with an asterisk are new to this publication. Back to table
2. - Signifies insufficient data in all columns rather than no change. Back to table
3. Because of data constraints Noise mitigation estimates are only available in 2017. Back to table
4. Noise mitigation asset value in 2017 has been included under Scottish total asset valuation in 2015 and 2016. Back to table
5. Urban cooling asset value in 2016 has been included under Scottish total asset valuation in 2015. Back to table

The total value of Scottish natural capital has declined 22% between 2015 and 2016, largely because of the 39% drop in the asset valuation of fossil fuels. The decline in the value of the fossil fuel abiotic provisioning service means that a greater proportion of the asset value was attributable to non-material benefits not directly captured in gross domestic product. The non-material benefits are regulating and cultural services, which made up 37% of the Scottish natural capital asset value in 2016, up from 29% in 2015.

Figure 1: Fossil fuels accounted for almost a quarter of the total annual value of services in 2016

Annual value by service, Scotland, 2016



Source: Office for National Statistics

Notes:

1. Noise mitigation annual value for 2017 is included.

In 2016, the total annual value of services was £3,857 million. Fossil fuel provisioning provided the highest annual valuation during 2016. This was followed by carbon sequestration, which provided an overall benefit of nearly £750 million, accounting for almost a fifth of the total annual value in 2016.

Of the services measured, urban cooling was the lowest valued service (£1 million) as not many Scottish "hot days" occurred during 2016. However, the cooling effect of green and blue spaces will provide greater benefit as summers tend to get warmer.

5 . Provisioning services

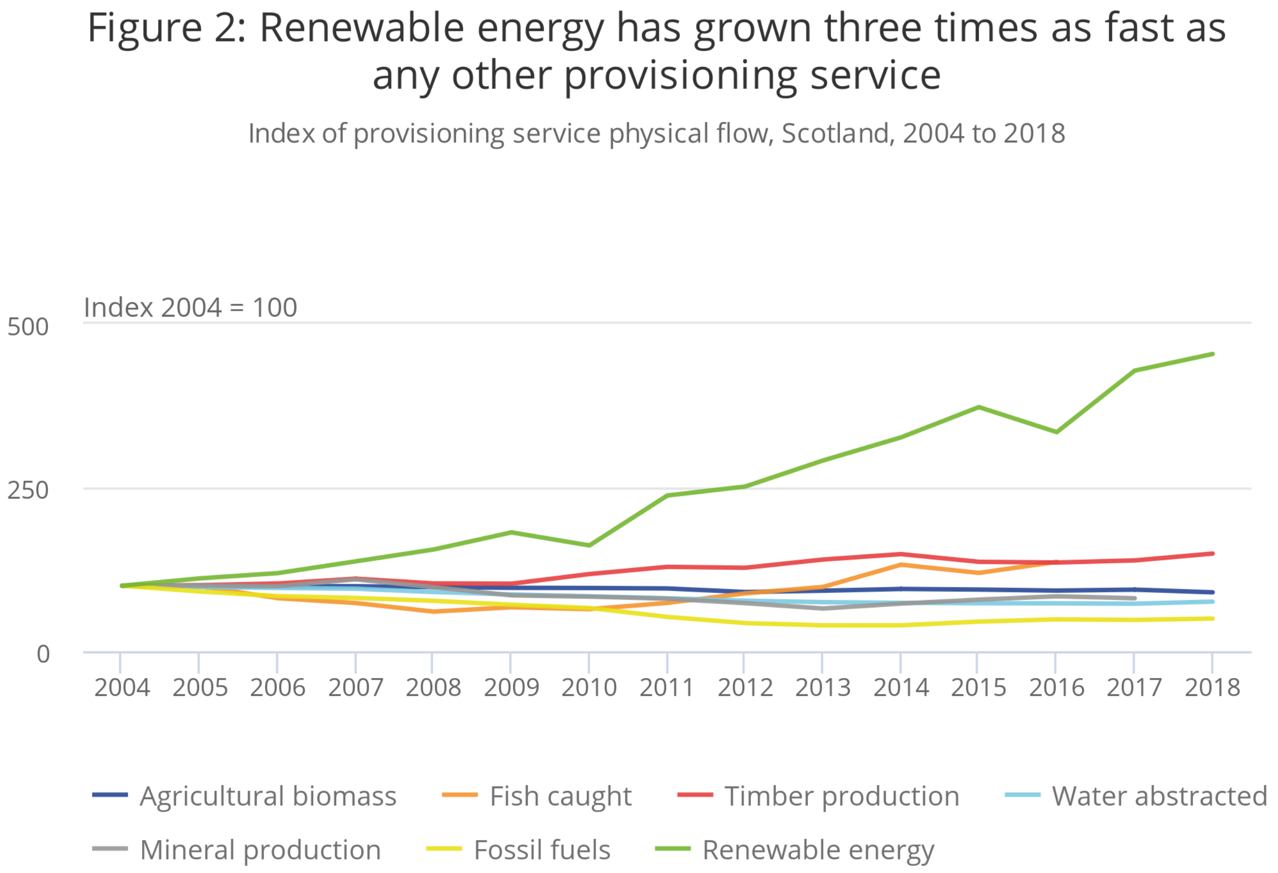
Provisioning ecosystem services create products that include food, water and materials. These are produced by nature and then consumed by society.

Provisioning services currently included in the Scottish ecosystem accounts are:

- agricultural biomass
- fish capture
- timber
- water abstraction
- minerals
- fossil fuels
- renewable energy

Figure 2: Renewable energy has grown three times as fast as any other provisioning service

Index of provisioning service physical flow, Scotland, 2004 to 2018

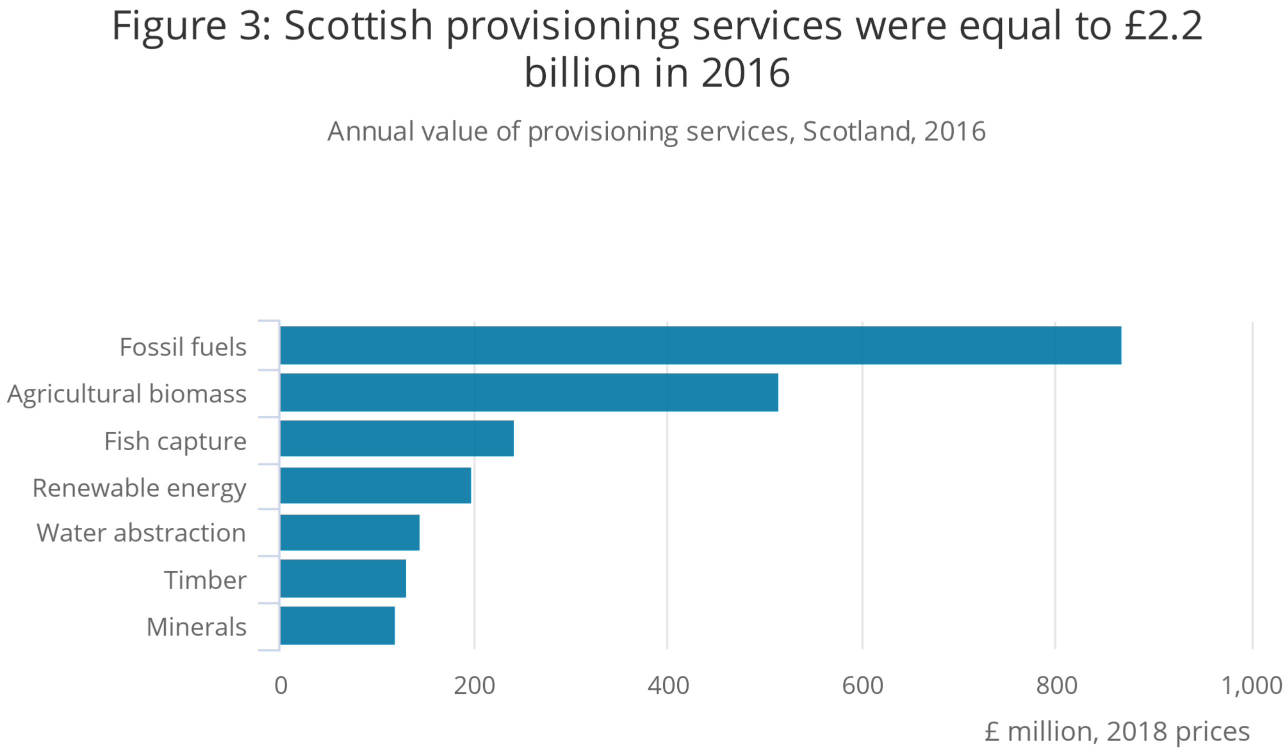


Source: Office for National Statistics, Scottish Government, European Commission: Scientific, Technical and Economic Committee for Fisheries, Forest Research and Scottish Water

Historically in Scotland fossil fuels have represented most of the provisioning service valuation but in 2016 this abiotic service represented only 40% of the value. Looking at the other services in 2016, agricultural biomass made up nearly a quarter of the total, followed by fish capture (11%).

Figure 3: Scottish provisioning services were equal to £2.2 billion in 2016

Annual value of provisioning services, Scotland, 2016



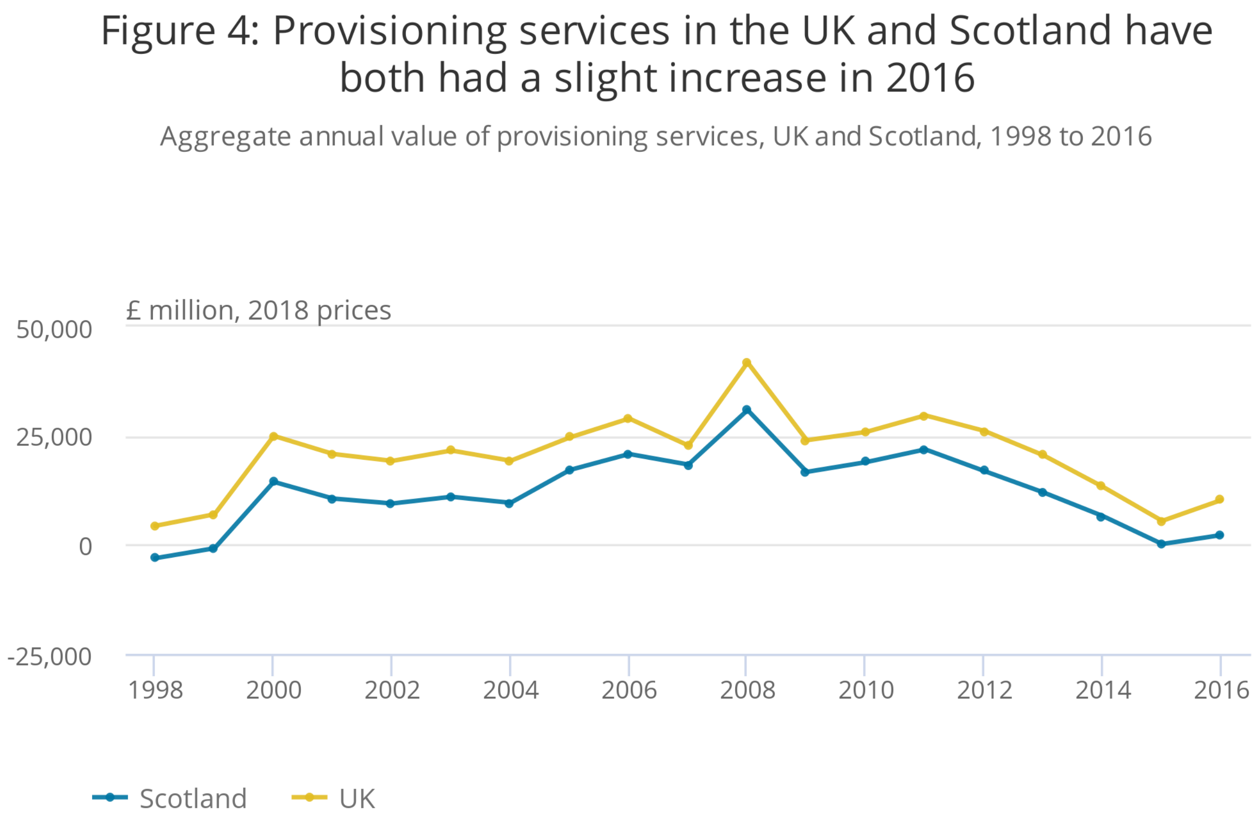
Source: Office for National Statistics, Scottish Government, European Commission: Scientific, Technical and Economic Committee for Fisheries, Forestry Commission and Scottish Water

Between 2011 and 2016, the total value of provisioning services in Scotland declined by 90%, largely because of a steep decline in the value of fossil fuels.

The UK has also seen a similar decline over the same period again caused by a fall in fossil fuels. Scotland represented 22% of the UK provisioning service value in 2016 from a peak of 81% in 2007.

Figure 4: Provisioning services in the UK and Scotland have both had a slight increase in 2016

Aggregate annual value of provisioning services, UK and Scotland, 1998 to 2016



Source: Office for National Statistics and Scottish Government

Notes:

1. Renewable generation excluded prior to 2008 due to lack of data.

2. Fish capture excluded prior to 2015 due to lack of data.

Agricultural biomass

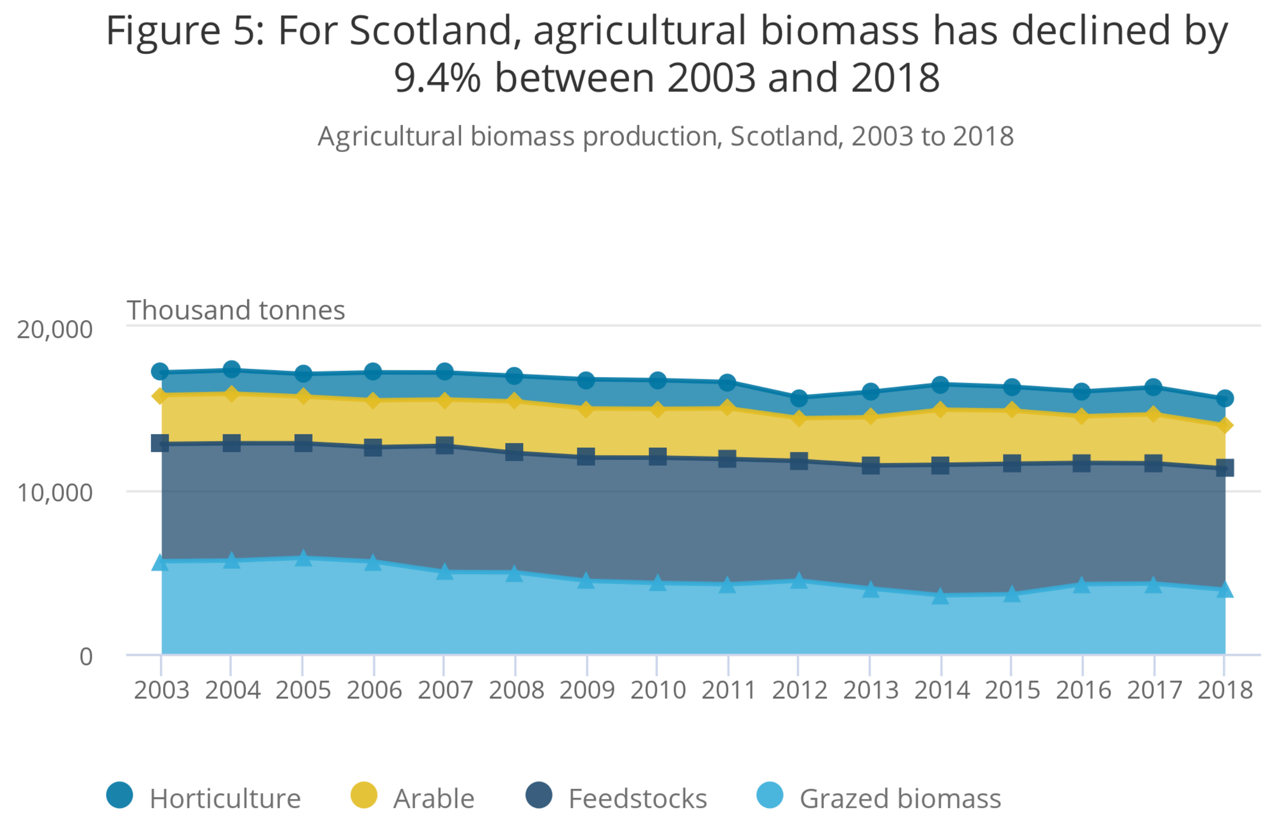
Agricultural biomass is the value of crops, fodder and grazing, which supports agricultural production in Scotland. Farmed animals are not included in these estimates as they are considered produced rather than natural assets. The food eaten by farmed animals, such as grass and feed, is included.

The volume of agricultural biomass in Scotland was 15.59 million tonnes in 2018, a 9.4% decrease since the value of 17.20 million tonnes in 2003. This is the lowest it has been recorded over this 16-year period.

One of the main reasons for this large decline is a fall in livestock (Scottish Agricultural Census 2019), which is shown in grazed biomass production. This used to make up nearly one-third of the agricultural biomass production total but is now responsible for only one-quarter.

Figure 5: For Scotland, agricultural biomass has declined by 9.4% between 2003 and 2018

Agricultural biomass production, Scotland, 2003 to 2018



Source: Office for National Statistics and Scottish Government

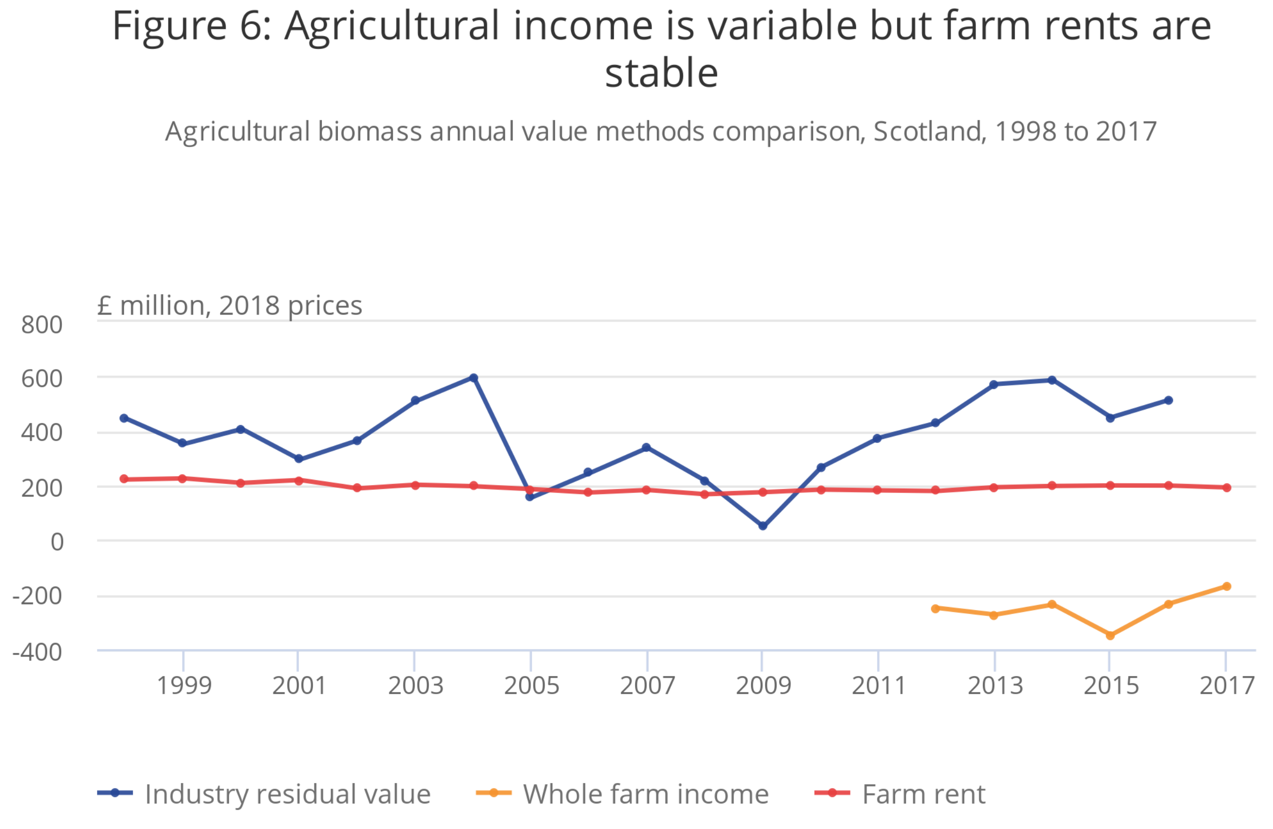
It is easy to see from Figure 5 that both grazed biomass and feedstocks have continuously contributed the most to agricultural biomass production. Grazed biomass declined by 30.8% between 2003 and 2018, whilst feedstocks increased 3.4% over the same period. In 2018, both feedstocks and grazed biomass made up 72.6% of the overall production for Scotland.

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. We have compared the industry resource rent residual value approach with an aggregated whole farm income and farm rent approach. Whole farm income is the total income from agricultural production (excluding subsidies) net of costs (excluding taxes). This is like the residual value approach but calculated at a farm output level. Farm rent is an imputed estimate of total rental costs for agricultural land. For further details on these approaches please see the methodology section.

Figure 6: Agricultural income is variable but farm rents are stable

Agricultural biomass annual value methods comparison, Scotland, 1998 to 2017



Source: Office for National Statistics and Scottish Government

Using the industry residual value, agricultural biomass provisioning service annual valuations show a high of £597 million in 2004 and a low of £49 million in 2009. In 2016, the agricultural biomass annual valuation was £514 million, making up 12% of the UK value.

Marine fish capture

Rising marine fish capture in Scottish waters has driven UK growth since 2003

We have been working to improve our fisheries statistics and more work is needed. We rely on a range of external sources, which all involve known uncertainties.

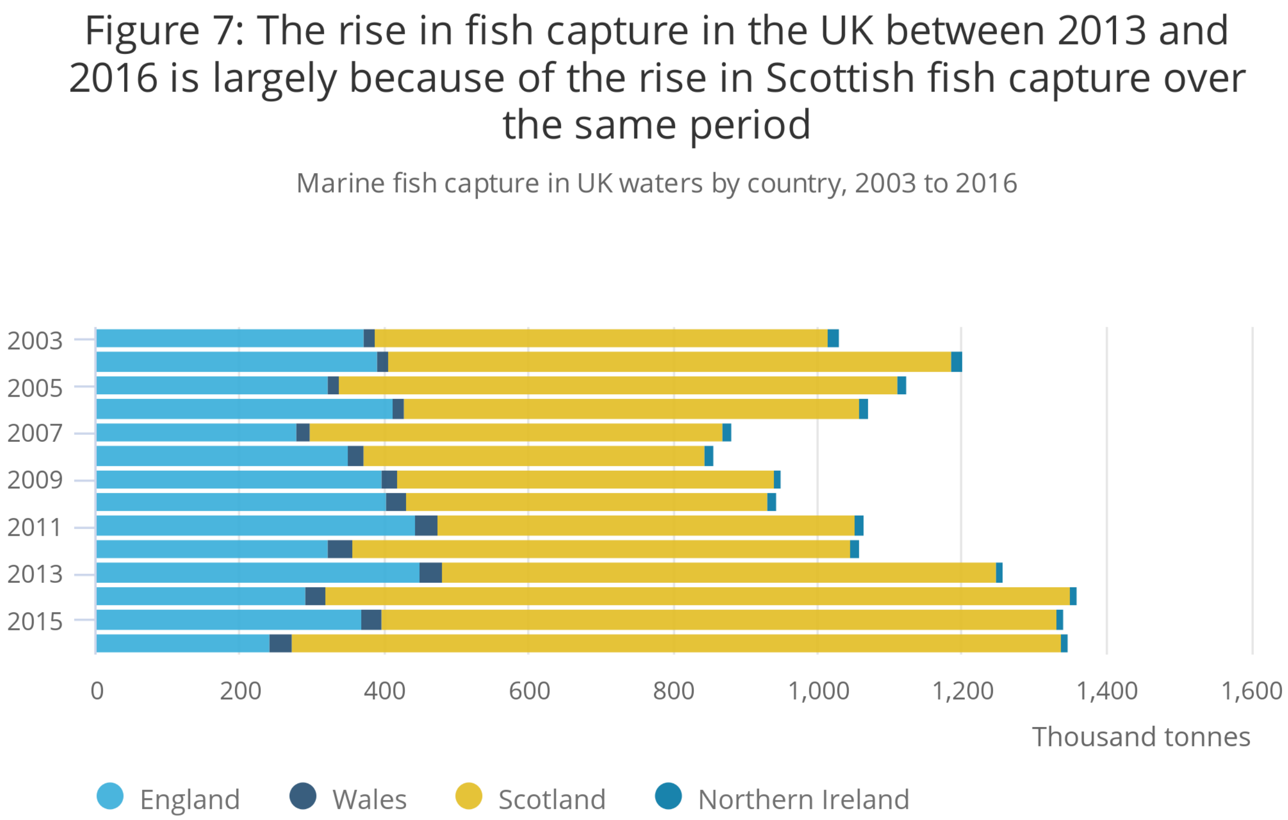
For instance, Norway and Faroese landings are excluded from this analysis. The economic data are based on UK fleet data, which we also apply to foreign vessels that may face different costs and prices. In addition, UK boundaries do not perfectly align with the geographical areas of fish capture statistics. For more detail on how fish capture in UK waters is estimated, see the [Marine Management Organisation Exclusive Economic Zone Analysis]() and associated publications.

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.

Fish capture in Scottish waters has risen from 628 thousand tonnes in 2003 to 1,065 thousand tonnes in 2016, an increase of 72% over the period (see Figure 7). We can also see that Scotland has always made up a large proportion of the overall UK fish capture, gradually increasing over time; in 2003, Scotland made up 61% of the UK total. This increased by 18 percentage points by 2016, meaning Scotland made up nearly four-fifths of total UK fish capture.

Figure 7: The rise in fish capture in the UK between 2013 and 2016 is largely because of the rise in Scottish fish capture over the same period

Marine fish capture in UK waters by country, 2003 to 2016

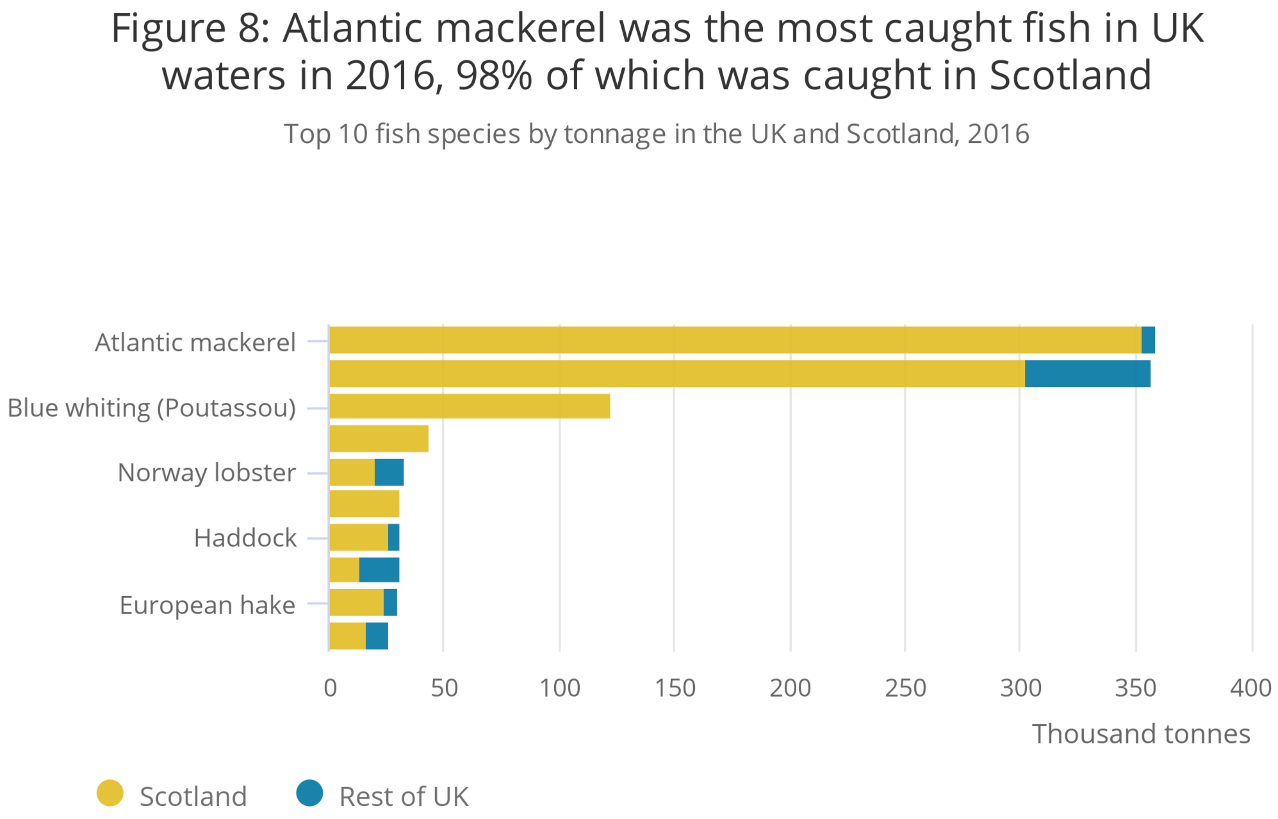


Source: Scientific, Technical and Economic Committee for Fisheries

There were 266 unique fish species caught in UK waters in 2016, 150 of which were found in Scottish waters. Some fish species were only caught in Scottish waters within the UK, such as Norway Pout and Black Scabbardfish to name a couple. However, the 10 fish species with the greatest tonnage captured represent 79% of total UK waters' fish capture, with 90% of these species caught in Scottish waters. Also, landings of Scottish vessels have grown dramatically since 2014 because of an increase in mackerel landings according to the UK seas fisheries 2016 report.

Figure 8: Atlantic mackerel was the most caught fish in UK waters in 2016, 98% of which was caught in Scotland

Top 10 fish species by tonnage in the UK and Scotland, 2016

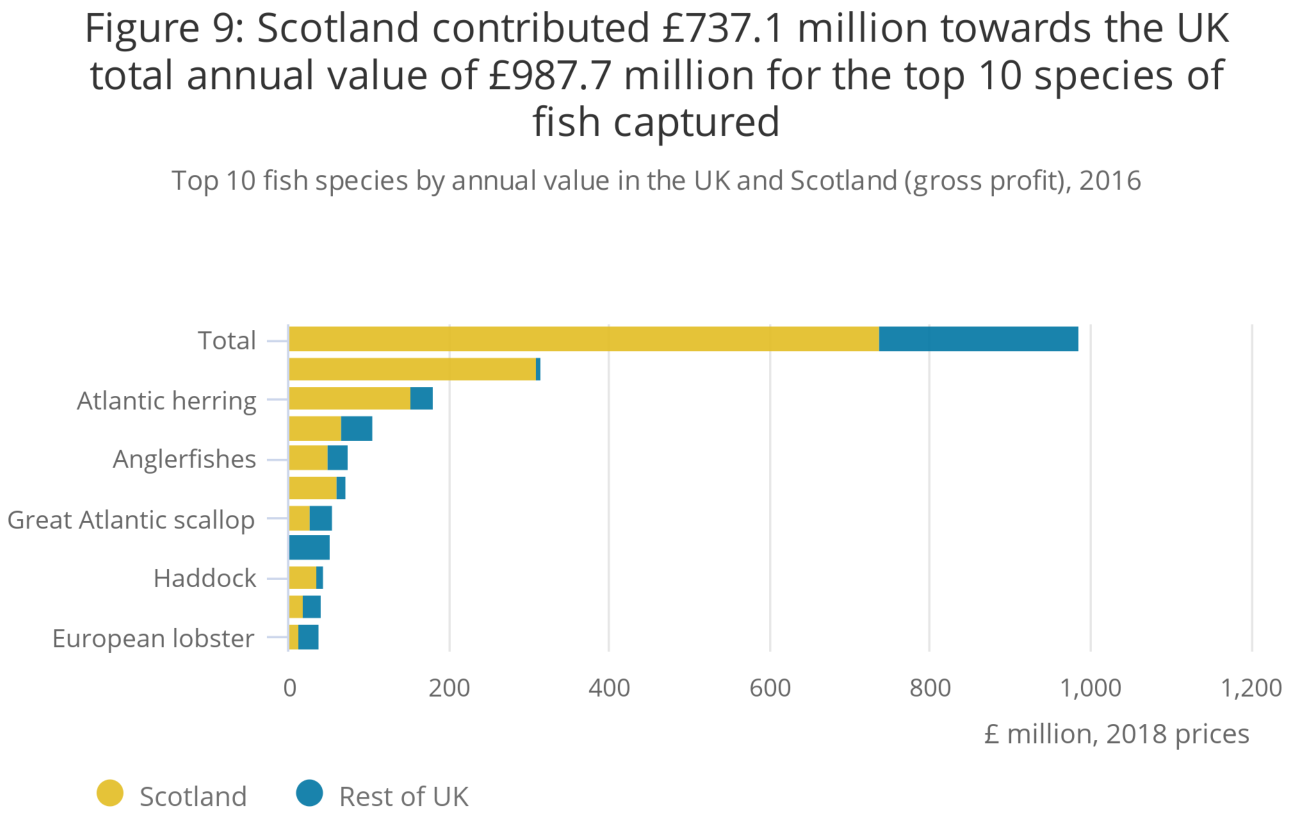


Source: Scientific, Technical and Economic Committee for Fisheries

Out of the 266 unique fish species caught in UK waters in 2016, the top 10 species by gross annual value made up 72% of the overall UK annual value. Whilst some of these species overlap with the highest tonnage species, such as Atlantic mackerel and herring, other species such as common sole are amongst the most valuable. Common sole was the most valuable species not caught in Scottish waters. The most valuable species caught almost entirely in Scottish waters was blue whiting (Poutassou), with a gross annual value of £2.8 million in 2016.

Figure 9: Scotland contributed £737.1 million towards the UK total annual value of £987.7 million for the top 10 species of fish captured

Top 10 fish species by annual value in the UK and Scotland (gross profit), 2016



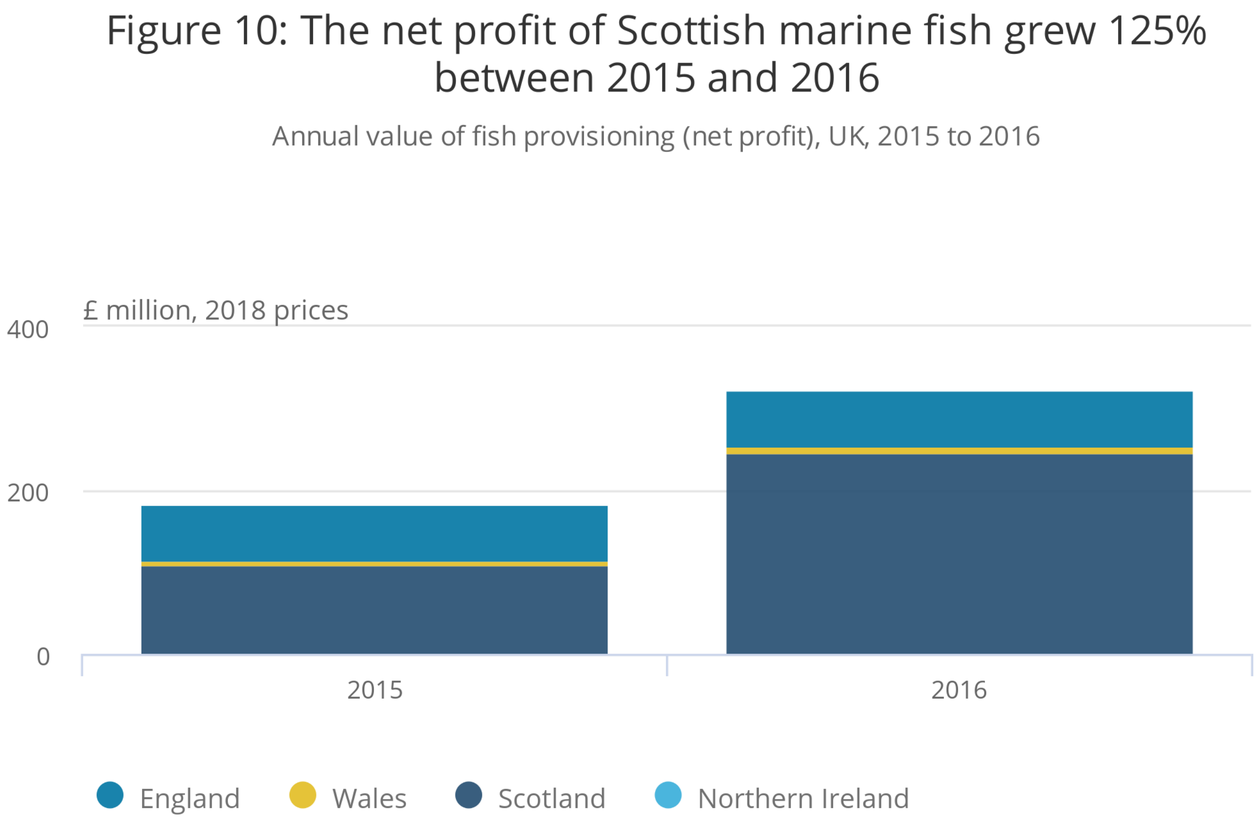
Source: Scientific, Technical and Economic Committee for Fisheries and Seafish

The value of fish capture is calculated using net profit per tonne (landed) estimates, provided by Seafish, for different marine species. Figure 10 shows the annual value of fish provisioning in the UK in 2015 and 2016.

We can see that Scotland's net profit is greater than the rest of the UK, having increased by 125% between 2015 and 2016, from £108.3 million to £243.4 million. The other UK countries remained relatively stable between the same periods, contributing less to the UK net profit total.

Figure 10: The net profit of Scottish marine fish grew 125% between 2015 and 2016

Annual value of fish provisioning (net profit), UK, 2015 to 2016



Source: Scientific, Technical and Economic Committee for Fisheries and Seafish

Mackerel makes up around one-third of all species fished in Scottish waters and the net profit for mackerel more than doubled between 2015 and 2016. According to the 2016 Scottish Sea Fisheries Statistic Report, mackerel was Scotland's most valuable stock for that year, with the average price increasing by around 35%, from £664 per tonne in 2015 to £895 per tonne in 2016.

Timber

Timber production in Scotland has doubled between 1997 and 2018

Timber production in Scotland increased by 106% between 1997 and 2018. In 2018, 9,188 thousand cubic metres overbark (m3) was removed. Between 2017 and 2018, there has been a 7.5% increase in timber removals compared with 2.4% between 2016 and 2017.

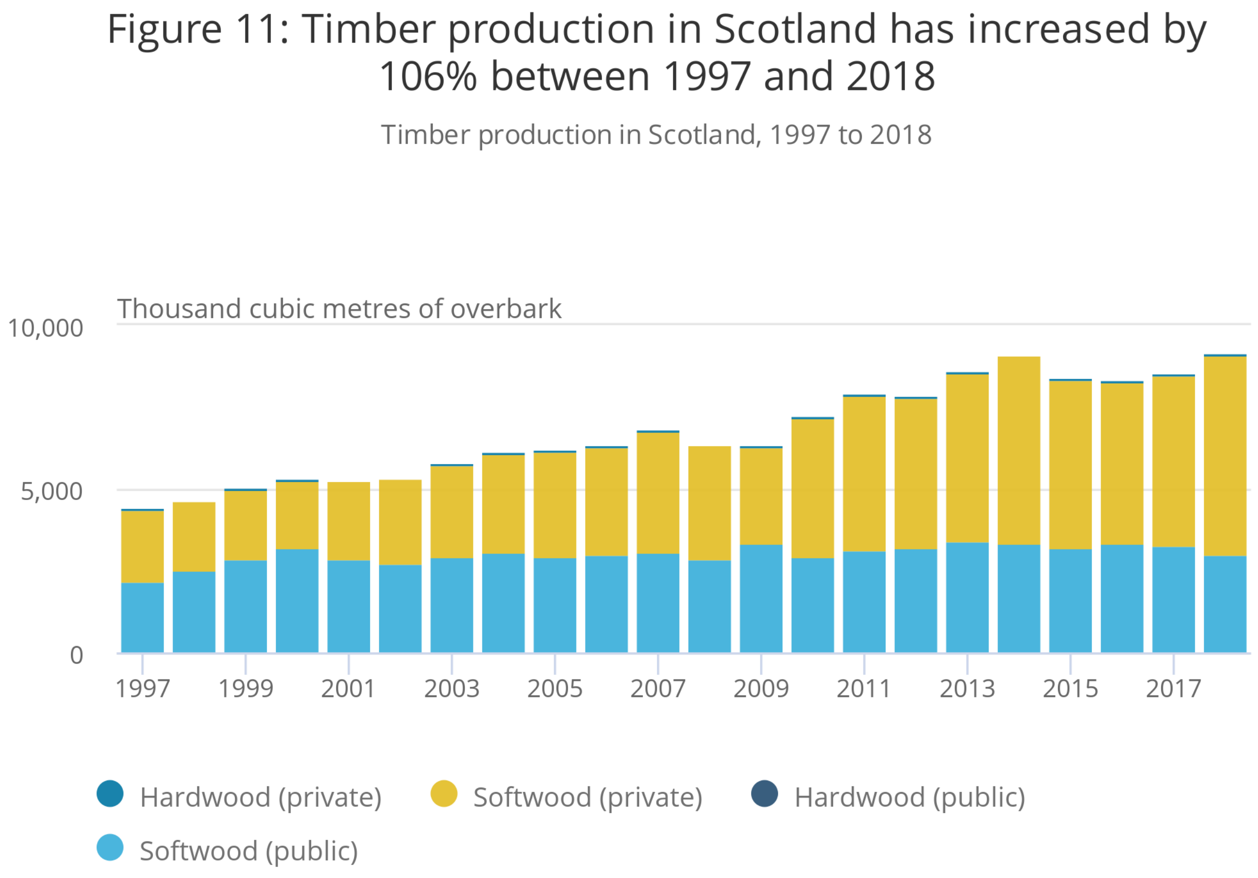
In 1997, the Forestry Commission produced 51% of the Scottish softwood production. This peaked in 2000, with 60% being produced, but has declined to 33% in 2018.

In the last 10 years, timber production has mainly come from the private sector, which has increased by 77.7% since 2008. Private sector timber production in 2018 was at its highest level of 6,203 thousand cubic metres overbark. In 2018, timber production from Forestry and Land Scotland (public sector) had risen by 34.2% since 1997. In comparison, the private sector had shown an increase of 176.8% for the same period.

The change is primarily the result of differences in the age structure and timing of timber production between woodlands on the public and private forest estates following a period of high levels of planting by the private sector in Scotland between 1970 and the late 1980s.

Figure 11: Timber production in Scotland has increased by 106% between 1997 and 2018

Timber production in Scotland, 1997 to 2018



Source: Forest Research

Notes:

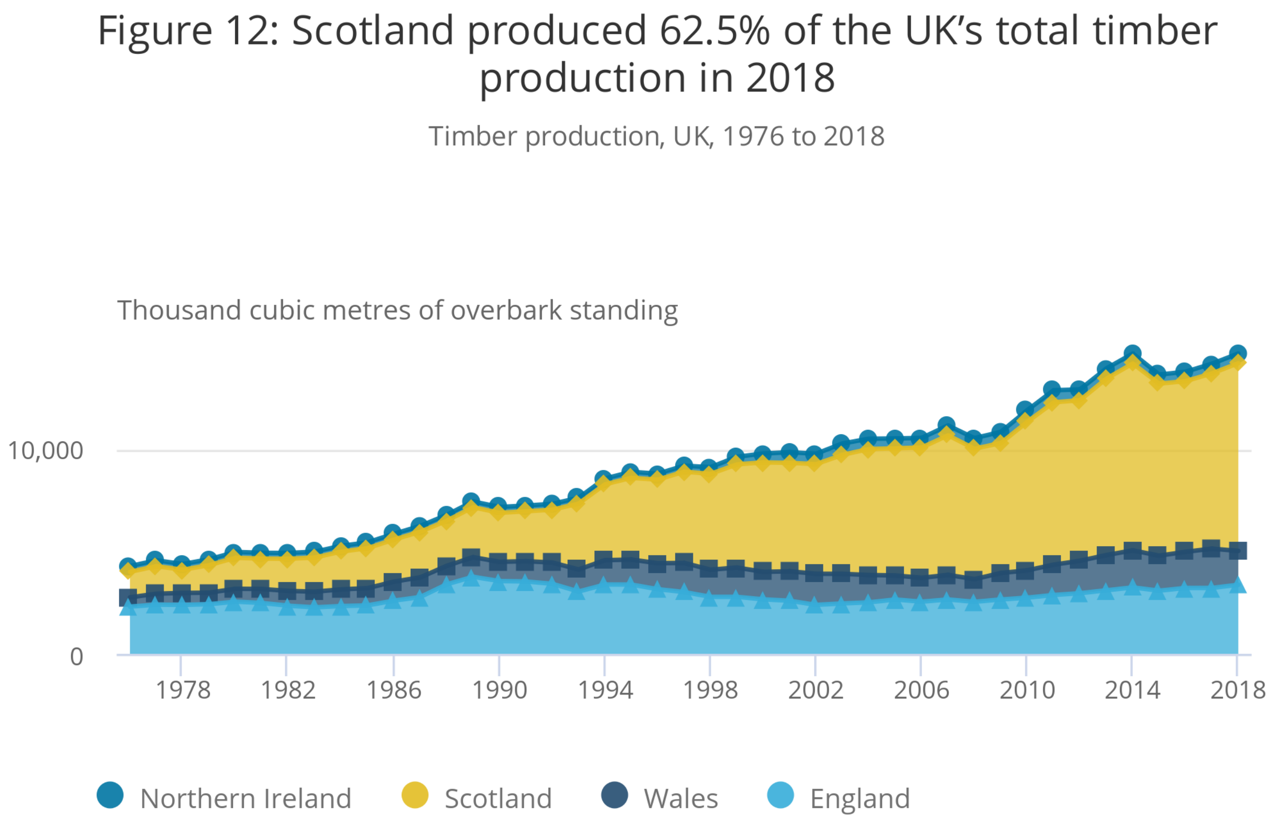
1. Public refers to Forestry and Land Scotland.

As can be seen from Figure 12, Scottish production has driven the UK trend. In 1997, Scotland produced 48.5% of the UK's total timber production but this has risen to 62.5% in 2018.

Looking at woodland area and planting data published by Forest Research this is not surprising as Scotland represents 66% of UK conifer (softwood) woodland area and the extent of Scottish woodland has been increasing at a faster rate than that of both England and Wales since 1998. Data published in the Forest Research Forestry Statistics 2019 show woodland area in Scotland has increased 12% between 1998 and 2019 while woodland areas in both England and Wales have expanded by only 6% and 3% respectively. Scotland represented 84% of new planting in 2019.

Figure 12: Scotland produced 62.5% of the UK's total timber production in 2018

Timber production, UK, 1976 to 2018

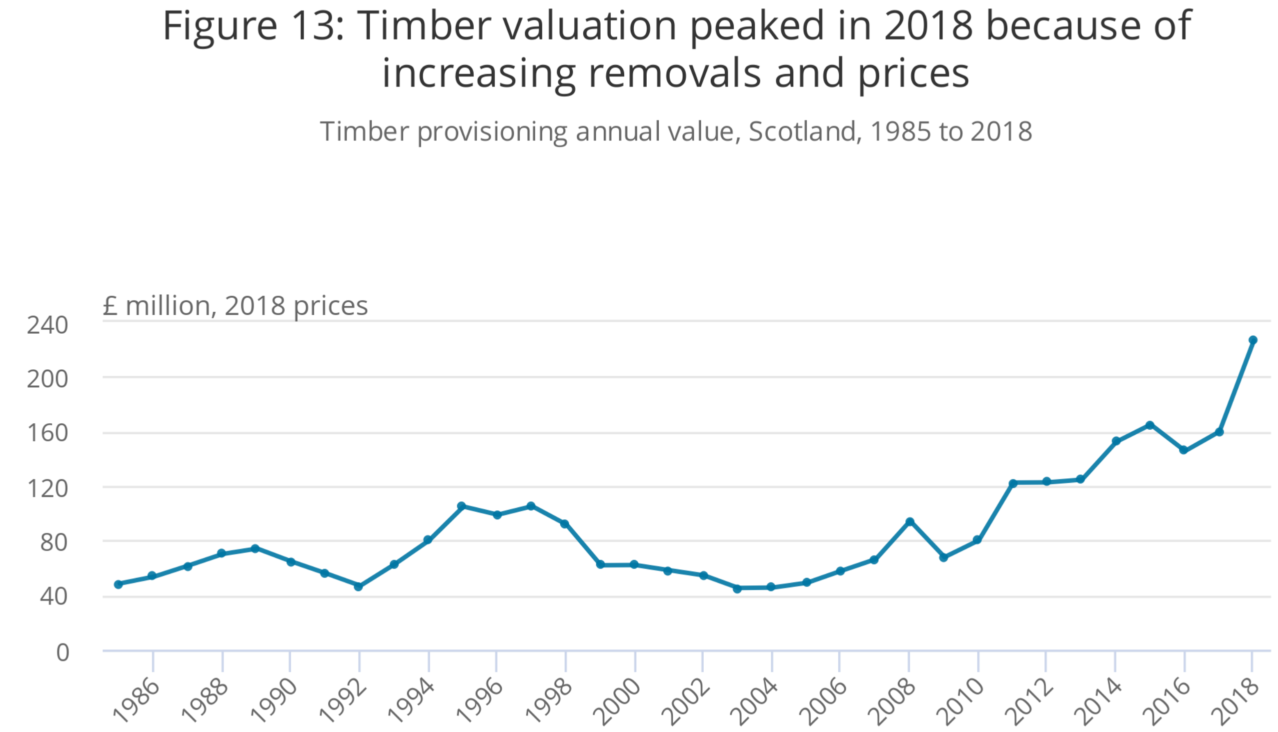


Source: Forestry Research

Timber valuation for Scotland has steadily increased from £67.77 million in 2009 to its highest level of £226.40 million in 2018. This increase in the annual value was caused by trends in stumpage prices, which have increased from £10.67 in 2009 to £24.64 in 2018. The stumpage price is the price paid per standing tree for the right to harvest timber from a given area.

Figure 13: Timber valuation peaked in 2018 because of increasing removals and prices

Timber provisioning annual value, Scotland, 1985 to 2018



Source: Office for National Statistics and Forest Research

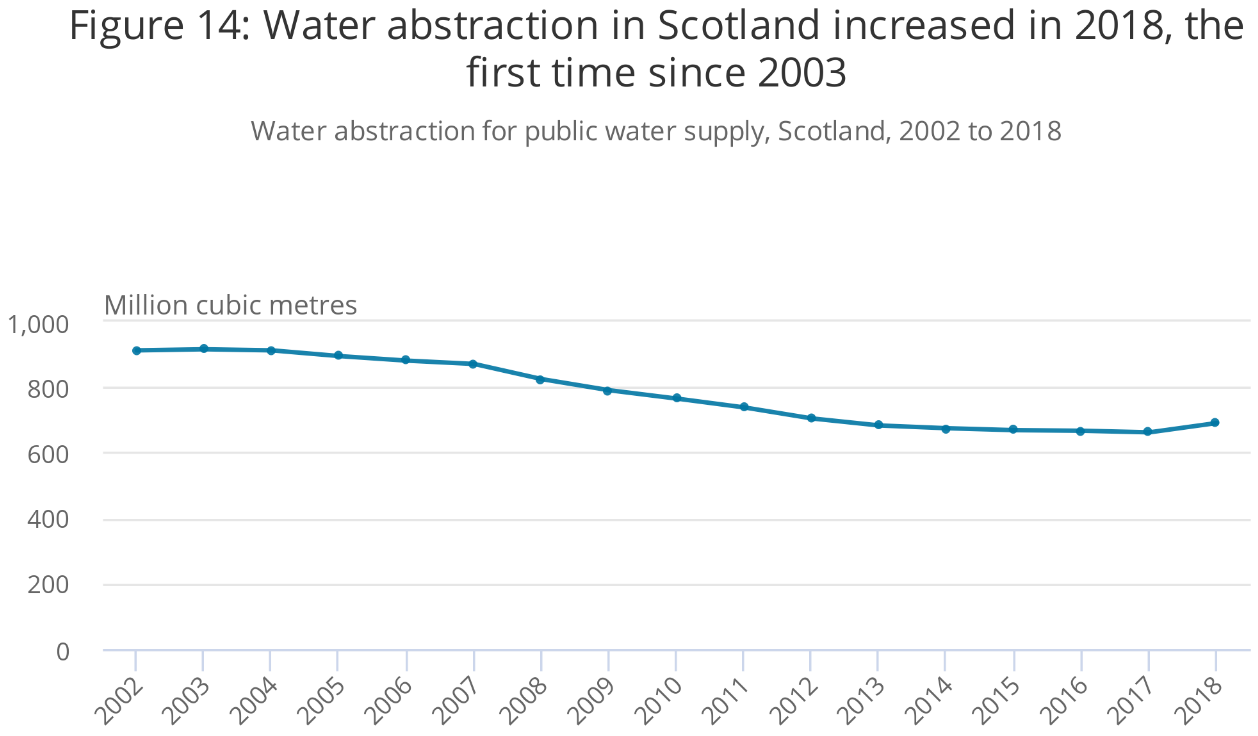
Water abstraction

From 2002 to 2018, the amount of water abstracted for public water supply in Scotland decreased by 24%, from 912 million to 690 million cubic metres. However, the recent trend has shown a rise in water abstraction, which increased by 4%, from 662 million to 690 million cubic metres in 2018.

Despite reduced leakages between 2017 and 2018, water abstraction increased with greater demand. Scottish water abstraction for public water supply made up between 10% and 13% of UK water abstraction levels, across 2002 to 2018.

Figure 14: Water abstraction in Scotland increased in 2018, the first time since 2003

Water abstraction for public water supply, Scotland, 2002 to 2018



Source: Scottish Water

The value of water abstraction continued to fluctuate between 2002 and 2016, with a peak of £153.84 million in 2003 and a low of £50.42 million in 2009. We derive the monetary estimates from information about economic activity, which relates to the collection, treatment and supply of water.

Although Scotland does not regularly suffer from long-term dry spells, localised areas can experience short-term dry periods, which can cause environmental problems. Climate change predictions from the Scottish Environment Protection Agency suggest that summers in Scotland are likely to get drier (PDF, 898KB). This may place pressure on areas not previously affected by water scarcity in Scotland.

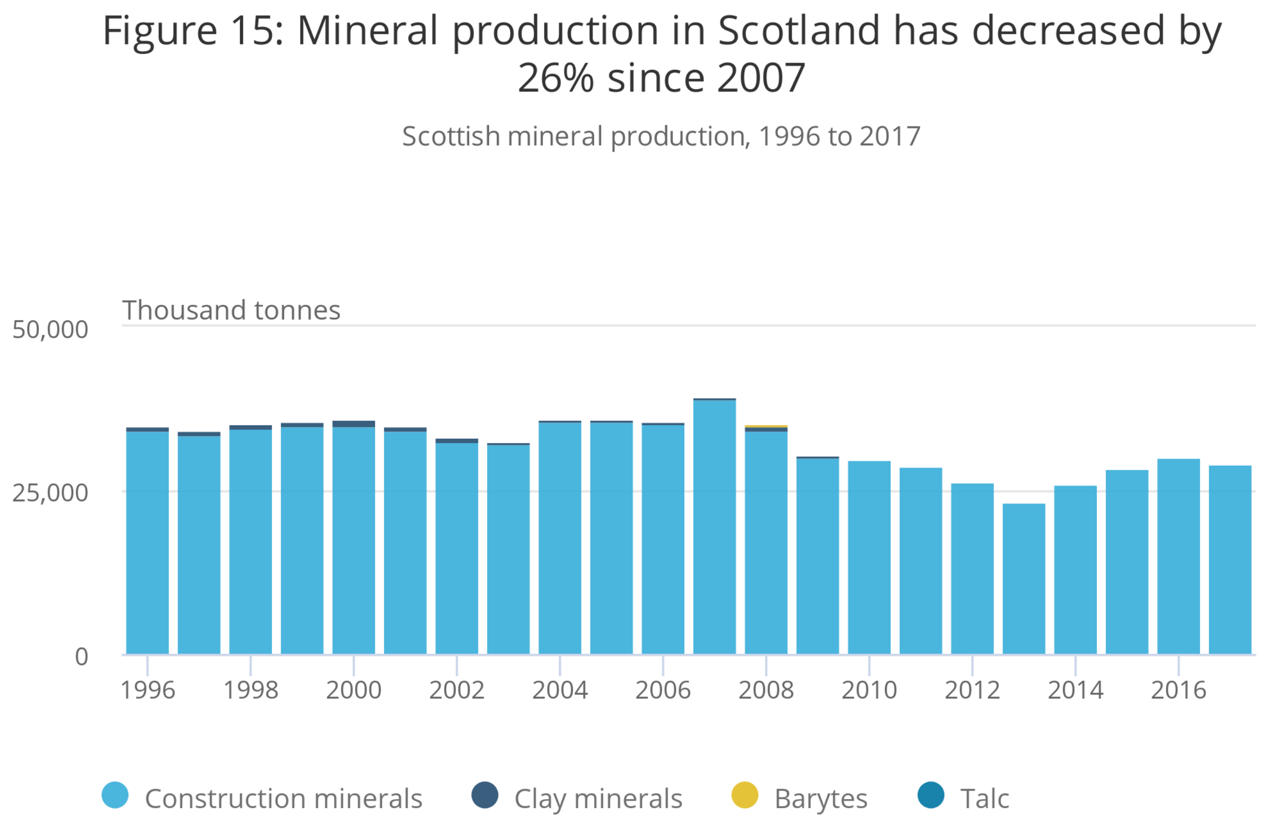
Minerals

The total mineral production in Scotland has decreased by 4% between 2016 and 2017. Mineral production peaked in 2007 with 39.4 million tonnes extracted but by 2017, this had declined by 9.9 million tonnes.

In the 10 years between 2007 and 2017, mineral production in Scotland decreased by 26%. Igneous rock fell by 29% and sand and gravel by 35.1% over the 10-year period.

Figure 15: Mineral production in Scotland has decreased by 26% since 2007

Scottish mineral production, 1996 to 2017



Source: British Geological Survey

Notes:

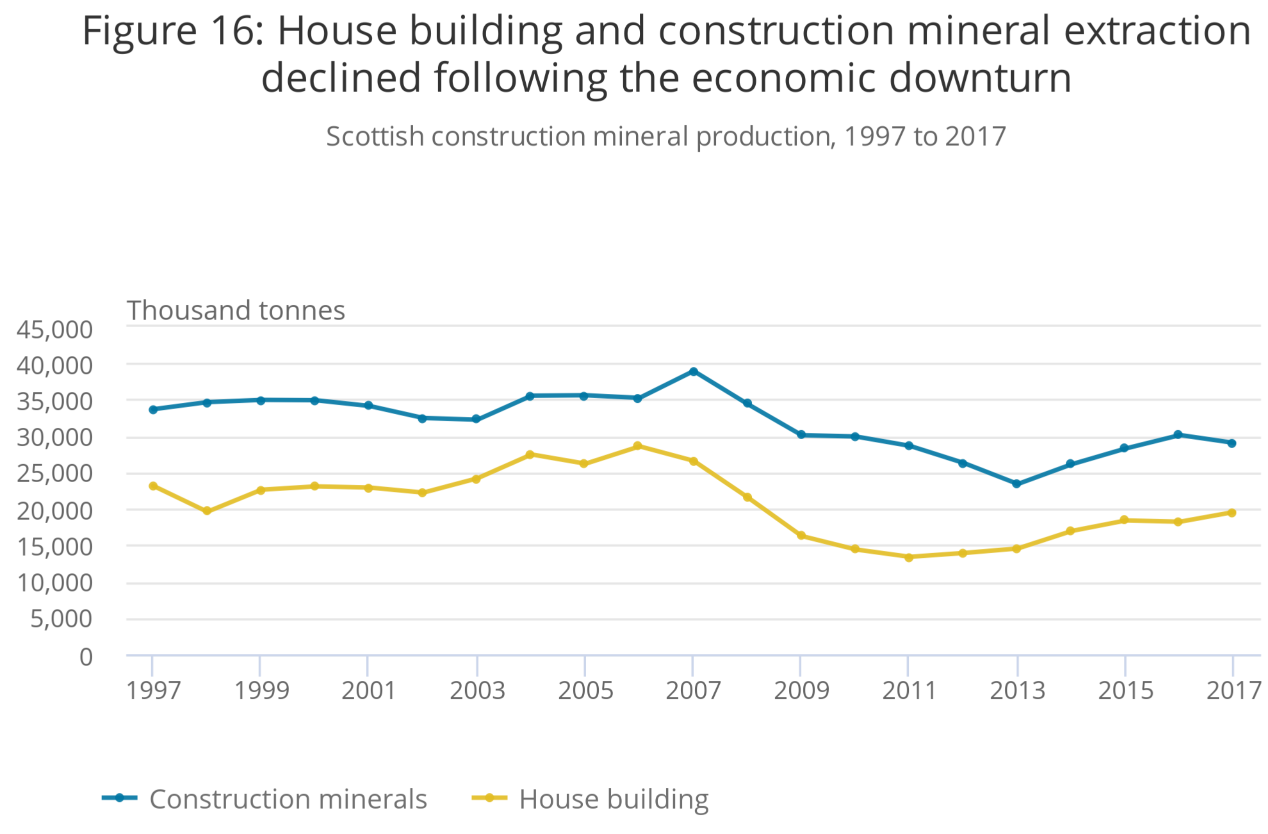
1. Construction minerals include sand and gravel, slate, igneous rock, limestone and dolomite, and sandstone.
2. Clay minerals includes fireclay, and clay and shale.
3. Mineral extraction after 2014 is estimated based on sales data.

The major source of barytes in the UK is from the Foss mine in Scotland. Barytes is used as a weighting agent for drilling fluids in oil and gas exploration (British Geological Survey). New production will start in the Duntanlich mine in Perthshire from December 2020.

Construction minerals are used for housing and infrastructure. The largest extraction declines were seen in 2008 and 2009, dropping 11.7% and 12.5% respectively. New house building in Scotland declined by 18.9% and 24.7% across the same periods. Since 2013, construction mineral production and new house builds have generally increased each year. This analysis excludes imports, exports, and movement of materials from within the UK.

Figure 16: House building and construction mineral extraction declined following the economic downturn

Scottish construction mineral production, 1997 to 2017



Source: British Geological Survey and Scottish Government

Notes:

1. Construction minerals include sand and gravel, slate, igneous rock, limestone and dolomite, and sandstone.

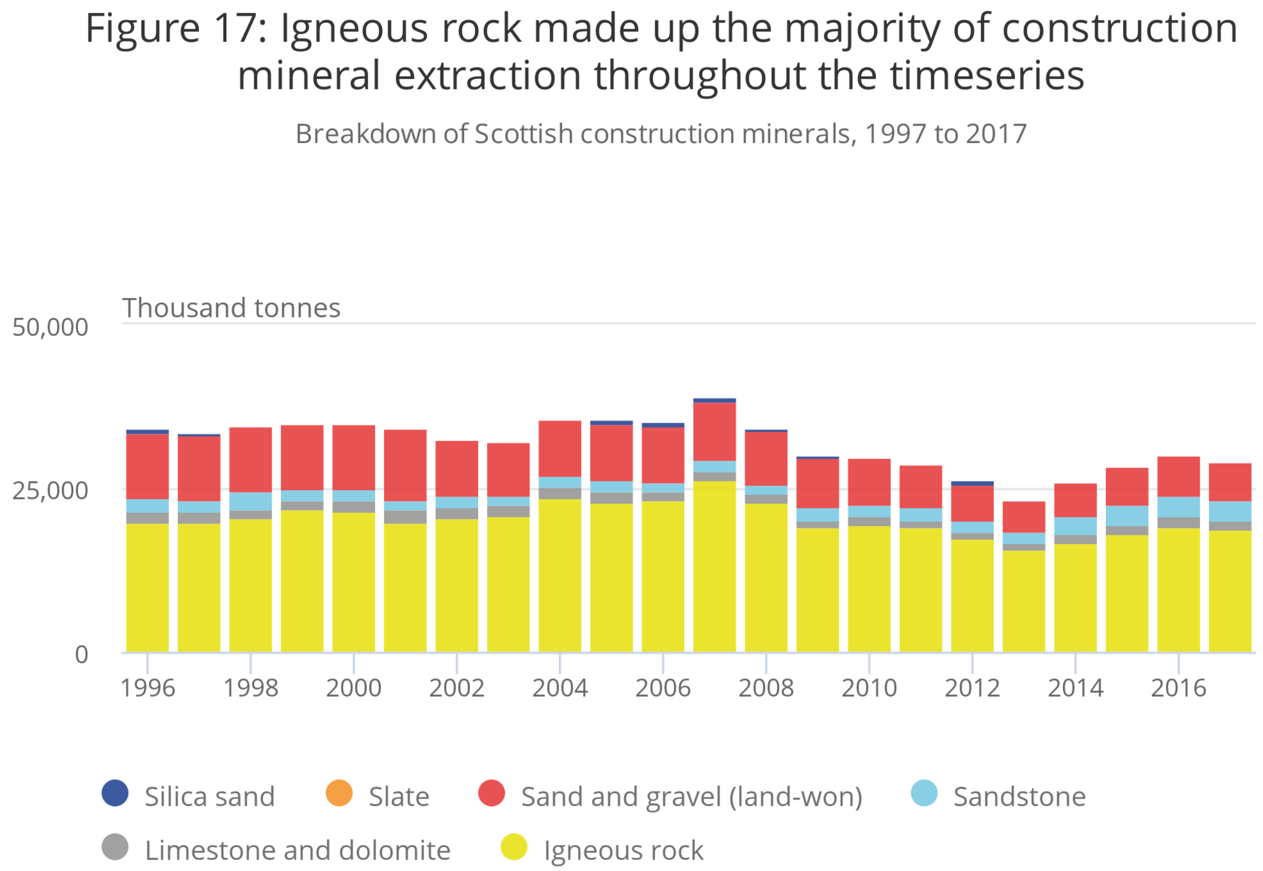
2. All sector new builds. A dwelling is regarded as started on the date that work begins on the foundations of the block of which the dwelling will form a part, and not on the date when site preparations begin.

In 2017, igneous rock accounted for 64.4% of the total construction minerals in Scotland. Igneous rock is formed through the cooling and solidification of magma. It is used for the construction of monuments, buildings and interior decoration, for example, kitchen worktops.

Sandstone production has increased by over 103% between 2007 and 2017. It accounted for 20.2% of the total construction minerals in Scotland in 2017. Sandstone is used for new buildings and the repair and maintenance of historic monuments.

Figure 17: Igneous rock made up the majority of construction mineral extraction throughout the timeseries

Breakdown of Scottish construction minerals, 1997 to 2017



Source: British Geological Survey

Notes:

1. Data for slate, gypsum and chalk not available.

2. Construction minerals include sand and gravel, gypsum, chalk, slate, silica sand, igneous rock, limestone and dolomite, and sandstone.

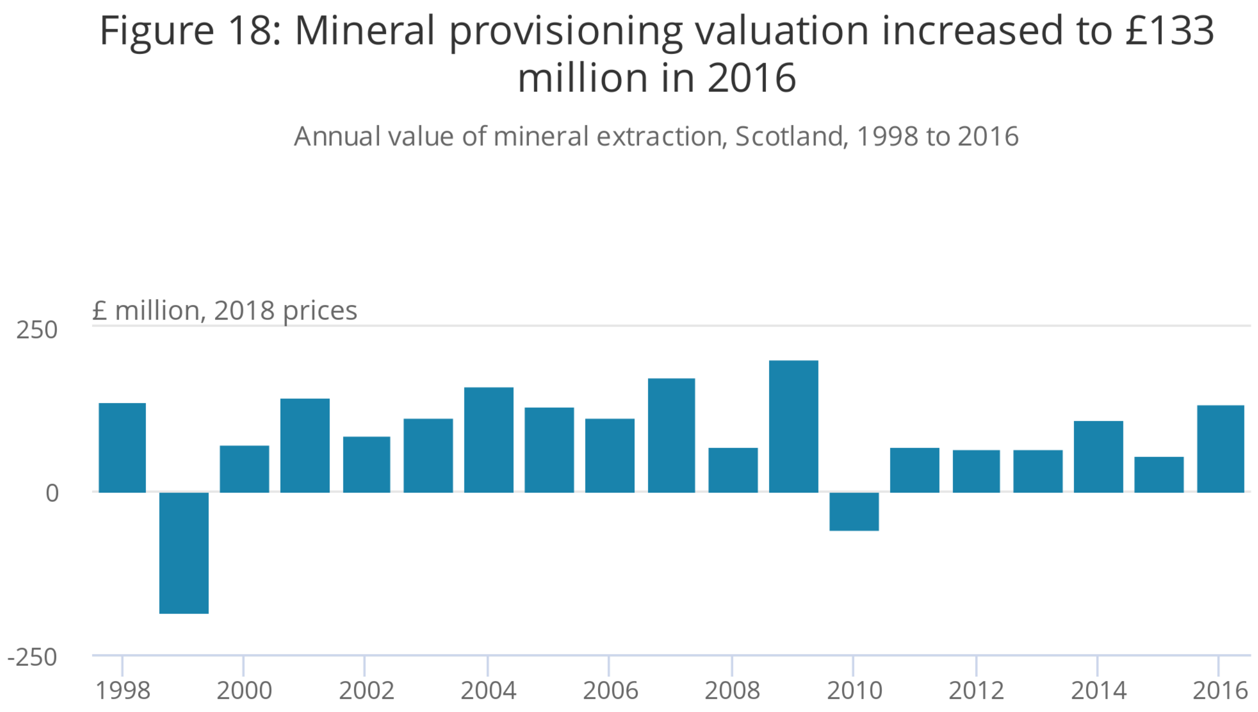
Scotland's construction mineral comparison with UK

In the 10 years since 2007, UK construction minerals extraction has seen a 18.3% reduction compared with Scotland's 25.4%. In 1997, Scotland produced 11.7% of the UK's construction minerals, growing to a peak of 17.5% in 2008. In 2017, Scotland's share of UK mineral production was 14.6%.

Using the resource rent approach (see Methodology guide), the annual value of mineral provisioning fluctuated between 1998 and 2016. 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 2016, the annual value increased to £133 million.

Figure 18: Mineral provisioning valuation increased to £133 million in 2016

Annual value of mineral extraction, Scotland, 1998 to 2016



Source: Office for National Statistics

Unstable valuations of the mineral production abiotic provisioning service and 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.

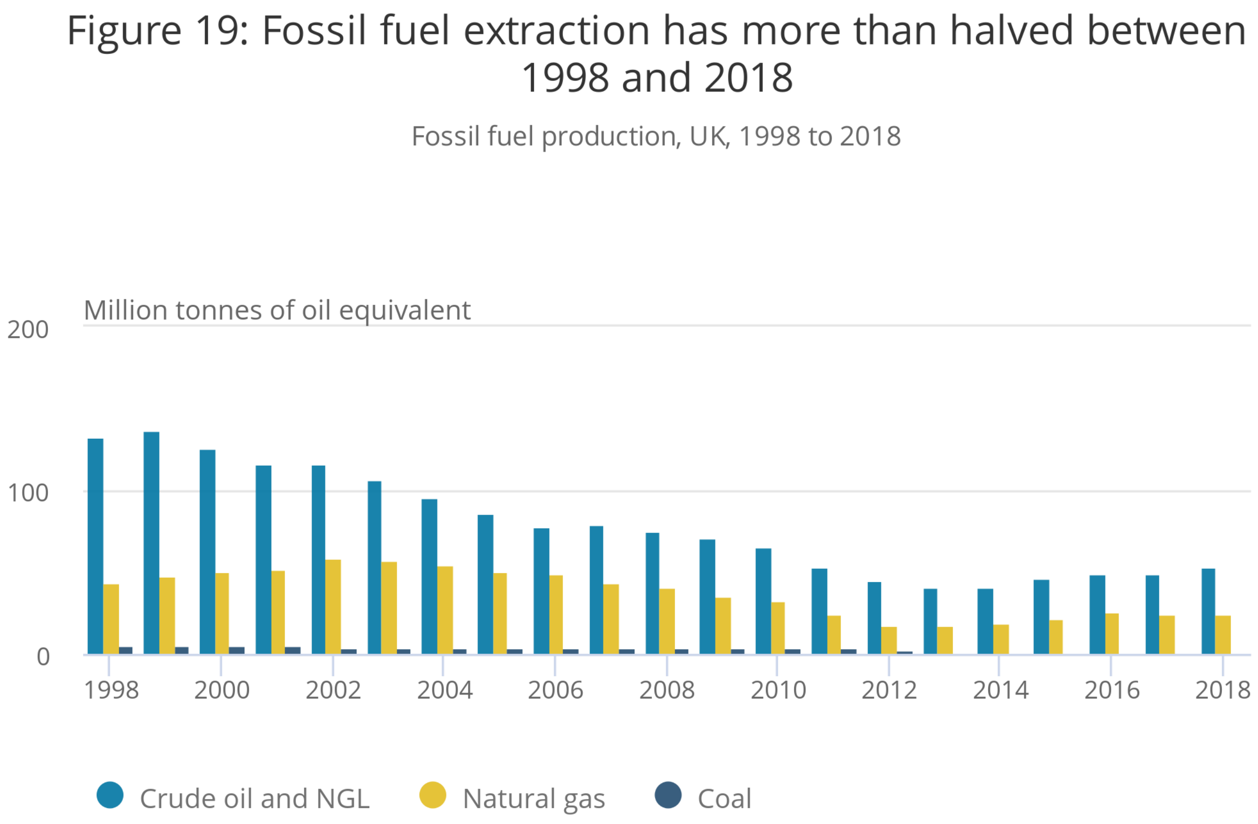
Fossil fuels

Section 9 provides details on the methodology used to estimate the value of oil and gas production. This is a “resource rent” approach, which estimates the surplus remaining to the extractor after all costs and normal returns are considered. This is closely related to profitability.

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 (that is, gross value added). Resource rent does not value, as benefits, government receipts, employment, supply chain activity or energy security.

Figure 19: Fossil fuel extraction has more than halved between 1998 and 2018

Fossil fuel production, UK, 1998 to 2018



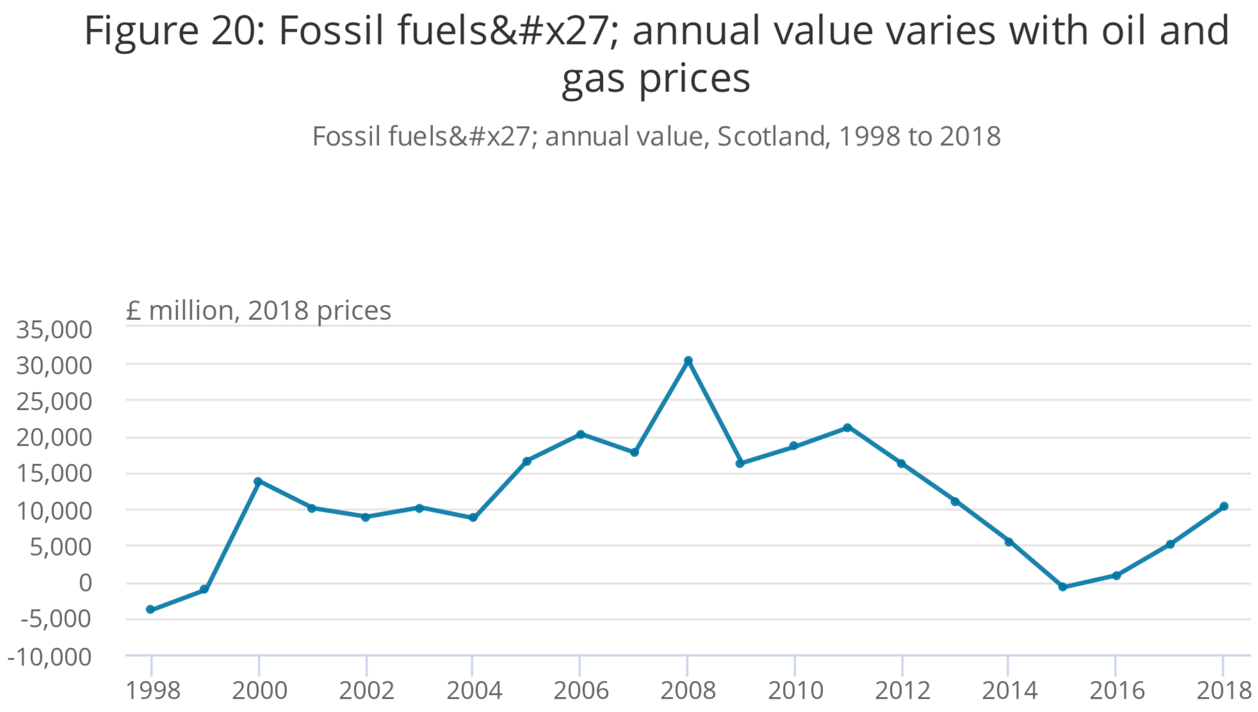
Source: Scottish Government and Department for Business, Energy and Industrial Strategy

Oil and gas production peaked around the start of the century and has gradually declined since. In recent years Scotland has made up 95% of UK oil production and 68% of gas.

With government policy to end coal-fired energy generation by 2025, coal extraction is generally being phased out across Great Britain. As of 2016, there are no coal power stations in Scotland. In 2018, Scottish coal production fell to an all-time low of 0.4 million tonnes of oil equivalent – about 8% of the quantity extracted 20 years earlier.

Figure 20: Fossil fuels' annual value varies with oil and gas prices

Fossil fuels' annual value, Scotland, 1998 to 2018



Source: Office for National Statistics

The annual valuation of fossil fuels abiotic provisioning has varied, driven largely by oil and gas price changes and production trends.

The largest year-on-year real price increases were seen from 1999 to 2000 (67% for oil and 100% for gas), which saw gas prices double, and 2007 to 2008 (41% for oil and 69% for gas). These spikes are reflected in the annual valuation. In 2018, the annual value increased to £10.28 billion, 89% of the UK value, because of oil and gas price increases of 24% and 31% respectively.

Renewable energy

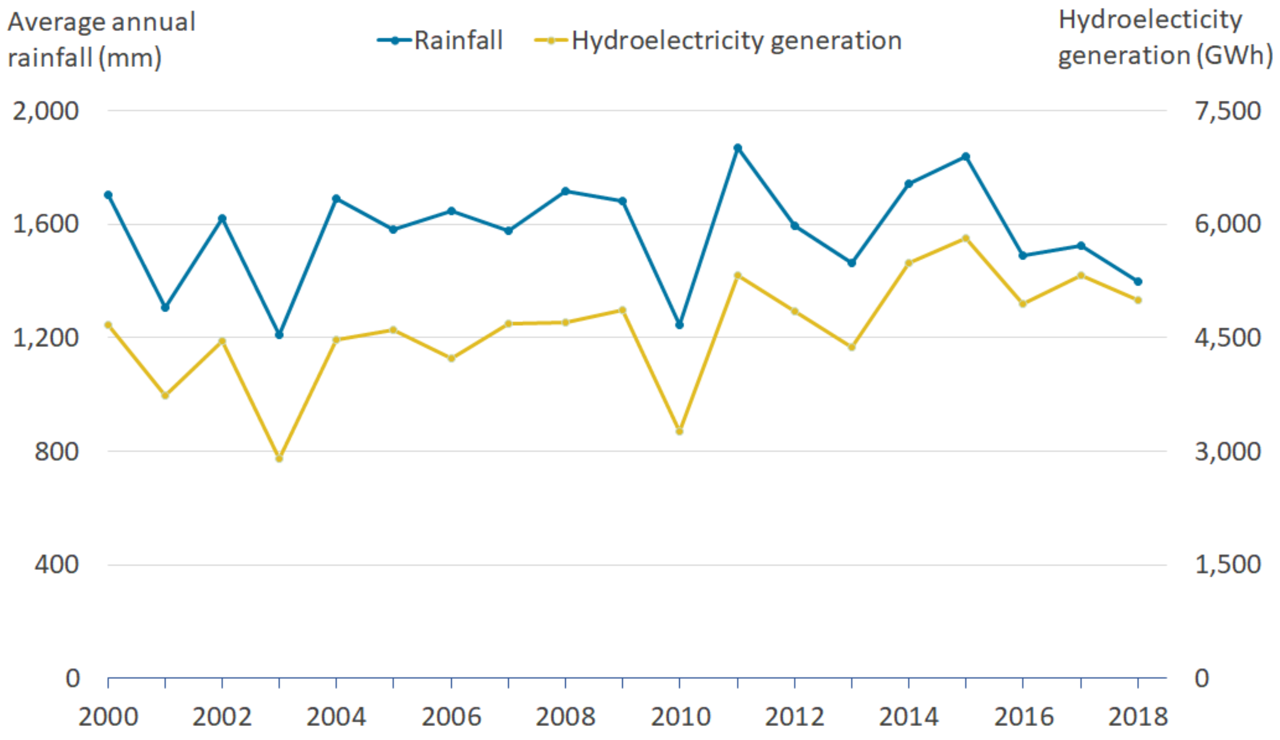
Scotland's renewable electricity generation has increased by 7% between 2017 and 2018. National and international incentives, including the EU Renewable Energy Directive and Renewable Obligation (RO) target, have helped contribute towards the increase.

Hydro power declined 5.4% between 2017 and 2018. The annual rainfall in Scotland has decreased by 8.3% for the same period. The hydro generation load factor has also shown a decrease of 4.1% for small-scale and 8.2% large-scale production. A load factor is a measure of generation efficiency being the utilisation of total generation capacity.

According to the Met Office climate projections Scotland is likely to experience generally wetter winters and drier summers, alongside general warming, which will impact the electricity from weather-dependent renewables.

Figure 21: With drier weather, hydroelectricity generation dropped 32.9% in 2010

Average rainfall and hydroelectricity generation, Scotland, 2000 to 2018

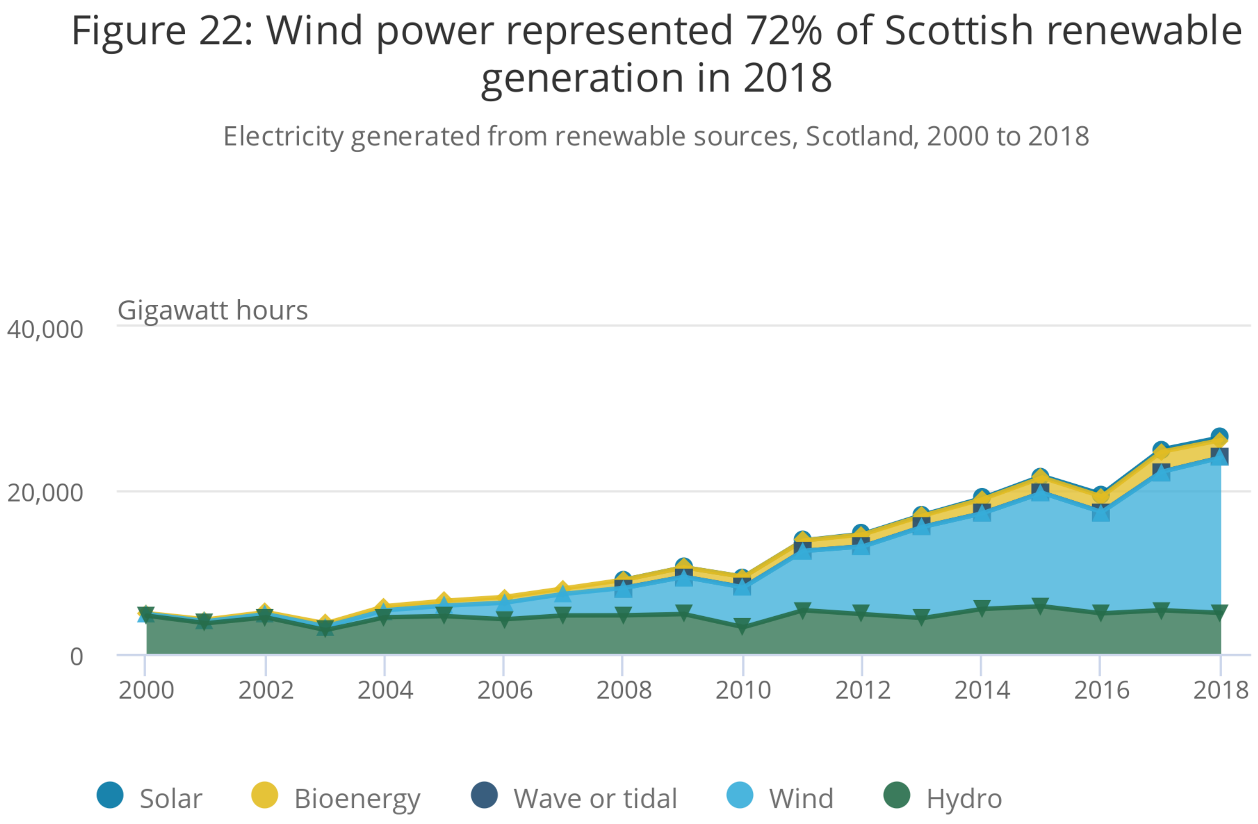


Source: Scottish Government and Met Office

Since 2010, wind power has become the largest source of renewable generation in Scotland. Wind power in 2018 was nearly six times larger than it was in 2008. In 2018, wind power produced almost 72% of the Scottish renewable electricity generation.

Figure 22: Wind power represented 72% of Scottish renewable generation in 2018

Electricity generated from renewable sources, Scotland, 2000 to 2018



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

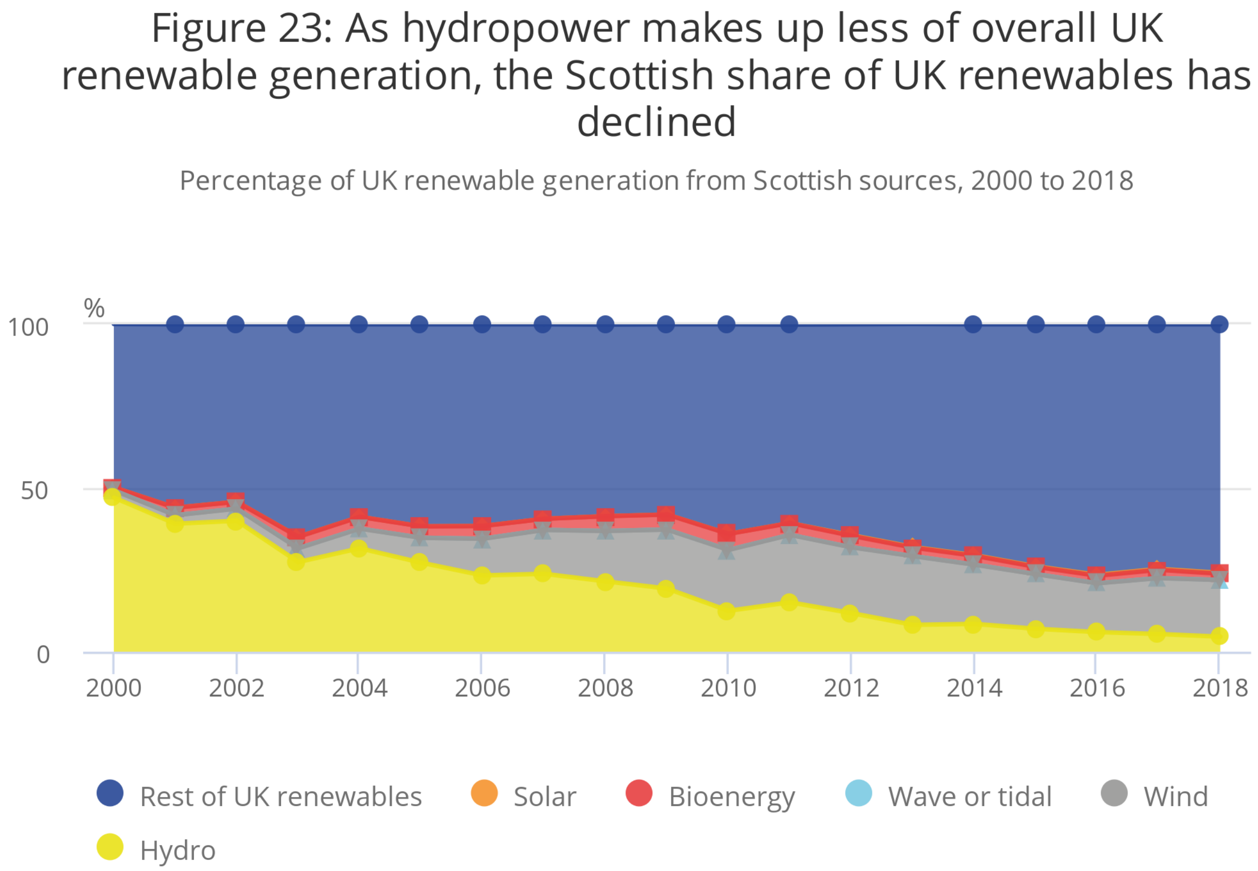
Notes:

1. Bioenergy includes landfill gas, sewage gas, and other bioenergy.

In 2000, Scotland produced 50.1% of the UK's renewable electricity generation. This has since declined to 24.1% in 2018. 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 across the UK, Scottish hydropower now only accounts for less than 5% of UK renewable generation, down from around 22% in 2008.

Figure 23: As hydropower makes up less of overall UK renewable generation, the Scottish share of UK renewables has declined

Percentage of UK renewable generation from Scottish sources, 2000 to 2018



Source: Department for Business, Energy and Industrial Strategy

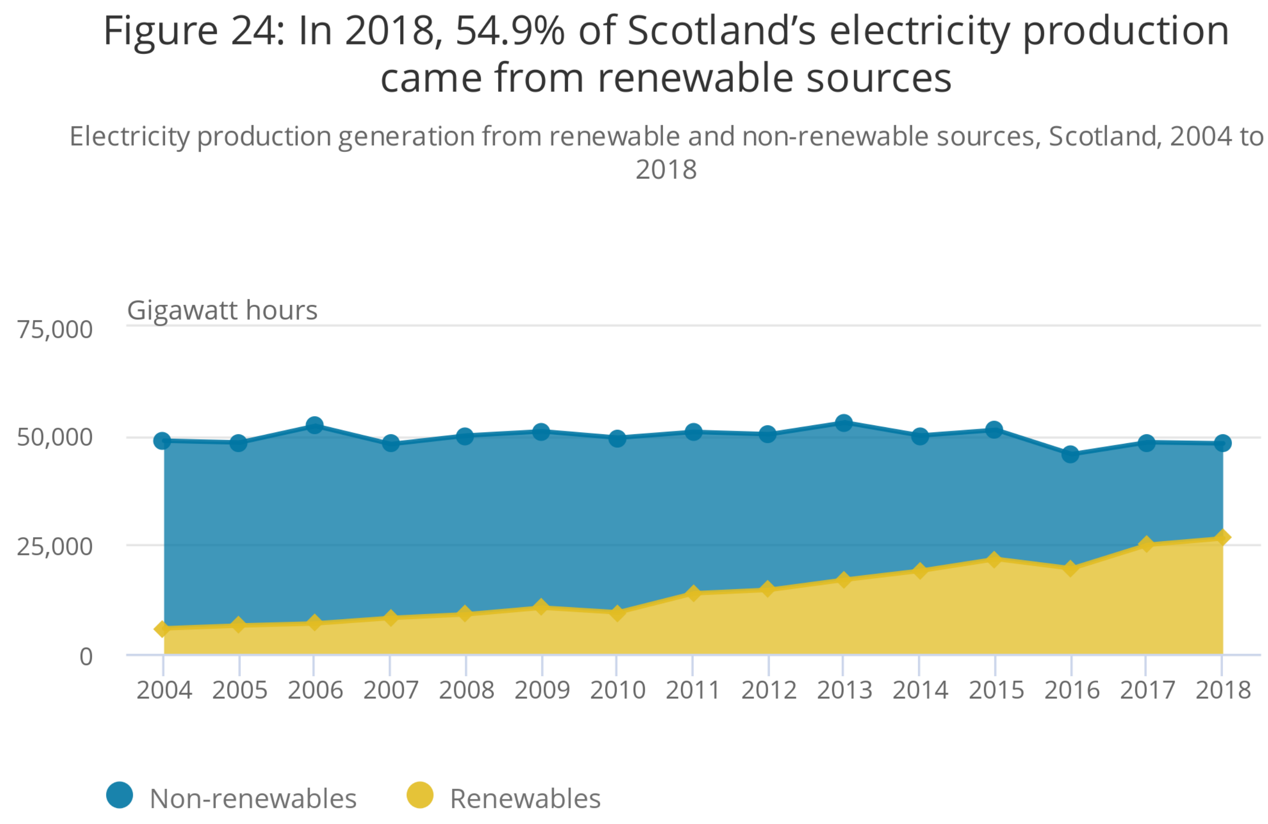
Notes:

1. Bioenergy includes landfill gas, sewage gas, and other bioenergy.

In 2008, Scottish renewables produced 18.1% or 9,058.5 gigawatt hours (GWh) of electricity generated from all sources (50,038.4 GWh). This has increased every year to a high of 54.9% or 26,472.5 GWh in 2018. Between 2017 and 2018, electricity production increased by 6% and electricity production from non-renewables decreased by 7%.

Figure 24: In 2018, 54.9% of Scotland’s electricity production came from renewable sources

Electricity production generation from renewable and non-renewable sources, Scotland, 2004 to 2018



Source: Department for Business, Energy and Industrial Strategy

Notes:

1. Renewables includes wind, hydro, solar, wave and tidal, and bioenergy.

2. Non-renewable includes coal, oil, gas, nuclear, other thermal, hydro pumped storage, and non-biodegradable waste combustion.

The annual value of renewable energy provisioning, being the additional service humans capture from wind, sun, and rain, increased eight-fold between 2008 and 2016, with the growth of the renewables sector. In 2016, the service was worth £199 million, 29% of the UK value.

6 . 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:

- carbon sequestration
- air pollution removal
- noise mitigation
- urban cooling

The pollutants covered in air pollution removal are:

- PM2.5
- PM10
- nitrogen dioxide (NO_2)
- ground-level ozone (O_3)
- ammonia (NH_3)
- sulphur dioxide (SO_2)

PM2.5 is a component of PM10.

Air pollution leads to respiratory diseases in humans. The risk of those diseases for a population can be estimated based on the levels of pollution and the health costs of that disease.

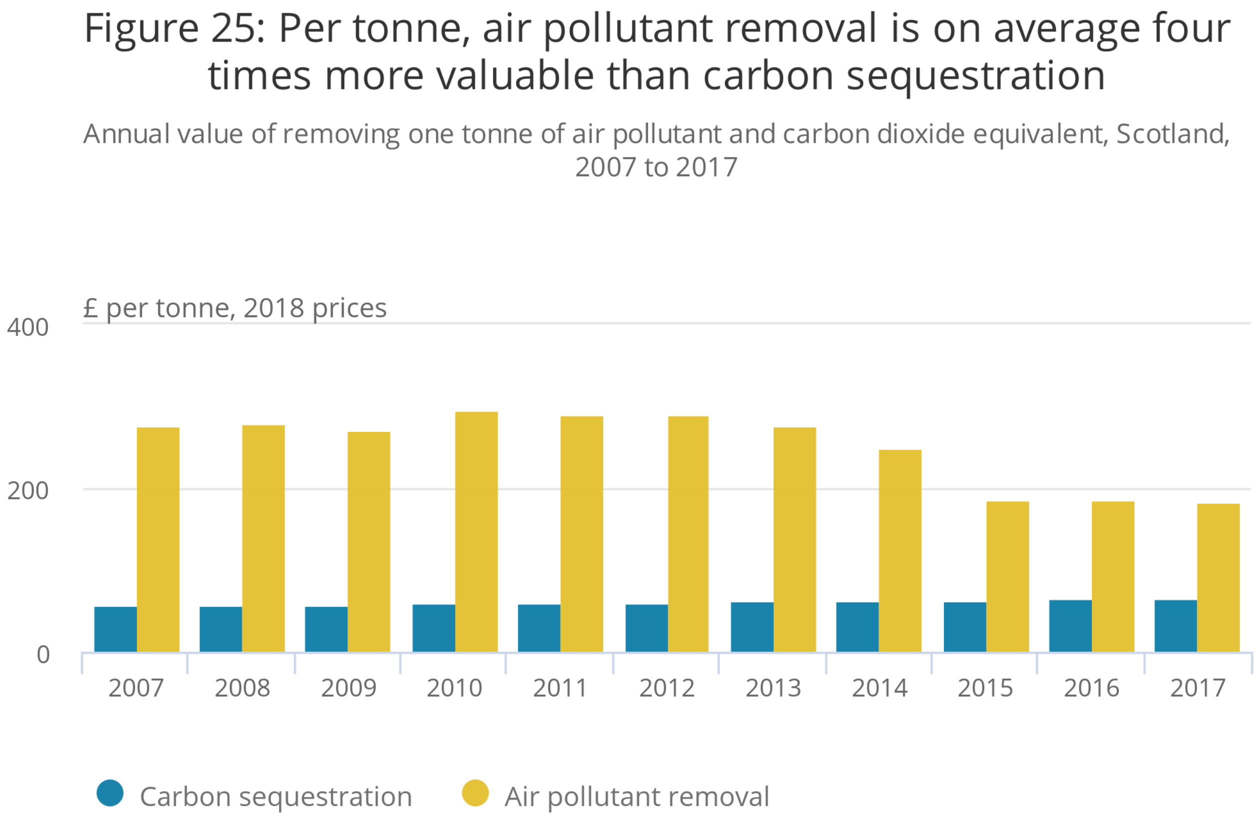
Both carbon sequestration and air pollution removal are carried out by vegetation. The capacity for vegetation to sequester carbon and remove air pollution changes with the amount of vegetation.

The valuation methods used differ; carbon sequestration is a removal cost, and air pollution removal is a societal cost. That is, we are measuring 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.

Figure 25: Per tonne, air pollutant removal is on average four times more valuable than carbon sequestration

Annual value of removing one tonne of air pollutant and carbon dioxide equivalent, Scotland, 2007 to 2017



Source: Office for National Statistics, Centre for Ecology and Hydrology and National Emissions Inventory

Green and blue areas in Scotland's urban areas can help reduce the temperature on hot days, leading to savings in productivity, as well as reduce noise disturbance. Regulating services, such as carbon sequestration and air pollution removal, are cross-cutting ecosystem services, provided by a range of habitats, although woodlands is the primary supplier. Analysis of these services are spoken about in more depth in the following sections.

In 2017, Scotland made up 25% of the UK's total regulating service value, with carbon sequestration in Scotland making up 40% of the UK's total value.

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. Furthermore, peatlands, which are a significant source of emissions, are only partially seen in the data.

A 2019 report by the Centre for Ecology and Hydrology (CEH) for the Department for Business, Energy and Industrial Strategy, estimates that damaged peatland in Scotland emitted 9.3 million tonnes of CO2 equivalent, almost completely negating the gross terrestrial sequestration of Scotland reported in the Greenhouse Gas Inventory (GGI).

Around 66% of UK peat is situated in Scotland, and 76% of forestland peat. The GGI treats peat in new forests as a source of emissions but peat under mature forest as sequestering carbon. As the forest matures, increasing litter inputs to soil is predicted to eventually outweigh loss because of oxidation. In contrast, the recent report by CEH estimates continued large annual emissions for peat under forestry. This difference represents a crucial area of uncertainty in the UK emissions estimates.

The 2019 Greenhouse Gas Inventory-adjusted forest management assumptions to match the latest data on the age distribution of forests and reported wood production. This introduced an observable discontinuity in forestland sequestration for 2011 and years immediately after. This is being refined to reduce the size of the discontinuity.

For more information on the challenges and data gaps please see the Quality and methodology section.

Natural capital accounts based only on nature free from human intervention would include sequestration from ancient woodland but may exclude plantation forests. Human-driven emissions from damaged green spaces, such as parks, would not be included but emissions from a volcano would.

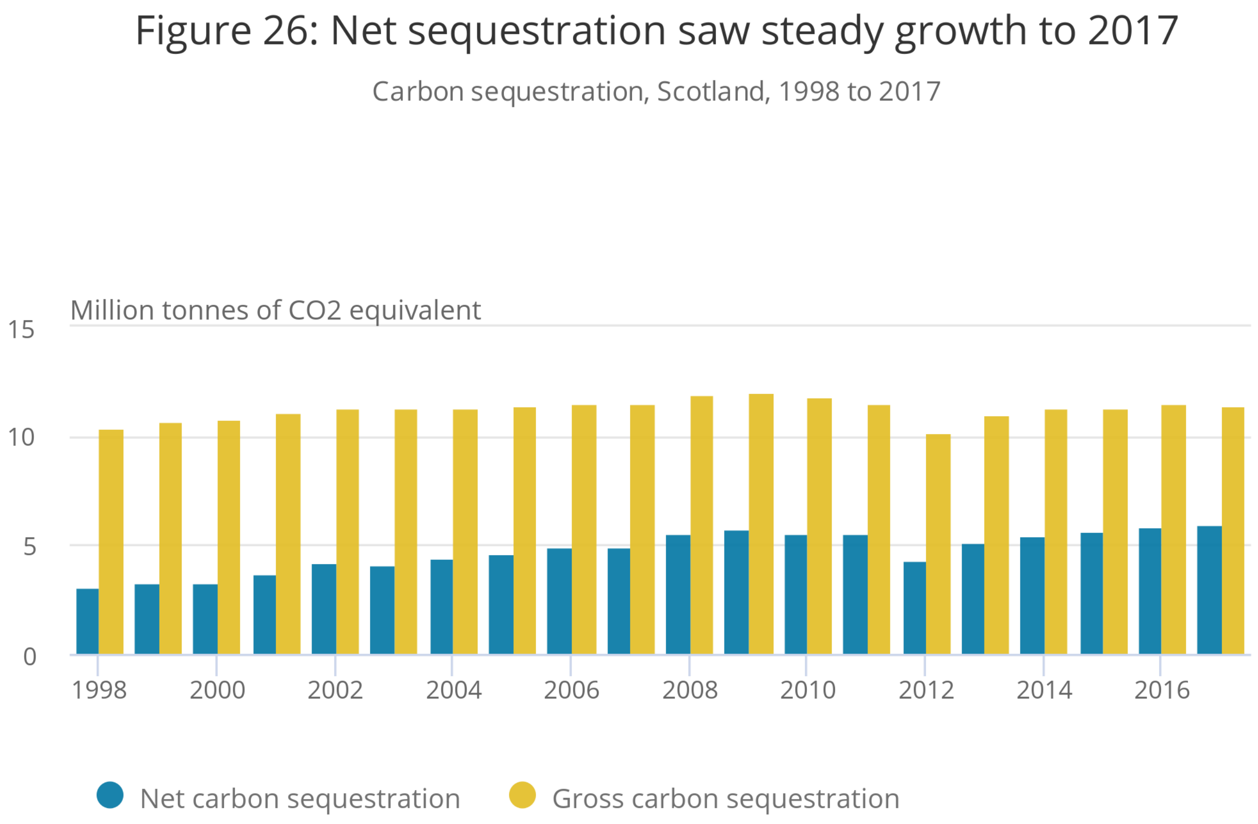
Another view of natural capital would state that all-natural habitats are somewhat modified. Usually human intervention is needed to capture value and so valuing many natural services (notably renewable energy) as if they were separate from human action is impossible. Under a human management of nature perspective, sequestration from plantation forest and emissions from degraded peatland should be included.

This is an area of research to consider further as our accounts develop. In this report we continue to use gross carbon sequestration as the asset value but present analysis of the net value to provide a rounded picture. The annual flow of the two approaches can be compared in Figure 26.

Looking only at sequestration, 11.4 million tonnes of carbon dioxide equivalent was sequestered by Scottish nature in 2017, 41% of UK gross carbon sequestration (28.0 million tonnes). This provided a £757 million service in 2017, with an asset value worth £41.7 billion, being the value of carbon sequestration by nature into the future. However, this excludes the emission costs related to the management of natural habitats.

Figure 26: Net sequestration saw steady growth to 2017

Carbon sequestration, Scotland, 1998 to 2017



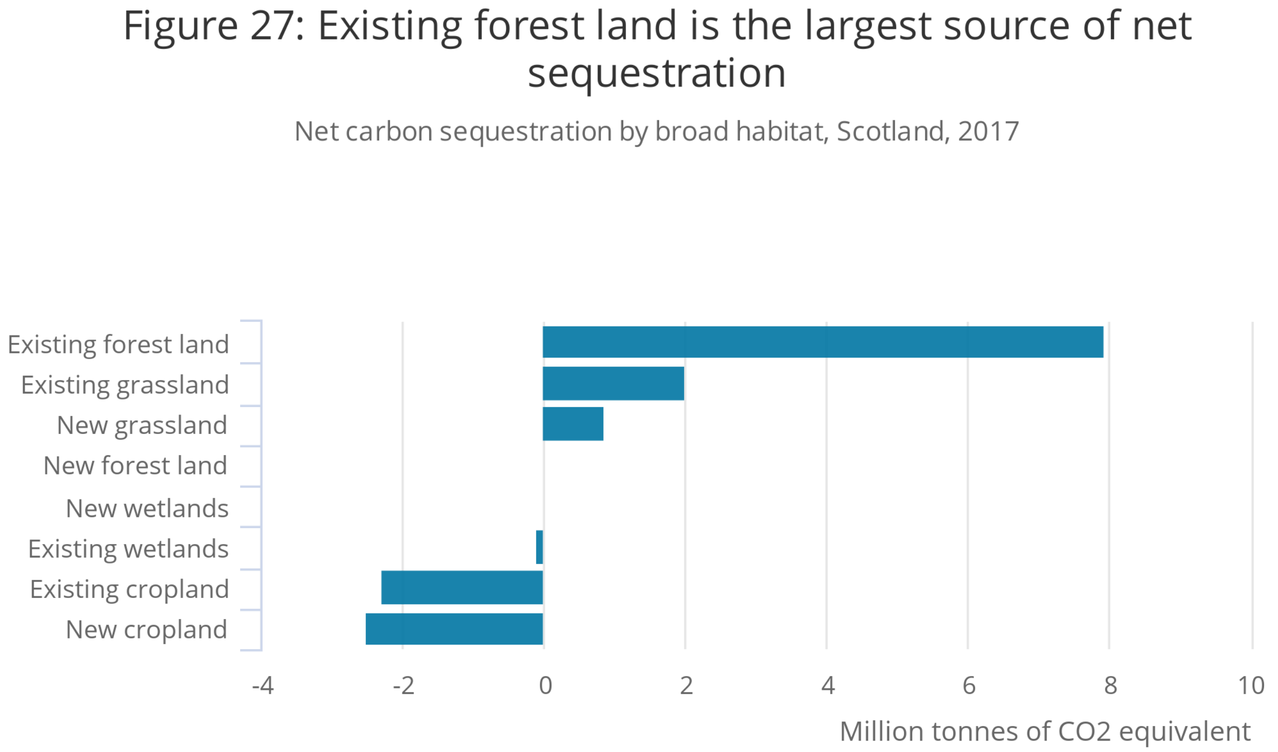
Source: Office for National Statistics and National Atmospheric Emissions Inventory (NAEI)

If we look at sequestration on a net basis, including emissions, 5.9 million tonnes of carbon dioxide equivalent was removed by nature in Scotland during 2017. Scottish forests removed 7.9 million tonnes of carbon in 2017 but croplands emitted 4.8 million tonnes. This means, whilst Scottish forests provided a £526 million service in 2017, Scottish croplands had emissions valued at negative £318 million.

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 27: Existing forest land is the largest source of net sequestration

Net carbon sequestration by broad habitat, Scotland, 2017

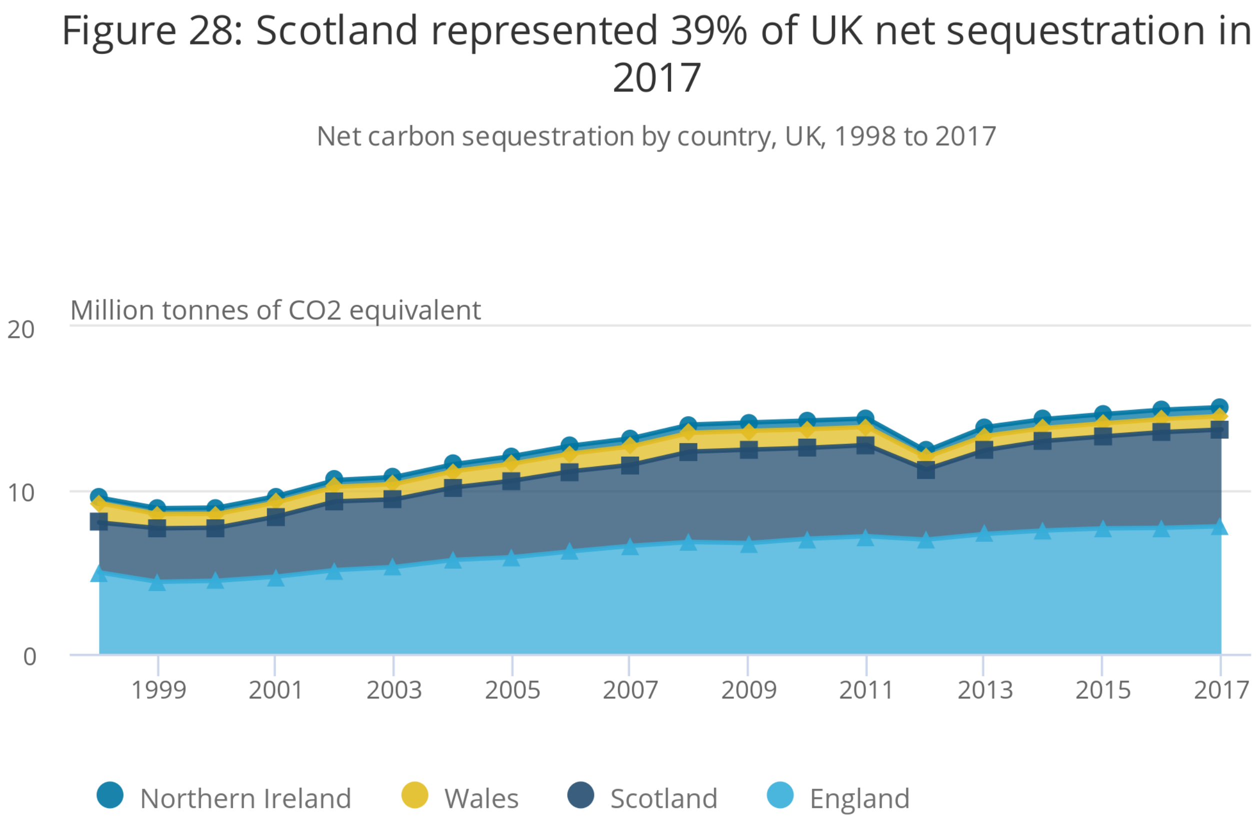


Source: Office for National Statistics and National Atmospheric Emissions Inventory (NAEI)

Scottish net carbon sequestration from land use was greatest in 2017, with 20% more carbon removed than 10 years earlier. Whilst forestland continues to be the largest source of carbon sequestration, increasing net sequestration was largely caused by declining cropland emissions and increasing grassland sequestration.

Figure 28: Scotland represented 39% of UK net sequestration in 2017

Net carbon sequestration by country, UK, 1998 to 2017

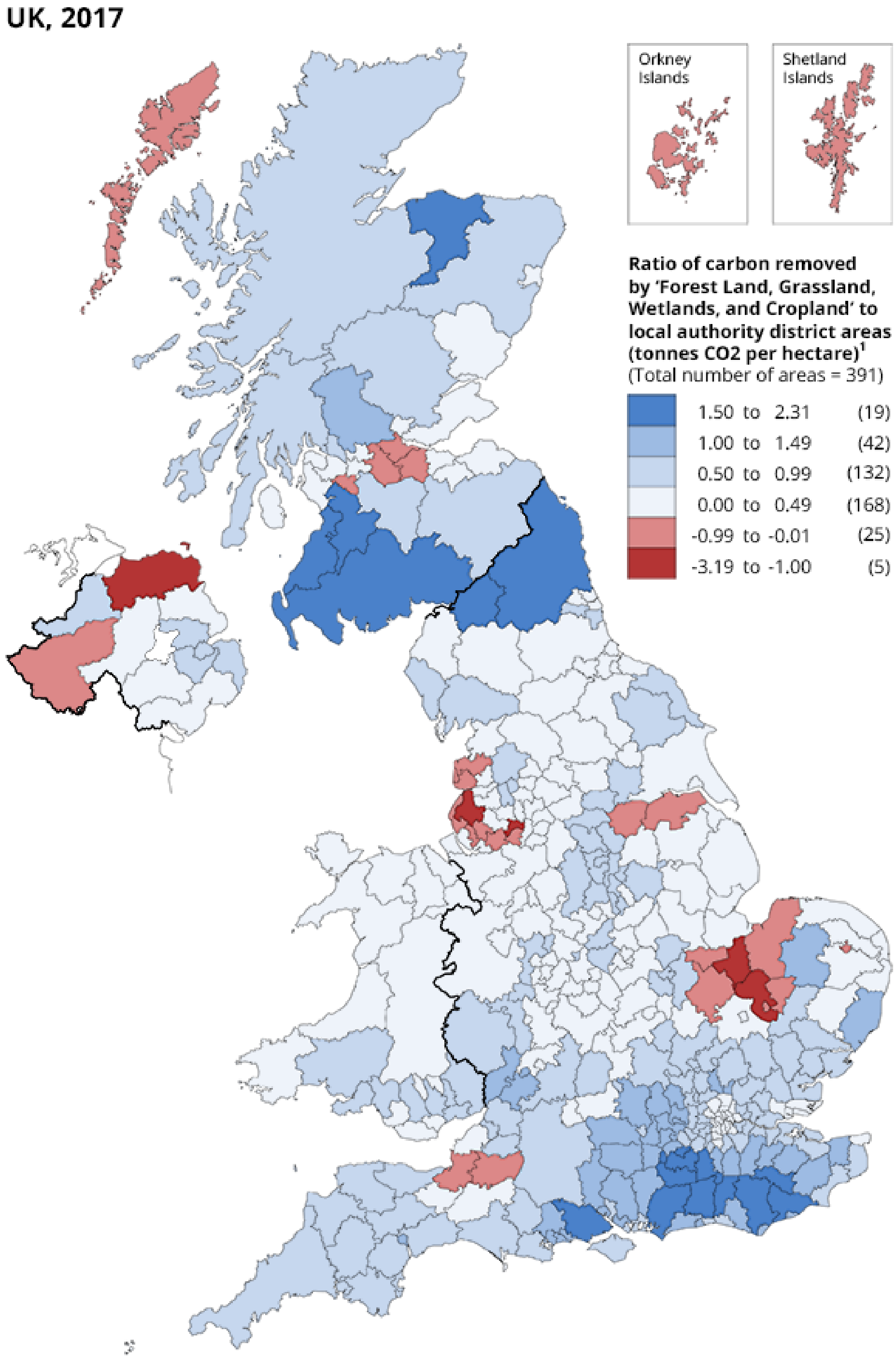


Source: Office for National Statistics and National Atmospheric Emissions Inventory (NAEI)

Overall net carbon sequestration in the UK was 15.1 million tonnes in 2017. By country, 52% of net carbon sequestration was from England, 39% from Scotland, 5% from Wales, and 4% from Northern Ireland. Per hectare, Scotland has the highest net carbon sequestration at 0.74 tonnes because it has the greatest forest cover. Woodland and forest currently cover about 18.5% of Scottish land area.

Figure 29: South Ayrshire sequesters the most carbon per hectare in Scotland

Carbon removed per hectare by "Forest land, Grassland, Wetlands, and Cropland" by local authority district areas



Source: National Atmospheric Emissions Inventory licensed under the Open Government Licence v.3.0. Prepared by the Centre for Ecology and Hydrology for the Department for Business, Energy and Industrial Strategy.
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Graphic created by ONS Geography

1 Sum of annual amount of carbon (measured in CO2 equivalent) removed by 'Forest Land, Grassland, Wetlands, and Cropland', divided by the area of each respective local authority district (hectares). Negative values occur for areas that have released more carbon than has been sequestrated because of a change in land use. Each resultant figure has been rounded to 2 decimal places.

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

Relative to its size, South Ayrshire sequesters the most carbon in Scotland, at 2.25 tonnes of CO_2 per hectare in 2017. This is because of the contribution of forestland in South Ayrshire, sequestering 318,000 tonnes, whilst croplands emitted 99,000 tonnes. Compared with other high sequestration rate areas across the UK, South Ayrshire sequesters less per hectare only than Guildford and Northumberland.

In 2017, West Lothian was the highest emitter of CO_2 equivalent per hectare in Scotland at 0.46 tonnes. Whilst grasslands in West Lothian contributed 0.90 tonnes of sequestration per hectare croplands emitted 1.40 tonnes.

Largely because of the vast area covered, the Scottish Highlands contributed 13% of UK net carbon sequestration in 2017. The Highlands have slightly higher carbon sequestration per hectare than the UK average, 0.77 tonnes per hectare compared with 0.64 tonnes, and represent 11% of the area of the UK.

Covering larger areas, with generally higher than the UK average carbon sequestration per hectare, Scottish councils represent 9 out of 10 of the highest sequestering areas in the UK.

Overall, increases in net carbon sequestration and carbon prices resulted in a 38.7% rise in the annual valuation from £282 million to £392 million between 2007 and 2017. This represented 39% of the UK net carbon sequestration value in 2017 (£999 million). Excluding any carbon emissions from the management of nature, the carbon sequestration valuation of Scotland was £757 million in 2017.

Air pollution removal by vegetation

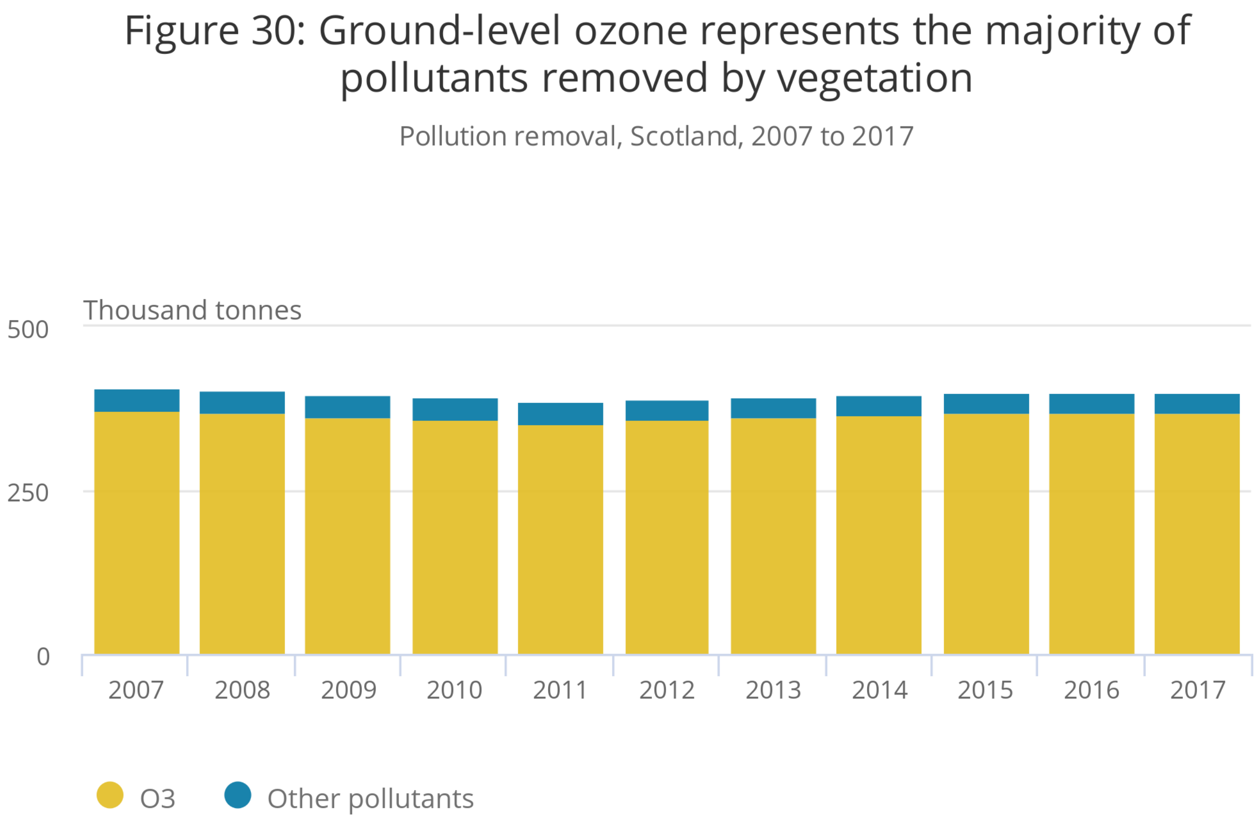
In 2017, vegetation in Scotland removed 400,000 tonnes of pollutants, which equated to a saving of £72.4 million in associated healthcare costs

Vegetation in woodland, semi-natural grassland and coastal margins all remove pollution from the atmosphere. We can measure the benefits of this to humanity by looking at the savings to health costs associated with breathing in air pollutants. The air pollutants we measure are PM_{10}, $PM_{2.5}$, SO_2, NH_3, NO_2 and 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.

Total vegetation in Scotland removed almost 400,000 tonnes of PM_{10}, SO_2, NO, NH_3 and O_3 (excludes $PM_{2.5}$ as a subset of PM_{10}). Ground-level ozone (O_3) represented the majority of total pollution removal (93%) in 2017 shown in Figure 30. PM_{10} is the second-largest pollutant removed, closely followed by NH_3. Scotland removed 30% of the total air pollution in the UK during 2017.

Figure 30: Ground-level ozone represents the majority of pollutants removed by vegetation

Pollution removal, Scotland, 2007 to 2017



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

Notes:

1. PM2.5 is a component of PM10.

Out of the pollutants, PM2.5 is the most harmful. In Scotland the local authority level that removed the most PM2.5 per hectare was South Ayrshire (1.62 kilograms per hectare), closely followed by Dumfries and Galloway (1.59 kilograms per hectare). Despite this, these areas do not feature in the top areas that benefit from the removal of air pollution and this is because these areas have low population densities compared with the city regions.

Figure 31: Woodland in Scotland removed the most harmful pollutant PM2.5 during 2017

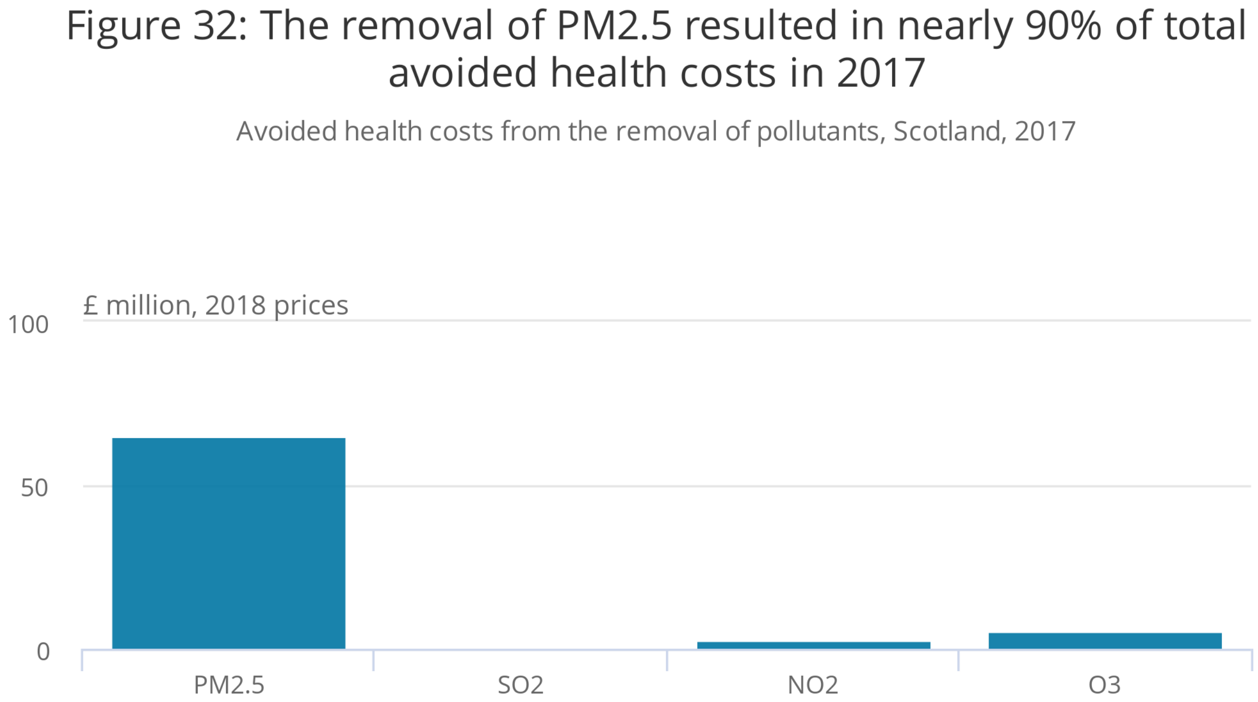
PM2.5 removed by habitat, Scotland, 2017

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

It is estimated that in 2017, 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 £72.4 million. Although the removal of PM2.5 represents only 1.6% of total pollution removed, nearly 90% of the avoided health impacts as a result of reductions in PM2.5 concentrations are removed primarily by woodland (see Figure 32).

Figure 32: The removal of PM2.5 resulted in nearly 90% of total avoided health costs in 2017

Avoided health costs from the removal of pollutants, Scotland, 2017



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

Most of the health benefits from air pollution removal in Scotland was in the form of avoided life years lost, with 1,549 avoided life years lost in 2017, equating to an avoided value of £67.54 million. This makes up 92% of the total Scottish annual value in 2017.

Table 2: The greatest value comes from the number of avoided years of life lost
Health impacts avoided because of the removal of air pollution by vegetation, Scotland, 2017

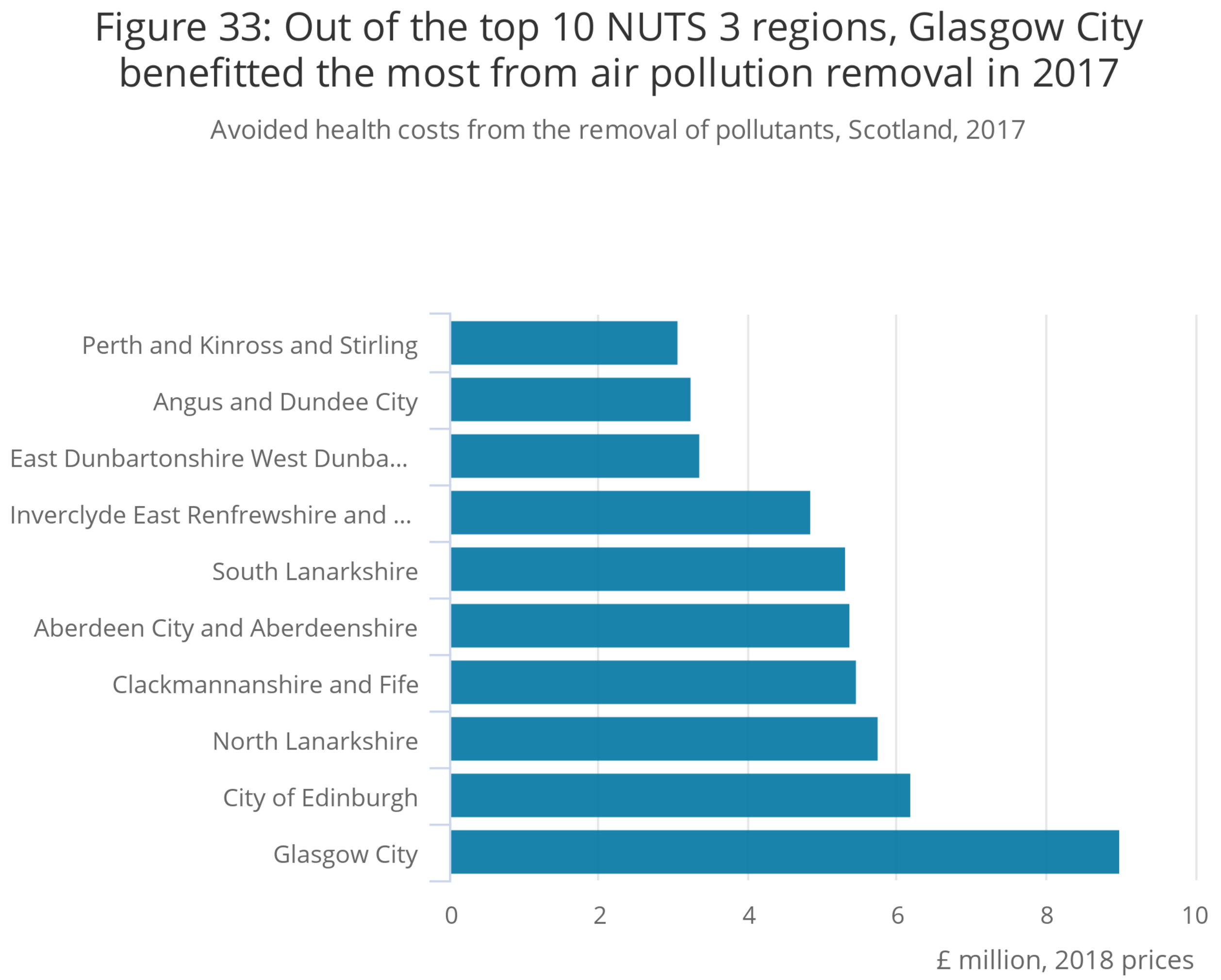
Pollutant	Avoided impacts	Count	Annual value (£ million, 2018 prices)
PM2.5	Respiratory hospital admissions	33	0.28
PM2.5	Cardiovascular hospital admissions	29	0.25
PM2.5	Life years lost	1,481	64.61
SO2	Respiratory hospital admissions	7	0.06
NO2	Respiratory hospital admissions	8	0.04
NO2	Cardiovascular hospital admissions	5	0.04
NO2	Life years lost	67	2.93
O3	Respiratory hospital admissions	408	3.45
O3	Cardiovascular hospital admissions	68	0.58
O3	Deaths	174	1.31
All combined	Respiratory hospital admissions	456	3.83
All combined	Cardiovascular hospital admissions	101	0.88
All combined	Life years lost	1,549	67.54
All combined	Deaths	174	1.31
All combined	Total	2,280	73.56

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

The two most populated areas in Scotland (Glasgow and City of Edinburgh) reported the most savings in associated health costs during 2017. This is because of the way the annual value estimates are calculated, which look at the total impact on health relating to the size of the population.

Figure 33: Out of the top 10 NUTS 3 regions, Glasgow City benefitted the most from air pollution removal in 2017

Avoided health costs from the removal of pollutants, Scotland, 2017



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

The present long-term asset value over a 100-year period, with income uplift and population growth, is £2.3 billion in 2017 (2018 prices), which makes up about 5% of the UK's total (£43.4 billion).

Noise mitigation by vegetation

One million people in Scotland are exposed to regular noise of 55 decibels or greater (Scottish Government), around the volume of normal speech. Vegetation acts as a buffer against noise pollution, such as road traffic noise. Noise pollution causes adverse health outcomes through lack of sleep and annoyance. 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 lower than estimates for other countries but this could be largely driven by the different noise metric used [1]. Where these metrics were compared, the metrics used in Scotland covered a smaller area than the metric used elsewhere.

To illustrate the potential underestimate: 7,000 buildings are predicted to benefit from noise mitigation in Scotland while 12,000 are predicted to benefit in Wales. For further methodological information please see the scoping study produced by Eftec and others (2018).

Table 3: 7,000 buildings benefitted from noise reduction resulting from urban vegetation in Scotland
Number of buildings where road noise levels are mitigated by natural capital in Scotland

Noise band in noise metric by decibel[1]	**Number of buildings benefitting from noise mitigation by urban vegetation[2] (rounded to the nearest thousand)**				
	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 (2018)

Notes

1. 5 dBA bands applied along with guidance in Defra’s noise pollution: economic analysis published in 2014. Back to table

2. Urban vegetation includes large woodlands (>3,000m²) and smaller woodlands (<3,000m²), but not very small woodlands (<200m²). Back to table

In 2017, the value of noise reduction in Scotland was £613,000 in avoided loss of quality adjusted life years (QALY) from sleep disturbance and annoyance. Valuations based on QALY are economic welfare values, which look in to how noise reduction affects people’s social welfare.

The annual avoided loss of quality adjusted life for the UK was worth £15.3 million in 2017.

Table 4: Noise mitigation from natural capital led to a saving of £613,000 in avoided loss of quality adjusted years associated with a loss of amenity and adverse health outcomes in Scotland
Monetary accounts for the noise mitigation of urban natural capital, UK, 2017

Noise band 1	**Annual value of noise mitigation of 1dBA (£ thousand, 2018 prices)**				
	England	**Scotland**	**Wales**	**Northern Ireland**	**UK**
More than 80	1	-	-	-	1
75.0-79.9	148	-	11	2	161
70.0-74.9	1,104	8	106	56	1,274
65.0-69.9	4,026	124	313	141	4,604
60.0-64.9	7,778	481	672	324	9,255
Total	13,057	613	1,102	523	15,295

Source: Eftec and others (2018)

Notes

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

The asset value of noise mitigation from vegetation in Scotland was £33 million in 2017. Scotland made up around 4% of the £833 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).

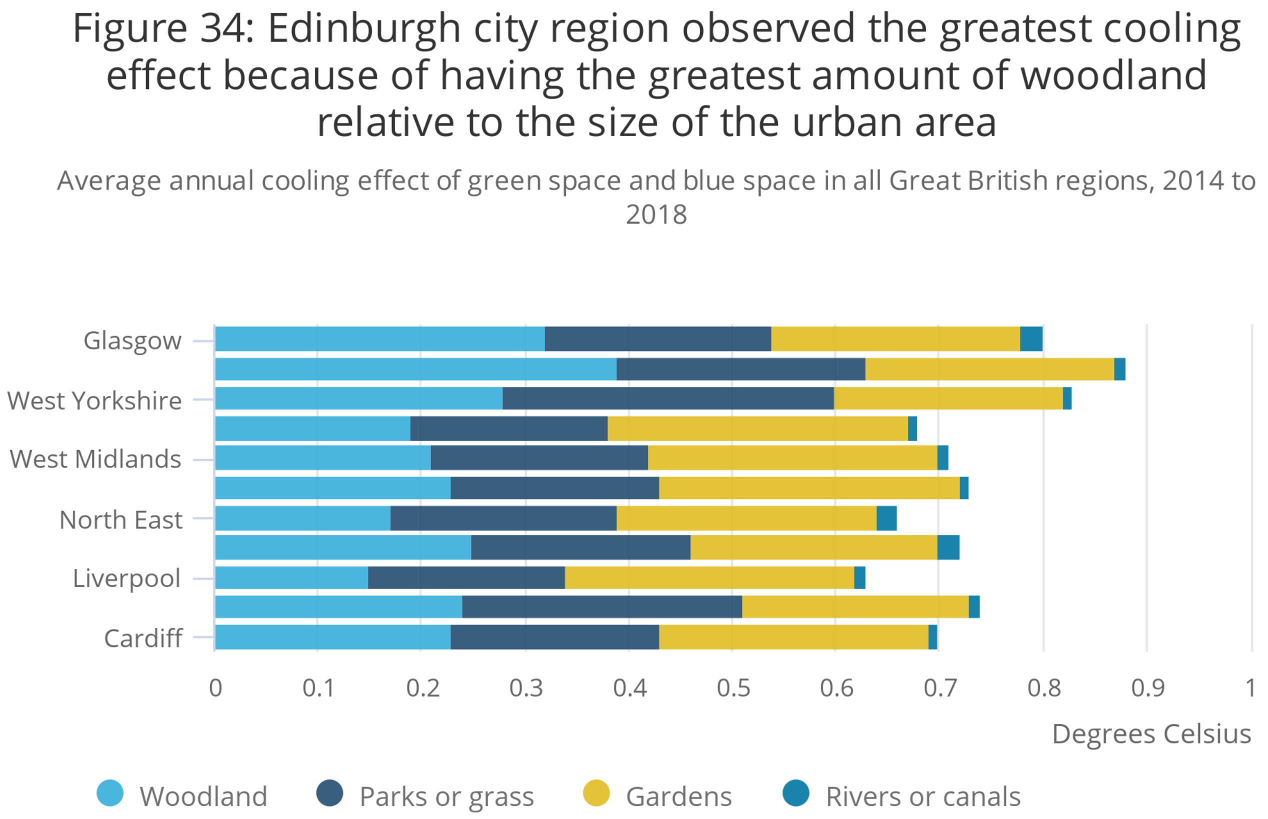
Eftec and others (2018) estimated the cooling effect provided by natural capital for 11 city regions across Great Britain, including two Scottish regions – Glasgow and Edinburgh. The cooling effect is based on reducing heat on hot days. Hot days throughout this section refers to any days equal to or between 28 degrees Celsius and 35 degrees Celsius.

As shown in Figure 34, the cooling effect in both Glasgow and Edinburgh is similar, with Edinburgh's green space providing just 0.08 degrees more cooling. Cooling is dominated by green spaces as opposed to blue spaces.

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 Britain 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 observed the greatest cooling effect because of having the greatest amount of woodland relative to the size of the urban area

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



Source: Eftec and others (2018)

It should be noted that conservative estimates of the cooling effects were chosen because of the relatively simple modelling approach. This means the cooling effect of blue spaces is likely underestimated. Furthermore, the approach does not account for the cooling effects on a local level, such as shading by street trees. For more information on all the caveats, please see the scoping study by Eftec and others (2018).

Table 5 shows the value of green space in avoided labour productivity losses and air-conditioning energy costs. Urban green space in Edinburgh and Glasgow prevented costs of £560,000 during the partial hot day in 2016. This value is low compared with other Great Britain city regions such as London, which had the highest avoided costs at £237.1 million. This is because London has the largest economy and had 8.2 hot days in 2016 (see Table 5).

“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.

Table 5 also shows that in 2017 the number of hot days decreased to zero in Scottish city regions. This means that avoided costs also decreased to £0. Between 2016 and 2017, most of the 11 city regions saw an increase in avoided costs. Unlike Edinburgh and Glasgow, many regions had an increase in the number of hot days (five more than 2016 overall).

There was a large increase in the number of hot days across the UK in 2018, nearly triple what was experienced in 2017, at 68 days. Scottish city regions experienced 1.5 hot days. This resulted in increased avoided costs for Scotland to £3.15 million from the £560,000 seen in 2016.

Table 5: The number of hot days for the Scottish regions increased from 0 days in 2017 to 1.5 days in 2018
Number of hot days in each of the 11 Great British regions

City region	**Number of hot days**		
	2016	**2017**	**2018**
Cardiff	1.3	3.1	5
Edinburgh	0.2	0	0.5
Glasgow	0.2	0	1
Greater Manchester	1	0.9	4.3
Liverpool	1	2.2	6.2
London	8.2	7.4	22.9
North East	0.4	0	0.1
Sheffield	2.4	1.9	5.7
West Midlands	2.8	4.6	10.6
West of England	1.6	4.6	8.5
West Yorkshire	1.1	1	2.8
Scottish Total	0.4	0	1.5
Total	20.2	25.7	67.6

Source: Eftec and others (2018) and Met Office

Table 6: Edinburgh and Glasgow had a total avoided cost from urban cooling of £3.15 million in 2018
Total annual value of cooling from green/blue space in each of Great Britain's regions (£ thousand, 2018 prices)

City region	Avoided costs		
	2016	**2017**	**2018**
Cardiff	3,370	5,260	4,150
Edinburgh	230	-	380
Glasgow	330	-	2,770
Greater Manchester	7,820	1,440	9,300
Liverpool	4,230	860	4,560
London	237,050	207,830	586,860
North East	350	40	60
Sheffield	3,460	3,180	8,210
West Midlands	12,640	16,080	26,490
West of England	4,650	11,370	9,530
West Yorkshire	4,710	1,770	7,530
Scottish Total	560	-	3,150
Total	278,840	247,830	659,840

Source: Eftec and others (2018) and Met Office

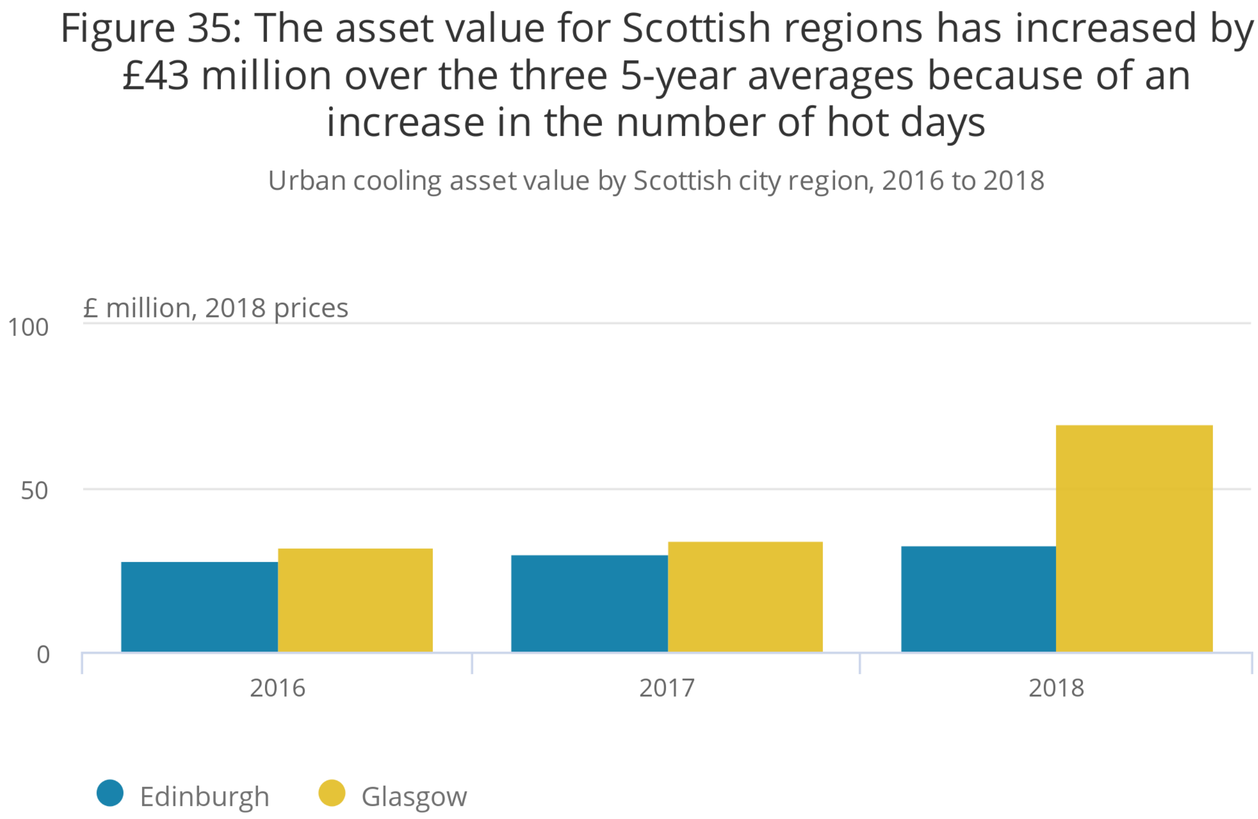
In Scotland, hot days are projected to increase as summer months are predicted to become up to 4.8 degrees Celsius warmer by the 2070s according to the Met Office UK Climate Projections. In England, summer temperatures have been estimated to be up to 5.8 degrees Celsius warmer. These estimations are based from a high greenhouse gas emission scenario; under lower emissions summer months could be 2.8 and 3.3 degrees Celsius warmer in Scotland and England.

Figure 35 shows the asset value of urban cooling for Glasgow and Edinburgh city regions. 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 asset value of the two Scottish regions combined increased marginally between 2016 and 2017 from £60 million to £64 million. The asset value for Scotland increased to a much larger extent in 2018, driven by an increase in hot days. This increase can be seen in Glasgow, having an average number of 0.10 hot days in the period 2013 to 2017, which more than doubled to an average of 0.28 in the period 2014 to 2018.

Figure 35: The asset value for Scottish regions has increased by £43 million over the three 5-year averages because of an increase in the number of hot days

Urban cooling asset value by Scottish city region, 2016 to 2018



Source: Eftec and others (2018)

Notes for: Regulating services

1. Lden was used since LA1018 was not available for Scotland.

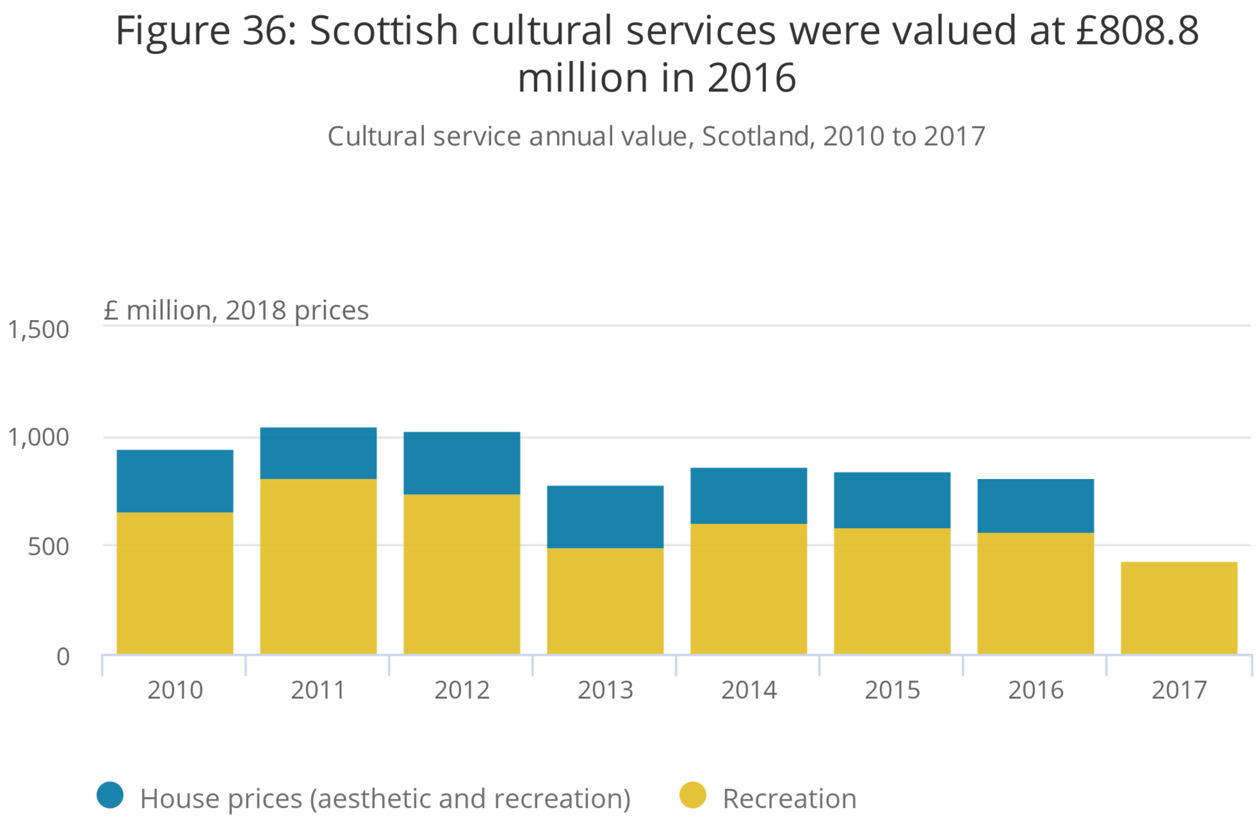
7 . Cultural services

This section presents some of the cultural services that nature provides to humanity. Cultural services are the non-material uses and experiences people have in the natural environment. They include recreation, education, art, sense of place and spirituality.

Here we show estimates for both the recreational and aesthetic benefits. Recreation accounted for 70% (£567 million) of the total valuation of cultural services in 2016. Recreation is the dominant cultural service over the time period seen in Figure 36, equating to an average of around £610.4 million over the time series. As well as measuring recreation by looking at surveys we also capture recreational and aesthetic values in the housing market by looking at the willingness to pay for living close to, and having views of, green and blue space (any open water).

Figure 36: Scottish cultural services were valued at £808.8 million in 2016

Cultural service annual value, Scotland, 2010 to 2017

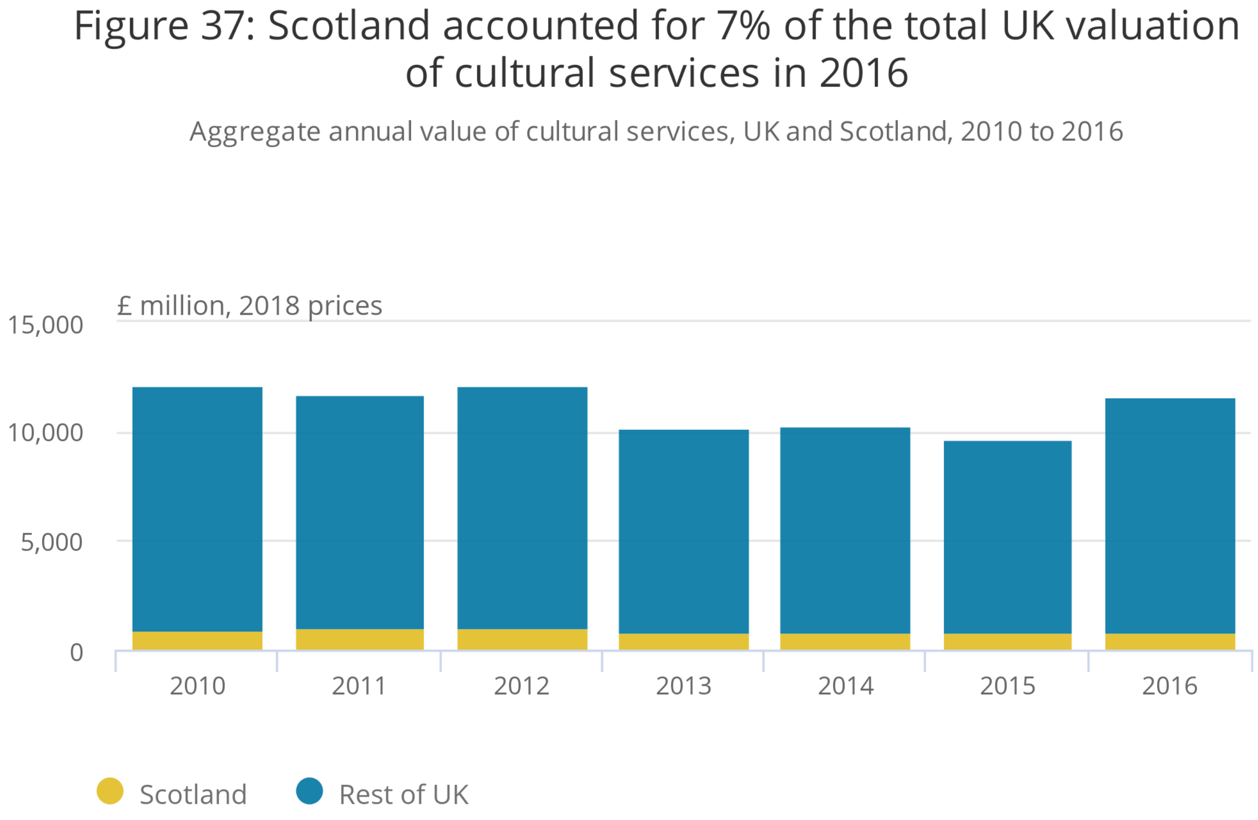


Source: Office for National Statistics, Scottish Recreation Survey, and Scotland's People and Nature Survey

The total cultural service valuation in Scotland has decreased by 22.9% between the high recorded in 2011, and 2016, whilst the rest of the UK increased by 1% during the same period. Despite the increase in the number of visits occurring in Scotland, the value decline seen in Figure 36 is because of falling spending per visit. Between 2010 and 2016, cultural services in Scotland made up on average 8% of the UK total cultural services.

Figure 37: Scotland accounted for 7% of the total UK valuation of cultural services in 2016

Aggregate annual value of cultural services, UK and Scotland, 2010 to 2016



Source: Office for National Statistics, Monitor of Engagement with the Natural Environment (MENE) survey, The Welsh Outdoor Recreation Survey, Scottish Recreation Survey, and Scotland's People and Nature Survey

Recreation

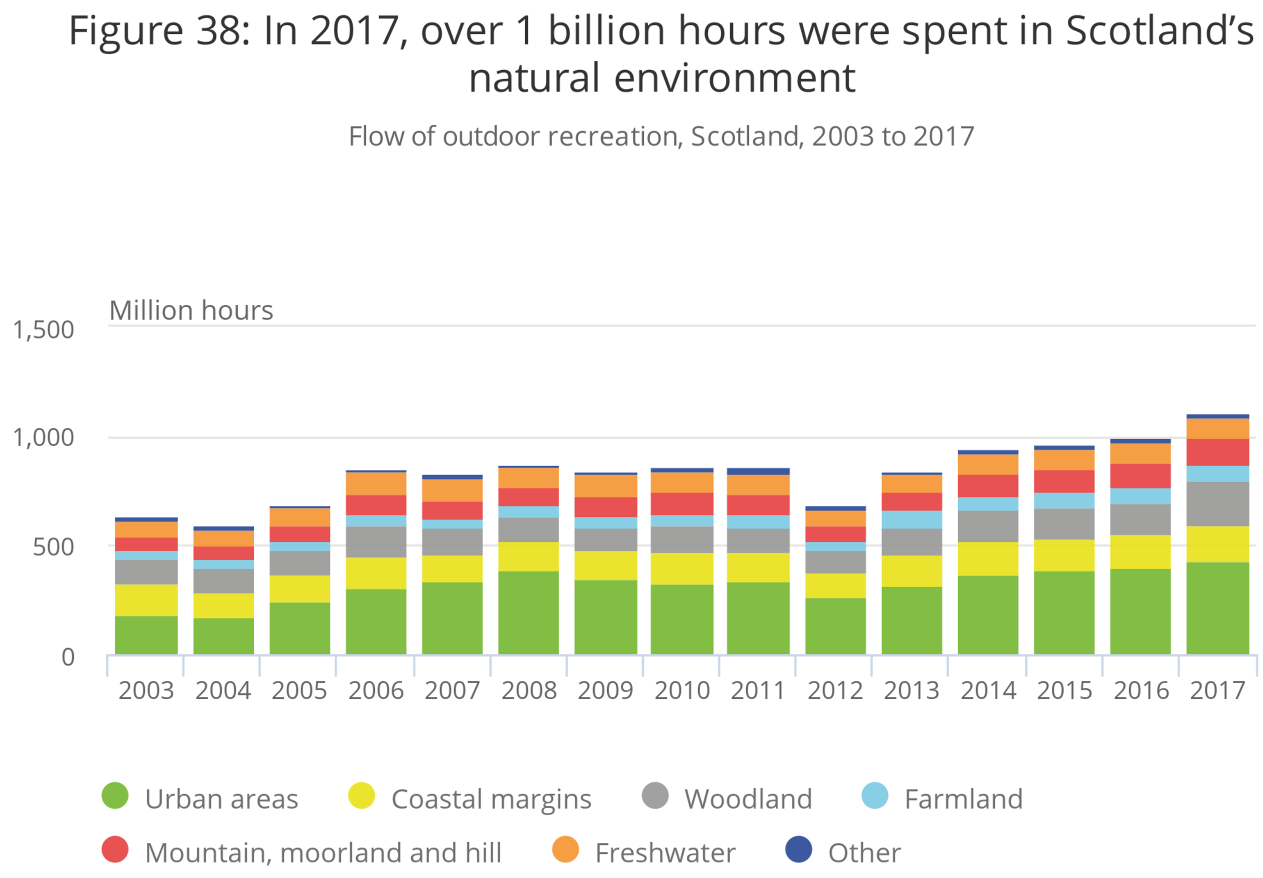
During 2017, people in Scotland spent more time on outdoor recreation than previously seen. On average Scottish people took 29 more visits than people across the UK during 2017. People in Scotland also spent 39 more hours on outdoor recreation while expenditure per year was £50 less.

In 2017, over 1 billion hours were spent on Scottish outdoor recreation (including travel time). Time spent in Scotland's natural environment has increased since 2012, following a decline in hours spent in all Scottish habitat areas except woodland, between 2011 and 2012 (see Figure 38). The Scottish Recreation Survey summary report (PDF, 1.51MB) suggests that this may have been because of poor weather. The estimated number of visits to the Scottish outdoors was 25% lower during the summer months of 2012, compared with 2011.

Estimates of outdoor recreation refer to people aged 16 years and over and excludes overnight and tourist visits.

Figure 38: In 2017, over 1 billion hours were spent in Scotland's natural environment

Flow of outdoor recreation, Scotland, 2003 to 2017



Source: Office for National Statistics and Scottish Natural Heritage

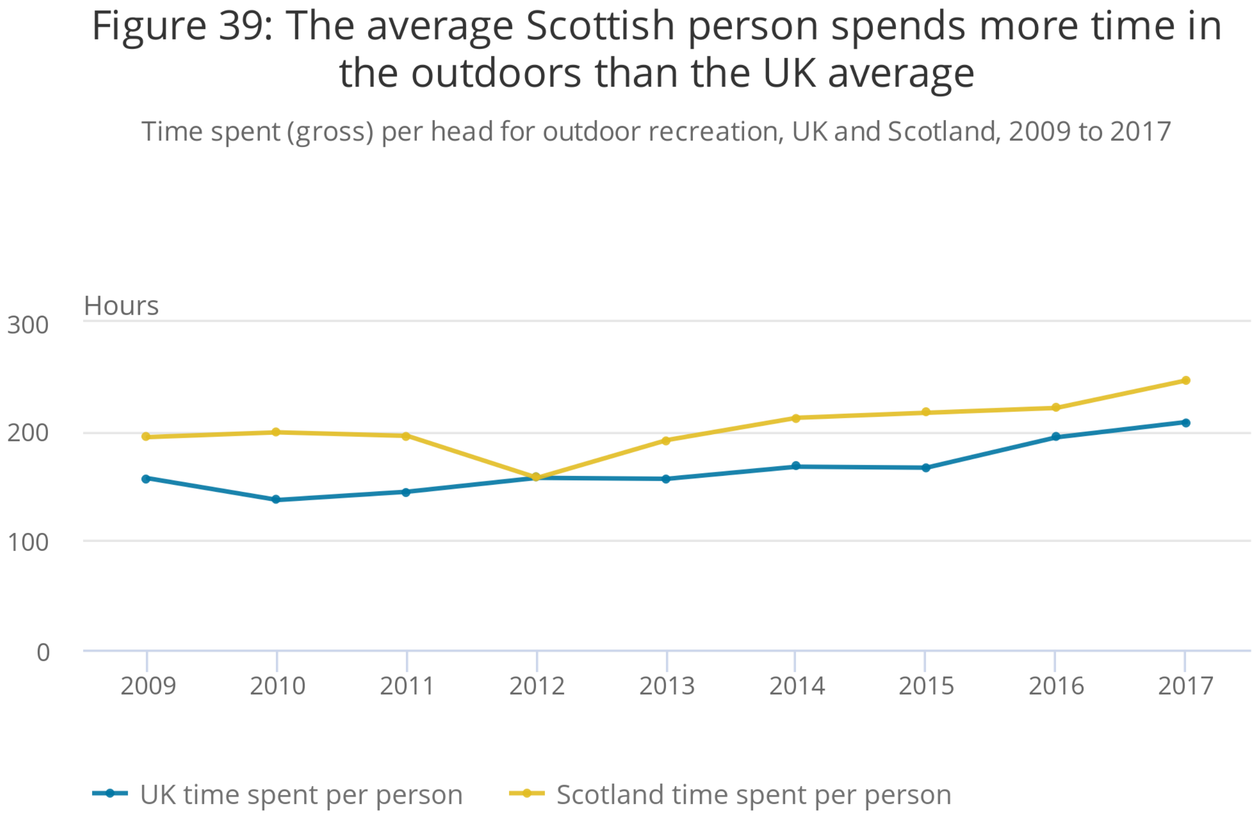
Between 2009 and 2017, the average length of an outdoor recreation visit in Scotland was two hours and seven minutes. One hour and 19 minutes was spent at the visit destination and 47 minutes was spent on travel to and from the visit destination. For some visitors travel time could be part of the enjoyment from nature, which is shown in their choice of route or travel method. For others it may represent a willingness to pay or a cost of accessing outdoor recreation.

Visits to urban outdoor areas (such as local parks and open spaces) made up the largest proportion of time spent. Between 2009 and 2017, 39% of time spent on outdoor recreation was in these areas. Scottish people visited urban areas the most (47% of visits). But the average visit lasted one hour and 45 minutes, the shortest visit of all habitat types. Visits to mountains and moorlands were longest, lasting on average three hours and two minutes. This was followed by trips to freshwater areas, such as lochs, at two hours and 41 minutes.

Scotland represented 10% of estimated UK time spent on outdoor recreation during 2017. In the same year, the average person in Scotland spent 247 hours on outdoor recreation. This was 18% higher than the UK average of 208 hours. This is because of more visits per person in Scotland. People in Scotland took 121 outdoor recreation visits in 2017, which were 29 (31%) more visits than the UK average of 92 visits.

Figure 39: The average Scottish person spends more time in the outdoors than the UK average

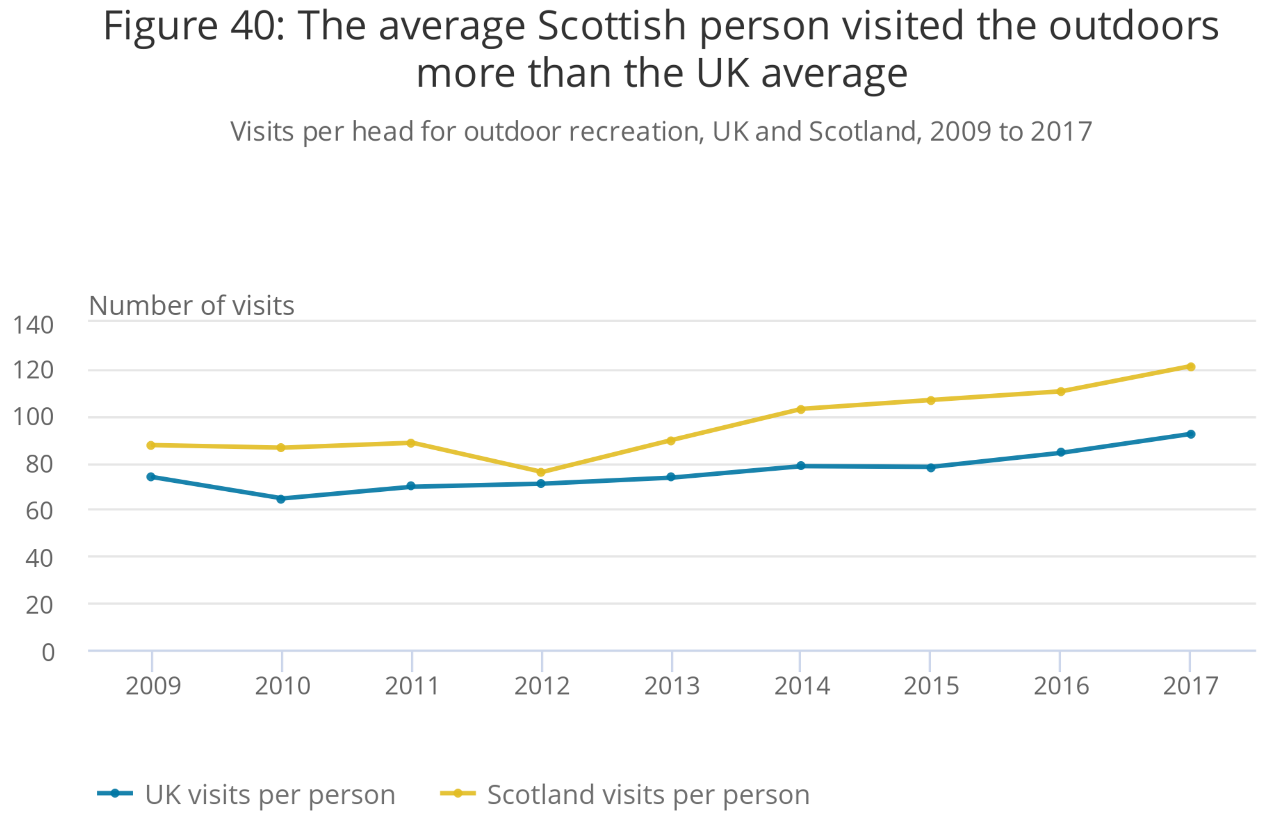
Time spent (gross) per head for outdoor recreation, UK and Scotland, 2009 to 2017



Source: Office for National Statistics and Scottish Natural Heritage

Figure 40: The average Scottish person visited the outdoors more than the UK average

Visits per head for outdoor recreation, UK and Scotland, 2009 to 2017



Source: Office for National Statistics and Scottish Natural Heritage

In 2017, UK natural capital provided outdoor recreation valued at £7,986 million. Scottish visits represented around 5% of this (£430 million).

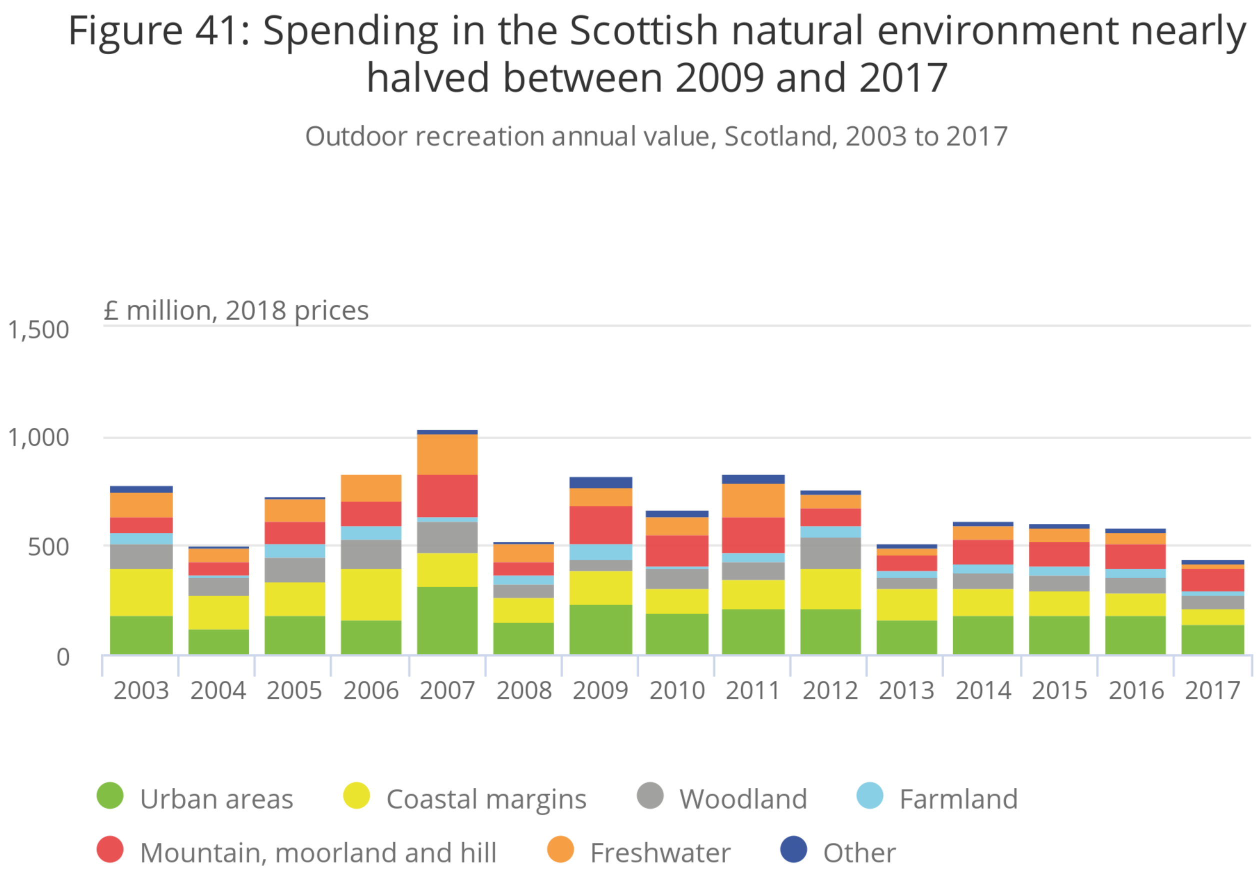
Between 2009 and 2017, the value of UK recreation decreased by 11% (from £8,959 million). This was despite visit numbers increasing 33% (from 3.7 billion to 4.9 billion). The value of Scottish recreation also decreased by 47% from £815 million to £430 million.

Scottish people are staying longer and visiting the outdoors more, while opting for cheaper visits. Average spend per visit in Scotland decreased from £2.16 in 2009 to £0.78 in 2017. The main driver of the fall in expenditure was falling travel costs, down from £1.68 to £0.55 per visit over the same period.

Time spent on outdoor recreation has many additional benefits beyond expenditure, such as health and well-being. The value of these benefits is not currently being captured in the recreation account.

Figure 41: Spending in the Scottish natural environment nearly halved between 2009 and 2017

Outdoor recreation annual value, Scotland, 2003 to 2017

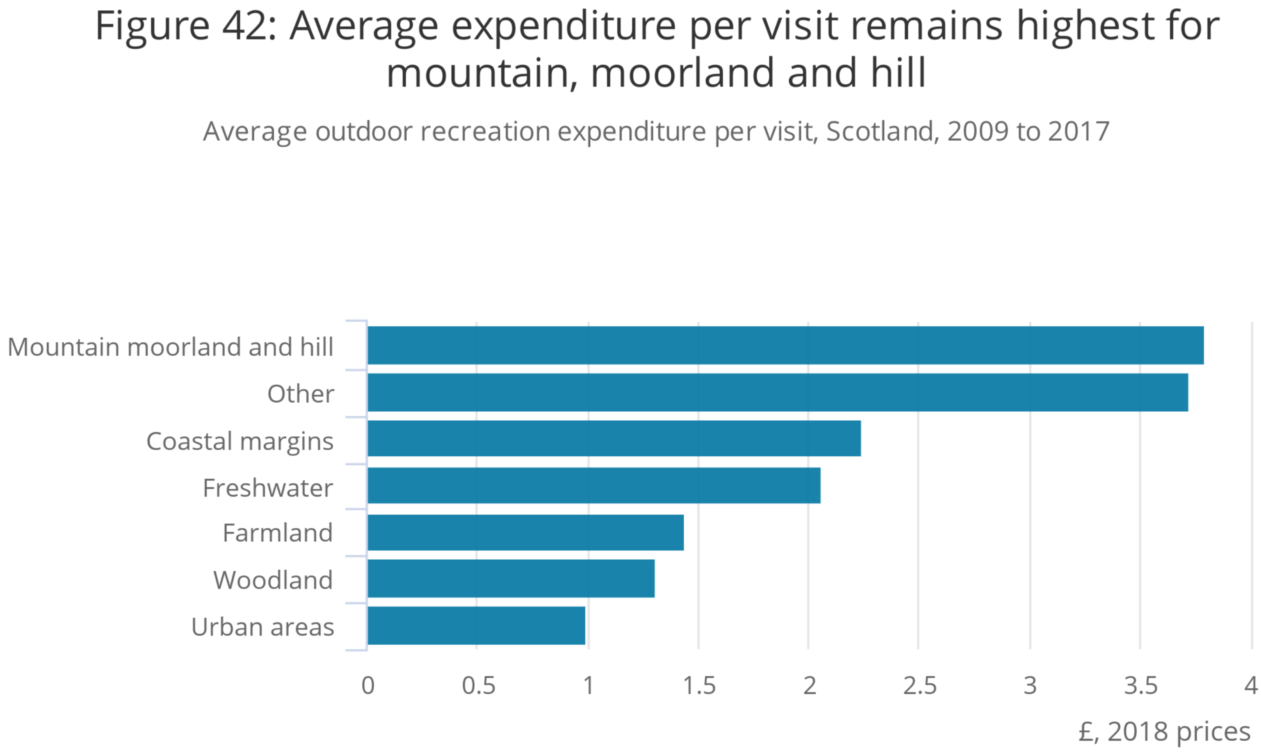


Source: Office for National Statistics and Scottish Natural Heritage

Outdoor recreation in urban areas and coastal areas had the largest average annual expenditure (£194 million and £126 million respectively). Meanwhile, average expenditure per visit during this period was greatest for mountain and moorland (£3.80), followed by “Other” areas (£3.73) and coastal margins (£2.24). This is despite urban areas (£1.00) having higher visit rates.

Figure 42: Average expenditure per visit remains highest for mountain, moorland and hill

Average outdoor recreation expenditure per visit, Scotland, 2009 to 2017

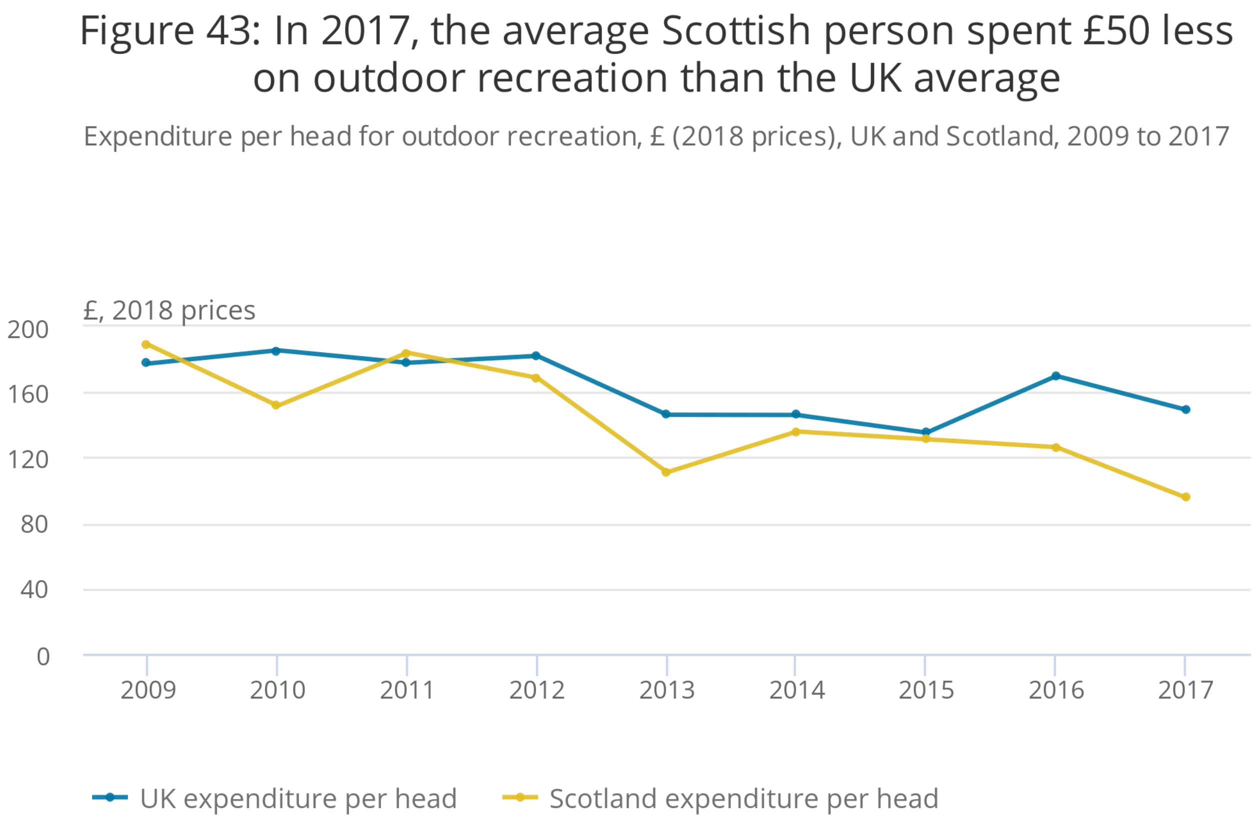


Source: Office for National Statistics and Scottish Natural Heritage

Urban areas (£3,342 million) and coastal margins (£1,640 million) in the UK saw the largest average annual expenditure. In contrast to Scotland, UK expenditure in mountain and moorland remains the smallest (£509 million). UK average annual expenditure per person in mountain and moorland was £9.80 between 2009 and 2017, as opposed to £26.56 in Scotland.

Figure 43: In 2017, the average Scottish person spent £50 less on outdoor recreation than the UK average

Expenditure per head for outdoor recreation, £ (2018 prices), UK and Scotland, 2009 to 2017



Source: Office for National Statistics and Scottish Natural Heritage

Recreation and aesthetic value in house prices

We have already estimated the value of green and blue spaces through house prices at the UK level . However, 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 [1], 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 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 selling price.

Living near (within 500 metres) publicly accessible green and blue spaces added on average £2,393 to property prices in Scottish urban areas. Please note that throughout this section when referring to “green spaces” this is publicly accessible green space [2].

The hedonic pricing approach analyses the variables that affect house prices, including the willingness to pay for living close to green and blue spaces. Table 7 shows the variables included in the 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. 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 7: Variables included in the 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

To work out the value of living near to urban green and blue spaces, we estimate the difference between the predicted house price based on real data and the predicted house price if there were no green or blue spaces [3]. In Scotland, the estimated effect of living near green or blue spaces was £2,393.3 on average in 2016 (see Table 8). This represents about 1.8% of the average Scottish property price in our sample.

In 2016, there were 2.57 million residential properties in Scotland. To work out the total stock value for green and blue spaces we multiply this by the average annual value – £2,393.3 – to get £6.1 billion. We can make a coarse estimate that there are around 2.16 million residential properties in urban areas of Scotland [4]. This would produce an alternative total stock value of £5.2 billion for 2016, though excluding the value of green and blue spaces in rural areas. Because of difficulties in obtaining urban housing estimates for the UK, we aim to fix this issue in the next iteration of the UK and Scottish natural capital accounts.

We can also split the total stock value to look at the separate recreational and aesthetic values (see Table 8).

The recreational services are measured by the distance to and area of blue and green spaces while the aesthetic services are captured by the view over green or blue spaces. For example, in 2016, the recreational benefit of living within 500 metres of green or blue space was estimated to be worth £5.6 billion, while the aesthetic benefit was valued at £0.54 billion.

Table 8: In 2016, the total stock value of living within 500 metres of green and blue space was estimated to be £6.1 billion

Value of cultural services capitalised into property prices, 2018 prices, Scotland, 2010 to 2016

Year	Average value (£)	95% CI lower bound	95% CI upper bound	Average value (%)	Stock value (£ billion)	Aesthetic value (£ billion)	Recreational value (£ billion)	N properties (million)
2010	4,679	4,199	5,159	2.41	11.61	1.26	10.35	2.48
2011	3,500	3,169	3,830	1.92	8.73	1.07	7.66	2.49
2012	4,187	3,828	4,546	2.3	10.5	0.99	9.51	2.51
2013	3,769	3,454	4,083	2.24	9.5	0.9	8.6	2.52
2014	3,217	2,960	3,475	1.97	8.15	0.86	7.3	2.53
2015	2,629	2,418	2,840	1.9	6.7	0.62	6.09	2.55
2016	2,393	2,182	2,605	1.77	6.14	0.54	5.6	2.57

Source: Office for National Statistics

Notes

1. The year of 2009 was excluded for Scotland as the sample size was too small. Back to table

For annual values, we can present an equivalent rental value of living within 500 metres of green or blue space shown in Table 9. “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 9: In 2016, the estimated rental value of living within 500 metres of green and blue space was estimated to be £242 million

Imputed rental benefit from green and blue space, £ million (2018 prices), Scotland, 2010 to 2016

Year	Total (£ million)
2010	290.4
2011	241.6
2012	283.7
2013	290.4
2014	257.9
2015	254
2016	241.8

Source: Office for National Statistics

Notes

1. The year of 2009 was excluded for Scotland as the sample size was too small. Back to table

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[5]. Table 10 presents the average effect of living near green and blue spaces in different TTWA. We report both the absolute effect and the effect relative to the average property price in the area.

Out of the 10 most sampled TTWA, Edinburgh had the greatest average effect (£6,800.4). Edinburgh also had the greatest average value percentage increase relative to the houses in that area (2.9%).

One explanation for this could be that people in Edinburgh use their local greenspace slightly more than the Scottish average in 2017[6], and that these residents are therefore relatively more willing to pay for closer proximity to green and blue space. Another reason could be that there is a slightly higher level of satisfaction with council parks and open spaces in Edinburgh than the Scottish average in 2018[7], and that the quality of this local greenspace is reflected in the higher average effect of living close to green or blue space.

Table 10: Edinburgh had the greatest increase in the average value from properties within 500 metres of green and blue spaces

Average effect of green and blue space on property price by travel to work area, Scotland, 2009 to 2016

Travel to work area	Average value (£, 2018 prices)	Average value of property price (%)	N validation set	Average distance to green spaces (m)	Average distance to blue spaces (m)
Glasgow	3,057.00	1.93	5911	276.2	333.5
Edinburgh	6,800.40	2.93	2415	253.7	390.1
Motherwell and Airdrie	2,055.00	1.65	1907	289.8	473
Falkirk and Stirling	2,319.60	1.56	1648	284.4	280.7
Livingston	2,514.40	1.77	1174	285.4	350.2
Kilmarnock and Irvine	1,845.20	1.71	1086	331.2	333.3
Ayr	1,595.90	1.01	729	289.6	366.7
Dunfermline and Kirkcaldy	2,224.00	1.73	601	314.5	355
Perth	2,954.90	1.75	585	262	344.6
Inverness	2,482.40	1.36	409	309	228.4

Source: Office for National Statistics

Table 11: The average effect of green and blue spaces as a proportion of the property price is relatively similar across most deciles

Average effect of green and blue space by Scottish Index of Multiple Deprivation (SIMD), Scotland, 2009 to 2016

SIMD decile	Average value (£, 2018 prices)	Average value of property price (%)	N validation set	Average distance to green spaces (m)	Average distance to blue spaces (m)
1	1,754.17	2.11	1196	219.3	384.7
2	1,783.76	1.82	1455	225.2	384.6
3	2,052.84	1.97	1742	239.8	363.6
4	1,732.10	1.5	1864	250.4	350.2
5	2,411.15	1.93	1916	263.1	329.7
6	2,704.41	1.87	1902	272.6	347.1
7	3,348.21	1.98	2033	284.3	311.6
8	3,650.59	1.92	2256	334.3	330
9	4,596.57	2.08	2392	335.9	340.4
10	7,103.64	2.46	2163	308.2	331.6

Source: Office for National Statistics

Notes for: Cultural services

1. See for instance this publication from Department for Education.

2. Any green space that has a specific function in its use, for example, public parks or gardens, playing fields or golf courses. These spaces contain natural land cover and can also include some blue space, for example, a park that has a lake within it. Blue spaces include all inland water bodies, for example, rivers, lakes, ponds, canals and so on.

3. We set areas and view of green and blue spaces to zero and distance to 500 metres.

4. See Table 2.16 for Scotland in the Scottish Household Survey local authority tables, excluding accessible and remote rural areas from urban stock of residential properties.

5. For more details on how travel to work areas (TTWA) are defined, see this publication from Office for National Statistics.

6. See Figure 10.7 for Edinburgh City in the Scottish Household Survey local authority tables, 2017.

7. See tab 2.16 of the Scottish Surveys Core Questions supplementary tables.

8 . Asset valuation

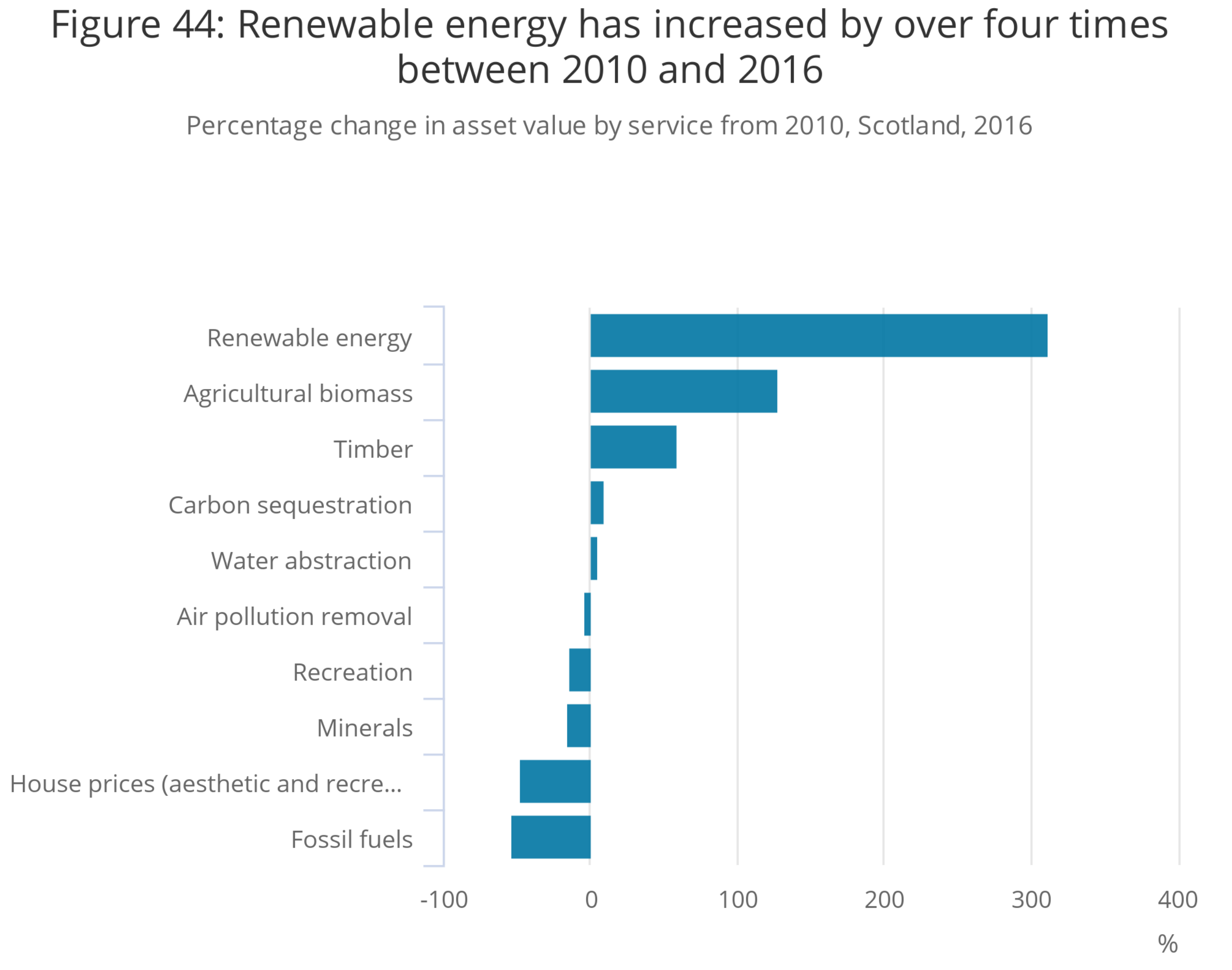
Here we present the asset values of Scottish natural capital by service. These values are estimated by capitalising the annual flow of services from the natural resource that are expected to take place over a projected period, known as the asset life. The annual environmental service flows provide the basis for the 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, where an asset life of 25 years has been assumed.

Since 2010, out of all the measured ecosystem services, the asset value of fossil fuels has declined by the greatest amount (over 50%) in 2016. This was closely followed by the asset value of the benefits of accessible green and blue spaces reflected in house prices, which decreased by 47% between 2010 and 2016. Meanwhile, renewable energy increased by four times since 2010.

Figure 44: Renewable energy has increased by over four times between 2010 and 2016

Percentage change in asset value by service from 2010, Scotland, 2016



Source: Office for National Statistics

Notes:

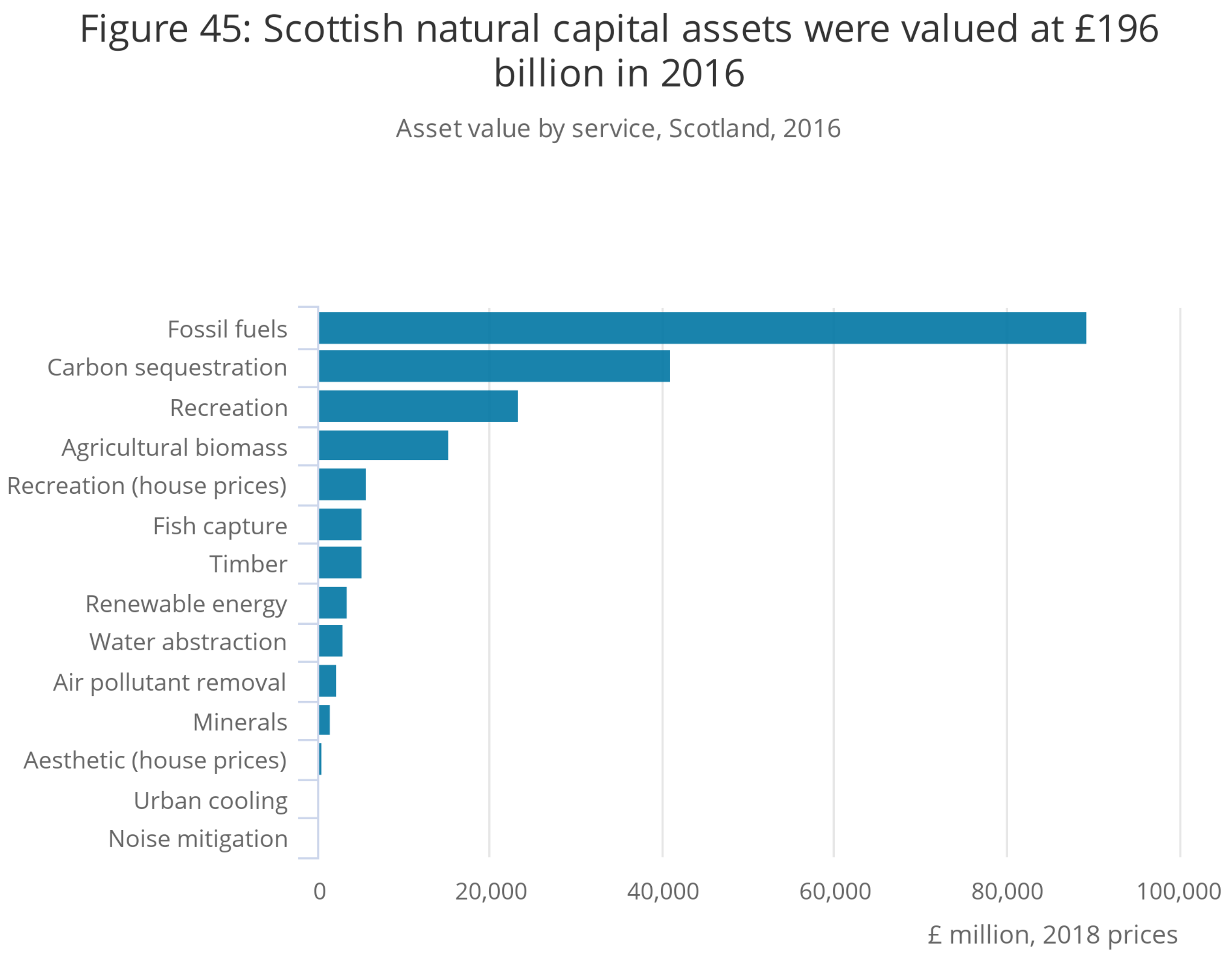
1. Excluding the comparison of asset values for fish capture, urban cooling and noise mitigation, due to data limitations.

Despite the asset value for fossil fuels declining by almost a half between 2010 and 2016, it still accounted for around 50% of the total Scottish asset value in 2016.

Carbon sequestration was the next-largest contributor to the total valuation, making up 21% of the asset value in 2016. The overall asset value of non-material services not captured directly in gross domestic product (GDP) (that is, regulating and cultural services) represented 37% of Scotland's asset value in 2016.

Figure 45: Scottish natural capital assets were valued at £196 billion in 2016

Asset value by service, Scotland, 2016



Source: Office for National Statistics

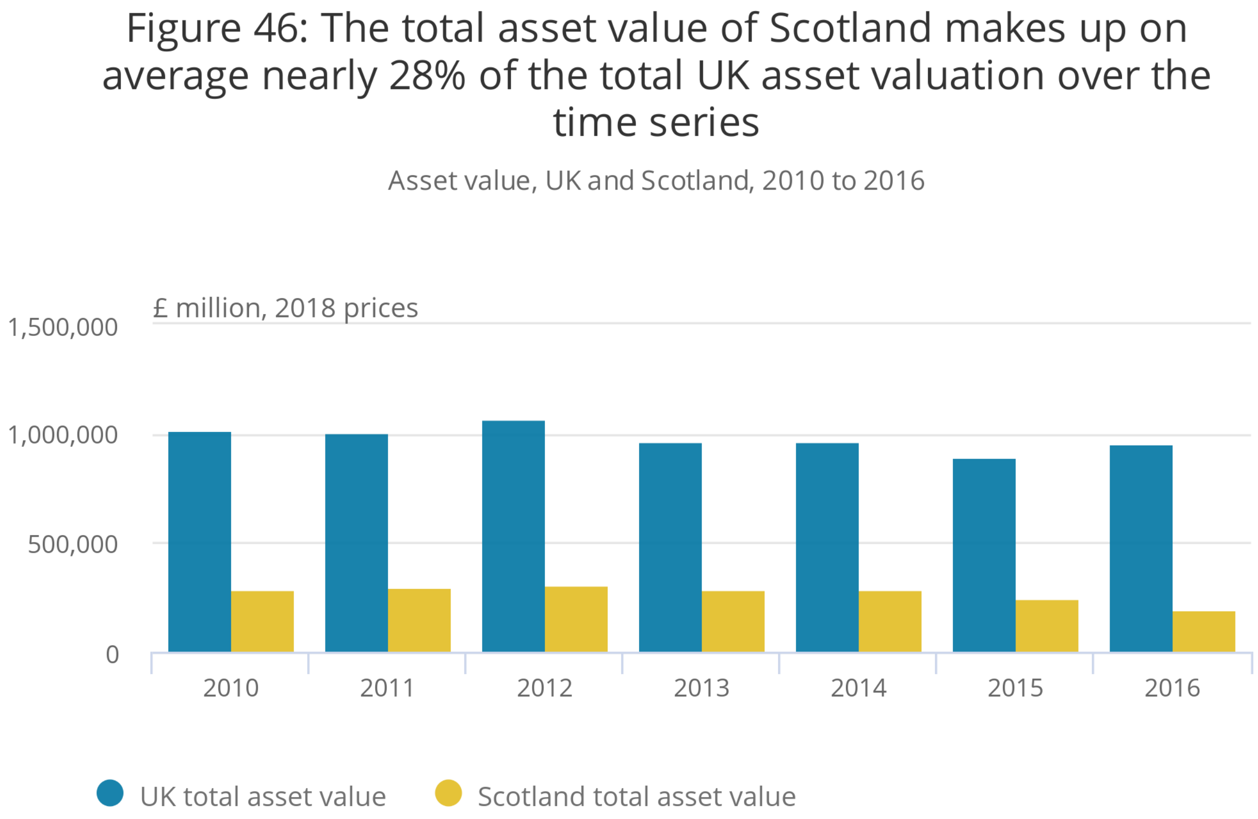
Notes:

1. Noise mitigation asset value for 2017 is included.

Between 2010 and 2016, the valuation of Scottish natural capital assets has made up on average 28% of the total UK assets of natural capital, mainly because of the large contribution of Scotland's fossil fuel production. However, because of the reduction in Scotland's fossil fuel asset valuation, the contribution of Scotland's natural capital declined to 20% of the UK total valuation in 2016.

Figure 46: The total asset value of Scotland makes up on average nearly 28% of the total UK asset valuation over the time series

Asset value, UK and Scotland, 2010 to 2016



Source: Office for National Statistics

Notes:

1. The value for noise mitigation in 2017 is included in 2016.

9 . Quality and methodology

The methodology used to develop these estimates remains under development; the estimates follow those reported in UK natural capital accounts: 2019. The estimates presented are experimental and should be interpreted in this context.

Experimental Statistics are those that are in the testing phase, are not yet fully developed and have not been submitted for assessment to the UK Statistics Authority. 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 article describes the methodology used to develop natural capital ecosystem service accounts. The broad approach to valuation and the overarching assumptions made are explained in this article. This is followed by a more detailed description of the specific methodologies 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 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.

An alternative appraisal of Scottish natural capital is available through Scottish Natural Heritage's Natural Capital Asset Index (NCAI). The NCAI is a composite index, which analyses nature's potential contribution to the well-being of Scotland's citizens.

We welcome discussion regarding any of the approaches presented.

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, renewable, and electricity generation a "residual value" resource rent approach is used. Before detailed data source and methodology is described, the resource rent approach is defined.

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 12. 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 12: Derivation of resource rent

Output	
Less	Operating costs
	Intermediate consumption
	Compensation of employees
	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 2016). 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 107) (PDF, 2.9MB) acknowledges that the use of the method may result in very 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 in 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

An important factor in the valuation of natural capital is determining the expected pattern of future flows of services. These paths are not observed and hence 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 an important component in the NPV model because it determines the expected term over which the service flows from an asset should be discounted.

Following the ONS and Defra principles 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 (2003, page 100). 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 paper.

Methodology by service

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

There have been significant methodological improvements from the previous Scottish natural capital accounts: 2019 so results should not be compared across accounts. Please use the data available **(unanswered query) in this** alongside this release for time series analysis. The scale of these changes varies across different ecosystem services. Table 13 provides a broad explanatory summary of these changes and the impact they have on service valuations.

Table 13: Percentage change in 2015 asset values by service because of methodological changes between 2019 and 2020 accounts
£ million (2018 prices), Scotland

Service	Value change	Percentage change	Explanation
Provisioning			
Agriculture	907	7%	Updated capital stocks data.
Fish capture	51	-2%	Switch to net profit per tonne from industry level resource rent. The switch to a bottom up valuation approach avoids disconnects between the coverage of fish capture from Scottish waters and the industry level data. For future development, the linkage between the valuation and flow may also allow integration of asset condition measures which enables sustainability to be considered in the valuation.
Fossil fuels	12,827	-8%	Improved oil and gas price data, updated operating cost expenditure data, updated capital stocks data, additional cost of coal industry resource rent.
Minerals	308	32%	Updated supply and use data and updated capital stocks data.
Timber	971	24%	Improved projection of pattern of expected future flows. The inclusion of Forest Research long term timber forecasts allows for improved estimates of the service provided over the lifetime of the asset.
Water abstraction	465	-14%	Updated capital stocks data, updated supply and use data, switch to intermediate use from gross operating surplus when apportioning UK capital stocks data. Relative intermediate use is more likely to align with net capital stock and consumption of fixed capital data.
Renewables	20,457	-90%	Switch to industry resource rent residual value from gross value added. Gross value added is likely to overestimate the service provided by natural capital as not all costs have been considered. In line with the principles of natural capital accounting and guidance from the UN System of Environmental–Economic Accounting, in the first instance, resource rent approaches should be used for valuing provisioning services.
Regulating			
Carbon sequestration	4,892	-11%	Updated greenhouse gas inventory data.
Air pollutant removal	200	10%	Updated damage cost estimates.
Urban cooling	-	-	New service.
Noise mitigation	-	-	New service.
Cultural			
Recreation	17,060	-41%	Improved estimates of cost sharing between the number of adults per vehicle on a visit. Previous Scottish expenditure estimations likely overestimated average vehicle running cost per adult for outdoor recreation trips. This was because the cost calculated from respondent distance travelled data was not divided by the estimated number of adults on the visit.
Recreation (house prices)	-	-	New service.
Aesthetic (house prices)	-	-	New service.
Total	53,366	-18%	

Source: Office for National Statistics

These experimental accounts are being continually revised to produce the best statistics with the available data and methods. Outlined in Table 14 are the ideas we have for future development, which will affect the overall numbers.

Table 14: Potential methodological changes in future accounts

Service	Potential future changes
Provisioning	
Agriculture	The price basis is likely to switch to either land rent or farm business income estimates. Either would reduce the total value of agriculture.
Fish capture	Net profit per tonne estimates cannot be used to estimate future income as effort per tonne captured is fixed. We hope to start by moving towards estimating income and cost separately which may have a minor impact on the overall value. Longer term we hope to estimate asset values using bioeconomic modelling of expected future fish production.
Fossil fuels	No planned change.
Minerals	No planned change.
Timber	No planned change.
Water abstraction	Long term we hope to net off the costs of any water restrictions to society from overall industry income.
Renewables	The Resource Rent approach is not appropriate for this service long term. We aim to use data on subsidies and levilised costs of operation to estimate the overall income for the renewables providers. The direction of the change is uncertain.
Regulating	
Carbon sequestration	Currently no changes are planned but if sequestration moved from a gross to a net sequestration basis the value would fall.
Air pollutant removal	We hope to update the models and data to provide more accurate and timely values. Direction of the change would be uncertain but it is unlikely to be large.
Urban cooling	Longer term it is desirable to use remote sensing temperature data to ground truth our estimates of 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.
Cultural	
Recreation	There are unlikely to be any significant methodology changes in the basic travel cost work. However we do hope to start including tourism spend estimates in excess of short day trips. This may significantly increase the value of recreation.
Recreation (house prices)	The original data source for advertised house prices is no longer readily available. We will therefore 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 is 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.

Source: Office for National Statistics

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 very 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 (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.

A whole farm income method was also produced, representing a farm output-level estimate of the industry residual value. Average whole farm income per hectare was calculated from the Farm Business Survey (Scotland). This is calculated as Output from agriculture (excluding subsidies and agri-environment payments) minus Costs for agriculture (excluding agri-environment activities), then divided by total farm area. For total whole farm income, whole farm income per hectare is multiplied by Scottish sole right agricultural area.

Theoretically, by aggregating data from farm-level outputs up, a whole farm income approach could be applied at any geography. A whole farm income approach has the potential to create data linkages with condition indicators. This would allow improved valuation of the service flows and bring them onto a consistent basis with the valuation of other provisioning services. The responsiveness of a whole farm income does result in significant fluctuations in the service valuation (shown in Figure 4), as outputs and costs are influenced by local and global external factors.

On a comparable basis, a farm rental approach was also examined. Total farm rental was estimating by applying an imputed rental cost to all agricultural land. Average rent per hectare for full tenancies, including crofts, from the Scottish agricultural survey were multiplied by Scottish sole right agricultural area.

In practice farm rental represents a more stable annual valuation of the natural asset, with future low-level disaggregation potential, which could be linked with indicators of condition. However, further work is needed to consider if rental prices are materially inflated by tax breaks or development potential.

Fish capture

Physical data on marine fish capture (live weight) are 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.

Valuations are calculated using net profit per tonne (landed) estimates, provided by Seafish, for different marine species. Net profit per tonne is calculated using Seafish economic estimates for fleet segments and 2013 to 2014 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. These data are aggregated for overall annual valuations of fish provisioning from the Scottish 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.

An important limitation of the fish capture provisioning valuation methodology is that landed weight net profits were 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 not all the physical flow is valued. Based on available net profit per tonne annual data, 95% of fish provisioning (live tonnes) was valued in 2015. In 2016, 93% of fish provisioning was valued.

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 used 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 (m3) overbark standing, using a conversion factor of 1.222 for softwood and 1.111 for hardwood.

The stumpage price is the price paid per standing tree, including the bark and before felling, from a given land area. Stumpage prices are sourced from the Forestry Commission Coniferous Standing Sales Price Index in the Timber Price Indices publication (2018). 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 was 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 extraction after 2014 is 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.

Monetary estimates are based on the “residual value” resource rent approach calculated from the SIC subdivision class: other mining and quarrying (SIC 08). 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 was 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 was 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 utilises 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 were 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 saltmarsh. Furthermore, peatlands are only partially covered. The Centre for Ecology and Hydrology estimates that damaged peatland in Scotland emitted 9.3 million tonnes of CO_2 equivalent. This nearly completely negated the gross terrestrial sequestration of Scotland reported in the Greenhouse Gas Inventory (GGI).

The carbon sequestration data come 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.

The LULUCF sector breakdown identifies net carbon sequestration activities in the following subcategories:

- forest land remaining forest land
- land converted to forest land
- grassland remaining grassland
- land converted to grassland
- cropland remaining cropland
- land converted to cropland
- wetlands remaining wetlands
- land converted to wetlands

For the years 1990 to 2017, estimates of Scottish carbon sequestration are sourced from the Greenhouse Gas Inventory. In the asset valuation, projections of carbon sequestration are provided for the years 2017 to 2050 using the central values. This is produced by the National Atmospheric Emission Inventory (NAEI) in the LULUCF emission projections. For years used in the projections beyond 2050, the carbon sequestration rate is assumed to be constant as at 2050 levels.

To work out 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 the Data table 3 of the Green Book supplementary guidance. Carbon prices are available from 2010 to 2100. Prices beyond 2100 are constant at 2100 levels.

The non-traded carbon prices are used in appraising policies influencing emissions in sectors not covered by the EU Emissions Trading System (ETS) (the non-traded sector). This is based on estimates of the marginal abatement cost (MAC) required to meet a specific emission reduction target. Beyond 2030, with the (expected) development of a more comprehensive global carbon market, the traded and non-traded prices of carbon are assumed to converge into a single traded price of carbon.

Air pollution removal by vegetation

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

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 (NO2))
- deaths (short-term exposure effects from ozone (O3))

The damage costs were updated in February 2019. For a method of how the damage costs are calculated (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 methodology report published by Defra.

Urban cooling

A brief overview of the methodology of urban cooling will be provided here but for 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 take into account 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 and 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 directly based on avoided losses in economic output and expenditure. Welfare values would be included if the valuation covered the non-market benefits to the general public of urban cooling, for example, the value of tree shading. In principle, some of these non-market benefits may be captured within the recreational account, to the extent that the cooling and shading features of green and blue space generate more recreational visits to such sites on hot days.

Additionally, avoided air conditioning energy costs are based on estimates in London and extrapolated to other city regions. To extrapolate to other city regions, data on the relative air-conditioned office space and percentage green space in other regions are used. This figure is more tentative. The value of the service will fluctuate year to year reflecting the number of hot days (defined as over 28 degrees Celsius) experienced.

The 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. The assessment of 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, adoption of 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. The questions used from these surveys can be broadly summarised as:

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

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 upon a different sample – those answering a question on habitats visited.

Table 15: Scottish recreation broad habitat classifications

Broad habitat	Scotland survey habitats
Built up areas and gardens	Village
	Local park or open space
	Towns
	Golf course/football stadium
	Local urban
	Local area
	City
	Country lanes
	Castle/historical building
	Garden/gardening
	Local show/festival
	Leisure/sports centre
	Streets/roads
Coastal margins	Sea/sea loch
	Beach/cliff
	Beach
	Cliff
	Wildlife area
Woodland	Woodland/forest - managed by Forestry Commission/Forest Enterprise
	Woodland/forest - other type of owner
	Woodland/forest - don't know owner
	Wildlife area
Farmland	Farmland - fields with crops
	Farmland - fields with livestock
	Farmland - mixed crops and livestock
	Wildlife area
	Farmland unspecified
	Country/countryside
Mountain, moorland and hill	Mountain/moorland
	Mountain/hill
	Moorland
	Wildlife area
Freshwater	Loch
	River/canal
	River
	Canal
	Wildlife area

	Reservoir
Other	Others
	None of these
	Don't 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 and aesthetic value in house prices

There is 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. There are two significant differences for consideration 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 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 selling price.