

An aerial view of a city street, likely in Manchester, showing a mix of historic and modern architecture. In the foreground, there's a large, ornate brick building with many arched windows. Behind it, several modern high-rise buildings are visible, including one with a distinctive cantilevered top. The sky is blue with scattered white clouds. A semi-transparent white box with a teal and green border is overlaid on the middle of the image, containing the title and authors.

Research to develop indicators that monitor adaptation: APR25

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ACRONYMS AND ABBREVIATIONS

ADAS	Not an acronym, but the name of the organisation
AES	Agri Environment Schemes
APR25	Adaptation Progress Report 2025
CCC	Climate Change Committee
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CS	Countryside Stewardship
EFFIS	European Forest Fire Information System
ES	Environmental Stewardship
FC	Forestry Commission
Ha	Hectares
JRC	Joint Research Centre
LIDAR	Light Detection and Ranging
MCM	Multi-Coloured Manual
MMO	Marine Management Organisation
MTC	Marine Temperature of the Catch
ONS	Office for National Statistics
OS	Ordnance Survey
RoFRS	Risk of Flooding from Rivers and Sea
RoFSW	Risk of Flooding from Surface Water
RPA	Rural Payments Agency
SFI	Sustainable Farming Incentive
UK	United Kingdom
UKCEH	UK Centre of Ecology and Hydrology

1 INTRODUCTION

1.1 Background

The Climate Change Committee (CCC) are mandated under the Climate Change Act (2008)¹ to report to Parliament every two years on progress in adapting to climate change in England. To support this assessment, the CCC use a set of metrics and indicators to assess and track changes in climate change risks and adaptation, whereby observed changes are monitored through time (using key data and information) across core components of adaptation .

To inform the CCC's report to Parliament on progress in adapting to climate change 2025 (APR25), several metrics and indicators that inform the basis of the assessment required updating.

1.2 Research purpose

This research reviews a subset of the CCC's full indicator set. The subset of indicators updated in this study were identified by the CCC. ADAS were not involved with the selection of indicators chosen. It is recognised that there may be alternative indicators that could also be suitable to demonstrate progress in adaptation. However, these were not considered within the scope of this project.

The subset of indicators assessed by ADAS in this project provides supporting evidence to inform current understanding of adaptation progress being made in England. It is expected that these indicators will be used by the CCC, alongside other indicators within the full indicator set, to inform the APR25.

The purpose of this research is not to provide a comprehensive or representative overview of adaptation progress in England, rather it is intended to provide updated indicators (within the context of climate resilience) to inform the CCC's current evidence base.

1.3 Approach

An initial feasibility study was undertaken to identify data availability for a wide range of potential indicators that could support in monitoring progress in climate adaptation. This analysis was provided to the CCC as a separate output and is not included within this report.

Nine indicators of climate-related risk and action were evaluated and summarised in this report. These indicators cover a range of sectors, including the built environment, infrastructure, and the natural environment (including agriculture, forestry, and fisheries). The data and information obtained came through a range of sources through consultation with stakeholders and industry representatives, as well as web-based searches.

For each indicator, a high-level description is provided, along with reference to the indicator type (as categorised under the CCC's assessment criteria).

Where robust datasets were available, with suitable indicators to demonstrate change over time, indicators were updated or developed to provide trends. Trends were then used to indicate progress in adapting to climate change. For each indicator, we provide detail on the data sources and methods

¹ Climate Change Act (2008). Available at: <https://www.legislation.gov.uk/ukpga/2008/27/contents> [Accessed 17 Feb. 2023]

used, outline the trends and implications for climate resilience, and assess the robustness of the indicator as a measure of assessing climate-related risks and actions.

For some indicators, where data was limited or sufficient time series were not available, partial datasets, industry insight, ad hoc data, grey literature, maps etc. were used instead.

1.4 Scope and interpretation of climate

The project scope was for England for devolved policy and the UK for reserved policy. However, for some indicators and evidence bases, disaggregated data was not available. In these instances, the data represented may be consolidated, such as where data is for England and Wales, or the UK, for example.

In this study we provide analysis of the available data and information. It is noted that these indicators are not purely climate driven or may have limited sensitivity to climate change. Subsequently, indicators are proxies and should be interpreted with caution and not used in isolation or out of context.

2 INDICATORS

The indicators in this section of the report were updated or developed as part of this study.

2.1 Area of impermeable surfacing in urban areas

Description: *Area of impermeable surfacing in urban areas*

Type: *Vulnerability*

Time Series: *2001 to 2024*

Region: *England*

2.1.1 Introduction

This indicator was last updated by ADAS (2023). The indicator provides the relative proportions of manmade and semi-natural surfaces in the urban environment, in England, between 2001 and 2024. This update provides new data and analysis for 2024.

2.1.2 Data source and method

The 'Topography' layer of Ordnance Survey's (OS) MasterMap product records the 'make' (i.e. surface material) of each land parcel as natural, manmade, multiple, unclassified or unknown. This information can be used as a proxy to indicate the porosity of land cover, which is noted as a useful attribute in applications such as in calculating surface run-off from rainfall (OS, 2010).

The surface materials are defined as:

- Natural (features that are not man-made but possibly man altered, for example, cliffs, areas of water and uncultivated/cultivated vegetation).
- Manmade (features that have been constructed, for example, areas of tarmac or concrete).
- Multiple (features that are a mixture of makes but are not depicted separately within the data, for example, the area around a dwelling may be a mixture of made and unmade surfaces).
- Unclassified (features that have not had a make allocated).
- Unknown (features the make of which is not known).

The area categorised as "Manmade" is assumed to be impermeable (e.g. buildings and structures) (OS, 2023). The "Multiple" category uses properties as a proxy for number of domestic gardens, which is assumed to be a mixture of permeable and impermeable surfaces (OS, 2023).

A methodology was developed by HR Wallingford (2012) to estimate the permeable fraction of the 'multiple' category, which uses analysis of housing density and urban creep factors, based on research of urban creep (Duckworth, 2005 in HR Wallingford, 2012). See HR Wallingford (2012) Appendix 2 for full detail. The assumption is that estimated urban creep rates could be applied to the areas within the 'multiple' category, to estimate the change in the proportion of the 'multiple' land use layer between time periods, to then determine the potential likely increase in intra-urban impermeable areas. The same method has been used for this indicator update.

Data was sourced from HR Wallingford (2012) for 2001, 2008 and 2011 data, and ADAS (2023) for 2016, 2018, 2020 and 2022 data. 2024 data was new analysis as part of this research using the most up-to-date OS MasterMap (2024) and AddressBase Plus (2024) datasets as well as additional

AddressBase property types (e.g., places of worship, garages and dual use residential properties) that were not used in previous analyses.

The focus of the assessment is on urban areas only (i.e. excluding rural villages and isolated dwellings etc.). To define the urban (built-up) area, up-to-date OS AddressBase Plus data was used to calculate the property density per 1km grid cell. Two methods were used to define the urban area:

- **Method 1:** Uses the method first developed by HR Wallingford (2012) that uses a property density of >500 properties per 1km cell to identify the urban area. This method is comparable to previous impermeable surface calculations dating back to 2001 (e.g. HR Wallingford , 2022; ADAS, 2023).
- **Method 2:** An improved method to include larger areas of greenspace within cities and towns, which are not captured in method 1. This improved approach takes account of the values of the neighbouring cells by taking an average of the central cell and its surrounding eight cells. This smooths the values, better defines the edge of urban areas and accounts for city centre greenspace. The original mask using > 500 properties per 1km cell was added to the revised mask to ensure inclusion of smaller settlements that would be missed by the revised method.

The methods for both approaches are comparable to previous impermeable surface area calculations carried out (ADAS, 2017; 2019; 2021; 2023). See ADAS (2021) for the full method.

Using the urban area as the focus, an assessment was then made of the manmade, natural and multiple (impermeable and permeable) fraction to assess urban creep.

2.1.3 Trends and implications for climate resilience

The area of built-up areas covered by impermeable surfaces is outlined for both methods of urban area calculation.

Method 1

The area of impermeable surfaces in urban areas is shown in Table 1 and Figure 1 for the current analysis (2024), alongside previous updates of this indicator in 2001, 2008 and 2011 (HR Wallingford, 2012), and 2016, 2018, 2020 and 2022 (ADAS, 2023).

The total impermeable area (manmade and multiple (impermeable)) has increased by 169,000 hectares (ha), from 477,000 ha in 2001 to 646,000 ha in 2024. The impermeable fraction of the total urban area has increased from 37% in 2001 to 46% in 2022 and remains at this fraction in 2024.

Table 1. Area (in thousand ha) of built-up urban areas covered by impermeable surfaces as estimated using OS MasterMap and using assumptions of urban creep (method 1). The multiple category represents domestic gardens, separated into multiple (permeable) and multiple (impermeable). Data sourced from HR Wallingford (2012) for 2001, 2008 and 2011 data, and ADAS (2023) for 2016, 2018, 2020 and 2022 data. 2024 data is new analysis as part of this study. Source: ADAS for the CCC.

Thousand ha	2001	2008	2011	2016	2018	2020	2022	2024
Manmade	384	398	401	429	451	461	468	466
Multiple (impermeable)	94	142	163	160	170	160	177	180
Total impermeable area	477	540	565	589	621	621	645	646
Total urban area	1298	1297	1296	1332	1383	1383	1396	1395
Impermeable fraction (%)	0.37	0.42	0.44	0.44	0.45	0.45	0.46	0.46

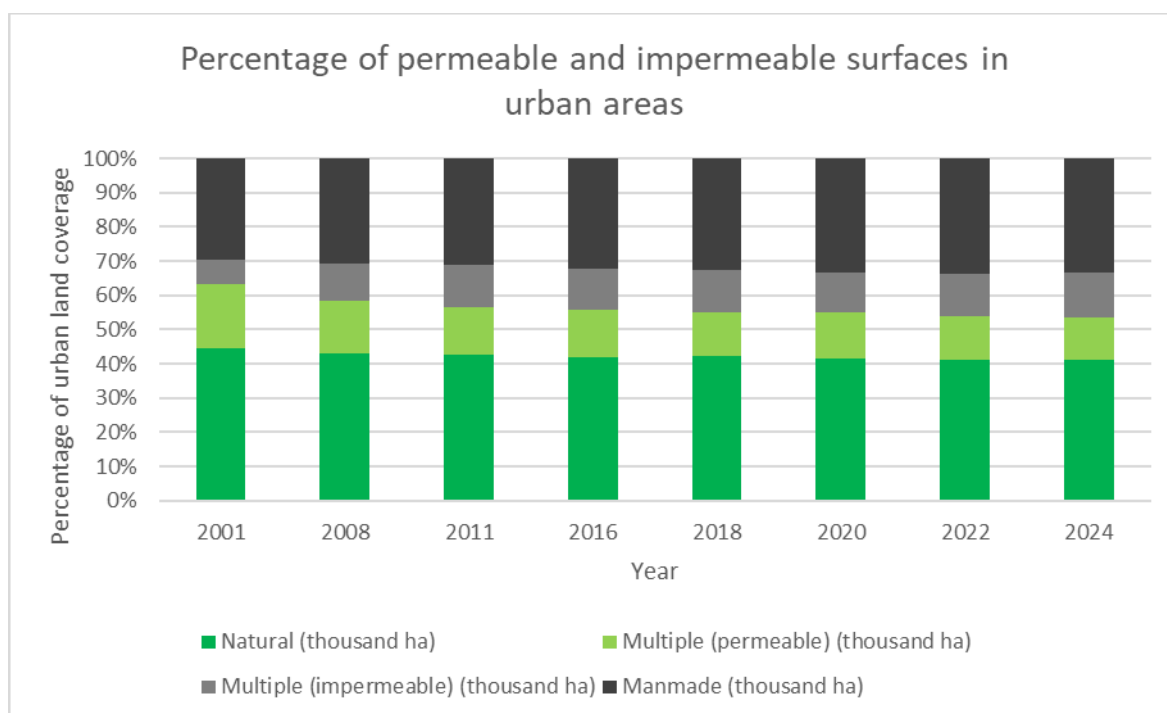


Figure 1. Changes in the proportion of permeable and impermeable surfaces in built-up urban areas (defined using method 1). The multiple category represents domestic gardens, separated into multiple (permeable) and multiple (impermeable). Data sourced from HR Wallingford (2012) for 2001, 2008 and 2011 data, and ADAS (2023) for 2016, 2018, 2020 and 2022 data. 2024 data was new analysis as part of this study. Source: ADAS for the CCC.

Method 2

Area of impermeable surfaces is shown for the current analysis (2024) and previous analyses of this indicator – updated using Method 2, which includes estimation of urban creep. Results are shown in Table 2 and Figure 2, outlining the area covered by each land surface type (ha).

Table 2. Area of built-up urban areas covered by impermeable surfaces as estimated using OS MasterMap and using assumptions of urban creep (method 2). Data sourced from ADAS (2023) for 2016, 2018, 2020 and 2022 data. 2024 data is new analysis as part of this project. Source: ADAS for the CCC.

Thousand ha	2016	2018	2020	2022	2024
Manmade	498	509	520	532	524
Multiple (impermeable)	184	180	170	188	194
Total impermeable area	682	689	690	720	718
Total urban area	1772	1730	1720	1778	1732
Impermeable fraction	0.38	0.40	0.40	0.41	0.41

As with the first method, the overall impermeable fraction of the total urban area has continued to increase, from 38% in 2016 to 41% in 2022 and remaining at 41% to 2024. The impermeable fraction is lower in all years compared to Method 1 due to the inclusion of more urban greenspace (i.e. additional grid cells using method two that capture more urban fringe areas), which means the

method is slightly more sensitive to the types of green space expansion that might be found in and around urban areas.

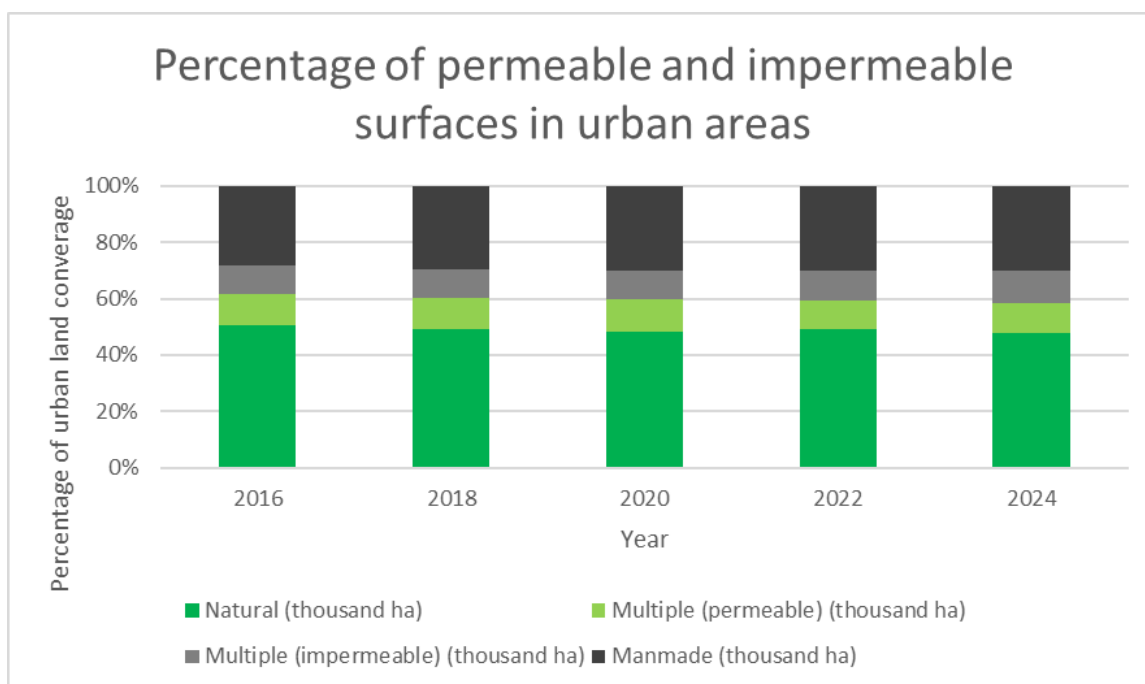


Figure 2. Changes in the proportion of permeable and impermeable surfaces in built-up urban areas in 2016, 2018, 2020, 2022 and 2024 (urban areas defined using method 2). Data sourced from ADAS (2023) for 2016, 2018, 2020 and 2022 data. 2024 data is new analysis as part of this project. Source: ADAS for the CCC.

2.1.4 Robustness of indicator

The indicator is designed to act as proxy record to indicate the extent permeable surfaces in urban areas, and therefore the potential for natural drainage. The underlying mapping used to represent impermeable surfaces (which uses OS MasterMap) is considered to be robust; OS is Great Britain’s national mapping agency, which carries out the official surveying of GB, providing the most accurate and up-to-date geographic data, relied on by government, business and individuals (GOV.UK, Not Dated).

However, an estimate had to be made of the impermeable fraction of the ‘Multiple’ surface type, using the findings from research into urban creep estimation (HR Wallingford, 2012). This may lead to under- or over-estimation of impermeable area (variable by geographic area and urban characteristics), but the data produced are still comparable over the time series, as the method is used consistently for all years of input data.

Different OS mapping products in different years have been used to estimate the number of properties. The Address point data used prior to 2016 was superseded by OS AddressBase. Furthermore, OS AddressBase Premium was used in 2018 while OS AddressBase Plus was used in 2020, 2022 and this analysis. The property data is used to identify housing densities which is subsequently used to define urban areas and density classes. Therefore, changes in the product used can impact on these calculations. Therefore, changes in the product used can impact on these calculations, and this is likely responsible for the reduction in urban area between 2022 and 2024 (Table 2 and Table 4).

Annual updates to OS AddressBase Plus data reflect changes in property configurations, such as subdivision into flats or amalgamation into larger units, leading to overlapping points at single XY

coordinates. Between 2020 and 2024, this reduced the classification of urban areas, as fewer grid cells met the threshold of >500 properties, potentially due to the removal of overlapping points from flat demolitions or similar developments. This was likely responsible for the decline in manmade and total urban area from 2022 to 2024 (Table 2).

2.2 Area of urban greenspace

Description: *Area of urban greenspace*

Type: *Vulnerability*

Time Series: *2001 to 2024*

Region: *England*

2.2.1 Introduction

This indicator was last updated by ADAS (2023). The indicator provides the relative proportions of semi-natural areas (greenspace) within towns and cities in England between 2001 and 2024. This update provides new data and analysis for 2024.

2.2.2 Data source and method

The method used was equivalent to that used for ‘the area of impermeable surfacing in urban areas’ (see section 2.1), except that the area of greenspace in urban areas was estimated from the area of the “Natural” material plus the permeable fraction of “Multiple”, to provide the total permeable area (‘urban greenspace’).

The ‘Topography’ layer of OS’s MasterMap product records the surface material of each land parcel as “Natural”, “Manmade” or “Multiple”. The area categorised as “Natural” is defined in MasterMap as features that are not man-made but possibly man altered, for example, cliffs, areas of water and uncultivated/cultivated vegetation. We have assumed that this category represents greenspace and semi-natural (i.e. permeable) areas. The “Multiple” category represents domestic gardens, which is assumed to be a mixture of permeable and impermeable surfaces. A methodology was developed by HR Wallingford (2012) to estimate the impermeable fraction of this category based on urban creep research under the assumption that estimated urban creep rates could be applied to these areas to determine the potential likely increase in intra-urban impermeable areas. The same method has been used for this indicator update. See section 2.1 and ADAS (2021) for the full method applied in this analysis.

Data was sourced from HR Wallingford (2012) for 2001, 2008 and 2011 data, and ADAS (2023) for 2016, 2018, 2020 and 2022 data. 2024 data is new analysis as part of this project.

2.2.3 Trends and implications for climate resilience

The area of built-up urban areas covered by permeable and/or natural surfaces (greenspace) is shown for both methods of urban area calculation.

Method 1

The area of permeable surfaces (greenspace) in urban areas is shown in Table 3 for the current analysis (2024), alongside previous updates of this indicator in 2001, 2008 and 2011 (HR Wallingford, 2012), and 2016, 2018, 2020 and 2022 (ADAS, 2023).

The total permeable area (natural and multiple (permeable)) has decreased by 72,000 ha, from 821,000 ha in 2001 to 749,000 ha in 2024. The permeable fraction of the total urban area decreased from 63% in 2001 to 54% in 2022 and remained at 54% to 2024. We are assuming all permeable area to be greenspace.

Table 3. Area of built-up areas covered by permeable surfaces (greenspace) as estimated using OS MasterMap and using assumptions of urban creep (Method 1). Data sourced from HR Wallingford (2012) for 2001, 2008 and 2011 data and ADAS (2023) for 2016, 2018, 2020 and 2022 data. 2024 data is new analysis as part of this project. Source: ADAS for the CCC.

Thousand ha	2001	2008	2011	2016	2018	2020	2022	2024
Natural	581	559	554	558	583	574	576	573
Multiple (permeable)	240	198	178	185	179	189	175	176
Total permeable area	821	757	732	743	762	763	751	749
Total urban area	1,298	1,297	1,296	1,332	1,383	1,383	1,396	1,395
Permeable fraction	0.63	0.58	0.56	0.56	0.55	0.55	0.54	0.54

See Figure 1 for a graph showing the percentage split between permeable and impermeable surfaces in the built-up urban area using Method 1.

Method 2

The area of permeable surfaces (greenspace) is shown for the current analysis (2024) and previous analyses of this indicator. Results are shown in Table 4.

Like Method 1, the overall permeable area fraction has remained consistent with 2022 at 59% of the total urban area in 2024. The permeable fraction is higher in all years compared to Method 1 due to the inclusion of more urban greenspace within the approach taken. Equally, the total urban area is higher in all years by ~500ha compared to Method 1, due to the inclusion of the urban fringe area in defining the urban areas in Method 2.

Table 4. Area of built-up areas covered by permeable surfaces (greenspace) as estimated using OS MasterMap and using assumptions of urban creep (Method 2). Data sourced from ADAS (2023) for 2016, 2018, 2020 and 2022 data. 2024 data is new analysis as part of this project. Source: ADAS for the CCC.

Thousand ha	2016	2018	2020	2022	2024
Natural	899	849	828	870	829
Multiple (permeable)	191	192	202	187	185
Total permeable area	1,090	1,041	1,030	1,058	1,015
Total urban area	1,772	1,730	1,720	1,778	1,732
Permeable fraction	0.62	0.60	0.60	0.59	0.59

See Figure 2 for a graph showing the percentage split between permeable and impermeable surfaces in the built-up urban area using Method 2.

2.2.4 Robustness of indicator

See section 2.1.4.

2.3 Weather impacts on Strategic Road Network

Description: *Annual number and length of delays to strategic road network caused by severe weather*

Type: *Realised impact*

Time Series: *2020 to 2024*

Region: *England*

2.3.1 Introduction

Severe weather, such as high temperatures, heavy rain and associated flooding, snow and ice, and strong wind can cause travel disruption to road networks. This can result in closures, delays and in some instances, severe and ongoing damage to critical infrastructure.

National Highways (formerly Highways England) are responsible for the operation, maintenance and improvement of England's motorways and major A roads.

This indicator looks at the annual number and length of delays to strategic roads caused by severe weather.

2.3.2 Data source and method

This indicator was last updated by ADAS (2019). Due to changes within the data recording, and the gap in the analysis being undertaken, a fresh analysis was undertaken within this research. The data was sourced directly from National Highways and gives a breakdown of the number of reported incidents by weather type, as well as region, month, and lane impact duration in minutes, for the period September 2016 through to October 2024. Weather categories included were flooding; heavy rain; snow, ice, and freezing rain; strong winds; and 'weather condition – other'.

National Highways' form for recording incidents has changed over time, most notably in September 2016 (when the process included transitioning to a new system whereby weather events are recorded within the sub code field, rather than in the final incident classification), and then again in June 2019 (when additional options in qualifier form fields were available). ADAS understands that this was when the new categories 'High Temperature' and 'Weather Type Not Recorded' were added, and thus these years are not directly comparable to later years.

Therefore, in this current analysis, we present data from 2020 to 2024 (covering a 5-year time span). Whilst it is recognised that the data excludes November and December 2024 and is therefore likely to be an underestimation of the total number of events and delay minutes within 2024, it presents a consistent and comparable time series.

The data should be used as a proxy indication to the types of weather event associated with road closures only, noting the caveats set out below:

- **Weather-related closures:** The data cannot be used to draw the conclusion that the lane closure was caused by severe weather. Only that a lane closure and severe weather occurred simultaneously. The cause of the lane closure may or may not have been connected to the severe weather that was recorded at the time.

- **Compliance:** Comparisons of data pre-June 2019 should not be made. Additional options in qualifier form fields were available from June 2019 onwards and so the dataset is not consistent prior to this.
- **Uncertainty:** These data are unlikely to cover all incidents on the strategic road network. They include incidents National Highways has been made aware of or had some involvement in.
- **Appropriateness:** National Highways ControlWorks data are recordings of operational events, typically describing a snapshot of the best information available at the time of an incident. Its purpose is not for robust analysis and as such is rarely updated after the incident.

2.3.3 Trends and implications for climate resilience

A total of 3,634 incidents were reported by National Highways between 1 January 2020 and 31 October 2024 that resulted in the carriageway closure, or total closure, of strategic roads linked to severe weather conditions being present at the time of the closure, shown in (Figure 3). Of these, 2,483 (68.3%) incidents were logged as occurring at the same time as flooding conditions; 158 (4.3%) heavy rain; 146 (4.0%) snow, ice and freezing rain; 102 (2.8%) strong winds; and 6 (0.2%) high temperatures. In a fifth of incidents, the weather type is not clear, being logged as either ‘weather condition - other’, 127 (3.5%), or weather type not specified, 612 (17%).

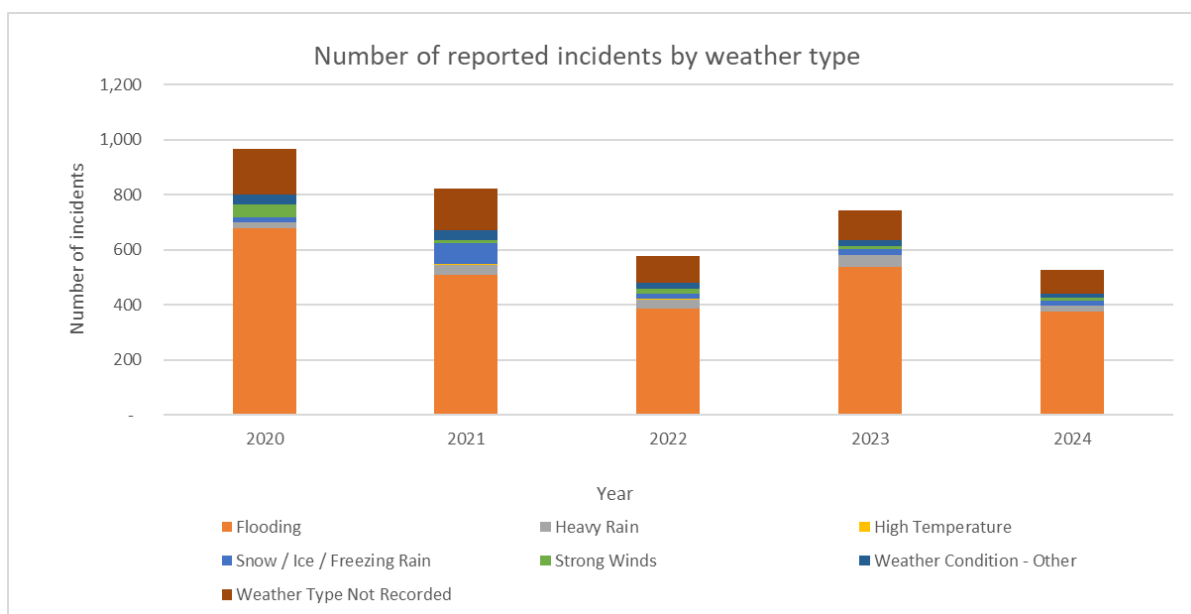


Figure 3. Number of reported incidents by weather type from 1 January 2020 to 31 October 2024, as recorded by National Highways. Source: ADAS for the CCC.

Figure 4 shows that the vast majority (1,173, 32.4%) of weather-related road closures that were logged occurred in the North West of England (1720 incidents). However, these differences do not necessarily indicate that some regions are more susceptible to severe weather-related road closures than others. Rather, it may simply reflect the number of main trunk roads in each region, among other reasons.

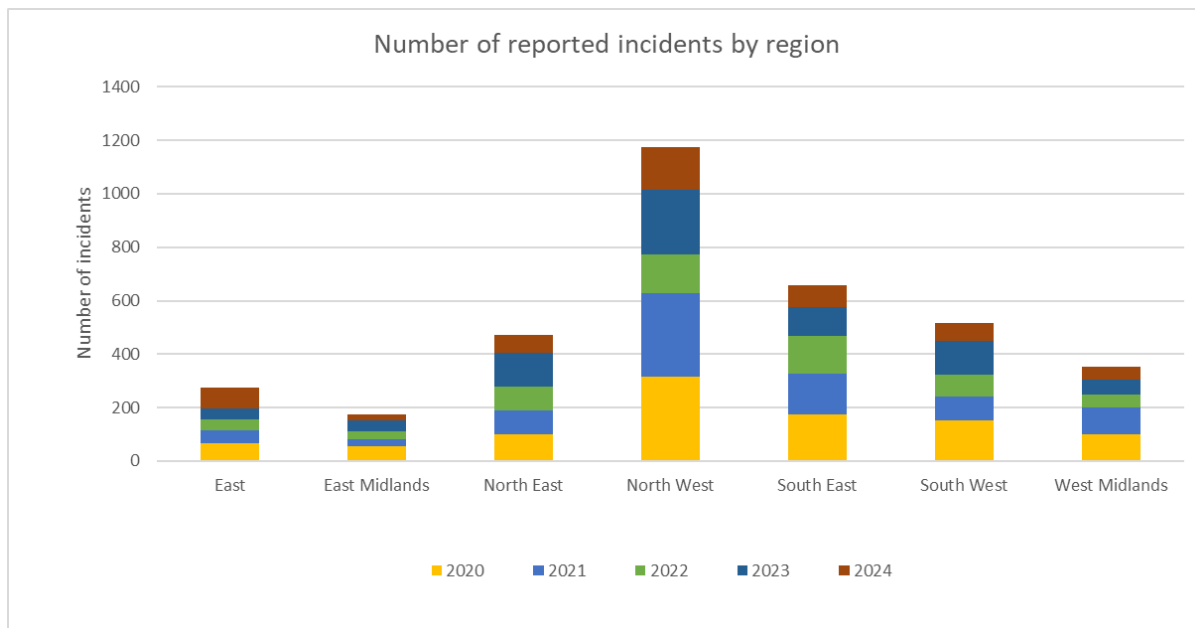


Figure 4. Number of reported incidents by region in England from 1 January 2020 to 31 October 2024, as recorded by National Highways. Source: ADAS for the CCC.

Figure 5 shows the total minutes of delay by weather type. The data indicates that 2020 and 2023 experienced the highest number of delay minutes. However, there are gaps in the data, with some logged incidents not having delay minutes provided. Therefore, the minutes illustrated are likely an underestimation overall.

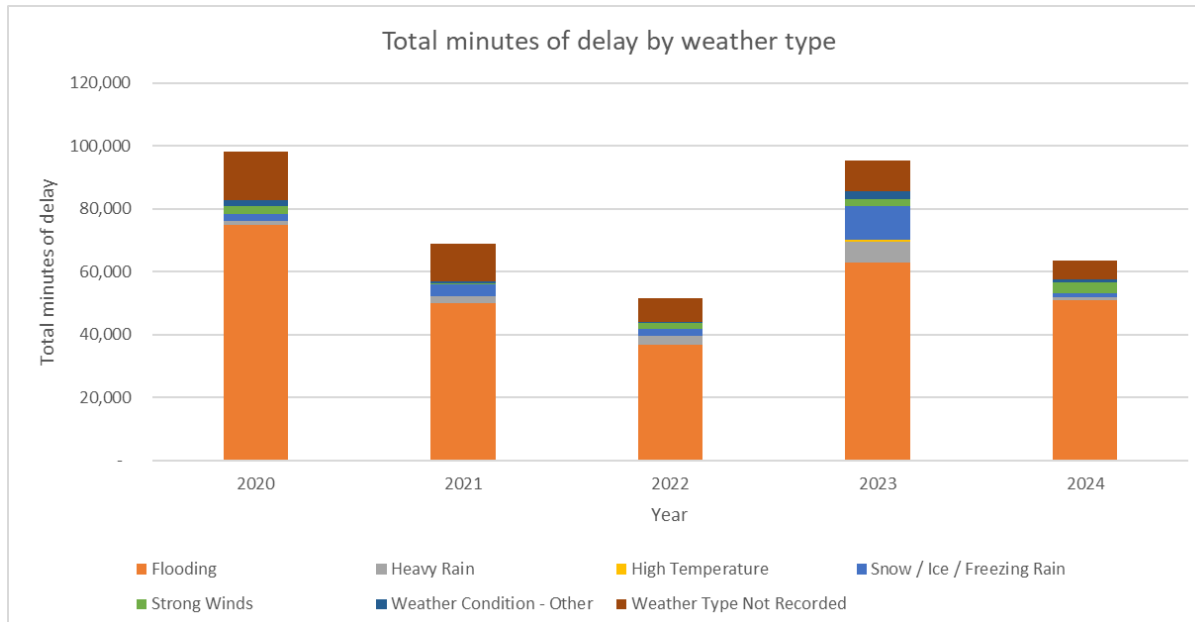


Figure 5. Total minutes of delay by weather type from 1 January 2020 to 31 October 2024, as recorded by National Highways. Source: ADAS for the CCC.

2.3.4 Robustness of indicator

Data pre-2020 was deemed to be non-comparable and therefore not presented in this analysis.

The data for 2020 to 2024 provides an indication into the number of road closures, and types of weather event that were observed at the time. Decision makers should be aware of the risks inherent in using the analysis, as outlined in the method. The data for 2024 is likely an underestimation as data was only provided for 1 January 2024 to 31 October 2024.

The dataset is not robust to conclusively illustrate whether one year, region, or weather type is inherently more prominent than another. This is because:

1. The data does not cover all road closures (only those logged);
2. Some logs only contain partial information (e.g. delay minutes are missing for some entries); and
3. The data cannot be used to draw the conclusion that the lane closure was caused by severe weather (only that a lane closure and severe weather occurred simultaneously and the cause of the lane closure may or may not have been connected to the severe weather that was recorded at the time).

2.4 Vineyards, area under vine, and volume of wine produced

Description: *Number of vineyards, area of vines planted, and volume of wine produced in England and Wales*

Type: *Realising Opportunity*

Time Series: *1989 to 2023*

Region: *England and Wales*

2.4.1 Introduction

This indicator was last updated by ADAS (2023). The indicator provides an assessment of the area of vines planted and volume of wine produced, in England and Wales, between 1989 and 2023, based on annual production data from the Wine Standards Branch of the Food Standards Agency. This update provides data for 2022 (replacing the estimates used in the previous update) and 2023. In addition, the number of active vineyards and wineries are included, covering the period 2011 to 2023.

2.4.2 Data source and method

Number of vineyards

Data on the number of vineyards was extracted from the English Wine website. The time series data used for this analysis was 2011 to 2023, providing information on the number of active vineyards and wineries in England and Wales. 2024 data was not available at the time of data extraction. Under European Union regulations, all vineyards of 0.10-ha or more (0.25-acres) have to be registered with the Wine Standards Branch of the Food Standards Agency who issue a Vineyard Register (English Wine, 2023).

Area under vine and volume of wine produced

Data on the area under vine and volume of wine produced for this analysis was sourced from English Wine, for the period 1994 to 2023. 2024 data was not available at the time of data extraction. These datasets are predominantly based on values supplied by the Wine Standards Branch of the Food Standards Agency. The Wine Standards Branch produce the official record of vintage production for DEFRA, based on annual harvest and production declarations provided to the Food Standards Agency from commercial vineyards. Data for 1989-93 has not been included in this analysis due to the Wine

Standards Branch figures including data from hobby vineyards and abandoned vineyards. Wine Standards Branch data for 1994 onwards includes the commercial area only and therefore provides a more consistent and representative time series. The commercial area is split between the area (ha) in production, and not in production.

The data for 2022 provides updated figures to the provisional estimates provided in ADAS (2023), and new data is provided for 2023.

2.4.3 Trends and implications for climate resilience

Number of vineyards

The number of active wine producing vineyards have been steadily increasing in England and Wales, rising to an estimated 1,030 vineyards in 2023 (WineGB, 2024a), up from 943 in 2022, shown in Figure 6. In addition, the number of wineries has also increased from 209 in 2022 to 221 in 2023 (WineGB, 2024b).

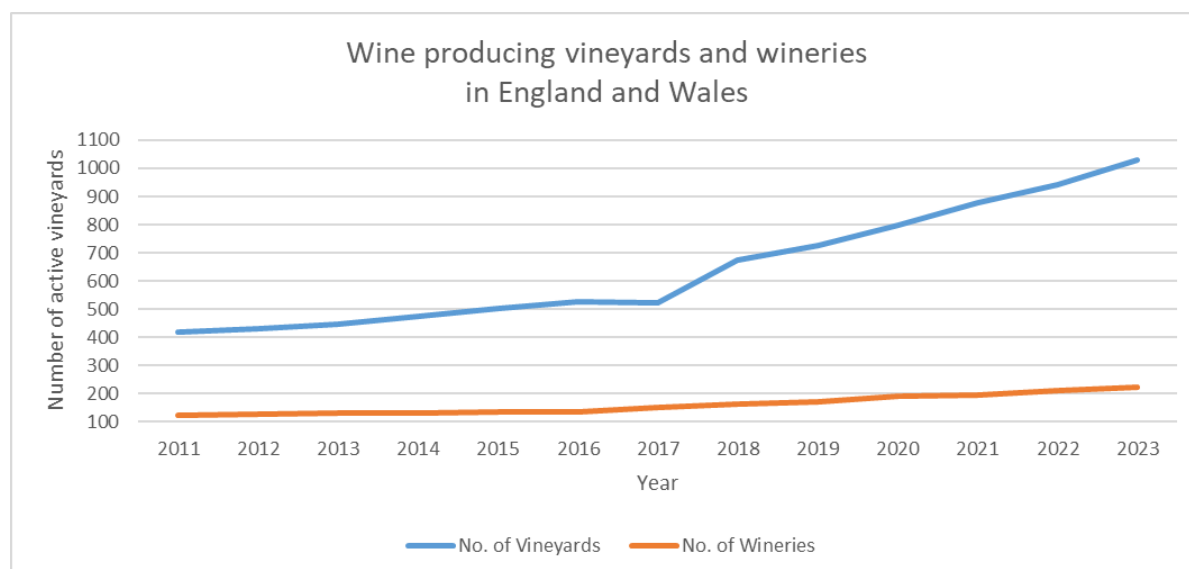


Figure 6. Number of wine producing vineyards and wineries in England and Wales from 2011 to 2023. Based on data from the Wine Standards Branch of the Food Standards Agency data, extracted from English Wine. Source: ADAS for the CCC.

Area under vine

The total commercial area under vine in England and Wales has almost tripled in the last decade from 1,384 ha in 2011, to 4,095 ha in 2023, shown in Figure 7. These values are for commercial vineyards only and exclude 'hobby vineyards' and 'abandoned vineyards', which in 2023 accounted for an estimated additional 116 ha collectively.

Approximately 89% (3,661 ha) of the total commercial area under vine in 2023 was in active production. Of the 11% of the planted area not in production, the majority is attributed to newly planted crops that have not yet been fully established, and thus not growing high quality fruit in the quantities required for active harvesting.

There is no indication in the datasets as to whether this increase in area is being driven by improving climatic conditions for the vines, or whether there are other economic reasons for the increase in

area. However, it anticipated that the climate is becoming more suitable for vine production and thus allowing the opportunity to be capitalised upon by growers interested in wine production.

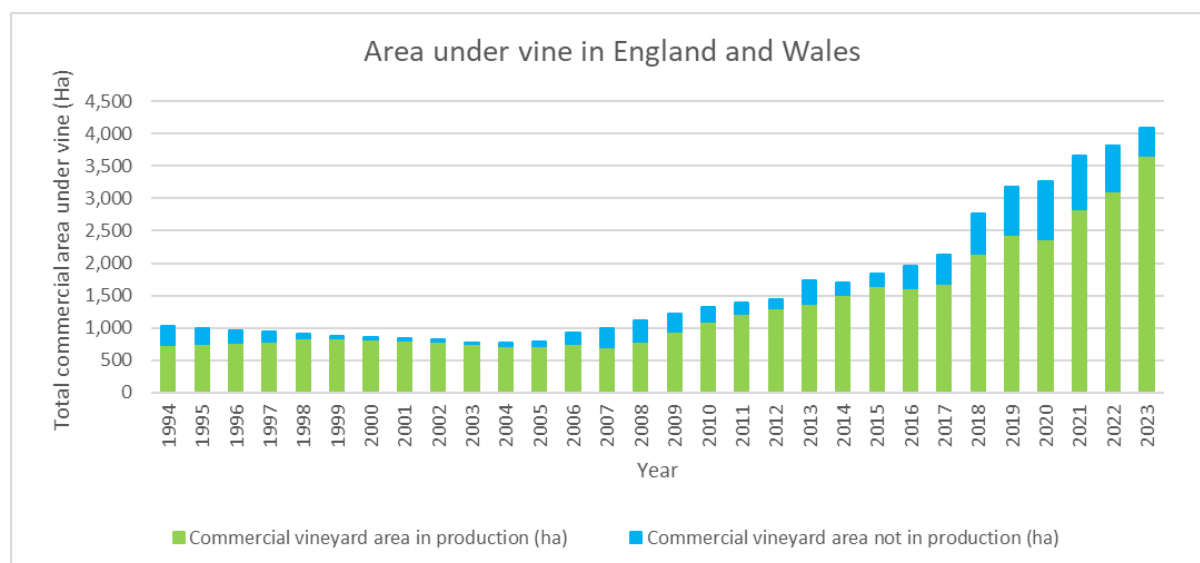


Figure 7. Total commercial area (ha) under vine each year, excluding 'hobby vineyards' or 'abandoned vineyards', split between area in production (green), and not in production (blue), for England and Wales from 1994 to 2023. Data sourced from English Wine, based on data supplied by the Wine Standards Branch of the Food Standards Agency for the period 1994-2023. Source: ADAS for the CCC.

Volume of wine produced

The total volume of wine produced each year (i.e., number of 75cl bottles produced) is shown in Figure 8. Despite the area in active production typically increasing year on year since 2004 (Figure 7) the volume of wine produced has been much more variable, with large peaks and troughs.

Years with relatively poor production volumes (taking into account increases in the total commercial area) include 2012 and 2016. Other years with relatively low yields include 2020. Potential reasons for these low volumes were outlined in ADAS (2023).

The latest analysis shows that 2023 was a record year in terms of wine production. Yields were the highest recorded in the UK, with 21.6 million 75cl bottles produced in 2023. This corresponds with the estimates of the Annual Harvest Report from WineGB, of between 20 and 22 million bottles produced (Skelton, 2023). This is a 60% increase on the previous record year for production, 2018. As in 2018, the 2023 growing season provided excellent weather conditions with low levels of spring frost, an extended period of hot weather through May and June enabling the vines to flower well. The yield was so great that several vineyards reported bunch thinning the crop to control yields (Skelton, 2023). Machine harvesting increased in 2023, with 13% of this year's vineyards machine harvested, compared to 6% in 2022 (Skelton, 2023).

Data for 2024 is not yet available. However, total wine production for 2024 across England and Wales was a small but good quality crop, projected to be between 6 and 7 million bottles (WineGB, 2024c). This is despite testing conditions, also experienced across Europe, the WineGB Harvest Yield Survey reveals (WineGB, 2024c).

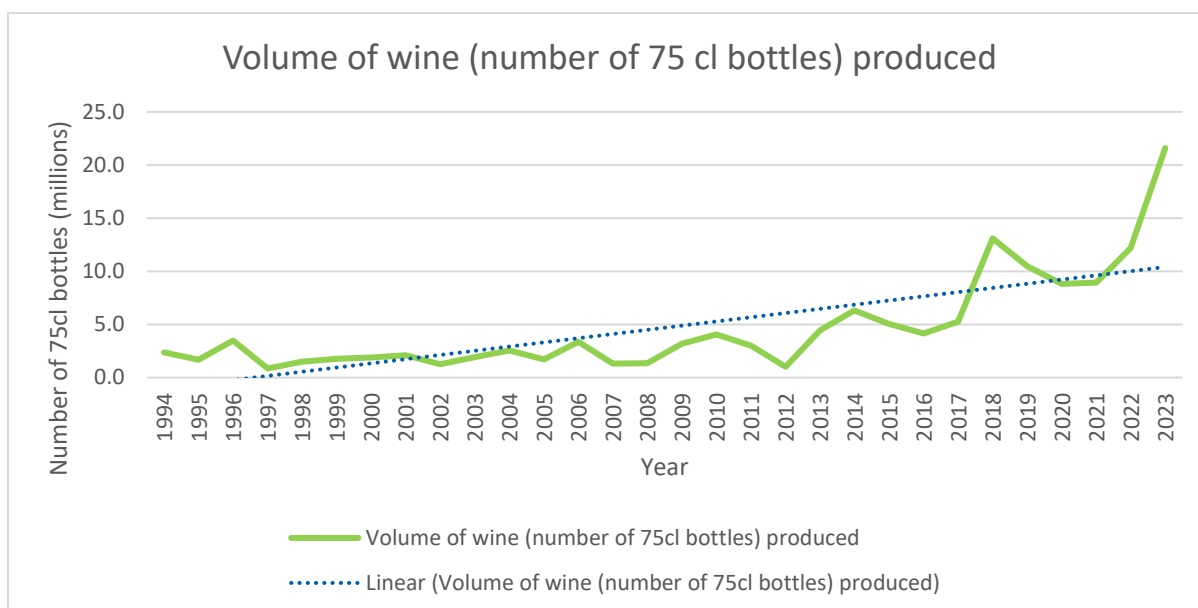


Figure 8. Wine production (millions of 75cl bottles produced) in the UK from 1994 to 2023. Data sourced from English Wine, based on data supplied by the Wine Standards Branch of the Food Standards Agency. Source: ADAS for the CCC.

2.4.4 Robustness of indicator

Number of vineyards

The vineyard register provides an indication of the number vineyards that are active. Unfortunately, owing to various factors, parts of the vineyard register are incomplete or estimated and cannot be relied upon to be 100% accurate (English Wine, 2023). However, the number of vineyards and direction of trend appears to be consistent with other industry reports, such as the Wines of Great Britain industry reports (WineGB, 2023).

Area under vine and volume of wine produced

The data sourced from English Wine, originally supplied by the Wine Standards Branch of the Food Standards Agency is considered to be fairly robust and consistent over the time series, providing a good indicator for the total area of commercial vineyards (both in and out of production), as well as robust estimations of the volume of wine produced. WineGB also hold a dataset, based on Wine Standards Branch data. Whilst there are some minor inconsistencies between the English Wine dataset and WineGB dataset, the majority of values match and any differences are considered to be materially insignificant to the larger trends shown.

The data for area under vine, area under production and yield for 2022 replace industry estimates used in the previous update of this indicator, providing more robust values for vineyard production for this period.

The original source of the Wine Standards Branch data comes from annual declarations on a survey, completed by commercial vineyard growers. It is anticipated that the Wine Standards Branch and/or English Wine or WineGB will continue to collect this data year-on-year, allowing for future updates of the indicator.

2.5 Mean Temperature of the Catch

Description: *Annual Mean Temperature of the Catch (fish and shellfish) for specified regions*

Type: *Realised impact*

Time Series: *1981 - 2023*

Region: *England and Wales combined and UK*

2.5.1 Introduction

Climate change is warming the oceans, affecting marine biological processes and the distribution of marine species globally (Simpson et al., 2011).

The Mean Temperature of the Catch (MTC) is an index that can be used as a signature of the impact of climate change on fisheries (Cheung et al., 2013). Globally, research has shown that the MTC has increased, suggesting increased catches of warm-water species and a decline in cold water species (Cheung et al., 2013). This indicator calculates the MTC for landings into the UK, to investigate changes in the fish and shellfish populations in UK territorial waters.

2.5.2 Data source and method

Multiple data sources inform this indicator, as outlined below.

UK Sea Fisheries Statistics (Marine Management Organisation, MMO) (2009 – 2024)

The MMO provide annual statistical reports on fish and shellfish landings into the UK, through the UK Sea Fisheries Statistics report (MMO, 2024). Data is available for the total amount landed and amount landed per species at the UK and four nation level (England, Scotland, Wales and Northern Ireland).

Historic Fisheries Statistics (National Archives) (1981 – 2011)

The National Archives (National Archives, n.d.) hold annual data on fish statistics from 1866 to 2011. Data from the National Archives has been used in this analysis for the years 1981 to 2008, as the MMO statistics provide data from 2009.

The data from 2004 onwards is available at the national level for England, Wales, Scotland and Northern Ireland. Prior to 2004 the data for England and Wales was aggregated. This data availability influenced the way the data has been cut in this indicator, hence why the analysis focuses on landings into England and Wales rather than individual nations.

AquaMaps (fish) and SeaLifeBase (shellfish)

AquaMaps (AquaMaps, n.d.) offers a database on aquatic species that uses a habitat suitability model to fit environmental variables to species. The data available includes the temperature preference by species. SeaLifeBase (SeaLifeBase, n.d.) is a database of biological and ecological information on non-fish marine organisms, which contains information on the temperature preference of non-fish species.

Data from the MMO of annual fish and shellfish landings and historic landings from the National Archives are combined to create the full timeseries of data. Information on the temperature preference for each fish and shellfish species is drawn from AquaMaps and SeaLifeBase respectively. Species temperature preference was calculated from the average of the 10th and 90th percentiles.

The MTC was calculated for each fish and shellfish species for each year of data, and for the whole catch for each year. This data was provided by experts at Cefas and checked by ADAS.

2.5.3 Trends and implications for climate resilience

There has been an increase in the MTC since 1981 (Figure 9). This indicates that fisheries are landing more fish and shellfish species with a warmer temperature preference than they have in previous years, where a greater number of cooler water species were landed. The data analysed is based on landings at UK ports, not catches at sea – some species may have been caught and discarded at sea. Therefore, the data used is simply a record of the species that arrive onshore and are actively targeted by UK fishing fleets, rather than a complete indication of changing fish stocks.

Comparison is made in Figure 9 between the trend in all landings in the UK and landings into just England and Wales. The long-term increase in the MTC is less pronounced for landings into England and Wales than landings into the UK, however, both show the same trend direction. UK fisheries landings are dominated by landings into Scotland, which is where most vessels catching pelagic fish, as well as cod and haddock land. There are far fewer landings into England and Wales which reduces the scale of change over time compared to the change in MTC for UK landings. In recent years, landings of finfish such as cod, haddock and plaice have decreased in England and Wales, and shellfish landings have increased.

The strength of the trend in both sets of data lessens after 2003. This is somewhat unexpected as scientific survey data from Cefas shows that warmer water species have continued to increase in abundance over the last 15 years whilst the abundance of cooler water species has declined (Cefas, 2025). Cefas (2025) suggest that fisheries have continued to target ‘traditional’ cooler water species rather than large-scale switching to alternative species. This is likely consumer and/or market driven to some extent. Quota restrictions and limited access rights may also have influenced the content of landings.

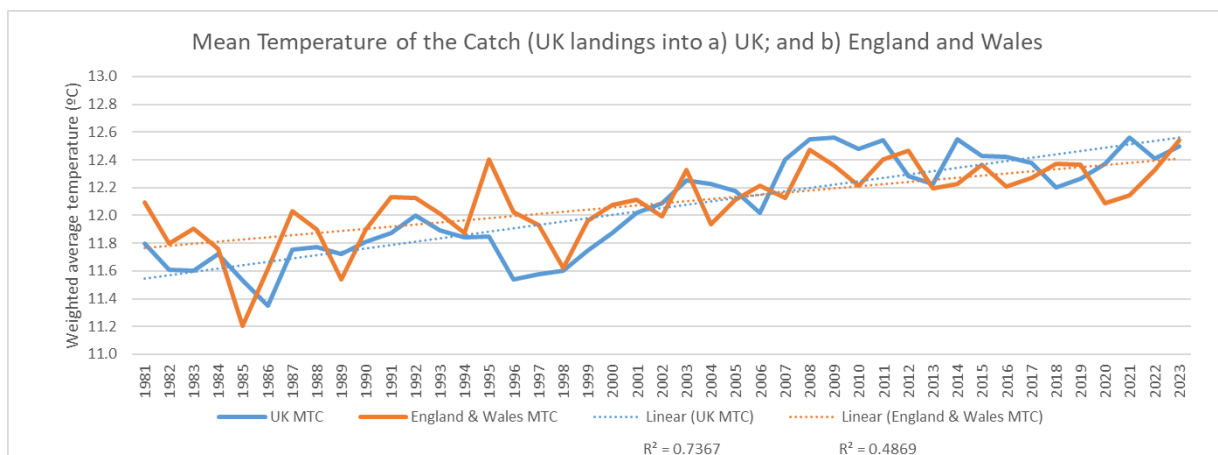


Figure 9. Mean Temperature of the Catch of UK landings into the UK (blue line) and into England & Wales (orange line) for 1981 to 2024. Source: Data sourced from MMO, National Archives, AquaMaps and SeaLifeFish with input from Cefas.

Changes in the location where UK fisheries operate will have had an impact on the MTC over the timeseries assessed. For example, it is thought that some of the cod and haddock landings in the early years of the timeseries may have been fish caught outside of the UK territorial waters (around Iceland and Norway) as there used to be a ‘distant water’ fleet based at Grimsby that was largely decommissioned during the 1990s through government decommissioning schemes (Cefas, 2025).

Cefas (2025) note that it is important to highlight that the attribution of these changes in MTC are not necessarily entirely climate driven. Changing ocean temperatures driven by climate change are largely agreed to be having an impact on the recruitment stage (early life) of warm or cold water species. However, other factors affecting landings data include the impacts of overfishing and habitat

degradation . Cod and haddock stocks boomed in the 1970s and 1980s but in following years were widely overfished. There are inherent difficulties in separating the influence of fishing pressure and environmental factors on fish stocks. Landings can also be affected by shifting consumer preferences and market demands. This may be a factor influencing the lessening trend in change in MTC post 2003.

2.5.4 Robustness of indicator

The data used is considered to be the best available (Cefas, 2025). However, a data quality concern was raised around the MMO landing statistics which delayed the release of the UK Sea Fisheries Statistics 2023 (MMO, 2024). The data for 2023 was the first MMO statistical publication after the voluntary and temporary suspension of the accredited Official Statistics designation. This voluntary removal by MMO of the accreditation was instigated by discrepancies found in 2024 in the UK Sea Fisheries Statistics, specifically in the landing data. Nonetheless, the MMO confirm that these statistics remain the best available data and continue to be considered a reliable measure of industry activity at a UK level. Prior to 2023, the data in the UK Sea Fisheries Statistics reports are accredited Official Statistics.

The National Archives note that whilst the historic data on landings were official statistics at time of release, care should be taken when comparing to more recently published material. The current analysis runs from 1981 to 2024, although records from the National Archives run back to 1866.

Data on the temperature preference for each species are considered to be from reliable sources, recommended by industry experts. AquaMaps uses global databases of ‘presence’ observations or occurrence data as well as environmental factors to fit a habitat suitability model to thousands of aquatic species. The data available from SealifeBase is derived from well-researched, reliable scientific sources.

2.6 Wildfire incidents and area burnt

Description: *Number of wildfire incidents and total area burnt*

Type: *Realised impact*

Time Series: *2009-10 to 2020-21; and 2015 to 2021*

Region: *England, and the UK*

2.6.1 Introduction

This indicator provides an assessment of the number of wildfire incidents and the total area burnt by land cover class from two different datasets:

- The Forestry Commission dataset covering wildfires in England, between 2009-10 and 2020-21. This update provides additional analysis of wildfires in built-up areas and gardens data. This part of the indicator was last updated by ADAS (2023).
- The European Forest Fire Information System (EFFIS) dataset covering wildfires in the UK. This update provides new data for 2015 to 2023. This part of the indicator was last updated by ADAS (2023).

2.6.2 Data source and method

Forestry Commission dataset

The Forestry Commission (FC) (2019) published a report 'Wildfire Statistics for England 2009-10 to 2020-21' in February 2023 (Forestry Commission, 2023). This was used in the previous update of this indicator (ADAS, 2023), which focussed on wildfires in the natural environment only.

The FC database also provides information on wildfire incidents in 'Built-Up Areas & Gardens' and incidents of 'No Classification'. These categories were excluded from previous analyses as the focus of the indicator was wildfires in the non-urban environment. In this analysis, existing data on wildfire incidents in 'Built-Up Areas & Gardens' have been included to investigate fires in the urban and rural-urban interface.

Built Up Areas & Gardens is an aggregated class from UKCEH made up of two Land Cover Classes: Urban and Suburban (UKCEH, 2021). Urban includes dense urban, such as town and city centres, where there is little, if any, vegetation. Urban also includes areas such as dock sides, car parks and industrial estates. It is sometimes confused with other non-vegetated surfaces, for example open cast quarries or more rarely coastal rocks or ploughed fields. Suburban includes suburban areas where the spectral signature is a mix of urban and vegetation signatures. Suburban and Urban lie on a continuum and confusion is expected.

The Joint Research Centre

The EFFIS consists of a modular web geographic information system that provides near real-time and historical information on forest fires and forest fire regimes in the European, Middle Eastern and North African regions.

Data was sourced from the annual reports produced by the Joint Research Centre (JRC) based on EFFIS information and supplemented by qualitative information submitted by representatives from the four devolved UK countries, for the years 2015 (San-Miguel-Ayanz et al., 2016), 2016 (San-Miguel-Ayanz et al., 2017), 2017 (San-Miguel-Ayanz et al., 2018), 2018 (San-Miguel-Ayanz et al., 2019), 2019 (San-Miguel-Ayanz et al., 2020), 2020 (San-Miguel-Ayanz et al., 2021), 2021 (San-Miguel-Ayanz et al., 2022), 2022 (San-Miguel-Ayanz et al., 2023) and 2023 (San-Miguel-Ayanz et al., 2024).

Data was also sourced from the EFFIS Live Reporting System (EFFIS, n.d.) to supplement the data available in the annual reports. The Live Reporting System provides data on wildfires over approximately 30 ha, showing both the annual burned area per country and the number of fires recorded annually from 2006 to present. The fires reported via this method may include fires set intentionally for vegetation management purposes.

The 'rapid damage assessment module' of EFFIS provides reliable and harmonized estimates of the areas affected by forest fires during the fire season. EFFIS rapid damage assessment is based on the analysis of the Moderate Resolution Imaging Spectroradiometer satellite imagery. The methodology and the spatial resolution of the satellite sensor data used for this purpose allows the mapping of all fires of 30 ha or larger.

Data for this analysis was extracted on the number of wildfires greater than 30 ha and 500 ha, and the area burnt (ha), from the annual reports.

2.6.3 Trends and implications for climate resilience

Statistics for England (Forestry Commission)

Between 2009-10 and 2020-21 there were 197,233 fires in built-up areas and gardens in England. This equates to 54% of the total wildfire incidents across the timeseries and land cover classes, as shown in Figure 10. The number of wildfire incidents in built-up areas and gardens each year are relatively consistent, with exception of 2009-10, 2010-11 and 2011-12. The reason for this change in the trend is unknown.

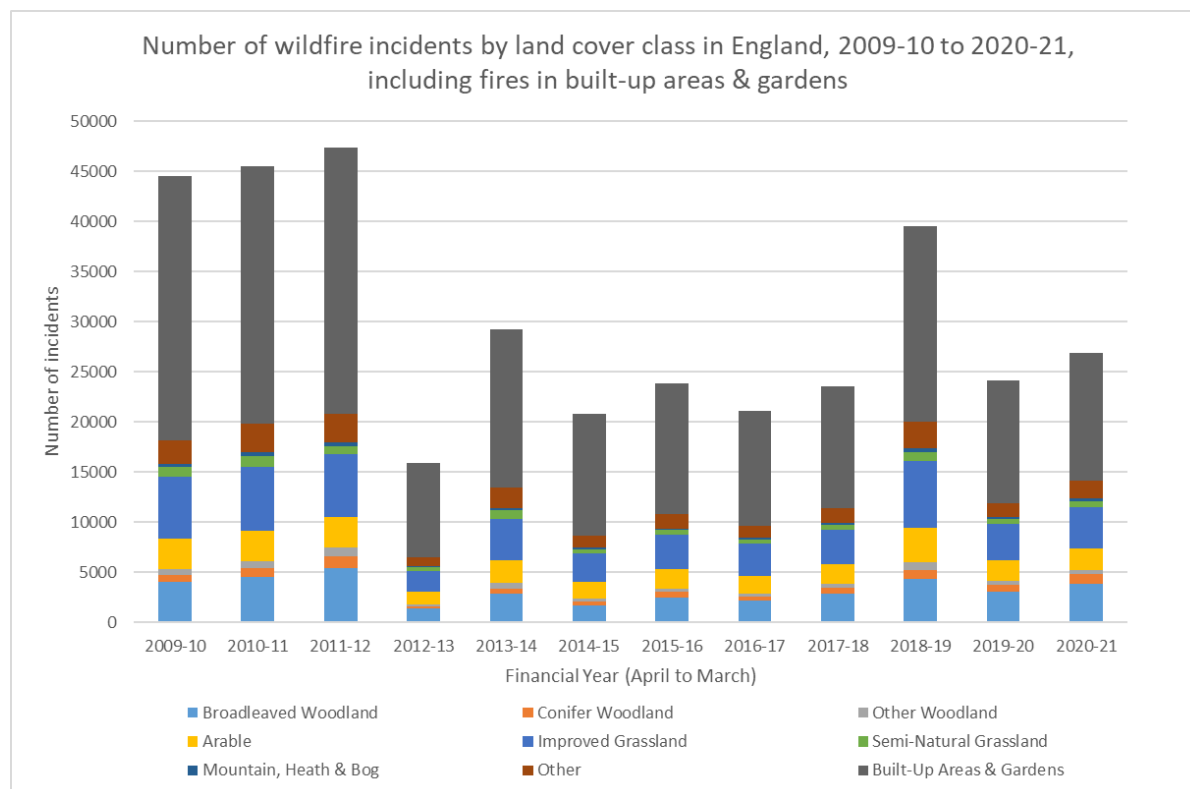


Figure 10. Total number of wildfire incidents recorded each year by the Fire and Rescue Services, split by land cover class, including built-up areas & gardens. Data sourced from the Forestry Commission (2023) report on wildfire statistics. Source: ADAS for the CCC.

The number of incidents occurring in the urban environment broadly mirror the pattern of the number of incidents in the rural land cover classes. The total area burnt in all built-up areas and gardens across 2009-10 to 2020-21 equates to 16% of the total area burnt. The average area burnt by wildfires in built-up areas and gardens is <math><0.07\text{ ha}</math>.

The data shows that built-up areas and gardens typically exhibit large numbers of wildfires but with a small area burnt. The exception to this is the years 2016-17, 2017-18 and 2018-19 where the area burnt in built-up areas and gardens was notably larger than in previous or following years, shown in Figure 11. The greatest total area burnt in built-up areas and gardens occurred in 2018-19 where 5,391 ha were burnt. Following this, the second greatest areas burnt was in 2016-17 where 4,365 ha were burnt.

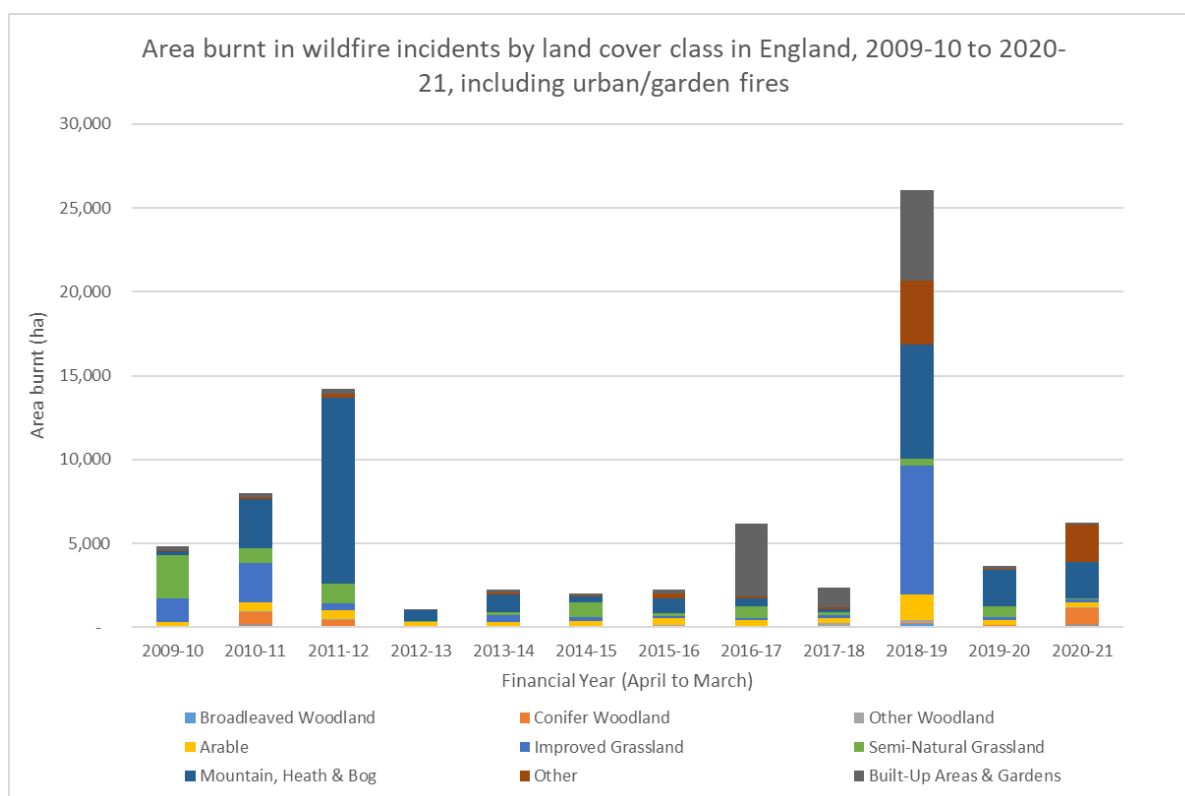


Figure 11. The total annual area burnt in wildfire incidents by land cover class, including built-up areas and gardens. Data sourced from the Forestry Commission (2023) report on wildfire statistics. Source: ADAS for the CCC.

Statistics for the UK (JRC EFFIS)

There are some inconsistencies in the statistics provided by the JRC between the data in the EFFIS Annual Reports and that in the EFFIS Live Reporting System, despite the fact that the two sources use the same dataset. The data in the Live Reporting System filters out fires of less than 30 ha, to enable consistent comparisons over time as previous to 2020, fires smaller than 30ha could not be mapped. The totals presented in the Annual Reports include all mapped fires of all sizes, although it is assumed by the JRC that the burnt areas are generally from fires over 30 ha. In 2020 the JRC applied the filter to the data presented in the Annual Report and only reported on fires over 30 ha. However, from 2021 onwards the JRC returned to their normal methods and reported the total burnt areas and number of fires in the report for fires of all sizes. As a result of these methodological changes, the filtered data from the EFFIS Live Reporting System has been used to gain the most consistent picture over time.

The number of wildfires in the UK for the years 2015 to 2024 is presented in Figure 12 using data from the EFFIS Live Reporting System.

The highest number of wildfires occurred in 2022, with 151 wildfires over 30 ha in size recorded. The second highest number of wildfires to occur in one year in the UK is 111, recorded in 2019. Analysis from the Met Office report that 2022 was a record warm year in the UK with all four seasons ranking in the top 10 warmest seasons for the UK from 1884 (Kendon et al., 2023). In the summer of 2022, the UK experienced an unprecedented heatwave in July, which was preceded and followed by weeks of sunny and dry weather. Additionally, the period of January to August was the driest across England and Wales since 1976, with drought declared across parts of England and all of Wales. This extended period of dry weather increased the risk of wildfires in the natural environment.

In comparison, far fewer wildfires were recorded in 2023 and 2024 than previous years, with 41 and 11 wildfires reported in 2023 and 2024, respectively. Whilst the second warmest year on record, with multiple temperature records broken, 2023 was overall a wet year for most regions in the UK (Kendon et al., 2024). This wet weather likely contributed to the relatively fewer wildfire incidents reported in 2023. Similarly, 2024 was provisionally the fourth warmest year on record yet also experienced the UK’s eighth wettest winter and sixth wettest spring (Met Office, 2025). This is reflected in the low number of wildfires reported for 2024, the lowest number reported since 2016.

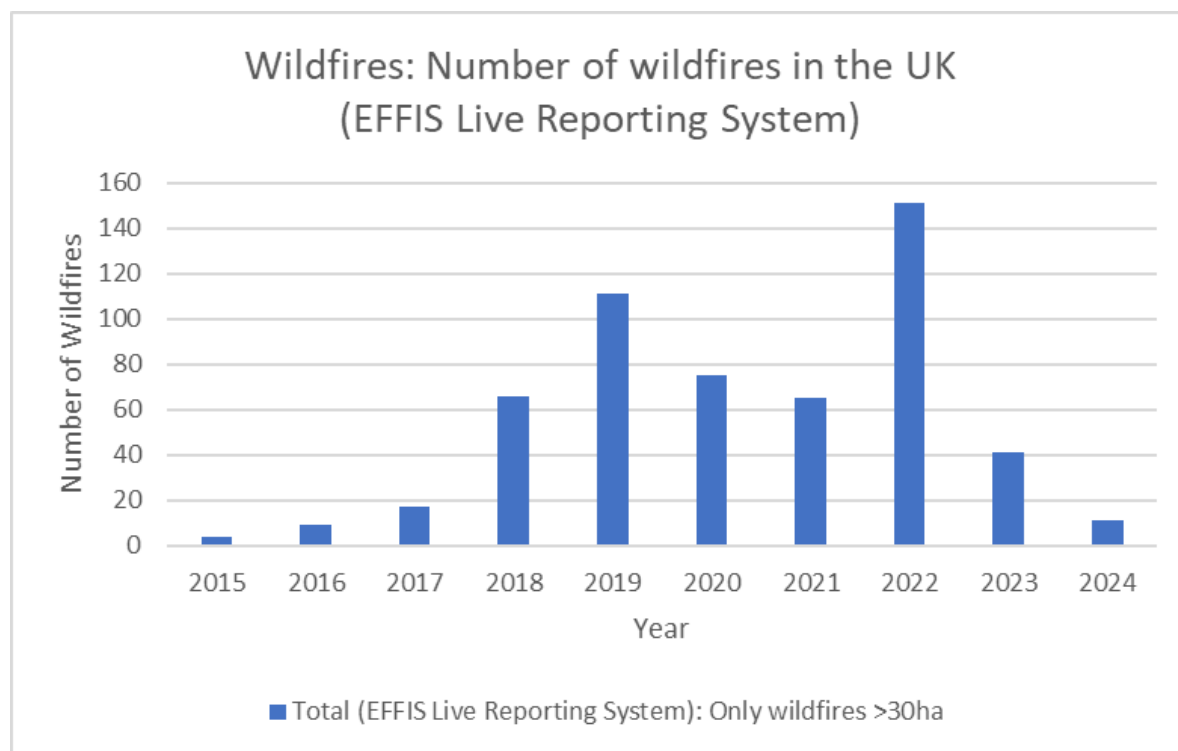


Figure 12. Number of wildfires in the UK between 2015 and 2024. Data sourced from the EFFIS Live Reporting System. Source: ADAS for the CCC.

The majority of the area burnt each year was classified as ‘other natural land’, with this land cover type accounting for between 91% and 97% of the total burnt area in each of the nine years, shown in Figure 13. The land cover categories are based on CORINE Land Cover 3.2, which is very broad and includes different land cover types for different countries. In the UK, the other natural land category largely includes fires on natural grassland, and moors and heathland, defined as:

- **Natural grassland;** grasslands under no or moderate human influence. Low productivity grasslands. Often situated in areas of rough, uneven ground, steep slopes; frequently including rocky areas or patches of other (semi-) natural vegetation.
- **Moors and heathland;** vegetation with low and closed cover, dominated by bushes, shrubs, dwarf shrubs and herbaceous plants, forming a climax stage of development. Including for example, wet heath distributed on humid or semi-peaty soils (peat depth < 30 cm); and dwarf-shrub covered areas with <30 cm peat and without visible sign of morphological features typical of bogs (e.g., pools, peat hags, peatland gullying).

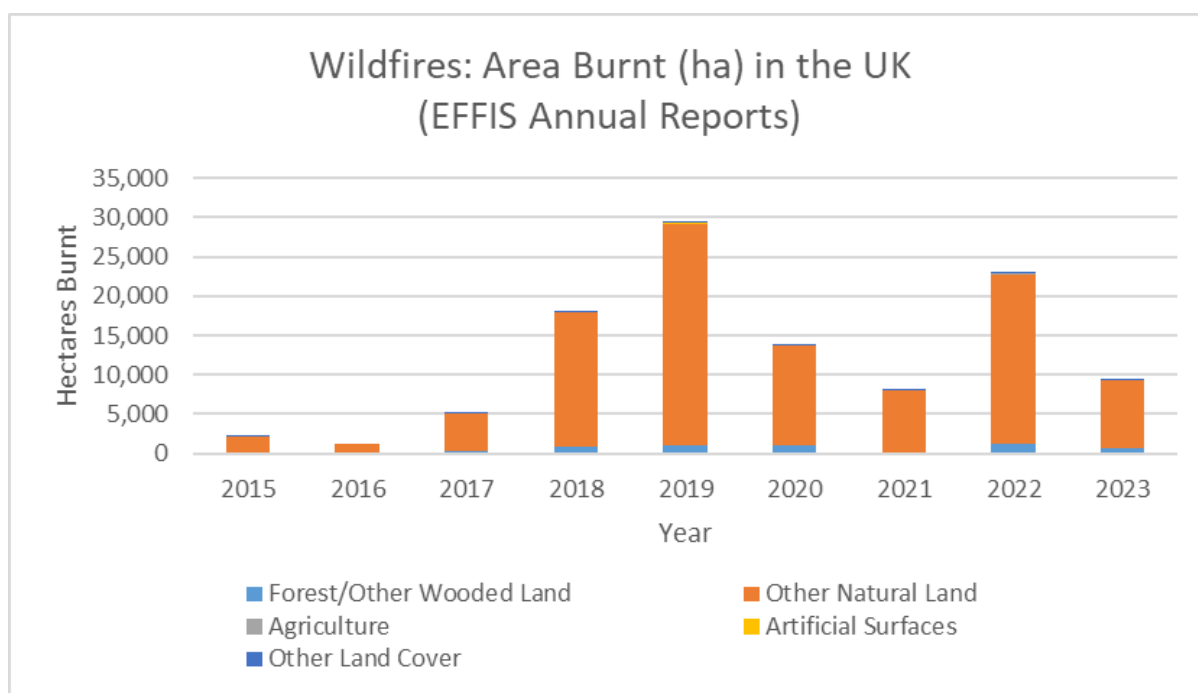


Figure 13. The area burnt by wildfires larger than 30 ha and 500 ha in size in the UK between 2015 and 2023. Data sourced from the Joint Research Centre (San-Miguel-Ayanz et al., 2016; 2017; 2018; 2019; 2020; 2021; 2022, 2023, 2024). Source: ADAS for the CCC.

Review of 2022

2022 had the highest area burnt since 2019 and was the worst fire season in the UK since 2019. The UK experienced multiple heatwaves over the summer of 2022, including an extreme heatwave from the 16th to 19th July (Met Office, 2022). In the 48-hour period between the 18th and 19th of July 84 separate wildfires were recorded in the UK. Notable fires included a large grassfire that spread in Wennington, east London on the 19th July, destroying 20 houses (National Emergencies Trust, n.d.).

There was also a high number of spring wildfires across England, Scotland and Wales in 2022. In Scotland, for example, 65% of large outdoor fires happened in spring 2022, compared to 25% in summer. There is concern from EFFIS that under similar conditions (e.g. a dry spring followed by hot summer) the 2022 fire season may signal a pattern of early spring wildfires extending into a second wildfire season, with high numbers of events occurring through until late summer (San-Miguel-Ayanz et al., 2023).

2.6.4 Robustness of indicator

Forestry Commission dataset

The data used within the Forestry Commission report was sourced from the Home Office's online Incident Recording System, which records all incidents attended by Fire and Rescue Services in England. This includes a wildfire element of the Incident Recording System that provides a record of the nature of incidents requiring a response by the Fire and Rescue Services, in line with the UK Vegetation Fire Standard. The Forestry Commission report is deemed to be robust with a consistent, recently improved methodology (using an updated database to calculate the number of wildfire incidents, and area burned, each financial year up to 2020-21), providing a continuous 12-year time series. It is not known when the Forestry Commission will publish its next report on wildfires. In future

updates it may be beneficial to create a separate indicator for the incidence of wildfires in built-up areas and gardens to support the increased focus on urban habitats.

Joint Research Centre dataset

The Joint Research Centre note that, due to the significant processing periods for fire statistics, it is not possible to gain access to Incident Recording System data for Great Britain, gathered from Fire and Rescue Services. The data is therefore based on qualitative information submitted by representatives from the four developed UK Countries (San-Miguel-Ayanz et al., 2021). However, reports since 2021 suggests it was from data recorded on the UK National Resilience Reporting Tool (San-Miguel-Ayanz et al., 2022, 2023, 2024). There are some differences observed between the EFFIS online dashboard and the published reports, although in most cases these are relatively small, and the trend direction remains the same. This analysis has considered data from both sources.

The Joint Research Centre analysis, based on EFFIS data and qualitative information, is considered to be less robust than the analysis conducted by the Forestry Commission (2023), which did have access to and used data sourced from the Home Office's online Incident Recording System. However, the Joint Research Centre analysis does provide an alternative metric to monitor wildfires over time, which appears to be a comparable indication (between years) of the number of large wildfires (i.e. >30 ha) and area burnt in the UK each fire season (i.e., calendar year).

2.7 Change in total hedgerow length

Description: *Length of hedgerows in England*

Type: *Climate Action*

Time Series: *1984 to 2022*

Region: *GB and England*

2.7.1 Introduction

This indicator was explored by ADAS (2021) and provided an assessment of the change in hedgerow length in England and Great Britain, between 1984 and 2007, based on data from the Countryside Survey (2007). Since the previous update, new data has become available from the Environment Agency and the UK Centre for Ecology & Hydrology (UKCEH) on hedgerow length up to 2022. This new data for hedgerow length in 2022 forms the basis of this update.

2.7.2 Data source and method

There are a couple of datasets that have been identified in this analysis, which provide information on hedgerow length in England. However, these datasets do present some data availability, access and licensing restrictions that limit their use. The datasets are:

Countryside Survey

Data for the years 1984, 1990, 1998 and 2007 were available in the Countryside Survey (2007), which was used in analysis by ADAS (2021). The programme in which this data was collected has been discontinued and therefore directly comparable data is not available to update the time series.

Environment Agency National LIDAR Programme for England

Between 2016 and 2021 the Environment Agency completed a national scale Light Detection and Ranging (LIDAR) programme which provides accurate elevation data at 1m spatial resolution across England. The data was aligned to the OS spatial framework, so are compatible with OS mapping and

products. This data was combined with Land Cover Map linear data and OS data by UKCEH to produce a dataset that models the extent and height of woody linear features on all field boundaries in England, including hedgerows, tree lines and semi-natural thickets of shrubs and trees. This dataset (UKCEH Land Cover Plus: Hedgerows 2016-2021 (England)) was published in January 2024 and is available to download from UKCEH at a cost.

Data on the length of hedgerows mapped by the Environment Agency LIDAR programme was extracted from a project report by UKCEH to Defra that is publicly available on the Defra Science Search website (Norton et al., 2024).

2.7.3 Trends and implications for climate resilience

Estimates for hedgerow length

Countryside Survey: See ADAS (2021) for estimates.

New UKCEH Hedgerow Map dataset: The total hedgerow length for all of England (excluding two land cover classes) was estimated to be 652,556 km in 2022. The excluded land cover classes were Intermediate Mountain tops/broad ridges in Northern England (land class 22e) and High Mountain summits/ridges in Northern England (land class 23e). This figure is based on data from a publicly available report by UKCEH for Defra using the data from the UKCEH Land Cover Plus: Hedgerows 2016-2021 (England) dataset. The report by Norton et al. (2024) is intended to be formally published as a scientific paper in September 2025.

The estimated total length of hedgerows in England for 2022 represents a 62% increase from 2007, illustrated in Figure 14.

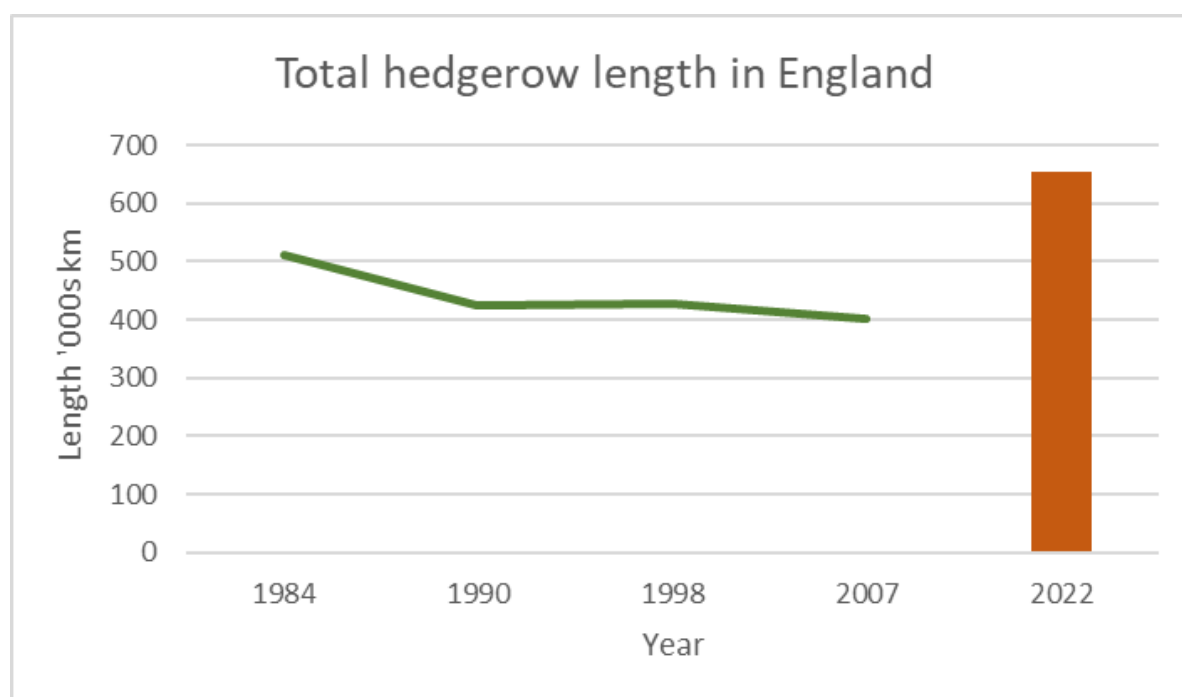


Figure 14. Total estimated hedgerow length ('000s km) for 1984, 1990, 1998, 2007 and 2022. Data for the green line chart (1984, 1990, 1998 and 2007) are sourced from the Countryside Survey. Data for shown by the brown bar (2022) is sourced from analysis of the UKCEH Land Cover Plus: Hedgerows 2016-2021 (England) dataset via a public report (Norton et al., 2024). Source: ADAS for the CCC.

It is recognised that estimates prior to 2022 are not directly comparable, and utilised different survey methods. Therefore, this figure is an indicative value may reflect differences in survey techniques and other factors, in addition to potential changes in hedgerow length.

Expected changes in hedgerow length in the future

It is expected that hedgerow length will show an increasing trend over the coming years, due to current and ongoing policy vehicles. For example, the Environmental Improvement Plan 2023, which builds on the 25 Year Environment Plan vision, has a commitment to support the creation and/or restoration of 30,000 miles of hedgerows by 2037 and 45,000 miles of hedgerows by 2050, returning hedgerow lengths in England to 10% above the 1984 peak of 360,000 miles / ~580,000 km (Defra, 2023a). It is noted that this target is based on 1984 estimates and not the 2022 figure for hedgerow length, which is estimated at 652,556 km (Norton et al. 2024).

Further analysis by Norton et al. (2024) has provided an indication of increasing hedgerow length over time through an assessment of hedgerows under agri-environment schemes (AES) in England for 2007, 2012, 2017 and 2022.

Table 5 shows the changes in hedgerow length under different AES scheme groupings. The length of hedgerow in England, under AES options that support hedgerow planting ('planting' options), has increased from 401 km in 2007 to 4,658 km in 2022. This pattern is mirrored by the increase in hedgerow length under AES options that support hedgerow restoration ('restoration' options), which has increased from 831 km in 2007 to 11,776 km in 2022.

Table 5. Change in hedgerow length under different agri-environment scheme options in England between 2007 and 2022. Data sourced from Norton et al. 2024. Source: ADAS for the CCC.

<i>Hedgerow length in England (000's km)</i>				
	2007	2012	2017	2022
'Managed' - under management options	248.4	360.0	187.9	127.7
'Restoration' - under restoration options	0.8	4.6	6.4	11.8
'Planting' - under planting options	0.4	1.3	1.6	4.7
Under all AES	249.7	366.0	195.9	144.2

2.7.4 Robustness of indicator

The robustness of the Countryside Stewardship (2007) dataset was outlined in ADAS (2021).

The data from Norton et al. (2024) is considered to be relatively accurate and reliable as it is derived from the UKCEH Land Cover Plus: Hedgerows 2016-2021 (England) dataset which in turn uses the LIDAR data collected by the Environment Agency through the national LIDAR programme. Therefore, the data included in Norton et al. (2024) provides the best up-to-date freely available data on the extent of hedgerows in England.

It is recognised that there are differences in the survey techniques applied in the two datasets, meaning they are not directly comparable. However, in the absence of other data sources, the datasets presented provide the best available indication of hedgerow length in England at this time.

2.9 Climate impacts on crop production in the UK

Description: *Observed impact of seasonal rainfall patterns on crop production by area and yield*

Type: *Realising impact*

Time series: *1999 to 2024*

Region: *England*

2.9.1 Introduction

Crop production in the UK is diverse and varies geographically. Broadly, arable farming is the most extensive system in the UK, with production most intensive in the east and south-east of England, while pasture-based livestock systems are situated in the west and north of England, as well as Wales, Scotland, and Northern Ireland (Wheeler and Lobley, 2021).

It is expected that changes in the climate will impact the distribution of areas suitable for the production of certain crops in the UK, presenting both risks and opportunities to crop production (Berry and Brown, 2021). Projections indicate that the impacts of climate change on UK agriculture will vary geographically and may present as gradual long-term shifts or through rapid events relating to extreme weather.

Opportunities presented by increasing temperatures include an increased viability of different crop types (e.g., grapes, hemp, chickpeas) that were only marginally viable under previous climatic conditions (Morison and Matthews, 2016). Longer growing seasons may also provide an opportunity for increased productivity for grassland and crops, although may also risk modifying plant phenology (Berry and Brown, 2021). However, weather extremes such as droughts and prolonged wet winters threaten crop productivity.

Assessing the impact of seasonal rainfall on crop production

Changes in the regional climate are likely to alter the suitability of different crop types, prompting shifts in the distribution of crops across the UK. In this analysis, we compare seasonal rainfall observations with the area in production and yield of the main arable crops in England, from 1999 to 2024. This provides a starting point for possible future ambitions to assess how seasonal weather patterns are projected to change under 2°C and 4°C of warming and to map the possible changes and opportunities for crop production in the UK. Understanding the potential scale of change will help to inform decisions on agricultural adaptation to climate change.

2.9.2 Data source and method

Defra Crop Statistics 2023

This indicator uses data from Defra (2024) on 'Cereal and oilseed rape production'. These are statistics updated annually by Defra with estimates of the cereal and oilseed rape production area data, including yields. The data is available at the UK, national and English regional level. Data was sourced from the dataset provided by Defra for the area in production and yield of key cereal and oilseed crops for the timeseries of 1999 to 2024 in calendar years. The dataset provides provisional figures for 2024. For this update of the indicator only arable crops were assessed as data on yield and area in production were readily available for a wider range of arable crops. The crops assessed are listed below.

- **Arable:** wheat, spring barley, winter barley, total barley, oats and oilseed rape.

The data used for all crops represents the crop area under production in thousand ha, and annual yield in tonnes per hectare.

Met Office observation data

The second dataset used to create this indicator is time-series data of seasonal precipitation values for England, available from the Met Office (n.d.). Observed precipitation data was extracted for 1999 to 2024 for each season, as listed below.

- **Winter** (December, January, February)
- **Spring** (March, April, May)
- **Summer** (June, July, August)
- **Autumn** (September, October, November)

2.9.3 Trends and implications for climate resilience

Wet autumn weather can impact the timing of arable operations either by preventing access to land to sow or manage crops as it is too wet, or by creating unsuitable growing conditions that either stunt or kill off newly sown crops. Typically, where a wet autumn prevents drilling, or a failed winter crop occurs, the land is replanted with a spring crop, often spring barley (or to a lesser extent, spring wheat). As a proxy, this indicator focusses on autumn precipitation totals and total annual area under spring barley production as an indication of where the autumn weather conditions correlate with changes in planned cropping in England.

Autumn is a key period in the agricultural calendar, when winter crops are traditionally sown. However, a multitude of factors affect crop production planning, including crop market prices, fertiliser costs, pest and disease pressures as well as weather conditions, climate and soil type, therefore the comparison of autumn precipitation with national spring barley planting is not directly attributable to the impacts of climate solely.

Figure 15 autumn precipitation in England against the annual area under spring barley production for 1999 to 2024.

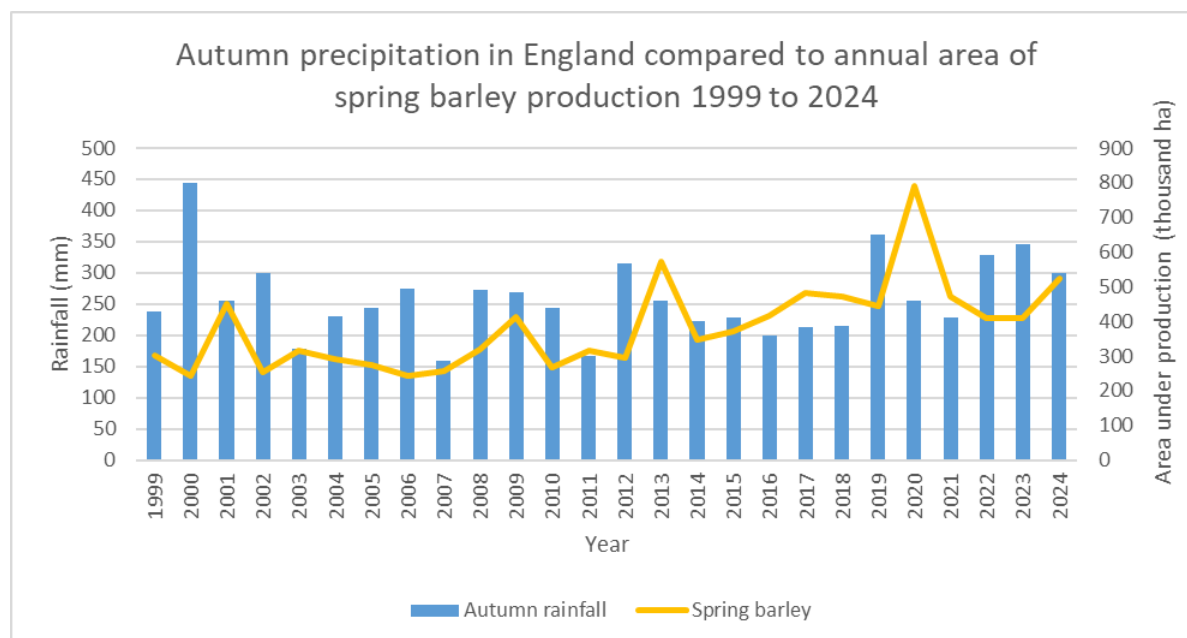


Figure 15. Comparison of observed autumn precipitation with annual area under spring barley production in England 1999 to 2024. Area under production data for 2024 is provisional. Data sources: Cereal and oilseed rape production (Defra, 2024a) and the Met Office. Source: ADAS for the CCC.

Whilst a direct cause and effect correlation is not attributable, some indicative trends are present. In the calendar years following high autumn rainfall, there is often an increase in the area of land under spring barley production and a decrease in the area under winter barley. For example, the autumn of 2000 was the wettest in the 26-year period assessed and was followed in 2001 by an 86% increase in area under spring barley, compared to 2000. Similarly, 2012 was a wet autumn (22% above the 26-year seasonal average) and was followed by the second highest spring barley production of the period in 2013. The autumns of 2019 and 2023 both also had high rainfall (39% and 33% above the 26-year average, respectively) and were followed by increased areas of spring barley production in 2020 and 2024.

This indicates what is known anecdotally, that where wet autumns either prevent sowing or stunt winter crop growth, there is a shift towards spring cropping.

These trends suggest that, if autumns were to become wetter in the future, then it might be expected to see an increase in spring cropping as an adaptation action to respond to unfavourable drilling conditions where wet autumns occur.

2.9.4 Robustness of indicator

It is noted that crop production is affected by several drivers including crop rotations, market prices, pest and disease pressures, and weather conditions at drilling etc. Specific changes in production due to the suitability of the climate is likely to be a contributing factor, but not necessarily the overall defining factor.

The dataset on 'cereal and oilseed production' was sourced by Defra based on the latest available data using a standardised methodology. The timeseries covered by the dataset was consistent for all crops assessed. For 2024 the data is provisional. The information holds accredited Official Statistics status therefore is deemed to meet the highest standards of trustworthiness, quality and public value and complies with the Code of Practice for Statistics. The statistics are updated annually, with the next update for provisional data for the 2025 calendar year expected to be published by Defra in summer 2025. Data is available for the UK, England, Scotland, Wales and Northern Ireland and at a regional level for England.

The data from the Met Office on observed seasonal weather data is considered highly robust. The Met Office are the leading scientific body collecting and analysing UK weather data.

2.10 Agri-Environment Schemes resilience actions

Description: *Uptake of agri-environment scheme options that provide resilience benefits*

Type: *Climate Action*

Time Series: *2023 - 2024*

Region: *England*

2.10.1 Introduction

This is a new indicator developed as part of this study. It aims to provide an indication of the change in uptake of agri-environment land management schemes made available to farmers in England by Defra through the Countryside Stewardship (CS), Environmental Stewardship (ES) and Sustainable Farming Incentive (SFI).

2.10.2 Data source and method

Defra CS, ES and SFI uptake data

This indicator uses data provided by Defra on the uptake of CS, ES and SFI options (Defra, 2024a). The data published provides a snapshot in time of:

- a) **The agreement count** – number of agreements for that option in that year, at time of publishing).
- b) **Total units of all agreements** – the unit varies with option, for example, area covered recorded in ha, whilst trees planted refers to the number of trees etc.

The dataset also provides the number of agreements for each of the CS, ES and SFI by international territorial level (equivalent to administrative areas). All data from this source is for England only.

For simplicity, the collective options from the three schemes are referred to as agri-environment scheme options (AES) in this analysis.

In total there were 659 AES options with uptake data available. Not all options were relevant to the topic of resilience, therefore a series of categories with relevance to resilience were identified and used to narrow down the list of options to a short list of those with climate resilience benefits. The categories that were assessed are listed along with the specific climate resilience focus in Table 6.

Table 6. Categories used to identify climate resilience actions from full list of AES options.

Category	Climate resilience focus
1. Riparian management strips	Focus on cooling water temperatures to adapt to increasing temperatures.
2. Natural flood management	Focus on reducing flood risk to adapt to wetter winters/extreme rainfall events.
3. Water harvesting and storage	Focus on storing water during high rainfall, for use during periods of water scarcity to adapt to drier summers/drought.
4. Nature based solutions	Focus on options that provide nature-based solutions specific purposes.
5. Supporting soil health	Focus on actions that build soil organic matter, improve soil structure and supports soil biology to improve soil resilience to a range of climate impacts.
6. Pest and diseases	Focus on actions that aim to reduce the spread of pest and disease.

A keyword search was used to identify the adaptation options of relevance to each of the six categories. For example, for category 1 (Riparian management strips) the AES option titles were searched for words such as ‘riparian’, ‘tree’, ‘buffer’ and ‘shade’.

The AES options that were found to include the searched keywords were then investigated further, using the option specific guidance provided online by Defra, to understand if the option was considered to provide the climate resilience benefits being considered. For each category, the relevant options were grouped together to build a picture of actions that were deemed to improve that broad category of climate resilience being assessed.

Data on a) the change in number of agreements, and b) units of the options (e.g. number of ha covered by an option), were assessed within the groups of relevant AES options for each category. For some categories, such as category 4 (Nature based solutions), a large number of relevant options were identified. In this instance, subgroups were formed (e.g. coastal, hedgerow, woodland, grassland etc.) to provide further granularity on the type of actions being implemented.

For some options, data was not available (e.g. where data has been suppressed due to low numbers, to preserve confidentiality) or was only available for one of the two years (meaning a comparison between years was not possible). These options were excluded from the analysis. Additionally, subgroups were formed for some categories due to the use of different units preventing direct comparison, for example, combining ha and number of units (i.e. trees planted) into a single number was not viable.

2.10.3 Trends and implications for climate resilience

1. Riparian buffer strips

This category consisted of one relevant AES option, the creation of a riparian management strip (SW11). This option aims to support the development of scrub alongside watercourses, which will provide habitat for wildlife as well as potentially shading and cooling the watercourse in time, as the scrub grows (GOV.UK, 2024).

Figure 16 indicates that there has been a small increase in the area under this agreement, from 200ha in 2023 to 300ha in 2024. However, the number of agreements has remained constant at 500.

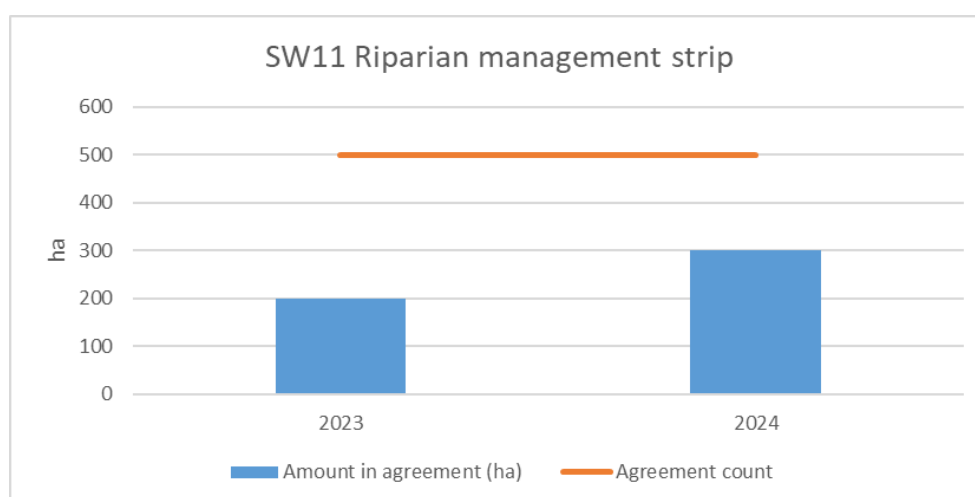


Figure 16. Change in number of agreements and number of ha covered by AES options relating to riparian buffer strips between 2023 and 2024. Data sourced from Defra (2024). Source: ADAS for the CCC.

2. Natural flood management (NFM)

There were several different types of NFM options identified, of which the data is captured using multiple different units, therefore the options were separated into sub-groups:

- Terrestrial options (area): HD10, HJ3, HJ4, HJ6, HK19, SW12, SW15, SW16, SW18, and WD1.
- Terrestrial options (units): RP9, RP32, RP33 and WN1

Terrestrial options (area)

Ten options relating to terrestrial NFM were identified in the terrestrial (area) NFM options subgroup, one of which was excluded (SW18) as there was insufficient data available for 2023. The remaining

nine options are represented in Figure 17. The total area covered by the nine options has fallen slightly from 11,260 ha in 2023 to 10,960 ha in 2024. These options include the number of ha of traditional water meadows under maintenance (HD10), which has decreased from 80 ha in 2023 to 70 ha in 2024. Similarly, the area under reversion to unfertilised grassland or low input grassland (HJ3 and HJ4 respectively), have both decreased by 200 ha and 300 ha respectively across the time series available. Other options included are making space for water (SW12), flood mitigation on arable reversion to grassland (SW15) and flood mitigation on permanent grassland (SW16), maintenance payments for woodland creation (WD1), preventing erosion or run-off from intensively managed grassland (HJ6) and a supplement for raised water levels (HK19).

These decreases may be due to the gradual replacement by Defra of the older ES options with the SFI options, whereby farmers are able to leave their ES agreements early and transfer to the SFI options. This is likely a cause behind some of the reductions seen in some agreements under ES options.

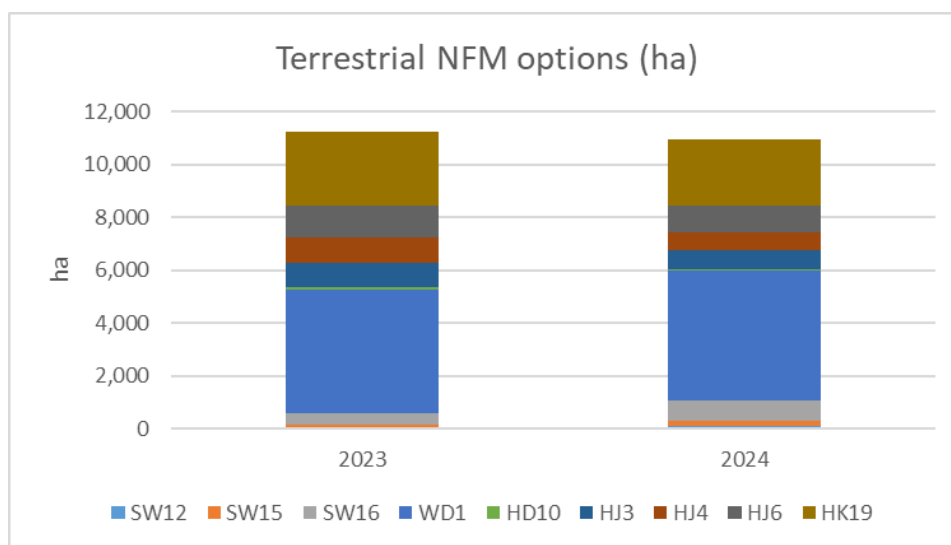


Figure 17. Change in number of ha covered by AES options relating to terrestrial NFM options (area) between 2023 and 2024. Data sourced from Defra (2024). Source: ADAS for the CCC.

Terrestrial options (units)

In comparison, the number of units of small and large leaky dams (RP32 and RP33 respectively) have both doubled from 2023 to 2024, shown in Figure 18. The number of units of earth banks and soil bunds (RP9) has also increased, from 200 units in 2023 to 300 units in 2024, shown in Figure 18. Not included in the graph is Grip blocking drainage channels (WN1), due to the size of the units, which shows an increase from 91,800 units in 2023 to 107,000 units in 2024.

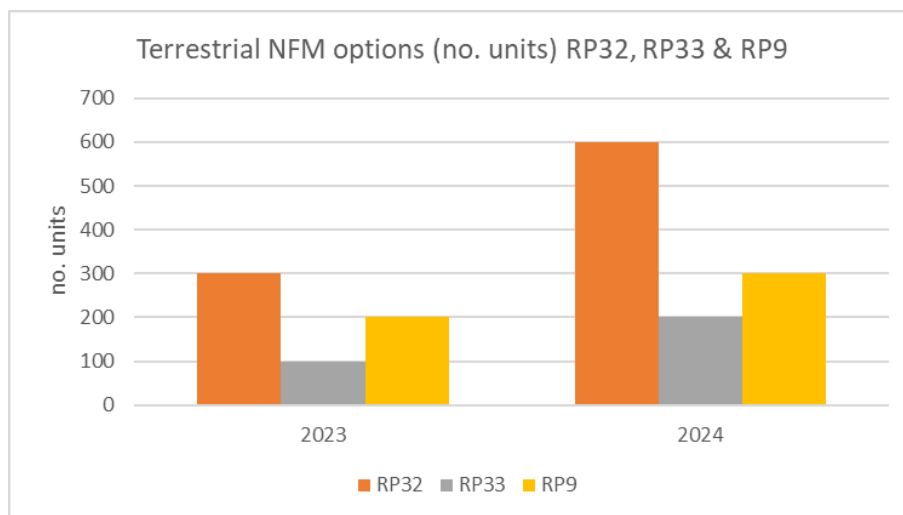


Figure 18. Change in number of units covered by AES options relating to terrestrial NFM options (small units) between 2023 and 2024. Data sourced from Defra (2024). Source: ADAS for the CCC.

3. Water harvesting and storage

Three AES options relevant to water harvesting and storage were identified, all of which have shown an increased uptake between the two years assessed. The total area of water storage tanks (both underground (RP17) and above ground (RP18)) funded through AES options increased from 50,900 m³ in 2023 to 74,100 m³ in 2024, shown in Figure 19. The third option, number of units agreed for first flush rainwater diverters and downpipe filters in support of rainwater harvesting (RP19) has increased by 25% from 2,000 units in 2023 to 2,500 units in 2024, shown in Figure 20.

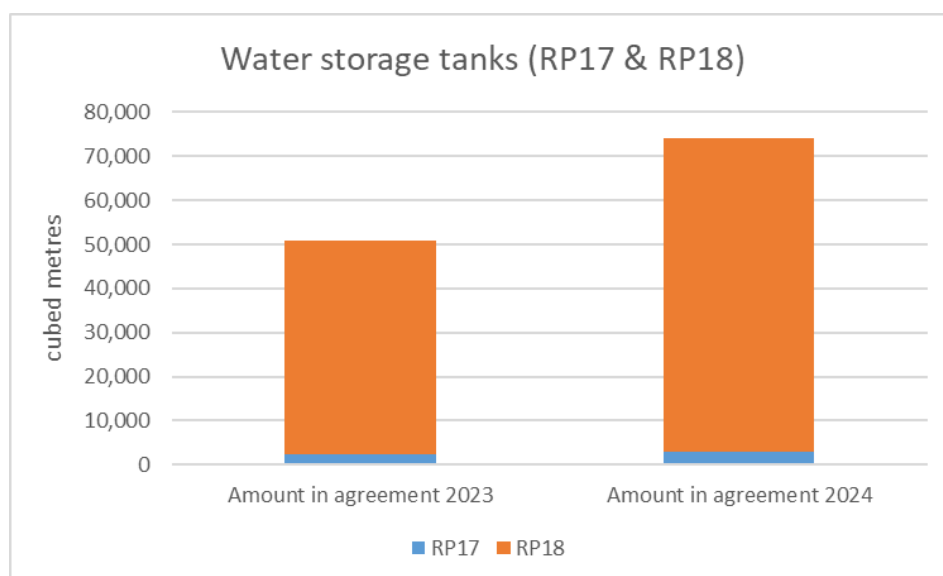


Figure 19. Change in number of cubed metres covered by AES options providing water storage tanks between 2023 and 2024. Data sourced from Defra (2024). Source: ADAS for the CCC.

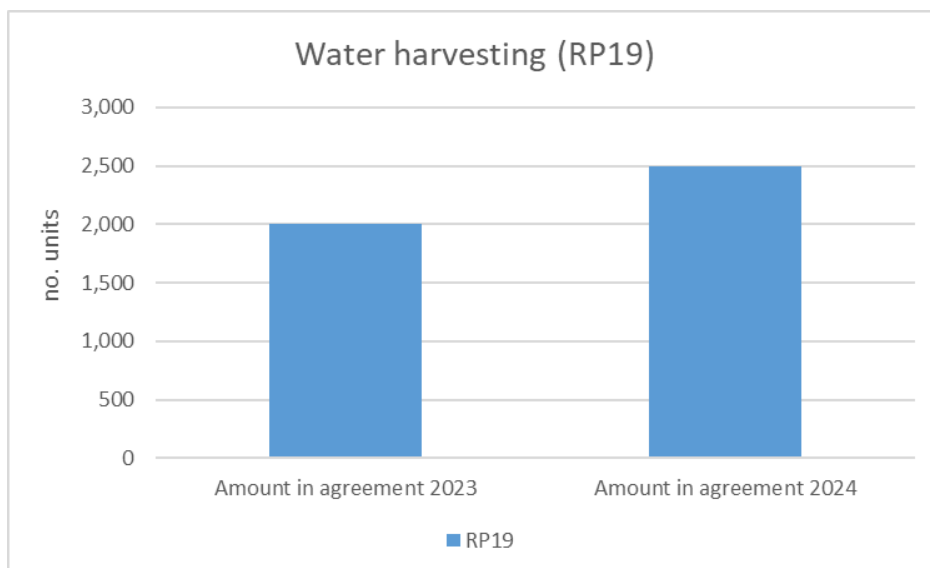


Figure 20. Change in number of units of water harvesting equipment through one AES option between 2023 and 2024. Data sourced from Defra (2024). Source: ADAS for the CCC.

4. Nature-based solutions

In total, 38 options that provide nature-based solutions (NbS) were identified. One was excluded from analysis as the units used for this option differed from the other options making comparison unfeasible. The 37 options carried forward were split into eight subgroups, categorised largely by habitat type. The subgroups consisted of coastal, new tree planting, hedgerow, woodland, grassland, wetland, heathland and scrub & moorland.

The data from a selection of subgroups are presented below.

Coastal

Four options (CT5, HP2, HP6 and HP8) from the AES were identified as providing NbS to coastal habitats. Between 2023 and 2024, the total area under these four coastal NbS options decreased from 1,580 to 1,390 ha. This decrease is assumed to be due to a shift from ES options to SFI options, as the decline was only within HP6 and HP8 which are both ES options. The area under option CT5 (part of the Countryside Stewardship grants) increased by 10 ha, whilst the area under HS2 remained the same.

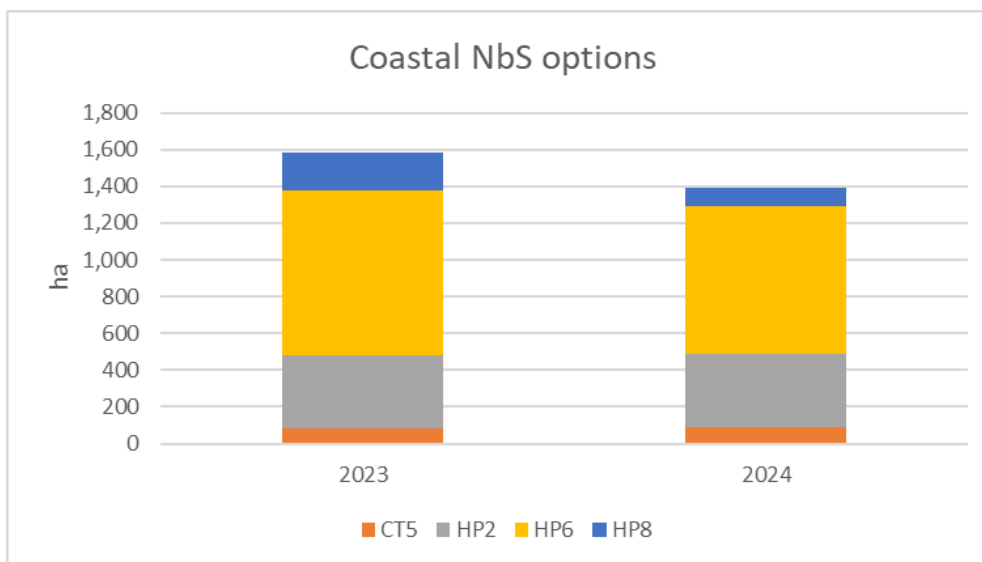


Figure 21. Change in area covered by AES options providing coastal nature-based solutions between 2023 and 2024. Data sourced from Defra (2024). Source: ADAS for the CCC.

New tree planting

Four options provided support for land managers to plant new trees. These options covered the planting of standard hedgerow tree (TE1), standard parkland tree (TE2), and fruit trees (TE3), as well as the funding to ‘supply and plant tree’ (TE4) in which the type of tree is unspecified.

The total number of trees planted within these four options has increased from 1,076,825 trees agreed to be planted in 2023 to 1,214,100 in 2024. Trees planted through TE4 make up the majority of the total number of trees planted within this indicator, as shown in Figure 22, although there have been increases in the number of trees planted through TE1, TE2 and TE3 between the two years also.

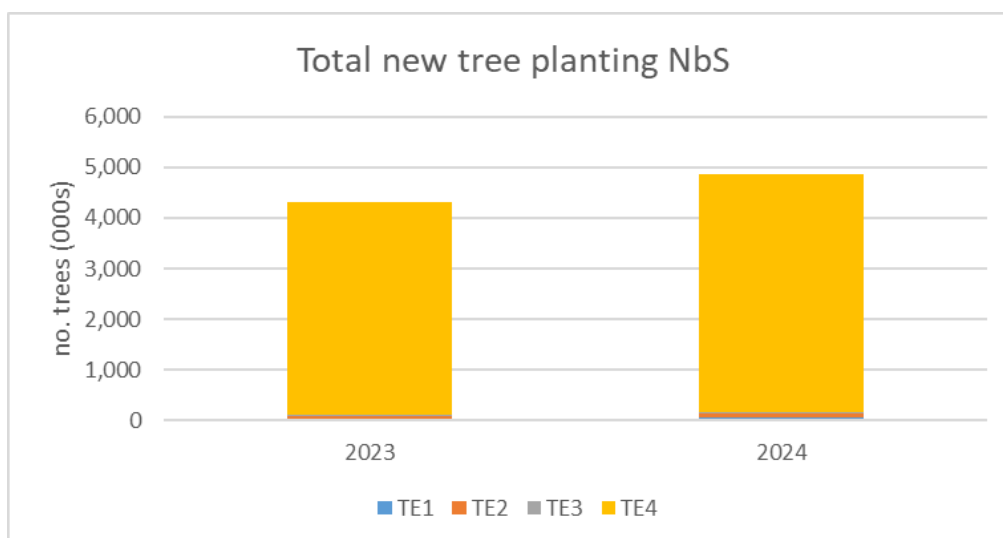


Figure 22. Change in number of new trees planted through AES funding between 2023 and 2024. Data sourced from Defra (2024). Source: ADAS for the CCC.

Woodland habitat restoration

Six options were identified as relevant to the restoration of woodland habitats, of which five were used (HC8, HC20, WD5, WD11, WS2) and one option excluded (HC13) due to incompatible units. There has been a small increase in the total area under woodland habitat restoration, from 20,200 ha in 2023 to 21,400 ha in 2024 (Figure 23).

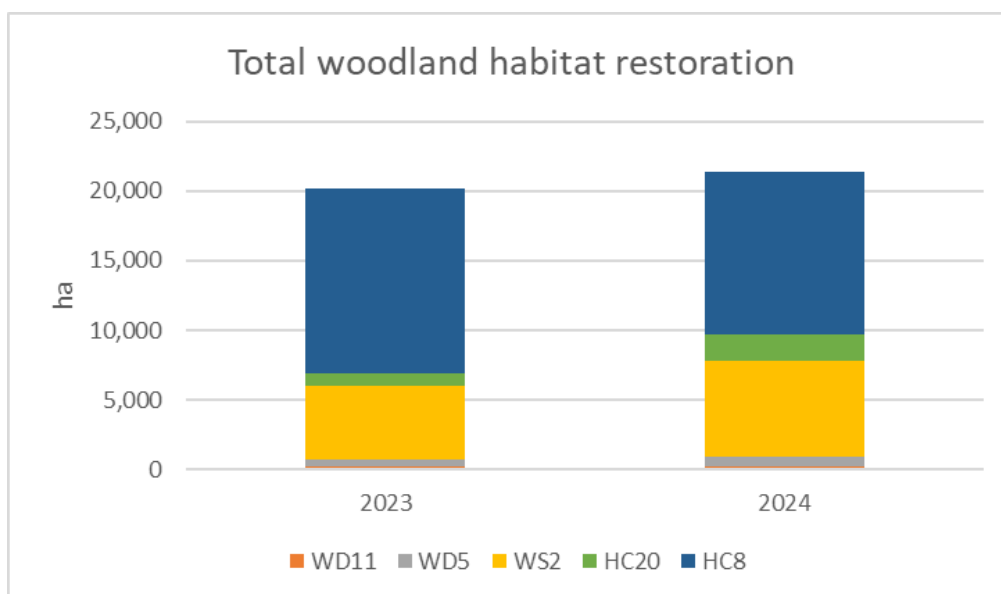


Figure 23. Change in area covered by AES options providing woodland habitat restoration between 2023 and 2024. Data sourced from Defra (2024). Source: ADAS for the CCC.

The greatest area of land under restoration was woodland (HC8), which covered 11,700 ha in 2024, a decrease from 13,300 ha in 2023. Conversely, the area of traditional orchards (HC20) increased by 1,000 ha, from 900 ha in 2023 to 1,900 ha in 2024. There has also been an increase in the area of lowland wood pasture (WD5) and parkland under restoration (WD11), from 500 ha to 700 ha across the two years compared.

5. Supporting soil health

Nine options were identified that supported soil health. Three were excluded from analysis as insufficient data was available for 2023 (SW18, SAM1 and SAM2). Of the six options included in the analysis (EJ2, HS9, SW5, SW6, SW7 and SW8), overall, there was an increase in the total area of land under AES options supporting soil health, from 79,500 ha in 2023 to 96,500 ha in 2024.

There is notable variation in the size of area covered by the six options assessed. Four options have seen an increase in area covered, shown in Figure 24, including the area under winter cover crops (SW6), which increased from 58,500 ha in 2023 to 70,700 ha in 2024.

HS9 (restricted depth crop establishment to protect archaeology under an arable rotation) has seen no change between the years. The option EJ2 (management of maize crops to reduce soil erosion) has recorded a decrease in total area from 500 ha to 300 ha, however, the area under option SW5 (enhanced management of maize crops) has increased from 9,800 ha to 14,000 ha. This is expected to be representative of a shift by land managers from ES options to the SFI, rather than an actual decrease in the area of land being managed to reduce soil erosion in maize crops.

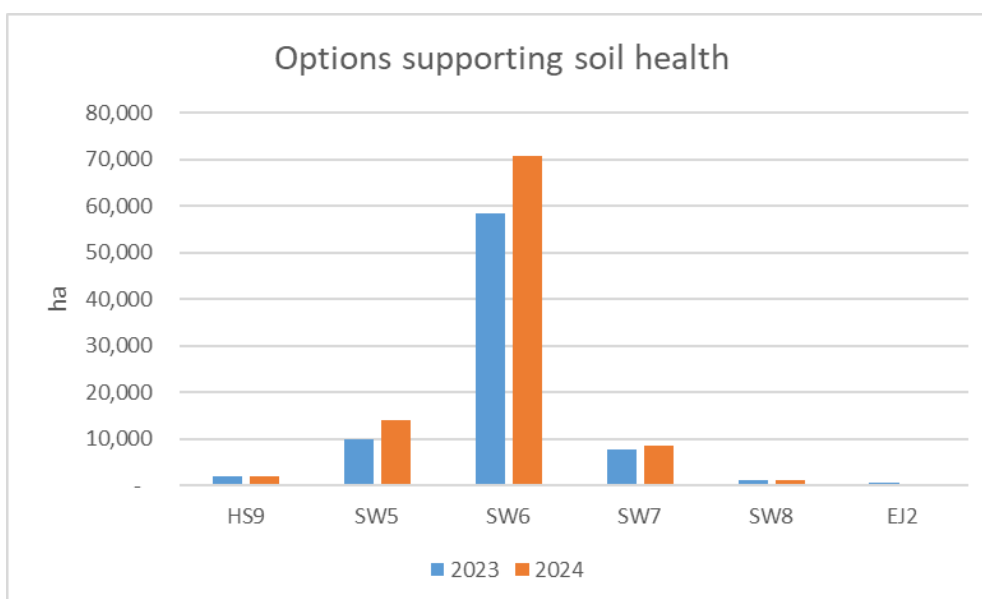


Figure 24. Change in area covered by AES options supporting soil health between 2023 and 2024. Data sourced from Defra (2024). Source: ADAS for the CCC.

6. Pests and diseases

Three options were identified that relate to pest and disease control. These options relate to the control of invasive plant species and the felling of diseased trees to prevent further spread. No options were identified that relate to pests or diseases on animals. The change in area under the options relating to pest and disease control are shown in Figure 25. For the option relating to scrub control and felling diseased trees (SB1), there has been an increase in the area under agreement from 3,000 ha in 2023 to 4,300 ha in 2024. The area under control of invasive plant species supplement (SP4) has also increased from 600 ha to 800 ha between the two years, whereas the supplement for control of invasive plant species (HR4) has decreased from 2,100 ha in 2023 to 1,500 ha in 2024. The change in HR4 is likely a result of land managers moving from the ES agreement to the newer schemes such as SFI and CS (Defra, 2023b). Data duplication is not considered a concern as land managers are able to make a direct swap from ES to mirror agreements, therefore one parcel of land should not be double counted for both an ES option and the mirrored CS option, for example (Defra, 2024b).

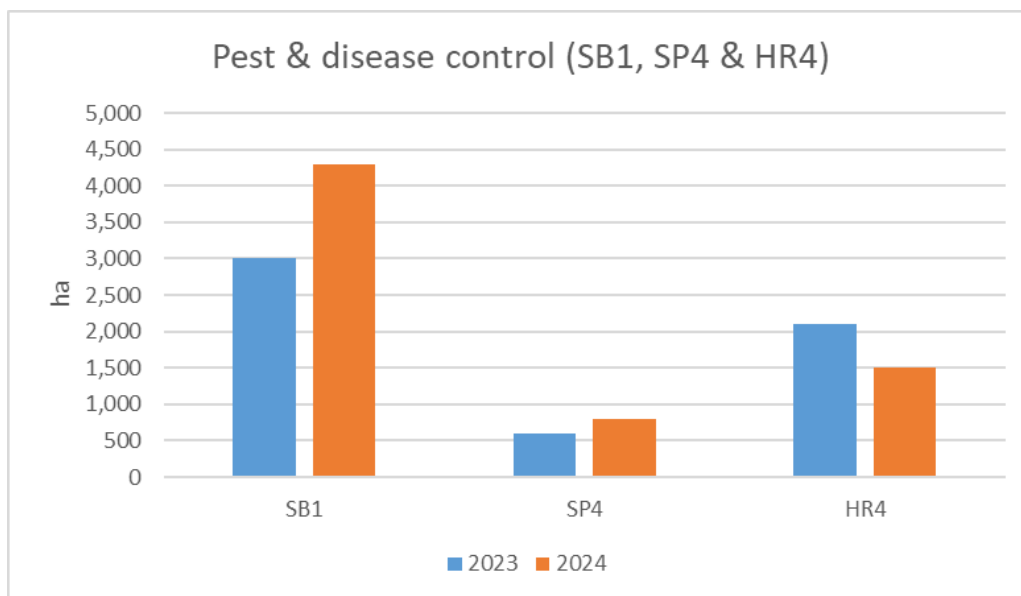


Figure 25. Change in area covered by AES options relating to pest & disease control between 2023 and 2024. Data sourced from Defra (2024). Source: ADAS for the CCC.

2.10.4 Robustness of indicator

Data availability restricted the robustness of this indicator as the schemes being analysed were first released as AES options in 2023, therefore, only two years (2023, 2024) of data exists. Nonetheless, the information provided by Defra has Official Statistics status therefore is deemed to meet the highest standards of trustworthiness, quality and public value and complies with the Code of Practice for Statistics. The statistics are updated annually for uptake of options within the Countryside Stewardship and Environmental Stewardship options. Quarterly reports are provided on the uptake of Sustainable Farming Incentive options. The data used in this indicator represent a snapshot in time of AES option uptake. The next update is expected to be in April 2025. However, the scheme is not continuous (i.e. funding dependent) and subject to changes in policy and Government (i.e. applications can be paused and the structure and options changed) so uptake year by year may not give a clear trend of uptake. Data on the number of agreements per geographical area are also provided but have not been used to inform this indicator.

Defra note a number of caveats within the dataset that should be considered when interpreting the data further. These include: areas where there are fewer than 5 agreements with the option have been suppressed; the data focusses on agreements that contain revenue funding, so capital-only agreements have been removed; and, capital items can be claimed at any time in the first 2 to 3 years of the agreement.

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