

# Projections of emissions and removals from the LULUCF sector to 2050

Contract Report prepared as part of the contract, *Inventory and Projections of UK Emissions by Sources and Removals by Sinks due to Land Use, Land-Use Change and Forestry (LULUCF)*

CEH Project Code: NEC04637

**Amanda Thomson<sup>1</sup>, Gwen Buys<sup>1</sup>, Janet Moxley<sup>1</sup>,  
Heath Malcolm<sup>1</sup>, Paul Henshall<sup>2</sup> and Mark  
Broadmeadow<sup>3</sup>**

<sup>1</sup>Centre for Ecology and Hydrology, Bush Estate, Penicuik, Midlothian, EH26 0QB. [lulucf@ceh.ac.uk](mailto:lulucf@ceh.ac.uk)

<sup>2</sup>Forest Research, Alice Holt Lodge, Farnham, Surrey GU10 4LH

<sup>3</sup> Forestry Commission England, Alice Holt Lodge, Farnham, Surrey GU10 4LH



**Centre for  
Ecology & Hydrology**

NATURAL ENVIRONMENT RESEARCH COUNCIL



**Forest Research**

**March 2017**

**Table of Contents**

- Summary for Policy Makers ..... 3
- 1 Introduction.....4
- 2 Basis for projections .....5
- 3 Assumptions underlying the scenarios.....8
  - 3.1 Afforestation ..... 9
  - 3.2 Wildfires ..... 10
  - 3.3 Land Use Change (LUC) ..... 12
  - 3.4 Deforestation ..... 15
  - 3.5 Cropland and Grassland management..... 16
  - 3.6 Agricultural drainage ..... 17
  - 3.7 Peat extraction ..... 17
- 4 Projections 2015-2050.....19
- 5 References .....32
- Annex 1: Methodology for projection of land use change to Settlement .....33
- Annex 2: Land use areas by Devolved Administration .....34
- Annex 3: Afforestation and Deforestation data .....38

## Summary for Policy Makers

- The UK reports projections for the Land Use, Land Use Change and Forestry (LULUCF) sector to inform policy concerning domestic and international climate change commitments. The full projections data are available on the NAEI website<sup>1</sup>.
- LULUCF activities can result in net annual emissions or removals of greenhouse gases, and changes in carbon stocks in the pools associated with LULUCF. This report provides projections at the UK and Devolved Administration (DA) level, with separate estimates for Scotland, England, Wales and Northern Ireland, which are summed to give the UK totals. The results presented here are based on the reporting conventions of the UNFCCC. They are not presented as potential future accounted emissions and removals under the Kyoto Protocol which are calculated formally at the end of each commitment period.
- LULUCF is divided into six land use types: Forest Land (4A), Cropland (4B), Grassland (4C), Wetlands (4D), Settlements (4E), Other Land (4F). Carbon stock changes from Harvested Wood Products are reported in an additional category, Harvested Wood Products (4G). The code refers to the IPCC (2006 Guidelines) inventory category of LULUCF. There is a separate inventory sector – not presented here – dedicated to other emissions, mainly methane and nitrous oxide, from agricultural activities.
- Projections are made for net emissions and removals of greenhouse gases to 2050, arising from LULUCF activities reported in the latest (1990-2014) greenhouse gas inventory, for the DAs and the UK excluding Overseas Territories and Crown Dependencies.
- Five scenarios (*Baseline 1*, *Baseline 2*, *Central*, *Low* and *Stretch*) have been described. The scenarios were developed by BEIS, Defra and the Forestry Commission and have been updated in 2016 following discussions with all of the UK administrations. The scenarios take account of current land use policies and aspirations. The *Baseline* scenarios are based on climate change-related and forestry policies extant in July 2009.
- The main results are:
  - At a UK level, the LULUCF sector has been a net sink since 1990 and is predicted to remain so under all scenarios until at least 2050, although at a declining level from the mid-2020s onwards (depending on the scenario).
  - At a DA level, England and Scotland remain net sinks under all scenarios
  - Wales is a small net sink under the *Stretch* scenario, but will become an increasing net source under the other scenarios between 2034 and 2049.
  - Northern Ireland is a small net source (except in 1998 and 1999) under the *Baseline* and *Central* scenarios, but will become a small net sink from the late 2030s onwards under the *Stretch* and *Low* scenarios.
  - The LULUCF sector in the UK and in each of the DAs is dominated by CO<sub>2</sub> emissions and removals, although N<sub>2</sub>O emissions also make a significant contribution.
  - The Forest Land, Cropland and Grassland categories determine the trend in the UK and DAs.
  - The main changes in the projections since the 1990-2013 projections are:
    - Forestry: a methodological revision of the forest carbon accounting model CARBINE to assign carbon stock changes to the correct reporting year, and the inclusion of the National Forest Inventory data (including, for the first time, small woods between 0.1 and 0.5 hectares in size) increasing tree cover and forest carbon stocks (this differs from the submitted 1990-2014 inventory).

---

<sup>1</sup> [http://naei.defra.gov.uk/reports/reports?report\\_id=927](http://naei.defra.gov.uk/reports/reports?report_id=927)

- Grassland: the revision of the emission factor used for grassland on drained organic soils has reduced the size of the grassland sink.

## 1 Introduction

The UK reports projections of greenhouse gas emissions and removals from Land Use, Land Use Change and Forestry (LULUCF) activities to inform a range of policy needs. LULUCF emissions and removals are projected to 2050, which is the target date for 80% emissions reductions below the 1990 baseline in the UK Climate Change Act. Projections are made for carbon stock changes and carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O) emissions arising from LULUCF activities reported in the latest UK Greenhouse Gas Inventory, for the period 1990-2014 (Brown *et al.*, 2016).

The specific policy needs for the projections are:

- The projections must be aligned with international commitments including the EU requirement for biennial reporting of projections with and without policy measures, and with additional measures.
- Second, and linked to both domestic and international commitments, BEIS produces annually updated Energy and Emissions Projections (EEP) which help to track progress towards Government climate targets.
- The projections support the development of the Emissions Reduction Plan (ERP), which will succeed the 2011 Carbon Plan, a statutory requirement of the UK's Climate Change Act following the setting of the 5<sup>th</sup> Carbon Budget (CB5) in July 2016. The ERP will lay out the strategy to be taken to achieve CB5.
- Projections are also required to monitor progress towards targets under the Climate Change (Scotland) Act, the Environment (Wales) Act and for the UNFCCC Framework Convention on Climate Change (UNFCCC).

There have been some changes to the projection scenarios this year, to reflect policy needs. Three policy scenarios (*Central*, *Low* and *Stretch*) have been constructed along with two *Baseline* scenarios which continue existing trends with no new policy interventions. These policy scenarios reflect conditions before the July 2016 referendum on the UK's membership of the European Union.

- *Baseline 1* scenario: Based on climate change-related and forestry policies extant in July 2009 (required for reporting the Forest Management Reference Level used in the Second Commitment Period of the Kyoto Protocol). The projections continue 2000-2009 average activity rates out to 2050.
- *Baseline 2* scenario: Based on climate change-related and forestry policies extant in July 2009 (as in *Baseline 1*). Forest planting rates drop to a low level after 2015 to project the impact of no further grant-aided planting beyond that which was contained in existing policy in 2009 under the then programme of the Common Agricultural Policy, other activities are projected to continue at 2000-2009 average rates until 2050. This is the EEP "baseline" scenario.
- *Central* scenario: Based on current policies and funding (as extant in 2014) continuing at the same rate into the future. Continues 2014 rates to 2050 for non-forest activities. For afforestation, 2014 planting rates are maintained for the remainder of the current Rural

Development Programme (RDP); to 2021), after which planting rates decline to those in *Baseline 2*. This is the EEP “reference” scenario.

- *Low* scenario: Climate change mitigation policy aspirations for each of the Devolved Administrations (DAs)<sup>2</sup> are projected forward beyond 2021. This scenario is needed for the ERP.
- *Stretch* scenario: This assumes an ambitious climate change mitigation programme exceeding current policy aspirations or funding.

The assumptions underlying the scenarios were developed by the Department of Energy and Climate Change (DECC; now the Department for Business, Energy and Industrial Strategy (BEIS)) with input from policy advisers from the Forestry Commission, Defra, the DAs and LULUCF experts. The scenarios are designed to capture the range of net emissions that could potentially be produced by LULUCF activities in the future, taking into account current land use policies and/or aspirations (e.g. achieving a certain percentage of forest cover by 2050). Domestic agriculture- and forestry-specific policies and funding are not in place to meet some of the aspirations, particularly for the *Low* and *Stretch* scenarios, and they must therefore be treated as theoretical. Separate projections have been developed for each administration (England, Scotland, Wales and Northern Ireland) and combined into a total for the UK.

## 2 Basis for projections

The LULUCF sector (IPCC sector 4 in the national greenhouse gas inventory) is divided into six land use types for reporting of emissions/removals: Forest Land (4A), Cropland (4B), Grassland (4C), Wetlands (4D), Settlements (4E) and Other Land (4F)<sup>3</sup>. Net carbon stock changes from Harvested Wood Products (HWP) are reported under an additional category 4G. Emissions of greenhouse gases to the atmosphere (carbon dioxide, methane and nitrous oxide) are expressed as positive quantities, and removals of carbon dioxide as negative quantities. Emissions of all three greenhouse gases are combined together into total CO<sub>2</sub> equivalents, using Global Warming Potential factors<sup>4</sup> of 1 for CO<sub>2</sub>, 25 for CH<sub>4</sub> and 298 for N<sub>2</sub>O. The net LULUCF emission is the total of emissions and removals across the seven categories (4A-4G). The balance between emissions and removals within the sector means that the net total LULUCF emission or removal may be small in comparison with other individual sector totals but the LULUCF sector remains significant as the relative small net LULUCF emission is the net balance of much larger emissions and removals. Furthermore LULUCF is the only sector which has the possibility of removing greenhouse gases from the atmosphere.

Calculations in the LULUCF inventory are on the basis of activities, which can fall across several land use types (Table 1). The current inventory (1990-2014) methodology is used to make the projections to 2050. There are detailed descriptions of the datasets and methodology in Chapter 6 and Annex 3.4 of the National Inventory Report (Brown *et al.* 2016). The *Afforestation* and *Land Use Change (soils)* activities contribute the majority of the emissions/removals in the LULUCF sector. Accordingly, most

---

<sup>2</sup> In this report the term “Devolved Administration” includes the administrations within the UK which have devolved governments (Scotland, Wales and Northern Ireland) and England which does not.

<sup>3</sup> There are no emissions or removals of greenhouse gases from the Other Land category.

<sup>4</sup> The GWPs for CH<sub>4</sub> and N<sub>2</sub>O were updated in the IPCC 2006 Guidance; previously a GWP of 21 was used for CH<sub>4</sub> and 310 for N<sub>2</sub>O.

consideration was given to the corresponding activities and to *Deforestation* when developing the assumptions for the different scenarios.

**Table 1: Activities producing emissions/removals of greenhouse gases in the LULUCF sector.**

| <b>Activity</b>                            | <b>Description</b>  | <b>Inventory category</b>   |
|--|---|---|
| <i>Afforestation and forest management</i> | Carbon stock gains and losses in trees, litter, soils and harvested wood products are calculated by the forest carbon accounting model CARBINE (Tier 3). The model uses data on forest planting, productivity, and forest management/harvesting patterns. N <sub>2</sub> O emissions from fertilization and drainage of forest soils are calculated from the same planting data (Tier 1). Estimates are adjusted to take account of forest area losses due to deforestation. The changes in the Harvested Wood Products (HWP) pool reflect changes in the forest harvesting rate and the use of forest products.  | 4A Forest Land (carbon stock changes, N <sub>2</sub> O emissions)<br>4G Harvested Wood Products (carbon stock changes)  |
| <i>Wildfires</i>                           | Emissions of greenhouse gases due to wildfires on forest land, cropland and grassland are modelled using the IPCC Tier 1 methodology. IPCC emission factors are used for estimating fuel consumption in non-forest wildfires, and biomass and litter densities calculated by the CARBINE model are used for forest wildfires.   | 4A Forest Land (CO <sub>2</sub> , CH <sub>4</sub> and N <sub>2</sub> O emissions), 4B Cropland (CH <sub>4</sub> and N <sub>2</sub> O emissions), 4C Grassland (CH <sub>4</sub> and N <sub>2</sub> O emissions)  |
| <i>Land Use Change</i>                     | Changes in biomass and soil carbon stocks due to non-forest land use change are modelled by a dynamic model of carbon stock change driven by land use change matrices calculated from land surveys (1950-2007) (Tier 3). Continuing changes in soil carbon stocks due to historical LUC (>20 years before current year) are reported under the relevant IPCC category e.g. Cropland remaining Cropland, and changes due to more recent LUC (<20 years) are reported under e.g. Land converted to Cropland. Changes in biomass stocks occur in the year of the land use change. N <sub>2</sub> O emissions associated with land use change are calculated from the same activity data using the IPCC Tier 1 methodology. | 4B Cropland (carbon stock changes, N <sub>2</sub> O emissions)<br>4C Grassland (carbon stock changes, N <sub>2</sub> O emissions)<br>4E Settlements (carbon stock changes, N <sub>2</sub> O emissions)  |
| <i>Deforestation</i>                       | Carbon stock changes in the soil due to deforestation to another land use are calculated using the dynamic model of carbon stock change, while changes in biomass and HWP are calculated using the CARBINE forest carbon accounting model (both Tier 3). A proportion of the felled trees are assumed to be burnt (releasing CO <sub>2</sub> , CH <sub>4</sub> and N <sub>2</sub> O), and the remainder are converted to timber products.   | 4A Forest Land (biomass carbon stock changes)<br>4B Cropland (soil carbon stock changes; CO <sub>2</sub> , CH <sub>4</sub> and N <sub>2</sub> O emissions)<br>4C Grassland (soil carbon stock changes; CO <sub>2</sub> , CH <sub>4</sub> and N <sub>2</sub> O emissions)<br>4E Settlements (soil carbon stock changes; CO <sub>2</sub> , CH <sub>4</sub> and N <sub>2</sub> O emissions)<br>4G Harvested Wood Products (carbon stock changes) |
| <i>Cropland management</i>                 | Changes in soil carbon stocks due to inputs of fertilizer, manure and crop residues and changes in biomass stock due to changes in crop type are calculated using the IPCC Tier 1 methodology.  | 4B Cropland (biomass and soil carbon stock changes)   |
| <i>Grassland management</i>                | Changes in biomass carbon stocks due to changes between grassland types are calculated using the IPCC Tier 1 methodology.   | 4C Grassland (biomass carbon stock changes)   |
| <i>Agricultural drainage</i>               | Emissions from drainage on lowland agricultural organic soils are estimated using the IPCC Tier 1 methodology.  | 4B Cropland (soil carbon stock changes)<br>4C Grassland (soil carbon stock changes)   |
| <i>Peat extraction</i>                     | The IPCC Tier 1 methodology is used to calculate on-site emissions from peat extraction and off-site emissions from the decomposition of domestically produced horticultural peat.  | 4D Wetlands (soil carbon stock changes; CO <sub>2</sub> and N <sub>2</sub> O emissions)   |

### 3 Assumptions underlying the scenarios

The scenario assumptions for each activity and Devolved Administration (summed to give the UK total) are described in this section. The following assumptions remain constant across all scenarios:

- Land areas for each country of the UK are assumed to remain constant. They are taken from the Standard Area Measurement<sup>5</sup> publication (national baseline). Land loss due to sea level rise is assumed not to have an impact before 2050. Changes in the UK land area due to coastal re-alignment are not considered.
- Non-forest LULUCF input data for the different countries 1990-2014 in the official GHG inventories have not been changed and feed through as the initial condition for the projected emissions.
- Forest input data is based on the latest National Forest Inventory (NFI) and small woods dataset (small woods between 0.1-0.5 ha size falling below the NFI threshold of 0.5 ha), so differs from the input data used in the 1990-2014 GHG Inventory.

Graphs of UK-level activity data are shown in this section; a break-down by DA is given in Annex 2. Table 2 shows which activities correspond to each UNFCCC land use category.

**Table 2: UNFCCC land use categories and contributing activities**

| UNFCCC LULUCF land use category | Carbon stock change or gas | Activity producing emissions/removals   |
|---------------------------------|----------------------------|---|
| <b>Forest Land (4A)</b>         | Carbon stock change        | Afforestation and forest management<br>Deforestation                              |
|                                 | CO <sub>2</sub> emissions  | Wildfires   |
|                                 | CH <sub>4</sub> emissions  | Wildfires   |
|                                 | N <sub>2</sub> O emissions | Afforestation and forest management<br>Wildfires                                  |
| <b>Cropland (4B)</b>            | Carbon stock change        | Land Use Change<br>Deforestation<br>Cropland management<br>Agricultural drainage  |
|                                 | CO <sub>2</sub> emissions  | Deforestation   |
|                                 | CH <sub>4</sub> emissions  | Wildfires<br>Deforestation  |
|                                 | N <sub>2</sub> O emissions | Wildfires<br>Land Use Change<br>Deforestation                                     |
| <b>Grassland (4C)</b>           | Carbon stock change        | Land Use Change<br>Deforestation<br>Grassland management<br>Agricultural drainage |
|                                 | CO <sub>2</sub> emissions  | Deforestation   |
|                                 | CH <sub>4</sub> emissions  | Wildfires<br>Deforestation  |

<sup>5</sup> <http://www.ons.gov.uk/ons/guide-method/geography/products/other/uk-standard-area-measurements--sam-/index.html>



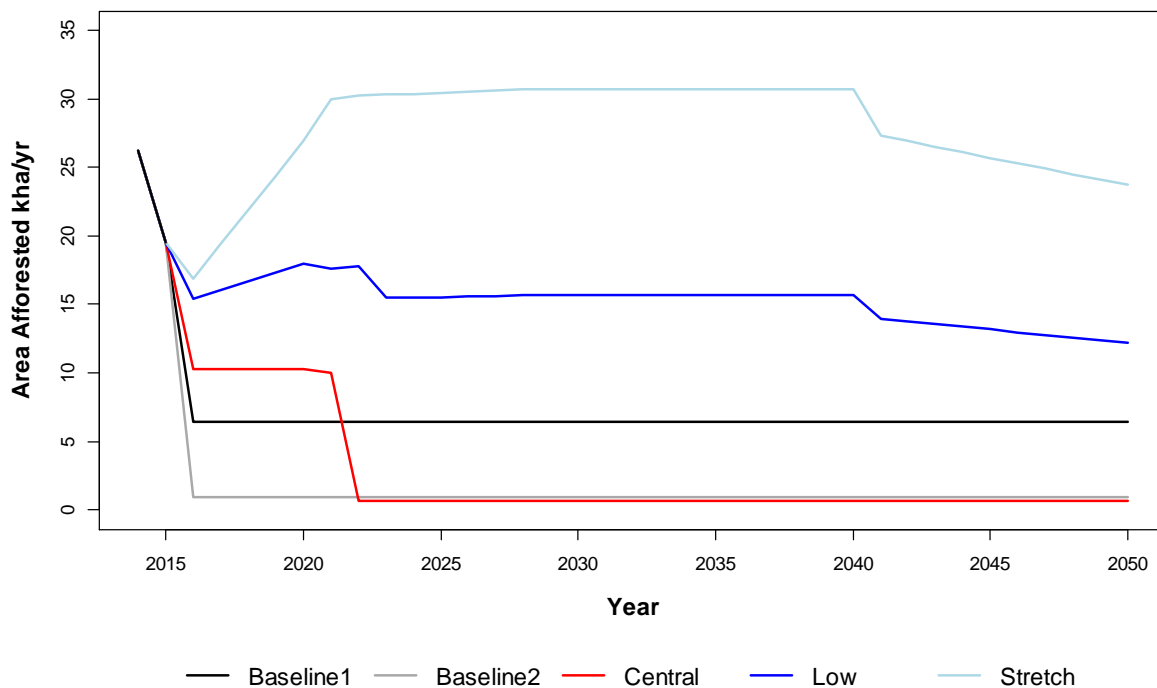
| UNFCCC LULUCF land use category     | Carbon stock change or gas | Activity producing emissions/removals                |
|-------------------------------------|----------------------------|--|
|                                     | N <sub>2</sub> O emissions | Wildfires<br>Land Use Change<br>Deforestation        |
| <b>Wetlands (4D)</b>                | Carbon stock change        | Peat extraction                                      |
|                                     | CO <sub>2</sub> emissions  | Peat extraction                                      |
|                                     | N <sub>2</sub> O emissions | Peat extraction                                      |
| <b>Settlements (4E)</b>             | Carbon stock change        | Land Use Change<br>Deforestation                     |
|                                     | CO <sub>2</sub> emissions  | Deforestation  |
|                                     | CH <sub>4</sub> emissions  | Deforestation  |
|                                     | N <sub>2</sub> O emissions | Land Use Change<br>Deforestation                     |
| <b>Harvested Wood Products (4G)</b> | Carbon stock change        | Afforestation and forest management<br>Deforestation |

### 3.1 Afforestation

This activity is driven by the amount of new forest planting in each DA and affects forest carbon stock changes, changes in the Harvested Wood Products pool, nitrogen fertilisation of forests and forest drainage (CO<sub>2</sub> and N<sub>2</sub>O).

- The *Baseline 1* scenario uses the 2009 planting rates for all projection years (2015 onwards), as per the Forest Management Reference Level (FMRL) used in the Kyoto Protocol reporting.
- The *Baseline 2* scenario assumes that grant-aided planting ceases after 2015, and uses a value of 10% of the average forest planting rate (from the 2008-2014 Rural Development Programme) out to 2050.
- The *Central* scenario uses forest planting rates to 2020-21 determined by the available grants for woodland creation within each DA. After 2021, planting rates drop to 10% of the *Baseline 1* rates, reflecting the lack of funding beyond the current Rural Development Plan.
- The *Low* (emissions) scenario uses forest planting rates to 2020-21 determined by the available grants for woodland creation within each DA, supplemented by additional planting activity in line with meeting policy aspirations after 2020. From 2021, planting rates are projected based on policy aspirations in each DA.
- The *Stretch* scenario assumes an ambitious planting programme exceeding current policy aspirations or funding (differentiated by DA).
- Planting rates for 2014 have been published and are used in the projections (see Annex 3).
- Proportion of conifer/broadleaf planting: for the *Baseline* scenarios the conifer/broadleaf split reported for 2009 is projected forward; and for all other scenarios each DA has proposed a conifer/broadleaf split consistent with current policy aspirations and grant availability/targeting (Scotland: 60% conifer; England: 30% conifer; Wales: 16% conifer (current 2014 value); Northern Ireland: 2% conifer (current 2014 value)).

The UK afforestation rates are presented in Figure 1, with a breakdown by Devolved Administration provided in Annex 3.



**Figure 1: Afforestation rates for the emissions scenarios (UK).** Note that a disaggregation of these data by Devolved Administration is provided in Annex 3.

### 3.2 Wildfires

Emissions from wildfires on Forest, Cropland and Grassland are presented in Figure 2, Figure 3 and Figure 4, respectively. This activity is driven by the area of forest, cropland and grassland burnt annually in wildfires, affecting GHG emissions from burning ( $\text{CO}_2$ ,  $\text{CH}_4$  and  $\text{N}_2\text{O}$ )<sup>6</sup>. Carbon dioxide emissions from wildfires on cropland and grassland are assumed to be replaced within the year by vegetation regrowth, so only emissions of methane and nitrous oxide are reported in 4B and 4C. The amount of fuel available to forest wildfires varies by Afforestation scenario.

The wildfire historical time series shows high inter-annual variability (dependent upon the weather conditions at certain times of year). Activity data are adjusted to ensure a smooth transition from the latest inventory year to the different scenarios (2014-2020) using a sigmoid curve.

- In the *Baseline 1* and *Baseline 2* scenarios the annual burnt area from 2015 onwards equals the average burnt area during the historical baseline period (2000-2009 for forest wildfires and 2001-2009 for cropland and grassland wildfires where the available time series was shorter).
- In the *Central* and *Low* scenarios the annual burnt area from 2015 onwards equals the average annual burnt area for the decade up to the latest inventory year (2014).

<sup>6</sup> There are no non-forest wildfire data for Northern Ireland, so the area burnt was estimated using the NI Countryside Survey areas for cropland and grassland scaled by the % burnt of cropland and grassland in Scotland 2010-2014. The time series was extended using the ratio of the estimated NI burnt area to the GB burnt area.

- In the *Stretch* scenario the annual burnt area from 2015 onwards is the value of the 5<sup>th</sup> percentile of the wildfire area time series for the decade up to the latest inventory year (2014).

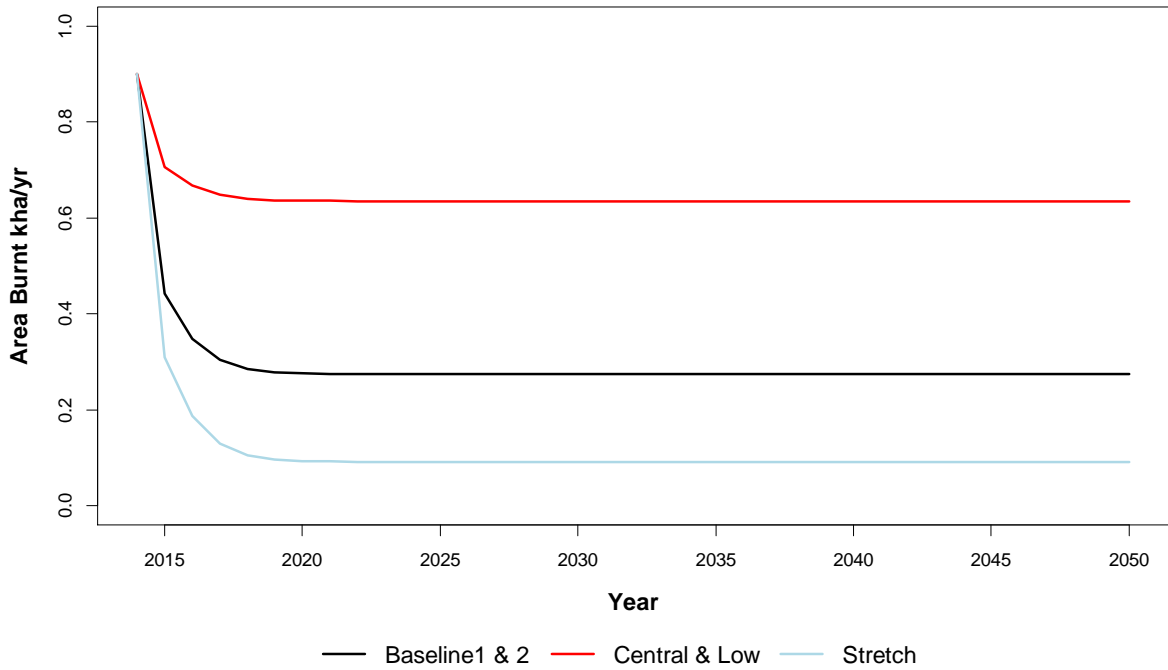


Figure 2: Forest wildfire activity data for the emissions scenarios (UK)

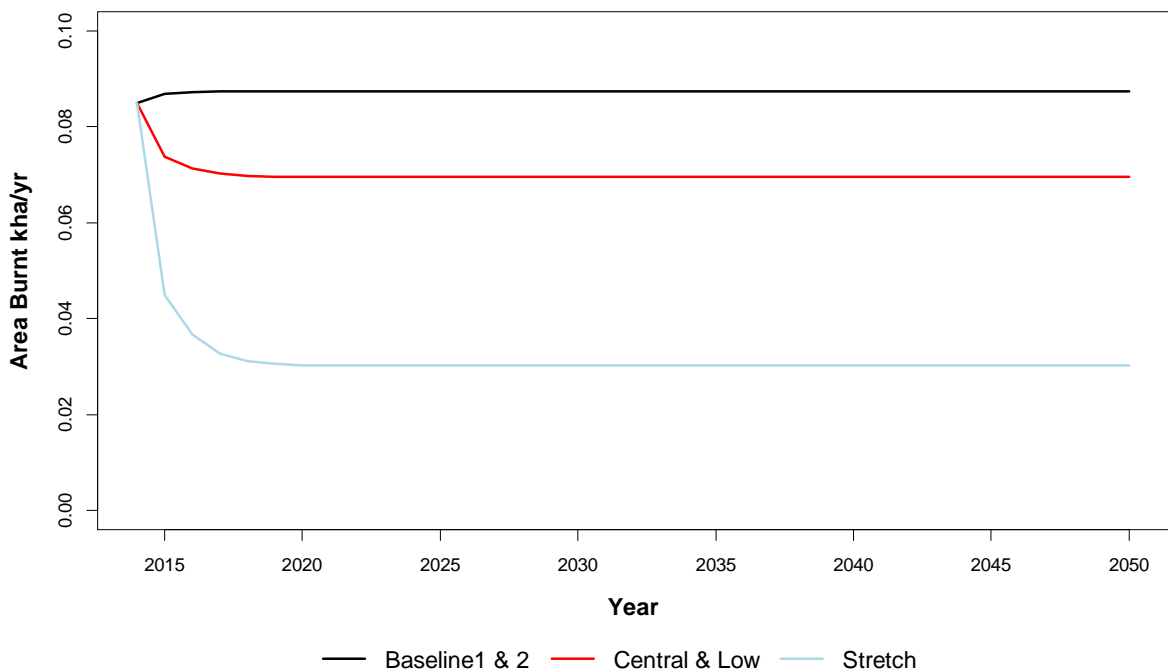


Figure 3: Cropland wildfire activity data for the emissions scenarios (UK)

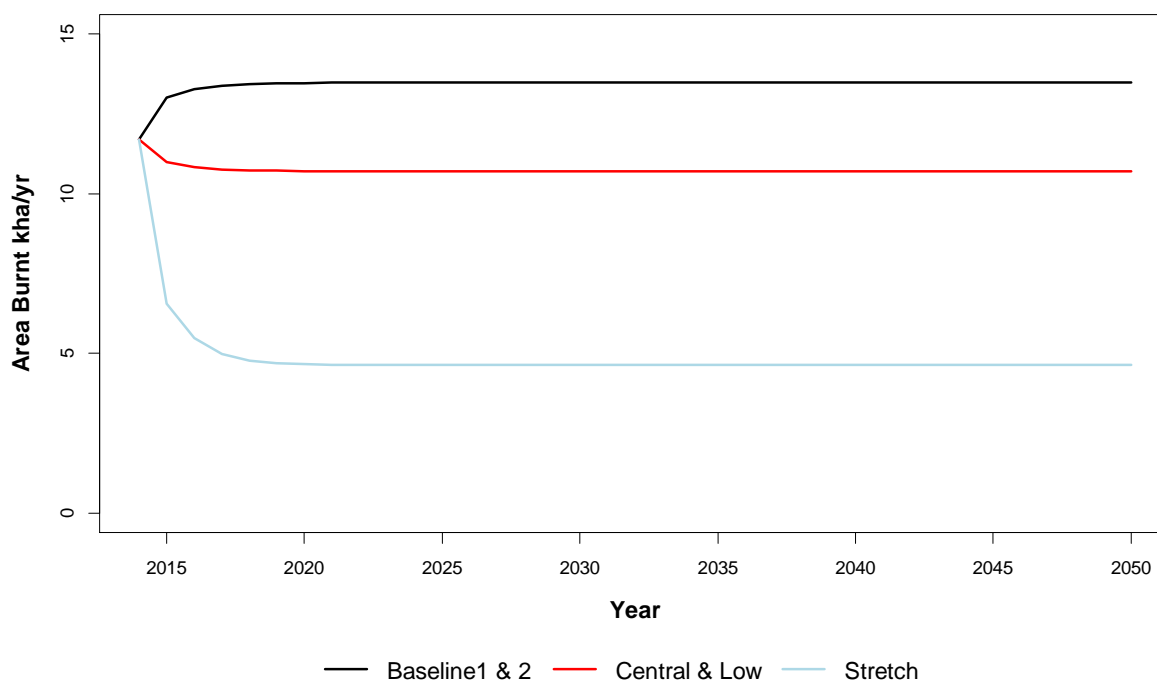


Figure 4: Grassland wildfire activity data for the emissions scenarios (UK)

### 3.3 Land Use Change (LUC)

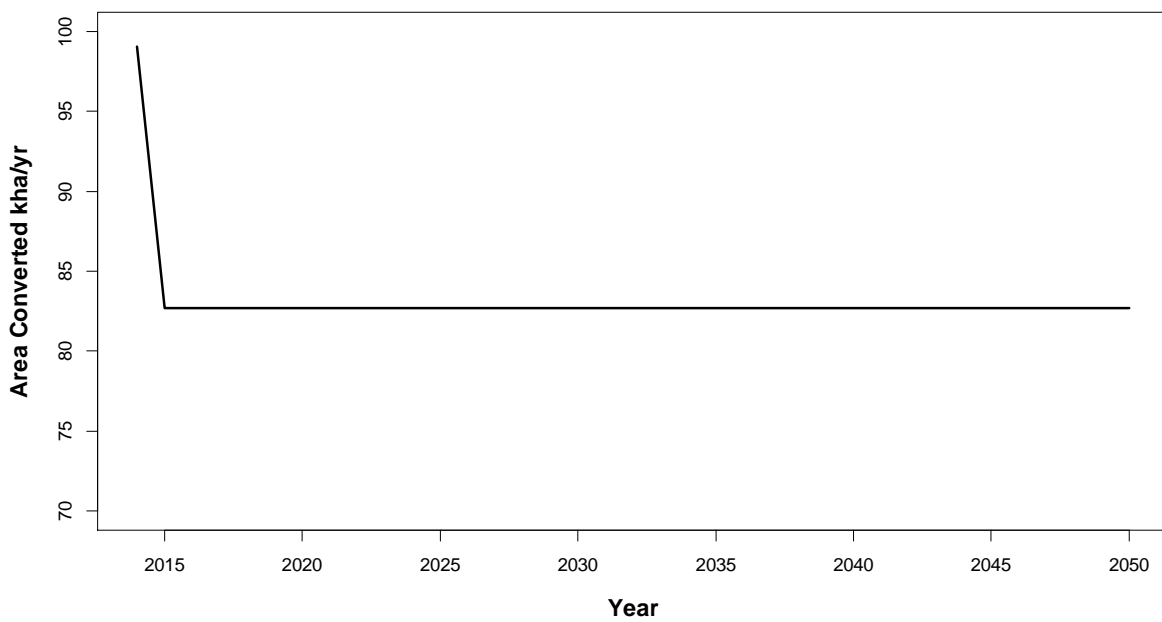
This activity is driven by the areas of annual land use change between Cropland, Grassland and Settlement (Figure 5, Figure 6 and Figure 7), affecting carbon stocks of biomass and soils, and N mineralisation to N<sub>2</sub>O as a result of carbon stock losses from land use change. Conversion to and from Forest Land are taken into account within the Afforestation and Deforestation activities.

The net Cropland area is assumed to remain stable for all DAs except Wales (where continuing permanent conversion of grassland to cropland is assumed, based on advice from Welsh Government experts). However, it is assumed that there is a constant level of cropland-grassland conversion and vice-versa across all projection scenarios (with no net change in areas). This reflects agricultural land rotation and is based on the average annual conversion each way 1990-2009 for each country (47.70 kha in England, 14.61 kha in Scotland, 4.75 kha in Wales and 3.66 kha in Northern Ireland each way).

Conversion to Settlement is based on different house-building scenarios (see Annex 1) and is assumed to be from Grassland (after taking Deforestation areas into account). The current inventory methodology does not capture the steep decline in construction (conversion to Settlement) after the 2008 financial crisis, hence the projected rates of conversion to Settlement are lower than the 2013 rates.

- In the *Baseline 1* and *Baseline 2* scenarios decadal averages (2000-2009) are used for each land use transition except in the following cases: in Scotland, Wales and Northern Ireland the annual area converted to Settlement is 70% of the *Central* scenario annual area; and a Grassland to Cropland conversion rate of 5.5 kha/y for Wales is assumed in addition to the rotation rate.

- In the *Central* scenario decadal averages (2000-2009) are used for each land use transition except in the following cases: conversion to Settlement assumes that house building is sufficient to meet the projected housing demand in each DA; and a Grassland to Cropland conversion rate of 10 kha/y for Wales is assumed in addition to the rotation rate.
- The *Low* and *Stretch* scenarios are the same as the *Baseline 1* scenario except that the annual area converted to Settlement is 50% of the *Central* scenario annual area for all countries.



All scenarios are the same

Figure 5: Activity data for Cropland to Grassland land use change for the emissions scenarios (UK)

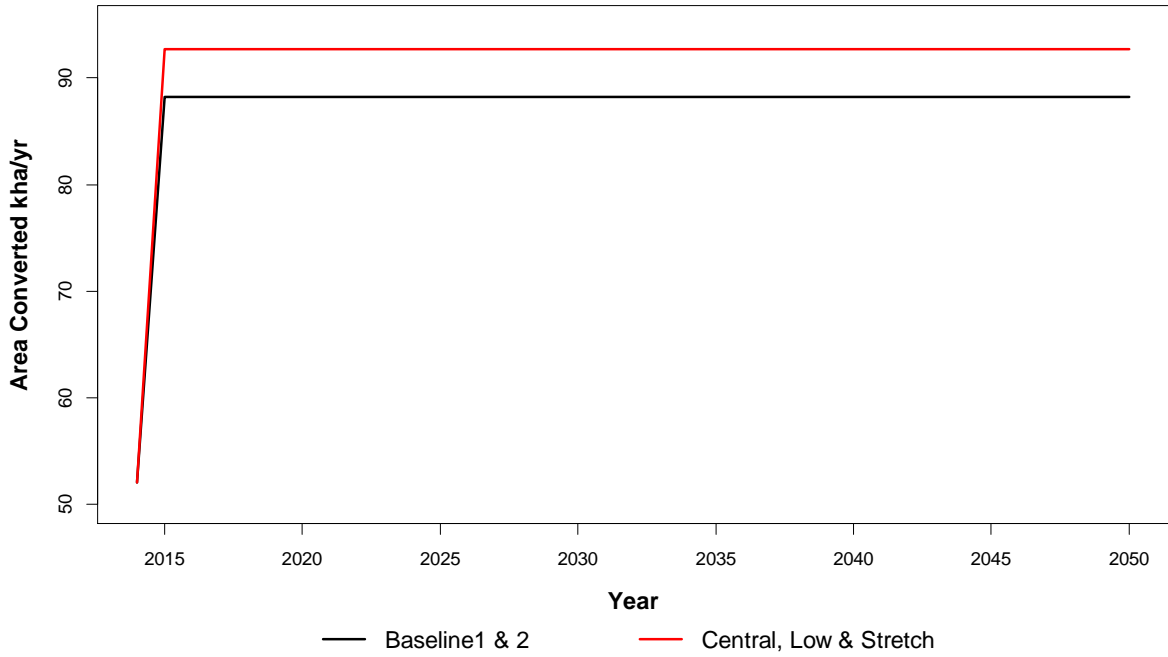


Figure 6: Activity data for Grassland to Cropland land use change for the emissions scenarios (UK)

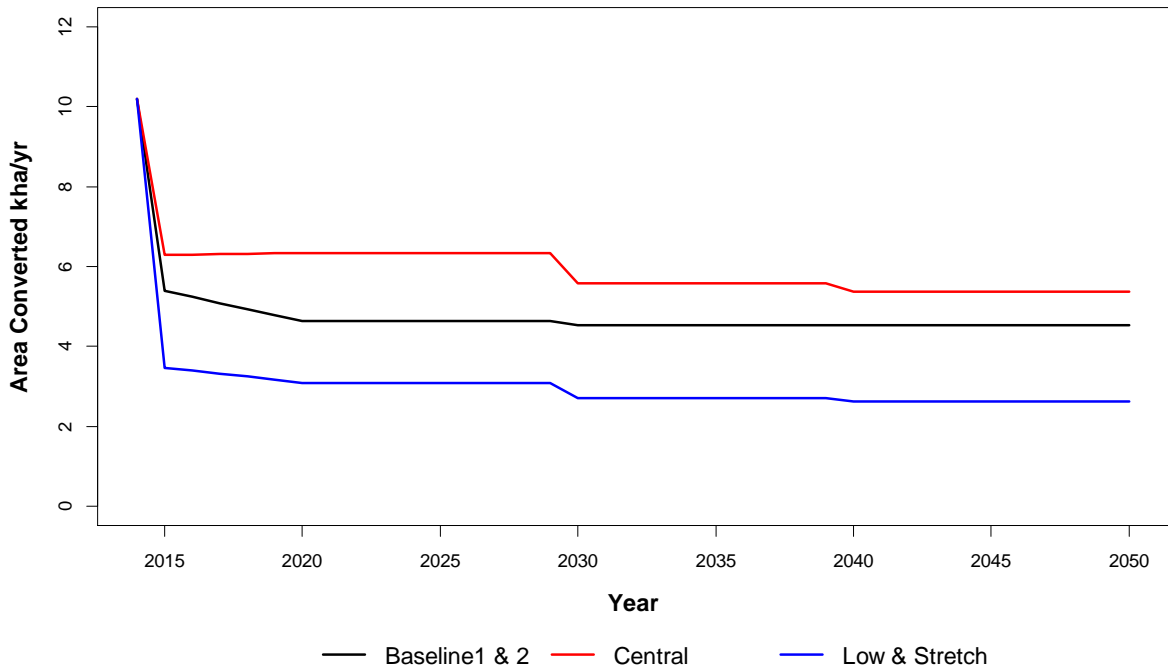


Figure 7: Activity data for Grassland to Settlement land use change for the emissions scenarios (UK)

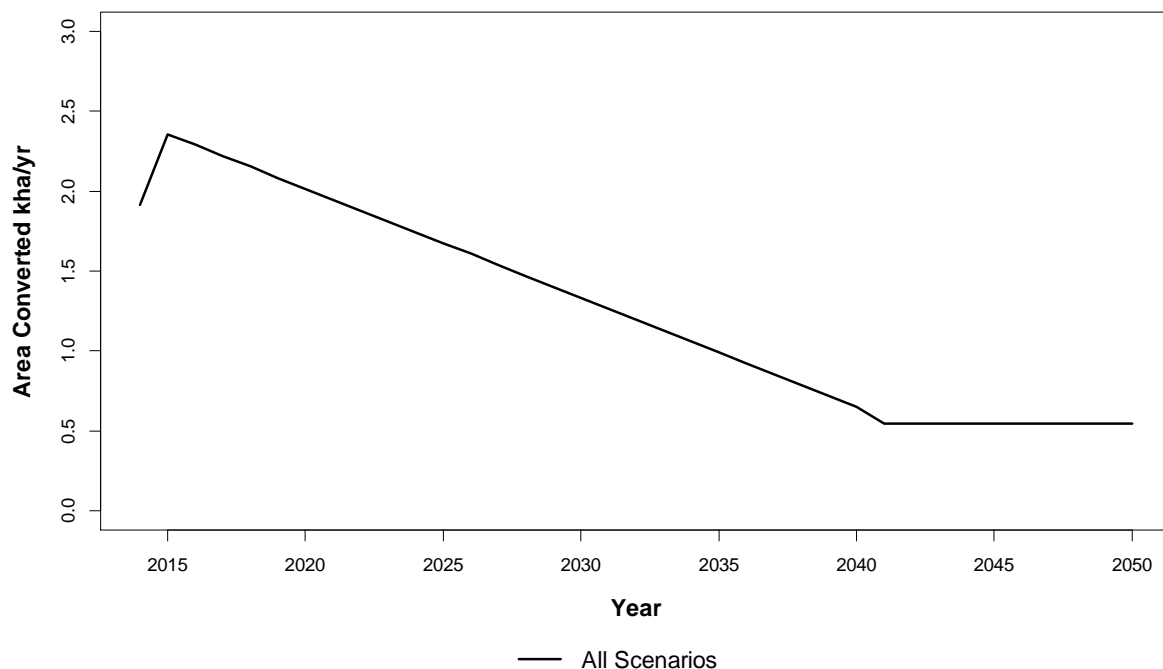
### 3.4 Deforestation

This activity is driven by the area of forest annually converted to other land uses (Figure 8). It affects forest carbon stocks, the Harvested Wood Products pool and GHG emissions from biomass burning (CO<sub>2</sub>, N<sub>2</sub>O, and CH<sub>4</sub>).

Rather than having three levels of deforestation ( $\pm 30\%$  around a central estimate) as in previous projection reports, this report uses a single deforestation level based on the most recent five years' (2010-2014) reported deforestation. This level is projected forward from 2015 and declines to a low, constant, rate from 2040 onwards. The reasons for the change are:

- It is difficult to assign deforestation levels to specific afforestation/emissions scenarios;
- Although policies affecting deforestation rates<sup>7</sup> are mentioned in the UK's LULUCF Action Plan and the 2011 Carbon Plan, they are not associated with explicit estimates of potential abatement and the impact of their implementation cannot be quantified;

The post-2040 deforestation rate assumes open habitat restoration programmes have been completed for all DAs, wind-farm development has no further impact on forested areas after this date, the UK Forestry Act and EIA (forestry) regulations continue to provide protection from conversion to cropland or grassland and that deforestation reflects historical rates of conversion to settlement only.



**Figure 8 : Deforestation rate for all emissions scenarios (UK). Note that a disaggregation of these data by Devolved Administration is provided in Annex 3.**

<sup>7</sup> The Scottish Government policy on 'the Control of Woodland Removal' and the Forestry Commission's Open Habitats policy (When to convert woods and forests to open habitats in England)

### 3.5 Cropland and Grassland management

Cropland Management activity is driven by differences between land management on cropland, mainly the balance between perennial and annual crops, manure inputs and crop residue inputs. Grassland management activity is driven by within grassland changes, e.g. from non-shrubby to shrubby grassland.

- For the *Baseline 1* and *Baseline 2* scenarios pre-2009 decadal average rates of management inputs are used (Table 3).
- For the *Central*, *Low* and *Stretch* scenarios, levels of management activity remain at 2014 levels until 2050.
- For Grassland Management the time series has been stable since 1999 so there is no difference between the scenarios.
- Cropland and grassland areas are adjusted over time to account for land use change, so the numbers shown in Table 3 are for the initial values.



**Table 3: Activity data for Cropland Management scenarios**

|                              |  | England/ Wales/<br>Northern Ireland  |                                      | Scotland            |                          |
|------------------------------|--|--------------------------------------|--------------------------------------|---------------------|--------------------------|
|                              |  | Baseline 1<br>and 2                  | Central/ Low/<br>Stretch             | Baseline 1<br>and 2 | Central/ Low/<br>Stretch |
| <b>Soil carbon stocks</b>    | % crop area receiving mineral N fertiliser | 89.8                                 | 92                                   | 95.8                | 97                       |
|                              | % crop area receiving Farmyard Manure      | 17.8                                 | 21                                   | 29                  | 30                       |
|                              | Tillage: full inversion % area             | 56                                   | 56                                   | 88.9                | 81                       |
|                              | Tillage: minimum tillage % area            | 40                                   | 40                                   | 11.1                | 11                       |
|                              | Tillage: None or direct seeding % area     | 4                                    | 4                                    | 0                   | 8                        |
|                              | % crop residue removed                     | 70.04 (E)<br>79.46 (W)<br>79.53 (NI) | 73.02 (E)<br>81.13 (W)<br>80.59 (NI) | 75.96               | 76.85                    |
|                              | % land manured                             | 8.79                                 | 12.25                                | 8.79                | 12.25                    |
|                              | % crop area with residue/stubble           | -                                    | -                                    | 38.6                | 40.9                     |
|                              | % crop area with bare fallow               | -                                    | -                                    | 14.9                | 19.3                     |
|                              | % crop area with cover crop                | -                                    | -                                    | 2.1                 | 3.2                      |
|                              | % crop area with autumn/winter crop        | -                                    | -                                    | 44.4                | 36.6                     |
| <b>Biomass carbon stocks</b> | Annual change in biomass carbon, tC        | -1805 (E)<br>-77 (W)<br>-87 (NI)     | 1106 (E)<br>-153 (W)<br>238 (NI)     | -9                  | 132                      |

### 3.6 Agricultural drainage

It is assumed that no new areas of agricultural organic soils have been drained since 2009 (or since 1990) so the area drained remains steady throughout the projected time series.

### 3.7 Peat extraction

Projections of emissions from peat extraction and extraction site restoration have been dealt with in more detail in this report (previously they were held steady). The area covered by the activity is small

compared with other land use activities (Figure 9). Even after extraction ceases, this area may not be converted to another land use (so it will remain in the Wetland category).

- For the *Baseline 1* and *Baseline 2* scenarios the area drained for peat extraction remains at 2009 levels for all DAs, except those in England with planned expiry dates, where restoration to target habitats is assumed to have a 50% success rate. The volume of horticultural peat extracted (and decomposing) each year is projected to be fixed at the decadal average for 2000-2009.
- For the *Central* scenario the area drained for peat extraction remains at 2014 levels for all DAs, except those in England with planned expiry dates, where restoration to target habitats is assumed to have a 50% success rate. The volume of horticultural peat extracted each year is projected to be fixed at the decadal average 2003-2014 for Scotland and Northern Ireland, but in England there is a projected 50% drop in volume production by 2030 on sites still in operation.
- For the *Low* scenario it is assumed that there is a cessation of all peat production with 50% successful site restoration by 2050 for sites in Scotland and Northern Ireland. In England, extraction is the same as in the Central scenario, with 100% restoration success to target habitats. The volume of horticultural peat extracted each year is projected to be fixed at the decadal average 2003-2014 for Northern Ireland, to decline to zero by 2050 for Scotland and drop to zero by 2030 for England.
- For the *Stretch* scenario, it is assumed that there is cessation of all peat extraction with 100% successful restoration in all countries by 2030, with a concomitant reduction in horticultural peat volume.

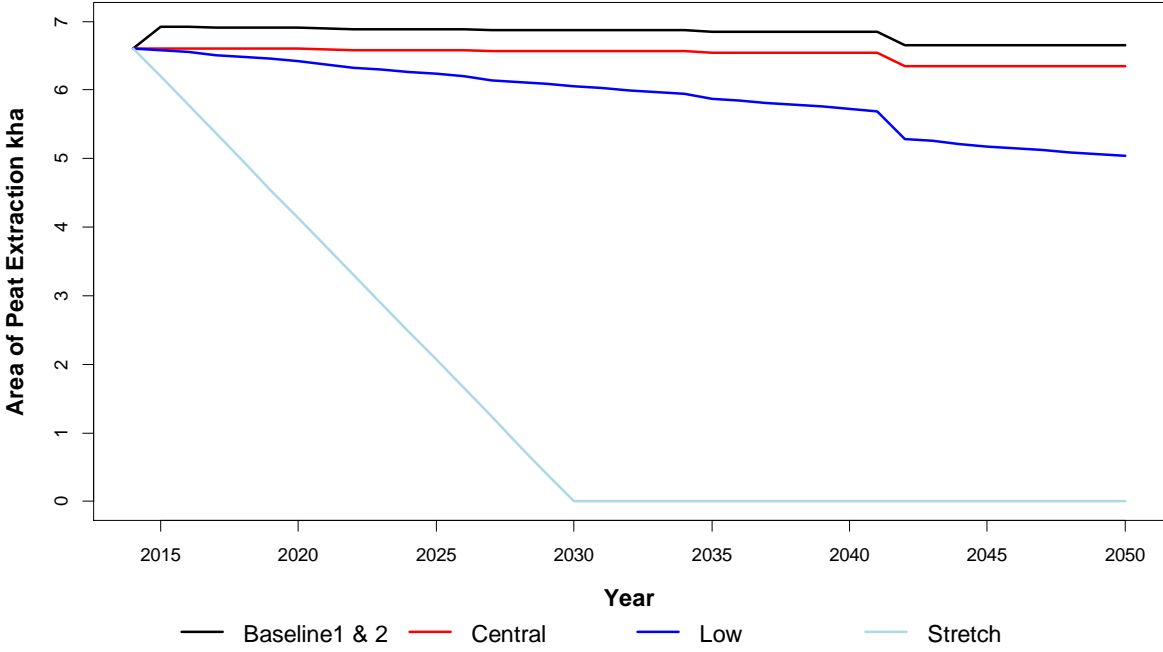


Figure 9: Peat extraction areas over time for all scenarios.

## 4 Projections 2015-2050

A summary of the results is given here. Detailed emission estimates by activity, country and scenario are available for download from the NAEI website<sup>8</sup>:

Table 4 shows the projected distributions of land use areas in the UK between 2015 and 2050 - the areas for each Devolved Administration are reported in Annex 2. The areas of land in each category were produced via extrapolation of the land use change matrices listed in the National Inventory Report (Brown *et al.*, 2016). These land use change matrices rely largely on Countryside Survey datasets and may therefore differ from other national datasets.

There is greatest land use change in the *Stretch* emissions scenario at the UK and DA level (due to increases in forest area and accompanying losses in grassland area). Wales shows the greatest land use changes under all scenarios, due to the assumption of additional grassland-cropland conversion in Wales. Grassland is lost at the expense of other land use types under all scenarios.

---

<sup>8</sup> [http://naei.defra.gov.uk/reports/reports?report\\_id=927](http://naei.defra.gov.uk/reports/reports?report_id=927)

Table 4: Land use areas 2014-2050 for the United Kingdom (24,418 kha)<sup>9</sup>

| <i>Emission scenario</i> | <i>Land use category</i> | <i>2014 area, kha</i> | <i>2020 area, kha</i> | <i>2030 area, kha</i> | <i>2040 area, kha</i> | <i>2050 area, kha</i> | <i>% of land area in 2014</i> | <i>% of land area in 2050</i> |
|--------------------------|--------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-------------------------------|-------------------------------|
| <b>Central</b>           | Forest land              | 3107                  | 3165                  | 3155                  | 3152                  | 3154                  | 13%                           | 13%                           |
|                          | Cropland                 | 5046                  | 5106                  | 5206                  | 5306                  | 5406                  | 21%                           | 22%                           |
|                          | Grassland                | 14281                 | 14129                 | 13954                 | 13792                 | 13630                 | 58%                           | 56%                           |
|                          | Wetland                  | 174                   | 174                   | 174                   | 174                   | 174                   | 1%                            | 1%                            |
|                          | Settlement               | 1962                  | 1998                  | 2062                  | 2119                  | 2173                  | 8%                            | 9%                            |
|                          | Other                    | 291                   | 307                   | 319                   | 327                   | 335                   | 0%                            | 0%                            |
| <b>Baseline 1</b>        | Forest land              | 3107                  | 3147                  | 3193                  | 3249                  | 3308                  | 13%                           | 14%                           |
|                          | Cropland                 | 5046                  | 5079                  | 5134                  | 5189                  | 5244                  | 21%                           | 21%                           |
|                          | Grassland                | 14281                 | 14180                 | 14027                 | 13871                 | 13711                 | 58%                           | 56%                           |
|                          | Wetland                  | 174                   | 174                   | 174                   | 174                   | 174                   | 1%                            | 1%                            |
|                          | Settlement               | 1962                  | 1992                  | 2037                  | 2079                  | 2122                  | 8%                            | 9%                            |
|                          | Other                    | 291                   | 299                   | 305                   | 309                   | 312                   | 0%                            | 0%                            |
| <b>Baseline 2</b>        | Forest land              | 3107                  | 3118                  | 3111                  | 3111                  | 3115                  | 13%                           | 13%                           |
|                          | Cropland                 | 5046                  | 5079                  | 5134                  | 5189                  | 5244                  | 21%                           | 21%                           |
|                          | Grassland                | 14281                 | 14206                 | 14104                 | 13999                 | 13891                 | 58%                           | 57%                           |
|                          | Wetland                  | 174                   | 174                   | 174                   | 174                   | 174                   | 1%                            | 1%                            |
|                          | Settlement               | 1962                  | 1994                  | 2042                  | 2089                  | 2135                  | 8%                            | 9%                            |
|                          | Other                    | 291                   | 299                   | 305                   | 309                   | 312                   | 0%                            | 0%                            |
| <b>Low</b>               | Forest land              | 3107                  | 3197                  | 3341                  | 3488                  | 3613                  | 13%                           | 15%                           |
|                          | Cropland                 | 5046                  | 5106                  | 5206                  | 5306                  | 5406                  | 21%                           | 22%                           |
|                          | Grassland                | 14281                 | 14110                 | 13830                 | 13559                 | 13304                 | 58%                           | 54%                           |
|                          | Wetland                  | 174                   | 174                   | 174                   | 174                   | 174                   | 1%                            | 1%                            |
|                          | Settlement               | 1962                  | 1978                  | 2001                  | 2019                  | 2038                  | 8%                            | 8%                            |
|                          | Other                    | 291                   | 307                   | 319                   | 327                   | 335                   | 0%                            | 0%                            |
| <b>Stretch</b>           | Forest land              | 3107                  | 3223                  | 3512                  | 3809                  | 4059                  | 13%                           | 17%                           |
|                          | Cropland                 | 5046                  | 5156                  | 5256                  | 5356                  | 5456                  | 21%                           | 22%                           |
|                          | Grassland                | 14281                 | 13922                 | 13512                 | 13103                 | 12730                 | 58%                           | 52%                           |
|                          | Wetland                  | 174                   | 174                   | 174                   | 174                   | 174                   | 1%                            | 1%                            |
|                          | Settlement               | 1962                  | 1988                  | 2001                  | 2010                  | 2022                  | 8%                            | 8%                            |
|                          | Other                    | 291                   | 322                   | 334                   | 342                   | 349                   | 0%                            | 0%                            |

<sup>9</sup> The Forest land areas reported here include only forest areas meeting the National Forest Inventory definition of woodland (>0.5 ha). Total tree cover, including small woods between 0.1 and 0.5 ha in size, has been included as part of the land use matrix and in calculations of emissions and removals from Forest Land.

Table 5, Table 6, Table 7 and Table 8 show projected emissions of CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O and total CO<sub>2</sub> equivalents for the LULUCF sector for the UK (similar summary numbers for each DA are included in Annex 2, and the full dataset is available for download with this report from the NAEI website). Graphs of greenhouse gas emissions at the UK and DA level for the whole LULUCF sector and for the individual land use categories are shown in Figure 10, Figure 12, Figure 13, Figure 14 and Figure 15. These graphs show the reported inventory estimates for the years 1990 to 2014, and projected data for 2015-2050.

At the UK level, (**Error! Reference source not found.**) the net CO<sub>2</sub> equivalent emissions / removals from all parts of the LULUCF sector combine to produce an increasing net carbon sink (increasing net removals) between 1990 and 2014. This trend continues until the 2020s, when the trend reverses, driven by the decreasing net removals in the Forest Land category. The different scenarios start to diverge at this point, with the *Central* and *Baseline* scenarios continuing towards zero (stabilising between -2.5 and -4.0 CO<sub>2</sub>e in the 2040s). The *Low* and *Stretch* scenarios do not follow as steep a gradient, with the *Low* scenario stabilising at around -7.0 Mt CO<sub>2</sub>e in 2040, and the *Stretch* scenario stabilising by the late 2030s and then becoming an increasing sink during the 2040s. The main driver of the trend in net total LULUCF emissions / removals over the projected time series is the reduction in the forestry net removals (this varies between scenarios), although the decline in settlement emissions and the reversal in the declining trend in cropland emissions also contribute.

Forestry is projected to be a net sink under all scenarios. It is relatively stable between 1990 and 2020, but then shows a net decrease in sink strength under all scenarios. This decrease continues until 2040 for the *Central* and *Baseline* scenarios, after which it stabilises. For the *Low* and *Stretch* scenarios, the decreasing trend stabilises earlier (during the 2030s) and then the net sink strength starts to increase again in the mid-2040s. The scenarios are driven by the projected planting rates and management, with the biggest projected sink coming from the *Stretch* scenario with high planting rates, and the smallest sink coming from the *Baseline* and *Central* scenarios with the most conservative planting rates. The decrease in the sink throughout the time series is due to large numbers of trees being thinned, or reaching maturity (some 35-50 years since planting) and hence being harvested, and a historically low planting rate during the 1990s and 2000s.

Cropland is projected to be a slowly increasing source post-2015, mostly driven by land use change to Cropland. Grassland is projected to be a slowly increasing sink. There is little difference between the scenarios for either of these land use categories as the differences in the scenario land use change assumptions are small.

Although the scenario assumptions for the Wetlands category have been revised this year, the scale of changes is small compared to the other land use categories. Figure 11 shows the changes in net emissions on a larger scale graph.

Emissions from (land use change to) Settlements are projected to decrease over the time period under all scenarios. Although Settlement areas are predicted to increase under all scenarios, the rate of change of land to Settlement (and hence emissions from land use change) is predicted to be less than historic levels.

Harvested Wood Products (HWPs) are projected to be a small sink over the period 2015 to 2050 with some inter-annual variation. The trend is driven by the balance between deforestation rates, thinning

and felling regimes and the expected lifetime of the HWP. There is little difference between the scenarios as the majority of harvest originates from trees planted before the projection time period.

The overall patterns of projected emissions and removals for England and Scotland (Figure 12 & Figure 13) are similar to the UK totals. Wales (Figure 14) is projected to become a net LULUCF GHG source by 2050 under all but the *Stretch* scenario, as it has a smaller forest sink and the increase in the cropland source is much larger (driven by a higher rate of conversion of grassland to cropland as described in section 3.3). Northern Ireland (Figure 15) is projected to be a net LULUCF GHG source for much of the time period, although under the *Stretch* and *Low* scenarios it is projected to become a small net sink by the 2040s. This is mainly driven by the trend in emissions from Settlements, which peak in 2015 and then decrease to 2050.

Carbon dioxide, arising from soil carbon stock changes, is the main greenhouse gas associated with LULUCF (Figure 16), although N<sub>2</sub>O emissions also make a significant contribution when their Global Warming Potential of 298 is taken into account. These N<sub>2</sub>O emissions arise from forest fertilisation, forest drainage, soil N mineralisation following land use change and from biomass burning. Methane (CH<sub>4</sub>) emissions (Global Warming Potential of 25) arising from biomass burning are included in the projections but they do not make a significant contribution to the overall totals.

There have been some significant changes to activity data and methods used for estimating the LULUCF emissions and removals since the previous inventory. These differences are shown at the UK level in Figure 17 by comparing the *Central* projections based on the 2014 inventory and the *Mid* projections based on the 2013 inventory. These recalculations and their impact on the inventory up to 2014 are described in chapter 6 of the National Inventory Report (Brown *et al.* 2016).

The forestry projections differ from the forestry numbers published in the 1990-2014 inventory because the input data to the forest carbon accounting model was based on the National Forest Inventory dataset (2011-2015) rather than the National Inventory of Woodland and Trees (1995-99) and, for the first time, includes woodlands between 0.1 and 0.5 hectares in area. This had the effect of increasing the forest area of the UK, and hence carbon stocks.

The emission factor used for estimating emissions from Grassland on drained organic soils was corrected (the Cropland emission factor rather than the Grassland emission factor was used in error last year).

Other changes to the methodology are a result of continuous improvement of the inventory.

- Carbon stock changes in biomass from cropland management and grassland management are reported for the first time.
- The land use change soils model calculation of deforestation fluxes was corrected: these affected emissions and removals from deforestation during the inventory period.

The projection scenarios have been revised to align them with specific policy needs. Broadly speaking, the *Central* scenario is equivalent to the “High emissions” scenario used in previous years, the *Baseline 1* and *2* scenarios are equivalent to the old “Business as Usual” scenario, the *Low* scenario is equivalent to the old “Mid emissions” scenario and the *Stretch* scenario is equivalent to the old “Low emissions” scenario.

**Table 5: LULUCF emissions and removals of CO<sub>2</sub> 1990-2050**

| Scenario   | Country | 1990                                     | 2014                                     | 2020                                     | 2030                                     | 2040                                     | 2050                                     |
|------------|---------|--|--|--|--|--|--|
|            |         | emissions/removals<br>Gg CO <sub>2</sub> | emissions/removals<br>Gg CO <sub>2</sub> | emissions/removals<br>Gg CO <sub>2</sub> | emissions/removals<br>Gg CO <sub>2</sub> | emissions/removals<br>Gg CO <sub>2</sub> | emissions/removals<br>Gg CO <sub>2</sub> |
| Central    | UK      | -3743                                    | -12602                                   | -13478                                   | -9612                                    | -5666                                    | -3643                                    |
| Baseline 1 | UK      | -3743                                    | -12602                                   | -13526                                   | -10002                                   | -6346                                    | -4973                                    |
| Baseline 2 | UK      | -3743                                    | -12602                                   | -13513                                   | -9812                                    | -5648                                    | -3666                                    |
| Low        | UK      | -3743                                    | -12602                                   | -13603                                   | -10613                                   | -8232                                    | -8216                                    |
| Stretch    | UK      | -3743                                    | -12602                                   | -13760                                   | -11187                                   | -10060                                   | -11915                                   |

**Table 6: LULUCF emissions and removals of CH<sub>4</sub> 1990-2050**

| Scenario   | Country | 1990                                     | 2014                                     | 2020                                     | 2030                                     | 2040                                     | 2050                                     |
|------------|---------|--|--|--|--|--|--|
|            |         | emissions/removals<br>Gg CH <sub>4</sub> | emissions/removals<br>Gg CH <sub>4</sub> | emissions/removals<br>Gg CH <sub>4</sub> | emissions/removals<br>Gg CH <sub>4</sub> | emissions/removals<br>Gg CH <sub>4</sub> | emissions/removals<br>Gg CH <sub>4</sub> |
| Central    | UK      | 0.83                                     | 1.57                                     | 1.57                                     | 1.32                                     | 0.99                                     | 0.96                                     |
| Baseline 1 | UK      | 0.83                                     | 1.57                                     | 1.45                                     | 1.18                                     | 0.85                                     | 0.81                                     |
| Baseline 2 | UK      | 0.83                                     | 1.57                                     | 1.45                                     | 1.18                                     | 0.85                                     | 0.81                                     |
| Low        | UK      | 0.83                                     | 1.57                                     | 1.57                                     | 1.32                                     | 0.99                                     | 0.96                                     |
| Stretch    | UK      | 0.83                                     | 1.57                                     | 1.13                                     | 0.85                                     | 0.52                                     | 0.47                                     |

**Table 7: LULUCF emissions and removals of N<sub>2</sub>O 1990-2050**

| Scenario   | Country | 1990                                      | 2014                                      | 2020                                      | 2030                                      | 2040                                      | 2050                                      |
|------------|---------|---|---|---|---|---|---|
|            |         | emissions/removals<br>Gg N <sub>2</sub> O | emissions/removals<br>Gg N <sub>2</sub> O | emissions/removals<br>Gg N <sub>2</sub> O | emissions/removals<br>Gg N <sub>2</sub> O | emissions/removals<br>Gg N <sub>2</sub> O | emissions/removals<br>Gg N <sub>2</sub> O |
| Central    | UK      | 5.62                                      | 3.72                                      | 3.60                                      | 3.80                                      | 3.78                                      | 3.62                                      |
| Baseline 1 | UK      | 5.62                                      | 3.72                                      | 3.53                                      | 3.59                                      | 3.53                                      | 3.39                                      |
| Baseline 2 | UK      | 5.62                                      | 3.72                                      | 3.52                                      | 3.58                                      | 3.53                                      | 3.38                                      |
| Low        | UK      | 5.62                                      | 3.72                                      | 3.55                                      | 3.64                                      | 3.57                                      | 3.40                                      |
| Stretch    | UK      | 5.62                                      | 3.72                                      | 3.52                                      | 3.62                                      | 3.55                                      | 3.39                                      |

**Table 8: LULUCF emissions and removals of CO<sub>2</sub> equivalents 1990-2050 (1 Mt CO<sub>2</sub>eq = 1000 Gg CO<sub>2</sub>eq)**

| Scenario   | Country | 1990  | 2014  | 2020  | 2030  | 2040  | 2050  |
|------------|---------|---|---|---|---|---|---|
|            |         | emissions/removals<br>Gg CO <sub>2</sub> eq | emissions/removals<br>Gg CO <sub>2</sub> eq | emissions/removals<br>Gg CO <sub>2</sub> eq | emissions/removals<br>Gg CO <sub>2</sub> eq | emissions/removals<br>Gg CO <sub>2</sub> eq | emissions/removals<br>Gg CO <sub>2</sub> eq |
| Central    | UK      | -2048                                       | -11453                                      | -12365                                      | -8446                                       | -4516                                       | -2539                                       |
| Baseline 1 | UK      | -2048                                       | -11453                                      | -12439                                      | -8903                                       | -5271                                       | -3944                                       |
| Baseline 2 | UK      | -2048                                       | -11453                                      | -12427                                      | -8716                                       | -4575                                       | -2640                                       |
| Low        | UK      | -2048                                       | -11453                                      | -12507                                      | -9495                                       | -7144                                       | -7178                                       |
| Stretch    | UK      | -2048                                       | -11453                                      | -12683                                      | -10087                                      | -8988                                       | -10892                                      |

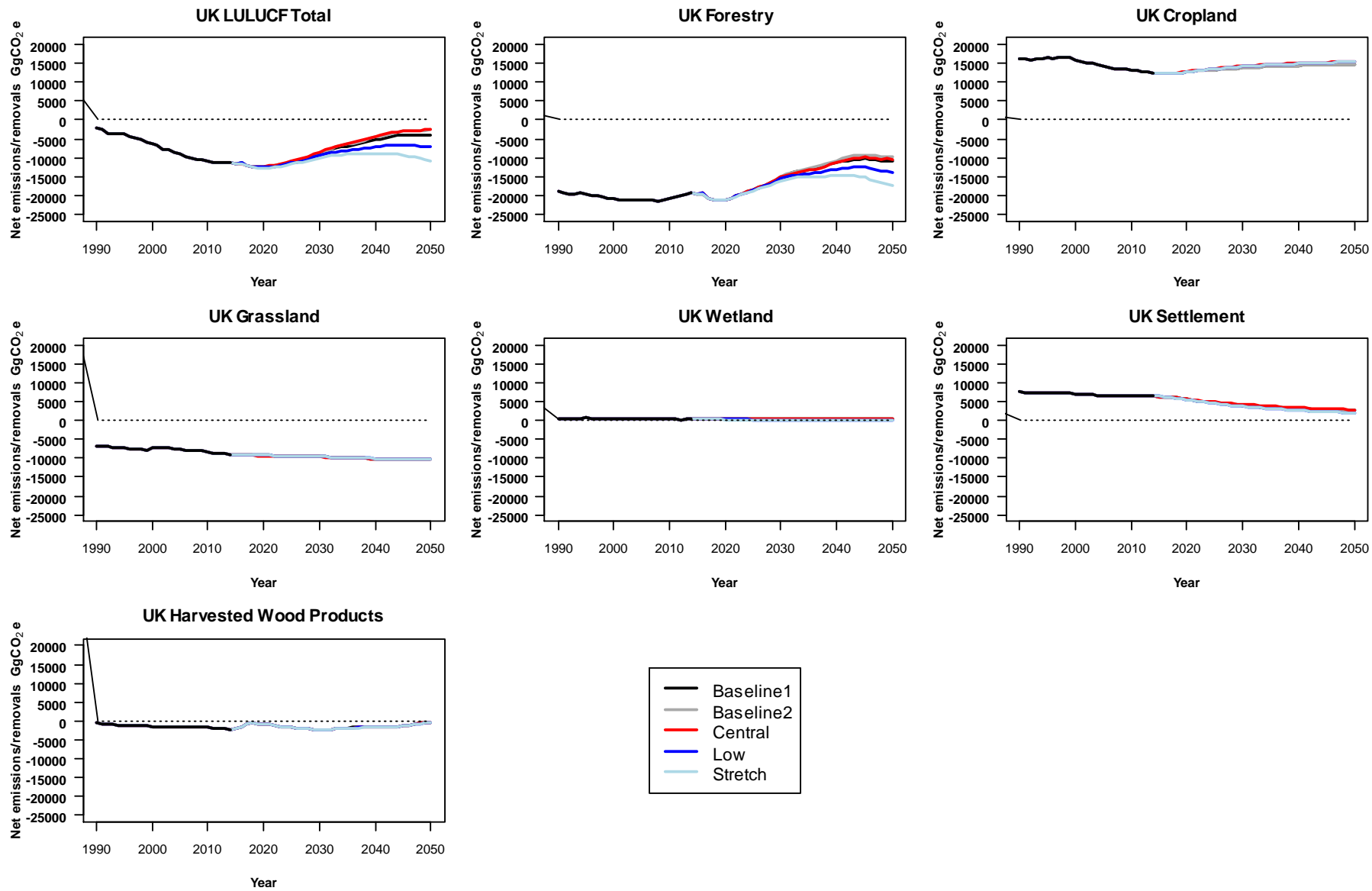


Figure 10: UK LULUCF CO<sub>2</sub> equivalent emissions scenarios 1990-2050. The individual graphs refer to LULUCF reporting categories; see Section 3 text for description of what is reported in these categories. (1 Mt CO<sub>2</sub>eq = 1000 Gg CO<sub>2</sub>eq)



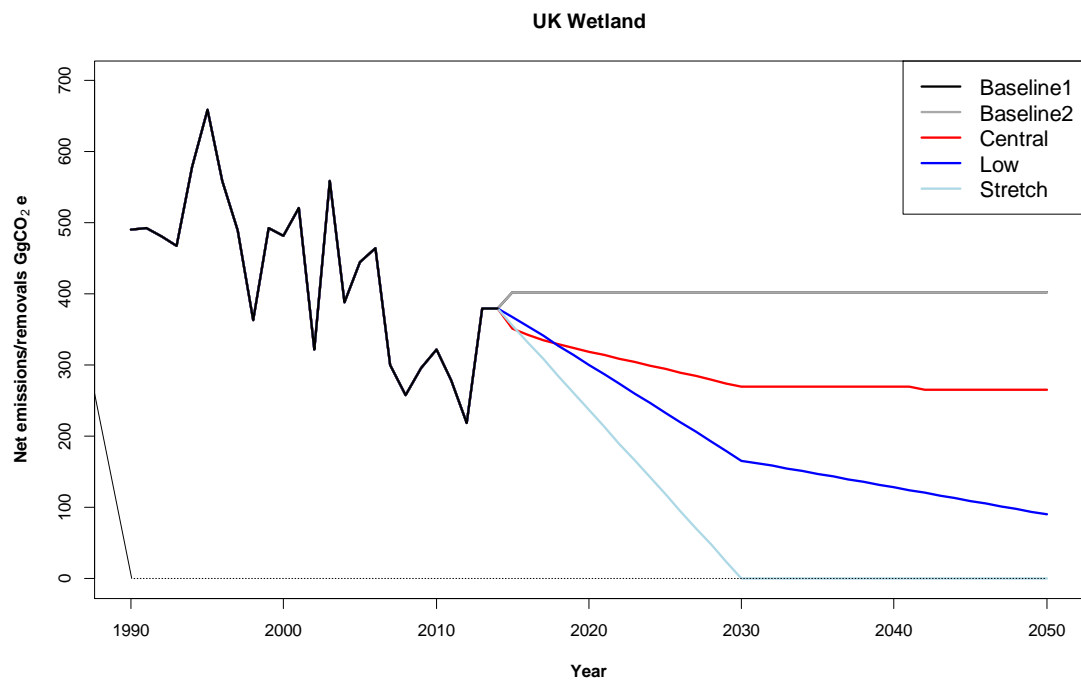


Figure 11: Net emissions from Wetlands under all scenarios (shown on larger scale for clarity) (1 Mt CO<sub>2</sub>eq = 1000 Gg CO<sub>2</sub>eq).

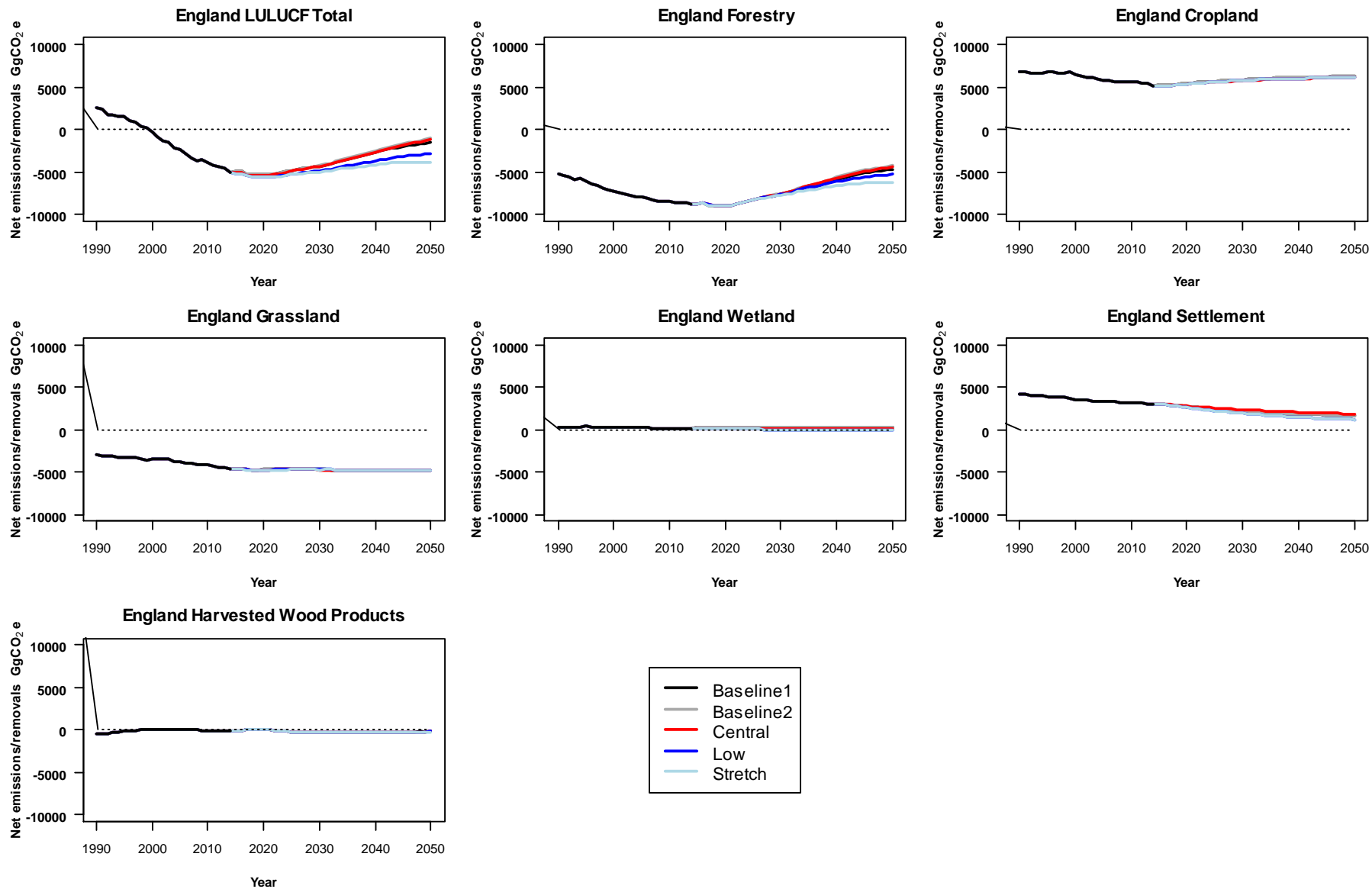


Figure 12: England LULUCF CO<sub>2</sub> equivalent emissions scenarios 1990-2050. The individual graphs refer to LULUCF reporting categories; see Section 3 text for description of what is reported in these categories. (1 Mt CO<sub>2</sub>eq = 1000 Gg CO<sub>2</sub>eq)

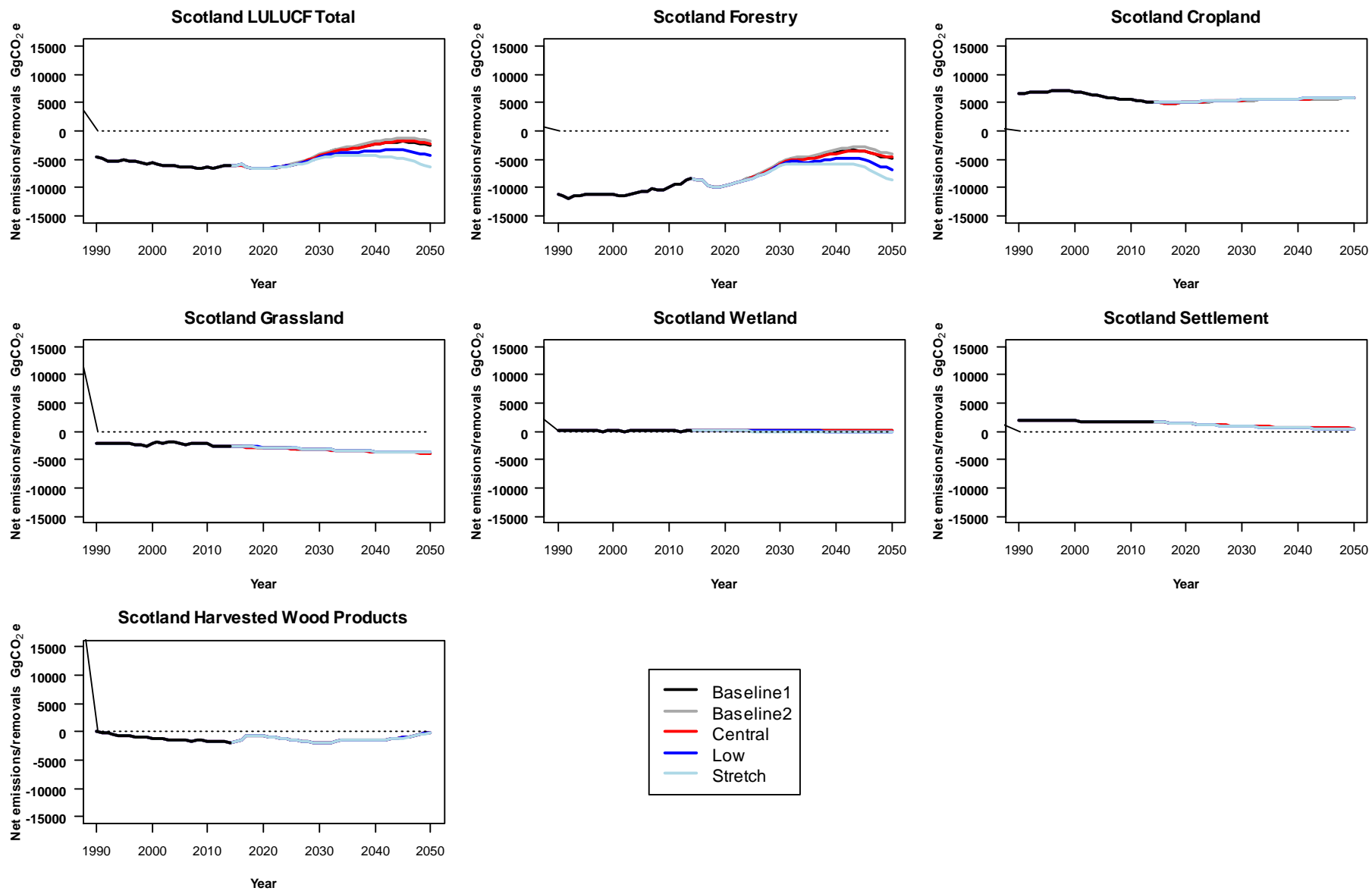


Figure 13: Scotland LULUCF CO<sub>2</sub> equivalent emissions scenarios 1990-2050. The individual graphs refer to LULUCF reporting categories; see Section 3 text for description of what is reported in these categories. (1 Mt CO<sub>2</sub>eq = 1000 Gg CO<sub>2</sub>eq)

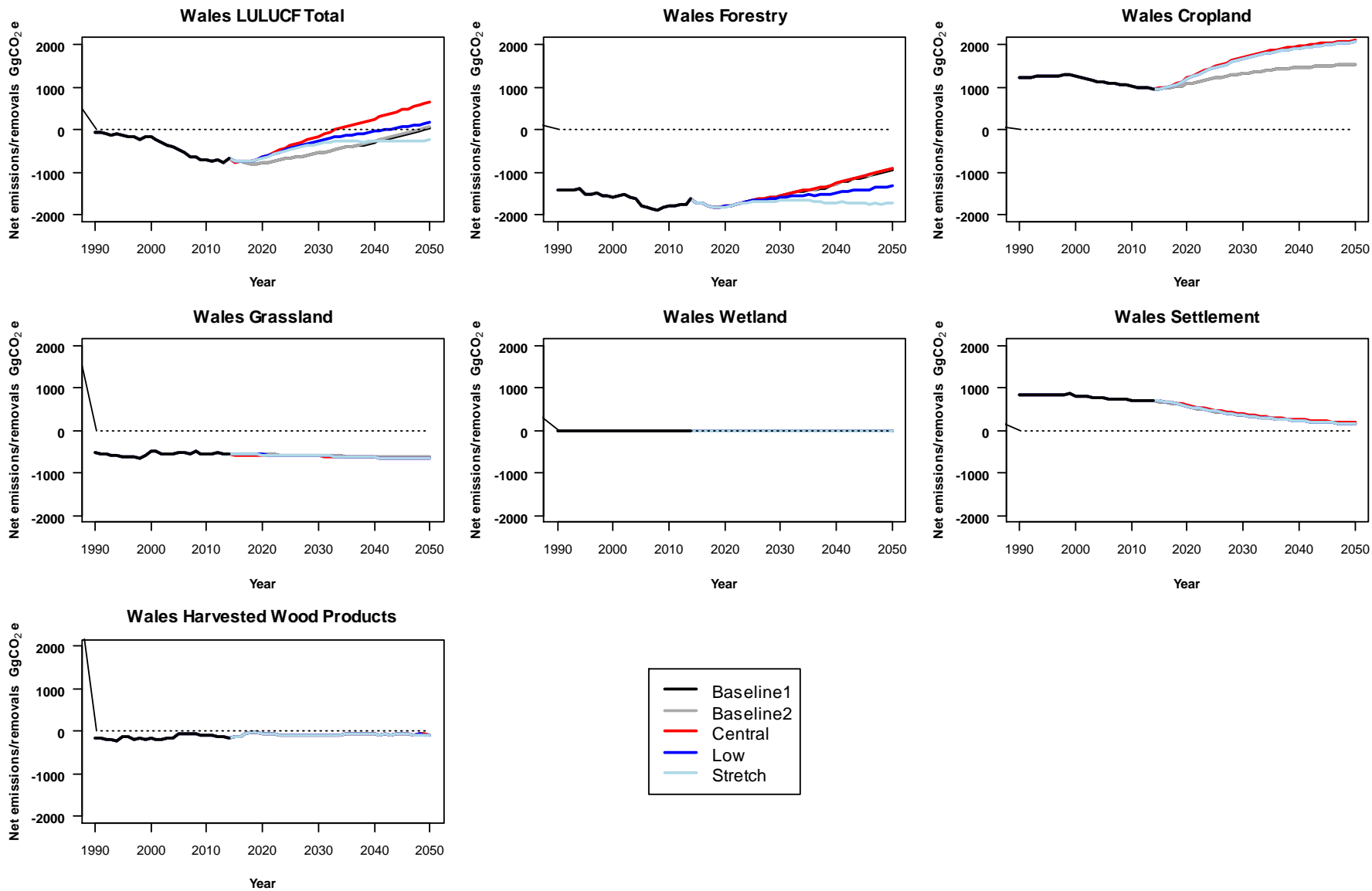


Figure 14: Wales LULUCF CO<sub>2</sub> equivalent emissions scenarios 1990-2050. The individual graphs refer to LULUCF reporting categories, which for cropland and grassland are mainly driven by land use change. (1 Mt CO<sub>2</sub>e = 1000 Gg CO<sub>2</sub>e)

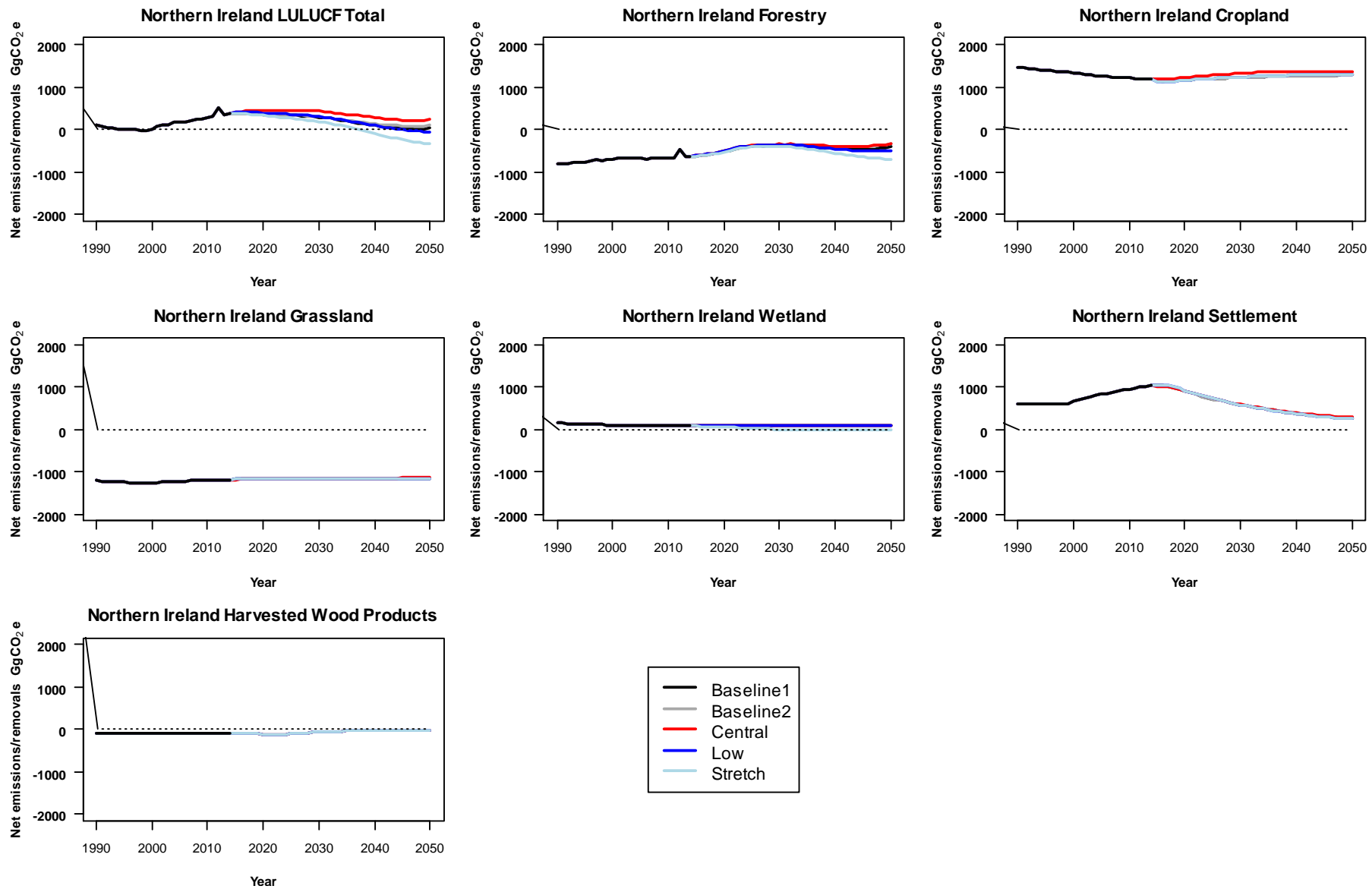


Figure 15: Northern Ireland LULUCF CO<sub>2</sub> equivalent emissions scenarios 1990-2050. The individual graphs refer to LULUCF reporting categories; see Section 3 text for description of what is reported in these categories. (1 Mt CO<sub>2</sub>eq = 1000 Gg CO<sub>2</sub>eq)

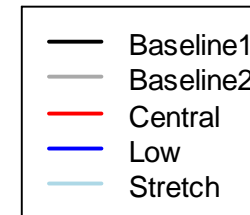
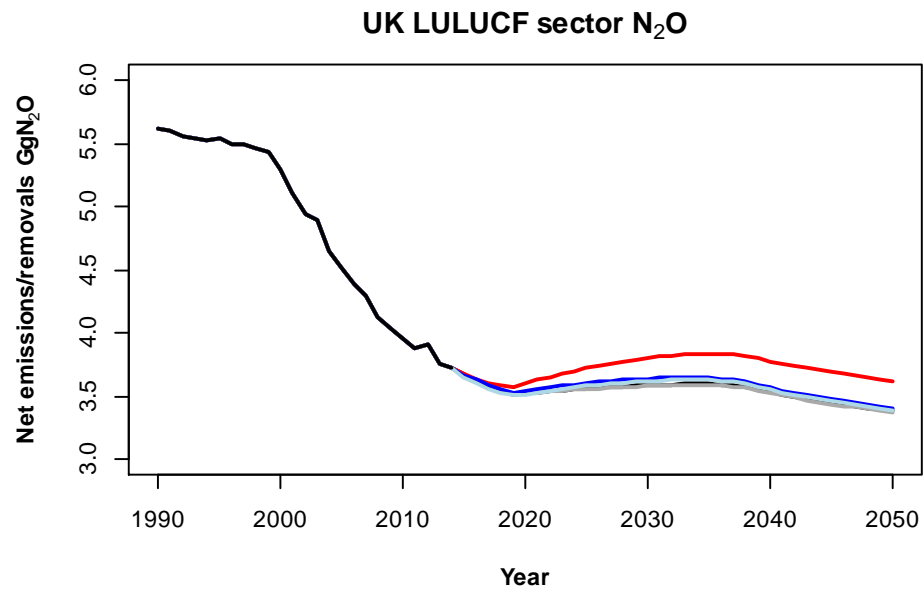
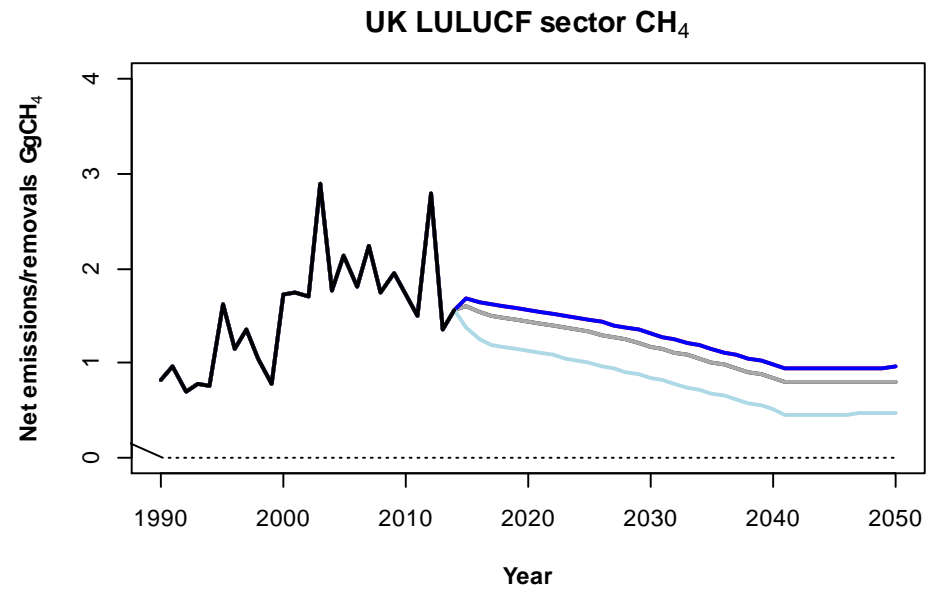
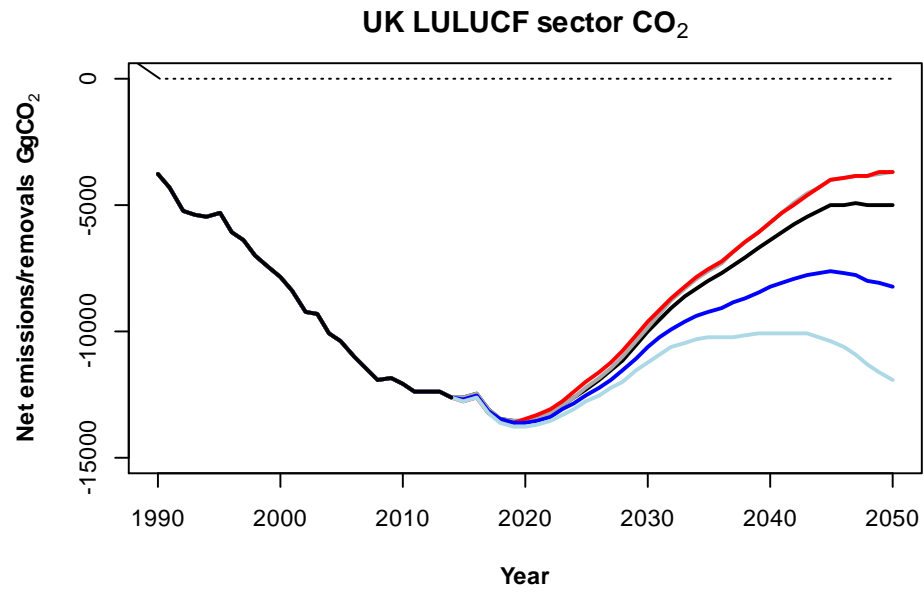


Figure 16: UK LULUCF Sector emissions of individual gases 1990-2050 (1 Mt CO<sub>2</sub>eq = 1000 Gg CO<sub>2</sub>eq)

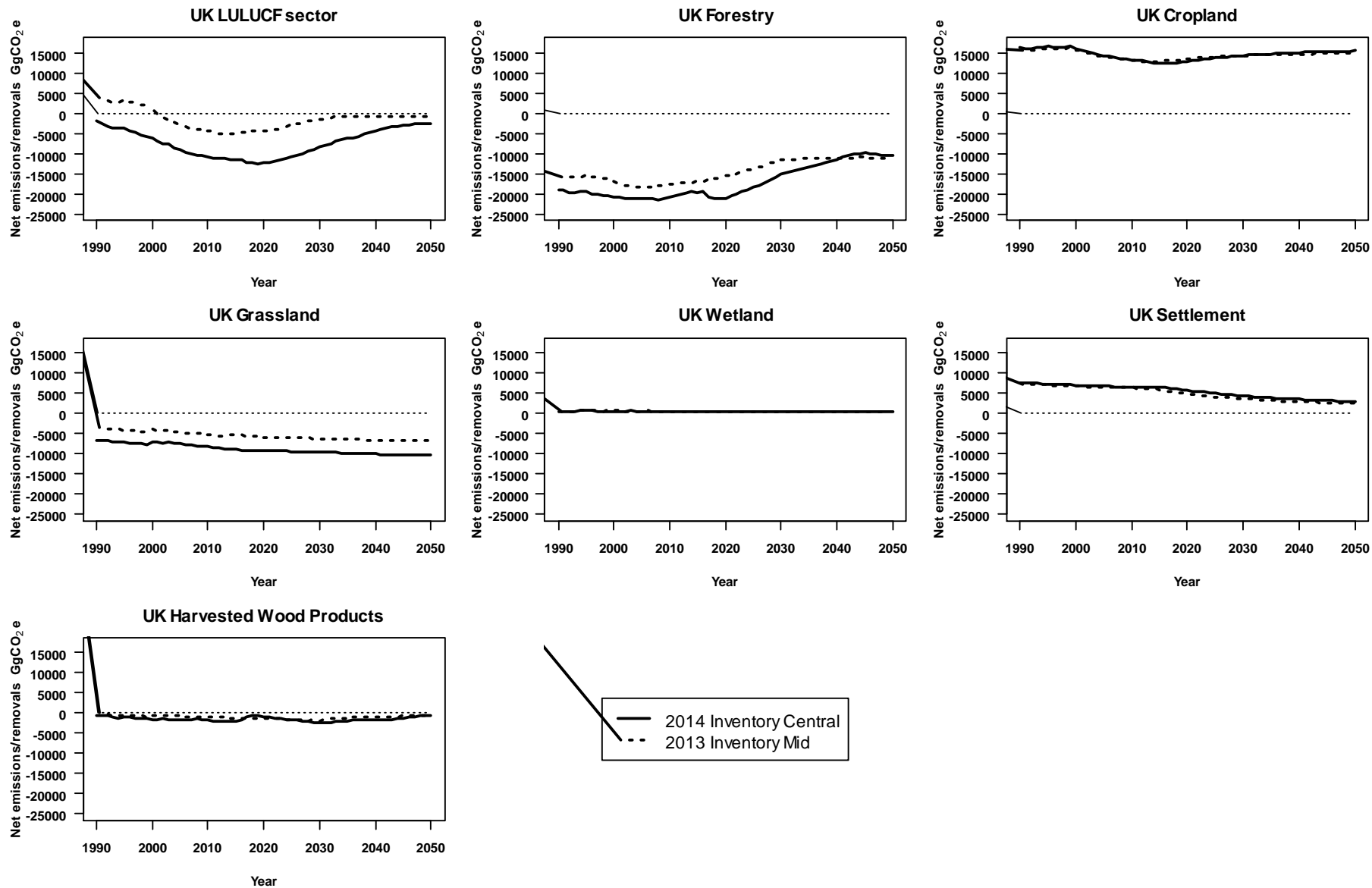


Figure 17: UK LULUCF CO<sub>2</sub> equivalent comparison of the Central and Mid emissions scenario for the 2014 and 2013 inventories respectively 1990-2050 (1 Mt CO<sub>2</sub>eq = 1000 Gg CO<sub>2</sub>eq)

## 5 References

Brown *et al.* (2016) UK Greenhouse Gas Inventory, 1990 to 2014. Annual Report for Submission under the Framework Convention on Climate Change. Ricardo-AEA. [https://uk-air.defra.gov.uk/assets/documents/reports/cat07/1605241007\\_ukghgi-90-14\\_Issue2.pdf](https://uk-air.defra.gov.uk/assets/documents/reports/cat07/1605241007_ukghgi-90-14_Issue2.pdf)

DCLG, 2016a. Land use change statistics in England: 2014-15. <https://www.gov.uk/government/statistical-data-sets/live-tables-on-land-use-change-statistics>

DCLG, 2016b. Live tables on house building. <https://www.gov.uk/government/statistical-data-sets/live-tables-on-house-building>

DCLG, 2016c. Live tables on household projections. <https://www.gov.uk/government/statistical-data-sets/live-tables-on-household-projections>



## Annex 1: Methodology for projection of land use change to Settlement

Statistics on recent conversion of undeveloped land to developed land (i.e. land conversion to Settlement) suggest that the rate of land conversion has declined significantly in recent years (DCLG, 2016a), compared with the rates of conversion between 1998 and 2007 (as calculated from the Countryside Survey data). There has also been much media coverage of the decline in house building and the need for increased construction to meet housing demand in the future. A new methodology for projecting land use change to Settlement was implemented in the projections report for 1990-2013 and is updated here. This methodology is based on the Land Use Change Statistics (LUCS) released by the Department of Communities and Local Government (DCLG) and projections of the number of households in the UK and its constituent countries (DCLG 2016b).

The LUCS data are based on records of land use change recorded by the Ordnance Survey during mapping updates and report change in land use to developed land for England only. The time series runs from 1989 to 2014/15. Changes to developed land use are broken down by previous land use (previously undeveloped: agriculture, urban land and other land not previously developed, residential gardens; previously developed: residential, minerals, landfill and defence, vacant and derelict land, other previously-developed use). The LUCS also contain information on the density of new residential dwellings and the percentage of dwellings built on previously developed or undeveloped land (England only). The DCLG also publishes statistics on house building by country (DCLG 2016c). The projections of household numbers use the 2011 national population census and trends in population demography and household formation to project household numbers to 2033-2037. The household time series runs from 1988/1991.

Five assumptions underpin the settlement projection methodology. The basis for these assumptions is described in the 1990-2013 projections report.

- It is assumed that the area of residential development can be estimated from the numbers of households and the average density of dwellings and projected on this basis.
- A percentage of new dwellings will be built on previously developed land (“brownfield”) and will not result in land use change (72% of new dwellings in England 2008-2011).
- The number of households in the future can act as a proxy for the amount of urban development.
- Additional urban development (non-residential) can be estimated as a percentage of the new residential area using historical urban development ratios (50:50 split between residential and non-residential use).
- The rate of urban development flat-lines after 2037 (the household projections only extend to 2037).

Projections of land use change to settlement in England were produced using this approach. Projections for the other DAs used the English dwelling density and undeveloped/developed land ratio with the DA-specific household number projections.

The *Central* scenario assumes that house building increases to meet the projected household demand. The other scenarios reflect what would happen if there was insufficient construction to meet demand, if there was an alteration in household demand, or if dwellings were constructed at a greater density or with a greater preference for previously developed sites, therefore reducing the amount of land use change (see section 3.3 for numbers).

## Annex 2: Land use areas by Devolved Administration

Table A2.1: Land use areas 2014-2050 for England (13,046 kha)

| <i>Emission scenario</i> | <i>Land use category</i> | <i>2014 area, kha</i> | <i>2020 area, kha</i> | <i>2030 area, kha</i> | <i>2040 area, kha</i> | <i>2050 area, kha</i> |
|--------------------------|--------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| <b>Central</b>           | Forest land              | 1299                  | 1313                  | 1311                  | 1310                  | 1310                  |
|                          | Cropland                 | 4156                  | 4156                  | 4156                  | 4156                  | 4156                  |
|                          | Grassland                | 6197                  | 6151                  | 6093                  | 6044                  | 5996                  |
|                          | Wetland                  | 21                    | 21                    | 21                    | 21                    | 21                    |
|                          | Settlement               | 1515                  | 1547                  | 1603                  | 1653                  | 1701                  |
|                          | Other                    | 107                   | 112                   | 115                   | 115                   | 115                   |
| <b>Baseline 1</b>        | Forest land              | 1299                  | 1314                  | 1334                  | 1356                  | 1378                  |
|                          | Cropland                 | 4156                  | 4156                  | 4156                  | 4156                  | 4156                  |
|                          | Grassland                | 6197                  | 6160                  | 6099                  | 6038                  | 5977                  |
|                          | Wetland                  | 21                    | 21                    | 21                    | 21                    | 21                    |
|                          | Settlement               | 1515                  | 1539                  | 1578                  | 1617                  | 1656                  |
|                          | Other                    | 107                   | 110                   | 111                   | 111                   | 111                   |
| <b>Baseline 2</b>        | Forest land              | 1299                  | 1303                  | 1300                  | 1299                  | 1299                  |
|                          | Cropland                 | 4156                  | 4156                  | 4156                  | 4156                  | 4156                  |
|                          | Grassland                | 6197                  | 6170                  | 6128                  | 6087                  | 6046                  |
|                          | Wetland                  | 21                    | 21                    | 21                    | 21                    | 21                    |
|                          | Settlement               | 1515                  | 1540                  | 1582                  | 1624                  | 1665                  |
|                          | Other                    | 107                   | 110                   | 111                   | 111                   | 111                   |
| <b>Low</b>               | Forest land              | 1299                  | 1323                  | 1369                  | 1417                  | 1454                  |
|                          | Cropland                 | 4156                  | 4156                  | 4156                  | 4156                  | 4156                  |
|                          | Grassland                | 6197                  | 6159                  | 6087                  | 6021                  | 5963                  |
|                          | Wetland                  | 21                    | 21                    | 21                    | 21                    | 21                    |
|                          | Settlement               | 1515                  | 1529                  | 1550                  | 1570                  | 1589                  |
|                          | Other                    | 107                   | 112                   | 115                   | 115                   | 115                   |
| <b>Stretch</b>           | Forest land              | 1299                  | 1332                  | 1427                  | 1524                  | 1599                  |
|                          | Cropland                 | 4156                  | 4156                  | 4156                  | 4156                  | 4156                  |
|                          | Grassland                | 6197                  | 6112                  | 5999                  | 5891                  | 5799                  |
|                          | Wetland                  | 21                    | 21                    | 21                    | 21                    | 21                    |
|                          | Settlement               | 1515                  | 1538                  | 1554                  | 1567                  | 1582                  |
|                          | Other                    | 107                   | 117                   | 120                   | 120                   | 120                   |

Table A2.2: Land use areas 2014-2050 for Scotland (7,881 kha)

| <i>Emission scenario</i> | <i>Land use category</i> | <i>2014 area, kha</i> | <i>2020 area, kha</i> | <i>2030 area, kha</i> | <i>2040 area, kha</i> | <i>2050 area, kha</i> |
|--------------------------|--------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| <b>Central</b>           | Forest land              | 1410                  | 1453                  | 1448                  | 1446                  | 1447                  |
|                          | Cropland                 | 589                   | 589                   | 589                   | 589                   | 589                   |
|                          | Grassland                | 5598                  | 5556                  | 5542                  | 5533                  | 5521                  |
|                          | Wetland                  | 92                    | 92                    | 92                    | 92                    | 92                    |
|                          | Settlement               | 199                   | 201                   | 205                   | 208                   | 212                   |
|                          | Other                    | 152                   | 161                   | 170                   | 177                   | 184                   |
|                          | <b>Baseline 1</b>        | Forest land           | 1410                  | 1433                  | 1458                  | 1487                  |
| Cropland                 |                          | 589                   | 589                   | 589                   | 589                   | 589                   |
| Grassland                |                          | 5598                  | 5574                  | 5543                  | 5508                  | 5471                  |
| Wetland                  |                          | 92                    | 92                    | 92                    | 92                    | 92                    |
| Settlement               |                          | 199                   | 201                   | 203                   | 204                   | 206                   |
| Other                    |                          | 152                   | 157                   | 161                   | 165                   | 168                   |
| <b>Baseline 2</b>        |                          | Forest land           | 1410                  | 1418                  | 1415                  | 1416                  |
|                          | Cropland                 | 589                   | 589                   | 589                   | 589                   | 589                   |
|                          | Grassland                | 5598                  | 5588                  | 5584                  | 5577                  | 5568                  |
|                          | Wetland                  | 92                    | 92                    | 92                    | 92                    | 92                    |
|                          | Settlement               | 199                   | 201                   | 204                   | 206                   | 209                   |
|                          | Other                    | 152                   | 157                   | 161                   | 165                   | 168                   |
|                          | <b>Low</b>               | Forest land           | 1410                  | 1465                  | 1538                  | 1610                  |
| Cropland                 |                          | 589                   | 589                   | 589                   | 589                   | 589                   |
| Grassland                |                          | 5598                  | 5541                  | 5458                  | 5379                  | 5299                  |
| Wetland                  |                          | 92                    | 92                    | 92                    | 92                    | 92                    |
| Settlement               |                          | 199                   | 199                   | 199                   | 198                   | 198                   |
| Other                    |                          | 152                   | 161                   | 170                   | 177                   | 184                   |
| <b>Stretch</b>           |                          | Forest land           | 1410                  | 1472                  | 1613                  | 1758                  |
|                          | Cropland                 | 589                   | 589                   | 589                   | 589                   | 589                   |
|                          | Grassland                | 5598                  | 5480                  | 5333                  | 5183                  | 5032                  |
|                          | Wetland                  | 92                    | 92                    | 92                    | 92                    | 92                    |
|                          | Settlement               | 199                   | 199                   | 197                   | 194                   | 191                   |
|                          | Other                    | 152                   | 169                   | 178                   | 185                   | 192                   |

Table A2.3: Land use areas 2014-2050 for Wales (2,078 kha)

| <i>Emission scenario</i> | <i>Land use category</i> | <i>2014 area, kha</i> | <i>2020 area, kha</i> | <i>2030 area, kha</i> | <i>2040 area, kha</i> | <i>2050 area, kha</i> |
|--------------------------|--------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| <b>Central</b>           | Forest land              | 316                   | 317                   | 315                   | 315                   | 315                   |
|                          | Cropland                 | 185                   | 245                   | 345                   | 445                   | 545                   |
|                          | Grassland                | 1435                  | 1373                  | 1272                  | 1171                  | 1069                  |
|                          | Wetland                  | 5                     | 5                     | 5                     | 5                     | 5                     |
|                          | Settlement               | 156                   | 158                   | 161                   | 162                   | 164                   |
|                          | Other                    | 16                    | 17                    | 16                    | 16                    | 16                    |
| <b>Baseline 1</b>        | Forest land              | 316                   | 317                   | 317                   | 319                   | 320                   |
|                          | Cropland                 | 185                   | 218                   | 273                   | 328                   | 383                   |
|                          | Grassland                | 1435                  | 1400                  | 1343                  | 1286                  | 1228                  |
|                          | Wetland                  | 5                     | 5                     | 5                     | 5                     | 5                     |
|                          | Settlement               | 156                   | 158                   | 160                   | 161                   | 162                   |
|                          | Other                    | 16                    | 16                    | 15                    | 15                    | 15                    |
| <b>Baseline 2</b>        | Forest land              | 316                   | 316                   | 315                   | 315                   | 315                   |
|                          | Cropland                 | 185                   | 218                   | 273                   | 328                   | 383                   |
|                          | Grassland                | 1435                  | 1400                  | 1345                  | 1289                  | 1233                  |
|                          | Wetland                  | 5                     | 5                     | 5                     | 5                     | 5                     |
|                          | Settlement               | 156                   | 158                   | 161                   | 161                   | 162                   |
|                          | Other                    | 16                    | 16                    | 15                    | 15                    | 15                    |
| <b>Low</b>               | Forest land              | 316                   | 326                   | 345                   | 364                   | 369                   |
|                          | Cropland                 | 185                   | 245                   | 345                   | 445                   | 545                   |
|                          | Grassland                | 1435                  | 1364                  | 1246                  | 1129                  | 1022                  |
|                          | Wetland                  | 5                     | 5                     | 5                     | 5                     | 5                     |
|                          | Settlement               | 156                   | 157                   | 157                   | 156                   | 156                   |
|                          | Other                    | 16                    | 17                    | 16                    | 16                    | 16                    |
| <b>Stretch</b>           | Forest land              | 316                   | 336                   | 375                   | 414                   | 424                   |
|                          | Cropland                 | 185                   | 295                   | 395                   | 495                   | 595                   |
|                          | Grassland                | 1435                  | 1289                  | 1153                  | 1019                  | 907                   |
|                          | Wetland                  | 5                     | 5                     | 5                     | 5                     | 5                     |
|                          | Settlement               | 156                   | 155                   | 154                   | 151                   | 151                   |
|                          | Other                    | 16                    | 18                    | 17                    | 17                    | 18                    |

Table A2.4: Land use areas 2014-2050 for Northern Ireland (1,413 kha)

| <i>Emission scenario</i> | <i>Land use category</i> | <i>2014 area, kha</i> | <i>2020 area, kha</i> | <i>2030 area, kha</i> | <i>2040 area, kha</i> | <i>2050 area, kha</i> |
|--------------------------|--------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| <b>Central</b>           | Forest land              | 82                    | 82                    | 81                    | 81                    | 82                    |
|                          | Cropland                 | 116                   | 116                   | 116                   | 116                   | 116                   |
|                          | Grassland                | 1051                  | 1049                  | 1047                  | 1045                  | 1043                  |
|                          | Wetland                  | 57                    | 57                    | 57                    | 57                    | 57                    |
|                          | Settlement               | 91                    | 92                    | 94                    | 95                    | 97                    |
|                          | Other                    | 16                    | 17                    | 18                    | 19                    | 19                    |
| <b>Baseline 1</b>        | Forest land              | 82                    | 83                    | 84                    | 87                    | 90                    |
|                          | Cropland                 | 116                   | 116                   | 116                   | 116                   | 116                   |
|                          | Grassland                | 1051                  | 1046                  | 1043                  | 1039                  | 1035                  |
|                          | Wetland                  | 57                    | 57                    | 57                    | 57                    | 57                    |
|                          | Settlement               | 91                    | 94                    | 96                    | 97                    | 98                    |
|                          | Other                    | 16                    | 17                    | 17                    | 17                    | 18                    |
| <b>Baseline 2</b>        | Forest land              | 82                    | 81                    | 81                    | 81                    | 81                    |
|                          | Cropland                 | 116                   | 116                   | 116                   | 116                   | 116                   |
|                          | Grassland                | 1051                  | 1048                  | 1046                  | 1045                  | 1044                  |
|                          | Wetland                  | 57                    | 57                    | 57                    | 57                    | 57                    |
|                          | Settlement               | 91                    | 94                    | 96                    | 97                    | 98                    |
|                          | Other                    | 16                    | 17                    | 17                    | 17                    | 18                    |
| <b>Low</b>               | Forest land              | 82                    | 83                    | 89                    | 97                    | 106                   |
|                          | Cropland                 | 116                   | 116                   | 116                   | 116                   | 116                   |
|                          | Grassland                | 1051                  | 1047                  | 1039                  | 1029                  | 1020                  |
|                          | Wetland                  | 57                    | 57                    | 57                    | 57                    | 57                    |
|                          | Settlement               | 91                    | 93                    | 94                    | 95                    | 95                    |
|                          | Other                    | 16                    | 17                    | 18                    | 19                    | 19                    |
| <b>Stretch</b>           | Forest land              | 82                    | 83                    | 97                    | 113                   | 130                   |
|                          | Cropland                 | 116                   | 116                   | 116                   | 116                   | 116                   |
|                          | Grassland                | 1051                  | 1041                  | 1027                  | 1009                  | 992                   |
|                          | Wetland                  | 57                    | 57                    | 57                    | 57                    | 57                    |
|                          | Settlement               | 91                    | 96                    | 97                    | 97                    | 98                    |
|                          | Other                    | 16                    | 18                    | 19                    | 19                    | 20                    |

## Annex 3: Afforestation and Deforestation data

Table A3.1 *Baseline 1 Scenario Afforestation and Deforestation (same for all scenarios) Rates (kha)*

| Year | Forest Planting Rate |          |       |            |          | Deforestation Rate |          |       |            |          |
|------|----------------------|----------|-------|------------|----------|--------------------|----------|-------|------------|----------|
|      | England              | Scotland | Wales | N. Ireland | UK Total | England            | Scotland | Wales | N. Ireland | UK Total |
| 2015 | 2.425                | 7.559    | 0.103 | 0.208      | 10.295   | 0.628              | 1.335    | 0.239 | 0.154      | 2.356    |
| 2016 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.615              | 1.294    | 0.231 | 0.149      | 2.289    |
| 2017 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.602              | 1.252    | 0.223 | 0.143      | 2.22     |
| 2018 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.589              | 1.211    | 0.215 | 0.138      | 2.153    |
| 2019 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.576              | 1.169    | 0.207 | 0.132      | 2.084    |
| 2020 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.562              | 1.128    | 0.198 | 0.127      | 2.015    |
| 2021 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.549              | 1.087    | 0.19  | 0.121      | 1.947    |
| 2022 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.536              | 1.045    | 0.182 | 0.116      | 1.879    |
| 2023 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.523              | 1.004    | 0.174 | 0.11       | 1.811    |
| 2024 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.51               | 0.962    | 0.166 | 0.105      | 1.743    |
| 2025 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.497              | 0.921    | 0.158 | 0.099      | 1.675    |
| 2026 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.484              | 0.88     | 0.15  | 0.094      | 1.608    |
| 2027 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.471              | 0.838    | 0.142 | 0.088      | 1.539    |
| 2028 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.457              | 0.797    | 0.133 | 0.083      | 1.47     |
| 2029 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.444              | 0.755    | 0.125 | 0.077      | 1.401    |
| 2030 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.431              | 0.714    | 0.117 | 0.072      | 1.334    |
| 2031 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.418              | 0.673    | 0.109 | 0.066      | 1.266    |
| 2032 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.405              | 0.631    | 0.101 | 0.061      | 1.198    |
| 2033 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.392              | 0.59     | 0.093 | 0.055      | 1.13     |
| 2034 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.379              | 0.548    | 0.085 | 0.05       | 1.062    |
| 2035 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.366              | 0.507    | 0.077 | 0.044      | 0.994    |
| 2036 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.352              | 0.466    | 0.068 | 0.039      | 0.925    |
| 2037 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.339              | 0.424    | 0.06  | 0.033      | 0.856    |
| 2038 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.326              | 0.383    | 0.052 | 0.028      | 0.789    |
| 2039 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.313              | 0.341    | 0.044 | 0.022      | 0.72     |
| 2040 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.3                | 0.3      | 0.036 | 0.017      | 0.653    |
| 2041 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.3                | 0.21     | 0.025 | 0.012      | 0.547    |
| 2042 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.3                | 0.21     | 0.025 | 0.012      | 0.547    |
| 2043 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.3                | 0.21     | 0.025 | 0.012      | 0.547    |
| 2044 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.3                | 0.21     | 0.025 | 0.012      | 0.547    |
| 2045 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.3                | 0.21     | 0.025 | 0.012      | 0.547    |
| 2046 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.3                | 0.21     | 0.025 | 0.012      | 0.547    |
| 2047 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.3                | 0.21     | 0.025 | 0.012      | 0.547    |
| 2048 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.3                | 0.21     | 0.025 | 0.012      | 0.547    |
| 2049 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.3                | 0.21     | 0.025 | 0.012      | 0.547    |
| 2050 | 2.515                | 3.44     | 0.189 | 0.289      | 6.433    | 0.3                | 0.21     | 0.025 | 0.012      | 0.547    |

Table A3.2 *Baseline 2 Emissions Scenario Afforestation Rates (kha)*

| Year | Forest Planting Rate |          |       |            |          |
|------|----------------------|----------|-------|------------|----------|
|      | England              | Scotland | Wales | N. Ireland | UK Total |
| 2015 | 2.425                | 7.559    | 0.103 | 0.208      | 10.295   |
| 2016 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2017 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2018 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2019 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2020 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2021 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2022 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2023 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2024 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2025 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2026 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2027 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2028 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2029 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2030 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2031 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2032 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2033 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2034 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2035 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2036 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2037 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2038 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2039 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2040 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2041 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2042 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2043 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2044 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2045 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2046 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2047 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2048 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2049 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |
| 2050 | 0.264                | 0.58     | 0.05  | 0.033      | 0.927    |

**Table A3.3 Central Emissions Scenario Afforestation Rates (kha)**

| Year | Forest Planting Rate |          |       |            |          |
|------|----------------------|----------|-------|------------|----------|
|      | England              | Scotland | Wales | N. Ireland | UK Total |
| 2015 | 2.425                | 7.559    | 0.103 | 0.208      | 10.295   |
| 2016 | 2.425                | 7.559    | 0.103 | 0.208      | 10.295   |
| 2017 | 2.425                | 7.559    | 0.103 | 0.208      | 10.295   |
| 2018 | 2.425                | 7.559    | 0.103 | 0.208      | 10.295   |
| 2019 | 2.425                | 7.559    | 0.103 | 0.208      | 10.295   |
| 2020 | 2.425                | 7.559    | 0.103 | 0.208      | 10.295   |
| 2021 | 0.252                | 0.344    | 0.019 | 0.029      | 0.644    |
| 2022 | 0.252                | 0.344    | 0.019 | 0.029      | 0.644    |
| 2023 | 0.252                | 0.344    | 0.019 | 0.029      | 0.644    |
| 2024 | 0.252                | 0.344    | 0.019 | 0.029      | 0.644    |
| 2025 | 0.252                | 0.344    | 0.019 | 0.029      | 0.644    |
| 2026 | 0.252                | 0.344    | 0.019 | 0.029      | 0.644    |
| 2027 | 0.252                | 0.344    | 0.019 | 0.029      | 0.644    |
| 2028 | 0.252                | 0.344    | 0.019 | 0.029      | 0.644    |
| 2029 | 0.252                | 0.344    | 0.019 | 0.029      | 0.644    |
| 2030 | 0.252                | 0.344    | 0.019 | 0.029      | 0.644    |
| 2031 | 0.252                | 0.344    | 0.019 | 0.029      | 0.644    |
| 2032 | 0.252                | 0.344    | 0.019 | 0.029      | 0.644    |
| 2033 | 0.252                | 0.344    | 0.019 | 0.029      | 0.644    |
| 2034 | 0.252                | 0.344    | 0.019 | 0.029      | 0.644    |
| 2035 | 0.252                | 0.344    | 0.019 | 0.029      | 0.644    |
| 2036 | 0.252                | 0.344    | 0.019 | 0.029      | 0.644    |
| 2037 | 0.252                | 0.344    | 0.019 | 0.029      | 0.644    |
| 2038 | 0.252                | 0.344    | 0.019 | 0.029      | 0.644    |
| 2039 | 0.252                | 0.344    | 0.019 | 0.029      | 0.644    |
| 2040 | 0.252                | 0.344    | 0.019 | 0.029      | 0.644    |
| 2041 | 0.252                | 0.344    | 0.019 | 0.029      | 0.644    |
| 2042 | 0.252                | 0.344    | 0.019 | 0.029      | 0.644    |
| 2043 | 0.252                | 0.344    | 0.019 | 0.029      | 0.644    |
| 2044 | 0.252                | 0.344    | 0.019 | 0.029      | 0.644    |
| 2045 | 0.252                | 0.344    | 0.019 | 0.029      | 0.644    |
| 2046 | 0.252                | 0.344    | 0.019 | 0.029      | 0.644    |
| 2047 | 0.252                | 0.344    | 0.019 | 0.029      | 0.644    |
| 2048 | 0.252                | 0.344    | 0.019 | 0.029      | 0.644    |
| 2049 | 0.252                | 0.344    | 0.019 | 0.029      | 0.644    |
| 2050 | 0.252                | 0.344    | 0.019 | 0.029      | 0.644    |



**Table A3.4 Low Emissions Scenario Afforestation Rates (kha)**

| Year | Forest Planting Rate |          |       |            |          |
|------|----------------------|----------|-------|------------|----------|
|      | England              | Scotland | Wales | N. Ireland | UK Total |
| 2015 | 2.425                | 7.559    | 0.103 | 0.208      | 10.295   |
| 2016 | 3.055                | 10       | 2.052 | 0.304      | 15.411   |
| 2017 | 3.685                | 10       | 2.052 | 0.304      | 16.041   |
| 2018 | 4.315                | 10       | 2.052 | 0.304      | 16.671   |
| 2019 | 4.945                | 10       | 2.052 | 0.304      | 17.301   |
| 2020 | 5.575                | 10       | 2.052 | 0.304      | 17.931   |
| 2021 | 5.126                | 10       | 2.009 | 0.514      | 17.649   |
| 2022 | 5.126                | 10       | 2.009 | 0.614      | 17.749   |
| 2023 | 5.126                | 7.672    | 2.009 | 0.664      | 15.471   |
| 2024 | 5.126                | 7.672    | 2.009 | 0.664      | 15.471   |
| 2025 | 5.126                | 7.672    | 2.009 | 0.714      | 15.521   |
| 2026 | 5.126                | 7.672    | 2.009 | 0.764      | 15.571   |
| 2027 | 5.126                | 7.672    | 2.009 | 0.814      | 15.621   |
| 2028 | 5.126                | 7.672    | 2.009 | 0.864      | 15.671   |
| 2029 | 5.126                | 7.672    | 2.009 | 0.864      | 15.671   |
| 2030 | 5.126                | 7.672    | 2.009 | 0.864      | 15.671   |
| 2031 | 5.126                | 7.672    | 2.009 | 0.864      | 15.671   |
| 2032 | 5.126                | 7.672    | 2.009 | 0.864      | 15.671   |
| 2033 | 5.126                | 7.672    | 2.009 | 0.864      | 15.671   |
| 2034 | 5.126                | 7.672    | 2.009 | 0.864      | 15.671   |
| 2035 | 5.126                | 7.672    | 2.009 | 0.864      | 15.671   |
| 2036 | 5.126                | 7.672    | 2.009 | 0.864      | 15.671   |
| 2037 | 5.126                | 7.672    | 2.009 | 0.864      | 15.671   |
| 2038 | 5.126                | 7.672    | 2.009 | 0.864      | 15.671   |
| 2039 | 5.126                | 7.672    | 2.009 | 0.864      | 15.671   |
| 2040 | 5.126                | 7.672    | 2.009 | 0.864      | 15.671   |
| 2041 | 4.926                | 7.672    | 0.509 | 0.864      | 13.971   |
| 2042 | 4.726                | 7.672    | 0.509 | 0.864      | 13.771   |
| 2043 | 4.526                | 7.672    | 0.509 | 0.864      | 13.571   |
| 2044 | 4.326                | 7.672    | 0.509 | 0.864      | 13.371   |
| 2045 | 4.126                | 7.672    | 0.509 | 0.864      | 13.171   |
| 2046 | 3.926                | 7.672    | 0.509 | 0.864      | 12.971   |
| 2047 | 3.726                | 7.672    | 0.509 | 0.864      | 12.771   |
| 2048 | 3.526                | 7.672    | 0.509 | 0.864      | 12.571   |
| 2049 | 3.326                | 7.672    | 0.509 | 0.864      | 12.371   |
| 2050 | 3.126                | 7.672    | 0.509 | 0.864      | 12.171   |

**Table A3.5 Stretch Emissions Scenario Afforestation Rates (kha)**

| Year | Forest Planting Rate |          |       |            |          |
|------|----------------------|----------|-------|------------|----------|
|      | England              | Scotland | Wales | N. Ireland | UK Total |
| 2015 | 2.425                | 7.559    | 0.103 | 0.208      | 10.295   |
| 2016 | 3.685                | 8.809    | 4     | 0.4        | 16.894   |
| 2017 | 4.945                | 10.059   | 4     | 0.4        | 19.404   |
| 2018 | 6.205                | 11.309   | 4     | 0.4        | 21.914   |
| 2019 | 7.465                | 12.559   | 4     | 0.4        | 24.424   |
| 2020 | 8.725                | 13.809   | 4     | 0.4        | 26.934   |
| 2021 | 10                   | 15       | 4     | 1          | 30       |
| 2022 | 10                   | 15       | 4     | 1.2        | 30.2     |
| 2023 | 10                   | 15       | 4     | 1.3        | 30.3     |
| 2024 | 10                   | 15       | 4     | 1.3        | 30.3     |
| 2025 | 10                   | 15       | 4     | 1.4        | 30.4     |
| 2026 | 10                   | 15       | 4     | 1.5        | 30.5     |
| 2027 | 10                   | 15       | 4     | 1.6        | 30.6     |
| 2028 | 10                   | 15       | 4     | 1.7        | 30.7     |
| 2029 | 10                   | 15       | 4     | 1.7        | 30.7     |
| 2030 | 10                   | 15       | 4     | 1.7        | 30.7     |
| 2031 | 10                   | 15       | 4     | 1.7        | 30.7     |
| 2032 | 10                   | 15       | 4     | 1.7        | 30.7     |
| 2033 | 10                   | 15       | 4     | 1.7        | 30.7     |
| 2034 | 10                   | 15       | 4     | 1.7        | 30.7     |
| 2035 | 10                   | 15       | 4     | 1.7        | 30.7     |
| 2036 | 10                   | 15       | 4     | 1.7        | 30.7     |
| 2037 | 10                   | 15       | 4     | 1.7        | 30.7     |
| 2038 | 10                   | 15       | 4     | 1.7        | 30.7     |
| 2039 | 10                   | 15       | 4     | 1.7        | 30.7     |
| 2040 | 10                   | 15       | 4     | 1.7        | 30.7     |
| 2041 | 9.6                  | 15       | 1     | 1.7        | 27.3     |
| 2042 | 9.2                  | 15       | 1     | 1.7        | 26.9     |
| 2043 | 8.8                  | 15       | 1     | 1.7        | 26.5     |
| 2044 | 8.4                  | 15       | 1     | 1.7        | 26.1     |
| 2045 | 8                    | 15       | 1     | 1.7        | 25.7     |
| 2046 | 7.6                  | 15       | 1     | 1.7        | 25.3     |
| 2047 | 7.2                  | 15       | 1     | 1.7        | 24.9     |
| 2048 | 6.8                  | 15       | 1     | 1.7        | 24.5     |
| 2049 | 6.4                  | 15       | 1     | 1.7        | 24.1     |
| 2050 | 6                    | 15       | 1     | 1.7        | 23.7     |