National Atmospheric Emissions Inventory

Projections of Emissions and Removals from the LULUCF Sector to 2050

(consistent with the 1990-2016 inventory)

Prepared by the UK Centre for Ecology & Hydrology (UKCEH) and Forest Research for the Department for Business, Energy and Industrial Strategy (BEIS) as part of the UK National Atmospheric Emissions Inventory

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Summary for Policy Makers

- The United Kingdom (UK) reports greenhouse gas (GHG) emission projections to 2050 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 national atmospheric emissions inventory (NAEI) website[1].
- LULUCF activities can result in net annual emissions or removals of GHG, and changes in carbon stocks in the pools associated with LULUCF. The results presented here are based on the reporting conventions of the United Nations Framework Convention on Climate Change (UNFCCC). They do not represent potential future reported or accounted emissions and removals under the Kyoto Protocol.
- This report provides projections at the UK and country (DA) level, with separate estimates for Scotland, England, Wales and Northern Ireland, which are summed to give the UK totals.
- LULUCF is divided into six land use types: Forest Land (4A), Cropland (4B), Grassland (4C), Wetlands (4D), Settlements (4E), and Other Land (4F). Carbon stock changes of Harvested Wood Products are reported in an additional category, Harvested Wood Products (4G). The code refers to the categories of the common reporting format for GHG inventories submitted to the UNFCCC. There is a separate inventory sector for Agriculture dedicated to emissions, mainly of methane (CH_4) and nitrous oxide (N_2O), from other agricultural activities, which are not covered in this report.
- The emissions resulting from five future scenarios (*Baseline 1, Baseline 2, Central, Low* and *Stretch*) have been described. The scenarios take account of current land use policies or 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 is a net sink and is predicted to remain so under all scenarios although declining from ~2020 to 2050. The maximum sink size is in the *Low* scenario for 2022 of 16.8Mt carbon dioxide equivalent (CO_2e). By 2050 the UK sink in the *Central* scenario is predicted to be 2.8Mt CO_2e
    - At a country level, Wales and Scotland remain net sinks under all scenarios
    - England is a net sink under the *Low* and *Stretch* scenarios reflecting policy ambition beyond those in place in May 2015, but will later become a net source under *Baseline 1* (2044), Baseline 2 (2045) and *Central* scenarios (2039). By 2050 the emissions in the LULUCF sector are estimated to be 0.9 Mt CO_{2e} in Baseline 1, 0.8 CO_2e in Baseline 2 and 1.9 CO_2e in the Central scenario.
    - Northern Ireland is a small net source of between 0.0 and 0.3 MtCO_2e under the *Baseline 1*, *Baseline 2* and *Central* scenarios, but will become a small net sink of between 0 and 0.3 MtCO_2e during the 2040s under the *Stretch* and *Low* scenarios.
    - The LULUCF sector in the UK and in each of the country is dominated by CO_2 emissions and removals, although N_2O emissions also make a significant contribution.
    - The changes in the Forest Land, Cropland, Grassland and Settlement categories determine the trend in the UK and DAs.
    - The main changes in the projections since the 1990-2015 projections are:
        - Forestry: the forest areas have been amended to bring the area of recent afforestation more in to line with the new planting statistics.
        - Settlements: new data on projected settlement expansion have been used to revise the scenarios.

[1] https://naei.beis.gov.uk/reports/reports?report_id=1012

Contents

1 Introduction

This report estimates projections of UK GHG emissions and removals from Land Use, Land Use Change and Forestry (LULUCF) activities in the period to 2050. Projections are made for carbon stock changes and carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) emissions arising from LULUCF activities reported in the latest UK GHG Inventory, for the period 1990-2016 (Brown *et al*., 2018).

The LULUCF projections address a number of policy needs including:

- Alignment with EU/international commitments for biennial reporting of projections with and without policy measures, and with additional measures;
- The projections feed into the annually updated Energy and Emissions Projections (EEP) published by the Department for Business, Energy and Industrial Strategy (BEIS) which help to track progress towards Government climate targets;
- The exploration of potential low carbon development strategies; and
- The requirement to monitor progress towards targets under the Climate Change (Scotland) Act, the Environment (Wales) Act.

There have been some changes to the forestry elements of the projection scenarios this year, but except for land use change to forest or settlement, land management elements are largely unchanged from the previous projections (based on the 1990-2015 inventory). Three policy scenarios (*Central*, *Low* and *Stretch*) have been constructed along with two *Baseline* scenarios which continue existing trends with no new policy interventions. All policy scenarios reflect conditions before the July 2016 referendum on the UK's membership of the European Union.

- *Baseline 1* scenario: Underpins the option to submit a technical correction to the Forest Management Reference Level for the Second Commitment Period of the Kyoto Protocol. It is based on climate change-related and forestry policies extant in July 2009. The projections continue 2000-2009 average activity rates out to 2050.
- *Baseline 2* scenario: This is the EEP "baseline" scenario. It is based on climate change-related and forestry policies extant in July 2009 as in *Baseline 1* for the duration of the original policy. Forest planting rates drop to a low level after 2017 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 not driven by policies with a specific time limit are projected to continue at 2000-2009 average rates until 2050.
- *Central* scenario: Based on current policies and the duration of agreed funding (as extant in 2017) continuing at the same rate into the future. Continues 2016 rates to 2050 for non-forest activities. For afforestation, 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 1*. This is the EEP "reference" scenario.
- *Low* scenario: Climate change mitigation policy aspirations for the UK and each of the Devolved Administrations (DAs) are projected forward beyond 2021.
- *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 for Business, Energy and Industrial Strategy (BEIS) with input from the Forestry Commission, the Department for Environment, Food and Rural Affairs (Defra), the Devolved Administrations (DAs) and LULUCF experts. The scenarios are designed to explore the magnitude of the changes in 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 exploratory. 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 (sector 4 in the UNFCCC Common Reporting Format for national GHG 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)[2]. Net carbon stock changes from Harvested Wood Products (HWP) are reported under an additional category (4G). Emissions of GHG to the atmosphere (CO_2, CH_4 and N_2O) are expressed as positive quantities, and removals of CO_2 as negative quantities. Emissions of all three GHG are combined into total CO_2 equivalents, using Global Warming Potential (GWP) factors from the fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC), published in 2007[3] of 1 for CO_2, 25 for CH_4 and 298 for N_2O. 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 currently seem small in comparison with other individual sector totals. However, the LULUCF sector remains significant as it represents the net balance of much larger emissions and removals that if altered through changes in land-use practice could shift LULUCF between a net sink to source. Furthermore, LULUCF is currently the only sector which currently includes removals of GHG from the atmosphere, offsetting emissions from other sectors.

Calculations in the LULUCF inventory are on the basis of activities, which can fall across several land use types (Table 1[4]). The inventory (1990-2016) 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*. 2018). The *Afforestation* and *Land Use Change (soils)* activities contribute the majority of the emissions/removals in the LULUCF sector. Accordingly, most consideration was given to the corresponding activities and to *Deforestation* when developing the assumptions for the different scenarios.

[2] There are currently no emissions or removals of GHG from the Other Land category in the UK.
[3] The GWPs for CH_4 and N_2O were updated in the GHG inventory guidelines adopted by the UNFCCC in 2013; previously a GWP of 21 was used for CH_4 and 310 for N_2O, as reported in the 2nd Assessment Report of the IPCC.
[4] The reference to Tiers 1-3 in Table 1 refers to the sophistication of the methodological approach: Tier 1 uses simple equations and default GHG emission factors provided by the IPCC; Tier 2 uses the same equations with country-specific emission factors and higher resolution activity data; Tier 3 uses complex country-specific models and inventory measurement systems with high resolution activity data).

Table 1: Activities producing emissions/removals of GHG in the UK's LULUCF sector.

Activity	Description	Inventory category
Afforestation and forest management	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 administration-specific data on forest planting, productivity, and forest management/ harvesting patterns. N_2O 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_2O emissions) 4G Harvested Wood Products (carbon stock changes)
Wildfires	Emissions of GHG due to wildfires on forest land, cropland and grassland are modelled with a Tier 1 approach; biomass and litter densities for forest land are taken from the CARBINE model output; biomass densities for Cropland and Grassland use UK-specific values.	4A Forest Land (CO_2, CH_4 and N_2O emissions), 4B Cropland (CH_4 and N_2O emissions), 4C Grassland (CH_4 and N_2O emissions)
Land Use Change	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 the transition sub-category e.g. Land converted to Cropland. Changes in biomass stocks are assumed to occur in the year of the land use change. N_2O 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_2O emissions) 4C Grassland (carbon stock changes, N_2O emissions) 4E Settlements (carbon stock changes, N_2O emissions)
Deforestation	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 on site (releasing CO_2, CH_4 and N_2O), and the remainder are converted to timber products.	4A Forest Land (biomass carbon stock changes) 4B Cropland (soil carbon stock changes; CO_2, CH_4 and N_2O emissions) 4C Grassland (soil carbon stock changes; CO_2, CH_4 and N_2O emissions) 4E Settlements (soil carbon stock changes; CO_2, CH_4 and N_2O emissions) 4G Harvested Wood Products (carbon stock changes)
Cropland management	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 except for reduced tillage or the absence of tillage.	4B Cropland (biomass and soil carbon stock changes)

Activity	Description	Inventory category
Grassland management	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)
Agricultural drainage	Emissions from drainage on lowland agricultural organic soils are estimated using the IPCC Tier 1 methodology.	4B Cropland (soil carbon stock changes) 4C Grassland (soil carbon stock changes)
Peat extraction	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. Emissions from the extraction of horticultural peat imported to the UK is not included in the UK inventory.	4D Wetlands (soil carbon stock changes; CO_2 and N_2O emissions)

3 Assumptions underlying the scenarios

The scenario assumptions for each activity and country (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[5] 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.
- LULUCF input data for 1990-2016 in the published GHG inventories[6] have not been changed and feed through as the initial condition for the projected emissions.

Graphs of UK-level activity data are shown in this section; a break-down by country 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
Forest Land (4A)	Carbon stock change	Afforestation and forest management
	CO_2 emissions from burning	Wildfires
	CH_4 emissions	Wildfires
	N_2O emissions	Afforestation and forest management Wildfires
Cropland (4B)	Carbon stock change	Land Use Change Deforestation

[5] https://www.ons.gov.uk/methodology/geography/geographicalproducts/otherproducts/ukstandardareameasurementssam
[6] https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-2016

UNFCCC LULUCF land use category	Carbon stock change or gas	Activity producing emissions/removals
		Cropland management
		Agricultural drainage
	CO_2 emissions from burning	Deforestation
	CH_4 emissions	Wildfires
		Deforestation
	N_2O emissions	Wildfires
		Land Use Change
		Deforestation
Grassland (4C)	Carbon stock change	Land Use Change
		Deforestation
		Grassland management
		Agricultural drainage
	CO_2 emissions from burning	Deforestation
	CH_4 emissions	Wildfires
		Deforestation
	N_2O emissions	Wildfires
		Land Use Change
		Deforestation
Wetlands (4D)	Carbon stock change	Peat extraction
	CO_2 emissions	Peat extraction
	N_2O emissions	Peat extraction
Settlements (4E)	Carbon stock change	Land Use Change
		Deforestation
	CO_2 emissions from burning	Deforestation
	CH_4 emissions	Deforestation
	N_2O emissions	Land Use Change
		Deforestation
Harvested Wood Products (4G)	Carbon stock change	Afforestation and forest management
		Deforestation

3.1 Afforestation

This activity is driven by the amount of new forest planting in each country and affects forest carbon stock changes, changes in the Harvested Wood Products pool, nitrogen fertilisation of forests and forest drainage (CO_2 and N_2O).

- The *Baseline 1* scenario uses the 2009 planting rates for all projection years (2017 onwards), as in the Forest Management Reference Level (FMRL) used in the Kyoto Protocol reporting.
- The *Baseline 2* scenario assumes that grant-aided planting ceases after 2017, when the current Rural Development programme finished, and reverts to an estimate of the level of afforestation that would occur without grants of 10% of the average forest planting rate from 2008 to 2014 out to 2050.
- The *Central* scenario uses forest planting rates to 2020 determined by the available grants for woodland creation within each DA. After 2021, planting rates drop to one tenth 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 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). This is consistent with the stretch scenario adopted as Maximum Technical Potential used in the Marginal Abatement Cost Curve for the development of the Impact Assessment for the 5th Carbon Budget regulations.
- Planting rates for 2017 have been published and are used in the projections (see Annex 3).
- Proportion of conifer/broadleaf planting: for the *Baseline(1)* scenario the conifer/broadleaf split reported for 2009 is projected forward; and for all other scenarios each country 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 default)).

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

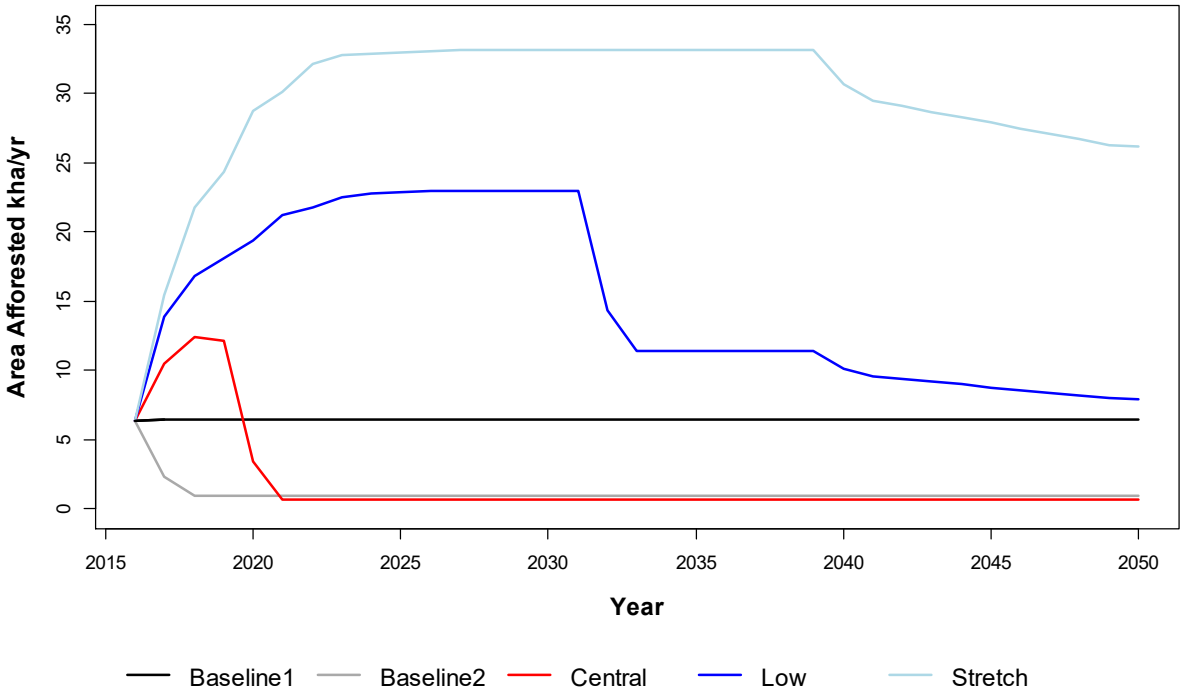

Figure 1: Afforestation rates for the emissions scenarios (UK). Note that a disaggregation of these data by country is provided in Annex 3.

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 (CO_2, CH_4 and N_2O)[7]. CO_2 emissions from wildfires on cropland and grassland are assumed to be replaced within the year by vegetation regrowth, so only emissions of CH_4 and N_2O are reported in 4B and 4C. The amount of fuel available to forest wildfires varies for each scenario as afforestation rates are different.

The wildfire historical time series (not presented here) shows high inter-annual variability (dependent upon the weather conditions at certain times of year). For forest land, activity data are adjusted to ensure a smooth transition from the latest inventory year to the different scenarios (2017-2023) using a sigmoid curve.

- In the *Baseline 1* and *Baseline 2* scenarios the annual burnt area from 2017 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* scenario the annual burnt area from 2017 onwards equals the average annual burnt area for the decade up to the latest inventory year (2016).
- In the *Low* and *Stretch* scenario the annual burnt area from 2017 onwards is the value of the 5th percentile of the wildfire area time series for the decade up to the latest inventory year (2016).

[7] 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 Great Britain (GB) burnt area.

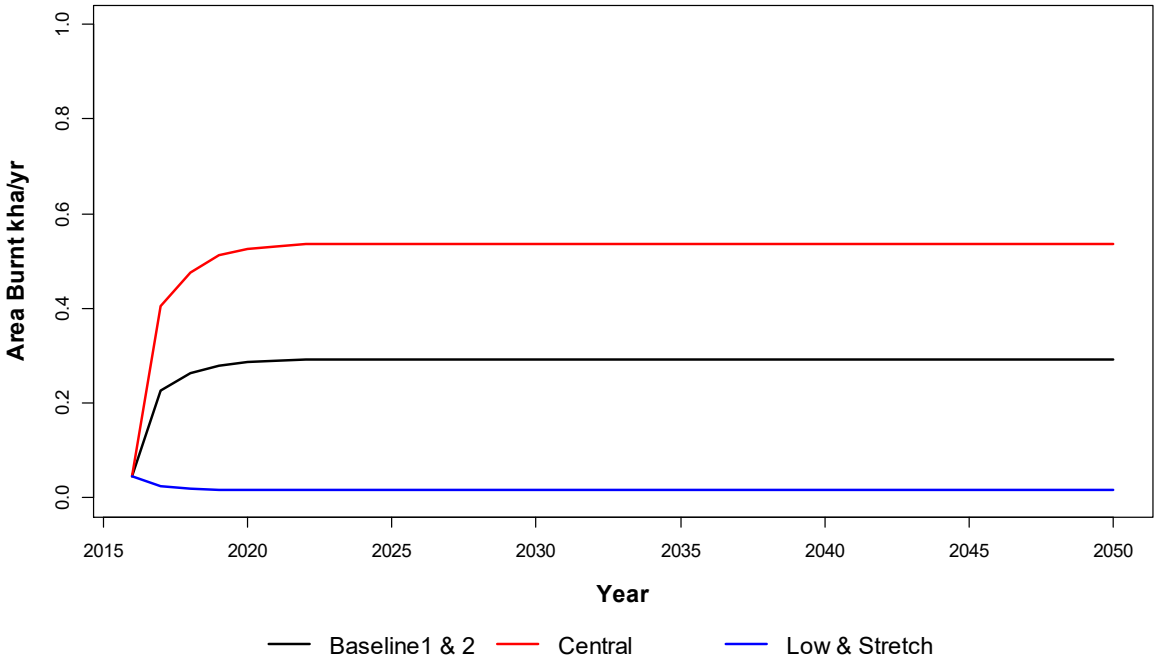

Figure 2: Forest wildfire activity data for the emissions scenarios (UK)

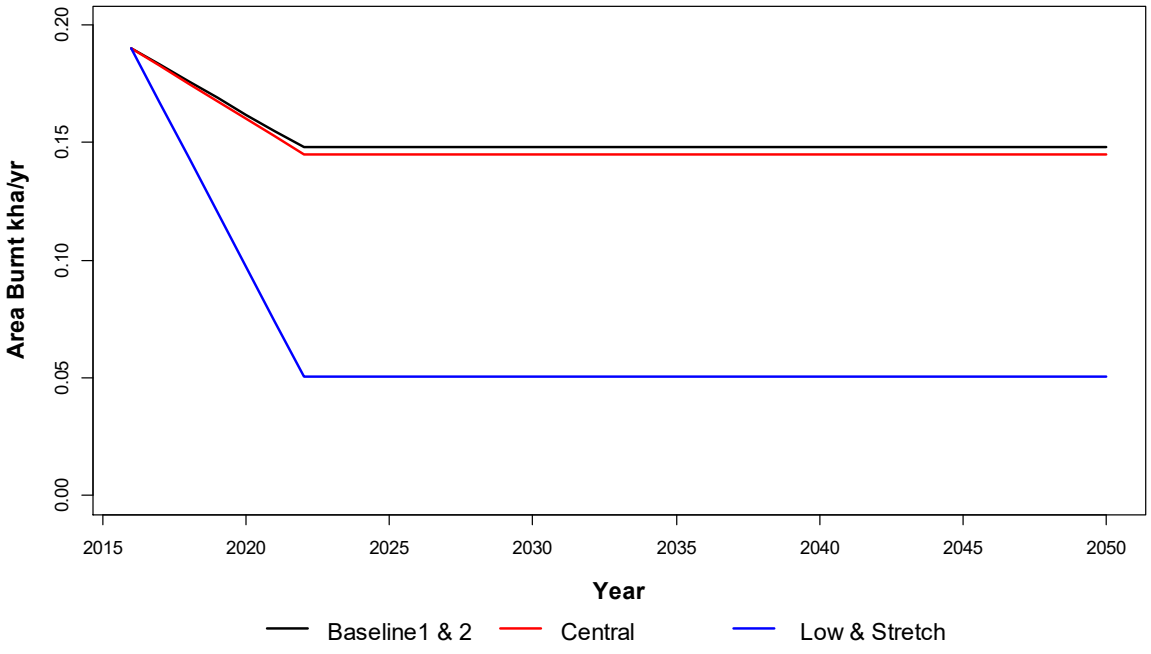

Figure 3: Cropland wildfire activity data for the emissions scenarios (UK)

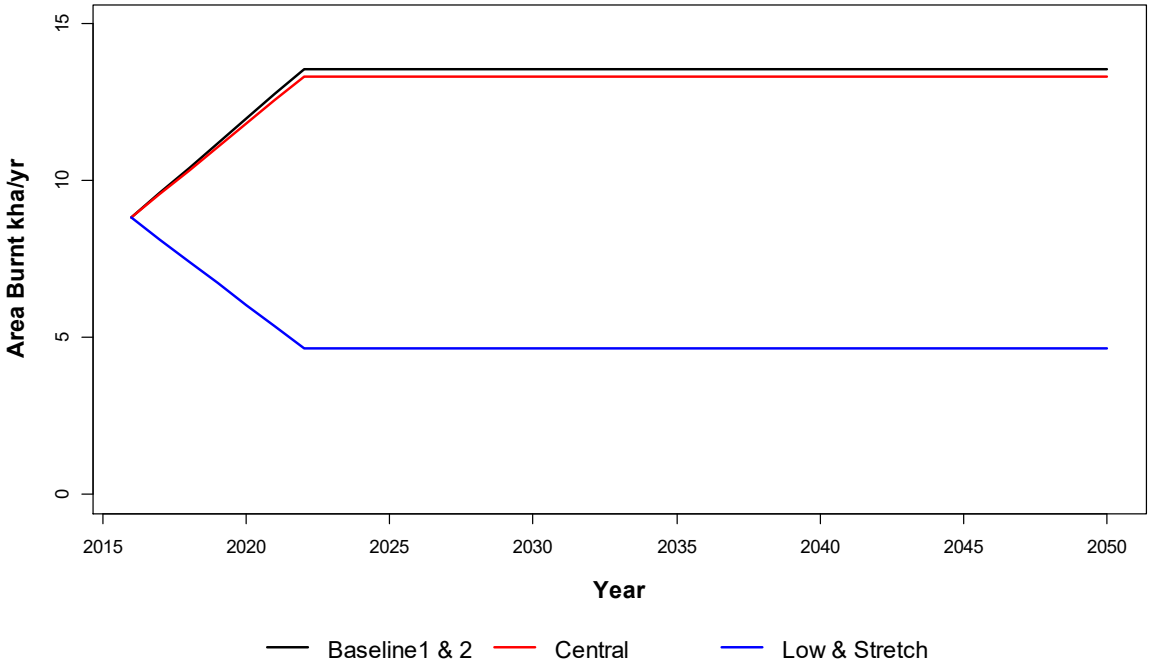

Figure 4: Grassland wildfire activity data for the emissions scenarios (UK)

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_2O 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.

In all DAs, 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) to reflect agricultural land rotation. This is based on the average annual conversion each way 1990-2009 for each country (56.6 kha in England, 16.7 kha in Scotland, 5.2 kha in Wales and 4.2 kha in Northern Ireland each way). In addition, an additional flux of conversion of grassland to cropland is assumed in Wales (based on advice from Welsh Government).

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).

- 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 for England; 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 in the *Baseline 1* scenario except that the annual area converted to Settlement is 50% of the *Central* scenario annual conversion area for all countries.

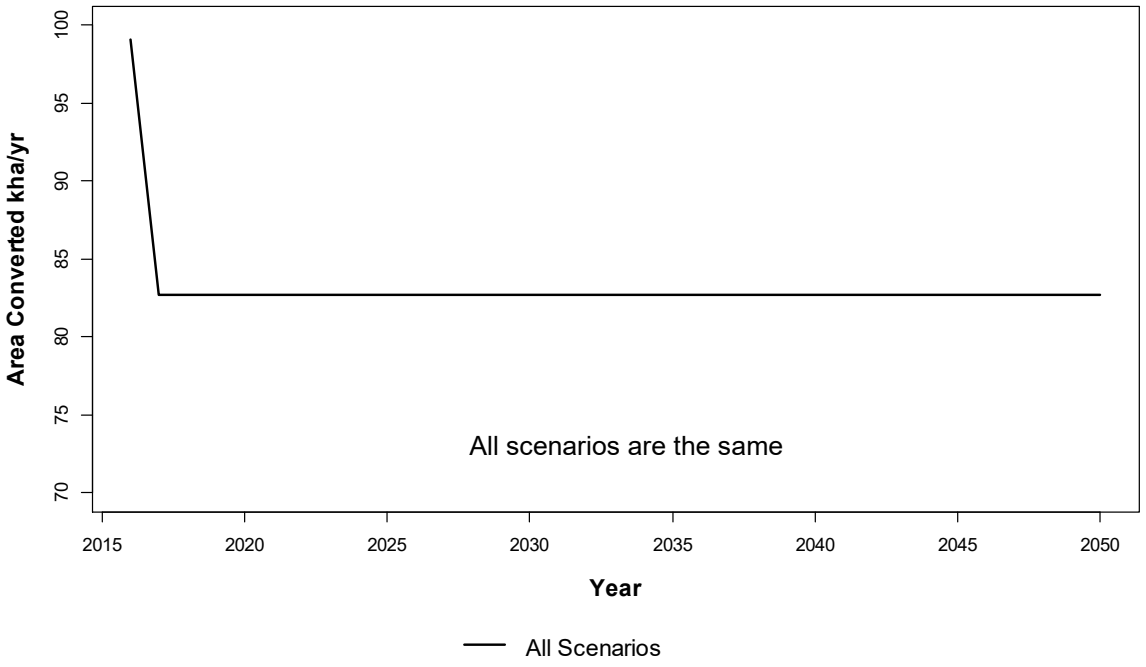

Figure 5: Activity data for Cropland to Grassland land use change for the emissions scenarios (UK)

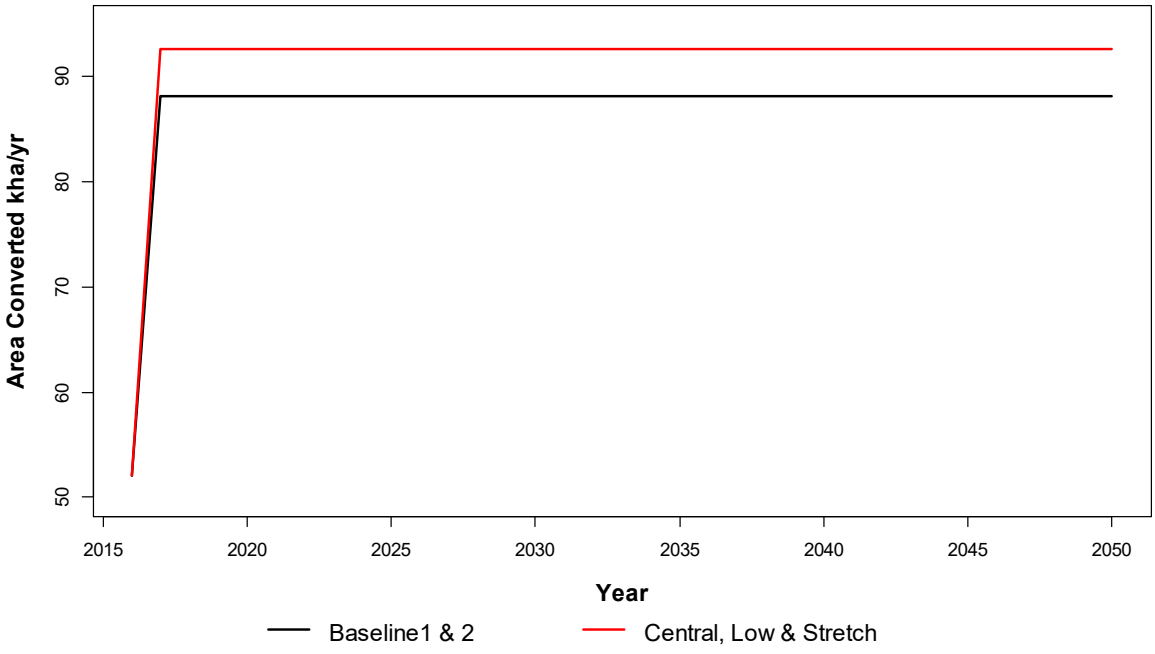

Figure 6: Activity data for Grassland to Cropland land use change for the emissions scenarios (UK)

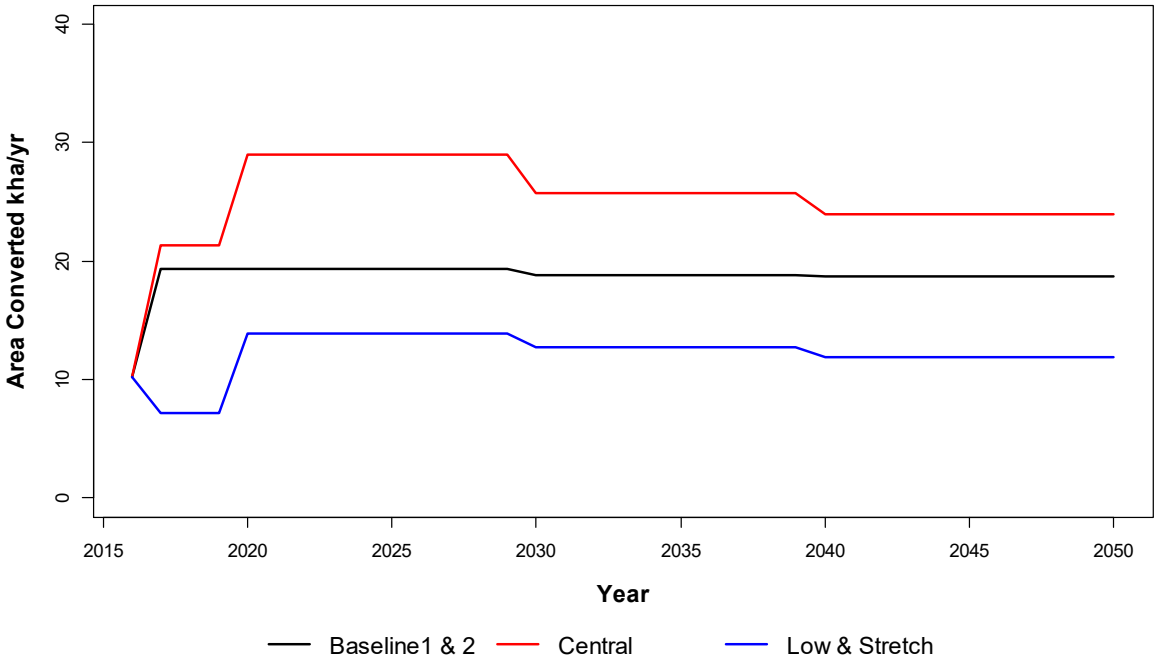

Figure 7: Activity data for Grassland to Settlement land use change for the emissions scenarios (UK)

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_2, N_2O, and CH_4).

It is difficult to assign deforestation levels to specific afforestation/emissions scenarios, as in some cases a low deforestation rate might arise when planting rates are low, with policy responding to avoid net deforestation. Alternatively, deforestation might be independent of afforestation, responding to economic and housing development, for example. Although the Scottish Government's policy on 'the Control of Woodland Removal' and FCE's Open Habitats policy (When to convert woods and forests to open habitats in England) 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.

Two deforestation levels have been used: *Baseline 1* projects the 2009 levels of deforestation forward at a constant level to 2050; reflecting the lack of explicit policies (see above) to reduce deforestation prior to this date. However, as there is a limit to the potential area available for restoration from forest to open habitat (currently the main driver of deforestation) this assumption represents a high emission assumption.

The other scenarios use a single deforestation level based on the average deforestation levels between 2010 and 2014[8], projected forward and declining to a low, constant, rate from 2040 onwards. The post-2040 deforestation rate assumes that: 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.

[8] These deforestation levels were compiled by forestry experts using reported definite land cover change and administrative data on habitat restoration and deforestation for wind farm development.

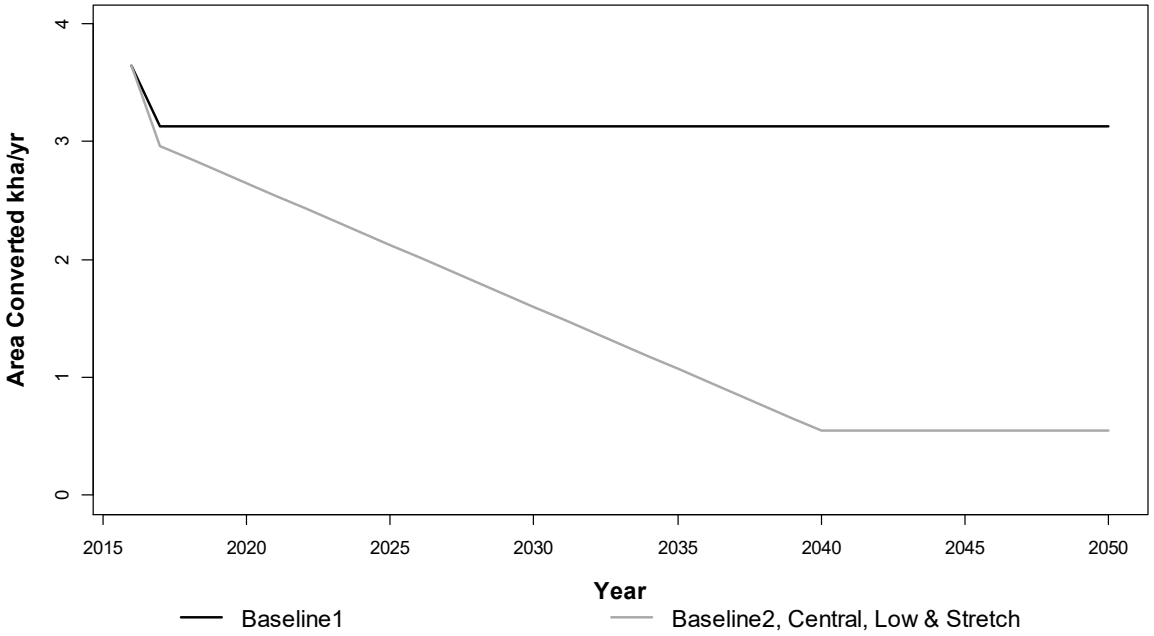

Figure 8 : Deforestation rate for all emissions scenarios (UK)[9].

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 2016 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 projected values.

[9] Disaggregation of these data by Country is provided in Annex 3.

Table 3: Activity data for Cropland Management scenarios.

		England (E)/ Wales (W)/ Northern Ireland (NI)		Scotland	
		Baseline 1* and *2	***Central/ Low/ Stretch***	***Baseline 1* and *2***	***Central/ Low/ Stretch***
Soil carbon stocks	% crop area receiving mineral N fertiliser	90	89	96	97
	% crop area receiving Farmyard Manure	18	22	29	31
	Tillage: full inversion % area	56 (E, W) 94 (NI)	56(E, W) 92 (NI)	89	90
	Tillage: minimum tillage % area	40 (E, W) 2 (NI)	40 (E, W) 6 (NI)	11	6
	Tillage: None or direct seeding % area	4 (E, W) 5 (NI)	4 (E, W) 1 (NI)	0	4
	% crop residue removed (average)	55 (GB)[10]	55 (GB)	55 (GB)	55 (GB)
	% land manured (average)	2.6 (GB)[11]	3.2 (GB)	2.6 (GB)	3.2 (GB)
Biomass carbon stocks	Annual change in biomass carbon, tC	-1824 (E) -69 (W) -111 (NI)	-2898 (E) -203 (W) -148 (NI)	2	-145

3.6 Agricultural drainage

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

3.7 Peat extraction

The area covered by peat extraction and extraction site restoration is small compared with other land use activities (Figure 9). Even after extraction ceases, this area may not always be converted to another land use and so remains 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 2016 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 2007-2016 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 extraction with 50% successful site restoration by 2050 for sites in Scotland, Wales and Northern Ireland. In England, extraction area in 2016 is the same as in the Central scenario, however with 100%

[10] Wheat 61%, Winter Barley 89%, Oats 15%, Oilseed Rape 25%, Spring Barley 92%, Maize or equivalent 95%, Sugarbeet 5%, Other Cereals 60%
[11] Winter/spring crop and manure-source specific

restoration success of inactive sites to target habitats. The volume of horticultural peat extracted each year is projected to be fixed at the decadal average 2007-2016 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.

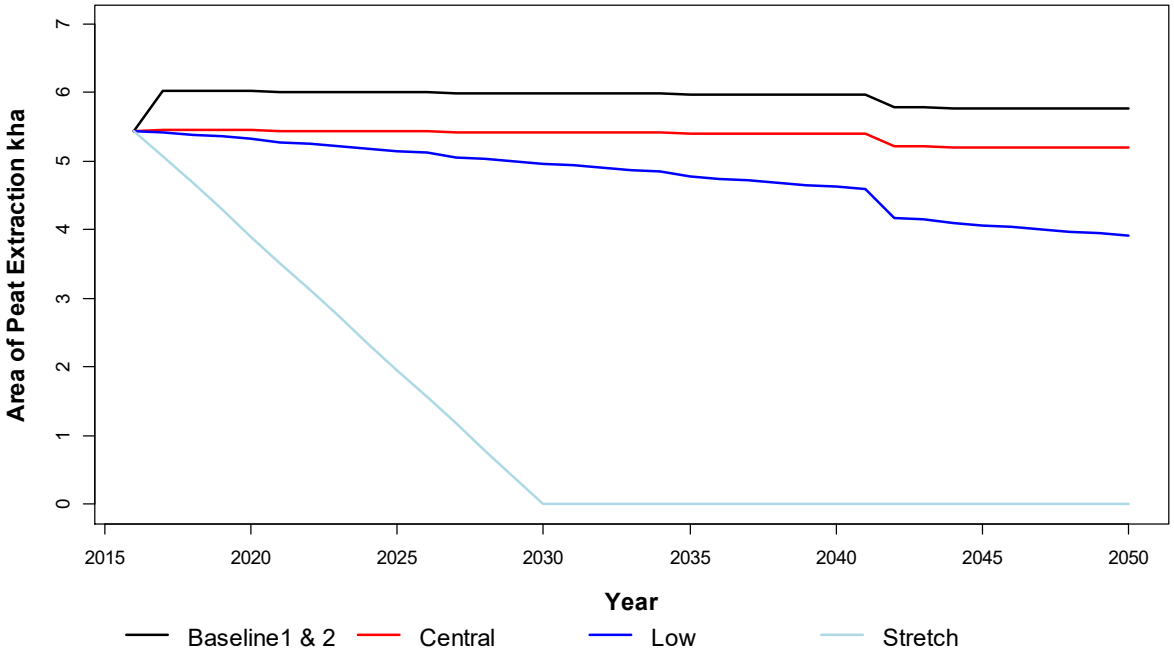

Figure 9: Peat extraction areas over time for all scenarios.

4 Projections 2016-2050

A summary of the results is given here. Detailed emission estimates by activity, country and scenario are available for download from the NAEI website[12].

4.1 Land Use Areas

Table 4 shows the projected distributions of land use areas in the UK between 2016 and 2050 - the areas for each country 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*., 2018). 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 country 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.

[12] https://naei.beis.gov.uk/reports/reports?report_id=1012

Table 4: Land use areas[13] 2016-2050 for the United Kingdom (24,419 kha).

Emission scenario	*Land use category*	*2016 area, kha*	*2020 area, kha*	*2030 area, kha*	*2040 area, kha*	*2050 area, kha*	*% of land area in 2016*	*% of land area in 2050*
Central	Forest land	3529	3555	3540	3535	3536	14%	14%
	Cropland	5065	5115	5215	5315	5415	21%	22%
	Grassland	13404	13198	12805	12442	12093	55%	50%
	Wetland	170	170	170	169	169	1%	1%
	Settlement	1780	1897	2192	2450	2691	7%	11%
	Other	471	483	497	507	515	2%	2%
Baseline 1	Forest land	3529	3542	3575	3608	3641	14%	15%
	Cropland	5065	5093	5148	5203	5258	21%	22%
	Grassland	13404	13246	12945	12652	12362	55%	51%
	Wetland	170	170	169	169	169	1%	1%
	Settlement	1780	1881	2083	2278	2473	7%	10%
	Other	471	488	500	508	515	2%	2%
Baseline 2	Forest land	3529	3522	3509	3507	3511	14%	14%
	Cropland	5065	5093	5148	5203	5258	21%	22%
	Grassland	13404	13268	13005	12726	12462	55%	51%
	Wetland	170	170	169	169	169	1%	1%
	Settlement	1780	1883	2090	2306	2504	7%	10%
	Other	471	484	498	508	515	2%	2%
Low	Forest land	3529	3585	3789	3906	3987	14%	16%
	Cropland	5065	5115	5215	5315	5415	21%	22%
	Grassland	13404	13221	12779	12436	12133	55%	50%
	Wetland	170	170	169	169	169	1%	1%
	Settlement	1780	1823	1956	2078	2192	7%	9%
	Other	471	505	510	515	523	2%	2%
Stretch	Forest land	3529	3607	3912	4230	4502	14%	18%
	Cropland	5065	5115	5215	5315	5415	21%	22%
	Grassland	13404	13192	12651	12118	11634	55%	48%
	Wetland	170	169	166	166	166	1%	1%
	Settlement	1780	1820	1945	2055	2160	7%	9%
	Other	471	515	530	534	542	2%	2%

[13] The percentages reflect the UK area including water bodies.

4.2 UK projected emissions and removals

Table 5, Table 6, Table 7 and Table 8 show projected emissions of CO_2, CH_4, N_2O and total CO_2 equivalents for the LULUCF sector for the UK; similar summary numbers for each country are included in Annex 2, and the full dataset is available for download with this report from the NAEI website[14]. Graphs of GHG emissions at the UK and country level for the whole LULUCF sector and for the individual land use categories are shown in Figure 10Figure 10, Figure 11Figure 11, Figure 12, Figure 13 and Figure 14. These graphs show the projected data to 2050 together with the reported inventory data for 1990-2016.

At the UK level, (Figure 10) the net CO_2 equivalent emissions / removals from all parts of the LULUCF sector are combined to produce an increasing net carbon sink (increasing net removals) between 1990 and 2016. This trend reverses around 2022, driven by the decreasing net removals in the Forest Land category as now mature forests planted when afforestation rates were at a maximum from the 1950s to 1980s are harvested, and an increasing trend in net Cropland and Settlement emissions. The difference between scenarios widens in the 2030s, with the *Central* and *Baseline* scenarios continuing towards zero and the *Low* and *Stretch* scenarios becoming increasing sinks again. 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 increase 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 an increasing sink between 1990 and 2010, and then shows some variation between then and 2020, before showing a net decrease in sink strength under all scenarios. This decrease continues until the mid-2030s when the *Central* and *Baseline* scenarios stabilise, while the net sink strength starts to increase again under the Low and Stretch scenarios. 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 between 2020 and 2035 is due to large numbers of trees being thinned or reaching maturity (some 35-50 years since planting) and hence being harvested, and a low planting rate from the 1990s.

Cropland is projected to be a slowly increasing source post-2016, mostly driven by land use change to Cropland and crop to grass rotations. 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.

The scale of changes in the Wetlands net source is small compared to the other land use categories. Figure 15 shows the changes in net emissions on a larger scale graph. The differences between scenarios are driven by assumptions about the reduction in peat extraction and the restoration of former extraction sites.

Emissions from land use change to Settlements are projected to decrease over the time period under the *Low* and *Stretch* scenarios, but to increase under the *Central* and *Baseline* scenarios (driven predominantly by the net emissions from England). 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) varies between the different scenarios. The activity data for the projections have been revised this year and are discussed further in Annex 1.

Harvested Wood Products (HWPs) are projected to be a small sink over the period 2017 to 2050. The trend is driven by the balance between deforestation rates, thinning and felling regimes and the expected lifetime of the HWPs. There is little difference between the scenarios as the majority of harvest originates from trees planted before the projection time period.

CO_2, arising from soil carbon stock changes, is the main GHG associated with LULUCF (Figure 16), although N_2O emissions also make a significant contribution when the GWP of N_2O of 298 is taken into account. These N_2O emissions arise from forest fertilisation, forest drainage, soil nitrogen mineralisation following land use change and from biomass burning. The *Stretch* scenario does not result in the lowest emissions of N_2O because the increased afforestation (with increased CO_2 removals) in this scenario also produces increased N_2O emissions from forest fertilisation and drainage. CH_4 emissions (GWP of 25) arising from biomass burning are included in the projections but they do not make a significant contribution to the overall totals.

4.3 Country-level projected emissions and removals

[14] https://naei.beis.gov.uk/reports/reports?report_id=1012

England shows a sharp reduction in the net sink strength after 2020 (Figure 11Figure 11), becoming a net source of LULUCF emissions by 2044-45 under the *Baseline* scenarios and 2039 under the *Central* scenario. The differences between the scenarios come mostly from differences in the Settlement category emissions, as there is little difference between the scenarios for the Forest Land category.

The projections for Scotland indicate a net LULUCF GHG sink for all scenarios, but the overall pattern of projected emissions and removals for Scotland (Figure 12) is similar to the UK, being driven primarily by the Forest Land sink.

Wales (Figure 13) is a net LULUCF GHG sink for all scenarios throughout the time series. The *Baseline 1* and *2* scenarios are a larger sink than the *Central*, *Low* and *Stretch* scenarios due to differences in projected land use change to Cropland (a lower additional rate of Grassland to Cropland conversion is assumed in the Baseline scenarios). Some differentiation between scenarios due to net removals from the Forest Land category also become apparent in the 2040s, contributing to a decline in the net LULUCF sink that is most apparent in the *Central* scenario, with net neutral emissions by 2050.

Northern Ireland (Figure 14) 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 during the 2030s-2040s. This is mainly driven by the trend in emissions from Settlements, which peak in 2018 and then decrease to 2050.

The relative contributions of the LULUCF sector from the countries to the UK total are shown in Figure 17 (Central scenario).

4.4 Changes from the 1990-2015 projections

There have been some changes to activity data and methods used for estimating the LULUCF emissions and removals since the previous projections report. These differences are shown at the UK level in Figure 18 by comparing the *Central* projections based on the 2016 and 2015 inventories.

In the Forest Land category the projections have changed because the forest areas have been amended to bring the area of recent afforestation more in to line with the new planting statistics. This changes the age structure of the forests which affects the magnitude of the carbon sink over time.

Projections from the Settlement category have changed because the published time series of house-building has been revised (and improved), leading to larger estimates of conversion to Settlement in England in particular. Further details are given in Annex 1.

Table 5: LULUCF emissions and removals of CO_2 1990-2050.

Scenario	Country	1990 Gg CO_2	2016 Gg CO_2	2020 Gg CO_2	2030 Gg CO_2	2040 Gg CO_2	2050 Gg CO_2
Central	**UK**	-4377	-16026	-17263	-12523	-7667	-4659
Baseline 1	**UK**	-4377	-16026	-17641	-13468	-8379	-5483
Baseline 2	**UK**	-4377	-16026	-17836	-14107	-9089	-6060
Low	**UK**	-4377	-16026	-17979	-14673	-11583	-11256
Stretch	**UK**	-4377	-16026	-17952	-14593	-11553	-12576

Table 6: LULUCF emissions and removals of CH_4 1990-2050.

Scenario	Country	1990 Gg CH_4	2016 Gg CH_4	2020 Gg CH_4	2030 Gg CH_4	2040 Gg CH_4	2050 Gg CH_4
Central	**UK**	0.64	1.39	1.38	1.11	0.75	0.77
Baseline 1	**UK**	0.64	1.39	1.45	1.55	1.54	1.59
Baseline 2	**UK**	0.64	1.39	1.29	1.02	0.66	0.67
Low	**UK**	0.64	1.39	1.04	0.68	0.32	0.32
Stretch	**UK**	0.64	1.39	1.04	0.68	0.32	0.32

Table 7: LULUCF emissions and removals of N_2O 1990-2050.

Scenario	Country	1990 Gg N_2O	2016 Gg N_2O	2020 Gg N_2O	2030 Gg N_2O	2040 Gg N_2O	2050 Gg N_2O
Central	**UK**	7.55	4.81	5.04	6.02	6.25	6.21
Baseline 1	**UK**	7.55	4.81	4.90	5.56	5.82	5.84
Baseline 2	**UK**	7.55	4.81	4.84	5.41	5.65	5.60
Low	**UK**	7.55	4.81	4.84	5.41	5.52	5.24
Stretch	**UK**	7.55	4.81	4.87	5.53	5.85	5.67

Table 8: LULUCF emissions and removals of CO_2 equivalents 1990-2050 (1 Mt CO_2e = 1000 Gg CO_2e).

Scenario	Country	1990 Gg CO_2 eq	2016 Gg CO_2 eq	2020 Gg CO_2 eq	2030 Gg CO_2 eq	2040 Gg CO_2 eq	2050 Gg CO_2 eq
Central	**UK**	-2111	-14557	-15726	-10700	-5785	-2788
Baseline 1	**UK**	-2111	-14557	-16145	-11771	-6606	-3701
Baseline 2	**UK**	-2111	-14557	-16362	-12468	-7390	-4375
Low	**UK**	-2111	-14557	-16511	-13045	-9930	-9687
Stretch	**UK**	-2111	-14557	-16475	-12927	-9802	-10878

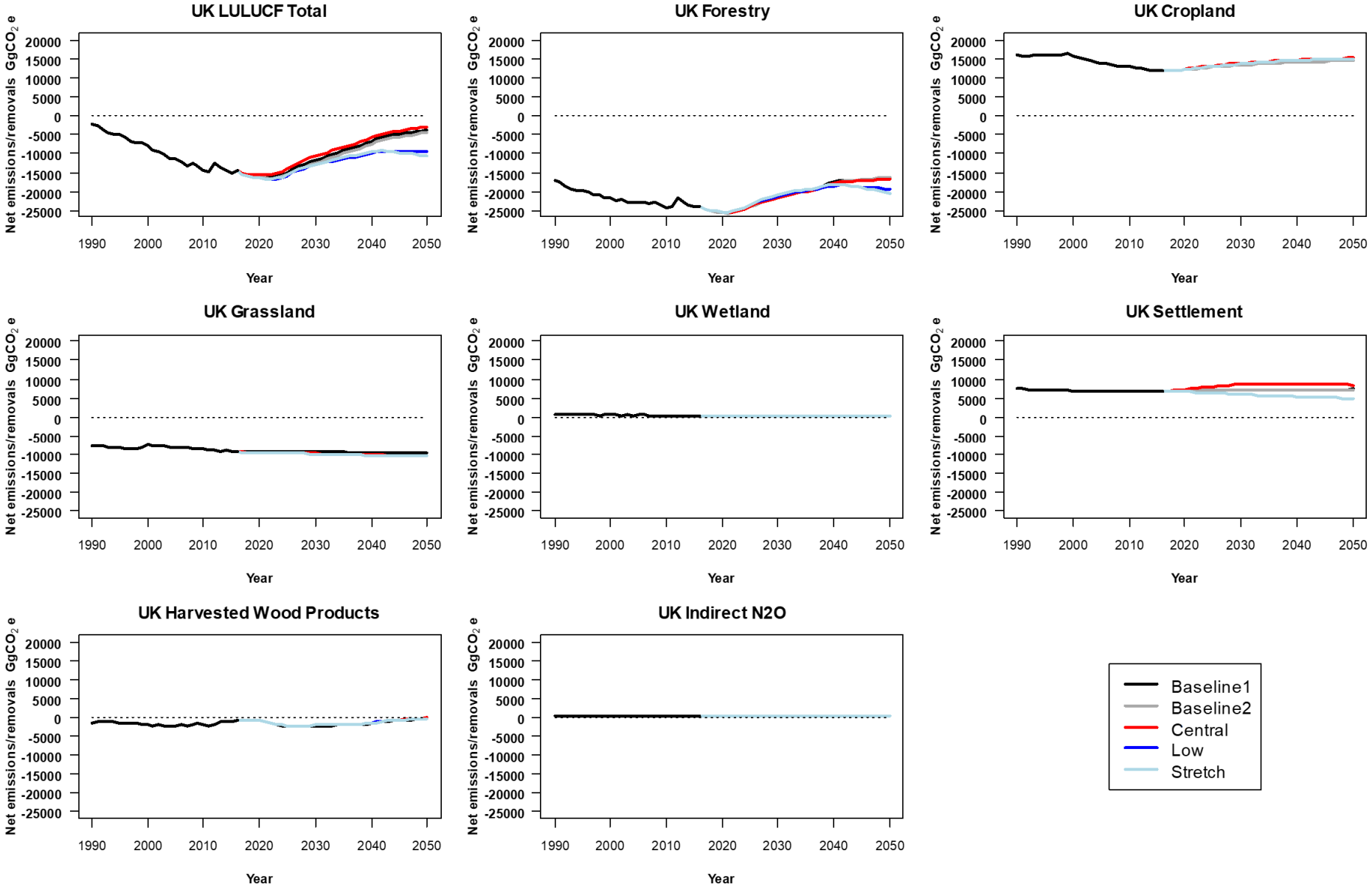

Figure 10: UK LULUCF CO_2 equivalent emissions scenarios 1990-2050. The individual graphs refer to LULUCF reporting categories; see Section 3 text for description of what is reported in these categories (1 Mt CO_2e = 1000 Gg CO_2e).

Projections of Emissions and Removals from the LULUCF Sector to 2050

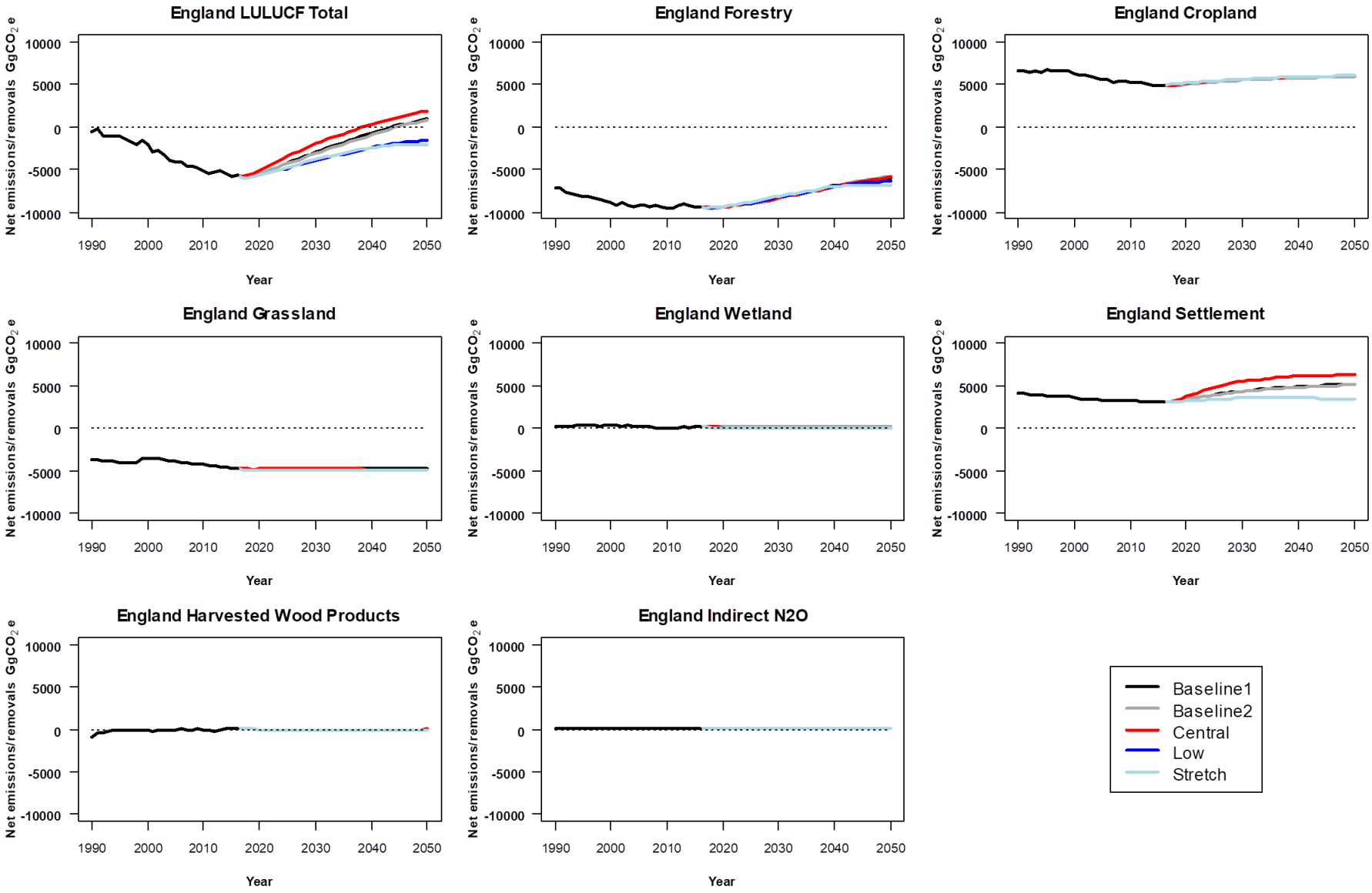

Figure 11: England LULUCF CO_2 equivalent emissions scenarios 1990-2050. The individual graphs refer to LULUCF reporting categories; see Section 3 text for description of what is reported in these categories (1 Mt CO_2e = 1000 Gg CO_2e).

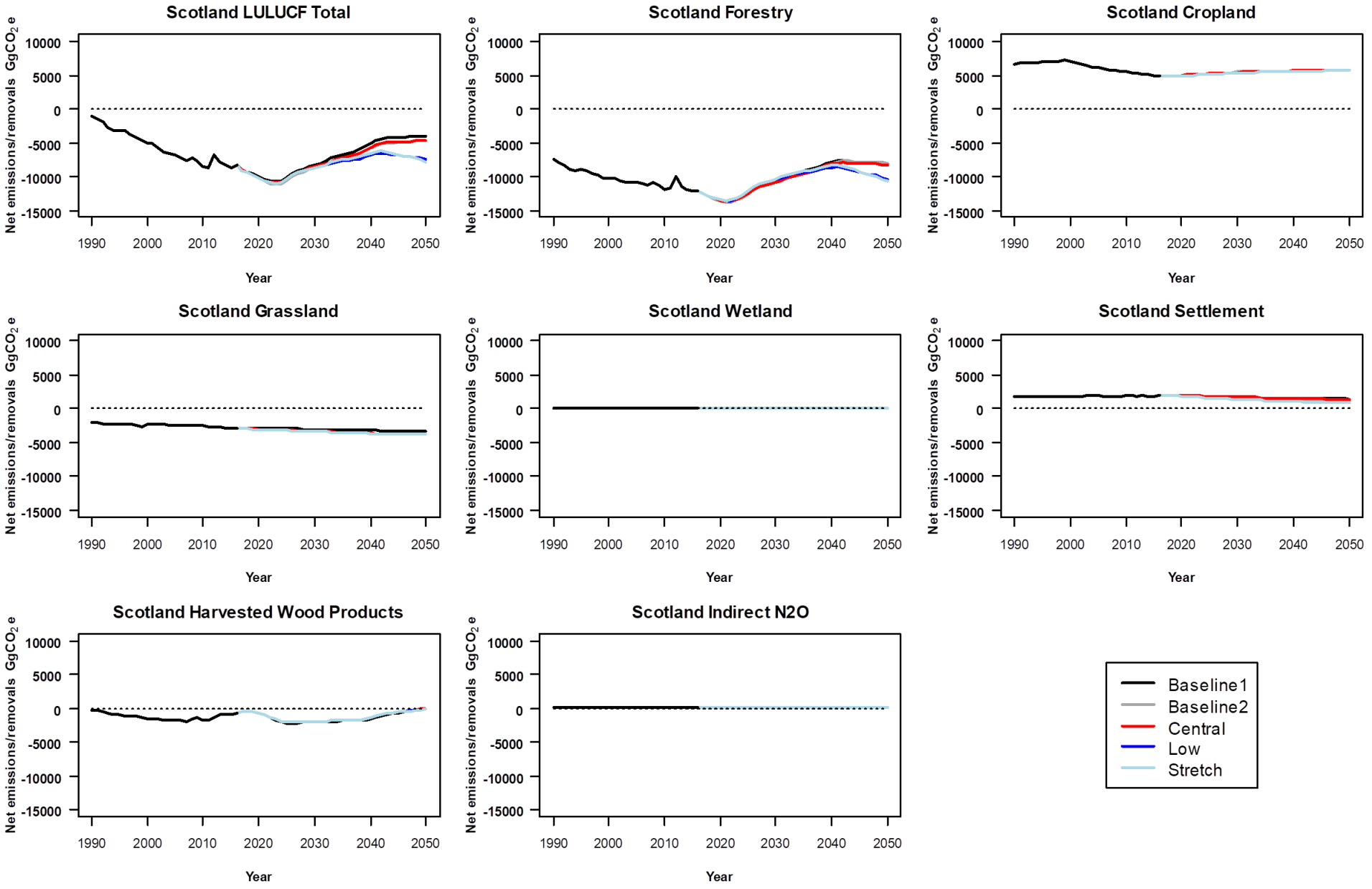

Figure 12: Scotland LULUCF CO_2 equivalent emissions scenarios 1990-2050. The individual graphs refer to LULUCF reporting categories; see Section 3 text for description of what is reported in these categories (1 Mt CO_2e = 1000 Gg CO_2e).

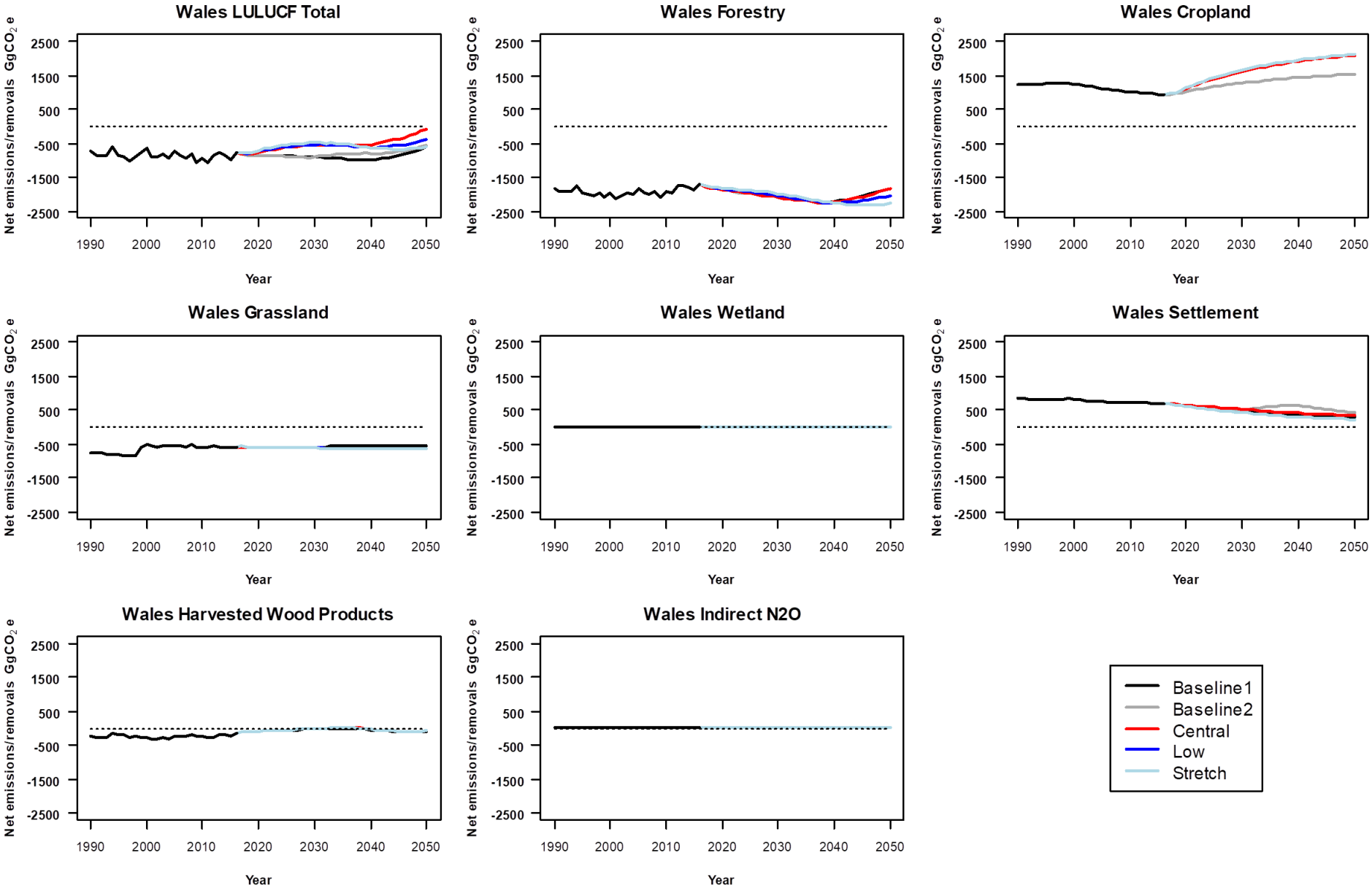

Figure 13: Wales LULUCF CO_2 equivalent emissions scenarios 1990-2050. The individual graphs refer to LULUCF reporting categories, which for cropland and grassland are mainly driven by land use change (1 Mt CO_2e = 1000 Gg CO_2e).

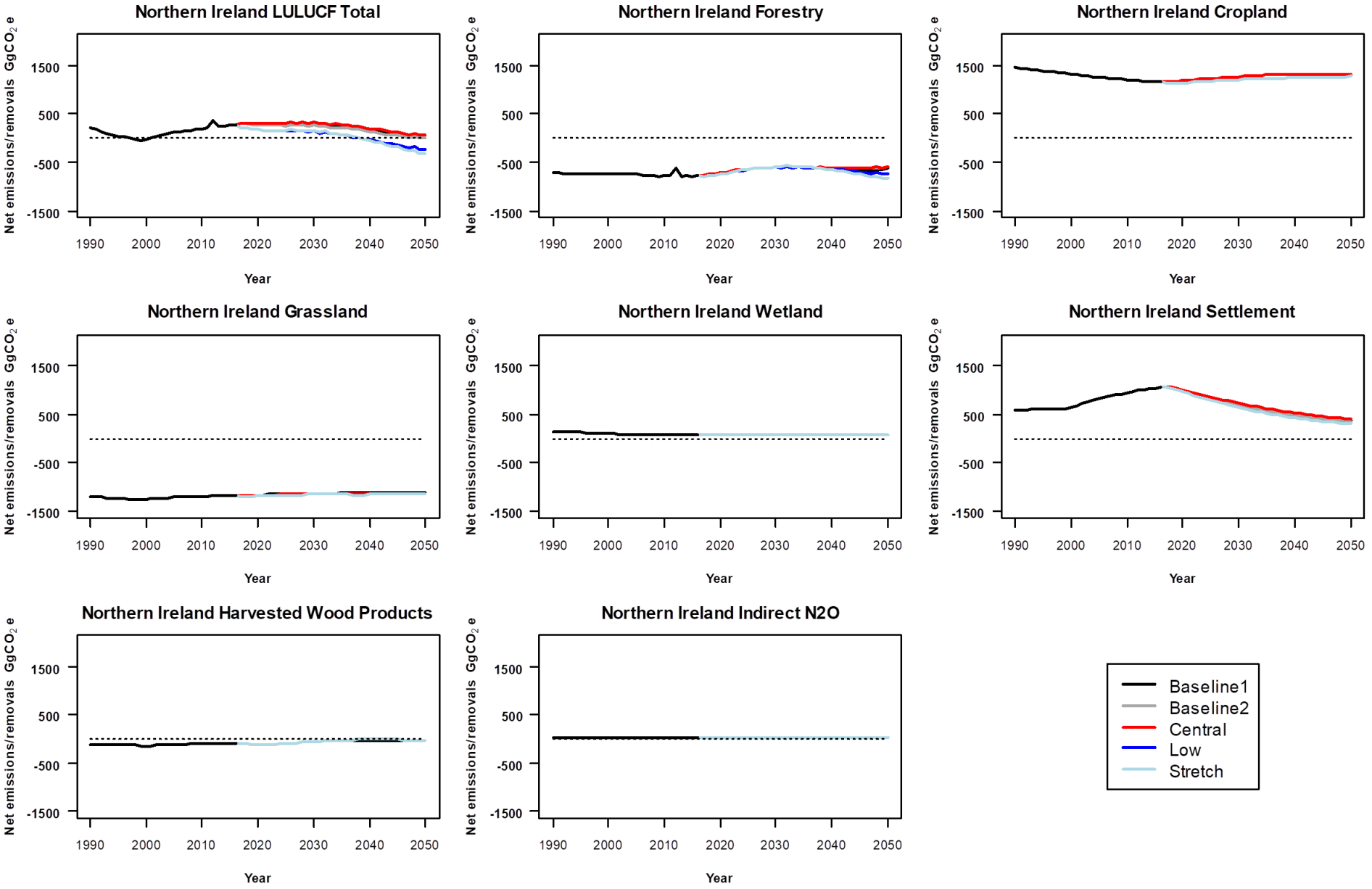

Figure 14: Northern Ireland LULUCF CO_2 equivalent emissions scenarios 1990-2050. The individual graphs refer to LULUCF reporting categories; see Section 3 text for description of what is reported in these categories (1 Mt CO_2e = 1000 Gg CO_2e).

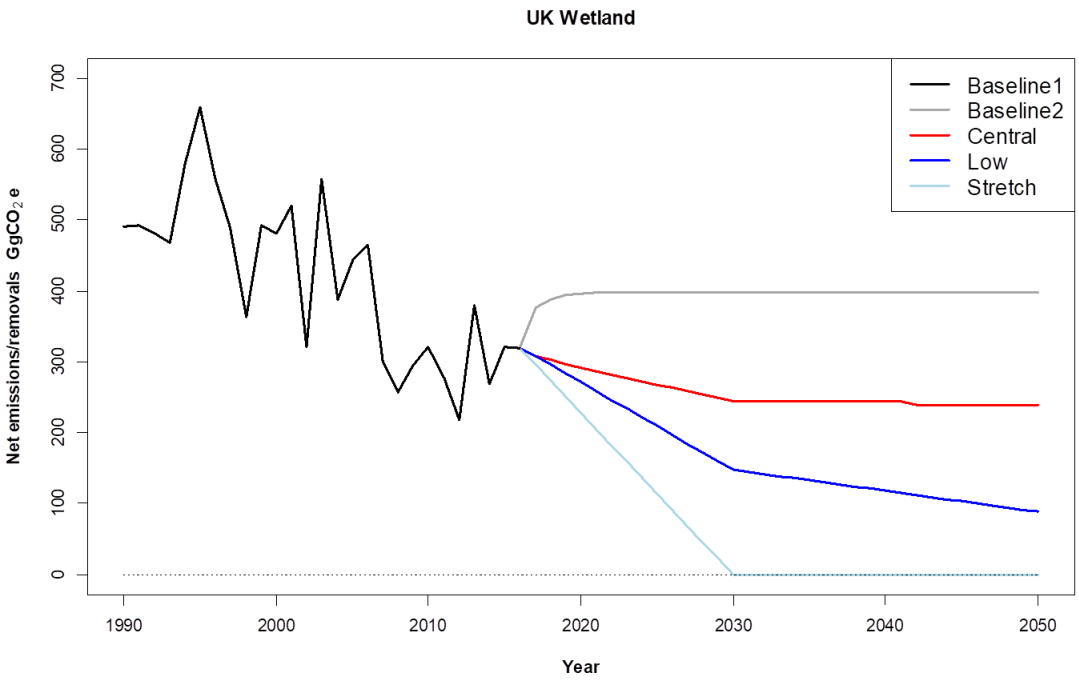

Figure 15: Net emissions from Wetlands under all scenarios (shown on larger scale for clarity) (1 Mt CO_2e = 1000 Gg CO_2e).

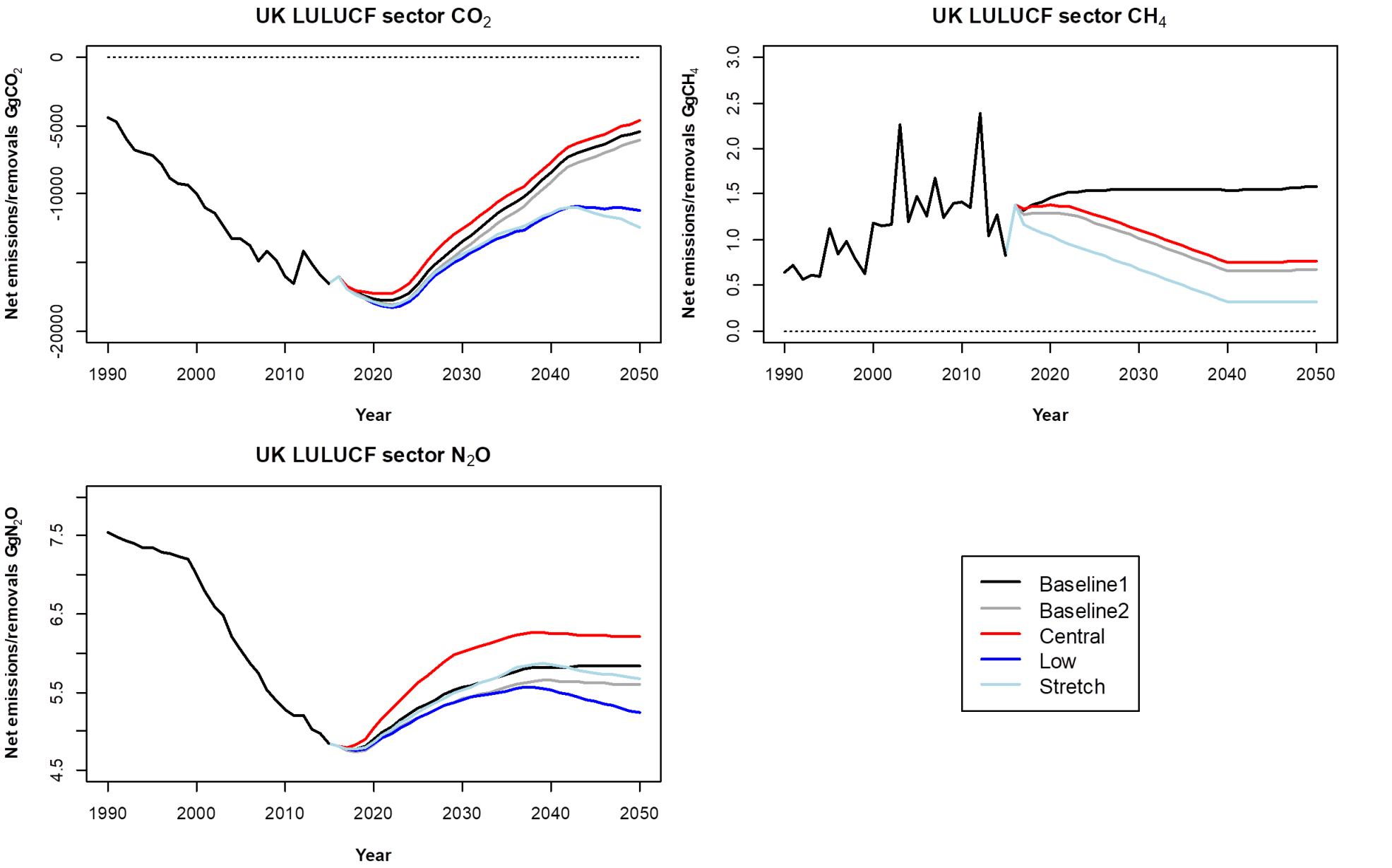

Figure 16: UK LULUCF Sector emissions of individual gases 1990-2050 (1 Mt CO_2e = 1000 Gg CO_2e).

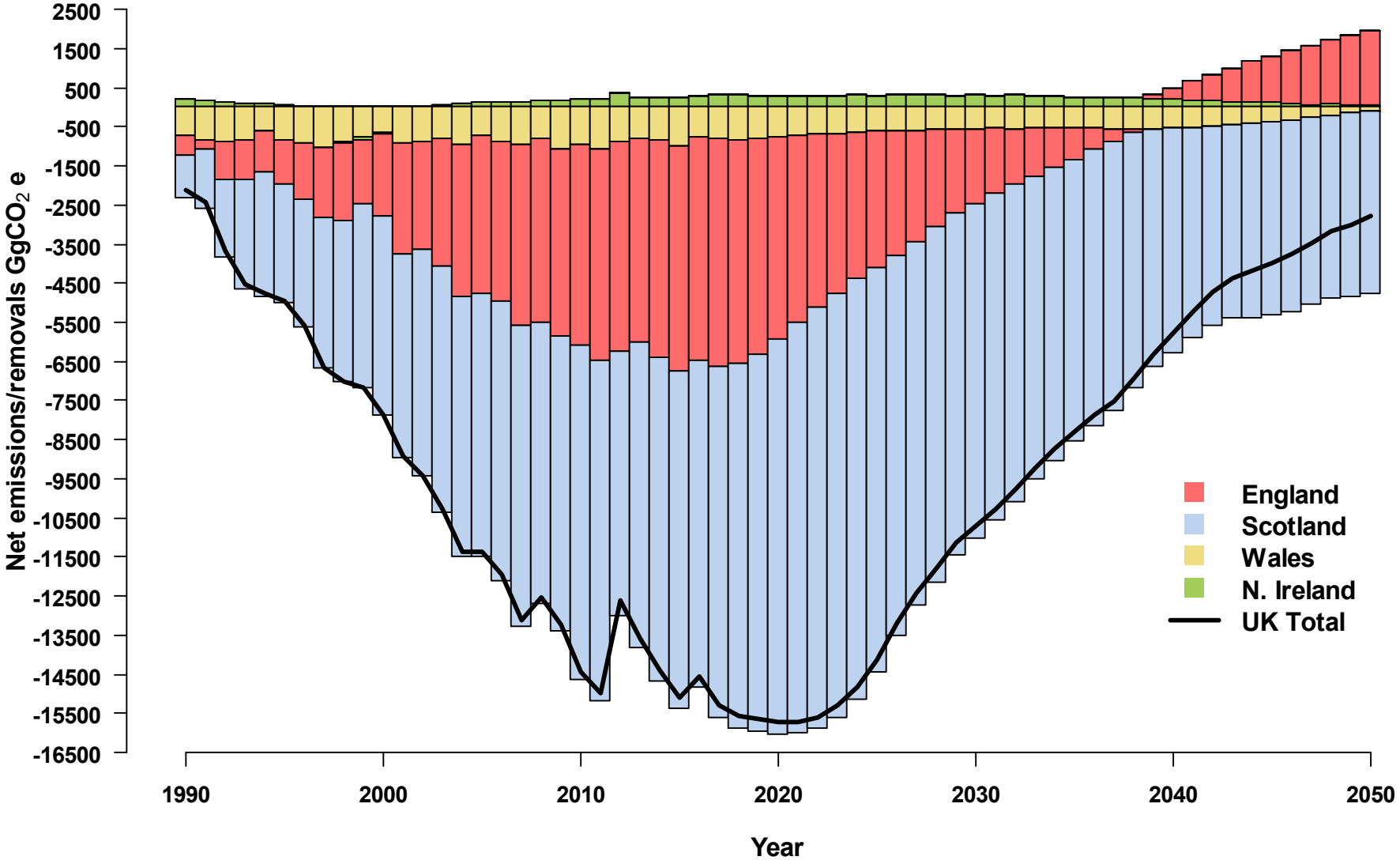

Figure 17: The combined total of the LULUCF emissions from each country for the *Central* emissions scenario.

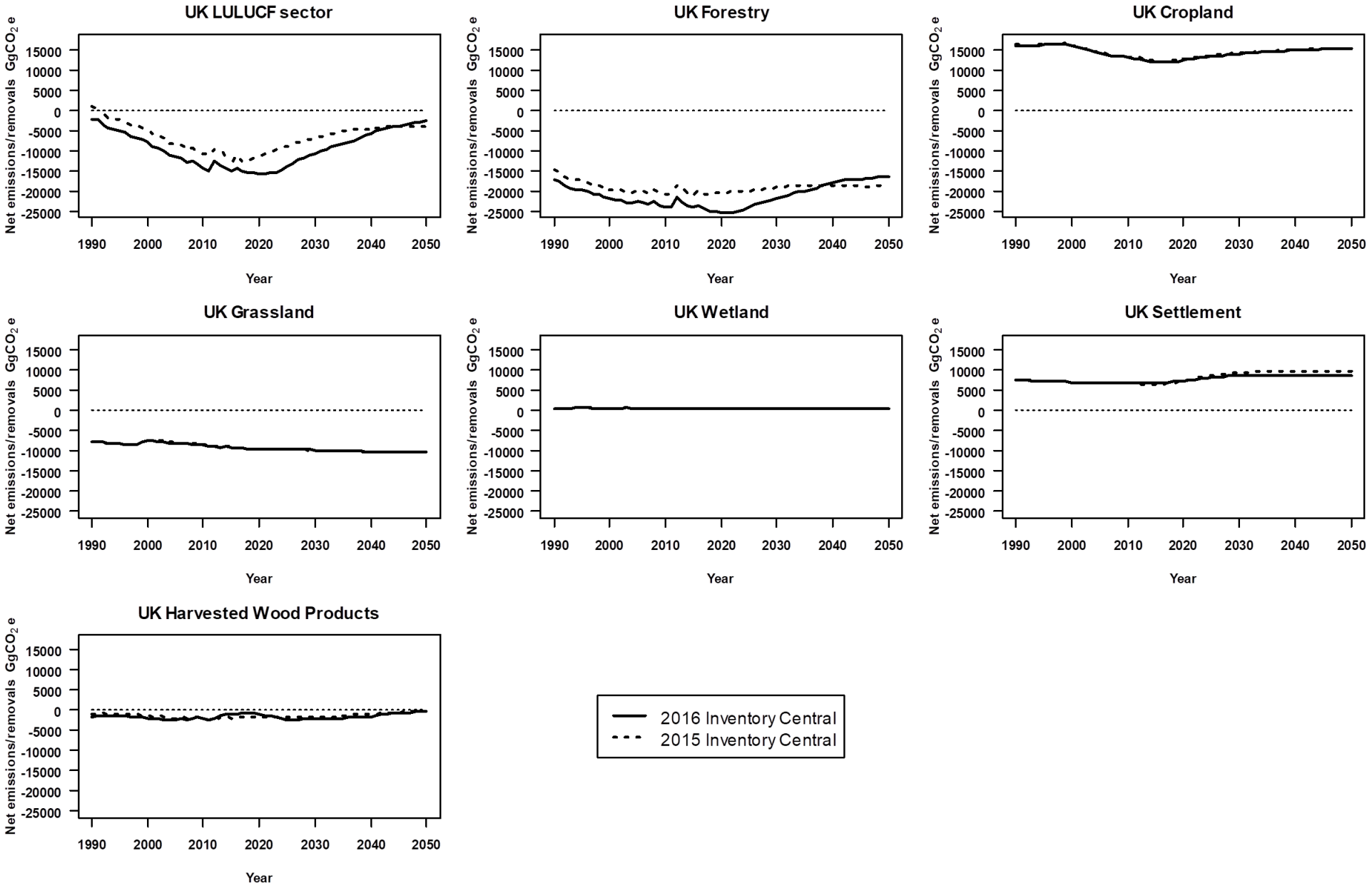

Figure 18 UK LULUCF CO_2 equivalent comparison of the Central and Mid emissions scenario for the 2015 and 2014 inventories respectively 1990-2050 (1 Mt CO_2e = 1000 Gg CO_2e).

5 References

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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 changed significantly in recent years (MHCLG, 2018a, b), 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 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), now the Ministry of Housing, Communities and Local Government (MHCLG), and projections of the number of households in the UK and its constituent countries (DCLG 2016).

The LUCS data describe land area change to developed use in England, based on the change to and from 28 land use categories. The latest LUCS data (2013-14 to 2016-17) are derived by a methodology based on changes in Ordnance Survey products, rather than the physical observations of the previous methodology. The change in methodology was sought by Government to increase cost-effectiveness and to enable more detailed statistical and spatial analysis of the LUCS dataset (DCLG 2015). There are important differences between the two methodologies and “due to the changes in methodology and land use classification, comparison and interpretation between the two series is not recommended” (p.6, DCLG 2015).

The LUCS dataset reports the annual areas changing from previously non-developed to developed use, the area converted to residential use, the proportion of residential development compared to all development and the average density of new residential dwellings (England only).

In the previous LUCS methodology implemented until the projections consistent with the 1990-2014 inventory, the total area of change from a previously non-developed use to a developed use in 2011 was 2180 ha, of which 1130 ha changed to residential use. The historic time series was used to derive

an assumption that 50% of all conversion from previously non-developed use was to residential use and 50% to non-residential use.

In the new LUCS methodology, the total area of change from a previously non-developed use to a developed use in 2016-17 is 13,049 ha, of which 3,331 ha is to residential use. The proportion (26%) is also explicitly given in the LUCS. This ratio is used in the LULUCF projections to extrapolate total area converted to developed land (Settlement) from the estimated area converted to residential land (from household projections and average housing density). Revisions in the MHCLG data on house building have changed the projected areas of residential and all developed land conversion in England for the latest projections based on the 1990-2016 inventory:

- 1990-2014 inventory: Residential use conversion at 2,639 ha yr^{-1}, all developed land conversion 5,278 ha yr^{-1} (Extrapolated values based on old methodology).
- 1990-2015 inventory: Residential use conversion at 4,619 ha yr^{-1}, all developed land conversion 26,792 ha yr^{-1} (New methodology).
- 1990-2016 inventory: Residential use conversion at 4,488 ha yr^{-1}, all developed land conversion 23,185 ha yr^{-1} (New methodology, revised house building figures).

The projections of household numbers (DCLG 2016) use the 2011 national population census updated to 2014 and trends in population demography and household formation to project household numbers to 2037-2039. In the LULUCF projections, the area of land converted to developed use is projected using the method described below and three key assumptions:

- The detailed LUCS data for England 2013-14 to 2016-17 are representative of the historic time series for projections to 2050 (this assumption can be refined as more annual data are published using the new LUCS methodology).
- The density of residential dwellings and the proportions of development on non-previously developed land in England are also representative of Scotland, Wales and Northern Ireland, in the absence of similar data.
- The projected number of households in the future can act as a proxy for the area of urban development (and a constant rate of additional households per year is assumed after 2037/39 as household numbers are only projected by MHCLG to this year).

The *Central* scenario assumes that residential development on previously non-developed (PND) land, and proportionally all development, is sufficient to meet the demand for housing predicted by the household projections dataset, where:

$aALL_i$ = Area of ALL conversion to developed land, ha, in year i

pcRes = % of new dwellings on PND land

densRes = average density of residential addresses created on PND land, dwellings per hectare

pcALL = % of residential development of all development on PND land

$\Delta Household_i$ = annual change in number of households (by country) for year i compared to year i-1

$$aALL_i = ((\Delta Household_i * pcRes)/densRes)/pcALL$$

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, thereby reducing the amount of land use change. The *Baseline* scenarios use the 2000-2009 average rate for conversion of PND land to developed land for England out to 2050. There are no equivalent rates for the other countries of the UK, so 70% of the decadal averages of the *Central* scenario are used. The *Low* and *Stretch* scenarios use 50% of the decadal average of the *Central* scenario for all countries.

The area of developed land, i.e. land converted to Settlement, is divided between conversion categories, using the projected areas of deforestation to Settlement, with the remaining area assigned to Grassland converted to Settlement.

Annex 2: Land use areas by Country

Table A2.1: Land use areas 2016-2050 for England (13,046 kha).

Emission scenario	*Land use category*	*2016 area, kha*	*2020 area, kha*	*2030 area, kha*	*2040 area, kha*	*2050 area, kha*
Central	Forest land	1598	1607	1602	1600	1599
	Cropland	4304	4304	4304	4304	4304
	Grassland	5534	5421	5162	4932	4718
	Wetland	19	18	18	18	18
	Settlement	1432	1533	1792	2024	2239
	Other	159	163	167	168	168
Baseline 1	Forest land	1598	1604	1621	1637	1654
	Cropland	4304	4304	4304	4304	4304
	Grassland	5534	5433	5235	5040	4846
	Wetland	19	18	18	18	18
	Settlement	1432	1521	1699	1878	2056
	Other	159	166	169	169	169
Baseline 2	Forest land	1598	1595	1590	1588	1588
	Cropland	4304	4304	4304	4304	4304
	Grassland	5534	5443	5263	5084	4903
	Wetland	19	18	18	18	18
	Settlement	1432	1522	1703	1884	2065
	Other	159	163	167	168	168
Low	Forest land	1598	1611	1655	1701	1737
	Cropland	4304	4304	4304	4304	4304
	Grassland	5534	5476	5307	5151	5012
	Wetland	19	18	18	18	18
	Settlement	1432	1468	1590	1701	1804
	Other	159	168	172	171	171
Stretch	Forest land	1598	1620	1712	1807	1879
	Cropland	4304	4304	4304	4304	4304
	Grassland	5534	5465	5256	5058	4886
	Wetland	19	18	15	15	15
	Settlement	1432	1467	1583	1688	1787
	Other	159	173	177	175	175

Table A2.2: Land use areas 2016-2050 for Scotland (7,881 kha).

Emission scenario	*Land use category*	*2016 area, kha*	*2020 area, kha*	*2030 area, kha*	*2040 area, kha*	*2050 area, kha*
Central	Forest land	1501	1518	1510	1508	1510
	Cropland	616	616	616	616	616
	Grassland	5260	5227	5206	5184	5160
	Wetland	91	91	91	91	91
	Settlement	180	188	207	223	239
	Other	233	240	250	258	265
Baseline 1	Forest land	1501	1507	1522	1537	1553
	Cropland	616	616	616	616	616
	Grassland	5260	5241	5204	5171	5139
	Wetland	91	91	91	91	91
	Settlement	180	184	197	207	217
	Other	233	242	250	258	265
Baseline 2	Forest land	1501	1497	1492	1492	1496
	Cropland	616	616	616	616	616
	Grassland	5260	5251	5234	5214	5192
	Wetland	91	91	91	91	91
	Settlement	180	185	198	209	220
	Other	233	240	250	259	265
Low	Forest land	1501	1536	1672	1716	1748
	Cropland	616	616	616	616	616
	Grassland	5260	5201	5060	5003	4957
	Wetland	91	91	91	91	91
	Settlement	180	182	187	194	201
	Other	233	254	254	262	268
Stretch	Forest land	1501	1541	1702	1872	2044
	Cropland	616	616	616	616	616
	Grassland	5260	5194	5019	4838	4655
	Wetland	91	91	91	91	91
	Settlement	180	182	186	189	192
	Other	233	257	267	276	282

Table A2.3: Land use areas 2016-2050 for Wales (2,078 kha).

Emission scenario	*Land use category*	*2016 area, kha*	*2020 area, kha*	*2030 area, kha*	*2040 area, kha*	*2050 area, kha*
Central	Forest land	348	347	345	345	345
	Cropland	93	143	243	343	443
	Grassland	1488	1434	1326	1220	1114
	Wetland	5	5	5	5	5
	Settlement	107	111	122	128	134
	Other	37	38	37	38	38
Baseline 1	Forest land	348	348	347	346	346
	Cropland	93	120	175	230	285
	Grassland	1488	1458	1397	1338	1279
	Wetland	5	5	5	5	5
	Settlement	107	110	117	122	126
	Other	37	38	37	38	38
Baseline 2	Forest land	348	347	346	345	345
	Cropland	93	120	175	230	285
	Grassland	1488	1458	1396	1321	1261
	Wetland	5	5	5	5	5
	Settlement	107	110	119	140	144
	Other	37	38	37	38	38
Low	Forest land	348	355	373	391	396
	Cropland	93	143	243	343	443
	Grassland	1488	1428	1307	1188	1080
	Wetland	5	5	5	5	5
	Settlement	107	108	112	114	116
	Other	37	40	39	38	38
Stretch	Forest land	348	362	400	437	447
	Cropland	93	143	243	343	443
	Grassland	1488	1419	1280	1146	1033
	Wetland	5	5	5	5	5
	Settlement	107	107	109	110	112
	Other	37	42	41	39	39

Table A2.4: Land use areas 2016-2050 for Northern Ireland (1,413 kha).

Emission scenario	*Land use category*	*2016 area, kha*	*2020 area, kha*	*2030 area, kha*	*2040 area, kha*	*2050 area, kha*
Central	Forest land	82	82	82	82	82
	Cropland	53	53	53	53	53
	Grassland	1121	1116	1110	1106	1102
	Wetland	55	55	55	55	55
	Settlement	61	65	70	74	78
	Other	41	42	43	43	44
Baseline 1	Forest land	82	83	85	87	89
	Cropland	53	53	53	53	53
	Grassland	1121	1115	1108	1103	1099
	Wetland	55	55	55	55	55
	Settlement	61	66	69	72	74
	Other	41	42	43	44	44
Baseline 2	Forest land	82	82	82	82	82
	Cropland	53	53	53	53	53
	Grassland	1121	1116	1112	1108	1105
	Wetland	55	55	55	55	55
	Settlement	61	66	69	72	75
	Other	41	42	43	43	44
Low	Forest land	82	83	90	98	107
	Cropland	53	53	53	53	53
	Grassland	1121	1116	1105	1094	1084
	Wetland	55	55	55	55	55
	Settlement	61	64	67	69	70
	Other	41	43	44	44	45
Stretch	Forest land	82	84	98	115	132
	Cropland	53	53	53	53	53
	Grassland	1121	1114	1096	1077	1059
	Wetland	55	55	55	55	55
	Settlement	61	64	67	68	70
	Other	41	43	45	45	45

Annex 3: Afforestation and Deforestation data

Table A3.1 *Baseline 1* Scenario Afforestation Rates (kha).

Year	Annual Forest Planting Rate				
	England	Scotland	Wales	N. Ireland	UK Total
2017	1.100	4.800	0.400	0.200	6.500
2018-2050	2.515	3.440	0.189	0.289	6.433

Table A3.2 *Baseline 1* Scenario Deforestation Rates (kha).

Year	Annual Deforestation Rate				
	England	Scotland	Wales	N. Ireland	UK Total
2017-2050	0.864	1.917	0.253	0.093	3.127

Table A3.3 *Baseline 2* Scenario Afforestation Rates (kha).

Year	Annual Forest Planting Rate				
	England	Scotland	Wales	N. Ireland	UK Total
2017	1.100	4.800	0.400	0.200	6.500
2018-2050	0.264	0.580	0.050	0.033	0.927

Table A3.4 *Central* Scenario Afforestation Rates (kha).

Year	Annual Forest Planting Rate				
	England	Scotland	Wales	N. Ireland	UK Total
2017	1.100	4.800	0.400	0.200	6.500
2018	3.973	7.559	0.103	0.208	11.843
2019	4.690	7.559	0.103	0.208	12.560
2020	4.117	7.559	0.103	0.208	11.987
2021-2050	0.252	0.344	0.019	0.029	0.643

Table A3.5 *Baseline 2/Central/Low/Stretch* Scenario Deforestation Rates (kha).

Year	Annual Deforestation Rate				
	England	Scotland	Wales	N. Ireland	UK Total
2017	0.995	1.588	0.290	0.093	2.966
2018	0.965	1.528	0.278	0.089	2.861
2019	0.935	1.468	0.267	0.086	2.756
2020	0.904	1.408	0.255	0.082	2.651
2021	0.874	1.348	0.244	0.079	2.545
2022	0.844	1.288	0.232	0.075	2.440
2023	0.814	1.229	0.221	0.072	2.335
2024	0.783	1.169	0.209	0.068	2.230
2025	0.753	1.109	0.198	0.065	2.125
2026	0.723	1.049	0.186	0.061	2.020
2027	0.693	0.989	0.175	0.058	1.914
2028	0.663	0.929	0.163	0.054	1.809
2029	0.632	0.869	0.152	0.051	1.704
2030	0.602	0.809	0.140	0.047	1.599
2031	0.572	0.749	0.129	0.044	1.494
2032	0.542	0.689	0.117	0.040	1.389
2033	0.512	0.629	0.106	0.037	1.283
2034	0.481	0.569	0.094	0.033	1.178
2035	0.451	0.510	0.083	0.030	1.073
2036	0.421	0.450	0.071	0.026	0.968
2037	0.391	0.390	0.060	0.022	0.863
2038	0.360	0.330	0.048	0.019	0.758
2039	0.330	0.270	0.037	0.015	0.653
2040	0.300	0.210	0.025	0.012	0.547
2041	0.300	0.210	0.025	0.012	0.547
2042	0.300	0.210	0.025	0.012	0.547
2043	0.300	0.210	0.025	0.012	0.547
2044	0.300	0.210	0.025	0.012	0.547
2045	0.300	0.210	0.025	0.012	0.547
2046	0.300	0.210	0.025	0.012	0.547
2047	0.300	0.210	0.025	0.012	0.547
2048	0.300	0.210	0.025	0.012	0.547
2049	0.300	0.210	0.025	0.012	0.547
2050	0.300	0.210	0.025	0.012	0.547

Table A3.6 *Low* Scenario Afforestation Rates (kha).

Year	Annual Forest Planting Rate				
	England	Scotland	Wales	N. Ireland	UK Total
2017	1.100	4.800	0.400	0.200	6.500
2018	3.973	10.000	2.052	0.304	16.328
2019	4.690	10.000	2.052	0.304	17.045
2020	4.117	12.000	2.052	0.304	18.472
2021	5.126	12.000	2.009	0.514	19.650
2022	5.126	14.000	2.009	0.614	21.750
2023	5.126	14.000	2.009	0.664	21.800
2024	5.126	15.000	2.009	0.664	22.800
2025	5.126	15.000	2.009	0.714	22.850
2026	5.126	15.000	2.009	0.764	22.900
2027	5.126	15.000	2.009	0.814	22.950
2028	5.126	15.000	2.009	0.864	23.000
2029	5.126	15.000	2.009	0.864	23.000
2030	5.126	15.000	2.009	0.864	23.000
2031	5.126	15.000	2.009	0.864	23.000
2032	5.126	15.000	2.009	0.864	23.000
2033	5.126	3.440	2.009	0.864	11.440
2034	5.126	3.440	2.009	0.864	11.440
2035	5.126	3.440	2.009	0.864	11.440
2036	5.126	3.440	2.009	0.864	11.440
2037	5.126	3.440	2.009	0.864	11.440
2038	5.126	3.440	2.009	0.864	11.440
2039	5.126	3.440	2.009	0.864	11.440
2040	5.126	3.440	2.009	0.864	11.440
2041	4.926	3.440	0.509	0.864	9.740
2042	4.726	3.440	0.509	0.864	9.540
2043	4.526	3.440	0.509	0.864	9.340
2044	4.326	3.440	0.509	0.864	9.140
2045	4.126	3.440	0.509	0.864	8.940
2046	3.926	3.440	0.509	0.864	8.740
2047	3.726	3.440	0.509	0.864	8.540
2048	3.526	3.440	0.509	0.864	8.340
2049	3.326	3.440	0.509	0.864	8.140
2050	3.126	3.440	0.509	0.864	7.940

Table A3.7 *Stretch* Scenario Afforestation Rates (kha).

	Annual Forest Planting Rate				
Year	England	Scotland	Wales	N. Ireland	UK Total
2017	1.100	4.800	0.400	0.200	6.500
2018	3.973	10.000	4.000	0.400	18.373
2019	5.550	12.500	4.000	0.400	22.450
2020	7.775	12.500	4.000	0.400	24.675
2021	10.000	15.000	4.000	1.000	30.000
2022	10.000	15.000	4.000	1.200	30.200
2023	10.000	17.500	4.000	1.300	32.800
2024	10.000	17.500	4.000	1.300	32.800
2025	10.000	17.500	4.000	1.400	32.900
2026	10.000	17.500	4.000	1.500	33.000
2027	10.000	17.500	4.000	1.600	33.100
2028	10.000	17.500	4.000	1.700	33.200
2029	10.000	17.500	4.000	1.700	33.200
2030	10.000	17.500	4.000	1.700	33.200
2031	10.000	17.500	4.000	1.700	33.200
2032	10.000	17.500	4.000	1.700	33.200
2033	10.000	17.500	4.000	1.700	33.200
2034	10.000	17.500	4.000	1.700	33.200
2035	10.000	17.500	4.000	1.700	33.200
2036	10.000	17.500	4.000	1.700	33.200
2037	10.000	17.500	4.000	1.700	33.200
2038	10.000	17.500	4.000	1.700	33.200
2039	10.000	17.500	4.000	1.700	33.200
2040	10.000	17.500	4.000	1.700	33.200
2041	9.600	17.500	1.000	1.700	29.800
2042	9.200	17.500	1.000	1.700	29.400
2043	8.800	17.500	1.000	1.700	29.000
2044	8.400	17.500	1.000	1.700	28.600
2045	8.000	17.500	1.000	1.700	28.200
2046	7.600	17.500	1.000	1.700	27.800
2047	7.200	17.500	1.000	1.700	27.400
2048	6.800	17.500	1.000	1.700	27.000
2049	6.400	17.500	1.000	1.700	26.600
2050	6.000	17.500	1.000	1.700	26.200