Projections of emissions and removals from the LULUCF sector to 2050

Contract Report prepared for the Department of Energy and Climate Change (DECC), the Scottish Government, the Welsh Government and the Northern Ireland Department of the Environment) 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)*

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Summary for Policy Makers

- The UK is required to report projections for the Land Use, Land Use Change and Forestry (LULUCF) sector for carbon budgets under the UK Climate Change Act, for the European Union Monitoring Mechanism, and for the UN Framework Convention on Climate Change. LULUCF activities can result in net 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.
- LULUCF is divided into six land use types: *5A Forest Land, 5B Cropland, 5C Grassland, 5D Wetlands, 5E Settlements, 5F Other Land*. The code refers to the IPCC inventory category of LULUCF. There is a separate inventory sector dedicated to other emissions, mainly methane and nitrous oxide, from agricultural activities. Carbon stock changes from Harvested Wood Products are reported in an additional category, *5G Other*.
- Projections are made for net emissions and removals of greenhouse gases to 2050, arising from LULUCF activities reported in the latest (1990-2012) greenhouse gas inventory, for the DAs and the UK, which excludes Overseas Territories and Crown Dependencies.
- The LULUCF inventory now uses the CARBINE model for estimating forest carbon stocks, and models all UK forest instead of just the post-1920 forest. As a consequence of the change in model, and corresponding changes in activity data, the projected sink for forestry is estimated to be much larger than in previous inventories. This has resulted in an increase in the total net sink for UK LULUCF being reported for all scenarios within the projections.
- Four scenarios (Business-As-Usual (BAU), High emissions, Mid emissions and Low emissions) were constructed initially. The non-BAU scenarios were later modified to include cropland-grassland rotations (churn), to take into account land use changes in land that has not reached equilibrium from previous changes in land use. The scenarios were developed by a policy maker stakeholder group from trajectories in the 2050 DECC calculator report and take account of land use policies and aspirations (DECC, 2010). The BAU scenario assumes no new policy intervention. The main results are:
    - At a UK level, the LULUCF sector has been a net sink since 1998 and is predicted to remain so under all scenarios until at least 2050, although at a declining level from around 2030-2037 onwards (depending on the scenario) mainly due to the number of trees being thinned or reaching maturity and harvested.
    - At a DA level, England will remain a net sink under all scenarios with the exception of the high emissions scenario with churn, which gives a net source from 2013 to 2016 and from 2045 onwards.
    - Scotland is a net sink under all scenarios
    - Wales is a small net sink under the Low scenarios, becomes a net source from 2043 onwards under the Mid scenario, and an increasing source from 2016 onwards under the High emissions scenario
    - Northern Ireland is either a small net sink or small net source depending on whether the churn factor is used. The LULUCF sector in the UK and in each of the DAs is dominated by CO_2 emissions and removals, although N_2O emissions also make a significant contribution.
    - The Forest Land, Cropland and Grassland land use categories determine the trend in the UK and each DA. The contribution from cropland and grassland to the overall

trend is from changes in land use rather than from land management activities as only a few cropland and grassland management activities are currently included in the inventory.

- The churn scenarios increase overall estimated net emissions for all scenarios for the UK and each DA, as net emissions from land use change to Cropland are maintained, rather than declining over time, as in the original scenarios.

1 Introduction

The UK is required to report projections of greenhouse gas emissions and removals from Land Use, Land Use Change and Forestry (LULUCF) activities for carbon budgets under the UK Climate Change Act, for targets under the Climate Change (Scotland) Act, for the European Union Monitoring Mechanism and for the UK Framework Convention on Climate Change.

Previously, the Centre for Ecology & Hydrology (CEH) projected emissions/removals to 2020 based on the continuation of current trends in forest planting, land use change and other land use activities (at the time this classified as the Mid scenario and is now similar to the current Business as Usual scenario). Scenarios of high and low emissions above and below this Mid scenario were based on reduced or increased rates of forest planting or the upper or lower limits of the 95% confidence interval of current activity rates. The UK now requires projections of emissions/removals to 2050, which is the target date for 80% emissions reductions below the 1990 baseline in the UK Climate Change Act. The method used for the 2020 projections was deemed inadequate, and a more refined methodology taking into account land use policies and aspirations (e.g. achieving a certain percentage of forest cover by 2050) was developed. Projected land use change needs to be internally consistent, so that the increased area of one land use type is matched by the reduced area of another.

Projections to 2050 have been made for carbon stock changes and CO_2, CH_4 and N_2O emissions arising from LULUCF activities reported in the latest (1990-2012) greenhouse gas inventory (Webb *et al.*2014). Three policy scenarios (High emissions, Mid emissions and Low emissions) have been constructed along with a fourth, Business as Usual scenario which continues existing trends with no new policy intervention. The policy scenarios have additionally been modified to include continuing cropland-grassland rotations (churn). Separate projections have been developed for each country (England, Scotland, Wales and Northern Ireland) and combined into a total for the UK. The assumptions underlying the projections were originally developed by a group of representatives from DECC, Defra, CEH and the DA governments, with an annual update in the assumptions as part of the inventory cycle (see Annex 1).

2 Basis for projections

The LULUCF sector (IPCC sector 5 in the national greenhouse gas inventory) is divided into six land use types for reporting of emissions/removals: 5A Forest Land, 5B Cropland, 5C Grassland, 5D Wetlands, 5E Settlements, 5F Other Land. Net carbon stock changes from Harvested Wood Products are reported under an additional category, 5G Other. Emissions of greenhouse gases to the atmosphere 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_2 equivalents, using Global Warming Potential factors of 1 for CO_2, 21 for CH_4 and 310 for N_2O. The net LULUCF emission is the total of emissions and removals across the seven categories (5A-5G). The balance between emissions and removals helps make the net total smaller than some individual category totals but this does not mean that LULUCF is less significant, especially as it 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 methodology was used to make the projections to 2050. There are detailed descriptions of the datasets and methodology in Chapter 7 and Annex 3.7 of the National Inventory Report (Webb *et al.*2014). *Afforestation* and *Land Use Change (soils)* 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. Emissions/removals from minor activities were held constant, except where noted otherwise.

Scenarios were originally developed from trajectories in the DECC 2050 Pathways Analysis calculator report (Section E: Agriculture and Land Use) (DECC 2010) in discussion with the projections group, with an annual review of the policy assumptions (Annex 1). The Low emission scenario was based on DECC trajectory C, which emphasizes bioenergy crop production and woodland creation. The High emission scenario was based on trajectory B, where the policy priority is to increase food production, and there is less focus on bioenergy crops and forestry. The Mid emission scenario used land use change, afforestation and deforestation rates midway between the High and Low scenario rates. The Business-As-Usual (BAU) scenario continued the afforestation rate from 2010 out to 2050: this is supposed to represent a “without additional policy and measures” scenario for Forest Management reference level reporting under the second commitment period of the Kyoto Protocol (DECC 2010). The BAU scenario uses the Low emissions scenario for deforestation (which takes into account the recent revisions in actual deforestation rates following expert judgement) and the Mid emission scenario assumptions for all other activities.

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

Activity	Description	Inventory category
Afforestation	The Forest Research carbon flow model, CARBINE, models carbon stock changes in forest biomass, litter, soil and timber products, driven by forest planting rates. Estimates are adjusted to take account of losses due to deforestation. Nitrogen fertilization of low nutrient forest soils (a subset of total forest planting) produces N_2O emissions.	5A Forest Land (carbon stock changes, N_2O emissions) 5G Harvested Wood Products (carbon stock changes)
Wildfires	Biomass burning emissions from wildfires on forest land, cropland and grassland.	5A Forest Land (CO_2, CH_4 and N_2O emissions), 5B Cropland (CH_4 and N_2O emissions), 5C Grassland (CH_4 and N_2O emissions)
Land Use Change (soils)	Soil carbon stock changes due to land use change (LUC) since 1950 are modelled using a combined land use change matrix/soil carbon model. Continuing changes due to historical LUC (>20 years before) 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.	5B Cropland (carbon stock changes) 5C Grassland (carbon stock changes) 5E Settlements (carbon stock changes)
Land Use Change (non-forest biomass)	Biomass carbon stock changes are modelled using the same land use change matrix approach as for soils. Biomass carbon stock changes due to changes to and from Forest Land are estimated under the *Afforestation* and *Deforestation* activities.	5B Cropland (carbon stock changes) 5C Grassland (carbon stock changes) 5E Settlements (carbon stock changes)
N_2O emissions from LUC to Cropland	N_2O emissions due to disturbance associated with land use conversion from forest land and grassland to cropland.	5B Cropland (N_2O emissions)
Deforestation	Carbon stock changes in forest biomass and soils due to permanent conversion of forest land. A proportion of the felled trees are burnt, and the remainder are converted to timber products.	5A Forest Land (biomass carbon stock changes) 5B Cropland (soil carbon stock changes; CO_2, CH_4 and N_2O emissions) 5C Grassland (soil carbon stock changes; CO_2, CH_4 and N_2O emissions) 5E Settlements (soil carbon stock changes; CO_2, CH_4 and N_2O emissions) 5G Harvested Wood Products (carbon stock changes)
Liming	Emissions of CO_2 from the application of lime (dolomite and limestone) to agricultural land.	5B Cropland (CO_2emissions) 5C Grassland (CO_2emissions)
Lowland drainage	Carbon stock losses from historic drainage of lowland wetlands (in England only)	5B Cropland (soil carbon stock changes)
Yield improvements	Annual increase in cropland biomass due to yield improvements (improved species strains or management).	5B Cropland (biomass carbon stock changes)
Peat extraction	On-site emissions of CO_2 and N_2O from peat extraction and off-site emissions of CO_2 from the decomposition of horticultural peat.	5D Wetlands (soil carbon stock changes; $CO_2$and N_2O emissions)

Assumptions that 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[1] (national baseline). Land loss due to sea level rise is assumed not to have an impact before 2050.
- LULUCF input data for the different countries 1990-2012 in the published inventories (Webb *et al* 2014) have not been changed and feed through as the initial condition for the projected emissions.
- Afforestation: The split in planting between conifers and broadleaves is assumed to stay the same as the 2012 planting data supplied by the Forestry Commission for each country (conifer: broadleaf ratios are 0.3:99.7 (England), 36:64 (Scotland), 18:82 (Wales), 6:94 (Northern Ireland)).
- Afforestation on settlement land (e.g. remediation of mineral workings) continues at same rate as currently. Otherwise, all conversion to forest land was from grassland.
- Land Use Change: the net Settlement area increases at 17 kha p.a. across the UK under all scenarios (based on the assumption of continuing historic change in the DECC 2050 Pathways Analysis report[2]). The 17 kha p.a UK value comprises 13.5 kha p.a in England, 1.9 kha p.a in Scotland, 1.4 kha p.a in Wales and 0.7 kha p.a in Northern Ireland.
- N_2O emissions resulting from land use conversion to Cropland: emissions are calculated using the same input data as for soil carbon stock changes from land use change.

The assumptions for each activity, by country and projection scenario, are shown in Table 2.

[1] http://www.ons.gov.uk/ons/guide-method/geography/products/other/uk-standard-area-measurements--sam-/index.html

[2] https://www.gov.uk/government/publications/2050-pathways-analysis which was derived from historical data

Table 2: Assumptions for the LULUCF projections

Activity	Business-As-Usual emission scenario	Low emission scenario	Mid emission scenario	High emission scenario	Reasons for assumptions
Afforestation	Afforestation rates remain at same level as in 2010. England: 1.994 kha p.a. Scotland: 2.718 kha p.a. Wales: 0.217 kha p.a. N. Ireland: 0.214 kha p.a.	Increased afforestation rates from 2012 onwards (see Annex 2) England: increasing from 3.7 to 9.1 kha p.a. by 2019, 10 kha p.a. 2020-2040, reducing to 6 kha p.a. by 2050 Scotland: increasing from 7 to 10 kha p.a. by 2020, 12.0 and 12.5 kha p.a. for 2021 and 2022 respectively and 10 kha p.a. 2021-2050 Wales: increasing from 3 to 5 kha p.a. by 2015, at 6 kha p.a. 2021-2030, at 5 kha p.a. to 2050 N. Ireland: 0.2 kha p.a. 2013-2014, increasing to 1.7 kha p.a. by 2029, at 1.7 kha p.a. 2030-2050	Afforestation rates are assumed to be midway between the Low and the High emission scenarios. England: increasing from 3.154 kha p.a. to 5.854 kha p.a. in 2019, 6.304 kha p.a. 2020-2040, reducing to 4.304 kha p.a. by 2050 Scotland: increasing from 8.0135 kha p.a. to 9.2635 kha p.a. in 2015, 9.5135 kha p.a. 2016-2050 with the exception of 10.514 and 10.764 kha p.a. for 2021 and 2022 respectively Wales: increasing from 1.877 kha p.a. to 2.377 kha p.a. in 2014, 2.877 kha p.a. 2015-2020, 3.377 kha p.a. 2021-2030, 2.877 kha p.a. 2031-2050 N.Ireland: increasing from 0.257 kha p.a. to 0.957 kha p.a. in 2028, 1.007 kha p.a. 2029-2050.	Afforestation rates remain at same level as in 2012 England: 2.608 kha p.a. Scotland: 9.027 kha p.a. Wales: 0.754 kha p.a. N. Ireland: 0.313 kha p.a.	The BAU scenario is without additional policies and measures for baseline comparison to 2050. The Low scenario afforestation rates for individual countries were supplied by the Forestry Commission, based on trajectory C (lower emissions from agriculture through investment in technology and increased emphasis on bioenergy and forestry) of the 2050s Pathways Analysis report. The High scenario continues 2012 planting rates (similar to historical rates). The Mid scenario assumed afforestation rates midway between those in the Low and High scenarios.
Wildfires (forest and non-forest)	Use Mid emission scenario.	5th percentile of 1990-2012 time series for each vegetation type	Average of previous 10 years (2003-2012) for each vegetation type	95th percentile of 1990-2012 time series for each vegetation type	Simplification of previous trend extrapolation with autoregression gave misleading impression of forecasting precision

Activity	Business-As-Usual emission scenario	Low emission scenario	Mid emission scenario	High emission scenario	Reasons for assumptions
Land Use Change (soils)	Use Mid emission scenario	Based on trajectory C (2050 calculator). England: net Cropland area is stable, net Settlement area increases 13.5 kha p.a., net Grassland area decreases 18.7-23.2 kha p.a[3]. Scotland: net Cropland area is stable, net Settlement area increases 1.9 kha p.a., net Grassland area decreases 10.7-11.7 kha p.a. Wales: 2.5 kha p.a. converted to cropland from grassland, net Settlement area increases 1.4 kha p.a., net Grassland area decreases 7.7-9.5 kha p.a. N.Ireland: net Cropland area is stable, net Settlement area increases 0.7 kha p.a., net Grassland area decreases 1.0-2.4 kha p.a. Grassland-Cropland churn each way England: 56.60 kha p.a. Scotland: 16.65 kha p.a. Wales: 5.24 kha p.a. N. Ireland: 4.19 kha p.a.	Land use change rates mid-way between the Low and High scenario rates. England: net Cropland area is stable, net Settlement area increases 13.5 kha p.a., net Grassland area decreases 16.1-19.1 kha p.a. Scotland: net Cropland area is stable, net Settlement area increases 1.9 kha p.a., net Grassland area decreases 7.0-8.0 kha p.a. Wales: 5.5 kha p.a. converted to cropland from grassland, net Settlement area increases 1.4 kha p.a., net Grassland area decreases 8.9-9.6 kha p.a. N.Ireland: net Cropland area is stable, net Settlement area increases 0.7 kha p.a., net Grassland area decreases 0.9-1.6 kha p.a. Grassland-Cropland churn each way: England: 56.60 kha p.a. Scotland: 16.65 kha p.a. Wales: 5.24 kha p.a. N. Ireland: 4.19 kha p.a.	Based on trajectory B (2050 calculator). England: net Cropland area is stable, net Settlement area increases 13.5 kha p.a., net Grassland area decreases 15.2 kha p.a. Scotland: net Cropland area is stable, net Settlement area increases 1.9 kha p.a., net Grassland area decreases 5.0 kha p.a. Wales: 10.0 kha p.a. converted to cropland from grassland, net Settlement area increases 1.4 kha p.a., net Grassland area decreases 11.6 kha p.a. N.Ireland: net Cropland area is stable, net Settlement area increases 0.7 kha p.a., net Grassland area decreases 0.9 kha p.a. Grassland-Cropland churn each way England: 56.60 kha p.a. Scotland: 16.65 kha p.a. Wales: 5.24 kha p.a. N. Ireland: 4.19 kha p.a.	The High and Low scenarios were based on trajectories from the 2050 calculator report, with the Mid scenario using rates mid-way between these. Separate cropland conversion rates were requested for Wales. Grassland-cropland churn rates were based on the average annual conversion of cropland to grassland and vice versa between 1990 and 2010 for each country.
Land Use Change (non-forest biomass)	Use Mid emission scenario	Based on same conversion areas as Land Use Change (soils) above)	Based on same conversion areas as Land Use Change (soils) above)	Based on same conversion areas as Land Use Change (soils) above)	Same assumptions as for Land Use Change (soils)

[3] See additional text on page 9

Activity	Business-As-Usual emission scenario	Low emission scenario	Mid emission scenario	High emission scenario	Reasons for assumptions
N_2O *emissions from LUC to Cropland*	Use Mid emission scenario	Zero post-2012 LUC to cropland for England, Scotland and N. Ireland Wales: 2.5 kha p.a. converted to cropland from grassland Grassland-Cropland churn as assumed for Land Use Change (soils)	Zero post-2012 LUC to cropland for England, Scotland and N. Ireland Wales: 5.5 kha p.a. converted to cropland from grassland Grassland-Cropland churn as assumed for Land Use Change (soils)	Zero post-2012 LUC to cropland for England, Scotland and N. Ireland Wales: 10.0 kha p.a. converted to cropland from grassland Grassland-Cropland churn as assumed for Land Use Change (soils)	Cropland areas assumed stable post-2012 for England, Scotland and N. Ireland. Separate cropland conversion rates were requested for Wales. Grassland-cropland churn rates were based on the average annual conversion of grassland to cropland between 1990 and 2010 for each country.
Deforestation	Use Low emission scenario	Deforestation rate assumed to be 70% of Mid or Business-As-Usual rate	Anticipated rates of deforestation to meet biodiversity/renewable energy/development objectives (see Annex 2).	Deforestation rate assumed to be 130% of Mid or Business-As-Usual rate	Deforestation is considered to be probably under-reported in the current LULUCF inventory, due to a lack of information. The Mid or Business-As-Usual scenario deforestation rates for individual countries were supplied by the Forestry Commission, based on expert knowledge and unpublished data from the latest National Forest Inventory. Current deforestation rates are approximately 70% of the Mid scenario rates (used as the Low scenario), so an equivalent uplift of 30% has been used for the High scenario.
Liming		Amount of lime applied is assumed to be 25% below the average for 2003-2012.	Amount of lime applied is assumed to be the same as the average for 2003-2012.	Amount of lime applied is assumed to be 25% above the average for 2003-2012.	No clear trend in this activity. (No new data for 2012)
Lowland drainage		Flux remains at 2012 value	Flux remains at 2012value	Flux remains at 2012 value	No clear trend in this activity. Only reported for England.
Yield improvements		Flux remains at 2012 value	Flux remains at 2012 value	Flux remains at 2012 value	No clear trend in this activity.
Peat extraction		Areas remain at 2012 level and current levels of extraction assumed to remain at same level as mean 2003-2012 level.	Current levels of extraction assumed to remain at same level as mean 2003-2012 level.	Current levels of extraction assumed to remain at same level as mean 2003-2012 level.	No clear trend in this activity. (No new data for 2012)

3 Projections 2013-2050

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

Table 3 to Table 5 show the projected distributions of land use areas in each country between 2012 and 2050. The areas of land in each category were produced via extrapolation of the land use change matrices listed in the National Inventory Report (Webb, 2014). These land use change matrices rely largely on Countryside Survey datasets and may therefore differ from other national datasets. Work is in progress to assimilate other datasets into the land use change matrices, and this methodology will be adopted in future.

The modified scenarios with increased cropland-grassland churn will have the same overall land use areas as cropland-grassland and grassland-cropland conversion are equal. There is greatest land use change in the Low emissions scenario at the UK level (due to increases in forest area), but for Wales the greatest land use change is under the High emission scenario, due to the assumption of grassland-cropland conversion. Grassland is lost at the expense of other land use types under all scenarios.

The land use change assumptions are listed in Table 2. Grassland areas in England are projected to decrease in the Low, Mid- and High emissions scenarios in accordance with the policy assumptions listed in Table 2. Separate projections are produced for the agriculture sector of the inventory as part of a different project based upon the FAPRI modelling system (Defra project DO108)[4]. These agricultural sector projections currently only go to 2022, and assume a small decline in total grassland area in England between 2010 and 2013, followed by an increase again until a peak value in 2016 followed by continual decreases to 2022. This trend in grassland areas does not match the assumptions used for the LULUCF projections. The definition of grassland used in DO108 differs from that used in LULUCF. Within the FAPRI model, grassland areas refer to land which is not subject to tillage, bare fallow, sole right rough grazing, woodland on holdings, other land on holdings or common rough grazing. With the exception of the different approaches used to project grassland areas, there is consistency in activity data used in the agricultural and LULUCF sectors of the greenhouse gas inventory.

[4]http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=17569

Table 3: Land use areas 2012-2050 in the Low emission scenario

Country	*Land use category*	*2012 area, kha*	*2020 area, kha*	*2030 area, kha*	*2040 area, kha*	*2050 area, kha*	*% of land area in 2012*	*% of land area in 2050*
England	Forest land	1044	1086	1179	1277	1352	8%	10%
13,044 kha	Cropland	4067	4067	4068	4068	4068	31%	31%
	Grassland	6284	6135	5906	5674	5464	48%	42%
	Wetland	20	20	20	20	20	0%	0%
	Settlement	1502	1610	1745	1880	2015	12%	15%
	Other	125	125	125	125	125	1%	1%
Scotland	Forest land	1238	1308	1404	1501	1599	16%	20%
7,881 kha	Cropland	959	959	959	959	959	12%	12%
	Grassland	5307	5221	5106	4990	4873	67%	62%
	Wetland	89	89	89	89	89	1%	1%
	Settlement	195	210	229	248	267	2%	3%
	Other	94	94	94	94	94	1%	1%
Wales	Forest land	280	310	369	417	466	13%	22%
2,078 kha	Cropland	374	394	419	444	469	18%	23%
	Grassland	1249	1188	1093	1005	918	60%	44%
	Wetland	5	5	5	5	5	0%	0%
	Settlement	155	167	181	195	209	7%	10%
	Other	14	14	12	12	12	1%	1%
Northern Ireland	Forest land	81	84	97	113	130	6%	9%
1,413 kha	Cropland	277	277	277	277	277	20%	20%
	Grassland	898	890	870	847	823	64%	58%
	Wetland	58	58	58	58	58	4%	4%
	Settlement	81	87	94	101	108	6%	8%
	Other	17	17	17	17	17	1%	1%
UK	Forest land	2643	2787	3048	3309	3547	11%	15%
24,415 kha	Cropland	5678	5698	5723	5748	5773	23%	24%
	Grassland	13738	13434	12975	12515	12077	56%	49%
	Wetland	172	172	172	172	172	1%	1%
	Settlement	1934	2074	2249	2424	2599	8%	11%
	Other	250	250	247	247	247	1%	1%

Table 4: Land use areas 2012-2050 in the Mid emission scenario

Country	Land use category	2012 area, kha	2020 area, kha	2030 area, kha	2040 area, kha	2050 area, kha	% of land area in 2012	% of land area in 2050
England	Forest land	1044	1065	1118	1174	1220	8%	9%
13,044 kha	Cropland	4067	4068	4068	4068	4068	31%	31%
	Grassland	6284	6151	5961	5770	5589	48%	43%
	Wetland	20	20	20	20	20	0%	0%
	Settlement	1502	1610	1745	1880	2015	12%	15%
	Other	125	129	131	131	131	1%	1%
Scotland	Forest land	1238	1279	1338	1399	1460	16%	19%
7,881 kha	Cropland	959	959	959	959	959	12%	12%
	Grassland	5307	5244	5161	5078	4994	67%	63%
	Wetland	89	89	89	89	89	1%	1%
	Settlement	195	210	229	248	267	2%	3%
	Other	94	100	104	108	112	1%	1%
Wales	Forest land	280	296	325	350	375	13%	18%
2,078 kha	Cropland	374	418	473	528	583	18%	28%
	Grassland	1249	1177	1079	984	890	60%	43%
	Wetland	5	5	5	5	5	0%	0%
	Settlement	155	167	181	196	210	7%	10%
	Other	14	15	14	14	14	1%	1%
Northern Ireland	Forest land	81	83	90	99	108	6%	8%
1,413 kha	Cropland	277	277	277	277	277	20%	20%
	Grassland	898	890	876	860	844	64%	60%
	Wetland	58	58	58	58	58	4%	4%
	Settlement	81	87	94	101	108	6%	8%
	Other	17	18	18	18	18	1%	1%
UK	Forest land	2643	2723	2871	3022	3163	11%	13%
24,415 kha	Cropland	5678	5722	5777	5832	5887	23%	24%
	Grassland	13738	13462	13078	12692	12317	56%	50%
	Wetland	172	172	172	172	172	1%	1%
	Settlement	1934	2075	2250	2426	2601	8%	11%
	Other	250	262	267	272	275	1%	1%

Table 5: Land use areas 2012-2050 in the High emission scenario

Country	Land use category	2012 area, kha	2020 area, kha	2030 area, kha	2040 area, kha	2050 area, kha	% of land area in 2012	% of land area in 2050
England	Forest land	1044	1048	1059	1075	1091	8%	8%
13,044 kha	Cropland	4067	4068	4068	4068	4068	31%	31%
	Grassland	6284	6164	6014	5864	5712	48%	44%
	Wetland	20	20	20	20	20	0%	0%
	Settlement	1502	1610	1745	1880	2015	12%	15%
	Other	125	133	136	136	136	1%	1%
Scotland	Forest land	1238	1250	1272	1295	1319	16%	17%
7,881 kha	Cropland	959	959	959	959	959	12%	12%
	Grassland	5307	5267	5217	5167	5117	67%	65%
	Wetland	89	89	89	89	89	1%	1%
	Settlement	195	210	229	248	267	2%	3%
	Other	94	106	115	123	130	1%	2%
Wales	Forest land	280	279	281	283	285	13%	14%
2,078 kha	Cropland	374	454	554	654	754	18%	36%
	Grassland	1249	1157	1041	925	809	60%	39%
	Wetland	5	5	5	5	5	0%	0%
	Settlement	155	167	181	195	209	7%	10%
	Other	14	16	16	17	17	1%	1%
Northern Ireland	Forest land	81	82	83	85	86	6%	6%
1,413 kha	Cropland	277	277	277	277	277	20%	20%
	Grassland	898	891	882	873	864	64%	61%
	Wetland	58	58	58	58	58	4%	4%
	Settlement	81	87	94	101	108	6%	8%
	Other	17	18	19	20	20	1%	1%
UK	Forest land	2643	2659	2695	2737	2782	11%	11%
24,415 kha	Cropland	5678	5758	5858	5958	6058	23%	25%
	Grassland	13738	13478	13153	12828	12501	56%	51%
	Wetland	172	172	172	172	172	1%	1%
	Settlement	1934	2074	2249	2424	2599	8%	11%
	Other	250	273	287	295	303	1%	1%

Tables 6 to 9 show projected emissions of CO_2, CH_4, N_2O and total CO_2 equivalents for the LULUCF sector for each DA. 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 1 to Figure 5. These graphs show the reported inventory estimates for the years 1990 to 2012, and projected data for 2013-2050. In some cases the new policy assumptions made for the projections (see Table 2) have caused an apparent step change between the 2012 and 2013 values, in reality the change would be smoothed out over several years.

At the UK level, (Figure 1) the net CO_2 equivalent emissions / removals from all parts of LULUCF combine to produce projected decreases in the net emissions until around 2030-2037 (depending on the scenario) followed by a gradual increase in emissions until 2050 under all scenarios. The land-use categories with provide the greatest contribution to the net LULUCF Sector Total are Forest land, Cropland and Grassland.

Forestry is projected to be a net sink under all scenarios. With the exception of the BAU, the scenarios show an increase in the forestry sink until about 2032 followed by a decrease to 2050. The scenarios are driven by the projected planting rates, with the biggest projected sink coming from the Low scenario with high planting rates, and the smallest sink coming from the BAU scenario with the most conservative planting rates. The decrease in the sink in the later part of the scenarios is due to large numbers of trees being thinned, or reaching maturity (some 35 – 50 years since planting) and hence being harvested.

Cropland (including land use change to cropland) is projected to be a declining source and Grassland (including land use change to grassland) a declining sink under the four main scenarios due to the low projected increase in cropland areas and the loss of grassland areas at the expense of other land uses. Land use change to Cropland releases CO_2 and N_2O and land use change to Grassland sequesters CO_2. The scenarios that include churn demonstrate the impact that cropland-grassland rotations can have upon overall GHG emissions, through carbon stock changes and N_2O emissions arising from conversion to Cropland. They increase overall net emissions for all scenarios, as net emissions from land use change to Cropland are maintained, rather than declining over time, as in the scenarios unmodified for churn. Their impact in the Grassland category is to increase the size of the net sink, which is otherwise projected to shrink under the main scenarios. Assumptions about cropland-grassland rotation, and its impact on soil carbon stock changes, are currently under investigation in DECC and Defra funded development programmes for the LULUCF inventory.

Emissions from Wetlands arise in this analysis from the extraction of peat which is subject to weather conditions and market conditions. There is therefore no clear trend in this activity and the projections are simply a continuation of the 2012 emissions.

Emissions from Settlements (land use change to) are projected to increase over the time period under all scenarios. Although net settlement area is the same under all 3 emissions scenarios, there are differences in the areas of land converted to and converted from settlement between the scenarios. Grassland to Settlement is responsible for the majority of emissions and the low scenario has a larger annual change from grassland to settlement, than the high scenario. This explains the counter-intuitive findings where the low emissions scenario gives the largest emissions under this-sub-category.

Harvested Wood Products (HWPs) are projected to be an increasing sink over the period 2013 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 HWPs.

The overall pattern of projected emissions and removals at the DA level (Figure 2 - Figure 5) are similar to the UK totals for the majority of DA LULUCF sectors. Notable exceptions are Forestry and HWPs in Scotland and Cropland in Wales. In Scotland (Figure 3) the BAU projections for Forestry and HWPs are significantly different to the Mid, High and Low projections. This is due to the planting rates in the BAU projection being set to the 2010 value, which for Scotland is considerably lower than the rates used in the other scenarios (see Table 2, Afforestation). For the other three DAs the Forestry BAU projections are between the Mid and High scenarios. For Wales (Figure 4) the Cropland (and hence LULUCF total) projections are more variable than those for the other DAs. This is due to the projected conversion of land to cropland under all scenarios (see Table 2, N_2O emissions from LUC to Cropland).

CO_2 is the main greenhouse gas associated with LULUCF (Figure 6), although N_2O emissions also make a significant contribution when their Global Warming Potential of 310 is taken into account. Emissions of N_2O are higher under the churn scenarios as N_2O is released when converting land to Cropland. Methane (CH_4) emissions (Global Warming Potential of 21) 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 the methods used for estimating the LULUCF emissions and removals and some minor changes to the projection assumptions since the previous inventory. These differences are shown at the UK level in Figure 7 by comparing the Mid projections based on the 2012 and 2011 inventories. The main methodological difference is the move to using the CARBINE carbon accounting model (covering afforestation, deforestation to other land used and HWPs) and the modelling of all UK forest instead of just post-1920 forest. CARBINE represents many more tree species and has a more flexible and realistic approach to modelling forest rotation lengths and thinning / felling regimes than the previously used CFlow model. It also represents a wider range of end-uses for wood products and hence an improved estimation of the carbon stored in HWP. This change in methodology and activity data have a significant impact on the estimated emissions and removals in the Forestry and HWPs sectors and a smaller impact on the Cropland, Grassland and Settlement sectors through deforestation to those land uses. The differences in projection scenarios are due to the use of the 2012 inventory data as a basis for the projections. The afforestation rates for the High scenario are based on the 2012 planting rates as opposed to the 2011 rates. This also affects the Mid scenario which is calculated as half way between the Low and High. The projected values for Liming, Wildfires and Peat Extraction are based on averages of the previous ten years' data and have hence changed slightly with the inclusion of the 2012 data. Projections for these activities are included in the Cropland, Grassland, Wetland, Settlement and Forestry sectors. In the 2011 inventory projections the Mid scenario values of soil emissions from Settlement were used for all three scenarios, for the 2012 projections these values are scenario dependent in line with the other LULUCF activities.

Table 6: LULUCF emissions and removals of CO_2 1990-2050

Scenario	Country	1990 emissions/removals Gg CO_2	2012 emissions/removals Gg CO_2	2020 emissions/removals Gg CO_2	2030 emissions/removals Gg CO_2	2040 emissions/removals Gg CO_2	2050 emissions/removals Gg CO_2
Low	**England**	2187.57	-1305.46	-2401.44	-3629.87	-4306.50	-4038.31
Mid	**England**	2187.57	-1305.46	-1931.74	-2789.28	-3145.21	-2592.74
High	**England**	2187.57	-1305.46	-1393.78	-1880.12	-1911.97	-1074.63
Low_churn	**England**	2187.57	-1305.46	-1485.30	-2409.34	-3040.29	-2852.59
Mid_churn	**England**	2187.57	-1305.46	-979.39	-1494.91	-1786.09	-1313.22
High_churn	**England**	2187.57	-1305.46	-477.64	-659.59	-645.75	111.09
BAU	**England**	2187.57	-1305.46	-1953.15	-2425.39	-2349.97	-1441.79
Low	**Scotland**	-1208.60	-6011.46	-8360.38	-9571.51	-9011.81	-6756.61
Mid	**Scotland**	-1208.60	-6011.46	-8250.33	-9484.29	-8932.60	-6716.80
High	**Scotland**	-1208.60	-6011.46	-8064.37	-9316.47	-8772.96	-6591.00
Low_churn	**Scotland**	-1208.60	-6011.46	-6525.16	-6905.80	-5976.73	-3619.63
Mid_churn	**Scotland**	-1208.60	-6011.46	-6297.40	-6626.65	-5667.91	-3320.14
High_churn	**Scotland**	-1208.60	-6011.46	-6229.15	-6650.76	-5737.88	-3454.03
BAU	**Scotland**	-1208.60	-6011.46	-6848.95	-6880.27	-6031.38	-4185.92
Low	**Wales**	-0.03	-558.09	-407.91	-814.02	-785.97	-528.06
Mid	**Wales**	-0.03	-558.09	-131.86	-373.97	-190.46	162.86
High	**Wales**	-0.03	-558.09	264.43	256.37	615.65	1090.64
Low_churn	**Wales**	-0.03	-558.09	-265.18	-622.23	-584.84	-337.19
Mid_churn	**Wales**	-0.03	-558.09	-144.62	-415.98	-281.24	37.31
High_churn	**Wales**	-0.03	-558.09	407.16	448.16	816.78	1281.51
BAU	**Wales**	-0.03	-558.09	-141.79	-246.79	38.64	483.49
Low	**Northern Ireland**	51.38	153.28	-291.18	-287.57	-298.20	-220.62
Mid	**Northern Ireland**	51.38	153.28	-193.15	-156.80	-132.03	-34.94
High	**Northern Ireland**	51.38	153.28	-149.74	-83.28	-28.85	80.96
Low_churn	**Northern Ireland**	51.38	153.28	-74.82	-0.01	-0.79	56.81
Mid_churn	**Northern Ireland**	51.38	153.28	23.99	134.02	169.53	247.80
High_churn	**Northern Ireland**	51.38	153.28	66.63	204.28	268.57	358.40
BAU	**Northern Ireland**	51.38	153.28	-230.83	-204.06	-135.85	7.25
Low	**UK**	1030.32	-7721.73	-11460.91	-14302.96	-14402.49	-11543.60
Mid	**UK**	1030.32	-7721.73	-10507.09	-12804.34	-12400.30	-9181.61
High	**UK**	1030.32	-7721.73	-9343.46	-11023.51	-10098.12	-6494.04
Low_churn	**UK**	1030.32	-7721.73	-8350.46	-9937.37	-9602.66	-6752.60
Mid_churn	**UK**	1030.32	-7721.73	-7397.42	-8403.51	-7565.71	-4348.26
High_churn	**UK**	1030.32	-7721.73	-6233.01	-6657.91	-5298.29	-1703.03
BAU	**UK**	1030.32	-7721.73	-9174.71	-9756.51	-8478.56	-5136.97

Table 7: LULUCF emissions and removals of CH_4 1990-2050

Scenario	Country	1990 emissions/removals Gg CH_4	2012 emissions/removals Gg CH_4	2020 emissions/removals Gg CH_4	2030 emissions/removals Gg CH_4	2040 emissions/removals Gg CH_4	2050 emissions/removals Gg CH_4
Low	**England**	0.49	0.89	0.54	0.38	0.22	0.22
Mid	**England**	0.49	0.89	0.98	0.77	0.54	0.56
High	**England**	0.49	0.89	1.46	1.20	0.91	0.95
Low_churn	**England**	0.49	0.89	0.54	0.38	0.22	0.22
Mid_churn	**England**	0.49	0.89	0.98	0.77	0.54	0.56
High_churn	**England**	0.49	0.89	1.46	1.20	0.91	0.95
BAU	**England**	0.49	0.89	0.78	0.64	0.48	0.50
Low	**Scotland**	0.30	1.37	0.27	0.28	0.20	0.21
Mid	**Scotland**	0.30	1.37	0.61	0.63	0.51	0.53
High	**Scotland**	0.30	1.37	1.04	1.07	0.92	0.94
Low_churn	**Scotland**	0.30	1.37	0.27	0.28	0.20	0.21
Mid_churn	**Scotland**	0.30	1.37	0.61	0.63	0.51	0.53
High_churn	**Scotland**	0.30	1.37	1.04	1.07	0.92	0.94
BAU	**Scotland**	0.30	1.37	0.53	0.55	0.46	0.47
Low	**Wales**	0.12	0.36	0.16	0.06	0.06	0.06
Mid	**Wales**	0.12	0.36	0.30	0.17	0.17	0.18
High	**Wales**	0.12	0.36	0.48	0.30	0.31	0.33
Low_churn	**Wales**	0.12	0.36	0.16	0.06	0.06	0.06
Mid_churn	**Wales**	0.12	0.36	0.30	0.17	0.17	0.18
High_churn	**Wales**	0.12	0.36	0.48	0.30	0.31	0.33
BAU	**Wales**	0.12	0.36	0.26	0.16	0.16	0.17
Low	**Northern Ireland**	0.06	0.45	0.05	0.03	0.01	0.01
Mid	**Northern Ireland**	0.06	0.45	0.15	0.12	0.09	0.10
High	**Northern Ireland**	0.06	0.45	0.18	0.15	0.11	0.13
Low_churn	**Northern Ireland**	0.06	0.45	0.05	0.03	0.01	0.01
Mid_churn	**Northern Ireland**	0.06	0.45	0.15	0.12	0.09	0.10
High_churn	**Northern Ireland**	0.06	0.45	0.18	0.15	0.11	0.13
BAU	**Northern Ireland**	0.06	0.45	0.13	0.11	0.09	0.10
Low	**UK**	0.98	3.08	1.02	0.76	0.49	0.51
Mid	**UK**	0.98	3.08	2.04	1.69	1.31	1.36
High	**UK**	0.98	3.08	3.16	2.73	2.25	2.34
Low_churn	**UK**	0.98	3.08	1.02	0.76	0.49	0.51
Mid_churn	**UK**	0.98	3.08	2.04	1.69	1.31	1.36
High_churn	**UK**	0.98	3.08	3.16	2.73	2.25	2.34
BAU	**UK**	0.98	3.08	1.69	1.45	1.20	1.24

Table 8: LULUCF emissions and removals of N_2O 1990-2050

Scenario	Country	1990 emissions/removals Gg N_2O	2012 emissions/removals Gg N_2O	2020 emissions/removals Gg N_2O	2030 emissions/removals Gg N_2O	2040 emissions/removals Gg N_2O	2050 emissions/removals Gg N_2O
Low	**England**	1.05	0.77	0.52	0.34	0.24	0.17
Mid	**England**	1.05	0.77	0.54	0.36	0.25	0.19
High	**England**	1.05	0.77	0.55	0.38	0.26	0.20
Low_churn	**England**	1.05	0.77	0.89	0.92	0.94	0.95
Mid_churn	**England**	1.05	0.77	0.91	0.94	0.95	0.96
High_churn	**England**	1.05	0.77	0.93	0.95	0.97	0.97
BAU	**England**	1.05	0.77	0.53	0.35	0.24	0.18
Low	**Scotland**	1.22	0.98	0.67	0.46	0.33	0.26
Mid	**Scotland**	1.22	0.98	0.69	0.47	0.35	0.27
High	**Scotland**	1.22	0.98	0.71	0.50	0.37	0.30
Low_churn	**Scotland**	1.22	0.98	1.10	1.12	1.13	1.15
Mid_churn	**Scotland**	1.22	0.98	1.12	1.14	1.15	1.16
High_churn	**Scotland**	1.22	0.98	1.14	1.16	1.18	1.19
BAU	**Scotland**	1.22	0.98	0.68	0.46	0.33	0.25
Low	**Wales**	0.22	0.19	0.15	0.13	0.12	0.11
Mid	**Wales**	0.22	0.19	0.19	0.18	0.18	0.18
High	**Wales**	0.22	0.19	0.25	0.26	0.27	0.28
Low_churn	**Wales**	0.22	0.19	0.21	0.22	0.22	0.23
Mid_churn	**Wales**	0.22	0.19	0.21	0.22	0.22	0.23
High_churn	**Wales**	0.22	0.19	0.30	0.35	0.38	0.40
BAU	**Wales**	0.22	0.19	0.19	0.18	0.17	0.17
Low	**Northern Ireland**	0.24	0.22	0.15	0.11	0.09	0.08
Mid	**Northern Ireland**	0.24	0.22	0.15	0.11	0.09	0.08
High	**Northern Ireland**	0.24	0.22	0.15	0.11	0.09	0.07
Low_churn	**Northern Ireland**	0.24	0.22	0.24	0.25	0.26	0.27
Mid_churn	**Northern Ireland**	0.24	0.22	0.24	0.25	0.26	0.26
High_churn	**Northern Ireland**	0.24	0.22	0.24	0.25	0.25	0.26
BAU	**Northern Ireland**	0.24	0.22	0.15	0.11	0.08	0.07
Low	**UK**	2.72	2.15	1.49	1.04	0.77	0.62
Mid	**UK**	2.72	2.15	1.56	1.13	0.87	0.72
High	**UK**	2.72	2.15	1.67	1.25	1.00	0.85
Low_churn	**UK**	2.72	2.15	2.44	2.50	2.55	2.59
Mid_churn	**UK**	2.72	2.15	2.49	2.54	2.58	2.61
High_churn	**UK**	2.72	2.15	2.62	2.72	2.77	2.82
BAU	**UK**	2.72	2.15	1.55	1.10	0.83	0.67

Table 9: LULUCF emissions and removals of CO_2 equivalents 1990-2050

Scenario	Country	1990 emissions/removals Gg CO_2 eq	2012 emissions/removals Gg CO_2 eq	2020 emissions/removals Gg CO_2 eq	2030 emissions/removals Gg CO_2 eq	2040 emissions/removals Gg CO_2 eq	2050 emissions/removals Gg CO_2 eq
Low	**England**	2522.28	-1048.58	-2229.73	-3515.83	-4228.68	-3980.02
Mid	**England**	2522.28	-1048.58	-1745.17	-2662.22	-3056.51	-2523.62
High	**England**	2522.28	-1048.58	-1191.01	-1738.52	-1810.73	-992.89
Low_churn	**England**	2522.28	-1048.58	-1196.90	-2116.00	-2745.18	-2553.98
Mid_churn	**England**	2522.28	-1048.58	-676.13	-1188.54	-1480.11	-1003.79
High_churn	**England**	2522.28	-1048.58	-158.18	-338.69	-327.24	433.15
BAU	**England**	2522.28	-1048.58	-1771.86	-2303.04	-2265.07	-1376.85
Low	**Scotland**	-824.19	-5680.11	-8147.45	-9424.03	-8905.19	-6672.47
Mid	**Scotland**	-824.19	-5680.11	-8024.85	-9324.18	-8814.44	-6621.06
High	**Scotland**	-824.19	-5680.11	-7821.78	-9138.93	-8638.49	-6478.70
Low_churn	**Scotland**	-824.19	-5680.11	-6178.36	-6552.63	-5620.85	-3259.81
Mid_churn	**Scotland**	-824.19	-5680.11	-5938.06	-6260.84	-5300.49	-2948.72
High_churn	**Scotland**	-824.19	-5680.11	-5852.70	-6267.53	-5354.15	-3066.04
BAU	**Scotland**	-824.19	-5680.11	-6627.49	-6725.97	-5919.88	-4098.54
Low	**Wales**	69.87	-491.15	-357.80	-773.01	-748.94	-492.99
Mid	**Wales**	69.87	-491.15	-66.64	-313.87	-131.29	221.85
High	**Wales**	69.87	-491.15	350.56	344.11	707.25	1184.99
Low_churn	**Wales**	69.87	-491.15	-197.45	-554.15	-515.02	-265.85
Mid_churn	**Wales**	69.87	-491.15	-71.87	-344.33	-208.06	111.80
High_churn	**Wales**	69.87	-491.15	510.90	562.96	941.17	1412.13
BAU	**Wales**	69.87	-491.15	-78.28	-188.04	96.00	540.18
Low	**Northern Ireland**	125.82	229.63	-243.83	-252.46	-269.56	-194.68
Mid	**Northern Ireland**	125.82	229.63	-142.66	-119.40	-102.12	-8.37
High	**Northern Ireland**	125.82	229.63	-98.20	-45.76	0.04	105.63
Low_churn	**Northern Ireland**	125.82	229.63	0.33	77.81	79.61	140.01
Mid_churn	**Northern Ireland**	125.82	229.63	102.28	214.14	251.20	331.62
High_churn	**Northern Ireland**	125.82	229.63	145.96	284.51	349.21	440.32
BAU	**Northern Ireland**	125.82	229.63	-180.83	-167.66	-107.73	30.96
Low	**UK**	1893.78	-6990.21	-10978.79	-13965.32	-14152.36	-11340.15
Mid	**UK**	1893.78	-6990.21	-9979.32	-12419.67	-12104.36	-8931.19
High	**UK**	1893.78	-6990.21	-8760.44	-10579.11	-9741.93	-6180.96
Low_churn	**UK**	1893.78	-6990.21	-7572.39	-9144.96	-8801.44	-5939.64
Mid_churn	**UK**	1893.78	-6990.21	-6583.79	-7579.57	-6737.46	-3509.09
High_churn	**UK**	1893.78	-6990.21	-5354.03	-5758.76	-4391.01	-780.44
BAU	**UK**	1893.78	-6990.21	-8658.45	-9384.71	-8196.67	-4904.25

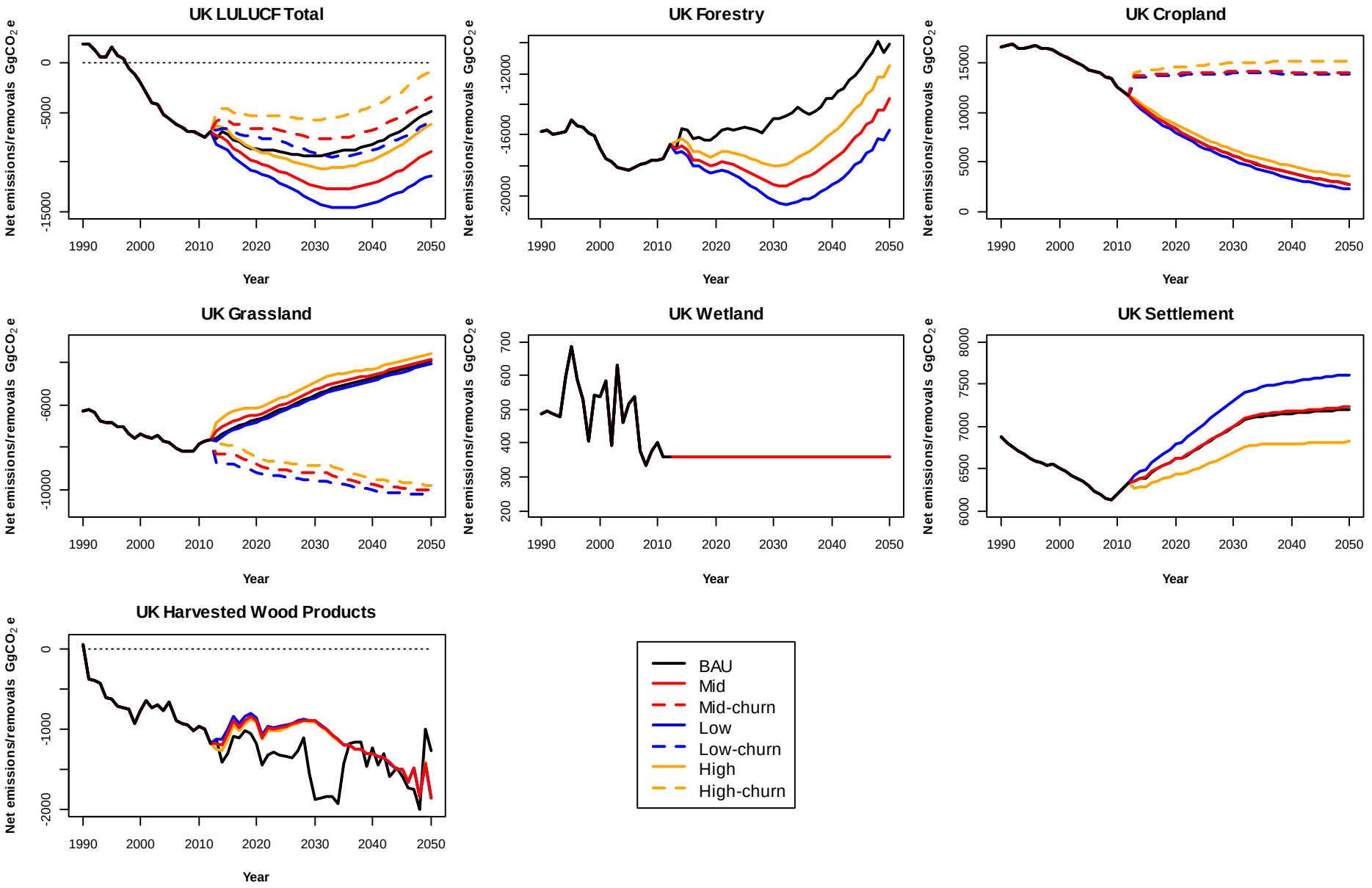

Figure 1: UK LULUCF CO_2 equivalent emissions scenarios 1990-2050. The individual graphs refer to LULUCF reporting categories; see Section 3 text for description of what is reported in these categories.

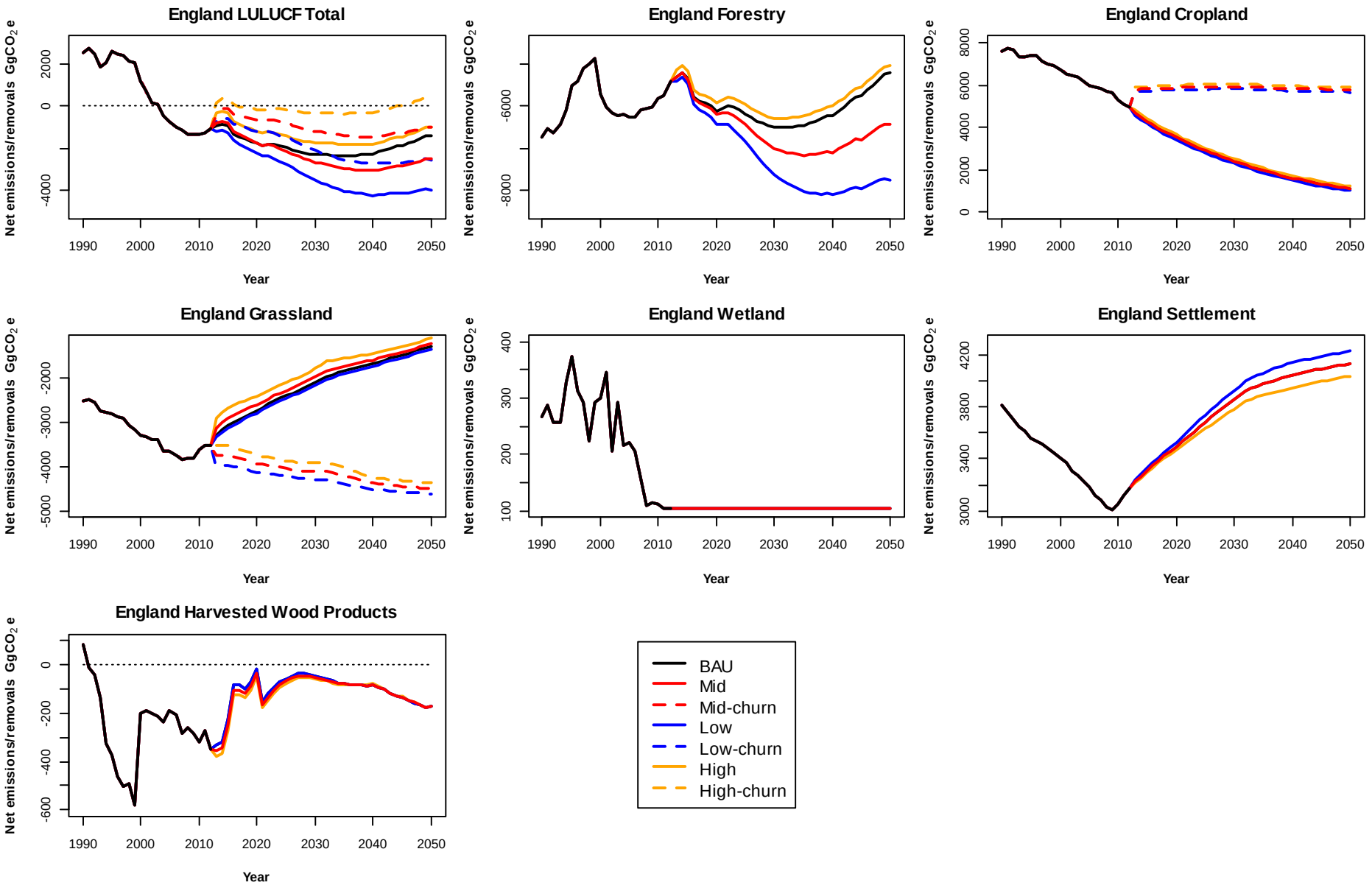

Figure 2: England LULUCF CO_2 equivalent emissions scenarios 1990-2050. The individual graphs refer to LULUCF reporting categories; see Section 3 text for description of what is reported in these categories.

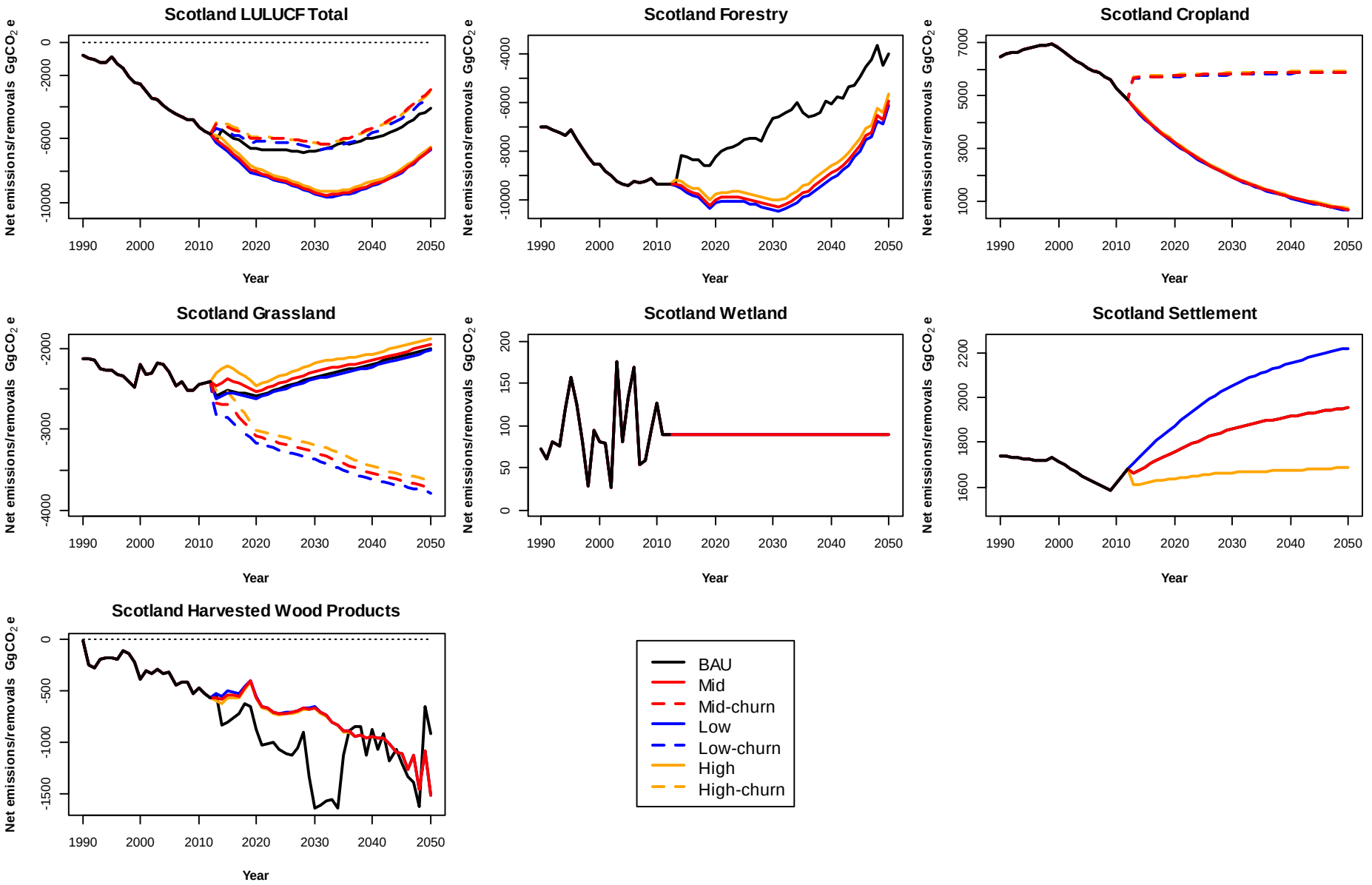

Figure 3: Scotland LULUCF CO_2 equivalent emissions scenarios 1990-2050. The individual graphs refer to LULUCF reporting categories; see Section 3 text for description of what is reported in these categories.

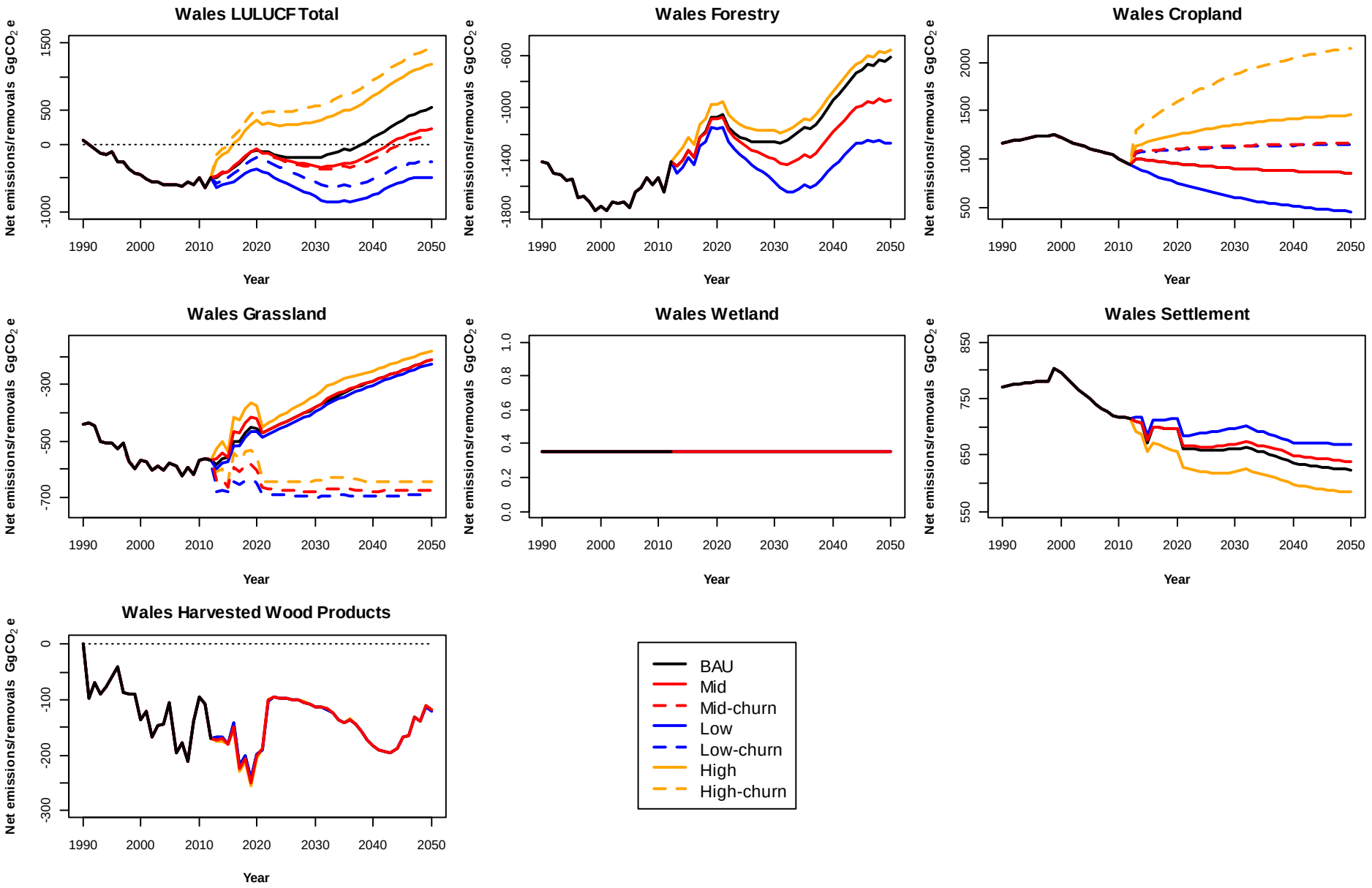

Figure 4: Wales LULUCF CO_2 equivalent emissions scenarios 1990-2050. The individual graphs refer to LULUCF reporting categories, which for cropland and grassland are mainly driven by land use change.

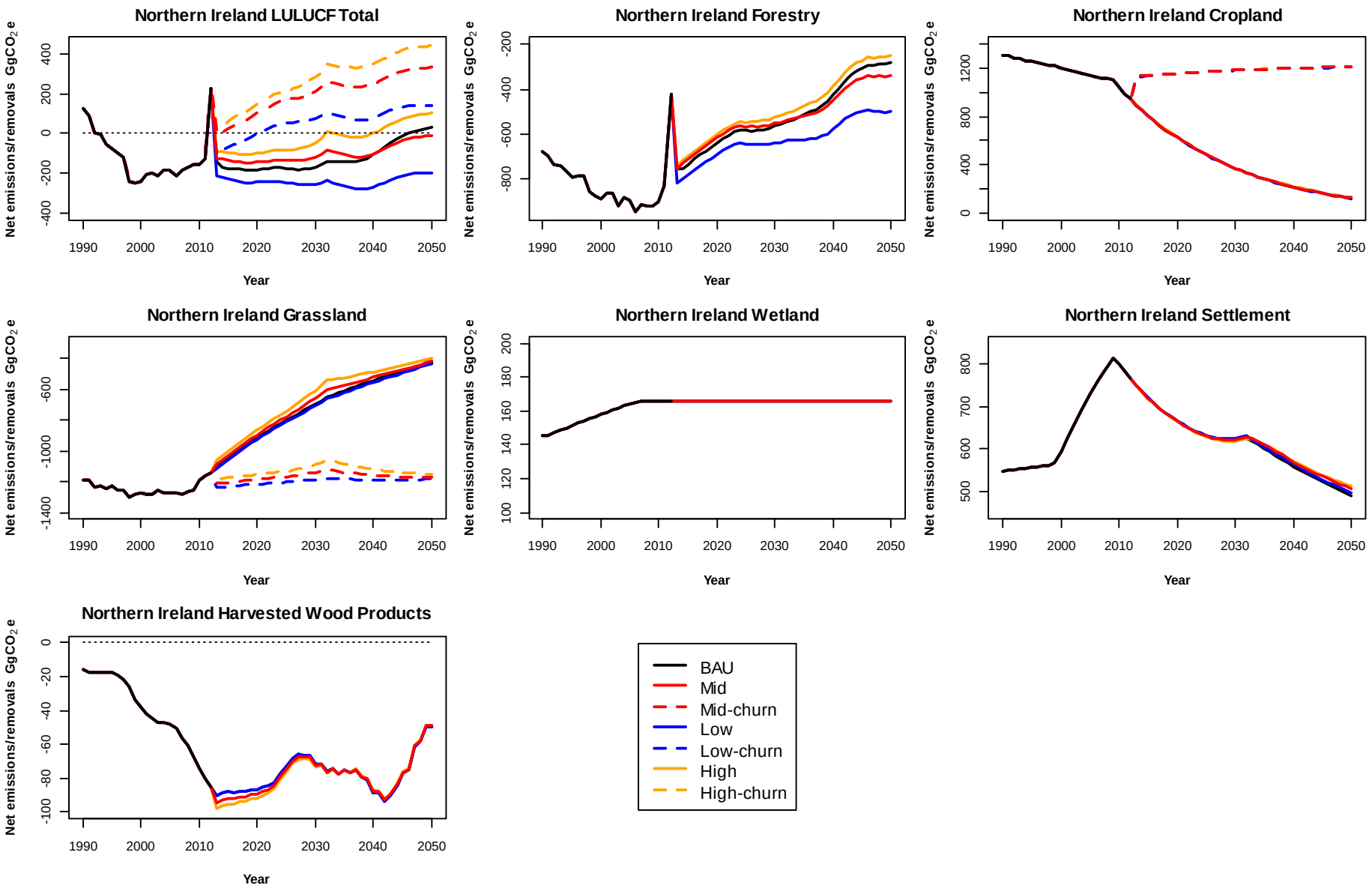

Figure 5: Northern Ireland LULUCF CO_2 equivalent emissions scenarios 1990-2050. The individual graphs refer to LULUCF reporting categories; see Section 3 text for description of what is reported in these categories.

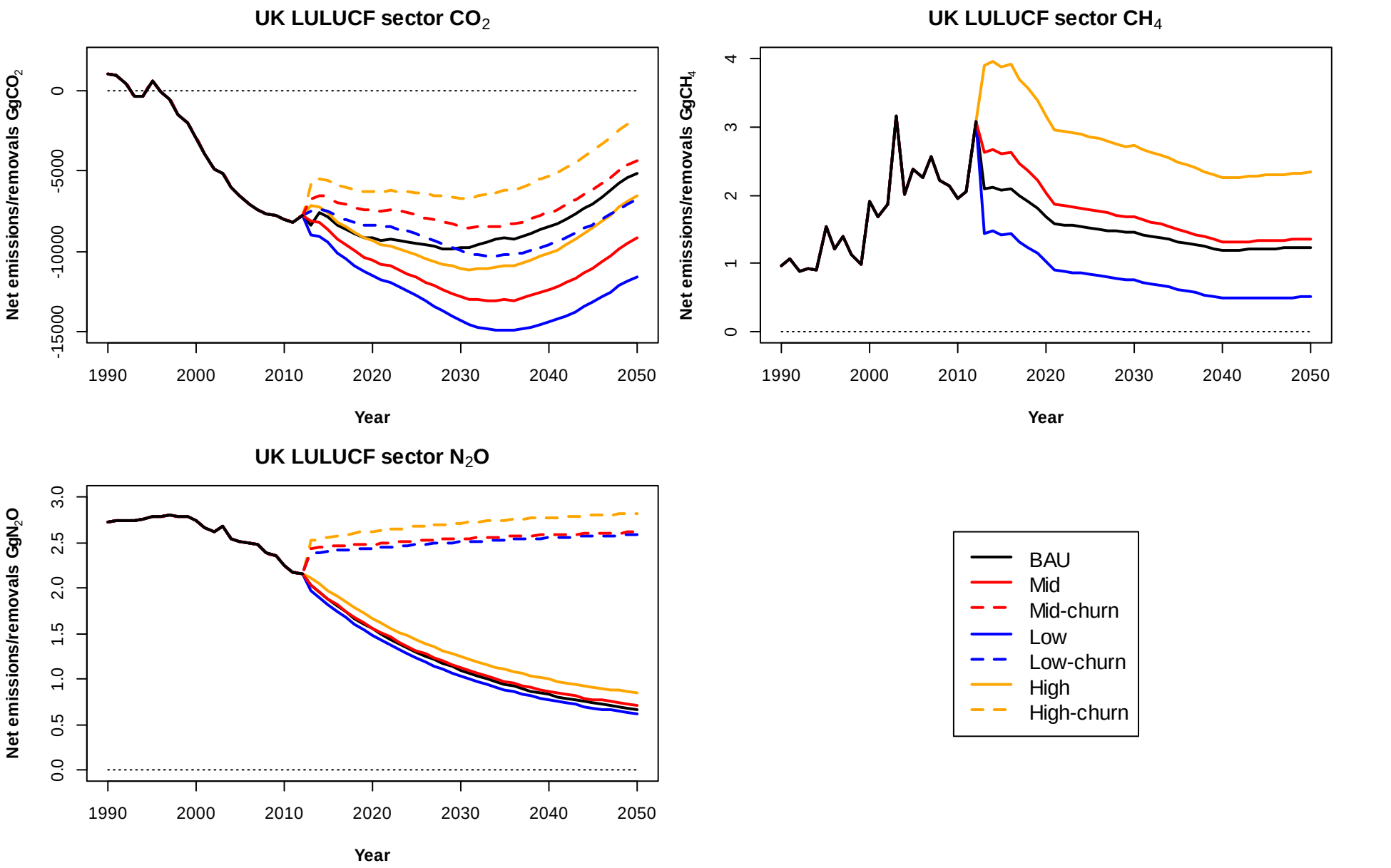

Figure 6: UK LULUCF Sector emissions of individual gases 1990-2050

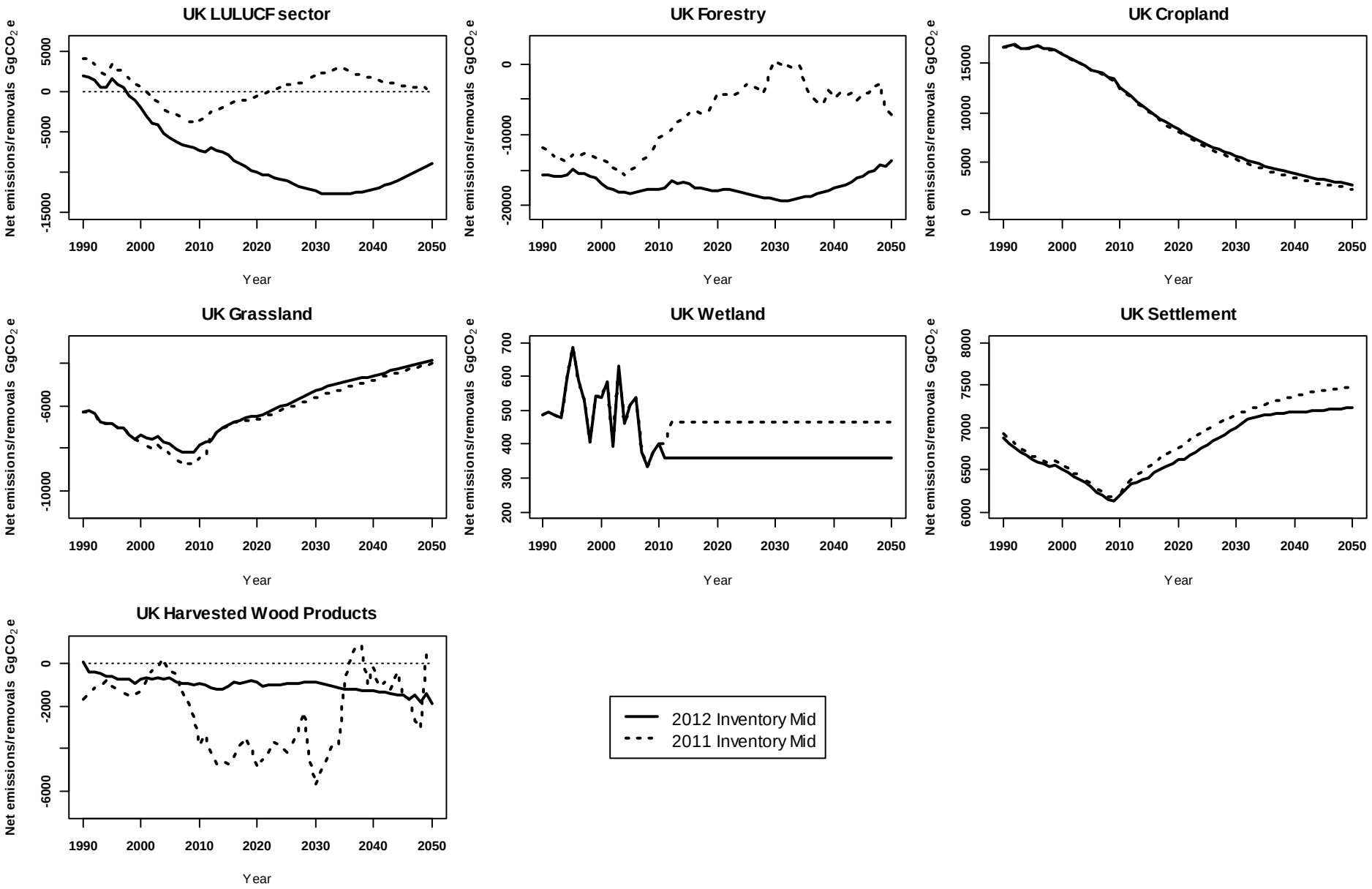

Figure 7: UK LULUCF CO_2 equivalent comparison of the Mid emissions scenario for the 2012 and 2011 inventories 1990-2050

4 Further work

The LULUCF projections are part of an annual cycle of development and publication, which feed into the UK Carbon Budget analyses. The stakeholder group will continue to discuss and modify the assumptions and scenarios as required.

Planned inventory improvements which will be incorporated into future projection updates include:

- further work looking at the impact of woodland management on net emissions in the Forest Land category (carried out by Forest Research). This will be incorporated into the projections once it becomes available.

- the Defra-funded project SP1113 (reporting later in 2014) will look at the impacts of cropland and grassland management on soil carbon, including projections out to 2050, and the results of this project will be incorporated into the LULUCF projections as they become available.

- a DECC-funded project (reporting in 2015) will look at the impacts of cropland and grassland management on carbon stocks in living biomass and the results of this project will be incorporated into the LULUCF projections as they become available.

5 References

DECC (2010) 2050 Pathways Analysis. HM Government. July 2010. http://www.decc.gov.uk/assets/decc/What%20we%20do/A%20low%20carbon%20UK/2050/216-2050-pathways-analysis-report.pdf

Webb N, Broomfield M, Brown P, Buys G, Cardenas L, Murrells T, Pang Y, Passant N, Thistlethwaite G, Watterson J (2014) UK Greenhouse Gas Inventory, 1990 to 2012. Annual Report for Submission under the Framework Convention on Climate Change. Ricardo-AEA, 594pp. April 2014. http://uk-air.defra.gov.uk/assets/documents/reports/cat07/1404251327_1404251304_ukghgi-90-12_Issue1.pdf

Annex 1: Members of the projection assumption development group

The following people were involved in producing the original policy scenarios for the first set of projections to 2050 (February 2012).

- Matthew Brown, Defra
- Judith Stuart, Defra
- Marjorie Roome. DECC
- Philip Earl, Defra
- Bill Parish, Defra
- Marion Rawlins, Defra
- Daniele Viappiani, Defra
- Jim Penman, DECC
- Sekai Ngarize, DECC
- Aimee Griffiths, DECC
- Amanda Thomson, CEH
- Heath Malcolm, CEH
- Mark Broadmeadow, Forestry Commission
- Robert Matthews, Forest Research
- Liam Kelly, Scottish Govt
- Sinclair Mayne, NI Govt
- Peter Scott, NI Govt
- James Skates, Welsh Assembly Govt

The following people were involved in reviewing the policy assumptions on which the projections of the 1990-2012 inventory were to be based (February 2014)

- Sekai Ngarize, DECC
- Laura Bates, DECC
- Judith Stuart, Defra
- Heath Malcolm, CEH
- Janet Moxley, CEH
- Gwen Buys, CEH
- John Landrock, Scottish Government
- Paul Devine, Northern Ireland Department of the Environment
- Ken Stebbings, Welsh Government
- John Watterson, Ricardo-AEA
- Sarah Choudrie, Ricardo-AEA

Annex 2: Forestry Commission estimates of afforestation and deforestation

Afforestation rates for the low emission scenario (gross area planted each year, kha)

Year	England	Wales	Scotland	NI
2013	3.7	3.0	7.0	0.2
2014	4.6	4.0	9.0	0.2
2015	5.5	5.0	9.5	0.3
2016	6.4	5.0	10.0	0.4
2017	7.3	5.0	10.0	0.5
2018	8.2	5.0	10.0	0.6
2019	9.1	5.0	10.0	0.7
2020	10.0	5.0	10.0	0.8
2021	10.0	6.0	12.0	0.9
2022	10.0	6.0	12.5	1.0
2023	10.0	6.0	10.0	1.1
2024	10.0	6.0	10.0	1.2
2025	10.0	6.0	10.0	1.3
2026	10.0	6.0	10.0	1.4
2027	10.0	6.0	10.0	1.5
2028	10.0	6.0	10.0	1.6
2029	10.0	6.0	10.0	1.7
2030	10.0	6.0	10.0	1.7
2031	10.0	5.0	10.0	1.7
2032	10.0	5.0	10.0	1.7
2033	10.0	5.0	10.0	1.7
2034	10.0	5.0	10.0	1.7
2035	10.0	5.0	10.0	1.7
2036	10.0	5.0	10.0	1.7
2037	10.0	5.0	10.0	1.7
2038	10.0	5.0	10.0	1.7
2039	10.0	5.0	10.0	1.7
2040	10.0	5.0	10.0	1.7
2041	9.6	5.0	10.0	1.7
2042	9.2	5.0	10.0	1.7
2043	8.8	5.0	10.0	1.7
2044	8.4	5.0	10.0	1.7
2045	8.0	5.0	10.0	1.7
2046	7.6	5.0	10.0	1.7
2047	7.2	5.0	10.0	1.7
2048	6.8	5.0	10.0	1.7
2049	6.4	5.0	10.0	1.7
2050	6.0	5.0	10.0	1.7

Deforestation rates for the mid emissions scenario (kha per year)

Year	England	Scotland	Wales	N Ireland
2013	1.65	1.50	0.20	0.16
2014	1.65	1.50	0.22	0.15
2015	1.65	1.50	0.05	0.15
2016	1.55	1.30	0.34	0.14
2017	1.45	1.10	0.28	0.14
2018	1.35	0.90	0.34	0.13
2019	1.25	0.70	0.35	0.13
2020	1.15	0.50	0.30	0.12
2021	1.10	0.50	0.04	0.12
2022	1.05	0.50	0.04	0.11
2023	1.00	0.50	0.04	0.11
2024	0.95	0.50	0.04	0.10
2025	0.90	0.50	0.04	0.10
2026	0.85	0.50	0.04	0.09
2027	0.80	0.50	0.04	0.09
2028	0.75	0.50	0.04	0.08
2029	0.70	0.50	0.04	0.07
2030	0.70	0.50	0.04	0.07
2031	0.66	0.48	0.04	0.06
2032	0.62	0.46	0.04	0.06
2033	0.58	0.44	0.04	0.05
2034	0.54	0.42	0.04	0.05
2035	0.50	0.40	0.04	0.04
2036	0.46	0.38	0.04	0.04
2037	0.42	0.36	0.04	0.03
2038	0.38	0.34	0.04	0.03
2039	0.34	0.32	0.04	0.02
2040	0.30	0.30	0.04	0.02
2041	0.30	0.30	0.04	0.02
2042	0.30	0.30	0.04	0.02
2043	0.30	0.30	0.04	0.02
2044	0.30	0.30	0.04	0.02
2045	0.30	0.30	0.04	0.02
2046	0.30	0.30	0.04	0.02
2047	0.30	0.30	0.04	0.02
2048	0.30	0.30	0.04	0.02
2049	0.30	0.30	0.04	0.02
2050	0.30	0.30	0.04	0.02