

Projections of emissions and removals from the LULUCF sector to 2050

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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 the European Union Monitoring Mechanism and 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 (the 'Business as Usual' or Mid scenario). Scenarios of high and low emissions above and below the 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 (the target date for 80% emissions reductions below the 1990 baseline in the UK Climate Change Act). Such an undertaking is more complex and cannot use the simple trend extrapolation of the 2020 projection methodology. Land use policies and aspirations (e.g. achieving a certain percentage of forest cover by 2050) need to be taken into consideration. Projected land use change also needs to be internally consistent, i.e. the increased area of one land use type will be matched by the reduced area of another.

Projections to 2050 have been made for carbon stock changes (resulting in net CO₂ emissions) and CO₂, CH₄ and N₂O emissions arising from LULUCF activities reported in the latest (1990-2009) greenhouse gas inventory. Three scenarios (High emissions, Mid emissions and Low emissions) have been constructed. 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 developed by a group of representatives from DECC, Defra, CEH and the Devolved Administration governments (see Annex 1).

Basis for projections

The LULUCF sector (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 in 5G Other. Emissions of greenhouse gases to the atmosphere are expressed as positive quantities, and removals of carbon dioxide as negative quantities. The net LULUCF emission is the balance of emissions and removals across the seven categories (5A-5G): the net total is smaller than most of the category totals.

Calculations in the LULUCF inventory are done 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 (MacCarthy et al. 2011). 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 these activities and to *Deforestation* when developing the assumptions for the different scenarios. Emissions/removals from minor activities were held constant, except where noted otherwise.

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

Activity	Description	Inventory category
<i>Afforestation</i>	The CEH carbon flow model, CFlow, models carbon stock changes in forest biomass, litter, soil and timber products, driven by forest planting rates since 1921. Estimates are adjusted to take account of losses due to deforestation. Nitrogen fertilization of 'poor' forest soils (a subset of total forest planting) produces N ₂ O emissions.	5A Forest Land (carbon stock changes, N ₂ O emissions) 5G Harvested Wood Products (carbon stock changes)
<i>Wildfires</i>	Biomass burning emissions from wildfires on forest land.	5A Forest Land (CO ₂ , CH ₄ and N ₂ O emissions)
<i>Land Use Change (soils)</i>	Soil carbon stock changes due to land use change since 1950 are modelled using a combined land use change matrix/soil carbon model.	5B Cropland (carbon stock changes) 5C Grassland (carbon stock changes) 5E Settlements (carbon stock changes)
<i>Land Use Change (non-forest biomass)</i>	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 <i>Afforestation</i> and <i>Deforestation</i> activities.	5B Cropland (carbon stock changes) 5C Grassland (carbon stock changes) 5E Settlements (carbon stock changes)
<i>N₂O emissions from LUC to Cropland</i>	N ₂ O emissions due to disturbance associated with land use conversion to cropland .	5B Cropland (N ₂ O emissions)
<i>Deforestation</i>	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 ₂ O emissions) 5C Grassland (soil carbon stock changes; CO ₂ , CH ₄ and N ₂ O emissions) 5E Settlements (soil carbon stock changes; CO ₂ , CH ₄ and N ₂ O emissions) 5G Harvested Wood Products (carbon stock changes)
<i>Liming</i>	Emissions of CO ₂ from the application of lime to agricultural land.	5B Cropland (CO ₂ emissions) 5C Grassland (CO ₂ emissions)
<i>Lowland drainage</i>	Carbon stock losses from historic drainage of lowland wetlands (in England only)	5B Cropland (soil carbon stock changes)
<i>Yield improvements</i>	Annual increase in cropland biomass due to yield improvements (improved species strains or management).	5B Cropland (biomass carbon stock changes)
<i>Peat extraction</i>	On-site emissions of CO ₂ and N ₂ O 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 ₂ O emissions)

Scenarios were developed from trajectories in the 2050 calculator report (Section E: Agriculture and Land Use) (DECC 2010) in discussion with the projections group (Annex 1). The Low emission scenario was based on 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 (exploring the highest level of emissions that the sector might produce). The Mid emission scenario used land use change, afforestation and deforestation rates midway between the High and Low scenario rates.

Assumptions that remained 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 (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 1990-2009 in the published inventories (MacCarthy et al 2011) have not been changed and will feed through to the projected emissions.
- Afforestation: The split in planting between conifers and broadleaves is assumed to stay the same as in 2009 in each country (conifer: broadleaf ratios are 1:99 (England), 34:66 (Scotland), 18:82 (Wales), 7:93 (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 Settlement area increases at 17 kha p.a. across the UK (based on assumption in the 2050 calculator report).
- N₂O 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. As the cropland area remains unchanged after 2010 in all countries except Wales, emissions from the activity are predominantly from historical change and decline over time.
- Deforestation: there is no baseline information on deforestation rates in Northern Ireland (although they can be assumed to be very low) and there is assumed to be zero deforestation in Northern Ireland under all scenarios.

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

Table 2: Assumptions for the LULUCF projections

Activity	Low emission scenario	Mid emission scenario	High emission scenario	Reasons for assumptions
<i>Afforestation</i>	Increased afforestation rates from 2010 onwards (see Annex 2) England: increasing from 2.3 to 10 kha p.a. by 2020, 10 kha p.a. 2021-2040, reducing to 6.0 kha p.a. by 2050 Scotland: increasing from 2.7 to 10 kha p.a. by 2020, at 10 kha p.a. 2021-2050 Wales: increasing from 0.1 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. 2010-2014, 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: 3.7 kha p.a. 2010-2019, 6.1 kha p.a. 2020-2039, 5.15 kha 2040-2050 Scotland: 5.95 kha p.a. 2010-2019, 6.75 kha p.a. 2020-2050 Wales: 1.8 kha p.a. 2010-2019, 3.0 kha p.a. 2020-2030, 2.6 kha 2031-2050 N.Ireland: 0.35kha p.a. 2010-2019, 0.75kha p.a. 2020-2039, 1.0 kha 2040-2050	Afforestation rates remain at same level as in 2009 England: 2.1 kha p.a. Scotland: 3.4 kha p.a. Wales: 0.1 kha p.a. N. Ireland: 0.3 kha p.a.	The Low scenario afforestation rates for individual countries were supplied by the Forestry Commission (based on policy aspirations). The High scenario continues 2009 planting rates (low level compared to historical rates). The Mid scenario assumed afforestation rates midway between those in the Low and High scenarios.
<i>Wildfires</i>	See Mid scenario. Trend plus pdf sampled at 5 th percentile	Trend extrapolation. Trend and associated probability distribution function (pdf) are derived by autoregression with 10 lagged terms, fitted to data from 1990 (as reported by the Forestry Commission to FAO-GFRA). Incidence of wildfire in future given by the trend plus sampling from the pdf.	See Mid scenario. Trend plus pdf sampled at 95 th percentile	Current practice for projections to 2020 extended to 2050.

<i>Land Use Change (soils)</i>	Based on trajectory C (2050 calculator). England: Cropland area is stable, Settlement area increases 13.5 kha p.a., Grassland area decreases 17.7-22.6 kha p.a. Scotland: Cropland area is stable, Settlement area increases 1.9 kha p.a., Grassland area decreases 10.2-11.7 kha p.a. Wales: 2.5 kha p.a. converted to cropland from grassland, Settlement area increases 1.4 kha p.a., Grassland area decreases 7.4-10.0 kha p.a. N.Ireland: Cropland area is stable, Settlement area increases 0.7 kha p.a., Grassland area decreases 1.0-2.4 kha p.a.	Land use change rates mid-way between the Low and High scenario rates. England: Cropland area is stable, Settlement area increases 13.5 kha p.a., Grassland area decreases 15.9-18.9 kha p.a. Scotland: Cropland area is stable, Settlement area increases 1.9 kha p.a., Grassland area decreases 7.6-8.3 kha p.a. Wales: 5.5 kha p.a. converted to cropland from grassland, Settlement area increases 1.4 kha p.a., Grassland area decreases 8.8-10.1 kha p.a. N.Ireland: Cropland area is stable, Settlement area increases 0.7 kha p.a., Grassland area decreases 1.0-1.7 kha p.a.	Based on trajectory B (2050 calculator). England: Cropland area is stable, Settlement area increases 13.5 kha p.a., Grassland area decreases 15.2 kha p.a. Scotland: Cropland area is stable, Settlement area increases 1.9 kha p.a., Grassland area decreases 4.8-5.2 kha p.a. Wales: 10.0 kha p.a. converted to cropland from grassland, Settlement area increases 1.4 kha p.a., Grassland area decreases 11.6 kha p.a. N.Ireland: Cropland area is stable, Settlement area increases 0.7 kha p.a., Grassland area decreases 0.9 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.
<i>Land Use Change (non-forest biomass)</i>	Flux remains at 2009 value	Flux remains at 2009 value	Flux remains at 2009 value	Current practice for projections to 2020 extended to 2050. Staffing issues prevented update of this activity
<i>N₂O emissions from LUC to Cropland</i>	Zero post-2010 LUC to cropland for England, Scotland and N. Ireland Wales: 2.5 kha p.a. converted to cropland from grassland	Zero post-2010 LUC to cropland for England, Scotland and N. Ireland Wales: 5.5 kha p.a. converted to cropland from grassland	Zero post-2010 LUC to cropland for England, Scotland and N. Ireland Wales: 10.0 kha p.a. converted to cropland from grassland	Cropland areas assumed stable post-2010 for England, Scotland and N. Ireland. Separate cropland conversion rates were requested for Wales.

<i>Deforestation</i>	Deforestation rate assumed to be the same as the average rate 2000-2009, declining to zero 2020-2030 for forest-grassland conversion. 2010-2020 England: 0.95 kha p.a. Scotland: 0.30 kha p.a. Wales: 0.06 kha p.a. N.Ireland: 0.0 kha p.a. 2030-2050 England: 0.31 kha p.a. Scotland: 0.10 kha p.a. Wales: 0.02 kha p.a. N.Ireland: 0.0 kha p.a.	Deforestation rates are assumed to fall midway between the Low and High scenario rates.	High rates of deforestation (see Annex 2). England: 1.65 kha p.a. 2011-2015, falling to 0.3 kha p.a. by 2040. Scotland: 1.5 kha pa. 2010-2015, falling to 0.5 kha p.a. in 2020 and 0.3 kha p.a. by 2040 Wales: 0.05-0.35 kha p.a. 2010-2020, then 0.036 kha p.a. until 2050 N. Ireland: zero deforestation	Deforestation is considered to be under-reported in the current LULUCF inventory, due to a lack of information. Therefore, the Low scenario uses the current inventory rates. The High 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.
<i>Liming</i>	Amount of lime applied is assumed to be 25% below the average for 2000-2009.	Amount of lime applied is assumed to be the same as the average for 2000-2009.	Amount of lime applied is assumed to be 25% above the average for 2000-2009.	No clear trend in this activity.
<i>Lowland drainage</i>	Flux remains at 2009 value	Flux remains at 2009 value	Flux remains at 2009 value	No clear trend in this activity. Only reported for England.
<i>Yield improvements</i>	Flux remains at 2009 value	Flux remains at 2009 value	Flux remains at 2009 value	No clear trend in this activity.
<i>Peat extraction</i>	Current levels of extraction assumed to remain at same level as mean 2000-2009 level.	Current levels of extraction assumed to remain at same level as mean 2000-2009 level.	Current levels of extraction assumed to remain at same level as mean 2000-2009 level.	No clear trend in this activity.

Projections 2010-2050

A summary of the results is given here. Detailed emission estimates by activity, country and scenario were supplied to DECC, Defra and the Devolved Administration governments, and are available by request from lulucf@ceh.ac.uk.

The distribution of land use areas in each country between 2010 and 2050 is shown in Tables 3-5. 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.

Projected emissions of CO₂, CH₄, N₂O and CO₂equivalents are shown in Tables 6-9. Graphs of the CO₂equivalents projections, for the UK and each Devolved Administration, are shown in Figures 1-5.

Table 3: Land use areas 2010-2050 in the Low emission scenario

Country	Land use category	2010 area, kha	2020 area, kha	2030 area, kha	2040 area, kha	2050 area, kha	% of land area in 2010	% of land area in 2050
England 13,044 kha	Forest land	1,133	1,177	1,270	1,367	1,444	9%	11%
	Grass- natural	2,597	2,557	2,467	2,372	2,293	20%	18%
	Grass- pasture	2,888	2,756	2,624	2,493	2,361	22%	18%
	Cropland	3,916	3,916	3,916	3,916	3,916	30%	30%
	Settlement	1,472	1,601	1,730	1,859	1,993	11%	15%
	Other	1,038	1,037	1,037	1,037	1,037	8%	8%
Scotland 7,881 kha	Forest land	1,343	1,425	1,523	1,622	1,721	17%	22%
	Grass- natural	4,832	4,750	4,652	4,553	4,454	61%	57%
	Grass- pasture	924	906	889	871	854	12%	11%
	Cropland	515	515	515	515	515	7%	7%
	Settlement	196	214	231	249	266	2%	3%
	Other	71	71	70	70	70	1%	1%
Wales 2,078 kha	Forest land	284	318	377	428	478	14%	23%
	Grass- natural	706	666	603	546	490	34%	24%
	Grass- pasture	735	703	671	639	607	35%	29%
	Cropland	76	101	126	151	176	4%	8%
	Settlement	150	163	177	189	202	7%	10%
	Other	127	127	124	125	125	6%	6%
Northern Ireland 1,413 kha	Forest land	88	92	105	122	139	6%	10%
	Grass- natural	486	483	471	455	439	34%	31%
	Grass- pasture	563	556	549	542	534	40%	38%
	Cropland	58	58	58	58	58	4%	4%
	Settlement	80	86	92	98	105	6%	7%
	Other	138	138	138	138	138	10%	10%
UK 24,415 kha	Forest land	2,848	3,012	3,275	3,539	3,781	12%	15%
	Grass- natural	8,621	8,456	8,193	7,925	7,676	35%	31%
	Grass- pasture	5,110	4,921	4,733	4,545	4,356	21%	18%
	Cropland	4,565	4,590	4,615	4,640	4,665	19%	19%
	Settlement	1,898	2,064	2,230	2,395	2,566	8%	11%
	Other	1,373	1,373	1,370	1,371	1,371	6%	6%

Table 4: Land use areas 2010-2050 in the Mid emission scenario

Country	Land use category	2010 area, kha	2020 area, kha	2030 area, kha	2040 area, kha	2050 area, kha	% of land area in 2010	% of land area in 2050
England 13,044 kha	Forest land	1,133	1,151	1,198	1,255	1,303	9%	10%
	Grass- natural	2,597	2,579	2,533	2,475	2,424	20%	19%
	Grass- pasture	2,888	2,757	2,625	2,494	2,362	22%	18%
	Cropland	3,916	3,916	3,916	3,916	3,916	30%	30%
	Settlement	1,472	1,603	1,734	1,866	2,000	11%	15%
	Other	1,038	1,037	1,037	1,037	1,037	8%	8%
Scotland 7,881 kha	Forest land	1,343	1,394	1,458	1,522	1,587	17%	20%
	Grass- natural	4,832	4,781	4,718	4,653	4,588	61%	58%
	Grass- pasture	924	906	889	871	854	12%	11%
	Cropland	515	515	515	515	515	7%	7%
	Settlement	196	214	231	249	266	2%	3%
	Other	71	71	70	70	70	1%	1%
Wales 2,078 kha	Forest land	284	300	330	356	381	14%	18%
	Grass- natural	706	683	649	617	586	34%	28%
	Grass- pasture	735	673	611	549	487	35%	23%
	Cropland	76	131	186	241	296	4%	14%
	Settlement	150	163	177	189	202	7%	10%
	Other	127	127	125	126	126	6%	6%
Northern Ireland 1,413 kha	Forest land	88	91	98	108	118	6%	8%
	Grass- natural	486	484	478	469	460	34%	33%
	Grass- pasture	563	556	549	542	534	40%	38%
	Cropland	58	58	58	58	58	4%	4%
	Settlement	80	86	92	98	105	6%	7%
	Other	138	138	138	138	138	10%	10%
UK 24,415 kha	Forest land	2,848	2,937	3,084	3,241	3,390	12%	14%
	Grass- natural	8,621	8,527	8,377	8,214	8,058	35%	33%
	Grass- pasture	5,110	4,891	4,674	4,456	4,237	21%	17%
	Cropland	4,565	4,620	4,675	4,730	4,785	19%	20%
	Settlement	1,898	2,066	2,234	2,402	2,573	8%	11%
	Other	1,373	1,373	1,371	1,372	1,372	6%	6%

Table 5: Land use areas 2010-2050 in the High emission scenario

Country	Land use category	2010 area, kha	2020 area, kha	2030 area, kha	2040 area, kha	2050 area, kha	% of land area in 2010	% of land area in 2050
England 13,044 kha	Forest land	1,133	1,139	1,150	1,166	1,184	9%	9%
	Grass- natural	2,597	2,588	2,574	2,554	2,534	20%	19%
	Grass- pasture	2,888	2,757	2,627	2,496	2,364	22%	18%
	Cropland	3,916	3,916	3,916	3,916	3,916	30%	30%
	Settlement	1,472	1,606	1,739	1,874	2,008	11%	15%
	Other	1,038	1,038	1,038	1,038	1,038	8%	8%
Scotland 7,881 kha	Forest land	1,343	1,364	1,394	1,424	1,456	17%	18%
	Grass- natural	4,832	4,811	4,782	4,751	4,720	61%	60%
	Grass- pasture	924	906	889	871	854	12%	11%
	Cropland	515	515	515	515	515	7%	7%
	Settlement	196	214	231	249	266	2%	3%
	Other	71	70	70	70	71	1%	1%
Wales 2,078 kha	Forest land	284	282	283	284	284	14%	14%
	Grass- natural	706	701	695	688	681	34%	33%
	Grass- pasture	735	628	522	415	308	35%	15%
	Cropland	76	176	276	376	476	4%	23%
	Settlement	150	163	176	189	202	7%	10%
	Other	127	128	126	127	127	6%	6%
Northern Ireland 1,413 kha	Forest land	88	91	94	97	100	6%	7%
	Grass- natural	486	485	483	481	479	34%	34%
	Grass- pasture	563	556	548	541	533	40%	38%
	Cropland	58	58	58	58	58	4%	4%
	Settlement	80	86	92	98	105	6%	7%
	Other	138	138	138	138	138	10%	10%
UK 24,415 kha	Forest land	2,848	2,876	2,921	2,971	3,024	12%	12%
	Grass- natural	8,621	8,584	8,534	8,474	8,414	35%	34%
	Grass- pasture	5,110	4,847	4,585	4,323	4,059	21%	17%
	Cropland	4,565	4,665	4,765	4,865	4,965	19%	20%
	Settlement	1,898	2,069	2,238	2,409	2,581	8%	11%
	Other	1,373	1,374	1,372	1,373	1,373	6%	6%

Table 6: LULUCF emissions and removals of CO₂ 2010-2050

Scenario	Country	2010 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	1503.73	2064.97	1561.97	112.54	-600.34
Mid	England	1687.57	2320.39	2308.53	1246.02	985.13
High	England	1872.08	2691.16	3120.22	2500.55	2624.69
Low	Scotland	-5938.68	-5040.98	-3010.80	-2169.79	-3109.81
Mid	Scotland	-5788.90	-4811.98	-2453.06	-1212.38	-1757.90
High	Scotland	-5659.55	-4511.46	-1813.59	-176.71	-312.99
Low	Wales	-280.45	151.20	-94.38	-817.73	-1655.82
Mid	Wales	-225.80	505.26	668.64	318.86	-162.36
High	Wales	-158.36	994.43	1587.73	1634.33	1512.46
Low	Northern Ireland	20.65	99.17	145.22	-147.63	-294.80
Mid	Northern Ireland	31.89	103.05	166.88	-51.04	-116.25
High	Northern Ireland	43.35	121.85	218.54	65.93	86.04
Low	UK	-4694.75	-2725.64	-1397.99	-3022.61	-5660.77
Mid	UK	-4295.24	-1883.27	691.00	301.46	-1051.38
High	UK	-3902.47	-704.02	3112.90	4024.10	3910.20

Table 7: LULUCF emissions and removals of CH₄ 2010-2050

Scenario	Country	2010 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	0.80	0.66	0.21	0.21	0.21
Mid	England	1.00	0.85	0.39	0.23	0.23
High	England	1.21	1.06	0.79	0.62	0.74
Low	Scotland	0.36	0.20	0.07	0.07	0.07
Mid	Scotland	0.80	0.44	0.26	0.16	0.16
High	Scotland	1.24	0.69	0.74	0.74	0.90
Low	Wales	0.08	0.04	0.01	0.01	0.01
Mid	Wales	0.18	0.16	0.03	0.03	0.02
High	Wales	0.27	0.28	0.11	0.14	0.17
Low	Northern Ireland	0.00	0.01	0.00	0.00	0.00
Mid	Northern Ireland	0.00	0.04	0.02	0.02	0.02
High	Northern Ireland	0.00	0.07	0.08	0.11	0.13
Low	UK	1.24	0.92	0.30	0.30	0.30
Mid	UK	1.98	1.49	0.70	0.45	0.43
High	UK	2.73	2.10	1.72	1.60	1.94

Table 8: LULUCF emissions and removals of N₂O 2010-2050

Scenario	Country	2010 emissions/removals, Gg N ₂ O	2020 emissions/removals, Gg N ₂ O	2030 emissions/removals, Gg N ₂ O	2040 emissions/removals, Gg N ₂ O	2050 emissions/removals, Gg N ₂ O
Low	England	0.80	0.49	0.30	0.18	0.11
Mid	England	0.80	0.49	0.30	0.18	0.11
High	England	0.80	0.49	0.30	0.18	0.11
Low	Scotland	0.90	0.55	0.33	0.21	0.13
Mid	Scotland	0.90	0.55	0.33	0.20	0.13
High	Scotland	0.90	0.55	0.34	0.21	0.13
Low	Wales	0.15	0.12	0.10	0.08	0.08
Mid	Wales	0.15	0.15	0.15	0.14	0.14
High	Wales	0.16	0.20	0.22	0.23	0.24
Low	Northern Ireland	0.19	0.11	0.07	0.04	0.03
Mid	Northern Ireland	0.19	0.11	0.07	0.04	0.03
High	Northern Ireland	0.19	0.11	0.07	0.04	0.03
Low	UK	2.03	1.26	0.80	0.51	0.34
Mid	UK	2.04	1.30	0.85	0.57	0.41
High	UK	2.05	1.35	0.92	0.67	0.51

Table 9: LULUCF emissions and removals of CO2 equivalents 2010-2050

Scenario	Country	2010 emissions/removals, Gg CO ₂ e	2020 emissions/removals, Gg CO ₂ e	2030 emissions/removals, Gg CO ₂ e	2040 emissions/removals, Gg CO ₂ e	2050 emissions/removals, Gg CO ₂ e
Low	England	1767.55	2229.76	1658.18	173.27	-561.49
Mid	England	1956.22	2489.30	2408.38	1306.69	1024.17
High	England	2145.38	2864.61	3228.86	2569.78	2675.26
Low	Scotland	-5653.48	-4867.04	-2905.88	-2104.81	-3069.05
Mid	Scotland	-5493.20	-4633.18	-2344.21	-1145.64	-1715.46
High	Scotland	-5353.81	-4327.27	-1694.10	-97.17	-253.97
Low	Wales	-233.19	187.94	-64.32	-791.43	-1631.75
Mid	Wales	-175.12	554.50	714.31	363.99	-117.49
High	Wales	-103.82	1061.32	1658.18	1709.96	1591.60
Low	Northern Ireland	78.44	134.88	167.05	-134.04	-286.20
Mid	Northern Ireland	89.68	139.45	189.21	-36.89	-107.24
High	Northern Ireland	101.25	158.93	242.15	81.98	97.57
Low	UK	-4040.68	-2314.47	-1144.97	-2857.00	-5548.50
Mid	UK	-3622.43	-1449.93	967.69	488.15	-916.02
High	UK	-3210.99	-242.42	3435.09	4264.55	4110.48

Figure 1: UK LULUCF sector emissions scenarios 1990-2050

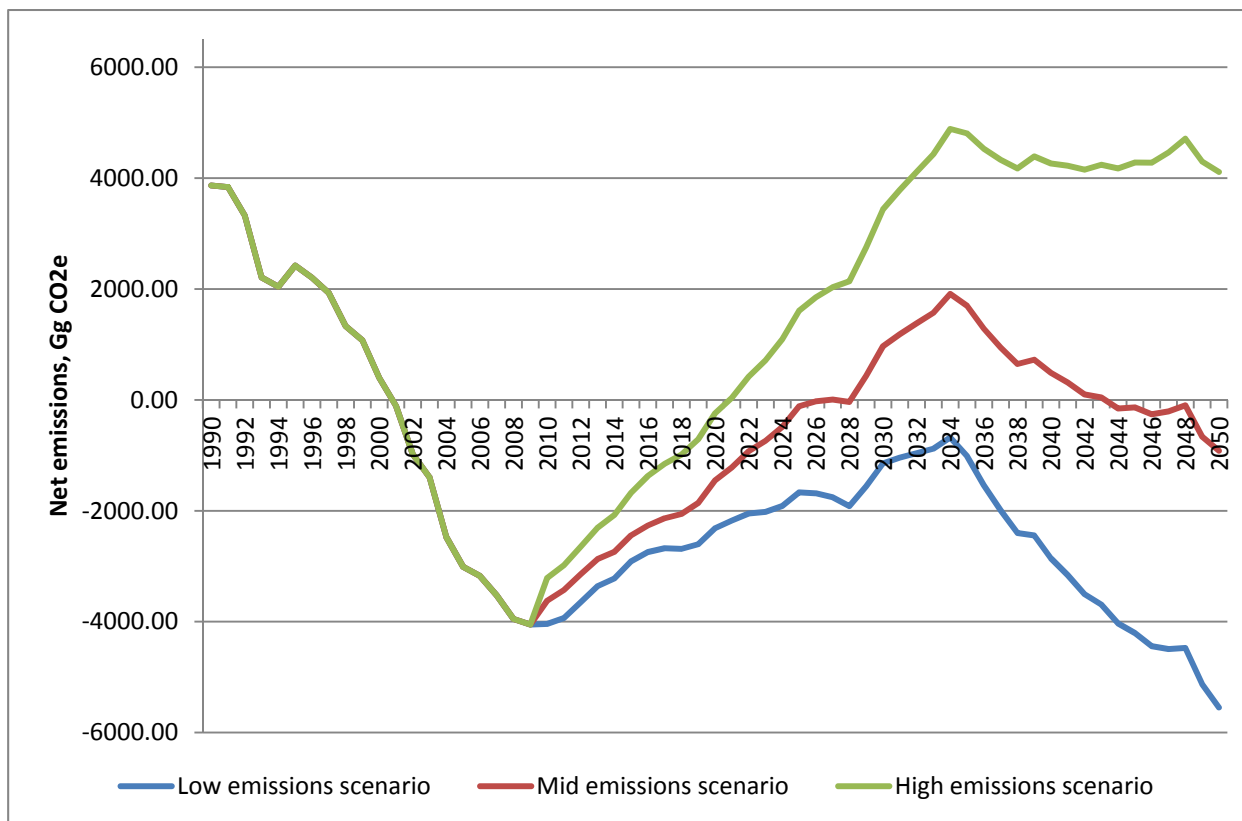


Figure 2: England LULUCF sector emissions scenarios 1990-2050

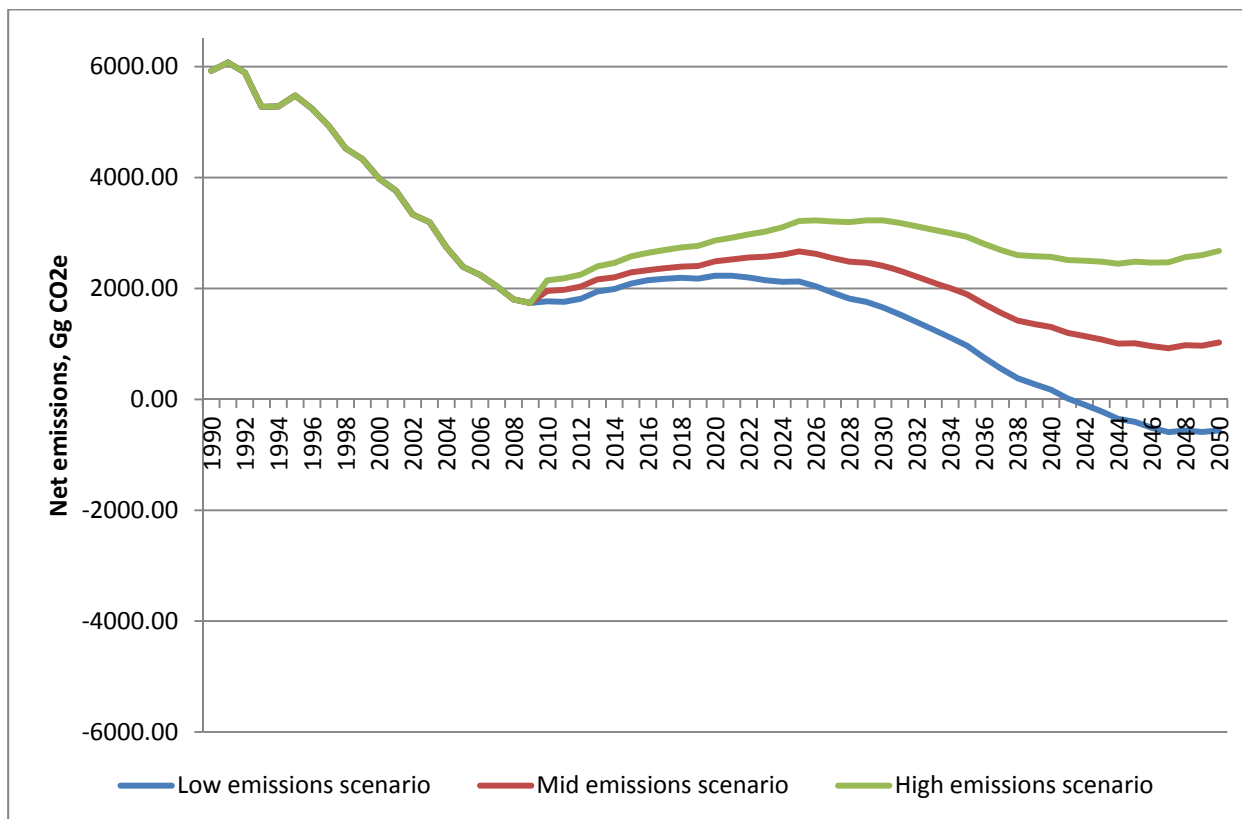


Figure 3: Scotland LULUCF sector emissions scenarios 1990-2050

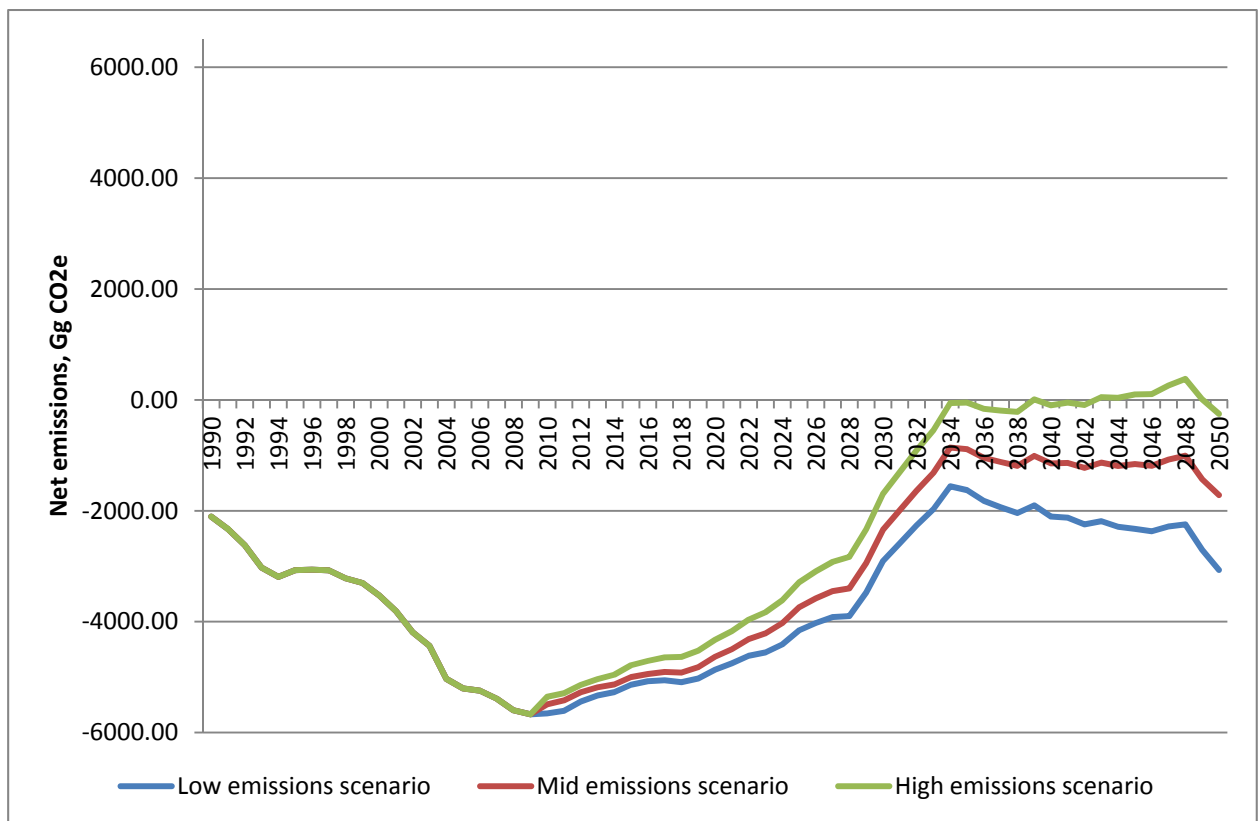


Figure 4: Wales LULUCF sector emissions scenarios 1990-2050

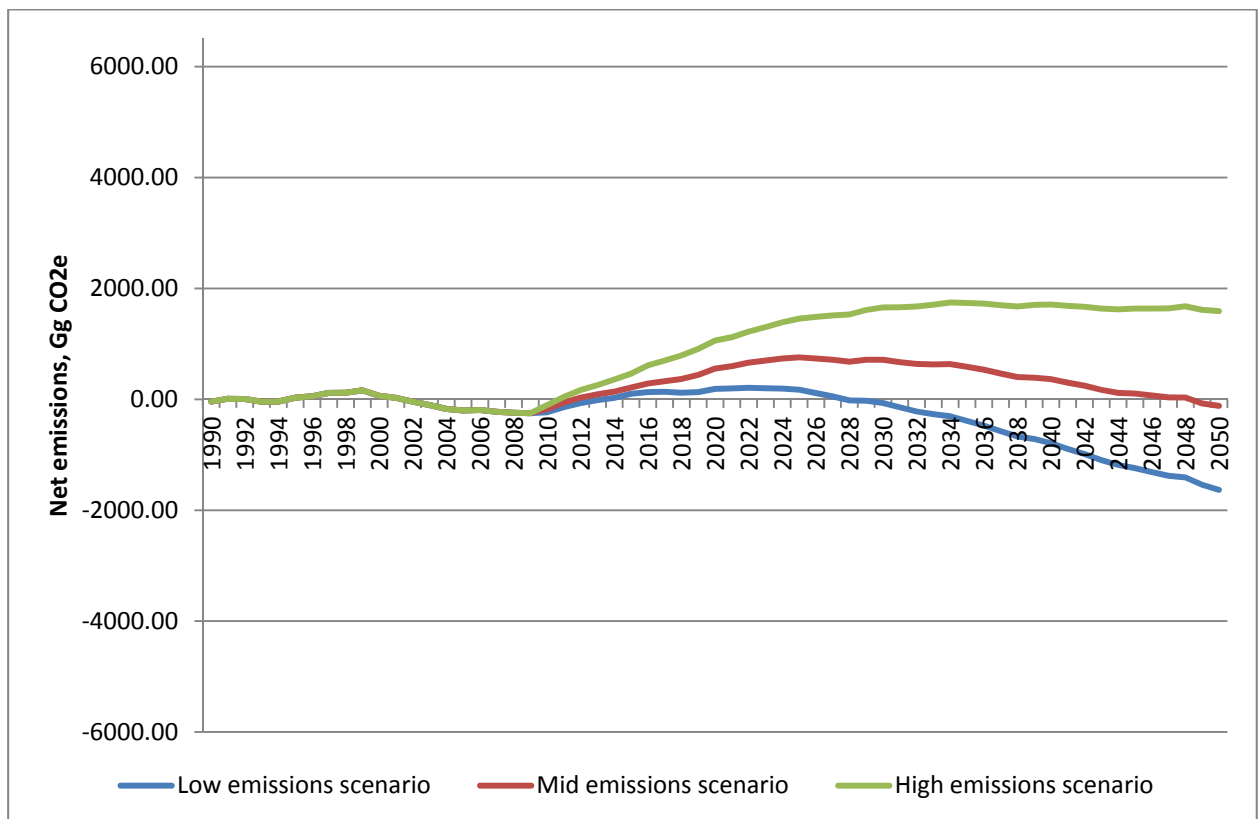
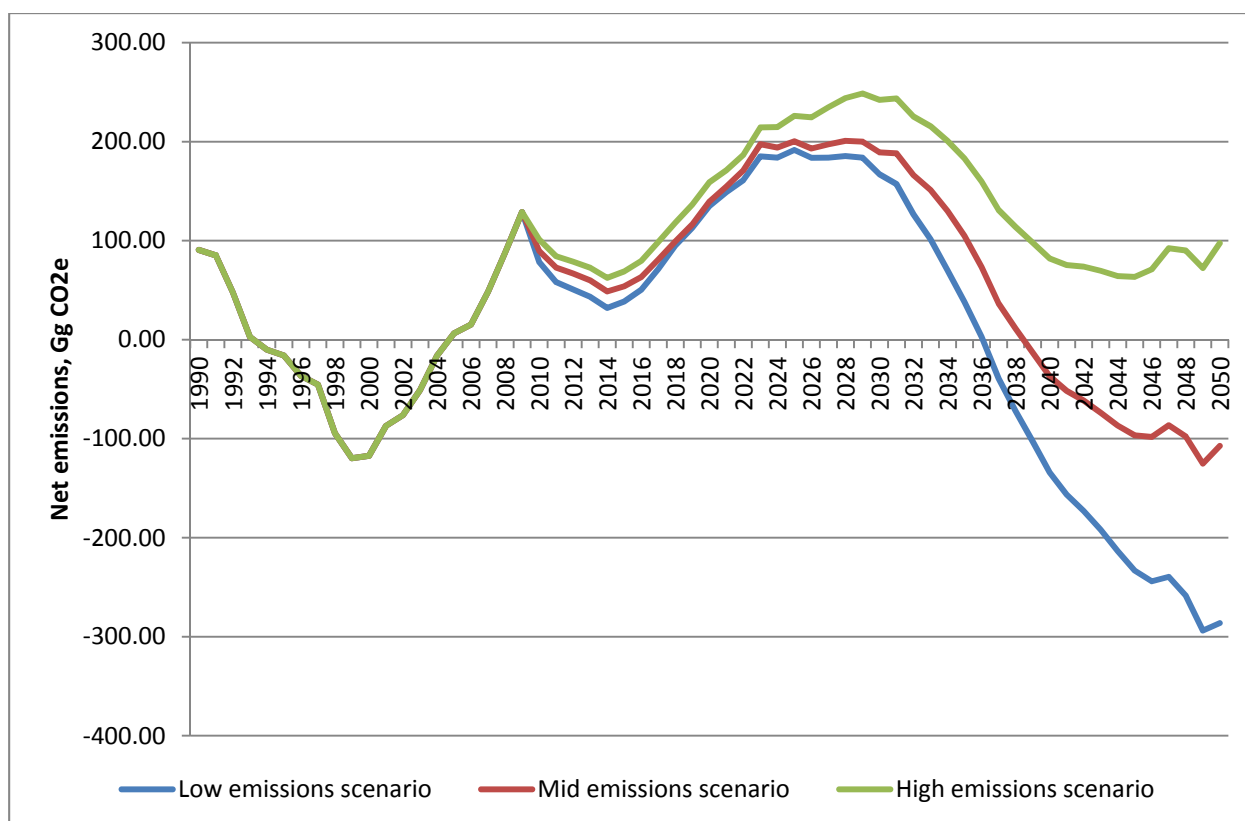


Figure 5: Northern Ireland LULUCF sector emissions scenarios 1990-2050 (scale is different from other graphs)



Further work

This work was envisaged as a first iteration of the projections, aiming to feed into the Fourth Carbon Budget analysis and encourage discussion of the assumptions. Forest Research is undertaking further work looking at the impact of woodland management on net emissions in the Forest Land category. This will be incorporated into the projections once it becomes available. The projections will also be updated with the latest inventory numbers when the 1990-2010 inventory is produced in early 2012. Further work to update these projections has not yet been planned.

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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
2010	2.3	0.1	2.7	0.2
2011	2.5	1.0	7.5	0.2
2012	3.0	2.0	8.0	0.2
2013	3.7	3.0	8.5	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	10.0	0.9
2022	10.0	6.0	10.0	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 high emissions scenario (ha per year)

Year	England	Scotland	Wales	N Ireland
2010	1475	1500	318	0
2011	1650	1500	308	0
2012	1650	1500	298	0
2013	1650	1500	202.7	0
2014	1650	1500	218.5	0
2015	1650	1500	50	0
2016	1550	1300	342.4	0
2017	1450	1100	280.6	0
2018	1350	900	340	0
2019	1250	700	351.3	0
2020	1150	500	295.4	0
2021	1100	500	36.36	0
2022	1050	500	36.4	0
2023	1000	500	36.4	0
2024	950	500	36.4	0
2025	900	500	36.4	0
2026	850	500	36.4	0
2027	800	500	36.4	0
2028	750	500	36.4	0
2029	700	500	36.4	0
2030	700	500	36.4	0
2031	660	480	36.4	0
2032	620	460	36.4	0
2033	580	440	36.4	0
2034	540	420	36.4	0
2035	500	400	36.4	0
2036	460	380	36.4	0
2037	420	360	36.4	0
2038	380	340	36.4	0
2039	340	320	36.4	0
2040	300	300	36.4	0

2041	300	300	36.4	0
2042	300	300	36.4	0
2043	300	300	36.4	0
2044	300	300	36.4	0
2045	300	300	36.4	0
2046	300	300	36.4	0
2047	300	300	36.4	0
2048	300	300	36.4	0
2049	300	300	36.4	0
2050	300	300	36.4	0