

# **Emissions and Removals of Greenhouse Gases from Land Use, Land Use Change and Forestry (LULUCF) for England, Scotland, Wales and Northern Ireland: 1990-2009**

Amanda M. Thomson, Stephen Hallsworth and Heath Malcolm,  
Centre for Ecology & Hydrology

15<sup>th</sup> April 2011

Department of Energy and Climate Change Contract GA0510

CEH Contract no. NEC03761



**Centre for  
Ecology & Hydrology**

NATURAL ENVIRONMENT RESEARCH COUNCIL

## Contacts

This work forms part of the Climate and Energy: Science and Analysis Research Programme of the Department for Energy and Climate Change. The land use, land use change and forestry (LULUCF) estimates are provided by the Centre for Ecology & Hydrology (CEH) Edinburgh (Contract GA0510).

Technical enquiries on land use, land use change and forestry should be addressed to Dr. Amanda Thomson or Heath Malcolm, Centre for Ecology & Hydrology (Edinburgh), Bush Estate, Penicuik, EH26 0QB, UK.

Tel: +44 (0) 131 445 8583, E-mail: [lulucf@ceh.ac.uk](mailto:lulucf@ceh.ac.uk)

## Introduction

The LULUCF sector includes carbon stock changes, emissions of greenhouse gases (carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O)) by sources and removals of CO<sub>2</sub> by sinks from land use, land use change and forestry activities. Removals of CO<sub>2</sub> are conventionally presented as negative quantities. Total greenhouse gas emissions are described as carbon dioxide equivalents (CO<sub>2</sub>e), using Global Warming Potentials (GWP) of 21 for CH<sub>4</sub> and 310 for N<sub>2</sub>O (as used in the inventories submitted to the UNFCCC).

Detailed information on the data and methods used in the LULUCF inventory is available in the 1990-2009 UK Greenhouse Gas Inventory Report, available on the National Atmospheric Emissions Inventory website <http://naei.defra.gov.uk/>. Chapter 7 and Annex 3.7 contain information on the LULUCF sector, and Chapter 11 contains additional information on the reporting of LULUCF activities for the Kyoto Protocol. Additional information on LULUCF and KP-LULUCF inventory reporting has been made available at <http://ecosystemghg.ceh.ac.uk/>.

The current LULUCF inventory methods use a combination of top-down and bottom-up approaches, based on activity data for each of the Devolved Administrations and the UK as a whole. As a result of this approach, estimates of emissions and removals from LULUCF activities are automatically produced at the DA and UK scale.

## Changes between the 2009 and the 2008 inventory

There are differences in the estimated net emissions in the 1990-2009 inventory compared with the previous inventory. There have been updates to methods and activity data this year, together with internal restructuring of the LULUCF calculation methods. Sector 5, which covers LULUCF emissions and removals reporting, now reports a slightly larger source in 1990 compared with the 1990-2008 inventory (3.876 vs. 2.953 Mt CO<sub>2</sub>e) and a larger sink from 2000 onwards (-4.005 vs. -1.942 Mt CO<sub>2</sub>e in 2008). These differences are due to the inclusion of new activity data for land use change between 2000 and 2007, the reporting of N<sub>2</sub>O emissions from land-use conversion to cropland, the reporting of on-site emissions for the 5D Wetlands category and other minor revisions to methods, activity data and emission factors. These changes have been undertaken as part of the development of the inventory, or in response to international review team recommendations. The main changes are described below, with the main differences between inventories in the Devolved Administrations described in their respective sections.

The inclusion of new data on land use change from the Countryside Survey 2007 has made a marked difference to the estimates of net emissions/removals. In previous inventories, rates of land use change were based on the rate of change between 1990 and 1998, rolled forward to the most recent inventory year. With the new dataset, we have been able to recalculate rates of change for 2000 to 2007, and have extrapolated rates for 2008 and 2009 using the most recent rates (the LUC model is set up to use decadal land use change, e.g. 1990-1999 and 2000-2009). Rates of land use change for 1999 are assumed to be the same as those for 1990-1998. Changes to the rates of land use change affect the estimates of soil carbon stock changes from these land use conversions.

### **5.A Forest Land**

Small changes in net emissions/removals from this category arise from updated activity data (resulting in re-allocation of afforestation between initial land types) and improved reporting of deforestation (so that any deforested area is consistently removed from the national forest area). Internally, the Forest Land category has been restructured to use a 20 year transition period from Land converted to Forest Land to Forest remaining Forest, in line with IPCC guidance. Grassland conversion to Forest Land has also been split between pasture and semi-natural grassland (values are included in the CRF Tables but are not reported here). The emission factor used for N<sub>2</sub>O emissions from direct nitrogen fertilization of forests has been updated to that recommended in the IPCC 2006 guidelines.

### **5.B Cropland**

Small changes in net emissions 1990-1999 arose from revisions to the land use change model, which now uses a bottom-up approach (summing 20-km square estimates) rather than a top-down approach (calculating at the national level). There are larger changes from 2000 onwards due to the inclusion of new activity data on land use change (Countryside Survey 2007). Land use change to Cropland in the UK between 2000 and 2009 was smaller than previously estimated, producing a smaller net source: 11.934 Mt CO<sub>2</sub> in 2008 in the 2009 inventory (12.579 Mt CO<sub>2</sub>e including N<sub>2</sub>O) vs. 14.346 Mt CO<sub>2</sub> in the 2008 inventory.

As part of the assessment of land use change data, carbon stock changes from post-1990 Forest conversion to Cropland were included for the first time, along with emissions from the associated biomass burning. There were small changes in CO<sub>2</sub> emissions from agricultural liming due to re-assignment of the limed area between Cropland and Grassland (updated activity data). N<sub>2</sub>O emissions from disturbance associated with land use conversion to Cropland were included for the first time. Due to the large GWP of N<sub>2</sub>O, small changes in the estimated emissions of this gas have a noticeable effect on the overall LULUCF sector.

### **5.C Grassland**

Emissions from peat extraction have been moved from the Grassland remaining Grassland to the 5D Wetlands category. Small changes in net emissions 1990-1999 arose from changes to the land use change model from a top-down to a bottom-up approach. There are larger changes from 2000 onwards due to the inclusion of new activity data on land use change (Countryside Survey 2007). Land areas converted to Grassland from other categories were larger than previously estimated, producing a larger net sink (-9.064 Mt CO<sub>2</sub> in 2008 in the 2009 inventory vs. -8.865 Mt CO<sub>2</sub> in the 2008 inventory).

There were small changes in CO<sub>2</sub> emissions from agricultural liming due to re-assignment of the limed area between Cropland and Grassland (updated activity data). New activity data on forest conversion to non-urban land use was included, and part of this area was also re-assigned to Forest converted to Cropland. This had a small effect on carbon stock changes and biomass burning emissions.

#### **5.D Wetlands**

On-site emissions of CO<sub>2</sub> due to peat production were reported in this category for the first time, and off-site emissions from horticultural peat were reported here rather than in the Grassland category. N<sub>2</sub>O emissions from wetland drainage (for peat production) were also reported here.

#### **5.E Settlements**

Small changes in net emissions 1990-1999 arose from changes to the land use change model from a top-down to a bottom-up approach. There are larger changes from 2000 onwards due to the inclusion of new activity data on land use change (Countryside Survey 2007). Land use changes to Settlement were smaller than previously estimated, producing a slightly smaller net source (6.068 Mt CO<sub>2</sub> in 2008 in the 2009 inventory vs. 6.220 Mt CO<sub>2</sub> in the 2008 inventory). Updated activity data on Forest converted to Settlements was included, affecting net emissions/removals from this subcategory and associated biomass burning emissions.

#### **5.G Other (Harvested Wood Products)**

Changing inputs to the harvested wood products pool (due to updated activity data for deforestation) resulted in small changes to the carbon stock changes from this category.

## **2 Emissions in England**

### **Summary of net emissions**

England is a net source of greenhouse gases from LULUCF activities although the size of this source has diminished by 71% between 1990 and 2009 from 5.932 to 1.710 Mt CO<sub>2</sub>e. Net emissions of CO<sub>2</sub> from land use and land use change (Figure 1) in the Cropland and Settlement categories are diminishing over time, while net removals from the Grassland category are increasing. Net removals from the Forest Land category increased to 2004 but are now diminishing. The Wetlands and Harvested Wood Products categories make small contributions to the total.

Estimates of CH<sub>4</sub> emissions from LULUCF activities are small, with 0.018 Mt CO<sub>2</sub>e of CH<sub>4</sub> in 2009. Estimated emissions of N<sub>2</sub>O are now larger than previously estimated due to the inclusion of N<sub>2</sub>O emissions from disturbance associated with land-use conversion to cropland for the first time. There were 0.250 Mt CO<sub>2</sub>e of N<sub>2</sub>O emissions in 2009.

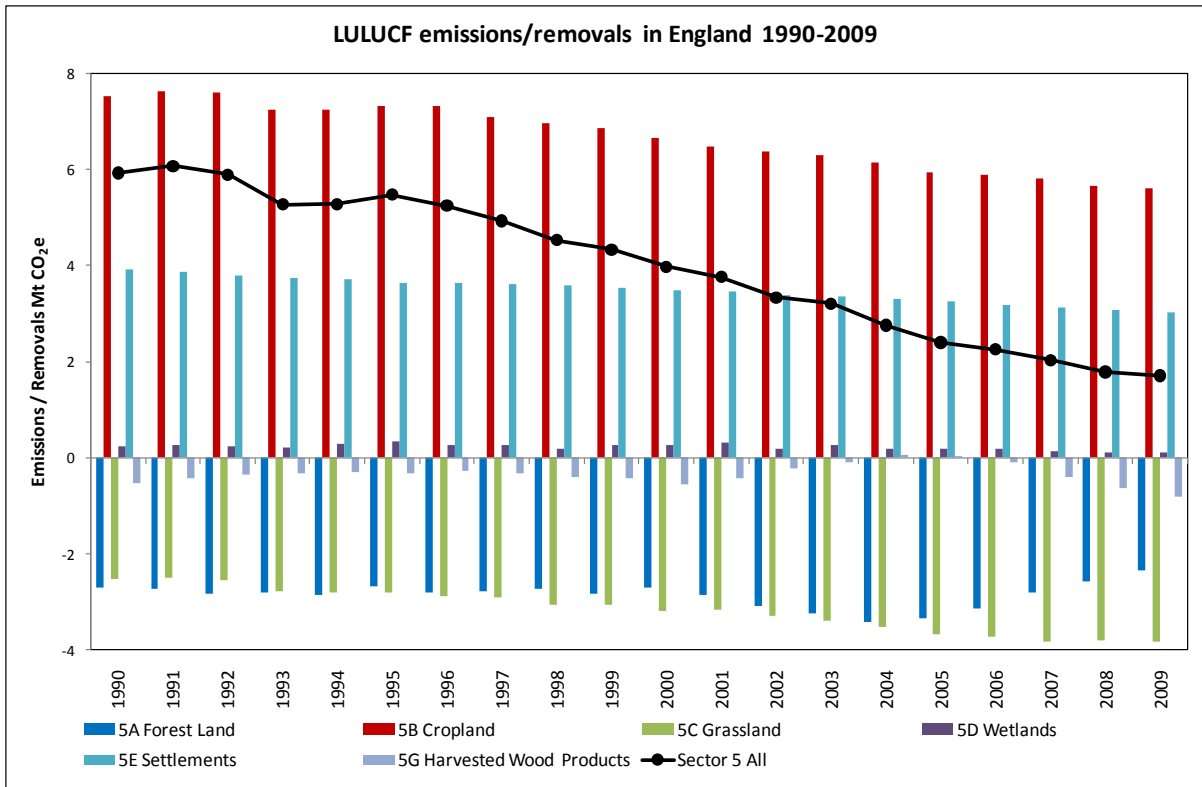


Figure 1: LULUCF inventory emissions and removals by category for England

### Differences from the 1990-2008 inventory

Net greenhouse gas emissions in 1990 were 5.737 Mt CO<sub>2</sub>e in the 2008 inventory and 5.932 Mt CO<sub>2</sub>e in the 2009 inventory. In 2008 they were 2.990 Mt CO<sub>2</sub>e in the 2008 inventory vs. 1.785 Mt CO<sub>2</sub>e in the 2009 inventory (Table 1).

Net emissions of CO<sub>2</sub> between 1990 and 1999 did not change significantly from the previous inventory (Figure 2). This conceals reduced emissions from the Land Use Change (LUC) to Cropland and LUC to Settlement categories and reduced removals from the LUC to Grassland category (due to the change in the LUC method from top-down to bottom-up) and increased emissions from Wetlands (reported for the first time). There were also reduced removals from Forest Land (due to adjustments accounting for deforestation losses). From 2000 onwards, there is a wider divergence between the inventories with the reduced emissions from Cropland making the most difference.

Carbon stock changes from post-1990 conversion of Forest Land to Cropland are included for the first time (in England) but only make a minor contribution (0.004 Mt CO<sub>2</sub> in 1990 and 0.002 Mt CO<sub>2</sub> in 2009). The inclusion of N<sub>2</sub>O emissions from disturbance associated with LUC to Cropland makes a bigger difference, as N<sub>2</sub>O has a large GWP. Net emissions of N<sub>2</sub>O from this activity were 0.99 Gg N<sub>2</sub>O in 1990 (0.306 Mt CO<sub>2</sub>e) and 0.80 Gg N<sub>2</sub>O in 2009 (0.248 Mt CO<sub>2</sub>e).

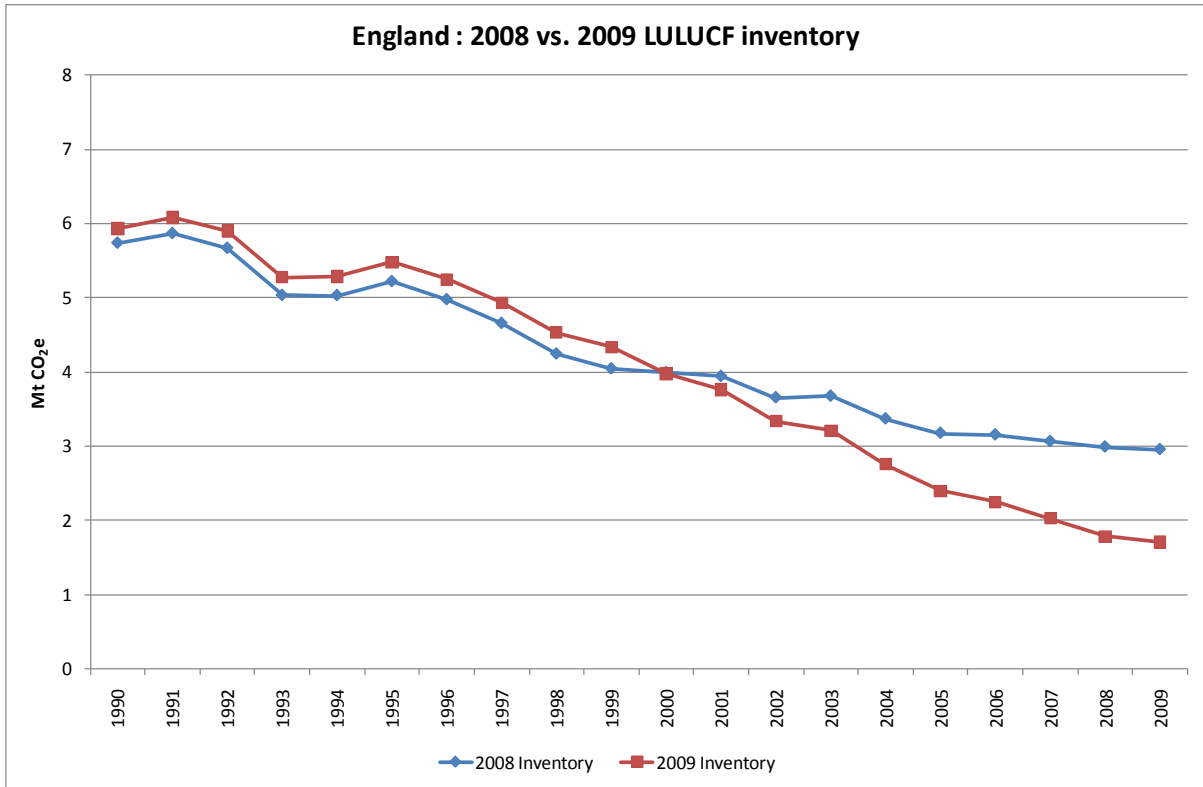


Figure 2: Differences between the 2008 and 2009 LULUCF inventory in England

Table 1: Difference in 2008 LULUCF net emission between 2008 and 2009 inventories in England

	5A Forest Land	5B Cropland	5C Grassland	5D Wetlands	5E Settlements	5G Other	Sector 5 All
<b>Difference between 2008 and 2009 inventory</b>	0.077	-0.791	-0.259	0.096	-0.282	-0.048	1.205

The annual land use matrices for 1990-1991 and 2008-2009 for England are shown here (Table 2 and Table 3). The off-diagonal items (land use change data from the Countryside Survey, forest planting and deforestation datasets) in the matrix are used to estimate the land use change fluxes in the LULUCF inventory. The diagonal items (land remaining in the same use, in italics) are included for information and have an uncertainty attached as there is not a perfect match between the sum across the columns and the sum across the rows. The total area of England is reported as 13,043.5 kha. This is the Standard Area Measurement to mean high water reported by the Office of National Statistics (ONS 2009).

Table 2: Land use transition matrix, kha, for England in 1990-1991

From: To:	Forest	Cropland	Grassland	Wetlands	Settlements	Other Land	Total (final)
Forest	1041.9±0.5	3.4	8.9	0	2.1	0.2	1057.1
Cropland	0.5	4318±1.0	62.9	0	0.6	0	4381
Grassland	8.7	55.3	5084.6±1.6	0	3.4	1.9	5155.5
Wetlands	0	0	0	5.9	0	0	5.9
Settlements	1.2	2.1	8.5	0	1418.5±2.2	0.2	1428.3
Other Land	0.2	0.1	0.7	0	0.2	1013.4±1.1	1015.7
<b>Total (initial)</b>	<b>1052.0</b>	<b>4380.0</b>	<b>5164.0</b>	<b>5.9</b>	<b>1427.0</b>	<b>1014.6</b>	<b>13,043.5</b>

Table 3 Land use transition matrix, kha, for England in 2008-2009

From: To:	Forest	Cropland	Grassland	Wetlands	Settlements	Other Land	Total (final)
Forest	1121±2.0	2.0	5.8	0	1.1	0.1	1128.0
Cropland	0.1	3889.1±8.7	35.4	0	0.1	0	3916.0
Grassland	2.9	53.1	5409.4±12.7	0	4.8	1.9	5484.7
Wetlands	0	0	0	4.6	0	0	4.6
Settlements	0.6	4.6	5.3	0	1462.4±0.7	0.2	1472.4
Other Land	0.4	1.6	6.1	0	0.1	1030.9±1.3	1037.8
<b>Total (initial)</b>	<b>1127.0</b>	<b>3959.0</b>	<b>5449.3</b>	<b>4.6</b>	<b>1469.2</b>	<b>1034.3</b>	<b>13043.5</b>

### Net emissions for Kyoto Protocol Article 3.3 and 3.4

The UK reports estimates of emissions and removals from activities in Article 3.3 (mandatory, Afforestation, Reforestation and Deforestation) and Article 3.4 (elective, Forest Management) of the Kyoto Protocol. The emissions and removals from Kyoto Protocol activities in England in 2009 are shown in Table 4. The methods and assumptions used in these reported emissions are described in Chapter 11 and Annex 3.7 of the National Inventory Report.

Table 4: Greenhouse gas emissions and removals from KP-LULUCF activities in England in 2009 (NO: not occurring)

Activity		England
<b>3.3 Afforestation &amp; Reforestation</b>	Area, kha	84.89
	Net CO <sub>2</sub> emissions/removals, Mt CO <sub>2</sub>	-0.898
	GHG emissions from biomass burning, Mt CO <sub>2</sub> e.	NO
	N <sub>2</sub> O emissions from N fertilization, Mt CO <sub>2</sub> e	0.0003
<b>3.3 Deforestation</b>	Area, kha	15.20
	Net CO <sub>2</sub> emissions/removals, Mt CO <sub>2</sub>	0.321
	GHG emissions from biomass burning, Mt CO <sub>2</sub> e	0.150.
	N <sub>2</sub> O emissions from LUC to cropland, Mt CO <sub>2</sub> e	0.0002
<b>3.4 Forest Management</b>	Area, kha	315.59
	Net CO <sub>2</sub> emissions/removals, Mt CO <sub>2</sub>	-1.485
	GHG emissions from biomass burning, Mt CO <sub>2</sub> e	0.047

### 3 Emissions in Scotland

#### Summary of net emissions

Scotland is a net sink of carbon from LULUCF activities (Figure 3). The size of this sink has increased by 170%, from -2.104 to -5.677 Mt CO<sub>2</sub>e, between 1990 and 2009. Net emissions/removals in Scotland are dominated by the large Forest Land sink (-8.681 Mt CO<sub>2</sub>e in 2009) and Cropland source (5.612 Mt CO<sub>2</sub>e in 2009).

Estimates of CH<sub>4</sub> from LULUCF activities are small, with 0.009 Mt CO<sub>2</sub>e of CH<sub>4</sub> in 2009. Estimated emissions of N<sub>2</sub>O are now larger than previously estimated due to the inclusion of N<sub>2</sub>O emissions from disturbance associated with land-use conversion to Cropland for the first time. There were 0.302 Mt CO<sub>2</sub>e of N<sub>2</sub>O emissions in 2009.

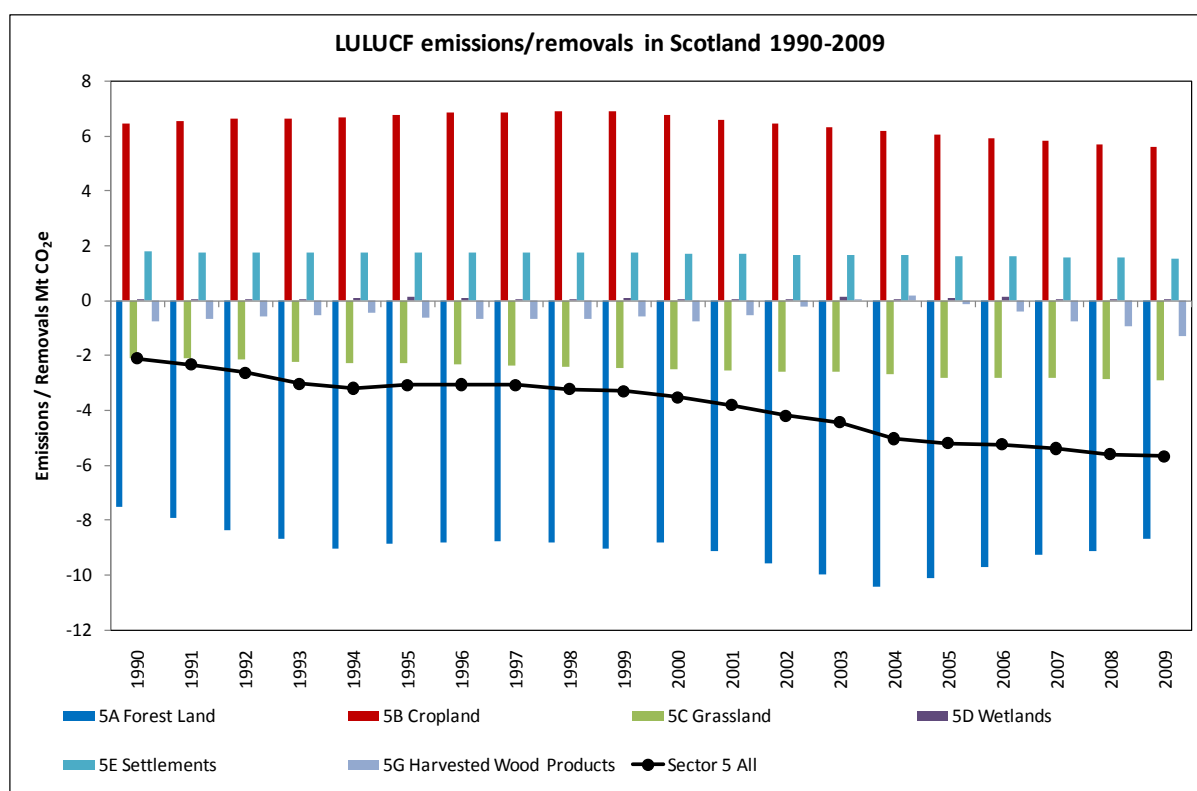


Figure 3: LULUCF inventory emissions and removals by category for Scotland

#### Differences from the 1990-2008 inventory

Net greenhouse gas emissions in 1990 were -2.518 Mt CO<sub>2</sub>e in the 2008 inventory and -2.104 Mt CO<sub>2</sub>e in the 2009 inventory. In 2008 they were -4.474 Mt CO<sub>2</sub>e in the 2008 inventory vs. -5.604 Mt CO<sub>2</sub>e in the 2009 inventory (Table 5).

Net emissions of CO<sub>2</sub> between 1990 and 2000 are slightly larger than in the previous inventory (Figure 4). There was a reduction in the size of the net sink due to slightly increased emissions from cropland, grassland and settlements (due to the change in the LUC method from top-down to bottom-up) and increased emissions from wetlands (reported for the first time). From 2001 onwards, there is a wider divergence between the inventories with the reduced emissions from cropland making the most difference.



The inclusion of N<sub>2</sub>O emissions from disturbance associated with land-use conversion to cropland makes a noticeable addition. Net emissions of N<sub>2</sub>O from this activity were 1.11 Gg N<sub>2</sub>O in 1990 (0.344 Mt CO<sub>2</sub>e) and 0.97 Gg N<sub>2</sub>O in 2009 (0.301 Mt CO<sub>2</sub>e).

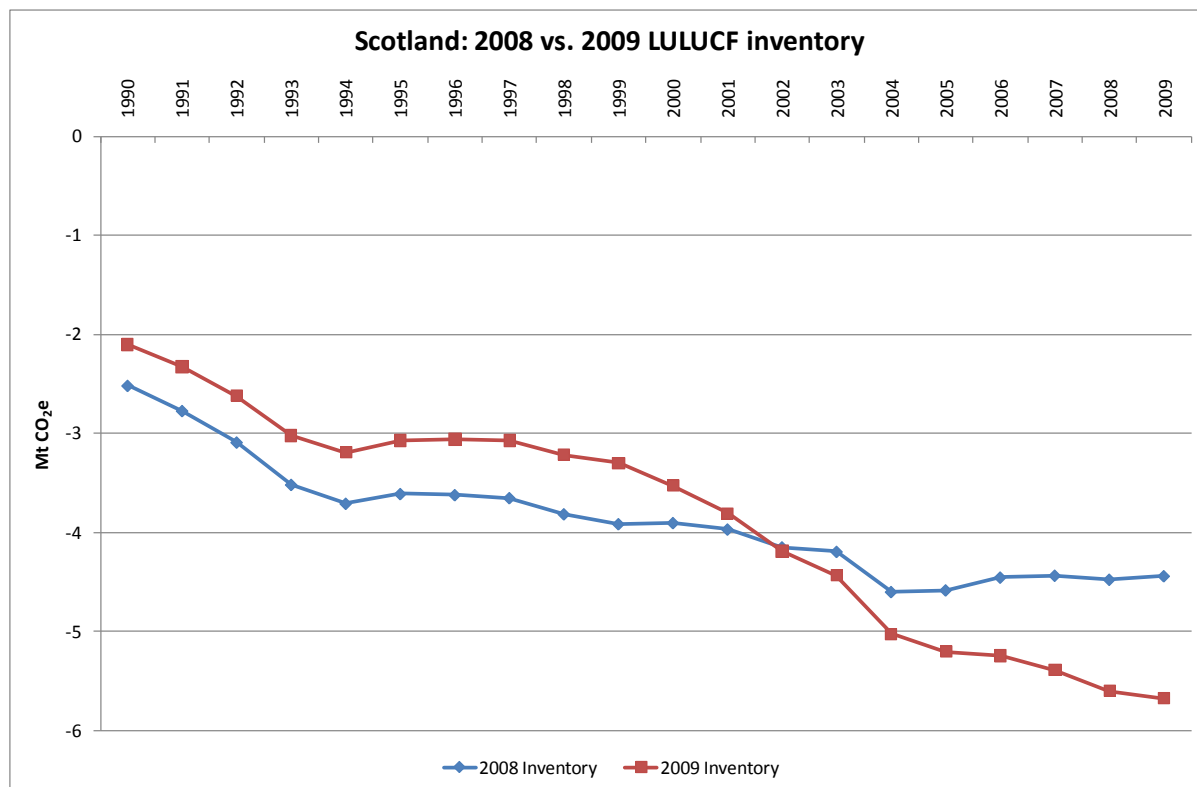


Figure 4: Differences between the 2008 and 2009 LULUCF inventory in Scotland

Table 5: Difference in 2008 LULUCF net emission between 2008 and 2009 inventories in Scotland

	5A Forest Land	5B Cropland	5C Grassland	5D Wetlands	5E Settlements	5G Other	Sector 5 All
<b>Difference between 2008 and 2009 inventory</b>	0.037	-0.946	-0.146	0.052	-0.112	-0.015	-1.130

Mt CO<sub>2</sub>e

The annual land use matrices for 1990-1991 and 2008-2009 for Scotland are shown here (Table 6 and Table 7). The off-diagonal items (land use change data from the Countryside Survey, forest planting and deforestation datasets) in the matrix are used to estimate the land use change fluxes in the LULUCF inventory. The diagonal items (land remaining in the same use, in italics) are included for information and have an uncertainty attached as there is not a perfect match between the sum across the columns and the sum across the rows. The total area of Scotland is reported as 7,880.7 kha. This is the Standard Area Measurement to mean high water reported by the Office of National Statistics (ONS 2009).

Table 6 Land use transition matrix, kha, for Scotland in 1990-1991

From: To:	Forest Land	Cropland	Grassland	Wetlands	Settlements	Other Land	Total (final)
Forest Land	1,198.1±2.7	0.6	11.1	0	0.2	0.1	1,212.8
Cropland	0.1	574.8±0.5	21.4	0	0.3	0	596.1
Grassland	5.0	16.8	5,662.9±1.5	0	0.7	1.2	5,685.1
Wetlands	0	0	0	1.6	0	0.1	1.7
Settlements	0.3	0.1	2.2	0	186.0±0.2	0.0	188.4
Other Land	0.2	0.3	1.0	0	0.6	195.0±0.6	196.5
<b>Total (initial)</b>	<b>1,201.0</b>	<b>593.0</b>	<b>5,700.0</b>	<b>1.8</b>	<b>188.0</b>	<b>196.9</b>	<b>7,880.7</b>

Table 7 Land use transition matrix, kha, for Scotland in 2008-2009

From: To:	Forest Land	Cropland	Grassland	Wetlands	Settlements	Other Land	Total (final)
Forest Land	1,333.3±2.7	0.3	4.0	0	0.6	0.1	1341.0
Cropland	0.0	505.4±0.5	9.5	0	0.0	0.0	515.3
Grassland	10.5	18.8	5,723.7±0.1	0	2.1	0.6	5755.8
Wetlands	0	0	0	1.3	0	0	1.3
Settlements	0.1	0.6	1.6	0	194.7±1.3	0.6	197.8
Other Land	0.7	0.1	1.2	0	0.1	71.9±4.5	69.5
<b>Total (initial)</b>	<b>1,342.0</b>	<b>524.7</b>	<b>5,739.9</b>	<b>1.3</b>	<b>195.2</b>	<b>77.7</b>	<b>7,880.7</b>

### Net emissions from Kyoto Protocol Article 3.3 and 3.4

The UK reports estimates of emissions and removals from activities in Article 3.3 (mandatory, Afforestation, Reforestation and Deforestation) and Article 3.4 (elective, Forest Management) of the Kyoto Protocol. The emissions and removals from Kyoto Protocol activities in Scotland in 2009 are shown in Table 8. The methods and assumptions used in these reported emissions are described in Chapter 11 and Annex 3.7 of the National Inventory Report.

Table 8: Greenhouse gas emissions and removals from KP-LULUCF activities in Scotland in 2009(NO: not occurring)

Activity		Scotland
<b>3.3 Afforestation &amp; Reforestation</b>	Area, kha	180.15
	Net CO <sub>2</sub> emissions/removals, Mt CO <sub>2</sub>	-1.677
	GHG emissions from biomass burning, Mt CO <sub>2</sub> e	NO
	N <sub>2</sub> O emissions from N fertilization, Mt CO <sub>2</sub> e	0.0006
<b>3.3 Deforestation</b>	Area, kha	4.71
	Net CO <sub>2</sub> emissions/removals, Mt CO <sub>2</sub>	0.099
	GHG emissions from biomass burning, Mt CO <sub>2</sub> e	0.046
	N <sub>2</sub> O emissions from LUC to cropland, Mt CO <sub>2</sub> e	NO
<b>3.4 Forest Management</b>	Area, kha	841.32
	Net CO <sub>2</sub> emissions/removals, Mt CO <sub>2</sub>	-6.988
	GHG emissions from biomass burning, Mt CO <sub>2</sub> e	0.050

## 4 Emissions in Wales

### Summary of net emissions

Wales is generally a small net sink of CO<sub>2</sub> from LULUCF activities (Figure 5): it was a small net source between 1997 and 1999. The size of this sink has slightly increased between 1990 and 2009: from -0.041 to -0.250 Mt CO<sub>2</sub>e. The Forest Land net sink (-1.193 Mt CO<sub>2</sub>e in 2009) and the Cropland net source (1.038 Mt CO<sub>2</sub>e in 2009) are the largest contributors to the LULUCF sector in Wales.

Estimates of CH<sub>4</sub> emissions from LULUCF activities are small, with 0.002 Mt CO<sub>2</sub>e of CH<sub>4</sub> in 2009. Estimated emissions of N<sub>2</sub>O are now larger than previously estimated due to the inclusion of N<sub>2</sub>O emissions from disturbance associated with land-use conversion to cropland for the first time. There were 0.055 Mt CO<sub>2</sub>e of N<sub>2</sub>O emissions in 2009.

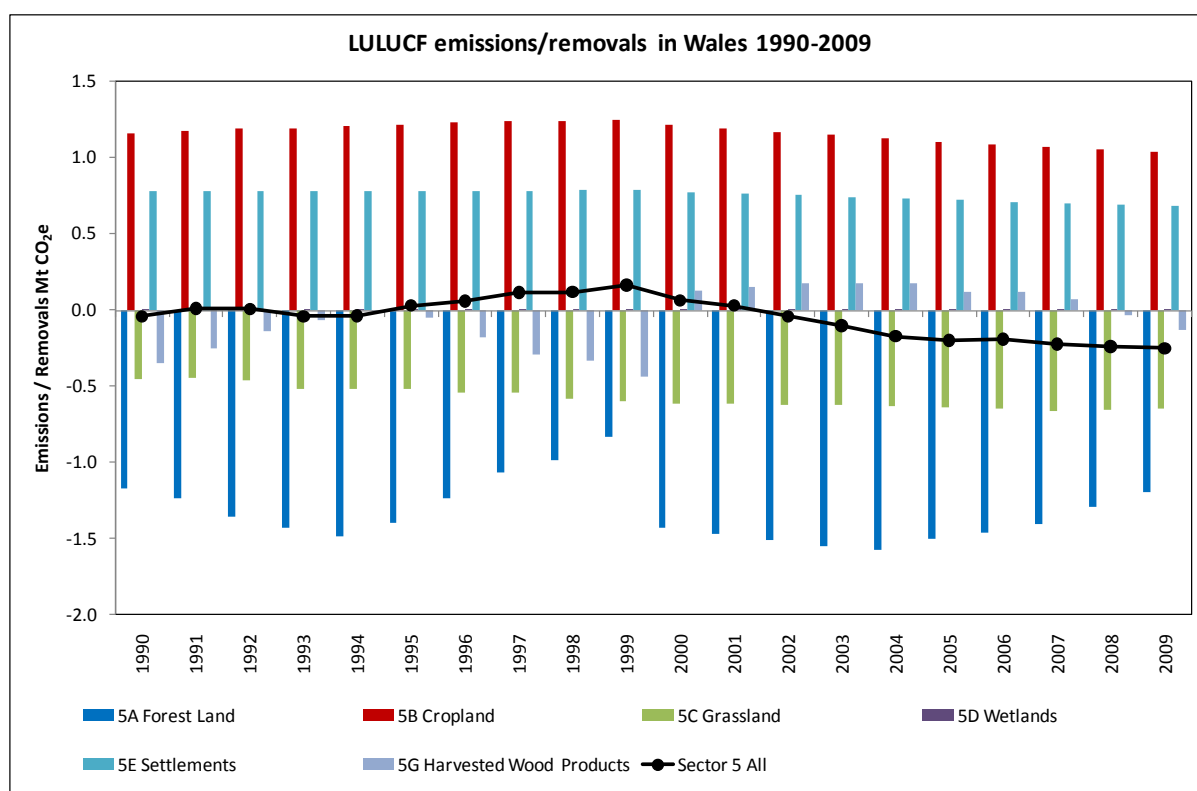


Figure 5: LULUCF inventory emissions and removals by category for Wales

### Differences from the 1990-2008 inventory

Net greenhouse gas emissions in 1990 were -0.237 Mt CO<sub>2</sub>e in the 2008 inventory and -0.041 Mt CO<sub>2</sub>e in the 2009 inventory. In 2008 they were -0.193 Mt CO<sub>2</sub>e in the 2008 inventory vs. -0.241 Mt CO<sub>2</sub>e in the 2009 inventory (Table 9).

Net emissions of CO<sub>2</sub> between 1990 and 1999 were higher in the 2009 inventory than in the 2008 inventory, and Wales was a small net source between 1997 and 2000. There were greater net emissions from LUC to cropland and LUC to settlements between 1990 and 1999 in the 2009 inventory, and greater net removals from LUC to grassland (due to changes from a top-down to a bottom-up approach in the LUC model). From 2000 onwards, net emissions decline at a faster rate in the 2009 inventory than in the 2008 inventory, with the reduced emissions from LUC to cropland making the most difference.

The inclusion of N<sub>2</sub>O emissions from disturbance associated with land-use conversion to cropland makes a bigger difference, as N<sub>2</sub>O has a high GWP. Net emissions of N<sub>2</sub>O from this activity were 0.196 Gg N<sub>2</sub>O in 1990 (0.061 Mt CO<sub>2</sub>e) and 0.178 Gg N<sub>2</sub>O in 2009 (0.055 Mt CO<sub>2</sub>e).

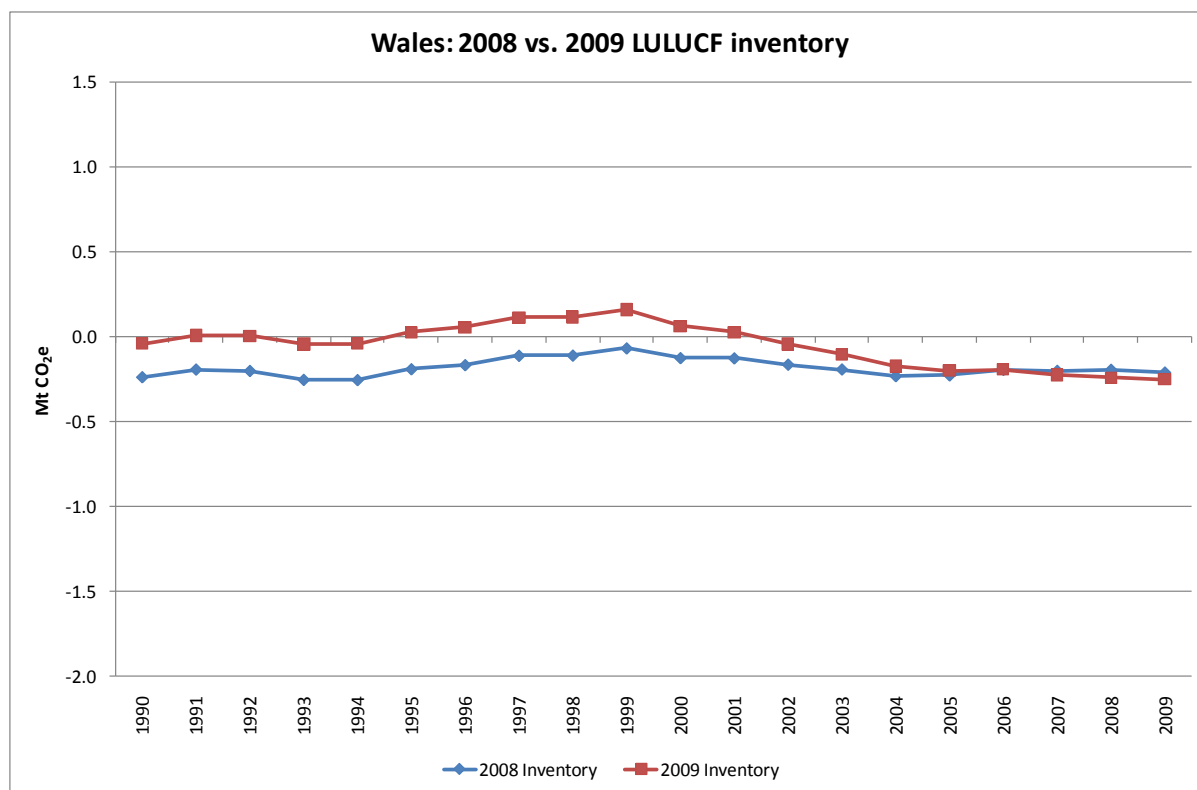


Figure 6: Differences between the 2008 and 2009 LULUCF inventory in Wales

Table 9: Difference in 2008 LULUCF net emission between 2008 and 2009 inventories in Wales

	5A Forest Land	5B Cropland	5C Grassland	5D Wetlands	5E Settlements	5G Other	Sector 5 All
<b>Difference between 2008 and 2009 inventory</b>	0.008	0.000	-0.053	0.000	-0.001	-0.002	-0.048

The annual land use matrices for 1990-1991 and 2008-2009 for Wales are shown here (Table 10 and Table 11). The off-diagonal items (land use change data from the Countryside Survey, forest planting and deforestation datasets) in the matrix are used to estimate the land use change fluxes in the LULUCF inventory. The diagonal items (land remaining in the same use, in italics) are included for information and have an uncertainty attached as there is not a perfect match between the sum across the columns and the sum across the rows. The total area of Wales is reported as 2,077.9 kha. This is the Standard Area Measurement to mean high water reported by the Office of National Statistics (ONS 2009).

Table 10 Land use transition matrix, kha, for Wales in 1990-1991

From: To:	Forest	Cropland	Grassland	Wetlands	Settlements	Other Land	Total (final)
Forest	282.0±0.3	0.2	2.4	0	0.2	0.0	284.5
Cropland	0.0	44.0±0.4	8.0	0	0.1	0	51.7
Grassland	1.5	5.5	1,451.6±1.8	0	0.6	0.2	1,461.1
Wetlands	0	0	0	0.5	0	0	0.5
Settlements	0.1	0.2	1.8	0	130.0±0.6	0.0	131.6
Other Land	0.1	0.0	0.2	0	0.0	148.7±0.5	148.5
<b>Total (initial)</b>	<b>284.0</b>	<b>50.3</b>	<b>1,462.2</b>	<b>0.5</b>	<b>131.5</b>	<b>149.3</b>	<b>2,077.9</b>

Table 11 Land use transition matrix, kha, for Wales in 2008-2009

From: To:	Forest	Cropland	Grassland	Wetlands	Settlements	Other Land	Total (final)
Forest	283.2±1.0	0.1	1.5	0	0.2	0.0	284.0
Cropland	0.0	71.2±0.5	4.0	0	0.0	0.0	75.7
Grassland	0.3	3.5	1,435.1±1.5	0	0.5	0.2	1,441.1
Wetlands	0	0	0	0.5	0	0	0.5
Settlements	0.1	0.0	1.2	0	148.5±0.5	0.0	150.3
Other Land	0.4	0	1.9	0	0.0	125.5±1.5	126.3
<b>Total (initial)</b>	<b>285.0</b>	<b>74.3</b>	<b>1,442.2</b>	<b>0.5</b>	<b>148.7</b>	<b>127.2</b>	<b>2,077.9</b>

### Net emissions for Kyoto Protocol Article 3.3 and 3.4

The UK reports estimates of emissions and removals from activities in Article 3.3 (mandatory, Afforestation, Reforestation and Deforestation) and Article 3.4 (elective, Forest Management) of the Kyoto Protocol. The emissions and removals from Kyoto Protocol activities in Wales in 2009 are shown in Table 12. The methods and assumptions used in these reported emissions are described in Chapter 11 and Annex 3.7 of the National Inventory Report.

Table 12: Greenhouse gas emissions and removals from KP-LULUCF activities in Wales in 2009(NO: not occurring)

Activity		Wales
<b>3.3 Afforestation &amp; Reforestation</b>	Area, kha	8.79
	Net CO <sub>2</sub> emissions/removals, Mt CO <sub>2</sub>	-0.095
	GHG emissions from biomass burning, Mt CO <sub>2</sub> e	NO
	N <sub>2</sub> O emissions from N fertilization, Mt CO <sub>2</sub> e	0.00003
<b>3.3 Deforestation</b>	Area, kha	1.03
	Net CO <sub>2</sub> emissions/removals, Mt CO <sub>2</sub>	0.022
	GHG emissions from biomass burning, Mt CO <sub>2</sub> e	0.010
	N <sub>2</sub> O emissions from LUC to cropland, Mt CO <sub>2</sub> e	NO
<b>3.4 Forest Management</b>	Area, kha	152.23
	Net CO <sub>2</sub> emissions/removals, Mt CO <sub>2</sub>	-1.111
	GHG emissions from biomass burning, Mt CO <sub>2</sub> e	0.014

## 5 Emissions in Northern Ireland

### Summary of net emissions

Northern Ireland was a small net source of greenhouse gases from LULUCF activities in 1990 of 0.091 Mt CO<sub>2</sub>e, a small net sink between 1993 and 2006 (reaching -0.140 Mt CO<sub>2</sub>e in 1999), and has now returned to being a small net source (Figure 7) of 0.100 Mt CO<sub>2</sub>e in 2009. The Cropland net source (1.077 Mt CO<sub>2</sub>e in 2009) and the Grassland net sink (-1.261 Mt CO<sub>2</sub>e in 2009) are the largest contributors to the LULUCF sector in Northern Ireland.

Estimates of CH<sub>4</sub> and N<sub>2</sub>O emissions due to LULUCF activities remain small: 0.0003 Mt CO<sub>2</sub>e of CH<sub>4</sub> and 0.030 Mt CO<sub>2</sub>e of N<sub>2</sub>O in 2009.

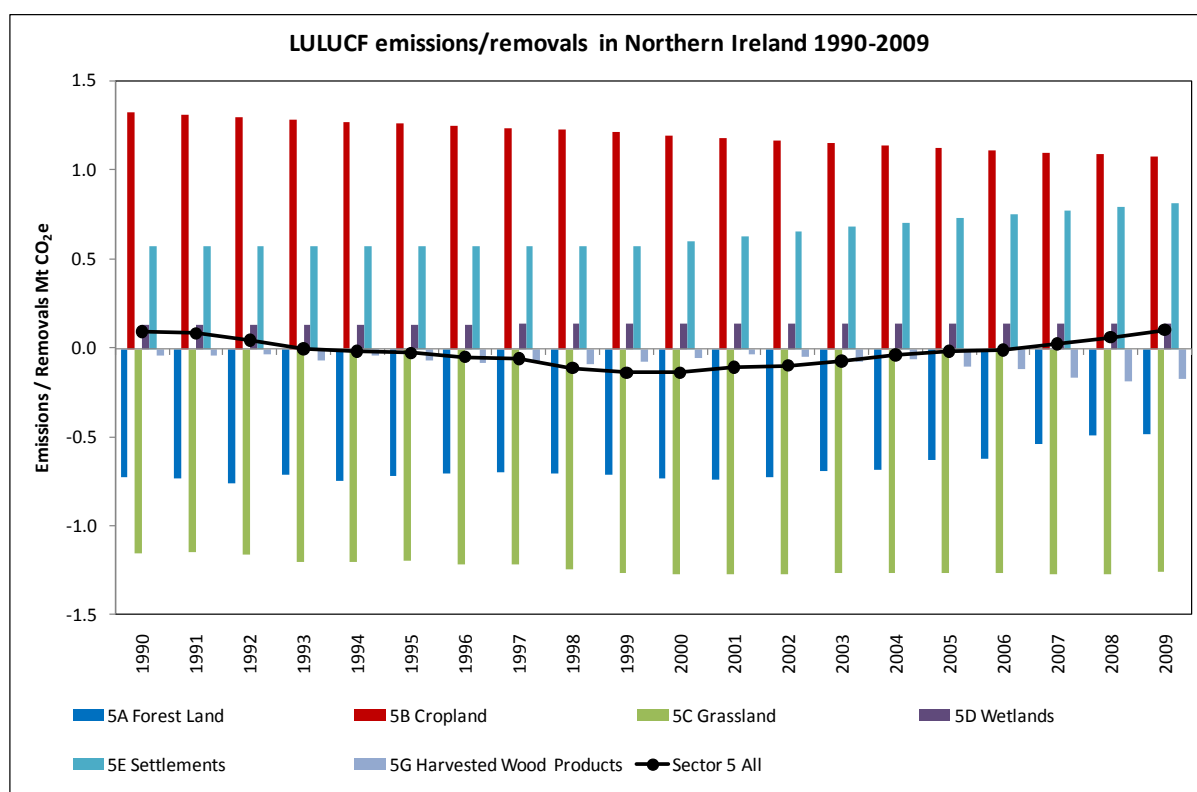


Figure 7: LULUCF inventory emissions and removals by category for Northern Ireland

### Differences from the 1990-2008 inventory

Net greenhouse gas emissions in 1990 were -0.028 Mt CO<sub>2</sub>e in the 2008 inventory and 0.091 Mt CO<sub>2</sub>e in the 2009 inventory. In 2008 they were -0.265 Mt CO<sub>2</sub>e in the 2008 inventory vs. 0.060 Mt CO<sub>2</sub>e in the 2009 inventory (Table 13).

Net emissions of CO<sub>2</sub> between 1990 and 1999 were slightly higher in the 2009 inventory compared to the 2008 inventory. This is due to a reduced net sink in the LUC to grassland category (due to changes in the LUC model from a top-down to a bottom-up approach) and increased emissions from the wetlands category (reported for the first time). From 2000 onwards, there is wider divergence between the inventories, with net emissions increasing at a greater rate in the 2009 inventory. This is from a combination of wetlands emissions, reduced net emissions from LUC to cropland and increased net emissions from LUC to settlements and grassland. Some emissions from peat

extraction were also moved from the grassland category to the wetlands category, applied to the whole time series.

The inclusion of N<sub>2</sub>O emissions from disturbance associated with land-use conversion to cropland makes a bigger difference, as N<sub>2</sub>O has a high GWP. Net emissions of N<sub>2</sub>O from this activity were 0.23 Gg N<sub>2</sub>O in 1990 (0.071 Mt CO<sub>2</sub>e) and 0.09 Gg N<sub>2</sub>O in 2009 (0.029 Mt CO<sub>2</sub>e).

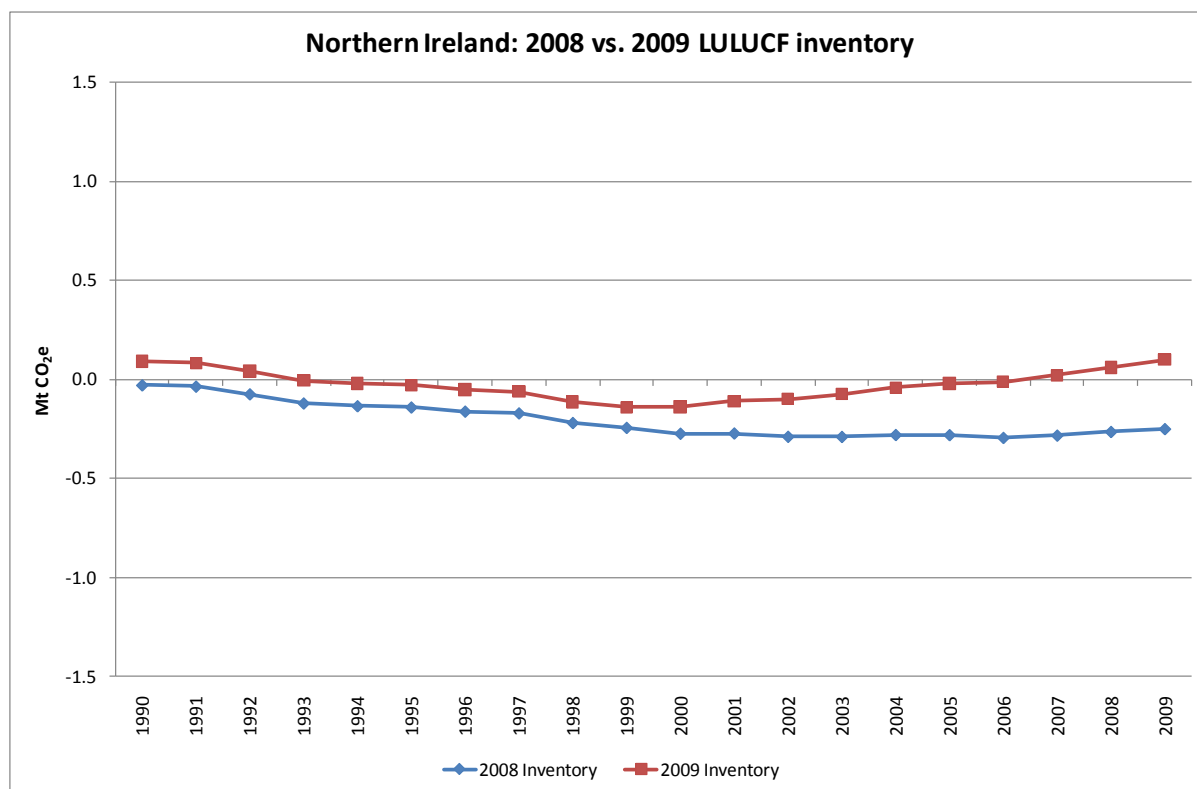


Figure 8: Differences between the 2008 and 2009 LULUCF inventory in Northern Ireland

Table 13: Difference in 2008 LULUCF net emission between 2008 and 2009 inventories in Northern Ireland

	5A Forest Land	5B Cropland	5C Grassland	5D Wetlands	5E Settlements	5G Other	Sector 5 All
<b>Difference between 2008 and 2009 inventory</b>	0.001	-0.016	-0.015	0.134	0.221	0.000	0.325

The annual land use matrices for 1990-1991 and 2008-2009 for Northern Ireland are shown here (Table 14 and Table 15). The off-diagonal items (land use change data from the Countryside Survey, forest planting and deforestation datasets) in the matrix are used to estimate the land use change fluxes in the LULUCF inventory. The diagonal items (land remaining in the same use, in italics) are included for information and have an uncertainty attached as there is not a perfect match between the sum across the columns and the sum across the rows. The total area of Northern Ireland is reported as 1,413.0 kha. This is the Standard Area Measurement to mean high water reported by the Office of National Statistics (ONS 2009).

**Table 14 Land use transition matrix, ha, for Northern Ireland in 1990-1991**

<b>From: To:</b>	<b>Forest</b>	<b>Cropland</b>	<b>Grassland</b>	<b>Wetlands</b>	<b>Settlements</b>	<b>Other Land</b>	<b>Total (final)</b>
<b>Forest</b>	73.5±0.2	0	1.6	0	0	0	<b>74.9</b>
<b>Cropland</b>	0.0	59.3±1.8	3.7	0	0	0	<b>64.7</b>
<b>Grassland</b>	0.3	5.9	1,070.6±0.1	0	0	0	<b>1,076.7</b>
<b>Wetlands</b>	0	0	0	4.5	0	0	<b>4.5</b>
<b>Settlements</b>	0.1	0.0	1.0	0	56.4±0.6	0	<b>56.9</b>
<b>Other Land</b>	0.0	0	0.7	0	0	135.6±1.0	<b>135.3</b>
<b>Total (initial)</b>	<b>74.0</b>	<b>63.4</b>	<b>1,077.6</b>	<b>4.5</b>	<b>56.9</b>	<b>136.6</b>	<b>1,413.0</b>

**Table 15 Land use transition matrix, ha, for Northern Ireland in 2008-2009**

<b>From: To:</b>	<b>Forest</b>	<b>Cropland</b>	<b>Grassland</b>	<b>Wetlands</b>	<b>Settlements</b>	<b>Other Land</b>	<b>Total (final)</b>
<b>Forest</b>	86.2±0.4	0	2.0	0	0.1	0.1	<b>88.0</b>
<b>Cropland</b>	0.0	55.2±2.5	3.2	0	0.0	0.0	<b>58.1</b>
<b>Grassland</b>	0.3	4.0	1,042.2±1.9	0	0.3	0.4	<b>1,049.1</b>
<b>Wetlands</b>	0	0	0	1.0	0	0	<b>1.0</b>
<b>Settlements</b>	0.1	0.1	2.1	0	75.5±0.1	0.1	<b>77.9</b>
<b>Other Land</b>	0.0	0.0	0.2	0	0.0	139.8±1.2	<b>138.8</b>
<b>Total (initial)</b>	<b>87.0</b>	<b>59.5</b>	<b>1,047.9</b>	<b>1.0</b>	<b>76.0</b>	<b>141.6</b>	<b>1,413.0</b>

#### **Net emissions for Kyoto Protocol Article 3.3 and 3.4**

The UK reports estimates of emissions and removals from activities in Article 3.3 (mandatory, Afforestation, Reforestation and Deforestation) and Article 3.4 (elective, Forest Management) of the Kyoto Protocol. The emissions and removals from Kyoto Protocol activities in Northern Ireland in 2009 are shown in Table 16. The methods and assumptions used in these reported emissions are described in Chapter 11 and Annex 3.7 of the National Inventory Report.



Table 16: Greenhouse gas emissions and removals from KP-LULUCF activities in Northern Ireland in 2009(NO: not occurring)

Activity		Northern Ireland
<b>3.3 Afforestation &amp; Reforestation</b>	Area, kha	14.81
	Net CO <sub>2</sub> emissions/removals, Mt CO <sub>2</sub>	-0.154
	GHG emissions from biomass burning, Mt CO <sub>2</sub> e	NO
	N <sub>2</sub> O emissions from N fertilization, Mt CO <sub>2</sub> e	0.00002
<b>3.3 Deforestation</b>	Area, kha	NO
	Net CO <sub>2</sub> emissions/removals, Mt CO <sub>2</sub>	NO
	GHG emissions from biomass burning, Mt CO <sub>2</sub> e	NO
	N <sub>2</sub> O emissions from LUC to cropland, Mt CO <sub>2</sub> e	NO
<b>3.4 Forest Management</b>	Area, kha	66.30
	Net CO <sub>2</sub> emissions/removals, Mt CO <sub>2</sub>	-0.328
	GHG emissions from biomass burning, Mt CO <sub>2</sub> e	0.003

## References

References used in the compilation of the inventory are listed in the 1990-2009 UK Greenhouse Gas Inventory Report.

## Acknowledgements

Robert Matthews and Gemma Miller of Forest Research.