

Mapping Carbon Emissions & Removals for the Land Use, Land Use Change & Forestry Sector

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1 Land Use, Land Use Change and Forestry in the National Inventory

The Department of Energy and Climate Change (DECC) takes the lead in the UK in preparing the annual Inventory of Greenhouse Gas Emissions for the United Nations Framework Convention on Climate Change. The Inventory is prepared in 6 main sections, or Sectors. DECC contract Ricardo-AEA to prepare the main greenhouse gas emissions inventory but contract the Centre for Ecology and Hydrology to prepare the data for the Sector 5 tables relating to Land Use, Land Use Change and Forestry in the UK.

In addition to the National Greenhouse Gas Inventory, the UK is required to provide reports to both the EU and the UNFCCC on its progress towards its Kyoto Protocol target. Article 3.3 of the Kyoto Protocol requires Parties in meeting their emissions reduction commitments to account for Afforestation, Reforestation and Deforestation (ARD) since 1990. Accounting for ARD under Article 3.3 requires i) a definition of forest, ii) knowledge of forest type and planting/deforestation date, iii) geographical location, and iv) a method to distinguish deforestation from areas harvested and replanted. Also, Article 3.4 of the Kyoto Protocol allows Parties flexibility to choose Forest Management, Cropland Management, Grazing Land Management and Revegetation towards meeting commitments, but this is not mandatory. For the first commitment period of the Kyoto Protocol, the UK elected Forest Management as an activity under Article 3.4, but did not elect Cropland Management, Grazing Land Management or Re-vegetation, or Wetland Drainage and Rewetting (Defra 2006), although these will be reported for the second commitment period following the EU Decision that these are now mandatory for Member States. The activities of afforestation, reforestation and deforestation are covered by Sector 5, the Land Use, Land Use change and Forestry Sector (LULUCF).

The Centre for Ecology and Hydrology annually prepares Sector 5 estimates for inclusion in the UK GHG Inventory. These estimates are made using dynamic models of changes in stored carbon driven by land use change data. For forestry, the model deals with plant carbon, dead organic matter, soil and harvested wood products and is driven by the area of land newly afforested each year. Changes in soil carbon are driven by estimated time series of land use transitions between semi-natural grassland, improved pasture, cropland, woodland and urban land uses. The models, and those for other LULUCF activities, are run for each of the four devolved administrative regions of the UK. Until the 1990-2004 inventory (submitted in 2006) no data were reported in map format at a scale below the devolved administrations (England, Scotland, Wales and Northern Ireland); here we report results from methods to provide estimates of LULUCF emissions and removals at the scale of Local Authority within the UK for the 2012 inventory year.

The LULUCF Sector differs from other sectors in the Greenhouse Gas Inventory in that it contains both sources and sinks of greenhouse gases. The sources, or emissions *to* the atmosphere, are given as positive values; the sinks, or removals *from* the atmosphere, are given as negative values.

1.1 Categories

The IPCC Good Practice Guidance (GPG) for Land Use, Land Use Change and Forestry (IPCC 2003) describes a uniform structure for reporting emissions and removals of greenhouse gases. This format for reporting can be seen as “land based”; all land in the country must be identified as having remained in one of six classes since a previous survey, or as having changed to a different (identified) class in that period. The six land classes are A: Forest Land, B: Cropland, C: Grassland, D: Wetlands, E: Settlements and F: Other land. Category G: Other is used for LULUCF activities that do not fall within any of the other categories.

The GPG allows modification of the basic set of six land classes to match national databases. In current UK reporting, the Wetlands category only includes peat workings and inland waters. Emissions from peat extraction sites have been allocated to their local authorities in Great Britain. Spatially disaggregated data is not available for Northern Ireland. Bogs, marshes and fens are currently included in the Grassland category. Naturally occurring emissions and removals from pristine areas of bog, marsh and fen are not included in the LULUCF. Only limited reporting of emissions from wetland drainage is currently reported in the LULUCF inventory, due to lack of data on the areas affected and the emissions arising this will be improved in future inventories when guidance in the IPCC2013 Supplement to the 2006 Guidelines for National Greenhouse

Gas Inventories: Wetlands (the Wetlands Supplement) is implemented. The Other land category includes lakes, rivers, reservoirs and rocky coastal land etc and no emissions or removals are reported. In addition, it is assumed that there are very few, if any, transitions of land to a type that is classified as 'Other'.

The UK land use change matrix can be simplified to that shown in Figure 1, including only Forest Land (A), Cropland (B), Grassland (C) and Settlements (E) (shown clockwise from top left). For each land use and land use transition, the change in stocks of carbon in living biomass (above and below ground), dead biomass and soil organic matter should be reported. In Figure 1, each arrow represents the possible change for an area of land between two time points showing the corresponding category designation; '1' refers to land that has not changed use (e.g. 5A1 is for Forest Land remaining Forest Land) , '2' refers to land that has undergone change (e.g. 5A2.1 is for Cropland converted to Forest Land). The very small areas of conversion between Wetland and Grassland as a result of peat extract activity and site restoration are not shown on this diagram.

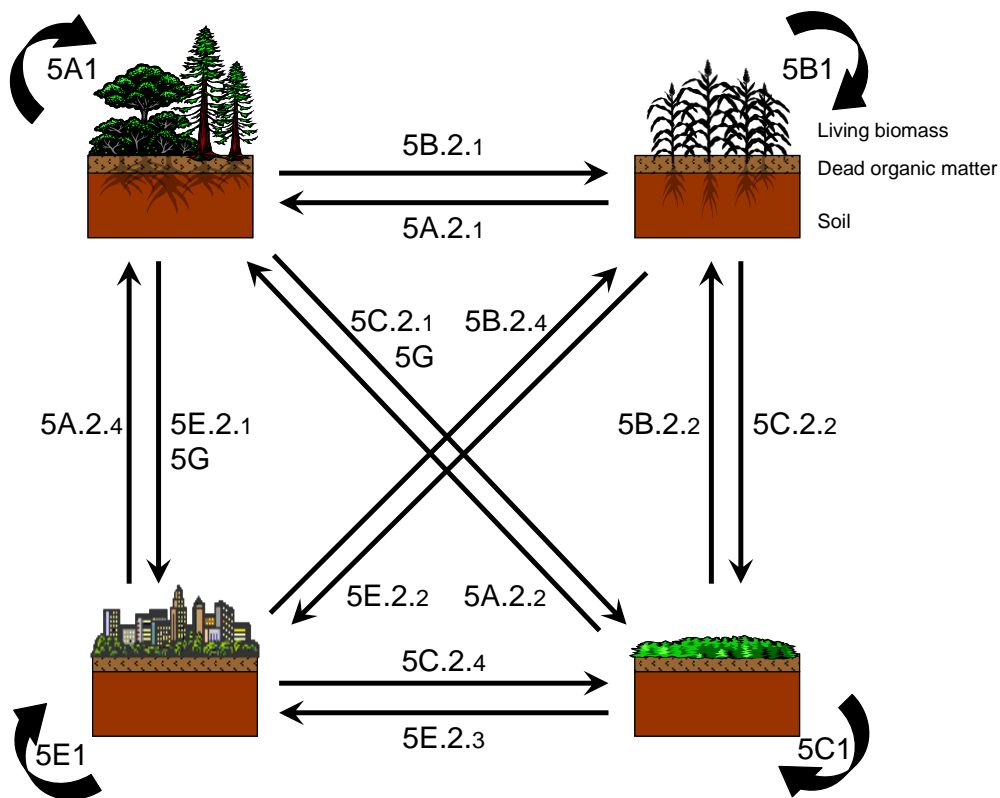


Figure 1: UK Sector 5 land use transitions showing categories for carbon stock change. See text for details.

Different activities are associated with each land use or land use change. For example, 'afforestation' refers to all land use change to Forest Land, 'liming' activity can relate to both Cropland and Grassland and 'peat extraction' affects Wetlands remaining Wetlands. However, there are no transitions to or from Wetlands and therefore this category is not shown in Figure 1. The change in carbon stocks of living biomass, dead biomass and soil organic matter must be reported for each activity together with other relevant non-carbon changes.

Further subdivision of the classes by ecosystem, administrative region or time of occurrence of change is also encouraged in the IPCC Good Practice Guidance. For the UK, the data is currently subdivided into England, Scotland, Wales and Northern Ireland where possible and some categories are further disaggregated into time periods relating to the effects of forest planting before or after 1990. Subdivision into smaller units, such as 20kmx20km regions, is appropriate for modelling purposes and the development of estimates at Local Authority scale are described in this report.

1.2 Activities

The activities relevant to LULUCF are listed in Table 1. The main category designations are listed with the activity description and the UK total emissions/removals (Gg C) for 2012 as reported in the 1990-2012 Inventory. The activities are sorted in order of magnitude and divided into four groups; afforestation, emissions from soils due to land use change, minor emissions and categories assumed to have zero emissions/removals for the UK. Full details are given in the National Inventory Report (Webb et al, 2014).

Table 1: The UK carbon emissions and removals in Sector 5 (Land Use, Land Use change and Forestry) for 2012 sorted in order of magnitude.

Category	Activity	2012 UK total GgC emission (+) or removal (-)
5A	Land converted to and land remaining Forest Land (not including emissions from wildfires)	-4776.23
5B	Land converted to and remaining Cropland (change in soil carbon not including losses from drainage of organic soils)	2731.06
5C	Land converted to and remaining Grassland (change in soil carbon)	-2378.12
5E	Land converted to and remaining Settlement (change in soil carbon)	1688.55
5B1	Cropland remaining Cropland (lowland drainage of organic soils)	286.00
5A1	Forest Wildfires	226.06
5B	Liming of Cropland	193.33
5C2	Forest Land converted to Grassland (deforestation to grass – not including soil changes)	192.96
5B1	Cropland remaining Cropland (Yield improvement)	-174.65
5D1	Wetlands remaining Wetlands (peat extraction)	97.98
5C	Liming of Grassland	84.69
5E	Forest Land converted to Settlements (deforestation to settlements - not including soil changes)	52.53
5E2	Non-Forest land converted to Settlements (change in non-forest living biomass)	-14.98
5B2	Non-Forest land converted to Cropland (change in non-forest living biomass)	1.68
5B2	Forest Land converted to Cropland (deforestation to settlements - not including soil changes)	1.66
5C2	Non-Forest land converted to Grassland (change in non-forest living biomass)	-0.0025

Each of the three (non-zero) groups of activities is described below. Emissions and removals from the LULUCF Sector are predominantly of CO₂. Emissions of other greenhouse gases are produced by biomass burning during wildfires or the conversion of Forest Land to Grassland or to Settlements (CH₄, N₂O, NO_x and CO), or by N fertilisation of new forests. Estimates of N₂O and CH₄ emissions and removals from other land use change activities are included in the 2012 inventory (3.1 Gg CH₄ or 17.8 Gg Ce for methane and 2.2 Gg N₂O or 186.0 Gg Ce for nitrous oxide across the UK). Emissions of these non-CO₂ gases from agricultural land (e.g. due to fertilization) are reported in the Agriculture sector of the Greenhouse Gas Inventory. Only changes in carbon resulting from emissions and removals of CO₂ are included in this report.

2 Forestry – Afforestation

For the National Inventory, the carbon uptake by forests planted in the UK is calculated by a carbon accounting model, CARBINE, as gains and losses in pools of carbon in standing trees, litter and soil in conifer and broadleaf forests and in harvested wood products. Forests accumulate carbon (by removing CO₂ from the atmosphere) in their biomass and soils as they grow, but timber harvesting and planting activities disturb this accumulation and result in loss of carbon via emissions of carbon dioxide, and other carbon-containing substances to the atmosphere. The net carbon stock change at any one time depends on the balance between these different activities. Forestry management cycles operate over long time scales (40 years+) so the rate of carbon dioxide removal *now* is driven by the rate of forest planting in previous decades. Two types of input data are required for the model; a) areas of new forest planted in each year in the past, and b) the stemwood growth rate and harvesting pattern.

The National estimates use the combined area of new private and state planting from 1920 to 2012 and estimated planting areas for pre-1920 for England, Scotland, Wales and Northern Ireland sub-divided into conifers and broadleaves. For mapping at LA (Local Authority) scale, the results from the CARBINE model for England, Scotland, Wales & Northern Ireland were disaggregated to 20km x 20km grid squares across the UK using estimates of planting data at this scale. The disaggregated data was then combined to provide estimates per Local Authority. This is achieved by taking the grid square data and assigning appropriate values to every 1km square in the UK. These smaller units can then be combined according to the LA boundaries (see Figure 2).

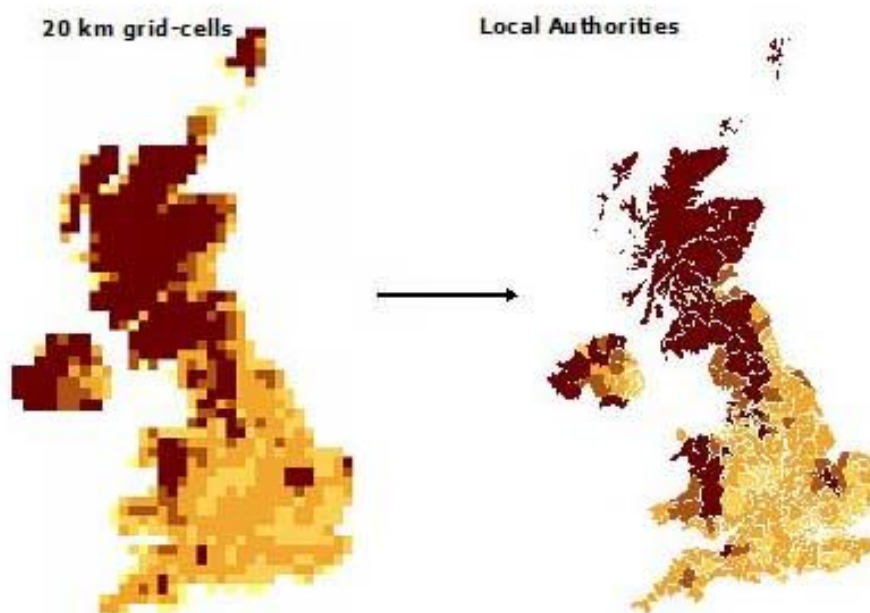


Figure 2: Model output is generated for 852 squares across the UK. Data are combined to provide estimates for each Local Authority (data for illustration only).

Figure 3 shows the distribution of carbon removals due to afforestation across the UK expressed as tonnes of Carbon per square kilometre (tC per km²). Maps of total carbon emissions/removals per LA can be misleading due to the wide range of different authorities' total area – maps tend to be dominated by the Highland region of Scotland.

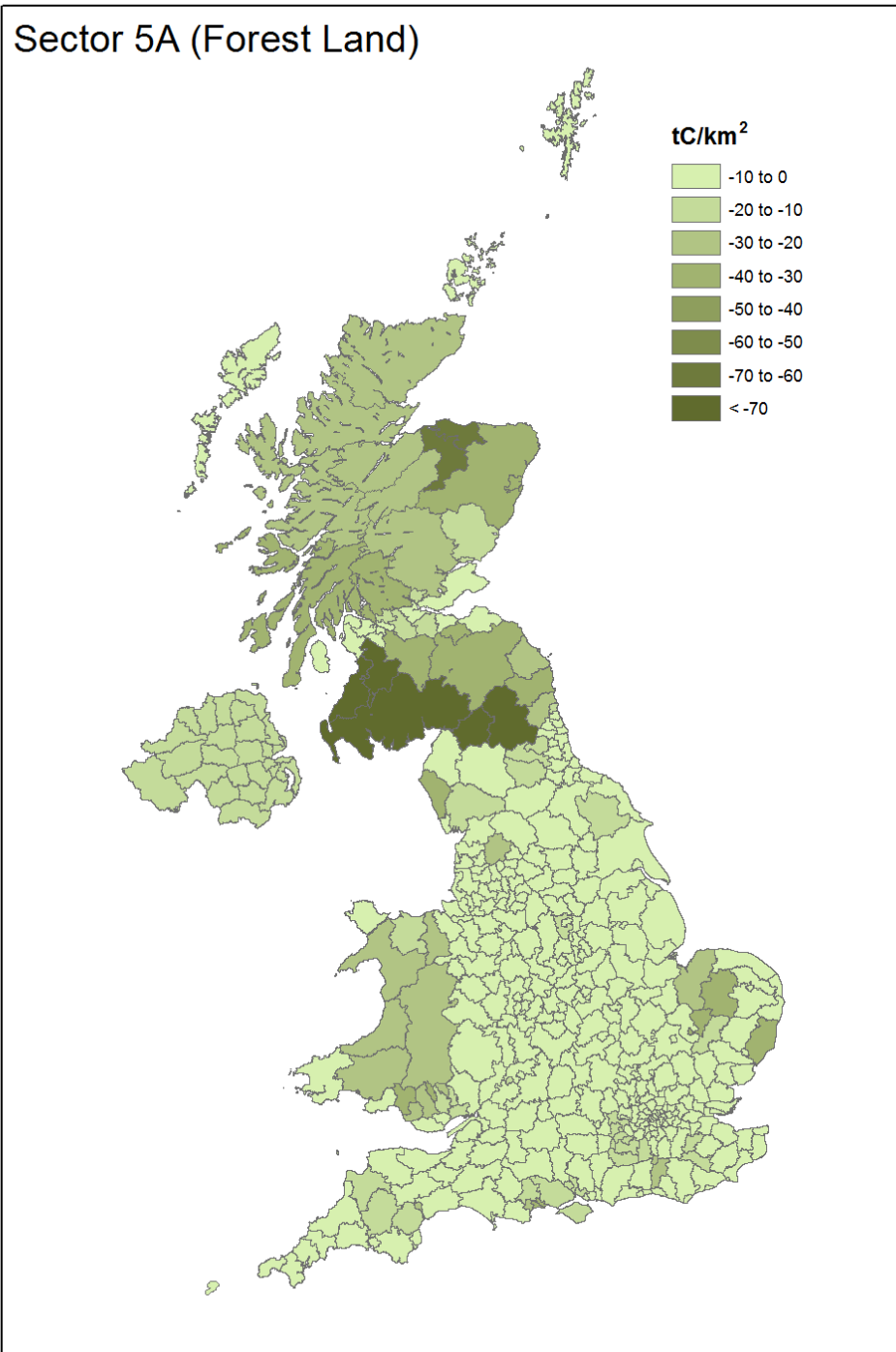


Figure 3: Distribution of carbon removals from the atmosphere due to afforestation across the UK expressed as tC per km².

3 Cropland, Grassland, Settlements – Emissions from Soils due to land use change

Changes from one land use type to another will result in a change in soil carbon stocks over time. The change in vegetation cover and management will affect the amount of carbon that goes into the soil from biomass decomposition. Also, the initial disturbance of the soil will release carbon from soils to the atmosphere as CO₂.

For the National Inventory, the method for assessing changes in soil carbon stock due to land use change links a matrix of change from land surveys to a dynamic model of carbon stock change. For Great Britain, matrices from the Monitoring Landscape Change data from 1947 & 1980 (MLC 1986) and the Countryside Surveys (CS) of 1984, 1990, 1998 and 2007 are used.

In Northern Ireland, for 1990 to 1998 and 1998 to 2007, a matrix for the whole of Northern Ireland was available from the Northern Ireland Countryside Survey (Cooper, McCann and Rogers 2009). The only data available pre-1990 for Northern Ireland are land use areas from the Agricultural Census and the Forest Service (Cruickshank and Tomlinson 2000). Matrices of land use change were then estimated for 1970-80 and 1980-90 using area data. The basis of the method devised assumed that the relationship between the matrix of land use transitions for 1990-1998 and the area data for 1990 is the same as the relationship between the matrix and area data for each of two earlier periods – 1970-79 and 1980-89. The matrices developed by this approach were used to extrapolate areas of land use transition back to 1950 to match the start year in the rest of the UK.

Time series of land use change in 20 x 20 km grid-cells (to match those used for the afforestation fluxes) have been developed using the Countryside Surveys covering periods 1984 to 1990, 1990 to 1998 and 1998 to 2007. The land use change matrices for the 20 x 20 km grid-cells are scaled to match those used in estimates of emissions and removals for the devolved administration areas in the United Kingdom. These matrices are then used for each grid-cell in a model analogous to that presently used for the full devolved area. The data are then combined to give estimates per Local Authority region (see Figure 4).

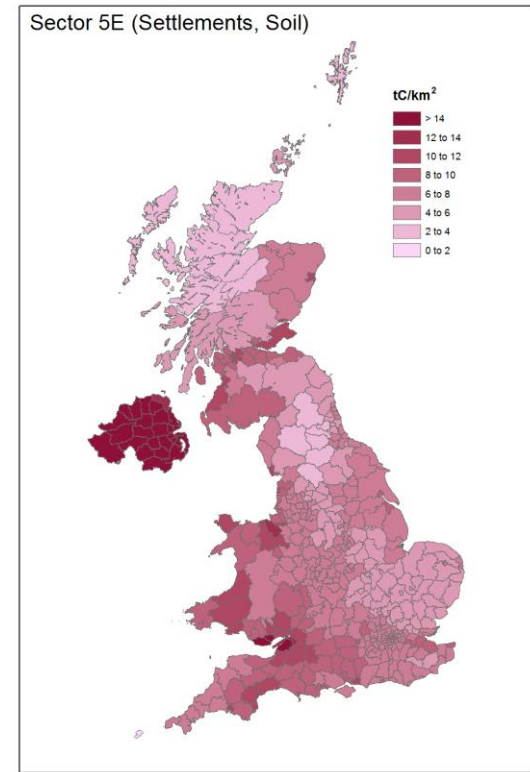
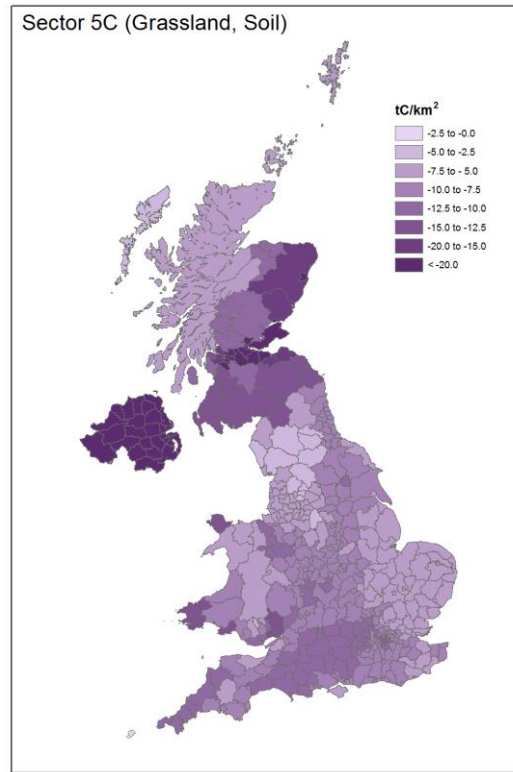
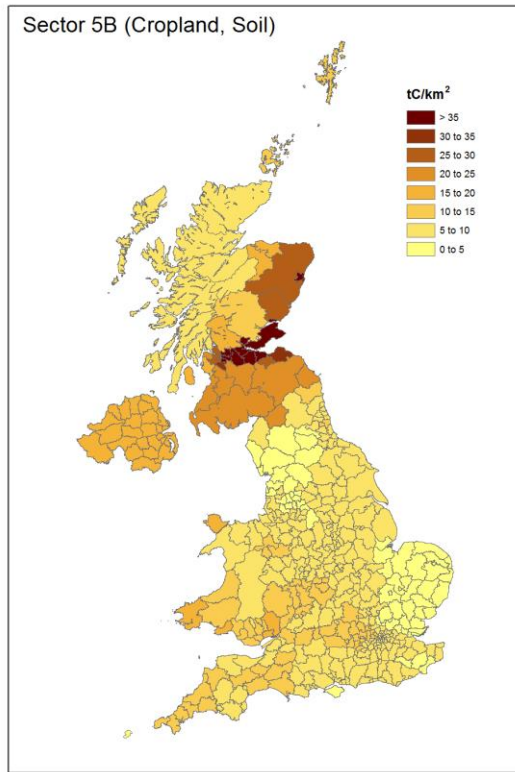


Figure 4: Emissions from soil due to land use change (tC/km²) for conversion of all land type to (a) Cropland (b) Grassland and (c) Settlements.

4 Estimates of various minor emissions

4.1 Liming of Cropland and Grassland

The National Inventory estimate of carbon flux due to liming of agricultural land (Grassland and Cropland) uses land use data from the Agricultural Census for the four devolved administrations, England, Scotland, Wales and Northern Ireland. Similar land use data is also available from the Census at a smaller scale, at local authority or regional groupings, so the flux can be estimated for each LA using the same method as used nationally (see Figure). For the local authority scale data we have assumed the same distribution as given for 2004. Due to non-disclosure and confidentiality issues the sum of the LA land use data from the Census does not exactly equal the published national totals; the estimated carbon flux data from the LA calculations do not exactly equal that submitted in the National inventory. We have assumed that the difference in published areas applies to all LAs in proportion to their area and have adjusted the flux estimates so that the sum is equal to the submitted inventory value (5B liming and 5C liming).

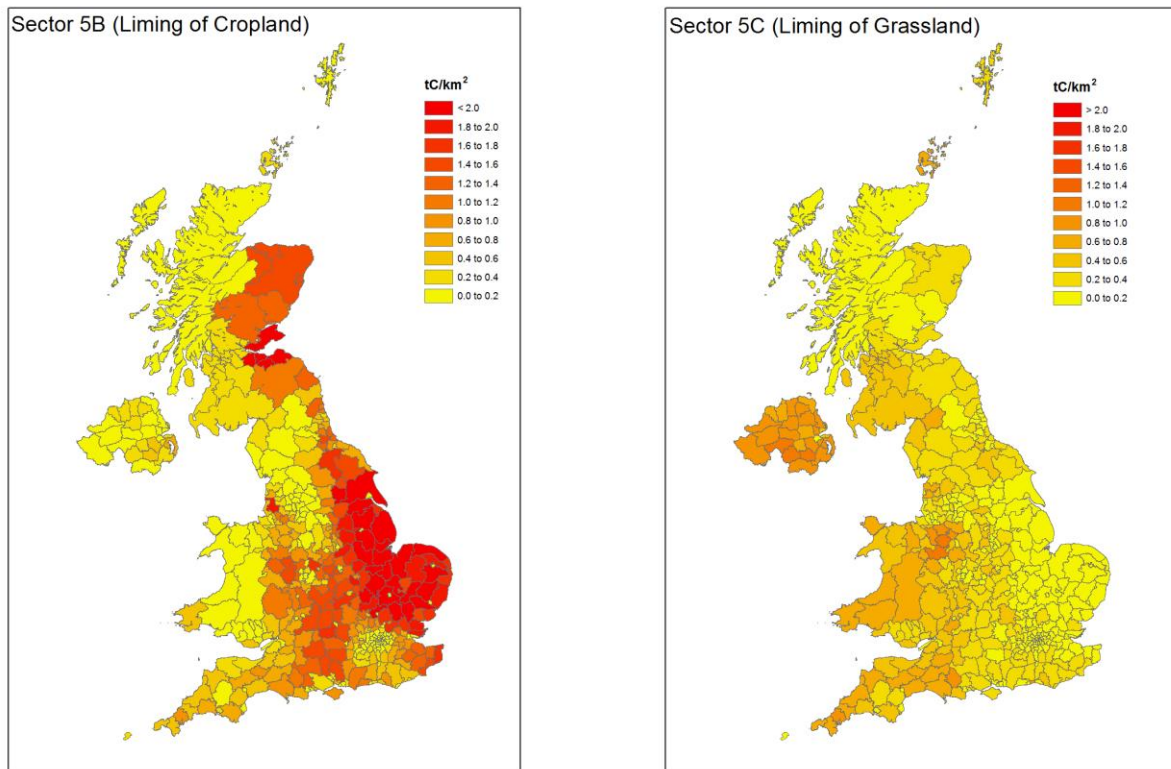


Figure 5: Carbon emissions due to liming of agricultural land, (a) Cropland and (b) Grassland

4.2 Other Biomass Changes

4.2.1 Non-forest Biomass

The different land use types have different biomass carbon densities at equilibrium. Change from one land use type to another can result in an increase or decrease in biomass carbon density. This category describes the annual change in the carbon stock in vegetation biomass due to all land use change to Grassland, Cropland or Settlements, excluding forests and woodland.

For the National Inventory, estimates of emissions and removals for this category are made using the Countryside Survey Land Use Change matrix approach, with biomass densities weighted by expert judgment. Changes in carbon stocks in biomass due to land use change are based on the same area matrices used for estimating changes in carbon stocks in soils. The biomass carbon density for each land type is assigned by expert judgement based on the work of Milne and Brown (1997). Five basic land uses were assigned initial biomass carbon densities, then the relative occurrence of these land uses in the four countries of the UK were used to calculate mean biomass carbon densities for each of the IPCC types, Cropland, Grassland and Settlements. The mean biomass carbon densities for each land type were then weighted by the relative proportions of change occurring between land types in the same way as the calculations for changes in soil carbon densities. Changes between these equilibrium biomass carbon densities were assumed to happen in a single year.

This matrix approach was extended and applied to each 20km x 20km grid square across the UK, and the results combined to give estimates for each Local Authority (see Figure 4).

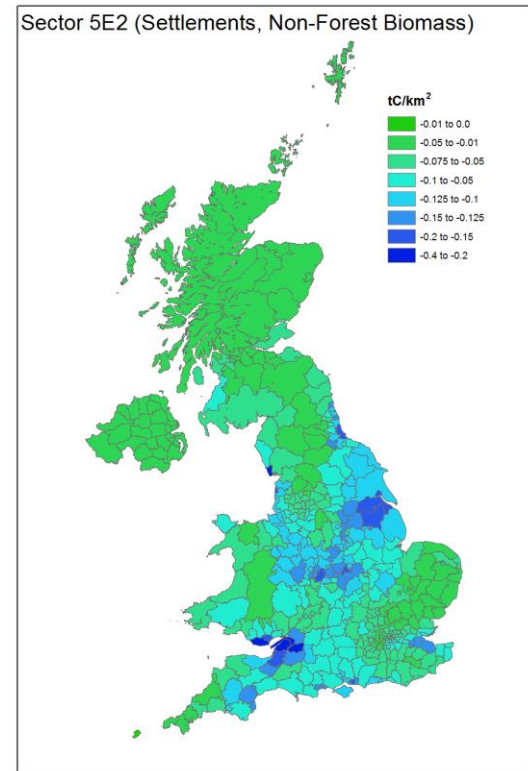
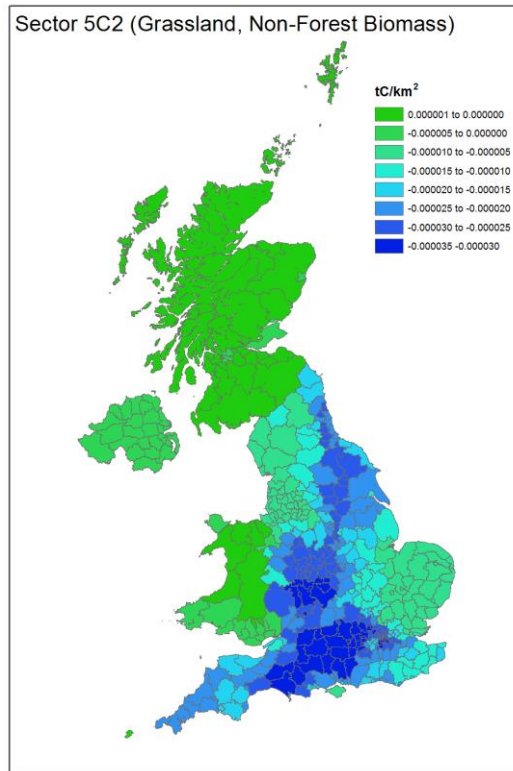
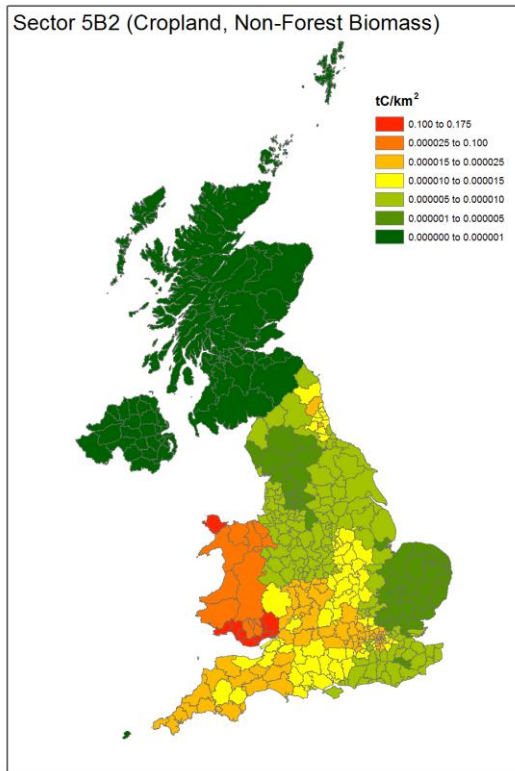


Figure 4: Carbon emissions and removals across the UK due to changes in living biomass following land use change to Cropland (5B2), Grassland (5C2) or Settlements (5E2).

4.2.2 Crop Yield Improvement

There is an annual increase in the biomass of cropland vegetation in the UK that is due to yield improvements (from improved species strains or management, rather than fertilization or nitrogen deposition). The increases in crop yield are calculated separately from those resulting from land use change. The method used for the national figures has been repeated separately for each Local Authority as the required cropland area data are available (see Figure 5).

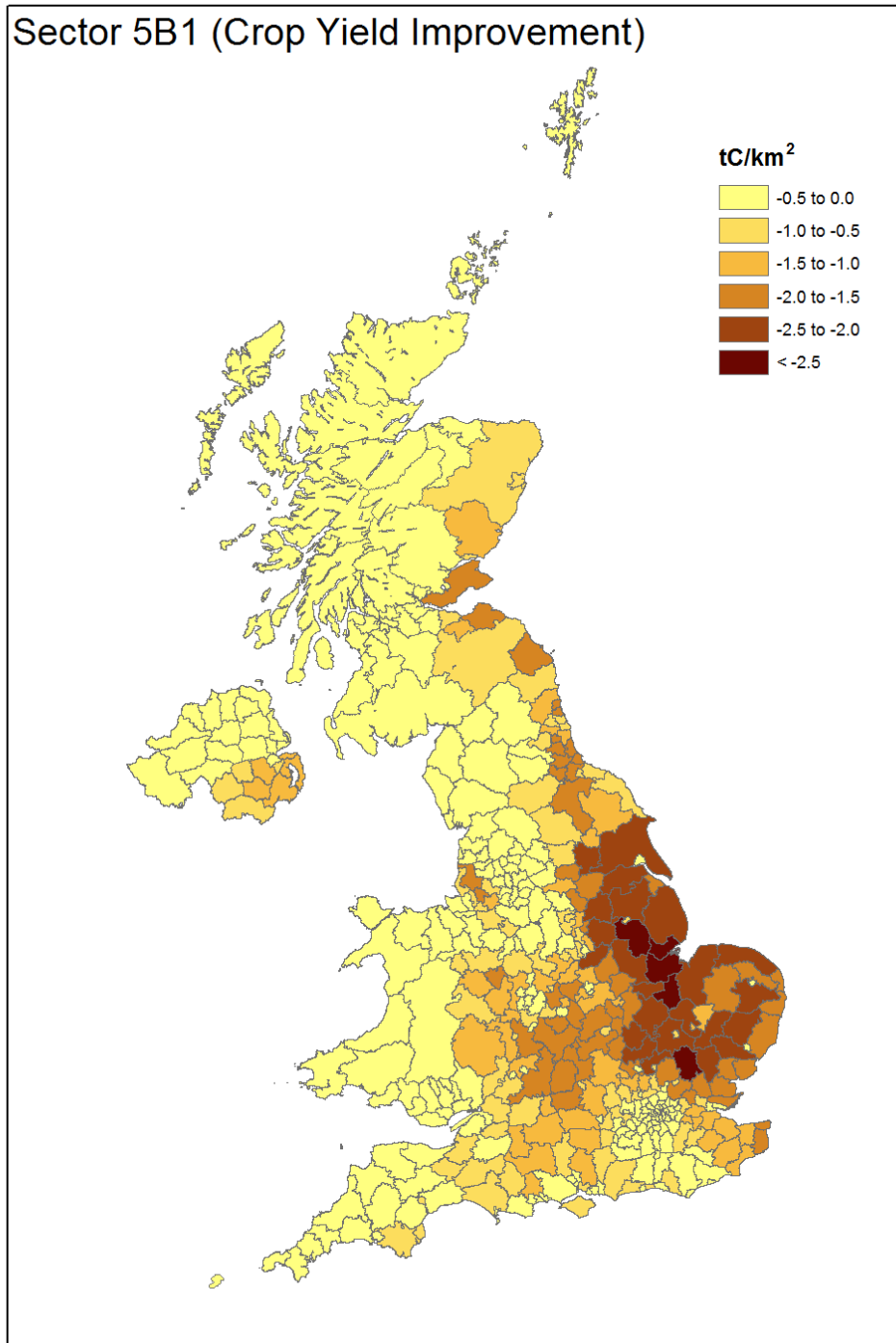


Figure 5: Carbon removals due to increases in Crop yield. This is part of the Cropland remaining Cropland category.

4.3 Peat Extraction

Carbon emission from peat extraction is calculated for the National Inventory based on data published in the *Mineral Extraction in Great Britain Business Monitor PA1007*. Historically, the data were available for smaller regions, e.g. North East England, but not at the LA level. It was then assumed that the data applied to all the LAs within the region in proportion to their area. For 2009 to 2011, peat extraction data were available at Local Authority scale. The peat extraction data for 2012 were not published in time for inclusion in this submission, so the volumes for 2012 were carried forward from 2011. The peat extraction data gives the area of origin of the peat and we have assumed that the carbon emission applies to this area (see Figure 6).

Due to rounding errors in the published figures, the sum of the extraction areas for the regions does not exactly equal the national totals. The emissions per LA have been adjusted in proportion to their area so that the total equals the submitted national emission. Emissions from peat extraction are reported in category 5D (Wetlands).

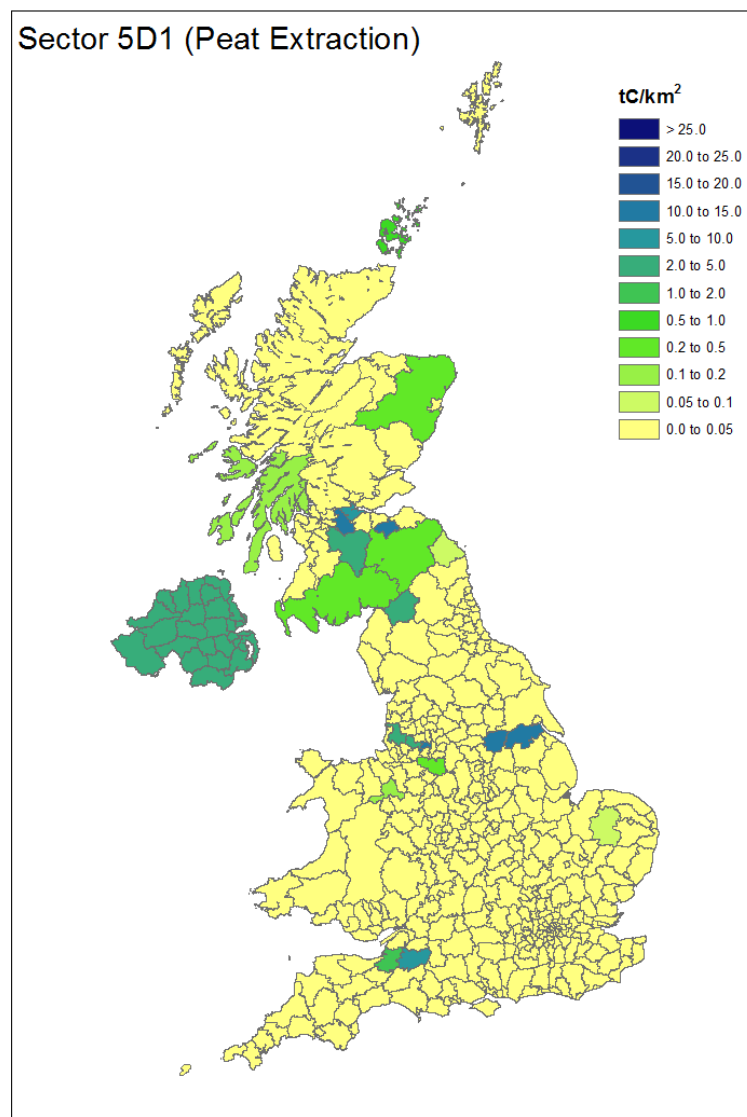


Figure 6: Carbon emissions, tC/km², resulting from the extraction of peat for horticultural use. This is part of the Wetlands category.

4.4 Lowland Drainage

Lowland wetlands in England were drained many years ago for agricultural purposes and continue to lose carbon from the soil as CO₂. Bradley (1997) has estimated that there is 1500 km² of lowland fen or peatland that has been drained in the past and is still emitting carbon dioxide. He states that the drained area is mostly in the East Anglian Fen and Skirtland with limited areas in the rest of England.

To estimate emissions at Local Authority scale, existing areas of lowland peat were compared with the areas of GB below sea level (this is assumed to have resulted from past drainage). This area was split by local authority and the individual areas calculated. Areas of lowland drainage (excluding the area below sea level) were assigned in proportion to the area of peatland still existing within local authority areas. Based on comments by Bradley and in Burton and Hodgson (1987) areas of peatland in the Norfolk broads, the south of England and on ground above 50m were excluded from the analysis. The remaining areas of lowland peat occurred in the northwest and east of England, and in the Somerset levels area. Of the 1500km², 860km² is estimated to occur in the 6 fenland LAs, or 979km² in the wider "fenland and skirtland" area. Figure 7 shows the estimated distribution and emissions (tC/km²).

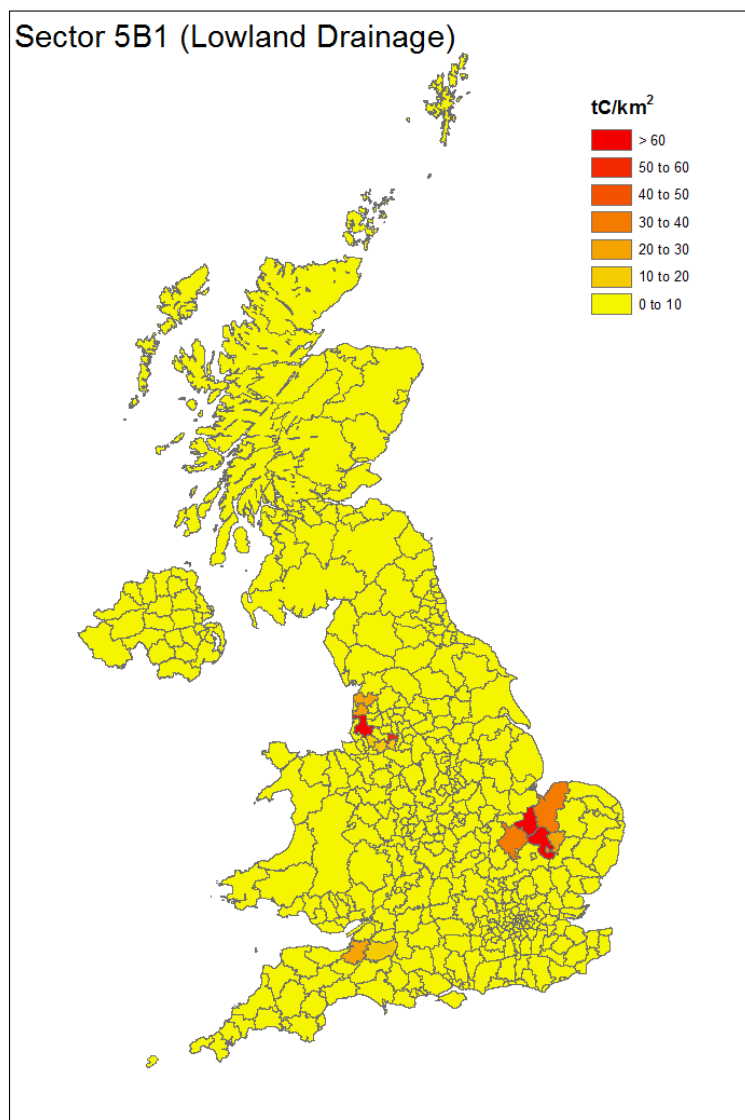


Figure 7: Carbon emissions due to lowland drainage in previous years.

4.5 Deforestation

Emissions due to deforestation are disaggregated into deforestation to Cropland (reported in 5B and only occurs in England), Grassland (5C) and deforestation to Settlements (5E).

The area of land deforested in each Local Authority is not currently available so we assume that the area deforested is proportional to the total area of forest in each LA, and that the relative conversion of forest to either Settlement or Grassland is the same for each LA (see Figure 8).

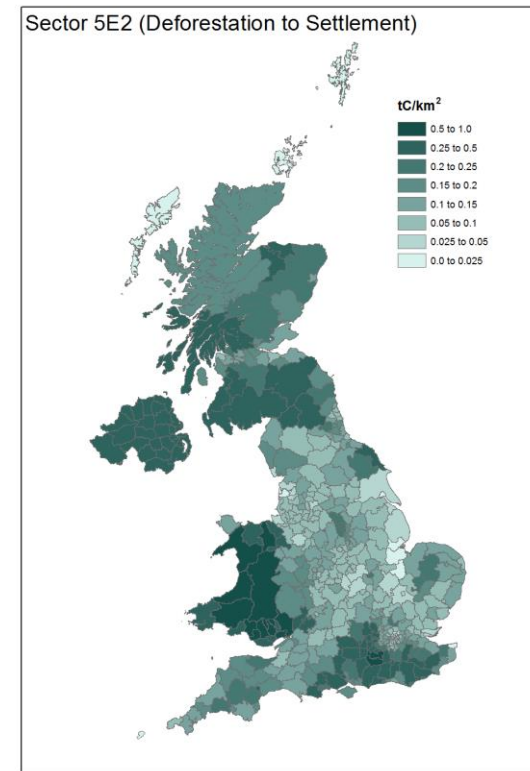
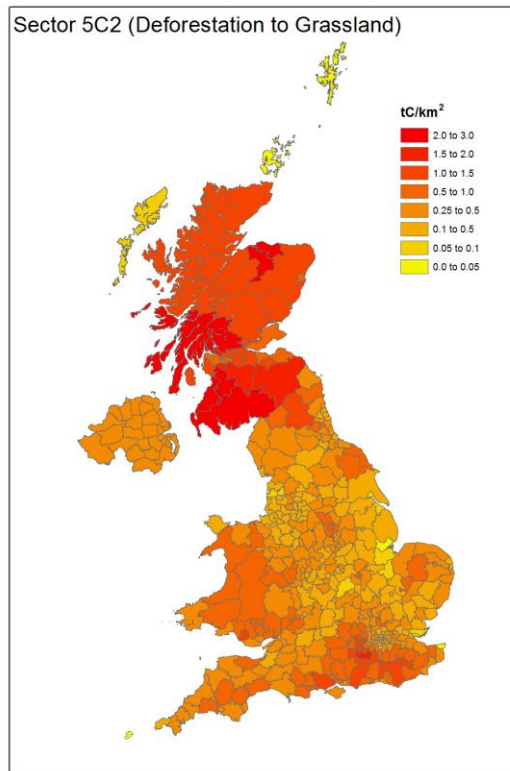
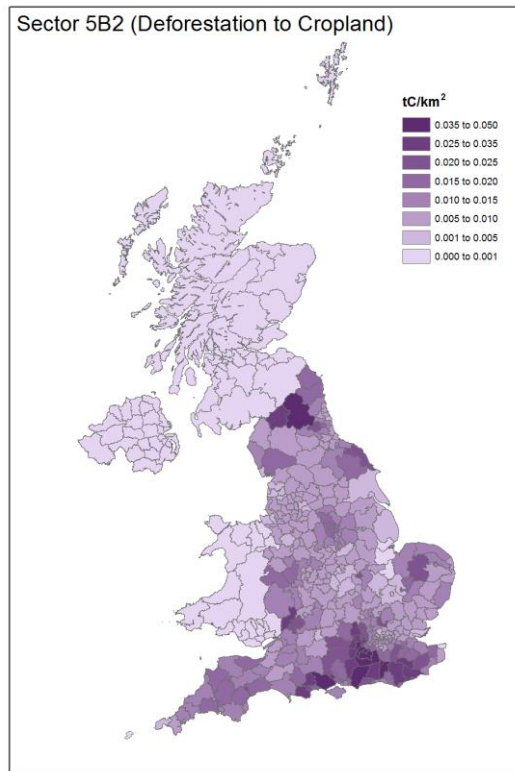


Figure 8: Emissions of carbon resulting from deforestation to Grassland or Settlements.

4.6 Wildfires

Information on areas of wildfires on forest land in Great Britain and in Northern Ireland is available. As areas of wildfires by Local Authority are not collected, the emissions are assigned between LAs in proportion to the total area of forest land in each LA. The results of this assignment can be seen in Figure 11.

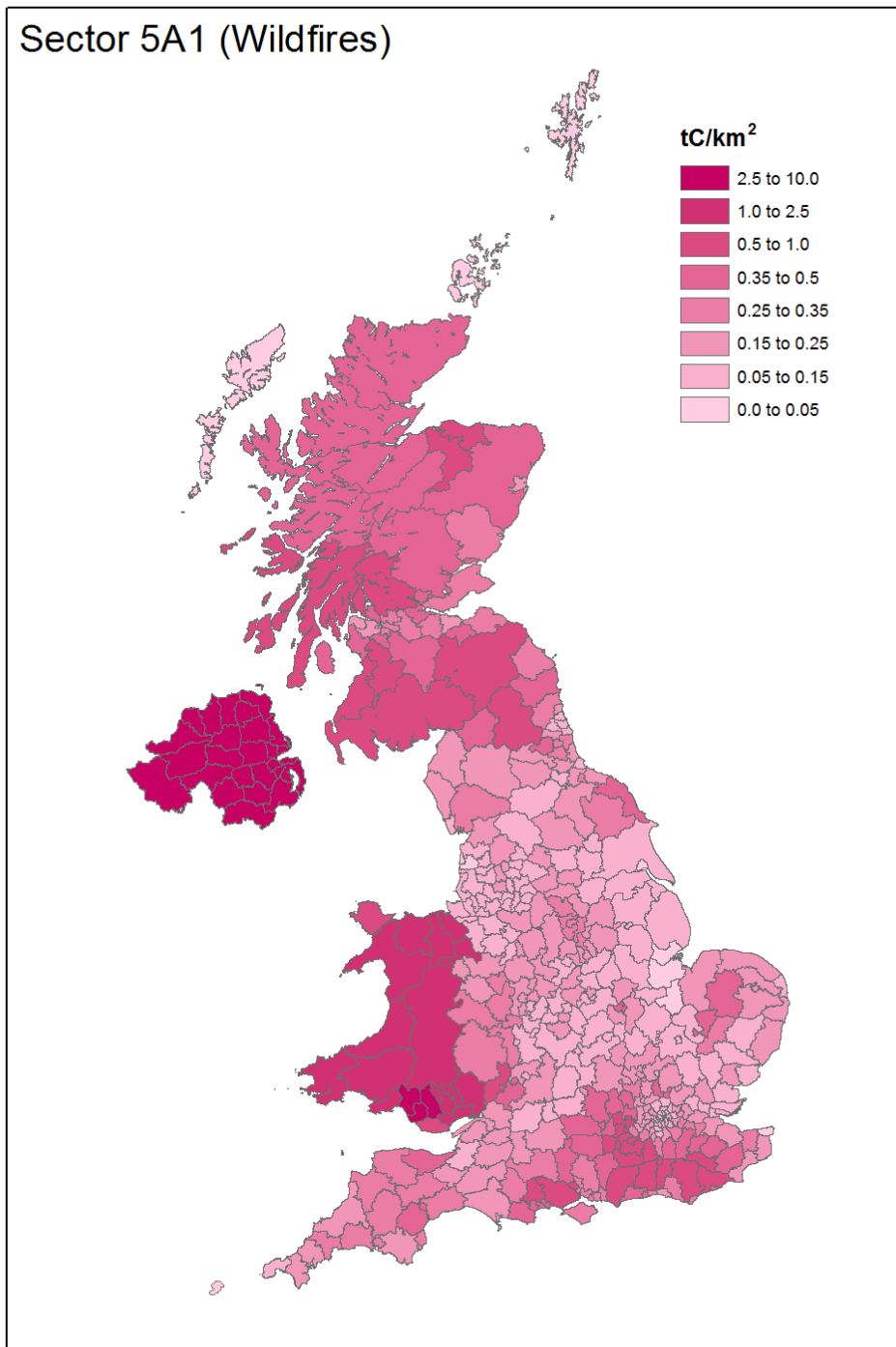


Figure 9: Emissions of carbon resulting from wildfires on Forest Land.

5 LULUCF Totals

The total carbon emissions for the UK land use, land use change and forestry sector (excluding harvested wood products which cannot be mapped) are shown in Figure 12.

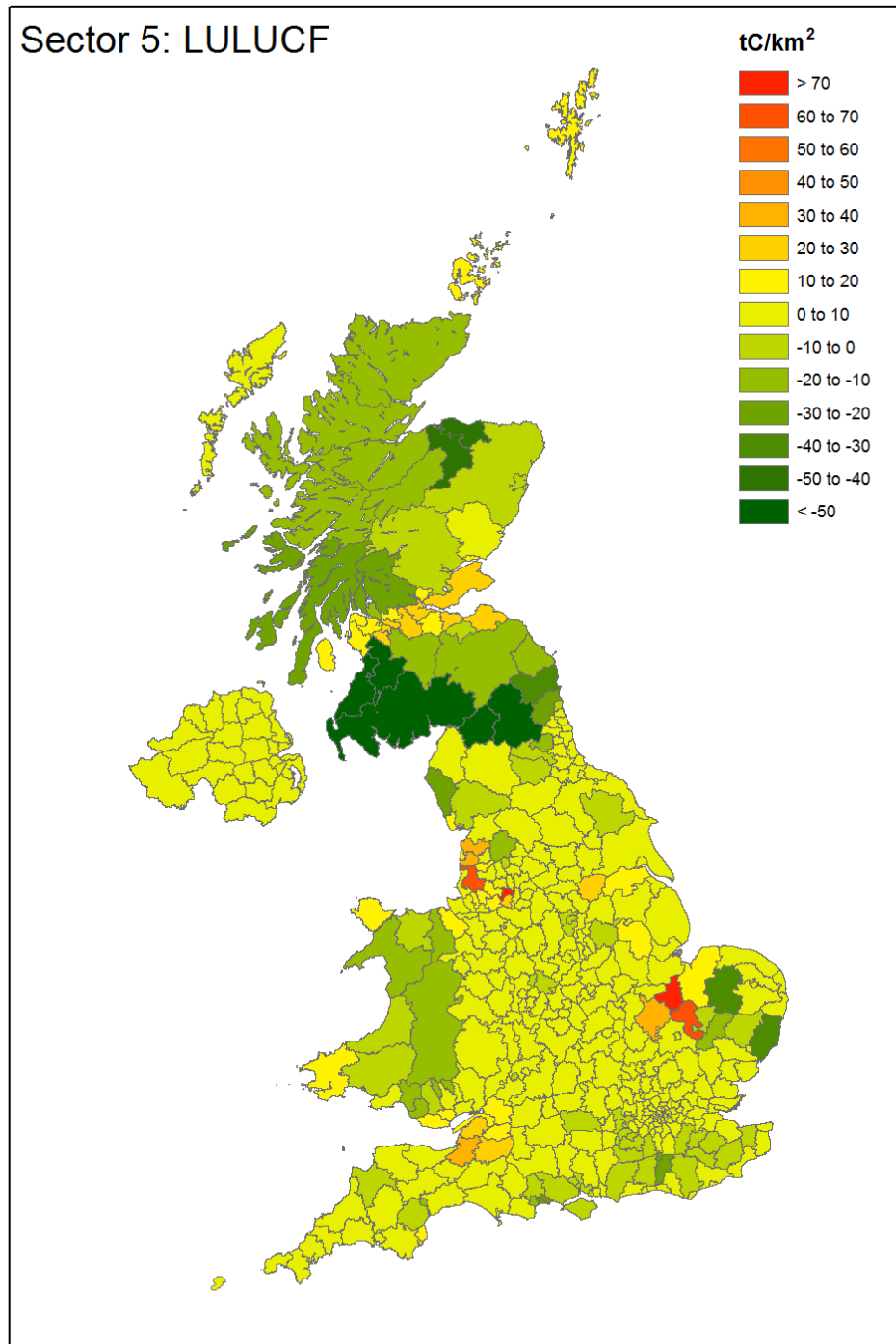


Figure 10: The total carbon emissions or removals for Sector 5 across the UK.

6 Recalculations

The National Inventory is often updated to include improved, or new, datasets and modelling techniques. In the 2012 inventory there was a major change in the LULUCF sector with regards to forestry. A transition was made to use the CARBINE model for forest carbon estimates which, compared to the previously used CFlow model, includes a wider range of tree species and rotation lengths. In addition to the model change, all UK forests were modelled for the first time instead of just post-1920 forests. This was achieved by using an estimated planting series for pre-1920 forests. More information can be found in the National Inventory Report (Webb et al, 2014) and in a separate model and data comparison report (CEH, 2014).

This change in forest modelling and input data resulted in a recalculation of the forest carbon sequestration for all LAs.

In addition to changes resulting from use of CARBINE there were some other updates to the LULUCF inventory for 2012. The main changes affecting non-Forest land are:

- a) Estimates of the areas of deforestation to grassland increased from 2000 onwards as a result of expert opinion (for England, Scotland, Wales).
- b) New estimates of tree biomass densities used to estimate carbon changes arising from deforestation (arising from the change to using the CARBINE model for forest modelling).
- c) New estimates of tree biomass densities used to estimate emissions from forest wildfires (arising from the change to using the CARBINE model for forest modelling).
- d) Addition of LimeX data (by-product from sugar manufacturing) to the lime activity data for the UK affecting both the cropland and grassland categories.

The changes between the 2011 and 2012 inventory for each year and LA have been calculated. As forestry has changed for all LA's, only changes which were less than 50% attributable to forestry were assessed. These are shown in Table 2 with the main reason for the change given as one of those listed above.

Table 2: Reasons for the main changes (other than forestry) between the 2011 and 2012 inventories.

Year	Local Authority	DA	Nature of Overall Change	Main Reasons for Change (other than forestry)
2005	Highland	S	Decreased sequestration	a,b
2005	West Dunbartonshire	S	Decreased sequestration	a,b
2006	Eden	E	Decreased emission	a,b
2006	Highland	S	Decreased sequestration	a,b
2006	West Dunbartonshire	S	Decreased sequestration	a,b
2007	East Devon	E	Decreased emission	a,b
2007	Hambleton	E	Increased emission	d,a,b
2008	Bedford	E	Increased emission	d
2008	Clackmannanshire	S	Increased emission	a,b
2008	Derbyshire Dales	E	Increased emission	a,b
2008	East Ayrshire	S	Decreased sequestration	a,b
2008	Edinburgh, City of	S	Increased emission	a,b
2008	Gwynedd	W	Decreased sequestration	a,b
2008	Highland	S	Decreased sequestration	a,b
2009	Clackmannanshire	S	Increased emission	a,b
2009	Highland	S	Decreased sequestration	a,b
2010	Bedford	E	Increased emission	d
2010	Derbyshire Dales	E	Increased emission	a,b,c
2010	East Ayrshire	S	Decreased sequestration	a,b
2010	Hambleton	E	Increased emission	d,a,b

2010	Monmouthshire	W	Decreased emission	c
2010	Orkney Islands	S	Increased emission	d
2010	Scarborough	E	Increased emission	a,b
2010	Stirling	S	Decreased sequestration	a,b
2010	West Oxfordshire	E	Increased emission	d
2011	Boston	E	Increased emission	d
2011	East Ayrshire	S	Decreased sequestration	a,b
2011	Edinburgh, City of	S	Increased emission	a,b
2011	Hambleton	E	Increased emission	d
2011	Stirling	S	Decreased sequestration	a,b

7 Trend Analysis

The trend analysis, examined eight years of Local Authority (LA) scale emissions and removals (2005-2012) for sector 5 (as calculated for the 2012 inventory year). The “maximum minus minimum” Sector 5 annual totals within the eight year period were calculated and the Local Authorities were ranked on these differences to find those with the greatest changes. The top ten, based on gigagrams of carbon per local authority (Gg C per LA) are shown in Figure 11. Tynedale, within the Northumberland Local Authority, has the largest change within the eight year period; with the area becoming less of a sink for carbon between 2005 and 2012 with relatively steady change over the period. The area has been sequestering carbon between 2005 and 2012.

Using the measure, Gg C per LA, the large changes tend to be associated with the largest local authorities. The average area of an LA in the UK is 566 km², see Table 3. The large changes presented in Figure 11, are usually associated with forest land, see Figure 12. Soil carbon fluxes due to conversion take many decades to reach equilibrium and the trends observed are a consequence of a fall off in the sequestration potential of forest land planted many years ago. Large changes therefore are to be expected in local authorities that have been extensively afforested in the past.

Since size of authorities differ widely, emissions and removals in this report have been mapped as tonnes of carbon per square kilometre (tC per km²), otherwise maps tend to be dominated by the Highland region of Scotland and other large LAs. The ten local authorities with the largest changes (in tonnes of carbon per square kilometre) over the eight year period as are shown in Figure 13. These LAs are not the largest in area and forest land (sector 5A) is less frequently the main reason for the large changes, see Figure 14. With this measure (tC per km²) forest land makes the largest contribution to the changes for some LAs, whereas for the others it is Land Use Change, see Figure 15 to Figure 17.

Table 3. The top ten LAs with the greatest changes within the eight year period based on gigagrams of carbon per local authority (Gg C per LA).

Local Authority	DA	Area of LA (km ²)	Largest change between any 2 years in an 8 year period (GgC/LA/year)
Tynedale	England	2246	67.46
Highland	Scotland	26277	40.14
Aberdeenshire	Scotland	6337	31.52
Dumfries and Galloway	Scotland	6455	20.57
Powys	Wales	5160	17.89
Perth and Kinross	Scotland	5389	16.96
Scottish Borders	Scotland	4742	16.11
Carlisle	England	1029	14.45
Argyll and Bute	Scotland	7153	13.40
North Lincolnshire	England	866	12.41

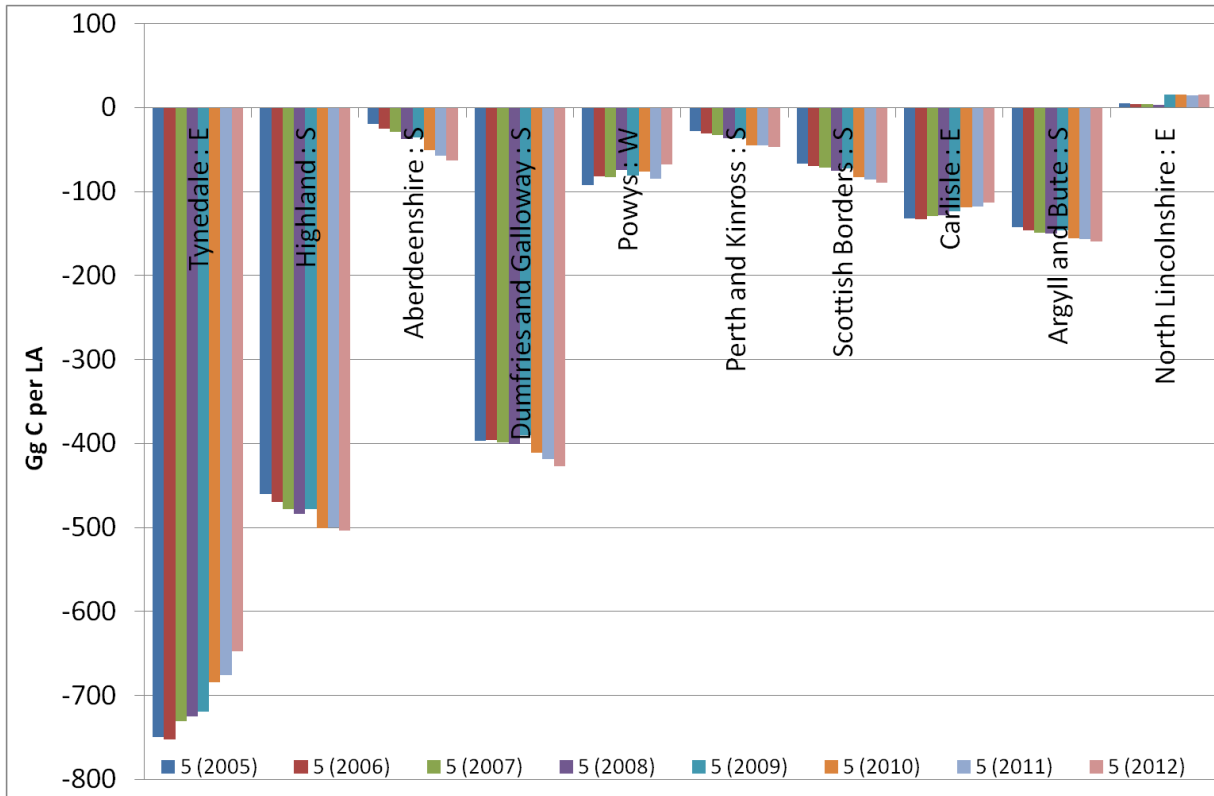


Figure 11: Sector 5 total emissions and removals for the ten local authorities with the largest changes within the period 2005 to 2012 as calculated in the 2012 inventory (Gg C per LA). Of these ten, Tynedale in England has the largest changes, with changes diminishing in magnitude for each LA from left to right until North Lincolnshire in England.

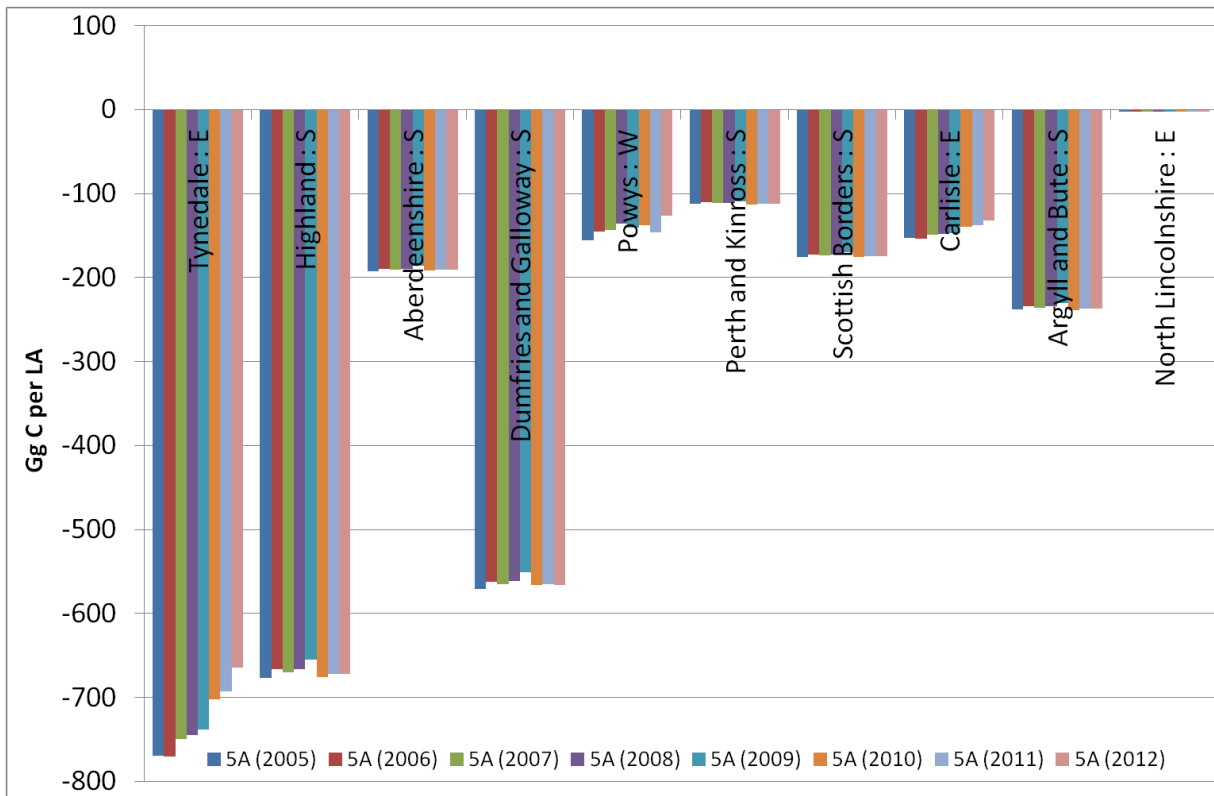


Figure 12: Sector 5A, forest land, emissions and removals in GgC per LA for the ten local authorities with the largest changes in Sector 5 totals, within the period 2005 to 2012.

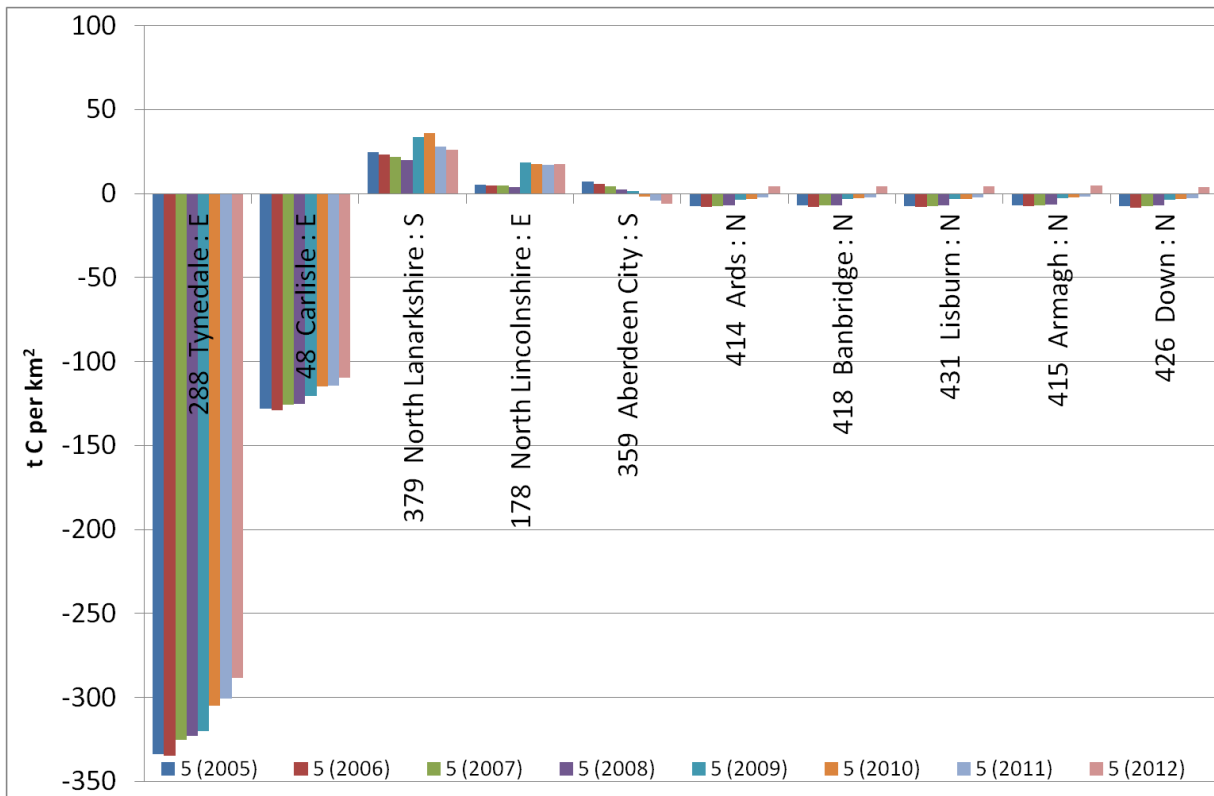


Figure 13. Sector 5 total emissions and removals for the ten local authorities with the largest changes within the period 2005 to 2012 as calculated in the 2012 inventory in tC per km². Of these ten, Tynedale in England has the largest changes, with changes diminishing in magnitude for each LA from left to right until Down in Northern Ireland.

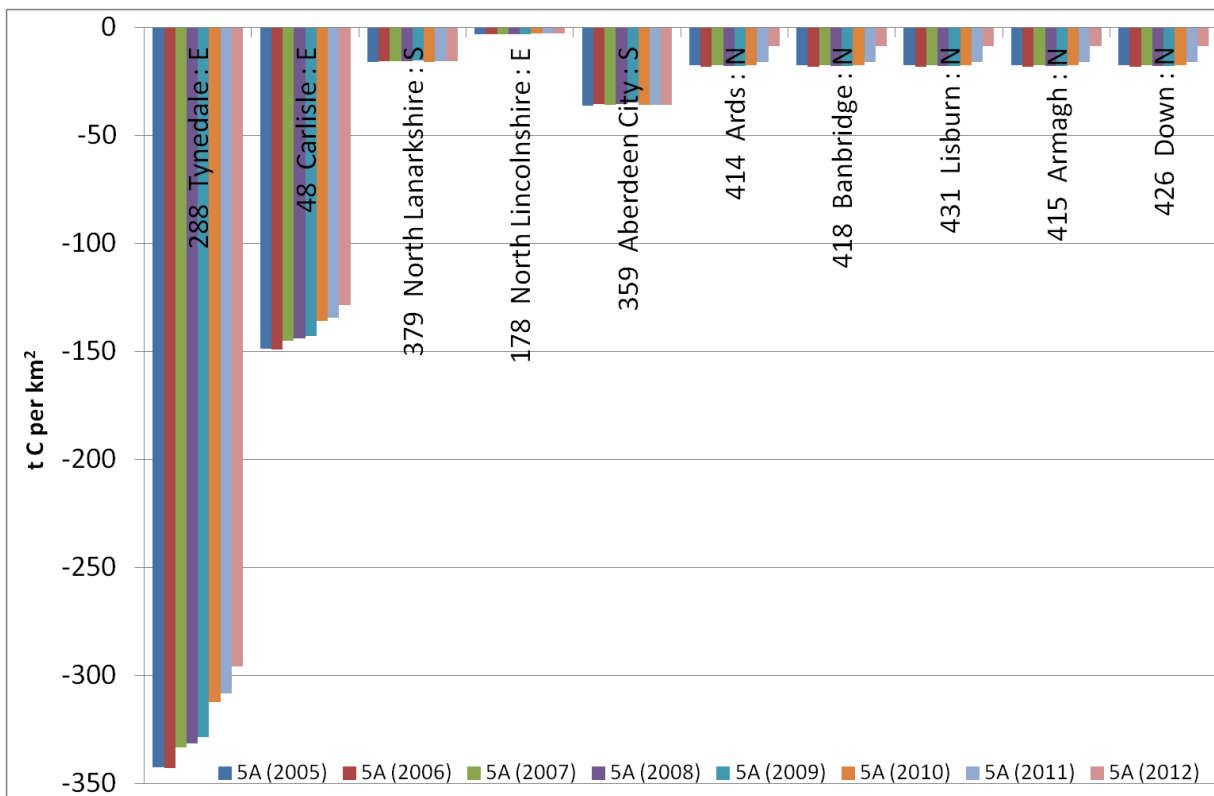


Figure 14. Sector 5A, forest land, emissions and removals in tC per km² for the ten local authorities with the largest changes in Sector 5 totals, within the period 2005 to 2012.

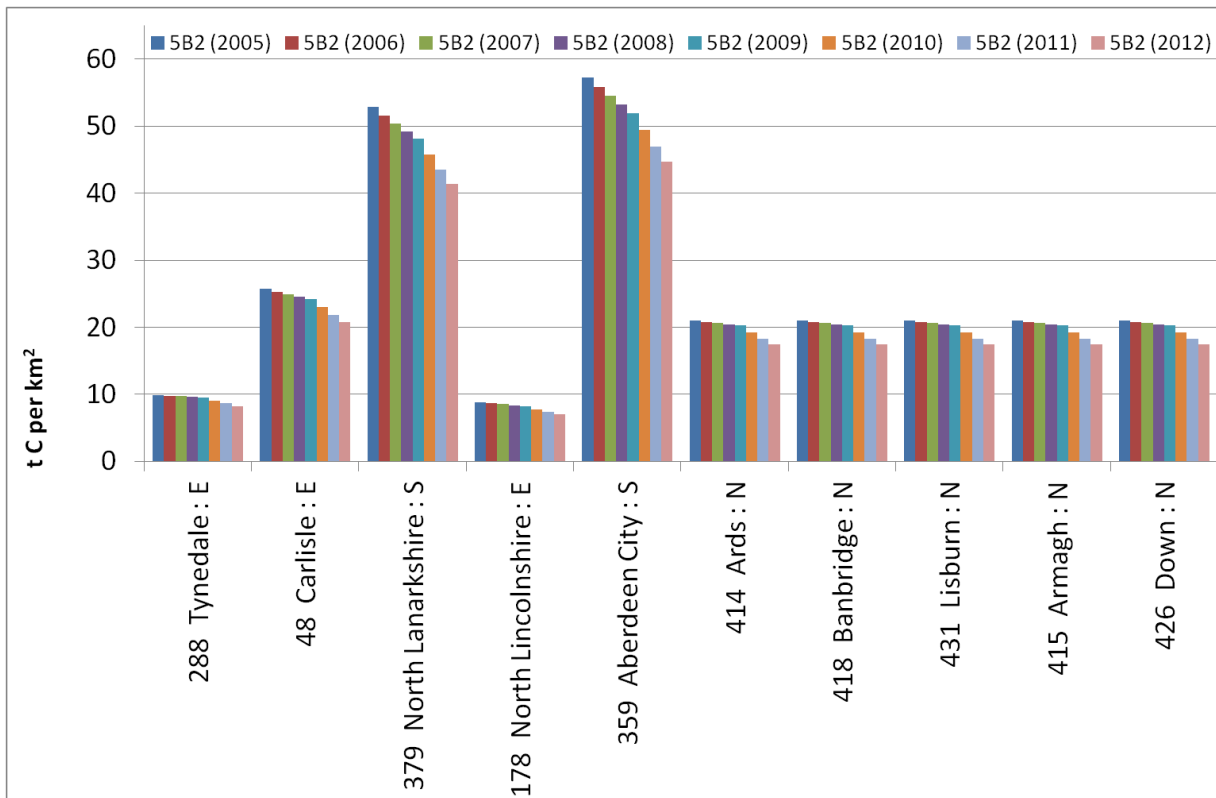


Figure 15. Sector 5B, cropland (soil), emissions and removals in tC per km² for the ten local authorities with the largest changes in Sector 5B totals, within the period 2005 to 2012.

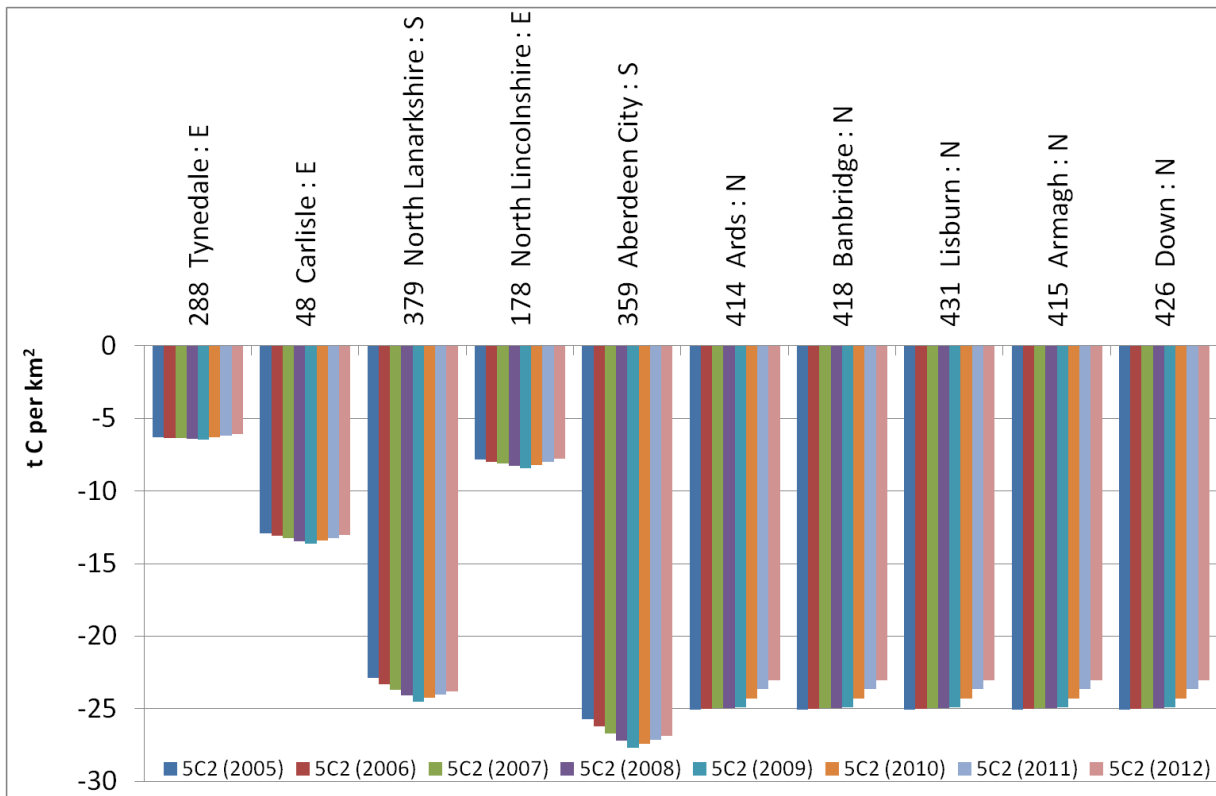


Figure 16. Sector 5C, grassland (soil), emissions and removals in tC per km² for the ten local authorities with the largest changes in Sector 5 totals, within the period 2005 to 2012.

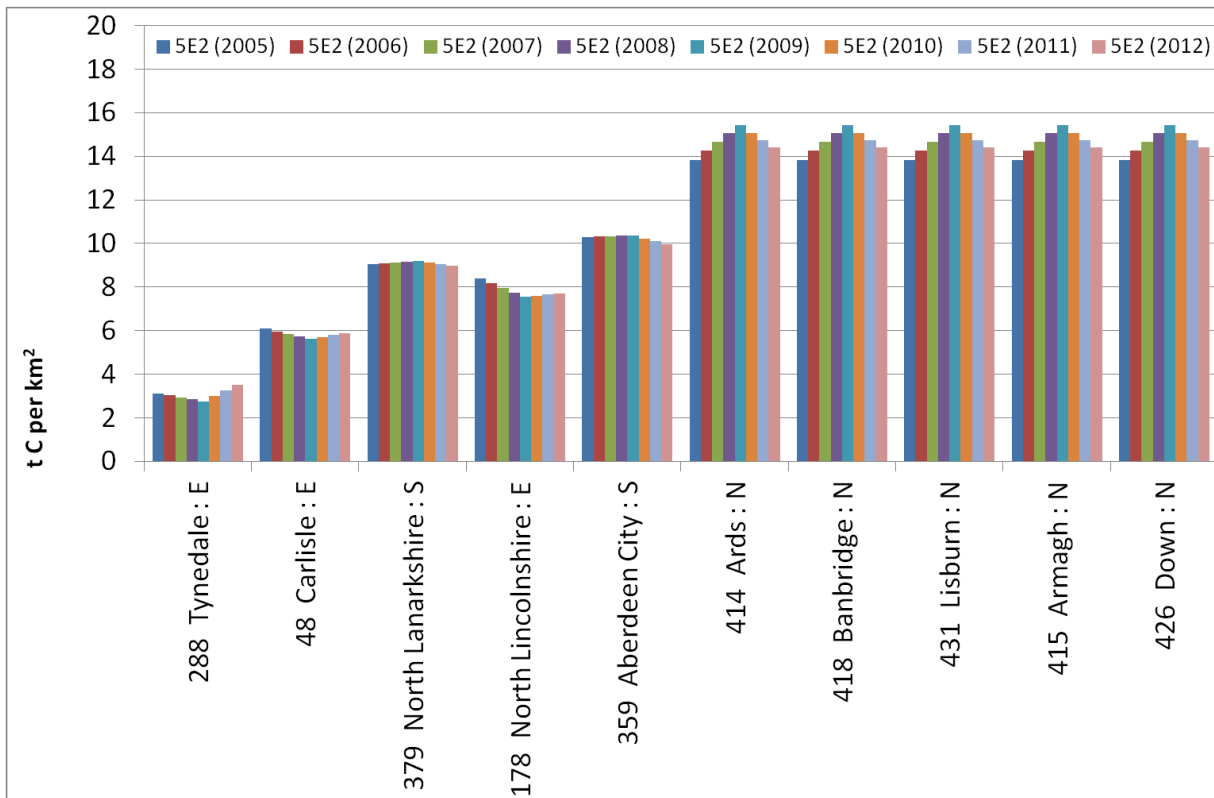


Figure 17. Sector 5E2, settlements (soil), emissions and removals in tC per km² for the ten local authorities with the largest changes in Sector 5 totals, within the period 2005 to 2012.

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