

# UK Natural Capital – Land Cover in the UK

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## Abstract

In this paper ONS develops Land Cover ecosystem accounts for the United Kingdom (UK). The initial land cover accounts based on data from the Countryside Survey show that the land cover changed significantly in the UK between 1998 and 2007. The cultivated land area decreased by over 550 thousand hectares, while the corresponding increase in the area of pasture and semi-natural grassland was about 295 and 155 thousand hectares respectively. The area of broadleaved, mixed and yew woodland increased by approximately 94 thousand hectares. Land Cover in England shows similar patterns of change as in the UK as a whole, while changes were less pronounced in Scotland and Wales. Changes in land cover in Northern Ireland displayed slightly different patterns.

## Acknowledgements

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## Introduction

In December 2012 ONS published a roadmap, "[Accounting for the value of nature in the UK \(786.5 Kb Pdf\)](#)", to include the natural capital within the UK Environmental Accounts. The roadmap set out a timetable to develop land use and land cover accounts. In June 2013 ONS published [experimental land use accounts for the UK \(527.8 Kb Pdf\)](#). However, since both land use and land cover are important in understanding the changes in the ecosystems and ecosystem services, the roadmap planned to develop land cover accounts in addition to land use accounts.

The purpose of this study is twofold. First, ONS's aim is to develop land cover accounts in accordance with the System of Environmental-Economic Accounting-Experimental Ecosystem Accounting<sup>1</sup> (SEEA-EEA) framework. This will be primarily used for international comparison purposes. Second, ONS aims to produce land cover accounts based on the UK National Ecosystem

Assessment (NEA) ecosystems, which would help to provide a cross-cutting picture of the individual Broad Habitat accounts that are currently being developed by the Department for Environment, Food and Rural Affairs (DEFRA) and ONS.

Since there is often confusion between the classification of land use and land cover, this paper starts with a brief discussion of definitions of land use and land cover. It then introduces the SEEA EEA suggested classes and the UK NEA broad habitats. It discusses the relative strengths and weaknesses of potential data sources, presents the estimation method and develops land cover accounts for the UK and at country level. Finally, it discusses future work.

## Notes

1. [SEEA 2012-Experimental Ecosystem Accounting](#)

## Definition of Land Cover

The System of Environmental-Economic Accounting Central Framework (SEEA CF)<sup>1</sup> defines land cover as “the observed physical and biological cover of the Earth’s surface and includes natural vegetation and abiotic (non-living) surfaces”<sup>2</sup>. Although land commonly refers to only terrestrial areas, SEEA CF also applies this term to inland water resources and, in some cases, extends to include coastal waters up to the country’s Exclusive Economic Zone (EEZ).

Eurostat’s Land Use/Cover Area Frame Survey (LUCAS)<sup>3</sup> summarises the difference between land cover and land use: “Land cover is the physical cover of the Earth’s surface and the land use is the socio-economic function of the land”.<sup>4</sup> It is possible to determine the function of the land from its physical properties, and vice versa. SEEA CF notes that “land use and land cover are interrelated. For example, agricultural production is closely aligned to crop area”<sup>5</sup>.

However, there are instances where land cover and land use do not correspond exactly. One land cover category may correspond to several functional categories. For example a land parcel of grass could correspond to a lawn in an urban setting, a rough pasture or a golf course. Conversely, one land use category could correspond to a range of land cover categories, i.e., a residential area can consist of lawns, buildings, tarmac roads, trees and bare soil.

In 2013 ONS published the first experimental physical asset accounts for UK Land Use for 2000-2010<sup>6</sup>. They provide an overview of the changes in land use in the UK over the last decade. Because land use and land cover are interrelated but do not fully overlap it is important to develop physical asset accounts for UK Land Cover as well as for Land Use to understand the changes in ecosystems and ecosystem services.

## Notes

1. [SEEA 2012-Experimental Ecosystem Accounting](#)
2. [SEEA White Cover Central Framework](#)
3. [SEEA White Cover Central Framework](#), p163, 5.257
4. [LUCAS](#) is a survey on the state and the dynamics of changes in land use and cover in the European Union conducted by EUROSTAT
5. [LUCAS](#): 3.4 Statistical concepts and definitions
6. [SEEA White Cover Central Framework](#), p164, 5.267
7. [In 2013 ONS published the first experimental physical asset accounts for UK Land Use for 2000-2010 \(527.8 Kb Pdf\)](#)

## Data Sources

### Land cover

ONS aims to measure the physical extent of different land cover and decided to favour data sources that encompass all broad habitats in a consistent way. In addition, ONS is interested in how the land cover changes over time and, potential data sources must also be available at regular intervals. Three potential data sources have been identified:

1. The Land Cover Map (LCM) 2000 and 2007
2. CORINE Land Cover 2000 and 2006
3. The 1998 and 2007 Countryside Survey

For the reasons set out below, it was decided to rely primarily on data from the 1998 and 2007 Countryside Survey and use CORINE Land Cover 2000 and 2006 to benchmark and analyse the results. Key differences in these datasets are summarised in Table 1.

**Table 1: Summary of the potential data sources**

	<b>LCM</b>	<b>CORINE</b>	<b>Countryside Survey</b>
Coverage	UK	EU	GB + Northern Ireland (NI Countryside Survey)
Recent releases	2000 and 2007	2000, 2006 and 2012	1998 and 2007
Type of data	Remotely sensed imagery	Remotely sensed imagery and visual interpretation	Field survey
Strengths	<p>Small Minimum Mappable unit (LCM2000: 25 x 25m square; LCM2007: parcels based on detailed national cartography);</p> <p>Comprehensive coverage of the UK</p>	<p>Changes are identified by computer-aided visual interpretation of satellite imagery;</p> <p>Comprehensive coverage of the UK;</p> <p>Likely to be updated in 2018</p>	<p>Sample squares mapped in great detail - Small Minimum Mappable unit</p> <p>(400m<sup>2</sup>);</p> <p>Longitudinal dimension allows changes in habitats to be recorded accurately</p>
Weaknesses	<p>Measurement error;</p> <p>Lack of comparability between LCM2000 and LCM2007 (risk of overestimating change);</p> <p>Technological changes mean future updates are unlikely to be consistent</p>	<p>Large Minimum Mappable Unit (25 hectares), (risk of underestimating the extent and changes of some habitats)</p>	<p>Stocks and changes are statistical estimates (imprecise estimates; low statistical power for some habitats);</p> <p>Unlikely to be updated in the future</p>

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## Land Cover Map

The main advantage of the Land Cover Maps (LCMs) is to provide very detailed information on the land cover of the UK based on satellite images. However, using data from LCMs to analyse change in land cover is problematic for several reasons. Firstly, the spatial structure differs across the two LCMs. In LCM2007 the spatial framework consists of land parcels derived from national cartography (such as the Ordnance Survey's MasterMap Topography Layer) by a generalisation process, while in LCM2000 land parcels were derived from image segments (25 x 25m square areas or 'pixels'). However, spatial inconsistency shouldn't be a problem if the measure of changes is at the country level. Secondly, and more importantly, satellite images have an error of around 20%, making it difficult to separate genuine changes in land cover from measurement error. Thirdly, the techniques used to classify areas into broad habitats differ slightly across the two LCMs, since new techniques were introduced in 2007 to improve the accuracy of the classification. In addition, the land classification used by the LCM does not fully match with the SEEA-EEA nomenclature. For instance, Montane is defined by altitude rather than land cover, which implies that it cannot be classified in accordance with the SEEA-EEA nomenclature.

Table A1 in Annex A shows an experimental land cover account derived using data from the LCM2000 and LCM2007. Very large changes are observed but it is not possible to distinguish between genuine changes in land cover and measurement error (e.g. reclassification of some areas from semi-natural grassland to pastures/improved grassland and dwarf shrub heath to open wetlands). Similarly, the observed 20,000 hectares reduction in urban areas cannot reflect an actual change in the land cover, but is a sign that measurement errors are large.

ONS therefore decided not to rely on LCMs, since changes in land cover cannot be credibly estimated based on these data. However, in the future LCMs may be used to derive a land cover account if classification techniques improve so that time differences can be attributed to a genuine change in land cover, rather than measurement error.

## CORINE Land Cover

CORINE Land Cover (CLC) is a map of the European land cover based on interpretation of satellite images. It provides comparable digital maps of land cover for each country for much of Europe. The UK component of CLC is initially based on data from the Land Cover Map, presented above.

A land cover map was produced for the reference year 2000 (CLC2000) and is used as the baseline map. Changes in land cover between 2000 and 2006 are identified by computer-aided visual interpretation of satellite imagery<sup>1</sup> and the CLC2006 is produced by integrating the data of land cover changes between 2000 and 2006 with CLC2000. This approach overcomes the limitation of the LCM2000 and LCM2007, which relied on spectral signature to identify land cover classes and, therefore, cannot be used to estimate changes in the area of habitat classes due to the high level of measurement errors. In addition, CLC classes match the SEEA-EEA based classification well.

CLC2000 uses a minimum mappable unit of 25 hectares, which forces the photo-interpreter to draw polygons that contain areas with different habitat classes and assign the polygons to the class occupying the greatest percentage of their surface. This approach underestimates the area of habitats which tend to be relatively scattered and hence unlikely to be dominant in these polygons. This is why, for instance, the surface area of woodland in CLC is considerably lower than from other sources<sup>2</sup>. The smallest mapped change is five hectares (and at least 100m wide). Therefore, total changes in land classes are likely to be underestimated since any change affecting an area of less than 5 hectares is not recorded.

An experimental account is derived using published data from CLC2000 and CLC2006 and reported in Table A2 in Annex A. Changes appear to be of a smaller magnitude when compared to estimates based on the LCM (or the Countryside Survey), which is not surprising since only changes affecting an area of more than 5 hectares are recorded and changes in non-dominant habitats cannot be identified. Therefore, ONS decided not to primarily rely on CLC data to produce the land cover accounts. However, CLC provides lower-bound estimates of changes in land cover.

### **The Countryside Survey**

ONS used data from the 1998 and 2007 Countryside Survey (CS), a study of the natural resources of the UK's countryside conducted by the Centre for Ecology and Hydrology. This Field Survey has been carried out at regular intervals since 1978, allowing ONS to measure the changes of land cover in the UK. The main advantage of this data source is that land cover is measured consistently over time and great care is taken by field surveyors when assessing whether land cover has changed. The main limitation is that, as it is a survey, relatively small changes cannot be detected.

The sample consists of a set of 1km x 1km squares at the intersection of a grid of 15km x 15km squares covering Great Britain. The sample is stratified on the basis of the Institute of Terrestrial Ecology<sup>3</sup> Land Classification, a classification of Great Britain into sets of environmental strata originally developed by the ITE in the late 1970s and regularly updated to meet the needs of the surveys. In 2007, the Land Classification was adjusted to 45 classes. Any square whose area is more than 90% sea or more than 75% urban is excluded from the sampling base. 591 sample squares were surveyed in 2007, up from 561 in 1983<sup>3</sup>. As far as possible, the same squares are sampled each time the CS is repeated. An extra 60 new squares have been added to the 2007 survey while 30 squares surveyed in 1998 could not be surveyed again.

The habitats in the whole of each sample square were mapped using a minimum mappable area of 400m<sup>2</sup> (20m x 20m through to 80m x 5m). Each mapped parcel was identified to belong to a Broad or Priority<sup>4</sup> Habitat. Some parcels are classified as 'Mosaic' if it is impossible to delimit an area of Broad and Priority Habitat because the habitats are spatially indistinguishable, or within a wider area patches are smaller than the minimum mappable unit. For these parcels, field surveyors are asked to assign a percentage cover of the different habitats the parcel consists of. ONS have used these percentages to estimate the surface area of the habitats. If the percentages for a parcel add up to less than 100%, the remaining area is classified as "No allocation". Sea areas are excluded from the analysis.

The proposed habitat classes are based on the SEEA-EEA nomenclature and adapted to the UK context<sup>5</sup>. ONS removed habitat classes which are not relevant to the UK land cover ('permanent snow and glacier') and split 'forest tree cover' into 'broadleaved, mixed and yew woodland' and 'coniferous woodland' and separate 'pastures' and 'semi-natural grassland'. 'Barren land' and 'sparsely vegetated areas' were combined into a single category, since these types of habitats are not very common in the UK. ONS aims to classify lands that could fall within the 'natural vegetation associations and mosaics' and 'agriculture associations and mosaics' classes according to their actual land cover. The urban and associated developed areas include not only buildings, roads and other built-up areas but also non built-up land such as gardens and parks. The 'Permanent crops, agriculture plantations habitat includes orchards and vineyards, fruit plants but not farm woodlands, which fall into either broadleaved, mixed and yew woodland or coniferous woodland.

The Broad and Priority Habitats were aggregated to match the classification outlined above. Mapping between the habitat classes adapted from the SEEA-EEA and the CS broad habitats is presented in Table 2. Some of the CS broad habitats had to be broken down to match the SEEA-EEA based classification. Additional information on the type of crops was used to distinguish between herbaceous and permanent crops. Similarly, information about the physiography cover was used to reclassify montane habitat to 'barren land/sparsely vegetated areas' or 'shrubland, bushland, heathland'. Any area covered by less than 10% vegetation is classified as 'barren land/sparsely vegetated areas'.

**Table 2: SEEA-EEA-based habitat classes and the Countryside Survey broad habitats**

SEEA-EEA-based habitat classes	Countryside Survey broad habitats
Urban and associated developed areas	Built up areas
Rainfed and irrigated herbaceous cropland	Arable and horticulture if herbaceous crops
Permanent crops, agriculture plantations	Arable and horticulture if permanent crops
Pastures/Improved grassland	Improved grassland
Semi-natural grassland	Neutral grassland Calcareous grassland Acid grassland Bracken
Broadleaved, mixed and yew woodland	Broadleaved, mixed and yew woodland
Coniferous woodland	Coniferous Woodland

SEEA-EEA-based habitat classes	Countryside Survey broad habitats
Shrubland, bushland, heathland	Dwarf shrub heath Montane if not covered by rock by more than 95%
Barren land/Sparsely vegetated areas	Inland rock Montane if covered by rock by more than 95% Any land if vegetation cover is less than 10%
Open wetlands	Fen, marsh, swamp Bog
Inland water bodies	Standing open waters Rivers and streams
Coastal margins	Supra-littoral rock Supra-littoral sediment

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**Table 3: UK NEA-based habitat classes and the Countryside Survey broad habitats**

<b>UK NEA-based habitat classes</b>	<b>Countryside Survey broad habitats</b>
Woodland	Broadleaved, mixed and yew woodland coniferous woodland
Enclosed farmland	Arable & horticulture Improved grassland
Semi-natural grasslands	Rough grassland Neutral grassland Calcareous grassland Acid grassland
Freshwater	Fen, marsh, swamp Bog Standing open waters Rivers and streams
Dwarf shrub heath (Heather and Heather Grassland)	Dwarf shrub heath
Montane habitats and inland rock	Montane habitats Inland rock
Coastal margins	Supra-littoral rock Supra-littoral sediment Saltmarsh
Urban	Built up areas
Marine	

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## Urban Areas

As mentioned above, predominantly urban areas are excluded from the scope of the Countryside Survey (CS). This results in the size of urban areas to be greatly underestimated if data from the CS is solely used. Data from the Ordnance Survey's GIS data product Meridian Developed Land Use Areas were used to estimate the size of urban areas and developed land. This dataset gives a generalised footprint of urban and suburban areas<sup>6</sup> and was used in the Land Use account published by ONS in 2013.

The definition of urban areas and developed land used in the land cover accounts is extensive and includes buildings, roads, and any other facilities, including their supporting spaces, deliberately installed for human activities. It also includes waste tips, derelict land in built-up areas, junk yards, city parks and gardens as well as land used for construction (including abandoned areas), manufacturing activities and land used for technical infrastructure, for example, telecommunications networks, electrical energy, transport and storage, commercial, financial and public services, recreational facilities and residential.

## Northern Ireland Countryside Survey

For Northern Ireland data from the 1998 and 2007 Northern Ireland Countryside Surveys (NICS)<sup>7</sup> were used, a survey of 288 quarter kilometre squares. The sampling procedure (stratified random sampling), the field protocol and the broad habitats classification are very similar to those of the CS. The main difference with the CS is that the two largest inland water bodies (Lough Erne and Lough Neagh) are excluded from the sampling base and their area has to be included as a constant when calculating the area of broad habitats.

## Marine Habitat

Data from the UK Hydrographic Office<sup>8</sup> were used to measure the area of the UK territorial waters and Exclusive Economic Zone (EEZ). Territorial waters are defined by the 1982 United Nations Convention on the Law of the Sea, as the belt of coastal waters extending at most 12 nautical miles from the baseline (defined as the mean low-water mark). The EEZ extends up to 200 nautical miles from the baseline. The estimates were calculated in November 2014.

## Notes

1. Experts interpret land cover changes by comparing satellite images from 2000 and 2006.
2. The surface area of woodlands in the UK is 20,331km<sup>2</sup> according to CLC2006, 28,789 km<sup>2</sup> and 28,680 km<sup>2</sup> according to LCM2007 and 2007 Countryside Survey respectively. The Forestry

Commission, using a slightly different definition, estimates the area of woodlands to be around 30,509 km<sup>2</sup> in 2012.

3. See Table D1 in Annex D for further detail.
4. Priority Habitats are habitats that have been identified as a priority for conservation in the UK Biodiversity Action Plan.
5. See Annex B for more detail.
6. Including Green spaces. This definition of urban areas is consistent with that of the Countryside Survey, so there is no risk of double counting.
7. [More information on this survey is available.](#)
8. [UK Maritime Limits and Law of the Sea - Detailed guidance - GOV.UK](#)

## Methodology

Land cover accounts are derived for the UK and at country level using data from the 1998 and 2007 Countryside Surveys<sup>1</sup>.

### Stocks and net changes

Since the broad habitat classes in the land cover accounts do not fully match those of in the Countryside Survey (CS) 2007 report the CS micro data files were used to produce estimates of stock and changes and to test their statistical significance. In order to derive estimates of stocks and net changes these steps were used:

1. Estimate the percentage of land covered by each broad habitat within each ITE land class
2. Derive national country estimates based on the area of each land class
3. Adjust estimates using the size of urban areas based on Ordnance Survey (OS) Meridian data

Until 2000 estimates of change were calculated using only squares that were surveyed in two consecutive waves while the extent of each broad habitat for each survey year was estimated using the full sample. As a result, point estimates of change in the area of broad habitats were not identical to the differences in the point estimates of extent of those broad habitats. The discrepancy came from the unbalanced nature of the longitudinal dimension of the dataset, since not all squares were surveyed in both panel waves. Since 2007 estimates of stock and change are derived using modelling techniques<sup>2</sup>. This modelling approach produces consistent estimates of stock and change using all the available information.

For each broad habitat the proportion of the habitat was estimated in each land class in each survey year using a mixed-effects model, a statistical modelling approach accounting for the unbalanced nature of the longitudinal dimension (i.e. for the fact that not all squares are surveyed in both time periods). Mixed effects models comprise two components, one for the fixed effects and one for the random effects. The fixed effect component is a standard regression model and consists of

an interaction of land class and survey year. The random effects component uses the longitudinal dimension of the data to describe the structure of the residuals. Each square is assumed to have a constant random difference from the land class average<sup>3</sup>.

For each habitat the estimated proportion in each land class was multiplied by the corresponding land class surface area and summed to derive an estimate of the total habitat extent in England, Scotland and Wales. Estimates were subsequently re-scaled to account for the fact that predominantly urban areas are not sampled and adjusted so that the total area is consistent with national surface area figures produced by ONS<sup>4</sup>. More specifically, the area to mean high water was used as a measure of the total surface area in 2001 and 2007. Estimates of the size of urban areas were adjusted based on OS geographic information system (GIS) data product used in the ONS Land Use Accounts. As the OS GIS data is for Great Britain only, the estimate of urban areas in Northern Ireland, based on the Northern Ireland Countryside Survey, is added to derive the UK figure. Estimates of the size of urban areas in England, Scotland and Wales, based on the CS, are adjusted using the size of urban areas in Great Britain from the OS GIS data product.

### **Confidence intervals**

Since the analysis relies on survey data, a test was needed as to whether the estimates of change in the habitat extent were significant (i.e. estimates differed significantly from zero). Standard statistical tests cannot be relied upon because the normality assumption, which stipulates that if the model was run over different samples the resulting statistical estimates would be normally distributed, is likely to be violated<sup>5</sup>. Therefore 95% confidence intervals were estimated using a bootstrapping procedure, a technique to infer about a population from sample data by resampling with replacement the original data. Separate estimates of the extent of each broad habitat were derived for each resample and the resulting distribution of estimates were used to test the significance of changes in the habitat extent between 1998 and 2007<sup>6</sup>.

### **Additions and reductions to stock**

Additions and reductions to stock were estimated using a sample restricted to squares surveyed in both 1998 and 2007, and subsequently rescaled using net changes estimated by modelling. On the basis of squares surveyed in both 1998 and 2007, additions and reductions to stock were calculated as a percentage of net change (calculated on the restricted sample) which was then multiplied to the estimates of net change derived using the modelling approach outlined above<sup>7</sup>.

## Notes

1. Note that separate accounts are not reported for Wales, as the sample size is too small to estimate changes between 1998 and 2007.
2. Scott, W. A (2008) 'Statistical Report', *CS Technical Report No.4/07*, Centre for Ecology and Hydrology.
3. See Annex D for more detail.
4. [UK Standard Area Measurements \(SAM\)](#)
5. Results from the bootstrap procedure suggest that indeed the normality assumption does not hold.
6. We use 1,000 replications.
7. See Annex D for more detail.

## Land Cover Accounts

### SEEA-EEA classification

This section presents the land cover accounts based on the SEEA-EEA classification for the UK as well as at the country level. These are statistical estimates and are associated with fairly large confidence intervals and therefore should be interpreted with appropriate caution<sup>1</sup>.

### UK

The land cover account presented in Table 4 provides information about the surface area of the broad habitats and how it changed between 1998 and 2007. Close to 40% of the land in the UK consists of pastures and semi natural grassland (22% and 17% respectively). Herbaceous and permanent crops cover 17.5% of the UK while 11.8% of the area of the UK is covered by woodlands. Urban and related developed areas make up 11.6% of the area of the UK, open wetlands 11.5%, and shrubland (dwarf shrub heath) 5.4%. The area of the territorial waters of the UK is 11,717,000 hectares, and the area of the Exclusive Economic Zone<sup>2</sup> amounts to 56,624,000 hectares.

The initial land cover account shows that the land cover changed significantly in the UK between 1998 and 2007. Table 4 suggests that the most notable changes were:

- The cultivated land area (herbaceous and permanent crops) decreased by over 560,000 hectares. The area used for cultivating herbaceous crops decreased by 503,000 hectares (10.5%)
- The area of pastures and semi-natural grassland increased by about 295,000 hectares (5.8%) and 155,000 hectares (3.9%) respectively

- The area of land covered by broadleaved, mixed and yew woodland increased by 94,000 hectares (6.9%)
- The area of inland water bodies increased by 7,000 hectares (2.4%)

Great care is needed when interpreting estimates of net changes that are not statistically different from zero. Although the change is not statistically significant, there is some indication that the surface covered by urban areas and developed land increased between 1998 and 2007, as data from CORINE Land Cover (CLC) suggests that the area of artificial surfaces increased by over 20,000 hectares between 2000 and 2006 (see Table A2 in Annex A). Similarly, while the estimate of net change in the area of shrubland and heathland (19,000 hectares) is not statistically significant, there are reasons to believe that areas covered by heath and heath grassland expanded between 1998 and 2007, as data from CLC indicate an increase in this area of habitat of a similar magnitude (28,500 hectares) between 2000 and 2006. Therefore, in spite of the changes not being statistically significant, it can be said urban areas and developed land, and shrubland and heathland, expanded between 1998 and 2007. However, the magnitude of these changes is not accurately estimated.

Estimates of additions and reductions to stock reported in Table 4 indicate that most habitats experienced large additions and reductions to stock, even if the net change was not significantly different from zero. Furthermore, where the net change was positive (or negative) relatively large reductions (additions) to stock were observed. This suggests that at local levels the land cover evolves more dynamically than reflected by the aggregated net changes. To some extent this may also reflect cyclical variations in land cover within the agriculture and forestry sector, as the squares may not have been surveyed at the same time of the year. When interpreting the estimates additions and reductions to stock one should bear in mind that if net change is not significant then it implies that additions and reductions are not statistically different from one another.

**Table 4: SEEA-EEA Land Cover Account, UK**

	Opening stock 1998	Additions to stock	Reductions to stock	Net change	Closing stock 2007
Urban and associated developed areas	2,753	175	-104	71	2,825
Rainfed herbaceous crops	4,779	376	-879	-503**	4,275
Permanent crops	114	26	-88	-62*	52
Pastures	5,069	963	-669	295**	5,363
Semi-natural grassland	4,002	670	-515	155*	4,157
Broadleaved, mixed and yew woodland	1,367	137	-43	94**	1,461
Coniferous woodland	1,500	48	-125	-77	1,423
Shrubland, bushland, heathland	1,293	110	-91	19	1,312
Barren land/ Sparsely vegetated areas	92	13	-8	5	97
Open wetlands	2,812	211	-223	-12	2,800
Inland water bodies	307	9	-2	7*	314
Coastal margins	150	7	-4	3	153
Unknown	183	-6	7	2	185
Total	24,419	2,739	-2,742	-3	24,417
Territorial Sea	11,717	-	-	-	11,717

	Opening stock 1998	Additions to stock	Reductions to stock	Net change	Closing stock 2007
Economic Exclusive Zone (Excluding Territorial waters)	56,624	-	-	-	56,624

**Table notes:**

1. Sources: Countryside Survey (1998;2007), Northern Ireland Countryside Survey (1998, 2007), OS Meridian, UK Hydrographic Office, ONS calculations
2. Figures expressed in thousand hectares
3. \*\* Net change is significant at the 5% level
4. \* Net change is significant at the 10% level

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**Country level accounts**

In this section the land cover accounts for England, Scotland and Northern Ireland are presented separately.

Table 5 shows the area of the SEEA-EEA-based broad habitats in England in 1998 and 2007 and related changes. Overall, England displays the same patterns of change as the UK as a whole. The surface area of lands covered by herbaceous crops decreased by 432,000 hectares (10.7%) while the area of pastures and semi-natural grassland correspondingly increased by about 217,000 hectares (7.4%) and 136,000 hectares (7.7%) respectively. Woodland areas expanded, with an increase of 51,000 hectares (5.6%) in the area covered by broadleaved and mixed forests. In addition, there was an increase in the area of shrubland and inland water bodies.

Table 6 shows the area of broad habitats in Scotland in 1998 and 2007. The land cover appears to have changed by a lesser extent in Scotland than in the UK as a whole, as only two broad habitats changed significantly between 1998 and 2007. Semi-natural grasslands expanded by 111,000 hectares (7.8%) while the area of coniferous woodlands decreased by around 79,000 hectares (7.6%). However, due to the relatively small number of squares that are surveyed in Scotland<sup>3</sup>, great care is needed when interpreting the results.

Table 7 shows the area of broad habitats in Wales in 1998 and 2007. None of the changes in the area of the different broad habitats are statistically significant.

Table 8 displays the area of the SEEA-EEA-based broad habitats in Northern Ireland in 1998 and 2007 and how it changed over that period. Between 1998 and 2007 urban and associated areas expanded by 18,000 hectares (30.3%) and the area of land covered by broadleaved, mixed and yew woodland increased by 19,000 hectares (29.5%). Meanwhile, the area of semi-natural grassland decreased by 38,000 hectares (12.8%).



**Table 5: SEEA-EEA Land Cover Account, England**

	Opening stock 1998	Additions to stock	Reductions to stock	Net change	Closing stock 2007
Urban and associated developed areas	2,199	94	-57	38	2,237
Rainfed herbaceous crops	4,036	252	-684	-432**	3,605
Permanent crops	89	8	-73	-65**	24
Pastures	2,937	628	-411	217*	3,154
Semi-natural grassland	1,771	481	-345	136*	1,907
Broadleaved, mixed and yew woodland	905	67	-16	51**	956
Coniferous woodland	301	13	-18	-5	295
Shrubland, bushland, heathland	303	36	-9	26	330
Barren land/ Sparsely vegetated areas	13	9	-5	5	17
Open wetlands	260	54	-36	18	278
Inland water bodies	113	7	-1	5*	119
Coastal margins	57	9	-1	7	64
Unknown	59	-1	1	0	58
<b>Total</b>	<b>13,043</b>	<b>1,656</b>	<b>-1,656</b>	<b>0</b>	<b>13,043</b>

**Table notes:**

1. Sources: Countryside Survey (1998;2007), OS Meridian, ONS calculations
2. Figures expressed in thousand hectares
3. \*\* Net change is significant at the 5% level
4. \* Net change is significant at the 10% level

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**Table 6: SEEA-EEA Land Cover Account, Scotland**

	Opening stock 1998	Additions to stock	Reductions to stock	Net change	Closing stock 2007
Urban and associated developed areas	277	37	-35	2	279
Rainfed herbaceous crops	549	75	-124	-49	501
Permanent crops	21	21	-17	5	26
Pastures	911	95	-79	16	927
Semi-natural grassland	1,426	199	-88	111**	1,537
Broadleaved, mixed and yew woodland	232	34	-13	20	252
Coniferous woodland	1,041	24	-103	-79	962
Shrubland, bushland, heathland	881	28	-50	-22	859
Barren land/ Sparsely vegetated areas	64	5	-3	3	67
Open wetlands	2,281	59	-77	-17	2,264
Inland water bodies	105	2	0	2*	106
Coastal water bodies	60	3	-1	2	62
Unknown	33	5	-1	4	38

	Opening stock 1998	Additions to stock	Reductions to stock	Net change	Closing stock 2007
Total	7,882	589	-591	-2	7,881

**Table notes:**

1. Sources: Countryside Survey (1998;2007), OS Meridian, ONS calculations
2. Figures expressed in thousand hectares
3. \*\* Net change is significant at the 5% level
4. \* Net change is significant at the 10% level

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**Table 7: SEEA-EEA Land Cover Account, Wales**

	Opening stock 1998	Additions to stock	Reductions to stock	Net change	Closing stock 2007
Urban and associated developed areas	219	16	-3	13	232
Rainfed herbaceous crops	74	-64	56	-8	66
Permanent crops	0	1	0	0	1
Pastures	652	134	-99	35	688
Semi-natural grassland	519	42	-98	-56	463
Broadleaved, mixed and yew woodland	157	8	-5	4	161
Coniferous woodland	108	11	-3	8	117
Shrubland, bushland, heathland	104	17	-5	12	116
Barren land/ Sparsely vegetated areas	8	-8	8	0	9
Open wetlands	96	-6	6	0	96
Inland water bodies	25	1	0	0	25
Coastal water bodies	25	1	-7	-6	18
Unknown	90	1	-5	-3	87
<b>Total</b>	<b>2,078</b>	<b>154</b>	<b>-154</b>	<b>0</b>	<b>2,078</b>

**Table notes:**

1. Sources: Countryside Survey (1998;2007), OS Meridian, ONS calculations
2. Figures expressed in thousand hectares
3. \*\* Net change is significant at the 5% level
4. \* Net change is significant at the 10% level

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**Table 8: SEEA-EEA Land Cover Account, Northern Ireland**

	Opening stock 1998	Additions to stock	Reductions to stock	Net change	Closing stock 2007
Urban and associated developed areas	59	19	-1	18**	77
Rainfed herbaceous crops	57	17	-26	-9	49
Permanent crops	2	0	-1	0	1
Pastures	559	98	-77	21	580
Semi-natural grassland	291	56	-94	-38**	253
Broadleaved, mixed and yew woodland	64	20	-2	19**	83
Coniferous woodland	65	3	-4	-2	64
Shrubland, bushland, heathland	14	4	-1	3	17
Barren land/ Sparsely vegetated areas	8	2	-4	-3	5
Open wetlands	221	9	-18	-9	212
Inland water bodies	68	0	-1	0	67
Coastal margins	9	0	0	0	9
Unknown	0	0	0	0	0

	Opening stock 1998	Additions to stock	Reductions to stock	Net change	Closing stock 2007
Total	1,416	228	-228	0	1,416

**Table notes:**

1. Sources: Northern Ireland Countryside Survey (1998;2007), ONS calculations
2. Figures expressed in thousand hectares
3. \*\* Net change is significant at the 5% level
4. \* Net change is significant at the 10% level

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**UK NEA broad habitats**

This section presents the land cover accounts based on the UK National Ecosystem Assessment (NEA) ecosystems. The aim of this account is to provide a cross-cutting picture of the individual Broad Habitat accounts that are currently being developed by DEFRA and ONS.

Table 9 shows the area of the UK NEA ecosystem classes in 1998 and 2007 and related changes. Overall, the area of woodland did not change significantly between 1998 and 2007, as the increase in the area of broadleaved woodland was offset by the decrease in the area of coniferous woodlands. The area of enclosed farmland decreased by 260,000 hectares (2.6%) while there was a 177,000 hectares (4.4%) increase in the area of semi-natural grassland. Other changes were not statistically significant different from zero.

Table 10 shows the area of the UK NEA ecosystem classes in 1998 and 2007 and related changes in England. The area of enclosed farmland decreased by 281,000 hectares (4.0%) while semi-natural grasslands expanded by 149,000 hectares (8.4%). The area of both woodland and dwarf shrub heath increased between 1998 and 2007, by 42,000 hectares (3.5%) and 34,000 hectares (10.5%) respectively.

Table 11 shows the area of the UK NEA ecosystem classes in 1998 and 2007 and related changes in Scotland. The area of semi-natural grasslands increased by 116,000 hectares (8.1%). Other changes were not statistically significant different from zero.

Table 12 the area of the UK NEA ecosystem classes in 1998 and 2007 and related changes in Wales. The area of montane habitat and coastal margins decreased by 2,000 and 6,000 hectares respectively.

Table 13 shows the area of the UK NEA ecosystem classes in 1998 and 2007 and related changes in Northern Ireland. The area of woodland and urban areas increased by 17,000 hectares (12.8%) and 18,000 hectares (30.3%) respectively while the area of semi-natural grassland decreased by 38,000 hectares (12.8%).

**Table 9: UK NEA Land Cover Account, UK**

	Opening stock 1998	Additions to stock	Reductions to stock	Net change	Closing stock 2007
Woodland	2,862	-706	713	7	2,869
Enclosed Farmland	9,950	380	-640	-260**	9,690
Semi-natural Grasslands	4,016	612	-435	177	4,193
Freshwater	3,065	-726	710	-16	3,049
Dwarf shrub heath (Heather and Heather Grassland)	1,319	89	-57	32	1,351
Montane Habitats and Inland Rock	126	2	-17	-15**	111
Coastal Margins	149	6	-3	3	152
Urban & Suburban	2,756	170	-101	69	2,824
Unknown	178	-1	1	0	178
Total	24,419	-173	171	-3	24,417
Territorial Sea	11,717	-	-	-	11,717
Economic Exclusive Zone (Excluding Territorial waters)	56,624	-	-	-	56,624

**Table notes:**

1. Sources: Countryside Survey (1998;2007), Northern Ireland Countryside Survey (1998, 2007), OS Meridian, UK Hydrographic Office, ONS calculations
2. Figures expressed in thousand hectares
3. \*\* Net change is significant at the 5% level
4. \* Net change is significant at the 10% level

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**Table 10: UK NEA Land Cover Account, England**

	Opening stock 1998	Additions to stock	Reductions to stock	Net change	Closing stock 2007
Woodland	1,204	71	-29	42*	1,247
Enclosed Farmland	7,057	223	-505	-281**	6,776
Semi-natural Grasslands	1,773	438	-289	149	1,921
Freshwater	361	37	-22	16	376
Dwarf shrub heath (Heather and Heather Grassland)	321	40	-7	34*	354
Montane Habitats and Inland Rock	14	0	-4	-3**	11
Coastal Margins	57	8	-1	7	64
Urban & Suburban	2,202	92	-55	37	2,239
Unknown	54	8	-7	1	55
<b>Total</b>	<b>13,043</b>	<b>918</b>	<b>-918</b>	<b>0</b>	<b>13,043</b>

**Table notes:**

1. Sources: Countryside Survey (1998;2007), OS Meridian, ONS calculations
2. Figures expressed in thousand hectares
3. \*\* Net change is significant at the 5% level
4. \* Net change is significant at the 10% level

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**Table 11: UK NEA Land Cover Account, Scotland**

	Opening stock 1998	Additions to stock	Reductions to stock	Net change	Closing stock 2007
Woodland	1,268	37	-101	-64	1,204
Enclosed Farmland	1,478	99	-118	-19	1,459
Semi-natural Grasslands	1,437	197	-82	116**	1,553
Freshwater	2,346	71	-90	-19	2,327
Dwarf shrub heath (Heather and Heather Grassland)	887	36	-53	-17	870
Montane Habitats and Inland Rock	100	1	-8	-7*	93
Coastal Margins	59	3	-1	2	61
Urban & Suburban	277	35	-33	2	279
Unknown	31	5	-1	4	35
<b>Total</b>	<b>7,882</b>	<b>485</b>	<b>-486</b>	<b>0</b>	<b>7,881</b>

**Table notes:**

1. Sources: Countryside Survey (1998;2007), OS Meridian, ONS calculations
2. Figures expressed in thousand hectares
3. \*\* Net change is significant at the 5% level
4. \* Net change is significant at the 10% level

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**Table 12: UK NEA Land Cover Account, Wales**

	Opening stock 1998	Additions to stock	Reductions to stock	Net change	Closing stock 2007
Woodland	265	13	-3	11	276
Enclosed Farmland	726	72	-41	30	756
Semi-natural Grasslands	522	47	-99	-52	470
Freshwater	120	-2	2	0	119
Dwarf shrub heath (Heather and Heather Grassland)	106	16	-4	13	119
Montane Habitats and Inland Rock	5	0	-2	-2*	3
Coastal Margins	24	1	-7	-6*	18
Urban & Suburban	218	15	-3	13	230
Unknown	91	2	-7	-5	86
Total	2,078	164	-164	0	2,078

**Table notes:**

1. Sources: Countryside Survey (1998;2007), OS Meridian, ONS calculations
2. Figures expressed in thousand hectares
3. \*\* Net change is significant at the 5% level
4. \* Net change is significant at the 10% level

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**Table 13: UK NEA Land Cover Account, Northern Ireland**

	Opening stock 1998 (km2)	Additions to stock	Reductions to stock	Net change	Closing stock 2007 (km2)
Woodland	130	19	-2	17**	147
Enclosed Farmland	616	85	-73	12	628
Semi-natural Grasslands	291	56	-94	-38**	253
Freshwater	289	9	-19	-9*	279
Dwarf shrub heath (Heather and Heather Grassland)	14	4	-1	3	17
Montane Habitats and Inland Rock	8	2	-4	-3	5
Coastal Margins	9	0	0	0	9
Urban & Suburban	59	19	-1	18**	77
unknown	0	0	0	0	0
<b>Total</b>	<b>1,416</b>	<b>194</b>	<b>-195</b>	<b>-</b>	<b>1,415</b>

**Table notes:**

1. Sources: Northern Ireland Countryside Survey (1998;2007), ONS calculations
2. Figures expressed in thousand hectares
3. \*\* Net change is significant at the 5% level
4. \* Net change is significant at the 10% level

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## Notes

1. Annex B reports estimates of net changes and associated 95% Confidence Intervals.
2. Excluding Territorial waters.
3. 198 in 2007, 203 in 1998.

## Future Work

There are uncertainties about whether the Countryside Survey will be conducted again in its current format. As explained above, the Countryside Survey is currently the best data source to derive land cover accounts.

Future work should investigate the possibility of using data from a satellite based land cover monitoring system currently being developed by the Centre for Ecology and Hydrology (CEH)<sup>1</sup>. This system will use satellite images in order to detect changes in the land cover. CEH has developed machine learning algorithms that analyse the patterns within historical land cover inventories to identify the association between these and optical reflectance. These highly automated techniques produce very high classification accuracies and could be used to provide accurate and frequent land cover information at relatively low cost, with the possibility of annual map production. This would allow ONS to update the land cover accounts annually and possibly to conduct detailed analysis at local levels.

DEFRA and ONS are currently developing individual broad habitat ecosystem accounts that follow the UK NEA classification. A key challenge going forward will be to compare and align data on habitat extent from individual asset accounts with the cross-cutting picture provided by the UK land cover accounts. Ultimately, the UK land cover accounts would form the primary account which supports and draws the other accounts together.

Further analysis examining interactions between land use and land cover would help to improve our understanding of the changes in the ecosystems and ecosystem services.

## Notes

1. We thank Daniel Morton from the Centre for Ecology and Hydrology for providing us with this information.

## Annexes

**Table A1: Land Cover Account using LCM2000 and LCM2007, UK**

	Opening stock 2000	Net change	Closing stock 2007
Broadleaved Woodland	1,560	-187	1,373
Coniferous Woodland	1,354	152	1,506
Arable & Horticulture	5,763	538	6,301
Improved Grassland	5,907	-670	5,238
Semi-natural Grasslands	4,132	-859	3,274
Open Wetlands	594	516	1,110
Freshwater	277	48	325
Dwarf shrub heath	2,702	-590	2,112
Montane habitats and Inland rock	621	0	622
Coastal margins	47	9	56
Marine	47	262	309
Urban	1,664	-199	1,465
Total	24,669	-980	23,689

**Table notes:**

1. Sources: LCM2000 and LCM2007
2. Figures expressed in thousand hectares

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**Table A2: Land Cover Account using CORINE Land Cover, UK**

	Opening stock 2000	Net change	Closing stock 2007
Artificial surfaces	1,940	21	1,960
Rainfed herbaceous crops	6,764	-7	6,757
Permanent crops	2	0	2
Agriculture associations and mosaics	255	-4	251
Pastures	7,053	-13	7,040
Natural grassland	1,940	-4	1,936
Broadleaved	673	5	678
Coniferous	1,381	-26	1,355
Shrubland, bushland, heathland	2,549	29	2,578
Sparsely vegetated areas/barren land	569	0	569
Open wetlands	1,164	0	1,164
Inland water bodies	220	0	220
Coastal water bodies	304	0	304
Total	24,814	-	24,814

**Table notes:**

1. Source: CLC2000 and CLC2006
2. Figures expressed in thousand hectares

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**Table B1: Habitat classes based on SEEA-EEA Land Cover/Ecosystem Functional Unit Class**

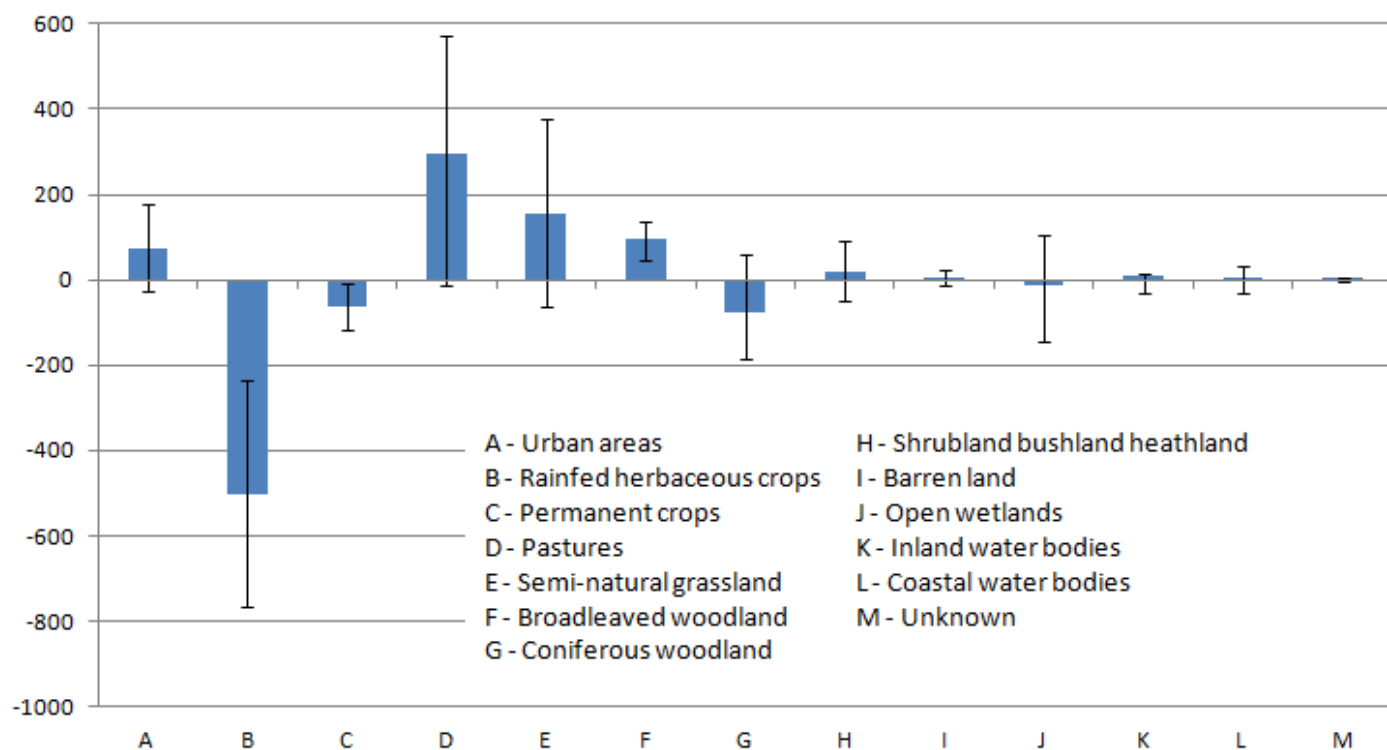
<b>SEEA-EEA Provisional Land Cover/ Ecosystem Functional Unit Class</b>	<b>Adapted habitat classes for the UK land cover account</b>
Urban and associated developed areas	Urban and associated developed areas
Rainfed and irrigated herbaceous cropland (including mosaics as well as medium to large fields)	Rainfed and irrigated herbaceous cropland
Permanent crops, agriculture plantations	Permanent crops, agriculture plantations
Pastures and natural grassland	Pastures/Improved grassland Semi-natural grassland
Forest tree cover	Broadleaved, mixed and yew woodland Coniferous woodland
Shrubland, bushland, heathland	Shrubland, bushland, heathland
Sparsely vegetated areas	Barren land/ Sparsely vegetated areas
Barren land	
Open wetlands	Open wetlands
Inland water bodies	Inland water bodies
Coastal water bodies	Coastal water bodies
Permanent snow and glaciers	Irrelevant to the UK land cover
Natural vegetation associations and mosaics	Classified according to actual land cover (herbaceous crops, pastures, etc)
Agriculture associations and mosaics	
Sea	Marine

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**Figure C1a: Estimates of net change and 95% Confidence intervals, UK**

SEEA-EEA Broad habitats

**Notes:**

- Source: Countryside Survey (1998;2007), Northern Ireland Countryside Survey (1998, 2007), UK Hydrographic ONS calculations; Figures expressed in thousand hectares

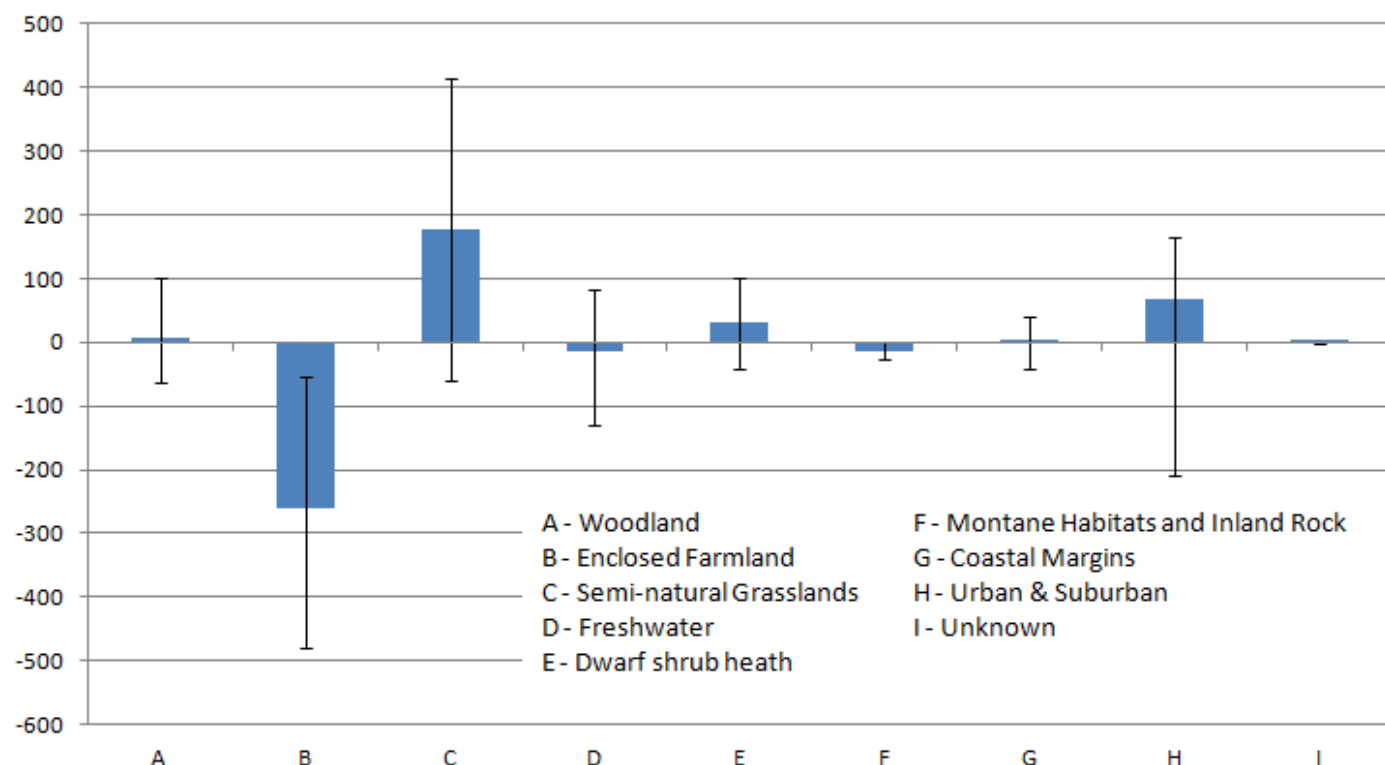
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**Figure C1b: Estimates of net change and 95% Confidence intervals, UK**

UK NEA Broad habitats

**Notes:**

- Source: Countryside Survey (1998;2007), Northern Ireland Countryside Survey (1998, 2007), UK Hydrographic ONS calculations; Figures expressed in thousand hectares

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**Table D1: Number of surveyed squares in the Countryside Survey**

	1998	2007
England	302	288
Scotland	203	196
Wales	64	107
GB	569	591

**Table notes:**

- Source: Countryside Survey (1998;2007)

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## Modelling Approach

For each broad habitat the proportion of the habitat in each land class in each survey year was estimated using a mixed effects model. The proportion of the habitat was modelled as a function of an interaction of land class and survey year (fixed effect) and a time-constant component (random effect):

$$BH_{xit} = \beta(YEAR_{it} \times LC_i) + \zeta_i + \varepsilon_{it}$$

With  $BH_{xit}$  being the proportion of the habitat  $x$  in the square  $i$  at survey year  $t$ ,  $YEAR_{it}$  denotes the survey year (eg takes a value of 0 for 1998, 1 for 2007) and  $LC_i$  is the ITE land class square  $i$  belongs to.  $\zeta_i$  is a time-constant error component that varies between squares but not over time.  $\varepsilon_{it}$  is a transitory error component, which varies over time.

## Additions and reductions to stock

Using a sample restricted to squares that were surveyed in both 1998 and 2007, additions and reductions to stock were calculated and expressed as a percentage of net change (estimates on the restricted sample). These percentages were then multiplied to the estimates of net change derived using the modelling approach outlined above.

More formally, the additions ( $A$ ) and reductions ( $R$ ) to a broad habitat  $x$  are given by

$$A_x = \frac{\sum_i \delta BH_{xi} 1(\delta BH_{xi} > 0) \times \text{weight}_i}{\sum_i \delta BH_{xi} \times \text{weight}_i} \times \widetilde{NC_{BHx}}$$

And

$$R_x = \frac{\sum_i \delta BH_{xi} 1(\delta BH_{xi} < 0) \times \text{weight}_i}{\sum_i \delta BH_{xi} \times \text{weight}_i} \times \widetilde{NC_{BHx}}$$

With  $\delta BHx_i$  being the change in the proportion of broad habitat  $x$  in square  $l$ ,  $1(\delta BHx_i > 0)$  an indicator function equals to 1 if the change is positive, zero otherwise.  $1(\delta BHx_i < 0)$  indicator function equals to 1 if the change is negative, zero otherwise.  $weight_i$  is the sampling weight based on the ITE land classes.  $NC_{BHx}$  is the estimate of net change derived using the mixed effects model.

## Background notes

1. Details of the policy governing the release of new data are available by visiting [www.statisticsauthority.gov.uk/assessment/code-of-practice/index.html](http://www.statisticsauthority.gov.uk/assessment/code-of-practice/index.html) or from the Media Relations Office email: [media.relations@ons.gsi.gov.uk](mailto:media.relations@ons.gsi.gov.uk)

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