Indicators and trends

Monitoring climate change adaptation

climate change
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Indicator name				Version
NA1 Comparison of land capability against actual land use				17/03/16
Indicator type:	**Risk/opportunity**	**Impact**	**Action**	
	X			

SCCAP Theme	SCCAP Objective	CCRA risk/opportunity
Natural Environment	N3: Sustain and enhance the benefits, goods and services that the natural environment provides	• AG25/AG51/AG52 Agricultural land classification and crop suitability • Cross-cutting (including changes in yields, changes in soil condition, human food supply)

At a glance

- Growing evidence that agricultural potential has, and is, changing in response to weather and climate.
- It is too early to tell whether there has been an associated change in land use.
- The degree to which such changes occur will be governed by a complex mix of biophysical, economic and social factors which will vary in space and over time.

Latest Figure	Trend
To date no single value indicator has been developed to summarise the relationship. The most recent published figures defining the relationship are for 2011 though data to support analysis for 2000-2014 are available.	No change detection or trend analysis has been undertaken.

Why is this indicator important?

There is a growing body of evidence that the agricultural potential as defined by the Macaulay system of Land Capability for Agriculture (LCA) has, and is, changing in response to weather and climate (Brown et al., 2008). Given that land use potential is changing in Scotland, there is interest in better understanding how these changes in potential may relate to actual changes in land cover, use and/or management. Intensification of production could be associated with increased pressures on the natural environment, though the balance of outcomes would depend heavily on the precise circumstances, land use systems and relative valuations of ecosystem services (provisioning vs. others) and beneficiaries (public vs. private).

Related indicators:
NA2 Area of Prime Agricultural Land (Land Capability)

What is happening now?

Maps of land capability and land use/cover derived from Scottish Government's Integrated Administration and Control System (IACS) have been combined to derive breakdowns of the mix of land use/cover for each of the LCA classes (Table 1), as shown in Figures 1 and 2 below (the first showing areas and the second proportions per LCA class). The most recent version of the analysis published is for the year 2011 (Miller et al., 2012)[1].

Table 1 LCA classes and associated land uses (Bibby et al., 1982)

Class	Category	Climate limitations	Land use
1	Prime	None or very minor	Very wide range of crops with consistently high yields
2	Prime	Minor	Wide range of crops, except those harvested in winter
3.1	Prime	Moderate	Moderate range of crops, with good yields for some (cereals and grass) and moderate yields for others (potatoes, field beans, other vegetables)
3.2	Non-prime	Moderate	Moderate range of crops, with average production, but potentially high yields of barley, oats and grass
4.1	Non-prime	Moderately severe	Narrow range of crops, especially grass due to high yields but harvesting may be difficult
4.2	Non-prime	Moderately severe	Narrow range of crops, especially grass due to high yields but harvesting difficulties may be severe
5	Non-prime	Severe	Improved grassland, with mechanical intervention possible to allow seeding, rotavation or ploughing
6	Non-prime	Very severe	Rough grazing pasture only
7	Non-prime	Extremely severe	Very limited agricultural value

[1] The analysis was undertaken as part of research in support of post-2015 CAP policy development rather than specifically in the context of climate change adaptation or mitigation

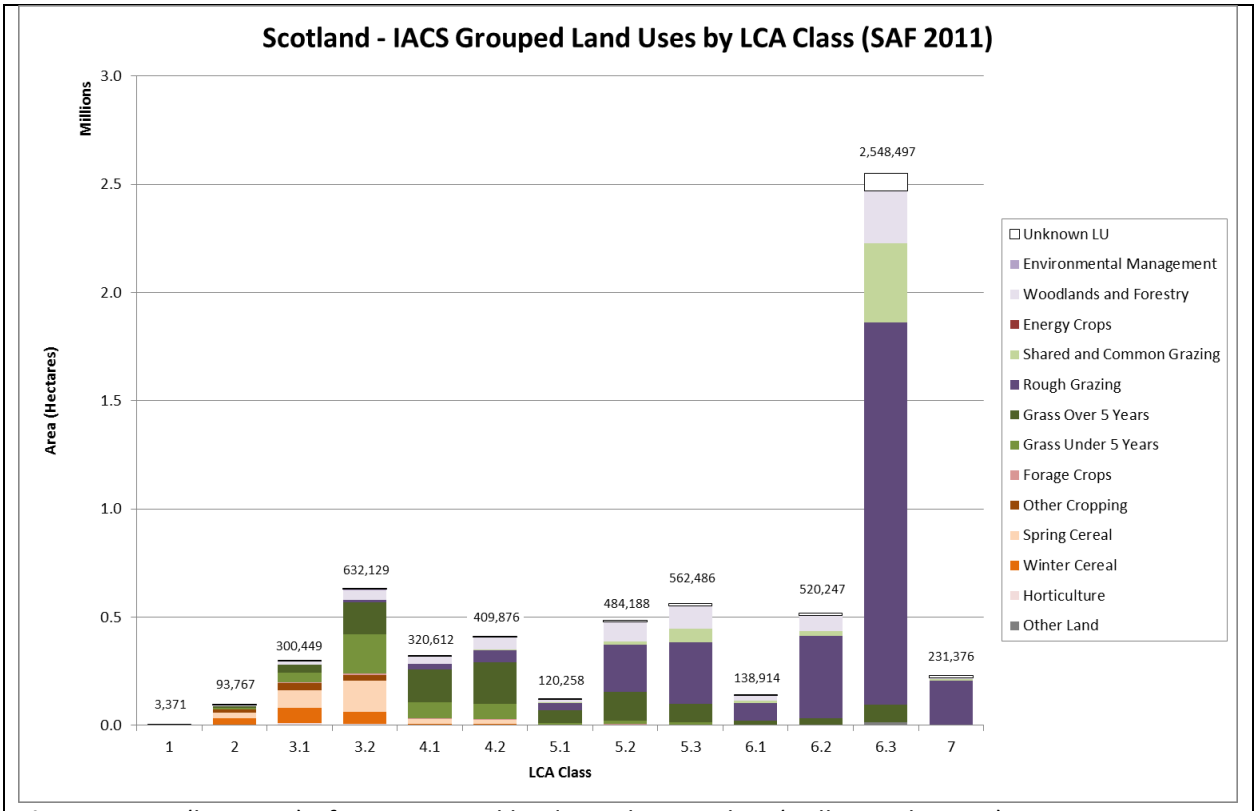

Figure 1 Area (hectares) of IACS grouped land uses by LCA class (Miller et al., 2012)

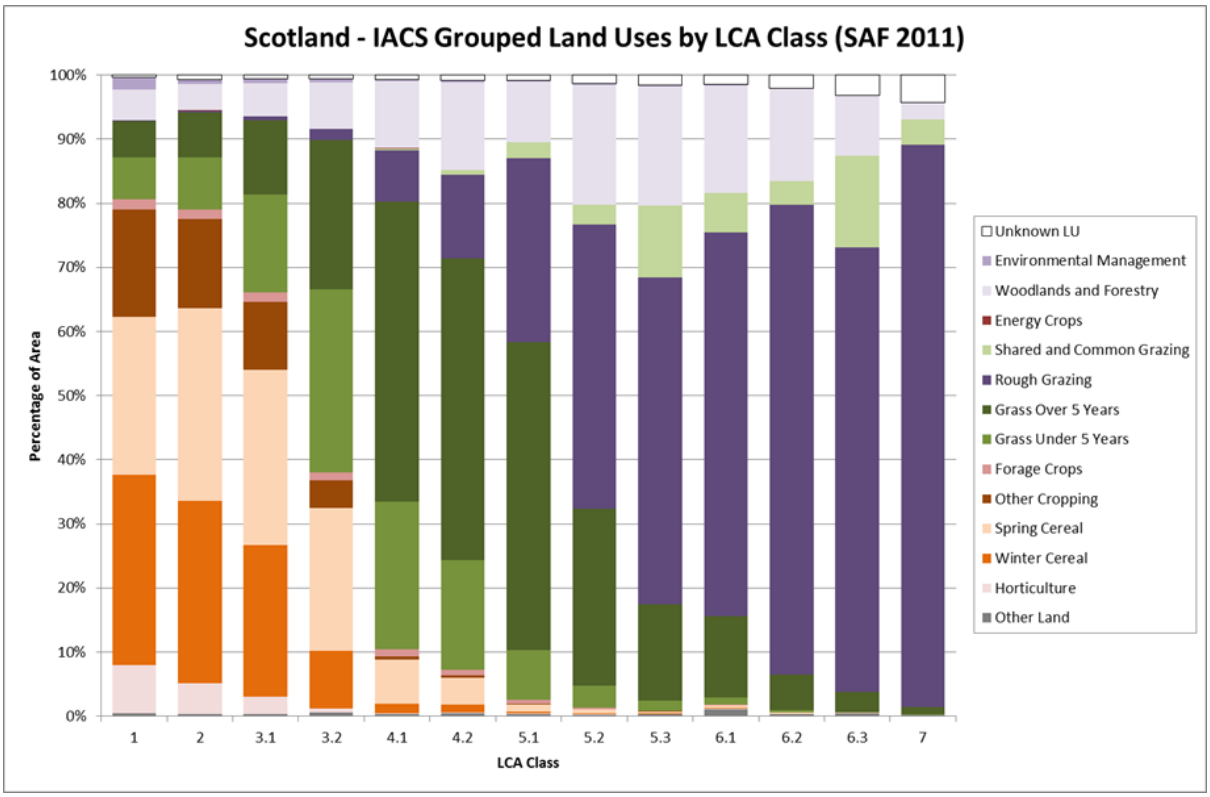

Figure 2 Proportion of IACS grouped land uses by LCA class (Miller et al., 2012)

What has happened in the past?

No analysis of past land use/cover change has currently been undertaken as part of this research.

What is projected to happen in the future?

Based on the outputs of models of future climate there are indications of possible improvements in land capability for some regions due to climate, but potentially limited by climate-soil-topography interactions. However, no projections of land use/cover response have yet been made. Changes in land use mix that could be associated with movement between capability classes can be inferred by comparison between columns in the proportions chart above (Fig. 2). The degree to which such changes occur will be governed by a complex mix of biophysical, economic and social factors which will vary in space and over time.

Patterns of change

Since the data is generated from field-scale land use data, it is possible to generate land use/cover mixes per land capability class for regions or other localities within Scotland. To date such information has been used for illustrative rather than analytical purposes – for example for Agricultural Regions in Miller et al., (2012).

Interpretation of indicator trends

No analysis of indicator trend has currently been undertaken.

Limitations

The key limitation on such an indicator is whether changes in land use/cover can be adequately attributed to climate induced changes in capability rather than other factors- environmental, economic, political and social drivers operating at local, national and international levels (e.g. changing market forces; policies to enhance biodiversity, promote forestry or renewable energy supply) (Miller et al., 2009; Slee et al., 2013). A secondary limitation is the degree to which any single indicator value can adequately reflect the diversity of system-wide, interlinked, changes occurring in a heterogeneous geographical space.

Technical limitations of the analysis relate to the two input datasets. For LCA these include: the availability of large scale (1:50,000) mapping in only 2.6M ha with another 5.1M ha covered at only 1:250,000 scale; the climate data embodied in the published mapping is for 1958 to 1978; the match between the edges of the two scales of LCA mapping and other technical issues arising from the conversion from paper to digital mapping. These are further detailed in communications with Scottish Government.

For land use/cover – mapping is available from 2000, but early coverage has a degree of bias in favour of lowland and agricultural land. Coverage has increased over time to 5.7[2] M ha in 2014 and can be supplemented with other decadal sources such as the National Forest Inventory.

The land use classifications within IACS are based on the need to administer support through particular payment schemes so there is change in classification over time. The use of IACS from 2009

[2] Polygon area of fields with declared land uses, 6.5M ha are included in the mapping but without land use/cover data.

as part of generating Agricultural Census data means that a fair degree of continuity can be expected in future. Since IACS is self-reported by land managers there can be issues of interpretation, for example differentiating between previously improved and semi-natural grassland.

References

Brown, I., Towers, W., Rivington, M., & Black, H.I.J. (2008) Influence of climate change on agricultural land-use potential: adapting and updating the land capability system for Scotland. *Climate Research*, 37, 1, 43-57.

Miller, D.G., Matthews, K.B., and Buchan, K. (2012) *Future CAP Payments: Determining the land use and farm-type mixes of land capability for agriculture class groupings in the regions of Scotland and the characteristics of holdings containing both land capability for agriculture classes 1 to 5.3 and 6.1 to 7 land*. Report to RESAS, available online at http://hutton.ac.uk/sites/default/files/files/ladss/LCAvsFarm-Type-and-Land-Use.pdf.

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Slee, B., Brown, I., Donnelly, D., Gordon, I.J., Matthews, K.B., Towers, W. (2013) The 'squeezed middle': Identifying and addressing conflicting demands on intermediate quality farmland in Scotland, *Land Use Policy*, 41, 206-216.

Further information

Bibby, J. S., Douglas, H. A., Thomasson, A. J., & Robertson, J. S. (1991) *Land Capability for Agriculture*, The Macaulay Land Use Research Institute, Aberdeen.

Acknowledgements

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Appendix One: Indicator metadata and methodology

Table 1: Indicator metadata

	Metadata
Title of the indicator	NA1 Comparison of land capability against actual land use
Indicator contact: Organisation or individual/s responsible for the indicator	Anna Moss (CXC, University of Dundee)
Indicator data source	Land Capability for Agriculture mapping – The James Hutton Institute. Land Use/Cover mapping– Scottish Government – Rural Payments and Inspections Directorate.
Data link: URL for retrieving the indicator primary indicator data.	Not Available

Table 2: Indicator data

	Indicator data
Temporal coverage: Start and end dates, identifying any significant data gaps.	2000-2014
Frequency of updates: Planned or potential updates	Annual
Spatial coverage: Maximum area for which data is available	Varies per year – minimum is 4.5M ha in 2000, rising to 5.7 M ha in 2014.
Uncertainties: Uncertainty issues arising from e.g. data collection, aggregation of data, data gaps	The spatial location and configuration of land uses is uncertain when multiple land uses are recorded per unit of mapping (i.e. per field). This may be significant where component land uses are radically different and when there are a range of land capability classes present. There are also uncertainties in the LCA data as detailed above.
Spatial resolution: Scale/unit for which data is collected	Land use/cover – per "field", but note that for unimproved land these areas can be substantial (in 2014 the largest is 16,659 ha net area after exclusions). The mapping scale is usually 1:5000 in lowlands and between 1:10,000 and 1;50,000 in uplands, with an expected accuracy of +/- 0.1 ha. The land capability assessment is underpinned by

	soils mapping, that is *map units* (1:250,000 scale mapping, with a minimum mapping unit of 75-100 ha) and *soil series* (1:25,000 scale mapping, with a minimum mapping unit in the order of 2.5 ha).
Categorical resolution: Potential for disaggregation of data into categories	13 land capability classes are defined. For land use classes, 208 have been present at some point between 2000 and 2014 with 30 present in all years. Other classes are also present in all years but have been differentiated or grouped together at various points in the time line which may limit utility. In general terms cropped land is well differentiated but grassland has only two classes determined by age (<= or > 5 years) and it is challenging to determine the uses to which individual grassland fields are put over a year (e.g. silage, grazing by dairy or beef cows or sheep). At holding level it is possible to determine an overall stocking rate for forage land based on June Census or December Survey returns. Unimproved grazings are differentiated only on the basis of tenure between rough grazing and common grazings.
Data accessibility: Restrictions on usage, relevant terms & conditions	The use of IACS data is controlled by SG-RIPD and Land Capability for Agriculture by The James Hutton Institute.

Table 3 Contributing data sources

Contributing data sources Data sets used to create the indicator data, the organisation responsible for them and any URLs which provide access to the data.
Land capability for Agriculture mapping at 1:250,000 and 1:50,000 scale. The James Hutton Institute. IACS land use/cover maps – SG-RIPD data manipulated by the James Hutton Institute. No data is available online.

Table 4 Indicator methodology

Indicator methodology The methodology used to create the indicator data
This methodology was previously published in Miller et al. (2012) and refers to work conducted in support of a Future CAP support options appraisal.

METHODS AND ASSUMPTIONS

Input Datasets

This analysis has been undertaken using land use data taken from the 2011 single application form (SAF) dataset held in the Integrated Administration and Control System (IACS) linked to the January 2012 field boundary dataset (a geographical information systems (GIS) dataset maintained by Scottish Government (SG)). To allow for meaningful interpretation of the land use data the IACS land use codes (n=101) have been classified into 14 "parent" classes. This classification is the same as was used for the Rural Land Use Study for SG[3] but modified to differentiate between temporary grassland (TGRS) and permanent grassland (PGRS), see the table below. The land capability for agriculture mapping used was the hybrid map that combines 1:50,000 scale mapping in the lowlands with 1:250,000 scale in the uplands (see the Final Report for the Pack Inquiry for more detail on the characteristics of the LCA mapping[4]).

Analyses

Quantifying the land use and farm-type mix for the LCA classes required the overlaying of the land use map with LCA map in a geographical information system (GIS). The resulting output map contains for each mapped field (6.4 M ha), the land use and LCA class combinations present. The map was summarised using MS Excel pivot tables that cross tabulate LCA area (in ha and percentage terms) and land use. The cross tabulations are presented both nationally and for each of the 14 agricultural regions.

Limitations of the Analysis

The IACS land use dataset is recorded as of 15th May each year. While it is possible to generate a field boundary map for this date, previous experience has shown that lags within the process of updating the field boundary map can mean that a later date gives a better match between SAF claims and the GIS mapping. In previous projects the authors have used a field boundary snapshot in mid-January (~18th) the next year (2012). In this case since there have been on-going efforts to improve the GIS mapping with considerable numbers of updates the match between claim and the field boundary map was poorer than previously (86 % of claims). Where a claim could not be matched to a field in the 2012 snapshot it was matched to the 2011 map instead (4.55 % or 292,182 ha of claims). The land uses in the 2012 map were then imputed from the 2011 map. This was the best compromise in terms of ensuring that the integrity of the 2012 field boundaries dataset was maintained while maximising the coverage of land use data. Where field mapping was available but no claim was present then if previous land uses were available from earlier claims these were used with the year noted from which the land use was imputed. Land use from previous years were used in 259,740 ha or 4.04 % of the area again for the sake of completeness of land use coverage. In the main this form of imputation occurred for semi-natural land uses, particularly rough grazing. An additional 194,542.802 ha or 3.03% was accounted for by reference to the National Forest Inventory 2011 map.

The analysis uses the predominant land use for each land parcel. While multiple land uses can be defined per field in SAF claims these have no spatial representation within the field. That is there is no way of determining where within the field each land use occurs. This means that where there are multiple LCA classes and land uses within the same field it is not possible to be certain of their relationship to one another. Predominance was assessed in the 2009 IACS land use data as occurring in ~2% of the mapped area and most often in semi-natural land use classes[5].

[3] http://www.scotland.gov.uk/Topics/Research/About/EBAR/RLUS/RLUSP1

[4] http://www.scotland.gov.uk/Publications/2010/11/01153620/0

[5] http://www.scotland.gov.uk/Publications/2011/05/05085633/0

The predominant land use is assumed to apply to the entire field. In some case the claimed land uses make up less than the complete area of the field and it is necessary to extrapolate the use of the remainder. Previous analysis using 2009 data has indicated that the need for extrapolation occurs more often in semi-natural land use classes (~10%) with cropping and grassland less affected (3% and 5% respectively)[5]. Some of this uncertainty can be reduced by combining the IACS land use dataset with other decadal data such as the National Forest Inventory (NFI). This has been undertaken and confirmed as feasible in subsequent analyses but is not included in the 2011 results presented in this document.

Land Use/Cover Classification Used in 2011 Analysis

The table below shows the parent land use class in to which the IACS land uses were grouped. Records shaded green indicate data derived from the National Forest Inventory. For these records, although mapped in IACS no claimed land use could be determined.

Table 1: Reclassification of IACS land use Codes into Parent Classes (14)

Parent Land Use Class	IACS or NFI Description	Record Count
Energy Crops	MISCANTHUS	1
Energy Crops	NON-FOOD SETASIDE - OILSEED RAPE FOR INDUSTRIAL USE	3
Energy Crops	REED CANARY GRASS	26
Energy Crops	SHORT ROTATION COPPICE	94
Energy Crops	SHORT ROTATION COPPICE ENERGY	5
Energy Crops	WINTER OILSEED RAPE ENERGY	2
Environmental Management	FALLOW	1107
Environmental Management	GREEN COVER MIXTURE	37
Environmental Management	LAND PREVIOUSLY STRUCTURAL SET-ASIDE	13
Environmental Management	LFASS INELIGIBLE ENVIRONMENTAL MANAGEMENT	783
Environmental Management	NORMAL SETASIDE - BARE FALLOW	7
Environmental Management	NORMAL SETASIDE - GREEN COVER MIXTURE	6
Environmental Management	NORMAL SETASIDE - NAT REGEN (AFTER CEREALS)	69
Environmental Management	NORMAL SETASIDE - NAT REGEN (AFTER OTHER CROPS)	4
Environmental Management	NORMAL SETASIDE - NEXT TO WATERCOURSES,HEDGES,WOODS,DYKES AND SSSIs	1
Environmental Management	NORMAL SETASIDE - OWN MANAGEMENT PLAN	10
Environmental Management	NORMAL SETASIDE - PHACELIA	2
Environmental Management	NORMAL SETASIDE - SOWN GRASS COVER	81
Environmental Management	NORMAL SETASIDE - WILD BIRD COVER	1
Environmental Management	POSITIVE ENVIRONMENTAL MANAGEMENT	87
Environmental Management	SFPS BEING CLAIMED ON AGRI-ENVIRONMENTAL OPTIONS	16
Environmental Management	WILD BIRD SEED	608
Environmental Management	NORMAL SETASIDE - MUSTARD	1
Environmental Management	FALLOW LAND FOR MORE THAN 5 YEARS	136
Forage Crops	ARABLE SILAGE FOR STOCK FEED	899
Forage Crops	FIELD BEANS	427
Forage Crops	FODDER BEET	93
Forage Crops	KALE AND CABBAGES FOR STOCKFEED	315
Forage Crops	OTHER CROPS FOR STOCK FEED	363
Forage Crops	PROTEIN PEAS	130
Forage Crops	RAPE FOR STOCK FEED	322
Forage Crops	SWEET LUPINS	21
Forage Crops	TURNIPS/SWEDES FOR STOCK FEED	774
Forage Crops	WHOLE CROP CEREALS	287
Grass Over 5 Years	GRASS OVER 5 YEARS	192429
Grass Under 5 Years	GRASS UNDER 5 YEARS	80042
Horticulture	AROMATIC, MEDICAL AND CULINARY PLANTS	2
Horticulture	ARTICHOKES	6
Horticulture	ASPARAGUS	4
Horticulture	BEANS FOR HUMAN CONSUMPTION	92
Horticulture	BEDDING AND POT PLANTS	1
Horticulture	BILBERRIES (AND OTHER FRUITS OF THE GENUS VACCINIUM)	6
Horticulture	BLACKBERRIES	1
Horticulture	BLACKCURRANTS	26
Horticulture	BRUSSEL SPROUTS	67
Horticulture	BULBS/FLOWERS	79
Horticulture	CABBAGES	33
Horticulture	CALABRESE	125

Horticulture	CARROTS	242
Horticulture	CAULIFLOWER	21
Horticulture	GOOSEBERRIES	1
Horticulture	LEEKS	6
Horticulture	LETTUCE	7
Horticulture	NURSERIES	1
Horticulture	NURSERY - FRUIT STOCK	4
Horticulture	NURSERY - ORNAMENTAL TREES	15
Horticulture	OTHER NURSERY STOCKS	8
Horticulture	OTHER SOFT FRUIT	5
Horticulture	OTHER VEGETABLES	160
Horticulture	PEAS FOR HUMAN CONSUMPTION	676
Horticulture	RASPBERRIES	54
Horticulture	REDCURRANTS	1
Horticulture	RHUBARB	14
Horticulture	SHOPPING TURNIPS/SWEDES	188
Horticulture	SOFT FRUIT	9
Horticulture	STRAWBERRIES	94
Horticulture	TOP FRUIT	12
No IACS or NFI Land Use Known	Null Land Use	9721
Other Cropping	LINSEED	24
Other Cropping	MAIZE	365
Other Cropping	MIXED CEREALS	150
Other Cropping	OILSEED RAPE	33
Other Cropping	RYE	5
Other Cropping	SEED POTATOES	1512
Other Cropping	SPRING OILSEED RAPE	166
Other Cropping	TRITICALE	84
Other Cropping	TURF PRODUCTION	62
Other Cropping	WARE POTATOES	1864
Other Cropping	WINTER OILSEED RAPE	3534
Other Land	OTHER LAND	1620
Other Land	PONDS, RIVERS, STREAMS OR LOCHS	556
Other Land	ROADS, YARDS OR BUILDINGS	1683
Other Land	SCREE OR SCRUB	1234
Rough Grazing	ROUGH GRAZING	35199
Shared and Common Grazing	COMMON GRAZING	2205
Shared and Common Grazing	SHARED GRAZING	13
Spring Cereal	SPRING BARLEY	36533
Spring Cereal	SPRING OATS	2230
Spring Cereal	SPRING WHEAT	831
Winter Cereal	WINTER BARLEY	4904
Winter Cereal	WINTER OATS	668
Winter Cereal	WINTER WHEAT	10918
Woodlands and Forestry	Assumed woodland	551
Woodlands and Forestry	Broadleaved	2849
Woodlands and Forestry	Conifer	3854
Woodlands and Forestry	EX STRUCTURAL SET-ASIDE (AFFORESTED LAND ELIGIBLE FOR SFPS)	103
Woodlands and Forestry	Felled woodland	216
Woodlands and Forestry	Ground prepared for new planting	87
Woodlands and Forestry	Low density	4
Woodlands and Forestry	Mixed (predominantly broadleaved)	365
Woodlands and Forestry	Mixed (predominantly conifer)	397
Woodlands and Forestry	NEW WOODLAND (ELIGIBLE FOR SFPS)	290
Woodlands and Forestry	NON-FOOD SETASIDE - TREES SHRUBS AND BUSHES	2
Woodlands and Forestry	NORMAL SETASIDE - 5 YEAR UNDER WGS	6
Woodlands and Forestry	OPEN WOODLAND(GRAZED)	3769
Woodlands and Forestry	STRUCTURAL SETASIDE - EX 5 YEAR STILL IN FWS	1
Woodlands and Forestry	STRUCTURAL SETASIDE - WGS, FWPS OR SFGS	4
Woodlands and Forestry	Shrub	28
Woodlands and Forestry	TREES SHRUBS & BUSHES	3633
Woodlands and Forestry	WOODLAND AND FORESTRY	28905
Woodlands and Forestry	WOODLAND/FORESTRY WITH UNIQUE FIELD IDENTIFIER	1
Woodlands and Forestry	Young trees	763