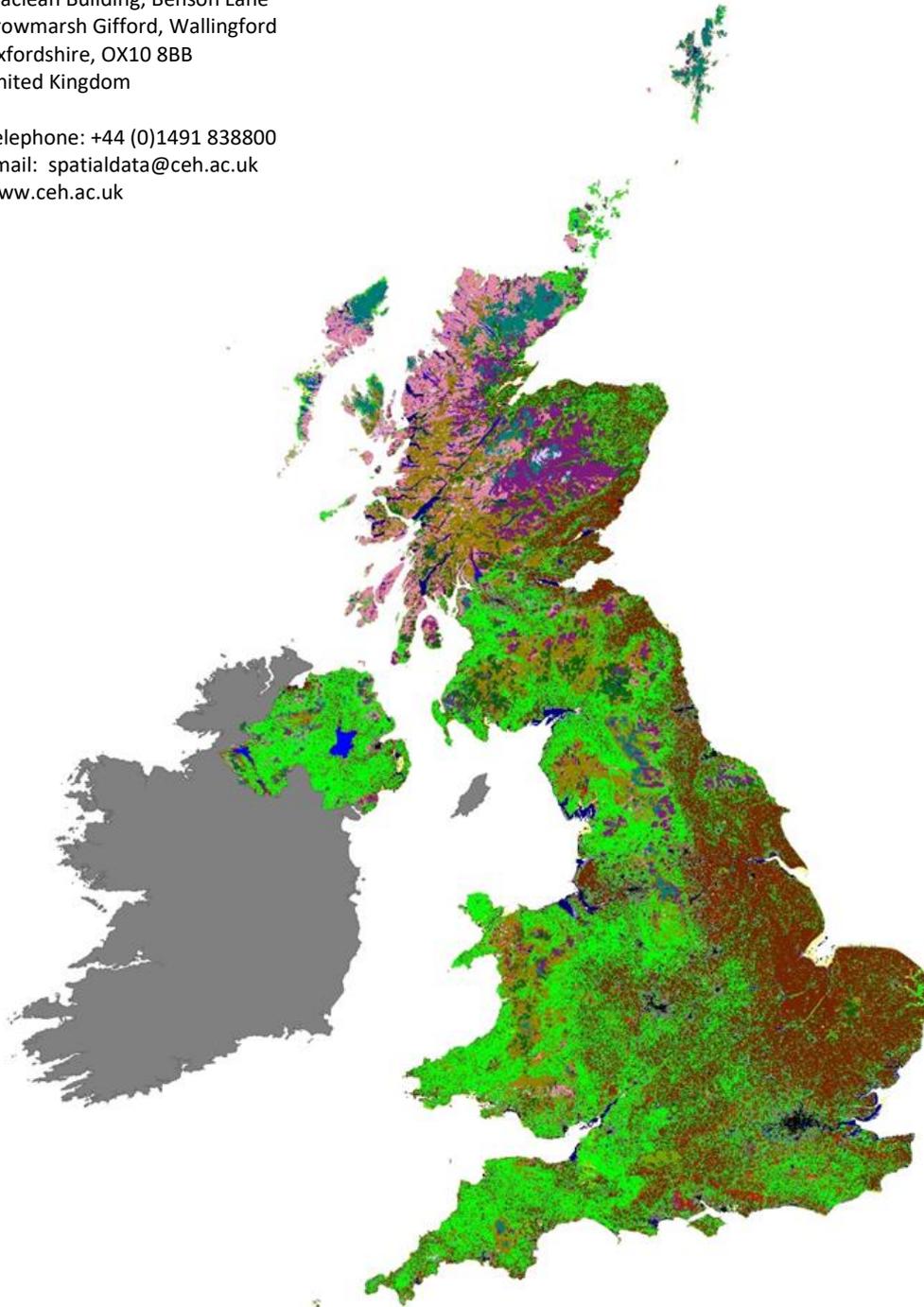




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Land Cover Map 1990

Dataset documentation

Version 1.1, 8/10/2020

Version	Date	Updates
1.0	02/07/2020	Original release
1.1	08/10/2020	Doi's updated in Tables 5 & 6

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Please note: LCM1990 is a complex data set.

To help get the most from this data and to guard against inappropriate use it is important that you familiarise yourself with the information in this document.

Introduction

Land Cover Map 1990 (LCM1990) is provided as a range of data products to support the diverse requirements of the LCM user community. This report provides a brief introduction to key aspects of the LCM1990 data sets for users and potential users. This document only covers LCM1990 data products. For details about other Land Cover Maps please consult the appropriate dataset documents.

Background

Land Cover Map 1990 (LCM1990) is a parcel-based land cover map for the UK, created by classifying satellite data into 21 land cover classes. The classes are based on the UK Biodiversity Action Plan Broad Habitat definitions (Jackson, 2000). LCM1990 was created by classifying two-date composite images and is based on data from Landsat-5 (30m resolution). LCM1990 replaces the previous version of LCM1990 (known as LCMGB). Like LCM2015, it uses an updated version of the LCM2007 spatial framework. LCM1990, like LCM2007 and LCM2015 before it, is therefore constructed from polygons that reflect real world boundaries. This increases both its ease of interpretation for users and also its compatibility with other geospatial data sets.

The LCM spatial framework was derived from generalised digital cartography (Ordnance Survey MasterMap topographic layer (OSMM) for GB and Land & Property Services Large scale Vector for Northern Ireland), refined with rural payment boundary data (see Morton *et al.*, 2011 for details).

The new version of LCM1990 has been recreated with the same methods used to produce LCM2015 to maximise compatibility between the two products (Table 1). This was done to enable the creation of a 25 years of land cover change product for the UK (Rowland *et al.*, 2020a; 2020b).

Table 1. A comparison of the specifications of LCMs 1990, 2000, 2007 and 2015.

	Spatial framework	Consistent classes	Directly comparable
LCM1990	Yes	Yes	Yes
LCM2000	No	No – 26 classes	No
LCM2007	Yes	No – 23 classes	No
LCM2015	Yes	Yes	Yes

LCM1990 product specification

LCM1990 maps land cover (not land use)

LCM1990 maps **land cover** and whilst this may be synonymous with **land use** it will not be in all cases. For example, an arable crop cover denotes arable land use, but often land use cannot be inferred, as, for example, grass used for recreation looks very similar to that which is grazed.

LCM1990 is a stable, archived data set and as such each data set has a Digital Object Identifier (DOI)
The DOI's should be cited when referring to the data set in publications (see Citing LCM1990 (DOI's)).

LCM1990 sets a minimum mappable area of >0.5 ha

Parcels less than 0.5ha and linear features less than 20m were dissolved into the surrounding landscape during the production process.

LCM1990 classes

LCM1990 maps 21 classes (Table 2), which are based on the UK's terrestrial Broad Habitats (Jackson *et al.*, 2000). In some cases, the Broad Habitats can be reliably divided further; based on their spectral signatures, so:

- The *'Built-up Areas and Gardens'* Broad habitat is divided into 'Suburban' and 'Urban' classes.
- The *'Dwarf Shrub Heath'* is divided into 'Heather' and 'Heather grassland' classes.
- The *'Littoral Sediment'* Broad Habitat is divided into 'Littoral sediment' and 'Saltmarsh' (a Priority Habitat).

LCM1990 has unique object labelling

During the production process each parcel is given a unique label which is stored in the Geometry Id (gid) attribute. All users of the LCM1990 vector products will receive data containing this attribute. It is recommended that the gid attribute is retained within the LCM1990 data set and any developments of it. This will allow unambiguous communication between LCM1990 users.

LCM1990 has rich metadata

During the production of LCM1990; like LCM2007, LCM2000 and LCM2015 before it; information about processing has been retained where possible. The LCM1990 vector data set therefore has a rich set of metadata for each polygon. The polygon attributes provide details about the dominant class for the polygon, but also a breakdown of the number of pixels classified as each land cover class in the polygon and the mean probability for the polygon from the classification algorithm.

LCM1990 has uncertainty information

The Random Forest classifier produces an estimate of per-pixel probability. This is included as a mean per-polygon value in the vector and in the 25m raster.

LCM1990 product overview

LCM1990 is distributed in a range of data formats, and at a range of thematic and spatial resolutions to supports the diverse range of LCM applications. The 'core' product is the LCM1990 vector from which the 25m raster is derived. The 25m raster is then used to produce the 1km percentage cover products for both the 21 target classes and the 10 aggregate classes (Table 2), which in turn are used to create the dominant cover products. Notes on each of the LCM classes are included in Appendix 1.

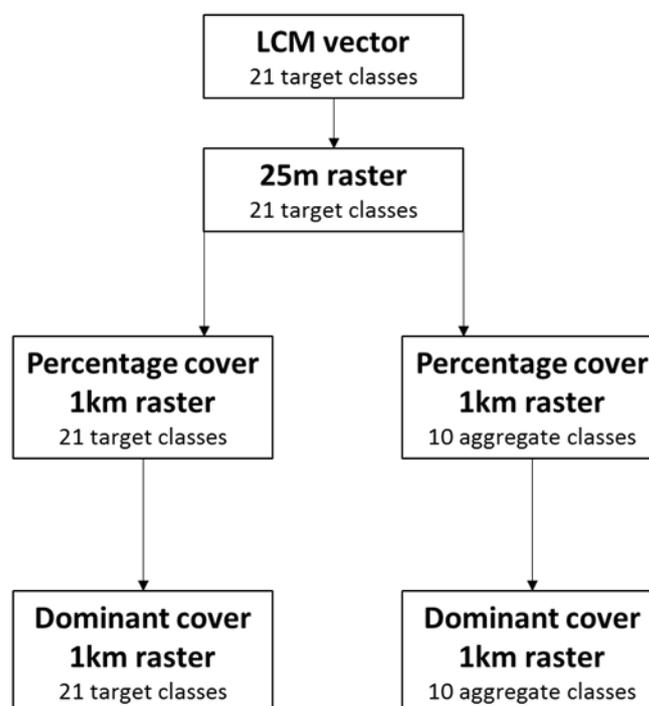


Figure 1. LCM1990 data products.

Table 2. Relationship between Aggregate classes, Broad Habitat and LCM1990 classes. Green shading highlights Broad Habitats as documented by JNCC (Jackson, 2000) and summarised in Appendix 2. ^{1,2} Aggregate class number and LCM1990 class number used for raster data sets.

Aggregate class	Aggregate class number ¹	Broad Habitat	LCM1990 target class	LCM1990 target class number ²
Broadleaf woodland	1	'Broadleaved, Mixed and Yew Woodland'	Broadleaved woodland	1
Coniferous woodland	2	'Coniferous Woodland'	'Coniferous Woodland'	2
Arable	3	'Arable and Horticulture'	'Arable and Horticulture'	3
Improved grassland	4	'Improved Grassland'	'Improved Grassland'	4
Semi-natural grassland	5	'Neutral Grassland'	'Neutral Grassland'	5
		'Calcareous Grassland'	'Calcareous Grassland'	6
		'Acid Grassland'	Acid grassland	7
		'Fen, Marsh and Swamp'	'Fen, Marsh and Swamp'	8
Mountain, heath, bog	6	'Dwarf Shrub Heath'	Heather	9
			Heather grassland	10
		'Bog'	'Bog'	11
		'Inland Rock'	'Inland Rock'	12
Saltwater	7	Saltwater	Saltwater	13
Freshwater	8	Freshwater	Freshwater	14
Coastal	9	'Supra-littoral Rock'	'Supra-littoral Rock'	15
		'Supra-littoral Sediment'	'Supra-littoral Sediment'	16
		'Littoral Rock'	'Littoral Rock'	17
		'Littoral Sediment'	Littoral sediment	18
Built-up areas and gardens	10	'Built-up Areas and Gardens'	Saltmarsh	19
			Urban	20
			Suburban	21

Example datasets

Figure 2 provides illustrations of the data sets available for Land Cover Map 2015 and the level of detail associated with each product. Spatially the vector data set and the 25m raster data set are quite similar, however the advantage of the vector data set is that each polygon has a set of metadata attached. The disadvantage of the vector is that this increases the file size and may make processing unwieldy for many applications/users. The 25m raster data set maybe useful in such circumstances, as it provides the same land cover detail, but without all of the metadata information and the polygon boundaries; this is more appropriate for many applications. The 1km data sets are typically used for modelling the whole of the UK in conjunction with other data, such as meteorological data or species distribution data. They are created by calculating the percentage of the 1km square covered by each class (e.g. urban) based on the distribution of the class (e.g. urban) in the 25m raster data set. Figure 3 shows the 1km aggregate percentage cover for 'Built-up areas and gardens' across the UK.

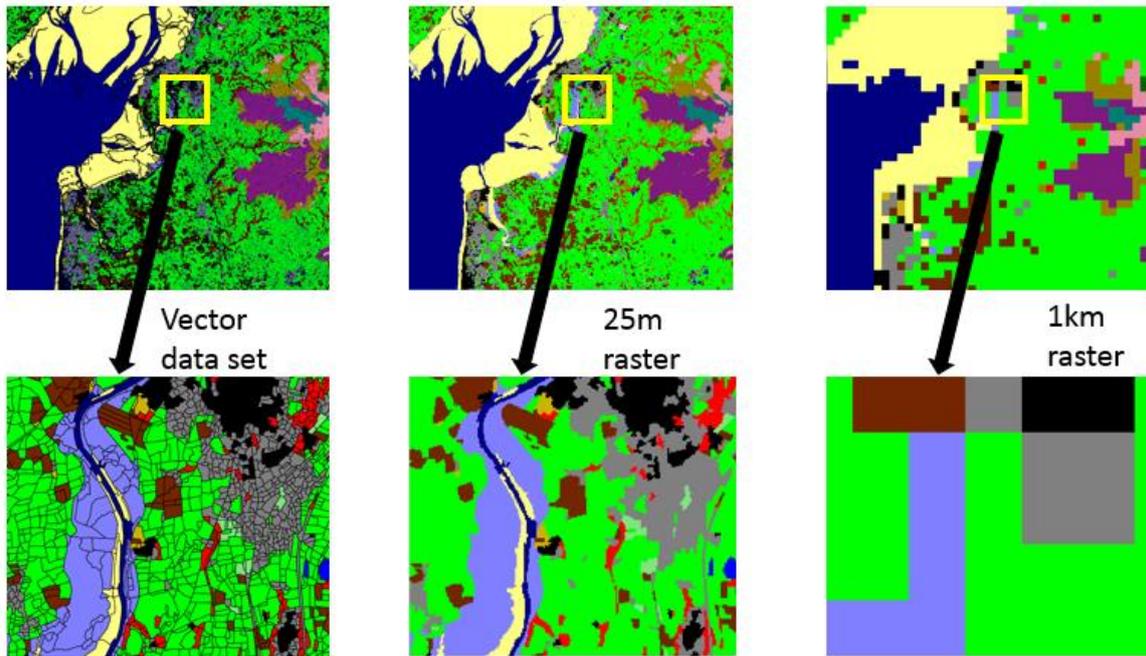


Figure 2. Comparison of the level of spatial detail in the vector data set, 25m raster data set and 1km dominant cover raster data set for an area ~ 35km x 35km (top images) and ~ 6km x 6km (lower images). (LCM2015 is used for illustrative purposes). © UKCEH 2017. © Crown Copyright 2007. Ordnance Survey Licence number 100017572.

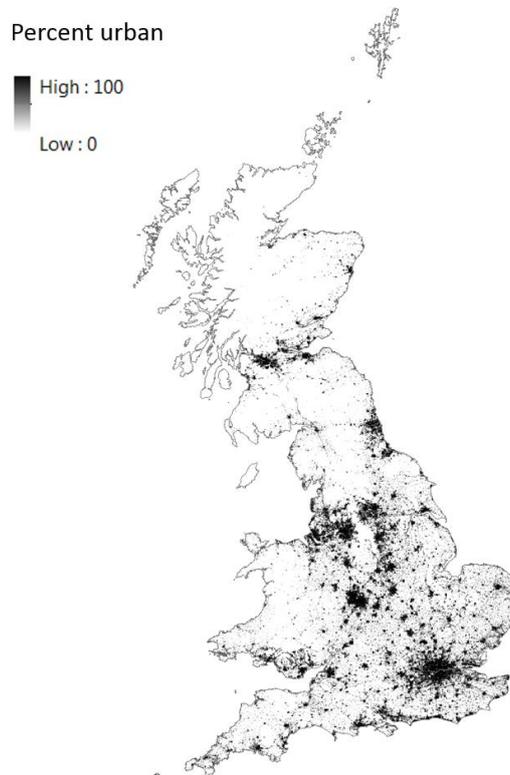


Figure 3. Map showing the 1km percentage cover aggregate product for Built-up areas and gardens. (LCM2015 is used for illustrative purposes). © UKCEH, 2017.

Vector data set

The vector data product is provided as polygons with each one having a list of attributes attached to it. The eight key attributes include land cover class (as text and integer), source image, uncertainty information, the number of pixels recorded for each class and the proportion of the polygon classified as the dominant class (Table 3). The vector data set contains 6.7 million polygons for Great Britain and 0.9 million for Northern Ireland.

Table 3. Description of the key attributes of the LCM1990 vector data set.

Attribute	Description
gid	Unique parcel identifier (geometry identifier) for each parcel.
_hist	This attribute gives a list of the classes present in the polygon, with the class number followed by the number of pixels of that class type. For example, a polygon with '20:1, 21:9' means 1 pixel of class 20 and 9 pixels of class 21.
_mode	RECOMMENDED FOR DISPLAY. This attribute gives the LCM1990 class as an integer code from 1-21 (see Table 2). Note this is often referred to as the LCM1990 target class (see Appendix 3 for standard LCM colour mapping).
_purity	Percentage of the polygon covered by the modal class (_mode)
_conf	Confidence – mean per polygon vote number from Random Forest, scaled between 0-100, where 0 is low confidence and 100 is high confidence.
_stdev	Standard deviation of the uncertainty.
_n	Number of pixels in polygon
cmp	The number of the composite image that the classification is derived from; 99 signifies manual infill (see Appendix 4 for details of composite images).

Raster data sets

The raster data were derived from the vector dataset to produce a 25m raster and a series of 1km products. Great Britain and Northern Ireland are provided in separate data sets to allow for their different projections. Not all applications need the thematic resolution of the complete set of LCM1990 classes, so LCM1990 has a defined set of Aggregate classes, based on merging LCM1990 classes (Table 2). The Aggregate classes are used for the 1km raster products.

25m raster

This is supplied as a 3-band raster, where band 1 is the LCM1990 classification (dominant) class per-polygon, band 2 is the mean per-polygon confidence (based on the vote number) from the Random Forest classifier and band 3 is the percentage of the polygon covered by the modal class. The relationship between the band 1 pixel value and corresponding LCM1990 class is shown in Table 2, with details about the extent of the data set and other metadata in Table 4.

1km raster

The 1km products for LCM1990 were created by summarising the LCM1990 25m raster data set to produce percentage cover for each class and to identify the dominant (most widespread) class in each 1km pixel. The products at 1km are:

- Dominant cover at 1km for LCM1990 Target classes (1-band)
- Dominant cover at 1km for LCM1990 Aggregate classes (1-band)
- Percentage cover at 1km for LCM1990 Target classes (21 bands)

- Percentage cover at 1km for LCM1990 Aggregate classes (10 bands)

For the percentage cover products, integer values are reported, so the rounding of each value means that in some cases the sum of all the layers may be slightly above or below 100. Around the coast the values will be sum to less than 100 reflecting the proportion of mapped area in the 1km square. One 1km x 1km pixel covers the area of 1600 25m pixels, consequently, a land cover type has to cover more than sixteen 25m-pixels to exceed 1% of the 1km pixel area and hence have a percentage cover value in the 1km percentage cover data sets.

Table 4. Metadata information for the LCM1990 25m and 1km raster data sets. Note: Different software packages define coordinates from different parts of the pixel. The values in Table 4 refer to the south-west corner of the lower left pixel. The data are distributed as uncompressed GeoTiffs, so file sizes may be reduced considerably by saving them as a format that allows compression.

	Great Britain		Northern Ireland	
	25m	1km	25m	1km
Pixel size				
Columns / Width (pixels)	28000	700	7600	190
Rows / Height (pixels)	52000	1300	6400	160
Lower left easting (m)	0	0	180000	180000
Lower left northing (m)	0	0	300000	300000
Pixel size (m)	25	1000	25	1000
Data type	Unsigned, uncompressed 8-bit GeoTiff			
Coordinate system	British National Grid		TM75 Irish Grid	
EPSG	27700 (https://epsg.io/27700)		29903 (https://epsg.io/29903)	

Citing LCM1990 (DOI's)

All LCM1990 products have individual DOI's, so you can cite the data in the same way that you cite other sources of information, such as journal articles. Citing the DOI's enables methods to be clear and repeatable as well as enabling better understanding of the levels of usage of different LCM1990 products, DOI's are also increasingly required by scientific journals. The DOI's are given for Great Britain (Table 5) and for Northern Ireland (Table 6).

When using the DOI in publications, please include the author(s) and date within the text and the full DOI citation in the references section.

For example, '(Rowland et al., 2020)' in the text and relevant reference:

'Rowland, C.S.; Marston, C.G.; Morton, R.D.; O'Neil, A.W. (2020). Land Cover Map 1990 (vector, GB). NERC Environmental Information Data Centre. <https://doi.org/10.5285/304a7a40-1388-49f5-b3ac-709129406399>' in the references.

For more information about data citation and DOIs, see <http://eidc.ceh.ac.uk/citing-data>

Table 5. Digital Object Identifier (doi) for LCM1990 products for Great Britain.

Product	DOI
GB vector	Rowland, C.S.; Marston, C.G.; Morton, R.D.; O’Neil, A.W. (2020). Land Cover Map 1990 (vector, GB). NERC Environmental Information Data Centre. https://doi.org/10.5285/304a7a40-1388-49f5-b3ac-709129406399
GB 25m raster	Rowland, C.S.; Marston, C.G.; Morton, R.D.; O’Neil, A.W. (2020). Land Cover Map 1990 (25m raster, GB) v2. NERC Environmental Information Data Centre. https://doi.org/10.5285/1be1912a-916e-42c0-98cc-16460fac00e8
GB 1km percentage cover target classes	Rowland, C.S.; Marston, C.G.; Morton, R.D.; O’Neil, A.W. (2020). Land Cover Map 1990 (1km percentage target class, GB) v2 NERC Environmental Information Data Centre. https://doi.org/10.5285/bb381b5b-d44e-4dbd-a9d1-efffd4c3e4a8
GB 1km dominant cover target classes	Rowland, C.S.; Marston, C.G.; Morton, R.D.; O’Neil, A.W. (2020). Land Cover Map 1990 (1km dominant target class, GB) v2 NERC Environmental Information Data Centre. https://doi.org/10.5285/f5e3bd00-efd0-4dc6-a454-aa597d84764a
GB 1km percentage cover aggregate classes	Rowland, C.S.; Marston, C.G.; Morton, R.D.; O’Neil, A.W. (2020). Land Cover Map 1990 (1km percentage aggregate class, GB) NERC Environmental Information Data Centre. https://doi.org/10.5285/c7195a20-7943-4d5d-9f6e-c9fead472dde
GB 1km dominant cover aggregate classes	Rowland, C.S.; Marston, C.G.; Morton, R.D.; O’Neil, A.W. (2020). Land Cover Map 1990 (1km dominant aggregate class, GB) NERC Environmental Information Data Centre. https://doi.org/10.5285/84c07c67-88a4-439a-a339-b0577afd3886

Table 6. Digital Object Identifier (doi) for LCM1990 products for Northern Ireland.

Product	DOI
NI vector	Rowland, C.S.; Marston, C.G.; Morton, R.D.; O’Neil, A.W. (2020). Land Cover Map 1990 (vector, N. Ireland). NERC Environmental Information Data Centre. https://doi.org/10.5285/d6a3588b-23a8-4715-88e9-e21ab0060727
NI 25m raster	Rowland, C.S.; Marston, C.G.; Morton, R.D.; O’Neil, A.W. (2020). Land Cover Map 1990 (25m raster, N. Ireland). NERC Environmental Information Data Centre. https://doi.org/10.5285/d446589e-478f-4206-80ed-38a5ff4a7dc0
NI 1km percentage cover target classes	Rowland, C.S.; Marston, C.G.; Morton, R.D.; O’Neil, A.W. (2020). Land Cover Map 1990 (1km percentage target class, N. Ireland) NERC Environmental Information Data Centre. https://doi.org/10.5285/4a5e720f-5f1d-4e96-8e34-ae32c668c613
NI 1km dominant cover target classes	Rowland, C.S.; Marston, C.G.; Morton, R.D.; O’Neil, A.W. (2020). Land Cover Map 1990 (1km dominant target class, N. Ireland) NERC Environmental Information Data Centre. https://doi.org/10.5285/d33593d7-5c4d-419e-924c-b341847fd6ae
NI 1km percentage cover aggregate classes	Rowland, C.S.; Marston, C.G.; Morton, R.D.; O’Neil, A.W. (2020). Land Cover Map 1990 (1km percentage aggregate class, N. Ireland) NERC Environmental Information Data Centre. https://doi.org/10.5285/1278d7b5-da47-46b5-b1a6-049e726425a7
NI 1km dominant cover aggregate classes	Rowland, C.S.; Marston, C.G.; Morton, R.D.; O’Neil, A.W. (2020). Land Cover Map 1990 (1km dominant aggregate class, N. Ireland) NERC Environmental Information Data Centre. https://doi.org/10.5285/380f49e5-9448-4d26-b832-fe176d3a1978

Map projection

The LCM1990 vector and raster data sets for Great Britain and Northern Ireland are in the British National Grid and Irish National Grid projections respectively (see Table 4 for details).

Data access

The LCM1990 25m and 1km raster data sets are available via the CEH Environmental Information Platform <https://eip.ceh.ac.uk/>

The full vector product is available under licence on request from CEH. For details on access see <https://www.ceh.ac.uk/services/land-cover-map-1990> or contact spatialdata@ceh.ac.uk for further details. Please note that licence fees may apply for some users and some applications.

Quality Assurance

The UK CEH Land Cover Maps are created using defined methods and code and are created by trained and experienced staff.

A series of QA checks are run against the data sets to ensure that they meet the product specification as described in this document. These include the following: checks that the projections are correct, checks to ensure the products are spatially complete, a check that there is a modal class in all polygons (vector products), checks that headings match the data set documentation (vector products), a check that all values fall in range 0-100 (raster percentage products, 1km) and a check that pixel sizes are correct (raster products).

The Land Cover Map parcel framework is based on 2007 Ordnance Survey Mastermap® data. Field boundary changes are relatively infrequent and so the effect on overall mapping accuracy is quite limited.

A full validation exercise has been carried out in order to assess the accuracy of the maps in comparison to other available datasets (for example the UK CEH Countryside Survey, National Forest Inventory data and a core set of LCM validation points). The results of this will form a separate publication.

Further Information

Further information about LCM1990 is available at:

<https://eip.ceh.ac.uk/lcm/lcmdata>

Queries should be addressed to: spatialdata@ceh.ac.uk

The LCM1990 journal paper is currently in preparation and will contain additional information.

Acknowledgement

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References

Jackson D.L., (2000). *Guidance on the interpretation of the Biodiversity Broad Habitat Classification (terrestrial and freshwater types): Definitions and the relationship with other classifications*. JNCC Report 307, 73pp. ISSN 0963 8091 (available online at: <http://www.jncc.gov.uk/page-2433>).

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Rowland, C.S.; Marston, C.G.; Morton, R.D.; O'Neil, A.W. (2020a). Land Cover Change 1990-2015 (25m raster, GB). NERC Environmental Information Data Centre. <https://doi.org/10.5285/07b6e5e9-b766-48e5-a28c-5b3e35abecc0>

Rowland, C.S.; Marston, C.G.; Morton, R.D.; O'Neil, A.W. (2020b). Land Cover Change 1990-2015 (25m raster, N. Ireland). NERC Environmental Information Data Centre. <https://doi.org/10.5285/a747aa7a-c875-42e1-ac31-984f6571f446>

Appendix 1. Comment on classes as mapped in LCM1990

(See also Appendix 2 for a summary of JNCC Broad Habitat definitions)

LCM1990 class	Brief Review
Broadleaved woodland	<p>Broadleaved woodlands are characterised by stands >5m high with tree cover >20%; scrub (<5m) requires cover >30% for inclusion in this BH. Such fine distinctions cannot be made through remote sensing. Open-canopy woodland (stands with trees <50%) is a particular problem, albeit occurring relatively rarely, and may not often be mapped consistently, due to the dominance of the non-woodland plants. Stands with near-closed canopies can be interpreted easily in the field and pure examples can normally be found for training the classifier. Broadleaved evergreen trees (part of this BH) rarely occur in stands >1ha (an area large enough to create suitable training areas appropriate for classification).</p> <p>Where individual stands of broad-leaved or evergreen trees exceeded the minimum mappable unit, they were treated as separate blocks within the woodland; in many parts of the UK, truly 'mixed woodlands' as opposed to those with mosaic-blocks of broadleaved and coniferous trees, are unusual.</p> <p>Mixed woodland – according to the JNCC Broad Habitat definitions a woodland with > 20% Deciduous woodland is classified as mixed woodland and as such recorded under the 'Broadleaf, Mixed and Yew Woodland' class (see also Appendices 1 & 2). For LCM2007 object-based classification methods were applied and mixed woodland stands were selected and used for training. In LCM1990 (and LCM2015), pure stands of Coniferous or Broadleaf woodland were chosen for training, with individual pixels being classified. The pixels are then summarised at the polygon level, with the <code>_mode</code> (Table 3) being assigned as the polygon label. This means that some mixed woodland with > 20% Broadleaf cover is likely to be assigned to the 'Coniferous Woodland' class, rather than the Broadleaved woodland class, users interested in investigating this can explore the <code>_hist</code> attribute in the vector product.</p>
'Coniferous Woodland'	<p>'Coniferous Woodland' includes semi-natural stands and plantations, with cover >20%. The recognition of coniferous woodland is generally straightforward. Rare examples of open canopy semi-natural pinewoods may have been classified according to the dominant understorey class. The BH includes new plantation and recently felled areas (this is a class where the BH definition is based on land use, i.e. forestry, rather than cover). New plantations, predominantly heather and/or grass, for example, are recorded as such by the spectral classification of image data. New plantations are only consistently recorded as conifers when tree cover is sufficient to strongly influence the reflectance. LCM1990 includes newly felled areas. Once they are fully recolonised by rough grass, heath or scrub, they are recorded according to that cover. Deciduous larch is discernible from other deciduous trees and is generally correctly included with other conifers.</p>
'Arable and Horticulture'	<p>This Broad Habitat includes annual crops, perennial crops such as berries and orchards and freshly ploughed land. Orchards with a ground flora are hard to distinguish.</p>
'Improved Grassland'	<p>Improved grassland is distinguished from semi-natural grasslands based on its higher productivity, lack of winter senescence and location and/or context. In some</p>

	<p>cases heavy grazing can cause mis-classification with, arable land or semi-natural grassland.</p> <p>Some confusion occurs between '<i>Improved Grassland</i>' and '<i>Calcareous Grassland</i>' and '<i>Neutral Grassland</i>', as '<i>Calcareous Grassland</i>' and '<i>Neutral Grassland</i>' are often very productive grassland and so spectrally very similar to '<i>Improved Grassland</i>'.</p>
' <i>Neutral Grassland</i> '	For LCM1990 ' <i>Neutral Grassland</i> ' is mapped spectrally, however, the inclusion of ancillary layers for slope and distance to rivers is expected to improve the classification of ' <i>Neutral Grassland</i> ' on flood plains. Areas identified as ' <i>Neutral Grassland</i> ' by LCM should probably be treated as having the potential to be ' <i>Neutral grassland</i> ' as for a conclusive classification field survey is required to make a determination based on botanical composition. ' <i>Neutral Grassland</i> ' also includes semi-improved grasslands managed for silage, hay or pasture (Jackson, 2000), which in LCM1990 will often be classified as ' <i>Improved Grassland</i> '.
' <i>Calcareous Grassland</i> '	For LCM1990 ' <i>Calcareous Grassland</i> ' is mapped spectrally, however, the inclusion of ancillary layers for slope is expected to improve the classification of ' <i>Calcareous Grassland</i> ' in some cases. Areas identified as ' <i>Calcareous Grassland</i> ' by LCM should probably be treated as having the potential to be ' <i>Calcareous Grassland</i> ' as for a conclusive classification field survey is required to make a determination based on botanical composition.
' <i>Acid Grassland</i> '	For LCM1990, ' <i>Acid Grassland</i> ' is mapped spectrally.
	Bracken can be mapped using LCM1990 methods, but it depends on image timing and suitable training areas (bracken often fails to offer stands sufficiently extensive for classification and training), so for consistency it is assigned to ' <i>Acid Grassland</i> '.
Note about grassland classes	The comparisons between previous LCM data and other data sets (for example the ground reference polygons and Countryside Survey in 2007 Broad Habitat maps) (Morton <i>et al.</i> , 2011), have shown that ' <i>Neutral Grassland</i> ' and ' <i>Calcareous Grassland</i> ' were often mis-classified as ' <i>Improved Grassland</i> '. Some users may wish to aggregate the grassland classes together, if this is appropriate for their needs.
'Heather' and 'Heather grassland'	' <i>Dwarf Shrub Heath</i> ' is divided into two classes, depending on the density of Heather, producing 'Heather' and 'Heather grassland' classes respectively. This is similar to LCM1990s and LCM2000s Open and Dense Shrub Heath classes.
(together form the ' <i>Dwarf Shrub Heath</i> ' Broad Habitat)	Note: the Land Cover Maps typically show confusion over the separation of ' <i>Bog</i> ' and ' <i>Dwarf Shrub Heath</i> ', however, this only affects the separation of these two BHs and they are often difficult to separate in the field.
	Note, the Broad Habitat classification treats ericaceous vegetation on peat >0.5m depth as ' <i>Bog</i> '.
' <i>Fen, Marsh and Swamp</i> '	' <i>Fen, Marsh and Swamp</i> ' includes fen, fen meadows, rush pasture, swamp, flushes and springs. From a remote sensing perspective ' <i>Fen, Marsh and Swamp</i> ' is problematic as it can be comprised of a wide range of land cover types and many patches of Fen are below the LCM1990 MMU. The small size of ' <i>Fen, Marsh and Swamp</i> ' patches, plus their typically mosaic nature make it difficult to find representative areas of sufficient size to conduct a spectral classification. Consequently, ' <i>Fen, Marsh and Swamp</i> ' will be underestimated by LCM1990.
' <i>Bog</i> '	' <i>Bog</i> ' includes ericaceous, herbaceous and mossy swards in areas with a peat depth >0.5m. ' <i>Bog</i> ' forms part of an ecological continuum covering ' <i>Acid Grassland</i> ', ' <i>Dwarf Shrub Heath</i> ' and some types of ' <i>Fen, Marsh and Swamp</i> ' and the separation of these habitats can be difficult, as the surface vegetation (i.e. land cover) maybe

	very similar and the division rests on the depth of peat. The division in the field can account for species presence, plus peat depth, but for LCM1990 the division is based on the spectral data and presumably also the slope data.
Saltwater	Saltwater is mapped to a limited extent around the coastline of the UK. The extent is constrained by the extent of the digital cartography, which covers land and tidal areas, but not sea.
Freshwater	This is based on merging two freshwater BHs (<i>Standing Open Water and Canals</i> and <i>Rivers and Streams</i>), as they cannot be reliably separated from each other using the methods and data used for LCM1990. In many cases small and/or narrow water bodies fall below the MMU. Water bodies >0.5ha are readily mapped, as are very wide rivers (>50m). The main exceptions are temporary water bodies, especially in quarries where the water body extent differs between the two images and differs from the associated polygon shape. Water in some quarries is strongly affected by the minerals in the rock and can result in strange water colours that maybe misclassified.
<i>'Inland Rock'</i>	This Broad Habitat type covers both natural and artificial exposed rock surfaces which are >0.25ha, such as inland cliffs, caves, screes and limestone pavements, as well as various forms of excavations and waste tips such as quarries and quarry waste. To be classified as <i>'Inland Rock'</i> the rock has to be the dominant spectral signature.
<i>'Urban'</i> and <i>'Suburban'</i> (together form the <i>'Built-up Areas and Gardens'</i> Broad Habitat)	Within the <i>'Built-up Areas and Gardens'</i> Broad Habitat LCM1990 recognises two categories that can be determined reliably: <i>'Urban'</i> and <i>'Suburban'</i> . <i>'Urban'</i> includes dense urban, such as town and city centres, where there is typically little vegetation. <i>'Urban'</i> also includes areas such as dock sides, car parks and industrial estates. <i>'Suburban'</i> includes suburban areas where the spectral signature is a mix of urban and vegetation signatures.
<i>'Supra-littoral Rock'</i>	Features that may be present in this coastal class include vertical rock, boulders, gullies, ledges and pools. Very limited areas are mappable using satellite remote sensing.
<i>'Supra-littoral Sediment'</i>	This class includes sand-dunes, which are reliably mapped in this class. Areas of coastal sand may be confused between this class and the <i>'Littoral sediment'</i> class.
<i>'Littoral Rock'</i>	These classes are those in the maritime zone on a rocky coastline. They are generally more extensive than supra-littoral rock and thus more readily mappable from satellite images.
<i>'Littoral sediment'</i> and <i>'Saltmarsh'</i> (together form the <i>'Littoral Sediment'</i> Broad Habitat)	Littoral sediment is mapped as two classes: <i>'Saltmarsh'</i> and <i>'Littoral sediment'</i> . Saltmarsh is a Priority Habitat and of sufficient extent and spectral distinction to be mapped consistently. The remaining <i>'Littoral Sediment'</i> is mapped spectrally, although there may be some confusion with the <i>'Supra-littoral sediment'</i> class.

Appendix 2: Biodiversity Action Plan (BAP) Broad Habitats

This section (reproduced from Morton *et al.*, 2011) provides a brief summary of the JNCC definitions of the Broad Habitats and is based on Jackson (2000).

There is some duplication of material for some classes between Appendix 2 and Appendix 1, however the intention is to provide users with the key information they require to understand the LCM1990 classes and the Broad Habitat definitions they are based on.

Note: class numbers here are JNCC's Broad Habitat class numbers, not LCM1990 numbers.

Classes 3, 9, 13, 14, 15, 22 below are not covered by the LCM

1. Broadleaved, Mixed and Yew Woodland

This Broad Habitat is characterised by vegetation dominated by trees >5m high when mature, with tree cover >20%. Scrub (<5m) requires cover >30% for inclusion in this Broad Habitat. It includes stands of both native and non-native broadleaved trees and yew. Woodlands dominated by coniferous species but with >20% cover by deciduous species are included in this category. Areas of fen woodland dominated by species such as willow (*Salix* spp.), alder (*Alnus glutinosa*) or birch (*Betula* spp.) are also included.

2. Coniferous Woodland

This Broad Habitat is characterised by vegetation dominated by trees >5m high when mature, which forms a canopy having a cover of >20%. 'Coniferous Woodland' includes semi-natural stands and plantations and includes both native and non-native coniferous trees.

3. Boundaries and Linear Features

This Broad Habitat type covers a range of linearly arranged landscape features such as hedgerows, lines of trees, walls, stone and earth banks, grass strips and dry ditches. These features are not mapped by LCM2007 as they are generally too narrow to be reliably captured from the satellite images. It is included here as its inclusion in Countryside Survey is relevant for the Comparison between LCM2007 and Countryside Survey in Chapter 4.

4. Arable and Horticulture

This Broad Habitat includes annual crops, perennial crops, woody crops, intensively managed commercial orchards, commercial horticultural land (such as nurseries, commercial vegetable plots and commercial flower growing areas), freshly-ploughed land, annual leys, rotational set-aside and fallow.

5. Improved Grassland

'Improved Grassland' is characterised by vegetation dominated by a few fast-growing grasses such as *Lolium* spp., and also white clover (*Trifolium repens*), on fertile, neutral soils. Improved Grasslands are typically either managed as pasture or mown regularly for silage production or in non-agricultural contexts for recreation and amenity purposes.

6. Neutral Grassland

This Broad Habitat type is characterised by vegetation dominated by grasses and herbs on a range of neutral soils usually with a pH of between 4.5 and 6.5. It includes enclosed dry hay meadows and pastures, together with a range of grasslands which are periodically inundated with water or permanently moist.

7. Calcareous Grassland

'*Calcareous Grassland*' is characterised by vegetation dominated by grasses and herbs on shallow, well-drained soils which are rich in bases (principally calcium carbonate) formed by the weathering of chalk and other types of limestone or base-rich rock. Soil pH tends to be high (>6) although it may be as low as 5.

8. Acid Grassland

'*Acid Grassland*' is characterised by vegetation dominated by grasses and herbs on a range of lime-deficient soils which have been derived from acidic bedrock or from superficial deposits such as sands and gravels. Such soils usually have a low base status, with a pH of <5.5.

9. Bracken

This Broad Habitat type covers areas dominated by a continuous canopy cover of bracken (*Pteridium aquilinum*) at the height of the growing season. It does not include areas with scattered patches of bracken or areas of bracken which are >0.25ha which are included in the Broad Habitat type with which they are associated.

10. Dwarf Shrub Heath

'*Dwarf Shrub Heath*' is characterised by vegetation that has >25% cover of plant species from the heath family (ericoids) or dwarf gorse *Ulex minor*. It generally occurs on well-drained, nutrient-poor, acid soils. This habitat type does not include dwarf shrub dominated vegetation in which species characteristic of peat-forming vegetation such as cotton-grass *Eriophorum* spp. and peat-building *sphagna* are abundant, or that occurs on deep peat (>0.5m) as these are included in the '*Bog*' Broad Habitat type.

11. Fen, Marsh and Swamp

This habitat includes fen, flushes, springs, fen meadows, rush pasture and swamp. Fens are peatlands which receive water and nutrients from groundwater and surface run-off, as well as from rainfall. Flushes are associated with lateral water movement, and springs with localised upwelling of water. Marsh is a general term usually used to imply waterlogged soil; it is used more specifically here to refer to fen meadows and rush-pasture communities on mineral soils and shallow peats. Swamps are characterised by tall emergent vegetation. Reedbeds (i.e. swamps dominated by stands of common reed *Phragmites australis*) are also included in this type. Apart from rush pasture, examples of this Broad Habitat are relatively rare.

12. Bog

This Broad Habitat type covers wetlands that support vegetation that is usually peat-forming and which receive mineral nutrients principally from precipitation rather than ground water. This is referred to as ombrotrophic (rain-fed) mire. The Bog Broad Habitat includes ericaceous, herbaceous and mossy swards in areas with a peat depth >0.5m.

13. Standing Open Water and Canals

This Broad Habitat type includes natural systems such as lakes, meres and pools, as well as man-made waters such as reservoirs, canals, ponds and gravel pits.

14. Rivers and Streams

The '*Rivers and Streams*' Broad Habitat type covers rivers and streams from bank top to bank top, or where there are no distinctive banks or banks are never overtopped, it includes the extent of the mean annual flood.

15. Montane

The '*Montane Habitats*' category includes a range of vegetation types that occur exclusively in the montane zone such as prostrate dwarf shrub heath, snow-bed communities, sedge and rush heaths, and moss heaths. The distinction between the sub-montane and montane zone is often blurred and the two usually merge through a band of transitional vegetation.

16. Inland Rock

This Broad Habitat type covers both natural and artificial exposed rock surfaces which are >0.25ha, such as inland cliffs, caves, screes and limestone pavements, as well as various forms of excavations and waste tips such as quarries and quarry waste.

17. Built-Up Areas and Gardens

This Broad Habitat type covers urban and rural settlements, farm buildings, caravan parks and other man-made built structures such as industrial estates, retail parks, waste and derelict ground, urban parkland and urban transport infrastructure. It also includes domestic gardens and allotments. This type does not include amenity grassland which should be included in the '*Improved Grassland*' category.

18. Supralittoral Rock

'*Supralittoral Rock*' occurs above the high water mark, in areas influenced by wave splash and sea-spray. Features that may be present include vertical rock, boulders, gullies, ledges and pools, depending on the wave exposure of the site and its geology.

19. Supralittoral Sediment

'*Supralittoral Sediment*' occurs above the high water mark, but in areas influenced by wave splash and sea-spray. Includes shingle beaches, sand dunes and machair.

20. Littoral Rock

The geology and wave exposure of the shore influence the form of Littoral Rock habitats, which can be as varied as vertical rock, shore platforms, boulder shores, or rocky reefs surrounded by areas of sediment. In general, '*Littoral Rock*' tends to be colonised by algae in wave-sheltered conditions, and by limpets, barnacles and mussels as wave-exposure increases.

21. Littoral Sediment

Areas of '*Littoral Sediment*' are widespread around the UK forming features such as beaches, sand banks, and intertidal mudflats. A large proportion of this habitat occurs in estuaries and inlets where it can cover extensive areas. Saltmarsh is included within this Broad Habitat.

22. Inshore Sublittoral Sediment

All areas of sea and estuary class are assumed to be '*Inshore Sublittoral Sediment*'. It is defined as within six nautical miles of the shoreline by JNCC.

Appendix 3: Recipe for standard LCM colour mapping.

LCM1990 class	LCM1990 class number	Red	Green	Blue
Broadleaved woodland	1	255	0	0
<i>'Coniferous Woodland'</i>	2	0	102	0
<i>'Arable and Horticulture'</i>	3	115	38	0
<i>'Improved Grassland'</i>	4	0	255	0
<i>'Neutral Grassland'</i>	5	127	229	127
<i>'Calcareous Grassland'</i>	6	112	168	0
Acid grassland	7	153	129	0
<i>'Fen, Marsh and Swamp'</i>	8	255	255	0
Heather	9	128	26	128
Heather grassland	10	230	140	166
<i>'Bog'</i>	11	0	128	115
<i>'Inland Rock'</i>	12	210	210	255
Saltwater	13	0	0	128
Freshwater	14	0	0	255
<i>'Supra-littoral Rock'</i>	15	204	179	0
<i>'Supra-littoral Sediment'</i>	16	204	179	0
<i>'Littoral Rock'</i>	17	255	255	128
Littoral sediment	18	255	255	128
Saltmarsh	19	128	128	255
Urban	20	0	0	0
Suburban	21	128	128	128

Appendix 4: Composite images used in LCM1990

Composite Name	Path	Row	Date 1	Date 2
a1	202	25	25/07/1990	27/11/1989
a2	202	24	06/05/1990	10/12/1988
a3	201	23	15/07/1989	21/02/1989
a4	201	24	15/07/1989	21/02/1989
a5	201	25	28/05/1989	21/02/1989
a6	202	23	06/05/1990	10/12/1988
a7	203	23	01/08/1990	30/10/1988
a8	203	24	01/08/1990	30/10/1988
a9	203	25	01/08/1990	30/10/1988
a10	204	20	18/06/1989	09/11/1989
a11	202	22	06/07/1989	27/11/1989
a12	204	22	04/07/1989	25/11/1989
a13	204	23	04/07/1989	06/09/1989
a14	204	24	04/07/1989	06/09/1989
a16	205	22	11/07/1989	03/11/1990
a17	206	18	02/05/1990	02/07/1989
a18	206	19	02/05/1990	08/02/1989
a19	206	20	02/05/1990	08/02/1989
a20	206	21	02/07/1989	02/05/1990
a21	207	19	22/05/1989	11/09/1989
a22	207	20	22/05/1989	11/09/1989
a23	207	22	06/05/1989	10/10/1988
a24	204	21	04/07/1989	04/05/1990
a25	205	21	11/07/1989	29/09/1989
a27	205	22	11/07/1989	02/05/1990
a28	204	24	18/06/1989	04/05/1990
a29	204	23	04/07/1989	15/01/1990
a30	205	23	14/07/1990	25/04/1990
a31	202	24	24/09/1989	06/05/1990
a32	204/203	21	14/05/1988	14/10/1988
a33	204/205	22	14/05/1988	29/09/1989
a34	206	22	18/07/1989	02/05/1990
a35	207/206	21/22	06/05/1989	02/05/1990
a36	204/205	24/25	08/05/1989	28/11/1990
a37	204	25	18/06/1989	06/09/1989
i2	201	24	15/07/1989	-
i5	202	24	06/05/1990	-
i6	202	25	25/07/1990	-
i7	203	23	01/08/1990	-
i8	203	24	01/08/1990	-
i9	203	25	01/08/1990	-
i12	204	22	04/07/1989	-
i13	204	23	04/07/1989	-
i16	204	24	18/06/1989	-

i18	202	22	06/07/1989	-
i19	204	25	04/05/1990	-
i21	206	18	02/05/1990	-
i23	206	19	02/05/1990	-
i24	206	20	02/05/1990	-
i25	206	21	02/05/1990	-
i28	201	23	21/02/1989	-
i29	201	24	21/02/1989	-
i34	203	23	30/10/1988	-
i39	204	22	04/07/1989	-
i43	205	18	06/04/1989	-
i52	207	22	10/10/1988	-
i53	206	22	02/05/1990	-
i63	204	24	04/05/1990	-
i64	208	19-20	02/11/1988	-
i66	204	23	23/07/1990	-
i67	204	20	04/07/1989	-
i68	205	20	29/09/1989	-
i69	207	20	01/09/1991	-
i70	208	19-20	11/06/1988	-
i71	205	20	11/07/1989	-
i73	204	22	14/05/1988	-
i75	204	21	14/05/1988	-
i78	202	23	04/04/1990	-
i79	200	25	06/04/1990	-
i82	203	22	04/03/1988	-
i83	203	22	11/06/1989	-
i84	202	23	06/07/1989	-
i86	207	21	11/09/1989	-