

CORINE Land cover 2000 update (Ireland)

FINAL REPORT

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NATIONAL CLC 2000 PROJECT TEAM (IRELAND):

In 1990, the CLC project (Ireland) was carried out by a large team incorporating groups from several different organisations both North & South of the border. Since then, the EPA was created and designated the National Focal Point for the European Environment Agency. The EPA was therefore designated the National Authority in charge of I&CLC2000 for Ireland.

The 2000 National team consisted of the EPA (National Focal Point) as project manager and co-ordinating organisation, and ERA Maptec, an environmental consultancy involved in the 1990 project. Several National experts involved in the original project were also called upon to provide expertise.

The members of the 2000 Project Team were:

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EXECUTIVE SUMMARY

The CORINE Land Cover 2000 (CLC 2000) project in Ireland forms part of the update of land cover maps for the whole of Europe which is being co-ordinated by the European Environment Agency. Ireland had participated in the CORINE 1990 land cover mapping project and the 2000 update was managed by the Environmental Protection Agency (EPA) in Ireland. ERA-Maptec was contracted by the EPA to undertake the technical aspects of the update and the work was supported by other independent advisors, Dr. Grace O'Donovan (UCD) and Katherine Duff (Natura), both of whom had been involved in the original CLC 1990 project.

The methodology used involved the assessment and correction of the CLC90 land cover database and images for geometric and thematic content followed by mapping of land cover changes using the Image 2000 satellite imagery and ancillary data. This work used visual on-screen interpretation in conjunction with GIS software. The results of the work were validated by the contractor and by the CLC2000 team of the EEA.

The main problems with the correction of the existing CLC 1990 were concerned with the poor geometric accuracy of the CLC90 database and images. This resulted in a large proportion of data requiring editing. In addition there were thematic changes that had to be made to the 1990 database; mainly due to changes in opinion by the national experts in the correct CORINE classes to be used for certain land cover classes in Ireland. These thematic changes mainly concerned upland blanket bog (classed as moors and heaths in the original CLC 1990, but now classed as peatland).

The production of the change and CLC 2000 databases was greatly aided by the large amounts of ancillary data which have become available for Ireland since the original CLC 1990 project. The importance of collating and storing these ancillary data sets on a national basis should be considered for future projects.

The main changes in land cover between 1990 and 2000 are: increase in artificial surfaces (from 1.4% of land area to 1.9% - an increase of 31%) which is mostly comprises of new housing, construction sites and roads; loss of peatlands (an 8% decrease mostly explained by afforestation) and the 68% increase in Sports and Leisure facilities).

The CORINE 2000 land cover database is a valuable benchmark for Ireland and it is hoped that the value in keeping the dataset current in future years will help to monitor overall changes in Ireland's environment.

1. INTRODUCTION

In 1985, Co-ORDination of INformation on the Environment (CORINE) was established by the EU to create databases on land cover, biotopes, soil map, acid rain. Land cover datasets are recognised by decision makers as key reference sources for spatial and territorial analysis and facilitate integrated environmental assessment. The CORINE land cover (CLC) project provides a pan-European inventory of biophysical land cover. This land cover data was interpreted from satellite images using a common methodology throughout Europe.

In 1992, a CORINE land cover project for Ireland commenced, with the objective of producing a land cover map for the entire island of Ireland. The project was undertaken as a co-operative cross-border initiative, jointly coordinated by the Ordnance Survey of Ireland and the Ordnance Survey of Northern Ireland.

The development of the CORINE land cover database was based on the visual interpretation of satellite imagery (for 1989 and 1990) and the allocation of land cover types to one of 44 standard land cover classes. The aim of the CLC 1990 (Ireland) project was to produce a digital land cover database of Ireland in GIS ARC/INFO format, at an original scale of 1:100,000, which was consistent and comparable with similar land cover databases being prepared in other European countries.

CORINE land cover is now recognised by decision-makers as a key reference data set for spatial and territorial analysis at different territorial levels. Within the European Commission Services such as DG-Regional policy, DG-Environment and DG-Agriculture as well as in EEA and its European Topic Centres (ETCs), there is a growing need to use spatial analysis for integrated environmental assessment. The CLC 1990 (Ireland) database was the first complete land cover database for the country. A recent review on its use, established that the data have been used widely – mainly by public bodies, researchers, scientists and private companies. The main applications include water management, air quality, land planning, waste management, telecommunications and agriculture/forestry.

Several users at National and European level expressed the need for an updated CORINE land cover database. The overall aim of updating was to produce the CLC2000 database and the CORINE land cover changes database between 1990 and 2000. To guarantee full coverage and to maximise consistency with the previous inventory, the CLC2000 project called upon existing local expertise and required access to both the ancillary data and the satellite data used for the first CORINE land cover inventory.

A preliminary review of needs for updating the CLC database for the Republic of Ireland was undertaken by the Environmental Protection Agency (EPA) in late 1998. This review concluded that among the main organisations and players involved or interested in this area of work, there was a general agreement on the need for an update of the inventory. In 2000, the EPA commissioned a *Scoping Study on the Updating of the CORINE Land Cover Inventory of Ireland*, the main objectives of which were to:

- Review further the needs at national level in respect of land cover data, in terms of its spatial resolution and level of classification;
- To review and recommend methodologies for the updating of the CLC database in the context of Irish needs and available data from other systems
- To identify the resources needed to enable the update of the CLC database.

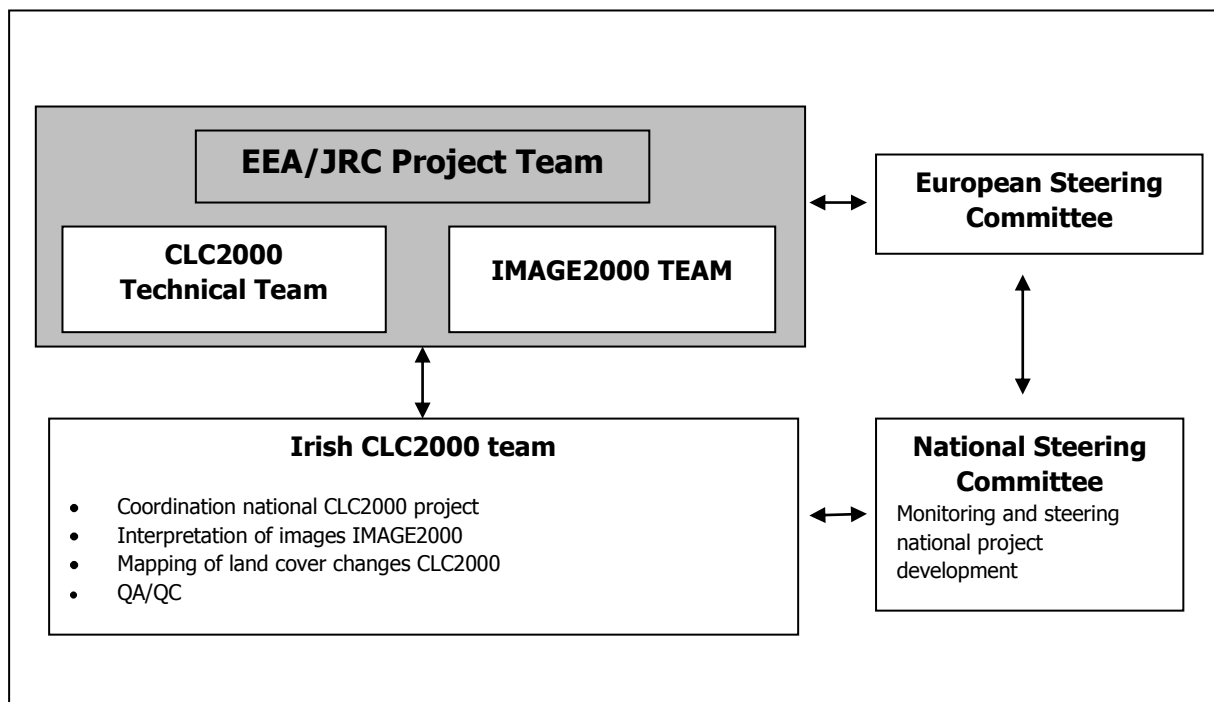
A workshop on CLC2000 was organised by the EPA in July 2000 as part of an extensive national consultative process conducted throughout 2000.

As part of the Good Friday agreement a number of areas for co-operation on the environment between the Republic of Ireland and Northern Ireland were identified. One of these areas includes cooperation on CORINE land cover. In 2001 a North-South working group was established to address cross-border compatibility issues relating to the differing approaches and methodologies to be adopted by the Republic of Ireland and the UK in the update of CLC 1990. An outline work programme for 2001 was prepared by this group and approved by the North-South Ministerial Council.

2. PROJECT ORGANISATION

The organisational structure for the CLC 2000 (Ireland) project is outlined in Fig. 1. The National project team consisted of an EPA team and an external consultant (ERA-Maptec Ltd). Dr. Grace O'Donovan (UCD) and Katherine Duff (Natura), who worked as part of the CLC 1990 team for Ireland, provided additional external expertise. These two experts provided valuable experience from the CLC1990 project as well as input into nomenclature and ground truth data collection (for peatlands and grasslands).

Fig. 1. Organisational Structure for the CLC 2000 (Ireland) Project.



3. METHODOLOGY

The methodology used followed the guidelines published in the "*Technical and Methodological guide for updating CORINE Land Cover data base, 1997*" (EUR17288EN) and the "*Corrigenda: Technical and Methodological guide for updating CORINE Land Cover data base, 1997*" (EUR17288EN) and the subsequent *CORINE Land Cover update I&CLC2000 project Technical Guidelines, 2002*.

The following steps were undertaken (each of these steps is discussed in more detail in the following sections):

Software and Ancillary Data

- Set-up software environment
- Collection of ancillary data

Images

- Selection and Acquisition of Images
- Preparation of images from 1990
- Preparation of images for 2000

Mapping Aspects:

- Training of National Team
- Correction of CLC90 database
- Change 2000 interpretation
- Creation of CLC2000 database
- Validation

Cross border Matching

- Matching CLC2000 Ireland with CLC2000 UK along the border with Northern Ireland

Metadata

- Production of metadata

4. SOFTWARE AND ANCILLARY DATA

4.1 Software

One of the main differences between the original production of CLC90 and the new CLC2000 has been the extensive use of image processing and GIS software throughout all aspects of the work programme. All image processing was performed using ERDAS image processing software, Erdas Imagine version 8.5, whilst ESRI ArcView GIS version 3.2 formed the basis of the image interpretation. The ArcView software was supplemented by the InterChange software; a customised front-end specifically designed for the CLC2000 project.

The InterChange program, developed by the Remote Sensing Centre of Földmérési és Távérzékelési Intézet (FÖMI) in Hungary, provided a tool for the revision of the CLC90 land cover database and supported the interpretation of land cover changes in order to create the CLC2000 database. InterChange is a macro package written in Avenue, ArcView's own macro language. The software is a supplement to ArcView 3.2 GIS. Training in the use of the InterChange software was provided by a technician from FÖMI in April 2002. The training involved introducing the capabilities of the software to the photo interpretation team. Additional training was supplied on ArcInfo tools (control AMLs which could be used after finishing work with InterChange).

Final treatment of the CLC90, Change and CLC2000 databases was performed using Arc/Info on a Unix workstation to produce the deliverable versions as E00 export files.

4.2 Ancillary Data

A number of ancillary data sets were collected to support the CORINE 2000 project. Where geographic coordinate information existed for the various datasets, shapefiles were created for display in ArcView. Where no geographic coordinate information existed, lists of addresses or other location information was used. The main ancillary data sets used are shown in Table 1. The main uses of the ancillary data are given in Appendix I.

Table 1. Ancillary data

Data Set Title	Organisation Responsible	Data Set Description
Land Parcel Identification Vectors (LPIS)	Local Government Computer Services Board	Vector boundaries of agricultural land parcels. Main attribute classes include a unique Parcel No., Area, Crop Type and details of aid applications. The LPIS programme was initiated in 1995 as an alphanumeric identification system for all agricultural parcels that are subject to Area Aid application.
Forestry Inventory (FIPS)	Forest Service, Dept. of Marine & Natural Resources	Boundaries for all forestry within the Republic of Ireland. Each forestry "compartment" holds details of property name, county no., year of survey, the land use type, mixture type. Other attributes subject to restricted release include species, planting year, yield class, area of stand, top height of stand, spacing and the number of stems per hectare
Forestry Inventory	Coilte Ltd	ArcView shapefile displaying the areas of Coillte Teoranta (the Irish Forestry Board) land of approximately 20ha or more where the land use is classified as felled, blown or burnt as defined. Definitions of each of these land use types is provided. Additional land use type classifications, e.g. Bare Plantable, Bare Unplantable and Bare Marginal are also included
Forestry Inventory	Greenbelt Ltd	New plantings or clearances in 2000/20001
National Coastline Survey	Marine Institute	The National Coastline Survey provides a comprehensive package of over 7000 digital pictures on CD ROM containing essential images of Ireland's coastal resource. There are 5 CD's in the series covering the entire Irish coast.
OSI Aerial Photo Index	Ordnance Survey Ireland (OSI)	Digital index to Irish National Grid
Conservation and Protected Areas.	Dúchas: The Heritage Service	Vector boundary coverage of Special Areas of Conservation, Special Protection Areas, Natural Heritage Areas (NHA), Nature Reserves, National Parks on a county basis derived from 1:10,560 series OSI maps. There is also an associated text file with site synopses on a county by county basis
Lacoast	ERA-Maptec	EU Lacoast land-use interpretation
Moland	JRC, Ispra	Dublin & Greater Dublin land-use
County & City Development Plans	Planning Departments in Local Authorities	The County & City Development Plan is a blueprint for the sustainable planning and development of the respective area for the next five/six years. It consists of a written statement (setting out planning policies and objectives) and a number of maps.
Natural Grasslands	Trinity College Dublin	ArcView shapefile displaying the areas of Natural Grassland in the Leinster province of Ireland. A survey of lowland (<300m) semi-natural grasslands in Leinster (grassland under traditional management and of long duration - includes grassland showing no evidence of recent ploughing or fertilizer addition.). Attribute data includes site name, county, area(ha), site description and Ireland National Grid Reference
Peatlands	Bord na Mona	ArcView shapefile displaying the areas of peat production in Ireland. Peat Energy & Fuels Divisions bogs are shown as well as undeveloped bogs.
Peatlands	Irish Peat Conservation Council (IPCC)	ArcView shapefile displaying in point coverage the location of IPCC peatland sites in Ireland. Attribute data includes site name, NHA name, NHA code, County, Area, Grid Ref., Habitat Type, Site description & designation.

Table 1. Ancillary data (Cont.)

BirdWatch Ireland Reserves	BirdWatch Ireland	ArcView shapefile displaying in point coverage the location of BirdWatch Ireland reserves in Ireland. Attribute data includes site name, county, location, site (ha & acres) & site description. BirdWatch Ireland maintains a growing network of bird reserves around the country, all located in areas of conservation importance for birds.
Sea Ports	Department of Marine & Natural Resources	Details of sea ports around Ireland. Attribute data includes port name, status, port office, address etc & lat./long. co-ordinates for the major ports.
Airports	Dept. of Public Enterprise	ArcView shapefile showing the location of civil, military & regional airports & aerodromes in Ireland. Attribute data includes aerodrome name & status, ICAO code, co-ordinates, aerodrome elevation AMS.
Quarries	Geological Survey of Ireland	Location of mineral exaction sites (quarries)
Landfills	Environmental Protection Agency	Location of licensed landfill sites
Salt Marshes	Skeffington and Curtis	Publication on the location of salt marshes T.G.F. Curtis and M.J. Sheehy Skeffington "The Salt Marshes of Ireland : An introductory and account of their geographical location". Biology And Environment: Proceedings Of The Royal Irish Academy, Vol. 98b, No. 2, 87–104 (1998). © Royal Irish Academy
Golf	Golf Association web site	Golf Ireland web site http://www.irelandgolf.com/IrelandGolfMap.htm

5. IMAGERY

5.1 Selection and Acquisition of Images

5.1.1 1990 Imagery Dates

The original CLC 1990 database use produced using Landsat 5 Thematic Mapper imagery at a resolution of 30m; the dates of the image acquisitions were:

Table 3. 1990 imagery for Ireland

Satellite	Sensor	Acquisition Date	Resolution (m)
Landsat 5	TM	06 May 1989	30
Landsat 5	TM	30 April 1990	30
Landsat 5	TM	02 May 1990	30

The CLC 1990 project involved the geometric correction of the landsat imagery and the production of photographic hardcopy at a scale of 1:100,000. These prints were then interpreted visually with annotation onto transparent overlays.

5.1.2 2000 Imagery Dates & Coverage

The CORINE 2000 methodology identifies Landsat 7 imagery as the prime source of data for the year 2000 update. One of the reasons for choosing Landsat 7 is the higher resolution which can be obtained by the panchromatic band (15m). Usable cloud free Landsat 7 imagery was available for most of Ireland from 2000/2001, except for a narrow strip covered by path 207 in the southern part of the country. Landsat 5 imagery (which lacks the panchromatic band) was selected to fill this gap.

A total of six full standard Landsat 7 ETM+ scenes and three full standard Landsat 5 TM scenes were supplied for the CORINE project in Ireland. These are summarised in Table 4 below and also shown in Figure 2.

A section of imagery from path/row 207-22 was missing from the data provided. This small section covered the tip of County Donegal and measured an area of approximately 24sqkm. Alternative imagery, in-house IRS, was used to fill this gap.

Table 4. Image2000 data for Ireland

Path/Row	Date	Imagery	Resolution (m)
208-22	22 July 2000	Landsat 7 ETM+	12.5
208-23	22 July 2000	Landsat 7 ETM+	12.5
208-24	22 May 2001	Landsat 7 ETM+	12.5
207-22	23 May 2001	Landsat 5 TM	25
207-23	23 May 2001	Landsat 5 TM	25
207-24	23 May 2001	Landsat 5 TM	25
206-22	24 May 2001	Landsat 7 ETM+	12.5
206-23	24 May 2001	Landsat 7 ETM+	12.5
206-24	24 May 2001	Landsat 7 ETM+	12.5

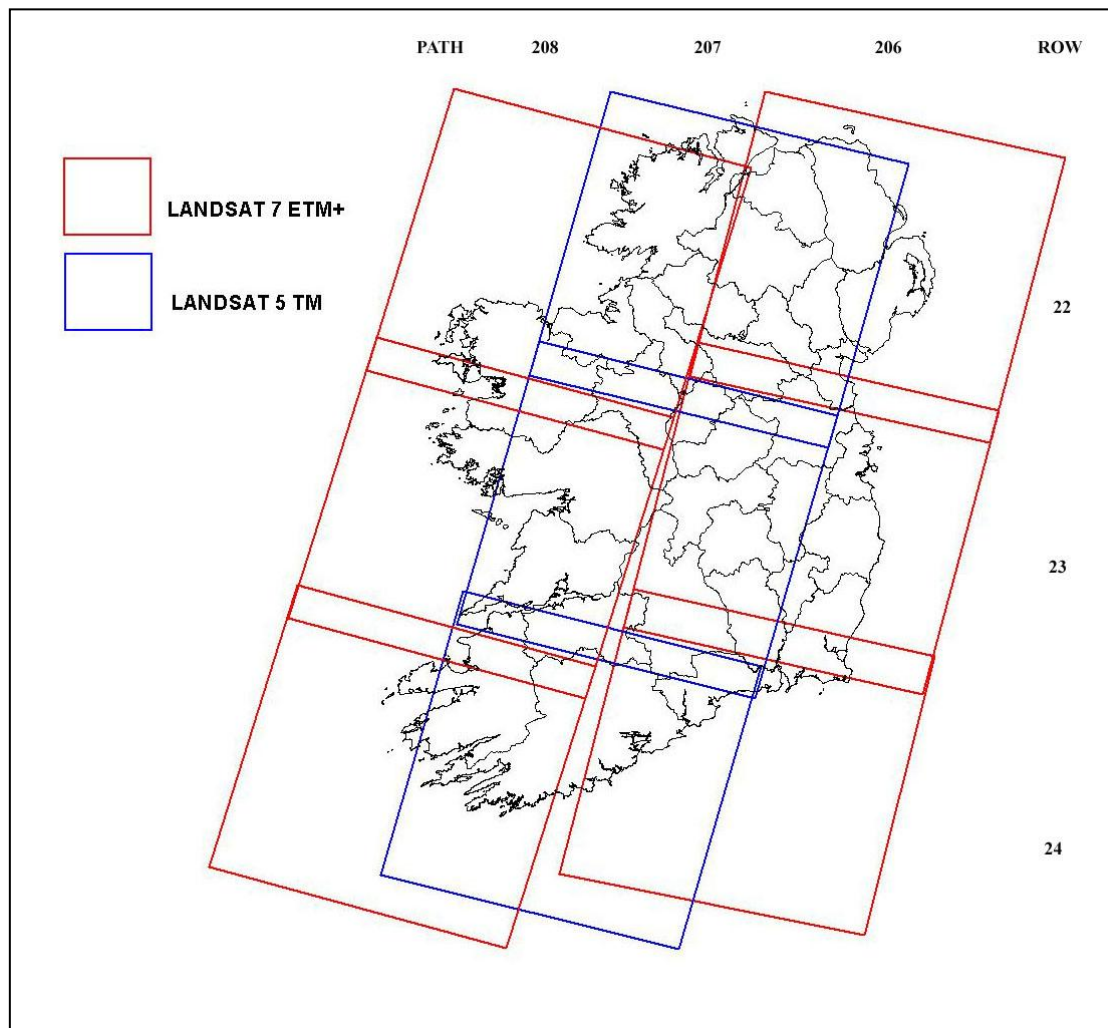


Figure 2. Image2000 coverage for Ireland

5.2 Image Preparation

5.2.1 1990 Image Quality Control

Original CORINE 1990 imagery exists in four separate tiles.

Sh250_1
Sh250_2
Sh250_3
Sh250_4

From these tiles, 30 satellite image sheets were prepared using the map sheet co-ordinates from the CORINE Land Cover Project (Ireland) Report (O'Sullivan *et al.*, 1994).

The correction error of each individual sheet was calculated using the Raster Geocorrection tool in Erdas Imagine 8.4. The 2000 Imagery was not available at the time and the Ordnance Survey 1:50,000 Raster Tiles were used as reference material. Twelve ground control points were collected per sheet to calculate the geocorrection error.

The overall RMS error for X and Y was calculated in an Excel spreadsheet. A total of 4 mapsheets out of the overall 30 had errors >50m. Since these 4 mapsheets came from Sh250_1 the complete tile was re-corrected. The mapsheets were prepared again from the re-corrected tile and their geocorrection error calculation repeated. All showed RMS errors under 50m

5.2.2 2000 Image Quality Control

SSC/Metria corrected the Image2000 data under contract from the EEA. Digital copies of Ordnance Survey Ireland (OSI) topographic maps and digital terrain model were supplied to SSC/Metria for use in the ortho-correction of the year 2000 images.

A quality control check was undertaken on each corrected image on delivery from SSC/Metria. The geometric accuracy of each individual Image 2000 sheet was calculated using the OSI 1:50,000 Raster Tiles and the Ordnance Survey Northern Ireland (OSNI) maps as reference data. Twelve ground control points were collected per sheet. Errors for 7 out of the 9 nine scenes for Ireland were below 50m and no recorection was necessary.

It appeared that the last two scenes for Ireland (Landsat 5), 207-22 (23-05-2001) and 207-23 (23-05-2001) had potential problems with the geometry. A check was made the RMS error on these scenes in relation to the adjacent Landsat 7 scenes. For each pair of scenes 11/12 control points were collected from the overlapping area. The RMS error was calculated using the same formula used for calculating the error of the 1990 vectors.

Table 5. Geometric Accuracy of Landsat 5 scenes for Image 2000

Path/Row	RMS error	X	Y
207-22 v 206-22		28.66	24.09
207-23 v 206-23		58.95	33.36
207-22 v 208-22		15.48	14.07
207-23 v 208-23		78.80	38.96

The error was most prevalent towards the edges of the scenes and the central parts were less distorted. Only the central parts were needed to fill the gap in the Landsat 7 scenes except where there are clouds on the Landsat 7 scenes.

5.2.3 2000 Image enhancements

For each Landsat 7 ETM+ scene the 12.5m panchromatic band was merged with the 25m colour bands to give a 12.5m colour product consisting of a three band combination 3,4,5. This was displayed as 4,5,3 (red, green, blue).

Landsat 5 TM scenes do not have the 12.5m panchromatic band and have a resolution of 25m.

A contrast stretch was carried out to improve the definition of the band combination.

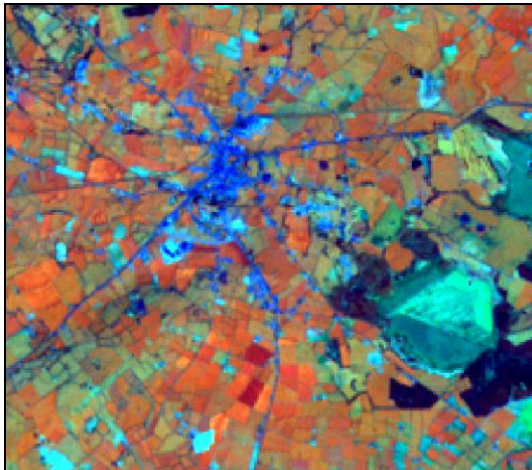


Figure 3. Landsat 5 TM Resolution 30m



Figure 4. Landsat 7 ETM+ Pan Merged Resolution 12.5m

5.2.4 Mapsheets

Thirty raster mapsheets were used in the CLC90 process. This number was increased to 50 sheets for CLC 2000, each measuring approximately 50km x 30km as recommended by the Technical Team. Each original mapsheet was split into two parts. The original Sheets 2E, 4E and 2W (bottom half) have been left out altogether as they are completely within the North of Ireland. Sheet 4W was enlarged to include a small section of the Republic previously within Sheet 4 (see figure 5)

Sheets that crossed the boundary of two full scene images were mosaiced together to give a complete mapsheet.

This process was repeated to produce 50 vector mapsheets in shapefile format. The smaller sheet size decreased the time needed to perform editing operations.

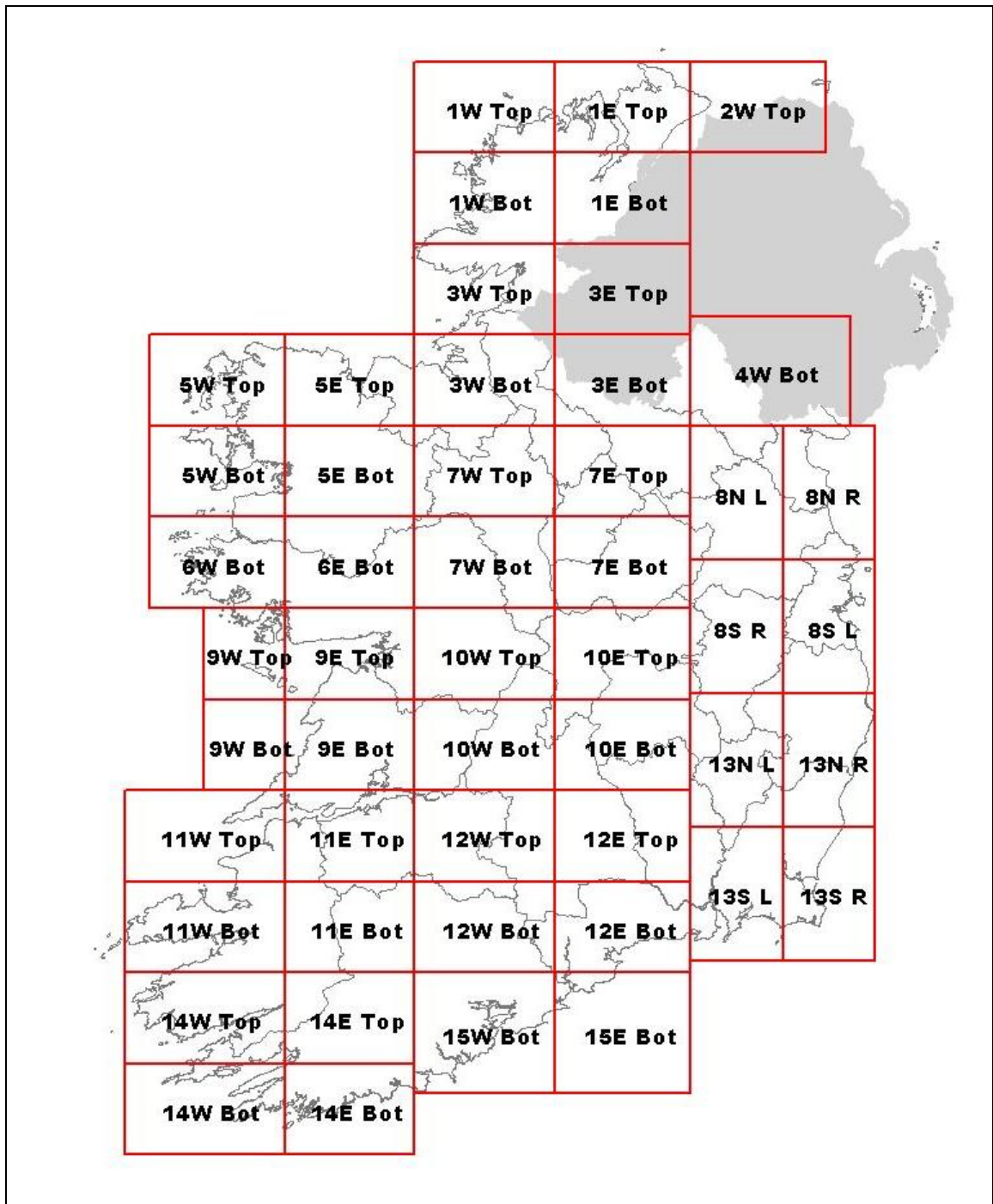


Fig. 5. CORINE 2000 Mapsheets

There were three final delivery products

- Revised CLC 1990
- Change database
- CLC 2000

6. MAPPING ASPECTS

6.1 Training of the National Team

In February 2002, members of the CLC2000 Technical Team came to Dublin. The training mission took place in the offices of ERA Maptec and lasted 2.5 days. The National Kick off meeting also took place during the training mission. Members of the National team from EPA and ERA-Maptec were represented as well as the national experts who were involved in CLC1990. During this mission, the National Team was introduced to the technical methodology of updating the CLC database. Issues specific to Ireland were also discussed and the project plan was presented and discussed.

As the interpretation of IMAGE2000 data was not yet started, discussions during the Training mission concentrated on the following issues:

- Geometrical fit of CLC90 data with IMAGE90 (and IMAGE2000)
- Application of nomenclature (semi-natural / agricultural / urban landscapes)
- Discussions of evident changes between 1990 and 2000 (emerging forests in peatbogs).

Altogether a sample of three mapsheets were presented in ArcView environment. IMAGE90 and IMAGE2000 data were available for all sheets. The trainers analysed jointly with the photo-interpreters these map sheets.

The discussions were concentrated on the CLC nomenclature relevant for Ireland, separation of the classes "arable land – permanent crops – heterogeneous agricultural areas" and especially "scrub and/or herbaceous associations – inland wetlands" and peatbogs. Attention was paid also to updating of the CLC2000. The Technical Team together with the interpreters analysed three working units of the CLC90 database.

The geometric correlation between IMAGE90 and IMAGE2000 was optimal. The team had already completed the elimination of registration errors found in IMAGE90 data.

The geometric quality of CLC90 database was heterogeneous. In some areas the geometry was very good, while a systematic mis-registration with a value up to 200m was observed in some parts. Small polygons (<25 ha) were found in almost all categories.

6.2 Correction of CLC1990 map and database

Problems with the CLC90 dataset can be divided into three main areas. These were geometric errors, thematic errors and polygon size errors. These problems resulted in a large proportion of data requiring editing.

6.2.1 Geometric Adjustments

The CORINE 1990 database exists in eight separate tiles. These were mosaiced into one shapefile using the Geoprocessing wizard in ArcView 3.2. Thirty shapefiles corresponding to the thirty image sheets used in CLC90 were clipped out of the complete mosaic.

The correction error of each individual clipped shapefile was calculated using the 1990 image sheets as reference material. 12 ground control points per sheet were collected. The overall RMS error for X and Y was calculated in a Microsoft Excel spreadsheet.

Registration was generally poor between the 1990 vectors and the 1990 rasters. Typically, the displacements were approximately 100m. In some cases there appeared to be systematic offset but in others these were not systematic.

The procedure outlined in Perdiago & Annoni (1997) was followed. The CLC90 vectors were all corrected manually during the revision process. Boundaries delineating land cover types, which were offset by more than 100m, were redigitised manually using InterChange and ArcView. Although this was time consuming, it seemed to be the most effective way, since the vector shifts were random and non-systematic. Polynomial transformations were therefore not necessary.

In some cases, however, when the corrected CLC1990 vectors were overlaid on the Image2000 data, it was found that the vectors were once again offset. 1st Order polynomial transformations were then carried out. In total 10 mapsheets required transformation. In most cases 9-12 GCPs were satisfactory, resulting in a RMS error of between 5-7m.

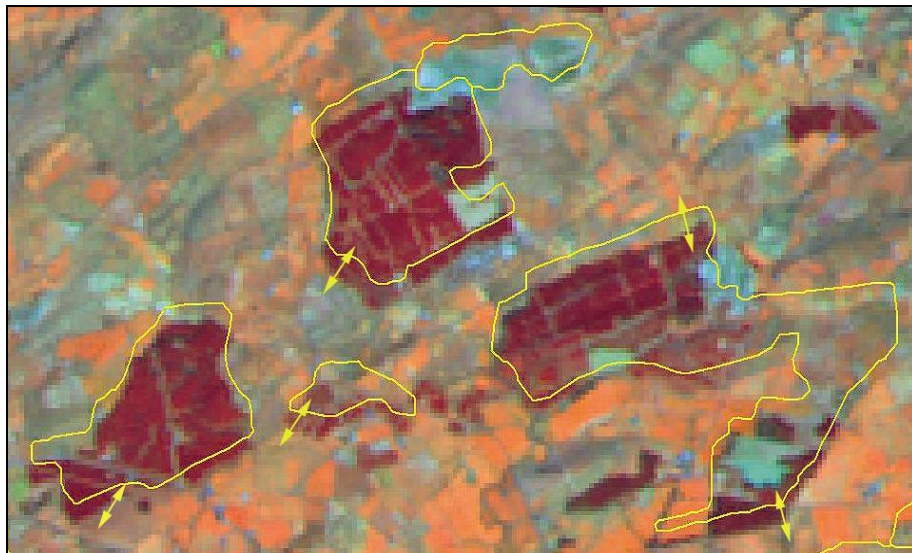


Fig 6. Example Systematic displacement >100m of 1990 vectors

6.2.2 CLC 1990 Thematic Adjustments

Analysis of the CLC 1990 database showed that classes were incorrectly labelled. Classes were either incorrectly labelled due to confusion with similar class codes or the class was incorrectly identified. The main issues were:

The most common labelling mistakes appeared to be confusion between classes 112 and 211. Often the code was simply reversed to give the incorrect code for that class (e.g. a section of non-irrigated arable land coded as discontinuous urban fabric).

The quality of the 1990 imagery appears to have affected further division of the mixture class land principally occupied by agriculture with significant areas of natural vegetation (243). It had already been noted that this would be a particular problem with the revision of the CLC90 dataset. Much of the vegetation put into class 243 actually belonged in class 231.

Several large tracts of peat (412) were divided further into natural grassland (321).

Several large tracts of heath and moorland (322) were recoded as peat (412).

Forestry was a minor problem with some broadleaf forestry (311) mislabelled as coniferous forestry (312). Some mixed forestry (313) was further divided into (311) and (312).

Large areas were found to have been misclassified in the original dataset and needed to be changed (especially in Co. Kerry).

Many of the smaller towns were not identified in 1990 due to reduced image quality. These were more easily identified with the ancillary dataset of vector town points.

6.2.3 CLC 1990 Polygon size Adjustments

Almost one fifth of the total number of polygons in CLC90 was under the 25ha limit as specified in the technical requirements for CORINE (see table 6)

Table 6. CLC90 polygons under 25ha

Total No. of Polygons	No. of Polygons under 25ha	Percentage (%)
24,232	4,524	18.67

The removal of polygons under 25ha was carried out using two methods based on polygon size.

Method 1: All polygons under 20ha were merged with the larger surrounding polygons. The merging was done on the basis of priority using a table provided by the EU Technical Team.

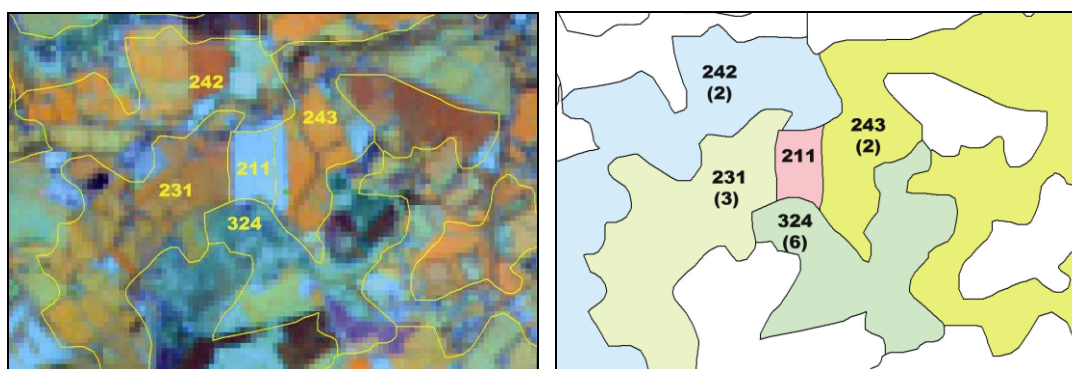


Fig. 7. and Fig. 8. Small polygon surrounded by two or more polygons.

If the small polygon was surrounded by two or more polygons, the small polygon was aggregated or subdivided proportionally to the neighbouring units. This aggregation depended on the type of land cover that was surrounding the area. Some aggregations to a specific land cover class are more "logical" than others, within the context of the CLC inventory. This so called "logical" aggregation was formalised in a priority list for aggregation of a small polygon to a specific land cover class.

Figure 8 above shows a centre polygon of 211. This polygon has an area of 10.43ha and must be removed from the dataset. Four polygons, 242, 243, 324 and 231 surround it. The priority table is used to determine the priority of each of the surrounding polygons. 1 is the highest priority. Larger numbers indicate lower priority.

Table 7. Sample priority table

	231	241	242	243	244	311	312	313	321	322	323	324
111	3	2	2	3	4	4	4	4	4	4	4	4
211	3	2	2	2	2	6	6	6	6	6	6	6

The small individual polygon 211 (<25 ha) should be aggregated to the polygon with the highest priority. Since two polygons surround 211 with equal priority, the area of the 211 is cut into two equal pieces and each part is allocated to the neighbouring polygon. This aggregation procedure was sometimes more complex in real situations with complex geographical structures. The split of the small polygon into two or more equal parts was done according to the structure of the landscape. It was not always possible to maintain equal areas after subdivision of the polygon.

Method 2: Polygons 20-25ha were looked at individually. If it was possible to increase the polygon size to >25ha by fixing the boundaries the polygon was redrawn. If not then the polygon were merged as in Method 1. (see figure 9)

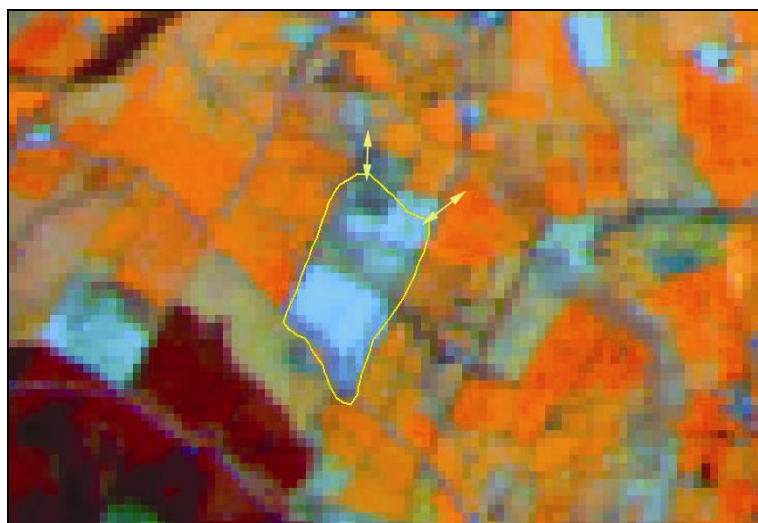


Fig 9. Polygon greater than 20ha but less than 25ha.

6.2.4 Statistical comparison of revised CLC 1990 with original CLC 1990

35 out of the 44 CORINE Level 3 classes were identified in Ireland during the original CLC90 project. This number has been reduced to 34 classes in the revised CLC90. Class 241, annual crops associated with permanent crops, was not identified. The CORINE Land Cover Project (Ireland) Report (1994) notes that this class was used for orchards in Co. Armagh in Northern Ireland. This county was not included in the CLC90 revision or CLC2000 update.

The number of polygons under 25ha has been greatly reduced. There were 4,524 polygons under 25ha in the original CLC90. There are now 132 polygons under 25ha in the revised CLC90. These polygons can be found along the buffer zone between Northern Ireland and the Republic of Ireland and were kept in the database in order to facilitate matching along the border between the two countries.

Since the area of the Revised CLC90 is reduced it is not useful to directly compare the area (ha) under each class or perform any other statistics between the two datasets.

Table 8. Comparison between CLC90 and Revised CLC90

	CLC90	Revised CLC90
Total no. of polygons	24,232	19,011
Polygons <25ha	4,524	132

6.3 Change Interpretation

The InterChange program provided a tool for the revision of the CLC90 land cover database and supported the interpretation of land cover changes in order to create the CLC2000 database. InterChange is a macro package written in Avenue, ArcView's own macro language. The software is a supplement to ESRI ArcView 3.2 GIS.

The InterChange software is a useful updating tool. It displays the CLC90 database and the change database in two separate View windows (Revision, Change) constantly synchronising their content. Among its features is an efficient error finding and correcting tool, which was used to filter the results of accidental mistakes. The tool alerts the interpreter when a polygon under the size limit is created and

when incorrect class codes are entered. Error checking was carried out twice per mapsheet. Once when revision of clc90 was complete and again when the updating to 2000 was completed.

6.3.1 Change identification

Based on the methodology outlined in the Technical Manual for updating the CORINE land cover, all changes greater than 5ha were included in the change database. The changes were digitised based on the visual interpretation of the image 2000 dataset, while the ancillary datasets were used for verification.

Most of the problems regarding updating the dataset related to deciding whether real change had actually taken place. Revision of CLC90 continued throughout the updating phase and many of the problems already mentioned regarding quality of the 1990 image meant that many perceived changes were unreal and simply required further revision of CLC90. For example if a town was not clear on the 1990 image but was obvious on the 2000 image this perceived change of e.g. pasture to urban fabric was not real and meant that the town had to be included in the 1990 database. The extensive use of ancillary data for CORINE 2000 also meant that certain features not identified as such in 1990 could now be identified using ancillary data. The best example for this is the use of the salt marshes data to correctly identify salt marshes not identified in 1990.

6.4 Generation of CLC 2000

The CORINE 2000 dataset was produced by GIS, merging the revised 1990 dataset with the change database. Each mapsheet had to be neighbour-matched with its surrounding sheets to ensure matching class codes along its borderlines. Overlaps and gaps created by the transformation of certain mapsheets also had to be dealt with.

Polygon size limits had to be checked and adhered to. No zero codes were allowed in the database.

6.5 Verification and Validation

The image supervisor carried out internal quality control for all mapsheets. Two external verification missions were carried out by the Technical Team to check the progress and quality of CORINE 2000. The first Verification Mission was carried out at 50% project completion. The second Verification Mission was carried out at 84% project completion.

6.5.1 Internal Verification and Validation

The image supervisor carried out quality control for all sheets. Checking was carried out on blocks of 4 mapsheets in ArcView. A summary problem/comment list was compiled and given to the original interpreter for each mapsheet. Recommended changes and suggestions were given on a polygon-by-polygon basis in the ArcView database file. The original interpreter corrected errors using the Interchange software.

6.5.2 External Verification

External verification was undertaken by the CLC Technical Team appointed by the EEA. There were two external verification visits. These took place in Dublin on 5 - 6 November 2002 and 13 – 14 March 2003.

First Verification Mission, Dublin 5 – 6 November 2002:

General conclusions of the first verification mission were presented in the Technical Team Report:

- The geometric adaptation of CLC90 database is successful in general. Although a few working units showed systematic geometric distortions larger than 100m which have to be corrected.
- Small polygons of the CLC90 database have been successfully generalised.
- The most serious thematic problem is the overestimation of changes. The average change rate inside all 33 tested units is 15.5%, which is about double of the expected rate. Seven verification units included changes above 25% of the total 100km² of the verification unit. One of the units included 59% changes (wu = 7w top).
 - The Change database included many changes of the natural landscape (321, 322, 412) to e.g. 231 which is more probable related to different interpretations in the two dates than a real change.
 - Many polygons without real changes were found between agricultural classes. e.g., 211-231, 231-211, 242-231, etc.
 - Changes between the two grassland categories 321-231 or 231-321 were found to be problematic.
 - Many polygons with unrealistic changes were found (e.g. 412-231, 322-312, 321-412).
- The thematic quality of the revised CLC90 database has improved, but still contains problems:
 - Very large 231 polygons which are not really homogeneous, but include >25 ha 211, 243, 242, 112.
 - Missing (mostly "linear") settlements, sometimes separated by less than 300m between houses (see generalisation principles in Addendum 2000).
 - Separation of 231 and 211 is still not satisfactory, although the significant improvement compared to the original CLC90 is evident.
 - There are some omitted linear objects wider than 100 m (rivers, highway under construction).
 - Class 322 seemed to be under-represented.
- Topological checks performed by ArcInfo on the submitted working units revealed several topological problems (multi-part polygons, holes in the database, etc.)
- Metadata were not yet available in the necessary format.

Recommendations made by the Technical Team included:

- Geometry of working units with systematic distortions > 100 meter should be corrected.
- The national team is requested to study detailed remarks of this verification mission and focus on correcting typical errors. Corrections should cover all interpreted areas not only the verified samples or rejected working units.
- The CLC changes database should include only real changes. The verification revealed that real changes were frequently overestimated as several change polygons included omitted revisions of CLC90. Therefore avoid any non-real changes in all interpreted working units.

- It is recommended to check all unrealistic changes (412-231, 322-312, 321-412) during interpretation phase and/or during internal QA/QC. This can be done automatically, if all changes, which are unrealistic (or impossible) under Irish conditions are collected in advance. InterChange used by the NT provides internal functionality for this purpose.
- Improve the revision of CLC90 database.
- Create CLC2000 database using revised CLC90 and CLC-Changes as the resulting CLC2000 is part of deliverables. CLC2000 should also be verified internally.
- Internal quality control should be reinforced, including two major components:
 - Technical control (e.g. topological correctness of working unit level databases). If InterChange functionalities are systematically used, NT will have very few remaining problems to correct by ArcInfo.
 - Thematic control (focusing on homogeneous understanding of nomenclature, and examining the validity of detected changes).

Final Verification Mission, Dublin 13-14 March 2003:

The work of the National Team since the first verification mission resulted in a significant improvement in the quality of the entire CLC database. The Technical Team complimented the National Team on taking into account suggestions and comments made at the first verification mission and acknowledged much improvement. Geometric accuracy improved substantially and the CORINE nomenclature was more rigorously applied. Most inconsistencies were resolved and unrealistic changes were eliminated to the satisfaction of the Technical Team. The points of discussion concerned the land cover classification and the following topics were covered:

The Verification Team were concerned with the large number of changes from Pasture (231) to Arable land (211). For national purposes it is preferable that Ireland map the rotational patterns of pasture and arable land and thus avoid the use of the mixed class (242). Ireland wishes to retain the distinction of these classes at level 3. Rotational agriculture is a common and traditional practice in Ireland and may occur on a 5-10 year basis. Changes from Pasture to Arable and from Arable to Pasture are among the most numerous changes found when updating CORINE giving a high percentage of changes per map sheet.

The Verification Team were concerned with lack of heath class in Ireland. In discussion with our national botanical experts it was agreed that much of the upland areas of Ireland that were classified as moors and heaths in CLC1990 should be re-classified as peatlands (greater than 0.5m peat). We also discussed this matter with the UK CLC2000 team, who were in agreement that a similar problem might occur in the UK.

There are two main recognised types of heath in Ireland; gorse and bracken (tall) and heather dominated (short). The classification of Heath is very problematical in Ireland due to its similarity to peatlands. These two classes differ mainly in the depth of the substrate. A review of the 1990 inventory by person's expert in the identification and classification of these classes has indicated that much of it should have gone into bog classes (412) or Transitional Woodland Scrub (324). The Verification Team suggested more usage of the mixture class 242, permanent pasture and arable land. However, in CLC1990 this class was probably over-estimated in Ireland due to grouping parcels >25ha in with it. Correcting the 1990 inventory to reflect this problem has reduced the amount of this class.

The Verification Team were concerned with changes of water bodies to grassland. Turloughs are unique to Ireland. They are transitory lakes that appear/disappear depending on the time of year and occur in limestone areas west of the Shannon. After the lakes have disappeared they leave a floor covered in grasses, sedges and herbs. This results in a change from 512 to 411 (if fen vegetation remains) or 321 (if grassland remains). The verification team were made aware of this fact.

The National Team significantly improved the quality of the 1990 database through detailed consultations with national experts. This resulted in the reclassification of large areas of moors and heathlands into peatbogs. The Technical Team agreed with this reclassification, which is a natural feature of the complex Irish landscape. The Team recommended that the National Report should emphasise the lack of heathland (322 - 1%) within the Irish landscape as a particular feature of the Irish situation as compared to peatbog (412 - 9%). The Team also recommended that the National Report should emphasise the mosaic of agriculture within the Irish landscape as a particular feature of the Irish situation.

The final national CLC2000 was delivered to the CLC2000 Technical Team for integration into the seamless European CLC2000 database and a final technical verification. The European dataset will be disseminated on-line through the EEA web site and on CD-ROM.

7. CROSS-BORDER MATCHING

It is a requirement of the CORINE methodology to ensure edge matching along national borders with adjacent countries. A section along the border between Northern Ireland and the Republic of Ireland was classified using methodologies both from CORINE 2000 and the UK Land Cover Map 2000.

The Northern Team provided a border shapefile. This was used to clip out the section from CLC90 to be worked on. The team from the south classified this area using CORINE 2000 methodology.

In the first instance all errors in the CLC90 dataset had to be corrected as described in section 5 (this report), 1990 Corrections. The area was then updated using the CORINE 2000 methodology.

A meeting was held with the UK's Centre for Ecology and Hydrology (CEH), Environment and Heritage Service of Northern Ireland and the National Project Team in November 2002 to discuss the results of the project comparing the CORINE/Land Cover methodologies used by ERA-Maptec and CEH for the test border area. It was found that the two methodologies compared favourably with a near-perfect correspondence over more than 90% of the area studied. This ensures that there will be no obvious "border" of different vegetation classes along the border between the North of Ireland and the Republic.

8. METADATA

Metadata is the information that gives characteristics of given dataset. Spatial metadata or geo-information (GI) metadata is the information that characterises spatial datasets.). Standardised CLC2000 metadata will help users find the data they need and determine how best to use it and how to get hold of it. Standardised and well structured metadata will help the users understand the differences in quality, accuracy and precision between datasets and products even if potential users would have no or limited knowledge about the CLC2000 data.

The National CLC2000 metadata contains information on the management of the project, on the basic and ancillary data used, *i.e.* satellite images, topographic maps etc., on data processing and the nomenclature, on hard- and software used for data processing, important indications on data and dataset quality, possible usage, ordering information.

An example metadata sheet for the CLC 2000 database is shown in Appendix IV.

9. LAND COVER IN IRELAND

9.1 Controlling factors on land cover in Ireland

Ireland has a predominantly maritime climate; situated on the NW fringe of Europe the country is the first landfall of rain bearing depressions crossing the Atlantic Ocean. As a consequence rainfall amounts are higher than most other European countries and extremes in temperature are rare. Without the intervention of man, the predominate vegetation cover in Ireland would be deciduous woodland scrub. Much of this natural woodland scrub was removed by the spread of agriculture in the 18th and 19th centuries. Because of the high rainfall and damp climate the country is not suited to arable crops (except for eastern parts of the country). The main form agriculture is based upon cattle in the lowlands and sheep in the uplands. Thus the predominant land cover is grassland of varying types both in the lowland and uplands, except in low lying wetlands and plateau uplands where peatlands predominate. The high dominance of animal based agriculture raises possible concerns about effluent run-off and water quality. The protection of wetland habitats (both lowland and upland) are also of concern in Ireland.

There is a low population density in Ireland. The total population is 3.9 million people of which about 1.7 million live in the main urban areas. The remaining rural population of 1.8 million is spread over 70,000 km² giving a rural population density of 25 persons per km². Thus, except for the main cities of Dublin, Cork, Waterford, Limerick and Galway, artificial surfaces are very minor form of land cover in Ireland. However, despite the low percentage of artificial land use in Ireland there has been a pronounced rise in population (from 3 million in 1991 to 3.9 million in 2002). The increase in population and associated infra-structure could threaten semi-natural habitats and rural landscapes.

It is against these concerns for habitats, landscapes and water quality the CORINE landcover 2000 project provides a timely input into monitoring environmental changes in Ireland.

9.2 Application of CLC nomenclature to Ireland

Since the production of the original CLC 1990 database it has been recognised that some of the actual land cover types in Ireland might not have put in the ideal CORINE land cover class. The main areas of concern of national botanical experts for CLC 1990 were:

- sport and leisure (142)
- several of the mixture classes (242,243)
- natural grassland (321)
- peat bogs (412)
- Coastal lagoons and salt marshes

Sport and leisure (142) can usually be found outside urban areas, *i.e.* golf courses and race courses. Many more golf courses exist in 2000 than 1990 and racecourses may not have been identified in 1990.

The practice of crop rotation is a feature of Irish agriculture (as discussed in Section 6.5.2). Land cover can change from arable to pasture to mixed on a 5 – 10 year basis. The mixture classes of permanent pasture and arable (242) and agriculture and natural vegetation (243) were previously over-estimated in Ireland. It was deemed important that any occurrence of a heterogeneous class within a mixed class polygon (e.g. 242 or 243) should be isolated and separated from the mixed class. Therefore, particular attention was paid to creating new polygons of arable and pasture greater than 25ha, where previously they were grouped in mixed classes (1990).

Low productivity natural grassland (definition 'not sown') (321) is common in Ireland on higher ground with a lack of field boundaries. This class includes Turloughs, Callows, Burren Hills, Acid grassland, Eskers and Machair. Turloughs are unique to Ireland. They are transitory lakes that appear/disappear depending on the time of year and occur in limestone areas west of the Shannon. After the lakes have disappeared they leave a floor covered in grasses, sedges and herbs. This often resulted in changes from water bodies (512) to natural grassland (321) or fen vegetation (411) to be seen. This change can also be considered a particular feature of the Irish landscape.

The classification of heaths and moors (322) is very problematical in Ireland due to too much classification in this category. It was decided that much of it should go into the peat bog class (412) or transitional woodland scrub (324). Ancillary datasets of Dúchas heath sites and the IPCC dataset allowed us to differentiate between bog and in particular dry lowland coastal heath. Heath around raised bogs was reclassified as transitional woodland scrub (324). Molinia grass was reclassified as Peat bog.

Coastal Lagoons (521), Estuaries (522) and Salt marshes (421) badly needed revising. Salt marshes (421) are often difficult to interpret in Ireland, as they resemble grassland. The recent survey of salt marshes by Curtis and Skeffington (1998) covers two-hundred-and-fifty marshes, and classifies them into five main types: estuary, bay, sand flats, lagoon and fringe and was used to identify many new salt marshes.

During the CLC 2000 project a detailed manual was produced with illustrations of the different land cover classes in Ireland. The following is a list of the CORINE land cover types found in Ireland:

Table 8. CORINE land cover classes present in Ireland in 2000

Code	Cover	Area (ha)	Percentage
111	Continuous Urban Fabric	5,067	0.07%
112	Discontinuous Urban Fabric	88,406	1.24%
121	Industrial or Commercial	6,252	0.09%
122	Road and Rail networks	2,037	0.03%
123	Sea Ports	1,079	0.02%
124	Airports	2,462	0.03%
131	Mineral extraction sites	8,225	0.12%
132	Dump	343	0.00%
133	Construction sites	2,791	0.04%
141	Green Urban areas	3,726	0.05%
142	Sport and Leisure facilities	16,751	0.24%
211	Non-irrigated arable land	546,916	7.68%
231	Pastures	3,661,571	51.40%
242	Complex cultivation	124,112	1.74%
243	Land principally occupied by agriculture with areas of natural vegetation	426,934	5.99%
311	Broad Leaved forest	30,901	0.43%
312	Coniferous forest	243,608	3.42%
313	Mixed forest	22,443	0.32%
321	Natural grassland	94,047	1.32%
322	Moors and Heaths	59,969	0.84%
324	Transitional woodland scrub	342,147	4.80%
331	Beaches, dunes, sand	14,744	0.21%
332	Bare rocks	16,726	0.23%
333	Sparsely vegetated	20,242	0.28%
334	Burnt areas	90	0.00%
411	Inland Marshes	18,017	0.25%
412	Peat Bogs	1,146,154	16.09%
421	Salt Marshes	3,105	0.04%
423	Intertidal flats	47,230	0.66%
511	Stream courses	9,668	0.14%
512	Water bodies	122,861	1.72%
521	Coastal lagoons	1,011	0.01%
522	Estuaries	33,716	0.47%
	Total	7,123,351	100.00

9.3 CLC 2000 Summary Statistics

The sum of the areas (ha) of each of the Level 1 categories (arranged in descending order) can be seen in Table 9.

Table 9. CORINE 2000 Level 1 classes by Area (ha)

Level	Name	Area (ha)	%
1	Artificial Fabric	137,138	1.93%
2	Agricultural Areas	4,759,533	66.82%
4	Wetlands	1,214,505	17.05%
3	Forest and semi-natural areas	844,915	11.86%
5	Water Bodies	167,255	2.35%
	Total	7,123,346	100.00%

The sum of the areas (ha) for each Level 3 class (arranged in descending order) can be seen in Table 10. The largest class in CORINE 2000 is pasture and the second largest peat bogs. Because of this it was decided to further classify these classes to Levels 4 and 5 in order to suit national needs. Of the 10 largest classes 4 are agricultural.

Table 10. CORINE 2000 Level 3 classes by Area (ha)

Code	Area (ha)
231	3,661,571
412	1,146,154
211	546,916
243	426,934
324	342,147
312	243,608
242	124,112
512	122,861
321	94,047
112	88,406
322	59,969
423	47,230
522	33,716
311	30,901
313	22,443
333	20,242
411	18,017
142	16,751
332	16,726
331	14,744
511	9,668
131	8,225
121	6,252
111	5,067
141	3,726
421	3,105
133	2,791
124	2,462
122	2,037
123	1,079
521	1,011
132	343
334	90

9.4 Land Cover Changes from CLC 1990 to CLC 2000

From the CLC 1990 and CLC 2000 it has been possible to analyse the changes in land cover in Ireland during the 10 year period between the two land cover maps. Figure 10 shows pie charts of the level 1 land cover for Ireland in 1990 and 2000. Perhaps the most significant changes are increase in artificial surfaces from 1.5% in 1990 to 1.9% in 2000 and the growth in forestry (from 10.2% to 11.9%) over the same period. Overall, 8.8 per cent of the total land area of the country has changed.

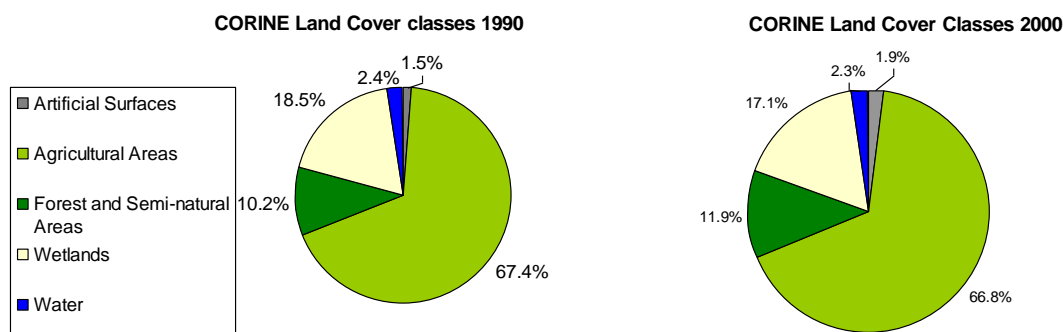


Figure 10. Level 1 land cover for Ireland

A more detailed summary of the changes by class in given in Table 11 shows the main land covers classes and percentage changes for each class. The changes are not simply the difference between CLC2000 and revised CLC1990. Many of the problems mentioned regarding quality of the 1990 image meant that many perceived changes were unreal and simply required further revision of CLC90. Therefore, great care was given to revising the 1990 database to ensure more accuracy for comparison. As stated in Section 6.3.1, revision of CLC90 continued throughout the updating phase. The extensive use of ancillary data for CORINE 2000 also meant that certain features not identified as such in 1990 were identified using ancillary data.

The ten largest changes (arranged by area) from 1990 to 2000 can be seen in Table 11 below. The major changes have taken place in agricultural classes, bogs and forestry.

The biggest changes from 1990 to 2000 are due to agricultural practices, from pasture to arable land and vice versa (231-211, 211-231, 231-242) totalling 284,750ha. There have also been major losses to our bogs (412-324, 412-312). A total of 100,121ha have been lost through cutting and afforestation making it the second largest change identified. The loss of forestry by felling (312-324) at 66,582ha is almost offset by the amount of new forestry plantings (412-312, 324-312) at 54,559ha.

Table 11. Summary Land Cover changes 1990 – 2000

		1990	2000	% change
Total Land Area (km²)		69,548.79	69,560.41	
Total Area (km²)		71,233.10	71,226.28	
Artificial Surfaces		1,048.86	1,371.38	30.75
111	Continuous Urban Fabric	50.67	50.67	0.00
112	Discontinuous Urban Fabric	718.76	884.06	23.00
121	Industrial & Commercial Units	40.38	62.52	54.83
122	Road & Rail Networks	2.64	20.37	671.59
123	Sea Ports	10.22	10.79	5.58
124	Airports	23.51	24.62	4.72
131	Mineral Extraction sites	55.93	82.24	47.04
132	Dump	3.48	3.43	-1.44
133	Construction sites	9.92	27.91	181.35
141	Green Urban Areas	35.13	37.26	6.06
142	Sport & Leisure facilities	98.22	167.51	70.55
Agricultural Areas		48,036.11	47,594.80	-0.92
211	Non-irrigated arable land	4,057.04	5,469.17	34.81
231	Pastures	38,444.14	36,615.17	-4.76
242	Complex cultivation patterns	1,167.15	1,241.12	6.34
243	Land principally occupied by Agriculture	4,367.78	4,269.34	-2.25
Forest and Semi-natural Areas		7,287.73	8,449.17	15.94
311	Broad-leaved Forest	309.44	309.01	-0.14
312	Coniferous Forest	2,500.02	2,436.08	-2.56
313	Mixed Forest	235.95	224.43	-4.88
321	Natural Grassland	950.3	940.47	-1.03
322	Moors & Heathland	606.44	599.69	-1.11
324	Transitional woodland scrub	2,166.25	3,421.47	57.94
331	Beaches, Dunes & sand	149.34	147.44	-1.27
332	Bare Rock	167.26	167.26	-
333	Sparsely vegetated area	202.42	203.32	0.44
334	Burnt areas	0.31	-	-
Wetlands		13,176.09	12,145.06	-7.83
411	Inland Marshes	185.54	180.17	-2.89
412	Peat bogs	12,486.91	11,461.54	-8.21
421	Salt marshes	31.5	31.05	-1.43
423	Intertidal flats	472.14	472.3	0.03
Water Bodies		1,684.31	1,665.87	-1.09
511	Stream courses	96.68	89.99	-6.92
512	Water bodies	1,240.36	1,228.61	-0.95
521	Coastal Lagoons	10.11	10.11	0.00
522	Estuaries	337.16	337.16	0.00

Table 12. Changes by Area (ha)

Change	Area (ha)
231→211	208,575
412→324	75,913
312→324	66,582
211→231	60,170
324→312	30,351
412→312	24,208
231→242	16,005
231→112	12,160
242→231	10,607
211→242	5,187

A number of important changes in land cover in Ireland are evident from the comparison on the CLC 1990 and CLC 2000 databases. The main changes are:

1. Increase in artificial surfaces
2. Loss of green urban areas
3. Increase in sports and leisure
4. Loss of peat bogs

9.4.1 Increase in Artificial Surfaces

There was a 30% increase in artificial surfaces between 1990 and 2000. Most of this increase is explained by the increases in the following

Discontinuous urban (sub-urban housing); increase of 165 km² or +23%

Infrastructure (roads and railways); increase of 18 km² or +672%

Mineral extraction sites (quarries and dumps); increase of 47 km² or +26%

Construction sites; increase of 181 km² or +18%

All of these increases are probably related to the economic growth in Ireland in the 1990s and the demand for new housing. There was also an extensive building of new infrastructure (mainly motorways) during this period.

As can be seen from table 13 (below), over 97% of the new artificial surfaces were replacing agricultural land.

Table 13. Areas which have changed to artificial cover in CLC2000

		km ²	%
Artificialisation of Surfaces:		312.31	
(to disc. Urban Fabric)		155.75	49.87
1990	2000		
<i>Agricultural Land</i>		305.02	97.67
211	112	19.89	
	121	7.79	
	122	2.21	
	131	5.48	
	133	8.57	
	142	12.59	
231	112	121.6	
	121	12.09	
	122	8.84	
	124	1.12	
	131	15.56	
	133	17.3	
	142	48.31	
242	112	4.33	
	122	0.44	
	123	0.16	
	131	2.27	
	133	0.34	
	142	0.89	
243	112	9.12	
	122	1.04	
	131	1	
	133	0.13	
	142	3.95	
<i>Forest</i>		1.24	0.40
311	112	0.38	
	131	0.13	
	142	0.14	
312	131	0.09	
	142	0.5	
<i>Semi-Natural Areas</i>		4.69	1.50
321	112	0.28	
324	112	1.85	
	131	0.58	
	142	0.07	
331	142	1.91	
<i>Wetlands</i>		1.36	0.44
412	112	0.15	
	131	1.21	

9.4.2 Loss of green urban areas

There was an overall 6.1 km² increase in green urban areas between 1990 and 2000 (2% increase). However, the statistics shows that not all green urban areas present in 1990 were preserved to 2000. About 6.8 km² of green urban areas in 1990 were lost to artificial surfaces (see table 14). More detailed analysis of the spatial locations of these losses is needed, but it might be expected that much of the loss has been the infilling of old abandoned pasture fields at the margin of the cities.

Table 14. Areas of lost Green Urban Cover CLC2000

Loss of Green Urban Areas			6.8 km²
<i>1990</i>	<i>2000</i>	<i>km²</i>	<i>%</i>
141	112	3.76	55.29
	121	1.48	21.76
	122	0.27	3.97
	133	1.29	18.97

9.4.3 Increase in sports and leisure facilities

After housing and infrastructure, the most prominent increase in artificial surfaces has been the growth in sports and leisure facilities. There was a 70% increase in the area covered by these facilities between 1990 and 2000 (+69 km²). Nearly 89% of these have been built of previously green field sites (pasture or arable) and a large proportion may be golf courses.

Table 15. Areas which have changed to sports and leisure cover in CLC2000

Sport & Leisure Facilities			68.62 km²
<i>1990</i>	<i>2000</i>	<i>km²</i>	<i>%</i>
133	142	0.26	0.38
211	142	12.59	18.35
231	142	48.31	70.40
242	142	0.89	1.30
243	142	3.95	5.76
311	142	0.14	0.20
312	142	0.5	0.73
324	142	0.07	0.10
331	142	1.91	2.78

9.4.4 Loss of peat bogs

Peat bogs account for an important land cover class in Ireland. They generally occur in lowland areas as raised bog or as upland plateau blanket bogs. Over 1,025 km² of peat bogs were 'lost' between 1990 and 2000 (-8.2%). The planting of new coniferous forestry accounted for 24% of the loss whilst the change to transitional woodland scrub (also generally new forest plantations without closed canopy) accounted for 74% of the loss.

Table 16: Reasons for loss of peat bogs CLC2000

Loss of Peat Bogs		1024.51 km²	
<i>1990</i>	<i>2000</i>	<i>km2</i>	<i>%</i>
412	112	0.15	0.01
	131	1.21	0.12
	231	9.33	0.91
	243	9.9	0.97
	311	0.41	0.04
	312	242.08	23.63
	313	0.41	0.04
	324	759.13	74.10
	334	0.9	0.09
	512	0.99	0.10

10. CONCLUSIONS

The aim of the CORINE 2000 project, *i.e.* the production of an updated digital land cover database of the Republic of Ireland according to the CORINE specifications, has been fully and successfully achieved.

The main problems to be addressed by the National Team related to the quality of the 1990 dataset. These problems resulted in a large proportion of data that required editing.

The problems encountered during the verification missions emphasise the need for consultations with national botanical experts. This ensures the most appropriate application of the CORINE nomenclature to the complexity of the land cover of Ireland.

CORINE 2000 is a valuable dataset for Ireland, particularly in light of the rapid growth in the economy in the last 10 years. The CLC 2000 should be an important input into monitoring the spatial strategy in Ireland and for any future revision of the strategy.

11. ACKNOWLEDGEMENTS

The National Team would like to acknowledge the input and assistance of the individuals and organisations that assisted in the successful implementation of this project.

In particular thanks are due to the EEA Technical Team (George Buttner, Jan Feranac, Susan Christensen, and Gergely Maucha) for their continued support and encouragement and invaluable technical advice.

Thanks are also due to the many organisations and individuals who provided ancillary data for the correct identification of many of the CORINE classes. The team acknowledge the valuable assistance of our consultants to the project provided by Dr. Grace O'Donovan and Katherine Duff for their expertise on the complexities of the Irish landscape.

We would also like to thank the following:

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Catriona Douglas – Dúchas
Ordnance Survey Ireland (OSI)
Irish Peatland Conservation Council (IPCC)
Coillte
The Geological Survey of Ireland (GSI)
Local Government Computer Services Board (LGCB)
UK's Centre for Ecology and Hydrology (CEH)
Clare Byrne
Bord na Mona
Environment and Heritage Service Northern Ireland (EHS)

12. REFERENCES

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Feehan, J. & O'Donovan, G. (1996) "The Bogs of Ireland. An Introduction to the Natural, Cultural and Industrial Heritage of Irish Peatlands".

O'Sullivan, G. *et al* (1994) "CORINE Land Cover Project (Ireland)". Project Report

Perdigao, V., Annoni, A. (1997) "Technical and Methodological Guide for Updating CORINE Land Cover Data Base". EUR 17288 EN

Taracsák, Gábor (2002) "InterChange 1.0" User Manual.

APPENDIX I Details of Ancillary Data

Data source/type	Title	Date of production (m/d/y)	Scale (spatial detail)	Description	Comment
Vector dataset	The salt marshes of Ireland: an inventory and account of their geographical variation	12-30-98		Vector point coverage of a comprehensive inventory of the salt marshes of the entire coastline of Ireland (Curtis & Skeffington, 1998). Two-hundred-and-fifty marshes are classified according to physical structure and origin.	Date given is publishing data.
Vector dataset	Airports	07-26-01		Vector point coverage of the location of civil, military & regional airports & aerodromes in Ireland.	Date given is that of production of ArcView shapefile
Vector dataset	BirdWatch Ireland Reserves	07-20-01		Vector point coverage of the location of BirdWatch Ireland reserves in Ireland. Attribute data includes site name, county, location, site (ha & acres) & site description.	Date given is that of production of ArcView shapefile
Digital aerial photographs	National Coastline Survey CD	2000	Image resolution 30cmx30cm	The National Coastline Survey shows high resolution images of the entire Irish coastline. Each digital picture covers a 600m coastal strip	
Vector dataset	Forestry Inventory - new plantings and clearings	Aug-01		Vector boundary coverage of Coillte land of approx 20ha or more where the land use is classified as felled, blown or burnt as defined by the Coillte Inventory Code.	
Vector dataset	FIPS	1998		Vector boundary coverage for all Coillte owned forestry within the Republic of Ireland.	

Vector dataset	Local Authority Landfill Monitoring Dataset	1998		Vector point coverage for landfill sites.	Date of publication of EPA's Millennium Report State of the Environment.
Vector dataset	Geological Survey Ireland (GSI) quarry dataset	2001			
Vector dataset	Semi-natural Grassland Communities in Eastern Ireland: Classification, Conservation and Management.	Dec-96		Vector point coverage of areas of Natural Grassland in the Leinster province of Ireland. Site data taken from "Semi-natural Grassland Communities in Eastern Ireland: Classification, Conservation and Management." Clare Byrne PhD. TCD. Dec 1996.	
Vector dataset	Irish Peatland Conservation Council dataset	06-27-2001		Vector point coverage of the location of IPCC peatland sites in Ireland. Attribute data includes site name, NHA name, NHA code, County, Area, Grid Ref, Habitat Type, Site description & designations.	
Vector dataset	Ireland Peatland Map.	1978	1:575,000	Vector boundary coverage of Ireland peatland map (Hammond, RF). Classes include man-modified peat and raised/blanket bog.	
Vector dataset	Sea Ports	08-21-2001		Vector point coverage displaying 49 ports around Ireland.	Date given is that of production of ArcView shapefile

Vector dataset	Special Areas of Conservation, Special Protection Areas, Natural Heritage Areas, Nature Reserves, National Parks.	Mar-02	1:10,560	Vector boundary coverage of SAC's, SPA's, NHA's, NR's & Nat Parks on a county basis derived from 1:10,560 series OSI maps. There is also an associated text file with site synopses on a county by county basis	
Vector and Raster datasets	IFIS data	Jun-98	Minimum spatial resolution of IFS classes is 1ha	Landcover Thematic Map. Parent material map derived from interpretation of stereo photographs and compilation of all existing published parent material and Quaternary geology data for County Mayo.	Available for certain counties.
Vector dataset	Heaths	06-18-2002		Vector point coverage of Dúchas Heath sites in Ireland. Attribute data includes site-name, county, Irish grid reference, altitude and probable habitat type	

APPENDIX II**Map Sheet Coordinates**

	Top Left Co-ordinates		Bottom Right Co-ordinates	
Sheet	Easting	Northing	Easting	Northing
1E Top	205000	460000	260000	422500
1E Bot	205000	422500	260000	385000
1W Top	147500	460000	205000	422500
1W Bot	147500	422500	205000	385000
2W Top	260000	460000	315000	422500
3E Top	205000	385000	260000	347500
3E Bot	205000	347500	260000	310000
3W Top	147500	385000	205000	347500
3W Bot	147500	347500	205000	310000
4W Bot	260000	355000	325000	310000
5E Top	95000	347500	147500	310000
5E Bot	95000	310000	147500	272500
5W Top	40000	347500	95000	310000
5W Bot	40000	310000	95000	272500
6E Bot	95000	272500	147500	235000
6W Bot	40000	272500	95000	235000
7E Top	205000	310000	260000	272500
7E Bot	205000	272500	260000	235000
7W Top	147500	310000	205000	272500
7W Bot	147500	272500	205000	235000
8N L	260000	310000	297500	255000
8N R	297500	310000	335000	255000
8S R	260000	255000	297500	200000
8S L	297500	255000	335000	200000
9E Top	95000	235000	147500	197500
9E Bot	95000	197500	147500	160000
9W Top	62000	235000	95000	197500
9W Bot	62000	197500	95000	160000
10E Top	205000	235000	260000	197500
10E Bot	205000	197500	260000	160000
10W Top	147500	235000	205000	197500
10W Bot	147500	197500	205000	160000
11E Top	95000	160000	147500	122500
11E Bot	95000	122500	147500	85000
11W Top	30000	160000	95000	122500
11W Bot	30000	122500	95000	85000
12E Top	205000	160000	260000	122500

12E Bot	205000	122500	260000	85000
12W Top	147500	160000	205000	122500
12W Bot	147500	122500	205000	85000
13N L	260000	200000	297500	145000
13N R	297500	200000	335000	145000
13S L	260000	145000	297500	90000
13S R	297500	145000	335000	90000
14E Top	95000	85000	147500	47500
14E Bot	95000	47500	147500	10000
14W Top	30000	85000	95000	47500
14W Bot	30000	47500	95000	10000
15E Bot	205000	85000	260000	35000
15W Bot	147500	85000	205000	35000

APPENDIX III – CORINE Nomenclature

Level 1	Level 2	Level 3
1. Artificial surfaces	1.1 Urban fabric	1.1.1 Continuous urban fabric
		1.1.2 Discontinuous urban fabric
	1.2 Industrial, commercial and transport units	1.2.1 Industrial or commercial units
		1.2.2 Road and rail networks and associated land
		1.2.3 Sea ports
		1.2.4 Airports
	1.3 Mines, dumps and construction sites	1.3.1 Mineral extraction sites
		1.3.2 Dump
		1.3.3 Construction sites
	1.4 Artificial non-agricultural vegetated areas	1.4.1 Green urban areas
		1.4.2 Sport and leisure facilities
2. Agricultural areas	2.1 Arable land	2.1.1 Non-irrigated arable land
		2.1.2 Permanently irrigated land
		2.1.3 Rice fields
	2.2 Permanent crops	2.2.1 Vineyards
		2.2.2 Fruit trees and berries plantations
		2.2.3 Olive groves
	2.3 Pastures	2.3.1 Pastures
	2.4 Heterogeneous agricultural areas	2.4.1 Annual crops associated with permanent crops
		2.4.2 Complex cultivation patterns
		2.4.3 Land principally occupied by agriculture with significant areas of natural vegetation
		2.4.4 Agro-forestry
3. Forest and semi-natural areas	3.1 Forests	3.1.1 Broad leaved forest
		3.1.2 Coniferous forests
		3.1.3 Mixed forest
	3.2 Scrub and/or herbaceous vegetation associations	3.2.1 Natural grassland
		3.2.2 Moors and heathlands
		3.2.3 Sclerophyllous vegetation
		3.2.4 Transitional woodland-scrub
	3.3 Open spaces with little or no vegetation	3.3.1 Beaches, dunes, sand
		3.3.2 Bare rocks
		3.3.3 Sparsely vegetated areas
		3.3.4 Burnt areas
		3.3.5 Glaciers and permanent snowfields

4. Wetlands	4.1 Inland wetlands	4.1.1 Inland marshes
		4.1.2 Peat bogs
	4.2 Coastal wetlands	4.2.1 Salt marshes
		4.2.2 Salines
		4.2.3 Intertidal flats
5. Water bodies	5.1 Continental waters	5.1.1 Stream courses
		5.1.2 Water bodies
	5.2 Marine waters	5.2.1 Coastal lagoons
		5.2.2 Estuaries
		5.2.3 Sea and ocean

APPENDIX IV Example Metadata Sheet

CLC2000 METADATA

- Please provide a single summary file for each interpretation sheet -

Title of working unit:	1. 1E_BOT
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A: GENERAL INFORMATION

Contractor:	EPA
Address:	PO Box 3000, Johnstown Castle Estate, Co. Wexford, Ireland
Phone:	+353 (0) 53 60600
Fax:	+353 (0) 53 60699
Responsible:	Micheal Lehane
E-mail:	m.lehane@epa.ie

Contracted:	ERA Maptec Ltd
Address:	36 Dame Street, Dublin 2, Ireland
Phone:	+353 (0) 1 679 9227
Fax:	+353 (0) 1 679 9798
Project leader:	Martin Critchley
E-mail:	mcritchley@era.ie

1. IMAGE2000 data used

1.1.2 Landsat ETM or other scene(s)

Satellite & Sensor	Path-	Row	Date (m/d/y)	1.1.3 Remark (e.g. clouds)
Landsat 7 ETM+	208	22	07/22/2000	Some small clouds from BL corner towards centre of unit.
Landsat 5 TM	207	22	05/23/2001	Small-scattered cloud towards east of unit.
Landsat ETM+	206	22	05/24/2001	Cloud-free

2. Topographic maps used (indicate in remark if digital)

Scale	Sheet id	Title/Name	Year of production	Year of last revision	Remark
1:50 000	2238	OS Discovery Series	1996		Digital Format
1:50 000	2240	OS Discovery Series	1996		Digital Format
1:50 000	2040	OS Discovery Series	1996		Digital Format
1:50 000	2038	OS Discovery Series	1996		Digital Format

3. Other ancillary data used (thematic data, satellite images, aerial photos, city maps, vegetation maps)

Id	Data source/type	Title (if relevant)	Date of production (m/d/y)	Scale (spatial detail)	Remark
	Vector boundary coverage for all Coillte owned forestry within the Republic of Ireland.	FIPS	1998		Attributes include the land use type, mixture type & age. Useful to delineate new forestry.

	Vector point coverage of the location of IPCC peatland sites in Ireland.	IPCC	06/27/2001		Attribute data includes site name, NHA name, NHA code, County, Area, Grid Ref, Habitat Type, Site description & designations. Useful for distinguishing between heath and bog.
	Vector point coverage of a comprehensive inventory of the salt marshes of the entire coastline of Ireland.	The salt marshes of Ireland: an inventory and account of their geographical variation	12/30/1998		Two-hundred-and-fifty marshes are classified according to physical structure and origin. Useful for identifying estuaries, lagoons and saltmarshes.
	Vector and raster datasets	IFIS data	Jun/1998	minimum spatial resolution of IFS classes is 1ha	Landcover Thematic Map. Parent material map derived from interpretation of stereo photographs and compilation of all existing published parent material and Quaternary geology data. Useful for bare rock class and peat/heath identification.
	Vector point coverage of Duchas Heath sites in Ireland.	Heaths	06/18/2002		Attribute data includes site-name, county, Irish grid reference, altitude and probable habitat type. Useful for distinguishing between peat and heath.
Region 4	Vector boundary coverage of Coillte land of approx 20ha or more where the land use is classified as felled, blown or burnt as defined by the Coillte Inventory Code.	Coillte	Aug/2001		Definitions of each of these land use types are provided. Additional land use type classifications, namely Bare Plantable, Bare Unplantable and Bare Marginal are also included. Useful for identifying felled forestry.
	Vector point coverage of towns in Ireland	Town points			Useful for identification of urban fabric.
	Vector point coverage of quarries in Ireland.	GSI quarry dataset	2001		Useful for locating quarry sites.

4. Photointerpreter(s)

Name	Affiliation	Phone	E-mail	interpretation		
				start (m/d/y)	end (m/d/y)	no. of days
Daniel McInerney	ERA Maptec	+ 35316330515	dmcinerney@era.ie	10/03/2002	10/07/2002	4
Ian Carolan	ERA Maptec	+ 35316330515	icarolan@era.ie	07/26/2002	07/26/2002	1

B: DATA PREPARATION

1. Checking and systematic correction of IMAGE90 data (*optional*)

Landsat TM or any other satellite scenes used (e.g. SPOT)							
Satellite & Sensor	path-	row	Date (m/d/y)	Max. systematic geom. error (m)	(<i>optional</i>) Checked & corrected (name)	(<i>optional</i>) Date (m/d/y)	(<i>optional</i>) Reference data
Landsat5 TM	207 (83.8%) 206 (16.2%)	22	05/06/1989 05/02/1990	X 38.30 Y 30.56	Jean Byrne	01/17/2002	1:50,000 OS Raster Maps

2. Checking and systematic correction of CLC90 data

1.1.4 Corrections	Type of correction	Checked and corrected by	Date (m/d/y)		Remarks
			Start	end	
Geometrical errors	Systematic correction				
	Local correction	Ian Carolan	06/03/2002	06/05/2002	
Thematic errors	Logical coherence*	Ian Carolan	06/03/2002	06/05/2002	
	Semantic accuracy** and exhaustiveness***	Ian Carolan	06/03/2002	06/05/2002	Bogs/heath

* = respectation of internal rules of CLC (100 m, 25 ha) according to Tech.Guide and Addendum

**= interpretation according to CLC nomenclature;

*** = details are appropriate

3. Verification and acceptance on national level

Date (m/d/y)	Accepted by	Signature	Remark
May 2002	Odile Le Bolloch		

C: INTERPRETATION OF CHANGES AND CREATION OF CLC2000

1. Photo-interpretation and internal quality control

Date of submission (m/d/y)	Control made by	Date of control (m/d/y)	Remark (errors, corrections, etc.)
	Jean Byrne	12/19/2002	<ul style="list-style-type: none"> Multipart polygons Too many non-real changes Some cloud cover – used tm5 for these areas Problems with arable identification when not bare soil-check green colour Silver to be removed Some polygons said to be in NI are actually in South. If corner of polygon is in south then consider whole polygon in South – otherwise pieces will be missing. 321 not being checked carefully enough – is clearly agricultural land and should have been classified as 243/231 etc.

2. Field checking (*if carried out*)

Date (m/d/y)	1.1.5 Itinerary 1.1.6 (main settlements crossed on the working unit)	Problems checked and main conclusions
	1.1.	

3. Border matching with neighbour working units or countries

working unit /Country	Controlled and corrected by	Date (m/d/y)	Remark
1E_Top	Daniel McInerney	03/18/03-03/19/03	
1W_Bot	Daniel McInerney	03/18/03-03/19/03	
2W_Bot	Daniel McInerney	03/18/03-03/19/03	
3W_Top	Daniel McInerney	03/18/03-03/19/03	

D: FINAL TECHNICAL QUALITY CONTROL

1. Control of topology, unnecessary boundaries, 25 ha limit, invalid codes and invalid changes

	Date (m/d/y)	Controlled by	Remark
CLC2000	September 2003	Daniel McInerney	
CLC Changes	September 2003	Daniel McInerney	
CLC90	September 2003	Daniel McInerney	

2. Verification and acceptance

	Date (m/d/y)	Name	Signature	Remark
National level	September 2003	Odile LeBolloch		
CLC2000 technical team				

E: SOFTWARE / HARDWARE

Work phase	Software used	Hardware used
Systematic geometric correction of IMAGE90	Erdas Imagine 8.5	PC
Systematic geometric correction of CLC90	ArcView 3.2a	PC
Topological and thematic corrections of CLC90	ArcView 3.2a	PC
Interpretation of changes	InterChange 1.0	PC
Creation of CLC2000	ARC/INFO	Unix
Technical quality control	ARC/INFO	Unix
Database integration (border matching)	ArcView 3.2a	PC