



European Environment Agency



CLC06IE

CORINE Land Cover – IRELAND

Land Cover Update for 2006

FINAL REPORT

Project assisted by Grant Agreement 3601/RO/CLC/B2007.EEA53008



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1. Background

Corine stands for *Coordination of Information on the Environment*. The EC established Corine in 1985 to create pan-European databases on land cover, biotopes (habitats), soil maps and acid rain.

Corine Land Cover (CLC) is a map of the European environmental landscape based on interpretation of satellite images and includes 44 standard land cover classes. It provides comparable digital maps of land cover for each country for much of Europe. Corine Land Cover 2006 is the third dataset in a series, the previous datasets corresponding to base years of 1990 and 2000.

In this document:

The CLC 1990 dataset is referred to as **CLC90_IE**

The CLC 2000 dataset is referred to as **CLC00_IE**

The revised CLC 2000 dataset is referred to as **CLC00_{rev}_IE**

The CLC change 2000-2006 dataset is referred to as **CHA06_IE**

The CLC 2006 dataset is referred to as **CLC06_IE**

In Ireland the CLC 1990 project was undertaken as a joint cross-border initiative by the Ordnance Survey of Ireland and the Ordnance Survey of Northern Ireland. The aim was to produce a land cover map for the entire island of Ireland (CLC90_IE). This was based on data for 1989 and 1990 and was created in GIS ArcInfo™ format, at an original scale of 1:100,000, which was consistent and comparable with similar land cover databases in other European countries.

The CLC 2000 database (CLC00_IE) was created by first assessing and correcting the CLC90_IE database and images for geometric and thematic content (using improved technologies and methodology), and then producing an updated land cover database using satellite imagery and ancillary data for the year 2000. This database was produced for Ireland under contract by ERA-Maptec.

Ireland's CLC 2006 update is part of a European project to update Europe's land cover maps. This project was coordinated by the European Environment Agency (EEA) in conjunction with the European Space Agency (ESA), the European Commission (including DG Joint Research Centre) and national agencies in Eionet¹ member countries. National CLC 2006 activities took place under the umbrella of the overall GMES Fast Track Service Precursor (FTSP) on Land Monitoring. In Ireland, the Environmental Protection Agency (EPA) provided national input into GMES FTSP services. ERA-Maptec was contracted by EPA to undertake the technical aspects of the CLC 2006 update.

This document is the Final Report documenting the creation of the following CLC 2006 update databases:

- Product 3 - change in CLC 2000 to 2006 - **CHA06_IE**, and
- Product 4 - CLC 2006 - **CLC06_IE**

These databases were identified in the implementation plan of the GMES FTSP on Land Monitoring project (EEA, 2006). The CHA06_IE dataset contains changes of at least 5 ha in Corine Land Cover between the base years of 2000 and 2006, and CLC06_IE contains the land cover according to the Corine nomenclature for 2006. The datasets were produced following technical guidelines (Bossard et al., 2000, Heymann et al., 1994, Büttner et al., 2002 and Büttner and Kosztra, 2007) and Corine nomenclature (Büttner et al., 2006).

¹ Eionet is the environmental information and observation network of the European Environment Agency.

The Corine land cover datasets are intended to fulfil a primary purpose of enabling inter-country comparisons of land use and land cover across Europe. Due to the characteristics of the Corine methodology the Corine dataset is not considered optimal in representing higher precision land cover variation.

2. Databases used in the project

The following databases were used in the national CLC 2006 project:

2.1.1. Primary Data

IMAGE2000 satellite imagery

IMAGE 2006 satellite imagery (first coverage, 18-04-2007; second coverage, 03-12-07)

CLC00_IE

2.1.2. Ancillary Data

Topographic maps (1:50,000 raster) - Ordnance Survey Ireland (OSI)

Orthophotos, 2004 - Ordnance Survey Ireland (OSI)

Land cover data -Teagasc

Forest Inventory (FIPS) - Forest Service, Department of Agriculture, Fisheries and Food

Land Parcel Identification vectors (LPIS) - Department of Agriculture, Fisheries and Food

Saltmarsh survey data – ‘Potential_national_saltmarsh_2007’ GIS polygon shapefile derived by M. McCorry as part of unpublished report ‘Saltmarsh Monitoring Project 2006 - Summary Report’ for National Parks & Wildlife Service, Department of Environment, Heritage and Local Government, Dublin.

LUCAS 2001 data was not used, as comparative LUCAS data for 2006 was unavailable for Ireland and other data sources were of sufficient detail to produce the CLC06_IE dataset.

2.1.3. IMAGE 2000 satellite imagery

The IMAGE2000 satellite mosaic was composed of six full standard Landsat 7 ETM+ scenes and three full standard Landsat 5 TM scenes (Table 1). This mosaic, along with CLC 1990, was the basis for the production of the CLC00_IE dataset.

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

Table 1: IMAGE2000

2.1.4. IMAGE 2006 satellite imagery

The first coverage of IMAGE2006 was received in April 2007 (Table 2, Figure 1, 2, 3). The geometric precision of orthoimages was assessed using CLC00_IE and imagery. As a result of this assessment the effects of altitude and the overall influences of relief were deemed to be minimal. The majority of the images are cloud free; however there is a substantial amount of cloud cover over the North West of the country (parts of counties Donegal and Mayo). The IMAGE2006 first coverage does not always have a break of 6 weeks between images. The second coverage was received in December 2007.

	IRS Orthoimages	SPOT Orthoimages
Sensor	IRS-P6-LISS III	SPOT 4, SPOT 5
Resolution	20m	20m
Spatial Coverage	Republic of Ireland	Republic of Ireland
1st Temporal Coverage	12 July 2005 – 09 June 2006	7 August 2005 – 22 September 2006
2nd Temporal Coverage	02 April 2007 – 12 April 2007	19 November 2005 – 27 September 2007

Table 2: IMAGE2006

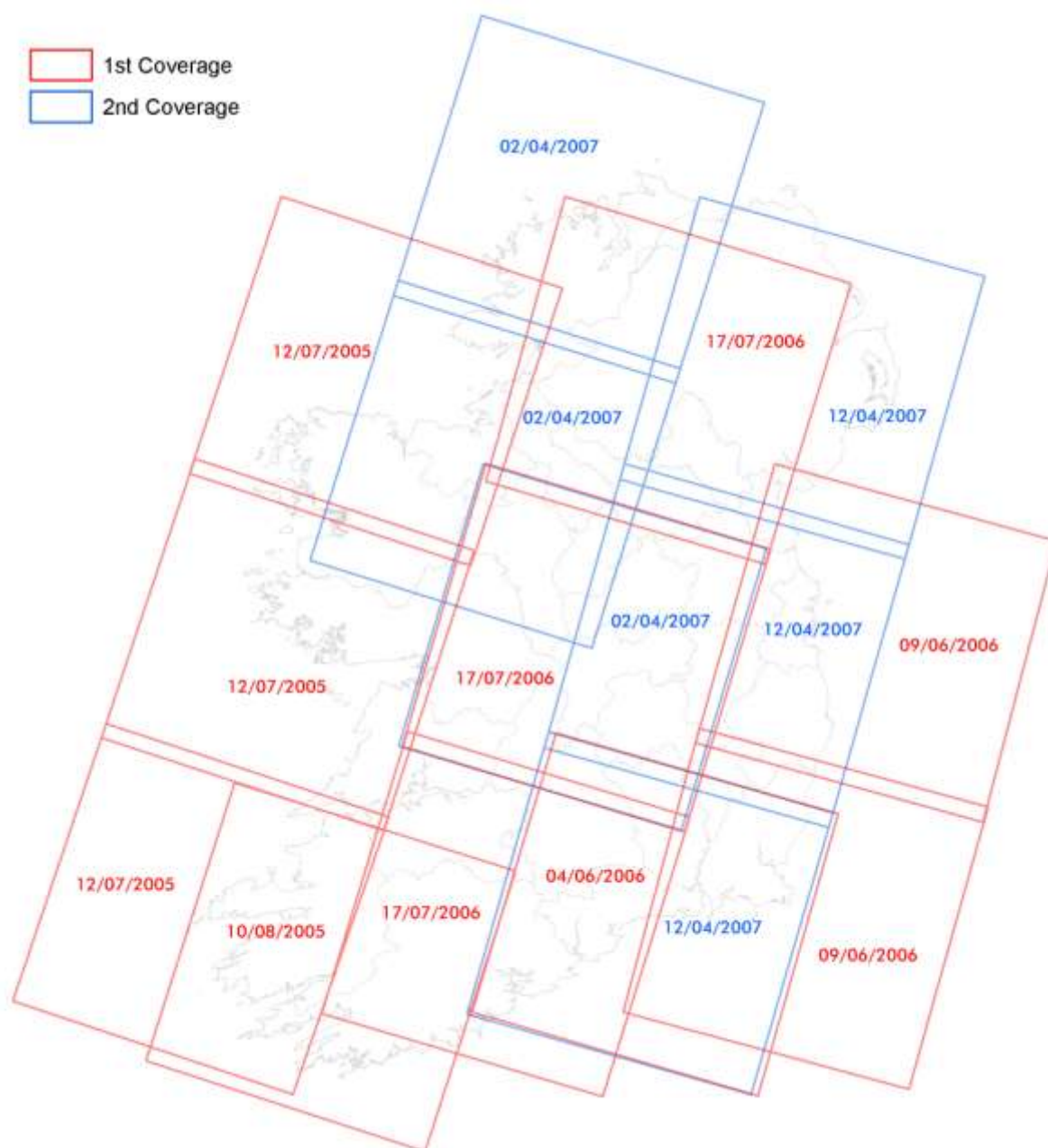


Figure 1: IRS coverage

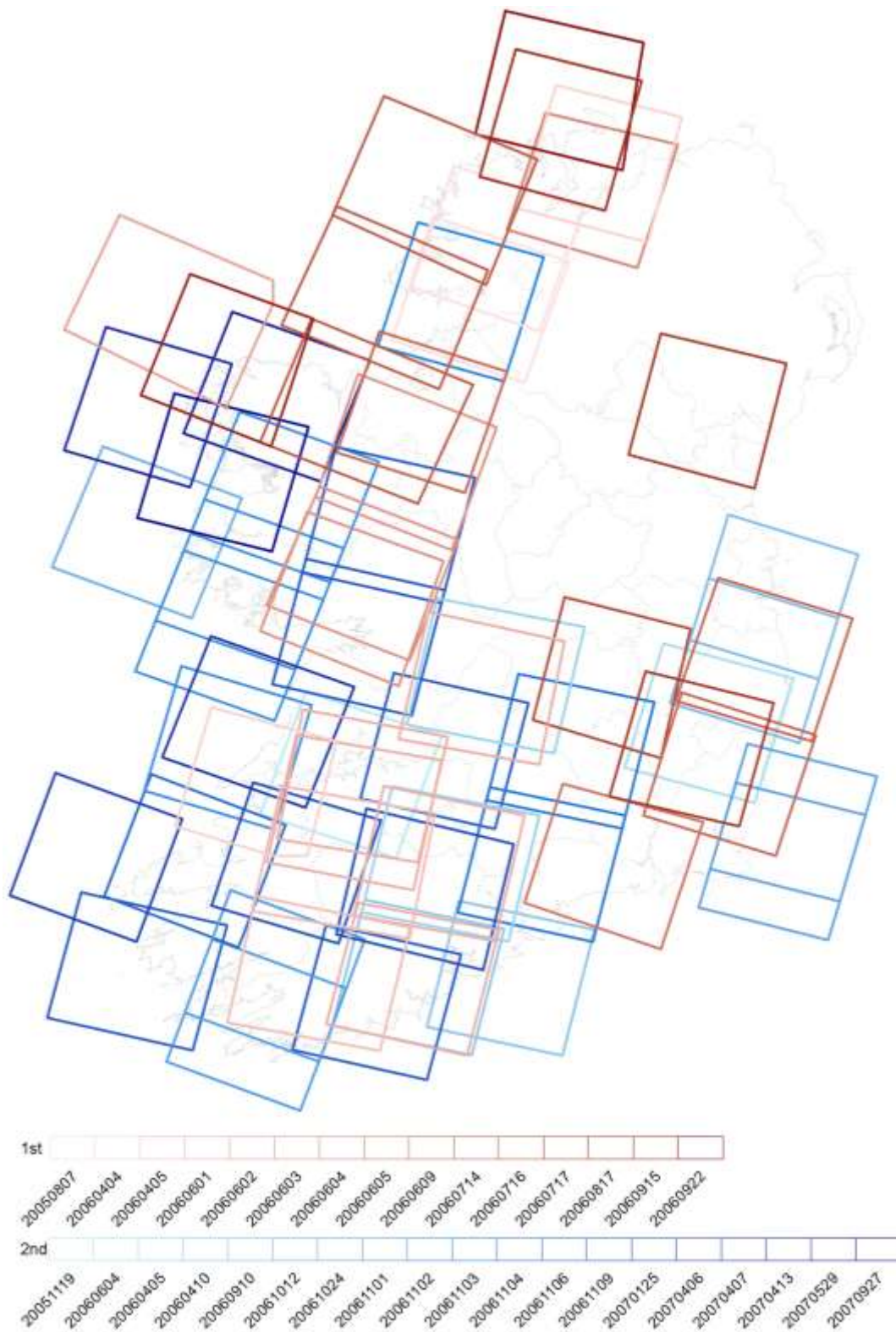


Figure 2: SPOT coverage

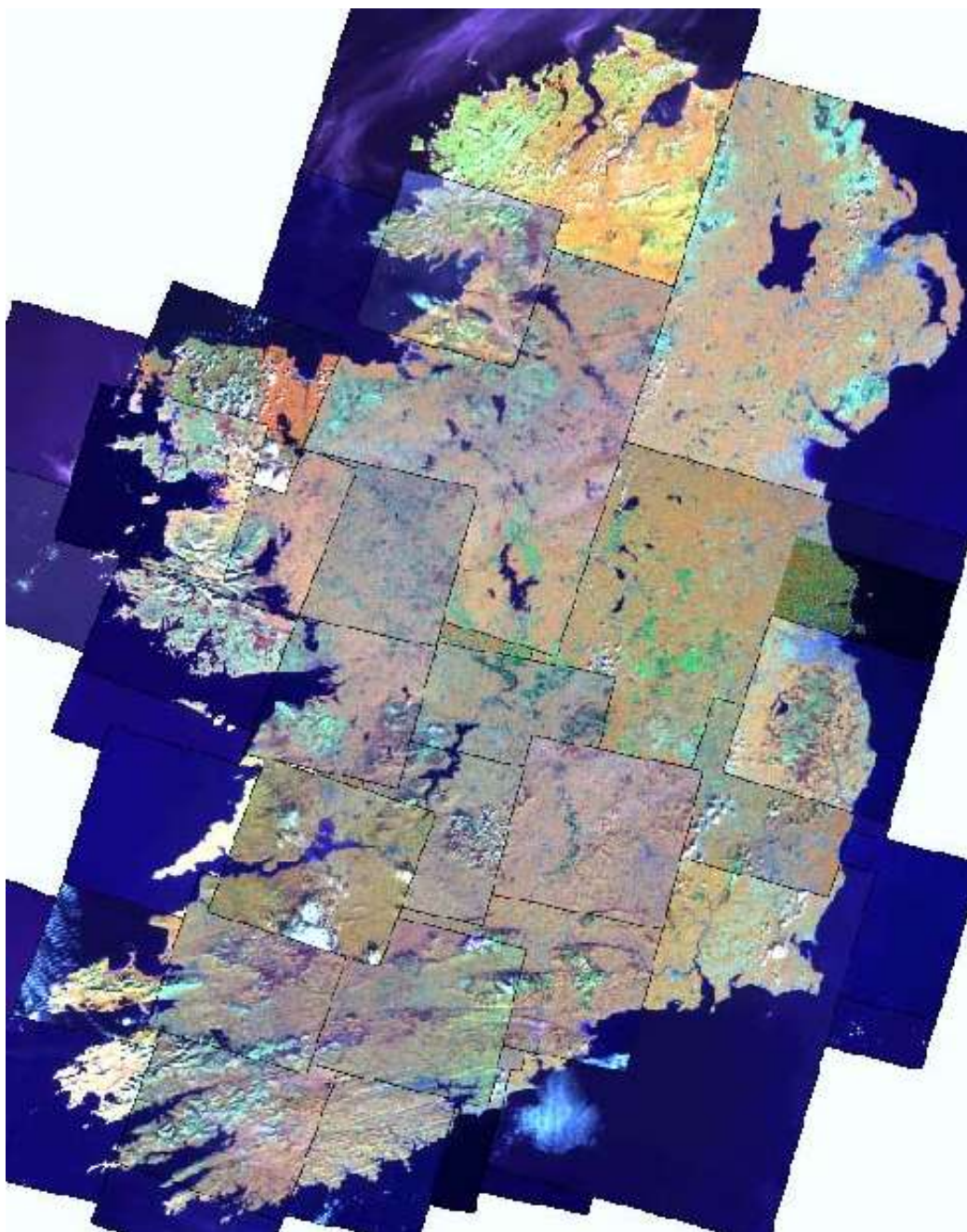


Figure 3: Second Coverage Imagery, FTSP

Both satellite mosaics were used in the interpretation of land cover changes between 2000 and 2006.

2.1.5. CLC00_IE

The CLC00_IE dataset delivered by the EEA, revised where necessary, was used as the basis for the visual interpretation of land cover changes between 2000 and 2006. Topographic maps and orthophotos, alongside the other environmental datasets listed above, were used as ancillary data to verify land cover where identification was questionable.

3. Organisation of the work at national level

The project started in April 2007 with the delivery of the first coverage imagery (Table 3).

3.1. Milestones

Milestone	Date
Image 2006 1 st coverage	April 2007
Image 2006 2 nd coverage	Dec 2007
Product 3 CHA06_IE completed	Feb 2009
Product 4 CLC06_IE completed	Feb 2009
Interim report completed	Feb 2009
Final report -	June 2009

Table 3: Milestones

3.2. Corine Land Cover 2006 training

A refresher training course for the Irish CLC team (interpreters and the relevant staff of the EPA) was requested at the start of the project. The CLC Technical Team was unable to provide training when requested (June 2007) because of other commitments. The Technical Team suggested the following:

- Not to have Corine Land Cover 2006 training in Ireland but to clarify questions via e-mail or phone.
- To schedule a first verification before 50% of the working units have been (\approx 30%) completed.

Training in the identification and analysis of technical changes only took place during the verification from October 13th – 17th 2008

3.3. Participating experts

National Team – Coordinators

George McHugh, Environmental Protection Agency – Project Manager up to 31 March 2009

Fiona O'Rourke, Environmental Protection Agency – Project Manager from 1 April 2009

Philip O'Brien, Environmental Research Centre, Environmental Protection Agency

Interpretation Team

Martin Critchley, ERA-Maptec Ltd

Claire FitzGerald, ERA-Maptec Ltd

Eilis Vaughan, ERA-Maptec Ltd

Terence O'Rourke, ERA-Maptec Ltd

John Jennings, ERA-Maptec Ltd

Grace O'Donovan, Broadview Ecology

National Steering Committee

Frank Barrett, Forest Service

Kevin Black, COFORD

Bernard Cassidy, Ordnance Survey Ireland (National Mapping Agency)

John Connolly, University College Dublin (peat lands)

Shelia Convery, University College Dublin (urban areas)

Jack Creaner, Department of Agriculture, Fisheries and Food (land parcels)

Ned Dwyer, University College Cork (Marine Irish Data Atlas)
Stuart Green, Teagasc (National Agricultural Research and Training Authority) – agricultural areas
Daniel McNerney, University College Dublin (urban areas)
Gearoid O' Riain, Compass Informatics (WFD contractor)
Gemma Weir, National Parks and Wildlife Service - habitats

3.4. Processing methodology

3.4.1. Software

The CLC 2006 Support Package is a significantly modified and improved version of the 2000 Support Package, which was provided to assist in the implementation of the European CLC 2000 project. This software has been developed by the Remote Sensing Centre of the Hungarian Institute of Geodesy, Cartography and Remote Sensing (FÖMI).

The CLC 2006 Support Package operates within the ESRI ArcView™ environment and is a supplement to ArcView 3.2/3.3 GIS. ArcView software is designed primarily for viewing GIS databases with tools for creating maps, menus for handling databases and graphical editing tools. At the same time, ArcView 3.2 includes only limited and less effective tools for creating and filling new polygon databases or modifying existing polygon databases.

The CLC 2006 Support Package is a macro package written in *Avenue*, ArcView's (version 3.2) own macro scripting language. The use of this Support Package significantly facilitates updating, change detection, quality control and correction of land cover databases by means of computer-assisted visual photo interpretation. As a solution, the CLC 2006 Support Package under ArcView provides an inexpensive tool for quick and comfortable editing and handling of CLC databases.

The support package includes InterPrepare and InterChange:

InterPrepare

This is used for the preparation of source files and work directories for change detection to be carried out with InterChange. It builds a pre-described directory structure for the interpreter which contains all the files needed for change detection.

InterChange

This program provides a tool for the revision of the CLC00_IE database and supports the interpretation of land cover changes in order to create the CLC06_IE database. The program provides a convenient and easy to use GUI of tiled viewers for editing and creating polygons during the interpretation process.

3.4.2. Mapping land cover changes in CLC 2006

CHA06_IE (mapping changes in Corine Land Cover between 2000 and 2006) is the primary and most important product of the project. CHA06_IE is an original product, (i.e., it is not derived from an intersection of CLC00_IE and CLC06_IE) and has a smaller MMU (5 ha) than CLC00_IE and CLC06_IE (25 ha).

3.4.3. Training of interpreters

Using the CLC 2006 Support Package, image interpreters were trained in CLC 2006 Interchange software.

3.4.4. Updating approach

Working units were prepared using InterPrepare before analysis using InterChange (Figure 4).

Data used for CLC 2006 program:

- CLC vector database of the previous CLC inventory (CLC00_IE)
- Landsat TM satellite imagery used for CLC00_IE (IMAGE2000)
- IRS and SPOT imagery for the new inventory (IMAGE2006)

Filenames that referred to the date and time of acquisition were assigned to the images e.g. 20060602_122537_122546. Orthorectified IMAGE2000 and IMAGE2006 images were provided to the contractor. The imagery was divided into 51x51 km working units including an overlap of 1 km between neighbouring working units (Figure 4). IRS and SPOT images were displayed with the band combination RGB in bands 342. A linear contrast stretch was applied to each image in order to improve the visual clarity for interpretation.

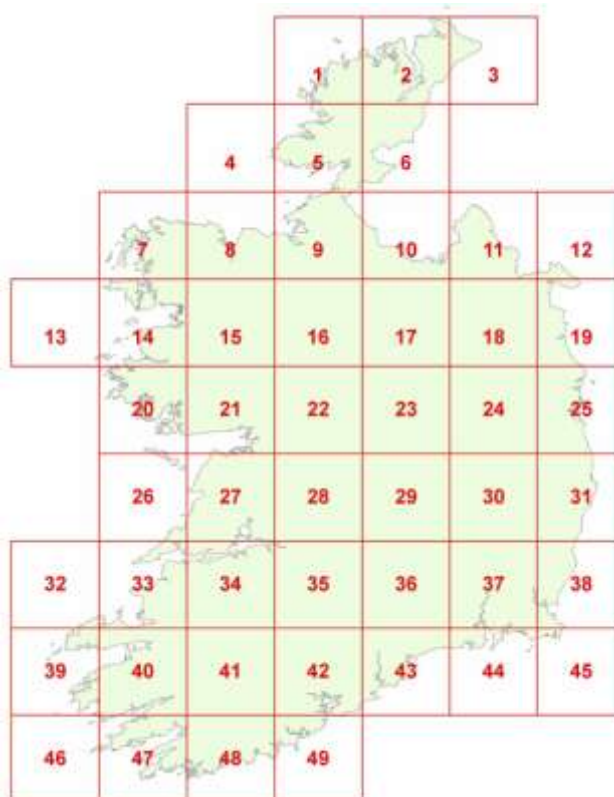


Figure 4: Working units

During the production of the CLC 2006 update databases, it was found necessary to make revisions to the CLC00_IE database used as the baseline for the interpretation of land cover change. This work resulted in the production of a revised CLC00_IE database (CLC00_{rev}_IE). Land cover changes were interpreted directly in the dual window environment using the MLog Interchange software built in ArcView3.2. If a CLC00_{rev}_IE polygon had changed it was taken over into the CHA06_IE database, where only the changed part was kept as a polygon. Delineation of changes was based

on CLC00_{rev}_IE polygons in order to avoid the creation of sliver polygons and false changes when producing the CLC06_IE database by intersecting data. The change polygons were then recoded to represent the land cover status of the given polygon as interpreted from the IMAGE2006 imagery. During the delineation of the changes the mapping rules of a minimum area of 5 ha and a width distance of 100m were followed.

Change polygons were then combined with CLC00_{rev}_IE to create the CLC06_IE database. The CLC06_IE database is computed accordingly:

$$\text{CLC06_IE} = \text{CLC00}_{\text{rev_IE}} (+) \text{CHA06_IE}$$

Where (+) means the following operation: CLC00_{rev}_IE and CHA06_IE are intersected, first CLC-Change polygons' code₂₀₀₀ is replaced by code₂₀₀₆ and neighbours with identical codes were unified. Areas of change less than 25ha were eliminated from the CLC06_IE database. In cases where several different CHA06_IE polygons (of differing land cover change) need to be combined to form a new CLC06_IE polygon, a decision is required for the actual code to be applied to the 2006 polygon. In these cases the priority matrix as specified in the Corine Land Cover 2006 Technical Manual was used to arbitrate when combining adjacent individual CLC06_IE change polygons to form CLC06_IE polygons with a minimum mapping unit of 25ha.

3.5. Level 4 and Level 6 Corine in Ireland

The CLC00_IE database in Ireland has level 4 and level 6 codes for peat bogs and pasture. These were included to CLC00_IE in order to map land cover classes related to important habitats in Ireland. However, for CLC06_IE the national steering committee was of the opinion that the MMU area of Corine (25ha) was too large to be of much use for mapping these habitats in Ireland and thus opted not to map level 4/level 6 classes in CLC06. In addition, the accurate mapping of grasslands at level 4 and level 6 would require multi-temporal imagery across a growing season which was not available in the IMAGE2006 dataset.

3.6. Internal quality control

In the Irish CLC00_IE database there were a number of large pasture polygons, the topology of which was examined and verified that there were no overlapping polygons prior to editing.

3.7. External quality control

The verification missions took place on October 10th-12th, 2007 (Feranec & Mari, 2007), and July 29th-31st, 2008 (Büttner & Kosztra, 2008). An additional verification mission requested by the EPA took place on October 13th-17th, 2008. The mission reports for verification missions one and two describe the verification methodology and main problems encountered during the verifications. The remarks made by the Technical Team were taken into account and the CLC00_IE and CHA06_IE datasets edited appropriately.

3.7.1. First Verification

The InterCheck2.0 software running under ArcView 3.2 was used as a support tool for verification. The verification experts selected verification units in an 'ad-hoc' fashion to cover all significant landscape types in the country. A minimum of one verification unit was selected in each working unit to cover different landscape features. IMAGE2000 and IMAGE2006 data were available for all verification units. The checking process was as follows:

- Checking validity of codes and neighbouring polygons with the same code (merge errors) in CLC00_IE
- Checking size errors in CLC00_IE
- Checking CLC00_IE statistics (to reveal non-relevant codes)
- Checking validity of codes and neighbouring polygons with the same code (merge errors) in CHA06_IE
- Checking size errors in changes
- Checking CHA06_IE statistics (to reveal non-relevant codes)
- Visual evaluation inside verification units

Approximately 14% of the country was prepared for the first verification. Of the five verification units all were conditionally accepted.

CLC00_IE: It was noted that data quality was good technically but required thematic improvement.

CHA06_IE

The technical team found that many changes were identified and coded properly but the number of changes was overestimated (Figure 5). Metadata sheets were not checked during this verification.

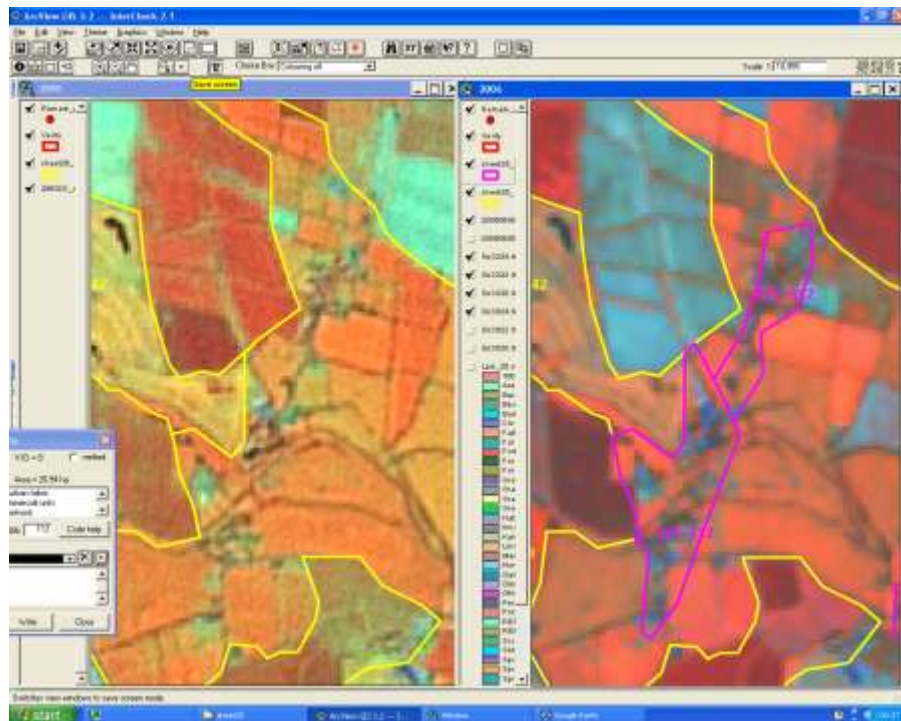


Figure 5: Non-real changes

3.7.2. Second Verification

Not all remaining working units could be verified because a large area (86% of the country) was to be checked; therefore only every second working unit was checked. The checking process was as follows:

- Checking validity of codes and neighbouring polygons with the same code (merge errors) in CLC00_IE
- Checking CLC00_IE statistics (to reveal non-relevant codes)

- Checking size errors and validity of codes in CHA06_IE
- Checking CHA06_IE statistics (to reveal non-relevant codes)
- Visual evaluation

Of the 23 verified working units, 5 were accepted, 15 were conditionally accepted and 3 were rejected. Remarks outlining required revisions to both the CLC00_IE and CHA06_IE datasets were documented.

3.7.3. Additional Verification

After the second validation there was a request by ERA-Maptec for additional technical assistance in the correction of CLC00_IE to cover the following:

- Agreement on forest changes
- Checking of sheets corrected to date
- Provision of training in technical changes
- Checking of sheets not verified in second verification visit
- Re-validation of corrected sheets off-site during November 2008

The remaining 28 working units not verified during the second visit were verified during the additional verification by George Büttner and Barbara Kosztra; of these, 8 were accepted, 10 were conditionally accepted and 10 were rejected. Remarks outlining required revisions to both the CLC00_IE and CHA06_IE datasets were documented for these 28 working units. Corrections were then applied to all the working units in accordance with the remarks of the Technical Team. All 49 corrected working units were then re-submitted for a final re-validation off-site (in Budapest) from November 2008 through January 2009. All necessary data was sent by ERA-Maptec to carry out this validation. The Technical Team accepted all map sheets.

3.8. Processing

An ArcInfo macro script is supplied by ETC-LUSI to derive CLC06_IE from CLC00_{rev}_IE and CHA06_IE. The program works in a semi-automatic way and includes generalisation of small polygons and preservation of polygons just below the 25 ha size limit for manual editing using the priority table as a guide. The CLC00_{rev}_IE and CHA06_IE map sheets were merged in a GIS process as follows:

$$\text{CLC06_IE} = \text{CLC00}_{\text{rev_IE}} + \text{CHA06_IE}$$

where

CLC06_IE is the CLC database for 2006 (25 ha MMU, 100 m minimum mapped width, standard level-3 classes)

CLC00_{rev}_IE is the corrected/revised CLC database for 2000 (25 ha MMU, 100 m minimum mapped width, standard level-3 classes)

CHA06_IE is CLC changes between 2000 and 2006 (5 ha MMU, 100 m minimum mapped width, two attributes, each according to standard level-3 classes)

+ is a GIS process, including automatic generalisation and some actions of a photointerpreter

3.9. Main difficulties and solutions

3.9.1. IMAGE2006

Delivery of the second coverage of imagery occurred 7 months after the start date of the project, hence many areas of change visible on the second coverage of imagery had not been mapped in areas where interpretation had been completed. This resulted in many areas being revisited.

3.9.2. CLC00_IE

Revision of CLC00_IE was required to delineate changes accurately. This proved to be more extensive than originally expected and took a considerable amount of time during the production of the CHA06_IE and CLC06_IE databases.

3.9.3. Verifications

The first CLC 2006 Verification Report stated that "the amount of changes is overestimated". It also commented, in paragraph 4.2.1, that "six years between 2000 and 2006 is usually too short time for agricultural land (2xx) or transitional woodland-shrub (324) to turn into forests (class 31x)". Relying on this statement, the photointerpreters reversed many of the transitions 324-31x already identified.

The second Verification Report, stated that "the amount of changes is underestimated" and identified many missing 324-312 changes. Many of these missing changes were as a result of applying the comments made in the first report. It was also noted that some recent changes in land use (especially urban fabric) had not been recorded.

The second Report also stated that "not always the latest image was interpreted". The latest 2006 image did not arrive until six months after photointerpretation had commenced and its general use would have involved reworking of many of the working units. Had the latest 2006 image been available at the start of the project then much of the confusion over forest interpretation (and new urban areas) could have been avoided.

The first and second verification visits also raised a question about the revision of CLC00_IE geometry (boundaries). Boundaries in CLC00_IE were, in the main, inherited from CLC90_IE, which has geometric inaccuracies due to the interpretation of hard copy images and subsequent digitising (Figure 6). Following the first and second verification visits the CLC00_IE (and CHA06_IE) boundaries were edited for the following classes:

- Coastline
- Lakes
- Urban fabric
- Forestry

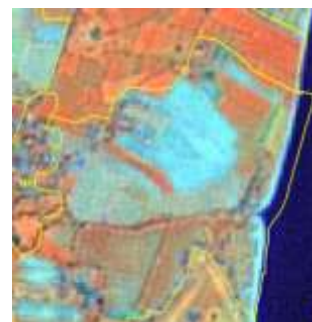


Figure 6

The first Verification Report noted that classes 243 (*agriculture with natural vegetation*), 231 (*pasture*) and 211 (*non-irrigated arable land*) contain polygons with very large areas, sometimes up to 200,000 ha, and the Technical Team suggested there might be too much generalisation of these classes. This classification, applied in CLC00_IE, has been revised where obvious errors have been

encountered; however it has not been specifically examined on a sheet-by-sheet basis. In Ireland large polygons of class 231 (*pasture*) exist due to extensive grasslands. In the case of the Technical Team's remarks on the shape of class 321 (*natural grasslands*) and on differentiating between them and class 231 (*pasture*), the Heritage Council noted that 'there are few, if any, natural grasslands in Ireland, particularly in the lowlands, as most have been modified or managed to some degree by grazing, mowing, fertiliser application or drainage. In the absence of such management, most grassland would revert to scrub, woodland or heath' (Fossitt, J. A, 2000). This goes some way towards explaining the very large polygons of pasture pointed out by the Technical Team as suggesting an over-generalisation of classes.

The second verification team had problems with the application of the 332 (*bare rocks*) class. It was suggested that class 332 might be more accurately classed as either 331 (*beaches, dunes and sand plains*) or 333 (*sparsely vegetated areas*). The Technical Team noted that 'IMAGE2000 data taken in early May were misleading for the CLC00_IE interpreter. IMAGE2006 taken in summer shows clearly that in some cases more than 10% of the area is covered in vegetation'. However, when CLC00_IE was created, it was based on the best imagery then available.

3.9.4. Generation of CLC06_IE

Further issues arose during the production of the CLC06_IE dataset, specifically with the ArcInfo macro supplied by the EEA. This resulted in topological errors and slivers. The macro could benefit from having an instruction to clean the data after the union to avoid these errors. The generalisation size limit was set to 23 ha but many polygons < 23 ha were not merged (Figure 7)



Figure 7: A class 312 polygon of 19.16 ha should have been automatically merged into neighbouring 242 polygons.

As Corine Land Cover in general does not allow for heterogeneous categories within a land cover area then polygons < 25 ha in size have been merged into neighbouring polygons, in some cases creating the illusion that important land cover classes such as *peat bog* (412) are decreasing in size when in reality they have been planted and are now class 324 (*transitional woodland-shrub*), with the remaining 412 merged into *pasture* (231). However, the priority table states that this 412

polygon should have been merged into 324 (*transitional woodland-shrub* - priority value of 4) ahead of 231 (*pasture* - priority value of 5).

3.10. Internal validation

There is a limited amount of external data that can be used for land cover validation in Ireland. The main data sets are the Forest Service forestry inventory data and the Department of Agriculture's LPIS data used for Area Aid subsidies. These have been used for validation in February 2009.

3.11. Database Technical Acceptance

Completed databases were delivered to GISAT. Upon delivery the data was subject to technical checks on topology, size and code errors, metadata etc. A request for improvements/clarification was sent to the National Team connected to the change dataset, CHA06. Errors in minimum mapping unit size, code errors and neighbouring polygons with the same code were checked, corrected or reclassified. The databases were resubmitted and final acceptance was made by GISAT on 10th April 2009. Ireland is the 22nd country ready with Corine 2006.

3.12. National Steering Committee

A Corine Land Cover Update 2006 Working Group, which effectively functioned as a national steering committee, was established at the beginning of the project. The tasks envisaged for this were:

- Provision of specific advice on the interpretation of satellite imagery for land cover identification, where requested
- Assistance with the photointerpretation of marginal areas, where requested
- Assistance with the use and understanding of topographic or specific thematic datasets (such as forestry) for verification of the results of interpretation
- Assistance with the interpretation of seasonal variations, where requested
- General advice on the supervision of the CLC 2006 project

It was envisaged that the Working Group would meet at two-monthly intervals to consider progress and plan future work. The Working Group would end its activities on project completion. The following were invited to join the Working Group:

- Owners of data to be used for verification/ground-truthing (e.g., biodiversity, forestry, etc.)
- Persons with experience in satellite image interpretation for environmental purposes, in particular land cover
- Users of previous Corine Land Cover datasets

The membership of the Working Group is shown in Table 4:

Specialist Area	Name	Affiliation	Data Provision
Agriculture	Jack Creaner	Department of Agriculture, Fisheries and Food (DAFF)	Land Parcel vectors
Agricultural Research	Stuart Green	Teagasc (National Agricultural Research and Training Authority)	Land cover data
Forestry	Frank Barrett	Forest Service - DAFF	Forest inventory data (FIPS)
	Kevin Black	Coford	
Habitats	Gemma Weir	National Parks and Wildlife Service	Saltmarsh data
Marine	Ned Dwyer	Coastal and marine Research Centre - UCC	
Topography	Bernard Cassidy	Ordnance Survey Ireland	Topographic data, orthophotography
Urban Areas	Shelia Convery	Urban Institute Ireland - UCD	
	Daniel McInerney	University College Dublin (UCD)	
Water	Gearoid O' Riain	Compass Informatics (WFD contractor)	
Wetlands	John Connolly	University College Dublin	

Table 4: Members of National Committee (Working Group)

The Working Group met on the following dates:

13 February 2007
12 March 2007
2 July 2007
10 September 2007
26 November 2007
19 February 2008
8 December 2008
10 February 2009
23 June 2009

4. Results

4.1. Summary

The datasets involved in the CLC 2006 update, including a 1 km buffer zone around the border with Northern Ireland (as was also the case with the CLC 2000 delivery), can be described in polygons as (Table 5):

Dataset	Number of polygons
CLC00_IE (original)	21051
CLC00 _{rev} _IE	21533
CHA06_IE	7439
CLC06_IE	22456

Table 5

The surface areas for the CLC06_IE and CHA06_IE datasets including the buffer zone are 7122266.88 ha and 171131.1 ha (2.4% of national cover) respectively. The statistical results presented here include the buffer zone.

Level	Name	Area (ha)	%
1	Artificial Fabric	162314.62	2.279
2	Agricultural Areas	4729064.43	66.398
4	Wetlands	1169225	16.417
3	Forest and semi-natural areas	899972.5	12.636
5	Water Bodies	161689.9	2.27
	Total	7122267	100

Table 6

The sum of the areas (ha) of each of the Level 1 categories (arranged in descending order) can be seen in Table 6. The sum of the areas (ha) for each Level 3 class (arranged in descending order) can be seen in Table 7. The largest class in Corine Land Cover 2006 is pasture and the second largest peat bogs. Of the 10 largest classes 4 are agricultural.

Class	Area (ha)	Class	Area (ha)
231	3598887.65	312	230202.54
412	1094436.02	242	147033.82
211	536638.22	512	119236.46
243	446504.74	112	108011.40
324	419156.12	321	89582.09

Table 7

Table 8 presents the area (ha) and the percentages per land cover class for the existing CLC00_IE and revised CLC00_IE (CLC00_{rev}_IE) datasets; Table 9 presents the area (ha) and the percentages per land cover class for the CLC00_{rev}_IE and CLC06_IE datasets.

4.2. Revision of CLC 2000

Improvements in geometric accuracy and classification errors have resulted in differences in area between the original CLC00_IE dataset and the revised CLC00_IE dataset, CLC00_{rev}_IE (Table 8). The area of many 111 (*continuous Urban Fabric*) polygons had been exaggerated in CLC00_IE; improvement in the delineation of this class resulted in a smaller national area for class 111, and a corresponding larger national area for class 112 (*discontinuous urban fabric*). Many streams had their width exaggerated in CLC00_IE to meet the minimum mapping unit criteria of 100m width; a correction resulted in a smaller area of class 511 (*stream courses*) in the revised dataset. The area of Class 512 (*water bodies*) had also been exaggerated to meet the minimum mapping unit of 25 ha – once this was rectified the overall area of class 512 was reduced. The entire coastline was revised, resulting in an increase in the areas of class 331 (*beaches, dunes, sand*); 421 (*salt marshes*) and 423 (*intertidal flats*); and a decrease in the areas of classes 521 (*coastal lagoons*) and class 522 (*estuaries*). The largest revisions were in the forestry classes – approximately 25000 ha was reclassified to class 324 (*transitional woodland-shrub*), increasing its national area to 367317.98 ha. Approximately 8000 ha of previously classified 312 (*coniferous forest*) were reclassified to 324.

4.3. CLC 2006

4.3.1. Summary

The CLC nomenclature contains forty-four classes of which thirty-three were recorded in the CLC06_IE dataset for Ireland. Class 231 (*pasture*) had the highest percentage coverage, with over 50% of the area (Table 9). Class 412 (*peat bogs*) comes next with 15.37% of the national coverage. Agricultural classes 211 (*non-irrigated arable land*), 243 (*land principally occupied by agriculture with areas of natural vegetation*) and 242 (*complex cultivation*) have a combined coverage of almost 16%. There has been no significant change in these classes since the Corine Land Cover 2000 project.

In forestry, class 312 (*coniferous forest*) has decreased slightly and class 324 (*transitional woodland-shrub*) has increased substantially; their combined coverage is over 9%. Other classes covering more than 1% of the total coverage area are class 512 (*water bodies*) 1.67%; class 112 (*discontinuous urban fabric*) at 1.52% and class 321 (*natural grassland*) at 1.26% (Table 10) The area of artificial classes 111, 112, 121, 122, 124, 131, 132 and 142 have increased since CLC00_IE; artificial classes 133 (*construction sites*) and 141 (*green urban areas*) both decreased in area as a direct result of the increase in the other artificial classes.

	Cover	Original CLC00_IE	Area	Revised CLC00 _IE (CLC00 _{rev} _IE)	Area
Class	Description	ha	% of total	ha	% of total
111	Continuous Urban Fabric	4981.33	0.07	2824.05	0.04
112	Discontinuous Urban Fabric	87868.79	1.24	93966.94	1.32
121	Industrial or Commercial	6085.02	0.09	7987.36	0.11
122	Road and Rail networks	2037.22	0.03	1860.73	0.03
123	Sea Ports	1078.97	0.02	1040.83	0.01
124	Airports	2256.94	0.03	2406.00	0.03
131	Mineral extraction sites	8224.50	0.12	7598.74	0.11
132	Dump	342.82	0.00	672.30	0.01
133	Construction sites	2790.59	0.04	2742.84	0.04
141	Green Urban areas	3726.02	0.05	3256.99	0.05
142	Sport and leisure facilities	16313.82	0.23	17350.66	0.24
211	Non-Irrigated arable land	544979.15	7.66	543245.24	7.63
231	Pastures	3659922.69	51.46	3621946.87	50.85
242	Complex cultivation	123587.59	1.74	147165.24	2.07
243	Land principally occupied by agriculture with areas of natural vegetation	426145.59	5.99	452493.76	6.35
311	Broad leaved forest	30852.41	0.43	29416.65	0.41
312	Coniferous forest	243573.92	3.42	236806.05	3.32
313	Mixed forest	22397.07	0.31	29529.53	0.41
321	Natural grassland	93389.57	1.31	90135.76	1.27
322	Moors and heath	59173.80	0.83	55822.76	0.78
324	Transitional woodland-shrub	342118.31	4.81	367317.98	5.16
331	Beaches, dunes, sand	14026.54	0.20	10899.21	0.15
332	Bare rocks	16730.76	0.24	14531.08	0.20
333	Sparsely vegetated	20175.15	0.28	20876.98	0.29
334	Burnt Areas	89.79	0.00	0.0000	0.00
411	Inland Marshes	18043.96	0.25	16503.62	0.23
412	Peat Bogs	1146311.68	16.12	1123793.15	15.78
421	Salt Marshes	3104.07	0.04	4839.38	0.07
423	Intertidal flats	44855.58	0.63	53586.29	0.75
511	Stream courses	9603.09	0.14	8119.31	0.11
512	Water bodies	122757.87	1.73	119206.98	1.67
521	Coastal lagoons	988.99	0.01	820.99	0.01
522	Estuaries	33566.36	0.47	33513.14	0.47
523	Sea				
Total		7112109.19	100	7122277.40	100

Table 8: Area (ha) and proportions (%) per land cover class for 2000 and 2000 revised datasets.

N.B. Small differences in total land area between 2000 and revised 2000 is due to reclassification of a few small areas of sea as land.

	Cover	Revised CLC00 (CLC00 _{rev_IE})	Area	CLC06_IE	Area
Class	Description	ha	% of total	ha	% of total
111	Continuous Urban Fabric	2824.05	0.04	2831.41	0.04
112	Discontinuous Urban Fabric	93966.94	1.32	108011.40	1.52
121	Industrial or Commercial	7987.36	0.11	9737.10	0.14
122	Road and Rail networks	1860.73	0.03	4213.25	0.06
123	Sea Ports	1040.83	0.01	1040.83	0.01
124	Airports	2406.00	0.03	2491.92	0.03
131	Mineral extraction sites	7598.74	0.11	8850.52	0.12
132	Dump	672.30	0.01	678.45	0.01
133	Construction sites	2742.84	0.04	2340.42	0.03
141	Green Urban areas	3256.99	0.05	2741.59	0.04
142	Sport and leisure facilities	17350.66	0.24	19377.73	0.27
211	Non-Irrigated arable land	543245.24	7.63	536638.22	7.53
231	Pastures	3621946.87	50.85	3598887.65	50.53
242	Complex cultivation	147165.24	2.07	147033.82	2.06
243	Land principally occupied by agriculture with areas of natural vegetation	452493.76	6.35	446504.74	6.27
311	Broad leaved forest	29416.65	0.41	29291.66	0.41
312	Coniferous forest	236806.05	3.32	230202.54	3.23
313	Mixed forest	29529.53	0.41	30064.82	0.42
321	Natural grassland	90135.76	1.27	89582.09	1.26
322	Moors and heath	55822.76	0.78	55362.15	0.78
324	Transitional woodland-shrub	367317.98	5.16	419156.12	5.89
331	Beaches, dunes, sand	10899.21	0.15	10905.06	0.15
332	Bare rocks	14531.08	0.20	14531.08	0.20
333	Sparsely vegetated	20876.98	0.29	20876.98	0.29
411	Inland Marshes	16503.62	0.23	16389.21	0.23
412	Peat Bogs	1123793.15	15.78	1094436.02	15.37
421	Salt Marshes	4839.38	0.07	4839.38	0.07
423	Intertidal flats	53586.29	0.75	53560.85	0.75
511	Stream courses	8119.31	0.11	8119.31	0.11
512	Water bodies	119206.98	1.67	119236.46	1.67
521	Coastal lagoons	820.99	0.01	820.99	0.01
522	Estuaries	33513.14	0.47	33513.14	0.47
523	Sea	6457676.23		6457686.75	
Total Land		7122277.40	100	7122266.88	100
Total		13579953.63		13579953.63	

Table 9: Area (ha) and proportions (%) per land cover class for the 2000 revised and 2006 datasets.
N.B. Small differences in total land area between 2000 and revised is due to reclassification of a few small areas of sea as land.

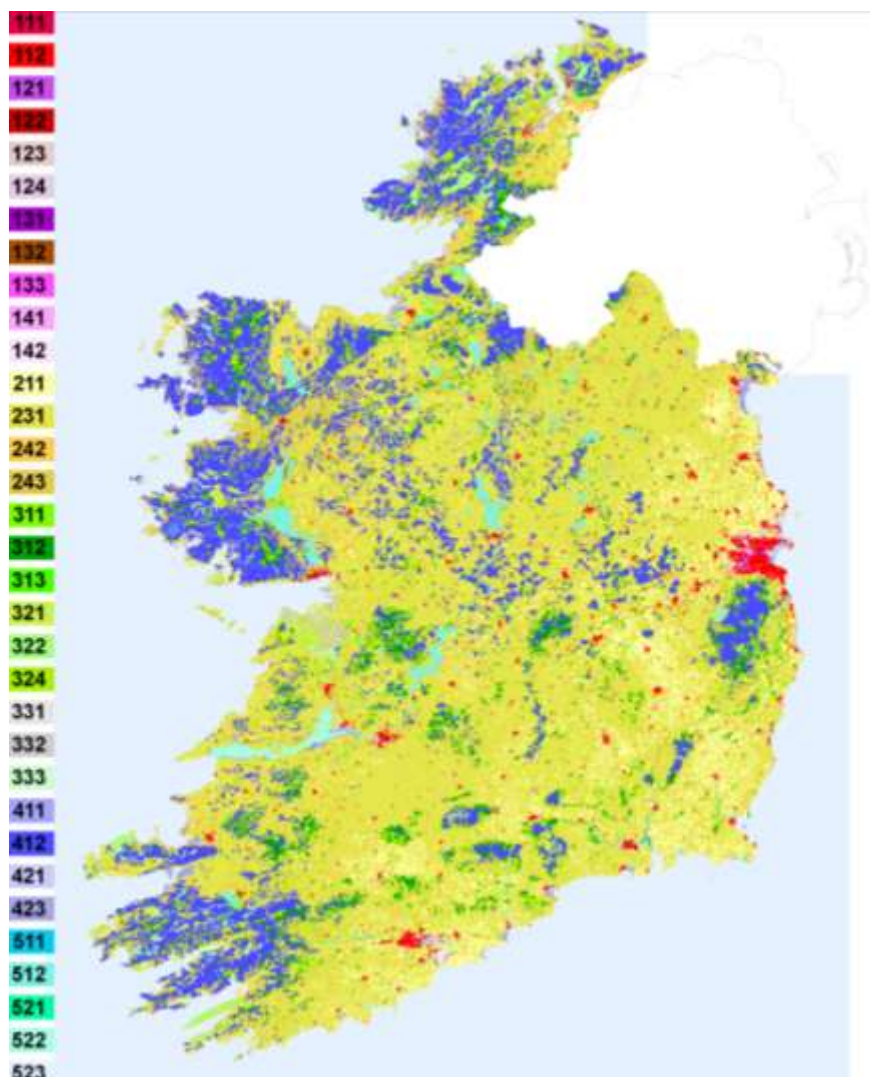


Figure 8: CLC 2006

Class	Cover	Area (ha)	%	No of polygons
231	Pastures	3598887.65	50.53	1869
412	Peat Bogs	1094436.02	15.37	1992
211	Non-Irrigated arable land	536638.22	7.53	4061
243	Land principally occupied by agriculture with areas of natural vegetation	446504.74	6.27	2398
324	Transitional woodland-shrub	419156.12	5.89	4196
312	Coniferous forest	230202.54	3.23	2276
242	Complex cultivation	147033.82	2.06	1378
512	Water bodies	119236.46	1.67	544
112	Discontinuous Urban Fabric	108011.40	1.52	756
321	Natural grassland	89582.09	1.26	457

Table 10: Most frequent land cover classes in CLC 2006

4.4. Changes

From the CHA06_IE dataset it has been possible to analyse the changes in land cover in Ireland during the 6 year period between the two land cover maps. Figure 9 shows pie charts of the level 1 land cover for Ireland in 2000 and 2006. The main changes are an increase in artificial surfaces from 2% in 2000 to 2.3% in 2006 and the growth in forestry (from 12% to 12.6%) over the same period.

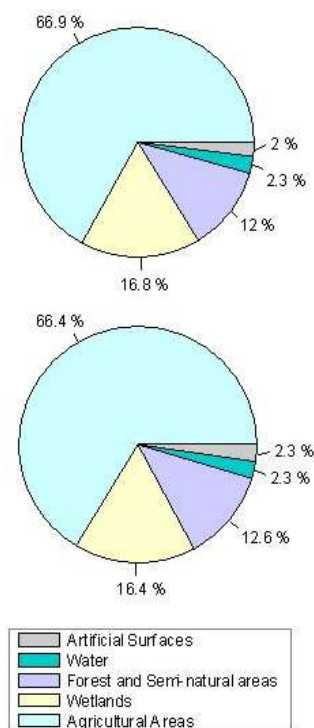


Figure 9: Corine 2000 and Corine 2006

4.4.1. Change per Level 1 class grouping

		2000	2006	% change
1. Artificial Surfaces (ha)		141707.4	162314.6	14.54
111	Continuous Urban	2824.05	2831.41	0.26
112	Discontinuous Urban	93966.94	108011.4	14.95
121	Industrial & Commercial	7987.36	9737.1	21.91
122	Road & Rail Networks	1860.73	4213.25	126.43
123	Sea Ports	1040.83	1040.83	0
124	Airports	2406	2491.92	3.57
131	Mineral Extraction sites	7598.74	8850.52	16.47
132	Dump	672.3	678.45	0.91
133	Construction sites	2742.84	2340.42	-14.67
141	Green Urban Areas	3256.99	2741.59	-15.82
142	Sport & Leisure	17360.66	19377.73	11.62

Table 11: Artificial surface percent change 2000-2006

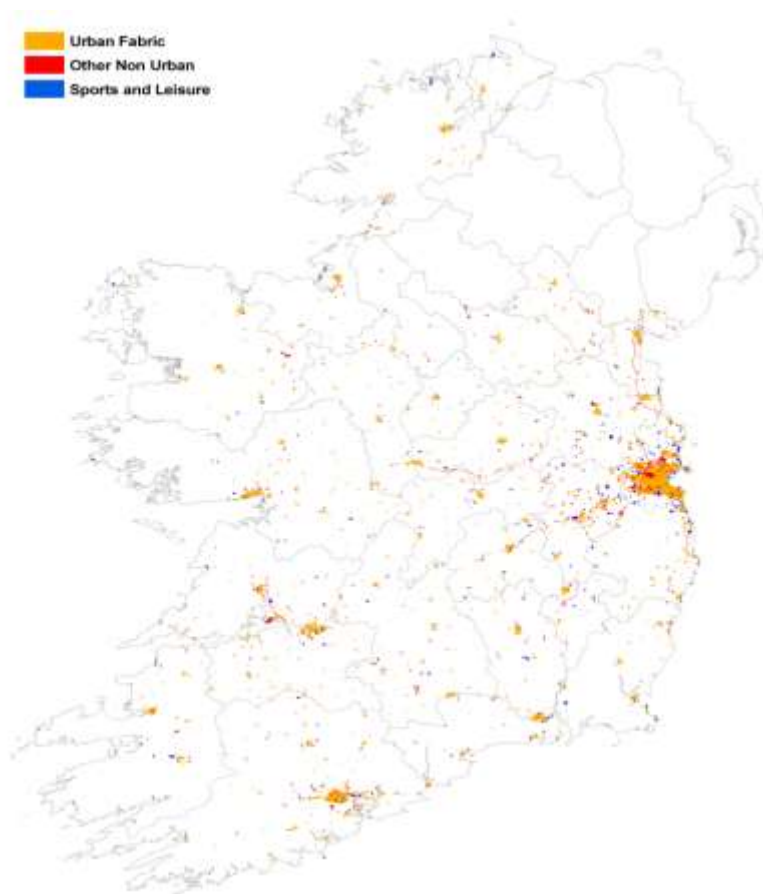


Figure 10: Artificial classes

		2000	2006	% change
2. Agricultural Areas (ha)		4764851	4729064	-0.75
211	Non-irrigated arable land	543245.2	536638.2	-1.22
231	Pastures	3621947	3598888	-0.64
242	Complex cultivation patterns	147165.2	147033.8	-0.09
243	Land principally occupied by Ag.	452493.8	446504.7	-1.32

Table 12: Agricultural areas percent change 2000-2006

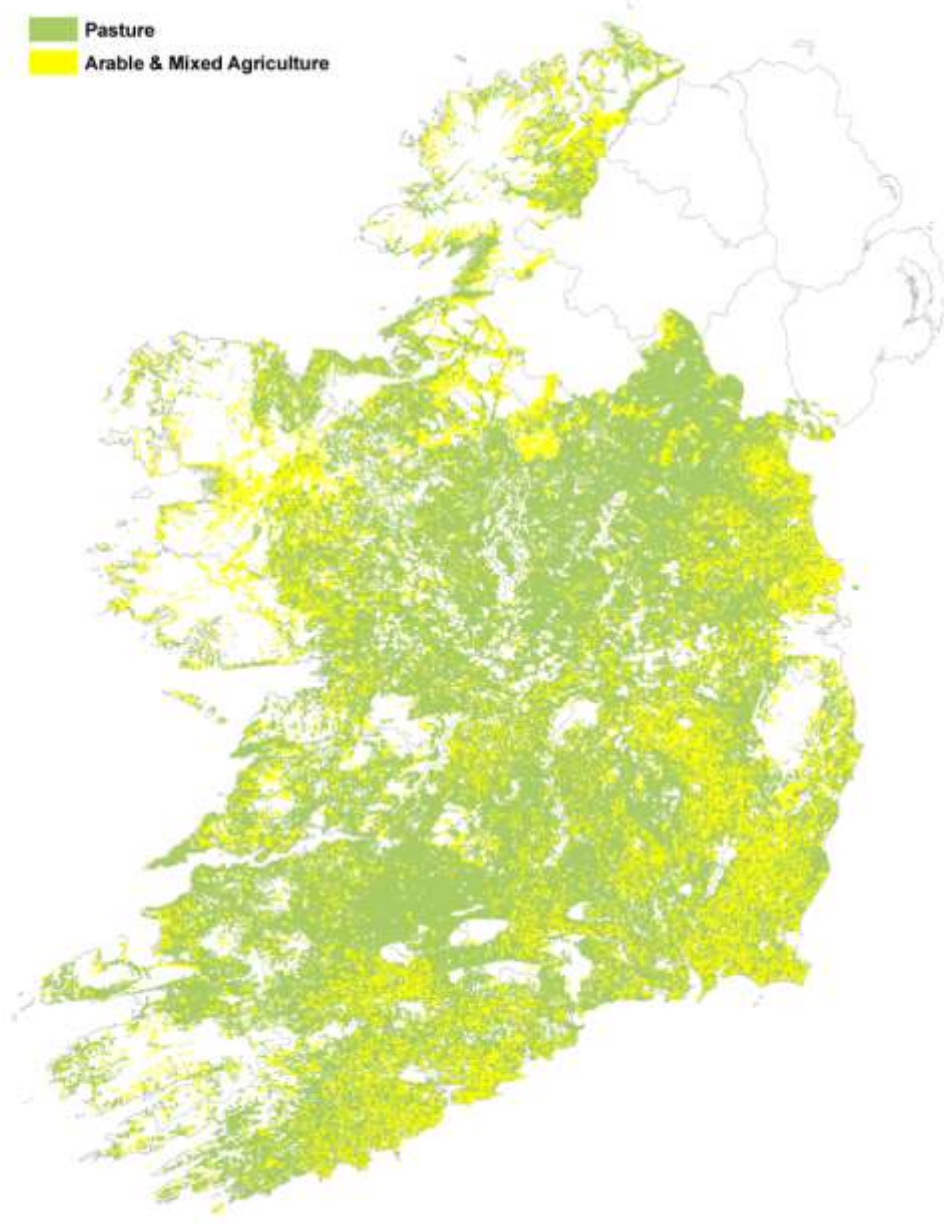


Figure 11: Agricultural classes

		2000	2006	% change
3. Forest		663070	708715	6.88
311	Broad leaved Forest	29416.65	29291.66	-0.42
312	Coniferous Forest	236806.1	230202.5	-2.79
313	Mixed Forest	29529.53	30064.82	1.81
324	Transitional woodland - shrub	367318	419156.1	14.11

Table 13: Forestry areas percent change 2000-2006

Please also see note on Forestry Statistics in Appendix IV.

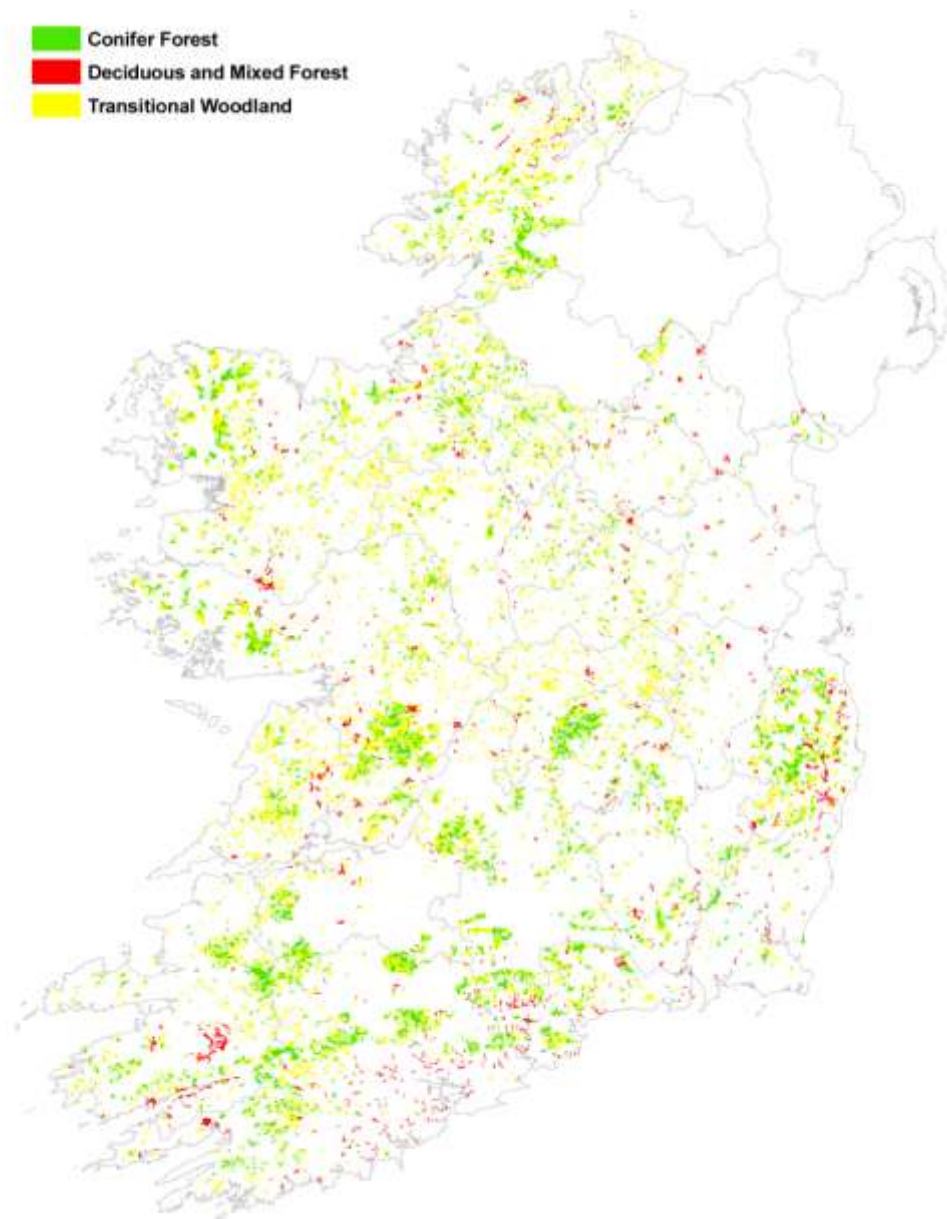


Figure 12: Forestry classes

		2000	2006	% change
4. Semi-natural Areas		192266	191257	-0.52
321	Natural Grassland	90135.76	89582.09	-0.61
322	Moors & Heath	55822.76	55362.15	-0.83
331	Beaches, Dunes & sand	10899.21	10905.06	0.05
332	Bare Rock	14531.08	14531.08	0
333	Sparsely vegetated area	20876.98	20876.98	0

Table 14: Semi-natural areas percent change 2000-2006

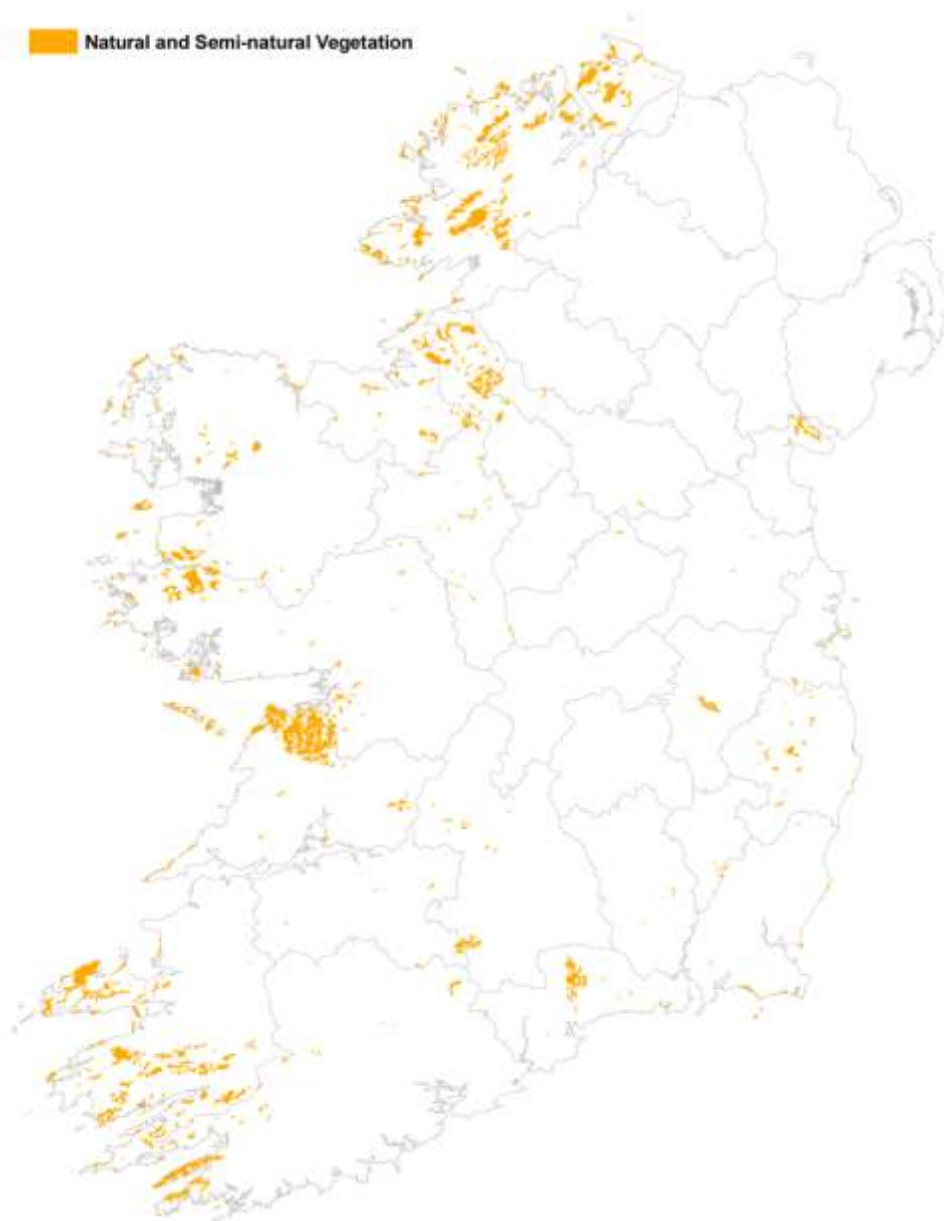


Figure 13: Semi-natural areas

	2000	2006	% change
5. Wetlands	1198722	1169225	-2.46
411 Inland Marshes	16503.62	16389.21	-0.69
412 Peat bogs	1123793	1094436	-2.61
421 Salt marshes	4839.38	4839.38	0
423 Intertidal flats	53586.29	53560.85	-0.05

Table 15: Wetlands percent change 2000-2006

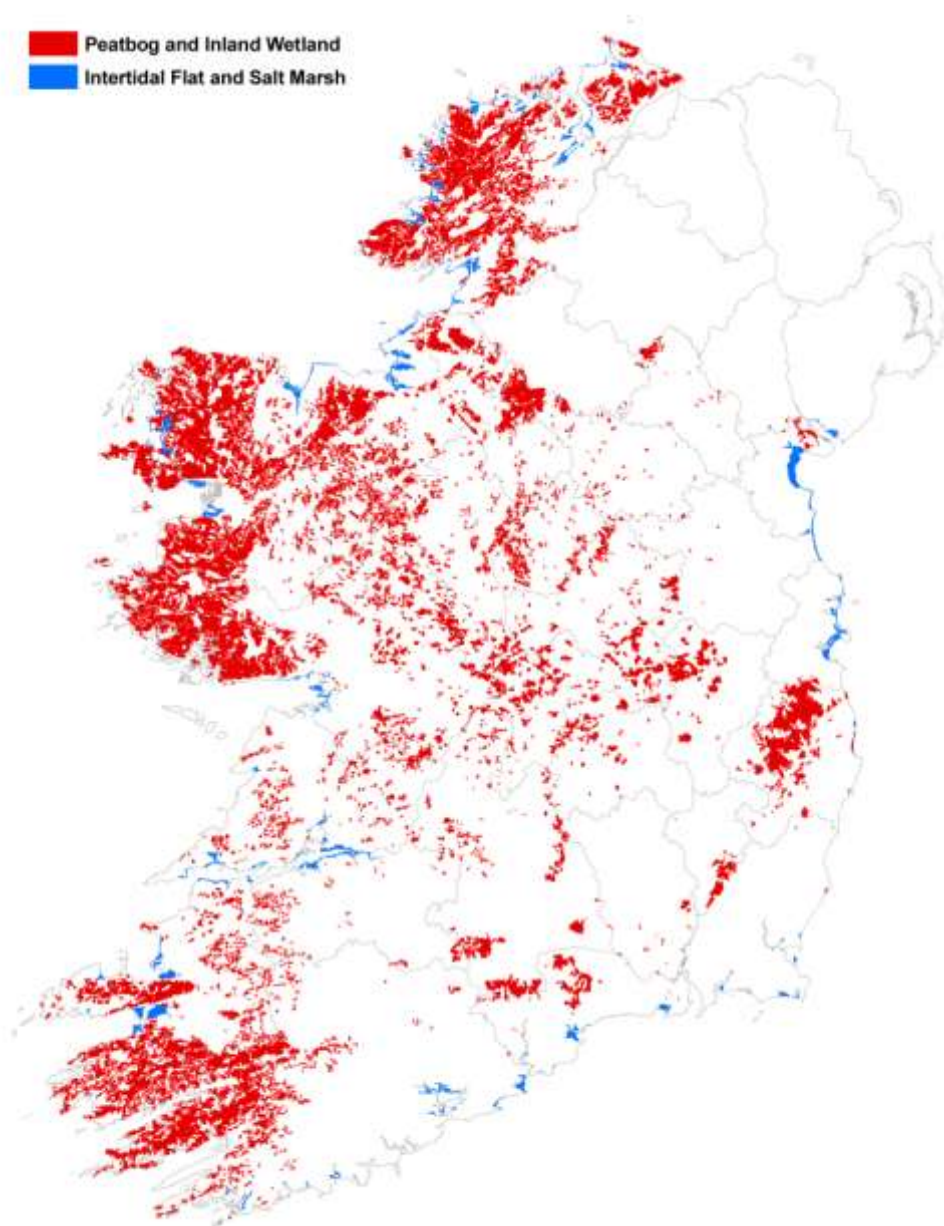


Figure 14: Wetlands

		2000	2006	% change
6. Water Bodies		161660.4	161689.9	0.02
511	Stream courses	8119.31	8119.31	0
512	Water bodies	119207	119236.5	0.02
521	Coastal Lagoons	820.99	820.99	0
522	Estuaries	33513.14	33513.14	0

Table 16: Water body percent change 2000-2006

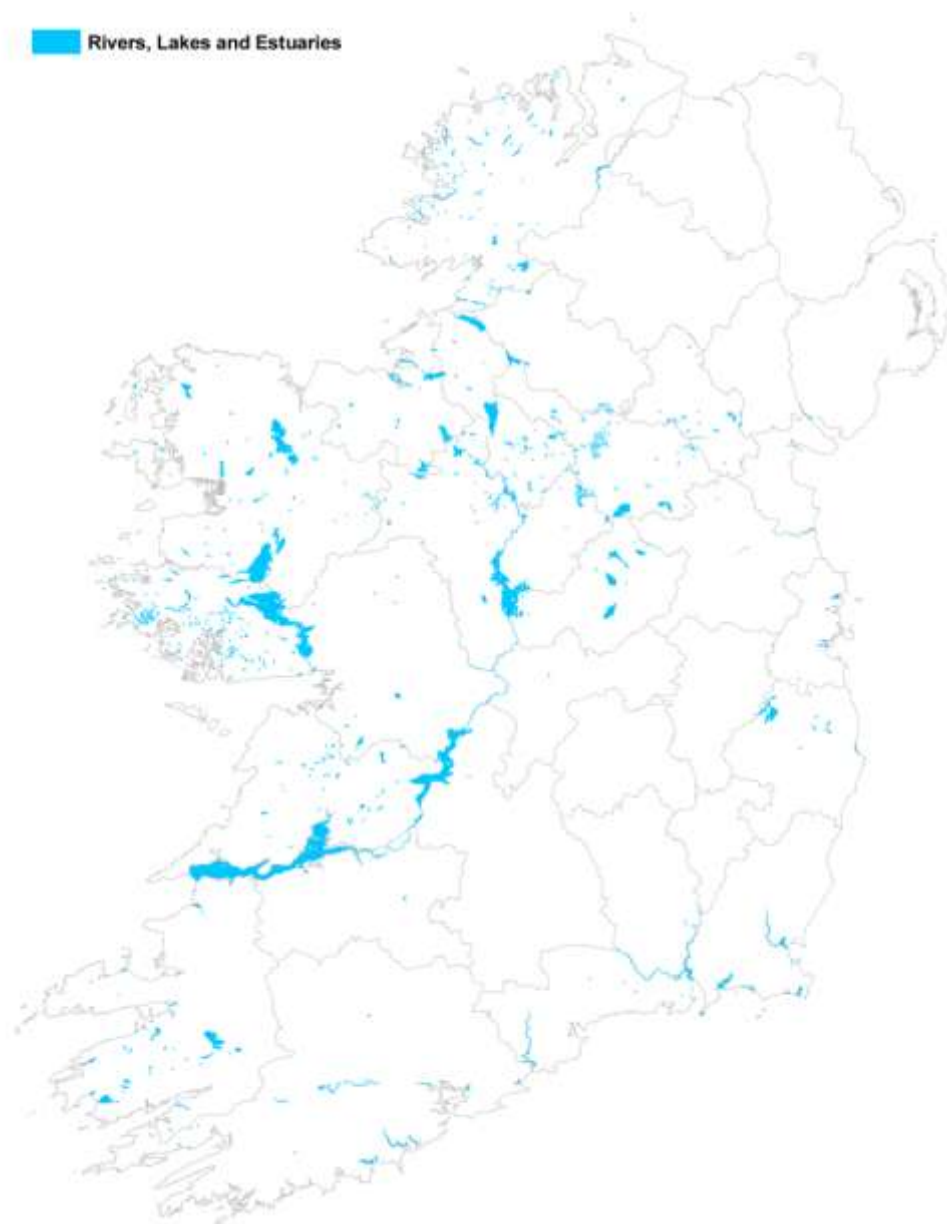


Figure 15: Water bodies

4.4.2. Largest Changes

The ten largest changes in area (arranged by decreasing area) from 2000 to 2006 can be seen in Table 17 below. Most of the changes were in forestry, a result of clear cuts (*coniferous forest* - 312 to *transitional woodland-shrub* - 324) and planting (*transitional woodland-shrub* – 324 to *coniferous forest* - 312, *peat bogs* - 412 to *transitional woodland-shrub* - 324 and *pasture* - 231 to *transitional woodland-shrub* - 324). 5766.77 Ha of class 324 (*transitional woodland-shrub*) and 1004.66 ha of class 312 (*coniferous forest*) have been mapped as a result of technical changes (Figure 23). These changes in forested areas accounted for 142935.4 ha of the total 171131.1 ha change area. The area of change to forestry can be accounted for by the change from bog, wetlands and agriculture (Figure 16, 17, 18, 19)

Change	From	To	Frequency	Area (ha)	% of total
312-324	<i>Coniferous forest</i>	<i>Transitional woodland-shrub</i>	1779	43776.82	25.49
324-312	<i>Transitional woodland-shrub</i>	<i>Coniferous forest</i>	983	37578.14	21.88
412-324	<i>Peat Bogs*</i>	<i>Transitional woodland-shrub</i>	980	29899.09	17.41
231-324	<i>Pasture</i>	<i>Transitional woodland-shrub</i>	677	12324.93	7.18
231-112	<i>Pasture</i>	<i>Discontinuous Urban Fabric</i>	591	7182.39	4.18
324-324	<i>Transitional woodland-shrub (generalized to a different class in CLC00_IE)</i>	<i>Transitional woodland-shrub</i>	458	5692.55	3.31
243-324	<i>Principally agriculture</i>	<i>Transitional woodland-shrub</i>	357	6632.94	3.86
211-112	<i>Non-Irrigated arable land</i>	<i>Discontinuous Urban Fabric</i>	147	2137.14	1.24
231-133	<i>Pasture</i>	<i>Construction sites</i>	130	2149.80	1.25
112-112	<i>Discontinuous Urban Fabric (generalized to a different class in CLC00_IE)</i>	<i>Discontinuous Urban Fabric</i>	91	1159.06	0.67

Table 17: Changes by Area (ha)

- - Please see note on afforestation on peatlands in Appendix IV.

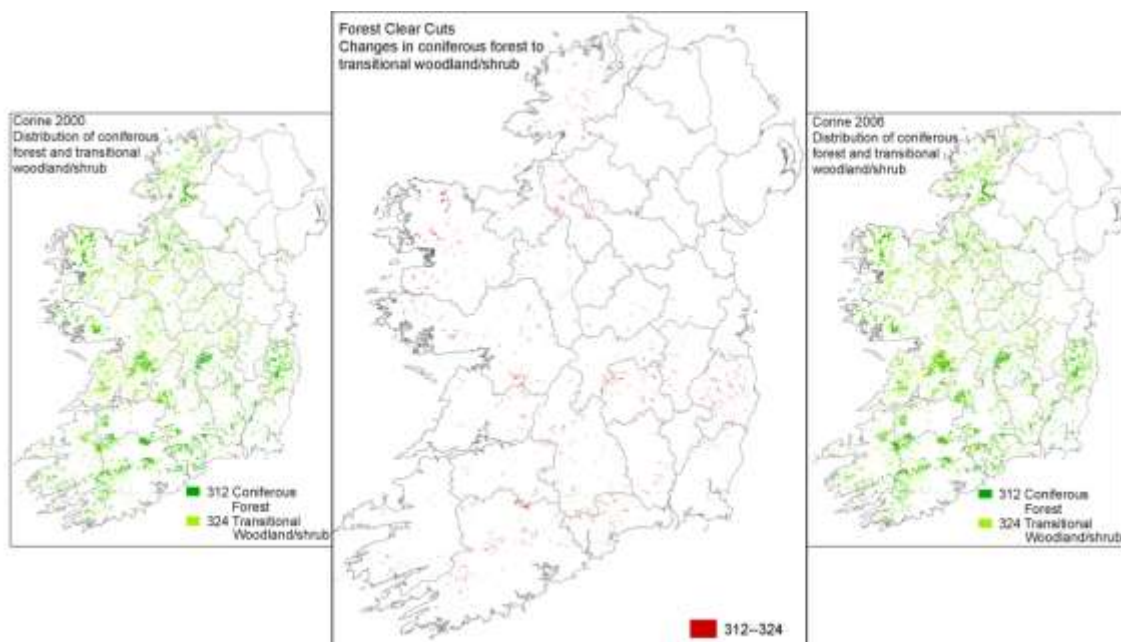


Figure 16: 312-324

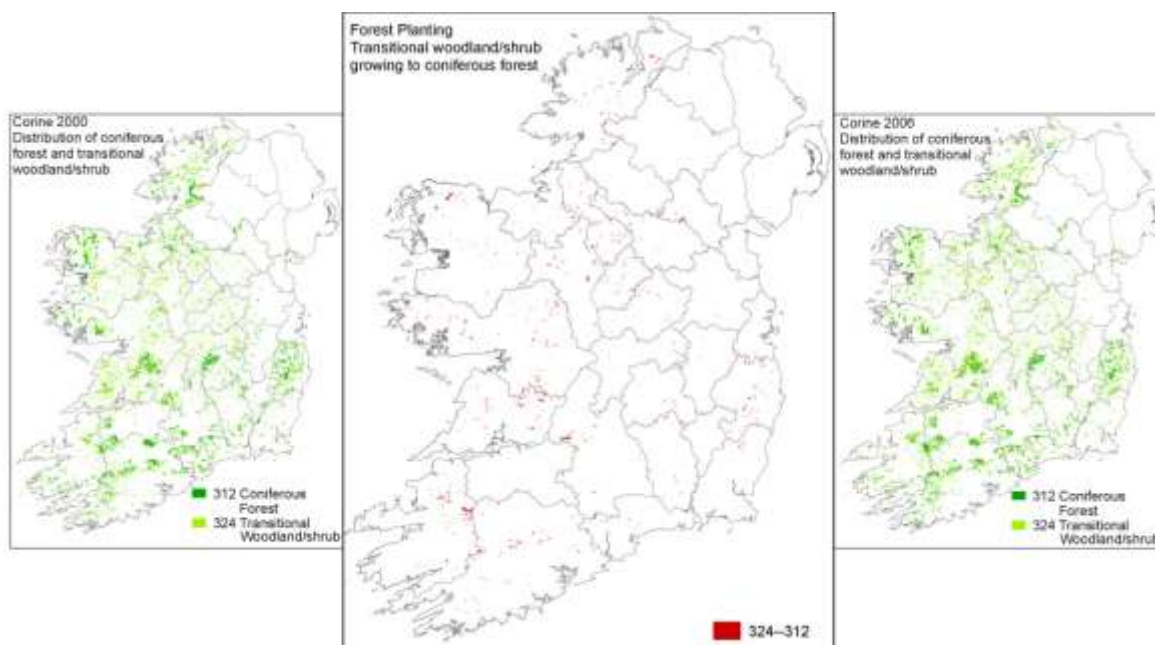


Figure 17: 324-312

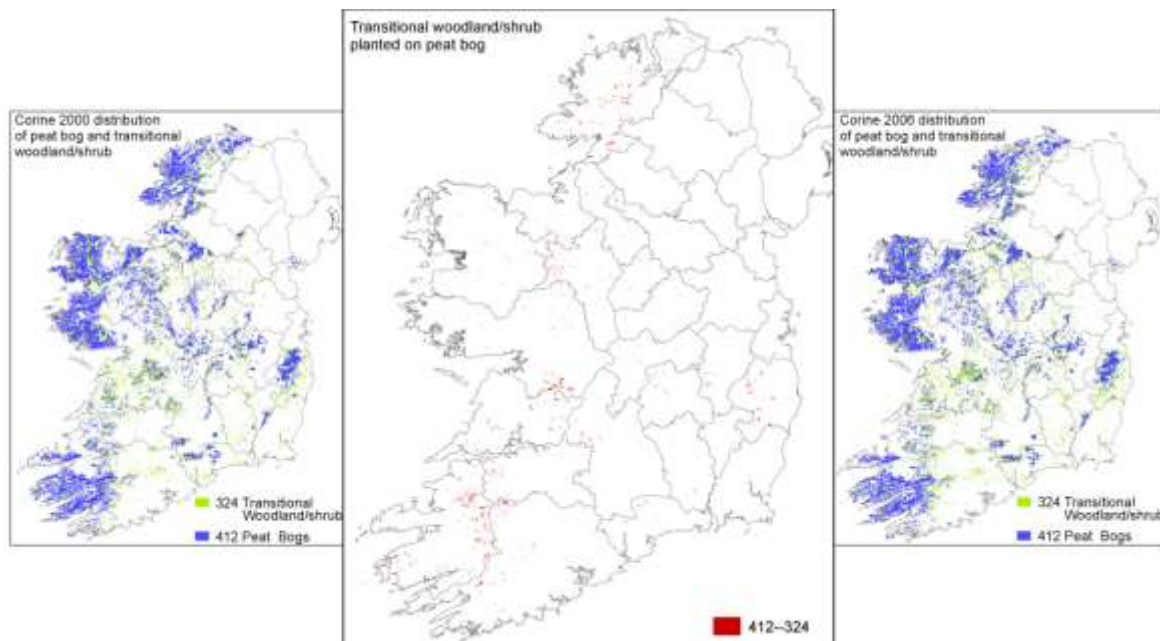


Figure 18: 412-324

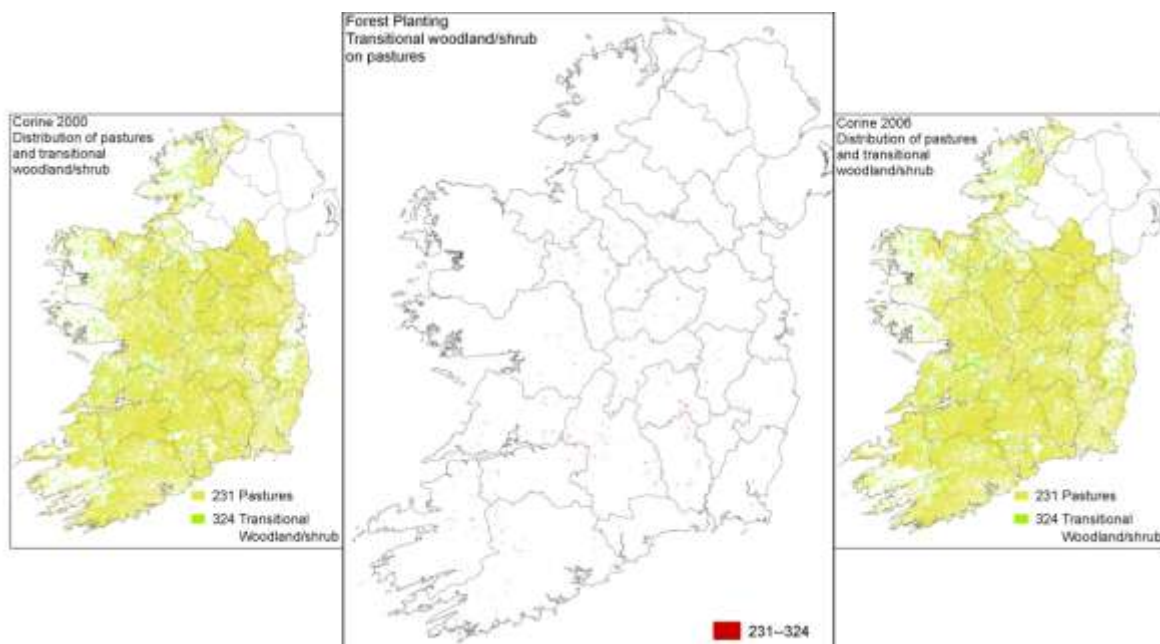


Figure 19: 231-324

4.4.3. Increase in Artificial Surfaces

There was almost a 15% increase in artificial surfaces between 2000 and 2006. Most of this increase is explained by the increases in the following (Table 18):

- Infrastructure (roads and railways); increase of 23.5 km² or +126.43%
- Industrial and Commercial; increase of 17.5 km² or + 21.91%
- Mineral extraction sites (quarries and dumps); increase of 12.52 km² or +16.5% (Figure 22)
- Discontinuous urban (sub-urban housing); increase of 140.45 km² or +14.95% (Figure 20, 21)

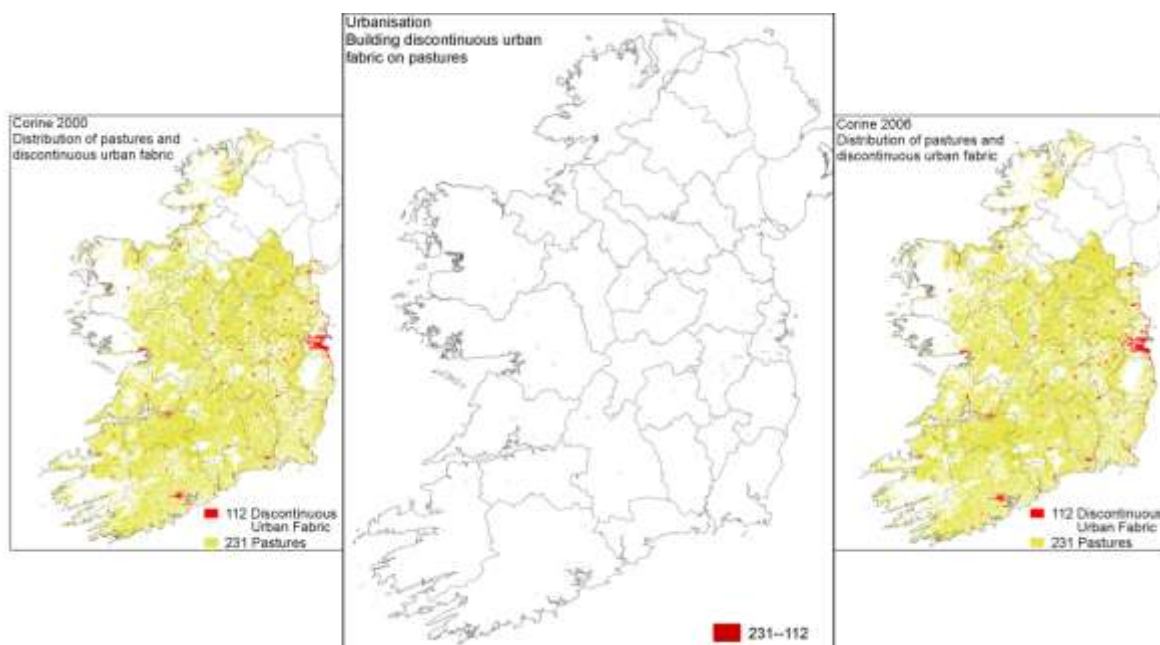


Figure 20: 231-112

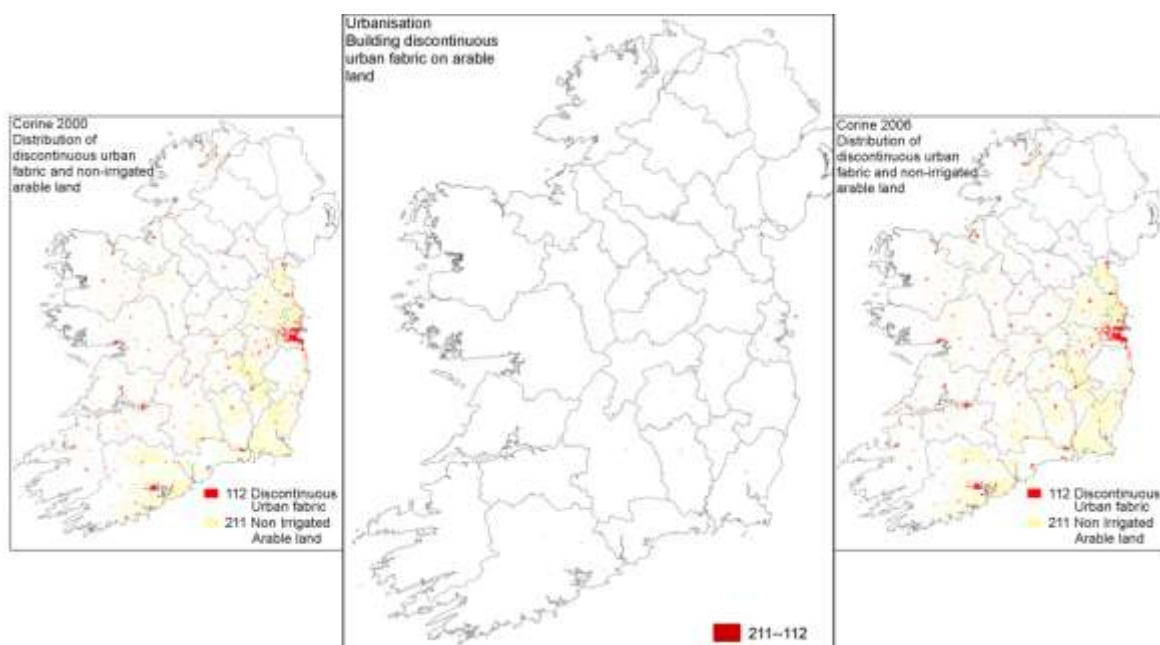


Figure 21: 211-112

These increases are probably related to the economic growth in Ireland and the demand for new housing (increase in discontinuous urban fabric accounts for 54.7% of the new artificial surfaces) . There was also an extensive building of new infrastructure (mainly motorways) during this period. As can be seen from table 18 (right); over 96% of the new artificial surfaces were replacing agricultural land.

4.4.4. Infrastructure Growth

Since 2000 the area covered by class 122 (*road and rail networks*) has more than doubled, with a percentage increase of 126.43%. About 1484 ha of agricultural land (class 2xx) in 2000 were lost to infrastructure in 2006. This increase in area of infrastructure networks can be coupled with the decrease in the area of construction sites (-14.67%) as projects were completed within the 6 year time span. The increase in mineral extraction sites (16.47%) may also be explained by the need for resources to complete so many infrastructure projects.

Road & Rail Networks			2389.9ha
2000	2006	ha	%
231	122	982.5	41.11
133	122	710.3	29.72
211	122	409.8	17.15
242	122	78.8	3.30
324	122	66.2	2.77
141	122	38.6	1.62
412	122	30.6	1.28

4.4.5. Urbanisation

After infrastructure, the most prominent increase in artificial surfaces has been the growth in discontinuous urban fabric and industrial and commercial units, with a 14.95% and 21.91% increase in these areas respectively. 76.25% of new discontinuous urban fabric and 69.17% of new industrial and commercial units were agriculture in 2000.

Urbanisation			15025.5ha
2000	2006	ha	%
231	112	7182.4	54.27
211	112	2137.1	16.15
133	112	1624.1	12.27
112	112	1159.1	8.76
231	121	783.4	43.73
211	121	442.2	24.68
133	121	261.5	14.60
121	121	185.1	10.33

New Artificial Surfaces CLC06:		20601.4 ha	
2000	2006	Ha	%
Agricultural Land		19784.7	96.03
211	112	2137.1	
	121	442.2	
	122	409.8	
	131	430.8	
	132	11.3	
	133	898.5	
	141	13.6	
231	142	875.2	
	112	7182.4	
	121	783.4	
	122	982.5	
	123	7.5	
	124	60.9	
	131	1019.1	
242	132	15	
	133	2149.8	
	141	123.6	
	142	727.3	
	112	244.8	
	122	78.8	
	131	28.3	
243	133	87	
	142	52.9	
	112	526	
	121	13.6	
	122	13	
	131	151.4	
	133	38.7	
321	141	56	
	142	227.2	
	112	15.7	
	131	5.3	
	112	5.1	
	122	16.5	
	131	57	
322	133	66.7	
	131	5.5	
	112	6.2	
	133	12.6	
	112	31.7	
	121	25.5	
	122	66.2	
324	124	5.1	
	131	88.9	
	133	231.5	
Forest		639.5	3.10
311	112	15.7	
	131	5.3	
	112	5.1	
	122	16.5	
	131	57	
	133	66.7	
	131	5.5	
321	112	6.2	
	133	12.6	
	112	31.7	
	121	25.5	
	122	66.2	
	124	5.1	
	131	88.9	
322	133	231.5	
	112	177.2	
	121	5.2	
	112	20.6	
	122	30.6	
	131	113.5	
	133	5.1	
423	122	2.2	
	112	15.7	
	131	5.3	
	112	5.1	
	122	16.5	
	131	57	
	133	66.7	
Wetlands		177.2	0.86
411	121	5.2	
	112	20.6	
	122	30.6	
	131	113.5	
	133	5.1	
	122	2.2	
	112	15.7	

Table 18: New artificial surfaces

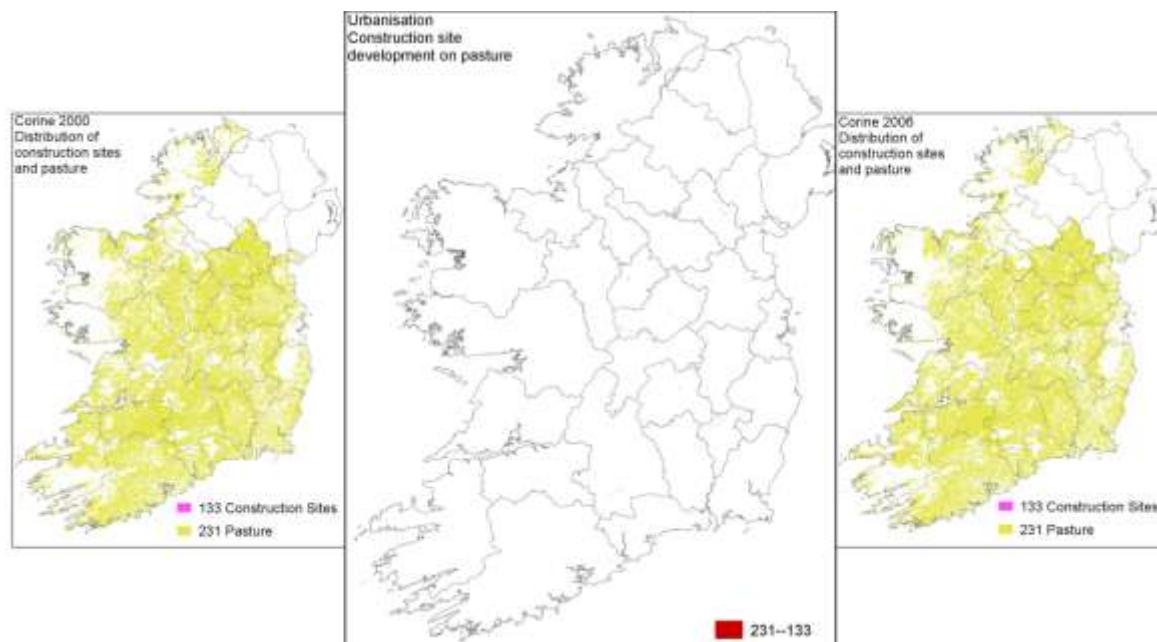


Figure 22: 231-133

4.4.6. Loss of Green Urban Areas

There was an overall 515.4 ha decrease in green urban areas between 2000 and 2006 (15.8% decrease). About 400 ha of green urban areas in 2000 were lost to artificial surfaces. The majority of this loss (almost 65%) was due to construction of housing and other urban fabric.

Loss of Green Urban Areas to			
Urban fabric			400.2ha
2000	2006	ha	%
141	112	258	64.47
	121	40.4	10.09
	122	38.6	9.65
	133	63.2	15.79

4.4.7. Increase in Sports and Leisure

Sports and leisure facilities have grown in area since 2000 by 11.7%. Nearly 93% of these have been built of previously green field sites (pasture or arable)

New Sport & Leisure Facilities			2027.07ha
2000	2006	ha	%
133	142	98.39	0.38
211	142	875.19	43.18
231	142	727.33	35.88
242	142	52.87	2.61
243	142	227.18	11.21
313	142	29.71	1.47

4.4.8. 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. The loss of 29357.13 ha of peat bogs between 2000 and 2006 can be accounted for by the change to transitional woodland-shrub (also generally new forest plantations without closed canopy). The change to transitional woodland-shrub accounts for 99.34% of all peat bog loss; peat bogs overall diminished in area by 2.6% between 2000 and 2006. For further information, see note on afforestation in Appendix IV.

Loss of Peat Bogs			29357.13ha
2000	2006	ha	%
412	324	29899.1	99.34
	131	113.5	0.38
	122	30.6	0.1
	112	20.6	0.07
	242	14.3	0.05
	312	16	0.05
	133	5.1	0.02

4.4.9. Technical Changes

A Technical change polygon is an auxiliary change polygon used for avoiding some major (minimum 5 ha, maximum 25 ha) inaccuracies of the CLC2006 databases. Technical change polygons do not represent a change of land cover in reality, but are consequences of the two different MMUs of CLC-Changes (5 ha) and CLC2006 (25 ha). They are used only in order to allow for the creation of a new polygon in CLC2006 by a GIS operation, after which they are deleted from the CLC-Changes database. Technical change polygons are drawn by the interpreter during change mapping over those patches < 25 ha and > 5 ha: whose land cover has NOT changed between 2000 and 2006 (although might include changed patches < 5 ha); that are not present as a polygon in CLC2000; but we still want them to exist as polygon/part of polygon in CLC2006. Technical change polygons must be given identical code2000 and code2006 AND an additional attribute that makes them identifiable and makes possible to select them automatically. In Ireland technical changes were mainly used for the transitional woodland (324) and discontinuous urban fabric (112) classes.

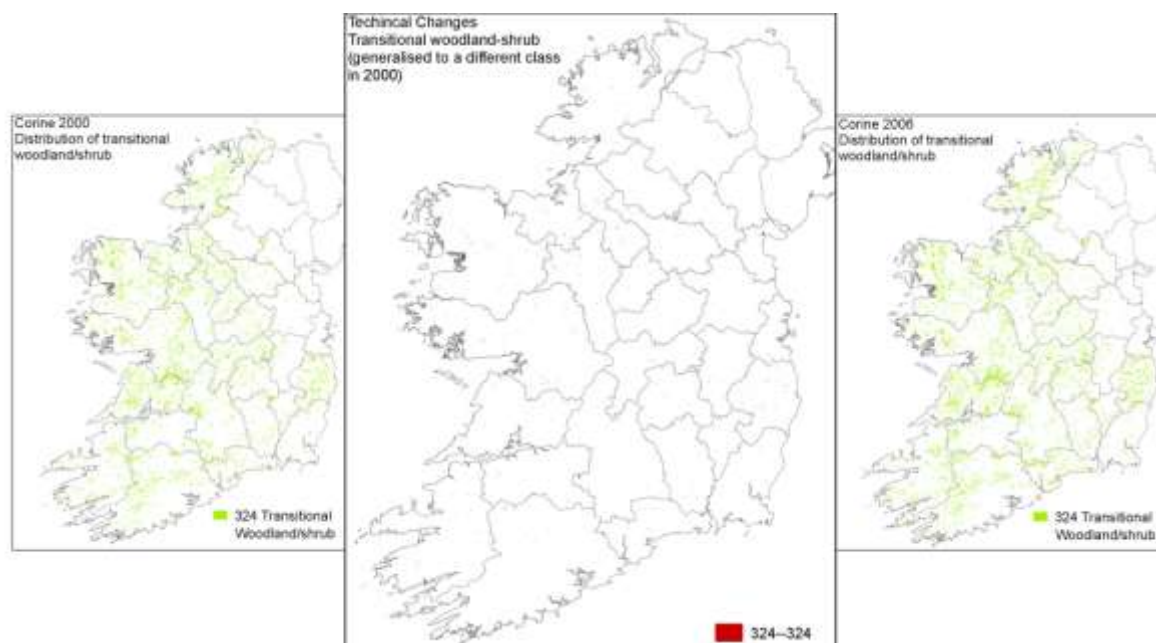


Figure 23: 324-324

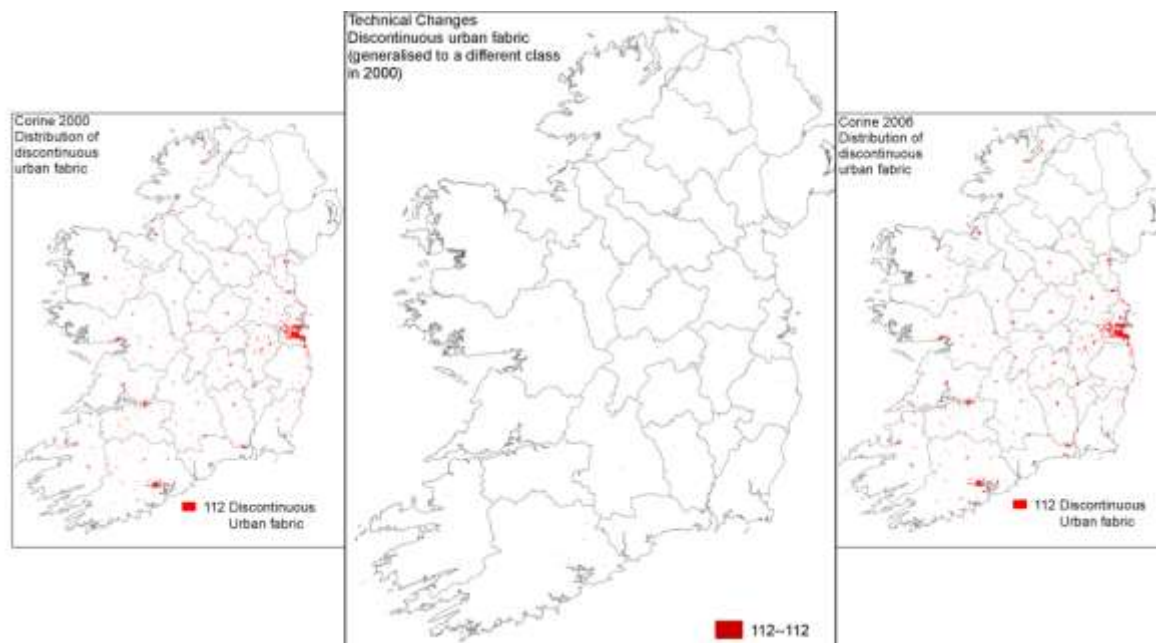


Figure 24: 112-112

4.4.10. Summary

Table 19 contains the level 3 class change pairs and their respective areas. The total area of changes in the CHA06_IE dataset is 171131.1 ha. The total number of change types is 120. The most frequent changes are shown in Table 17. Most of the changes related to forestry, a result of clear cuts (*coniferous forest* - 312 to *transitional woodland-shrub* - 324) and planting (*transitional woodland-shrub* – 324 to *coniferous forest* - 312, *peat bogs* - 412 to *transitional woodland-shrub* - 324 and *pasture* - 231 to *transitional woodland-shrub* - 324). 5766.77 ha of class 324 (*transitional woodland-shrub*) and 1004.66 ha of class 312 (*coniferous forest*) have been mapped as a result of technical changes. These changes in forested areas accounted for 142935.4 ha of the total 171131.1 ha change area. The area of change to forestry (Table 20) can be accounted for by the change from bog, wetlands and agriculture.

CLC	112	121	122	123	124	131	132	133	141	142	211	231	242	243	311	312	313	321	322	324	331	411	412	423	523	Total
112	1159.1	6.3	11.5																							1176.8
121		185.1																								185.1
122																										
123																										
124																										
131		28.4				411.0					35.6	48.6								191.7						715.2
132							5.4																			5.4
133	1624.1	261.5	710.3		20.0				56.4	98.4	55.2	139.7	2.0													2967.6
141	258.0	40.4	38.6					63.2	21.0																	421.2
142	20.5		12.7					57.2		13.0		63.5														166.9
211	2137.1	442.2	409.8			430.8	11.3	895.5	13.6	875.2		705.0	8.6							662.0						6591.0
231	7182.4	783.4	982.5	7.5	60.9	1019.1	15.0	2149.8	123.6	727.3	532.4	9.4	762.4			14.7				12324.9						26695.4
242	244.8		78.8			28.3		87.0		52.9	5.3	6.0								390.5						893.7
243	526.0	13.6	13.0			151.4		38.7	56.0	227.2	34.5					31.1				6632.9						7724.3
311	15.7					5.3									21.5					252.1						294.6
312	5.1		16.5			57.0		66.7				7.5				1004.7				43776.8						44934.2
313	2.6		17.2			19.8		14.9		29.7							35.3			1020.3						1139.9
321						5.5														868.7						874.2
322	6.2							12.6												668.7						687.4
324	31.7	25.5	66.2		5.1	88.9		231.5				11.4		9.9	239.9	37578.1	1372.8			5692.6						45353.5
331																									35.3	35.3
411		5.2																		121.9						127.1
412	20.6		30.6			113.5		5.1					14.3			16.0				29899.1						30099.1
423			2.2																							2.2
523																					41.1					41.1
Tot	13233.8	1791.6	2389.8	7.5	85.9	2330.6	31.7	3622.1	270.6	2023.7	663.0	991.0	787.2	9.9	261.4	38644.7	1408.1			102502.1	41.1				35.3	171131.1

Technical Changes: 9428.9 ha

Table 19: Change pair area in ha based in CLC06 change database (rows = 2000, columns = 2006)

Change	Change from		Change to	
To/From class type	Area	%	Area	%
Artificial	5637.95	3.29	25815.74	15.07
Agriculture	41932.78	24.48	2451.11	1.43
Forestry	93403.21	54.53	142935.41	83.45
Nat Vegetation	35.26	0.02	41.11	0.02
Bog, Wetlands, Water	30269.43	17.67	35.26	0.02
Total	171278.63	100	171278.63	100

Table 20: Changes between classes

Within the urban classes an important change is from *construction sites* (133) to *discontinuous urban fabric* (112) - 1624.14 ha, *industrial or commercial* (121) - 261.53 ha and *road and rail networks* (122) - 710.3 ha. A total of 1159.06 ha of 112 (*discontinuous urban fabric*) has been mapped as a result of technical changes (Figure 24). Other significant changes to artificial classes are 2137.14 ha, 7182.39 ha and 525.95 ha of *non-irrigated arable land* (211), *pasture* (231) and *land principally occupied by agriculture* (243) ha respectively to *discontinuous urban fabric* (112).

The following changes are less common and are a direct result of the growth of artificial cover:

- Construction Sites (133) to non-irrigated arable land (211): 55.15 ha
- Construction Sites (133) to *pasture* (231): 139.66 ha
- Construction Sites (133) to complex cultivation (242): 2.03 ha

These changes usually occurred where construction sites developed into urban fabric, road and rail networks and other artificial cover and the surrounding area reverted back to agriculture.

5. Qualitative assessment of high resolution soil sealing layer

5.1. Background

The high-resolution soil sealing layer is being produced centrally in the frame of the GMES Land Monitoring Fast Track Service Precursor. ERA-Maptec carried out a verification of this layer (Figure 25) on behalf of Irelands Eionet National Reference Centre on Land Use and Spatial Information (EPA), based on a qualitative assessment of the mapped area. Guidelines as agreed at the Eionet workshop on quality control and validation of land cover data (Copenhagen, 12-13 November 2007) were used as support in verifying the layer.

The soil sealing data is produced by a consortium of European service providers under contract with EEA and is based on the classification of the IMAGE2006 satellite data. The overall objective is the production of a seamless European high resolution core land cover dataset of built-up areas, including degree of soil sealing, for the reference year 2006. Built-up areas are characterized by the substitution of the original (semi)-natural cover or water surface with an artificial, often impervious, cover. This artificial cover is usually characterized by long cover duration (FAO Land Cover Classification System, 2005). Impervious surfaces of built-up areas account for 80 to 100% of the total cover. A per-pixel estimate of imperviousness (continuous variable from 0 to 100 percent) is provided as index for degree of soil sealing for the whole geographic coverage. The data will be produced in full spatial resolution, i.e. 20 m by 20 m, which provides the best possible core data for any further analysis. The classification accuracy per hectare (based on a 100 m x 100 m grid) of built-up and non built-up areas should be at least 85%, for the European product.

The qualitative assessment was carried out in May 2008 and feedback was given to the EEA. This qualitative assessment supported by NRCs is part of the grant agreement between EEA and participating countries in the GMES project land monitoring fast track service precursor/CLC2006. Guidelines were provided for the preparatory work, the inventory of reference data that will be used, the description of the geometric and thematic quality and the overall qualitative assessment. The document template provided was used to report on the verification of the data, additional text and illustrations (e.g. examples from screenshots) were also provided.

A quantitative assessment or final validation of the European dataset was carried out by EEA in collaboration with Eionet during late 2008-2009. This European validation was based as much as possible on the results of national validations.

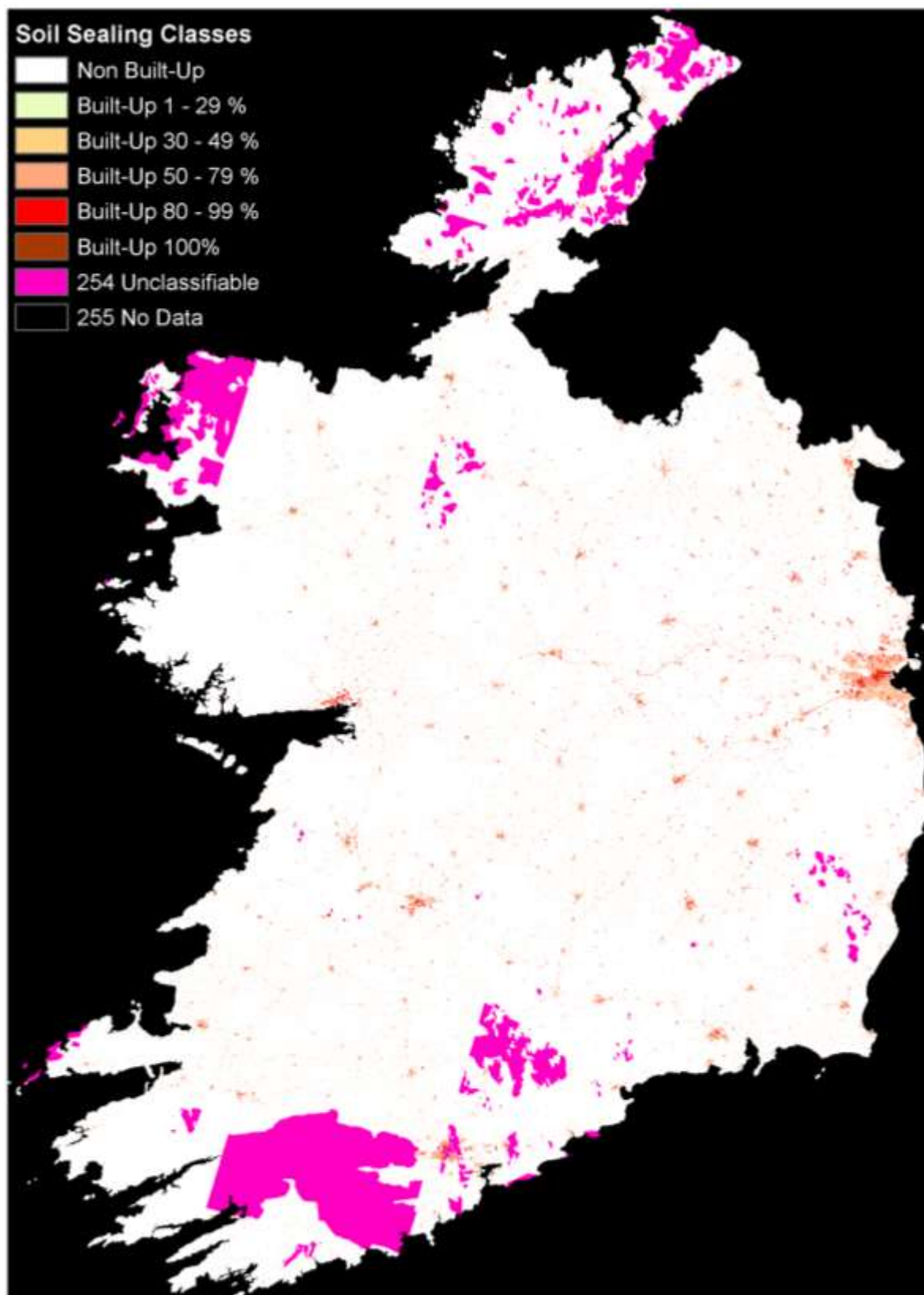


Figure 25: Soil sealing layer, Irish coverage

5.2. Assessment

5.2.1. Preparatory work

The data that was made available by EEA was uploaded. Available reference data to be used during the verification was sourced and prepared. It was advised that the average time needed for this verification was estimated at one person/day per 10.000 km², with Ireland's area denoting a time frame of 7 days.

5.2.2. Reference data

- Topographic maps, 2001, national coverage
- Aerial orthophotos, 2004 – 2006, national coverage
- Very high resolution satellite data, 2005 – 2006, national coverage
- CLC2000, national coverage

5.2.3. Geometric quality

A qualitative assessment of the geometric quality of the data was conducted, the objective of which was to perform a visual analysis of the soil sealing dataset concerning its co-registration when put in overlay with the other reference datasets. There was no visible shift and the projection used was correct.

5.2.4. Thematic quality

A qualitative assessment of the thematic quality of the data was conducted, the objective of which was to perform a visual comparison between the available reference data and the soil sealing dataset. A number of land cover classes (similar to the CLC classes at levels 2 or 3) were assessed to check if any errors in the data could be identified. For this part of the verification, a binary mask was used (built-up/non-built-up area) in overlay with the reference data. A lookup table was applied to map all pixels > 80% degree of soil sealing as built-up area; and checks performed on pixels > 80% degree of soil sealing by screening for each of the land cover classes if built-up or non built-up areas were correctly mapped. Screenshots with examples to illustrate the quality judgement were added.

The following categories were provided to aid in the assessment:

Excellent	meaning that you expect that the accuracy of the built-up data is reaching almost 100%; no errors could be found in the areas that were verified.
Good	meaning that you are confident that the classification results are at least 85 % correct; only sporadic errors were encountered in the areas that were verified.
Acceptable	meaning that you estimate that in most of the verified areas the classification results will probably reach an accuracy of 85 %; some minor errors could be detected in the areas that were verified.
Insufficient	meaning that you do not expect that the classification results will reach the minimum of 85 % accuracy; you encountered several errors in different regions.

Very poor meaning that you are confident that the classification results are bad with regard to presence of built-up area; most of the areas verified are wrongly mapped.

5.2.5. Classifications

Urban Fabric: Excellent. The accuracy of the built-up data is excellent with only one point not reaching almost 100% (this is due to confusion between the spectral signatures of bare soil and built-up areas).

Industrial or Commercial units: Excellent. Occasion where bare soil was misclassified as built-up

Road and Rail networks and associated land: Good, bare soil misclassified as built-up in parts.

Port areas: Good, bare soil and water misclassified as built-up in parts.

Airports: Excellent, no errors found.

Mine, dump and construction sites: Insufficient, many bare soil and water misclassified as built-up

Arable land: Acceptable. Similar spectral signals from built areas and land cover at this time of year has lead to confusion between the classes. Also some problems at the edges of fields.

Heterogeneous agricultural areas: Acceptable. Spectral confusion between crop type and artificial surfaces.

Forest: Very poor. Bare soil and cleared forest misclassified as built-up, transitional woodland classified as built area, residential gardens identified as built-up areas.

Scrub and/or herbaceous vegetation associations: Acceptable. Bare soil and crop rotation leading to confusion among spectral signatures.

Beaches, dunes and sands: Very poor. Sand, sea and rock wrongly identified as built-up.

Bare rocks: Very poor. Rock misclassified as built-up.

Sparsely vegetated areas: Insufficient. The nature of the class leads to confusion between bare soil and artificial surfaces.

Inland wetlands: Acceptable, bare soil misclassified as built up.

Intertidal flats : Very poor. Shadow, sand and water all lead to confusion in the classification.

Coastal lagoons : Very poor. Sand and water misclassified as built-up areas.

5.3. Thematic content check

In most cases 30 locations were sampled for each class (Table 21)

Classification errors are highest when looking at land cover composed of exposed rock and bare soil (see chart above), and lowest amongst the classes composed of artificial surfaces, with the classes

containing mixed parcels of permanent crops and scattered housing having a large range of accuracy (Figure 26)

Class	No. Points	Excellent	Good	Acceptable	Insufficient	Very poor	Quality
Urban Fabric	30	97	0	0	0	3	Excellent
Airports	29	93	7	0	0	0	Excellent
Industrial/Commercial	30	77	0	7	3	13	Good
Ports	29	76	7	3	10	3	Good
Roads & Rail	30	73	0	7	7	13	Good
Arable	30	60	23	3	0	13	Acceptable
Scrub & Herbaceous	30	53	7	3	0	37	Acceptable
Inland Wetlands	30	47	13	7	10	23	Acceptable
Agriculture	30	27	30	17	17	10	Acceptable
Sparsely Vegetated	30	33	10	10	0	47	Insufficient
Forest	30	27	10	3	0	60	Very poor
Beaches	30	27	13	13	10	37	Very poor
Intertidal Flats	29	21	10	3	14	52	Very poor
Coastal Lagoons	17	18	18	24	6	35	Very poor
Mines & Dumps	30	17	0	0	3	80	Very poor
Bare Rocks	30	10	7	3	0	80	Very poor

Table 21: Points were randomly selected for each class and assessed using the categories given above

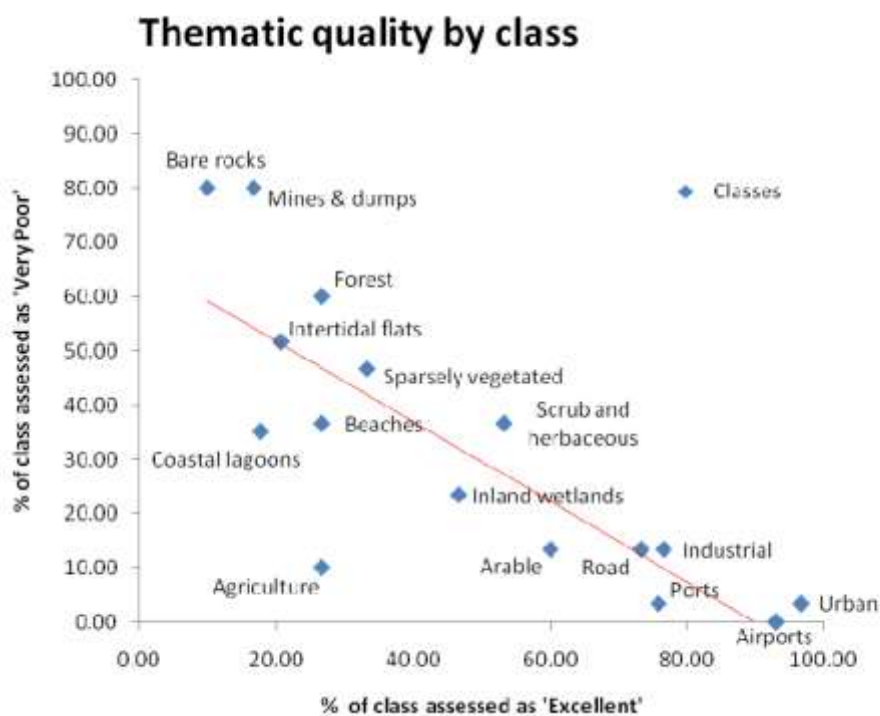


Figure 26 : Thematic quality by class

5.4. Overall qualitative assessment of the data

While the previous thematic quality assessment looked at the data class by class, this section provides an assessment of the quality of the whole territory.

The overall quality of the mapped built-up/non built-up areas for the dataset provided was assessed as acceptable.

Areas of bare soil, exposed rock, water bodies and sand have all been misclassified as built areas, with coastal areas being the worst affected by this. Urban areas are correctly identified but anomalies in the classification occur at the edges of these areas.

We feel that the soil sealing layer will be useable in urban areas only in Ireland.

We suggest that the data set could be improved by the use of ancillary data, such as the high water mark (to remove coastal errors); quarries database and forestry database. All these ancillary data are available in digital format in Ireland

5.5. Quantitative validation

A statistical validation (quantitative assessment) of the national dataset is not planned. Although we do not at present intend to undertake a formal quantitative assessment, two agencies (Urban Institute Ireland and the national agricultural research organisation Teagasc) indicated some interest in carrying out a more targeted qualitative verification. Contribution to the final validation of the European dataset is agreed to in principle. This is not budgeted for at present.

5.6. Fitness for Purpose

The Corine land cover datasets fulfil the primary purpose of enabling inter-country comparisons of land use and land cover across Europe. However use of these datasets in studies at national or sub-national level has shown that they should be employed with caution, and only after users understand the precise definition of the various land cover classes.

Due to the characteristics of the Corine methodology, including

- the defined Corine Land Cover classes (and the existence of mixed classes),
- the relative large (in national terms) minimum polygon size used (25ha),
- the resolution of the source imagery files (20m) and
- the time periods between updates,

the Corine dataset is not considered optimal in representing higher precision land cover variation. As such, the Corine datasets may not be suitable for land cover comparative studies at high spatial or temporal resolution (corresponding to local areas or regions).

Prior to acquiring the Corine land cover dataset, intending users should ensure that the dataset is appropriate to their needs. In case of doubt, please contact the GIS unit of the EPA.

6. Conclusions

Ireland is characterised by thirty-three of the forty-four Corine land cover classes. The main land cover in Ireland is agriculture (66.4%) with class 231 (Pasture) occupying over 50%. Peat bog and wetlands cover 18.69%. Land classified as forest areas occupies around 12% of the country. The surface area occupied by artificial areas has increased from 1.99% to 2.28%. Areas with low vegetative classes, including beaches, dunes and sand; bare rocks and sparsely vegetated areas cover less than 1% of the country (Table 22).

Cover	Area (ha)	%
Agriculture	4729064.42	66.40
Bog & Wetlands	1330915.35	18.69
Forestry	853659.38	11.99
Artificial	162314.62	2.28
Low Vegetation	46313.12	0.65
Total	7122266.88	100

Table 22: % coverage

The total change area between 2000 and 2006 is 171131.13 ha with 9428.9 ha of this being technical changes.

Significant changes in Ireland include:

- Coniferous forest (312), peat bogs (412) and pastures (231) to transitional woodland shrub (324)
- Transitional woodland-shrub (324) to coniferous forest (312)
- Agriculture (231, 211, 243) to urban (112)
- Pastures (231) to construction sites (133)
- Construction sites (133) to urban classes (112, 121, 122)

The aim of the Corine 2006 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 2000 dataset. These problems resulted in a large proportion of data that required editing.

7. References

EEA documents

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APPENDIX I - Details of Ancillary Data

Data source/type	Title	Date of production (m/d/y)	Scale (spatial detail)	Description	Comment
Vector dataset	Land cover data, Teagasc	2007			
Vector dataset	Forest Inventory (FIPS), Forest Service	2007		Vector boundary coverage for all Coillte owned forestry within the Republic of Ireland.	
Vector dataset	Land Parcel Identification vectors (LiPS), Department of Agriculture	2007			Date given is that of production of ArcView shapefile
Ortho-photographs	OSI Orthophotos	2004	1:40000		
Raster dataset	OSI Topographic maps	2001	1:50000		
Vector dataset	Potential_national_saltmarsh_2007	2007			ArcView shapefile prepared as part of unpublished report 'Saltmarsh Monitoring Project 2006 - Summary Report' for National Parks & Wildlife Service, Department of Environment, Heritage and Local Government, Dublin.

APPENDIX II - Map Sheet Coordinates

Spatial Reference System – Irish National Grid (TM65 / Irish Grid)

EPSG: 29902

	Top Left Co-ordinates		Bottom Right Co-ordinates	
Sheet	Easting	Northing	Easting	Northing
1	150000	460000	200000	410000
2	200000	460000	250000	410000
3	250000	460000	300000	410000
4	100000	410000	150000	360000
5	150000	410000	200000	360000
6	200000	410000	250000	360000
7	50000	360000	100000	310000
8	100000	360000	150000	310000
9	150000	360000	200000	310000
10	200000	360000	250000	310000
11	250000	360000	300000	310000
12	300000	360000	350000	310000
13	0	310000	50000	260000
14	50000	310000	100000	260000
15	100000	310000	150000	260000
16	150000	310000	200000	260000
17	200000	310000	250000	260000
18	250000	310000	300000	260000
19	300000	310000	350000	260000
20	50000	260000	100000	210000
21	100000	260000	150000	210000
22	150000	260000	200000	210000
23	200000	260000	250000	210000
24	250000	260000	300000	210000
25	300000	260000	350000	210000
26	50000	210000	100000	160000
27	100000	210000	150000	160000
28	150000	210000	200000	160000
29	200000	210000	250000	160000
30	250000	210000	300000	160000
31	300000	210000	350000	160000
32	0	160000	50000	110000
33	50000	160000	100000	110000
34	100000	160000	150000	110000

35	150000	160000	200000	110000
36	200000	160000	250000	110000
37	250000	160000	300000	110000
38	300000	160000	350000	110000
39	0	110000	50000	60000
40	50000	110000	100000	60000
41	100000	110000	150000	60000
42	150000	110000	200000	60000
43	200000	110000	250000	60000
44	250000	110000	300000	60000
45	300000	110000	350000	60000
46	0	60000	50000	10000
47	50000	60000	100000	10000
48	100000	60000	150000	10000
49	150000	60000	200000	10000

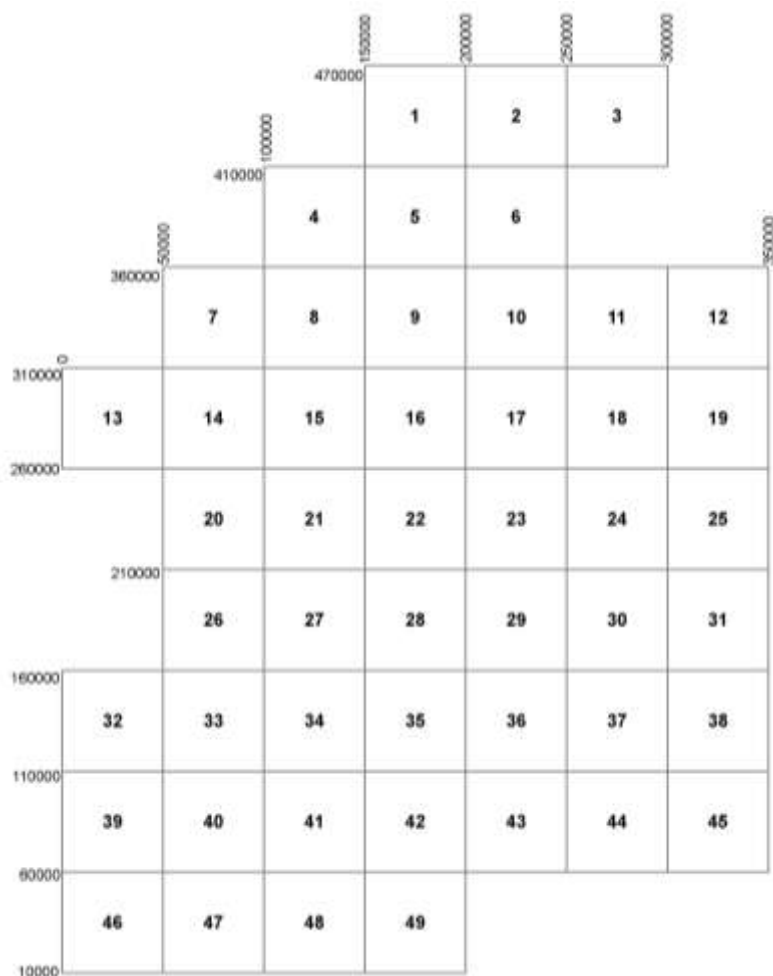


Figure 27: Map Sheet coordinates

APPENDIX III - Corine Land Cover 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
		2.4.1 Annual crops associated with permanent crops
	2.4 Heterogeneous agricultural areas	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
		2.4.5 Pastures
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-shrub
	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
	4.1 Inland wetlands	4.1.1 Inland marshes
		4.1.2 Peat bogs
4. Wetlands	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 - Note on Forestry Statistics

Afforestation

Please note that changes from non-woodland classes to woodland classes (311,312, 313,324) as these may differ from official afforestation statistics, such as those contained in the National Forest Inventory (NFI). The NFI involved a detailed field survey of Ireland's forests and woodlands and should be used to obtain statistics on plantation amounts, as planting in the year (or even two years) prior to the acquisition of CLC images might not show up on imagery and thus not be put into a forest class.

In addition there may be a different distribution of wooded area between forest (classes 31x) and transitional woodland-shrub (class 324) because of differing forest definitions.

In CLC a forest is defined as a collection of trees which, under normal climatic conditions, are higher than 5m with a canopy closure of at least 30 %. In case of young plantations, the minimum cut-off-point is 500 trees per ha. The NFI defines a forest as land with a minimum area of 0.1 hectare, a minimum width of 20 m, trees higher than 5 m and a canopy cover of more than 20% within the forest boundary, or trees able to reach these thresholds in situ.

The differing requirements for canopy cover could result in CLC delivering a lower total area for immature CLC forests (classes 31x) than that shown by the NFI. New NFI forest plantations would be most likely assigned CLC class 324.

Afforestation on Peatlands

Particular care should be taken in interpreting the transition from class 412 (*peat bogs*) to class 324 (*transitional woodland-shrub*).

A full reconciliation between CLC statistics and statistics of afforestation on peatlands contained in the NFI is difficult because of:

1. Differing definitions of peatbogs/peatlands and difficulty in assigning soil depth.

Any upland area with peaty soils is classified as peat bogs in CLC. CLC class 412 covers areas of peaty soil > 0.3m depth with Sphagnum and Molinia, etc. For an area to be classified as peat in the NFI, the peat depth has to be greater than 0.3m on drained and 0.45m on undrained land. The vegetation (land cover) visible in the satellite image is the means by which the image interpreter infers or assigns a CLC classification (peatland or otherwise) to a particular area. However a remote sensing approach such as that adopted for CLC cannot identify soil types or depth.

2. Definition of class 324 (*transitional woodland-shrub*).

Class 324, in addition to young forests, also includes:

- marginal zones of bogs with a vegetation composed of shrubs and pine bogs which cover more than 50 % of the surface (transitional bogs on peaty soils);
- natural grassland areas with small forests < 25 ha and/or with trees intermixed which cover more than 30 % of the surface.

The natural evolution of the marginal zone of a bog (leading to the transition 412 -> 324) could be misinterpreted as afforestation.

The Forest Service of the Department of Agriculture, Fisheries and Food compared the national CLC2000 database with higher-resolution national spatial data from the Service's afforestation database and suggested that circa 30% of the area classified as peat bog in CLC2000 may have been misclassified. This was recently confirmed by NFI statistics, which suggested that the percentage of peat afforestation between 1990 and 2000 ranged from 46 to 51% of the total afforested area and not 84% as originally reported for CLC2000.

National Forest Inventory:

The results from NFI have been informed by a ground based survey of forest soils at 1742 locations throughout the country. The NFI has been designed to be statistically sound and to report at the 95% confidence level for statistics related to carbon reporting (Kyoto Protocol), the MCPFE (Ministerial Conference on the Protection of Forests in Europe), and to meet FAO data requirements.

Methodology

The primary dataset used for estimating forest cover in the NFI was the 2000/2004 digital ortho-photography database obtained from Ordnance Survey Ireland. Forest and 26 other land use type were recorded from the ortho-photography on a 2 km grid. Each of the 17,423 points on the 2 km grid were assigned to one of the 27 land use types. The photography used in the interpretation exercise was captured at a scale of circa 1:40,000 and with a 1 m per pixel resolution. In order to capture forest that was not visible on the ortho-photography, i.e., recently planted forests (planted 2000-2006), three dataset were used to aid in the identification of forest and non-forest areas:

- a digital map of Forest Service grant aided forest,
- digital forest maps from the Forest Inventory and Planning System (FIPS 1998) survey and,
- a comprehensive digital forest inventory database sourced from Coillte Teoranta, the Irish Forestry Board.

(See

http://www.agriculture.irlgov.ie/media/migration/forestry/nationalforestinventory/ireland/snationalforestinventoryconference/NFI_Methodology.pdf)

Interpretation of land use type was based on the criteria established for the NFI forest definition. If it was unclear whether a sample point should be classified as Forest or another land-use type, the sample point was classified as a "check plot". Sample points classified as either forest or check plots became the focus of the ground survey for the NFI.

The underlying technology used in the NFI is an integrated system of hardware and software developed by Institute of Forest Ecosystem Research Ltd (IFER), Czech Republic. It allows for the preparation of a NFI database, background maps, and plot generation. This in turn enables the creation of projects for field teams, and facilitates the field data collection process. Data analysis and results generation are by IFER and the Forest Service.

For further information on NFI methodology, see

<http://www.agriculture.gov.ie/media/migration/forestry/nationalforestinventory/nationalforestinventorypublications/4350NFIMethodology.pdf>

Results:

<http://www.agriculture.gov.ie/media/migration/forestry/nationalforestinventory/nationalforestinventorypublications/4330NFIRResults.pdf>

For further information on the National Forest Inventory, see the following online documents or contact the Forest Service at:

Forest Service, Department of Agriculture, Fisheries and Food, Johnstown Castle Estate, Co. Wexford

Tel: 053 916 3400.

Email: nfi@agriculture.gov.ie