The National Landcover and Habitats Working Group

WP1 Classification system review

Work Package 1, 2016

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1. Executive Summary

Ireland currently has no recognised national Landcover classification system. The technical working group of the National Landcover and Habitat Map (NLCHM) working group was tasked to develop such a system which could be used to map a new national landcover and habitat dataset. During an initial proof-of-concept pilot project covering Co. Roscommon in 2012, it was first proposed that the existing Fossitt habitat classification system (Fossitt, 2000) could be redesigned to include a new landcover level which would replace the existing level 2 (Lydon, 2013). A draft version of this 'level 2B' was drawn up and the Roscommon pilot area of Prime 2 was classified to it successfully.

Whilst the draft new 'Fossitt 2B' level was accepted in principle by the landcover working group, there has to date been no wider user consultation to gauge public opinion on this approach and offer stakeholders the opportunity to comment and provide feedback. This task was then assigned under Work Package 1 of the 2016 work programme for the NLCHM group. The full scope of the Work Package is listed below and the results of the task work are documented within this report:

i. Review of national land monitoring systems and trends in Europe.
ii. Undertake a wide scale stakeholder consultation exercise, giving potential user groups and individuals the opportunity to review the proposed system and to offer their own feedback.
iii. Recommend a classification approach to be adopted by the NLCHM and outline any further steps which need to be taken to implement such a system.

Section 2 provides a detailed review of the production processes and classification systems used by other European countries in producing their own national landcover/ land use datasets (land monitoring systems) with table 2.1 on pages 7 and 8 listing the details of twenty known national land monitoring systems in Europe. Recent trends in land monitoring approaches are reviewed, showing that there is a move away from conventional rigid classification systems towards more comprehensive 'landscape description' systems, where a pure landcover level forms the basis of a description model with further detailed information on landuse and environmental characteristics provided to give a more comprehensive picture of the landscape.

Section 3 gives the results of the stakeholder survey process where 116 landcover data users from over 50 public agencies, private companies and academia in Ireland and abroad answered an online survey which was circulated in June 2016 (https://www.surveymonkey.com/r/Irish_Landcover_Survey_2016). The survey contained 48 questions and was designed to elicit feedback on the proposed classification and also to scope user requirements for other landcover, landuse and habitat information which is not included. The survey generated a large amount of quality feedback and comments which can be drawn upon to inform further refinement of the proposed classification system. The survey process also served the purpose of identifying clearly the potential user-base of a national landcover, landuse or habitat dataset. This resource can be drawn upon for future outreach initiatives.

The majority of survey responders were satisfied with the proposed Fossitt-based landcover classification approach. Just under 70% of users said that they agree with this approach with a minority of responders saying that they would prefer to see either a stand-alone system separate to Fossitt (13.3%), or the Fossitt system as a whole revised (9.7%). The survey enables us to confidently expect a high user uptake as over 80% of responders said that they would use the data if produced with fifty different policy, assessment, monitoring, research and education applications given on page 19. Detailed feedback was also received on individual landcover thematic areas (e.g. artificial, grasslands) with recommendations for each individual landcover group given in the relevant category section in 3.4.

In general the survey results showed that there are two main user categories / needs:

A. Users who want a standardised, 'off-the-shelf', landcover dataset which they can readily use as a primary data source for their own reporting, modelling, assessment, etc. work.
B. Users who want highly detailed, topic-specific information on a particular element of the landscape, typically detailed habitat or landuse information.

The two above user need types were previously seen as being in conflict with one another, as no one system would fully satisfy both requirement levels. However, the 'landscape description' system may offer the capability to fulfil both user needs. The Fossitt-based 'pure landcover' classification level will best suit the user needs in group A above providing a standardised, unbiased description of the earth's bio-physical surface. The ability to add extra information on landuse and environmental characteristics can then be used to target specific thematic topics or geographical areas required by users in group B.

Section 4 then gives a recommended approach to adopting a landscape description system for an Irish land monitoring programme. The Fossitt level 2B, further revised based on feedback received from the survey process, can form the base level of data in an Irish land description system. Additional landuse, habitat and environmental characteristics can then be attributed on a non-mandatory basis where data is available. It is anticipated that the initial baseline data release will focus on the primary landcover level and that the level of added attribution would increase over time with future iterations of the dataset.

To allow for full compatibility with the new landcover level 2B, the entire Fossitt classification schema would ideally be revised. This can be done separately or as part of the landcover data production cycle. It is recommended to also allow scope for further refinement of the revised landcover level during production of the dataset and to publish the finalised classification system along with the first release of the dataset.

The final list of recommendations arising from WP1 and described in more detail in section 4 are:

1. Adopt a 'landscape description' data model, similar to the EAGLE data model and matrix for an Irish land monitoring programme. This will involve producing a core landcover data level, mapped to the PRIME2 spatial database, which is then further augmented by attribution on landuse and environmental characteristics where such information is available.
2. Continue to base the core landcover level on the adapted Fossitt level 2, making provisions for the full Fossitt system to be revised in future to ensure full compatibility between all three classification levels.
3. Use the most recent draft of the Fossitt level 2B given in section 4 (fig 4.1) as the basis of a landcover description level and allow for final refinement during the production process.
4. Publish the finalised landcover classification level along with the first iteration of a national landcover dataset when complete.

2. Review of European land monitoring programmes and classification systems

In the late 1980's, the Nederlands (Thunnissen et al. 1992) and Luxembourg were the first European countries to develop a national landcover / landuse database. At the same time, plans were being developed for a pan-European landcover dataset which became the baseline 1990 CORINE landcover database, the first pan-European spatial dataset of any kind (Feranec et al, 2016). The CORINE dataset was quickly adopted by policy makers, researchers and industry across Europe as a vital source of environmental information, feeding into documents such as the EEA's state of the Environments reports (EEA, 2015). Whilst it was initially the only source of landcover data for most European countries, individual countries began to develop their own land monitoring programmes throughout the 1990's and 2000's to overcome the limitations of CORINE and address their own national needs. Table 2.1 on pages 7 & 8 list European countries which have implemented a national land monitoring programme, giving details on the technical specification of the datasets and production process used. CORINE continues to be co-ordinated centrally by the European Environment Agency (EEA) and produced nationally by the thirty eight European countries who are members of the EEA Information and Observation NETwork (EIONET) land monitoring topic group, following a common methodology and data specification (Büttner et. al. 2006).

2.1 European national Land monitoring – Data production models

The production methods used by different countries in delivering a national landcover dataset has evolved and developed over the 25 year period since 1990, generally in-line with advancements in technology over that period. This includes developments in both general information technology and services but also specifically in the GIS and Remote Sensing technology sector. Examples of technological developments are increased computational capabilities and data storage capacity, improved satellite imagery resolution and availability, GIS and Remote Sensing software developments such as object-oriented image analysis and machine-learning classification algorithms.

The five main production methods currently used in national landcover monitoring programmes are:

1. **Manual photo-interpretation:** Visual interpretation of either aerial photography or satellite imagery using GIS software to manually digitise and classify areas on the image.
2. **Pixel-based image interpretation:** Individual pixels of satellite images are classified using statistical algorithms and rules which utilise training sets of data/pixels to automatically classify all pixels in an image. More recently high-powered machine-learning statistical programmes (e.g. Random Forests) have been developed to further enhance this process.
3. **Object-oriented image segmentation and classification**: This approach has two components: i) Image Segmentation - Neighbouring pixels with similar spectral properties are grouped into 'objects' which represent real features on the ground (e.g. field parcels, water bodies). These objects are then used as primary spatial units, in the same way parcels in a topographic database could be. ii) Object-oriented classification – Using the software tools, the user writes a classification algorithm (rule-set) which is a step-by-step procedure to classify the objects in a semi-automated fashion. The rule-based can bring in additional in-situ vector data (e.g. agri-landuse datasets), thematic rasters (e.g. elevation & soil), geometric properties of object (e.g. object area & width), object neighbourhood functions (e.g. proximity & border sharing) and unique user expert knowledge (e.g. environmental policy and cultural factors) to provide a 'knowledge-rich' classification (Blaschke, 2008).

4. **Utilisation of topographic datasets:** National cadastre vector datasets are used to provide the core spatial framework for a landcover dataset. The spatial dataset is then classified using manual, pixel or object-based techniques.
5. **Data-integration:** Various sources of in-situ vector and raster datasets are integrated in a bespoke production model to provide either a direct source of landcover information or to aid further analysis using spectral classification.

As stated, the production process chosen by individual countries is continually evolving over time and commonly involves a combination of two or more of the methods listed above. It is normally dependent on the availability of data and level of expertise within countries at the time. The production options chosen by the U.K. in its three different releases of the Landcover Map (LCM) – 1990, 2000 and 2007 is a good case study which charts the evolution of Land monitoring methods over that time period. Subsequent programmes developed by Austria and Spain demonstrate the more recent trends in national land monitoring to date.

UK Landcover Map (LCM)

The 1990 LCM covered Great Britain (not Northern Ireland) and was produced by the UK Centre for Ecology and Hydrology (CEH). The production method used was a supervised maximum likelihood pixel-based classification approach using 25m Landsat TM satellite imagery (Fuller et al 1994a). The LCM1990 data product was a 25m raster dataset (see fig. 2.1) with 25 non-hierarchal habitat-influenced landcover classes. A generalised 1km version is also available.

The second release of the LCM – LCM2000 - saw significant technical upgrades to the dataset and an extension to also cover Northern Ireland. A new hierarchal landcover classification nomenclature was developed which was based on the UKs Joint Nature Conservation Committee (JNCC) Broad Habitats, covering the whole range of UK habitats. A new production methodology was also implemented utilising the newly developing Object-Oriented image segmentation and classification approach. The objects created during image segmentation were classified to the new nomenclature and exported as a 0.5ha vector dataset (see fig 2.1). A generalised 25m raster dataset was also produced.

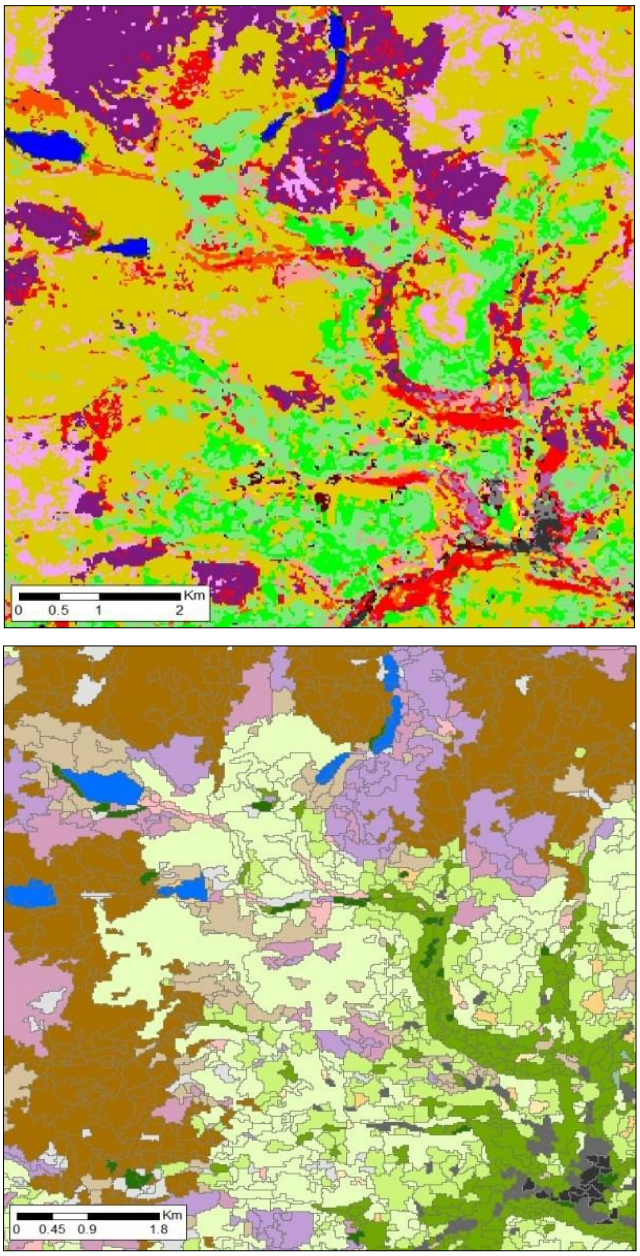


Fig 2.1 Samples of LCM1990 (top) and LCM 2000(bottom)

The third and most recent release of the LCM -LCM2007- further evolved in terms of its production methodology and utilised the OS GB's Mastermap vector cadastral dataset. The use of this dataset replaced the need to perform image segmentation to provide real ground-feature objects. The

Mastermap objects were classified in a similar manner to the 2000 dataset i.e. an object-oriented approach, utilising both raster imagery and in-situ vector data sources (see fig 2.2). The utilisation of the Mastermap increased the spatial accuracy of the dataset and overcame the concerns of the long-term reliability of image-based segments (Morton et al. 2014).

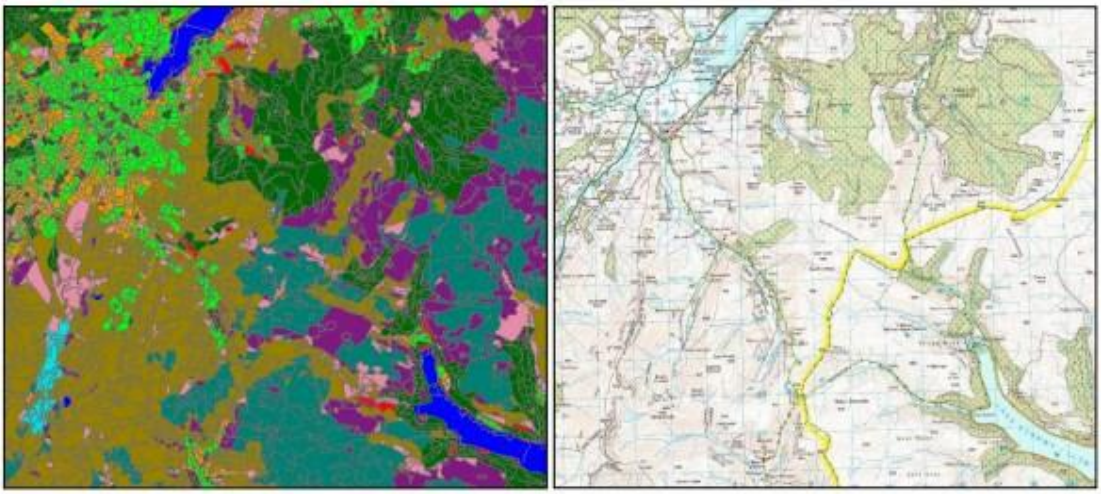


Fig 2.2 Sample of the LCM 2007

Use of national cadastral datasets as spatial frameworks for land monitoring programmes

The evolution of the LCM data model from pixel-based in 1990 through to Object-Oriented in 2000 and then using existing national topographic datasets as the spatial framework in the 2007 release draws a good timeline of the general trend in national landcover mapping at the time with the UK being one of the more progressive and experimental nations over that period in this area. Aswell as the UK, the many other European countries began to develop their own digital high resolution vector topographic databases over this period, the equivalent in Ireland being the OSi's PRIME2 database. Since the mid 2000's there has been an increasing trend of countries using these cadastral or topographic databases as a spatial framework for national land monitoring systems, be they landcover or landuseorientated.

Some countries such as Germany (DLM-DE, 2009) and Sweden (GSD Landcover, 2000), classified their respective cadastral dataset to CORINE Level 3, enabling semi-automated generalisation to provide the 25ha CORINE dataset as a by-product of a national dataset. Other countries have populated these cartographic datasets with their own bespoke classification systems to varying levels of detail from 41 class hierarchal systems (Icelandic Land Use Database) to more basic <10 class landuse or landcover datasets, e.g. Denmark's 'Kort10' and Romania's 'TOPRO5' systems. The Austrian LISA system (Land Information System Austria) is unique in that it maps landcover using image segmentation techniques but maps landuse separately using the national cadastral database, see fig. 2.3 below.

Fig 2.3 Sample showing the separated LISA landuse and landcover data models

Country	Organisation	Dataset name	Url:	Release year(s)	Data model	Production type	Data source	Classification system	Resolution
Austria	Environmental Agency Austria	LISA - Land Information System Austria	Link	2009, 2012	Separated Landuse & Landcover data model	Object-oriented Image segmentation & classification	IRS & SPOT Satellite imagery, Aerial Photography & Laser scanner data. Additional in-situ data used specifically for landuse	Non-hierarchal. Land cover: 15 classes with 12 attributes. Landuse: 25 classes with 72 attributes	25m2 mmu
Belgium	Flemish Geographical Information Agency (FGIA)	Regional Land Cover and Land use map of Flanders		Ongoing	Separated Landuse & Landcover data model	Object-oriented Image segmentation & classification	Landsat ETM+	Non-hierarchal. Land cover: 9 classes Landuse: 19 classes	18m Pixel size
Bulgaria	Agency of Electronic Communication Networks and Information Systems	Landcover Reference Layer	Link	2009-2010	Landcover with additional environmental attributes	Pixel based and manual Image interpretation.	Landsat 5, topographic maps & field survey	FAO Global Landcover Classification System	1 ha mmu
Denmark	Danish Geodata Agency	Kort10	Link	Ongoing 5 year cycle	Cartographic model with basic LC information	Digitisation of historic maps, updated with Interpretation of satellite imagery and aerial photography.	Landsat Tm & ETM	7 basic LC classes and 47 thematic classes.	1:10,000
Finland	Finnish Environment Institute, SYKE	CORINE Land Cover, 25m	Link	2006	25 metre release of CORINE 2006, mapped to Level 4	Pixel based and manual Image interpretation combined with in-situ data integration.	Various EO imagery, Topographic maps, aerial photography, in-situ data and field survey	CORINE level 4 (49 classes)	25 metre
Finland	Finnish Environment Institute, SYKE	SLICES, Separated landuse element of Finland		2000, 2005, 2010	Landuse database based on topographic maps and data integration	In-situ data integration	Topographic maps and various sectorial in-situ data sources	Hierarchal 48 Classes	0.25ha mmu
Germany	Federal Agency for Cartography and Geodesy	Digital Land Cover Model for Germany DLM-DE	Link	2009	National vector topographic database classified to CORINE level3.	Object-based image classification using pre-defined vector data model.	Vector data model, Spot, IRS and RapidEye imagery	CORINE Level 4	1 ha mmu
Hungary	Institute of Geodesy, Cartography and Remote Sensing (FOMI)	CLC50	Link	1998 / 1999	Enhanced CORINE dataset mapped to Level 5	Manual photo-interpretation	SPOT Imagery	CORINE level 5 (79 classes)	4ha, 1ha for water
Iceland	Agricultural University of Iceland (AUI)	Icelandic Land Use Database (IGLUD)	Link	Annual since 2006	National landuse database	Data integration, pixel based image interpretation and field survey	SPOT & Landsat imagery, aerial photography, in-situ data and field survey	Hierarchal landuse (41 classes)	0.196 ha
Ireland	Teagasc	The national Teagasc Landcover Map 1995	Link	1995	Landcover and habitat map	Pixel-based satellite image interpretation	Landsat 5	Hierarchal Landcover / Habitat nomenclature	15 ha
Luxemburg	Luxemburg Dept. of Environment	National land cover map of the Grand Duchy of Luxembourg	Link	1989, 1999, 2007	Landcover dataset	Manual and pixel-based interpretation of aerial photography & satellite imagery	Aerial photography ('89 & '99)	CORINE Level 5	500 m2

Country	Organisation	Dataset name	Url:	Release year(s)	Data model	Production type	Data source	Classification system	Resolution
Nederlands	Alterra - Wageningen University and Research Centre	Land use/cover database of the Netherlands	Link	Every +/- 4 years since 1986	Landuse / landcover dataset based on 25 X 25m grid cell	Pixel based and manual Image interpretation combined with in-situ data integration.	Landsat, SPOT, IRS satellite imagery and aerial photography	Hierarchal LC / LU nomenclature (39 classes)	25m2
Nederlands	Central Office of Statistics (CBS)	Land use database	Link	Every 2-4 years	Landuse data attributed to topographic database	Data integration and interpretation of aerial photography	National vector topographic database (Top10NL) and aerial photography	Hierarchal LU (38 classes)	1:10,000
Norway	Norwegian Forest and Landscape Institute	Land resource survey (AR5)	Link	Continuous updates	Landcover, landuse and land capability database	Initial complete field survey of all area under the tree line, updated via continuous aerial photo-interpretation. Less frequent satellite interpretation above tree line.	Field survey, manual and pixel-based interpretation of aerial photography and satellite imagery	Non-hierarchal LU/LC system (125 classes)	Multiple resolutions, 1:5,000, 1:50,000, 1:250,000
Portugal	Portuguese Geographic Institute (IGP)	COS2007 - Land Use and Land Cover Map of Continental Portugal for 2007	Link	2007	CORINE Level5 LC/LU dataset	Manual photo-interpretation of high resolution aerial imagery	High-resolution aerial photography	CORINE to Level 3 with a bespoke LU/LC system compatible with Kyoto at L4 & L5 (193 classes)	1 ha mmu
Romania	National Agency for Cadastre and Land Registration	Land Cover TOPRO5	Link	Ongoing	Topographic database with basic LC/LU information	Data integration and interpretation of aerial photography	Topographic database and aerial photography	Hierarchal Landcover/ Landuse	1:5,000
Spain	National Geographic Institute of Spain	SIOSE Spanish Land cover/Land use Information System	Link	2005, 2009, 2011	LC/LU dataset	Object-oriented Image segmentation & classification of landcover and additional environmental characteristics. Bottom-up production at regional level	SPOT5 & Landsat imagery, aerial photography and other regional in-situ datasets	Non-hierarchal Landcover with ability to add information on environmental characteristics. Simple and compound (mosaic) features types possible	Varies with LC type. 0.5-2ha
Sweden	Swedish property and land surveying agency	GSD-Land Cover	Link	2000	LC/LU dataset	In-situ data integration and interpretation of satellite imagery.	Landsat imagery, Topographic data, aerial photography and other in-situ data	Modified CORINE nomenclature (58 classes)	Variable mmu (1-25ha) for different classes
Switzerland	Swiss Federal Statistical Office (FSO)	Swiss Land Use Statistics	Link	2004, 2009	LU & LC database	Manual interpretation of points at 100m intervals using aerial photography and field survey	Aerial photography	Hierarchal LU, LC classes (73 classes)	100m 2 grid
U.K	Centre for Ecology and Hydrology	Land Cover Map	Link	1990, 2000, 2007	Landcover data product	1990 - Pixel based classification. 2000 - Object-oriented segmentation and classification. 2007 - Object-oriented classification of vector topographic boundaries	IRS, Landsat, SPOT and AWiFS satellite imagery, topographic database (2007) and other in-situ data.	Hierarchal Landcover based on broad habitats	0.5ha

Table 2.1 List of European countries which have developed a national land monitoring programme with technical details of each programme

2.2 European national Land monitoring – Classification approaches

Apart from the production methodology used, the other main defining factor of a land monitoring programme is the classification system used. As with the production methodologies, classification approaches and designs have developed over time, often mirroring advances in image resolution and data availability. More detailed thematic descriptions are now possible with more detailed spatial resolution available from topographic datasets. However, there is still a large degree of variation in landcover schema design with a number of core system types.

2.2.1 Hybrid landcover/landuse classification systems

A fundamental problem with designing a landcover classification system is drawing the line between the three codes of Landcover, Landuse & Habitats. Landcover itself is quite a broad and generic concept with the traditional definition of landcover being*: 'The observed bio-geophysical cover on the earth's surface'* (Di Gregorio, 2000). Core bio-geophysical properties translate into broad descriptions, normally at the Level 1 detail in Landcover classification schemas e.g. 'Grassland' or 'Water'. These descriptors are normally used as the starting point of a classifications system with more detailed levels and sub-categories designed to meet the user needs or policy requirements. This is where the schema normally deviates from a pure landcover schema and is influenced by dominant landuse practises and common lay-terms for describing the landscape. These are known as 'hybrid' Landcover / Landuse systems and is normally used in systems with medium to low spatial resolution (>1ha mmu) where there is commonly a mixture of cover types with a parcel due to the inability to map discrete objects.

The CORINE classification nomenclature - http://uls.eionet.europa.eu/CLC2000/classes/index_html - is the most widely used example of a hybrid system. For example, the class '112 - Discontinuous urban fabric' describes a landscape with a mixture of buildings, sealed and unsealed surfaces. Quite a few countries, including Germany (DLM-DE,2009); Hungary (CLC50, 1999) and Finland (CORINE 25m, 2006) used the CORINE nomenclature when producing their own national dataset, often utilising the more detailed level 4 and level 5 levels in the CORINE nomenclature to provide more thematic detail. Portugal took a unique approach with their COS 2007 programme where they used CORINE up to level 3, then creating their own levels 4 and 5, using the Kyoto nomenclature as a guideline (Caetano, 2009).

2.2.2 Separated Landcover and Landuse classification systems

In other systems, landcover and landuse are separated with either dual or standalone 'pure' land cover and 'pure' landuse systems. Pure landuse systems are often managed by a cadastral mapping agency or a central statistics agency and are designed to provide official national landuse statistics. They are normally mapped to national vector topographic or cadastral mapping databases but in other countries such as Norway and the Nederlands they are based on national grid databases (e.g. 1km sq. grids). The Austrian LISA system (Banko et al. 2010) has a 'dual' approach whereby a separate landuse and landcover schema are used within the same land monitoring system. In pure Landcover systems the classification sticks closer to the true bio-physical landcover

Broad Habitat	LCM2007 class	LCM2007 class number[2]
'Broadleaved, Mixed and Yew Woodland'	**Broadleaved woodland**	1
'Coniferous Woodland'	*'Coniferous Woodland'*	2
'Arable and Horticulture'	*'Arable and Horticulture'*	3
'Improved Grassland'	*'Improved Grassland'*	4
Rough Grassland	**Rough grassland**	5
'Neutral Grassland'	*'Neutral Grassland'*	6
'Calcareous Grassland'	*'Calcareous Grassland'*	7
'Acid Grassland'	**Acid grassland**	8
'Fen, Marsh and Swamp'	*'Fen, Marsh and Swamp'*	9
'Dwarf Shrub Heath'	**Heather**	10
	Heather grassland	11
'Bog'	*'Bog'*	12
'Montane Habitats'	*'Montane Habitats'*	13
'Inland Rock'	*'Inland Rock'*	14
Saltwater	**Saltwater**	15
Freshwater	**Freshwater**	16
'Supra-littoral Rock'	*'Supra-littoral Rock'*	17
'Supra-littoral Sediment'	*'Supra-littoral Sediment'*	18
'Littoral Rock'	*'Littoral Rock'*	19
'Littoral Sediment'	**Littoral sediment**	20
	Saltmarsh	21
'Built-up Areas and Gardens'	**Urban**	22
	Suburban	23

Fig 2.4. Table showing the UK LCM classification system, based on the UK Broad Habitats system.

description of the earth's surface and as a result resembles a traditional habitat map in the more detailed levels of a hierarchal system. The system adopted by the UK in LCM 2000 and LCM 2007 is a good example of this where they took the UK's JNCC Biodiversity Action Plan Broad Habitat types and adjusted the classes to suit mapping via remote sensing. The resulting nomenclature can be seen in fig 2.4. This 'pure landcover' approach has the advantage of describing the landscape in a neutral as possible way, avoiding a bias towards any sector, enabling users to interpret the classes as specifically for their own purposes.

2.2.3 Landscape description systems

The Spanish 'Sistema de Informatión de Ocupación de Suelo en Espana (SIOSE) system (Valcarcel, 2008), pioneered a new classification approach in 2005 which is becoming recognised as the new best practise in European landscape monitoring. This is known as a 'Landscape description' model of classification, where instead of deciding to focus on either landcover or landuse, several separate sets of data attribution can be added, including pure landcover, landuse, habitat and additional environmental characteristics. The system aims to give the maximum amount of descriptive detail possible for the landscape and as such is more of a 'land description' system than a singular land classification system. In SIOSE, land parcels, derived from topographic spatial databases and image segmentation, are given a primary landcover type but are also given a percentage breakdown of constituent types within the spatial units. This is particularly useful for heterogeneous mosaic areas. The system is designed to also accommodate the respective CORINE class for a land parcel, enabling generalisation to produce CORINE data products. Fig 2.5 shows an example of where an urban parcel is primarily described as a residential, built up area with further breakdown of the different landscape elements.

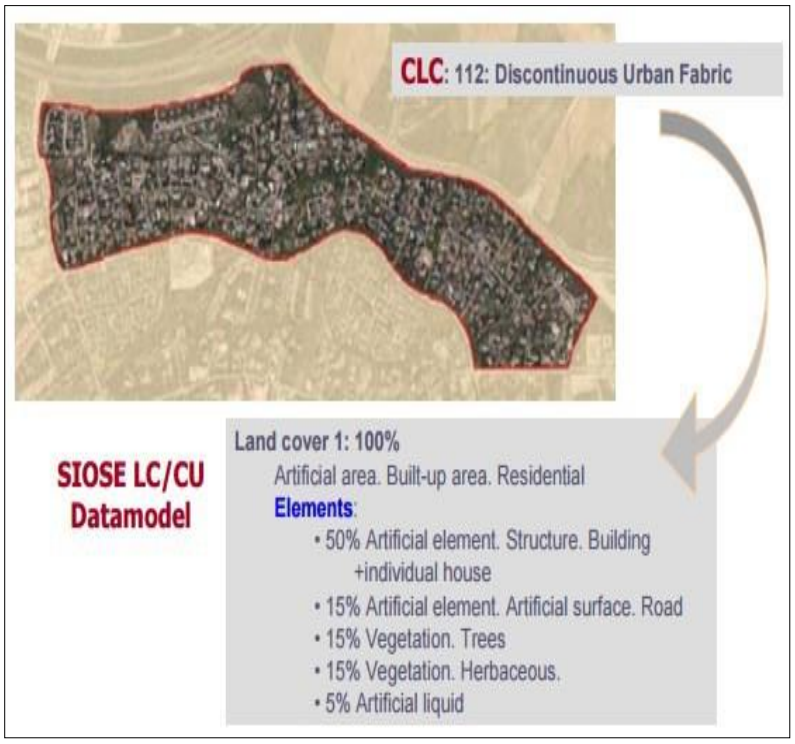


Fig 2.5 Example of classification approach of the SIOSE system

2.2.3.1 The EAGLE group

The landscape description concept has been further developed by a collaborative group of landcover mapping experts across Europe known as EAGLE (EIONET Action Group on Land monitoring in Europe) http://land.copernicus.eu/eagle/documentation-and-tools . EAGLE has been tasked by the EEA to develop a means by which bottom-up national mapping systems can be translated into a homogenous European landcover system such as CORINE. They produced a translation matrix which uses the landscape description system to list all identified types of landcover, landuse and environmental characteristics. A national system can be entered into the matrix (see Fig 2.6) via a scoring mechanism using the parameters listed below. A barcode-type scoring algorithm then computes the equivalent CORINE class for each national landcover category entered.

x= landscape element must not occur in this class
0= landscape element is insignificant in this class
1= landscape element is expected in this class but is not defining.
2= landscape element is a defining and obligatory element of this class and must be present

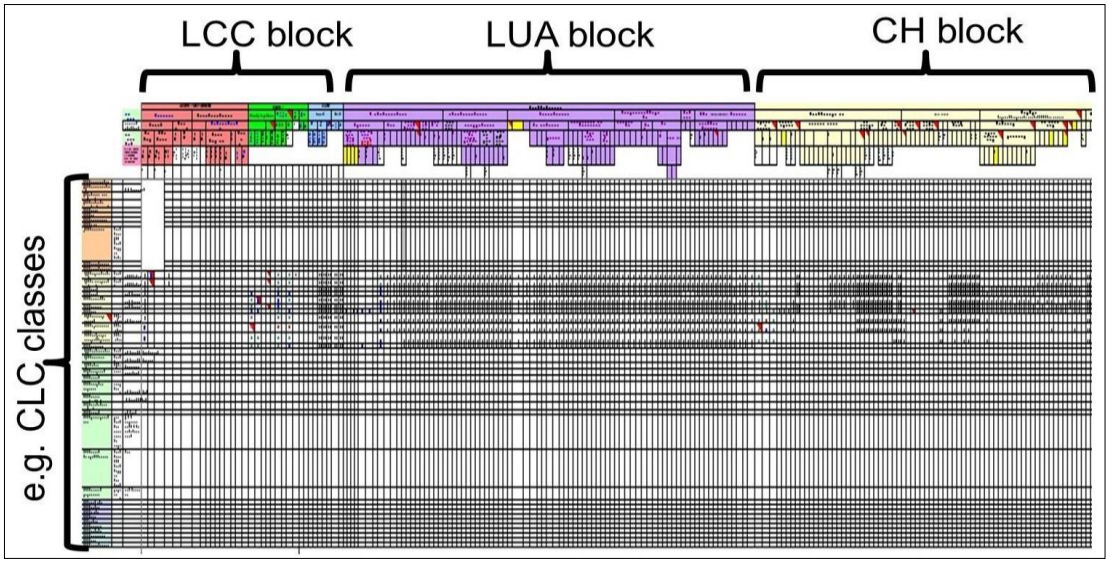


Fig 2.6 EAGLE classification translation matrix tool

The EAGLE model can also be used as a template to aid the design of new national systems and can be easily extended to include additional nationally specific landscape elements. Fig 2.7 shows a generalised version of the classification data model which separates landcover into Abiotic, Biotic and Water components with additional attribution of Landuse and environmental characteristics. No country has yet to adopt EAGLE on a national level although there are ongoing trials on regional test areas in Europe. In parallel with the EAGLE group a FP7 funded project called HELM (Harmonised European Land Monitoring), (Ben-Asher, Z. (ed.), 2013) brought together recognised national experts in Europe, including EAGLE participants to look at how land monitoring systems in Europe can be better co-ordinated. The project published a handbook on the best way towards a common European land monitoring system which recommends the adoption of the EAGLE land monitoring approach http://www.umweltbundesamt.at/fileadmin/site/en/pdf/HELM_Book_2nd_Edition.pdf

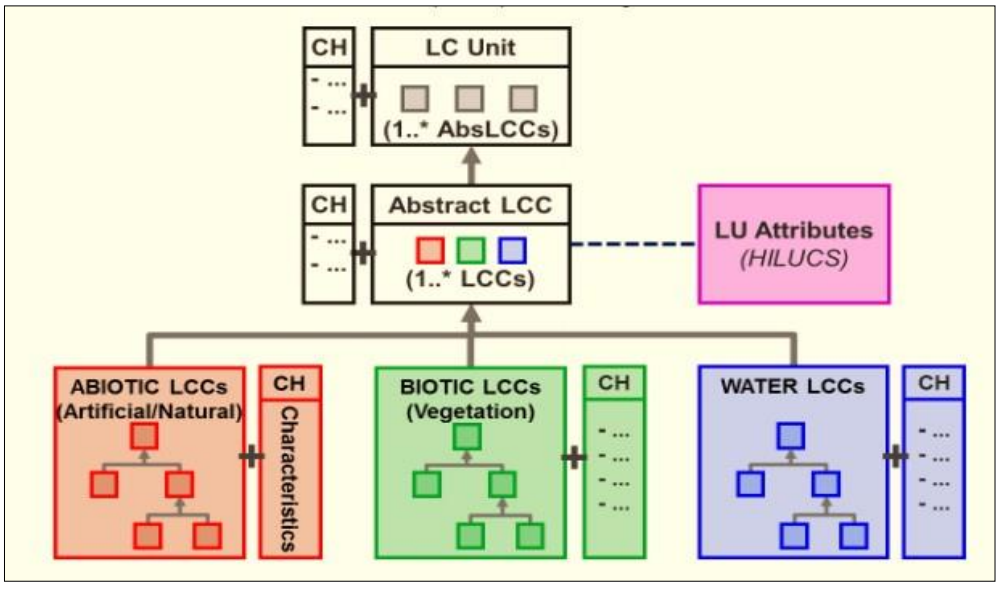


Fig 2.7 Generalised EAGLE classification model

2.2.3.2 Applying the EAGLE landscape description system on a national level

There are two core reasons why the level of detail obtained in the EAGLE landscape description system is now achievable on a national level for European countries. i) Most European countries now have national high resolution cadastral or topographic spatial databases such as OSi's PRIME2 database. These map unique elements of the landscape such as buildings, road networks and field parcels. This removes the problem of mixed classes and enables precise description of land features. ii) Recent advances in data management systems (e.g. data modelling, integration and storage capabilities), coupled with improved data access & sharing practises nationally means that the possibilities in terms of data attribution is vastly increased. It is now possible to add multiple types and levels of attribution and applied to a land monitoring system. With intelligent data modelling, countries can now design systems which can hold separate landcover and landuse information aswell as a potentially infinite amount of additional environmental attributes such as habitat type, climatic information, secondary landuse, population information, forestry planting dates, etc. This data can link back to metadata and working datasets on production databases where processing, updating and validation occurs.

2.3 Proposed revised Fossitt Landcover level

During the Roscommon pilot project in 2012, it was first proposed that instead of designing a brand new national landcover schema, a new landcover level could be integrated within the Fossitt 2000 Habitat classification schema (Fossitt, 2000), replacing the existing level 2 with a new landcover level, 'Level 2B' (Lydon, 2013), see fig 2.8.

The Fossitt schema is widely recognised and used for habitat mapping in Ireland, serving as the de-facto national habitat classification system since its release in 2000. Fossitt is a three-level hierarchal system, with the central level 2 roughly equivalent to what we know as a landcover description level, that being the 'observed bio-physical properties of the earth's surface' (Di Gregorio, 2000). It is more detailed than the general groupings of level 1 but without he needs for detailed descriptions of individual vegetation species at level 3.

Draft Landcover classification levels 1 & 2			
Level 1		Level 2	
F	Freshwater	FL	Freshwater lakes
		FR	Reservoirs & artificial water bodies
		FW	Freshwater courses
		FS	Freshwater swamp
G	Grassland and Marsh	GI	Improved grassland
		GS	Semi-improved grassland
		GN	Semi-natural grassland
		GM	Marsh
H	Heath and dense bracken	HH	Heath
		HD	Dense bracken
P	Peatlands	PR	Raised bog
		PB	Blanket bog
		PD	Degraded and cutover bog
		PF	Fens and flushes
W	Woodland and scrub	WB	Broadleaved forest
		WC	Coniferous forest
		WM	Mixed forest
		WT	Clearfelled and transitional coniferous forest
		WS	Scrub
E	Exposed rock and disturbed ground	ER	Exposed rock
		EG	Exposed sand, gravel or till
		ES	Bare soil and disturbed ground
		EQ	Open quarries and mines
		EC	Refuse and civic amenity facilities
B	Cultivated and built land	BA	Arable land
		BH	Horticulture and flower beds
		BL	Buildings
		BS	Open sealed surfaces
		BG	Urban and amenity grass areas
		BI	Roads, ways and other infrastructure
C	Coastland	CS	Sea cliffs and islets
		CW	Inter-tidal water bodies
		CM	Salt marshes
		CB	Shingle and gravel
		CD	Sand dune systems
L	Littoral	LR	Intertidal rocky shores
		LG	Shingle and gravel shores
		LS	Sandy shores
		LM	Muddy shores
		LX	Mixed sediment shores
S	Sublittoral (subtidal)	MW	Marine water body
M	Marine water body		

Fig 2.8 Draft revised Fossitt level 2 with existing level 1

The basic concept of the revised level 2B was to take the existing level 2 and adjust it to allow for mapping using remote sensing of satellite imagery. This approach is similar to the approach adopted by the UK in developing their LCM classification system in 2000 (see section 2). This 'pure landcover approach' will give an unbiased description of the bio-physical surface cover, catering for the maximum amount of user group needs. If required, this can be then brought forward into a landscape description approach, where the landcover level is the core level of detail and additional tables can be brought in to give additional information on landuse and environmental characteristics.

2.4 Conclusions

The production methods, technical specifications and classification systems associated with landcover and landuse programmes has been constantly developing since the late 1980's, driven primarily by technological developments in the general and spatial IT sectors. A wide range of production models were trialled by various different European countries throughout the 90's and 2000's. There has been much development and conceptual activity in land monitoring in Europe in the last 5 - 6 years, with several collaborative projects and forums such as EAGLE as HELM been established, undertaking important work in developing standards, data models and a roadmap for a more modern and harmonised approach to land monitoring in Europe. There has however, been no new national land monitoring system developed or dataset produced in any country in Europe in the last 6 years with the fourth release of CORINE- CORINE2012 – and the associated Copernicus High Resolution Layers being the most significant addition to the landcover data in European in this period.

National and pan-European- scale Landcover classification and mapping appears then to be currently in a state of transition in Europe and potentially on the cusp of a major paradigm shift (Arnold et al. 2015). The high spatial resolution offered by national spatial databases, vastly improved increased data access and advances in interpretation capabilities have all combined to expand the potential information which can be provided and hosted by national land monitoring systems. The landscape description system which is being promoted by EAGLE, HELM and the EEA, seems to be best placed to fully utilise these new capabilities.

It is not yet clear to what degree the EAGLE landscape description concept will be adopted across Europe or if countries will continue to primarily use combined landcover / landuse systems. It is likely that countries will at least attempt to use EAGLE to translate bottom-up national systems into the pan-European CORINE system for its next release in 2018. In order to do this though, a country would need a contemporaneous national dataset.

For countries, like Ireland, who are looking to develop wholly new land monitoring system, the template offered by EAGLE is worth strong consideration, given that much research has already gone into this approach and it is being endorsed by the EEA and land monitoring experts from the more progressive land monitoring European countries. It offers a way to take full advantage of the high spatial resolution of OSi's PRIME2 database which will form the spatial framework of any Irish national dataset. It also allows the facility to fulfil multiple user requirements and needs by giving information on various different aspects of the landscape through the landscape description approach. A core, pure landcover level could provide the national standard landcover dataset which is strongly needed by all user groups, whilst additional landuse and environmental characteristics could give more detailed added information to topic-specific user groups.

3. Stakeholder Survey

It was decided that the best method of stakeholder interaction would be a wide-ranging online survey. In most cases there is no recognised, authoritative expert or group in most of the thematic landcover topic areas, making it difficult to get definitive advice on any one landcover thematic field. Opinion on classification systems is also very subjective with various potential approaches possible and people invariably are biased towards maximising the balance of detail towards their particular field of interest. In order to get a balanced view of the schema a large user-interaction base was required so that overall trends in the responses would overrule interest-specific subjectivity. The web-based survey option was seen as the ideal approach to achieve this. It was also anticipated that an online survey would have a higher user-uptake than the alternate option of hosting a one day seminar and inviting interested parties to attend.

The Survey Monkey (https://www.surveymonkey.com) platform was used as it is well recognised and it has useful tools and functionality to present a survey in an easy to follow format.

3.1 Survey design and circulation

Designing the survey was complicated as we wanted to primarily get focused feedback on the proposed classification system but at the same time use it as a scoping exercise to enable responders to make suggestions for additional or alternative information that they may think of themselves without prompting. Where possible we anticipated alternative options which users may wish to see and asked them directly if they required such information. This and the use of free comment boxes throughout the survey gave responders ample opportunity to offer any alternative ideas, suggestions, etc. that they may think of themselves outside of any question we asked directly.

The survey starts by laying out the background context to the survey, the current stage of work that the NLCHM working group is at and how the answers to the survey will feed back into this work. It then outlines the classification approach, i.e. how it will be a landcover/habitats based schema feeding compatible with the existing Fossitt system and it then shows the current draft of the schema. The first ten questions are general questions regarding the suggested approach and try to gather initial feedback on this aswell as extracting information from the user on their work area, their preferences for landcover, habitat and landuse data and how they will potentially use a national landcover dataset. The survey then moves onto theme-specific question pages, with a page each covering the different landcover surface types, e.g. artificial, grassland, water, forestry, etc. These thematic question pages are designed to extract detailed feedback from expert users in the respective fields. At the start of the survey participants are encouraged to answer the general question page and then whichever thematic page which is relevant to their work/area of interest.

The survey was circulated through several channels in order to optimise the maximum response rate. The main channel for responses was the CORINE dataseries user register which is log of users who have downloaded the different releases of the CORINE dataseries since 2000. The register is maintained by the EPA who is responsible for disseminating the data. Any person who downloaded either the 2006 or 2012 CORINE dataset was put on a mailing list and sent an invitation to complete the survey. There were a total of 1,361 names in this list for which 83 people completed the survey. This provided a large proportion of the total responses for the survey and included a wide variety of user types including academic, professionals, etc. Apart from this the survey was publicised via social media, initially through the main EPA Ireland twitter account (@EPAIreland) which has over 6,000 followers. This was then retweeted 39 times by IRLOGI, NPWS, NBDC and other well know environmental profiles within Ireland Any person who was known to be a prominent landcover,

landuse or data user who was not reached by the above avenues was personally contacted by the survey team and invited to participate. People who took part in the Use-case analysis study were also contacted and invited to participate.

3.2 Survey responses and results

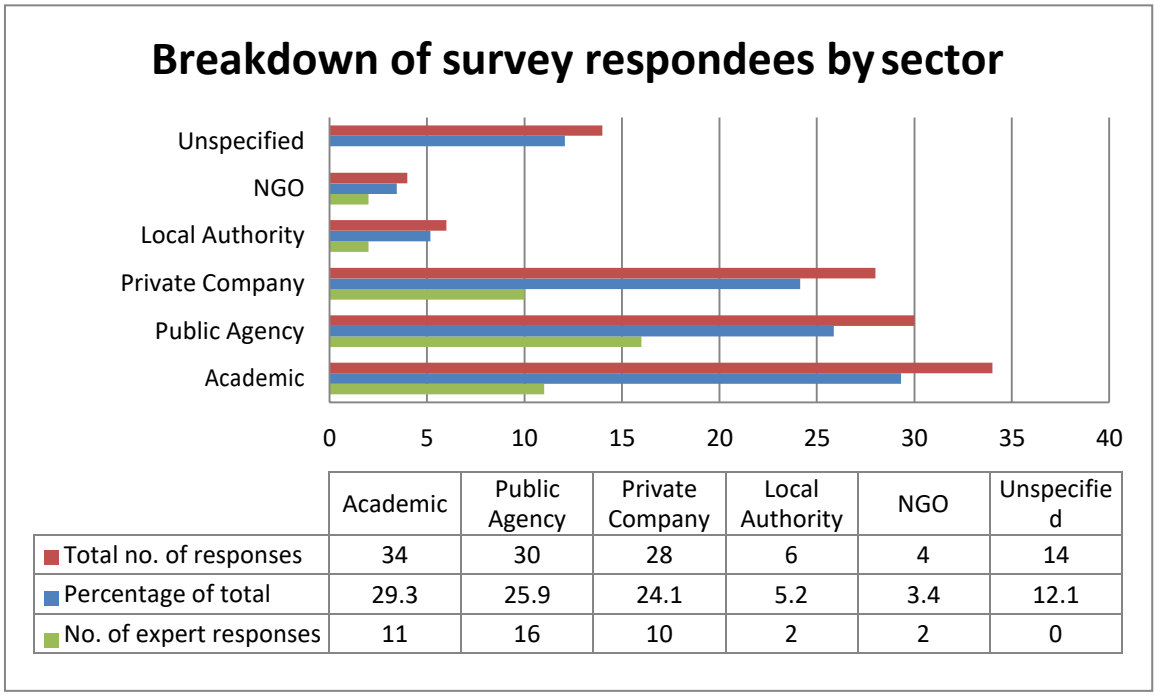
3.2.1 Breakdown of Responders

There were 160 individual responses with a number of these deemed to be ineligible due to the failure of the responder to complete the first section of the survey. There were then 116 eligible responses at the end of the survey. The responders were categorised into the following user groups:

Survey response user groups:

1. **Public agencies**
   - EPA
   - NPWS
   - GSI
   - Teagasc
   - CSO
   - Forest Service
   - DAFM
   - Irish Water
   - Marine Institute
   - NBDC
   - SFPA
   - ESRI
2. **Academic**
   - DIT
   - UCD
   - UCC
   - NUIG
   - TCD
   - Sligo IT
   - University of Leeds
   - SEMRU, NUIG
   - CIIMAR
   - Mary Immaculate College
   - All Ireland Research Observatory (TCD)
   - UCD Soil Science
   - CERIS ITSligo
   - MaREI Centre – UCC
   - Independent researchers
   - University of Nis, Serbia
3. **Private companies**
   - RPS Group Ltd.
   - BEC Consultants
   - JBA Consulting
   - Compass Informatics Ltd.
   - Atkins
   - Arup
   - McCarthy Keville O Sullivan
   - Mallon Technology
   - Ted Walsh & Associates ltd
   - ADAS
   - Curtin
   - BEC Consultants Ltd
   - EcoAnalysis
   - Envo-Geo Environmental Geoinformatics
   - Ecology Ireland Ltd.
   - FERS
   - Bluesky International
   - Tony BAMFORD planning
   - Gaelectric Development Ltd
   - Mapsphere
   - Malone O'Regan
   - Self Employed
4. **Local Authorities**
   - Sligo County Council
   - Cork County Council
   - Galway County Council
   - Kerry County Council
   - Tipperary county council
   - Westmeath County Council
   - Eastern & Midlands Regional Assembly
   - Waterford City and County Council
5. **NGO's**
   - BirdWatch Ireland
   - Irish Peatland Conservation Council
   - Bat Conservation Ireland
   - Wildlife Conservation Society
   - Friends of Merlin Woods
6. **Unspecified** – *No details given*

The three largest sectors, in order are Academic, Public agencies and private companies with 34, 30 and 28 people responding from each sector respectively. Local authority responders were separated out from public agencies as they are seen as a distinct sub-group within that sector, six people responded from different LA's across the country. Five staff from NGO's responded and these were all from interest-specific ecological charity groups. Fourteen people who responded did not give any details regarding their work / organisation. It was decided to make a category for 'expert users' from all the above categories, this will enable us to isolate response patterns from these users from more general non-expert users. It will also provide a targeted list of expert users for future outreach purposes. In total, 41 responders were nominated as being experts, the breakdown of these in relation to the work sector categories can be seen in table 3.1.



	Academic	Public Agency	Private Company	Local Authority	NGO	Unspecified
Total no. of responses	34	30	28	6	4	14
Percentage of total	29.3	25.9	24.1	5.2	3.4	12.1
No. of expert responses	11	16	10	2	2	0

Table 3.1 Breakdown of survey responders by work sector and expert opinion

3.3 Section 1 – General questions

This section dealt with ten general questions, designed to firstly ascertain who the responder is, their level of knowledge of landcover, habitat and landuse data and their requirements for same.

Question 1

The first question asked 'How is Landcover, Landuse or Habitat data relevant for your work?' The answers shown in chart 1 below show that 83% of people identified themselves as Landover users, 70% of people identified themselves as Habitat data users and 68% of people identified themselves as Landuse data users. A high percentage of people identified themselves as a user of

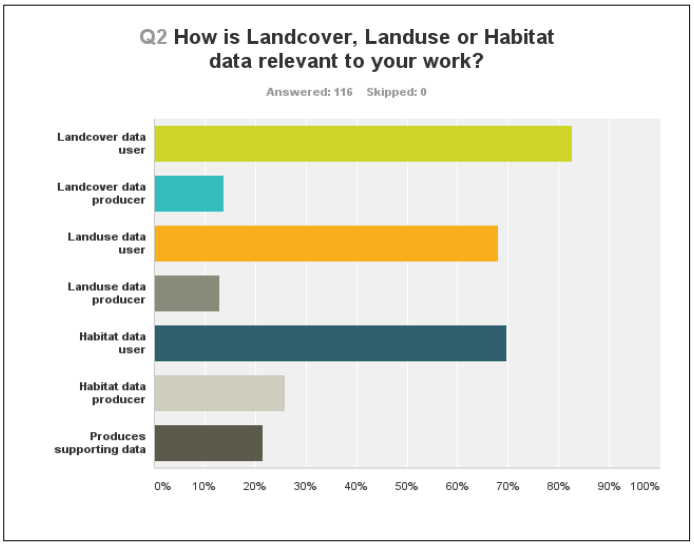


Chart 3.2. Chart showing breakdown of answers to question 1

all three data types. When looking at responders who said that they were a data producer, the highest response came from habitat producers at 25.9% with Landover and landuse data producers coming in at 13.8% and 12.95% respectively.

Question 3 Question three detailed the methodological approach of the system, i.e. using PRIME2 as the base spatial unit and populating this with a landcover classification which is based on a revised level 2 of the existing Fossitt system. Responders were then asked if they broadly approve of this approach in principle

Answer Choices	Responses	
i agree with the approach outlined	69.91%	79
I agree but entire Fossitt system needs to be revised	9.73%	11
Would prefer to see a new stand alone Landcover schema, with look-up tables to convert to/from Fossitt and other systems.	13.27%	15
Would prefer if landuse was fully incorporated into the schema and not attributed seperatley	5.31%	6
No opinion	6.19%	7
Total Respondents: 113		

Table 3.1. Answers to Question 3 - 'Do you agree with the approach outlined?'

The proposed approach received a strong level of support from responders with 69.9% of people agreeing that it is the correct approach to take. However, that leaves 30% of responders who think otherwise. This includes 13% who would favour a standalone system to Fossitt and a further 9.3% who agree but feel Fossitt as a whole needs to be revised. This is a combined 23% of responders who are not satisfied with the currently proposed Fossitt-based approach.

In the comments section of this question, respondents who agreed with the approach mainly did so as they saw the benefit in maintaining the status quo of the existing accepted habitat system (Fossitt) and were cautious in undoing the benefit Fossitt has brought by harmonising habitat mapping in Ireland since its introduction. Several comments however suggested that there is definite need for improvement of the Fossitt system, particularly in the area of grassland and forestry classification. Alternative suggestions for existing system on which to base the new Landover level are the EUNIS, JNCC and Annex 1 systems. Direct criticism of the new Landover level included the removal of the natural element of forestry and the linear woodland category which represents hedgerows. Strong welcome was given to the inclusion of a semi-natural grassland class which is not currently included in Fossitt. These issues will be addressed in more detail later in the report.

Question 4 When asked about the level of classification detail they need, the need for each system listed in table 3.2 was comparatively similar. The need for information on Annex 1 habitats scored the highest at 61.76%, over 10% higher than the existing Fossitt level 3 at 50.51%. The proposed landcover level scored 60.19% over 11% higher than the expressed need for CORINE which is the current de-facto national landcover dataset.

	Strong need for data at this detail level	Useful to have but not essential	No need for data at this detail level	Total
Annex 1 habitats	61.76% 63	35.29% 36	2.94% 3	102
Fossitt Level 3	50.51% 50	45.45% 45	4.04% 4	99
Proposed Landcover level	60.19% 62	36.89% 38	2.91% 3	103
Fossitt Level 1	40.86% 38	50.54% 47	8.60% 8	93
CORINE	58.65% 61	35.58% 37	5.77% 6	104

Table 3.2 Table showing the answers to question 4 – 'What is your need to have Information at the following levels of detail?'

Question 5 deals with the issue of landuse data specifically and the users need to have landuse information attribute to the Prime2 object aswell as the proposed landcover classification. Landuse was dealt with separately in this way as it is being dealt with separately to both landcover and habitats in the classification. The results show a strong desire amongst respondents for attribution of landuse information with 62% of people saying they have a definite need and a further 35% saying that it would be useful information to have. Only 3% of users explicitly said that they had no need for landuse information.

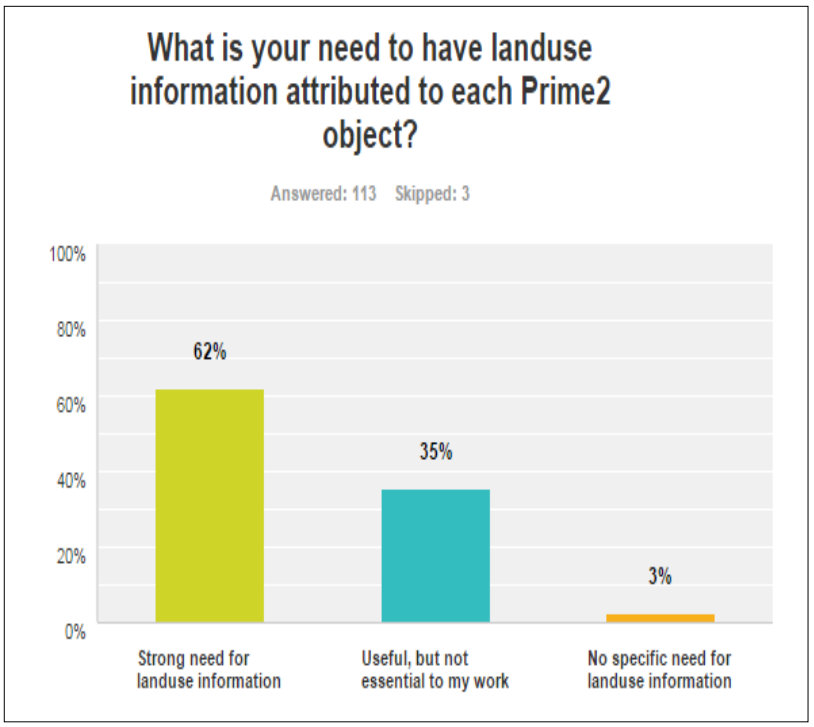


Chart 3.3. Responses to Question 5

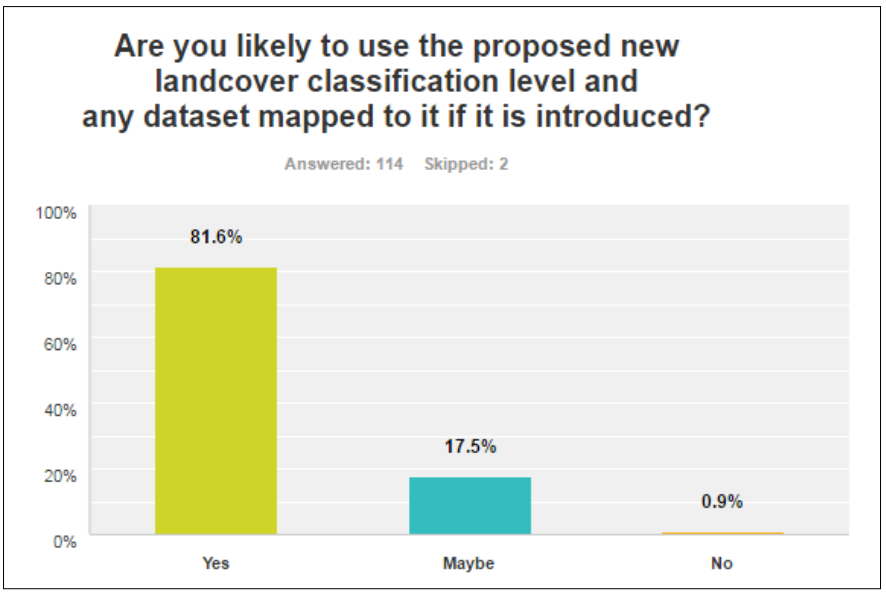


Chart 3.4 Percentage breakdown of responses to question 6

Question 6 asked the question 'Are you likely to use the proposed new landcover classification level and any dataset mapped to it if it is introduced?' to which over 81% of responders said they would which 17.55% saying they maybe would. Only one person (<1%) said that they wouldn't.

Question 7 then asks responders for details on how they would use the proposed dataset. Responses were given in open comment form and ninety responses were given in total. Although there was a certain degree of overlap in some responses up to fifty unique uses were given for the proposed datasets. These potential uses are listed overleaf on page 19.

Potential uses of proposes dataset as given by survey respondents in Q 7.

Policy, Reporting & Planning

1) Annual reporting of GHG emissions under UNFCCC and Kyoto Protocol.
2) Part of baseline dataset for the Regional Economic and Spatial Strategy.
3) EU reporting under Articles 12 & 17.
4) Informing policy related to ecosystem services.
5) European marine habitat reporting - Marine Strategy Framework Directive, OSPAR, Maritime Spatial Planning Directive, Water Framework Directive, Shellfish Waters Directive.
6) Assessment of distribution and change in areas of High Nature Value farmland (required under CAP reporting).
7) Design, targeting, implementation and monitoring of agri-environment schemes (national & local).
8) Local Authority planning and development, including City and County Development plans.
9) Advice on sustainable development and management of the forest sector.
10) For reporting to Eurostat and for the development of ecosystem accounts.
11) Reporting on planning applications, planning enforcement cases.
12) Land use planning, route/site selection, sensitivity mapping.
13) Reviewing development & conservation plans for peatlands.

Monitoring and assessment

14) Strategic Environmental Assessment (SEA), Environmental Impact Assessment (EIA) & Appropriate Assessment (AA) for planning applications, waste permit applications and local area planning.
15) Ecological surveys - including habitat and bird surveys.
16) Environment constraints mapping.
17) Mapping, Assessment & Valuation of Ecosystems Services.
18) WFD assessment including Catchment characterisation
19) Route/site selection for infrastructure projects
20) Evaluation of Agricultural Diffuse Pollution.
21) Mapping invasive species – e.g. bracken encroachment
22) Habitat assessment of proposed afforestation applications
23) Coastal zone management.
24) Forestry related hydrological assessment e.g. contaminant transport.
25) Environmental sensitivity mapping and environmental assessment in support of land use planning and biodiversity conservation.
26) Assessing groundwater zones of contributions.
27) Biomass production and burnt areas dynamics assessment.
28) Archaeological landscape studies, including the impact of landscape change on archaeological monuments.
29) Hydrological assessment for contaminant transport.
30) Spatial constraints studies for large linear projects.
31) Heritage statistics and identification of sites of ecological importance
32) Preparation of baseline ecological surveys & habitat maps.
33) Assessing landcover change within WFD catchments.
34) Urban green space, ecosystem services, urban biodiversity.
35) Hedgerow Surveys / Appraisal
36) Mapping land use in relation to soil attributes.
37) Preliminary site assessment
38) Indicator of urban soil bodies.
39) To aid planning for field mapping campaigns.

Education and research

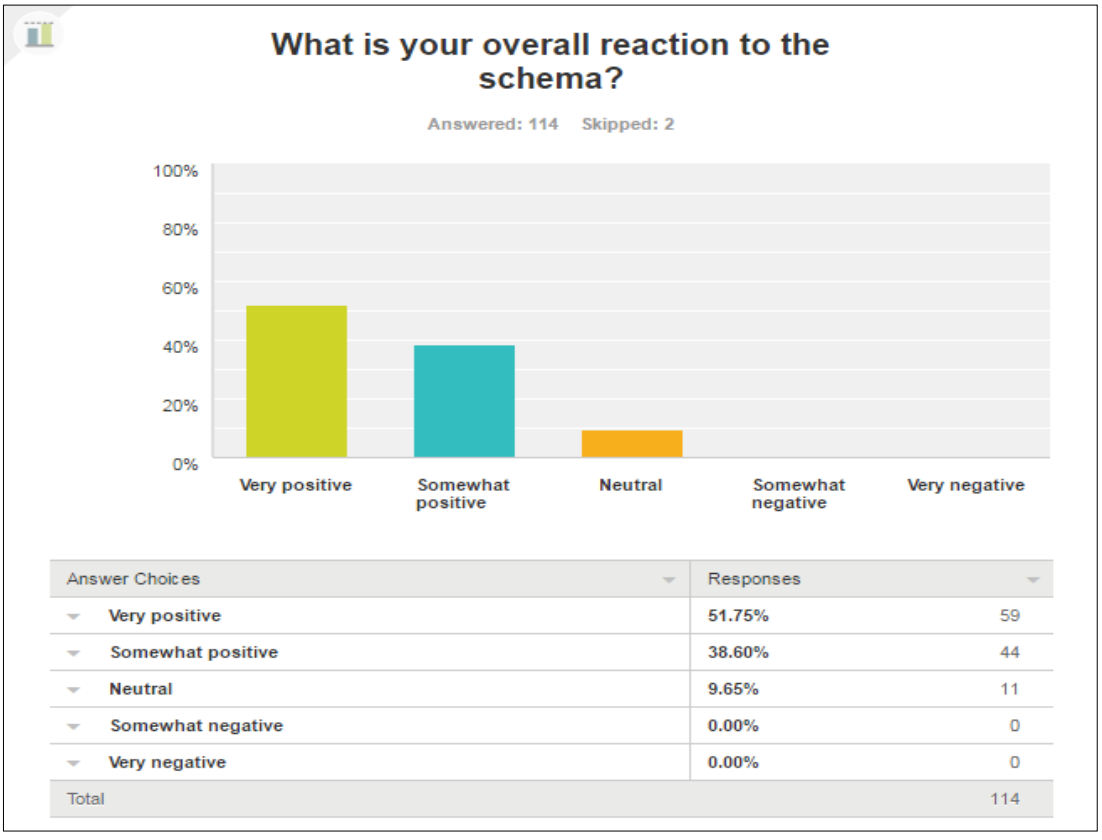
40) Research supporting biodiversity measures in Ireland.
41) Ecological surveys for both habitats and species.
42) Analysis of bat occurrence & modelling impacts of climate change on bats.
43) Remote sensing validation
44) Spatial stratification strategies for biological monitoring.
45) Habitat fragmentation analysis
46) Assessment of bird and habitat / landcover relationships.
47) To help create a floral resource heat-map of Ireland for pollinators.
48) Research in relation to low intensity agricultural systems.
49) Research into land-water interactions for lakes.
50) Web Mapping and Public dissemination of data.

Question 8:

Twenty five people responded to the question *"If you are not likely to use the proposed landcover level 2 and associated dataset, why not?"* The breakdown of those 25 responses is given in table 4 below. Eight people had some dissatisfaction with the proposed system, six people were satisfied with currently available systems and four people said they did not use landcover data in their work.

Answer Choices		Responses	
I do not use Landcover data in my work		16.00%	4
Satisfied with classification schemas and datasets currently available		24.00%	6
Does not include key categories which are relevant to my work		32.00%	8
I disagree with the design of the proposed schema		8.00%	2
Other (please specify)	Responses	24.00%	6
Total Respondents: 25			

Table 3.3: Breakdown of responses to Q8 - If you are not likely to use the proposed landcover Level 2 and associated dataset, why not?



Answer Choices	Responses	
Very positive	51.75%	59
Somewhat positive	38.60%	44
Neutral	9.65%	11
Somewhat negative	0.00%	0
Very negative	0.00%	0
Total		114

Chart 3.5: Answers to question 9 what is your overall reaction to the schema?

Question 9. Over 90% of respondents had an overall positive response to the proposed schema with 9.65% of people having a neutral response.

Summary of general section (Q1-Q9) responses:

The survey was successful in attracting a good response rate from a wide and varied user base. One hundred and sixteen valid responses were received from sixty three public agencies, companies, academic institutions, NGOs and private individuals. The three main sectors in this area are public agencies and local authorities, academic institutions and private companies which combined to supply 84.5% of the responses to the survey. An initial success of the survey is to identify and record this user base which to date has been only loosely identified.

The responders gave a favourable response to the proposed Fossitt-based classification schema with just under 70% of responders agreeing with the proposed system. A minority of responders said that they would prefer to see wither a stand-alone system separate to Fossitt (13.3%) or that they would like to see the Fossitt system as a whole revised (9.7%). There were several additional comments on this question saying that if Fossitt is to be used then it needs to be refined in certain areas. In total 81.6% of responders said that they would use the system if it was introduced and when asked about what they would use it for over fifty unique applications and users of the data were given (see pg. 18).

A strong need was shown to have attribution of landuse information attached to the dataset with 65% of responders saying that they have a definite need for this and a further 35% saying that it would be useful. There was also a strong need shown for further information on additional environmental characteristics and conditions specific to individual landcover types. Overall the user-base showed a strong understanding and knowledge of the issues and concepts of landcover, habitat and landuse mapping and its application in an Irish context. They demonstrated a large appetite for detailed data in this area and intend to use this data if made available.

3.4 Section 2 - Thematic based questions

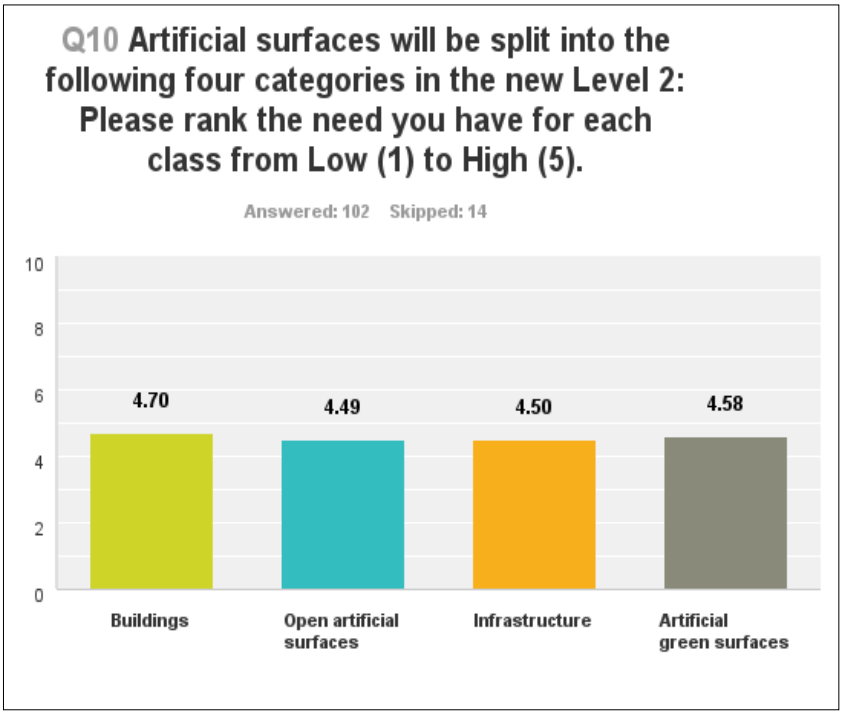


Chart 3.6. Answers to question 10

3.4.1 Artificial areas

The four proposed artificial landcover classes (Buildings, Open sealed surfaces, Infrastructure and Artificial green surfaces) were presented and respondents were asked to score their need for each of the four classes out of five.

All four classes received an average score of 4.49 or more out of 5. Respondents were invited to suggest alternative or additional classes or naming conventions to use in the comments section (see below).

Question 11 asked if users would like to see artificial areas grouped into areas of high, medium or low artificial density, similar to what **is** currently done in CORINE. 55.05% of respondents said they would welcome this information, with comments showing that they would not prefer it at the expense of spatial resolution. Some comments noted that this information would be very useful for analysing development patterns over time, in particular in rural areas.

Question 12 then asked if respondents would like to see building to be categorised by their usage, i.e. Residential, Commercial and Industrial. 72.07% of responders replied that they would like to see this information, potentially as an added landuse attribute. It was suggested that the GeoDirectory could possibly be used to aid attribution.

Question 13 was an open comment section, asking respondents if there was any other aspect of the artificial and urban landscape which they would like to see mapped. Comments / suggestions included:

- Construction sites
- Industrial land
- Separate artificial green surfaces from natural green spaces and synthetic surfaces
- Green infrastructure, cycle paths etc.
- Permeability
- Ruined / historic buildings
- Cultural / heritage information
- Wildlife corridors
- Refuse and/or 'Spoil' from mining, dredging and similar activities.
- Include historical landuse
- Categorise Infrastructure (e.g. road class)
- Waste land / brownfield sites
- Derelict sites and open spaces
- Sports and recreation facilities
- Urban trees

Artificial areas –Summary

Responders were generally satisfied with the four proposed artificial landcover categories but they were a number of requests for additional classes and information. There was a strong demand for Landuse information for buildings in terms of them being residential, commercial, and industrial or amenity. The categorisation of infrastructure was also requested and there was some degree of confusion as to what would be classified as an 'open sealed surface' and an 'Artificial green surface' with a number of responders asking for clarification on what would be meant by the class 'Artificial green areas'. It was requested that a distinction be made between artificially planted vegetation, naturally occurring vegetation in an urban setting and artificial semi-sealed green surfaces such as synthetic sports fields. The omission of constructions sites was noted and this should be included either in the artificial or exposed surfaces group.

Artificial areas recommendations:

1. Four main proposed classes:
   - Buildings – Retain and categorise landuse type
   - Infrastructure – Retain and categorise infrastructure type
   - Open sealed surface – Change to '*Other sealed surfaces'* and attribute surface type.
   - Artificial green surfaces – Change to 'Urban and amenity green areas' and attribute type (Garden, park, playing field, etc.)

2. Incorporate additional class to cover:
   - Construction sites, brownfield/derelict sites and other un-vegetated, unsealed urban-based surfaces. E.g. 'Exposed urban land'. Use attribution to differentiate
   - Synthetic outdoor courts, tracks and playing fields.
   - Embankments

3. Supply information via attribution where possible:
   - Urban density
   - Sports and recreation facilities
   - Green infrastructure, cycle paths etc.
   - Embankments
   - Cultural / heritage information
   - Waste land, brownfield sites, derelict sites and unused open spaces
   - Urban trees

3.4.2 Water features

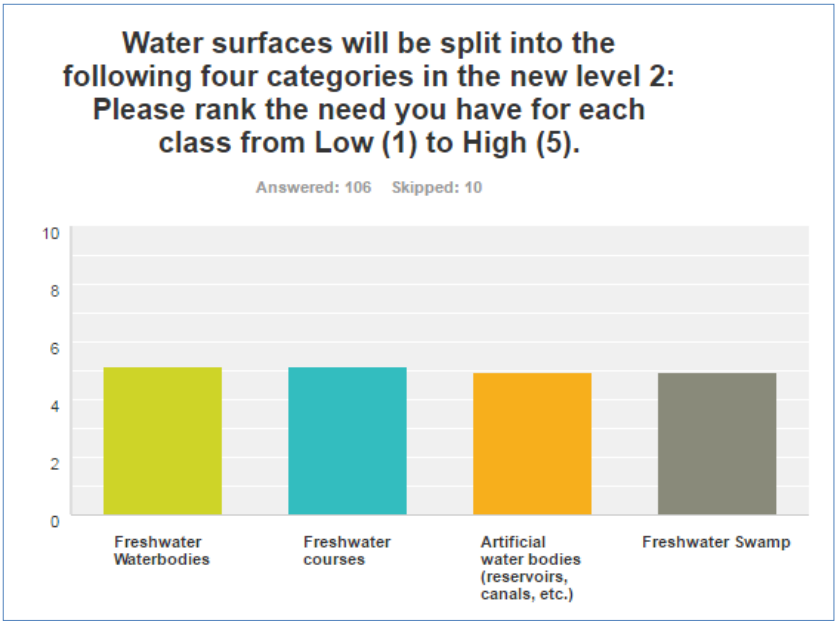


Chart 3.7 – Chart showing response to question 14

There was a high degree of need expressed for the four proposed water categories i) Freshwater waterbodies, ii) Freshwater courses, iii) Artificial water bodies and iv) Freshwater Swamp in question 14 with all classes scoring greater than 4.95 out of 5, as shown in chart 3.7.

There was significant request for further information, much of which was anticipated and covered in the following questions.

Differentiating between natural and artificial water features

In *Question 15* respondents showed a strong desire (71%) to have a distinction between artificial water courses such as canals and natural water courses such as rivers. A smaller desire to differentiate between artificial and natural water bodies was given with only 29% saying they require it and 49.5% saying that they have not requirement but it would be useful. In the comments section a strong desire to have drainage channels mapped and categorised on their own was shown.

Differentiating between large and smaller water features

There was a strong preference shown (82%) in *Question17* to differentiate between medium to large water courses such as rivers from smaller water courses such as streams and drainage channels. There was less demand to differentiate between large and small water bodies.

Question 20 asks the responders 'what is their need to have the 'Freshwater Swamp' class?' 33.3% responded that they have a definite need with a further 38.6% responding that tit would be useful. Several comments suggested that there should be a separate 'Freshwater Wetland' category with subcategories including swamp, marsh and fen.

Further requests were given in the comments sections of questions 14-21 for details on the following water feature types and components:

- Groundwater
- Temporary water bodies & courses
- Drainage channels and ditches
- Areas subject to flooding
- Transitional water bodies and courses
- Align to the WFD
- Align to JNCC instead
- Separate class for drainage channels

Water Features – Summary

Responses to the survey showed that people would like to see some additional information on water features than was provisionally proposed. The separation of artificial and natural water courses and the mapping of drainage channels was particularly requested. It was suggested that the category should be aligned to the categorisation implemented in the WFD. It was also suggested that the Freshwater swamp class should be included in a separate wetland category with other inland wetland types. The mapping of seasonal water bodies principally turloughs was requested and the inclusion of a class for groundwater-fed water bodies.

Water features - Recommendations:

1. Four main proposed classes:
   - Standing water bodies - Attribute as natural/man-made
   - Watercourses - Attribute as natural/man-made
   - Freshwater Swamp - Consider adding to new inland wetland category

2. Give consideration to mapping of drainage channels, ditches and embankments.

3. Give attribution information on:
   - Natural / artificial
   - Watercourse size/type – river, stream, channel
   - Groundwater-fed lakes
   - Temporary water bodies & courses (esp. turloughs)
   - Drainage channels and ditches
   - Areas subject to flooding
   - Transitional water bodies and courses

3.4.3 Grasslands and agricultural areas

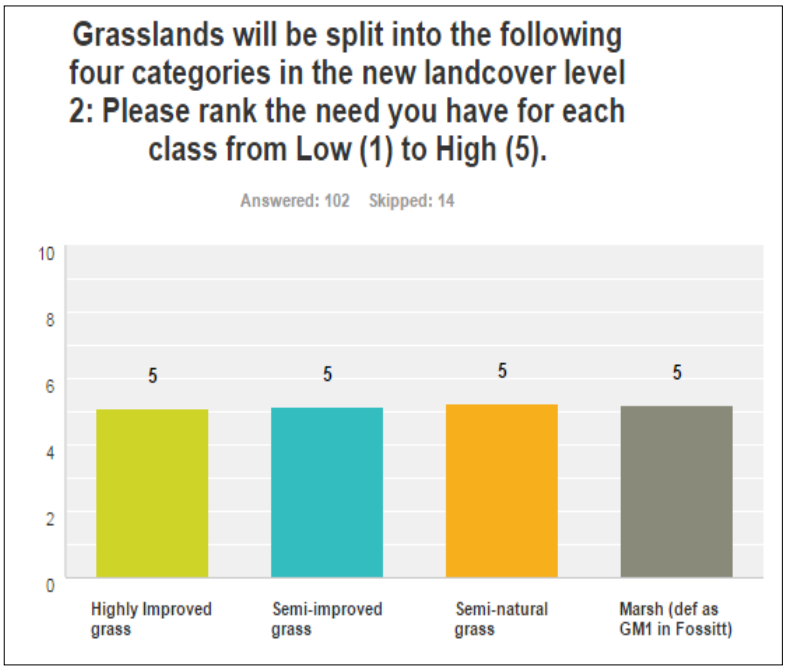


Chart 3.8: chart showing responses to question 22

There was a strong need expressed for all four proposed grassland categories, shown in chart 8. The comments section provided more insight into the needs of users with a numbers of experts suggesting that discerning between semi-improved and semi-natural grassland in particular may be difficult. It was suggested that we should only try to discern between these two if it can be done accurately and consistently. The intention to discern between these two was however widely welcomed.

There was also a strong desire from agricultural and ecological users to discern between wet and dry grasslands. Mapping of wet grasslands in particular was requested as much of Ireland's 'semi-improved' agricultural grass falls into the GS4 category (Wet grassland).

Question 23 was a scoping question, gauging the need of users to have additional, more detailed information on certain environmental characteristics of grasslands, as shown in chart 9. Again, when offered the choice of having additional information the majority of people responded that they would welcome the inclusion of such information. Information on drainage, biodiversity and stocking rates was particularly requested. The difficulty in obtaining and maintaining such detailed data was recognised by many responders.

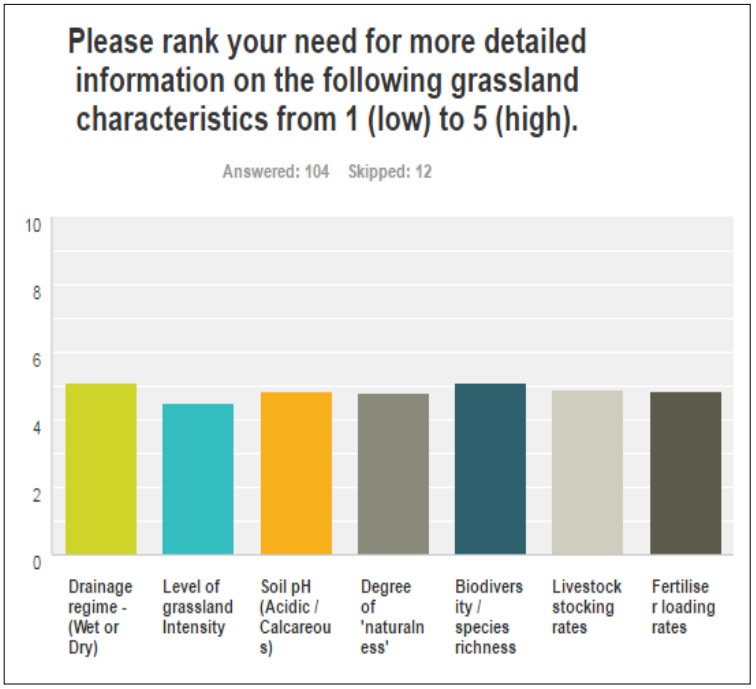


Chart 3.9 Chart showing responses to question 23

Questions 24 and 25 then focused on how field parcels will be mapped and attributed. Question 24 first asked users if they would prefer to only know the dominant grass type or if they would like to

know each grass type present over a certain area – a minimum mapping area would have to apply in this scenario. 42.11% responded that just knowing the dominant grass type is sufficient regardless of size and a further 23.16% stated that one dominant class up to a maximum threshold is sufficient, suggested thresholds were typically either 5ha or 10ha. As can be seen in table 5 below, over 65% of users would therefore be happy to know the dominant grass type in fields up to 5-10ha in size. Over this threshold, they would prefer more information. 34.74% of responders stated that they need to know all grass types present over a minimum threshold, typical minimum thresholds suggested were between 0.2 and 5ha. The survey provided an aerial image of various field parcel sized to guide the responders.

Answer Choices	Responses
One dominant class sufficient regardless of field size	42.11% 40
One dominant class sufficient up to maximum threshold (please give suggested threshold e.g. <10ha)	23.16% 22
Need to know all grass types present over a minimum threshold (please give suggested threshold e.g. > 1ha)	34.74% 33
Total	95

Table 3.4 answers to question 24: 'When classifying individual agricultural field parcels, would you be satisfied to know the single dominant grass type within that field, OR would you need to know of any other grass types if present?'

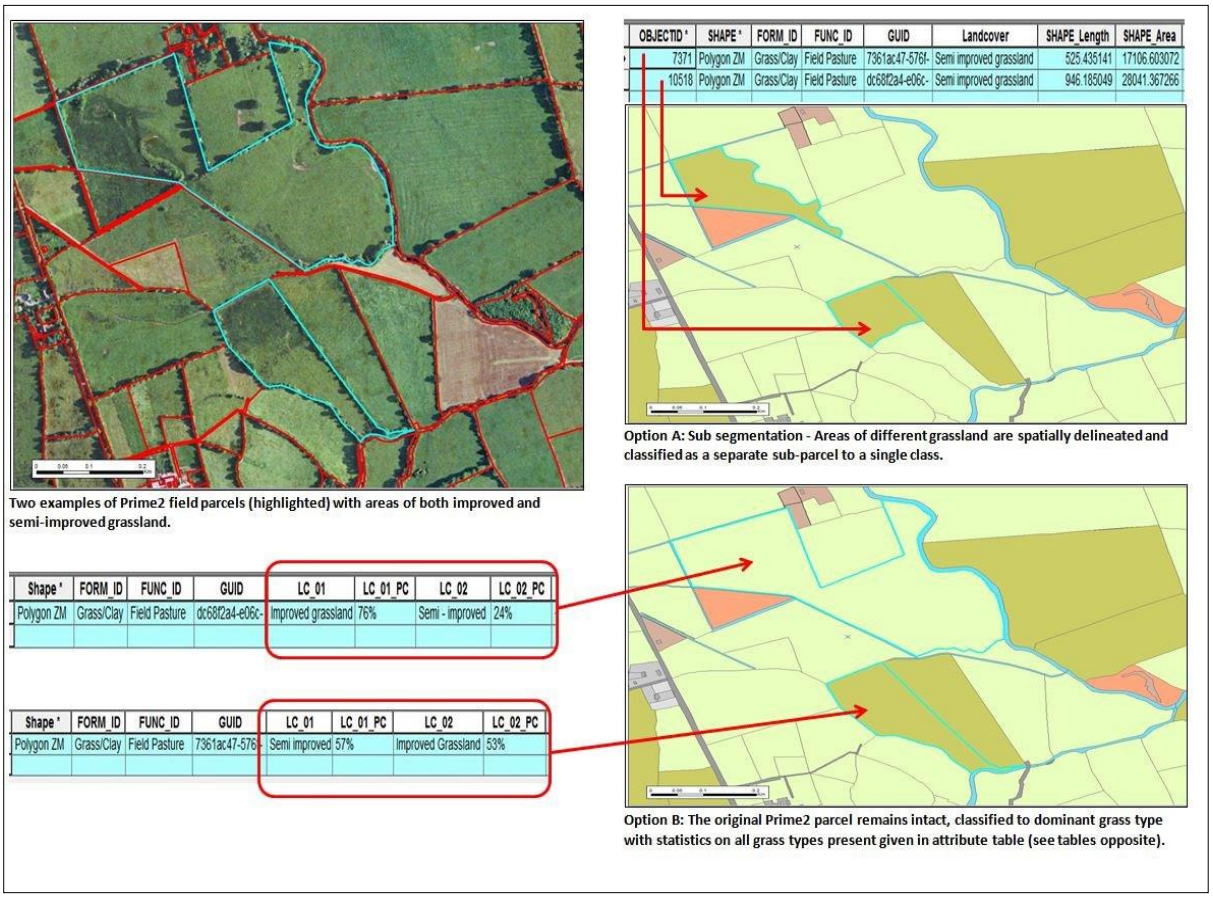
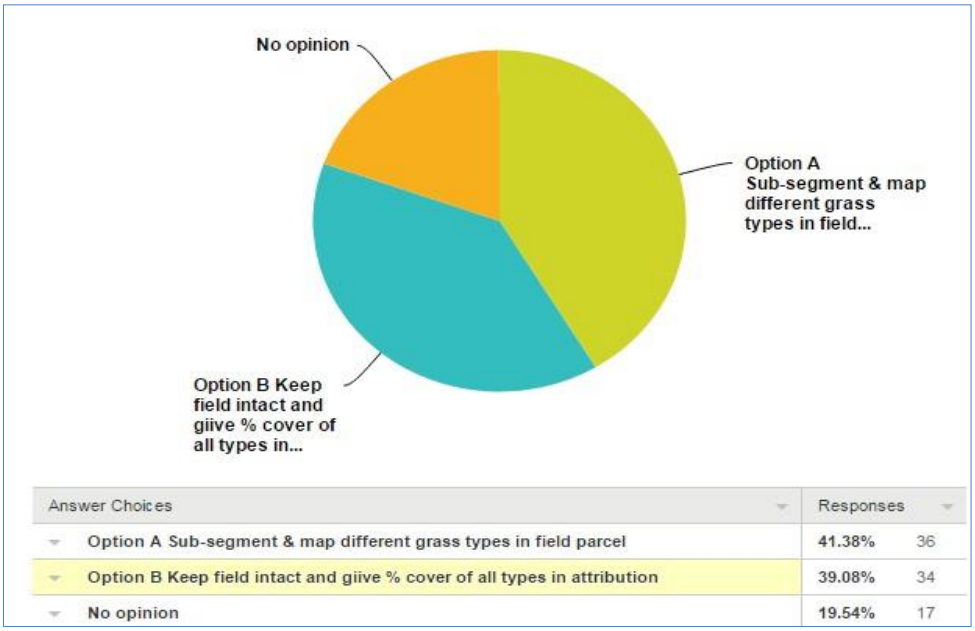


Figure 3.1: Example shown to users to demonstrate the two options (A&B) for field parcel classification

Question 25 offered two scenarios for spatially mapping and classifying fields with different grass types present within the field boundary (a common scenario in Ireland). Option A involves spatially sub-segmenting the field parcel and explicitly mapping and attributing each grass type present.

Option B involves keeping the field parcel intact as a single unit but listing the constituent grass types in the attribute in terms of the percentage cover. Figure 3.1 illustrates above both scenarios and chart 10 below shows the responses to the question. There was relatively similar opinion given for both option with 41.38% and 39.08% of people in favour of option A and B respectively. Either way there was support for the idea of incorporating information on additional grass types present within a single Prime2 field parcel.



Answer Choices	Responses	
Option A Sub-segment & map different grass types in field parcel	41.38%	36
Option B Keep field intact and giive % cover of all types in attribution	39.08%	34
No opinion	19.54%	17

Chart 3.10 responses to question 25 asking survey responders if they prefer to A) sub-segment field boundaries to each grass type or B) keep field boundary intact and list additional grass types in attribution

Questions 26 & 27 then focused on arable crops and horticultural areas. In question 26 a clear preference was shown to separate horticultural areas from horticultural areas with 82.86% of responses indicating this.

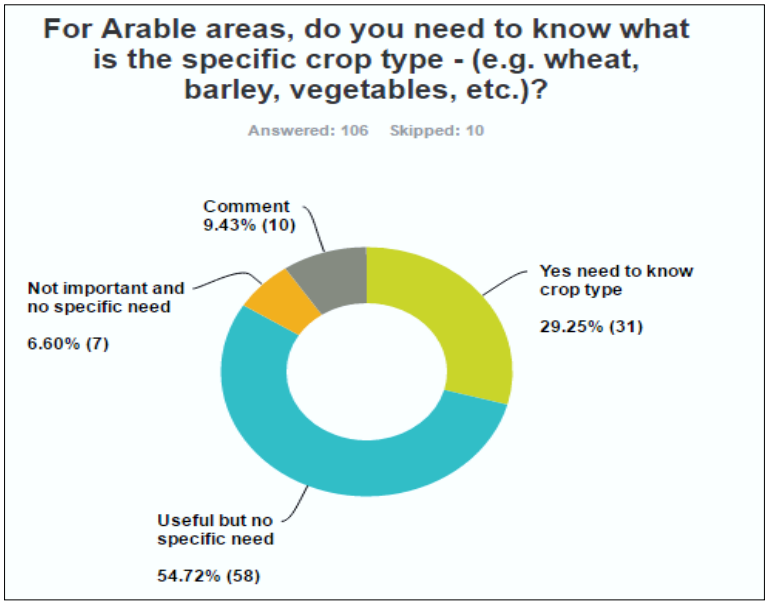


Chart 3.11 responses to Q 27

Question 27 asked if users needed to know what is the specific crop type in arable fields. Chart 11 below shows that 29.25% of responders said that they do need to know this with a further 54.72%

saying that it would be useful but they have no specific need. In the comments given, a number of users pointed out that crop types rotate annually and so this information would need to be updated annually and as such may not be viable with an e.g. 5 year update cycle. A small numbers of responders indicated that knowing the crop type is vital for their work in particular for the important use of national carbon accounting purposes.

Grasslands and Agricultural areas – Summary

The proposal to introduce a third main grassland category (Semi-improved grassland) was welcomed although any users suggested that it would be difficult to separate this from the Semi-natural grassland class. Information on suggested additional environmental attributes was strongly welcomed and the possibility of doing this should be explored. Users were happy to see the dominant grass type only listed for field parcels up to 5-10ha in area. Over this size they would like to see information on additional grass types present. There was a relatively similar preference shown for the two options given for mapping sub-parcel variation in grass types. The method used should be chosen by the project team during production. The attribution of crop type for arable fields would be welcomed but this may potentially conflict with the update cycle of the datasets.

Grassland and agricultural areas - Recommendations

1. Four main grassland types:
    - Improved grassland - Based on grassland intensity (NDVI) and attributed as Wet or Dry
    - Semi-Improved grassland - Based on grassland intensity (NDVI) and attributed as Wet or Dry
    - Semi-natural grassland - Use additional data to aid identification (NPWS data, slope, elevation, etc.)
    - Marsh - Consider adding to new inland wetland category

2. Provide either spatial or attribute information on multiple grass types within a field parcel over a defined mmu e.g. 5ha. Project team to decide method of doing this.

3. Two arable / horticulture classes:
    - Arable land
    - Horticulture, fruit trees and nurseries

4. Provide attribution on additional environmental characteristics where available:
    - Crop type
    - Biodiversity information (floristic properties, habitats)
    - Stocking rates
    - Fertiliser loadings
    - Soil pH
    - Other important environmental attributes in future.

3.4.4 Forested areas

Question 29 dealt with the proposed change to the woodland / forestry categorisation where it is proposed in the new schema that the term 'forestry' will be used instead of 'Woodland'. Tree parcels will then be classified primarily by their type i.e. coniferous, deciduous or mixed and not by their state of naturalness. 69.61% of responders were generally satisfied with this change with 23.53% of responders against it. In the comments section to this question a lot of responders indicated that whereas they are happy with the switch to using the term forestry', they would definitely like to see some information on whether the trees are planted or natural occurring as this has significant implications for local biodiversity.

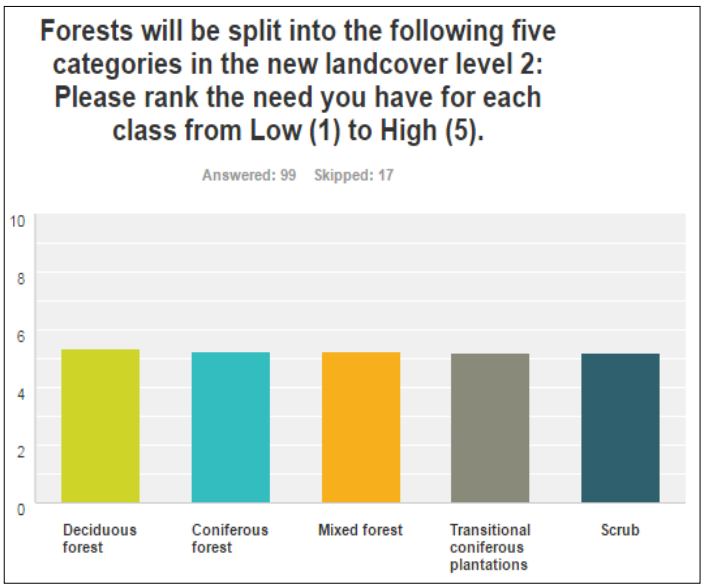


Chart 3.12: Responses to Question 30

Question 30 then asked responders to rank their need for each of the five proposed forestry categories. As shown in chart 3.12, each category received a very high (>4.95) scoring, indicating that most users require all five classes. Again, many responders indicated that they would like to see a differentiation between planted and naturally occurring forestry. It was also suggested that having information on the planting date would also be very useful in the case of planted trees. In terms of the proposed categories, the omission of a category for linear woodland which would represent hedgerows was criticised.

Questions 31 and 32 showed that users would prefer to see the terms Broadleaved and Coniferous used instead of Deciduous and Evergreen to describe the two main forestry types. In *Question 33*, 51.46% of responders said that they had a need for a distinction between transitional and mature coniferous forestry. Users who would like to see this information appeared to have a strong need for it, whereas nearly half 48.54% said they did not need it. In *Question 34*, 65.35% of responders said that they would like to see separate classes for transitional coniferous plantations and scrub. These two forestry sub-types are currently mapped under the one category in CORINE despite the fact that they are very different ecologically. *Question 35* then asked users if they think the invasive species such as rhododendron should be classified as scrub, in a broad horticulture and ornamental plants category or in their own class. Table 6 below shows that a strong majority of 77.66% of users would welcome the mapping of invasive species in their own dedicated class.

Answer Choices	Responses	
Classify as Scrub	14.89%	14
Classify as anadditional (sixth) L2 class within the Forestry category (e.g. Ornamental and invasive shrubs / woody plants).	77.66%	73
Classify into a broader L2 'Horticulture, flower beds and ornamental plants' class in the cultivated category	7.45%	7
Total		94

Table 3.5 showing responses to question 35: 'How do you think non-native, ornamental and invasive shrubs should be classified?'

Additional Forestry characteristics responders requested information on:

- Naturalness
- Planting date
- Open clearings within forests
- Transitional deciduous
- Temporarily stocked forests
- Urban trees / woods and parklands

Forested areas – Summary

Responders were generally satisfied with the proposed classes with two main changes/additions requested. Firstly that Broadleaved and coniferous be used to describe the two main forest types and secondly that the classification will retain information on whether a forest is natural or planted. The provision of a planting date if planted or a term such as 'natural' or 'non-planted' if not planted may facilitate this. A separate category for invasive species would be welcomed but this has been untested and so it is recommended to investigate this but not include it at the moment in the schema. The omission on a category for linear woodlands was strongly criticised as it would include hedgerows which are nationally a significant landcover feature. Hedgerows are currently no mapped in Prime2 and so they would have to be mapped by other means. The importance of spatially mapping hedgerows is however recognised and linear woodland should be included to facilitate the inclusion of hedgerows into the database in future. A potential solution would be to modify the 'Scrub' class to 'Scrub and linear woodland' thus enabling the inclusion of hedgerows when mapped in future. I many cases hedgerow shave the same species and components of scrub (brambles, shrubs and stunted deciduous species) and in marginal land they often merge into one another on the ground. The term 'linear woodland' does however conflict with the switch to using 'Forestry' as the main group descriptor.

Recommendations for forested areas:

1. Six main forest classes:

    - Broadleaved forest - Attribute as natural or planted
    - Coniferous forest - Attribute with planting date
    - Mixed forest - Attribute as natural or planted
    - Transitional coniferous forest - Afforestation, clearfelling and replanting
    - Scrub and linear woodland - Include linear woodland with scrub when mapped

2. Investigate further the mapping and/or attribution of the following;
    - Linear woodland
    - Invasive species
    - Open clearings within forests
    - Temporarily un-stocked forests
    - Urban trees / woods
    - Parklands
    - Transitional deciduous

3.4.5 Peatlands, Heathlands and Exposed surfaces

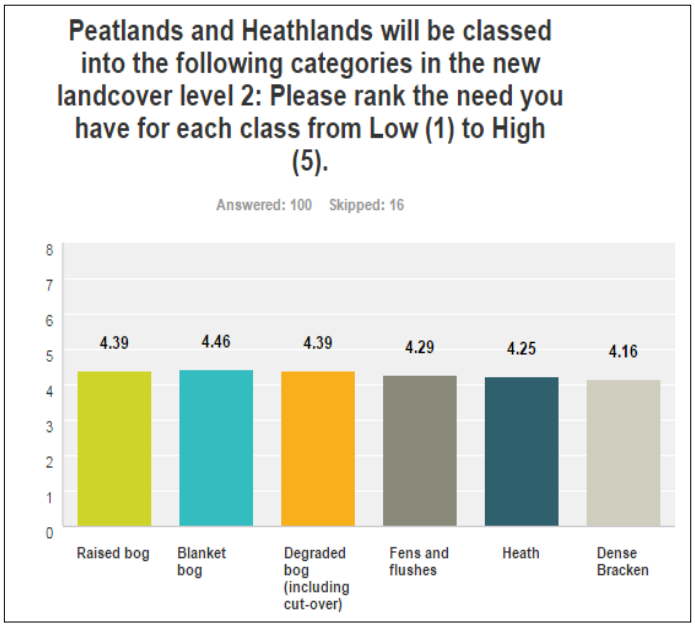


Chart 3.13 Weighted average of answers to question 36

Question 36 asked responders to rank their need for the six proposed peatland and heathland classes as shown in chart 3.13. A strong need was expressed for all six classes with comments asking in a lot of cases for even more detail than is proposed. A distinction between degraded and cutover bog in particular was requested by several users, this was also shown later in question 38 where 43.14% of users said that they have a definite need for this information and a further 46.08% said it would be useful. Other responders suggested that information on grazed bogs and transitional zones would be useful.

Question 37 specifically dealt with the question of whether the classification level should distinguish between wet and dry heaths. Responders were asked clearly for their need for this data, as shown in chart 3.14. 45.54% of repsonders said that they have a definite need for this information and a further 44.55% said that this information would be useful but they have no definite need for this distinction. Only 9.90% of reposnders said that they have no need for this disnticntion and that a single heath class would be suffecient.

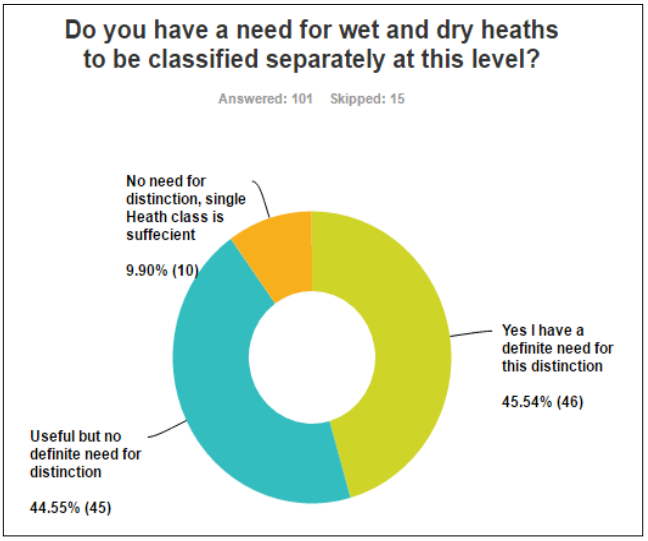


Chart 3.14 Pie chart showing responses to question 37

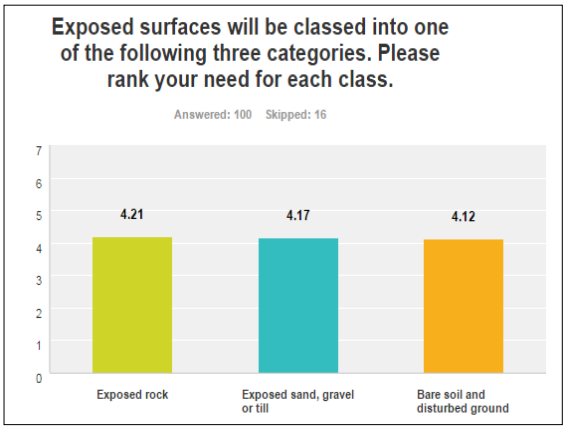


Chart 3.15 chart showing responses to question 40

Question 40 asked users on their need for the three proposed exposed surfaces classes as shown in chart 3.15. All three classes had a score between 4.12 and 4.21 out of 5. This is lower than the average score of other classes suggesting that this group is no strongly required by all users. However, the comments given show that it is very important for some users, notably geological users. It was suggested that it is important to distinguish properly between the exposed surfaces of tilled, reseeded, quarried, and construction site lands.

Peatlands, Heathlands and Exposed areas – Summary

These three groups are typically the main composition of unenclosed areas, particularly in uplands. A strong desire was shown for all proposed peat and heathland categories with more detail requested in the comments section, in particular the distinction between cutover and degraded bog as they are ecologically very different. Distinction between wet and dry heath was strongly requested and differentiation between different types of exposed soil surfaces such as tilled, replanted land and construction sites.

Peatlands, Heathlands and Exposed areas - Recommendations

1. Five main peatland classes (as per Fossitt)
    - Raised bog - Intact raised bog
    - Blanket bog - Attribute as upland / lowland
    - Eroding blanket bog
    - Cutover bog – Cutover raised and blanket bog
    - Fen and flush – Consider adding to new inland wetlands class

2. Two classes for heath and bracken category
    - Heathland – Attribute as wet/dry where possible
    - Bracken - Add to invasive class if created

3. Exposed areas
    - Exposed rock
    - Exposed sand till and gravel
    - Bare soil and disturbed ground – Clarify if to include tilled, replanted, construction sites and other non-naturally occurring exposed soil surfaces.

4. Attribute all above with mosaic information if available.

3.4.6 Coastal and Marine Zone

Questions 42, 43 and 44 asked users to rank their need for the eleven landcover classes that cover the coastal, littoral and marine zone. These classes were largely unchanged from the original classes in Fossitt and had an average scoring of 4 out of five in terms of users need for them. This is below the level of need expressed for other landcover categories. An example of a coastal section of Prime2, classified to the proposed landcover level 2 was given, see fig 3.2
The main change in this group is the removal of the sub-littoral category as this cannot be mapped using Prime 2 and earth observation imagery which is the main data source for this system.

Question 44 asks the survey responders if they need to have sub-littoral features mapped or if it was OK not to map them. Most responses accepted the exclusion of this class, with 22.34% of responders stated that they had a definite need for it and so it was not OK to map sub-littoral features as Marine Water as proposed. The comments section showed that the INFOMAR project has mapped some sub-littoral areas of the country and that it may be worth then linking up with this project to ensure interoperability between the two datasets, ensuring a consistent transition from terrestrial to marine areas.

Answer Choices	Responses	
OK to map sub-littoral as Marine Water	32.98%	31
Useful to have info on sub-littoral but no specific need	44.68%	42
Not OK to map sub-littoral as Marine Water, have definite need for info on this area	22.34%	21
Total		94

Table 3.6 showing answers to Question 44: 'We do not plan to map sub-littoral features and all areas below the low water mark will be mapped as (MW) Marine water body. Do you need to have information on sub-littoral feature types?'

Figure3. 2. An example given in the survey of a classified coastal section of Prime2, Myross Co. Cork

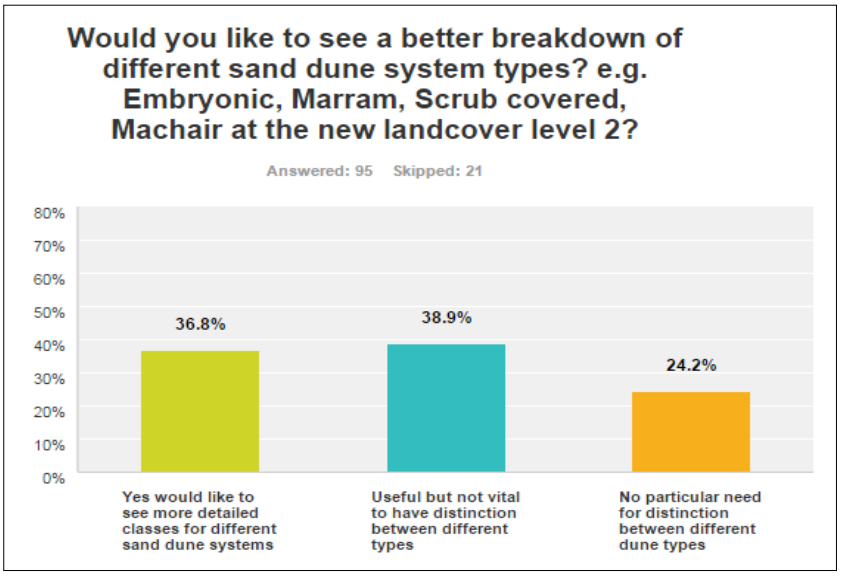


Chart 3.16 responses to question 46.

Question 46 asked if users would like to see more detailed categorise for sand dune systems, sub-categorising them based on their cover. 36.85 of users replied that they would like to see such information and a further 38.9% stated that it would be useful but not vital to have this information. Comments showed that this information would be very useful for bird surveying and appropriate assessment.

Question 47 then asked if users would like to see any other features of the coastal and marine zone mapped. Suggestions included:

- Retention of coastal constructions
- Distinction between (till) vs bedrock cliffs
- Aquaculture and fish farms
- Submerged paleo landscape features – bogs, polders, etc.
- Shoreline

Coastal and marine areas – Summary

The coastal and marine classes were largely unchanged from Fossitt, the main change being the removal of the sub-littoral group as this cannot be mapped by remote sensing and / or Prime2. The coastal construction class was also removed as it is not known if this will be mapped in Prime2. The class can be re0introduced if such features are mapped in Prime2 as they was some desire expressed to retain it.

Coastal and Marine areas - Recommendations

1. Five coastland classes:
   - Sea cliffs and islets
   - Inter-tidal water bodies
   - Salt marshes
   - Shingle and gravel
   - Sand dune systems
2. Five inter-tidal classes:
   - Intertidal rocky shores
   - Shingle and gravel shores
   - Sandy shores
   - Muddy shores
   - Mixed sediment shores
3. One Marine water class
4. Investigate if coastal constructions are included in PRIME2 and if the class can included in the schema.
5. Investigate the linking up to marine mapping programmes such as Infomar (GSI) and MIDA (The Marine Irish Digital Atlas, CMRC) to provide mapping of the sub-littoral zone.

4. Summary and Recommendations for an Irish Land monitoring programme

4.1 Current trends in European land monitoring and classification systems

The classification review in section 2 showed that land monitoring systems in Europe have developed in parallel with technological advances since the late 1980's with many European trialling different approaches to developing a national land monitoring systems between 1990 & 2009. Since 2009 however, there has been no new national system developed. This is largely due to the fact that land monitoring in Europe is currently undergoing a transitional period as the sector assesses the best way to utilise the rapid recent advancement in IT capabilities. The age of 'big data' has brought significant improvements in data availability, processing and storage capabilities. As a result, there has been much conceptual development and modelling in land monitoring systems in Europe over the last 5-6 years with a number of collaborative initiatives and forums bringing together land monitoring experts from across Europe to map out how to use these advances to progress land monitoring in Europe

A blueprint for developing a national land monitoring system and translating this into a common pan-European data product is provided by the EAGLE data model. This model takes a 'landscape description' approach instead of a traditional landcover/landuse classification approach. In this system a core landcover level provides the base level of description and it is then augmented by additional attribution of both landuse and additional environmental characteristics. This additional data can be typically added through integration of pre-existing national data sources such as habitat, demographic, farming and forestry datasets. The high resolution provided by national spatial cadastral databases such as OSi's PRIME2 enables such precise labelling of individual landscape features, acting as spatial 'holding units' for an infinite amount of data attribution.

4.2 Revised Fossitt level 2 and Stakeholder interaction process

During the 2012 Roscommon pilot project it was decided to adopt the approach taken by the UK's LCM data series and base a new landcover classification level on the existing accepted national habitat classification system, 'A guide to habitats in Ireland' (Fossitt, 2000). The existing level 2 of this system is equivalent to a pure landcover description system, i.e. a description of the earth's surface based purely on its bio-physical properties. This was taken as a template and classes were adjusted to suit the envisaged data production model (remote-sensing and data-integration based).

A stakeholder survey was widely circulated amongst known landcover data users in Ireland to provide them with an opportunity to review the proposed schemes and offer any feedback on the system. The survey also tried to scope the needs or requirements of responders for additional types and levels of data to provide a full picture of the needs of Irish landcover data users. The survey attracted 116 responses from 59 individual public agencies, companies, academic researchers and NGOs. This defined user-base will provide a useful avenue for further stakeholder outreach in future.

The majority of survey responders were both satisfied and impressed with the proposed Fossitt-based landcover classification approach. Just under 70% of users said that they agree with this approach with a minority of responders saying that they would prefer to see either a stand-alone system separate to Fossitt (13.3%) or that they would like to see the Fossitt system as a whole revised (9.7%). The survey enables us to confidently expect a high user uptake as over 80% of responders said that they would use the data if produced with over fifty potential policy, assessment, monitoring, research and education applications listed

on page 19. Detailed feedback was received on all landcover thematic areas with recommendations for each individual landcover group given in the relevant category section 3.4.

There was a similar level of need expressed for information on all three of the main landscape aspects – landcover, landuse and habitats. A strong need was shown to have attribution of landuse information attached to the dataset with 65% of responders saying that they have a definite need for this and a further 35% saying that it would be useful. There was also a strong desire shown for further information on additional environmental characteristics and conditions specific to individual landcover types. The very high resolution provided by Prime2 seems to satisfy user needs in relation to the spatial mapping of the landscape and so it is recommended to continue the plan to use this as a spatial framework for a national landcover and habitat mapping programme.

In terms of the classification and description system, user desire for detailed data attribution is high. The appetite for knowledge-rich data was particularly shown by topic-specific users who require the maximum level of detail possible for their particular field of interest (e.g. info on wet / dry heathland and grasslands). At the same time, there is still a large cohort of users who require a dataset mapped to a well-defined common standard which they can use 'off the shelf' confident that it is compatible with other national and international classification systems and reporting structures.

4.3 Recommended Classification and attribution approach

It may now be possible to satisfy these two requirement levels described above. The availability of improved spatial data (PRIME2), satellite imagery (Sentinel) and in-situ thematic data combined with increased data modelling and production capabilities means that it is now possible to implement a 'landscape description' classification model as proposed by EAGLE in Ireland. Adopting such as system would simultaneously provide the national-standard landcover dataset on one hand whilst allowing the potential to add additional landuse and environmental attribution where data is available. This approach is also supported by the results of the TaLAM project (Cawkwell et. al., 2016) which investigated the mapping of unenclosed uplands in Ireland.

A relatively simple modular approach can be taken to data production and attribution, (see fig 4.1). The first module is the core landcover level of detail. This is the revised Fossitt 'pure landcover' level. Levels 1 & 2 will be mapped initially with level 3 (habitats) phased-in when possible. The second module is the landuse attribution which will be attributed using primarily in-situ data from various sources. Landuse data for all Prime2 features does not currently exist so this will have to be a non-mandatory field, populated where possible. The third module is the additional data-rich attribution of 'Environmental Characteristics'. These fields will be non-mandatory and will be populated when relevant information is available or required. The environmental attribution data will vary from one landcover type to another and will primarily be drawn from the integration of externally produced in-situ datasets. The environmental attributes facility can be used to bridge the gap where there is Level 3 habitat data for some classes or geographical areas but not enough to produce a full national level 3 dataset. For example, information on the drainage of both grasslands and heathlands (i.e. wet or dry) can be attributed where possible without the need to produce a full national level 3 map for all habitats.

This landscape description approach works particularly well with an object-based mapping approach which we are implementing via Prime2. The additional landuse and environmental attribution will have the added benefit of ensuring cross-compatibility with CORINE and the ability to generalise up to CORINE using the EAGLE matrix. The core landcover classification level will not be dependent on the landuse or environmental attribution and an accuracy assessment report will be provided separately for the landcover level(s) with additional environmental and landuse data validated at source before attribution. There must be scope to

edit, add or remove fields in future and to facilitate change mapping in future iterations. Historic and change data can be added in a similar manner to the environmental attributes. This template is consistent with the Conceptual Data Model designed in WP2.

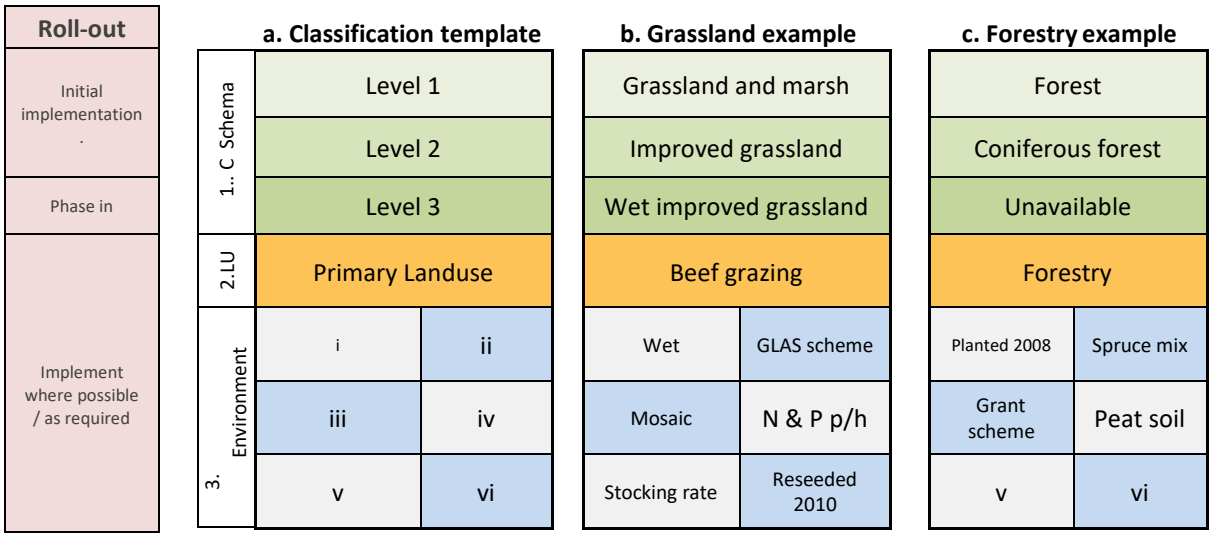


Figure 4.1, Data classification template (a) and populated examples for improved grasslands (b) & Coniferous forestry (c).

4.2 Recommended Classification Schema:

As detailed in section 4.2, it appears that the majority of users would be satisfied with proceeding with the Fossitt-based approach. Using this approach would ensure compatibility with existing habitat datasets, enable the future development of a national habitat dataset and provide a neutral 'pure landcover' description of the land surface which can be augmented with additional landuse and environmental data.

However, there was been notable feedback in the survey showing that there are some improvements which could be made to Fossitt as a whole and through initial attempts to integrate a new level 2 into the Fossitt schema, is has become clear that it will be necessary to revise the whole schema in order to make a valid hierarchal classification system. As it stands there are some changes which need to be made to the existing level 2 which will make it incompatible with the existing level 3, e.g. the change from woodland to forestry description of forested areas. Some disadvantages to the Fossitt system cited in the survey feedback are:

- No wetlands category
- No mosaics category
- No agricultural category – Artificial and arable mapped in the same category
- No sub division of artificial areas
- Only 2 categories for grassland at L2 – no semi-improved grassland
- Forestry mapped as native/non-native woodland

Most of the concerns around Fossitt can be addressed by further revision of levels 1 and 3 and therefore it is recommended to retain the plan to base the classification schema on the existing Fossitt system, but to fully revise the whole schema over time. Incorporate the topic-specific feedback provided in survey responses and re-issue the whole schema as either a second-edition Fossitt guide to Habitats or re-brand as a new Irish national landcover and habitat classification system. It is advised to publish the new system along with the first release of the landcover dataset, allowing the opportunity to make any alterations during production of the first dataset.

Alternate options

The revised Fossitt level 2 could also be used as a stand-alone, non-hierarchal landcover level, with added habitat information via the environmental characteristics capability in the data model. It could then link back to the original Fossitt via a look-up table. The alternative to this approach is to develop a new, stand-alone Irish land classification and description system. This could borrow heavily from Fossitt, especially in the habitats domain, however it would allow a re-alignment of classes and groups, allowing for example, a wetlands class and the introduction of mosaic classes. An example of the potential design of this is shown in appendix 1.1, as seen it can borrow heavily from the EAGLE model as shown in section 2.

4.3 Revised Fossitt schema.

In terms of the final individual classes used in the revised level 2, table 4.1 shows the revised level 2 adjusted to take into account the feedback received in the survey. In order to give a definitive and final list of classes, it is recommended to use this as a working schema and allow the option to make minor revision during the first production cycle as there may be unexpected issues or landcover types which will only be realised through the technical implementation of the data model. The final schema can be published along with the first release of the dataset.

Freshwater F:

1. FL- name changed to 'Standing water bodies': To be attributed as natural or artificial.
2. FW- class retained as is. To be attributed as natural or artificial.
3. FP – Springs: Class to be removed in L2 and generalised into appropriate neighbouring polygon.
4. FS –Swamps: To be retained as is.

Grassland and Marsh G:

1. GA Improved grassland split into improved grasslands (GI) and Urban and amenity green areas (BG). GI To be attributed as wet or dry where possible.
2. New semi-improved grassland (GS) category introduced.
3. Semi-natural grassland to be kept as is, separated from semi-improved and attributed as wet or dry where possible.
4. GM Freshwater Marsh – to be kept as is.

Heath and Dense Bracken H:

1. Classes are retained as is, i.e. two classes of Heath (HH) and Dense Bracken (HD). HH to be attributed as wet or dry where possible.

Peatlands P:

1. PR Raised bog – Kept as is.
2. PB Blanket bog – Kept as is.
3. PC Cutover bog – Kept as is.
4. PD Eroding blanket bog – Kept as is.
5. PF Fens and flushes – Kept as is.

Level 1		Level 2	
F	Freshwater	FL	Standing water bodies
		FW	Water courses
		FS	Freshwater swamp
G	Grassland and Marsh	GI	Improved grassland
		GS	Semi-improved grassland
		GN	Semi-natural grassland
		GM	Marsh
H	Heath and dense bracken	HH	Heath
		HD	Dense bracken
P	Peatlands	PR	Raised bog
		PB	Blanket bog
		PC	Cutover bog
		PD	Eroding blanket bog
		PF	Fens and flushes
W	Woodland and scrub	WB	Broadleaved forest
		WC	Coniferous forest
		WM	Mixed forest
		WT	Transitional coniferous forest
		WS	Scrub and linear woodland
E	Exposed rock and disturbed ground	ER	Exposed rock
		EG	Exposed sand, gravel or till
		ES	Bare soil and disturbed ground
		EQ	Open quarries and mines
B	Cultivated and built land	BA	Arable land
		BH	Horticulture, fruit trees and nurseries
		BL	Buildings
		BI	Infrastructure
		BK	Embankments
		BS	Other sealed surfaces
		BG	Urban and amenity green areas
		BC	Synthetic playing surfaces and tracks
		BE	Unsealed and exposed urban surfaces
C	Coastland	CS	Sea cliffs and islets
		CW	Transitional water bodies
		CM	Salt marshes
		CB	Shingle and gravel
		CD	Sand dune systems
L	Littoral	LR	Intertidal rocky shores
		LG	Shingle and gravel shores
		LS	Sandy shores
		LM	Muddy shores
		LX	Mixed sediment shores
S	Sub-littoral	MW	Marine water body
M	Marine water body		

Table 4.1 Fossitt level 2b with incorporated changes following survey feedback

Woodlands W: - changed to Forestry and woodland (F)

Difficult grouping to adjust to landcover whilst maintain link to L3 habitats.

1. Change from natural/planted woodland description to forest type.
    - WB – Broadleaved forest
    - WC – Coniferous forest
    - WM – Mixed forest
    - WT – Transitional coniferous forest
    - WS - Scrub and linear woodland

Exposed rock and disturbed ground E:

1. Underground rock class (EU) removed
2. Disturbed ground (ED) split into Exposed gravel & till (EG) and Bare soil and Disturbed ground (ES).
3. Active quarries & mines retained as Open quarries and mines (EQ).

Cultivated and built land B:

1. Cultivated land and artificial surfaces are grouped together – should we continue this?
2. Cultivated land (BC) split into Arable and horticulture
3. How will we deal with tilled land? Also should re-seeded pasture land fall under this class?
4. Built land split into three classes – Buildings, Other sealed surfaces and Infrastructure.

Coastland C:

1. Brackish waters (CW) renamed to Transitional water bodies (as in WFD).
2. Shingle and gravel (CB) retained as is.
3. Coastal constructions (CC) – To be removed

Littoral L:

1. Littoral rock renamed to Inter-tidal rocky shores (LR)
2. Sea caves will be generalised in L2B
3. Littoral shores broken down into
    - LG Shingle and gravel shores
    - LS Sandy shores
    - LM Muddy shores
    - LX Mixed sediment shores.

Sub littoral S:

1. Sub littoral to be removed and mapped as Marine Water.

Marine Water body M:

1. Retained as is.

4.4 List of final recommendations

The final list of recommendations arising from WP1 and described in more detail in section 4 are:

5. Adopt a 'landscape description' data model, similar to the EAGLE data model and matrix for an Irish land monitoring programme. This will involve producing a core landcover data level, mapped to the PRIME2 spatial database, which is then further augmented by attribution on landuse and environmental characteristics where such information is available.
6. Continue to base the core landcover level on the adapted Fossitt level 2, making provisions for the full Fossitt system to be revised in future to ensure full compatibility between all three classification levels.
7. Use the most recent draft of the Fossitt level 2B given in section 4 (fig 4.1) as the basis of a landcover description level and allow for final refinement during the production process.
8. Publish the finalised landcover classification level along with the first iteration of a national landcover dataset when complete.

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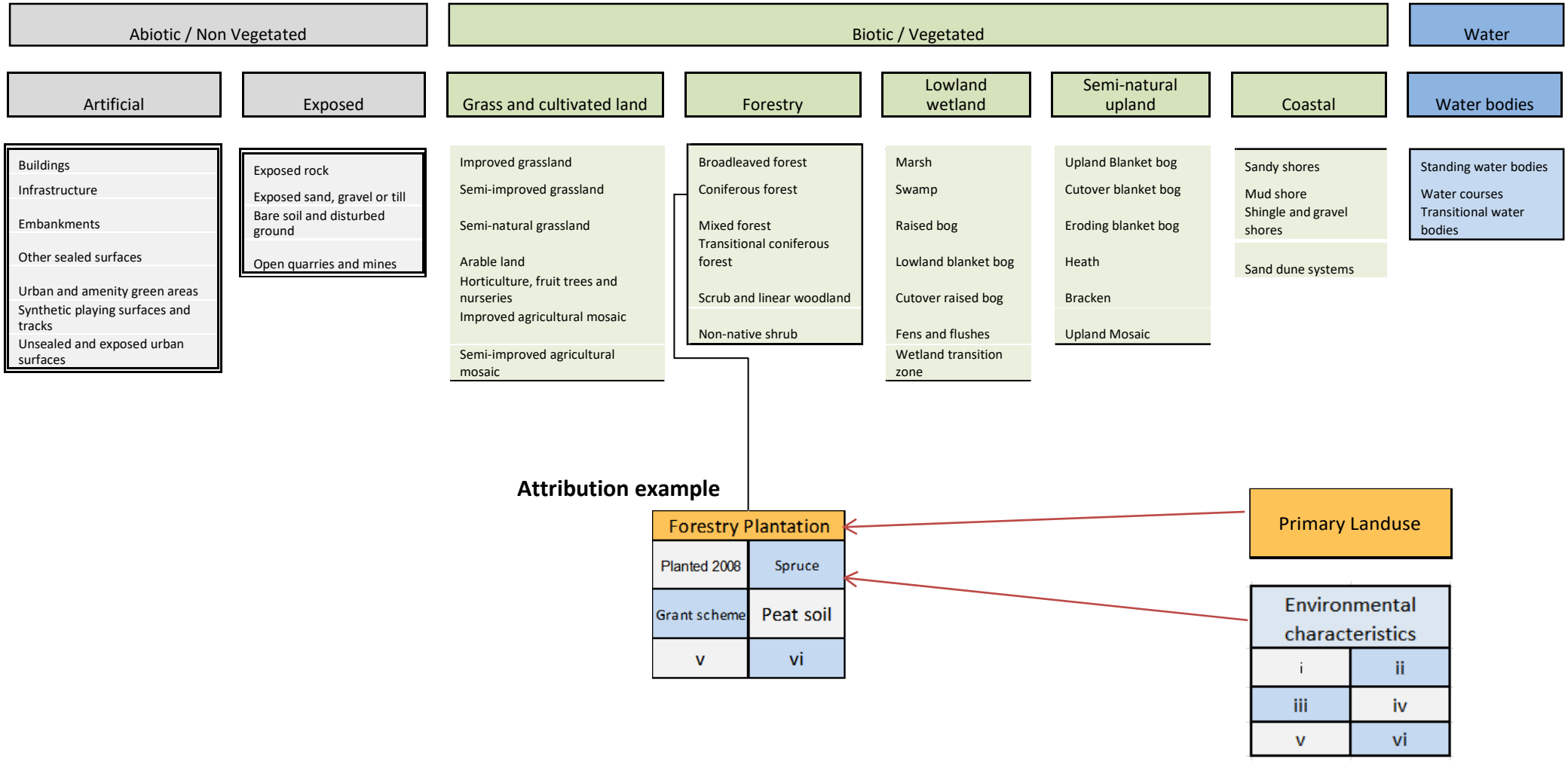
Appendix 1.1


Abiotic / Non Vegetated
Biotic / Vegetated
Water
Artificial
Exposed
Grass and cultivated land
Forestry
Lowland wetland
Semi-natural upland
Coastal
Water bodies
Buildings
Infrastructure
Embankments
Other sealed surfaces
Urban and amenity green areas
Synthetic playing surfaces and tracks
Unsealed and exposed urban surfaces
Exposed rock
Exposed sand, gravel or till
Bare soil and disturbed ground
Open quarries and mines
Improved grassland
Semi-improved grassland
Semi-natural grassland
Arable land
Horticulture, fruit trees and nurseries
Improved agricultural mosaic
Semi-improved agricultural mosaic
Broadleaved forest
Coniferous forest
Mixed forest
Transitional coniferous forest
Scrub and linear woodland
Non-native shrub
Marsh
Swamp
Raised bog
Lowland blanket bog
Cutover raised bog
Fens and flushes
Wetland transition zone
Upland Blanket bog
Cutover blanket bog
Eroding blanket bog
Heath
Bracken
Upland Mosaic
Sandy shores
Mud shore
Shingle and gravel shores
Sand dune systems
Standing water bodies
Water courses
Transitional water bodies
Attribution example
Forestry Plantation
Planted 2008
Spruce
Grant scheme
Peat soil
v
vi
Primary Landuse
Environmental characteristics
i
ii
iii
iv
v
vi