B04.1

Extending the dimensionality of OS MasterMap™: land use and land cover

Andrew Harrison, Consultant, National Land Use Database

Abstract

Land use and land cover together provide a multi-purpose description of the land that is capable of meeting a wide variety of user requirements. With the launch of OS MasterMap™ the ability to classify and monitor land use and cover at a very detailed level has become technically possible.

The Office of the Deputy Prime Minster (ODPM) is developing a new classification for land use and land cover. This will harmonise the existing National Land Use Database (NLUD) and Land Use Change Statistics (LUCS) classifications with the aim of providing a consistent nomenclature for land-based classification across government and a proposed national standard. Harmonisation will be achieved using a multidimensional approach, which represents land use and land cover as separate dimensions, and enables both dimensions to be classified simultaneously. Using this approach to define new land use and enhanced land cover attributes using OS MasterMap™ yields a rich classification of land and buildings which is useful for many applications.

Joint ODPM/Ordnance Survey research is developing methods to populate and maintain new land use and enhanced land cover attributes using OS MasterMap™. The current focus of this work is on automated methods of attribution in which existing data sources are integrated with OS MasterMap™ followed by spatial inference procedures to extract land use and land cover. A large-scale trial, based on South Yorkshire, is providing prototype data to evaluate the technical and business feasibility of these methods.

Background

The National Land Use Database (NLUD) project developed out of research carried out in the mid-1990's by the Department of Environment (DOE, now Office of the Deputy Prime Minister) to address the paucity of information about the extent and distribution of land use in England.

The research identified the need for comprehensive information on land use and the need to establish baseline data from which to monitor changes in land use in both the rural and urban environment. Subsequent work tested a variety of methods for building baseline data by associating land use information with polygons defined within experimental structured digital mapping from Ordnance Survey (OS).

The launch and first release of OS MasterMap™ data in November 2001 has reinvigorated the initial NLUD research on building land use data in conjunction with structured OS digital mapping. To take this research forward the *NLUD Baseline* project has been initiated to develop prototype land use data sets and to assess the technical and business options for providing these data nationally (Harrison et al. 2001; Harrison and Garland, 2001). This paper describes ongoing work that is developing and testing a new classification approach for NLUD in conjunction with OS MasterMap™.

NLUD data framework

To achieve this vision for NLUD the project is working to establish the underlying data framework for land use information that will enable data to be collected, assembled, integrated and maintained at national, regional and local levels using consistent and standard procedures.

OS MasterMap™ and British Standard BS7666 provide the spatial-referencing standards for NLUD. OS MasterMap™ has developed from the Digital National Framework (DNF) project and provides the basis for delineating and maintaining land use parcels. BS7666 provides a national standard address specification for land and property (Cabinet Office, 2002) and offers a means of linking to land use related information held in address-based data sets, although as yet most address-based data sets holding land use information do not conform to this standard.

The key NLUD data standard is the NLUD land use classification. Work is now underway to harmonise the current version with existing land-based classifications with the aim of providing a consistent and standard nomenclature for land use across government departments.

Development of NLUD classification

Development of a standard land use classification is central to the creation of land use data sets and is the key data standard for NLUD.

During 2001 research commenced on the development of a new land use classification for NLUD. This work has three main objectives:

- to harmonise the existing NLUD and LUCS classifications used by ODPM,
- to develop a new multidimensional approach to land classification allowing land use and land cover to be separately identified and classified, and
- to harmonise the new NLUD classification with other classifications in widespread use.

Harmonisation of LUCS and NLUD

The LUCS classification originated in the mid-1980's and was constructed to enable collection of land use change data as an adjunct to OS large scale map revision (Sellwood, 1987). The classification was designed to meet the particular requirements of DOE and to accommodate working practices of OS surveyors and portrayal of land use features on OS mapping. Land use change data have been collected by OS, on behalf of government, since 1985 and are now used routinely by ODPM in monitoring progress towards its sustainable housing and planning targets (DTLR, 2002).

Although the original NLUD classification was based on LUCS, additional classes and definitions were introduced following the extensive review of user and policy requirements carried out during the NLUD feasibility work of the mid-1990's (Dunn and Harrison, 1994). Harmonisation of LUCS and NLUD classifications was therefore long overdue and was necessary to provide a consistent approach to land use classification across government, and within ODPM in particular. In addition, given that the LUCS methodology was based upon the OS map revision process, it also provided an opportunity to review approaches to land classification employed by OS data collection and the new feature classification within OS MasterMap™.

Multidimensional classification

Both the existing NLUD and LUCS classifications mix land use and cover terms. Land use relates to the activity or socio-economic function for which land is used, whereas land cover relates to the physical nature or form of the land surface. These nomenclatures describe different dimensions of the land surface and can lead to ambiguous interpretations. Consequently a primary objective of the harmonisation process has been to establish a clear separation between land use and land cover in the new classification.

To achieve this separation between land use and land cover a multidimensional approach to classifying the land is being developed. This recognises that different users will have different views of the land, and buildings upon it, in relation to their application or business requirements. A multidimensional approach offers the potential to develop a generic land-based classification capable of harmonising different classification schemes and satisfying the requirements of different users. This multidimensional approach to land-based classification is now incorporated into a number of national classification schemes (APA, 1999; Eurostat, 2000 & 2001)

A new harmonised NLUD classification

Following these principles, a new harmonised classification comprising land use and land cover dimensions has been prepared (Figure 1). The classification was designated as version 4.1 (Pre-Release) as it was not the original intention to make it widely available, recognising that it would change in response to further review and feedback from potential users. As with previous NLUD classifications it should be viewed as a standard reporting framework for land use and land cover that facilitates linkage to more detailed classifications developed for specific applications.

The land use dimension is organised as a three-tier hierarchy comprising 10 orders, 22 groups and 12 sub-groups. This structure was primarily designed to demonstrate a high degree of continuity with the LUCS classification. The group level essentially mirrors the 24 category level of LUCS. Whereas the third-tier comprises the detailed categories introduced in response to the review of user and policy requirements conducted during earlier development of the NLUD classification.

The land cover dimension is organised essentially as a two-tier hierarchy comprising 8 orders and 33 groups comprising 'rural and 'urban' cover categories.

The 'rural' land cover categories were obtained as a by-product of the NLUD-LUCS harmonisation process. These categories were introduced into the original NLUD classification following the earlier review of user requirements and a detailed review of existing land cover classification schemes (Dunn and Harrison, 1994).

The 'urban' land cover categories describing buildings and structures and developed surfaces are recent additions. These categories are derived from an analysis of the OS MasterMap™ version 1 topographic area feature classification within urban areas, which provides a detailed description of urban morphology at the scale of individual buildings, structures and surfaces (OS, 2001).

As part of the *NLUD Baseline* research a number of prototype data sets based on OS MasterMap™ data have been created for a number of pilot areas. Figure 2 uses one of the 'urban' pilot sites (Aylesbury) to illustrate the potential for the NLUD classification to extend the existing OS MasterMap™ feature classification to enable simultaneous classification of land use and land cover.

Figure 2 illustrates the direct 1:1 relationship that exists between land cover and OS MasterMap™ topographic areas compared to the more complex relationship between OS MasterMap™ and land use. Methods for modelling basic spatial units (BSUs) for land use applications, using the topographic areas defined by OS MasterMap™, and associated problems of representation are considered more fully in Harrison (2000).

Standardisation of NLUD classification

This fundamental restructuring of the NLUD classification has provided the basis for a thorough review of completeness and compatibility of terms and definitions in relation to other key classifications in widespread use. Separate reviews of the land use and land cover dimensions have been carried out and have proposed a series of recommendations for revising and extending the classification.

Review of land use

The review of the land use dimension is based on a detailed comparison with National Land Use Classification (NLUC). NLUC was developed during the early 1970's to provide a standard land use

classification to aid the collection and dissemination of land use by local planning authorities and related bodies (Rhind and Hudson, 1980).

It is a hierarchical activity-based classification of land use comprising: 15 orders at Level 1, 78 groups at Level 2, 150 sub-groups at Level 3 and over 600 classes at Level 4. This structure and level of detail provides a flexible approach to classification that can be applied at the level of the BSU, the hereditament or at a more aggregated level (HMSO, 1975).

Despite the time that has elapsed since publication, the NLUC provides the most complete presentation of a nationally applicable land use classification and provides a single reference nomenclature for land use with which to evaluate the NLUD land use dimension. It is still used by a number of local planning authorities and remains an official government land use classification (Hansard, 1991).

Detailed comparisons between NLUD land use and NLUC had two broad objectives. First, to remove overlap between the use and cover dimensions in relation to buildings. As buildings are identified by the land cover dimension it is unnecessary to separately discriminate between buildings and land within the same land use group. Second, to define a complete and consistent two-tier land use classification hierarchy that extends the existing NLUD categories by drawing upon the NLUC Order – Group – Sub-group nomenclature.

Review of land cover

The review of the land cover dimension is based upon a detailed comparison with the national standard land cover nomenclature proposed by the Countryside Survey 1990 (Wyatt et al, 1994), in conjunction with the emerging standard Broad Habitat Classification (Jackson, 2000).

The Baseline Classification of land cover categories of national importance was developed as part of Countryside Survey 1990 to provide a single integrating classification of land cover. The work involved a detailed study and systematic comparison of nationally and internationally important classifications used in the UK. The Baseline Classification provides a single reference nomenclature for land cover derived from a comprehensive study of other approaches and classifications with which to evaluate the NLUD land cover dimension.

Detailed comparisons between NLUD land cover and these existing land cover classifications had three broad objectives. First, to define a complete and consistent two-tier land cover classification hierarchy that extends the existing NLUD categories by drawing upon the Baseline Classification. Second, to consider definitional differences between NLUD land cover and the Broad Habitat classification. Third, to review the 'urban' land cover categories following a Classification Workshop held with OS data collection and research staff at OS Headquarters in May 2002.

NLUD classification v4.2 (Consultation Draft)

Figure 3 presents a revised and extended NLUD land use and land cover classification based on the recommendations from the review work described above. This revised classification is designated version 4.2 (Consultation Draft) as it will form the basis of a consultation with key users and organisations employing land use classifications.

The proposed land use dimension extends the current approach based on LUCS to provide a new two-tier land use nomenclature for NLUD. The resulting land use classification is more complete and consistent at each level within the nomenclature and integrates fully with the proposed land cover classification. The proposed land cover dimension provides a slightly restructured set of groups and associated definitions and provides a balanced two-tier land cover nomenclature to match the land use dimension.

The consultation with key users and organisations is underway. The aim is to publish a new national standard for land classification that will be widely adopted by all bodies involved in routine collection and assembly of land use and land cover data later this year.

NLUD Baseline research

Under the *NLUD Baseline* project ODPM and OS have initiated a joint programme of research to demonstrate the potential for incorporating detailed land use and land cover information into OS MasterMap™. Results from the NLUD research pilots completed in August last year have demonstrated that valuable use and cover intelligence based upon OS MasterMap™ can be derived semi-automatically from existing MasterMap™ feature codes and a limited set of nationally available data sources (Harrison et al, 2001).

The current phase of the *Baseline* research aims to improve the methodology developed for the research pilots and to produce a county-wide dataset for technical evaluation and research purposes. The former county of South Yorkshire, comprising Barnsley, Doncaster, Sheffield and Rotherham, has been selected as the area for this evaluation data set.

The specific aims of the current research are:

- to develop an improved methodology to produce greater coverage and accuracy for allocating land use and land cover intelligence to OS MasterMap™ polygons,
- to create an evaluation data set for South Yorkshire, using an improved Semi-Automatic Data Driven Analysis (SADDA),
- to produce a revised data creation specification based on the revised methodology; and to provide an estimate of cost for producing land use and land cover data sets for England.

Development of the South Yorkshire data set is well underway through an ODPM contract with Infoterra Ltd. The contract commenced in October 2001.

The new NLUD classification (v4.1) is being used as the basis of the data set. This is providing an opportunity to evaluate the classification in a data production environment and has necessitated the development of separate data creation flow lines for land use and land cover.

So far excellent progress has been made with the land cover dataset. Methods have been developed that enable automatic attribution of land cover from three key data sets: Land Cover Map 2000, Forestry Commission Woodland Inventory and OS MasterMap™ topographic area attributes. These methods and data sources enable > 98% of OS MasterMap™ to be assigned a land cover attribute at levels of accuracy in the order of 80% to 90%.

Figures 4 and 5 show 'urban' and 'rural' areas respectively, extracted from the land cover layer created as part of the NLUD Baseline research.

Current land cover attribution in OS MasterMap™ version 1 is incomplete and implementation of the *DescriptiveTerm* attribute for Natural Environment features is open to possible misinterpretation by users. The new land cover information can be derived automatically and would clearly enhance the land cover attribution.

Developing a complete land use data set is more challenging given the lack of existing data sources capable of providing comprehensive information on land use. It is hoped that an improved methodology for classifying building use based on OS MasterMap™ textual attributes and a series of address-based data sources will increase the levels of completeness and accuracy achieved in the pilot study areas (Harrison et al, 2001).

Conclusions

Based upon a multidimensional approach to classifying the land, the new NLUD classification is a significant step towards the development of a national classification standard. The classification comprises separate nomenclatures for land use and land cover which enables harmonisation with existing

classifications and has provided the basis for a review of completeness and compatibility in relation to other key classifications in widespread use.

Following consultation with potential users and final revision this new NLUD classification should be published as a national standard later this year. The classification has been tested in conjunction with OS MasterMap™ as part of *NLUD Baseline* research that is investigating methods for deriving land use and land cover from existing data sources.

This research has demonstrated that there is a 1:1 relationship between land cover and OS MasterMap™ topographic areas, and that an enhanced land cover attribution for OS MasterMap™ could be achieved automatically from a limited set of nationally available data sources. Developing a complete land use layer would require primary data collection as existing data sources are unable to provide comprehensive information on land use.

The large-scale data creation trial that is nearing completion, based on South Yorkshire, is testing the data capture and integration processes required for creating a national land use and land cover datasets. Following completion of the trial, OS will assess the business and technical feasibility of this approach for incorporating land use and land cover data into future releases of OS MasterMap™.

The proposal to integrate a standard land use classification with OS MasterMap™ provides the potential for creating nationally complete, consistent and spatially detailed information on land use and land cover. Using OS MasterMap™ as the base could ensure the development of a high-quality, consistent and maintained land use dataset.

References

American Planning Association (1999) *Land-Based Classification Standards* (available from http://www.planning.org/lbcs).

Cabinet Office (2002) *UK Online Information Architecture for Address and Personal Details (v1.1)*, UK GovTalk/GSG/01, Cabinet Office, Office of the e-Envoy.

Dunn, R. and Harrison, A.R. (1994) *Feasibility study for deriving information about land use stock*, Final Report to the Department of the Environment.

DTLR (2002) Land Use Change in England: Residential Development to 2001, National Statistics Statistical Release, DTLR: London. (available from http://www.planning.dtlr.gov.uk/stats.htm).

Eurostat (2000) *Manual of Concepts on Land Cover and Land Use Information Systems*, Office for Official Publications of the European Communities: Luxembourg.

Eurostat (2001) *LUCAS: Land Use/Land Cover Area Frame Statistical Survey*, Technical Document No 4, Instructions for Surveyors, Eurostat: Luxembourg.

Hansard (1991) Response by Secretary of State for the Environment to question on Government coordination of land use and economic activity classifications, 19th June 1991, HMSO: London.

Harrison A.R. (2000) The National Land Use Database: developing a framework for spatial referencing and classification of land use features, *Proceedings of the AGI Conference at GIS 2000*, Olympia, London, 5.6.1 – 5.6.8.

Harrison, A.R. & Garland, B. (2001) The National Land Use Database: building new national baseline data of urban and rural land use, *Proceedings of the AGI Conference at GIS 2000*, Olympia, London, t2.5.1 – t2 .5.11.

Harrison A.R., D'Souza G. & Smith G.M. (2001) Integrated analysis of spatial data sets to create baseline urban and rural land use data, *Proceedings of First Annual Conference of Remote Sensing and Photogrammetry Society*, DTI, London, 485 – 495.

HMSO (1975) *National Land Use Classification*, HMSO: London.

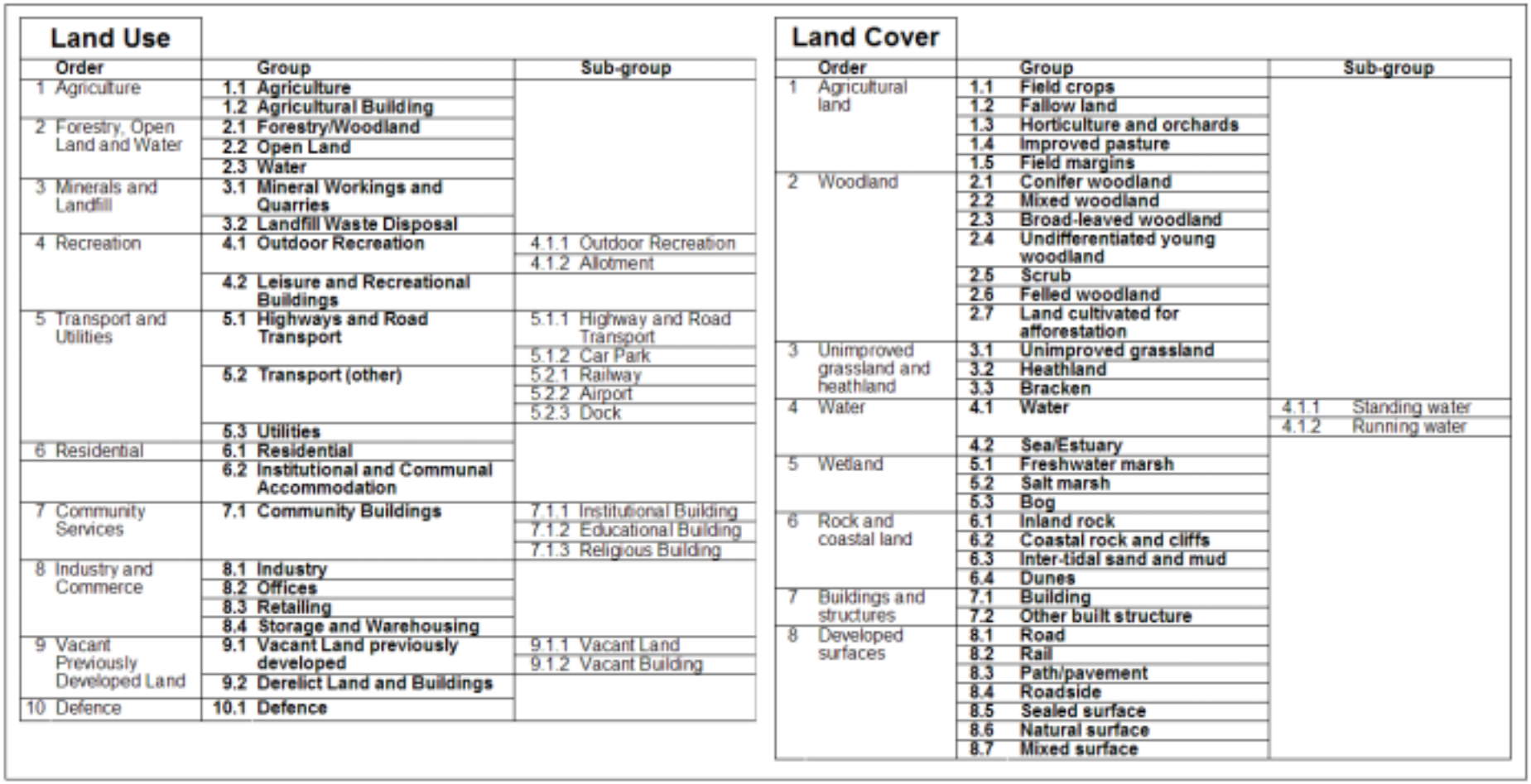
Jackson, D.L. (2000) *Guidance on the interpretation of the Biodiversity Broad Habitat Classification (terrestrial and freshwater types): definitions and the relationships with other habitat classifications.* JNCC Report No. 307, Joint Nature Conservation Committee: Peterborough

OS (Ordnance Survey) (2001) Classification and attributes of OS MasterMap features, Chapter 7 in *OS MasterMap User Guide v1.0*, Ordnance Survey: Southampton.

Rhind, D. and Hudson, R. (1980) *Land Use*, Methuen: London.

Sellwood, R. (1987) Statistics of Changes in Land Use: A New Series, *Statistical News*, November 1987, 79, 79.11 - 79.16.

Wyatt, B.K., Greatorex-Davies, J.N., Hill, M.O., Parr, T.W., Bunce, R.G.H. and Fuller, R.M. (1994) *Comparison of Land Cover Definitions*, Department of the Environment: London



Land Use

Order	Group	Sub-group
1 Agriculture	1.1 Agriculture	
	1.2 Agricultural Building	
2 Forestry, Open Land and Water	2.1 Forestry/Woodland	
	2.2 Open Land	
	2.3 Water	
3 Minerals and Landfill	3.1 Mineral Workings and Quarries	
	3.2 Landfill Waste Disposal	
4 Recreation	4.1 Outdoor Recreation	4.1.1 Outdoor Recreation
		4.1.2 Allotment
	4.2 Leisure and Recreational Buildings	
5 Transport and Utilities	5.1 Highways and Road Transport	5.1.1 Highway and Road Transport
		5.1.2 Car Park
	5.2 Transport (other)	5.2.1 Railway
		5.2.2 Airport
		5.2.3 Dock
	5.3 Utilities	
6 Residential	6.1 Residential	
	6.2 Institutional and Communal Accommodation	
7 Community Services	7.1 Community Buildings	7.1.1 Institutional Building
		7.1.2 Educational Building
		7.1.3 Religious Building
8 Industry and Commerce	8.1 Industry	
	8.2 Offices	
	8.3 Retailing	
	8.4 Storage and Warehousing	
9 Vacant Previously Developed Land	9.1 Vacant Land previously developed	9.1.1 Vacant Land
		9.1.2 Vacant Building
	9.2 Derelict Land and Buildings	
10 Defence	10.1 Defence	

Land Cover

Order	Group	Sub-group
1 Agricultural land	1.1 Field crops	
	1.2 Fallow land	
	1.3 Horticulture and orchards	
	1.4 Improved pasture	
	1.5 Field margins	
2 Woodland	2.1 Conifer woodland	
	2.2 Mixed woodland	
	2.3 Broad-leaved woodland	
	2.4 Undifferentiated young woodland	
	2.5 Scrub	
	2.6 Felled woodland	
	2.7 Land cultivated for afforestation	
3 Unimproved grassland and heathland	3.1 Unimproved grassland	
	3.2 Heathland	
	3.3 Bracken	
4 Water	4.1 Water	4.1.1 Standing water
		4.1.2 Running water
	4.2 Sea/Estuary	
5 Wetland	5.1 Freshwater marsh	
	5.2 Salt marsh	
	5.3 Bog	
6 Rock and coastal land	6.1 Inland rock	
	6.2 Coastal rock and cliffs	
	6.3 Inter-tidal sand and mud	
	6.4 Dunes	
7 Buildings and structures	7.1 Building	
	7.2 Other built structure	
8 Developed surfaces	8.1 Road	
	8.2 Rail	
	8.3 Path/pavement	
	8.4 Roadside	
	8.5 Sealed surface	
	8.6 Natural surface	
	8.7 Mixed surface	

Figure 1 NLUD Classification version 4.1 (Pre-Release)

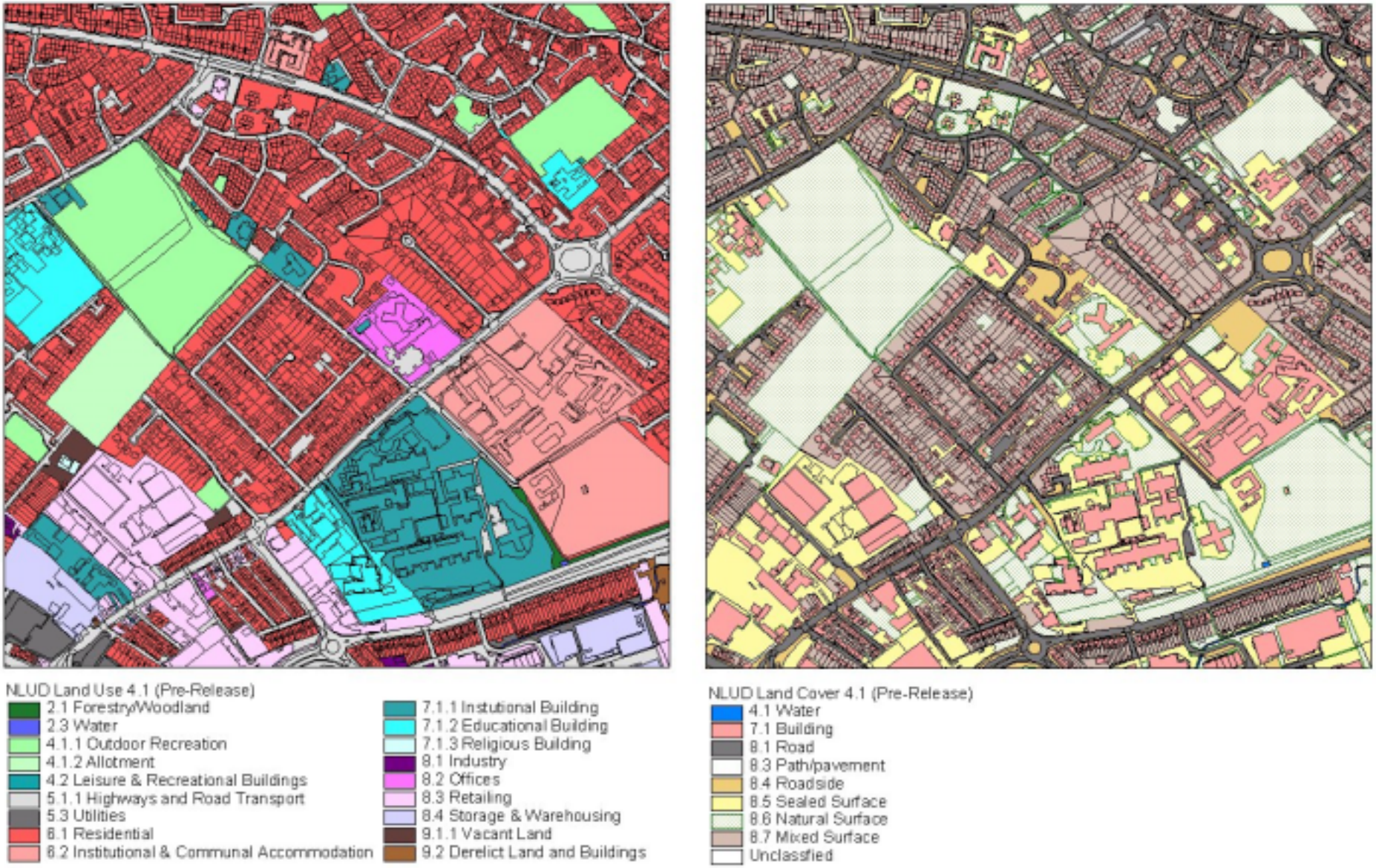


Figure 2 Prototype NLUD Land Use/Land Cover Data for 'Urban' Pilot Site (Aylesbury)

Land Use

Order	Group
1 Agriculture and fisheries	1.1 Agriculture
	1.2 Fisheries
2 Forestry	2.1 Forestry
	2.2 Other woodland uses
3 Minerals	3.1 Mineral workings and quarries
4 Recreation and leisure	4.1 Amenity, amusement and show places
	4.2 Libraries, museums and galleries
	4.3 Sports facilities
5 Transport	5.1 Transport tracks and ways
	5.2 Transport terminals and interchanges
	5.3 Water transport
	5.4 Mechanical handling and pipelines
	5.5 Goods handling
6 Utilities and infrastructure	6.1 Energy production and distribution
	6.2 Water storage and supply
	6.3 Sewage disposal
	6.4 Refuse disposal
	6.5 Human remains storage and disposal
	6.6 Post and telecommunications
7 Residential	7.1 Dwellings
	7.2 Institutional and communal residences
8 Community services	8.1 Medical and health care services
	8.2 Places of worship
	8.3 Education
	8.4 Other community services
9 Industry and commerce	9.1 Manufacturing
	9.2 Offices
	9.3 Retailing distribution and servicing
	9.4 Storage and warehousing
	9.5 Wholesale distribution
10 Vacant previously developed	10.1 Vacant
	10.2 Derelict
11 Defence	11.1 Defence
12 Low-level use	12.1 Unused land
	12.2 Unused water

Land Cover

Order	Group
1 Cultivated land	1.1 Field crops
	1.2 Fallow land
	1.3 Horticulture
	1.4 Orchards
	1.5 Field margins
2 Grassland	2.1 Improved grassland
	2.2 Unimproved grassland
	2.3 Amenity grass
3 Woodland	3.1 Conifer woodland
	3.2 Mixed woodland
	3.3 Broad-leaved woodland
	3.4 Undifferentiated young woodland
	3.5 Managed coppice
	3.6 Shrub
	3.7 Felled woodland
	3.8 Land cultivated for afforestation
4 Heathland and bog	4.1 Heathland
	4.2 Bracken
	4.3 Bog
5 Inland rock	5.1 Inland rock
6 Water and wetland	6.1 Standing water
	6.2 Running water
	6.3 Freshwater marsh
7 Coastal features	7.1 Sea/Estuary
	7.2 Inter-tidal sand and mud
	7.3 Salt marsh
	7.4 Dunes
	7.5 Coastal rock and cliffs
8 Buildings and structures	8.1 Building
	8.2 Roofed structure
	8.3 Other built structure
9 Developed surfaces	9.1 Road
	9.2 Rail (permanent way)
	9.3 Path/pavement
	9.4 Roadside
	9.5 Other artificial surface
	9.6 Mixed surface
	9.7 Bare natural surface

Figure 3 NLUD Classification version 4.2 (Consultation Draft)

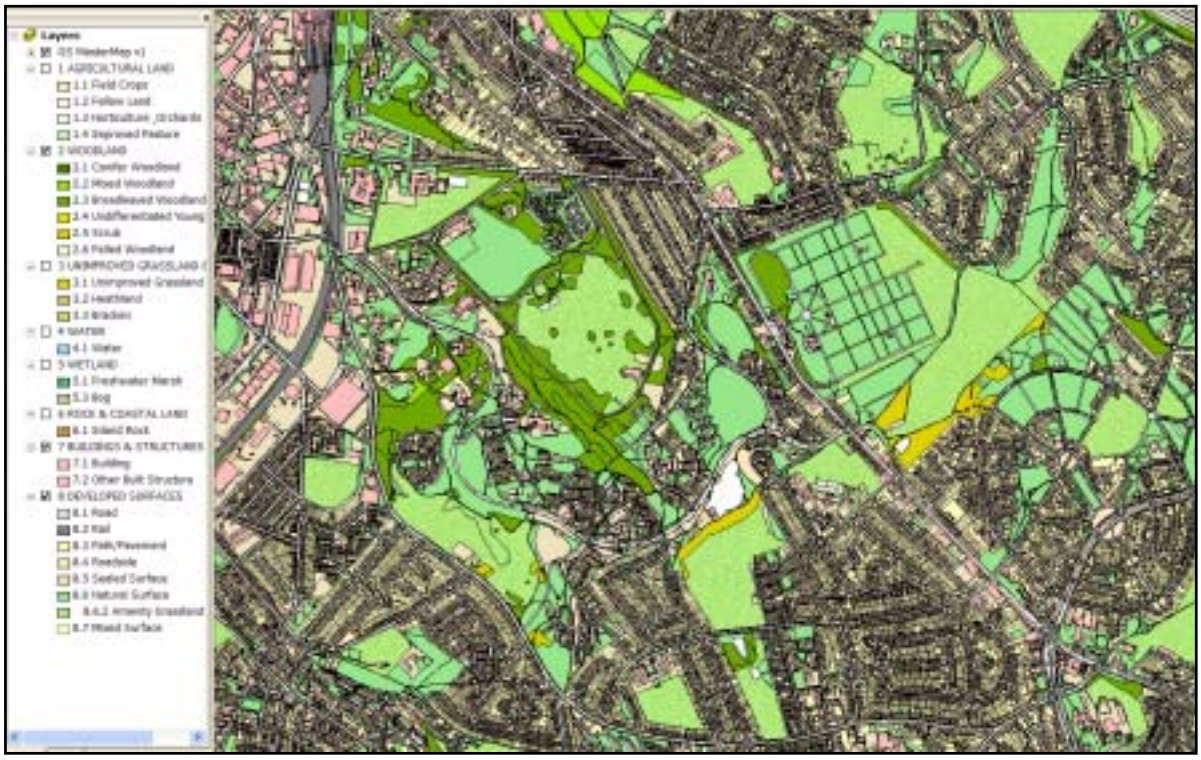


Figure 4 'Urban' land cover extract from South Yorkshire NLUD Baseline demonstrator data set

© Crown Copyright

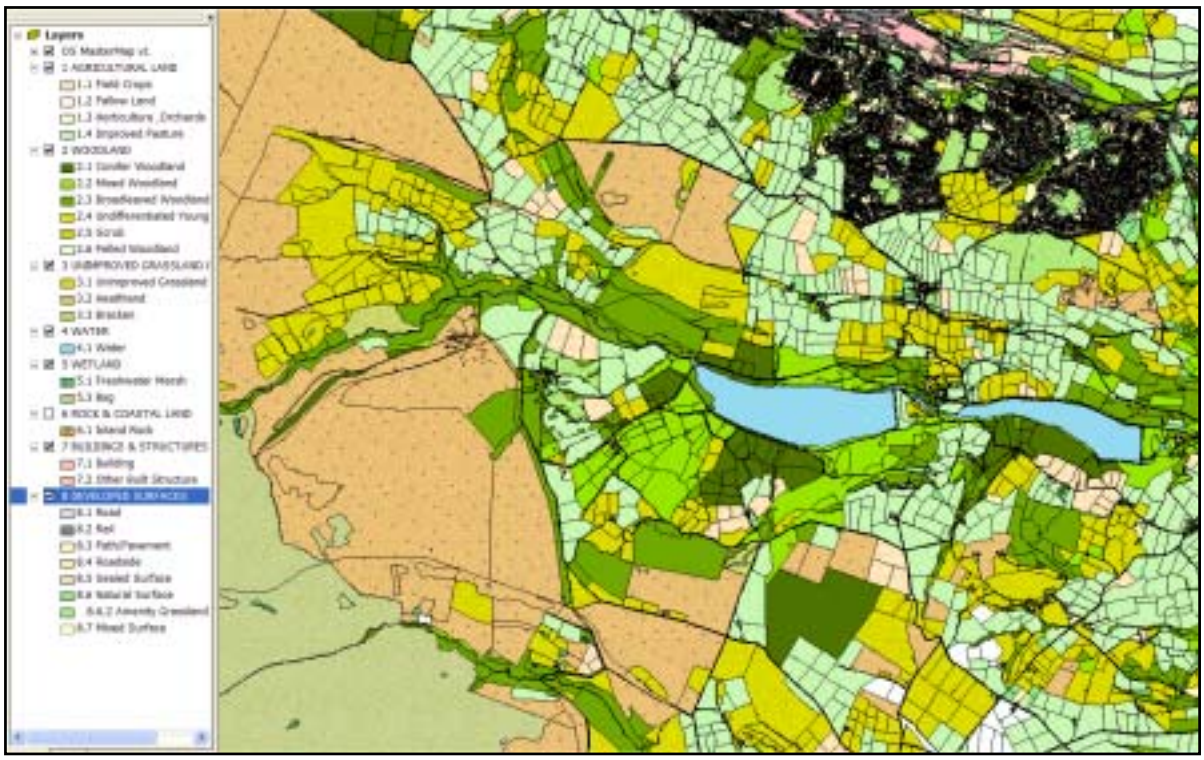


Figure 5 'Rural' land cover extract from South Yorkshire NLUD Baseline demonstrator data set © Crown Copyright

Authors

Andrew Harrison[1], Bob Garland[2], Mike Turner[2], Simon Gomm[3], Jenny Harding[3], Giles D'Souza[4] and Jane D'Souza[4]

[1]Independent Consultant, [2]ODPM, [3]Ordnance Survey, [4]Infoterra Ltd