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Experiences of using NLUD for urban areas

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Abstract

Following publication of version 3.3 of the National Land Use Database (NLUD) specification in April 2001, The GeoInformation Group has completed a series of classifications in major urban areas of the UK. The projects have taken existing Land-Line® data and overlain this with land use information based on the NLUD specification, primarily derived from aerial photography but also supported by field verification.

The underlying objective for these projects was to create a representative pattern of urban land use that could be used both for strategic planning and detailed analysis for specific locations.

Although NLUD consists of 52 classes many of these are rarely applicable to the urban environment. As a consequence there are some major land use types that are covered by only one or two very generic classes. This in turn masks significant urban patterns that have direct consequences on issues such as crime and disorder, social disadvantage and urban renewal. For example, all residential land use comes under one class (with the exception of community residences). As a result an enhancement to NLUD was developed that classified residential properties by age and type.

A second key weakness derives from the three dimensional nature of the built environment. Within NLUD there are few options to measure change through different levels of a building. Likewise mixed use is not an option within the current NLUD specification and as a result it is very difficult to accurately reflect the inherent variation in the commercial centre of an urban area.

As a consequence of these experiences it is clear that using NLUD as it stands in urban areas is less than adequate. This paper details some of the weakness in NLUD that have been highlighted by the work of GeoInformation and ways in which the specification may be enhanced in the future.

Introduction

The purpose of land use mapping is to monitor the range of current uses, depict patterns and inter-relationships and to show change over time, to aid better planning in the future. It was a failure of the early land use mapping of the 1930's and 1960's that they 'failed to provide a consistent long-term monitoring system for land use change' (Perkins and Parry, 1996).

The importance of such mapping has a very real application today with the increasing pressure for new homes, especially affordable homes in the South East, the changing nature of the industrial infrastructure and the pressure on the rural landscape.

In a recent Land Use Change Statistics release (LUCS-17, May 2002) the Office of the Deputy Prime Minister reported on behalf of UK government on the location of new homes built in 2001. The key results of this report were that:

- In 2001, 61 per cent of new dwellings were provided on previously-developed land.

- The proportions continued to vary regionally, from the highest proportion in London (90 per cent), to less than 50 per cent in the North East, South West and East Midlands.

- Over the four years up to 2000, some 3 per cent of new dwellings were built within Green Belts, but three-fifths of these were on previously-developed land.

- Over the four years up to 2000, about 11 per cent of new dwellings were built within the Environment Agency Flood Risk Areas.

Land use mapping in the UK has a rather fragmented history. It was not until the 1930's that the first comprehensive land use mapping was undertaken for the UK. This was primarily the work of a group led by L. Dudley Stamp who launched the First Land Utilisation Survey in 1930, which attempted to record the current use of every acre across the England, Wales and Scotland. The resulting maps were published from 1933 onwards at a scale of 1:63,360 (1 inch to the mile) and were based on the Ordnance Survey outline topographic map series at that scale. A similar map series was published for Northern Ireland by the Geographical association of Northern Ireland and the Department of Geography, Queens University Belfast.

The First Land Utilisation Survey really focused on rural areas, with urban areas characterised as 'land agriculturally unproductive'. The only urban area features that were extracted were allotments and areas of commercial horticulture. The over riding achievement of the Stamp survey was that it achieved virtually complete national survey of land cover, a feat never attempted before.

A Second Land Utilisation Survey was initiated in 1960 under the direction of Alice Coleman. The survey again involved considerable field collection with a final classification consisting of 64 categories. The survey was based on 1:25,000 series mapping and included a comparative representation with the Stamp survey and a more detailed second level. Due to the cost and lack of governmental support only 120 sheets were published, the last in 1977.

Cities Revealed Land Use Programme

In September 2001, a programme of Land Use mapping projects was commenced for a series of UK local government authorities with responsibilities for predominantly urban areas. The land use databases were created by The GeoInformation Group Ltd (TGG), based in Cambridge UK. The land use classification was compiled on the Ordnance Survey's Land-Line® large scale mapping base which each of the authorities held under a service level agreement.

The land use was generated primarily from photo interpretation of large scale aerial photography (mainly 1:7,000 imagery which was the basis of 12.5cm resolution ortho databases). This photography was flown as part of the companies Cities Revealed programme. The photo interpretation was supported by field verification and verification from the information already contained within Landline.

The land use classification was based on the National Land Use Database Specification version 3.3 published in April 2001 (Harrison and Garland, 2001). The purpose of this paper is to review TGG's experience gained from applying the NLUD classification to the urban environment, to consider why alterations were made to the guidance given in how to apply the specification and where NLUD remains deficient in representing an overview of the urban landscape.

National Land Use Database (NLUD)

The National Land Use Database programme was established by the then Department of the Environment in the early 1990's. The principle outcome of the programme to date has been the creation of a National Land Use Database Specification. This has three levels although the first two are the most significant, with 13 classes at level 1 and 52 classes at level 2. This has been published and is widely referred to as the national standard for future land use products. The class breakdown is shown in Figure 1.

There have been a series of studies to test different methods of capturing land use related to the Ordnance Survey large scale mapping base. These demonstrated the problems of automatic data classification based on mapping and a number of supplementary sources, in particular highlighting issues of consistency and accuracy and the weaknesses in the Ordnance Survey Landline product when used for this purpose. However this latter is at least partly addressed with the introduction of the Ordnance Survey's new structured large scale database, initially known as DNF but now branded MasterMap™.

NLUD Land Use Classification (v3.3)

1 *Agricultural*

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 Broadleaved 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
3.5 Upland mosaics

4 **Water and Wetland**

4.1 Sea/Estuary
4.2 Standing water
4.3 Running water
4.4 Freshwater marsh
4.5 Salt marsh
4.6 Bog

5 **Rock and Coastal Land**

5.1 Inland rock
5.2 Coastal rocks and cliffs
5.3 Inter-tidal sand and mud
5.4 Dunes

6 **Minerals and Landfill**

6.1 Mineral workings and quarries
6.2 Landfill waste disposal

7 *Recreation*

7.1 Leisure and recreational buildings
7.2 Outdoor recreation
7.3 Allotments

8 **Transport**

8.1 Roads
8.2 Public car parks
8.3 Railways
8.4 Airports
8.5 Docks

9 **Residential**

9.1 Residential
9.2 Institutional and communal accommodation

10 **Community Buildings**

10.1 Institutional buildings
10.2 Educational buildings
10.3 Religious buildings

11 **Industrial and Commercial**

11.1 Industry
11.2 Offices
11.3 Retailing
11.4 Storage and warehousing
11.5 Utilities
11.6 Agricultural buildings

12 **Vacant Land and Buildings**

12.1 Vacant land previously developed
12.2 Vacant buildings
12.3 Derelict land and buildings

13 **Defence Land and Buildings**

Additional TGG Codes

88.1 Map base out of date
88.2 Image base out of date
88.3 Unknown which is more up to date
99 Unknown/Not classified

*Figure 1. NLUD Version 3.3 (April 2001) classes*

A series of studies are now focusing on the methodologies for associating land use with MasterMap. The additional sources being considered are address data in the form of Address-Point ® and Code-Point ®

from the Ordnance Survey and business codes from the Valuation Office's NNDR database in urban areas, and the LMC2000 data together with woodland information from the Forestry Commission in rural areas. The results so far published for these automatic processes even for Level 1 classifications have not been altogether encouraging, with accuracies of less than 90% for rural areas and less than 75% for urban areas (Harrison and Garland, 2001).

It should be made clear that the original purpose of the NLUD programme is not to undertake the land use classification, but rather to prepare an overall framework and national specification together with methodologies that other agencies, local government or commercial companies can adopt. Within this context it is hoped that the experience gained within the Cities Revealed programme will contribute to the development of this framework.

Cities Revealed Land Use Programme

In 2001, The GeoInformation Group commenced the process of creating a land use database for selected urban areas on behalf of local authority clients. It was intended that the classification would be based solely on NLUD version 3.3, taking into account published guidance notes, including those available for the preceeding version of NLUD, version 3.2. Figure 2 is an example of the type of mapping output that can be generated from the database.
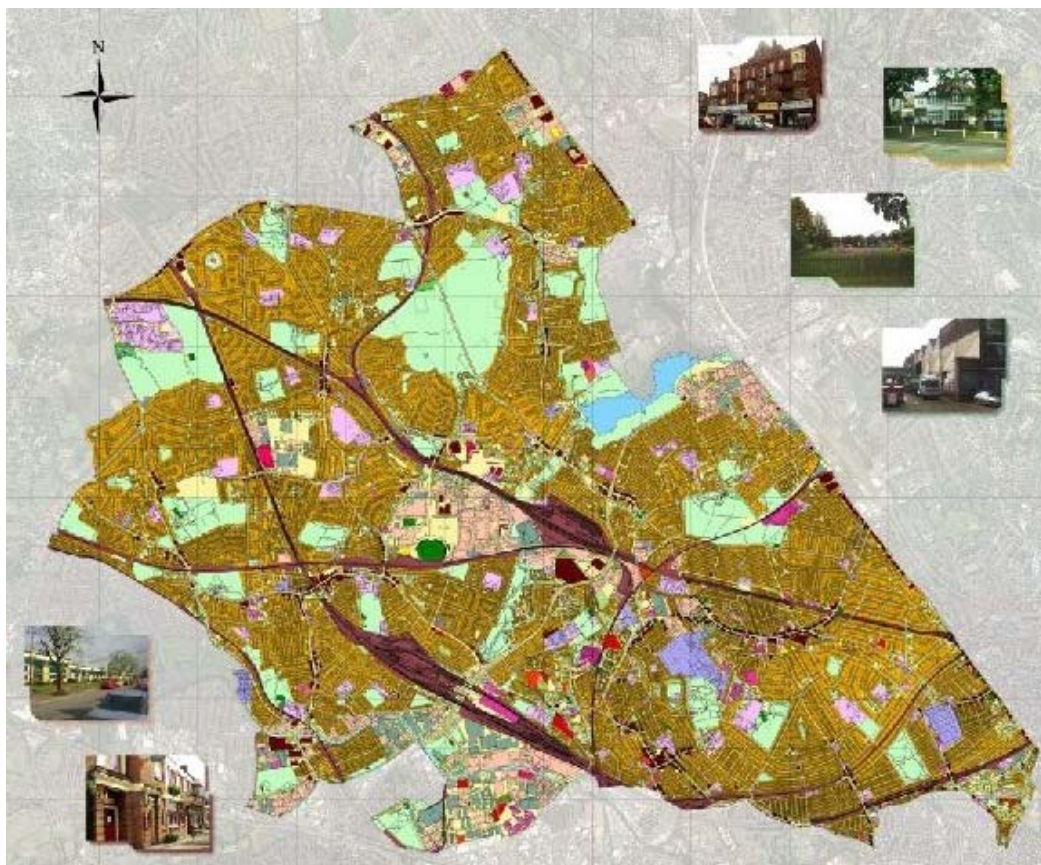
Figure 2. London Borough of Brent Land Use Map based on NLUD version 3.3

TGG discussed the likely applications of the land use data with its clients and reviewed their expectations in terms of accuracy and consistency. It was clear from the outset that the NLUD classification at the 52 class level presented some severe limitations, particularly in the way it could be used to accurately represent the complexities of the urban environment.

The fundamental issue centred around the question of how accurately land use can be depicted in urban areas and what limitations were introduced by using both Land-Line and NLUD. This then had implications for how general land use patterns were represented and what this might mean for the end user.

The clearest example of this is that NLUD consists of just one generic category for residential land use. As this inevitably represents a large part of any urban area it is likely to obscure important structural patterns. As a result TGG currently publishes a companion dataset of residential buildings classified by age and type.

Within the adopted process, which initially used a polygonised version of Land-Line and the pre-defined NLUD specification, there was clearly going to be a need to make difficult interpretative decisions.

As an example a single building represented by a single bounding polygon may have several land uses associated with it. The ground floor may be retail with offices above and possibly residential accommodation above that. The dominant use on any one level may vary as will the use on different floors. In a typical Victorian shopping high street the principle land use characteristic may be retail, but the dominant land use in terms of floor space may office or residential (Figure 3). The question then relates to the overall character of that area which may be seen as retail, office or residential or a mixture?

In consideration of this last issue it was necessary to set down an underlying principle for the land use data. This principle was set out in the *First Rule* to be used in the creation of the land use databases, which was that the resulting interpretations must reflect the overall character of the urban environment under consideration.
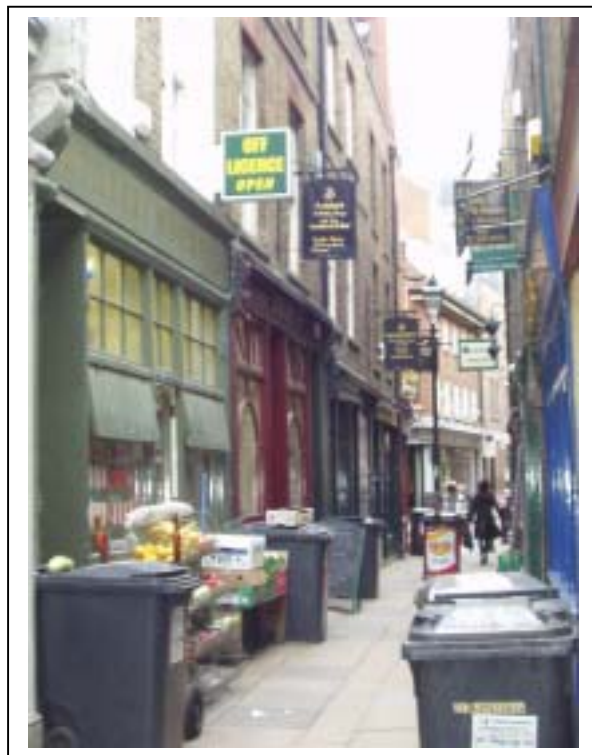
Figure 3. An example of a Victorian shopping street in Central London.

Accounting for the third dimension

One of the biggest problems in undertaking a land use survey for urban areas is accounting for the complexity in both plan and elevation. Unfortunately, the Land-Line mapping is essentially a two

dimensional representation of a complex three dimensional environment and the NLUD classification does not accommodate mixed land uses.

Essentially therefore the *Second Rule* that was adopted for the land use programme was that the land use would in the first instance be that of a 'Ground Floor' classification. However, no sooner is this rule adopted than it has to be qualified based on the need to accommodate the *First Rule*.

The best example of this is when creating the land use classification for the City of London. By any stretch of the imagination the heart of the city can only be regarded as predominantly office accommodation with retail elements supporting this dominant usage, located primarily at ground level along the main roads. However most of the big city office blocks, which have shops on the ground floor, at least in the front part of the building, if classified using only Rule Two would become retail. This would change the character of the city suggesting in percentage land use terms that retail is more dominant than offices and the character would be similar to that of the West End of London (Figure 4).

Figure 4. Examples of mixed use buildings in the City of London.

This problem is compounded by Land-Line. In many cases single large buildings many storeys high are represented by a single bounding polygon. Small retail units are often not differentiated and as a consequence a whole building can have only a single land use.

Mixed Use Categories

The urban environment is dominated by mixed usage. Some of this usage relates to different levels while other mixed uses are integrated within a single area.

It is a significant weakness of the current NLUD classification that it does not accommodate mixed use classes. While it might not be prudent to have an endless range of options there are some key ones which in complex urban environments go a long way to help represent the character of the area. The following is an example.

A small inner city site, made up of several linked but distinctive buildings can be seen to have several activities going on at the same time. One building is given over to storage, another to manufacturing or processing of some sort and another to office. Such sites are often clearly owned by a single company or

organisation, and the use is effectively an integration of industry (11.1), office (11.2) and storage (11.4). An example is shown in Figure 5.

Figure 5. Mixed use inner city commercial complexes

In the UK Land Utilisation Surveys of the 1930's and 1960's-1980's, the urban environment is classified using the term commercial and residential. While this broad classification does nothing to address the problems described here, the use of the term commercial as a mixed use category may provide a solution to some of the current problems. The idea that a single site which is owned by one company or organisation and which is dedicated solely to the business of the organisation but might include a building for manufacturing, a storage building and offices. It would be inappropriate on many smaller inner city sites, and often difficult, to differentiate the different uses, but such sites could well be classified under the more generic term of 'commercial'.

Specific Issues within NLUD

In addition to these more generic issues there are a range of very specific problems encountered when applying NLUD to the urban environment.

1 Banks

Banks present a particular type of problem. Under the guidance notes for NLUD banks should be classified as Institutional Buildings (10.1). However this would mean that for many main shopping streets there would be several buildings with an institutional classification. These buildings are commercial properties with public access and a use focusing on financial transactions, but which are an integrated part of the shopping environment. It therefore seems much more appropriate to classify banks under a retail (11.3) classification.

Also Land-Line identifies all buildings that are 'banks'. These include some but not all retail banks on the high street and offices used by banks. The latter are clearly offices (11.2) under NLUD. If the institutional class was used much of the City of London would revert to this classification, another example of adjusting to meet the First Rule.

2 Temporary land uses

A particular example of this problem in London and other inner city areas is the street market. The streets are clearly identified on Landline and there are few options for designating part of a road as a different land use. Temporary structures like markets, exist for only a short period of time (a few hours in a day) but re-

occur regularly. As such they are an integral part of the urban fabric, often being key focal points within the inner urban neighbourhood structures. However under the current NLUD classification and using Land-Line it is impossible to represent these temporary retail areas.

3 Playing areas and grass areas around large estates
One of the most difficult areas to show are extensive high rise estates, particularly those developed in the 1960's and later, where there are open areas, mainly laid to grass. These are essentially public access spaces for walking dogs or for children to play on. They are intended for the use of local residents and could be construed as part of the residential use of that area. However as they are accessible to the public and there is a particular interest in designating these areas because of maintenance issues, they were classified as Outdoor Recreation (7.2) and not part of the residential classification. The other option would have been to classify them as part of the road and curtlage network (8.1) running through the estate but this seems inappropriate on the grounds it exaggerates the idea that these estates are 'tarmac jungles'.

The issue for those undertaking the classification becomes one of how large the green space needs to be before it crosses from road/curtlage to outdoor recreation. In most estates only 'significant' grass areas are singled out, although no precise area figure was given, allowing the intepreter to judge which areas should be selected to give the right overall impression of an area.

A complicating factor is the existence of small gardens or fenced areas within such estates, which were generally treated as private gardens and therefore classified as residential (9.1).

4 Institutional Buildings (10.1)
The category of institutional buildings includes many public service buildings. However it can be used for more obscure features, even discounting the issue of banks. The general principle adopted was that buildings or sites that have a particular significant to society should be an institutional land use, even if they might otherwise fall into another category. Therefore the Houses of Parliament, Buckingham Palace and the Bank of England were classified as 10.1. In addition Town Halls were Institutional because of their public access role, whereas other council offices were merely classed as offices (11.2) as indicated by the NLUD guidance notes.

5 When is a road not a road?
Inevitably when undertaking a 100% land use classification there are small areas around the edge of identifiable features which are either too small to classify or indistinguishable as a particular land use. These by default tend to fall within the road/curtlage category.

For other sites, in particular large institutional sites such as hospitals, depending on how Land-Line is structured, roads may be separately identifiable or they may not. The general principle that was adopted was that roads, even though they allow public access across a site are part of the hospital and are therefore classified as the institutional land use and not as roads.

Quality of land use databases

An important issues for users is the overall quality of databases. This has to take into consideration not just the issues associated with the classification and base mapping but the ability of a team of interpreters to create an accurate and consistent dataset.

TGG conducted a survey for Doncaster Metropolitan Borough to a user-defined classification of some 145 classes. This was initially undertaken purely from photo interpretation and then field checked. An overall polygon classification accuracy of nearly 98% was achieved. However in all cases TGG undertakes a level of field verification to ensure a consistent level of quality id achieved.

There is an important issue associated with making statement about accuracy. It may be possible to classify 95% of all polygons accurately but the 5% error rate can be many thousands of polygons. What is important is that within any mapping dataset there are many small polygons that are largely unimportant in

the overall land classification. However getting the 'one' major polygon incorrect could have major implications – a wrongly classified building.

Achieving accuracy and consistency is founded on the experience of the photo interpreters. They have to have strong PI skills but associated with this good backgrounds in related subjects such as architecture, social history and planning, and wherever possible enhance this with local background knowledge.

The building up of experience and the creation of an individuals own reference database when undertaking the PI is critical to this. Hence experienced teams with several studies to their name will give much better results.

Conclusion

In conclusion land use can be accurately collected from aerial photography by photo interpretation, enhanced by field verification. TGG has undertaken a series of projects for clients which have resulted in the creation of land use databases for much of London and significant parts of other major UK cities. These have been based on the NLUD classification linked to the Ordnance Survey large scale mapping base. There are however a number of limitations when applying NLUD to the urban environment. TGG has developed both a production philosophy and detailed case law in order to create and effective product but in the future there will need to be enhancements to NLUD to accommodate the key areas of weakness.

References

Cassettari, S. (2003, To be published) **A review of Urban Land Use Mapping in the UK** Cartographic Journal Vol XXI

Harrison, S. and B. Garland (2001) **The National Land Use Database: building new national baseline data and rural land use.** Proceedings AGI Conference 2001, Track 2.5.

Perkins C. R. and R. B. Parry (1996) **Mapping the UK,** Bowker-Saur, East Grinstead.