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Monitoring land cover and land use for urban and regional planning

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This chapter focuses on the use of GIS in national and regional – i.e. strategic – aspects of land use planning. The use of GIS in strategic planning raises issues which go to the core of the concept of land use itself, including the definition of a land use, the definition of the 'parcels' into which land is divided, and the acquisition of data on what occupies the Earth's surface. A key concept underlying all these issues is that the term 'land use' (as opposed to much of what is called 'land cover') defines a social purpose and not a set of physical qualities. Regarding land use in this way means, among other things, that many more datasets can be used to investigate land use matters than is customarily assumed and that GIS has the key role to play in the processing and integration of such data. The scope of policies and the range of data generated for strategic land use planning are best understood in specific institutional contexts, and the chapter develops examples from the United Kingdom.

1 INTRODUCTION

The representation and analysis of land cover and land use has been a major area of GIS applications since the introduction of the technology in the early 1970s (Coppock and Rhind 1991; Tomlinson 1967). Since then, national and local governments have developed a variety of land use related applications of GIS (Campbell et al 1993; Masser et al 1996). Such applications are part of the process of 'collective will formation' attempting to shape and form the natural and built environment (Rydin 1994). From the perspective of public administration orthodoxy (Fox and Miller 1995; Waldo 1948), land use planners may be seen as professionals working within a rational bureaucracy granting or withholding consent to undertake particular developments on the basis of observable facts and policy rules. Land use information in planning plays two distinct types of role in this process: in aiding the development of policy rules and in forming the basis on which policy is applied to individual cases. GIS has a clear potential to support both roles.

This chapter concentrates on how GIS has been used to generate information about land use for policy purposes, rather than on the use of systems to control development directly. In Britain the latter process is known as 'development control' (Cullingworth and Nadin 1994; Morgan and Nott 1995; and see also Wakeford 1990). Because of their bureaucratic importance, substantial effort has been devoted to the establishment of information systems to support development control decisions (England et al 1985). There is, however, a critical disjunction between the application of information systems such as GIS in the day-to-day work of development control and their use in strategic planning (Bibby and Shepherd 1992). In part, this disjunction occurs because the administrative activity associated with development control (which records changes in land use) can provide only a small portion of the information needs implied by the orthodox (rational) model of public administration. Because the amount of change in urban land use over, say, a decade, is so small relative to the area of a territory – in England it amounts to less than two per cent

(Bibby and Shepherd 1990, 1996, 1997) – these data cannot be used to produce a strategic picture of land use. Administrative sources of land use data must, therefore, be complemented by more basic information gathering.

In this chapter the focus is on the authors' work for national and local governments in the UK. Although GIS technology transcends barriers of language and political organisation, the processes of forming and implementing strategies for the environment generally do not. Both the scope of policies and the range of administrative data generated for strategic purposes are best understood in specific institutional contexts. However, even in the UK, where there has been half a century of strong land use planning, appropriate land use data to support strategic planning have been more notable by their absence than their presence. The pre-GIS response to lack of land use information was two massive national scale land utilisation studies in which data were collected in the field and recorded on paper maps (Coleman 1962; Stamp 1948). GIS, as an integrating technology, appears to offer, at first glance at least, an extremely attractive alternative to such costly and organisationally difficult exercises. This is one of the key reasons why GIS and related technology are central to the proposal of the UK Department of the Environment for the development of a comprehensive and detailed National Land Use Stock System (Dunn and Harrison 1994).

2 LAND COVER OR LAND USE?: MEANING AND SPATIAL SCALE

The use of GIS to combine data relating to land use raises issues which take us to the core of the concept of land use itself. These include the relationship between the definition of a land use, the definition of the 'parcels' into which land is divided, and the issues of acquiring empirical data about what occupies a particular element of the Earth's surface. A key concept underlying all these issues is that the term 'land use' defines a social purpose and not a set of physical qualities. This notion underlies the distinction between 'land use' and 'land cover' (see, for example, Dickinson and Shaw 1977; Rhind and Hudson 1980). Studies of land cover attempt to describe the Earth's surface with minimal reference to social purpose, referring to '. . . the vegetational and artificial constructions covering the land's surface' (Burley 1961). In practice, however, the application of this distinction proves to be elastic. Land cover descriptions should refer to the 'stuff' that covers the surface of the Earth in terms of its physical structure (see also Aspinall, Chapter 69; Barnsley, Chapter 32; Estes and Loveland, Chapter 48). This may be of a natural kind (e.g. a tree or water), or an artefact (e.g. concrete or tarmac).

Descriptions of land use, by contrast, are descriptions of social purpose. They refer to objects distinguished by function. Thus a school is a school by virtue of its educational function and not its physical structure. The term 'car park' refers to a land use, whilst 'paved area' refers to the land cover associated with that use. The fact that land use is social purpose means that many more datasets can be used to investigate land use matters than is customarily assumed. This is demonstrated in the course of this chapter, and this distinction underlies much of the discussion of Martin (Chapter 6). Land use studies may also be characterised by their scale. The term 'scale' applies here in two senses: it means both the spatial extent of the objects of interest and the generality of the conception of social purpose employed. Figure 1 depicts GIS applications in land use studies as ranging from those concerned with the use of individual land parcels, through the recognition of residential areas or other types of urban sector, to the definition of settlements, urban areas, or rural regions such as 'countryside character' areas or landscape types. A key challenge for the GIS land use analyst interested in strategic issues and policy is how the same data may be used to realise these conceptions at each of the representative scales.

Finally, there is the important matter of data acquisition in land cover/land use studies. Acquiring data about the matter that occupies a particular part of the Earth's surface is expensive. Traditional methods of collecting land use data by field survey start with a cartographic representation which forms the 'frame' within which observations of land use are fitted. Technology in the form of remotely-sensed imagery, particularly in combination with GIS, seemed, at one time, to offer the hope of measuring land cover without the complexities associated with the idea of purpose and the problems of representation (Davis and Simonett 1991). The streams of data collected through remote sensing relate to minimal elements of the Earth's

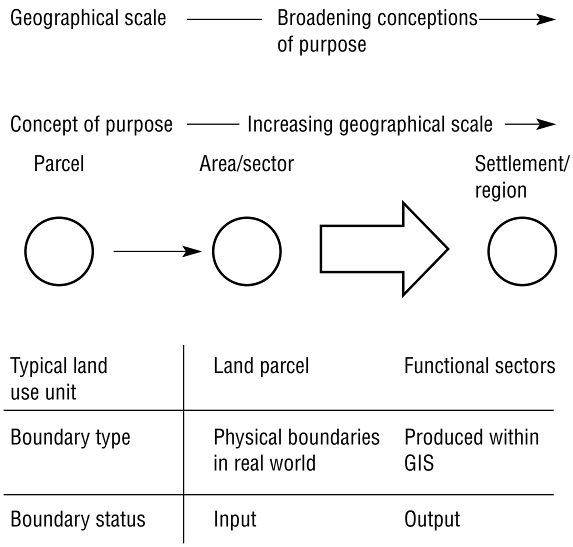


Fig 1. GIS in land use analysis: increasing scale and broadening social purpose.

surface and themselves have no notion of purpose. An individual 'pixel' of land cover data would represent a point to the left of individual land parcels in the 'scale arrows' in Figure 1.

3 LAND COVER DATA VIA MECHANICAL PERCEPTION

Unfortunately, recourse to mechanical perception as a means of collecting land cover data is not a panacea. Notwithstanding some of the developments described by Barnsley (Chapter 32) and Fischer (Chapter 19) in so-called 'intelligent' and pattern-seeking image classifiers, there are two main issues here. First, it is not clear that remote sensing data are capable of revealing the physical structure of matter on the Earth's surface and hence permitting the automatic identification of land cover. Second, it is by no means always the case that inferences can be made about land use from knowledge of physical structure.

With regard to the first issue, there can be no doubt that remote sensing and other imagery can contribute to our understanding of land cover sufficient for certain practical purposes. The Institute of Terrestrial Ecology in Great Britain, for example, has been able to produce a land cover map of Great Britain (Bunce et al 1992; Fuller et al 1994). This is based on LANDSAT Thematic Mapper data which record visible and infra red radiation reflectance from 30 m squares on the ground providing digital measures of reflectance in seven broad bands of the electromagnetic spectrum. These data are processed by the Institute of Terrestrial Ecology to generate a 25-fold classification of land cover types including an 'urban development' and 'suburb-rural development' class. A simplified version with 17 cover types has been included in the Countryside Information System, funded by the UK Department of the Environment as a decision support system for policy and planning (Department of the Environment 1994a, 1994b). According to Fuller and Groom, '. . . the [resulting] maps have been compared to various ground based and aerial surveys and, depending on the level of spatial detail to be examined and the classes in question, results indicate a seventy-five to ninety-five per cent success rate in mapping the land cover . . . for most classes these represent the most accurate if not the only representations of British land cover, certainly in the last 30 years' (Fuller and Groom 1993).

The second problem, that of inferring land cover from unmediated sensor perception, is of some importance. Satellites return measures of spectral radiance from different parts of the electromagnetic spectrum referring to arbitrary elements of area. These quasi perceptual mechanisms capture the attributes only of the scan area of their receptors. Such perceptual limits define the basic elements of land 'covered'. Interpretation of these digital data, however, is far from straightforward. Data relating to solar and thermal wavelengths are weather dependent and use of remote sensing imagery involves not only georeferencing of images but also the need for sensor calibration and correction for atmospheric, illumination, and viewing geometry effects (Duggin 1985). Even with extensive 'ground truthing' (often, on cost grounds, on the basis of samples which are statistically inadequate), remote sensing imagery may fail to provide satisfactory information about land cover. Thus, in a recent paper, satellite data alone are discounted as a means of updating the land cover map of Scotland (Birnie 1996). This echoes Coppock and Kirby's (1987) claim that very few land cover studies using digital image processing in Great Britain had produced satisfactory results.

In practice, therefore, it has for long been seen as necessary to complement remote sensing data with a range of other data (Aldrich 1979; Anderson and Hardy 1976), and to enhance them by the application of technologies such as GIS. Air photo interpretation is an important source of additional land cover information (see Dowman, Chapter 31). It was used, for example, in the production of the Land Cover of Scotland 1988 dataset (Dunn et al 1995). Here, information is transferred to Ordnance Survey 1:25 000 base maps and then digitised. The combined use of a range of land cover sources is well illustrated by the Monitoring Landscape Change Project commissioned in 1984 by the UK Department of the Environment (Hunting Technical Services 1986). This project used air photo interpretation, satellite data analysis, and field data collection to generate information about the current distribution of land cover features in England and Wales and about rates of change since 1940. In these projects some of the ambiguities of the interpretation of remote sensing data are partly reduced by reference to the physical barriers that partition the Earth's surface – field boundaries for example – and an understanding of other aspects of human spatial organisation (Dunn et al 1995). It thus turns out in practice that understanding of land use is important in generating land cover information.

4 LAND USE DATA AND SPATIAL REPRESENTATION

Although ecological interests motivate a concern for land cover as part of an integrated physical system, Britain's regulatory planning effort is primarily concerned with land use (Cullingworth and Nadin 1994). The prime sources of data here are not unmediated mechanical perception but are rooted in spatial and other representations, whether these be digital definitions of urban areas (Ordnance Survey 1995), policy areas defined on local plans (Healey 1986), or simply lists of retailers and other commercial organisations as in machine readable 'Yellow Pages' directories of business telephone users (Bibby 1992). In creating such representations GIS plays a key role, but the use of GIS to generate land use information for policy highlights the incommensurability of different land use descriptions and demands their resolution. It was, for example, the introduction of information systems such as, in the UK, the General Information System for Planning (Department of the Environment 1972), that prompted the development of a National Land Use Classification and generated debate about definitions of land use and 'activity' (Department of the Environment 1975; Dickinson and Shaw 1977). The Department of the Environment report noted, for example, the '. . . lack of general consensus among those consulted on basic questions about the concept of a standard classification'. Moreover, differences in meaning imply differences in geometry and vice versa, a fact which becomes increasingly important as more general social purposes are defined in land use studies (i.e. in moving rightwards along the arrows of Figure 1). Broader discussions of these representational issues are provided by Raper (Chapter 5) and Martin (Chapter 6).

The practical significance of such issues can be seen in the attempts to answer the apparently simple policy question: how much land has been developed for industry and employment? Because of changes in the technology of production, industrial development now frequently takes the form of business parks – commercial and industrial units set in landscaped open space. Typically, less than one-third of a business park is given over to buildings, the remainder being covered by grass, trees, open water, soft landscaping, and car parking. Nevertheless, the amount of land in category 'B1' (an administrative category in England and Wales indicating light industry or office use), may be argued to be three times the area of such buildings and would be indicated as such in local plans. There is a disjunction here between the concerns of GIS technologists and the needs of practitioners. GIS technologists are characteristically more concerned with error in digitising the boundary of areas (perhaps 2 per cent), than with that attributable to the problem of meaning, which could be 300 per cent (see, for example, Chrisman 1987; Unwin 1995).

5 THE PROBLEM OF LAND PARCELS

The discussion to this point implies that land use studies which use GIS must either produce standardised definitions or develop methods of reconciling meanings. Land use analysts, particularly those concerned with Land Information Systems or 'LIS' (Dale and McLaren, Chapter 61), have tended to give priority to the division of space and devote considerable effort to defining standardised land parcels. Applications in this vein which predate widespread use of GIS have been subsumed within later GIS developments, culminating in the UK in the proposal for a national land information system or 'NLIS' (Dale and McLaren, Chapter 61; Smith 1994; see also Smith and Rhind, Chapter 47, for a general discussion of such 'framework data'). The requirement for standardised land parcels in such work has resulted in the definition of a British Standard Basic Land and Property Unit or 'BLPU' (BS 7666 Part 2). See also Pearman (1993), Pugh (1992), and Sabel and Ralphs (1994).

Standardisation of land parcels could proceed on a number of bases. Dale and McLaughlin note, for example, that parcels may be defined by reference to land ownership or an area subject to a tax as well as to a unit of use (Dale and McLaren, Chapter 61; Dale and McLaughlin 1990). The (incomplete) ownership boundaries defined by Her Majesty's Land Registry Agency (HMLR) scheduled to be accessible online by 1998 (Sabel and Ralphs 1994) is an example of the first; whilst the parcels used for non-domestic rating purposes are an example of the second. It would seem likely, however, that different bases will generate parcels of significant difference. In the majority of cases they coincide, the more so where they refer to units of residential property. Hardie (1993), for example, estimates that 80 per cent of property inquiries can be successfully handled by reference to postal addresses. Work on the NLIS pilot project in Bristol, UK, attempted to match Valuation Office and Land Registry data in two districts of Bristol. While there was a 95 per cent match between HMLR and the Valuation Office Agency (VOA) for domestic properties, the matching rate with non-domestic properties was only 55 per cent (Smith 1994). In practice, however, it is the non-domestic properties which tend to be of most interest in land use studies and it is here that problems of incommensurable definition assume substantial importance.

As different substantive modes of parcel definition generate different parcels, the drive towards standardisation focuses increasingly on a particular representation of reality, namely the large scale map. Within such a framework, the land use activities recognised depend on the prior identification of curtilages and these in turn depend, in part, on cartographic representation. The cartographic imperative underlies the requirement of BS 7666 that if BLPUs were all identified at one time they would exhaust the land surface without gaps or overlaps. Where the physical structure of space does not dictate a 'unique' set of land parcels (e.g. in moorland and other open areas where land has not been physically parcelled up), cartographic 'Gestalt' takes over. The lineage of Ordnance Survey (OS) maps provides one set of predefined approximations to curtilages and forms the basis for national initiatives such as the proposed Land Use Stock System (Dunn and Harrison 1994) and the series of Land Use Change Statistics collected since 1985 (Sellwood 1987). The latter provides information about the area of land changing between 24 categories of land use at individual sites (represented as points), where OS have changed the lineage or annotation of large scale maps.

6 LAND USE ANALYSIS: BROADER PURPOSES, BROADER EXTENTS

The issues discussed above lie at the interface between site-based (local) and strategic studies. The interests of strategic policy makers tend to focus on broader definitions of social purpose and land use, and are usually concerned with wider areal extents. Thus, for example in the UK, there has been longstanding debate about the amount of vacant land in cities (Department of the Environment 1988a) and about the rate at which land is being converted from urban to rural uses (Best 1981; Hall 1988). Moreover, a key concern of planning policy is with attempting to manipulate urban growth to generate sustainable patterns of development (Breheny 1992; Department of the Environment 1994c). Moving along the arrows of Figure 1, very broad notions of land use are deployed alongside policy related constructs such as 'shopping centres', 'town centres', 'urban areas', and 'rural settlements'. On the basis of such constructs rest assessments of the implications of the settlement pattern of entire counties or regions for the costs of providing services or for achieving environmental sustainability.

The use of GIS to provide information to inform planning policy at this level involves an appeal to general ideas, the estimation of various aggregates, and the construction of broader geographical areas. The construction of policy-relevant information involves simple aggregation when, for example, generating information about development and redevelopment of industrial and commercial property as an indicator of the economic health of urban areas. The Department of the Environment (DOE) has commissioned work to develop such indicators from planning consent information and from the Land Use Change Statistics referred to above. The analyses reveal the geographical variation in the intensity of urban redevelopment in the late 1980s, highlighting the attractiveness of much of outer southeast England and also illustrating sharp contrasts between areas with first generation Urban Development Corporations (such as London and Merseyside), and neighbouring local authorities.

Alternatively, attempts may be made to generate aggregate information from sample data gathered in the field and GIS may be used in the construction of the sample. For example, the National Survey of Vacant Land in Urban Areas of England (Shepherd and Abakuks 1992) was based on an initial sample of 4100 Ordnance Survey maps at 1:1250 scale (i.e. each map covering 25 hectares) aligned to urban areas with more than 10 000 population. Map squares, which formed the unit for perambulation by land surveyors, were stratified into 21 'first stage' strata representing Standard Regions, DOE Administrative Regions, Urban Programme Areas, the Inner and Outer Areas of London, and the larger and smaller towns of southeast England. In addition, there were three 'second stage' categorisations of sampling units based upon the amount of urban land within each square (Figure 2). This procedure ensured efficiency in terms of field survey of vacant land parcels and provided early evidence of the need for sample re-adjustment (Shepherd and Abakuks 1992: 49–57). Surprisingly, this study is a rare example of the use of GIS in the derivation, management, and analysis of sampled land use data and, curiously, remains a neglected area even in calls for increased analytical functionality in GIS software (see, for example, Openshaw 1991).

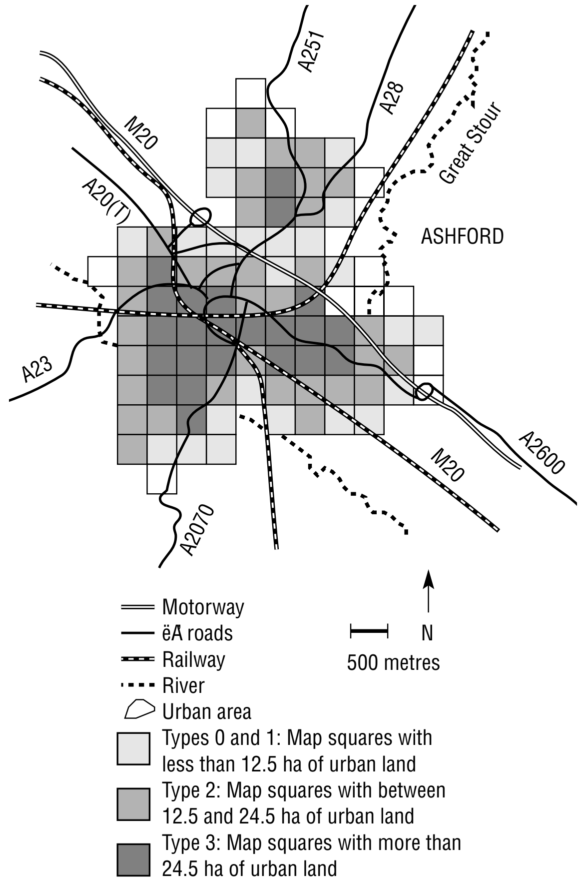


Fig 2. A national (strategic) spatial sampling frame for measuring vacant land. This figure shows the allocation of map square types to a single urban area. GIS facilitated the management of 4100 such squares across 800 urban areas and 63 sample strata.

7 CONSTRUCTING LAND USE POLICY AREAS

Alongside the construction of aggregate information, planning policy demands the construction of broader geographical areas. This may proceed on at least three distinct bases. The first involves simply digitising lines deemed to encircle areas regarded as possessing some general quality of policy import (e.g. 'shopping areas' or 'industrial areas'). The second involves defining broader areas by 'planning fiat' as in the case of UK Green Belts, National Parks, or policy areas in local plans (Rydin 1994). Third, GIS may be used to define broader areas and purposes on the basis of smaller areas of more specific kinds (such as individual land parcels). It is to this third approach that we now turn: Openshaw and Alvanides (Chapter 18) provide a spatial analytic perspective on such zonation problems.

7.1 Defining UK rural settlements

Much discussion of GIS has focused on large systems which form significant parts of the information infrastructure of the organisations they serve, whether they are regarded as encapsulating states of the world or as part of the organisation's communicative infrastructure (see, for example, Johannesson 1995). Bureaucracies concerned with land use planning are no exception and policy makers frequently demand the construction of 'one-off' analyses for strategic purposes. The reuse of familiar, easily available datasets or the operational datasets of individual organisations can, with a little imagination, be made to illuminate broader issues. Such analyses exploit both the analytic functionality of GIS and the nature of land use as social purpose to address policy issues.

This approach can be illustrated by work undertaken to construct a gazetteer of rural settlements. The requirement for such a gazetteer comes from several government departments. For example, both the Rural Development Commission and the Housing Corporation (concerned with the financing of social housing) in England seek, for various reasons, to identify rural settlements and to estimate their populations. To do this at a national scale is a significant undertaking. Map-derived gazetteers of place names exist but are of low spatial resolution and invariably lack population information for villages. The reason for this lies in the lack of a tractable and consistent relationship between official census reporting units and physical settlements (Coombes 1995). Within a GIS framework this problem has been circumvented by the use of a geocoded address list – Royal Mail's Postcode Address File on CD-ROM (now called Address Manager) – which permits the 'construction' of settlements on the basis of small clusters of individual properties.

Using these data, two approaches to approximating physically defined rural settlements can be employed. Amongst the data items in Address Manager are locality names associated with individual properties (e.g. 'Bladon', Oxfordshire, UK) and a UK national grid reference held to 100 m resolution (Raper et al 1992). It is thus possible, first, to aggregate delivery points into minimal reporting units ($100m^2$ i.e. hectare cells). By amalgamating contiguous occupied units, 'settlements' can be identified and provided with an explicit geometry. Alternatively, individual properties can be aggregated on the basis of a 'locality' name – a 'natural language' approach which reflects the terms people customarily use to describe where they live and which represents an attempt to infuse cognitive constructs into GIS (see Mark, Chapter 7).

Using the latter approach, calculation of mean 'eastings' and 'northings' for the referenced properties provides a spatial reference for the settlement. The first approach was implemented by creating an ARC/INFO point coverage converted to GRID on the basis of dwelling density and then converted to a polygon coverage representing 'settlements'. The second approach used ORACLE to define weighted centroids which were then imported as an ARC/INFO point coverage. The final product was constructed by overlaying the point-referenced clusters defined on the basis of locality names on official urban area definitions (Ordnance Survey 1995), to exclude those localities typically regarded as 'urban'. Populations of the settlements so defined were then estimated on the bases of dwelling counts derived from Address Manager and locally variable household size estimates generated on the basis of census enumeration district data converted to a grid (Rural Development Commission/Housing Corporation 1997).

7.2 Synthesising urban sectors: the example of UK shopping centres

The identification of town centres and shopping centres, and questions of their accessibility, provide a more complex example of the construction of areas for land use policy. Two examples of such work can be given: the impact on retail businesses of parking and waiting restrictions on strategic traffic routes in Greater London (so-called 'Red Routes'); and the creation of the strategic policy framework for planning retail investment across London.

The first example illustrates how terms such as 'town centres' and 'accessibility' may be expressed in GIS, and thus contribute to the further development of policy. The UK government has recently strengthened retail planning policy by seeking to direct retail investment into existing urban areas that are highly accessible by public as well as private transport (Department of the Environment 1988b). The key to describing every, even the lowest, level of the retail hierarchy across a major metropolitan area in a short, client driven timescale, lies in the exploitation of non-standard land use data.

For these studies, lists of shops from the Business Database (i.e. postcode-referenced and machine readable Yellow Pages), were used to construct shopping centres and to supplement more traditional information about retail 'offer' provided by proprietorial sources such as the 'GOAD' shopping centre maps for the UK. Employee size band information which forms part of the Business Database information was converted to estimated employment for each individual shop as a first step. Explicit geometry was provided by linking to the unit postcode in Address Manager and then creating an ARC/INFO point coverage. Employment estimates generated from the list data were aggregated into 100 m × 100 m (1 hectare) cells and converted to a grid representation. This made it possible to define areas where retail employment density exceeded ten jobs per hectare. Contiguous hectare cells with retail densities above this threshold were treated as 'shopping centres'.

Other research on the definition of centres of 'high accessibility' shows how such constructed areas can be combined with other planning policy constructs. 'Accessibility' is another term from natural language of the highest land use policy importance which imaginative use of GIS has helped to make operational (London Planning Advisory Committee 1994). In this case, an operational definition of accessibility was provided by modelling the anticipated turnover of a hypothecated archetypal retail outlet at any hectare cell where current retail employment density exceeds ten persons per hectare. This could be achieved by bringing together information about estimated spending by area of residence, the nature of retail destinations, and travel times by transport mode. Recourse to travel time matrices, from public and private transport models, and small area retail expenditure estimates completed the data requirement. ARC/INFO played the vital role in overlaying the zoning systems (wards for retail expenditure), two differing sets of transport zones, and the synthesised retail areas, thus allowing the calculation of factors for estimating 'modal' ward-to-shopping-centre travel times. The results, which highlight the marked contrast between the city centre serving pattern of public transport accessibility and the high accessibility of outer suburban areas to private car users, are shown in Figure 3. GIS has made little impact so far on specialised land use/transportation modelling. This example demonstrates the integration of land use and travel time data for this purpose, though much analytical work had to be carried out outside of the GIS environment. In substantive terms, these patterns demonstrate very clearly the difficulty of achieving land use planning goals where both private sector interests and private car users favour peripheral locations.

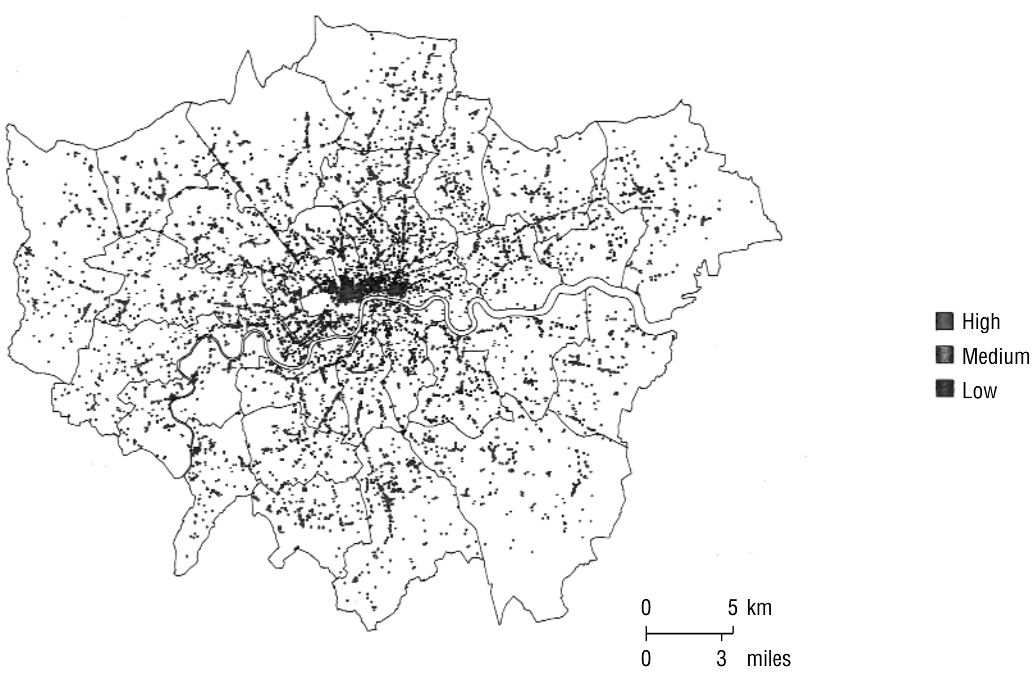


Fig 3. Integrating land use and accessibility data for identifying high inaccessibility shopping centres.

8 PROJECTING URBAN GROWTH AND CHANGE IN ENGLAND

More recent applications of GIS to land use studies have demonstrated its ability to penetrate to the heart of the policy debate. Research on urbanisation in England (Bibby and Shepherd 1996), has produced projections and graphics which illustrate why Government has been treading so warily in what has become a political minefield (*Planning*

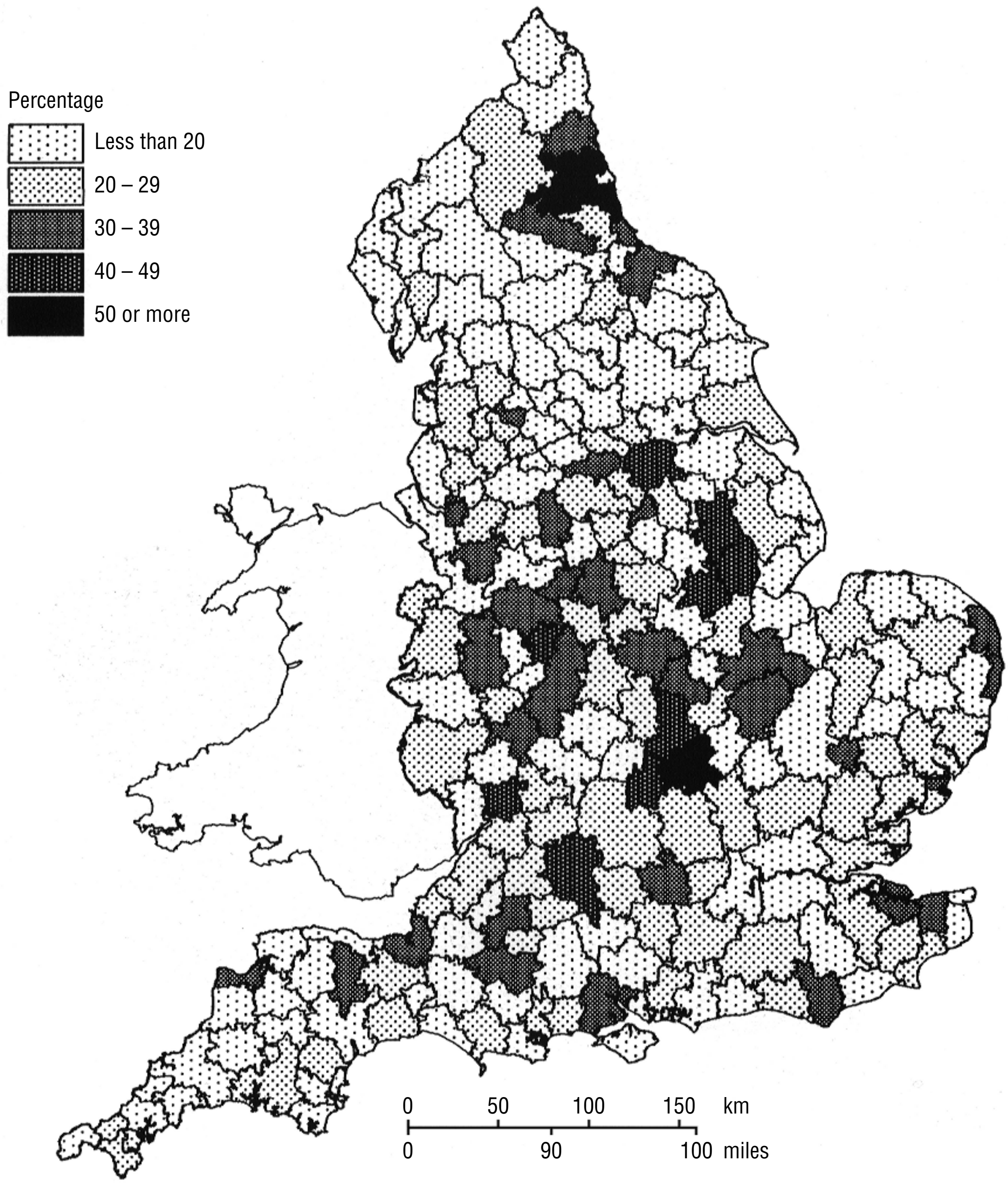


Fig 4. The projected rate of urban growth in England, 1991–2016

1996). Despite the pivotal role of rural-to-urban land conversion in the origins and continuing debate on land use planning in Britain, the factual basis for assertions about the rate at which urban growth is actually taking place at national and regional levels has been extremely weak. This has been given added policy weight with the publication of the most recent household projections which suggest that land must be found to accommodate 4.4 million new households by 2016 (Department of the Environment 1996). Using several different datasets, but principally two relating to urban areas (Ordnance Survey 1995) and land use change sites, the data integrating and analytic power of GIS has been used to model the future pattern of urbanisation in England on both administrative and socioeconomic spatial bases. This is shown in Figure 4, where the projected rate of urban growth is the area of land changing from urban to rural uses as a percentage of the land already in urban use. GIS enables us easily to represent growth on an administrative (county) and socioeconomic (travel to work) basis.

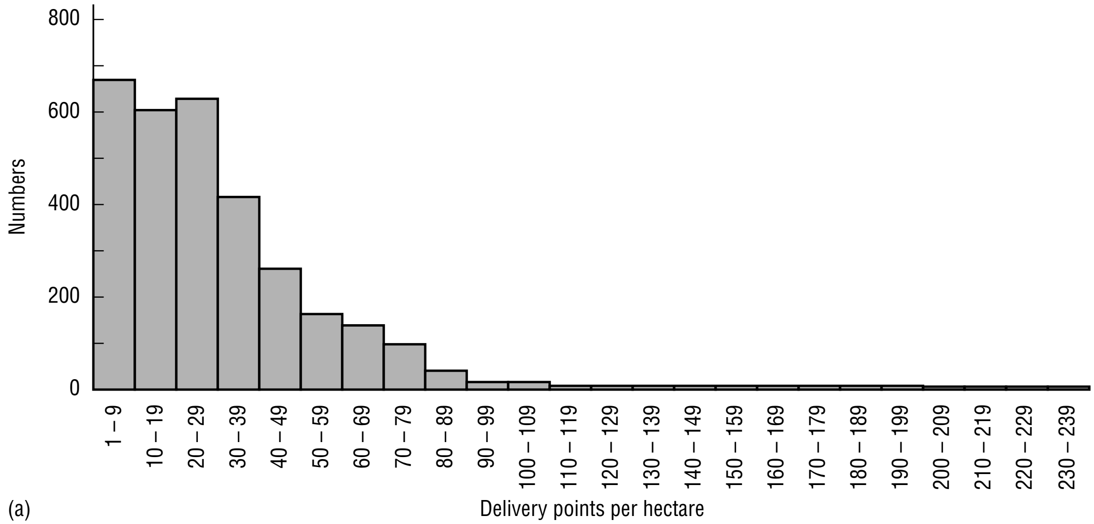
9 SYNTHESISING URBAN AREAS

Work on synthesising urban areas has mainly used ‘bespoke’ (albeit very new) sources of land use data managed in a GIS framework. Using techniques similar to those described for rural settlements in section 7.1 above, urban areas have been constructed from detailed data. Such data are not normally considered as land use-oriented. Here, areas with broader social meaning are produced without the need to digitise a line drawn around the object which the brain imposes upon the traces on a map (itself the product of a previous construction). This procedure is illustrated by the use of postal address points alone to define urban areas from the number of residential delivery points in any hectare cell, without reference either to area boundaries or to the configuration of underlying parcels. This method has been used by Bibby (1992) in finding paved areas in the Frome catchment for calculating runoff for drainage purposes on the basis of a delivery point density cutoff. The results shown in Figure 5 illustrate how the high resolution ($100m^2$) of address-based data from Royal Mail’s Address Manager database allows an accurate determination of the paved area of a river catchment for flood analysis purposes. Among the uses for this technique have been the estimation of urban areas where insufficient conventional data are available (Bibby 1992) and in investigations of settlement form on the need to travel (Halcrow Fox/SERRL 1997).

10 CONCLUSIONS

These examples illustrate, in broad terms, a move from left to right on Figure 1. In such a move the distinction between land use data and other data becomes less clearcut. Eventually, the distinction between land use and other data breaks down entirely. If GIS is treated as a constructional system, even data presented in the form of address lists may be used to generate information about policy-relevant constructs not only as in the examples above, but also in relation to a range of other applications including local employment analyses, urban sectoral maps, and a classification of rural settlement patterns. Moreover, indicators of the extent of urban development and redevelopment, based on aggregations of land use change information, can be used to reveal facets of the health of a local economy and so contribute towards the assessment of potential for urban regeneration, now a crucial concern of land use planning policy in the older industrialised countries (Bibby and Coppin 1994).

In more general terms, this chapter has attempted to illustrate some issues which arise when GIS is put to work in the interests of land use policy. It has moved from considering the biophysical character of tiny elements of the Earth’s surface without reference to social purpose, to notions of land use at a broad spatial scale which involve appeals to general ideas about the way the world is and how it might be organised. The chapter has illustrated how intentionality permeates the treatment of land use through both representation and policy, and as such echoes the general representational arguments presented by Martin (Chapter 6) and Raper (Chapter 5). The boundaries of geographical objects expand and contract as purpose shifts allowing the definition of a much wider range of geographic objects than ‘traditional’ use of GIS appears to permit. From this perspective GIS may be treated as a constructional system and GIS users may be seen as wittingly or unwittingly constructing the world. It is for this reason that the notion that land use applications of GIS are limited merely to drawing maps of land parcels should be rejected.



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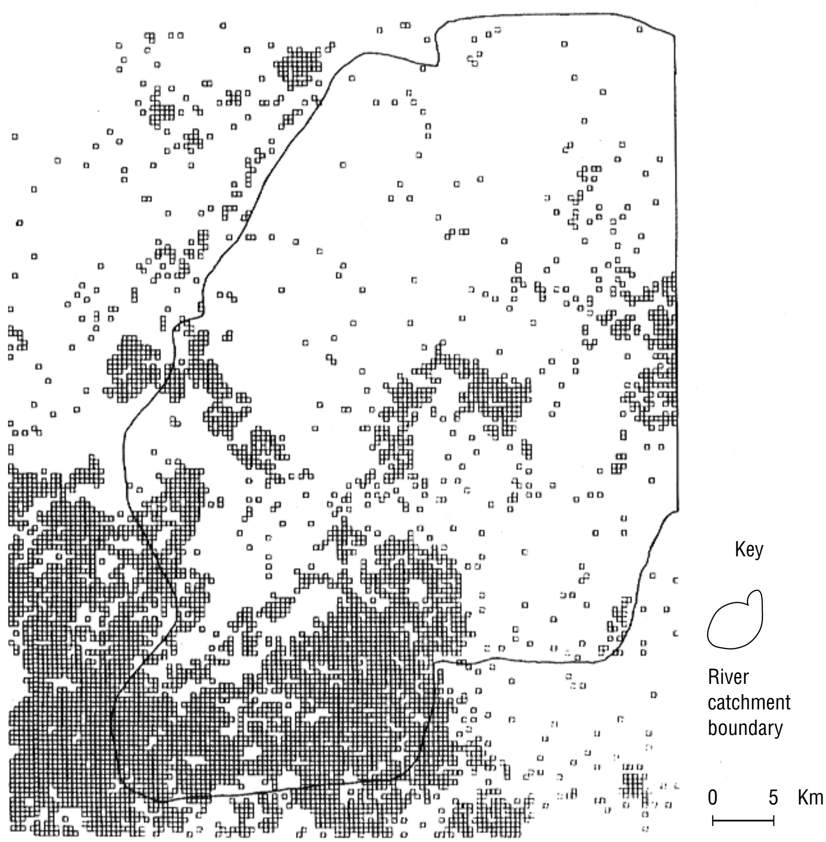

(b)

Fig 5. (a) The frequency distribution of address densities for a catchment area of the River Frome, Bristol, UK; (b) a plot of postcode grid references displayed as one-hectare squares indicating urban land.

References

Aldrich R C 1979 *Remote sensing of wild land resources, a state of the art review*. General Technical Report RM 71. Fort Collins, GIS World Inc.

Anderson J R, Hardy E F 1976 A land use and land cover classification system for use with remote sensor data. *US Geological Survey, Professional Paper 964.* Washington, USGS

Best R H 1981 *Land use and living space*. London, Methuen

Bibby P R 1992 Postcodes in town planning. In Raper J, Rhind D W, Shepherd J W (eds) *Postcodes: the new geography*. Harlow, Longman: 230–3

Bibby P R, Coppin P 1994 Analyses of land use change statistics. *SERRL Occasional Monographs No. 1*. London, Birkbeck College Department of Geography

Bibby P R, Shepherd J W 1990 *Rates of urbanisation in England 1991–2001*. London, Her Majesty's Stationery Office

Bibby P R, Shepherd J W 1992 GIS: strategic choice or laundry lists? *Proceedings, Association for Geographic Information Annual Conference Birmingham, England:* 2.31. 1–2.31.7

Bibby P R, Shepherd J W 1996 *Urbanisation in England: projections 1991–2016*. London, Her Majesty's Stationery Office

Bibby P R, Shepherd J W 1997 Projecting rates of urbanisation in England 1991–2016: method, policy applications and results. *Town Planning Review* 68: 93–124

Birnie R 1996 *Methodologies for detecting national land cover changes in Scotland*. Report on behalf of the Scottish Office Agriculture, Environment and Fisheries Department

Breheny M (ed.) 1992 *Sustainability and urban form*. London, Pion

Bunce R G H, Barr C J, Fuller R M 1992 Integration of methods for detecting land use change, with special reference to Countryside Survey 1990. In Whitby M C (ed.) *Land use change: the causes and consequences*. London, Her Majesty's Stationery Office: 69–78

Burley T M 1961 Land use or land utilisation? *Professional Geographer* 13: 18–20

Campbell H J, Masser I, Poxon J, Sharp E 1993 *Monitoring the take up of GIS in British local government*. London, Local Government Management Board

Chrisman N R 1987b The accuracy of map overlays: a reassessment. *Landscape and Urban Planning* 14: 427–39

Coleman A 1962 The Second Land Use Survey: progress and prospect. *Geographical Journal* 127: 168–86

Coombes M 1995 Dealing with census geography: principles, practice and possibilities. In Openshaw S (ed.) *Census users' handbook*. Cambridge (UK), GeoInformation International

Coppock J T, Kirby R P 1987 *Review of approaches and sources for monitoring changes in land cover*. Edinburgh, Scottish Development Office

Coppock J T, Rhind D W 1991 The history of GIS. In Maguire D J, Goodchild M F, Rhind D W (eds) *Geographical information systems: principles and applications*. Harlow, Longman/New York, John Wiley & Sons Inc. Vol. 1: 21–43

Cullingworth J B, Nadin V 1994 *Town and country planning in Britain*, 11th edition. London, Routledge

Dale P F, McLaughlin J D 1990 *Land and information management*. Oxford, Clarendon Press

Davis F W, Simonett D S 1991 GIS and remote sensing. In Maguire D J, Goodchild M F, Rhind D W (eds) *Geographical information systems: principles and applications*. Harlow, Longman/New York, John Wiley & Sons Inc. Vol. 1: 191–213

Department of the Environment 1972 *General information system for planning*. London, Her Majesty's Stationery Office

Department of the Environment 1975 *National Land Use Classification*. London, Her Majesty's Stationery Office

Department of the Environment 1988a *Vacant urban land, a literature review 1976–1986.* Cambridge (UK), University of Cambridge, Department of Land Economy

Department of the Environment 1988b *Planning Policy Guidance Note 6: Major retail development*. London, Her Majesty's Stationery Office

Department of the Environment 1994a *Countryside Information System, user guide* 5. London, DOE

Department of the Environment 1994b *Countryside Information System, dataset guide*. London, DOE

Department of the Environment 1994c *Planning Policy Guidance Note 13: Transport*. London, Her Majesty's Stationery Office

Department of the Environment 1996 *Household growth – where shall we live*? London, Her Majesty's Stationery Office

Dickinson G C, Shaw M A 1977 What is land use? *Area* 9: 38–42

Duggin M J 1985 Factors limiting the discrimination and quantification of terrestrial features using remotely-sensed radiance. *International Journal of Remote Sensing* 6: 3–27

Dunn R, Harrison A 1994 *Feasibility study for deriving information about land use stocks*. London, DOE

Dunn R, Swanwick C, Harrison A 1995 *Evaluation of the Land Cover of Scotland 1988 Project*. Final Report. Edinburgh, Scottish Office Environment Department

England J, Hudson K, Masters R, Powell K, Shortridge J (eds) 1985 *Information systems for policy planning in local government*. Harlow, Longman

Fox C J, Miller H T 1995 *Postmodern public administration: toward discourse*. Thousand Oaks, Sage Publications

Fuller R, Groom G B 1993 The Land Cover Map of Great Britain. *Mapping Awareness* 7(9): 18–20

Fuller R, Groom G B, Jones A R 1994 The Land Cover Map of Great Britain: an automated classification of LANDSAT Thematic Mapper data. *Photogrammetric Engineering and Remote Sensing* 60: 553–62

Halcrow Fox/SERRL 1996 *Rural accessibility in England*. Report to the Rural Development Commission. London, Birkbeck College

Hall P 1988 The industrial revolution in reverse? *The Planner* 74: 15–19

Hardie P 1993 Using a gazetteer and spatial analysis to integrate local authority records. *Mapping Awareness* 7(10): 28–30

Healey P 1986 The role of development plans in the British planning system, an empirical assessment. *Urban Law and Policy* 8: 1–32

Hunting Technical Services 1986 *Monitoring landscape change*. Report to the DOE. 10 vols. Elstree, Hunting Technical Services

Johannesson P 1995 Representation and communication: a speech act-based approach to information systems design. *Information Systems* 20: 291–303

London Planning Advisory Committee 1994 *High accessibility town centres in London*. London, LPAC

Masser I, Campbell H, Craglia M 1996 *GIS diffusion: the adoption and use of GIS in local government in Europe*. London, Taylor and Francis

Morgan P H, Nott S 1995 *Development control: law, policy and practice*, 2nd edition. London, Butterworth

Openshaw S 1991c Developing appropriate spatial analysis methods for GIS. In Maguire D J, Goodchild M F, Rhind D W (eds) *Geographical information systems: principles and applications*. Harlow, Longman/New York, John Wiley & Sons Inc. Vol. 1: 389–402

Ordnance Survey 1995 *Urban Areas 91, user guide*. Southampton, Ordnance Survey

Pearman H 1993 Designing a land and property gazetteer. *Mapping Awareness* 7(5): 19–21

Planning 1996 Government's urban growth projections. London, November

Pugh D 1992 The National Land and Property Gazetteer. *Mapping Awareness* 6(5): 32–3

Raper J F, Rhind D W, Shepherd J 1992 *Postcodes: the new geography*. Harlow, Longman

Rhind D W, Hudson R 1980 *Land use*. London, Methuen

Rural Development Commission/Housing Corporation 1997 *The rural settlements gazetteer of England*. London, Rural Development Commission/Housing Corporation

Rydin Y 1994 *The British planning system: an introduction*. London, Macmillan

Sabel C E, Ralphs M P 1994 Domesday 2000, a National Land Information System for Britain. *Mapping Awareness* 6(5): 55–8

Sellwood R 1987 Statistics of changes in land use: a new series. *Statistical News* 79: 11–16

Shepherd J, Abakuks A 1992 *The national survey of vacant land in urban areas of England*. London, Her Majesty's Stationery Office

Smith B 1994 National Land Information System pilot project. *Mapping Awareness* 8(10): 34–5

Stamp D 1948 *The land of Britain: its use and misuse*. Harlow, Longman

Tomlinson R F 1967 *An introduction to the geographic information system of the Canada Land Inventory*. Ottawa, Department of Forestry and Rural Development

Unwin D J 1995 Geographic information systems and the problem of error and uncertainty. *Progress in Human Geography* 19: 549–58

Wakeford R 1990 *American development control: parallels and paradoxes from an English perspective*. London, Her Majesty's Stationery Office

Waldo D 1948 *The administrative state: a study of the political theory of American public administration*. New York, Ronald Press