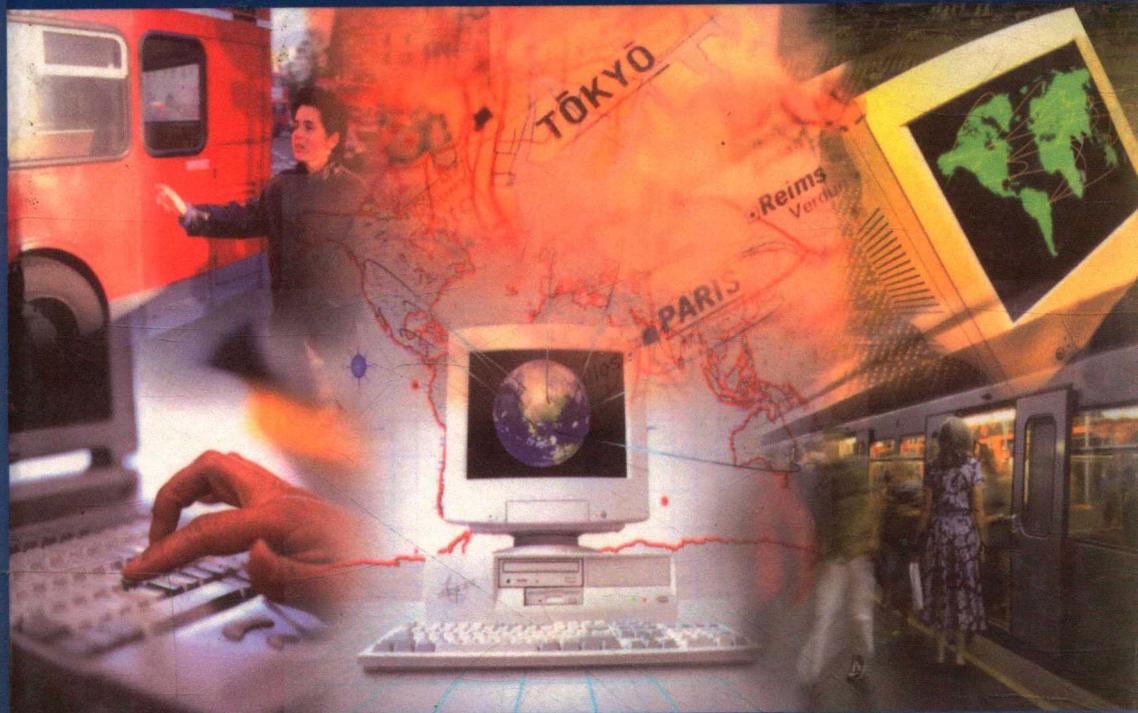


# APPLIED GIS and SPATIAL ANALYSIS



 WILEY

Editors

**John Stillwell**  
**Graham Clarke**

# Applied GIS and Spatial Analysis

**Editors**

**JOHN STILLWELL  
GRAHAM CLARKE**

*School of Geography, University of Leeds*



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# List of Contributors

**Shelley Alexander**, Department of Geography, Faculty of Social Sciences, University of Calgary, 2500 University Drive NW, Calgary, Alberta T2N 1N4, Canada

**Seraphim Alvanides**, Department of Geography, University of Newcastle-upon-Tyne, Newcastle-upon-Tyne NE1 7RU, United Kingdom

**Mark Birkin**, School of Geography, University of Leeds, Leeds LS2 9JT, United Kingdom

**Jan Bleeker**, GGD Rotterdam e.o., PO Box 70032, 3000 LP Rotterdam, The Netherlands

**Paul Boyle**, School of Geography and Geosciences, University of St Andrews, St Andrews, Fife KY16 9AL, United Kingdom

**António Câmara**, New University of Lisbon, 2825 Monte de Caparica, Lisbon, Portugal (and YDreams, SA, Madan Park, Caparica, Lisbon, Portugal)

**Tony Champion**, Department of Geography, University of Newcastle-upon-Tyne, Newcastle-upon-Tyne NE1 7RU, United Kingdom

**Graham Clarke**, School of Geography, University of Leeds, Leeds LS2 9JT, United Kingdom

**Martin Clarke**, GMAP Limited, 1 Park Lane, Leeds LS3 1EP, United Kingdom

**Mike Coombes**, Centre for Urban and Regional Development Studies (CURDS), University of Newcastle-upon-Tyne, Newcastle NE1 7RU, United Kingdom

**Massimo Craglia**, Sheffield Centre for Geographic Information and Spatial Analysis, University of Sheffield, Sheffield S10 2TN, United Kingdom

**Richard Culf**, GMAP Limited, 1 Park Lane, Leeds LS3 1EP, United Kingdom

**António Eduardo Dias**, University of Evora, Evora, Portugal (and YDreams, SA, Madan Park, Caparica, Portugal)

**Robin Flowerdew**, School of Geography and Geosciences, University of St Andrews, St Andrews, Fife KY16 9AL, United Kingdom

**A. Stewart Fotheringham**, Department of Geography, University of Newcastle-upon-Tyne, Newcastle-upon-Tyne NE1 7RU, United Kingdom

**Martin Frost**, South East Regional Research Laboratory (SERRL), School of Geography, Birkbeck College, University of London, 7-15 Gresse Street, London W1T 1LL, United Kingdom

**Stan Geertman**, URU and Nexpri, Faculty of Geographical Sciences, Utrecht University, PO Box 80.115, 3508 TC Utrecht, The Netherlands

**Richard Harris**, School of Geography and South East Regional Research Laboratory (SERRL), Birkbeck College, University of London, 7-15 Gresse Street, London W1T 1LL, United Kingdom

**Tony Hernandez**, Centre for the Study of Commercial Activity (CSCA), 350 Victoria Street, Ryerson University, Toronto, Ontario M5B 2K3, Canada

**Mark E.T. Horn**, Commonwealth Scientific and Industrial Research Organisation (CSIRO), Mathematical and Information Sciences, GPO Box 664, Canberra A.C.T. 2001, Australia

**Ken Jones**, Centre for the Study of Commercial Activity (CSCA), 350 Victoria Street, Ryerson University, Toronto, Ontario M5B 2K3, Canada

**Tom de Jong**, URU, Faculty of Geographical Sciences, Utrecht University, PO Box 80.115, 3508 TC Utrecht, The Netherlands

**Pauline Kneale**, School of Geography, University of Leeds, Leeds LS2 9JT, United Kingdom

**Steven Laposa**, PricewaterhouseCoopers (PwC), 1670 Broadway, Suite 1000, Denver, CO 80202, USA

**Paul Longley**, Department of Geography and Centre for Advanced Spatial Analysis (CASA), University College London, 1-19 Torrington Place, London WC1E 6BT, United Kingdom

**Paul Paquet**, Faculty of Environmental Design, University of Calgary, 2500 University Drive NW, Calgary, Alberta T2N 1N4, Canada

**Simon Raybould**, Centre for Urban and Regional Development Studies (CURDS), University of Newcastle-upon-Tyne, Newcastle NE1 7RU, United Kingdom

**Philip Rees**, School of Geography, University of Leeds, Leeds LS2 9JT, United Kingdom

**Peter Rogerson**, Department of Geography, University of Buffalo, Buffalo NY 14261, USA

**Linda See**, School of Geography, University of Leeds, Leeds LS2 9JT, United Kingdom

**John Shepherd**, South East Regional Research Laboratory (SERRL), School of Geography, Birkbeck College, University of London, 7–15 Gresse Street, London W1T 1LL, United Kingdom

**Paola Signoretta**, Sheffield Centre for Geographic Information and Spatial Analysis, University of Sheffield, Sheffield S10 2TN, United Kingdom

**David Simmonds**, David Simmonds Consultancy, Suite 23, Miller's Yard, Mill Lane, Cambridge CB2 1RQ, United Kingdom

**Andy Skinner**, MVA, 26th Floor, Sunley Tower, Manchester M1 4BT, United Kingdom

**John Stillwell**, School of Geography, University of Leeds, Leeds LS2 9JT, United Kingdom

**Grant Thrall**, PricewaterhouseCoopers (PwC), 1670 Broadway, Suite 1000, Denver, CO 80202, USA (and University of Florida, Gainesville, FL 32611, USA)

**Nigel Waters**, Department of Geography, Faculty of Social Sciences, University of Calgary, 2500 University Drive NW, Calgary, Alberta T2N 1N4, Canada

**Coen Wessels**, Nexpri, Utrecht University, PO Box 80.115, 3508 TC Utrecht, The Netherlands

**Leo van Wissen**, Faculty of Spatial Sciences, University Groningen, PO Box 800, NL-9700 AV Groningen, The Netherlands, and Netherlands Interdisciplinary Demographic Institute (NIDI), The Hague, The Netherlands

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# 1

## Introduction

*Graham Clarke and John Stillwell*

### Abstract

Applied work in geographical information systems (GIS) and spatial analysis has been a persistent component of research activity in geography and regional science for several decades. This introductory chapter of this book establishes the background to the contemporary flurry of applied activity, explains the structure of the book and introduces the contents of the chapters that constitute the various parts into which the book has been divided.

### 1.1 Background

The history of applied spatial modelling has been a chequered one. If we ignore the elements of simple numerical reporting in the early commercial geographies of the nineteenth century, then we can probably trace the origins of applied quantitative spatial analysis to the fields of transportation modelling, especially at the University of Pennsylvania, in the early 1960s (Herbert and Stevens, 1960; Harris, 1962). Mathematical geography became prevalent in planning circles both in the USA and in Europe from this time onwards. The early 1960s also witnessed the emergence of statistical geography: the search for patterns or similarities in spatial data sets and the testing for significance, with the aim of providing universal spatial theories and laws (or at least theories that worked well in the real world). Although this was often very empirical in nature, it seldom extended beyond the academic geography community. There are excellent summaries in Haggett (1965) and Haggett *et al.* (1977).

Foot (1981) has reviewed a number of the more well-known applications of large-scale models in the United Kingdom (UK) during the 1960s. The Portbury Dock

study in 1964 was one example of an application of mathematical modelling to estimate the future flow of exports through UK ports and hence the evaluation of the need for a new major dock facility at Portbury, in South West England. The Haydock shopping study (1966) was another classic example, incorporating a spatial interaction model of retail expenditure in North West England to estimate the potential revenues for a new regional shopping centre located roughly half-way between Liverpool and Manchester (a concept ahead of its time perhaps!). Another major study was the analysis carried out to quantify the impact of a third London airport at various locations in the South East of England. Paralleling these studies, were a large number of comprehensive land-use/transportation models built as part of local authority strategic planning. Batty (1989, 1994) has reviewed these applications in detail.

The fierce critiques of urban modelling in the 1970s (Lee, 1973; Sayer, 1976) brought the first era of applied modelling to an end. Lee believed the various large-scale models to be generally too complex, mechanical and ultimately unworkable. Sayer's critique was based on the role of agents in modelling – that is, that urban dynamics were as much the result of key decisions made by urban gatekeepers as they were due to land-use/transportation changes. In 1976, models were banned from being used in many UK retail planning enquiries because of the conflicting evidence they supposedly produced. More generally in land-use modelling, May (1991) argues that the decline in planning applications using models resulted from model-builders being too keen to present blueprints rather than alternative options. Wilson (1997) queries whether it was simply easier for planners to face the very difficult political decisions associated with cities 'in a haze rather than with maximum clarity' (Wilson, 1997, p. 18). Academics, meanwhile, retreated back to theory in an attempt to address the concerns expressed by humanist and Marxist geographers. For example, the 1970s and the early 1980s witnessed a research agenda dominated by the desire to incorporate dynamics into urban models (Allen and Sanglier, 1979; Wilson, 1981; Dendinos, 1985). As Wilson (1997) reflects: 'While it can be argued that the full breadth of the attack was misguided – Marxian economists, for example, had no hesitation in using mathematical models – the analysis does point to the need for an understanding of deeper underlying structures that might be at the core of urban evolution' (Wilson, 1997, p. 10).

For much of mainstream academic geography, however, quantitative methods had become irrelevant and indeed counterproductive as the focus switched from serving the interests of planners to looking for grand theories of social change. The cause of quantitative geography was not helped by the desertion of some of its key pioneers (especially in the UK) such as David Harvey and Doreen Massey. The UK story is mirrored in many other parts of Europe and the USA. The full story of the retreat from quantitative geography is well told by Johnston (1996).

However, some remained loyal to the cause. A few geography departments around the world remained strong quantitatively, whilst the growth of the discipline of regional science helped the surviving quantitative geographers find allies amongst regional economists and planners (Plane, 1994). Slowly, through the 1980s and into the 1990s, quantitative geography began to claw its way back into the discipline (although it would not, to date, seriously challenge the stranglehold of 'critical human geography'). The reasons for this are numerous and a fuller account is

provided by Clarke and Wilson (1987). However, it is clear that there were two fundamental drivers of change. The first was the focus anew on applications. Statistical and mathematical geography became much more focused on how it could solve real location problems in fields such as health, education, retailing, transport and deprivation analysis. The pioneers here were undoubtedly the quantitative geographers at the University of Leeds who began to find commercial applications for their models in both the public and private sector, leading to the formation of GMAP in the late 1980s (see Chapter 3). The second driver of change was the developments occurring in the fields of geographical information systems (GIS) and geodemographics. Interestingly, both of these originated outside the discipline of geography. However, as they became well known in planning and business circles, the quantitative geographers were quick to realise that they provided a new platform on which to sell their wares. In the UK, a number of geography departments benefited from the Economic and Social Research Council (ESRC) initiative to create a series of research laboratories in GIS (see the final chapter in this collection by Flowerdew and Stillwell for a review of this initiative).

Alongside these two major developments came a series of other enabling factors which helped to promote applied quantitative analysis. First, the personal computer (PC) allowed the planner (both public and private sector) to have immediate desktop access to powerful software for spatial mapping and analysis. Second, spatial data was also becoming more routinely available in most application areas, including planning, as evidenced in Stillwell *et al.* (1999). Third, pressure was mounting on academics to interact more with the outside world in order to attract new income streams. Finally, we might acknowledge a genuine sea-change in attitudes of many academics – an increase in the desire to see their models usefully applied to social and economic problems – as well as a parallel change of attitude by private and public sector clients who began to recognise more seriously the benefits available from the exploitation of large data sets by new geotechnologies. The variety of planning support systems now being used in practice (Geertman and Stillwell, 2002) is one reflection of this new interest. The more generic set of issues also allowed a new emphasis on applied research in regional science (Clarke and Madden, 2001), and in non-quantitative aspects of human and physical geography (Pacione, 1999).

## 1.2 Aims and Contents

Against this background, the aim of this book is to illustrate the applied nature of contemporary quantitative geography through a series of case studies. It is clearly only a selection but there are still only relatively few examples of commissioned research in the literature (for further examples, see Clarke and Madden, 2001). The paucity of applied work in academic journals is perhaps not surprising since the results of many such projects are confidential, especially for private sector applications. Here, however, we have collected together a suite of case studies of funded work which has been applied to particular real-world problems confronted by either private or public sector organisations. Between them, these case studies involve the application of GIS, statistical models, location-allocation models and network or

flow models. However, rather than presenting these case studies on the basis of the methodologies they adopt, the book is arranged thematically in four parts around important subject areas: business applications; social deprivation studies; transport and location problems; and national spatial planning applications.

The initial quarter of the book (Part One) contains a collection of chapters focused on applications in the private sector, predominantly drawn from retailing. The first two chapters draw upon experiences with various clients. This shows the strength of applied work in retail analysis. Both Jones and Hernandez and Birkin *et al.* draw upon their experiences with many global organisations involved in retail location analysis. Jones and Hernandez give a very useful US/Canadian overview of commercial applications of GIS and spatial analysis. Their main conclusion is that the market is moving (slowly!) from one of simple mapping to the use of more sophisticated data mining and visualisation techniques. This argument is taken up in Birkin *et al.* where the authors examine a number of difficult applied location problems that have been faced by a number of clients. They begin to show how these problems may be addressed from an analytical point of view. The study by Câmara and Dias is a very novel use of network analysis for guiding shoppers around a major shopping centre complex in Lisbon, Portugal, undertaken in cooperation with SONAE, the company responsible for running the shopping centre. As the use of mobile phones for location-based services becomes more sophisticated, it is apparent that their use for pinpointing the geographical location of various types of services will increase. There is an important role for spatial analysis in optimising the best ways to maximise access to geographical information of this sort. Finally, in this part of the book, Laposa and Thrall investigate the use of GIS and models for the study of house price variations for PricewaterhouseCoopers. Thrall has been involved with applications of GIS in the business sector for many years, specialising in the real estate sector (Thrall, 2002). The main contention of the chapter is that the use of GIS, three-dimensional modelling and visualisation of house sale prices provides greater explanatory power than typical hedonic residential price models for estimating zonal or regional average house prices.

The set of chapters that are presented in Part Two have been commissioned by various local authorities helping to expose different aspects of social problems, especially deprivation and crime. The second chapter by Boyle and Albanides examines a problem that many urban areas face in the UK. This is the so-called 'two-speed' growth problem. On the one hand, there are areas of cities experiencing rapid growth in the number of jobs, levels of service provision, house prices and/or residents. On the other hand, other parts of cities get left behind and remain as pockets of acute deprivation. In Europe, there are European Union (EU) monies available for those cities in most need of support. However, often the pockets of deprivation are not large enough to allow credible and integrated programmes to be mounted. This was the case in point with the city of Leeds, UK. The authors of this chapter, commissioned by the City Council, demonstrate how it is possible to identify a contiguous set of enumeration wards within the Leeds area which, when aggregated together, represent a relatively large concentration of households with a high deprivation score. The initial chapter in this part of the book, by Harris and Longley, takes a more reflective look at existing deprivation indicators used in socio-economic planning. In

particular, they evaluate the combination of data obtained from lifestyle databases with that available from high-resolution satellite imagery. They show how the latter can help to evaluate the degree of homogeneity in census-based deprivation scores (or income estimates) and offer a potential for representing deprivation or income clusters at more precise spatial scales. The third chapter relates deprivation in the city to the problems of child care. Sponsored by the local social service department, Craglia and Signoretta explore the use of GIS for the construction of a 'Children's Services Plan' in Sheffield, UK. In a sense, this is a children's census; data is put together on all aspects of children's health, status of care and behaviour (crime, attendance at school, etc.). Each of these variables is then ranked by small geographical area. The final product is a child deprivation score for the entire city. The final chapter in this part of the book is by Rogerson who looks at one dimension of social deprivation in more depth: namely, crime within Metropolitan Buffalo, sponsored by various city agencies. He uses GIS linked to the very latest spatial statistical analysis tools to find regions with significantly higher crime than could be expected under a random distribution of crime activity. He also uses various statistical techniques to examine the dynamics of crime patterns.

The set of chapters comprising Part Three relate to transport networks and location problems. The first chapter by Horn is a good example of using transport models to investigate the potential impact of a number of future transport plans. The case study is based on the Gold Coast, a rapidly expanding area of South East Queensland in Australia. The model is set up to help assess the viability of several road-based 'demand-responsive' transport modes (taxis, multi-taxis and so-called roving buses) designed to supplement existing bus, rail and taxi services. The analysis tool is a simulation model driven by demand simulators that replicate likely or future patterns of consumer demand. Network simulators help to service that demand by tracking the movements of individual vehicles and allocating the closest vehicle. The benefits and costs of operating such a system have been articulated and now the transport planners in Queensland have to make the ultimate decision of whether to introduce the scheme. The second chapter by Simmonds and Skinner uses a well-known land-use/transport model (DELTA) to examine the future transport plans of both West and South Yorkshire in the UK in the context of the preparation of Regional Planning Guidance for Yorkshire and the Humber (Government Office for Yorkshire and the Humber, 2001). As was noted in Section 1.1, land-use/transport models have a long history of applied success in planning. The model here helps to address two key questions: how can the authorities design an integrated and sustainable transport policy for the future, and how can the most urgent problems be specifically addressed? The following chapter by Geertman *et al.* reports the response to a classic geographical problem – where to site ambulance stations in a city context in order to minimise the time taken to access all parts of that city. The methodology adopted combines traditional shortest-path network analysis from a major proprietary GIS package with an in-house accessibility indicator package based on spatial interactions of flows. The work was commissioned by Rotterdam Municipal Health Authority. The final chapter by Alexander *et al.* reports on a very common environmental consequence of road construction, especially in areas well inhabited by wildlife. The construction of roads in such areas can cut-off access to pathways or

routeways historically used by various types of wildlife. The authors present a case study of the use of GIS to identify optimal placement sites for structures that facilitate wildlife passage across, or under, highways in the Canadian Rocky Mountains.

Part Four of the book contains a set of chapters that look at large-scale national social and economic problems. These are largely funded by government departments. The first chapter by Rees *et al.* was commissioned by the UK Department of Environment, Transport and the Regions (DTLR now the Office of the Deputy Prime Minister, ODPM). A key concern of DTLR was to balance population growth across the UK. In order to achieve this, they need to equalise future regional population growth in situ, but also to reduce migration losses from northern regions (flowing to the south). The chapter describes a two-stage migration model built to enable policy makers to investigate the first-round quantitative impacts of alternative economic and policy scenarios on gross flows of population between regions. The model used is a very disaggregated spatial interaction model, calibrated using statistical regression techniques. The second chapter continues the theme of policies for regional balanced population and economic growth. Van Wissen explores the concept of regional 'carrying capacities' as a framework for establishing policies on regional economic growth in the Netherlands. The concept of 'carrying capacity' is borrowed from ecology – the maximum use of land that can be sustained over time. This idea is translated into an economic context by a model of inter-industry linkages. It is argued that the growth potential of an individual firm in a locality relates to the size and composition of the population of firms in that locality. The final model is a mixture of a spatial interaction and an input–output model.

The chapter by Coombes and Raybould reports on the process of finding sites for a potential new UK government information service (funded by the Lord Chancellor's Department). It is another classic location problem and, not surprisingly, it fits into a framework of many public sector location–allocation problems. In this case, the problem is to locate a new information service for those couples facing the prospect of filing for divorce from a possible 647 candidate sites. The chapter by Frost and Shepherd looks at another issue of increasing concern to the UK DTLR (now ODPM) – rural accessibility. As the level of service provision declines in rural areas, there is an urgent need to measure rural accessibilities. Frost and Shepherd use GIS to build a parish-based survey of access to services. They also evaluate the changing role of the local market town in rural areas, in order to be able to identify market towns with strong/weak service centre functions. The final chapter by Kneale and See addresses a key problem faced by the Environmental Agency in the UK and elsewhere – how can we improve our flood forecasting methodologies. This comes at a time when the UK has faced a number of very wet periods and the amount of flooding has been severe. Yet, despite advances in most aspects of computer technology, the ability to predict the consequences of these floods has not been very successful. The approach by Kneale and See uses neural networks to improve the forecasting process and to give more time for operators to send out alarms.

The concluding chapter of the book addresses some of the issues and concerns that confront those working in an academic environment when attempting to undertake applied research. Flowerdew and Stillwell reflect on the advantages and limitations of applied research by drawing on two different university experiences during the 1990s: the ESRC-funded Regional Research Laboratory (RRL) initiative (with

comments based largely on the activities of the North West RRL at the University of Lancaster) and the Yorkshire and Humberside Regional Research Observatory established at the University of Leeds. They conclude that despite various difficulties associated with applied research (frequently done through consultancy arrangements), much valuable work has been undertaken already and the opportunities for making use of new GIS, analysis methods and modelling techniques in the future are very exciting.

We hope that the contributions assembled in this collection provide a useful representation of what has been achieved in recent years.

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