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Introduction

1.1 The geography of crime

Crime has an inherent geographical quality. When a crime occurs, it happens at a place with a geographical location. For someone to have committed a crime they must have also come from a place (such as their home, work or school). This place could be the same location where the crime was committed or is often close to where the crime was perpetrated (Frisbie *et al.*, 1977; Brantingham and Brantingham, 1981; Rossmo, 2000; Wiles and Costello, 2000). 'Place' therefore plays a vital role in understanding crime and how crime can be tackled.

The study of crime has traditionally been the preserve of other disciplines such as sociology and psychology (Georges, 1978) and it was not until the late 1970s that the 'place' and the spatial dimension to crime began to be more fully explored. The police have long recognised the inherent geographical component of crime by sticking pins into maps displayed on walls, where each pin represented a crime event, but it was studies such as those from the 'Chicago School' of the 1930s (Shaw and McKay, 1931) that first demonstrated the importance of geography in understanding crime.

What has taken time, and only seriously surfaced in the 1970s, was the realisation that crime could be explained and understood in more depth by exploring its geographical components. New techniques emerged – techniques that included identifying patterns and concentrations of crime; the exploration of the relationships between crime and environmental or socio-economic characteristics; and techniques to assess the effectiveness

GIS and Crime Mapping Spencer Chainey and Jerry Ratcliffe

of policing and crime reduction programmes that are targeted to geographical areas. What has materialised from this emergence of academic and practitioner activity is the field of crime mapping – a progressive blend of practical criminal justice issues with the research field of Geographical Information Systems (GIS).

1.2 A brief history of GIS and crime mapping

Since the 1960s GIS has emerged as a discipline in its own right. From its origins in land use applications in Canada to an all-pervasive technology used today in applications as diverse as in-car navigation, retail store site location, customer targeting, risk management, construction, weather forecasting, utilities management and military planning, GIS has become ubiquitous in modern life.

The infancy of GIS grew through applications such as planning for the US Census of Population in 1970 (and other national censuses in many other countries since) and from the national mapping agencies that began using this technology to help automate their cartographic draughting. Imagery of the earth from satellites has also played a significant role in the development of GIS, particularly through the military where GIS was the platform into which imagery could be displayed and analysed for the purpose of intelligence gathering. Indeed it was the military that were responsible for the first uniform system of measuring location, driven by the need for accurately targeting missiles. The military were also initially responsible for the development of the Global Positioning System (GPS). However, it was not until the 1980s that reductions in the price of computer technology created a conducive environment for the development of the GIS software industry and the subsequent growth in cost-effective GIS applications (Longley *et al.*, 2001).

These reductions in the cost of computer hardware were complemented by improved operating systems, electronic storage media and developments in computer software, and have had a wide and significant impact in introducing GIS technologies to new areas, such as policing and crime reduction. The computerisation of police records has come with a realisation that this material can be used for crime and intelligence analysis (Ratcliffe, 2004), and in turn used to better recognise patterns of crime that can be targeted for action, patterns that evidence suggests police officers are not necessarily aware of (Ratcliffe and McCullagh, 2001).

The early use of GIS for mapping crime was often held back by organisational and management problems (Openshaw *et al.*, 1990), issues

with sharing information (Chainey, 2001), technical problems (Hirschfield *et al.*, 1995) and geocoding problems (Craglia *et al.*, 2000). These problems were shared with many of the other industries and disciplines trying to implement GIS, and it took several innovators to resolve these issues and show how they could be overcome. In reality many of these problems have not simply gone away, and several new ones have emerged, so in this book we try to help the reader by pointing to ways in which many of these technical and organisational issues can be overcome.

Much of the innovation in crime mapping was driven in the United States by the National Institute of Justice's Crime Mapping Research Center (CMRC). Renamed in 2002 as the Mapping and Analysis for Public Safety (MAPS) programme, the impact of this US government initiative was not isolated to the USA, but has also been the foundation for the development of crime mapping in many other countries, including the United Kingdom, Australia, South Africa and across South America. The MAPS programme has raised awareness of crime mapping through arranging seminars, conferences and producing publications, and by developing crime mapping software tools and funding new fields of crime mapping research. The MAPS programme, joined now by many other institutions and organisations, continues to be an active player in supporting the development of crime mapping with the result that crime mapping is now more widely recognised by government and law enforcement services as a tool to aid policing and crime reduction.

Many argue that the 'systems' development of GIS has in recent years been overtaken by the 'scientific' development of the discipline (Goodchild, 1992, 1997; Longley *et al.*, 2001). This geographical information science has seen the development of analytical methodologies, techniques and processes for the advancement of spatial understanding, and as a result has contributed to many disciplines where understanding space and place is important, such as with crime (Ratcliffe, 2004). The geographical analysis of crime has also shown strong parallels with the field of spatial epidemiology and continues today to learn from this related field, using many of the analysis techniques that were originally designed for the study of disease patterns. We cover a number of these techniques in this book.

1.3 Using GIS in policing and to prevent crime

Crime mapping can play an important role in the policing and crime reduction process, from the first stage of data collection through to the

monitoring and evaluation of any targeted response. It can also act as an important mechanism in a more pivotal preliminary stage, that of preventing crime by helping in the design of initiatives that are successful in tackling a crime problem. In subsequent sections of this book we present and discuss a wide range of applications for crime mapping, but as a resumé to demonstrate how it can support many central processes to policing and crime reduction we include the following application areas:

- Recording and mapping police activity, crime reduction projects, calls for service and crime incidents;
- Supporting the briefing of operational police officers by identifying crimes that have recently occurred and predicting where crime may occur in the future;
- Identifying crime hotspots for targeting, deploying and allocating suitable crime reduction responses;
- Helping to effectively understand crime distribution, and to explore the mechanisms, dynamics and generators to criminal activity, through pattern analysis with other local data;
- Monitoring the impact of crime reduction initiatives; and
- Using maps as a medium to communicate to the public crime statistics for their area and the initiatives that are being implemented to tackle crime problems.

Crime mapping is becoming central to policing and crime reduction in the 21st century, and this book aims to make a contribution to its continued growth. As Clarke (2004, p. 60) notes, 'Quite soon, crime mapping will become as much an essential tool of criminological research as statistical analysis is at present.'

1.4 The audience for this book

This book has been written to appeal to a wide range of professionals, academics and students interested in crime mapping. The book's style and content is one that should interest analysts working in policing and law enforcement, and analysts working in other services that support crime reduction, such as those who work in a crime reduction partnership, or those that are involved in analysing or researching crime problems within national or regional government bodies. The book should also appeal to academics and lecturers in GIS, crime science, crime prevention, criminal justice, law enforcement, policing, community safety or criminology, and

to researchers and students studying in these disciplines. The book also aims to be of international appeal by focusing on generic themes in GIS and crime mapping, and by drawing from worldwide experiences and developments in the active areas of crime mapping.

1.5 The content and structure of the book

This book has been written to support readers with the essential theory, scientific methodologies, analysis techniques and design processes that they require for applying crime mapping as a tool to help understand crime. The book's content is also illustrated with examples and case studies designed to bring depth to the explanation of certain principles and to demonstrate crime mapping at work. The book can also be used as a reference text which can be dipped into on relevant occasions, and to complement existing texts on the subject.

The book is divided into four main parts: Part One covers the basics required for mapping crime; Part Two covers crime mapping and GIS techniques; Part Three presents and discusses a comprehensive range of methodologies and applications of crime mapping; and Part Four aims to bring together much of what has been described and discussed by explaining how to make maps work to their best effect, and the organisational and management arrangements that can help to ensure that these outputs are used.

'The basics' included in Part One begins in the next chapter which describes the different professional areas where crime mapping is being applied, clarifies the definitions of terms and professions and explains the geographic jurisdictional and hierarchical boundaries of policing and crime reduction services. Chapter 3 further explores the basics of crime mapping by describing the starting point for converting raw crime data into a computer map. This chapter also explains some of the key concepts of GIS and geographic data, and in particular the chapter discusses and addresses the issues with geocoding crime data. Chapter 4 covers the essential theoretical concepts for interpreting and understanding the geographical aspects of crime. It includes an explanation of how thinking about crime and space has developed into the field of environmental criminology and demonstrates many of the key theoretical concepts in a practical sense. This chapter provides the essential backcloth to why there is value in crime mapping.

Part Two emphasises geographic information techniques and processes that can be applied to crime mapping. This part begins by providing

a grounding in spatial statistics, from descriptive spatial statistics through to more advanced techniques such as spatial autocorrelation and spatial regression. The theme of spatial statistics continues in Chapter 6 where a range of different methods are discussed for identifying crime hotspots. The concept of using crime data with non-police data is then explored in Chapter 7, which discusses the use of non-crime data sources to complement the picture of criminal behaviour and the possible causes that account for that behaviour. The chapter also explores the data that these other sources may have available to share, and reviews the information-sharing challenges and the technical processes for combining geographic information. The analytical techniques for understanding crime patterns in space are complemented in Chapter 8 where we explore ways to visualise the temporal and spatio-temporal patterns of crime. This includes helping the reader to recognise the value that the temporal dimension contributes to understanding crime as well as equipping the reader with a range of tools that can be used to identify and interpret temporal and spatio-temporal patterns.

Part Three focuses on crime mapping applications and approaches in its use, grouping these applications into three separate chapters. Chapter 9 describes the ways in which maps are incorporated into the operational thinking of police organisations, and are used to inform police officers wishing to reduce crime. This is illustrated with examples that describe the principles and functions of the CompStat process; describe the intelligence products of Britain's National Intelligence Model; discuss the importance of repeat victimisation identification in crime prevention research and outline the components of the 'Hotspot Matrix' as a way to understand and establish suitable responses to crime problems based on their spatial and temporal characteristics. Chapter 10 describes how crime mapping can support the tactical and investigative requirements of law enforcement and crime reduction, particularly in terms of catching offenders or gathering facts that can be useful in targeting diversion schemes, focusing the control of behaviour and directing crime prevention strategies. The chapter includes analytical methods for understanding offenders; discusses the importance of understanding the journey to crime; presents the main concepts of geographic profiling and how this important tool has been used to help serial crime investigations; describes the key requirements to consider when producing maps for prosecution evidence and explains the concept of offender self-selection. Part Three's final chapter begins by re-examining the main spatial crime theoretical structures to examine the different types of geographical scale and strategies that provide the link between theoretical understanding of crime and its spatial extent. This chapter includes an overview of the current paradigms in policing and

crime reduction and whether these can be effectively employed in a spatial sense to prevent crime. These discussions then extend to the analysis of neighbourhoods and understanding the underlying drivers of crime.

Part Four focuses on pulling together the outputs of crime mapping into a form that makes them work, be effective and reach the right audience. Chapter 12 examines the end of the crime mapping process – getting the message across to the audience. The main focus of this chapter is gearing the output to the needs of the client or audience, and in this chapter we offer the reader tips, techniques and theories to ensure that their effort is not wasted. More specifically, the chapter looks at key principles of cartographic design, the effective use of colour and the incorporation of maps into presentations. The book's final chapter helps to identify the ways in which crime mapping can be managed and organised in policing and crime reduction services. It discusses the GIS and crime mapping implementing process, the role of crime mapping (and analysis) and its effective use and the integration of crime mapping products into information-driven processes.

1.6 Putting it all in perspective

To put this book into a functional perspective, the following case study illustrates the developmental process of getting a crime mapping system up and running. It also shows the myriad of ways in which mapping technology can aid the policing and crime reduction effort. Chief Casady's experiences are probably similar to that of many innovative police departments and show how effective use of mapping does not instantly occur, but rather happens as a result of a combination of technological advancement and organisational change, both of which have been achieved through Chief Casady's leadership.

Case study: Crime mapping in Lincoln, Nebraska

Material supplied by Tom Casady – Chief of Police, Lincoln Police Department

Geography is basic to policing, and all good police officers are intimately familiar with the lay of the land in their area. They know their beat like the back of their hand. Perhaps because 'place' is such an important component of policing, maps are a common tool. Police officers cut them

into manageable pieces, they punch them for a ring binder, they clip them out of phone books, they laminate them, and they fold them into their pockets.

Back at police headquarters in Lincoln, someone was sticking coloured pins in a map on the wall when Teddy Roosevelt was President. In those days the pins represented saloons, or horse thefts, stick-ups or burglaries, maybe accidents, houses of ill repute, homes of officers, or any of hundreds of other events, facts or people. The map was a picture in time of a phenomenon, and told its story with a glance.

Today, the pin map has often been replaced by a much more powerful analytical tool – a GIS. Almost all printed maps are produced by high tech computer software today, but the real power of a GIS lies not in the printed output, but in the ability to interact with the data. Law enforcement is a relative latecomer to the use of GIS, but the use of GIS in policing has grown dramatically in the past several years. As this field grows, more and more police departments are discovering GIS as an incredibly valuable resource that in many cases is already at their disposal in their own community (if not hidden elsewhere in their own police department, it can often be found in the city hall or county government office).

This is exactly what happened to the Lincoln Police Department in the 1990s. Well before we began our crime mapping and analysis programmes, the Lancaster County Engineer and the Lincoln Public Works and Planning Departments had developed an extensive GIS, and were anxious to share their mapped data with other government agencies. In 1997 we began our first GIS applications in policing, making extensive use of the accurate basemap components, such as streets, land parcels, aerial photographs, and many other layers of geographic information that had already been developed and were being maintained by several city and county agencies. What we added to this cartographic mix was our police data about places.

Virtually everything we do as a police department revolves around an address or location. All of our dispatch records, incident reports, citations, intelligence reports have a place, and all of these are records collected in the ordinary course of business. GIS software allows mappers to use these computerised records of such things as crimes, by automatically placing the 'pins' on the map.

Each day, the preceding 24 hours of dispatch records, incident reports and field interviews are electronically mapped, as well as the addresses of gang members, registered sex offenders and parolees. The power of the GIS software allows our analysts to query this data rapidly to illuminate trends and patterns that would be lost in the sheer volume of

events. With 400 dispatches on a typical day, no one has the full picture of everything that has occurred. Even in a much smaller agency, the differences in shifts and days off make it quite possible that two officers investigating similar thefts from the laundry rooms of two side-by-side apartment buildings are each unaware of the other's case. A GIS pulls these connections together out of stacks of reports by enlisting the power of the computer to extract data through time, date, modus operandi, crime type queries and queries that are geographically based.

We primarily use our GIS for operational and tactical purposes: locating crime series and intervening in these quickly. But we also use these data in many other ways. We often print large maps of crime scenes and the surrounding area as a visual aid in major crime investigations. GIS also helps identify other crimes that may be the work of the same suspect. Adding geography to the modus operandi can reveal information about the offender's target selection. Following an arrest, GIS analysis can help identify other cases that are prospects for a multiple clearance.

GIS also supports strategic decision-making. The power of GIS, for example, dramatically simplifies the time-consuming task of redistricting or adjusting boundaries in patrol areas. In 1998 we were studying the need to add a fifth patrol team area, and considering the need to move one of our major patrol boundaries. Working on one single scenario, our planners spent a full week examining the workload implications of redrawing one boundary between the Center and Northeast Team Areas. When we applied GIS to this analysis, we were able to examine dozens of alternatives and their impacts during a 4-hour management staff meeting. We have used GIS analysis to support decisions on locating substations, targeting crime in fragile neighborhoods, and developing problem-oriented policing projects.

Crime mapping has changed dramatically during the years since we produced our first GIS crime map in December, 1997. Among the major developments for us have been automating our geocoding process, simplifying our interface, and deploying our mapping applications to a much wider range of personnel. With our new applications, anyone in the department who knows how to book their airline tickets online is perfectly capable of doing their own geographic analysis. Officers and employees with basic Internet skills can produce high-level GIS analysis with nothing more than an Internet connection and a browser. Our easy-to-use Intranet-based mapping application is available to everyone on the department at anytime of the day or night. Officers can query crime type, date range, certain MO patterns, and proximity to addresses or landmarks and quickly obtain both maps and tables of matching incidents. In a matter of moments, our employees can produce analysis and maps that a few years ago would

have required expensive software, high-powered computers, and extensive GIS expertise.

We also make mapping available to the general public through the Internet. Our public mapping application allows citizens to select crime types and date ranges, and to produce both tables and maps of incidents near a specific address, a landmark such as a school, or within the boundaries of a specific neighborhood association. Although the query functions of this public Internet application are intentionally throttled back and the data reduced considerably to protect the confidentiality of crime victims, it remains a valuable asset to landlords, neighborhood associations, and other interested members of the public. At a recent meeting of the Lincoln City Council, a neighborhood association was testifying during a public hearing on a zoning issue. Their representative was using data and maps about crimes to bolster the association's case.

I recognized the layouts and the data as being from our public web mapping application.

Further reading

LaVigne, N.G. and Groff, E.R. (2001). The evolution of crime mapping in the United States. In A. Hirschfield and K. Bowers (eds) *Mapping and Analysing Crime Data*, pp. 203–221. London: Taylor & Francis.

Weisburd, D. and McEwen, T. (eds) (1997). Introduction: Crime mapping and crime prevention. In *Crime Mapping and Crime Prevention*, pp. 8, 1–23. New York: Criminal Justice Press.

These two references offer a comprehensive history of how crime mapping has developed from its infancy to its use in modern policing and crime reduction.

The United States National Institute of Justice's Mapping and Analysis for Public Safety programme http://www.ojp.usdoj.gov/nij/maps/briefingbook.html.

The National Institute of Justice's Mapping and Analysis for Public Safety (MAPS) programme's website offers a 'briefing book' that outlines many of the key ways in which crime mapping is used. The MAPS website also offers a number of other resources on crime mapping including links to software, online publications and details of crime mapping conferences.

Leipnik, M.R. and Albert, D.P. (2003) *GIS in Law Enforcement: Implementation Issues and Case Studies*. London: Taylor & Francis.

Leipnik and Albert offer a useful crime mapping resource list of internet sites, key publications and agencies that support crime mapping.

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