Police Practice and Research,
Vol. 5, No. 1, March 2004, pp. 05–23

Routledge
Taylor & Francis Group

The Hotspot Matrix: A Framework for the Spatio-Temporal Targeting of Crime Reduction

Jerry H. Ratcliffe

The growth of intelligence-led policing has placed even greater emphasis on the clear identification of crime hotspots as well as the choice of the crime reduction or detection strategy identified to combat a problem. Crime hotspots are becoming central to policing strategy in many locations, as they enable an operational commander to focus resources into the areas of highest need. This paper outlines the techniques used to identify the spatial and temporal components of crime hotspots, and utilizes these methods to identify three broad categories of temporal hotspot and three broad categories of spatial hotspot. These categories are described in the form of a Hotspot Matrix. Real examples show how the spatial and temporal characteristics combine within the hotspot matrix, and the paper concludes by showing how operational commanders and crime prevention practitioners might employ the hotspot matrix to determine an appropriate prevention or detection strategy.

Keywords: Intelligence-led Policing; Hotspots; Crime Reduction; GIS

The Increasing Use of Hotspots in Crime Reduction

The use of hotspots to determine policing and crime prevention strategies has grown over recent years. Crime hotspots—areas of high crime intensity—have appeal to both crime prevention practitioners and police managers. With the development of planning solutions such as Crime Prevention through Environmental Design

Jerry H. Ratcliffe is an Associate Professor in the Department of Criminal Justice at Temple University, Philadelphia. Correspondence to: J. H. Ratcliffe, Associate Professor, Dept. of Criminal Justice, Temple University, Philadelphia PA, USA. Email: jhr@temple.edu.

ISSN 1561–4263 (print)/ISSN 1477–271X online/04/010005-19 © 2004 Taylor & Francis Ltd
DOI: 10.180/1561426042000191305

(CPTED) (Jeffery & Zahm, 1993) and situational crime prevention (Brantingham & Brantingham, 1990; Clarke, 1992; Ekblom & Tilley, 2000), there have been greater claims on the crime prevention budgets of local authorities and city planners. Hotspots allow local councillors to determine the areas of greatest need. Similarly in policing there has been a considerable shift towards greater use of hotspots as the foundation for problem-oriented policing (Goldstein, 1990) and as a focal point for the identification of 'problems' which can be resolved with the SARA problem-solving technique (Eck & Spelman, 1987; Greene, 2000). More recently, hotspot policing has gained prominence as an operational tactic, most notably in the British drive toward intelligence-led policing (see, for example, Audit Commission, 1993; Heaton, 2000; HMIC, 1997; Maguire, 2000; Ratcliffe, 2002c; Smith, 1997), but also in the USA with the growth of both intelligence and crime analysis practice (Andrews & Peterson, 1990; Carter, 1990; Gottlieb, Arenberg, & Singh, 1998) and in Australia (AFP, 2001; CJC, 1996; Seddon & Napper, 1999). In times of fiscal constraint, both crime prevention practitioners and police find appeal in a mechanism that allows them to focus resources on the areas of most need and to have a process for explaining their objective decision-making to others.

Beyond the immediate practical applications, academic interest in hotspots has come from two directions: different theoretical explanations for hotspots and techniques for the detection of crime hotspots. In the first area, a number of researchers have worked to find theoretical explanations for hotspots, including the development of places as crime attractors or crime generators (Brantingham & Brantingham, 1995a), a better understanding of offender spatial behaviour (Brantingham & Brantingham, 1981; Rossmo, 2000), and the development of our understanding of the spatial dynamics of drug markets (Rengert, 1996). The US National Institute of Justice's Drug Market Analysis Program placed significant emphasis on hotspots of drug activity by mapping the spatial characteristics and the police response with computer mapping programs, and the research sites produced a number of papers with implications for spatial policing strategies, including the work of Weisburd and Green (1995) on control strategies for drug market hotspots. A useful summary of environmental criminology can be found in the work of Bottoms and Wiles (2002), while evaluation of some hotspot crime prevention strategies is summarized in the work of Eck (1998).

As the use of geographic information systems (GIS) has grown within the practitioner community it has also grown in the academic environment beyond the original field of geography, enabling criminal justice professionals and criminologists to explore questions of spatial criminology in greater detail than ever before. To answer these more specific questions of spatial crime location has required improvements in the available methods for the description of crime hotspots, and these are discussed below. The paper then outlines some broad categories of spatial and temporal hotspots in the form of a hotspot matrix. Some applications of the hotspot matrix as a practitioner tool in the determination of crime prevention and detection tactics will also be discussed. The paper begins by outlining the techniques that are available to researchers for the description of spatial and temporal hotspots.

Spatial Hotspot Identification Processes

Techniques for the detection of crime hotspots have been developed for a number of years, though are by no means at the stage where they are both definitive and easily applicable. The real innovations have taken place in recent years with the improvements in computing power associated with the information technology (IT) revolution. Some spatial techniques that have been applied include the use of location quotients (Brantingham & Brantingham, 1995b), the development of kernel surface estimation algorithms (McLafferty, Williamson, & McGuire, 2000), and Local Indicators of Spatial Association (LISA) such as Getis and Ord *Gi* and Moran Local *I* (Mencken & Barnett, 1999; Messner et al., 1999). The limitation with these techniques is that they are generally applied to administrative areal units such as block groups, police divisional boundaries or census tracts. Spatial analysis of crime when aggregated to administrative units runs the risk of falling foul of the Modifiable Areal Unit Problem (MAUP). The MAUP occurs when the result of an analysis changes when the spatial arrangement of the study units is varied (Bailey & Gatrell, 1995; Openshaw, 1984; Unwin, 1996). In other words, an analysis of crime hotspots may look different if the crimes are aggregated to police beats or to census tracts. Some spatial analyses of crime hotspots use an underlying social phenomenon with which to calculate a rate of crime, and this necessitates the use of administrative boundary units, such as census tracts or police beats. However, some researchers have also recognized that a simple spatial concentration of crime can also be valuable. For example, although it might be interesting to count the robbery rate per 1,000 residents in an area, this does not provide much information for the commander of a city centre police station. The lack of a residential population in the central business district of most cities negates the value of a rate per 1,000 residents. The operational commander in this situation is therefore simply interested in the resource allocation issue and wants to know where to find the greatest concentration of robberies. Police need does not necessarily coincide with that of the researcher, and a simple map of hotspots can have great operational policing benefit.

Policing adoption of computer mapping processes has been swift in comparison to IT uptake in other areas (Weisburd, 2001), and mapping crime hotspots has been applied to general crime analysis (Canter, 1998; Harries, 1999; LaVigne & Wartell, 1998; Rich, 1995, 2001), vehicle crime analysis (Ratcliffe & McCullagh, 1998a; Rengert, 1997), serial crime investigations (Cook, 1998; Hubbs, 1998; Rossmo, 1995), and gang activity (Kennedy, Braga, & Piehl, 1998). One of the more well-known techniques for determining a crime hotspot has been a computer program for analysing the Spatial and Temporal Analysis of Crime (STAC). STAC analyses point data-sets to determine areas of higher intensity. These are displayed for output as standard deviational ellipses (Harries, 1999; ICJIA, 1996). Although the limitation of output as standard deviational ellipses and the rather arbitrary selection of program parameters have come in for some criticism (Bowers & Hirschfield, 1999; Craglia, Haining, & Wiles, 2000; Ratcliffe, 2002b) the program has been utilized by a number of law enforcement agencies in the USA, attracted by the ability to determine specific hotspot areas, albeit elliptical ones.

A number of other programs are available which will not dictate a specific shape but will produce a hotspot surface map, rather similar to a temperature map one might see on the evening weather report (McLafferty et al., 2000). These surface maps actually show a kernel density surface map of crime intensity, by dividing the map into a fine grid and calculating a value for each grid cell based on an intensity value calculated from the number and proximity of crime points in the surrounding area. These maps are advantageous because the flow of hotspots mimics the underlying crime patterns and often follows urban geographic features that are known to police officers and other users. Only a few attempts have been made to establish a methodology that enables users to determine a statistically significant hotspot that does not conform to a predetermined shape, but that more closely matches the shape of the underlying crime hotspot. Both of the following groups applied LISA statistics to an existing grid pattern. Chakravorty (1995) used local Moran *I* on grid cells of crime in Philadelphia, finding the technique worked in general, but not so well on his example data. Ratcliffe and McCullagh (1999) used Getis and Ord statistics on crime patterns in Nottingham (UK) and established some basic parameters for determination of statistically significant hotspot regions. Although this appears to be more applicable, the technique still requires custom-written software and an appreciation for the influence of different parameters on the analytical outcome.

While there are therefore a number of methods for the determination of crime hotspots, each have their strengths and weaknesses. Location quotients require arbitrary administrative units and are susceptible to the MAUP, but are also easy to calculate and map. STAC ellipses are tied to one type of shaped output, yet have the advantage of showing definitive hotspot regions. Surface maps are fairly easy to create and interpret, but show a gradual change from a hotspot area to a less dense crime area with no indication of cut-off points, and while the use of LISA statistics with grid maps gets around most of these problems by creating fine grid maps with definitive regions that are statistically sound, they are difficult to create. It is clear from this that a considerable research effort has gone into the detection of spatial clusters of crime, but what about temporal factors?

Temporal Hotspot Identification Processes

While considerable research effort has been expended in the search for statistically determined spatial hotspots, much less effort has gone into the temporal dynamics of local crime patterns. Some work has examined crime changes over lengthy periods of time, either to examine seasonality (Block, 1984) or to look at long-term changes (Cohen & Felson, 1979; LeBeau, 1992), while others have examined the influence of days or weeks on the risk of repeat victimization (the significant bibliography includes Anderson, Chenery, & Pease, 1995; Bowers, Hirschfield, & Johnson, 1998; Farrell & Pease, 1993; Johnson, Bowers, & Hirschfield, 1997; Polvi, Looman, Humphries, & Pease, 1991; Ratcliffe & McCullagh, 1998b; Robinson, 1998). Few studies have looked at the changing victimization throughout the day, with the work of George Rengert being a notable exception (Rengert, 1997). The main sticking point appears to be the lack of detail in many police crime databases, the source of much of the raw data for crime studies. Given that police are rarely in attendance when a property crime occurs, the police are left to record a start (or 'from') time and an end (or 'to') time for an offence, being the times when the victim last saw the property and when they returned to find it stolen. While crime analysts have been aware of a method of weighting a crime event based on the 'start' and 'end' time to determine a possible time of offence (Gottlieb et al., 1998), Ratcliffe and McCullagh (1998a) initially proposed the development of temporal weighting to include the spatial component, an idea further refined for analytical and mapping purposes and referred to as 'aoristic analysis' (Ratcliffe, 2000, 2002a).

The basic premise of the method is that if a time of an event is not known, then the start and end time can be used to estimate a probability matrix for each crime event for each hour of the day. The start and end time of crime events are extracted and the probability of the event happening in each hour (or whatever time period the user wishes) is determined. So, for example, if a victim parked their car at 10 a.m. and returned at 1 p.m. to find it missing, the 'time span' of the theft is three hours. Each of the hour blocks is allocated 0.33 (one crime event divided by the time span). This event is combined with others to determine the 'aoristic signature' for vehicle theft in the study region. This process is explained in greater depth in Ratcliffe (2002a), and shown in Figure 1 where the first crime is the example event here.

Figure 1 shows that crime events with a shorter time span are able to influence the final outcome more than crimes with longer time spans, as it is easier to determine the

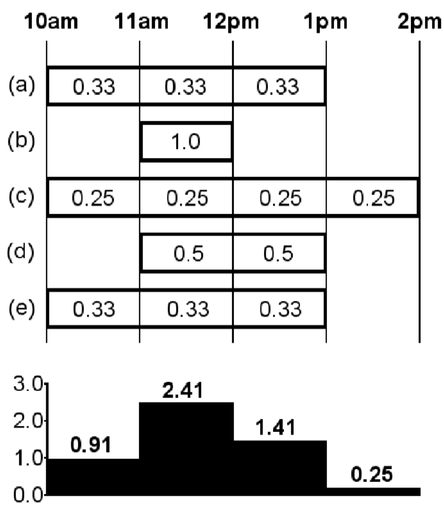

Figure 1 Aoristic Temporal Analysis Method. In the top part of the figure, five horizontal bars indicate five vehicle thefts (a–e) where the time of the offence is unknown, running across a timeline that runs from left to right covering the period 10 a.m. to 2 p.m., split into hour blocks. In offence (a) the owner of the car last saw the vehicle when it was parked at 10 a.m. and the theft was discovered when the victim returned to the car park at 1 p.m. This offence has a time span of three hours, so each hour block of the offence is allocated 1/3 = 0.33. Offence (b) was known to happen between 11 a.m. and noon, so this hour block is allocated the full value of the crime = 1.0, and so on. The lower half of the diagram shows the graph of the summed values for all crimes. For example, the 0.91 for offences between 10 a.m. and 11 a.m. is constructed from 0.33 from crime (a), 0.25 from crime (c), and 0.33 from crime (e). This represents the probabilistic amount of vehicle crime that could be attributed to this time period.

possible time of the offence. The shorter time span events have a higher weighting as the numerator for any weighting is the number of crime events (on an individual basis always one) and the denominator is the time span. If the time span is short then the weighting component for each hour in the analysis will be correspondingly higher. An event of known time of occurrence will have a value of one. Aoristic analysis enables the user to determine a temporal pattern for a crime hotspot (or any study region) based on an objective analysis of the data, where crimes with a known time of occurrence will have greater influence over the final shape of the graph.

Aoristic analysis lends itself to policing strategies, as crime hotspots are areas of significant policing concern, yet policing tactics must also reflect the realities of policing within a budget. Aoristic analysis allows operational managers the opportunity to determine the best times for patrols for high volume crime problem areas (Ratcliffe, 2002a). Aoristic analysis also enables the broad categorization of high volume crime hotspots based on temporal characteristics, as will be seen in the next section.

The Hotspot Matrix

The combination of spatial and temporal techniques allows us the possibility of establishing a typology of spatio-temporal characteristics of hotspots, as the spatial features of the crime patterns within the hotspot can be established, and each crime hotspot can be queried to determine its 'aoristic signature' (Ratcliffe, 2002a). While there are theoretically infinite spatial arrangements of crime events within a crime hotspot, analytical work in this area over the last few years has established three broad categories of within-hotspots spatial patterns. Similarly, there are considerable variations in the temporal patterns that could occur in a given region. This paper proposes three broad categories of temporal pattern. We start with spatial events.

Dispersed

This is a type of crime hotspot where the points that generate the hotspot are spread throughout the hotspot area. They are still more concentrated than in other areas of the study (or else they would not be a hotspot) but do not cluster or congregate in any particular part of the hotspot region. An example might be a housing estate where burglary events are spread throughout the estate, due to poor design of the properties. The events within the hotspot do not cluster as each property is as vulnerable as the next.

Clustered

This is a type of hotspot where the events that make the hotspot tend to cluster at one or more particular areas within the hotspot region. An example of this might be a hotspot region that includes a sports stadium. While the stadium may be the focus of a number of vehicle crimes, it does not preclude the possibility that other areas in the vicinity are also victimized by auto crime.

Hotpoint

This is a particular type of crime hotspot generated by one single criminogenic feature. This feature would no doubt be considered a crime attractor or generator (Brantingham & Brantingham, 1995a). An example of this might be a shopping centre car park in the middle of a busy city. All of the available cars for vehicle crime are concentrated in the shopping centre car park, making all of the crime events that generate that hotspot occur in one place. This differs from the clustered hotspot in that clustered events still have a high concentration in one or more areas, but can also have numerous crime events happen elsewhere in the hotspot.

Examples of these spatial patterns can be seen in Figure 2. In each of the three images a single hotspot shape is shown with 12 crime events within the hotspot. In the first two, all 12 points are visible and are respectively dispersed and clustered. Some readers will note that this terminology springs from terms used to describe nearest neighbour analysis, and there are some similarities. It should be pointed out however that dispersed in terms of a hotspot indicates the points are dispersed *within* the hotspot, and are still highly concentrated with regard to the rest of the study area (otherwise there would be no hotspot). In the third image (C) the shape of the hotspot more reflects the fact that all 12 points are co-located at the same site within the hotspot. In these circumstances, the hotspots tend to be circular in shape.

Temporal events can be broadly distinguished in three ways.

Diffused

These are crime hotspots where the crime events could happen at any time over the 24-hour period of a day, or because the time span of events is so large that it is not possible to determine any significant peaks of activity. This does not preclude the diffused hotspot from having some peaks and troughs, but it does mean that none are significant enough to be considered useful from a crime prevention perspective.

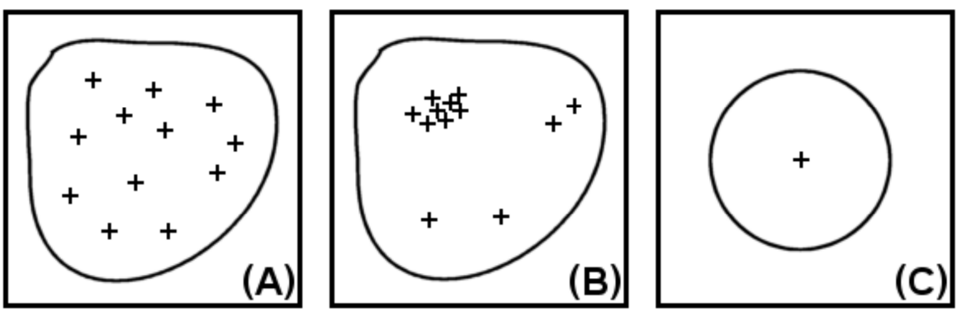

Figure 2 Three Types of Spatial Hotspot: Dispersed (A), Clustered (B), and Hotpoint (C). Each image shows 12 crime points located within a hotspot. In (A) the points are dispersed throughout the hotspot. In (B) there are points throughout the hotspot but there is clear evidence of clustering at one point in the top left of the hotspot. In (C), all 12 points are co-located at the same point in the centre of a circular hotspot.

Focused

This type of crime hotspot may have crime happen throughout the day, but there are times when there is significantly more activity than at other times. The determination of significance may be statistical, or may be judged on its value from a crime reduction perspective. In other words, a police inspector, examining the aoristic signature of a crime pattern, may determine that the peak over a three-hour period is strong enough to warrant the deployment of extra officers at that time.

Acute

This is a rare group of hotspots where the temporal activity is confined to a small period of time, or where the aoristic signature almost negates the possibility of criminal activity at some time periods. This does not mean that some events cannot occur in other periods, except that unlike the focused hotspot, there are few events happening outside the acute time.

These types of temporal hotspot are shown in Figure 3 where vertical bars indicate the level of risk for each hour of the day, running from midnight through to midnight again. In the first, there is a general level of crime risk throughout the day and night, suggesting a diffused temporal hotspot. In the second, although there is a general risk, there is also a period of heightened risk focused during the evening, suggesting a focused temporal hotspot. Finally in the last image (C) the risk is concentrated in the period of early evening, suggesting an acute temporal hotspot.

Examples of Hotspot Types

To demonstrate some of the hotspot types suggested here, the following section shows two example crime hotspots using real data. It should be noted that this paper describes spatio-temporal crime hotspots by describing the temporal component first, followed

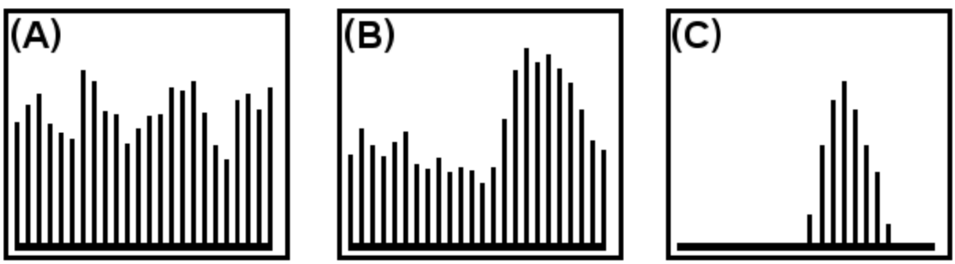

Figure 3 Three Temporal Hotspot Categories. In each figure, the probabilistically weighted offence times are shown as vertical bars. Each bar represents one hour, running left to right from 00:00–00:59 to 23:00–23:59 hours, or more simply, hourly from midnight to midnight. The three temporal hotspot types are diffused (A), focused (B), and acute (C). In (A) it can be seen that while the risk of crime rises and falls there is a general risk throughout the hours of the day and night. In (B), although there is a general level of risk, there is also a period in the evening of significantly higher crime risk. In (C) it can be seen that the risk of crime is most acute in the early evening only.

by the spatial component. Figure 4 shows one burglary hotspot from an analysis of all burglaries at shops in the city of Canberra, Australia for 1999 and 2000. This analysis generated a number of statistically significant hotspots, one of which was located in the commercial area of Fyshwick in the south-east of the city. The hotspot is shown, along with the 197 crime events that make up the crime hotspot. The regular sides of the hotspot are a function of the grid cell size used to determine the hotspot area. Further details of the technique can be found in Ratcliffe and McCullagh (1999). Due to repeat victimization at a number of locations, the sizes of the grey points (used to indicate the level of repeat victimization) varies. It can be seen that although there are a few locations that were targeted more than others, there is a spread of targeted properties throughout the hotspot. This suggests a spatially *dispersed* range of events within the hotspot. The chart of incidence by time of the day below the map shows that there is little activity during the day. From midnight, the first vertical bar, there is a high level of activity that reduces rapidly by the time the shops open, then returns to higher values again after closing time and into the evening. This suggests a temporally *focused* crime hotspot. This hotspot is therefore best described as a *focused, dispersed* hotspot.

The second map and graph show a different type of hotspot (Figure 5). The pattern of thefts from motor vehicles in the Eastern Beaches area of Sydney, Australia also produced a number of statistically significant hotspots, and one of these was in the car park of the East Gardens shopping centre. This hotspot, shown in Figure 5, does have a couple of other crime points nearby, however, the hotspot is dominated by the shopping centre car park. This suggests a *hotpoint* type spatial pattern. The temporal pattern of activity for the offences at the car park is shown in the graph below the map. This aoristic analysis shows that there is an acute period of five to six hours where most of the activity takes place. It could be argued that this could also represent a focus type temporal hotspot, however, the lack of crime during other times suggests that this is an acute pattern. Had there been a significant degree of crime during other times, with a strong peak in the afternoon, then a focus type temporal hotspot might have been appropriate. This hotspot is therefore best described as an *acute, hotpoint* hotspot.

These real examples demonstrate two types of hotspot found in the matrix, and individually show two of the three types of spatial and temporal hotspot. The paper now goes on to discuss practical applications of the hotspot matrix.

Application of a Hotspot Matrix

Where is the value in such classification systems as the hotspot matrix? Simple typologies have an advantage in the area of crime reduction where practitioners do not have the training opportunities that are afforded academic researchers with time on their hands. For example, a simple typology of hotspots can be created alongside a list of possible remedies. This may be easier to teach a police crime analyst as a limited set of systems, rather than attempt to communicate the complexity of environmental theory and the whole gamut of prevention literature and publications such as the extensive 'What works?' report from the National Institute of Justice (Sherman et al., 1998). While this paper does not claim that every possible hotspot structure can be easily

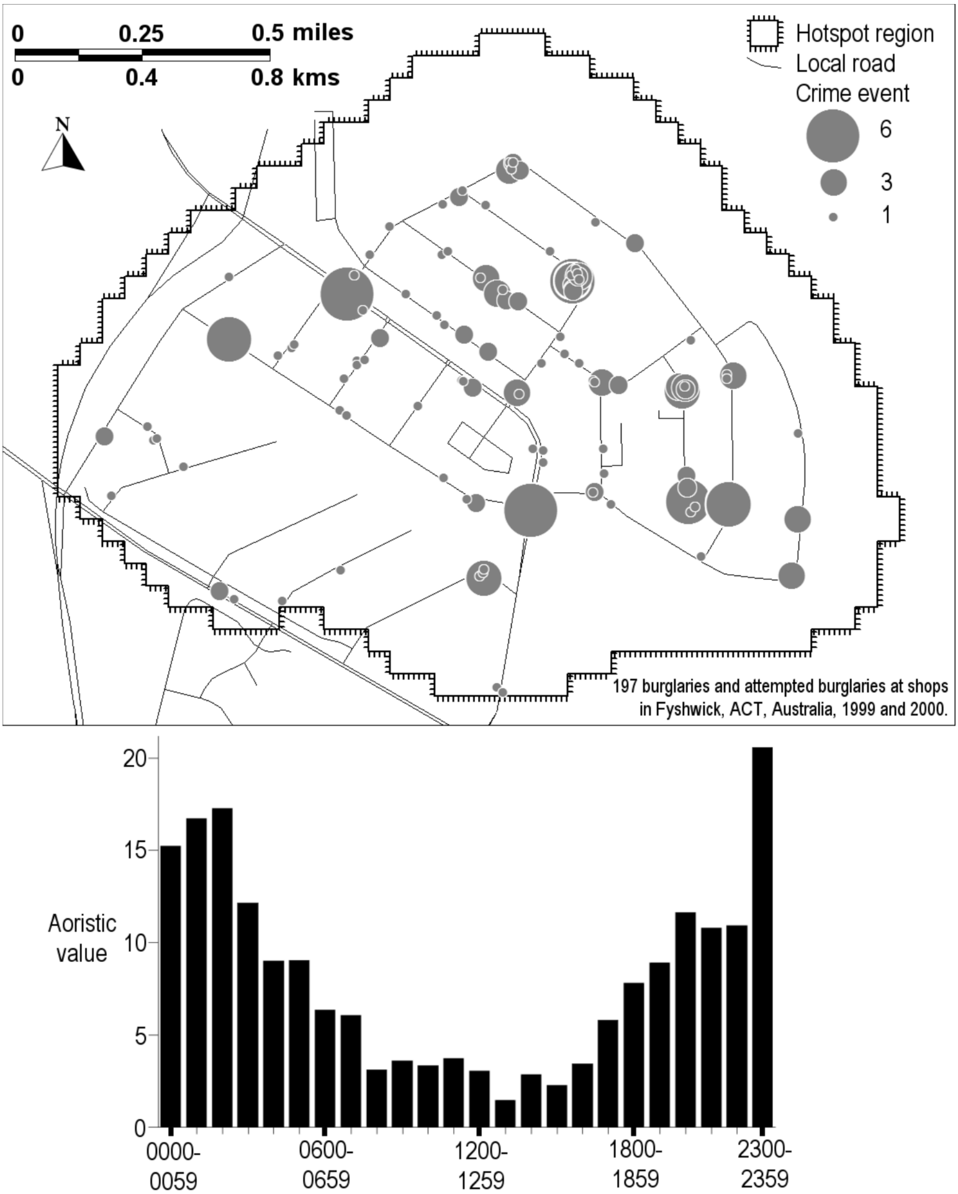

Figure 4 A focused, dispersed hotspot of burglaries and attempted burglaries at shops in the Fyshwick area of Canberra, Australia during 1999 and 2000. The map shows the locations of properties affected over a two-year period. Repeat incidents are indicated by larger symbol sizes. The chart shows the aoristic signature of the events in Fyshwick, suggesting a strong focus for overnight offences with little burglary activity during the day.

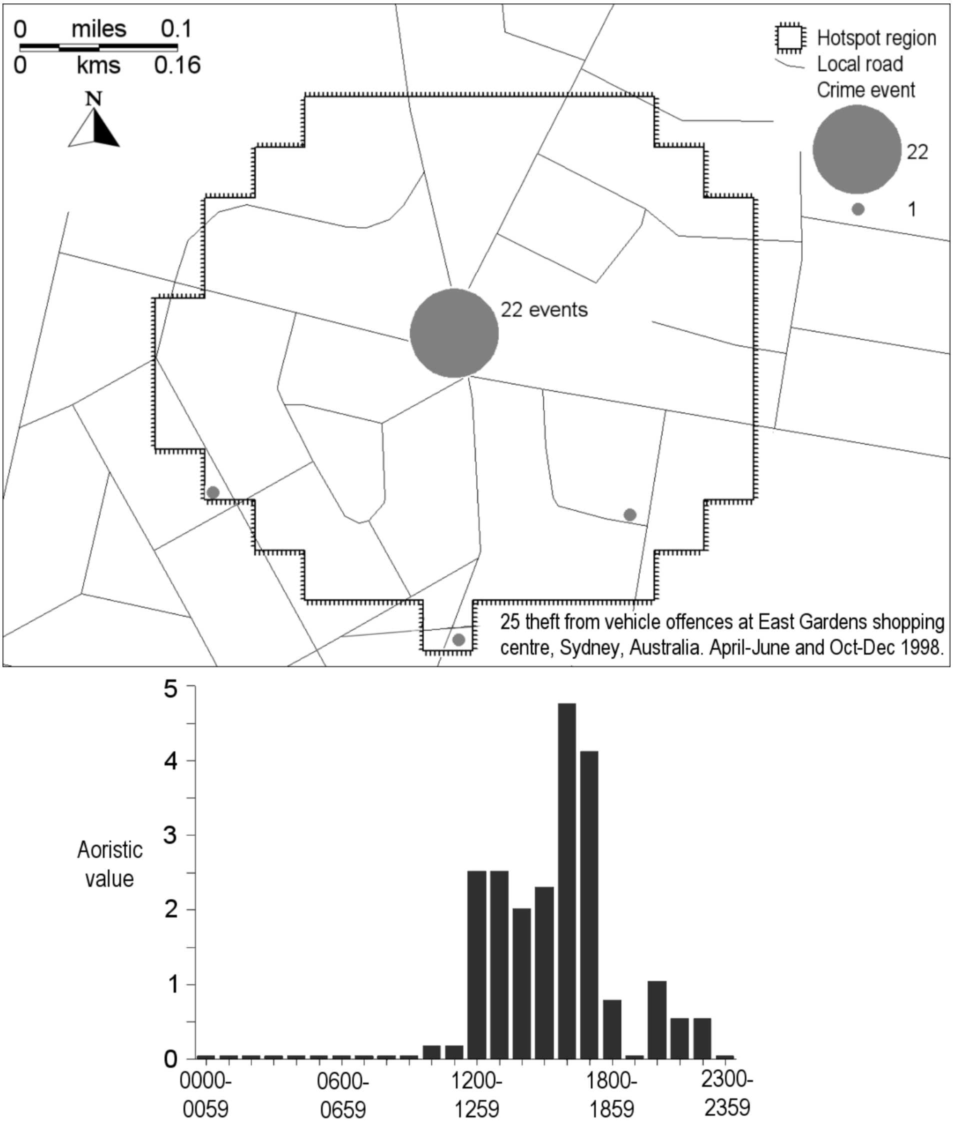

Figure 5 An acute, hotpoint hotspot of thefts from vehicles at a shopping centre in the eastern beaches of Sydney, Australia. Data drawn from two three-month periods (April–June and October–December 1998). The hotspot is dominated spatially by the shopping centre, and although there are a couple of other points, the central shopping centre is the single most important area, suggesting a *hotpoint*. The temporal pattern in the graph below the map shows that there is a significant block of six hours where the vast majority of incidents occur. Although it could be argued that this could be interpreted as a focus, there is negligible activity outside this period, more suggestive of an *acute* temporal hotspot.

contained within three spatial and three temporal patterns, there is value in advancing a simple hotspot typology so that in the future researchers and practitioners can discuss practical crime reduction with regard to a specific, commonly agreed view of hotspots. Once an established set of hotspot typologies can be communicated, it allows practitioners the advantage of being able to evaluate specific crime prevention strategies with regard to different types of hotspot. The following section explores how one such hotspot matrix might operate.

Policing Solution Hotspot Matrix

The development of crime reduction partnerships in the UK, formed as a result of the 1998 Crime and Disorder Act (Bowers, Jennings, & Hirschfield, 2002; Hough & Tilley, 1998), suggests that there is a realization that law enforcement is unable to combat the problem of crime on its own. While there is a consciousness that policing does not address the root causes of crime, there is also an understanding that certain policing tactics can influence the short-term patterns of crime. Indeed, the use of local community partnerships can take some time to coordinate and organize, and some law enforcement tactics can be implemented at short notice to fill the gap. These include crackdowns (Sherman, 1990), intelligence-led operations (Ratcliffe, 2001), and problem-oriented policing (Goldstein, 1990; Leigh, Read, & Tilley, 1996). These strategies are part of a whole toolbox of possible tactics that an operational commander can employ, including flooding an area with uniform patrols, deploying surveillance units, using car patrols, and in some countries deterring offenders by setting up random breath tests in high crime areas. Some of these tactics are geared more towards crime prevention, while others (such as the use of surveillance units) have a crime detection focus. All of these tactics have an associated outlay, and the job of the operational commander is to balance the potential results with the specific costs that will be incurred. Successful tactics can be shared so that particular types of hotspot can be tackled with strategies that have been successfully employed elsewhere. Alternatively police commanders can try a number of tactics and establish for themselves what works with a particular hotspot type.

Figure 6 shows one potential hotspot matrix that could be created for a solution to the different types of hotspot explained earlier. The solutions in Figure 6 could, for example, be applied to a crime hotspot on a problem housing estate.[1] Choice of appropriate measures would clearly be a decision for operational commanders based on a variety of factors, including availability of units, cost and likelihood of success. It can be seen from Figure 6 that there is a shift in tactics as the hotspots become more temporally and spatially concentrated, the shift moving from visible uniform patrols and high visibility tactics such as roadblocks and breath testing, to tactics more likely to result in arrests, including surveillance units and unmarked patrols. This can be described as a more general shift in focus from prevention to detection. These are just some suggestions for policing strategy, where the police have an option to choose between prevention and more aggressive measures.

Policing Hotspot Matrix		Spatial: Dispersed	Spatial: Clustered	Spatial: Hotpoint
Temporal	Diffused	Uniform vehicle patrols, architectural changes, public education campaign	Random breath tests, foot patrols, architectural changes, publicity campaign	Roadblocks, plain clothes patrols, random breath tests, private security, CCTV
Temporal	Focused	Uniform vehicle and foot patrols, improved lighting, public education campaign	Vehicle and foot patrols, random breath tests, private security, improved lighting	Surveillance units, plain clothes foot patrols, CCTV, surveillance of entry/exit points
Temporal	Acute	Unmarked vehicle patrols, private security, improved lighting	Surveillance and plain clothes patrols, CCTV	Surveillance, arrest squads, CCTV, unmarked police units

Figure 6 An example hotspot matrix for a housing estate (possible strategies indicated are examples only and are not indicative of strategies evaluated for these types of spatio-temporal hotspot).

The hotspot matrix also considers longer term strategies that could be put into place in conjunction with short-term police operations. A number of police agencies have been experimenting for many years with the inclusion of a crime prevention officer as part of their sworn staff, and in some UK police services the crime prevention officer has been an established figure for many years. Again, cost and likelihood of success come into the decision-making process of the crime prevention officer. The hotspot matrix will look the same in shape and composition, but the range of options for a crime prevention officer may be different. Longer-term options may include closed circuit television (CCTV) systems, increased guards, improved lighting and architectural changes to enable better natural surveillance of the housing estate. Again, decisions regarding cost may be made in the light of the spatial and temporal signature of the hotspot problem. For example, it might be prohibitively expensive to install CCTV throughout the estate, negating the use of CCTV for a temporally 'diffused' and spatially 'dispersed' hotspot. CCTV may, however, be an option to prevent problems at a key location where introduction of one CCTV camera may not be beyond the available budget. CCTV therefore becomes a possibly viable option for an 'acute hotpoint' hotspot.

Discussion

For many readers, the introduction of the temporal component will be the new feature of the paper, as many readers will be familiar with the various techniques for establishing spatial hotspot areas. This paper has not sought to provide detailed explanations of the spatial hotspot techniques as these methods are more thoroughly explained elsewhere, and references are indicated earlier in this paper for further reading. The temporal component has received less research attention yet is arguably of equal value to an operational police commander or crime prevention officer. For the police commander, a significant resource that he or she will have is personnel, but personnel cost money. This cost is both a factor of extra officers and extra patrol time. Understanding the spatial dynamics of hotspots enables a commander to limit the spatial area of patrol, reducing the number of officers. Greater understanding of the temporal dynamics of hotspots will enable the commander to limit the time costs of extra patrols, if patrols are the chosen crime reduction method. Most usefully, the aoristic analysis method for temporal analysis referred to in this paper, is not required for all crime types. Victims of assault generally know when they were assaulted and police "start' and 'end' times tend to be the same. It would appear, from statistical tests shown in Ratcliffe (2002a), that the aoristic method is only required for high volume property offences such as burglary and vehicle crime, while assault and robbery can be easily calculated simply from the time of offence.

Categorization of crime hotspots, both spatially and temporally, will to some degree be a subjective decision. It may be argued that a significant distinction may exist between a focused and an acute temporal hotspot, but it is recognized that a degree of subjectivity may creep into this type of analysis. The main point, however, is that the aim of this work is to enable operational police officers to include spatial and temporal factors in their thinking. Although there may be some disagreement between officers as to the exact nature of a crime hotspot, chances are that the discussion will still generate positive thinking about the best operational tactic to employ to combat the particular hotspot problem. Within the framework of SARA (Eck & Spelman, 1987; Greene, 2000), the hotspot matrix may be useful, resulting from the SARA analysis stage, as a method of determining the most appropriate response.

This has been a first attempt to describe a typology of crime hotspots in a spatio-temporal manner. It is possible that some types of hotspot, such as an acute, dispersed hotspot are quite rare. It may also be the case that later work by other researchers may reveal different types of hotspot by adding to (or removing) either the spatial or the temporal typologies. It is recognized that this is a first step toward a broader descriptive capacity for crime hotspots.

Although there is the option of adding hotspot typologies and increasing the definitions, the main aim of this paper is to describe hotspots in a practical way so that practitioners such as crime analysts, police managers, and crime prevention practitioners can discuss and evaluate crime reduction strategies that are targeted to the spatial and temporal characteristics of the problem. It would be possible to describe a whole myriad of crime hotspot shapes and patterns, but significant additions to the relatively simple typology presented here may prove counter-productive to the aim of a simple tool for collaboration and crime reduction. Academia does sometimes struggle to convey its message to practitioners, and this paper attempts to reduce the complexity of space-time high-volume crime interactions to a practical level.

Finally, the choice of strategies proposed in the matrices are merely shown as examples, and empirical evaluation of strategies that have been employed in the past is likely to yield a more beneficial list of options. The move in Figure 6 from prevention to detection is likely to remain in most policing matrices, given the higher costs in maintaining surveillance of plain clothes units in large areas over long time periods. There are some strategies mentioned, such as roadblocks and random breath tests, that are not available or legal in some places. The onus is therefore on the practitioner reading this to replace the tactics with more acceptable local strategies.

Conclusion

Any discussion of crime hotspots is of clear interest to police managers, interested as they are in devising suitable strategies for crime reduction in high crime areas. As the 'gatekeepers' (Ericson & Haggerty, 1997) to most crime knowledge for the rest of the criminal justice system, they are both at the forefront of providing pertinent information to other agencies in a digestible form, as well as being required to formulate operational policy to combat crime hotspots themselves. Up until this point nearly all discussions of crime hotspots have focused entirely on spatial characteristics. However the introduction of a methodology for examining the temporal characteristics allows us to see a different dimension to the composition of hotspots, and this additional feature has clear benefits for policing strategy.

Resources are usually required to combat a crime problem, and resources incur a cost. Law enforcement managers may wish to identify the temporal patterns of crime hotspots as well as the spatial patterns in order to utilize their resources at the most appropriate times, getting the best 'bang' for their 'buck.' After all, there is little value in having night-duty officers perform high visibility patrols on overtime in a crime hotspot if the temporal pattern suggests that the middle of the day is the highest crime time. In times of fiscal constraint where police are being asked to do more with the same, or fewer, resources (Ratcliffe, 2001), justifying a policing strategy based on objective analysis of spatial and temporal characteristics of high crime areas is an attractive option. While the choice of an appropriate strategy is more subjective at present, over time there will grow a bank of knowledge regarding the most appropriate strategy for different scenarios within the hotspot matrix and this will similarly provide the objective ammunition for operational police commanders to combat the holders of the departmental purse strings. Well-considered crime reduction policy, based on an objective assessment of crime hotspots combined with an objective choice of crime reduction strategy, is a difficult thing to argue against.

Notes

[1] It should be stressed that the strategies that populate the example matrix here are examples only, and do not necessarily represent empirically evaluated crime reduction tactics.

References

AFP [Australian Federal Police]. (2001) *Anchorage: An excellent example of intelligence-led policing, 592/2001* Australian Federal Police ACT Policing media release, Canberra.

Anderson, D., Chenery, S. and Pease, K. (1995) Biting back: Tackling repeat burglary and car crime., *Police Research Group: Crime Detection and Prevention Series,* Paper 58, 1–57.

Andrews, P. P. and Peterson, M. B. (1990) *Criminal intelligence analysis*. Loomis, CA: Palmer Enterprises.

Audit Commission (1993) *Helping with enquiries: Tackling crime effectively*. London: HMSO.

Bailey, T. C. and Gatrell, A. C. (1995) *Interactive spatial data analysis*. London: Longman.

Block, C. R. (1984) *Is crime seasonal?* Chicago: Illinois Criminal Justice Information Authority.

Bottoms, A. E. and Wiles, P. (2002) Environmental criminology. In M. Maguire, R. Morgan, & R. Reiner (Eds.), *The Oxford handbook of criminology*. London: Oxford University Press.

Bowers, K. J. and Hirschfield, A. (1999) Exploring the link between crime and disadvantage in north-west England: An analysis using geographical information systems, *International Journal of Geographical Information Science, 13*(2), 159–184.

Bowers, K. J., Hirschfield, A. and Johnson, S. D. (1998) Victimization revisited, *British Journal of Criminology, 38*(3), 429–452.

Bowers, K. J., Jennings, J. and Hirschfield, A. (2002) The Crime and Disorder Audit process: A post-mortem on the first round, *Crime Prevention and Community Safety, 4*(2), 19–32.

Brantingham, P. L. and Brantingham, P. J. (1981) *Environmental criminology*. Prospect Heights, IL: Waveland Press.

Brantingham, P. L. and Brantingham, P. J. (1990) Situational crime prevention in practice., *Canadian Journal of Criminology, 32*(1), 17–40.

Brantingham, P. L. and Brantingham, P. J. (1995a) Criminality of place: Crime generators and crime attractors, *European Journal of Criminal Policy and Research, 3*(3), 5–26.

Brantingham, P. L. and Brantingham, P. J. (1995b) Location quotients and crime hotspots in the city. In C. Block, M. Dabdoub, & S. Fregly (Eds.), *Crime analysis through computer mapping.* Washington, DC: Police Executive Research Forum.

Canter, P. R. (1998) Geographical information systems and crime analysis in Baltimore County, Maryland. In D. Weisburd & T. McEwen (Eds.), *Crime mapping and crime prevention* (pp. 158–190). Monsey, NY: Criminal Justice Press.

Carter, D. L. (1990) *Law enforcement intelligence operations: An overview of concepts, issues and terms.* Washington, DC: National Institute of Justice.

Chakravorty, S. (1995) Identifying crime clusters: The spatial principles, *Middle States Geographer, 28,* 53–58.

CJC [Criminal Justice Commission] (1996) Intelligence at work inside the CJC., *Criminal Justice Commission Issue Paper Series,, 3*(1), 12.

Clarke, R. V. (1992) *Situational crime prevention: Successful case studies*. Albany, NY: Harrow & Heston.

Cohen, L. E. and Felson, M. (1979) Social change and crime rate trends: A routine activity approach, *American Sociological Review, 44,* 588–608.

Cook, P. (1998) Mapping a murderer's path. In N. LaVigne and J. Wartell (Eds.), *Crime mapping case studies: Successes in the field* (pp. 123–128). Washington, DC: Police Executive Research Forum.

Craglia, M., Haining, R. and Wiles, P. (2000) A comparative evaluation of approaches to urban crime pattern analysis, *Urban Studies, 34*(4), 711–729.

Eck, J. (1998) Preventing crime at places. Chapter 7, *Preventing crime: What works, what doesn't, what's promising.* Washington, DC: National Institute of Justice.

Eck, J. and Spelman, W. (1987) *Problem solving: Problem-oriented policing in Newport News*. Washington, DC: Police Executive Research Forum.

Ekblom, P. and Tilley, N. (2000) Going equipped: Criminology, situational crime prevention and the resourceful offender, *British Journal of Criminology, 40*(3), 376–398.

Ericson, R. V. and Haggerty, K. D. (1997) *Policing the risk society*. Oxford: Clarendon Press.

Farrell, G. and Pease, K. (1993) Once bitten, twice bitten: Repeat victimisation and its implications for crime prevention., *Police Research Group: Crime Prevention Unit Series,* Paper 46.

Goldstein, H. (1990) *Problem-oriented policing*. New York: McGraw-Hill.

Gottlieb, S., Arenberg, S. and Singh, R. (1998) *Crime analysis: From first report to final arrest*. Montclair: Alpha Publishing.

Greene, J. R. (2000) Community policing in America: Changing the nature, structure, and function of the police. In J. Horney (Ed.), *Criminal justice 2000: Policies, processes, and decisions of the criminal justice system* (pp. 299–370). Washington, DC: National Institute of Justice.

Harries, K. (1999) *Mapping crime: Principles and practice*. Washington, DC: National Institute of Justice.

Heaton, R. (2000) The prospects for intelligence-led policing: Some historical and quantitative considerations, *Policing and Society, 9*(4), 337–356.

HMIC [Her Majesty's Inspectorate of Constabulary] (1997) *Policing with intelligence*. London: Her Majesty's Inspectorate of Constabulary.

Hough, M. and Tilley, N. (1998) Auditing crime and disorder: Guidance for local partnerships., *Police Research Group: Crime Detection and Prevention Series,* 91.

Hubbs, R. (1998) The Greenway rapist case: Matching repeat offenders with crime locations. In N. LaVigne & J. Wartell (Eds.), *Crime mapping case studies: Successes in the field* (pp. 93–97). Washington, DC: Police Executive Research Forum.

ICJIA [Illinois Criminal Justice Information Authority] (1996) *STAC user manual*. Chicago: ICJIA.

Jeffery, C. R. and Zahm, D. L. (1993) Crime prevention through environmental design, opportunity theory, and rational choice models. In R. V. Clarke & M. Felson (Eds.), *Routine activity and rational choice* (pp. 323–350). New Brunswick, NJ: Transaction Publishers.

Johnson, S. D., Bowers, K. and Hirschfield, A. (1997) New insights into the spatial and temporal distribution of repeat victimization., *British Journal of Criminology, 37*(2), 224–241.

Kennedy, D. M., Braga, A. A. and Piehl, A. M. (1998) The (un) known universe: Mapping gangs and gang violence in Boston. In D. Weisburd & T. McEwen (Eds.), *Crime mapping and crime prevention* (pp. 219–262). Monsey, NY: Criminal Justice Press.

LaVigne, N. and Wartell, J. (1998) *Crime mapping case studies: Successes in the field*. Washington, DC: Police Executive Research Forum.

LeBeau, J. L. (1992) Four case studies illustrating the spatial–temporal analysis of serial rapists, *Police Studies, 15,* 124–145.

Leigh, A., Read, T. and Tilley, N. (1996) Problem-oriented policing., *Police Research Group: Crime Detection and Prevention Series,* 75.

Maguire, M. (2000) Policing by risks and targets: Some dimensions and implications of intelligence-led crime control, *Policing and Society, 9*(4), 315–336.

McLafferty, S., Williamson, D. and McGuire, P. G. (2000) Identifying crime hot spots using kernel smoothing. In V. Goldsmith; P. G. McGuire; J. H. Mollenkopf, & T. A. Ross (Eds.), *Analyzing crime patterns: Frontiers of practice* (pp. 77–85). Thousand Oaks, CA: Sage.

Mencken, F. C. and Barnett, C. (1999) Murder, non-negligent manslaughter and spatial autocorrelation in mid-South counties, *Journal of Quantitative Criminology, 15*(4), 407–422.

Messner, S. F., Anselin, L., Baller, R. D., Hawkins, D. F., Deane, G. and Tolnay, S. E. (1999) The spatial patterning of county homicide rates: An application of Exploratory Spatial Data Analysis, *Journal of Quantitative Criminology, 15*(4), 423–450.

Openshaw, S. (1984) The modifiable areal unit problem., *Concepts and Techniques in Modern Geography,* 38.

Polvi, N., Looman, T., Humphries, C. and Pease, K. (1991) The time course of repeat burglary victimization, *British Journal of Criminology, 31*(4), 411–414.

Ratcliffe, J. H. (2000) Aoristic analysis: The spatial interpretation of unspecific temporal events, *International Journal of Geographical Information Science, 14*(7), 669–679.

Ratcliffe, J. H. (2001) Policing urban burglary., *Trends and Issues in Crime and Criminal Justice,* 213.

Ratcliffe, J. H. (2002a) Aoristic signatures and the temporal analysis of high volume crime patterns, *Journal of Quantitative Criminology, 18*(1), 23–43.

Ratcliffe, J. H. (2002b) Damned if you don't, damned if you do: Crime mapping and its implications in the real world, *Policing and Society, 12*(3), 211–225.

Ratcliffe, J. H. (2002c) Intelligence-led policing and the problems of turning rhetoric into practice, *Policing and Society, 12*(1), 53–66.

Ratcliffe, J. H. and McCullagh, M. J. (1998a) Aoristic crime analysis, *International Journal of Geographical Information Science, 12*(7), 751–764.

Ratcliffe, J. H. and McCullagh, M. J. (1998b) Identifying repeat victimisation with GIS, *British Journal of Criminology, 38*(4), 651–662.

Ratcliffe, J. H. and McCullagh, M. J. (1999) Hotbeds of crime and the search for spatial accuracy, *Geographical Systems, 1*(4), 385–398.

Rengert, G. F. (1996) *The geography of illegal drugs*. Boulder, CO: Westview Press.

Rengert, G. F. (1997) Auto theft in Philadelphia. In R. Homel (Ed.), *Policing for prevention: Reducing crime, public intoxication and injury* (pp. 199–219). Monsey, NY: Criminal Justice Press.

Rich, T. F. (1995) *The use of computerized mapping in crime control and prevention programs*. Washington, DC: National Institute of Justice.

Rich, T. F. (2001) *Crime mapping and analysis in community organization in Hartford, Connecticut*. Washington, DC: National Institute of Justice.

Robinson, M. (1998) Burglary re-victimization—the time period of heightened risk British Journal of Criminology *38*(1), 78–87.

Rossmo, D. K. (1995) Place, space, and police investigations: Hunting serial violent criminals. In D. Weisburd & J. E. Eck (Eds.), *Crime and place* (pp. 217–235). Monsey, NY: Criminal Justice Press.

Rossmo, D. K. (2000) *Geographic profiling*. Boca Raton, FL: CRC Press.

Seddon, K. and Napper, R. (1999) *Integrated crime management model discussion paper*. Unpublished, New South Wales Police Service, Sydney.

Sherman, L. W. (1990) Police crackdowns: Initial and residual deterrence. In M. Tonry & N. Morris (Eds.), *Crime and justice: An annual review of research* (pp. 1–48). Chicago: University of Chicago Press.

Sherman, L. W., Gottfredson, D., MacKenzie, D., Eck, J., Reuter, P. and Bushway, S. (1998) *Preventing crime: What works, what doesn't, what's promising.* Washington, DC: National Institute of Justice.

Smith, A. (1997) *Intelligence led policing*. International Association of Law Enforcement Intelligence Analysts, Inc.

Unwin, D. J. (1996) GIS, spatial analysis and spatial statistics, *Progress in Human Geography, 20*(4), 540–551.

Weisburd, D. (2001) Translating research into practice: Reflections on the diffusion of innovation in crime mapping., *International Crime Mapping Research Conference,* Dallas, TX, keynote seminar, December 2001.

Weisburd, D. and Green, L. (1995) Policing drug hot spots: The Jersey City drug market analysis experiment, *Justice Quarterly, 12,* 711–735.