ORIGINAL PAPER

Hot Spots of Juvenile Crime: A Longitudinal Study of Arrest Incidents at Street Segments in Seattle, Washington

David Weisburd · Nancy A. Morris · Elizabeth R. Groff

Abstract   Recent studies have shown that crime is concentrated at micro level units of geography defined as hot spots. Despite this growing evidence of the concentration of crime at place, studies to date have dealt primarily with adult crime or have failed to distinguish between adult and juvenile offenses. In this paper, we identify crime incidents in which a juvenile was arrested at street segments in Seattle, Washington, over a 14-year period, to assess the extent to which officially recorded juvenile crime is concentrated at hot spots. Using group-based trajectory analysis, we also assess the stability and variability of crime at street segments over the period of the study. Our findings suggest that officially recorded juvenile crime is strongly concentrated. Indeed, just 86 street segments in Seattle include one-third of crime incidents in which a juvenile was arrested during the study period. While we do observe variability over time in trajectories identified in the study, we also find that high rate juvenile crime street segments remain relatively stable across the 14 years examined. Finally, confirming the importance of routine activity theory in understanding the concentration of juvenile crime in hot spots, we find a strong connection between high rate trajectory groups and places likely to be a part of juvenile activity spaces. Though place-based crime prevention has not been a major focus of delinquency prevention, our work suggests that it may be an area with great promise.

Keywords   Juvenile crime · Crime hot spots · Juvenile activity spaces

D. Weisburd (✉)
Hebrew University, Jerusalem, Israel
e-mail: msefrat@mscc.huji.ac.il

D. Weisburd
George Mason University, Fairfax, VA, USA

N. A. Morris
Southern Illinois University, Carbondale, IL, USA

E. R. Groff
Temple University, Philadelphia, PA, USA

⚇ Springer

Introduction

Over the last decade there has been a substantial body of research documenting the importance of crime places in understanding and controlling crime (Eck and Weisburd 1995; Sherman 1995; Taylor 1997; Weisburd 2002). At the core of this academic interest are a series of studies that show that crime is highly concentrated at small units of geography. Whether the unit of analysis is defined as an address, a street segment, or a cluster of street segments, a large number of studies now document that crime is clustered at what have come to be termed "crime hot spots" (Brantingham and Brantingham 1999; Crow and Bull 1975; Pierce et al. 1986; Roncek 2000; Sherman et al. 1989; Weisburd et al. 1992, 2004; Weisburd and Green 1994). This concentration of crime, moreover, has recently been found to be stable across relatively long periods of time (Weisburd et al. 2004).

The extent of the concentration of crime at place is dramatic. In one of the pioneering studies in this area, Lawrence Sherman et al. (1989) found that only 3% of the addresses in Minneapolis produced 50% of all calls to the police. Fifteen years later in a study in Seattle, Washington, Weisburd et al. (2004) reported that between 4 and 5% of street segments in the city accounted for 50% of officially recorded crime incidents for each year over 14 years. These studies and others (Brantingham and Brantingham 1984; Clarke 1983; Curtis 1974; Maltz et al. 1990 [2000]; Pyle 1976; Rengert 1980; Skogan 1990) have established small units of geography or micro places as an important focus of criminological inquiry and practical crime prevention.

Despite this growing evidence of the concentration of crime at place, studies to date have dealt primarily with adult crime or have failed to distinguish between adult and juvenile offenses. This is not to say that the geography of juvenile delinquency has not been a focus of scholars. There has been a sustained interest dating back to the Chicago School in the distribution of juvenile delinquents' residences (Bursik and Webb 1982; Schuerman and Kobrin 1986; Shaw and McKay 1942 [1969]; Sickmund et al. 1997). Indeed, in a study mapping the location of the homes of juvenile offenders in Chicago, Shaw et al. (1929:10) argued that "the study of juvenile delinquency necessarily begins with the study of its geographical location." But despite this early interest in the spatial distribution of juvenile delinquency, a focus on the locations in which juveniles commit their crimes has been largely ignored by criminological researchers (for exceptions, see Stephenson 1974; Turner 1969).

The absence of systematic examination of the distribution of juvenile crime across micro units of geography is particularly surprising given the use of routine activity theory (Cohen and Felson 1979) as a guiding theoretical framework for many crime and place studies (e.g., Sherman et al. 1989; Smith et al. 2000). Routine activity theory emphasizes the importance of the convergence of suitable targets, lack of capable guardianship and motivated offenders in space and time for explaining criminal events. A number of empirical studies suggest that the location of crime events is strongly linked to the routine activities of potential offenders and victims (Brantingham and Brantingham 1975, 1981 [1991]; Duffala 1976; Hunter 1988; LeBeau 1987; Mayhew et al. 1976; Rengert 1980, 1981). In this context, as we describe below, juveniles are likely to have limited "activity spaces" (i.e., areas they are familiar with and visit routinely) and thus the convergence of motivated offenders and suitable targets in space and time is likely to be salient for juvenile crime as it is for adult crime. Routine activity theory, in this context, would predict very high concentrations of juvenile crime at specific places.

In this paper, we provide the first examination of the concentration of officially recorded juvenile crime at micro place units of analysis. Identifying crime incidents in which a juvenile was arrested at street segments (both sides of a street between two intersections) in Seattle, Washington over a 14-year period, we assess the extent to which officially recorded juvenile crime is concentrated at hot spots. Using group-based trajectory analysis (Nagin and Land 1993; Nagin 1999, 2005), we also assess the stability and variability of crime at street segments over the period of the study. Our findings suggest that officially recorded juvenile crime is strongly concentrated at hot spots. Indeed, just 86 street segments in Seattle include one-third of crime incidents in which a juvenile was arrested during the study period. While we do observe variability over time in trajectories identified in the study, we also find that high rate juvenile crime street segments remain relatively stable across the 14 years examined. Finally, confirming the importance of routine activity theory in understanding the concentration of juvenile crime in hot spots, we find a strong connection between high rate trajectory groups and places likely to be a part of juvenile activity spaces.

We begin our paper with a description of the developing importance of micro crime places in research on crime and crime prevention and the relevance of this approach for juvenile crime. We also discuss the specific theoretical framework and rationale that led to the study of the concentration of juvenile crime at micro places. We then provide a description of our data, methods and results. In our discussion we focus on the specific limitations of our data, and the implications of our findings for policy and practice.

Crime at Micro Units of Geography and its Relevance for Juvenile Delinquency

Criminologists have had a long and enduring interest in the idea of place and its role in the production of crime (Weisburd and McEwen 1997; Weisburd et al. 2009). In the early 19th century European scholars examined the distribution of crime across large administrative areas that formed the basis for official government record keeping (e.g., see Guerry 1833; Quetelet 1831 [1984]). Almost 100 years later sociologists associated with the Chicago School (Burgess 1925a, b [1967]; Park et al. 1925 [1967]; Shaw et al. 1929; Shaw and McKay 1942 [1969]; Thrasher 1927) also directed their attention to the distribution of crime at place, focusing on how crime varies across communities. Interest in variations in crime across neighborhoods and communities, in turn, continues to be an important concern of criminologists (e.g., see Reiss and Tonry 1986; Sampson et al. 1997).

In recent years, there has been growing interest in looking at the distribution of crime at smaller geographic units of place such as addresses or street segments, or clusters of these micro units of geography (Eck and Weisburd 1995; Sherman 1995; Taylor 1997; Weisburd and Green 1995). An important catalyst for this interest came from theoretical perspectives that emphasized the context of crime and the opportunities presented to potential offenders (Weisburd 2002). In a groundbreaking article on routine activities and crime, for example, Cohen and Felson (1979) suggest the importance of recognizing that the availability of suitable crime targets and the presence or absence of capable guardians influence crime events. Researchers at the British Home Office, in a series of studies examining "situational crime prevention," also challenged the traditional focus on offenders and communities (Clarke and Cornish 1983). These studies showed that crime situations and opportunities play significant roles in the development of crime (Clarke 1983).

Places in this "micro" context are specific locations within the larger social environments of communities and neighborhoods (Eck and Weisburd 1995). They are sometimes defined as buildings or addresses (Green 1996; Sherman et al. 1989), sometimes as block faces or street segments (Sherman and Weisburd 1995; Taylor 1997), and sometimes as clusters of addresses, block faces or street segments (Block et al. 1995; Weisburd and Green 1995). Research in this area began with attempts to identify the relationship between specific aspects of urban design (Jeffery 1971) or urban architecture (Newman 1972) and crime, later taking into account a much larger set of characteristics of physical space and criminal opportunity (Brantingham and Brantingham 1975, 1981 [1991]; Duffala 1976; Hunter 1988; LeBeau 1987; Mayhew et al. 1976; Rengert 1980, 1981; Roncek and Faggiani 1985).

Recent studies point to the potential theoretical and practical benefits of focusing research on micro crime places (Eck and Weisburd 1995; Sherman 1995; Taylor 1997; Weisburd 2002). A number of studies, for example, suggest that significant clustering of crime at place exists, regardless of the specific micro unit of analysis defined (Brantingham and Brantingham 1999; Crow and Bull 1975; Pierce et al. 1986; Roncek 2000; Sherman et al. 1989; Weisburd et al. 1992; Weisburd and Green 1994). Sherman et al. (1989), for example, found that only 3% of the addresses in Minneapolis produced 50% of all calls to the police. More recently, Weisburd et al. (2004) have shown not only that a similar level of crime concentration exists at street segments in Seattle, but that the concentration of reported crime incidents at micro places is stable over a 14-year period.[1] Weisburd et al. (2004) also point to the importance of recognizing dynamic developmental trends across micro units of geography. Using group-based trajectory analysis (Nagin and Land 1993; Nagin 1999, 2005), they classify the 29,849 street segments in Seattle, Washington into 18 trajectory groups that reflect distinct longitudinal crime patterns.

Juvenile Crime at Places

To date, criminologists have not examined whether juvenile crime at micro place geographic units follows patterns of hot spots concentrations and whether such concentrations vary over time. This is not to say that the location of juvenile crime has been ignored by criminologists. There has long been an interest in the location of where juvenile delinquents live and how that affects the pattern of crime in a city (Baumer et al. 1998; Bursik and Grasmick 1993; Chilton 1964; Gordon 1967; Guerry 1833; Schmid 1960a, b; Schmitt 1957). One of the most influential studies of juvenile delinquency and geography is Shaw and McKay's (1942 [1969]) examination of the spatial distribution of delinquency residences across metropolitan urban communities of Chicago. They identified considerable variation in rates of delinquency (as measured by the residences of delinquents) across

---

[1] It is important to note that portraits of the concentration of crime at place might be altered if larger geographic units were examined. This is often referred to as the 'the modifiable areal unit problem' (Unwin 1996). However, the MAUP problem in studies of micro places is considerably lessened because the unit of aggregation is still extremely small and such studies generally use theoretically-driven units of analysis rather than ones of convenience. Street blocks for example, are much smaller than neighborhoods, census tracts or cities and thus have minimal aggregation bias. While some researchers have experimented with the use of grid cells to minimize the MAUP (Hirschfield et al. 1997), we believe that the use of a theoretically driven micro unit of analysis is a more defensible strategy. As we note below regarding our own approach, following Taylor (1997, 1998), we use street 100 blocks to represent 'behavior settings' and thus provide a theoretical basis for our choice of aggregation unit.

square mile units of geography, with delinquency heavily concentrated in areas next to the center of the city and less concentrated in more remotely located areas (Shaw and McKay's 1942 [1969]). Moreover, they found that the clustering of residences of delinquents within certain Chicago area neighborhoods was relatively stable over time (Bursik and Webb 1982; Shaw and McKay 1942 [1969]).

Schuerman and Kobrin (1986) also examined the residences of delinquents, and used data collected in 1950 and 1960 in Los Angeles to explain the developmental patterns that ultimately resulted in a community being designated as a high crime area in 1970. Schuerman and Kobrin (1986) found three general patterns that led to high crime rates in 1970. The first pattern is termed "emerging", and refers to those clusters that were relatively crime free in 1950 but had moderate to high crime in 1960 and 1970, respectively. The second pattern, "transitional", refers to those clusters that had moderately high crime in 1950, a higher level in 1960 and an even higher level in 1970. The last pattern is referred to as "enduring" and describes those clusters that had persistently high crime rates at all points in time. The vast majority of census tracts within the clusters were designated as having enduring crime rates over the time span, with fewer census tracts in the transitional and emerging categories. These findings indicate that although there is considerable stability in delinquency at the community level over time, there is also variability, as there were areas that began the time series with few crimes and increased over time.[2]

Despite interest in the geographic distribution of the residences of juvenile delinquents, studies examining the distribution of the actual location at which a juvenile crime occurs are a rarity. We could locate only four studies that examined the area in which the juvenile committed a crime. Two examined the classification of crimes by whether the juvenile lived and offended in the same neighborhood (Burgess 1925a, b [1967]; Lind 1930). These studies employed an early version of a spatial typology for classifying crimes called mobility triangles (Groff and McEwen 2005; Normandeau 1968; Rand 1986; Tita and Griffiths 2005). Burgess (1925a, b [1967]) offered an initial description of different types of mobility triangles related to delinquency. Lind (1930), relying on court data, found that the frequency in which juveniles offended in their own neighborhood was related to the type of crime being committed. Neither study detailed the distribution or concentration of juvenile crime within the city.

A third study by Stephenson (1974) examined the dispersion of juvenile residences and crimes across the city of Phoenix, Arizona. He found that the dispersion of offense locations, as measured by juvenile arrests, was greater than the dispersion of home address locations. Turner (1969) measured the distance juveniles travel to commit crime, finding that juveniles travel short distances (the median was about a half a mile) from their residence to the location of the crime event. Notably, Turner's work emphasized the importance of examining the location of a criminal event rather than the location of a juvenile residence for understanding crime. He identified areas, for example, where juvenile residency was low but juvenile crime was high.

---

[2] Several studies have examined the concentration and stability of officially recorded crime in communities over time (Griffiths and Chavez 2004; Schmid 1960b). Additionally, several studies within the communities and crime literature have documented the concentration of self-reported crime within certain communities (Sampson and Groves 1989; Sampson et al. 1997). These studies have examined crime more generally, and have not disaggregated juvenile crime from adult crime.

Routine Activity Theory and the Distribution of Juvenile Crime at Place

While scholars have largely ignored the question of whether juvenile crime is concentrated at micro places, there is strong reason to believe that the concept of crime hot spots is also salient for juvenile crime. Most studies of crime hot spots have relied on routine activity theory (Cohen and Felson 1979) as an explanation for why crime trends vary at places and as a basis for constructing practical crime prevention approaches (Eck and Weisburd 1995; Sherman et al. 1989; Weisburd et al. 2004). The main assumptions of this perspective are that specific characteristics of places such as the nature of guardianship, the presence of motivated offenders, and the availability of suitable targets will strongly influence the likelihood of criminal events (Felson 2002). Studies examining the factors that predict crime at micro places generally confirm this relationship (Roncek and Bell 1981; Roncek and Maier 1991; Smith et al. 2000).

What we know about the routine activities of juveniles suggests that they are strongly concentrated, and accordingly that juvenile crime should be highly concentrated at specific places. This follows from the fact that juveniles are encouraged and often required to be at certain places at specific times. Schools for example, provide a very strong nexus for routine activities of juveniles. Schools and other areas of juvenile activity (e.g., community centers, movie theatres or malls) are places where potential juvenile offenders and juvenile victims come into close contact in contexts where guardianship may not always be high. In this context, Roman (2002, 2005) has found evidence suggesting that the presence of a school in an area increases the probability of violent crimes, even more so around those times of day which are associated with high juvenile activity.

The routine activities of offenders and victims are also affected by routes of travel to and from school. Students are likely to wait at specific bus stops, or take specific paths to schools. In the course of these routine activities they are also likely to identify opportunities for crime both in regard to other students and to the community at large. In this context, the concentration of students in their teenage years in large middle and high schools likely serves to reinforce the role of schools as "focal points" of crime since they increase the concentration of potential offenders and victims in areas proximate to schools and on travel routes to and from schools (Brantingham and Brantingham 1995).

Juveniles are also assumed to be attracted to very specific types of activities which in turn influence their "activity spaces" (Felson 2006). Malls and movie theatres for example, are well known "hang outs" for youth, and indeed such businesses seek to draw young people as customers. Moreover, because such activity spaces will attract large numbers of not only potential offenders, but also potential targets, we might expect large concentrations of juvenile crime in such places. For example, several researchers have found that juvenile delinquency is strongly associated with time spent socializing in unstructured activities with peers in the absence of authority figures (Agnew and Peterson 1989; Osgood et al. 1996; Wallace and Bachman 1991). The fact that juveniles are most likely to victimize other juveniles (Snyder 2003) reinforces the importance of such activity spaces in the development of juvenile crime.

The Data

Our data are drawn from reported crime in the city of Seattle, Washington for the time period of 1989 through 2002. We chose the city of Seattle as a site after a careful screening of available crime data on American cities with populations of over 200,000. We found the

Seattle Police Department to be among a small group of police agencies which kept a relatively long history of official data in computerized format. Seattle was also chosen because it included a diverse population, significant levels of crime during the study period, and was guided by a police administrator fully committed to aiding a basic research program on crime places.

Seattle spans approximately 84 square miles. According to the 2000 US Census, it is the 22nd most populous city (563,374) in the United States and its population has remained relatively constant from 1970 to 2000. Although Seattle's population is primarily Caucasian (70.1%), it has a substantial ethnic mix of African Americans (8.4%), Asians (13.1%), Hispanics (5.3%) and Native Americans (1.0%). The number of crimes per 100,000 people in Seattle was 8,004 in 2002, 1.4 times the average for cities with populations between 100,000 and 1,000,000 (FBI 2003). Compared with cities in a narrower population range (±100,000 of Seattle's population), Seattle's crime rate was slightly higher than the average (7,640) and ranked eighth in 16 jurisdictions in this category.

Unit of Analysis

The geographic unit of interest for this study is the street segment (sometimes referred to as a street block or face block) which is defined as the two sides of a street between two intersections.[3] We chose the street segment for a number of reasons. First, scholars have long recognized the relevance of small areas in organizing life in the city (Appleyard 1981; Jacobs 1961; Smith et al. 2000; Taylor 1997). Taylor (1998), for example, argues that the visual closeness of block residents, interrelated role obligations, acceptance of certain common norms and behavior, common regularly recurring rhythms of activity, the physical boundaries of the street, and the historical evolution of the street segment make the street block a particularly useful unit for analysis of place (Hunter and Baumer 1982; Taylor et al. 1984).

Second, the choice of street segments over smaller units such as addresses (e.g., see Sherman et al. 1989) minimizes the error likely to develop from the miscoding of addresses in official data (Klinger and Bridges 1997; Weisburd and Green 1994).[4] For example, when a crime is committed on the street rather than at a particular residence or store, police may have difficulty accurately identifying a specific address for the crime. They are more likely to accurately identify the overall street segment and thus address range of the crime's occurrence. At the same time, we recognize that crime events may be linked across street segments. For example, a drug market may operate across a series of blocks (Weisburd and Green 1995; Worden et al. 1994), and a large housing project and problems associated with it may traverse street segments in multiple directions (Skogan and Annan 1994). Nonetheless, we thought the street segment a useful compromise because it allows a unit large enough to avoid unnecessary crime coding errors, but small enough to avoid aggregation that might hide specific trends.

---

[3] Normally, a street segment in Seattle is delimited in multiples of 100. For example, addresses from 100 to 199 Main Street would most likely occur on one street segment, between two intersections or other divisions. Following this, the database supporting the Seattle street map was used to develop "100 blocks" for each city street in Seattle. For example, if the base map listed a street as spanning house numbers 1 through 399, we created four segments from this range: 1–99, 100–199, 200–299, and 300–399. See Weisburd et al. (2004) for further discussion of the geo-coding process.

[4] The use of a street segment rather than an area (i.e., neighborhood, census tract, block group, zip code, etc.) also avoids the myriad of difficult coding issues that have been identified when trying to define perceptually-based geographic units such as a neighborhood (See Sampson et al. 2002; Suttles 1972).

Identifying Juvenile Crime Incidents

We sought in our study to identify trends of juvenile crime at micro places. Our first problem was to find a method for identifying when a crime involved a juvenile offender. Prior studies of crime at micro place units of analysis have generally relied on emergency calls to the police or officially recorded crime incidents. However, neither of these data bases includes a direct measure of the age of the offenders involved in the crimes identified. In the case of emergency calls, the police are simply responding to a request for police service, which often does not include information on the characteristics of offenders. Indeed, many times citizens simply inform the police of their suspicion that a crime has been committed. Incident reports are generally more detailed, since they include details of the crime as known to the officer and victim at the time a report is taken. However, even in these cases the characteristics of offenders are generally not known, and when they are known, there is often no way to determine the age of offenders with any accuracy.

Among official data, arrest reports provide the most accurate listing of the ages of suspects. However, arrest reports provide a measure of "offenders" and not "offenses." In our case, we were not interested in how many offenders had been arrested in a specific place, but in how many crimes were committed there. Following this interest we first used arrest reports to identify all juvenile offenders, and then linked these arrest reports to incident reports to identify crime incidents in which at least one juvenile offender (age 8–17) was arrested. We term these events in our paper as "juvenile arrest incidents" in order to distinguish these data from arrests per se, and incident reports more generally.

While this approach allows us to identify crime incidents which had juvenile involvement, it also means that our measure of juvenile crime is necessarily limited to those crimes that led to an arrest. This approach is common in study of official juvenile crime for the reasons we have noted above (McCord et al. 2001), but nonetheless has specific limitations. For example, only 16.8% of incident reports included an arrest in Seattle during the study period. In turn, arrest reports are likely to be strongly correlated not only with where juveniles commit crime but also with where police are heavily concentrated. We turn to these limitations of our data and their implications for drawing inferences from our study in more detail when we discuss our findings.

Describing the Distribution of Juvenile Crime Across Place

Figure 1 displays the overall annual trend of crime incidents in which a juvenile was arrested at a street segment in Seattle between 1989 and 2002.[5] The trend here not only mirrors the overall crime trend for Seattle (Weisburd et al. 2004), but also the national

---

[5] We want to remind the reader that our data refer only to crime at street segments and not crime at intersections. Of the 2,028,917 crime records initially obtained from the city from 1989 to 2002, 19% were linked to an intersection. Our decision to exclude these events was primarily technical. Intersections could not be assigned to any specific street segment because they were generally part of four different ones. However, it is also the case that incident reports at intersections differed dramatically from those at street segments. Traffic-related incidents, which are unlikely to involve juveniles, accounted for only 4.5% of reports at street segments, but for 44% of reports at intersections. Because we linked arrest data only to a street segment data base, we can not directly assess the number of juvenile arrest incidents that were dropped because of the exclusion of intersections. In a recent study by Braga et al. (1980–2008, Unpublished Manuscript) which compared shooting incidents using three different units of analysis (intersections, street segments, and both intersections and street segments) they found consistent overall results regardless of unit of analysis.

Fig. 1 Distribution of juvenile arrest incidents on Seattle street segments, 1989–2002

level trend (Blumstein and Wallman 2000). Incidents peaked in 1993 and decreased sharply from 1994 to 2002. From 1989 to 2002, Seattle experienced a 41% decline in juvenile arrest incidents. Figure 2 presents the percentage of segments which account for 50 and 100% of juvenile arrest incidents each year. We find that approximately 3–5% of the street segments are responsible for all incidents during any given year. Less than 1% of total street segments are responsible for 50% of the arrest incidents during any given year. These findings suggest strong concentration of juvenile arrest incidents, which is consistent with our discussion earlier regarding the limited activity spaces of juveniles.

One problem in assessing the extent of this concentration is that we would expect just by chance for there to be some concentration of juvenile arrest incidents. The fact that there
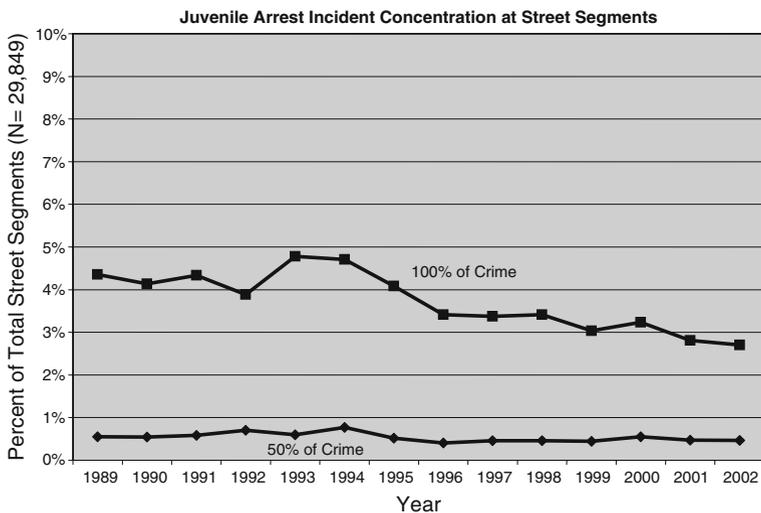

Fig. 2 Juvenile arrest incident concentration at street segments

are fewer than 3,000 crime incidents in which a juvenile was arrested each year and almost 30,000 street segments in Seattle overall, means that even if there was a random distribution of crime at street segments only a small proportion would have any juvenile arrest incidents. Moreover, just by chance, there is likely to be some fluctuation and concentration in certain places. To examine this question we constructed a Poisson distribution detailing the expected number of street segments that would have from "0" to "5 or more" incidents for each year. We then conducted a chi square goodness of fit test to examine whether the concentration of events at street segments is greater than would be expected from chance alone. Our results show that the concentration of arrest incidents is significantly different from what would be expected by chance for each year (see Appendix). Indeed, the differences between the expected and observed values are generally very large. For example, in every year observed the Poisson distribution shows a significantly lower expected count of segments with 0 arrest incidents than those actually observed in our data. Whereas the Poisson distribution indicates that we should expect virtually no street segments to have three or more crime incidents in which a juvenile was arrested each year, our observed frequencies show that large numbers of street segments have three or more incidents.

Our data so far suggest that juvenile arrest incidents are highly concentrated in each year of the period we studied, and that this concentration of juvenile crime at place is fairly stable across the 14 years we examined. However, the descriptive analyses we have employed so far do not allow us to examine patterns of change across this time period. Is there stability in terms of patterns of change across street segments, or do different groups of street segments evidence divergent patterns? For example, do the same street segments evidence high levels of juvenile arrest incidents each year, or do segments show high variability across time? Such questions are particularly important in drawing policy conclusions regarding hot spots of crime from our data. If high rate juvenile crime hot spots moved from street segment to street segment across the study period, there would be little benefit to focusing crime prevention on juvenile crime hot spots.

Trajectories of Juvenile Crime at Place

We use group-based trajectory analysis (Nagin and Land 1993; Nagin 1999, 2005) to answer these questions. Although trajectory analysis was originally developed to examine longitudinal patterns of individual offending over time, it has recently been applied to crime at different levels of geography (Griffiths and Chavez 2004; Weisburd et al. 2004). Trajectory analysis is a group-based modeling approach that is able to model dynamic developmental processes by using groups to approximate an unknown, continuous distribution (Bushway et al. 1999; Nagin 2005).[6]

---

[6] We recognize that we could have used other statistical techniques such as hierarchical linear modeling (Bryk and Raudenbush 1987, 1992; Goldstein 1995), growth mixture modeling and nonparametric growth mixture modeling (Kreuter and Muthen 2008; Meredith and Tisak 1990; Muthen 1989) to identify developmental processes in our data. However, we thought that the trajectory approach was most fit to our interest in identifying specific crime patterns for street segments over time and visually displaying those patterns. While the interpretations drawn from the trajectory approach regarding whether groups are "real" have recently been criticized by some criminologists (e.g., see Eggleston et al. 2004; Sampson and Laub 2005), even its critics argue for the "scientific value of description and pattern recognition" (Sampson and Laub 2005: 911) that the trajectory approach offers. And indeed, this is precisely our interest in the use of trajectory analysis in this paper.

Table 1 Summary data and trajectory model diagnostics

Group	% Of segments	% Of juvenile arrest incidents	Average total juvenile arrest incidents	Estimated group probability	Average posterior probability
1	1.00	6.85	6.92	0.0122	0.82
2	88.79	11.92	.14	0.8676	0.97
3	8.57	26.14	3.07	0.1034	0.84
4	1.13	14.82	13.16	0.0114	0.89
5	0.22	7.01	31.43	0.0023	0.95
6	0.13	8.36	62.73	0.0012	1.00
7	0.03	10.65	399.63	0.0002	1.00
8	0.13	14.21	112.24	0.0013	0.98

Nagin (2004, 2005) has repeatedly emphasized, however, that these trajectory groups are not inherently real or immutable over time. As with all statistical analyses, trajectory analysis is an approximation of reality and is driven primarily by the data which it uses to produce estimations. Thus, as with virtually all statistical approaches, the methodological issues pertaining to the time span studied, and the quality of the data substantively impact the findings (Eggleston et al. 2004; Nagin 2004). Moreover, since trajectory analysis is a statistical approximation of reality, it can never reproduce that reality without error, and as such, there is some degree of accuracy lost (Nagin 2004). However, simulation studies of trajectory analysis approximations have suggested that this loss is rather small, and the flexibility and descriptive utility of the method arguably outweigh these drawbacks (Brame et al. 2006; Nagin 2004).

We used the Poisson model with quadratic functions to estimate the trajectories.[7] After fitting a number of groups to the data and assessing model fit using several diagnostics, we chose the eight group solution as our final model. Nagin (2005) has specified several ways to assess model adequacy.[8] The average posterior probability in our study is the average probability of a street segment i, being classified into group j given segment i's data over time. Average posterior probabilities that are near or equal to 1.00 are ideal, as this indicates that the majority or all of the segments in a trajectory group had near perfect assignment. Nagin (2005) suggests that average posterior probabilities above .70 are acceptable. Table 1 displays the trajectory model diagnostics and summary statistics. All eight average posterior probabilities meet Nagin's suggested cut-off point indicating that the model is an acceptable fit to the data. Results from the remaining diagnostic

---

[7] We also used the zero-inflated Poisson model to accommodate over-dispersion and results are substantively similar to those generated by the non-inflated Poisson model. Given that the non-inflated model is more parsimonious, we report results from the Poisson model.

[8] A comparison of the Bayesian information criterion (BIC) across models is also useful for determining which models fit the best given the data. The BIC is useful for determining the optimal number of trajectory groups and is expressed in the following form:

$$BIC = \log(L) - 0.5 \times \log(n) \times (k)$$

where "L" is the value of the model's maximized likelihood, "n" is the sample size, and "k" is the number of parameters (specifically groups). One very important benefit of the BIC is that it institutes a penalty for increasing the number of groups in the model. Expansion of the model by adding more groups is only desirable if the resulting improvement in the log likelihood exceeds the penalty for more parameters (Nagin 2005).

Eight Trajectory Groups
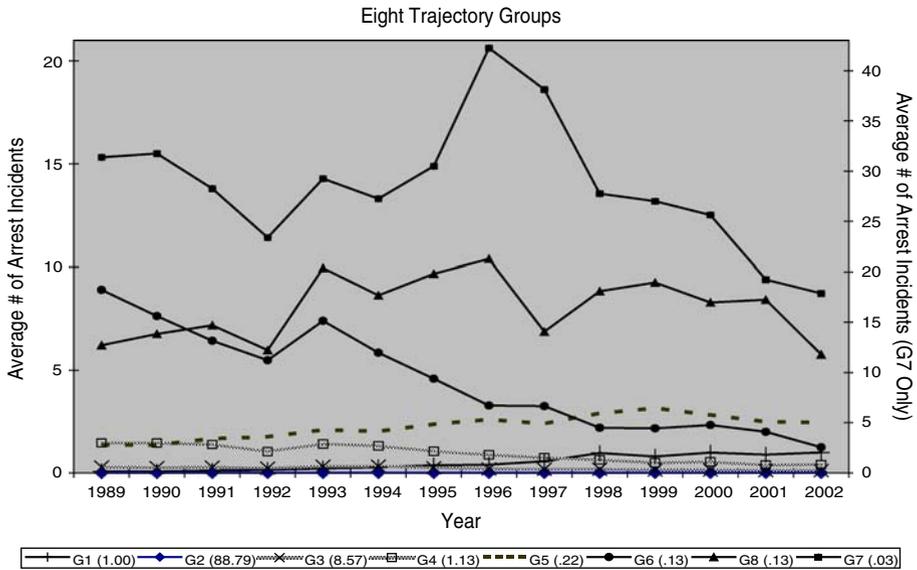
*Note: Trajectory group G7 follows the right axis.

Fig. 3 Eight trajectory groups

assessments also indicate that the model is fitting the data well and has high assignment accuracy.[9]

Figure 3 displays the average number of juvenile arrest incidents for street segments in each of the eight trajectory groups across the 14 years of study. The average number of juvenile arrest incidents for street segments in trajectory group 7 corresponds to the right axis, and all the values for the remaining trajectory groups correspond to the left axis. Confirming our earlier analyses, it is clear that the vast majority of street segments have very little or no juvenile crime as measured by arrest incidents throughout the time period. Trajectory group 2 contains approximately 89% of all street segments, yet the segments in this trajectory group only account for 12% of all juvenile arrest incidents during the period of study.

This analysis also reinforces our earlier finding regarding the concentration of juvenile arrest incidents. Perhaps most striking about Fig. 3 is the substantially higher average level of incidents exhibited by a relatively small number of street segments. Although trajectory groups 6, 7 and 8 include only .29% ($n = 86$) of the street segments in the city, about a third of all juvenile arrest incidents occurred on those street segments during the 14-year period studied. This concentration of juvenile arrest incidents is striking, and we believe has important policy implications. At the same time, as we discuss below, some degree of

---

[9] For example, the odds of correct classification (OCC) estimates for all the trajectory groups are equal to or greater than 5.00, indicating that the model has high assessment accuracy. The odds of correct classification are a function of both the probability and posterior probability. Additionally, assignment accuracy is high when both the estimated group probabilities and the proportion of the sample assigned to the group on the basis of the maximum posterior probability rule are equivalent or correspond highly with each other.
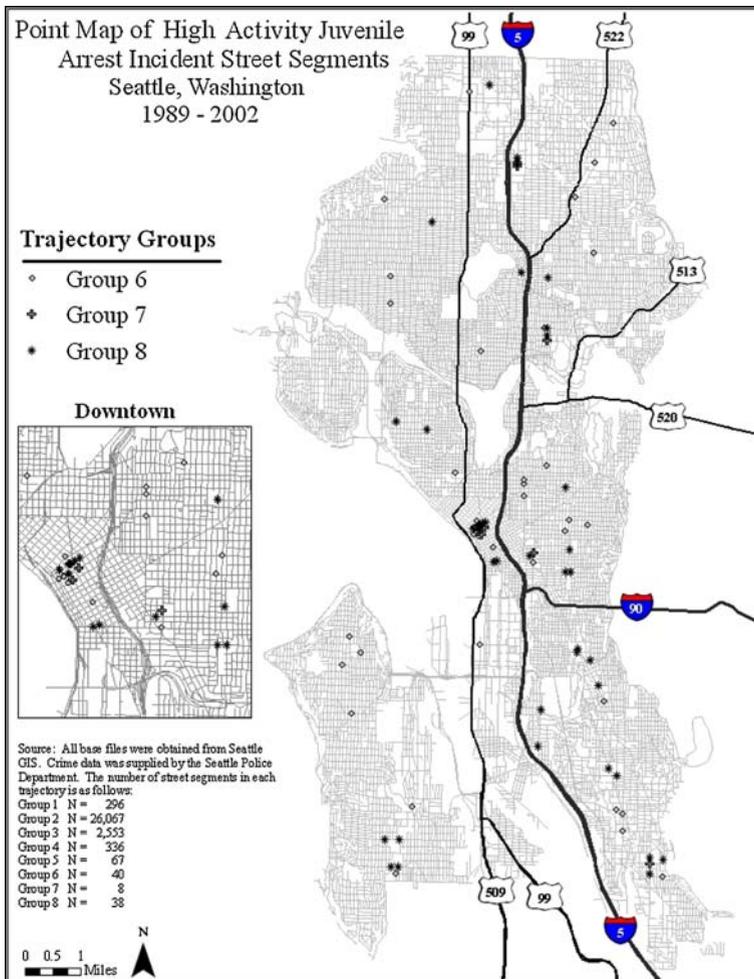
Fig. 4 Point map of high activity juvenile arrest incident street segments Seattle, Washington 1989–2002

the clustering may be due to police patrol concentrations rather than juvenile crime concentrations themselves.

Figure 4 presents the exact location of these high activity hot spot street segments on the Seattle city map. On the one hand there is a good deal of geographic spread of the data, with hot spots street segments found throughout the city. At the same time, there is a clear clustering of such street segments in the downtown business section (highlighted in the map). But even here, it is useful to note the street by street variability in the data.[10]

---

[10] One intriguing question regarding this concentration of crime in juvenile crime hot spots is whether such places are spatially dependent. In another paper using these data, Groff, Weisburd and Morris (2009) have examined the spatial patterns of trajectory group members using a variety of local geographic measures. Overall, they found tremendous street segment to street segment variation in temporal patterns of juvenile crime.

Table 2 Trajectory group membership by location of incident ($N = 30{,}004$)

Group	Location of incident						
	School, youth center (%)	Shops, malls, restaurants (%)	Street, alley, public spaces (%)	Private dwelling (%)	Bars, clubs, taverns (%)	Other (%)	Total (%)
1	1.9	10.2	32.1	47.3	.2	8.3	100.0
2	1.8	2.1	53.7	34.3	.1	8.0	100.0
3	2.9	4.8	43.3	40.1	.3	8.6	100.0
4	3.9	14.3	42.5	29.8	.2	9.3	100.0
5	6.5	26.0	40.7	14.3	.4	12.2	100.0
6	17.1	34.3	32.5	5.2	2.5	8.4	100.0
7	12.7	75.4	8.8	.2	.1	2.9	100.0
8	30.7	38.9	21.5	.7	.0	8.0	100.0

Looking at the eight trajectories it is clear that there is considerable stability among street segments in levels of officially reported juvenile crime (see Fig. 3). For example, street segments in trajectory group 7 had the highest level of juvenile arrest incidents at the outset of the study period and remained the highest level trajectory at the end of the study period. Trajectory group 8 which began with the third highest average rate for street segments, had the second highest rate at the end of our observations. Similarly, trajectory groups 1, 2 and 3, which had very low levels of juvenile arrest incidents at street segments at the outset of study period, also had low levels at the conclusion. Nonetheless, despite the stability of average crime levels for street segments in the trajectory groups, it is interesting to note the different trends in juvenile arrest incidents across the trajectory groups.

Although most of the trajectory groups exhibit decreasing trends over time that are consistent with the overall crime decline in Seattle, there is also evidence of trajectories that exhibit increasing juvenile arrest incident trends during this time period. Street segments in trajectory group 5 begin with an average number of arrest incidents close to one in 1989, but show a steadily increasing trend through the late 1990s to an average of almost two and a half events per year. Though only 67 street segments are found in this group, it represents an interesting pattern because it goes against the overall citywide trend in Seattle.

Trajectory groups 6 and 8 illustrate that the initial level of juvenile arrest incident activity at places does not necessarily predestine future juvenile crime activity. Street segments in trajectory groups 6 and 8 have on average relatively similar levels of officially recorded juvenile arrest incidents (8.22 and 6.20) in 1989. But while trajectory group 8 ends with a slightly higher average value in 2002, trajectory group 6 has a declining trend through the 14 years, ending with an average of only 1.25 juvenile arrest incidents. The differences at the end of the period are statistically significant.[11]

---

[11] We constructed a 95% confidence interval around the average point estimate in 2002 for trajectory groups 6 (95% CI: 1.08–1.55) and 8 (95% CI: 5.94–7.09) to ensure that their respective end points did not overlap and were indeed significantly different. Confidence intervals indicated that each point estimate was distinct.

At the outset of the paper we argued that juvenile crime is likely to be highly concentrated at places, in good part because juvenile activity spaces are also concentrated. Data drawn from incident reports provide confirmation of the relevance of juvenile activity spaces and routine activity theory for understanding the very high concentration of juvenile arrest incidents in Seattle. The incident reports include a field which notes the type of location that was associated with a specific incident. Table 2 displays trajectory group membership by percent of arrest incidents that were committed at specific types of activity spaces.

The highest rate trajectories (6–8) are less likely to include crimes committed at private dwellings as compared to the low rate trajectory groups. Indeed, only 5.2% of places where incidents occurred are listed as private dwellings in trajectory 6, and less than 1% in trajectory groups 7 and 8. By contrast, the lowest rate trajectories (1–4) have substantially more incidents that occurred at private dwellings (between 29.8 and 47.3%). Trajectory group 5, which shows an increasing slope across the time period and forms an intermediary rate trajectory, is closer to trajectories 6 through 8 in this regard with only 14.3% of incidents occurring in private dwellings.

The highest rate trajectories are much more likely to have arrest incidents committed at schools and/or youth centers, and shops/malls and restaurants, as compared to low rate trajectory groups. In each of the low rate trajectory groups (1–4) fewer than 4% of the arrest incidents occurred at schools or youth centers. However, more than 30% of the arrest incidents in trajectory group 8 occurred at a school or youth center. About 12.7% of the incidents in trajectory group 7 and 17.1% of the incidents in trajectory group 6 occurred at a school or youth center. The differences between the high rate and low rate groups are even more pronounced when we look at the proportion of arrest incidents found at shops, malls and restaurants. While fewer than 15% of incidents in each low rate trajectory group (1–4) occurred at these types of locations, between 34.3 and 75.4% of arrest incidents in trajectories 6 through 8 occurred at shops, malls and restaurants. Again, trajectory group 5 forms an intermediate group both in terms of the frequency of arrest incidents and of the location of the incidents.

These data provide important support for the assumption that juvenile crime is concentrated because of the concentration of juveniles in juvenile activity spaces. Incidents in the highest rate trajectories are most likely to be found at and around schools and youth centers, or shops, malls and restaurants. This means that hot spots of juvenile crime, as evidenced by arrest incidents, are likely to be located in places where juveniles congregate. Not surprisingly, given the nature of our sample, very few arrest incidents are found at bars, clubs and taverns. While prominent activity places for adults, and often crime hot spots (Roncek and Bell 1981; Roncek and Maier 1991), they are not part of the activity spaces of juveniles.

Discussion

Our findings suggest that the hot spots paradigm has significant relevance to juvenile crime. Using crime incidents in which a juvenile was arrested as a measure, we find very significant clustering of juvenile crime at place. Our data also show a good deal of stability over time in juvenile arrest incidents at micro places, confirming what has been found not only in the study of micro crime places (Weisburd et al. 2004) but also more generally in studies of juvenile crime trends (as measured by the residences of delinquents) at larger units of geography (Bursik and Webb 1982; Schuerman and Kobrin 1986; Shaw and

McKay 1942 [1969]; Sickmund et al. 1997). We also find preliminary support for the salience of routine activity theory (Cohen and Felson 1979) and its emphasis on the convergence in time and space of suitable targets and motivated offenders. Looking at the places where juvenile arrest incidents are committed we find that juvenile activity spaces are prominent.

These findings are the first we know of to describe the distribution of juvenile crime across micro units of geography, and thus provide significant new data on the relationship between juvenile crime and place. Nonetheless, we think it important to focus on the limitations of our data before concluding, and how they might impact upon the portrait of juvenile crime that we gain. Our interest in identifying where juvenile crime is concentrated led us to rely on juvenile arrests to identify juvenile crime incidents. As noted earlier, without an arrest there is simply no method for identifying the age of offenders involved in crime incidents. This is a common limitation for research on juveniles using official data or studies examining juvenile crime trends at the national level (McCord et al. 2001), but nonetheless raises important questions regarding the inferences we can draw from our study.

Is it reasonable to conclude that arrests of juvenile offenders reflect more generally juvenile offending patterns? While there has long been an assumption that juvenile crime is particularly prone to reporting biases, recent research suggests that for juveniles as for adult offenders, official data and self report data are consistent in identifying overall offending patterns (Brame et al. 2004). This is not to say that arrests provide an accurate portrait of juvenile offending. Indeed, most scholars agree that there is severe underreporting of juvenile crime even as contrasted with adult crime either because crimes are not detected or police choose not to pursue an arrest (Erickson and Empey 1963; Gold 1966; Williams and Gold 1972). Nonetheless, Brame et al. (2004, p. 269) conclude that juveniles "who are arrested more often tend to self-report involvement in offending at greater levels than those who have been arrested less often." In our data, we identify only 30,004 crime incidents in which a juvenile was arrested, a figure that certainly underestimates the number of juvenile crimes in Seattle during the study period. However, if Brame et al.'s analyses on individual juvenile offending can be extrapolated to juvenile arrest incidents at places, it is reasonable to conclude that our data, while underestimating the frequency of juvenile arrest incidents, reflect more broadly the overall concentration of juvenile crime.

Underreporting of juvenile arrests is not the only bias relevant to our data. Our interest in the concentration of crime also raises a concern regarding possible police enforcement bias at places. Certainly it is true that police activities are not randomly spread through the urban landscape and this might lead to specific concentrations of crime incidents in those places where police are concentrated. In this context, we might expect schools, stores and other commercial areas to figure more prominently than other areas in the allocation of police patrol and other resources.

While such biases are present in our data as in studies more generally of crime at place using official crime information, other influences on police resource allocation suggest that they may be less consequential than is sometimes assumed. A number of scholars have emphasized the extent to which the allocation of police resources in a city is not determined by the priorities of police executives, but the requests of citizens through emergency response systems (Mazerolle et al. 2005; Sparrow et al. 1990). This means that the concentration of police presence is strongly related to where citizens or business owners identify crime, and suggests that the distribution of police resources does follow at least to some extent the distribution of crime as it is known to crime

victims in the city. In this context it is not surprising that similar portraits of crime concentration are found when identifying specific types of hot spots (e.g., for drugs and disorder) using arrests, incidents, or calls for service (Lum 2003; Weisburd and Green 1994).

Nonetheless, it is clear that police priorities may impact the distribution of crime as measured by incidents in which juveniles are arrested. While there is no direct way for us to assess the actual extent of this bias, the distribution of offenses in our data provide an indirect measure of proactive police activities. High rates of drug crime arrests or arrests for disorderly behavior are much more likely to reflect proactive policing efforts at particular places, since such crimes are often the direct result of police observing such behaviors on the street and making an immediate arrest. In our data, only 22.3% of the incidents that are recorded are for disorder, drugs or prostitution. In this regard, it is interesting to note that the proportion of such crimes here is not very much different from a study of crime incidents generally in Seattle where 17% of incidents were classified as disorder, drugs or prostitution (Weisburd et al. 2004). In turn, if we just look at the three highest rate trajectory groups the proportion of incidents categorized as disorder, drugs or prostitution is even lower, ranging between 2.9 and 13.6%. While these data do not provide conclusive evidence regarding the impact of proactive enforcement on our findings, they do suggest that such influences in our data may not be greater than that found in prior studies of crime more generally.

Our approach is the only method we know of at this time to identify where juvenile crime is located in the city given available data sources. It is clear, however, that our reliance on arrest data to identify the age of offenders involved in a crime incident limits our ability to draw direct conclusions regarding juvenile crime itself. The fact that our findings are consistent with a series of prior studies that indicate strong concentration of crime at place (Eck and Weisburd 1995; Sherman 1995; Taylor 1997; Weisburd 2002), and more generally with the assumptions of routine activity theory gives them added weight. Nonetheless, having identified the presence of juvenile crime hot spots in official crime data, it is important for other scholars to examine these trends across other urban contexts and to explore different methods of data collection. For example, Oberwittler and Wikström (2009) examine the location of crime events for juveniles from self-report studies in the UK. Though such data do not allow for an accounting of crime events outside the sample, they would allow for examination of clustering of crime within the samples examined.

Despite the limitations of our data, we think they do reflect more general concentrations of juvenile crime in urban contexts. This in turn raises the question of whether juvenile crime is less or more concentrated than adult crime. We noted earlier that the limited nature of juvenile activity spaces suggests that juvenile crime should be particularly concentrated. But routine activity theory has also been used as an explanation for the concentration of adult crime, and there is, as we have noted, strong evidence of concentration of crime generally in crime hot spots (Brantingham and Brantingham 1999; Crow and Bull 1975; Pierce et al. 1986; Roncek 2000; Sherman et al. 1989; Weisburd et al. 1992, 2004; Weisburd and Green 1994). One indication of the extent of juvenile crime clustering is the degree to which juvenile arrest incidents are concentrated in the highest activity trajectory groups. Fully one-third of the crime incidents in which a juvenile was arrested are found in the 86 street segments in these groups. This statistic alone is striking. There is no comparable study that we know of that isolates adult crime, or that identifies arrest incidents as we have defined them. In a study in Seattle (Weisburd et al. 2004) that looked at all crime incidents between 1989 and 2002, the highest rate

trajectory was relatively stable and also accounted for a significant proportion of all crime incidents examined. However, in this case about 256 street segments accounted for 21% of all crime incidents.

This suggests that a relatively larger proportion of juvenile crime can be found at a relatively smaller number of street segments in Seattle, but it does not in itself mean that juvenile crime is more strongly concentrated per se. Even if we discount the differences between arrest incidents as defined here and crime incidents as defined by Weisburd et al. (2004), it is important to keep in mind the large differences in crime frequencies between the studies. Just by chance we would be likely to find a larger proportion of crime in a smaller proportion of the street segments in the present study. If crime incidents were randomly distributed over streets in Seattle in the Weisburd et al. (2004) study we would expect about one-third of the street segments to contain about 50% of the crime incidents.[12] In fact about 4.5% of the street segments were found to contain 50% of the crime incidents. In the present study we found that about one half a percent of the segments contained 50% of the arrest incidents. If arrest incidents were distributed randomly we would expect about 4% of the segments to contain 50% of the arrest incidents.

We do not think it is possible to draw a strong conclusion from these data regarding the relative concentration of juvenile crime. But this does not diminish the importance of our observations regarding juvenile arrest incidents in Seattle. Our study suggests that juvenile crime is highly concentrated at crime hot spots. This finding is consistent with prior studies of crime at place, but is the first to identify the importance of small units of geography in understanding juvenile crime.

The fact that so high a proportion of juvenile arrest incidents are found in such a small number of street segments suggests significant opportunities for the police and crime prevention more generally. There is a strong body of evidence that police efforts focused on crime hot spots can impact crime and disorder in those areas without creating spatial displacement (Braga et al. 1999; Braga and Weisburd, Hot spots policing, Unpublished Manuscript; Skogan and Frydl 2004; Weisburd and Eck 2004; Weisburd et al. 2004). Indeed, there is a growing body of evidence that policing hot spots will lead to a diffusion of "crime control benefits" (Clarke and Weisburd 1994) to areas nearby those targeted (Braga et al. 1999; Weisburd et al. 2006). We think our findings here suggest that juvenile crime hot spots also offer an important opportunity for crime prevention.

But are the police the right agents to address juvenile crime hot spots? Rosenbaum (2006) points out there may be unintended and negative consequences of hot spots policing. Policing juvenile hot spots, in this regard, may lead unnecessarily to labeling and stigma of young people that may have long term negative consequences. Moreover, recent research on juvenile crime suggests that delinquency can be prevented by altering the supervision and structure of juvenile activities. Osgood et al. (1996) have shown a strong causal relationship between "unstructured socializing" such as getting together with friends or going out for fun and recreation and juvenile delinquency.

We find that hot spots of juvenile arrest incidents are clustered in places likely to be part of juvenile activity spaces. We might speculate in this regard that the juvenile crime hot

---

[12] We use the Poisson distribution to approximate the expected number of streets with exactly × incidents for both studies.

spots we have identified are places where unstructured socializing is common, and that one explanation for high numbers of arrest incidents in those areas is that they are not adequately structured and supervised. A number of scholars have pointed to the importance of "place managers" in preventing crime at places (Eck and Wartell 1998; Felson 1995). It may be that place managers are particularly important in creating supervised socializing for young people. Our findings of very strong concentrations of juvenile crime at hot spots suggest that the introduction of such place managers in a small number of places might have strong crime prevention benefits.

Conclusions

There has been a considerable amount of research using group-based trajectory analysis to identify distinctive long-term patterns of offending among individuals (see Piquero 2008 for a review). The current study extends this approach to the study of juvenile crime at places over time by using trajectory analysis to identify patterns of juvenile arrest incidents at places. To our knowledge this study provides the first portrait of the distribution of officially recorded juvenile crime events across micro units of geography. We find that crime incidents in which a juvenile is arrested, like crime more generally (Brantingham and Brantingham 1999; Crow and Bull 1975; Pierce et al. 1986; Roncek 2000; Sherman et al. 1989; Weisburd et al. 1992, 2004; Weisburd and Green 1994), are concentrated at crime hot spots and evidence significant stability at such places over time. Moreover, our paper identifies the salience of routine activity theory for understanding such concentrations of juvenile crime at place.

The very high concentration of juvenile arrest incidents in Seattle points to the importance of place-based crime prevention for reducing juvenile crime. By addressing only a relatively small number of street segments in the city, police or other crime prevention authorities can potentially target a large proportion of officially recorded juvenile crime. The finding of stability across time further reinforces the importance of place-focused crime prevention. If the most active hot spots are likely to stay very active over time, they provide a very stable focus for intervention. Though place-based crime prevention has not been a major focus of delinquency prevention, our work suggests that it may be an area with great promise.

Appendix

See Table 3.

Table 3 Distribution of all juvenile arrest incidents in Seattle by observed and expected number of street segments each year, (a) 1989–1993, (b) 1994–1998, (c) 1999–2002

(a)

# Of crimes	1989*		1990*		1991*		1992*		1993*	
	Observed	Expected	Observed	Expected	Observed	Expected	Observed	Expected	Observed	Expected
0	28,549	27,428	28,614	27,571	28,555	27,554	28,689	27,887	28,422	27,225
1	970	2,320	924	2,189	959	2,204	869	1,896	1,051	2,505
2	165	98	149	87	160	88	162	64	197	115
3	52	3	57	2	60	2	40	1	55	4
4	24	0	28	0	32	0	29	0	27	0
5>	89	0	77	0	83	0	60	0	97	0

(b)

# Of crimes	1994*		1995*		1996*		1997*		1998*	
	Observed	Expected	Observed	Expected	Observed	Expected	Observed	Expected	Observed	Expected
0	28,444	27,362	28,631	27,609	28,831	27,748	28,842	27,943	28,831	27,915
1	1,015	2,380	888	2,154	736	2,026	737	1,844	736	1,870
2	214	104	176	84	134	74	133	61	145	63
3	66	3	58	2	55	2	56	1	37	1
4	26	0	27	0	18	0	18	0	32	0
5>	84	0	69	0	75	0	63	0	68	0

(c)

# Of crimes	1999*		2000*		2001*		2002*	
	Observed	Expected	Observed	Expected	Observed	Expected	Observed	Expected
0	28,944	28,083	28,884	28,055	29,010	28,280	29,042	28,422
1	660	1,713	694	1,739	614	1,527	585	1,393
2	112	52	142	54	114	41	111	34

Table 3 continued

# Of crimes	1999*		2000*		2001*		2002*	
	Observed	Expected	Observed	Expected	Observed	Expected	Observed	Expected
3	47	1	50	1	40	1	49	1
4	19	0	17	0	17	0	11	0
5>	67	0	62	0	54	0	51	0

* $p < .001$

References

Agnew R, Peterson DM (1989) Leisure and delinquency. Soc Probl 36:332–350

Appleyard D (1981) Livable streets. University of California Press, Berkeley

Baumer EP, Lauritsen JL, Rosenfeld R, Wright R (1998) The influence of crack cocaine on robbery, burglary, and homicide rates: a cross-city longitudinal analysis. J Res Crime Delinq 35:316–340

Block C, Dabdoub M, Fregly S (eds) (1995) Crime analysis through computer mapping. Police Executive Research Forum, Washington, DC

Blumstein A, Wallman J (eds) (2000) The crime drop in America. Cambridge University Press, Cambridge

Braga AA, Papachristos AV, Hureau D (1980–2008) The concentration and stability of gun violence at micro places in Boston (Unpublished Manuscript)

Braga AA, Weisburd D, Waring EJ, Mazerolle LG, Spelman W, Gajewski F (1999) Problem-oriented policing in violent crime places: a randomized controlled experiment. Criminology 37:541–580

Brame R, Fagan J, Piquero AR, Schubert CA, Steinberg L (2004) Criminal careers of serious delinquents in two cities. Youth Violence Juv Violence 2:256–272

Brame R, Nagin DS, Wasserman L (2006) Exploring some analytical characteristics of finite mixture models. J Quant Criminol 22:31–59

Brantingham PL, Brantingham PJ (1975) Residential burglary and urban form. Urban Stud 12:104–125

Brantingham PJ, Brantingham PL (1981) Environmental criminology. Waveland Press, Prospect Heights [1991]

Brantingham PJ, Brantingham PL (1984) Patterns in crime. Macmillan, New York

Brantingham PL, Brantingham PJ (1995) Criminality of place: crime generators and crime attractors. Eur J Crim Pol Res 3:5–26

Brantingham PL, Brantingham PJ (1999) Theoretical model of crime hot spot generation. Stud Crim Crim Prev 8:7–26

Bryk AS, Raudenbush SW (1987) Application of hierarchical linear models to assessing change. Psychol Bull 101:147–158

Bryk AS, Raudenbush SW (1992) Hierarchical linear models for social and behavioral research: application and data analysis methods. Sage Publications, Newbury Park

Burgess EW (1925a) The growth of the city: an introduction to a research project. In: Park RE, Burgess EW, McKenzie RD (eds) The city. University of Chicago Press, Chicago, pp 47–62 [1967]

Burgess EW (1925b) Can neighborhood work have a scientific basis? In: Park RE, Burgess EW, McKenzie RD (eds) The city. University of Chicago Press, Chicago, pp 142–155 [1967]

Bursik RJJ, Grasmick HG (1993) Neighborhoods and crime: the dimensions of effective community control. Lexington Books, New York

Bursik RJJ, Webb J (1982) Community change and patterns of delinquency. Am J Sociol 88:24–42

Bushway S, Brame R, Paternoster R (1999) Assessing stability and change in criminal offending: a comparison of random effects, semi-parametric, and fixed effects modeling strategies. J Quant Criminol 15:23–61

Chilton RJ (1964) Continuity in delinquency area research: a comparison of studies for Baltimore, Detroit, and Indianapolis. Am Sociol Rev 29:71–83

Clarke RV (1983) Situational crime prevention: its theoretical basis and practical scope. In: Morris N, Tonry M (eds) Crime and justice: a review of research, vol 14. University of Chicago Press, Chicago, pp 225–256

Clarke RV, Cornish DB (1983) Crime control in Britain: a review of policy research. State University of New York Free Press, Albany

Clarke RV, Weisburd D (1994) Diffusion of crime control benefits: observations on the reverse of displacement. In: Clarke RV (ed) Crime prevention studies, vol 3. Criminal Justice Press, Monsey, pp 165–184

Cohen LE, Felson M (1979) Social change and crime rate trends: a routine activity approach. Am Sociol Rev 44:588–608

Crow W, Bull J (1975) Robbery deterrence: an applied behavioral science demonstration—final report. Western Behavioral Science Institute, La Jolla

Curtis LA (1974) Criminal violence: national patterns and behavior. Lexington Books, Lexington

Duffala DC (1976) Convenience stores, armed robbery, and physical environmental features. Am Behav Sci 20:227–246

Eck JE, Wartell J (1998) Improving the management of rental properties with drug problems: a randomized experiment. In: Mazerolle LG, Roehl J (eds) Civil remedies and crime prevention. Crime prevention studies, vol 9. Criminal Justice Press, Monsey, pp 161–185

Eck JE, Weisburd DL (1995) Crime places in crime theory. In: Eck JE, Weisburd DL (eds) Crime and place. Criminal Justice Press, Monsey, pp 1–33

Eggleston EP, Laub JH, Sampson RJ (2004) Methodological sensitivities to latent class analysis of long-term criminal trajectories. J Quant Criminol 20:1–26

Erickson ML, Empey LT (1963) Court records, undetected delinquency, and decision-making. J Crim Law Police Sci 54:456–469

Federal Bureau of Investigation (2003) Crime in the United States 2002. Retrieved 21 May 2005 from: http://www.fbi.gov/ucr/cius_02/html/web/offreported/02- ncrimeindex01.html

Felson M (1995) Those who discourage crime. In: Eck JE, Weisburd DL (eds) Crime and place. Willow Tree Press, Monsey, pp 53–66

Felson M (2002) Crime in everyday life. Sage, Thousand Oaks

Felson M (2006) Crime and nature. Sage, Thousand Oaks

Gold M (1966) Undetected delinquent behavior. J Res Crime Delinq 3:27–46

Goldstein H (1995) Multilevel statistical models, 2nd edn. Arnold, London

Gordon RA (1967) Issues in the ecological study of delinquency. Am Sociol Rev 32:927–944

Green L (1996) Policing places with drug problems. Sage, Thousand Oaks

Griffiths E, Chavez JM (2004) Communities, street guns, and homicide trajectories in Chicago, 1980–1995: merging methods for examining homicide trends across space and time. Criminology 42:941–978

Groff ER, McEwen T (2005) Exploring the spatial configuration of places related to homicide events. National Institute of Justice, Washington, DC

Groff ER, Weisburd D, Morris N (2009) Where the action is at places: examining spatio- temporal patterns of juvenile crime at places using trajectory analysis and GIS. In: Weisburd D, Bernasco W, Bruinsma GJN (eds) Putting crime in its place: units of analysis in geographic criminology. Springer, New York, pp 61–86

Guerry A-M (1833) Essai sur la Statisticque morale de la France. Crochard, Paris

Hirschfield A, Yarwood D, Bowers K (1997) Crime pattern analysis, spatial targeting and GIS: the development of new approaches for use in evaluating community safety. In: Evans-Mudie N (ed) Crime and health data analysis using GIS. SCGISA, Sheffield

Hunter RD (1988) Environmental characteristics of convenience store robberies in the state of Florida. American Society of Criminology, Chicago

Hunter AJ, Baumer TL (1982) Street traffic, social integration, and fear of crime. Sociol Inq 52:122–131

Jacobs J (1961) The death and life of great American cities. Vintage Books, New York

Jeffery CR (1971) Crime prevention through environmental design. Sage, Beverly Hills

Klinger D, Bridges G (1997) Measurement error in calls-for-service as an indicator of crime. Criminology 35:705–726

Kreuter F, Muthen B (2008) Analyzing criminal trajectory profiles: bridging multilevel and group-based approaches using growth mixture modeling. J Quant Criminol 24:1–31

LeBeau JL (1987) The methods and measures of centrography and the spatial dynamics of rape. J Quant Criminol 3:125–141

Lind AW (1930) Some ecological patterns of community disorganization in Honolulu. Am J Sociol 36:206–220

Lum C (2003) The spatial relationship between street-level drug activity and violence. Department of Criminology and Criminal Justice, University of Maryland, College Park

Maltz MD, Gordon AC, Friedman W (1990 [2000]) Mapping crime in its community setting: event geography analysis. Originally published by Springer, New York, Internet edition available at http://www.uic.edu/depts/lib/forr/pdf/crimjust/mappingcrime.pdf. Accessed 15 August 2009

Mayhew P, Clarke RV, Hough M, Sturman A (1976) Crime as opportunity. Home office research study 34. H.M Stationary Office, London

Mazerolle L, Rogan D, Frank J, Famega C, Eck JE (2005) Managing calls to the police with 911/311 systems. US Department of Justice, National Institute of Justice, Washington, DC

McCord J, Widom CS, Crowell NA (eds) (2001) Juvenile crime, juvenile justice. National Academies Press, Washington, DC

Meredith W, Tisak J (1990) Latent curve analysis. Psychometrika 55:107–122

Muthen B (1989) Latent variable modeling in heterogeneous populations. Psychometrika 54:557–585

Nagin DS (1999) Analyzing developmental trajectories: a semiparametric group-based approach. Psychol Methods 4:139–157

Nagin DS (2004) Response to "methodological sensitivities to latent class analysis of long-term criminal trajectories". J Quant Criminol 20:26–37

Nagin DS (2005) Group-based modeling of development over the life course. Harvard University Press, Cambridge

Nagin DS, Land KC (1993) Age, criminal careers, and population heterogeneity: specification and estimation of a nonparametric, mixed Poisson model. Criminology 31:327–362

Newman O (1972) Defensible space: crime prevention through environmental design. Macmillan, New York

Normandeau A (1968) Trends and patterns in crimes and robbery. University of Pennsylvania, Philadelphia

Oberwittler D, Wikström PH (2009) Why small is better: advancing the study of the role of behavioral contexts in crime causation. In: Weisburd D, Bernasco W, Bruinsma GJN (eds) Putting crime in its place: units of analysis in geographic criminology. Springer, New York, pp 35–59

Osgood DW, Wilson JK, O'Malley PM, Bachman JG, Johnston LD (1996) Routine activities and individual deviant behavior. Am Sociol Rev 61:635–655

Park RE, Burgess EW, McKenzie RD (eds) (1925) The city. University of Chicago Press, Chicago [1967]

Pierce G, Spaar S, Briggs LR (1986) The character of police work: strategic and tactical implications. Center for Applied Social Research, Northeastern University, Boston

Piquero AR (2008) Taking stock of developmental trajectories of criminal activity over the life course. In: Liberman AM (ed) The long view of crime: a synthesis of longitudinal research. Springer, Washington, DC, pp 23–78

Pyle GF (1976) Spatial and temporal aspects of crime in Cleveland, Ohio. Am Behav Sci 20:175–198

Quetelet AJ (1831) Research on the propensity for crime at different ages. Anderson Publishing, Cincinnati [1984]

Rand A (1986) Mobility triangles. In: Figlio RM, Hakim S, Rengert GF (eds) Metropolitan crime patterns. Criminal Justice Press, Monsey, pp 117–126

Reiss AJ Jr, Tonry M (eds) (1986) Communities and crime. Crime and justice: a review of research, vol 8. University of Chicago Press, Chicago

Rengert G (1980) Spatial aspects of criminal behavior. In: Georges-Abeyie DE, Harries KD (eds) Crime: a spatial perspective. Columbia University Press, New York, pp 47–57

Rengert GF (1981) Burglary in Philadelphia: a critique of an opportunity structure model. In: Brantingham PJ, Brantingham PL (eds) Environmental criminology. Waveland Press, Prospect Heights, pp 189–201

Roman CG (2002) Schools as generators of crime: routine activities and the sociology of place. Department of Sociology, American University, Washington, DC

Roman CG (2005) Routine activities of youth and neighborhood violence: spatial modeling of place, time, and crime. In: Wang F (ed) Geographic information systems and crime analysis. Idea Group, Hershey, pp 293–310

Roncek DW (2000) Schools and crime. In: Goldsmith V, McGuire P, Mollenkopf JH, Ross TA (eds) Analyzing crime patterns: frontiers of practice. Sage, Thousand Oaks, pp 153–165

Roncek DW, Bell R (1981) Bars, blocks and crimes. J Environ Syst 11:35–47

Roncek DW, Faggiani D (1985) High schools and crime: a replication. Sociol Q 26:491–505

Roncek DW, Maier PA (1991) Bars, blocks, and crimes revisited: linking the theory of routine activities to the empiricism of "hot spots". Criminology 29:725–753

Rosenbaum DP (2006) The limits of hot spots policing. In: Weisburd D, Braga A (eds) Police innovation: contrasting perspectives. Cambridge University Press, Campbridge, pp 245–263

Sampson RJ, Groves WB (1989) Community structure and crime: testing social disorganization theory. Am J Sociol 94:774–802

Sampson RJ, Laub JH (2005) Seductions of method: rejoinder to Nagin and Tremblay's 'developmental trajectory groups: fact or fiction'. Criminology 43(4):905–913

Sampson RJ, Raudenbush SW, Earls F (1997) Neighborhoods and violent crime: a multilevel study of collective efficacy. Science 277:918–924

Sampson RJ, Morenoff JD, Gannon-Rowley T (2002) Assessing "neighborhood effects": social processes and new directions in research. Annu Rev Sociol 28:443–478

Schmid CF (1960a) Urban crime areas: part I. Am Sociol Rev 25:527–542

Schmid CF (1960b) Urban crime areas: part II. Am Sociol Rev 25:655–678

Schmitt RC (1957) Density, delinquency and crime in Honolulu. Sociol Soc Res 41:274–276

Schuerman L, Kobrin S (1986) Community careers in crime. In: Reiss AJ Jr, Tonry M (eds) Crime and justice: a review of research, vol 8. University of Chicago Press, Chicago, pp 67–100

Shaw CR, McKay HD (1942) Juvenile delinquency and urban areas. University of Chicago Press, Chicago [1969]

Shaw CR, Zorbaugh H, McKay HD, Cottrell LD (1929) Delinquency areas. University of Chicago Press, Chicago

Sherman LW (1995) Hot spots of crime and criminal careers of places. In: Eck JE, Weisburd DL (eds) Crime and place. Criminal Justice Press, Monsey, pp 35–52

Sherman LW, Weisburd D (1995) General deterrent effects of police patrol in crime 'hot spots': a randomized, controlled trial. Justice Quart 12:625–648

Sherman LW, Gartin PR, Buerger ME (1989) Hot spots of predatory crime: routine activities and the criminology of place. Criminology 27:27–55

Sickmund M, Snyder HN, Poe-Yamagata E (1997) Juvenile offenders and victims: 1997 update on violence, statistics summary. Office of Juvenile Justice and Delinquency Prevention, Washington, DC

Skogan WG (1990) Disorder and decline: crime and the spiral of decay in American cities. Free Press, New York

Skogan WG, Annan S (1994) Drugs and public housing: toward an effective police response. In: MacKenzie D, Uchida CD (eds) Drugs and crime: evaluating public policy initiatives. Sage, Thousand Oaks

Skogan W, Frydl K (eds) (2004) Fairness and effectiveness in policing: the evidence. National Academies Press, Washington, DC

Smith WR, Frazee SG, Davison EL (2000) Furthering the integration of routine activity and social disorganization theories: small units of analysis and the study of street robbery as a diffusion process. Criminology 38:489–523

Snyder HN (2003) Juvenile arrests 2001. Juvenile justice bulletin. Office of Juvenile Justice and Delinquency Prevention, Washington, DC

Sparrow MK, Moore MH, Kennedy DM (1990) Beyond 911: a new era for policing. Basic Books, New York

Stephenson LK (1974) Spatial dispersion of intra-urban juvenile delinquency. J Geogr 73:20–26

Suttles GD (1972) The social construction of communities. University of Chicago Press, Chicago

Taylor RB (1997) Social order and disorder of street blocks and neighborhoods: ecology, microecology, and the systemic model of social disorganization. J Res Crime Delinq 34:113–155

Taylor RB (1998) Crime and small-scale places: what we know, what we can prevent, and what else we need to know. Crime and place: plenary papers of the 1997 conference on criminal justice research and evaluation. National Institute of Justice, Washington, DC, pp 1–22

Taylor RB, Gottfredson SD, Brower S (1984) Block crime and fear: defensible space, local social ties, and territorial functioning. J Res Crime Delinq 21:303–331

Thrasher FM (1927) The gang: a study of 1, 313 gangs in Chicago. University of Chicago Press, Chicago

Tita G, Griffiths E (2005) Traveling to violence: the case for a mobility-based spatial typology of homicide. J Res Crime Delinq 42:275–308

Turner S (1969) The ecology of delinquency. In: Sellin T, Wolfgang EM (eds) Delinquency: selected studies. Wiley, New York, pp 27–60

Unwin DJ (1996) GIS, spatial analysis and spatial statistics. Prog Hum Geogr 20:540–541

Wallace JM, Bachman JG (1991) Explaining racial/ethnic differences in adolescent drug use: the impact of background and lifestyle. Soc Probl 38:333–357

Weisburd DL (2002) From criminals to criminal contexts: reorienting crime prevention. In: Waring E, Weisburd D (eds) Crime & social organization. Advances in criminological theory, vol 10. Transactions Publishers, New Brunswick, pp 197–216

Weisburd D, Eck JE (2004) What can police do to reduce crime, disorder, and fear? Ann Am Acad Pol Soc Sci 593:42–65

Weisburd D, Green L (1994) Defining the drug market: the case of the Jersey City DMA system. In: MacKenzie D, Uchida CD (eds) Drugs and crime: evaluating public policy initiatives. Sage, Thousand Oaks

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

Weisburd DL, McEwen T (1997) Introduction: crime mapping and crime prevention. In: Weisburd DL, McEwen T (eds) Crime mapping and crime prevention: Crime prevention studies, vol 8. Criminal Justice Press, Monsey

Weisburd D, Maher L, Sherman L (1992) Contrasting crime general and crime specific theory: the case of hot spots of crime. In: Adler F, Laufer WS (eds) Advances in criminological theory, vol 4. Transaction, New Brunswick, NJ, pp 45–70

Weisburd D, Bushway S, Lum C, Yang S-M (2004) Trajectories of crime at places: a longitudinal study of street segments in the city of Seattle. Criminology 42:283–321

Weisburd D, Wyckoff LA, Ready J, Eck JE, Hinkle JC, Gajewski F (2006) Does crime just move around the corner? A controlled study of spatial displacement and diffusion of crime control benefits. Criminology 44:549–592

Weisburd D, Bernasco W, Bruinsma GJN (eds) (2009) Putting crime in its place: units of analysis in geographic criminology. Springer, New York

Williams JR, Gold M (1972) From delinquent behavior to official delinquency. Soc Probl 20:209–229

Worden R, Bynum T, Frank J (1994) Police crackdowns on drug abuse and trafficking. In: MacKenzie D, Uchida CD (eds) Drugs and crime: evaluating public policy initiatives. Sage, Thousand Oaks