ABSTRACT

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| Title: | THE GEOGRAPHY OF JUVENILE CRIME PLACE TRAJECTORIES |
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The crime drop of the 1990s has been the subject of a large body of research, which has suggested juvenile crime was the major source of this decline. However, a satisfactory explanation for the crime drop remains elusive. While most of the work has focused on longitudinal studies of the development of delinquency in juveniles and macro-level patterns of juvenile crime, recent empirical and theoretical developments indicate that the processes driving crime trends may be operating at micro-level places. Thus, an examination of micro-level places may hold clues to understanding the crime drop. This research builds on two earlier studies in Seattle, Washington, that used trajectory analysis to identify temporal changes in crime at street blocks over a fourteen-year time period. Specifically, this research used a variety of spatial techniques to describe the distribution of the street blocks in each trajectory and their relationship to one another.

THE GEOGRAPHY OF JUVENILE CRIME PLACE TRAJECTORIES

By

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# Acknowledgements

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# Chapter 1: Introduction

Trends in the crime rate at the local and national level have received a generous amount of study, especially the unprecedented crime drop that occurred during the 1990s (Blumstein and Wallman 2000a; Cook and Laub 1998; Cook and Laub 2002; McCord, Widom, and Crowell 2001). This particular pattern was not forecast by any of the leading researchers, who instead were calling for crime increases over the period. Subsequent analyses have suggested that juvenile crime was a major source of the crime drop. While juvenile arrests make up only a small proportion of all arrests, research found that young offenders (under age 25) most likely drove both the crime increase in late 1980s and the subsequent reduction in crime during the 1990s.

To date, research conducted to explain the crime drop by focusing on juveniles has concentrated on studying how delinquency develops in juveniles (McCord, Widom, and Crowell 2001), characteristics of juveniles involved in crime (Cook and Laub 1998; Cook and Laub 2002) or the impact of concurrent social and economic factors on delinquency (Blumstein and Wallman 2000a). Studies of individuals have provided important information on the development, persistence and desistence of criminal behavior among juveniles. Both national and community-level social and economic factors, such as the rise in drug prevalence and gun violence as well as later economic prosperity, have been linked to the crime drop (Blumstein and Wallman 2000b; Cook and Laub 2002). However, the causes of the trend remain without satisfactory explanation despite this wide range of research (Blumstein and Wallman 2000b; McCord, Widom, and Crowell 2001).

One recent and promising line of research pertinent to understanding crime trends involves a shift in the unit of analysis from individuals or communities to micro-level places. General theoretical developments in the 1970s and 1980s introduced the notion that place-based analysis might better explain crime rates (Eck and Weisburd 1995; Weisburd 2002; Weisburd, Bushway, Lum, and Yang 2004).[1] Over the same time period, technological advances in computing enabled the collection of data for smaller geographies. During the 1990s, computer mapping and spatial statistical software became widely available. The combination of more detailed data and the appropriate tools have facilitated the shift to exploring micro-level place characteristics associated with crime and delinquent behavior. Together, these developments suggest there might be value in disaggregating the drop in crime by places, as well as people.

The fact that crime is differentially distributed across places is well known and has been for quite some time (Guerry 1833; Quetelet 1842 [1969]). Many researchers have documented the phenomenon at the various geographic levels of analysis from the level of a nation, state, county, city, neighborhood, and individual address (Brantingham and Brantingham 1999; Georges 1978; Groff and LaVigne 2001; Sherman, Gartin, and Buerger 1989). Another body of research has demonstrated the clustering of crime in 'hotspots' (Eck and Weisburd 1995; Georges 1978; Sherman, Gartin, and Buerger 1989; Weisburd and Green 1994; Weisburd, Maher, and Sherman 1992). Other researchers in the field of "situational crime prevention" have confirmed the important role of place in preventing crime (Clarke 1983). These

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[1] See Weisburd et al (2004) for an excellent review of literature summarizing the trends in criminology leading to a recognition of the importance of place.

efforts have culminated in a wider recognition of the extent to which crime is concentrated at specific places and a call to focus on crime events rather than criminals (Eck 2001; Sherman 1995; Weisburd 2002).

The publication of a series of "opportunity" theories in the criminological literature provided the on-going empirical research with a cohesive theoretical framework. Opportunity theories focus on understanding how the circumstances involving the convergence of motivated offenders and suitable targets in time and space either foster or inhibit the opportunity for a crime to occur. Routine activity theory and environmental criminology have been particularly influential in framing this line of research. Routine activity theory emphasizes the convergence of motivated offenders and suitable targets without capable guardians as the key element in understanding changes in crime rates (Cohen and Felson 1979). Extensions to routine activity theory include the roles of intimate handlers (Felson 1987) and place managers (Eck 1995b) as potential guardians and the incorporation of place (Felson 1987). The Brantinghams' (1981b; 1984) environmental criminology theory also notes the importance of human behavior in the convergence of victims and offenders but emphasizes the role that the characteristics of 'place' play in crime events. The dual influence of routine activity theory and environmental criminology has contributed to the refocusing of the unit of analysis from individuals and communities to micro-level 'places'.

Research on juvenile crime and delinquency has followed a similar pattern of evolution. Traditionally, the focus was on identifying either the characteristics of individuals or the communities in which they lived (Chilton; Gottfredson and Taylor

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1986; Shaw and McKay 1942 [1969]). Some research integrated the two perspectives to explore the effect of community characteristics on individual behavior (Gottfredson, McNeil III, and Gottfredson 1991). However, little attention has been paid to where juveniles commit crime. Three researchers examined the issue by comparing the characteristics of communities where juveniles committed crimes with those communities where delinquents reside (Burgess 1967[1925]; Lind 1930; Morris 1957). Later researchers shifted from a study of juveniles to places. Specifically, they focused on the role of juvenile-related facilities, in particular schools, on crime rates in general but did not make a distinction between juvenile and adult offenders (Roncek and Lobosco 1983; Roncek and Faggiani 1985). Even recent research that identified schools as generators of crime for surrounding areas, although it incorporated the locations of juvenile arrests, did not differentiate between crime committed by juveniles or adults (Roman 2002).

Meanwhile, still other criminologists interested in individual offending behavior began examining the "criminal careers" of individuals (Blumstein, Cohen, Roth, and Visher 1986; Moffitt 1993; Reiss 1988; Sampson and Laub 1993). This line of research described the frequency with which individuals offend, the prevalence rate of offending in a population, the mix of crimes that are committed by an individual and the duration of criminal activity within an individual's lifetime (Reiss 1986).

Community-level researchers applied "criminal career" concepts to the exploration of "community crime careers" and concentrated on explaining changes in community-level crime rates over time (Reiss 1986). Bursik (1986a) noted that the

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study of crime and delinquency, as situated in the urban environment, was central to the work of Shaw and McKay. This perspective also underpinned Schuerman and Kobrin's (1986) seminal examination of urban change from a community crime career perspective and Bursik and Webb's (1982) longitudinal analysis of delinquency and neighborhood change. Unfortunately, early research on community crime careers has been hampered by a shortage of longitudinal data and appropriate statistical techniques to quantify change over time (Reiss 1986). These challenges still exist, though the accumulation of longitudinal data and better tools for analysis have improved the situation.

More recently, Sherman (1995) made the argument that places as well as persons have criminal careers. He compared research that found that 18% of offenders accounted for over 50% of arrests with research that found that 3% of the places produced over 50% of the crimes and concluded that crime was six times more concentrated at places than among people. He then extended this line of thought and noted crime was potentially six times more predictable at places. Thus, places are a logical focus of both crime prevention and crime theory research.

As previously noted, both longitudinal data and appropriate statistical techniques were needed when the goal of the research was to describe changes over time. One recently developed technique involved the identification of distinct groups of individuals with similar behavior over time (Nagin 2005; Nagin and Tremblay 1999). Although frequently applied to people, the use of this technique to study individual places over time has only recently been explored. Nagin's group-based developmental trajectory technique has been applied at the neighborhood (Griffiths

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and Chavez 2004) and street block levels of analysis (Weisburd, Bushway, Lum, and Yang 2004; Weisburd, Groff, and Morris In progress).

In the original study, which examined all crime incidents, Weisburd et al (2004, 5) uncovered "developmental patterns" in crime levels experienced by micro-level places. While most places exhibited stable crime trajectories, it was the places involved in the decreasing crime trajectories that drove the city-wide (macro-level) crime drop in Seattle, Washington. Interestingly, the overall crime drop occurred while some places within Seattle were experiencing large increases in crime.

Weisburd, Morris and Groff (In progress) used a subset of Seattle data to isolate only those crimes committed by juveniles. The researchers defined juvenile crime as the place the crime occurred rather than the arrest location or home address. This definition was substantively different from studies that traditionally attributed the crime committed by juveniles to their area of residence. The use of an incident-based definition of juvenile crime enables analysis of where the crimes take place as opposed to where juveniles who commit crimes live. Using this crime-location based definition the research uncovered eleven distinctive trajectories of juvenile crime at the street block level of analysis between 1989 and 2002.

These two studies confirmed two important characteristics of crime changes over time. First, that crime was concentrated at relatively few places while the majority of places had little or no crime. Second, that the temporal pattern of crime at micro-places followed a variety of distinct trajectories, rather than increasing and decreasing with the observed macro-level patterns actually. In addition, the identification of trajectories trending in different directions and with such a variety of

slopes demonstrated that changes in micro-level crime rates do not move in the same direction or at the same rate. While group-based trajectories offer significant promise in understanding the types of temporal patterns that underlie changes in crime rates over time, the spatial relationships among street blocks in particular groups has yet to be fully explored. Weisburd et al (2004) offered a cursory, descriptive exploration via a density analysis. The results indicated that street blocks of trajectory groups were spread throughout the city at low density and in a few places at higher densities. However, their analysis stopped short of quantifying the extent of the spatial dependence in the distributions. The geographic distribution of juvenile crime trajectory blocks was not examined by Weisburd et al (In Progress). Consequently, previous research has not been able to make specific, statistically rigorous statements about the role of space in micro-level, longitudinal processes.

The purpose of the research undertaken here was to systematically investigate the geography of juvenile crime trajectories using spatial analysis techniques. These techniques enabled a more precise description of the spatial relationships and processes that underlie changes in macro-level crime trends. This methodology required that the tabular data on juvenile crime be spatially enabled to allow the relationships among trajectory assignments to be analyzed. Spatially enabling the tabular data describing street blocks, made it possible to quantitatively examine street blocks in the context of their neighboring street blocks. Since little is known about the geographical distribution of places that share a common trajectory, the study made use of exploratory spatial data analysis techniques (ESDA) to describe the geographical patterns of and relationships among street blocks of different

trajectories. Specifically, the spatial properties of distance, distribution, pattern and density of the street blocks of particular trajectories were examined. Then formal tests were used to determine: 1) whether the patterns of street blocks which belong to a particular trajectory were random, clustered or dispersed and 2) whether patterns of particular trajectories were related. Underlying this investigation was the search for evidence of micro-level processes that might drive macro-level patterns and the goal of gaining insight into how the processes producing patterns of crime trajectories were related both to one another and to the observed macro-level pattern.

Information gained from the analysis of the geography of trajectories is especially valuable for two reasons. First, it informs our knowledge of the level at which processes driving macro-level crime patterns are operating. Second, it could be used to target prevention and intervention efforts at these critical places and thus reduce the crime rate for the whole city.

# Chapter 2:  Literature Review

A variety of theoretical and empirical research was available to inform the investigation of spatial distribution of place trajectories in general.  The first section of the chapter discusses the role of place in understanding crime from a historical perspective.  Next, the role of opportunity theories in providing the theoretical grounding for much of the micro-level place-based inquiry is discussed.  A description of the current state of the knowledge regarding crime at micro-level places and the few studies that have examined changes over time follows.  Finally, the implications of this investigation for policy and practice are presented.

## *Why Are Places Important to Understanding Crime?*

The importance of places in criminological inquiry has waxed and waned over time.  Following Beccaria (1764, translated 1963) most early criminologists were more interested in individuals than places.  Two exceptions were the early French studies done by Guerry (1833) and Quetelet (1842 [1969]) which found that crime was not evenly distributed across France.  In the following century, Chicago School scholars were the first to focus on communities as a relevant geographical unit of inquiry (Park, Burgess, and McKenzie 1967 [1925]; Shaw and McKay 1942 [1969]).  They noted that the homes of delinquents tended to be concentrated in a few communities and that concentration tended to be stable over time.  In the 1960s a few scholars focused their attention on the distribution of crime events rather than criminals (Boggs 1965; Schmid 1960a; Schmid 1960b).  These studies found that the areas in which crimes were committed were also concentrated.

In the next decade, work by Newman (1975) and Jeffrey (1976) examined the physical characteristics of the built environment that promoted or impeded criminal behavior. They found that specific characteristics of the built environment were associated with higher crime rates. These observations spawned the Crime Prevention Through Environmental Design (CPTED) movement, that advocates making changes in the physical characteristics of a place to reduce crime. Other researchers began to focus on the relationship between types of land uses or facilities, and criminal opportunity. In a series of studies, Roncek and others examined the relationship between public housing (Roncek, Bell, and Francik 1981), bars (Roncek and Bell 1981; Roncek and Maier 1991), schools (Roncek 2000; Roncek and Faggiani 1985); place characteristics of the residential environment (Roncek 1981) and crime rates. These studies demonstrated that the characteristics of micro-level places were associated with crime rates at and near those locations.

More recent efforts have focused on individual addresses rather than areas. Work by Sherman, Gartin and Buerger (1989) found that only three percent of addresses generated over half of all calls for service. They termed these concentrations of crime 'hot spots'. Results such as these have further documented the concentration of crime at relatively few places. This line of research had a tremendous impact on the study of crime places because it demonstrated that community-level studies were not capturing intra-area variations in crime and thus were unable to identify or examine the processes behind those variations.[2]

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[2] The movement toward greater specificity in research has not been limited to geographic units. There has also been a trend toward disaggregation of crime events by specific characteristics. This change has been particularly noticeable in homicide research (Groff and McEwen 2005b; Zahn and Jamieson 1997).

As the concentrated nature of crime has become more widely recognized in policing, law enforcement has responded by adopting targeted deployment strategies (Taylor 1997a). To support this type of strategy, police can no longer depend on neighborhood-level crime statistics but rather require information about crime at specific addresses or street blocks. Other recent trends in policing also emphasize the importance of place. Both community-oriented policing (COP) (Bayley 1988; Kelling and Moore 1988; Weisburd and McElroy 1988) and problem-oriented policing (POP) (Goldstein 1979; Goldstein 1990; Kelling and Moore 1988) involve police work at specific places within communities. Another policing strategy directly related to places is *order maintenance* policing (Kelling and Sousa 2001; Wilson and Kelling 1982). This strategy holds that by paying attention to minor crimes such as window-breaking and graffiti, police could reduce the incidence of more serious crime (Kelling and Sousa 2001). All of these strategies entail targeted enforcement at specific micro-level places.

The new focus by police on specific places as well as people was supported by empirical evidence. Results of the *Kansas City Preventive Patrol Experiment* had demonstrated the limited value of preventative patrol by police (Kelling, Pate, Dieckman, and Brown 1974). However, the findings of later research pointed toward the effectiveness of directed patrol in very small areas. Sherman and Weisburd's (1995) randomized experiment of directed patrol in hot spot areas found that the strategy reduced crime.

The historical development outlined here served as the basis for the Eck and Weisburd's (1995) call for the creation of a theory of crime places. Their book Crime

and Place, along with increased data availability, advancements in computing power and more user-friendly mapping software, sparked a new wave of research on the spatial distribution of crime across micro-units of analysis and interest in formalizing the role of place in crime. One of the major challenges to conducting place-based research concerns the definition of place.

*Defining Place*

Despite the volume of work examining places, there is no standard definition for a place. Previous criminological research has always situated place within a particular neighborhood or community context (Eck and Weisburd 1995; Weisburd, Bushway, Lum, and Yang 2004). Weisburd et al (2004) summarized the different definitions of place as single addresses, street segments, block faces and clusters of addresses. Other researchers have defined places in micro-analysis as street blocks, intersections or individual addresses (Brantingham and Brantingham 1991).

Eck and Weisburd (1995), following Sherman et al (1989) advocated for a micro-level definition of crime places, one in which crime places are seen as "specific locations within the larger social environment" (Eck and Weisburd 1995 3). They suggested that micro-level places can be street addresses, apartment complexes, intersections or street blocks. Whatever the specific unit of measurement, a place was always very small and was treated separately from the larger neighborhood or city in which it exists.

Some researchers have suggested that place does not have a single definition. They viewed place as an elastic spatial concept and developed several typologies to depict the hierarchy of communities within which human interaction occurred (Bursik

and Grasmick 1993; Hunter and Suttles 1972; Lee 1968). The geographical cone of resolution provided the most spatially-oriented conceptual vehicle for thinking about spatial processes that occur at different scales and thus would be related to the definition of place (Brantingham, Dyreson, and Brantingham 1976). When applied to crime patterns, the geographical cone of resolution demonstrated how both the processes and the observed patterns of crime were different at each scale. For example, regional patterns of crime often masked important variation that was visible at the county-level of analysis and neighborhood boundaries 'smoothed out' important intra-neighborhood variation.

Yet another conception of place was found in the Brantinghams' (1991) typology of three scales of analysis. Macro-analysis examined crime patterns across cities, counties or states. Studies of within-city patterns were conducted at the meso-analysis level, which included most neighborhood studies. The smallest level was micro-analysis, which covered patterns across street blocks, intersections or individual addresses. Under this typology, the definition of place used for any particular study depended on the level of analysis germane to the research.

The geographical extent of the place definition chosen for a study has been considered a critical decision in study design. Taylor (1997a) emphasized both the importance of identifying the proper scale of analysis to illuminate the phenomena under study and the use of appropriate theories to explain the patterns noted at various spatial and temporal scales. While neighborhoods, usually operationalized as census tracts or blockgroups, have frequently been used as units of analysis they do not allow for the examination of within neighborhood processes. A growing body of empirical

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analyses has demonstrated the existence of significant within-neighborhood variation in crime occurrence (Block, Dabdoub, and Fregly 1995; Groff and LaVigne 2001; Sherman and Weisburd 1995; Weisburd and Green 1995). This has led some researchers to the study of micro-level places such as hot spots.

Hot spots researchers used the hot spots themselves as the unit of analysis (Sherman and Weisburd 1995; Weisburd and Green 1995). A hot spot has been defined as the places where crime was most concentrated in space (Brantingham and Brantingham 1999). Generally, hot spots consisted of clusters of events delineated by a standard deviational ellipse.[3] Although, some researchers have aggregated street segments and intersections based on both quantitative and qualitative information (Weisburd and Green 1995). One disadvantage to using hot spots as places is related to the modifiable areal unit (MAU) problem, which arises whenever areal boundaries are applied to discrete data (Haining 1990; Openshaw 1983). Specifically, the placement of the boundaries affects the area to which observations are assigned.

The decision regarding the appropriate definition of place is driven by the theoretical grounding for the research being undertaken. The family of opportunity theories emphasizes the role of place and context in crime events and thus provides a logical basis for most of the place-based research reviewed here.

*Opportunity Theories of Crime*

Opportunity theories of crime broadened the attention from the offender to the crime event. Specifically, the focus of these theories is on the crime event as an outcome of a series of decisions made by the participants and influenced by the social

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[3] The CrimeStat manual contains an extremely thorough treatment of the available statistical methods for computing hotspots (Levine 2005).

and physical context of the place. Rather than relying solely on offender motivation to explain criminal behavior, these theories examine all the actors (both witting and unwitting) as well as the characteristics of the place where the crime occurs. Three theories have exemplified this approach: rational choice perspective (Clarke and Cornish 1985), routine activity theory (Cohen and Felson 1979) and environmental criminology (Brantingham and Brantingham 1981a). Recently, an integrative framework called the criminal event perspective (CEP) has emerged (Meier, Kennedy, and Sacco 2001).

The rational choice perspective addresses how offenders make the decision to offend (Clarke and Cornish 1985; Clarke and Cornish 2001). Under the rational choice perspective, offenders use a form of 'bounded rationality' when making the decision to commit a specific offense. Rational choice perspective does not assume offenders have perfect knowledge but rather recognizes that offenders make decisions based on previous experience and situational factors. The perspective assumes that offender behavior is essentially similar to that of non-offenders and that familiarity of an offender with a place tends to reduce the perceived risk. Finally, the decision to commit a specific crime is represented as an evaluation of three factors: the suitability of the situation, the presence of a viable target and the level of guardianship.

Routine activity theory originally identified three elements necessary for a crime to occur, a motivated offender, a suitable target and the lack of a capable guardian (Cohen and Felson 1979). More recent extensions have added the roles of intimate handlers (Felson 1987) and place managers (Eck 1995a) as potential guardians and acknowledged the importance of place (Felson 1987). However, the

most important contribution of routine activity was the connection with routine human behavior as influenced by societal trends. The theorists were also the first to highlight convergence of actors in space and time as critical to a crime taking place. Both of these advances were integral to the development of place-based explanations of crime.

When putting forward environmental criminology, the Brantinghams' (1991 [1981]) identified five necessary elements for a crime: a law, a motivated offender, a suitable victim, lack of capable guardian and place. Two of those elements, offender behavior and place, have been consistently emphasized in their writing. Environmental criminologists view offenders as constantly aware of opportunities to commit a crime. They see potential offenders gathering information about places through their daily routine activities. Only if the potential benefit outweighs the risk would an offender then commit an offense. Environmental criminology also emphasizes the dual role of place in crime. Places serve as a crime attractors or crime generators based on their function (Brantingham and Brantingham 1995). For example, a bar may be a crime generator because it attracts both offenders and potential victims. Specifically, robbers who want to take advantage of inebriated patrons. An intersection may serve as a crime attractor because drugs are sold there. Junkies are attracted to by the availability of drugs and they burglarize nearby homes and businesses for cash to buy the drugs. Places are also integral components of the overall urban form of a city. The accessibility of a place determines both how many people are aware of it and how willing they are to travel there. In this way, place characteristics and urban form work together to impact the spatial behavior of both

offenders and victims, and thus are fundamental to understanding why crimes occur where they do.

Most recently Meier, Kennedy and Sacco (2001) have proposed an integrative framework they call the criminal event perspective (CEP). CEP seeks to better understand the criminal act as part of a chain of actions and influences through combining offender and victim behavior with environmental context. The interaction among the roles of offender, victim and bystander are viewed as dynamic rather than static. The development of criminal events and the resulting aggregate patterns are grounded in the dynamic conflation of individual decisions that are influenced by the societal mores/subculture and the physical environment of the place in which they are made. Their dynamic view of victimization echoes that of Rountree and Land (1996) who noted that previous victimization affects future behavior. Routine behaviors of victims are altered, which in turn changes the risk associated with them.

Together these theoretical developments and empirical studies have led to an increasing recognition of the importance of micro-level places in achieving a better understanding of crime patterns. They also provide a solid foundation from which to examine the spatial distribution of juvenile crime place trajectories.

## *Micro-level Crime Research*

### Cross-sectional studies of crime

A great deal of theoretical and empirical research has been conducted on the identification of crime places and their characteristics. Policy-focused research in situational crime prevention (Clarke 1983) and work done under the rubric of environmental criminology (Brantingham and Brantingham 1984; Brantingham and

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Brantingham 1991 [1981]; Brantingham, Dyreson, and Brantingham 1976; Roncek 1981; Roncek and Lobosco 1983; Roncek and Bell 1981) have supported the link between place characteristics and crime at the micro-level. Other cross-sectional research has examined the association between the characteristics of individual addresses and the crime committed there (Groff and LaVigne 2001; Jefferis 2004). Still other studies have examined the characteristics of street blocks (Smith, Frazee, and Davison 2000) and census blocks (Roman 2002; Roncek 1981) and the neighborhoods in which they are embedded.

Unfortunately, all of these investigations were cross-sectional and thus unable to adequately inform the question of change over time. In the aggregate, these studies clearly indicated that high crime micro-level places tend to be clustered and share specific characteristics. In addition, the findings demonstrated that significant variation in crime occurrence existed even with neighborhoods. The implication of these findings is that the processes driving crime patterns may be occurring at the micro-level, which analysis conducted at larger levels of analysis would be unable to capture. Consequently, the micro-level may be a more appropriate level of analysis for examining the processes driving those differences.

While criminologists have become adept at identifying the characteristics of crime places, few studies have explored changes in places over time. The need to join spatial and temporal examination of places was noted by Sampson (1993). In response, he suggested a new paradigm of dynamic contextualism, which examined individual change over time as situated within the environmental and structural context of larger units of analysis. A full implementation of dynamic contextualism

would have been beyond the scope of this inquiry.  The more modest goal of examining the spatial distribution of places with similar temporal crime histories was pursued here.  Consequently, previous studies using block faces or street segments to constitute places, and incorporating a temporal dimension, were of particular importance to this investigation and are discussed next.

Overview of Spatial Patterns in Micro-level Longitudinal Studies

Spatial patterns identified in three studies that examined micro-level crime trends over time have informed this research.[4]  These  studies were identified in Weisburd et al (2004) and remain the only examples of micro-level longitudinal studies in publication that the author could uncover.

One example was work done by Spelman (1995) in his study of the criminal careers of specific types of public places (i.e. high schools, public housing projects, subway stations and parks).  Using official call for service data and a pooled time-series cross-sectional design he tracked crime over a four-year period from 1977 through 1980.  The research also found a high degree of concentration with the worst 10 percent of locations accounting for 30 percent of the calls for service.  Spelman also found evidence of spatial and temporal effects for crime-related calls for service in high schools, housing projects and parks.  Despite the high level of random variability over time and space there were also long-term differences that existed among locations.  These findings led him to argue that the proper focus of crime trend research is to examine the characteristics of hot spots over time.

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[4] Although not discussed in detail here because they are at a different level of analysis, two recent efforts have applied a developmental perspective to neighborhood level data (Griffiths and Chavez 2004; Kubrin and Herting 2003).

As part of a long-term research program undertaken to improve our understanding of the link between crime, disorder and fear of crime, Taylor (1999) studied ninety street blocks in Baltimore, Maryland. Data were collected measuring physical conditions on the street blocks in two discrete time periods, 1981 and 1994. He found spatial patterns in deterioration, most of which occurred close to the downtown and east and west of the city center.

Given the originality of using group-based trajectory analysis to micro-level places, it was not surprising that the spatial distribution of places of the same trajectory group has received only cursory attention. Weisburd et al (2004) were the first to examine the spatial distribution of micro places by type of trajectory. They had aggregated the eighteen trajectories from the original analysis into three groups, stable, increasing and decreasing. The aggregation assisted with presentation of both tabular and cartographic results. Three separate kernel density maps representing street blocks in stable, increasing and decreasing trajectories were created. This enabled the visual inspection of the crime levels of street blocks that were members of each type of group.[5]

Examination of the density maps revealed that stable trajectories were spread throughout the city with areas of concentration especially in the north. Increasing and decreasing trajectories were also dispersed throughout the city but at much lower levels of concentration. The highest concentration of both increasing and decreasing trajectories was in the center of the city. The authors noted that the spatial

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[5] Kernel density is a spatial smoothing technique that uses known values to provide estimates for every location on a map. The resulting map resembles a 'weather map' and is more intuitive to interpret. For more information on kernel density, see Bailey and Gatrell (1995) and Fotheringham (2000)

coincidence of both increasing and decreasing trajectory places may reflect similarities in the processes underlying the pattern.

As a group, these studies have provided evidence of spatial effects that persist over time. Results from the trajectory study by Weisburd et al (2004) were most pertinent to this investigation. They suggested that places with similar trajectories were spread throughout the city with a few clusters in certain areas. However, two major areas of investigation were left unexplored. The first involved an examination of the variation in physical and structural characteristics of street blocks that might explain why places ended up in particular trajectories. The second concerned a more rigorous exploration of the spatial relationships in the distribution of trajectories. The second area of investigation was pursued here. While the Weisburd et al (2004) study provided a visualization of patterns, the current research quantitatively assessed the degree of clustering in the distribution. In addition, the current analysis used spatial statistics to examine whether the spatial patterns of different types of trajectory blocks were independent of one another and of the existing pattern of street blocks. The answers to these questions were critical to identifying whether the processes underlying the observed data were occurring at the micro-level and to quantifying the strength and spatial extent of those processes.

*Place-based Research on Juvenile Crime*

Most research on juvenile delinquency has studied juveniles at the individual person level of analysis. These studies were interested in discovering the precursors to juvenile behavior and understanding patterns in the frequency and type of

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offending.[6]  Another extensive body of research examined the community context of juvenile delinquency.[7]  These studies examined the characteristics of communities that foster or impede the development of adolescent delinquent behavior.

Across this body of work, the dependent measure has been either the number of juvenile delinquents in a community or the number of crimes that juvenile delinquents report committing.  Studies in both these literatures routinely attributed the spatial aspects of juvenile delinquency to the community where the juvenile resided, rather than the community where the crime was committed.  Whether studying rates of delinquency or rates of crime, both criminality and crimes were assigned to the community in which the juvenile resided.  Offenses assigned to the juvenile's community of residence reflected the influence of where he or she lived, which was not necessarily where he or she offended.  The next few sections examine the issue of delinquency areas versus crime areas in more detail.  Then an overview of findings regarding spatial patterns in crime and delinquency is provided.  Finally, different constructs for measuring juvenile crime are discussed.

Spatial Patterns and Issues in Community-level Studies

The vast majority of place-related research addressing delinquency has been conducted at the community level.  Shaw and McKay (1942 [1969]) were the first to identify and characterize delinquency areas.  They defined communities with high concentrations of juvenile offenders as delinquency areas and found that some

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[6] Please see the following for a good overview of these types of studies (Blumstein and Wallman 2000a; McCord, Widom, and Crowell 2001)

[7] A full review of this topic is outside the scope of the current investigation.  There are a wide variety of studies available that emphasize community (Bursik 1986a; Bursik 1986b; Bursik 1988; Bursik and Grasmick 1993; Bursik and Webb 1982; Shaw and McKay 1942 [1969]).  There are also several good theoretical overviews about the origins of criminal behavior (Cullen and Agnew 1999; Lilly, Cullen, and Ball 1995; Vold, Bernard, and Snipes 2002).

communities had higher levels of delinquents than other communities. Moreover, they discovered that areas with higher levels of delinquency were both temporally and spatially stable.

Some have argued that the emphasis on juvenile residence rather than location of crime was not warranted, and a more appropriate definition of a delinquency area would be to incorporate where juveniles commit crimes (Morris 1957 20-21). In particular, Morris suggested that there were two types of delinquency areas ---"areas of *crime commission* and areas of *delinquent residence*" (Morris 1957 20).

Only three studies have examined the area in which the juvenile committed a crime, and none reported any empirical results. Two early studies classified crimes by whether the juvenile lived and offended in the same neighborhood (Burgess 1967 [1925]; Lind 1930).[8] Burgess offered the initial description of different types of mobility triangles related to delinquency but did not report any empirical results.[9] Lind (1930) found that the frequency that juveniles offended in their own neighborhood was related to the type of crime being committed. However, once again no quantitative measures were included in the text.

A fourth study, by Turner (1969b), examined the distance juveniles travel to commit crime. It is the only study that quantified the distances juveniles travel to commit index offenses. He manually measured the distance from juvenile home address to the location of the crime along the street network using a map measure

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[8] These studies employed an early version of a spatial typology for classifying crimes called mobility triangles. Crime events were classified based on the locations of the crime, offender's home address and victim's home address. Neighborhood triangles involved crimes in which all three locations were in the same area. There is a growing literature on mobility triangles (Groff and McEwen 2005b; Normandeau 1968; Rand 1986; Tita and Griffiths 2005).
[9] Burgess (1967 [1925] 152-153) was describing research done by Miss Evelyn Buchan on female delinquency. He included diagrams and descriptions of each type of mobility triangle.

device.  The median distance traveled was about 41% of a mile (2,152 feet).  Almost

three quarters of youth offenses occurred within a mile of their home.  The

probability of offending behavior decreased with distance from home.  In addition to

the predominance of short distances in juvenile crime travel, he found a buffer zone

about 1 to 2 blocks from the juveniles' residence within which offending was less

likely.  Turner hypothesized that this was due to worry about personal or property

recognition.  He used the example of a bicycle thief who steals the bike from outside

the area where he plans to use it.  Turner also examined the affect of co-offending on

distance.  He found that co-offenders tended to live close to one another and that

solitary offenders had a higher probability of offending close to home.  In sum,

Turner concluded that "there would be little difference between defining a high

delinquency area in terms of the offender's residence or offense location.  A program

designed to lower the number of delinquents in an area could reasonably expect a

drop in the number of delinquencies in that area" (Turner 1969a 25).

Turner's research suggested that juveniles do not travel far to commit their

crimes.  The number of crimes committed decreased with distance from the

offenders' home addresses.  Thus, there should be a high degree of clustering near

places with large populations of juveniles or in places where juveniles routinely

congregate (e.g. schools, malls, movie theaters etc.).[10]  The small buffer zone around

juvenile residence identified by Turner suggests that future studies should be

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[10] The distance decay phenomenon in offender behavior, regardless of age, has been widely recognized (Costanzo, Halperin, and Gale 1986; Groff and McEwen 2005a; Groff and McEwen 2005b; Rengert 1992; Rhodes and Conly 1981; Rossmo 2000; van Koppen Peter and Jansen 1998).  In addition, Rengert (1988) found that the activity spaces of individuals are oriented around 'anchor points' such as home, school, recreation.  A review of the literature on activity spaces and travel behavior is beyond the scope of this research.  See Brantingham and Brantingham (1991 [1981]) or Rossmo (2000) for a good introduction to offenders and Golledge and Stimson (1997) for general travel behavior.

undertaken at a sub-neighborhood level in order to capture the variation at small distances. After only one study, the issue of juvenile residence versus crime location requires further investigation.

Studies of Juvenile Crime Trajectories at Micro-level Places

Up to this point there has been only a single study examining trajectories of juvenile crime over time. Weisburd, Groff and Morris (In progress) conducted a group-based trajectory analysis of juvenile crime in Seattle, WA over a fourteen-year period.[11] Following the suggestion of Morris (1957), their research examined the locations where juveniles committed crime rather than where they lived. The 29,849 street blocks in the City were used as the unit of analysis. All crimes committed by juveniles age 8 to 17 inclusive were assigned to the street block on which they occurred.[12] Using a combination of official crime and arrest data, the researchers identified 38,145 crimes that were committed by juveniles. As expected, the distribution of crimes across places was highly skewed with most crime occurring at relatively few places. The distribution of crime over time followed the national pattern.

In general, they found that juvenile crime was concentrated in a few places and that the majority of places were stable with low rates of juvenile crime. Approximately 77% of street blocks experienced no juvenile crime over the entire period (N=22,925) and about 90% had two or less crimes. The remaining 819 street blocks (1.2%) accounted for the rest of the juvenile crime in Seattle.

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[11] They used the same base data as the initial study by Weisburd, Bushway, Lum and Yang (2004).
[12] Only juvenile crimes for which an arrest was made were included in the study since that was the method for identifying which crimes were committed by juveniles rather than adults.

Following the methodology of the earlier study by Weisburd, Bushway, Lum and Yang (2004), the authors used the TRAJ technique. TRAJ is a developmental technique that finds groups of individuals with similar histories of behavior (Nagin 2005; Nagin and Tremblay 1999). TRAJ was the only technique they could locate that allowed them to determine if there were different patterns of crime across street blocks and whether these patterns followed identifiable trajectories. TRAJ treated each street block as an individual in the analysis. The group-based trajectory analysis identified eleven distinct trajectories of juvenile crime places.[13]

The trajectory analysis demonstrated that temporal changes in juvenile crime were not uniform; there was much variation among individual street blocks. In order to facilitate description of the changes, the authors grouped the individual trajectories into four main groups. One group consisted of street blocks that consistently zero crimes or very low crime rates; these were termed 'stable'. Four of the other trajectories exhibited generally decreasing trajectories over time and were grouped into a 'decreasing' category. Two trajectories clearly increased over the time period and became the 'increasing' group. The remaining four trajectories described street blocks that began and ended the study period at about the same crime level but had considerable variation over the time period; these became the 'variable' group. Using these groupings, the relative impacts of each group of street blocks on the overall crime rate were examined (Figure 1). As with all crime in the earlier study, street blocks in the decreasing group drove the overall decrease in crime. These results

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[13] A variety of models were tested. A twelve group model would not converge. The models with 8, 9, 10 and 11 groups met the established 'rules of thumb'. However, the 11 group model had the highest posterior probabilities for all groups. In addition, it provided the most detailed view of group membership. See Weisburd, Groff and Morris (In progress) for complete details.

showed there was considerable variation at the street block level of analysis.

However, the authors did not address the question of whether all the street blocks

with similar trajectories were near one another in space or spread throughout the city.

Figure 1:  Relative Contributions of Individual Trajectories to Juvenile Crime Rate
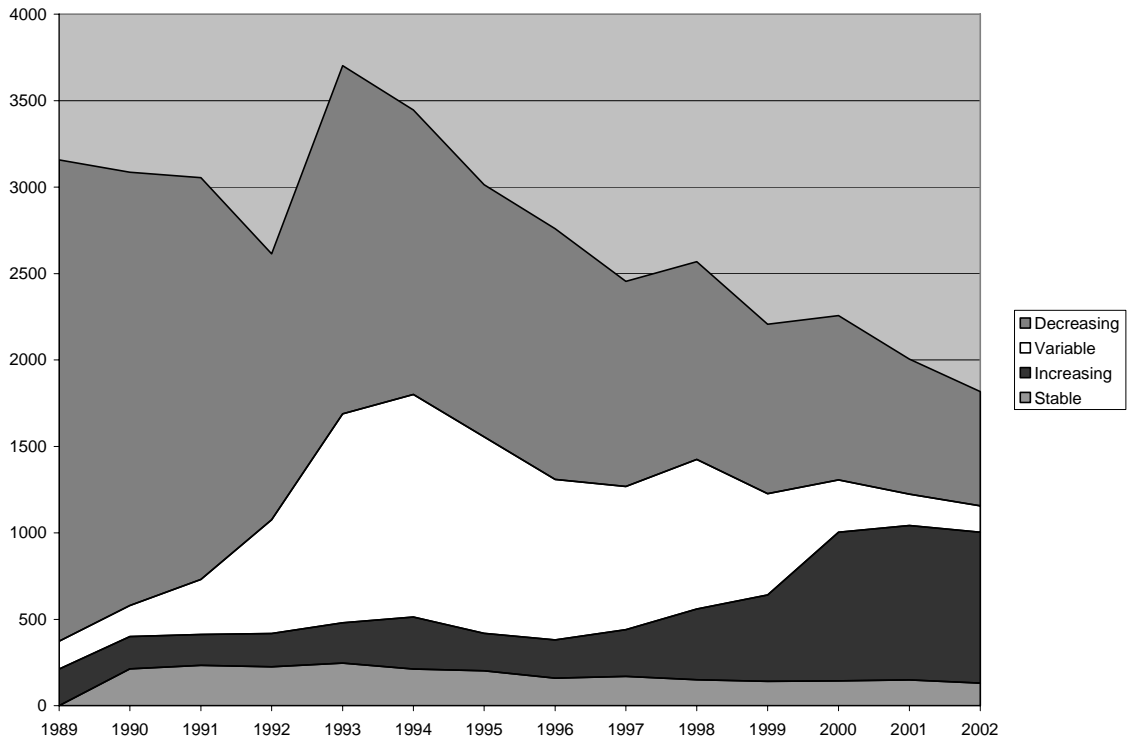


*Figure reproduced by permission from Weisburd, Groff and Morris (In progress).

### *Measuring Juvenile Crime*

Quantifying juvenile crime, a difficult undertaking at the macro-level,

becomes even more challenging at the micro-level.  All three of the major types of

data used to represent crime (i.e. official data, victimization survey data and self-

report data) have been identified as containing significant drawbacks where micro-

level patterns of juvenile delinquency are concerned.  Official data can be broken

down into information about crime incidents and arrests.  While official crime

incident data have frequently been used to represent crimes known to the police, they do not differentiate between crimes committed by juveniles and those committed by adults. Consequently the data have been considered unsuitable for characterizing juvenile crime rates (McCord, Widom, and Crowell 2001).

Official arrest data allow the identification of juvenile arrests and have often been used to measure juvenile crime. However, they suffer from drawbacks also. First and most general of the drawbacks is the low clearance rate (Blumstein and Wallman 2000a; McCord, Widom, and Crowell 2001). There exists no way of knowing the multitude of ways that arrested individuals might be different from the actual population of individuals who committed crimes. So there is a good chance that juvenile arrests will be biased in ways that are difficult to quantify. Second, in the case of multiple arrests of the same individual, all of those events are counted as arrests. Thus, arrest statistics measure number of arrests not the number of offenders. To complicate matters even further, juveniles tend to offend in groups rather than alone. So one incident could generate more than one arrested juvenile and artificially inflate a juvenile crime rate based on the number of arrests (McCord, Widom, and Crowell 2001). Despite these issues, juvenile arrests have been the most frequently used measure of juvenile crime (Snyder 2001).

Emergency or 911 calls for service represent another type of official data available at the micro-level. These data could potentially be used to identify incidents involving juveniles as victims or offenders. However, the information is rarely available and when obtained, is not usually entered in a format that is analyzable.

Two other data sources, victimization and self-report data, measure different dimensions (McCord, Widom, and Crowell 2001). Victimization surveys ask about suspect information and have been used to estimate the proportion of reported victimization perpetrated by juveniles (subject to the well-known limitations of recall data). However, these data have rarely been released at the micro-level. They also attribute the location of the victimization to the residence of the reporting individual. Self-report data have often been used and represent a valuable source of information at the macro-level. However, none of the surveys collect information on where the crime was committed. So while they provide valuable information about the frequency in which respondents engage in criminal activity and/or delinquency, there has been no mechanism to link behavior with place.

In sum, the hybrid of official arrest and crime data used in earlier research represented a solid method for identifying where juveniles are committing crime (Weisburd, Groff, and Morris In progress). The incorporation of arrest data enabled the identification of crimes committed by juveniles, which is a more accurate measure of juvenile activity than all crime. Despite the limitation of using only crimes for which an arrest was made, the hybrid measure of juvenile crime locations was still an improvement over using all crimes or juvenile arrest locations by themselves.

*The Present Study*

While the study of macro level crime rates has produced a wealth of information about the characteristics associated with both crimes and criminals, it has failed to uncover satisfactory explanations for the crime drop of the 1990s. Recent work has pointed to micro-level places as a useful unit of analysis. Two related

studies by Weisburd et al have demonstrated that only a few street blocks were responsible for the reduction in crime that occurred in Seattle (Weisburd, Bushway, Lum, and Yang 2004; Weisburd, Groff, and Morris In progress). Their work has also identified groups of places that have similar 'criminal careers'. However, a comprehensive exploration of the geographical distribution of street blocks from different trajectory groups has yet to be undertaken.

The literature review provided a broad foundation for this inquiry. Cross-sectional research has clearly demonstrated that regardless of the unit of analysis, the crime rates of places tend to be more similar to nearby places and tend to be clustered in space. Studies at the micro-level have found tremendous variation within even smaller units of analysis such as neighborhoods. Thus, a small unit of analysis is essential to identifying and describing the micro-level variation in juvenile crime. The few studies employing a longitudinal design provided mixed evidence for the stability of crime at micro places over time. In addition, the short distances that most juveniles travel to commit crime also called for small units of analysis to capture the variation.

Opportunity theories have highlighted the role of place and urban form in general in facilitating the convergence of victims and offenders. Research under the rubric of opportunity theories has identified particular land uses and facilities associated with higher crime rates and which form the nucleus of many of the hotspots observed. In general, places with high crime rates share certain physical characteristics that make them attractive for crime. The unanswered question is how changes in crime rates over time at one 'place' are related to changes at other 'places'

in the same city.  This research extended two previous studies using trajectory

analysis and attempted to shed light on the geographic aspects of that question.

When undertaking spatio-temporal research, the dependent variable has

usually consisted of the numbers of crimes per street block.  The current investigation

was unique in that it made use of the outcome of a group-based temporal technique.

Specifically, it used the trajectory group classification of the earlier study by

Weisburd, et al., (In Progress) that identified groups of street blocks that experienced

similar changes in juvenile crime rates over time as the dependent variable for the

current research.  This dependent variable of trajectory group membership elegantly

captured the temporal variation in juvenile crime.  However, the trajectory

assignment itself was aspatial and unable to address questions of the geographical

distributions of those 'places'.

The ability to classify a street block as a member of a particular trajectory

group does not provide any information about how the trajectory of that street block

relates to street blocks adjacent to it.  This occurs because the 'hundred block'

identifier itself is aspatial (i.e., it does not know where it is on the Earth's surface).

As mentioned earlier, it was necessary to spatially enable the data to be able to

answer questions about the spatial relationships among street blocks.  Spatial analysis

techniques were then used to explore the spatial patterns street blocks that shared a

common juvenile crime trajectory.  Questions such as, are blocks that had increases in

juvenile crime clustered, random or dispersed?  Is it more likely that spatially

proximate street blocks would share the same trajectory?  To what extent are street

blocks of the same trajectory found across the entire city?  These are questions that

had not been directly addressed by prior research and were addressed here through the use of a variety of distance and attribute-based techniques.

The present study used a data set originally developed by Weisburd, et al. (2004) and extended by Weisburd, et al. (In progress). The previous studies used trajectory analysis to classify every street block in Seattle, WA based on the number of crimes over the period from 1989 to 2002. Weisburd, et al. (In Progress) examined just those crimes committed by a juvenile. This research used the group classifications developed by Weisburd, et al. (In Progress) as the dependent variable. The trajectory group assignment was then used to explicitly examine the spatial distribution of street blocks by trajectory. The following research questions were addressed: 1) What is the spatial pattern of street blocks that follow specific trajectories of juvenile crime? and 2) Are trajectories of street blocks related to the trajectories of nearby blocks? The investigation of these questions will provide the foundation for subsequent studies incorporating the characteristics of place. The ultimate goal of this research program is to inform our understanding of the micro-level patterns of crime places over time and in doing so, inform our knowledge of the processes underlying macro-level juvenile crime trends.

# Chapter 3: Data and Methods

The incorporation of spatial methods into criminological research has increased rapidly since the 1990s (Messner and Anselin 2004). Researchers have taken seriously the error introduced by failing to account for spatial effects when analyzing spatial data and have responded by incorporating a range of spatial data analysis techniques.[14] This research continues that trend by using spatial statistics to describe the geographic patterns of street block level juvenile crime place trajectories.

## *Study Area, Data and Time Period*

The study area was the city of Seattle, Washington. The base data used in the study consisted of the list of street blocks in the city and was developed as part of the first study in Seattle (Weisburd, Bushway, Lum, and Yang 2004). The dependent variable for this study consisted of the trajectory group assignment for each street block. These assignments were done using the TRAJ routine as part of a previous research project (Weisburd, Groff, and Morris In progress). The trajectory assignments were based on the frequency of juvenile crime incidents for the period of 1989 to 2002.[15] This period was used because 1989 was the earliest date for which reliable crime data were available at the street block. The time period also coincided well with the crime drop of the early 1990s. In addition to the juvenile crime

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[14] The volume of research explicitly examining spatial dependence or spatial error in their models is far too large to detail here. The following studies are provided as examples (Baller, Anselin, Messner Steven, Deane, and Hawkins 2001; Chakravorty and Pelfrey 2000; Cohen and Tita 1999; Cork 1999; Jefferis 2004; Morenoff and Sampson 1997; Roman 2002).

[15] The geographic street block locations and geocoded crime data were originally developed by Weisburd et al (Weisburd, Bushway, Lum, and Yang 2004; Weisburd, Lum, and Yang 2004). A subsequent study by Weisburd et al (In progress) used arrest data to identify the crimes from the original data set that were committed by juveniles. A complete description of the creation of the data is available in the original publications.

trajectory data, the study used data from Seattle GIS including the street centerline, city limits, and water bodies. Unfortunately, no one spatial statistics package that included all the necessary functions combined with a powerful cartographic display engine exists, so data analysis and display were done using a variety of software packages including SPlus© Spatial Stats module, SPlancs©, CrimeStat©, GeoDa© and ArcGIS© 9.1.

*Geocoding Process*

In order to examine the spatial patterns in the data the first step was to assign each street block (e.g. 100 Main St) geographic coordinates (i.e., X, Y). The process of assigning geographic coordinates is called geocoding. For this study geocoding was done using a combination of ArcGIS 9.1 and ArcView 3.2 software.

A multi-step geocoding process was used to ensure the highest accuracy level possible. First, the file received from the earlier study was geocoded in batch mode.[16] This resulted in the successful geocoding of 28,948 street blocks (out of the original 29,849 street blocks used to discover the trajectory groups). The remaining 901 street blocks were then matched interactively. Each hundred block was inspected and matched to the correct record in the geographic information system (GIS). Interactive geocoding matched another 381 records. The remaining 417 unmatched street blocks were then imported into ArcView 3.2 for the final round of geocoding.[17] Twelve

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[16] The batch mode used the following parameters: 1) Spelling Sensitivity = 80; 2) Minimum candidate score = 10; 3) Minimum Match Score = 85; and 4) Do not match if candidates tie. These settings are considered rigorous for geocoding. While they result in more records that have to be manually inspected, they reduce the probability of a record being matched to an incorrect location. Thus they enable greater confidence that the records from the database have been assigned the correct physical location in Seattle.

[17] The use of ArcView 3.2 was necessary because it has routines to allow an unmatched record to be matched to the cursor location on a map. These routines do not exist in ArcGIS 9.1.

additional street blocks were matched to their locations on the map.[18]  In the end,

29,405 (98.6%) of the original street blocks were able to be geocoded and were used

in this analysis.

There was very little loss of juvenile crime data from the geocoding process.

Only, eleven of the street blocks that were not geocoded (and thus dropped from the

geographic analysis) experienced any crime during the time period.  Those eleven

street blocks experienced 66 juvenile crimes.  The other 394 street blocks that were

not geocoded had zero crimes for the entire period.  Thus the total number of crimes

represented in the geocoded data was 38,079 (99.8%) compared to the 38,145 used to

generate the trajectories.

*Level of Analysis*

The decision to use street blocks as the unit of analysis was critical to the validity

of the research.  Physically, a street block was represented by the street segment

between two intersections.  A street block included the set of addresses that existed

on both sides of the street segment and thus encompassed both 'block faces'.[19]

Substantively, there were several reasons to focus on street blocks as the preferred

unit of analysis for examining the patterns of juvenile crime trajectories at places.

First, routine activity theory is essentially a micro-level theory and thus was most

appropriately used at that level of analysis.  Second, a street block constituted a single

behavior setting that was bounded by time and space and both must be considered if

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[18] The majority of the remaining 410 street blocks did not have a street block number (342), were not in the street centerline (28), were outside Seattle (36) or were intersections or duplicates (4) and thus not eligible for geocoding.
[19] See Weisburd, Lum and Yang (2004) for a full description of the methodology used for aggregating data to street blocks.

we are to understand the dynamics of place (Jacobs 1961; Taylor 1997a; Taylor

1997b). Taylor viewed street blocks as "a key mediating social and spatial construct"

(1997b 115).[20] Third, using micro places such as individual addresses, intersections

and street blocks minimizes the aggregation in the analysis and consequently, the risk

of ecological fallacy (Brantingham, Dyreson, and Brantingham 1976). Fourth, when

considering policing strategies as they relate to place, a key factor was how much of

the variation in crime involves factors the police were able to address (Taylor 1997a).

Street blocks offered a manageable size for police and police-coordinated

interventions to be identified and applied. Fifth, and most pragmatically, data on

juvenile crime trajectories were available at the street block level from earlier

research (Weisburd, Groff, and Morris In progress).

Finally, on a more technical note, the use of street blocks to define places

reduced the problem of spatial heterogeneity among the units of observation that has

been shown to exist when larger areal units were used (e.g. blockgroups and census

tracts) (Smith, Frazee, and Davison 2000). Spatial heterogeneity refers to within-

observation variation in measures. This phenomenon has been observed when a

measure that was valid for a larger areal unit does not accurately represent the within-

area variation. For example, a measure such as single family housing may have

labeled a neighborhood "sixty percent single-family housing" but that label masked

street to street variation in the proportion of housing. One street may have been one

hundred percent single-family residential, another may be ten percent. Empirical

research has noted the existence of extensive block by block variation in

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[20] See Taylor (1997b) for a comprehensive discussion of street blocks and their role in maintaining social control.

characteristics of the physical environment as it was related to criminal activity such as calls for service and burglaries (Groff and LaVigne 2001) and auto thefts (Potchak, McGloin, and Zgoba 2002). Street blocks offered relatively homogenous units of analysis and thus minimized possible reductions of the size of effects (Smith, Frazee, and Davison 2000).

*Variables Used in the Study*

Trajectory Designation

Each street block in Seattle was assigned a trajectory group designation (Weisburd, Groff, and Morris In progress). The group membership designation identified which street blocks experienced similar trends in juvenile crime incidents over the entire study period. The trajectory group assignment produced by the earlier study was a limited categorical variable. As described in the literature review there were eleven trajectories identified. All figures reported in this section referred to the analysis of geocoded crime data and reflect the slight loss of data that occurred during geocoding.

The number of street blocks in each trajectory varied widely (Table 1). The largest trajectory (trajectory 11) accounted for 23,866 street blocks with low and stable juvenile crime rates over the entire period. The next largest trajectory (trajectory 1) had only 1,818 street blocks and evidenced decreasing juvenile crime over the study period. The trajectory with the smallest number of street blocks was trajectory 7, and contained only sixty street blocks. Following the previous studies, the eleven individual trajectories were grouped into four general categories that described the changes in juvenile crime rates over time: 1) increasing, 2) decreasing,

3) variable and 4) stable.  The last column in Table 1 reflects the group assignment of each individual trajectory.

Table 1:  Number of Street Blocks Per Trajectory and Trajectory Group Assignment

| Trajectory | Original Trajectory Analysis | Geocoded Analysis | Trajectory Group |
|---|---|---|---|
| 1 | 1,128 | 1,126 | Decreasing |
| 2 | 760 | 759 | Variable |
| 3 | 779 | 778 | Increasing |
| 4 | 492 | 491 | Variable |
| 5 | 196 | 196 | Increasing |
| 6 | 437 | 437 | Variable |
| 7 | 60 | 60 | Variable |
| 8 | 449 | 446 | Decreasing |
| 9 | 80 | 80 | Decreasing |
| 10 | 167 | 166 | Decreasing |
| 11 | 25,301 | 24,866 | Stable |

The grouping of trajectories produced 1,818 (6.2%) street blocks with decreasing crime and 974 (3.3%) that experienced increasing crime over the time period.  There were 1,747 (5.9%) street blocks in the variable group, which consisted of street blocks that increased and decreased but began and ended the study period at about the same level.  The final group, stable, consisted of those street blocks with low crime rates that were stable over the time period.  The stable group was the largest with 24,866 street blocks (84.6% of all blocks).  Table 2 summarizes the effect of geocoding on the number of street blocks in each of the trajectory groupings used in the analysis.  All but eleven of the street blocks that did not geocode had no juvenile crime over the entire time period.

Table 2: Number of Street Blocks Geocoded Per Group Assignment

| Trajectory | Number of Blocks in Original Trajectory Group | Number of Geocoded Blocks |
|---|---|---|
| Stable | 25,301 | 24,866 |
| Decreasing | 1,824 | 1,818 |
| Increasing | 975 | 974 |
| Variable | 1,749 | 1,747 |
| **Total** | **29,849** | **29,405** |

Before proceeding it should be noted that there were several potential shortcomings to the application of trajectory analysis to places rather than people. First, the assignment of trajectories was done without regard to the life cycle stage of a particular street block. Thus the trajectory assignment may have grouped places at different stages of development in the same group. However, any impact on the current study would have been lessened because the substantive goal was to better understand changes in crime over a particular time period, rather than to describe life-cycle changes in general; the impact of similar historical circumstances changing in concert was the focus. Second, the trajectory technique was inherently aspatial. It ignored the geography of places and in doing so did not account for spatial effects that may have been at work.

While acknowledging the importance of both issues, addressing them in this study was not possible. Future studies could ameliorate the impact of different street ages through the use of a joint trajectory analysis that incorporated age of street. This would enable the trajectory analysis to take into account the age of the street at the start of the study period. Addressing the second issue would require incorporating geography into trajectory analysis. Spatio-temporal measures exist that can identify local and global clustering across both time and space. But those statistics were not

group-based and consequently would not produce the same type of output as the TRAJ procedure and could not answer the research questions posed here.

Previous studies have taken a sequential approach; conducting a spatial analysis of the output of the developmental statistic (Griffiths and Chavez 2004; Kubrin and Herting 2003; Weisburd, Bushway, Lum, and Yang 2004). That was the approach taken in this analysis. This research focused on explicitly addressing the geography of the groups of street blocks through the use of ESDA techniques. These techniques enabled an in-depth examination of the spatial distribution of places by group membership.

Juvenile Crime Construct

The variable of juvenile crime per street block provided the basis for the trajectory assignments that were used here.[21] Thus it would be worthwhile to explain the rationale for the definition of juvenile crime on which the trajectories of juvenile crime places were based. Because this research was interested in the changes in crime at places, the locations of crimes committed by juveniles capture this construct the best. However, this operational definition of juvenile crime required a combination of official crime and arrest data and as a result incorporated the advantages and disadvantages of both. The trajectory analysis used juvenile crime counts to identify the groups of street segments that experienced similar variations in juvenile crime over the study period. The current study began by examining the geographic distribution of trajectory group members. The construct validity of this definition of juvenile crime is discussed next.

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[21] The small numbers of total juvenile crime per segment per year precluded an analysis by type of crime which would have reduced the number of observations even further.

Construct validity pertains to the relative strength of the inferences that can be made about the study constructs using the particular measured variable in the study, in this case juvenile crime (Kerlinger and Lee 2000; Shadish, Cook, and Campbell 2002). Said another way, how well did the number of crimes committed on a street block for which a juvenile was arrested represent the construct of juvenile crime?[22] Since the measure relied on official crime and arrest data from the Seattle Police Department it was subject to the standard limitations of those types data that have been discussed elsewhere (Gove, Hughes, and Geerken 1985). Drawbacks of using official incident data as they relate to juveniles were discussed in the literature review.

Specific to this study, the limitations of using this measure of juvenile crime were as follows. The measure only included reported crime. In general, reported crime represents a subset of crime that occurs and only includes crimes for which an officer takes a report. The sample of crime analyzed here was not only a subset of all crime but also a subset of all juvenile crime. In order to identify a crime as being committed by a juvenile, it was necessary to know the age of the perpetrator. The most reliable method for determining age of offender was to restrict the sample to include only those crimes for which an arrest was made. Unfortunately, low clearance rates further restricted the pool of crimes for which offender age was known.[23] In addition, since clearance rates tend to be higher for violent crimes then

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[22] For a more complete discussion of the dataset and methodology used in the original studies please see Weisburd, Morris and Groff (2005) details on the juvenile crime data used and Weisburd, Bushway, Lum and Yang (2004) for the creation of the original crime database.

[23] In 2002, arrests were made for only 20 percent of all index offenses (46.8 percent for violent crimes and 16.5 percent of property crime) (FBI 2003 3). Clearance rates were relatively stable from the 1995 rates when the average was 21 percent for all index offenses, 45 percent for violent crimes and 18 percent for property crimes (FBI 1996).

property crimes, the sample may have been biased toward juvenile violent crime incidents.

Previous research has shown that the validity of reported crime varies by crime type. Specifically, reported crime represents more serious crimes better than more trivial crimes, such as Part II crimes (Gove, Hughes, and Geerken 1985). Therefore, the validity for more serious crimes such as homicide, rape, robbery and assault was higher than for burglary, auto theft and Part II crimes. In addition, the reliability of information contained in the reports increased with seriousness of crime. Since juveniles tend to commit more property crimes than violent ones, the sample of juvenile crime used here over represented violent crime incidents committed by juveniles and under represented property crime incidents. Studies on journey to crime have shown that offenders tend to travel farther to commit property crime than violent crime so the juvenile crimes in this sample will reflect juveniles who live close to the location of the offense.

In addition, since police resources have often been concentrated on violent rather property crime wherever it occurs, it seems reasonable that a greater proportion of violent crimes than property crimes will be represented in the data. To the extent that violent crimes cluster in different places than property crimes, the spatial distribution of events may be biased. However, the degree of bias is unknown since the total distribution of property and violent crimes committed by juveniles is also unknown.

As noted earlier, the differences between arrested individuals and those that avoided arrest are unknown, which could introduce bias into the measure (Blumstein

and Wallman 2000a; McCord, Widom, and Crowell 2001).  Another source of bias, specifically spatial bias, could come from systematic differences in clearance rates of juvenile crime.  Specific to this study, differential arrest rates geographically would bias the distribution of juvenile crime.  While the impact on juvenile crime is not known, Lum (2003) compared the spatial pattern of drug arrests with calls for service for drugs and found similar patterns for both.  This indicated that concerns over spatial bias in clearance rates may be overstated.  However, questions about the existence and extent of spatial bias in clearances of juvenile crime cannot be known definitively without further study.

Despite its shortcomings, this measure of juvenile crime location had several benefits.  First and most importantly, this measure characterized juvenile crime in terms of where it is committed and thus was measuring a different construct than traditional measure of juvenile crime which represented juvenile crime by residence location.  This characterization of juvenile crime better reflects the study's focus on juvenile crime at place by capturing the number of crimes on each street block that were committed by juveniles.  Second, the measure offered no disadvantages in comparison with those studies which used juvenile arrests.  Both were limited to studying only those events in which an arrest was made.   Third, the use of official crime data enabled the study to examine a long time period for no additional cost (Kerlinger and Lee 2000).  Finally, the measure enabled the exploration of how the geographic location of places factors into the processes at work in the onset, persistence and desistance in the criminal careers of places (Jefferis 2004; Smith, Frazee, and Davison 2000).

*Analytical Approach*

The main focus of this research was to describe the spatial patterns in the outcome of a group-based trajectory analysis of juvenile crime at the street block level of analysis. Since this research involved the initial systematic investigation of the geography of trajectory groups, an exploratory data analysis (EDA) approach was warranted.[24] EDA is often used when the goal of the research is to identify patterns and suggest hypotheses from a data set while employing as few assumptions about the structure of the data as possible (Tukey 1977). Exploratory spatial data analysis (ESDA) represents a variation on EDA that explicitly examines the spatial distribution of a phenomenon to recognize spatial outliers, discover spatial association in attributes, identify clusters of events, suggest spatial heterogeneity and recognize spatial trends (Anselin and Getis 1992; Bailey and Gatrell 1995; Fotheringham, Brundson, and Charlton 2000; Haining 1990; Messner, Anselin, and Baller 1999).

The analysis of spatial patterns was divided into two main sections that address the following research questions: 1) What is the spatial pattern of street blocks that follow specific trajectories of juvenile crime? and 2) Are trajectories of street blocks related to the trajectories of nearby blocks? If there was a systematic pattern present in the data, a next logical question would concern the scales over which it operated? For instance, if increasing blocks were clustered, was it only for the closest neighbors or did the clustering extend to all spatial scales? The exercise of

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[24] Only two previous studies used ESDA and a group-based trajectory analysis to examine the spatial distribution of trajectories of places (Griffiths and Chavez 2004; Weisburd, Bushway, Lum, and Yang 2004). Griffiths & Chavez (2003) used census tracts rather than street blocks as their unit of analysis, and thus their experience informs the macro analysis of trajectories. Weisburd et al (2004) limited their geographic analysis to density maps of the different trajectories.

quantifying the patterns in the data was conducted to further our understanding of the "underlying process that generated the points" and enable the creation of models to explain the observed patterns (Fotheringham, Brundson, and Charlton 2000 131). A series of spatial statistical techniques were used to analyze the spatial patterns of street blocks. Each street block was represented by a dot on the map (also called a point). In general, the spatial techniques used to analyze a collection of points are referred to as point pattern techniques.

Analysis of the Spatial Patterns of Trajectory Group Members

Several formal tests of the spatial distribution of crime events were employed to characterize spatial patterning, both globally and locally. Global statistics were used to describe variation across the entire distribution and capture first order effects related to the variation in both mean and variance across the entire distribution. Local statistics described the variation in the immediate area of an observation, quantifying the distances between a street block and other street blocks of the same trajectory. Local statistics can also be used to describe how the attributes of street blocks tend to vary (i.e. how likely an "Increasing Trajectory" street block is to be in the vicinity of another "Increasing Trajectory" street block). Local statistics specifically examined the second order effects (i.e. local relationships) related to spatial dependence. Since spatial patterns tend to be a product of both first and second order effects, both were examined here (Bailey and Gatrell 1995).

A variety of point pattern statistical techniques were available to describe both first and second order effects in the distributions of juvenile crime and juvenile crime trajectories. An intensity map of the distribution of all juvenile crime across street

blocks was created to provide a good initial description of the global distribution of street blocks in a particular trajectory.[25] By examining the resulting image for juvenile crime, overall trends in the data can be identified.[26]

Next, second order or local variation in the data was examined using the nearest neighbor (Ghat) and the K function. Both of these statistics use a set of inter-event distances to characterize the distribution. For example, from one street block to the nearest street block of the same trajectory type. One drawback of the nearest neighbor statistic is that it measures the inter-event distances only at a very small scale (Bailey and Gatrell 1995). Thus, it will be an ineffective measure of spatial dependence at longer distances. The K function, on the other hand, measures spatial dependence at a wider range of scales, which complements the information provided by the nearest neighbor statistic. In order to make more formal statements about the point patterns, it was necessary to compare the summary statistics calculated from the observed distribution of street blocks with those calculated from a model distribution: for example, complete spatial randomness (CSR). When used in this way the K function is able to identify whether the observed pattern is significantly different than what would be expected from a random distribution (Bailey and Gatrell 1995). Ripley's K was calculated and then compared to a reference line that represents CSR: if $K(h) > \pi d^2$ then clustering is present (Bailey and Gatrell 1995, 90-95; Kaluzney et al 1999, 162-163). Both of these techniques were used to describe the proximity of street blocks in the same trajectory.

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[25] The technique of kernel smoothing is used to describe the mean number of events per unit area. The kernel function in S-Plus uses a quartic kernel to smooth the distribution.

[26] Absence of an overall trend indicates that the distribution has first order stationarity, in other words the "statistical properties are independent of absolute location" in the study area (Bailey and Gatrell, 1995).

Finally, a cross-K or bivariate-K function was used to test for independence between movement patterns. This statistical technique answers whether the pattern of street blocks belonging to one trajectory is significantly different than the pattern of street blocks in another trajectory. Further, the output from the bivariate-K function can be used in the investigation of whether the pattern of street blocks belonging to one juvenile trajectory is related to the pattern of another (Bailey and Gatrell 1995; Rowlingson and Diggle 1993). All of these measures are distance-based and characterize the spatial patterning of the street block locations. The next section examines the distribution of the trajectory group membership across the study area through the use of spatial autocorrelation.

Spatial Autocorrelation in Juvenile Crime

One challenge faced in this research was the limited nature of the dependent variable, in this case trajectory group membership. Typically, measures of spatial autocorrelation such as Moran's I measure the patterns in the deviation of an observation from the mean for the distribution. This requires a ratio level variable such as the number or rate of juvenile crime. For example, if number of crimes was the dependent variable, Moran's I would characterize the existence and strength of the relationship between the number of juvenile crimes at one street block and the rates of juvenile crime on nearby street blocks. However, the focus of this research was on the distribution of street blocks by type of trajectory, which involved a limited dependent variable and made the use of spatial autocorrelation techniques inappropriate without recoding. Following recent research, this study dummy coded

the dependent variable to allow a series of comparisons; each trajectory group, in turn, was compared to all others (Griffiths and Chavez 2004).

The challenge just outlined only applies to the micro-level of analysis. It would not be an issue if the analysis of trajectory group membership was aggregated to a more macro level analyses where the dependent variable could be calculated by aggregating to the area unit of analysis. This would result in four new dependent variables reflecting of the numbers of decreasing, increasing, variable and stable trajectory blocks per area. So the dependent value would be the number or proportion of trajectory street blocks per census tract rather than trajectory group membership. In this case, a spatial autocorrelation statistic would be measuring the extent to which areas with similar numbers of street blocks from a particular trajectory were 'near' each other.

# Chapter 4:  Results

A variety of statistical techniques were used to explore the research questions raised.  The first two sections address the results pertinent to the more general question: What is the spatial distribution of street blocks that follow specific trajectories of juvenile crime?  The final section examines the second research question: Are trajectories of street blocks related to the trajectories of nearby blocks?

## *Global Trends in Trajectory Locations*

The analysis of global trends in the distributions of blocks by type of trajectory grouping was undertaken using a variety of software packages. CrimeStat© was used for the spatial portion of the centrographic analysis of mean and median centers.  SPSS© was used for the one-way ANOVA to test the differences in the group means and general data manipulation.  The kernel estimation and all cartographic products were done in ArcGIS©.  All of the analyses were conducted on the trajectory groups only.

### Distributions of Trajectory Blocks

Point maps offer an excellent initial view of the distribution of street blocks in each group.  Map 1 depicts the locations of all the stable trajectory street blocks as points on a street map of Seattle and is included to provide a reference for the distribution of all street blocks.  The large number of these stable street blocks virtually guarantees that they would be spread throughout the city and they were. Additional maps show the locations of street blocks that were part of each trajectory group, decreasing (Map 2), increasing (Map 3) and variable (Map 4).  The general

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pattern for each trajectory shared the following two characteristics. All types of

trajectory groups were distributed throughout the city and had particular areas where

they were clustered. In addition, street blocks from all of the trajectory groups

evidenced a higher level of clustering in the downtown area; not surprising given the

higher concentration of street blocks in that area of the city.

Map 5 overlays the locations of decreasing, increasing and variable blocks.[27]

The composite map clearly demonstrates the degree to which trajectory groups were

both dispersed throughout the city and interspersed among each other. This pattern

indicated that the variability in temporal patterns discovered in the earlier study also

existed in street block's spatial patterns; street blocks with identifiable temporal

trends in juvenile crime were not all in the same place or in just a few places but

rather spread about the city. In addition, there was variation in trajectory type from

one block to another. However, the analyses undertaken in the following sections are

needed to determine if the visual patterns are supported by quantitative techniques.

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[27] Stable trajectory street blocks were not drawn because they overwhelmed the map. Basically, any street without a colored dot on it was part of a stable trajectory.

Map 1: Stable Trajectory Group Street Blocks

Map 2: Decreasing Trajectory Group Street Blocks



Point Map of Decreasing Trajectory Blocks
Seattle, Washington
1989 - 2002
N = 1,818

Legend

◆  Decreasing

Source: All base files were obtained from Seattle GIS.
Crime data was supplied by the Seattle Police Department.
Trajectory grouping assignments were generated by Weisburd,
Groff, and Morris (In Progress) and are used by permission.

Map 3:  Increasing Trajectory Group Street Blocks



Point Map of Increasing
Trajectory Blocks
Seattle, Washington
1989 - 2002
N = 974

Legend

♦    Increasing

Montana
Washington
Idaho
Oregon
California    Nevada

N

0  0.5  1       2       3
Miles

Source:  All base files were obtained from Seattle GIS.
Crime data was supplied by the Seattle Police Department.
Trajectory grouping assignments were generated by Weisburd,
Groff, and Morris (In Progress) and are used by permission.

Map 4:  Variable Trajectory Group Street Blocks



Point Map of Variable
Trajectory Blocks
Seattle, Washington
1989 - 2002
N = 1,747

Legend

◆  Variable

Source:  All base files were obtained from Seattle GIS.
Crime data was supplied by the Seattle Police Department.
Trajectory grouping assignments were generated by Weisburd,
Groff, and Morris (In Progress) and are used by permission.

Map 5:  All Trajectory Group Street Blocks

Centrographic Measures

As with aspatial descriptions of a data set, statistics such as mean and median can be used to describe the overall distributions of street blocks that are associated with the individual trajectories. Map 6 depicts the mean and median centers of all the street blocks in Seattle, the street blocks that had any juvenile crime (i.e. active street blocks) and those of the four trajectory groups. The median center for all street blocks in Seattle provides a reference distribution to which the trajectory group distributions were compared. The median center of the distribution of stable blocks was the north of the median center of all street blocks indicating the preponderance of stable blocks were north. Looking just at the active blocks (blocks that had a juvenile crime over the study period), their median center was south of the median for all blocks and very near the medians for the other trajectory groups. Thus the distribution of street blocks experiencing juvenile crime was weighted to the southern part of Seattle. All other types of trajectory groups medians were south of the all street blocks median. Heading southward, the order of median centers is variable, decreasing and increasing trajectory groups. Overall, the mean and median centers of these three groups tend to cluster just to the southeast of the downtown area.

Map 6– Mean and Median Centers of Trajectory Blocks
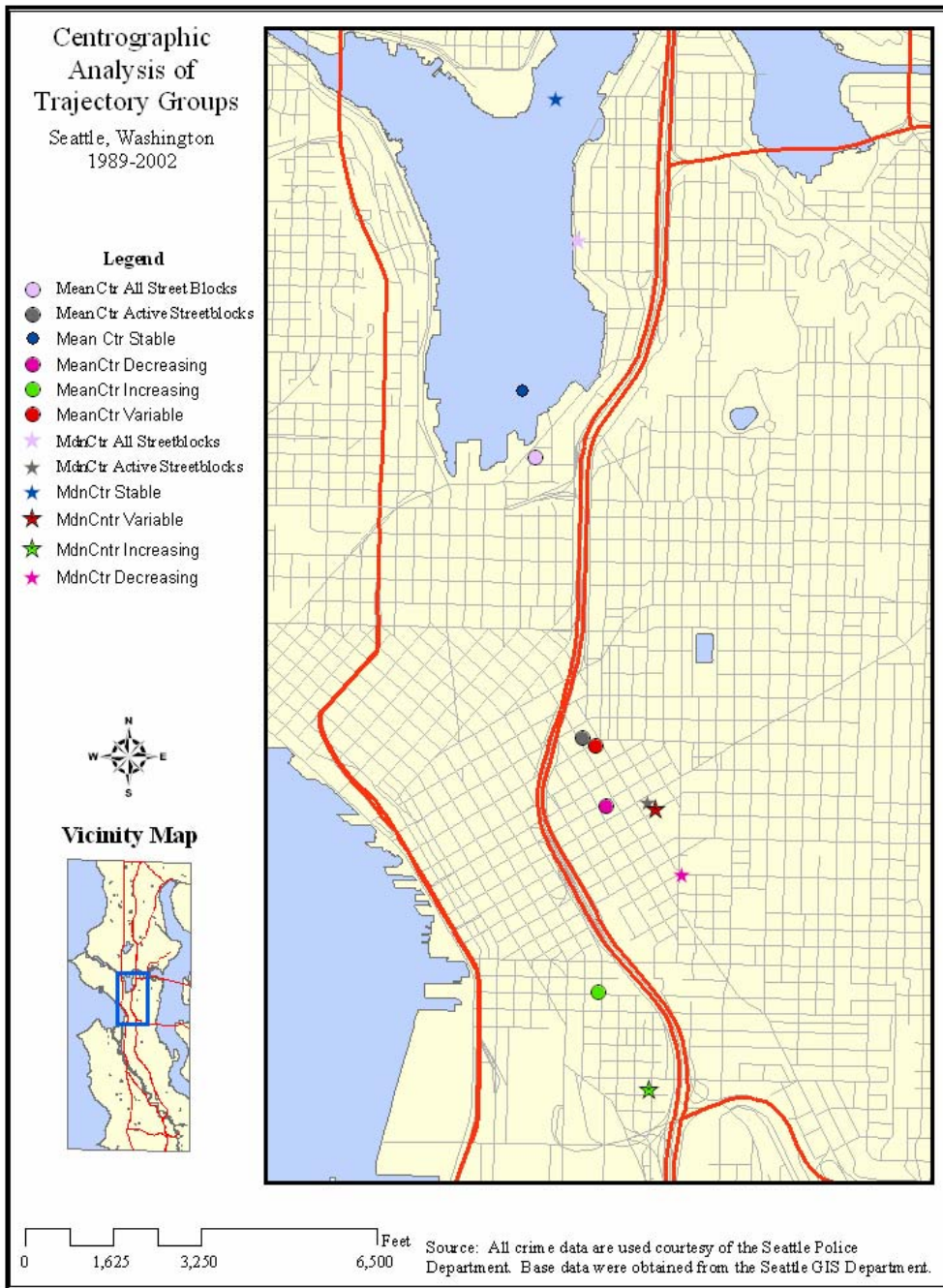
One-way analysis of variance was used to examine whether the mean centers of the distributions were significantly different from one another.[28] The ANOVA indicated that there were significant differences among the group means for both the X and the Y coordinate (at p = .000). A post hoc test using the Tukey HSD (honestly significant difference) test was used to identify which trajectories had significant differences in the location of their mean centers.[29] The X and Y coordinate of the stable trajectory group was significantly different than all other groups. The Y coordinate of the increasing group was significantly different from the decreasing and variable groups. These findings emphasized the relative importance of north-south spatial effects rather than east-west ones. Taken together these findings indicated a slight directional effect that may be, in large part, due to the shape of the city itself.

Visualization of Global Intensity

Kernel density surfaces were valuable when evaluating the existence of global trends in a distribution of locations. A kernel density was estimated for each of the groups and provided a probability surface describing the concentration of blocks across the entire city. A kernel density in ArcGIS provides a measure of relative density and the output is points per square mile (Mitchell 1999). For this analysis the output was number of blocks per square mile. The kernel density process involved

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[28] Two one-way ANOVAs were performed, one for the X and the other for the Y coordinate. SPSS 11.5 automatically uses the harmonic mean, a weighted average sample size, for each comparison which is necessary in situations like this with unequal group sizes. Prior to using ANOVA, the distributions were checked for normality and homogeneity of variance using the Kolmogorov-Smirnov(a) and Levene tests respectively. Distributions of both the X and Y coordinates were normally distributed at the p < .05 level. The Levene Test for Equality of Variances was significant at p < .01. So the assumptions that the data were normally distributed and variances were equal were accepted for the ANOVA.

[29] Post hoc results from the Tukey HSD and the Bonferroni were in general agreement. However, the more conservative Scheffe test found far fewer significant differences.

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creating a temporary grid over the entire study area and computing a density value for

each cell in the grid using a circular 'neighborhood'. The term kernel refers to size of

the 'neighborhood' (also called bandwidth) that was taken into account when

computing the density. The total number of street blocks within the bandwidth were

totaled and divided by the area under the circle. The resulting value was assigned to

the current cell. Blocks outside the bandwidth were not considered. Each cell in the

raster was evaluated using the bandwidth and a density value computed. A kernel

density surface was computed for each trajectory group (Maps 7 – 10).[30]

The kernel density maps confirmed the pattern noted from examination of the

point pattern maps. Street blocks in each trajectory group had a large spatial extent

appearing all over the city at low densities and in a few places at higher densities. A

slight tendency toward higher concentrations of stable street blocks in the north was

also visible. However, there did not seem to be a general gradient across the city that

would indicate an overall trend in the data. Nor was there a noticeable ridge of higher

values, which would indicate a global effect. In the case of the stable trajectory street

blocks, there did seem to be a plateau of higher densities in the northern half of the

city but additional plateaus are visible in the southwest and southeast sections of the

city. Thus the patterns of the intensity surfaces pointed toward local spatial

dependence and interaction rather than global trends.

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[30] A bandwidth of 1,320 feet (one quarter mile) and a cell size of 100 feet were used to generate all
kernel density surfaces. The quarter mile distance has often been used to represent the potential
walking area for individuals in urban areas and by extension their potential area of interaction
(Calthrope 1993; Duaney and Plater-Zyberk 1993; Nelessen 1994).

Map 7: Kernel Density of Stable Trajectory Streets



Kernel Density for Stable Trajectory Street Blocks
Seattle, Washington

There were 24,866 street blocks classified as stable during the study period of 1989-2002.

Legend

Density of Stable Blocks

- 3 - 136
- 137 - 269
- 270 - 402
- 403 - 536
- 537 - 669

Source: All base files were obtained from Seattle GIS. Crime data was supplied by the Seattle Police Department. Kernel density surfaces were generated using a 100 foot cell size with a 1,320 foot bandwidth. Densities are reported in square miles.

Map 8:  Kernel Density of Decreasing Trajectory Streets



Kernel Density for
Decreasing Trajectory Blocks
Seattle, Washington

There were 1,818 street blocks
classified as decreasing during
the study period of 1989-2002.

Legend

**Density of Decreasing Blocks**

- 1 - 51
- 52 - 102
- 103 - 152
- 153 - 202
- 203 - 253

Source:  All base files were obtained from Seattle
GIS. Crime data was supplied by the Seattle
Police Department. Kernel density surfaces were
generated using a 100 foot cell size with a 1,320
foot bandwidth. Densities are reported in square miles.

Map 9:  Kernel Density of Increasing Street Blocks



Kernel Density for
Increasing Trajectory Blocks
Seattle, Washington

There were 974 street blocks
classified as increasing during
the study period of 1989-2002.

Legend

**Density of Increasing Blocks**

| | |
|---|---|
| | 1 - 41 |
| | 42 - 82 |
| | 83 - 123 |
| | 124 - 163 |
| | 164 - 204 |

Source:  All base files were obtained from Seattle GIS.
Crime data was supplied by the Seattle Police Department.
Kernel density surfaces were generated using a 100 foot
cell size with a 1,320 foot bandwidth.  Densities are reported
in square miles.

Map 10:  Kernel Density for Variable Street Blocks



Kernel Density for
VariableTrajectory Blocks
Seattle, Washington

There were 1,747 street blocks
classified as variable during
the study period of 1989-2002.

Legend

**Density of Variable Blocks**

| | |
|---|---|
| | 1 - 35 |
| | 36 - 69 |
| | 70 - 104 |
| | 105 - 138 |
| | 139 - 172 |

Source: All base files were obtained from Seattle GIS.
Crime data was supplied by the Seattle Police Department.
Kernel density surfaces were generated using a 100 foot
cell size with a 1,320 foot bandwidth. Densities are reported
in square miles.

The previous series of city-scale maps provides information about the distribution of each trajectory group individually. Changing the scale of the map and narrowing the display area enables the comparison of trajectory group patterns at a local scale. Map 11 illustrates the overlap and adjacency effects in one small area near downtown Seattle. This area has concentrations of increasing and decreasing trajectories that overlap in some places and are offset in another. Theory suggests that offset areas of concentration may point toward diffusion and/or displacement of crime from one set of adjacent blocks to nearby blocks. This type of visual display, while powerful, cannot provide a clear answer regarding diffusion. Quantitative techniques, such as those applied in the sections examining local trends in the data, are needed to understand the magnitude of the local effects and assess their level of significance.

Map 11: Large Scale Comparison of Decreasing and Increasing Concentrations



Comparison of Kernel Density for
Decreasing and Increasing Trajectory Blocks

Legend

Density of Increasing Blocks

| | |
|---|---|
| | 1 - 41 |
| | 42 - 82 |
| | 83 - 123 |
| | 124 - 163 |
| | 164 - 204 |

Legend

Density of Decreasing Blocks

| | |
|---|---|
| | 1 - 51 |
| | 52 - 102 |
| | 103 - 152 |
| | 153 - 202 |
| | 203 - 253 |

N

0    0.5    1
Miles

Source: All base files were obtained from Seattle GIS. Crime data were supplied by the Seattle Police Department. Kernel density surfaces were generated using a 100 foot cell size with a 1,320 foot bandwidth. Densities are reported in square miles.

Quantifying Global Intensity

Two statistics that were helpful in describing the form of the distribution were nearest neighbor analysis (NNA) and Moran's I. The NNA statistic is a distance measure. It simply measures the distance from each member of a trajectory group to the closest member of the same trajectory group and calculates one statistic to describe the entire distribution. Simulations of point patterns were used to test

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whether the subject distribution is more or less clustered than would have been

expected under the assumption of complete spatial randomness.

Figure 2 depicts the results from the NNA. First, the nearest neighbor statistic

was calculated for every street block in the study area providing a reference for

interpreting the results of the individual trajectories analyses. The distribution of all

street blocks had a nearest neighbor distance of 108 feet. Among the trajectory group

street blocks, the stable group had the shortest nearest neighbor distance at about 140

feet. The extremely large number of street blocks that were stable virtually ensured a

nearest neighbor distance similar to the one for all street blocks. Decreasing street

blocks had the next longer distance followed by variable trajectory street blocks.

Increasing street blocks had the largest nearest neighbor distance (NN=673 feet). All

of the trajectory groups were more clustered than would be expected under complete

spatial randomness (CSR).[31] This finding suggests that there was some degree of

spatial dependence at short distances. Related to the first research question, the

nearest neighbor results indicated the distribution of street blocks in particular

trajectories was clustered rather than random or dispersed.

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[31] All tests used p<.001.

Figure 2:  Nearest Neighbor Distances



Mean NN Distance For Each Trajectory Group
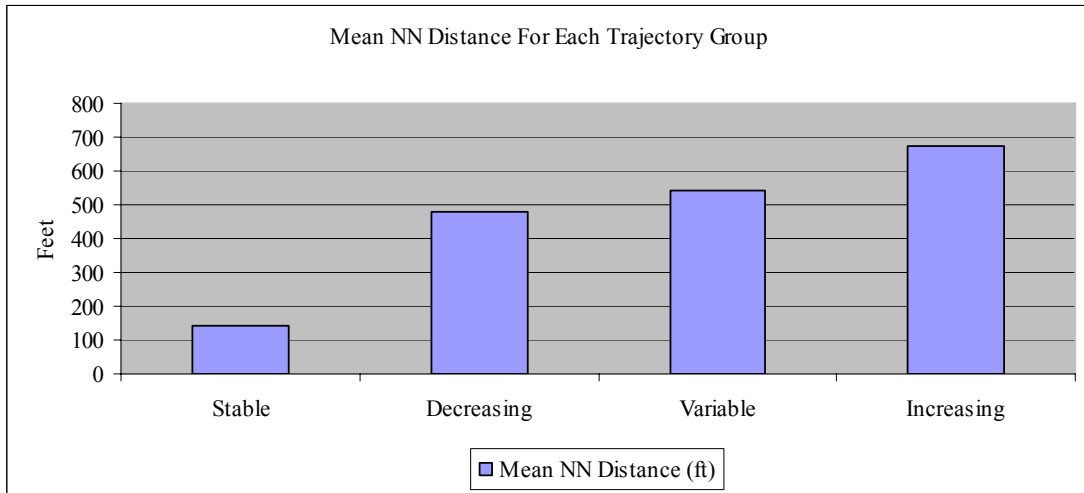
Moran's I is a spatial autocorrelation measure that describes how alike one

street block is to all others.  To use Moran's I, each member of the trajectory group

being evaluated was coded with a '1' and all other street blocks were coded with '0'.

This was repeated four times, once for each trajectory group.  The statistic calculated

the mean value for each location and then compared it to the mean value for all other

locations.  If a high score was next to a high score, positive spatial autocorrelation

was indicated.  If a high score was next to a low score, negative spatial

autocorrelation was indicated.  The values of Moran's I ranged from -1 to 1.  A value

of -1 indicated negative spatial autocorrelation and a value of 1, positive spatial

autocorrelation.  Zero showed essentially no relationship.  A Moran's I value was

calculated for each trajectory group with the following results: Stable = .1018,

Decreasing = .0082, Increasing = .0210 and Variable = .0085.  These results indicate

at the global level of the city of Seattle there is very little spatial dependence: for the

city as a whole, street blocks of the same trajectory do not tend to be located near one

another.  This result was most likely a function of the degree to which street blocks of

different trajectories are intermingled.

An examination of local relationships offered information critical to understanding the existence and extent of spatial dependence in the trajectory groups. Once again, two measures were used, a distance measure and a measure of spatial autocorrelation. Ripley's K provided the distance-based measure and a univariate local indicator of spatial autocorrelation or LISA offered a measure of local spatial autocorrelation. Together the two provided a more nuanced picture of local variation than would be possible with either one alone. The spatial autocorrelation analyses were calculated in GeoDa© and the results displayed using ArcGIS©. Splancs© extension to R© was used for the cross K function.

Distance-based Measure of Proximity

Ripley's K provided information on whether blocks of the same trajectory were more likely to be near each other as compared to complete spatial randomness. The statistic reported from Ripley's K in Crimestat was the L value. This was a rescaled Ripley's K where CSR was represented by a horizontal zero line. In order to provide a measure of significance, one hundred Monte Carlo simulations were used to develop an envelope of the minimum and maximum values under CSR. The odds of getting a result outside the envelope were one in one-hundred (or .01). Figures 3 – 7 depict the results for all street blocks and for each of the trajectory groups separately. The presence of the L-value line (dark blue line, L_T) above both the CSR line (pink line, L_CSR) and the simulation envelopes (dashed lines, L_T_MIN and L_T_MAX) indicated that all of the street block patterns were significantly more clustered than would be expected under CSR (i.e. the distances between street blocks of the same

trajectory group were shorter than would be expected under CSR).  This relationship

held at all tested distances (i.e. up to 10 miles).

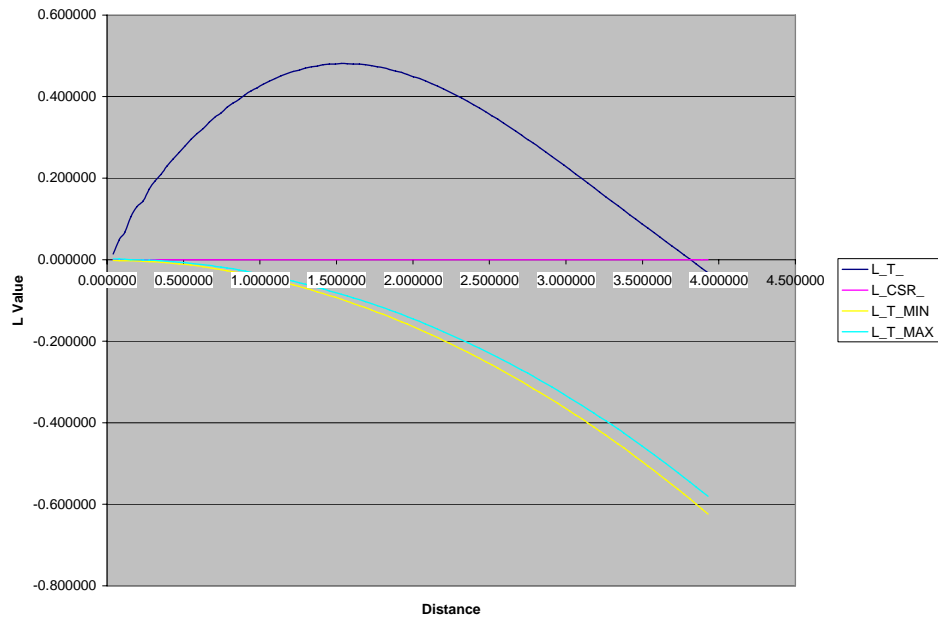Figure 3:  Ripley's K Results for All Blocks



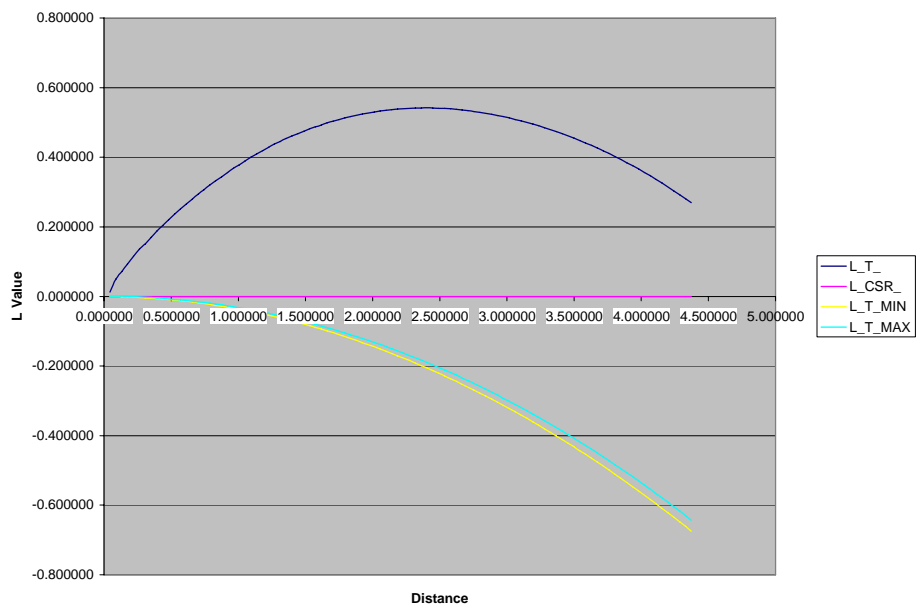Figure 4:  Ripley's K Results for Stable Trajectory Blocks

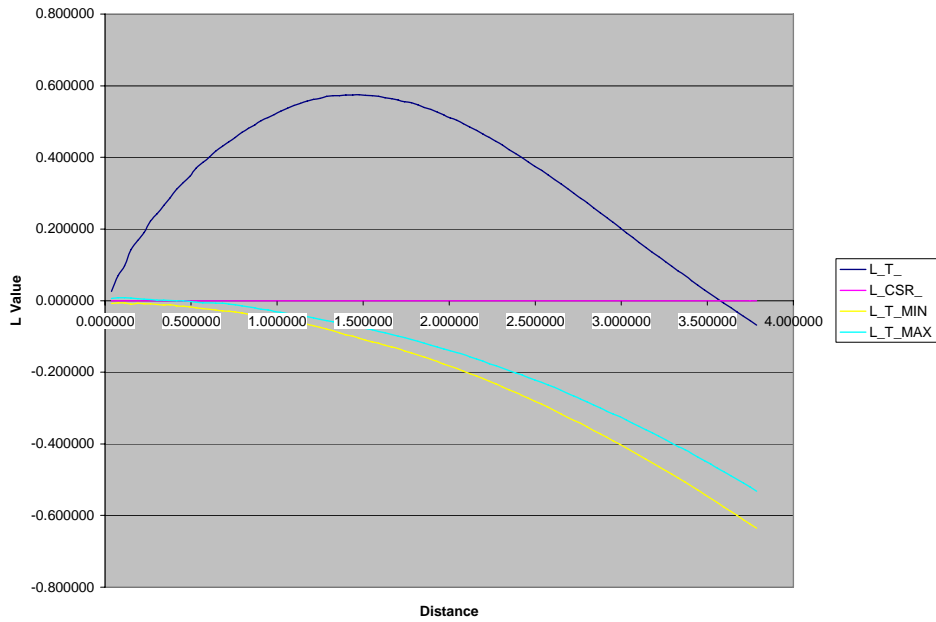Figure 5: Ripley's K Results for Decreasing Trajectory Blocks



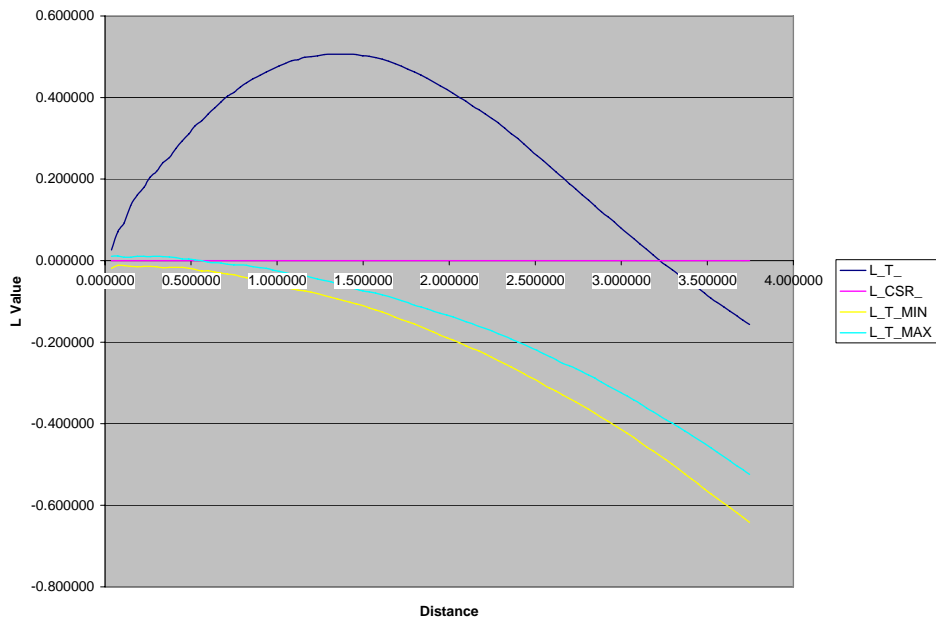Figure 6: Ripley's K Results for Increasing Trajectory Blocks

Figure 7:  Ripley's K Results for Variable Trajectory Blocks
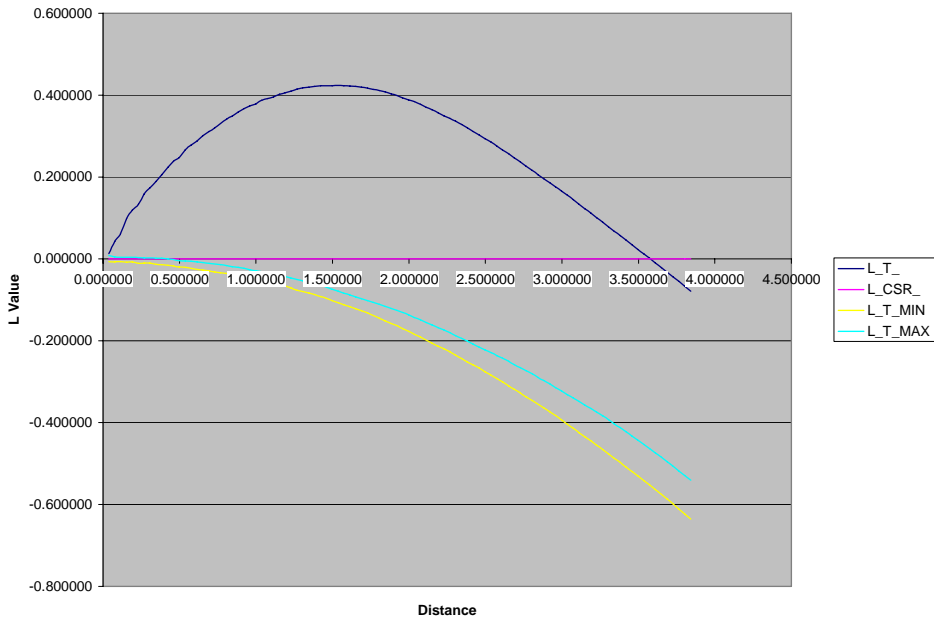


The results of Ripley's K document clustering as the dominant spatial pattern for all trajectory groups and at scales up to 10 miles.  This relationship was significantly different than what would be expected under CSR.  Thus, the answer to the first research question was that the pattern of trajectory groups was clustered rather than random or dispersed.  This also meant that at least some of the processes that were behind a street block's juvenile crime patterns over time were local ones.

Spatial Autocorrelation Among Trajectory Groups

As explained earlier, the use of local measures of spatial autocorrelation such as the Univariate LISA enabled the measurement of the extent to which street blocks of a single trajectory group were near other members of the same group or isolated. This was accomplished by identifying four different types of positive and negative spatial autocorrelation.  Because of the limited dependent variable, group membership, each of the patterns of the four trajectory groups needed to be analyzed

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separately. For example, when decreasing trajectory blocks were the focus, all the decreasing blocks were coded as "1" and all street blocks of other trajectories were coded as "0" (i.e. other). To continue the example, there are four potential outcomes of the analysis. Under an analysis of the decreasing trajectory group positive spatial autocorrelation would refer to: 1) the tendency of decreasing blocks to be near other decreasing blocks (dark red) and 2) the tendency of 'other' street blocks to be spatially proximal to one another (dark blue). Negative spatial autocorrelation would occur in the following two situations: 1) where other trajectory blocks were associated with the presence of decreasing trajectory blocks (light blue) and 2) where decreasing trajectory blocks were associated with the presence of other trajectory blocks (light red).

Maps 12 – 15 depict the results of the Univariate LISA. Only those street blocks with significant differences ($p < .05$) were drawn on the map. Looking first at the stable trajectory street blocks, there were large sections of Seattle that had concentrations of stable blocks (i.e. dark red dots) (Map 12). Most of these areas were in the northern section of the city but there were also large clusters in the southeastern portion of the city. In addition, there were large clusters of 'Other-Other' positive spatial autocorrelation in both those areas. Another striking feature of the distribution was the amount of negative spatial autocorrelation present. There were many 'Stable-Other' block groupings, which were often interspersed in the large clusters of 'Other-Other' trajectory block groupings located in the downtown area and in the southern half of Seattle. In addition, there were instances of 'Other-Stable' negative correlations spread throughout the city, although far fewer of them.

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Map 12:  LISA – Stable Trajectory Blocks



Univariate LISA for Stable
Trajectory Blocks
Seattle, Washington

There were 24,866 street blocks
classified as stable during the
study period of 1989-2002.

Legend

Univariate LISA for Stable Blocks

◆  Stable-Stable
◆  Other-Other
◇  Other-Stable
◇  Stable-Other

0    0.5    1
Miles

Source:  All base files were obtained from Seattle GIS.
Crime data was supplied by the Seattle Police
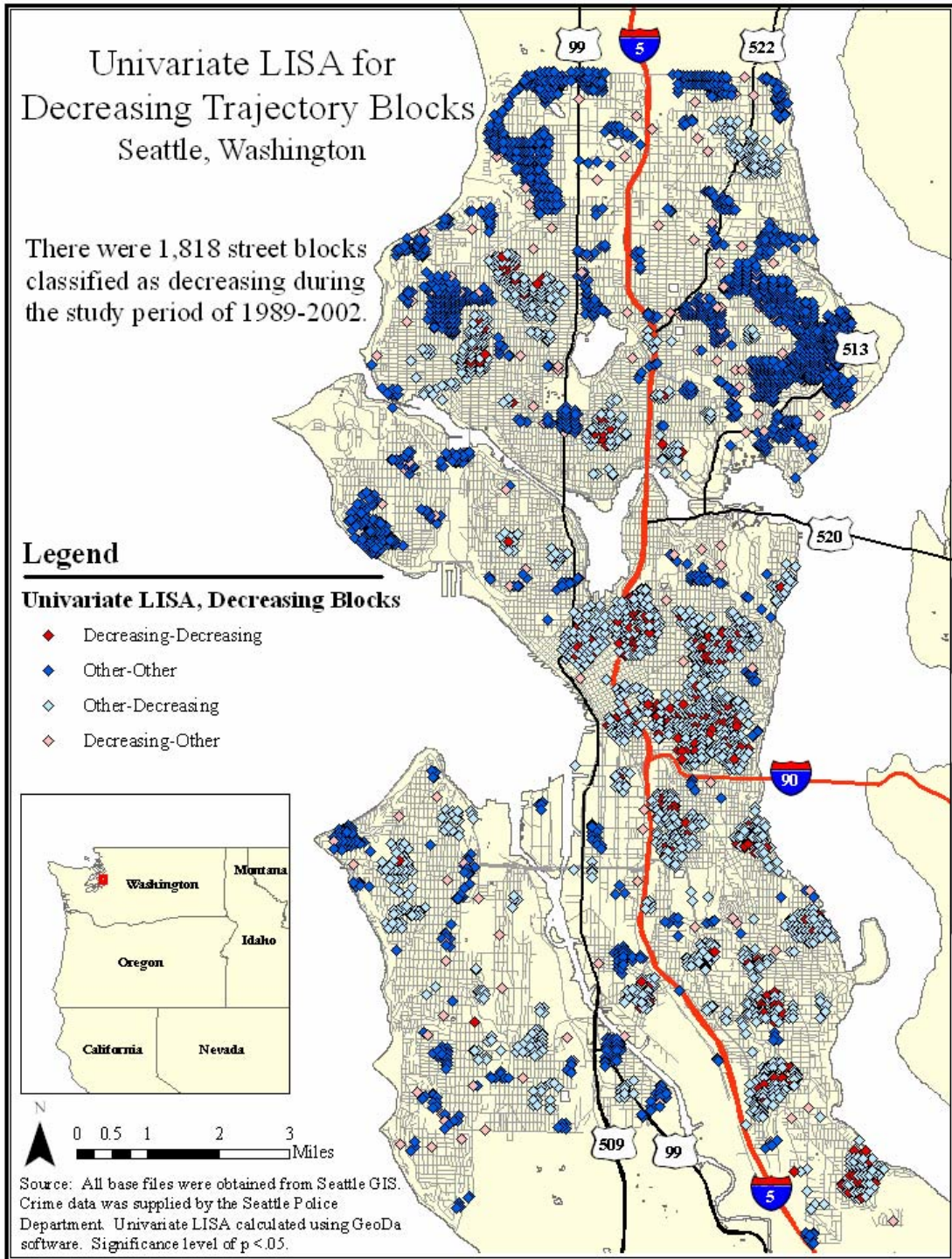Department.  Univariate LISA calculated using GeoDa
software.  Significance level of p < .05.

Spatial autocorrelation for the distribution of decreasing trajectory street blocks looked very different from the distribution of stable trajectory street blocks (Map 13). There were far fewer decreasing segments with positive spatial autocorrelation among decreasing streets. More of the positive spatial autocorrelation in the distribution was among 'Other-Other' streets and tended to be in the northern part of Seattle. There were also many smaller pockets all over the city where negative spatial autocorrelation was dominant.

The pattern for increasing streets was different from that observed for decreasing streets (Map 14). While both had a concentration of negative and positive correlation in the downtown area, the increasing streets continued that concentration southeastward and formed a large area in the southwest section of the city. In the same area, the decreasing streets had a series of smaller, more discrete pockets of street blocks displaying both negative and positive autocorrelation.

Map 13:  LISA – Decreasing Trajectory Blocks



Univariate LISA for
Decreasing Trajectory Blocks
Seattle, Washington

There were 1,818 street blocks
classified as decreasing during
the study period of 1989-2002.

Legend
Univariate LISA, Decreasing Blocks
◆  Decreasing-Decreasing
◆  Other-Other
◇  Other-Decreasing
◇  Decreasing-Other

Source:  All base files were obtained from Seattle GIS.
Crime data was supplied by the Seattle Police
Department.  Univariate LISA calculated using GeoDa
software.  Significance level of p < .05.

Map 14: LISA – Increasing Trajectory Blocks



Univariate LISA for
Increasing Trajectory Blocks
Seattle, Washington

There were 974 street blocks
classified as increasing during
the study period of 1989-2002.

Legend

**Univariate LISA, Increasing Blocks**

◆ Increasing-Increasing
◆ Other-Other
◇ Other-Increasing
◇ Increasing-Other

Source: All base files were obtained from Seattle GIS.
Crime data was supplied by the Seattle Police
Department. Univariate LISA calculated using GeoDa
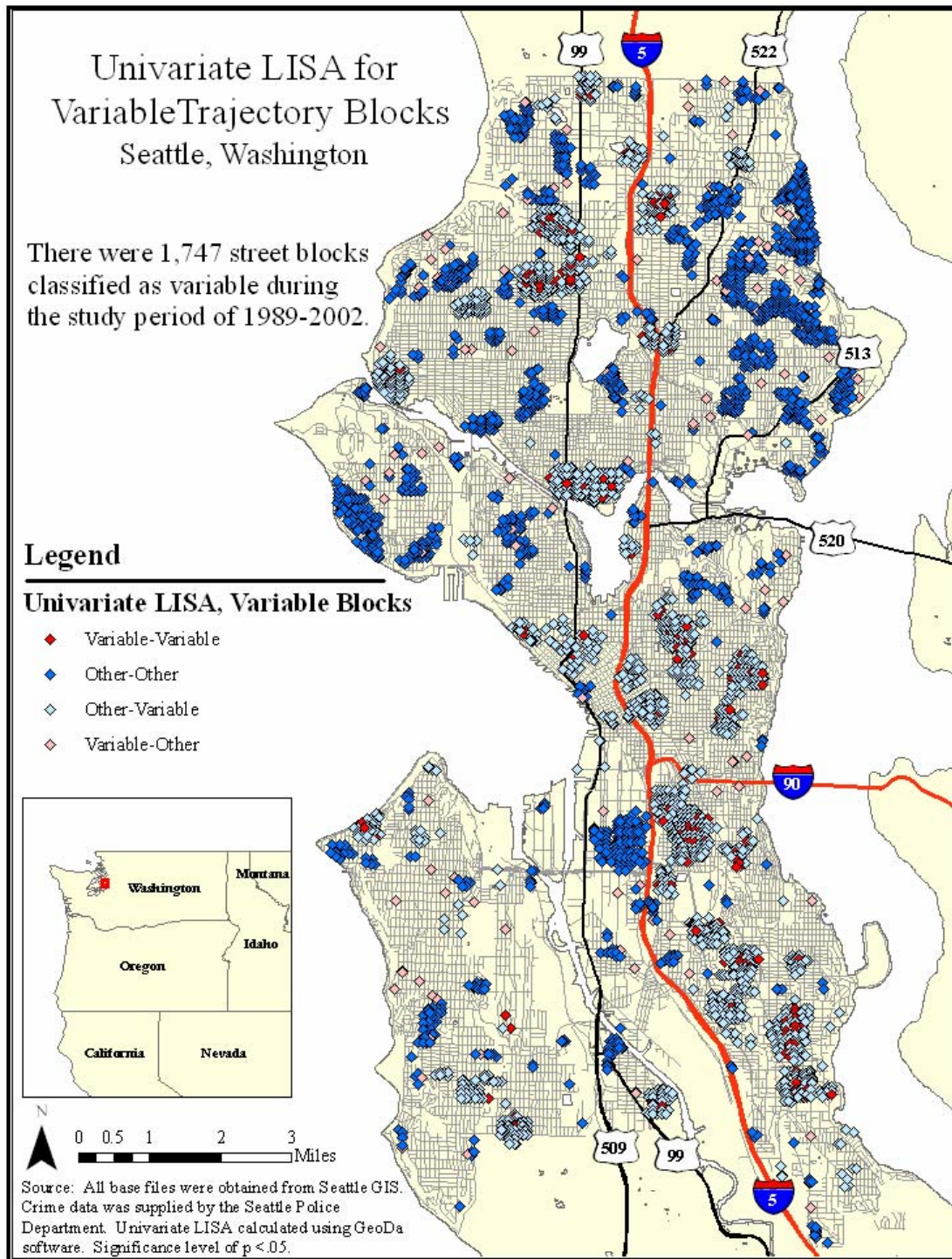software. Significance level of p < .05.

Variable street blocks followed the same general pattern of both positive and negative autocorrelation as the other types of trajectories, but displayed some differences from the other types of trajectories (Map 15). Their pattern was unique in that it had the smallest concentration of significant blocks in the downtown area. Similar to the increasing and decreasing trajectory patterns, there was quite a bit of both positive ('Variable-Variable') and negative correlation ('Other-Variable') in the section of the city bounded by I-90 and I-5. Overall, variable street blocks were spread throughout the city with distinct, spatially compact clusters of significant spatial autocorrelation.

While the specifics of the patterns were difficult to describe because of their complexity, the degree of negative spatial autocorrelation in the distribution offers strong evidence that there were localized processes operating at the street block level of analysis. The finding of both negative and positive autocorrelation in each of the patterns of trajectory groups indicated that the presence of street blocks of one type of trajectory was related to the presence of other trajectories. In some cases, the block was located among blocks of the same trajectory. These cases pointed to a process affecting the nearby blocks in the same direction. In other cases, a block was surrounded by blocks of other trajectories. These cases identified an anomaly where the local process was affecting on block differently then the rest. However, this analysis did not enable the specific trajectory group relationships to be identified. For example, the question were decreasing trajectory blocks found near variable blocks could not be answered without the use of the cross K function described in the next section.

The uniqueness of the patterns revealed by the analysis deserves recognition. It is especially unusual to observe negative spatial autocorrelation in distribution describing human-related processes (Fotheringham, Brundson, and Charlton 2000). Typically, human-related processes reflect positive, not negative spatial autocorrelation. Using the street block level of analysis was the only way to discover these interesting processes because higher levels of aggregation would have masked these potentially important variations.

**Map 15: LISA – Variable Trajectory Blocks**



Univariate LISA for
VariableTrajectory Blocks
Seattle, Washington

There were 1,747 street blocks
classified as variable during
the study period of 1989-2002.

Legend

Univariate LISA, Variable Blocks

◆ Variable-Variable
◆ Other-Other
◇ Other-Variable
◇ Variable-Other

Source: All base files were obtained from Seattle GIS.
Crime data was supplied by the Seattle Police
Department. Univariate LISA calculated using GeoDa
software. Significance level of p < .05.

Which Trajectory Groups Tend to Interact?

The use of a cross or bivariate K function can reveal whether two patterns were independent of one another. As described thy Rowlingson and Diggle (1993) and applied here, the bivariate K function expresses the expected number of street blocks of a particular trajectory (e.g. decreasing) within a distance (s) of an arbitrary point of a second type of street block (e.g. increasing), divided by the overall density of increasing street blocks. This information was directly related to the second research question: Are trajectories of street blocks related to the trajectories of nearby blocks? The advantage to this technique over the previous ones is that two point patterns can be compared directly.

Following the simulation approach used with both nearest neighbor and Ripley's K, simulation was used to test whether two patterns were independent. This was accomplished by using a series of random toroidal shifts on one set of points and comparing the bivariate K function of the shifted points with another fixed set (Rowlingson and Diggle, 1993).[32] If the shifted pattern fell within the envelope of independence then the two patterns were independent of one another: there was no evidence of spatial interaction (i.e. attraction or dispersion). If the K value fell above the envelope, significant attraction existed at that distance.[33] If the K value line was below the envelope, significant dispersion was present between the two patterns. The x-axis (s) represents the distance in feet, and the y-axis the cross K value.

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[32] A toroidal shift provides a simulation of potential outcomes under the assumption of independence. This is accomplished by repeatedly and randomly shifting the locations for one type of street block and calculating the cross K function for that iteration. The outcomes are used to create test statistics in the form of an upper and lower envelope. One hundred iterations were used for each simulation.

[33] Since street blocks are stationary, attraction in this context refers to a tendency for street blocks of one trajectory to be found in closer proximity to street blocks of another trajectory than would be expected under independence: their patterns are similar.

Figures 9 – 14 depict the results of the cross K function with simulation envelopes for each of the trajectory group comparisons. Figure 8 contains the results of comparing stable trajectory block locations to decreasing trajectory block locations. Since K(i,j) was above the line of independence, the two types of street blocks were not independent but rather have a slight attraction between the distances of about one mile and seven miles. However, since the K(i,j) line is within the confidence envelope the relationship was not significant. Interestingly, the K(i,j) line was right on the upper bound of the simulation envelope between one and two miles, indicating that at those distances the attraction between the two types of locations was just barely not significant. At all other distances the cross K statistic for stable and decreasing locations were inside the simulation envelope which, as stated previously, indicated that the distances were not significantly different from independence.

The relationship between stable street blocks and increasing street blocks was also one of attraction between one and seven miles with the cross K statistic on the upper bound between one and two miles but this relationship was not significant either (Figure 9). At all other distances, the locations of stable street blocks and increasing street blocks were independent. Finally, stable street blocks and variable street blocks also had a slight attraction essentially identical to that of decreasing street blocks but the distance at which the cross K was on the upper bound was longer, from one to three miles (Figure 10). At all other distances the locations of stable and variable street blocks were independent. But again the relationship was not significant so there was no significant spatial interaction between stable trajectory blocks and variable trajectory blocks: they are independent.

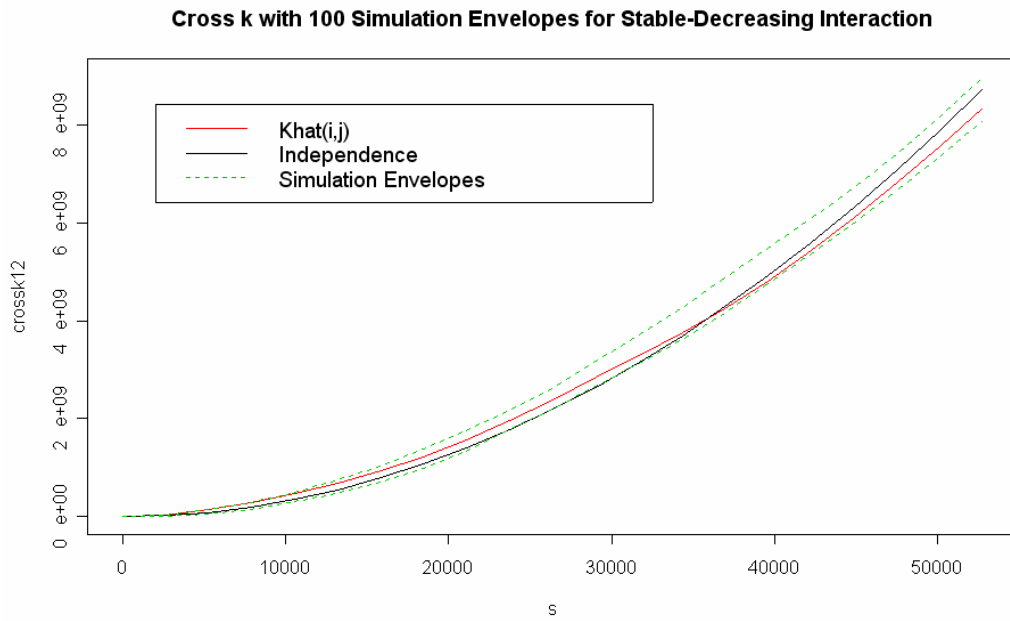Figure 8: Cross K with Simulation for Stable vs. Decreasing Blocks



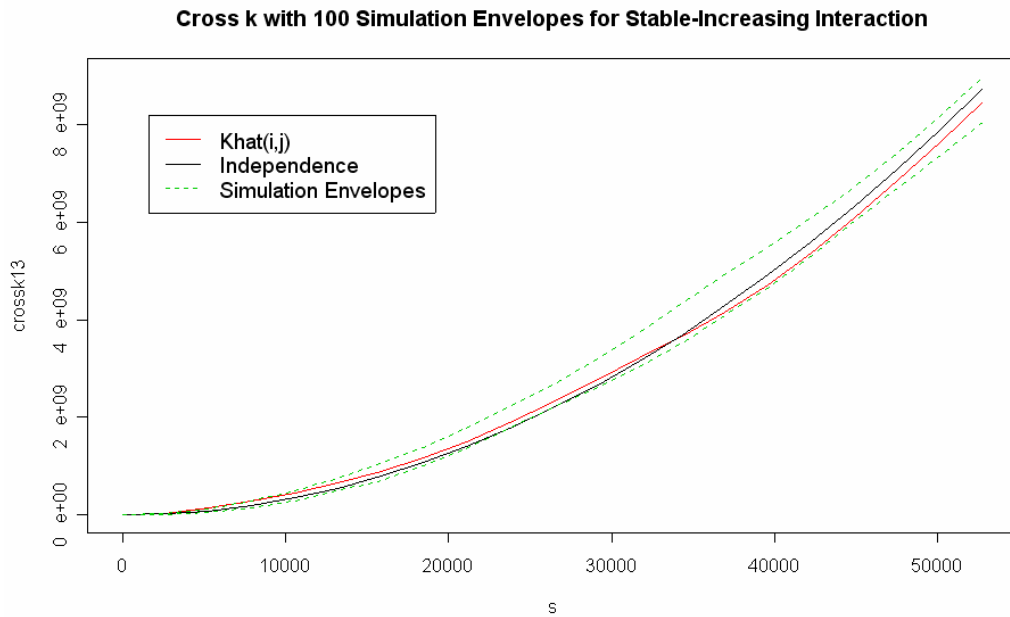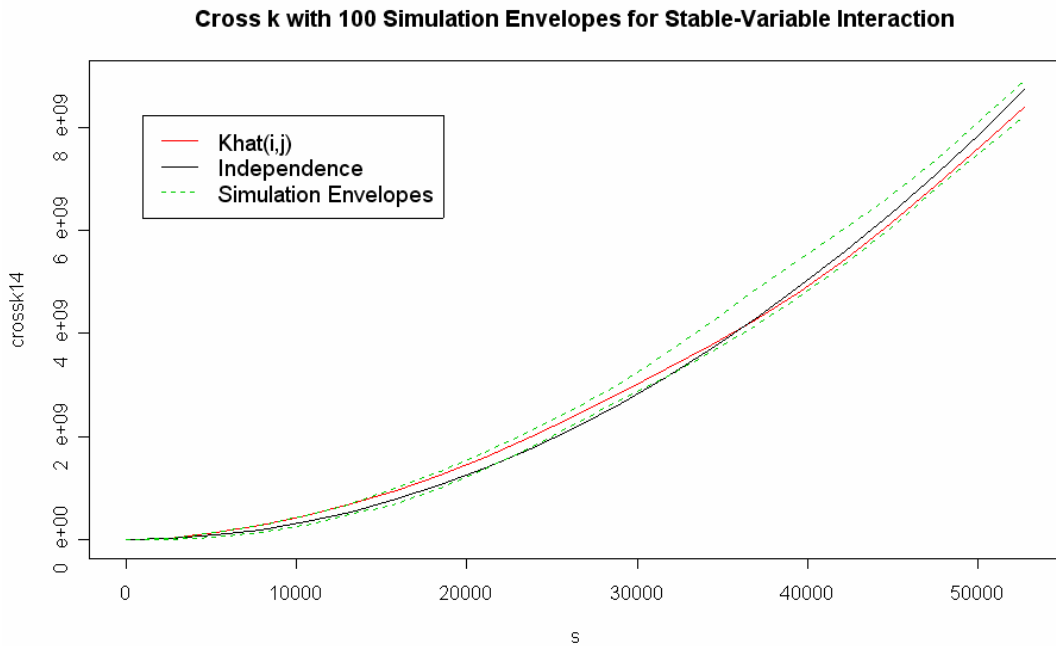Figure 9:  Cross K with Simulation for Stable vs. Increasing Blocks

Figure 10: Cross K with Simulation for Stable vs. Variable Blocks



Cross k with 100 Simulation Envelopes for Stable-Variable Interaction

The cross k function for the relationship between decreasing street blocks and increasing street blocks showed the two types of street blocks were closer than would be expected under an assumption of independence (Figure 11). In addition, the graph illustrates that the process driving the pattern was operating between about a quarter-mile and nine miles. However, the difference was only significant between about a quarter of a mile and just over two miles. As noted in earlier comparisons, there were sections where the cross k function followed the upper bound of significance, once to about three miles and then again between six and seven miles. Since the Khat(i,j) was slightly outside the envelope of independence at shorter distances, this demonstrates that the patterns of decreasing and increasing trajectory street blocks were not independent at distances of up to about two miles but were independent at larger distances.

Figure 11: Cross K with Simulation for Decreasing vs. Increasing Blocks



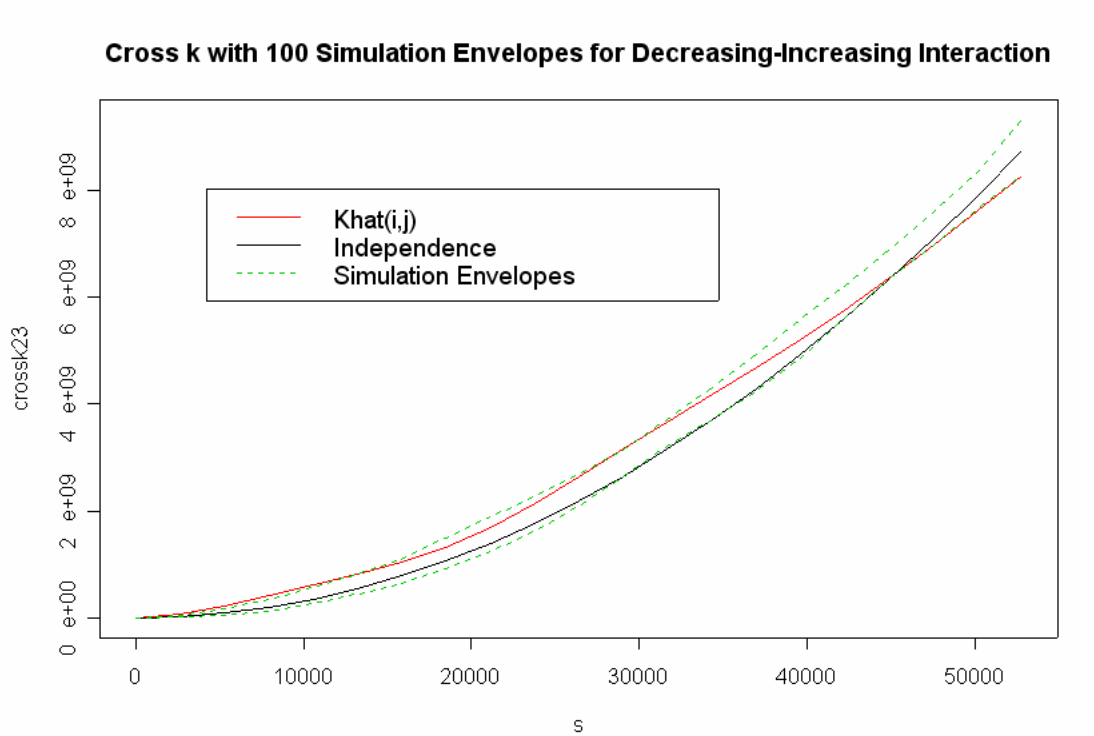**Cross k with 100 Simulation Envelopes for Decreasing-Increasing Interaction**

Figure 12 contains the cross K function for decreasing street blocks as compared to variable street blocks. An attraction existed between the two types of street blocks between the distances from about three quarters of a mile and to just under nine miles. However, as with the relationship between decreasing and increasing street blocks, the attraction was only significant at distances of just under a mile to just over two miles. It is worth noting, however, that the cross K values followed the upper bound of significance under one mile, between two and three miles, and again at just under six to just under seven miles. Thus, the two patterns are barely independent at those distances. At all other distances the locations were clearly independent.

Figure 12: Cross K with Simulation for Decreasing vs. Variable Blocks
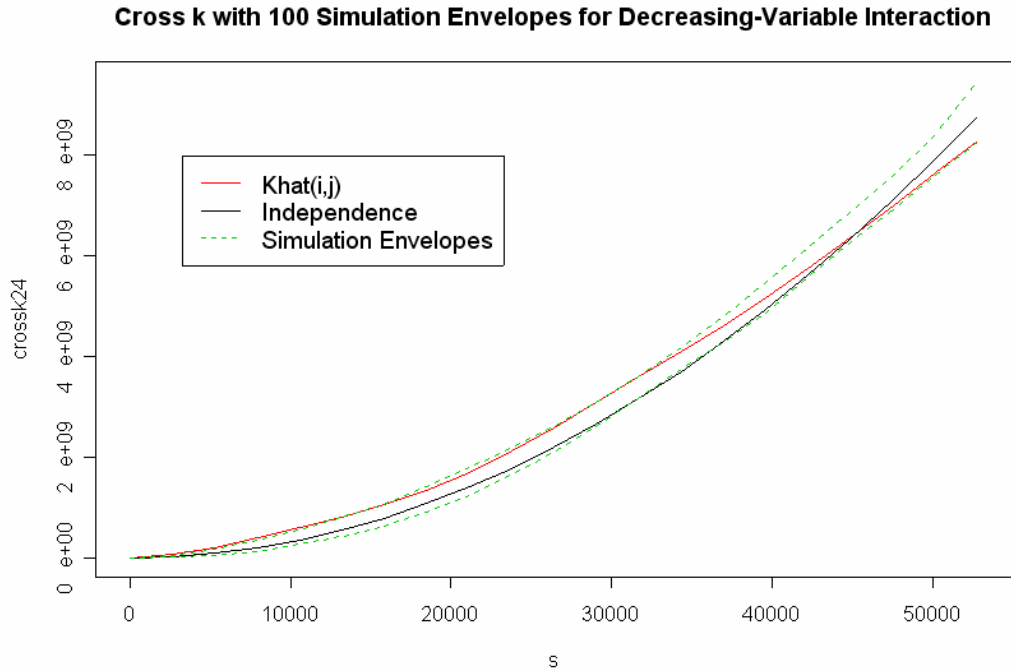


The final comparison was between increasing street blocks and variable street blocks (Figure 13). Once again the cross K indicated attraction between two patterns but the distances this time were from just under one mile to just over eight miles. The simulation results however, show the cross K line followed the upper bound of significance until about three and a half miles and then departed to independence. However, those results were not significant so the pattern of increasing street blocks was independent of the pattern of variable street blocks.

Figure 13: Cross K with Simulation for Increasing vs. Variable Blocks
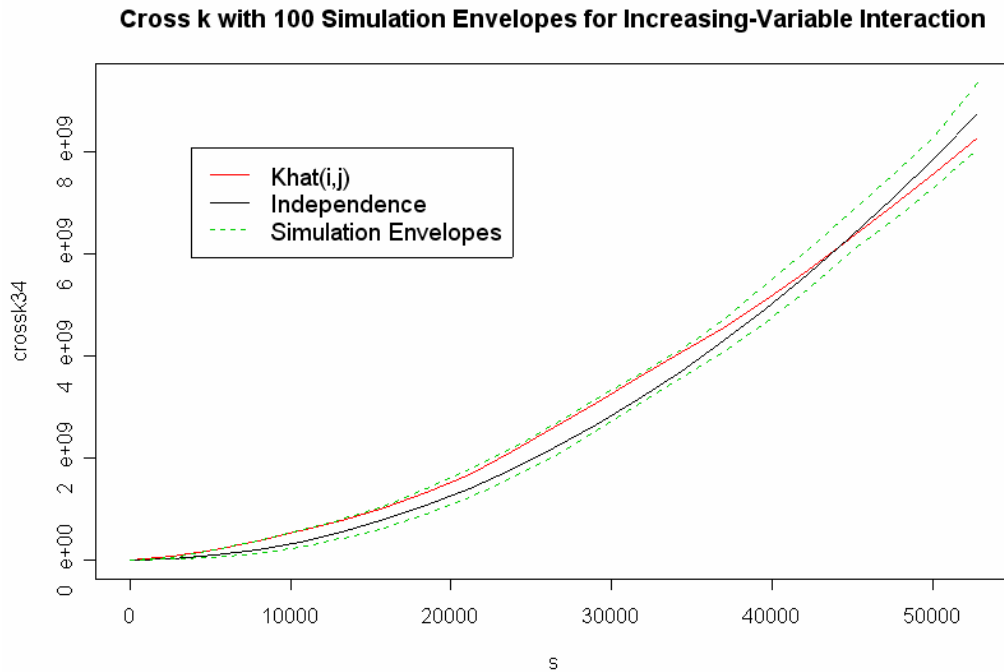


Altogether, the results of the cross K function with simulation indicated that while most group comparisons indicate attraction, the relationship was not consistently significant.  One borderline instance was in the case of the locations of increasing blocks compared to variable street blocks where the relationship was right 'on the line' of significance.  Two exceptions to the general results were the relationships between decreasing and increasing and decreasing and variable locations.  Decreasing and increasing street block locations were dependent from a quarter of a mile to just over two miles and decreasing and variable blocks were significantly dependent from just under one mile to just over two miles.  This suggests that some common underlying process or processes existed among street blocks of those groups at distances between just under one and two miles overall.

Lack of data describing the characteristics of the street blocks made it difficult to identify the specific processes at work. What was clear from the analysis was that the patterns of blocks in different trajectories were, for the most part independent of each other. There were different processes underlying most but not all of the trajectories. So in terms of the second research question asking were the trajectory groups of street blocks related to nearby street blocks, the answer was a qualified yes, but only for specific groups. Only decreasing trajectory block groups were related to the patterns of both increasing and variable trajectory blocks and then only at shorter distances. One potential explanation for this result lies in the temporal pattern of the trajectories themselves. Crime rates for the decreasing trajectories and the variable trajectories were both going down near the end of the study period but the increasing trajectories were experiencing rising crime levels. Since the effects are very local (i.e., approximately one to two miles), a shift in the location of a popular youth hangout could be the source of the change. For example, if juveniles were hanging out in a park adjacent to a school but then a 24-hour fast food restaurant opened up about a mile away. Food and drink are big attractors for juveniles so the group decides to move to block with the fast food restaurant. The original block experiences a decrease in crime and the new block undergoes an increase in crime both from the same 'process', a new fast food restaurant opening.

# Chapter 5:  Discussion

Place-based research has demonstrated the utility of examining places and contexts as well as individuals to developing a multi-dimensional conception of criminal events.  Recent efforts by Weisburd and others have pointed toward micro-level places such as street blocks as important in understanding changes in crime rates.  Specifically, Weisburd, Groff and Morris' (In Progress) current work examines the use of trajectory analysis to identify types of places that experience similar 'juvenile crime trajectories' over time.  Using this method, they were able to identify that the criminal careers of street blocks fell into four major types, stable, decreasing, increasing and variable over the study period.  Their results showed that crime increases and decreases at more macro levels of analysis (e.g. city, county, state and nation) were being driven by heterogeneous changes at the street block level.  In addition, their findings provided the first evidence that a particular set of juvenile crime places were contributing more to the drop in juvenile crime than all others.  However, the researchers did not conduct a systematic, in-depth investigation of the geographic distribution and thus could not comment on the spatial processes that might underlie the tabular results.

This research provided a more comprehensive examination of the geography of juvenile crime place trajectories.  The two research questions explored were: What is the spatial pattern of street blocks that follow specific trajectories of juvenile crime? and 2) Are trajectories of street blocks related to the trajectories of nearby blocks?  The ultimate goal of this research was to illuminate whether examining

spatio-temporal patterns at a very micro-level could improve our understanding of changes in crime rates observed at larger levels of aggregation, most specifically the crime drop of the early 1990s. The use of a micro-level, geographic approach in the study was essential for three reasons. First, examining the spatial distribution enabled the first quantitative description of the spatial distribution of juvenile crime trajectory groups. For example, were all the decreasing trajectory street blocks in one part of Seattle or were they spread throughout? Second, the micro-level provided a fine-grained description of the spatial distribution of trajectories to explore whether street blocks of certain trajectories tend to be located near one another. Third, the approach enabled the identification and description of underlying processes that may be important in driving macro-level patterns but that are lost to studies at the neighborhood-level of analysis.

*Geographic Distribution of Trajectories*

Both the point maps and the kernel density maps illustrated that the street blocks in each trajectory group tend to be spread out over much of Seattle. The consistently large spatial extent of each of the trajectory groups demonstrated that the same temporal patterns appeared all over the city. The maps also indicated the existence of visual clustering among street blocks within the same trajectory. However, when the different trajectory assignments were symbolized as points and drawn on the same map, extensive intermingling among street blocks of different trajectories was apparent.

A simple visual inspection of the locations of trajectory groups yielded two findings. First, blocks belonging to each temporal trajectory were found all over

Seattle.  The large spatial extent of each of the temporal trajectories points toward the existence of global/societal factors.  Variation of these factors over time may produce city-wide effects, albeit at different strengths.  Three of the most often mentioned factors in urban areas include: 1) appearance of crack cocaine; 2) increase in hand gun use and 3) employment opportunities (Blumstein and Wallman 2000a).  Second, a high degree of spatial variety was discovered in the temporal trajectory group patterns.  In many cases, adjacent blocks had different and sometimes opposite temporal trends.  This observation fits closely with the conception of street blocks as 'behavior settings' in and of themselves, even though they are situated within a larger social unit such as a neighborhood (Jacobs 1961; Taylor 1997a; Taylor 1997b).

In addition, both routine activity theory (Cohen and Felson 1979; Felson 1987) and the environmental criminology perspective (Brantingham and Brantingham 1991 [1981]) hold that the convergence of motivated offenders and suitable targets in the absence of guardians and at a particular places are the necessary elements for a crime to occur.  Time/space convergence is driven by the characteristics of the place and the routine activity structure of the population.  In addition, the occurrence of a crime event is contextually driven.  Given the situationally dependent nature of crime, the finding of block by block variation in crime is consistent with opportunity theories of crime.

The visual evidence for clustering was reinforced by both global and local spatial statistical techniques using distance and spatial autocorrelation.  Both the nearest neighbor analysis and the Ripley's K analysis supported the existence of clustering as compared to complete spatial randomness.  Importantly, the Ripley's K

provided evidence for clustering at all distances up to ten miles.  Consequently, and in concurrence with the literature documenting the concentration of crime, this finding suggests that places with similar juvenile crime careers tend to be closer to one another than would be expected by random.

The exploration of local spatial autocorrelation revealed significant positive and negative spatial autocorrelation when each trajectory group of street blocks was compared to all others.  Each of the trajectories had different patterns of spatial autocorrelation results.  Also for each trajectory, there were instances where street blocks of the same trajectory type were located in statistically significant clusters.  In addition, there were areas of clustering among street blocks of all other trajectory types.  Perhaps even more interesting were the street blocks exhibiting negative spatial autocorrelation (i.e. they were significantly different from their neighbors).  This result reinforced the block by block differences in trajectory group that were revealed in the composite point map and points toward the validity of place-based theories.  The finding of no global spatial autocorrelation remains without a clear explanation although the small ratio of other trajectories in relation to stable trajectories is probably at the root of it.

### *Summary of Spatial Interaction Among Trajectories*

The second major question investigated here concerned whether certain trajectories interacted with one another.  This was determined by using a cross k function to compare sets of trajectory street blocks (e.g. increasing with stable).  The resulting analysis specified whether the patterns of the street blocks of one type of trajectory were independent from the pattern of street blocks of another trajectory.

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Each pair of trajectory groups examined (e.g. increasing vs. decreasing, stable vs. variable etc.) evidenced attraction rather than repulsion. However, only two of the paired relationships were significant.

Both of the significant relationships involved the decreasing trajectory group. Decreasing street blocks and increasing trajectory street blocks, exhibited spatial interaction at distances of about a quarter of a mile to just over two miles. Decreasing and variable trajectory groups were not independent from just under a mile to a little over two miles. This meant that at shorter distances the same processes that were acting on decreasing trajectory blocks were most likely acting on variable and increasing blocks also. It is worth noting that street blocks part of changing trajectories were spatially independent of stable trajectory blocks. Thus, it is likely that the spatial processes underlying the temporal patterns captured in trajectory analysis are different between stable and all other types of street blocks.

These findings reflect what is known about crime at places and travel behavior of people in general and offender behavior in particular. Previous studies have demonstrated that individuals tend to take the shortest, most convenient route between places (Felson 1987). Research on intervening opportunities has shown that in most instances where two choices are roughly equal people will stop at the first opportunity (Golledge and Stimson 1997). Thus most trips are shorter rather than longer. Studies on offender behavior, both juvenile and adult, have indicated that the average crime trip is short, although there are differences by type of crime (Capone and Nichols 1976; Costanzo, Halperin, and Gale 1986; Groff and McEwen 2005b; McIver 1981; Rengert, Piquero, and Jones 1999). Crime trips undertaken by

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juveniles tend to be especially short (Turner 1969a). These empirical results provide clues to the processes that might underlie the finding that the pattern of decreasing street blocks is not independent of variable and increasing trajectory street blocks at short distances.

In addition, there is a structure to the impacts of characteristics of both the built and social environment. For example, blocks encompassing a major road are more accessible than those with a neighborhood road. Given the tendency for people to take the most convenient route, blocks with major roads are more likely to be part of a greater number of activity spaces than are neighborhood street blocks. Since roads are linear, the street blocks involved will also have a linear pattern of end-to-end adjacency. However, these blocks may be very different from the street blocks only one block over on either side. In the same way, both the street block with a major crime attracting facility and the blocks along the route to that facility are more likely to be known to potential offenders than other street blocks and are thus at higher risk for crime. Social characteristics such as number of offenders residing nearby are also important considering the short length of the average crime trip. If many offenders live near a street block (not necessarily on it) all street blocks nearby are at greater risk, with the absolute increase in risk varying by other characteristics including accessibility. Accordingly, future research to understand what processes that may be at work will need to include place characteristics in the analysis.

*Geography and the Crime Drop*

The results of this study represent yet another incremental bit of progress in the search for a better understanding of the crime drop. The disaggregation of the

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crime drop by age, race and sex has yielded a more specific view of exactly who was driving the crime drop of the 1990s (Blumstein and Wallman 2000a; Cook and Laub 2002; McCord, Widom, and Crowell 2001). These studies pointed toward criminal activity by juveniles as an important factor. Accordingly, this study examined the crime committed by juveniles during a study period roughly comparable to the crime drop years.

In the same way, disaggregating geography to the street block unit of analysis provided more precise information about the spatio-temporal character of juvenile crime. This study provided the first exploration of the spatial distribution of trajectories of juvenile crime. Most important to the crime drop, the study identified the spatial locations and analyzed the spatial relationships of the 1,818 street blocks that drove the crime drop in Seattle. The locations of those street blocks were quantitatively different from the locations of stable street blocks. This means that the processes at work in the blocks with decreasing crime were different than those for blocks with stable crime. This new knowledge regarding the spatio-temporal structure of the crime drop in Seattle provides the basis for both further research and practitioner intervention. It also provides further evidence for Smith et al.'s (2000) contention that street blocks are important to understanding the onset, persistence and desistance continuance in the criminal careers of places.

The results of the research documented here provide promising evidence that the spatio-temporal structure of crime changes is variable at the street block level of analysis. However, the current study was unable to address the specific characteristics of street blocks that are causing the observed patterns. As Weisburd et

al (2004) noted, an in-depth examination of place characteristics is essential to understanding the processes behind the patterns observed here.

Fortunately, a broad theoretical and empirical body of evidence exists to guide the collection of attributes that may be important to juvenile crime. Taken together, opportunity theories and the results of empirical research on place characteristics and crime provide a broad range of specific attributes that may be important to understanding how changes in crime rates evolve. These sources could be drawn upon to incorporate the characteristics of the urban environment into future work.

In addition to the consideration of place characteristics, future studies should also explore the use of alternative methods that simultaneously incorporate space and time in the analysis. One example of such a technique is Markov chains. Markov chains take into account both the spatial and temporal attributes of set of places that consist of two or more subsets that are behaving differently. While more work remains to be done, the practical significance of the current findings is discussed next.

*Implications for Practice*

The study's results have immediate potential to assist police practice. Many of the current policing strategies require identifying and understanding problems. Any and all of these policing strategies would be strengthened by better information on *where* to concentrate police efforts. Street blocks represent discrete 'places' that are consistent with the language of policing, in that law enforcement officers tend to communicate in 'hundred blocks' (i.e. street blocks). Thus, these units have immediate relevance to law enforcement officers and the results of studies that use street blocks will be immediately understandable to them. In addition, street blocks

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are both small enough to see an immediate impact from prevention and enforcement efforts and large enough to provide an aggregate effect toward changing their immediate context. Finally, the power of spatial analysis and display cannot be overstated. Tabular data describing crime does not convey how those addresses might be related to one another on the ground.

One concrete way in which these findings could be used by law enforcement is to identify those street blocks in their city that are following increasing trajectories. In the case of Seattle, there were 974 increasing street blocks that are spread throughout the city. This type of analysis provides important information on where those street blocks are located and how they relate to one another. Of those 974, less than 200 street blocks were part of the highest groups averaging almost two crimes per year. Alternatively, officers could focus on the 80 street blocks that decreased over the study period but represented streets with the highest level of juvenile crime, averaging about 10 crimes per year. These street blocks have the best potential for providing the highest reduction in juvenile crimes per street block.

The aspatial identification of places that exhibit similar juvenile crime trajectories over time by Weisburd et al (In progress) was the first step in providing more empirically-based evidence for deployment of police and community resources. Achieving a better understanding of the geography of particular trajectories advances the effort and makes the results more actionable for police. Collecting information on the characteristics of street blocks over time is the next logical step and will contribute contextual information in which to situate crime information.

*Conclusions*

This study examined the spatial distribution of the 'criminal careers' of street blocks. By examining the spatial distribution of street blocks in particular trajectory groups, it was discovered that members of trajectory groups were distributed across most of the city, rather than being clustered in just one or two neighborhoods. This result indicated the influence of global processes on juvenile crime. Local processes were also at work as evidenced by the findings that: 1) street blocks were likely to be spatially proximal to another street block of the same trajectory type and 2) street blocks of differing types were often adjacent to one another. Finally, at distances under a mile to about two miles, decreasing trajectory blocks tend to be near increasing and variable trajectory street blocks. This could reflect some characteristic of these types of street blocks (as opposed to stable group members) that makes them susceptible to changes in juvenile crime. Sometimes those changes are upward, sometimes downward and sometime variable but all share a tendency toward change rather than stability.

This research has discovered that there is significant micro-level variation in the distribution of temporal trajectories and given every indication that there may be micro-level processes at work that are affecting the spatial patterns of those trajectories. However, it is just the first step to identifying those processes more specifically. The next steps involve collecting more data and utilizing additional methods. Collecting data on street block characteristics will allow the identification of common characteristics that are shared within trajectories and how changes in those characteristics might influence the future juvenile crime trajectories of places.

The exploration of additional statistical techniques will provide new sources of information regarding the spatio-temporal variation in crime at street blocks and the processes underlying it.

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