Mapping the Spatial Influence of Crime Correlates: A Comparison of Operationalization Schemes and Implications for Crime Analysis and Criminal Justice Practice

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Abstract

Decades of criminological research have identified a variety of independent variables that correlate significantly with particular crime outcomes. Less is understood about how these correlates, or factors, of crime can be operationalized to maps in ways that best represent their spatial influences on the emergence of nearby crime events. A geographic information system (GIS) enables the exploration of spatial influence, which refers to the way in which features of a landscape affect places throughout the landscape. For example, empirical knowledge that bars correlate with locations of violent crimes can be mapped in several ways to show more or less crime-prone places, such as places with bars, places within certain distances from bars, or places with higher concentrations of bars. Rather than just a feature's presence, its influence on space is important because context affects criminal behavior. GIS enables analysts to move beyond just creating maps of points that coexist with crime to creating visual narratives of how settings become conducive to crime. With growing use of spatial risk assessments and predictive modeling in the criminal justice community, operationalizing crime correlates to geographic units across a landscape is an important task that requires careful consideration. This article presents (1) a detailed discussion of the theoretical framework relevant to risk analysis and spatial influence and (2) three primary methods for operationalizing criminogenic features to a geographic map. One of these maps is included in a risk terrain model (RTM) along with three other spatially operationalized maps of different criminogenic features to produce a composite map of criminogenic

Abstract (continued)

contexts for shootings in Irvington, New Jersey. The RTM is then deconstructed to show how each spatially operationalized map layer adds to the overall predictive validity. Finally, the article demonstrates how producing an RTM of theoretically grounded operationalizations of spatial influence from many risk factors can be used as a control measure of environmental context when evaluating the spatial effect of place-based interventions on future crime events. Tending to the detail of mapping the spatial influence of crime correlates is particularly important and necessary for maximizing the reliability and validity of assessments of the likelihood of crime to occur at certain places within a study area.

Introduction

Imagine an unfamiliar visitor to an American city. As she stands on the sidewalk, she calls a local friend on the cell phone to meet; he asks where she is. No street signs are nearby. As she walks to the street corner to figure out the specifics of her location, she nonchalantly describes the area as the "bar district" to break the silence over the phone and in hopes that her friend knows where she is talking about. She is not in a bar and may not even be directly in front of a bar. Why, then, would she describe this part of the city as the bar district? The simple answer, perhaps, is because she observed a high concentration of bars within the area and defined that quality of the landscape to be a bar district. From a criminological perspective, bars and other liquor establishments are known to correlate with robberies (for example, Tilley et al., 2005; Wright and Decker, 1997). The person might be at even greater risk of being robbed if she is within one block from a bar (Smith, Frazee, and Davison, 2000) as opposed to farther away. Therefore, it could be argued with empirical support that she is at greater risk of robbery where she stands talking on the phone compared with other places in the city with a lower concentration of bars and she would not be near any of them. Kennedy and Van Brunschot (2009: 4) define risk as "a consideration of the probabilities of particular outcomes." In the previous example, the visitor's risk of robbery is not only a function of the criminogenic features (that is, bars) themselves, but also the distribution of those features throughout the landscape, her proximity to them, and the distal limits of the influences those features have—both individually and combined—on the attraction of potential offenders, suitable victims, and crime (Cohen and Felson, 1979).

Location matters when assessing the likelihood of crime because crimes cluster at certain locations (Eck et al., 2005; Harries, 1999; Ratcliffe, 2006; Sherman, 1995; Sherman, Gartin, and Buerger, 1989; Weisburd, 2008; Weisburd and Braga, 2006). Environmental characteristics of these locations influence and enable the seriousness and longevity of crime problems and ensuing "hotspots" (Mastrofski, Weisburd, and Braga, 2010; Sherman, 1995). Criminal activity concentrates at specific, select spots—a trend that is well supported by research and comports with the daily experiences of analysts in law enforcement agencies around the world. The identification of crime hotspots informs researchers where illegal behavior is clustered, however, not necessarily why it is clustered at a particular location. Understanding the spatial interaction effects of certain correlates, or factors, of crime is key to assessing and valuing criminogenic place-based risk (Caplan, Kennedy, and Miller, 2011; Weisburd, 2008).

For many decades, criminologists have identified factors at (or features of) places that help explain occurrences and distributions of criminal behavior and reported crime incidents. Yet, it is not the mere presence or absence of the factors that attracts or generates crime (Brantingham and Brantingham, 1995). It is the spatial influence of these criminogenic factors on their environments that enables motivated offenders and increases the likelihood of illegal activity at certain places. For example, as presented previously, the spatial influence of bars as a risk factor for robbery could be described as "being within a certain distance from a single bar heightens a person's risk of victimization"; or, "being at a place with a nearby high concentration of bars heightens a person's risk of victimization." Both of these situations could be true at the same time, or only one or neither, depending on the location within the city (Basta, Richmond, and Wiebe, 2010). Notice, though, that at the microlevel unit of "the place where a person is standing," the risk of being robbed could vary according to the spatial influences that bars have on the urban landscape.

With the growing use of spatial risk assessments and predictive analytics in the criminal justice community (Rubin, 2010; Weisburd, 2008; Weisburd et al., 2001), operationalizing the spatial influence of crime factors to geographic units throughout a landscape is an important task that requires special consideration and tools (Raines, Sawatzky, and Bonham-Carter, 2010; Tomlin, 1994). In particular, a geographic information system (GIS) enables analysts to create visual narratives of how environmental settings become conducive to crime. GIS enables the exploration of spatial influence, which refers to the way in which features of a landscape affect places throughout the landscape. This concept can apply to many types of environments, including small and large extents (for example, local or global) and rural, suburban, and urban areas. This article explores ways in which correlates of crime can be operationalized to maps, using GIS, to represent the correlates' effects on the environments in which the crimes occur. Tending to this detailed level of mapmaking is particularly important and necessary for maximizing the reliability and validity of assessments of the likelihood of crime to occur at certain places within a study area, and it is something that has been neglected in much of the work that attempts to make such assessments. Following an expanded discussion of the theoretical framework relevant to risk analysis and spatial influence, this article presents three primary methods for operationalizing criminogenic features to a geographic map: (1) presence of the features, (2) concentration of the features, and (3) distance from the features. One of these maps is included in a risk terrain model (RTM)—a framework that Caplan, Kennedy, and Miller (2011) proposed to assess spatial crime risks, along with three other spatially operationalized maps of different criminogenic features. After testing the predictive validity of the RTM for shootings in Irvington, New Jersey[1], the article presents the deconstruction of the model to show how each spatially operationalized map layer adds to the overall predictive validity—primarily because each individual operationalization of spatial influence is statistically valid by itself; when combined, they are more precise. Finally, the article shows how producing an RTM

[1] The New Jersey State Police provided shooting data through the Regional Operations Intelligence Center.

of theoretically grounded operationalizations of spatial influence from many risk factors yields a value of risk that can be used as a control measure of “environmental context” when evaluating the spatial effect of place-based interventions on future crime events.

Conceptual and Theoretical Framework: The Case for Operationalizing Spatial Influences

Routine activities—a popular theory in the criminal justice sciences—states that crime is likely to occur when motivated offenders converge, suitable targets exist, and capable guardians are lacking (Cohen and Felson, 1979). What is more likely to occur is that motivated offenders will commit crime against suitable targets at certain places according to the environmental characteristics of those places that make it easier to complete the crime successfully and reap the rewards without punishment (for example, not getting caught; Clarke and Felson, 1993). Routine activities theory is event focused. To apply the theory to practice, police need to focus on future events by anticipating and controlling the behavior of individuals no matter where they are or where they are traveling. This endeavor is very difficult. What is more manageable for police agencies is to allocate resources to places that are most attractive to motivated offenders and to places where crime is most likely to occur given certain environmental characteristics (Weisburd, 2008). These places have the greatest crime risk. In the long-standing debate in criminology concerning what promotes crime, it is not enough to say that crime risk increases when the number of criminals increases. What is more likely is that the crime risk at places that have criminogenic attributes is higher than at other places because these locations attract motivated offenders (or more likely concentrate them in close locations) and are conducive to allowing certain events to occur. This assessment is different from saying that crime concentrates at highly dense hotspots. It suggests, instead, that individuals at greater risk to commit crime will congregate at locations that are best suited for perpetrating it. This statement does not imply that more or better targets of crime exist (because there may be less to steal and fewer rewards from robbing individuals), but rather that the conditions for criminal behavior (for example, lower risk of apprehension or retaliation) are better at these places than at others.

Paul and Patricia Brantingham provided important conceptual tools for understanding relationships between places and crimes. They referred to the “environmental backcloth” that emerges from the confluence of routine activities and physical structures overlaying areas (Brantingham and Brantingham, 1981). This backcloth is dynamic and can be influenced by the forces of “crime attractors” and “crime generators” which contribute to the existence of crime hotspots (Brantingham and Brantingham, 1995). Attractors are those specific things that attract offenders to places to commit crime. Generators refer to the greater opportunities for crime that emerge from increased volume of interaction occurring at these areas. The concentration of crime at specific places or hotspots is consistent with the idea of an environmental backcloth, is well supported by research (for example, Eck, 2001; Eck et al., 2005; Harries, 1999; Sherman, Gartin, and Buerger, 1989), and comports with the daily findings of crime analysts in law enforcement agencies around the world (Weisburd, 2008). Crime hotspots indicate where behavior is clustered. Connecting criminal behavior to precursory environmental context is more challenging, but important for comprehensive crime analysis and forecasting efforts. As Abbott (1997: 1152) states about the central tenets of the human ecologists who were the first to systematically study crime in space, "the Chicago School thought that no social fact makes any sense abstracted from its context in social (and often geographic) space and social time. …Every social fact is situated, surrounded by other contextual facts and brought into being by a process relating it to past contexts." Ecologists ranging from Burgess (1928) to Shaw and McKay (1969) sought out ways to extract social indexes from data on communities for use in their explanations of crime occurrence and distribution.

Operationalizing the spatial influence of a crime factor tells a story about how that landscape feature affects behaviors and attracts or enables crime occurrence at places near to and far from the feature itself (Freundschuh and Egenhofer, 1997). When certain motivated offenders interact with suitable targets, the risk of crime and victimization conceivably increases. When motivated offenders interact with suitable targets at certain criminogenic places, however, the risk of criminal victimization is even higher. Similarly, when certain motivated offenders interact with suitable targets at places that are not conducive to crime, victimization risk is lowered. GIS can produce maps that visually articulate these environmental contexts in which certain crimes are more or less likely to occur as a result of the combined influence of one or more criminogenic features affecting the same place (Caplan, Kennedy, and Miller, 2011). In this way, criminal behavior is modeled as less deterministic and more functional of a dynamic interaction that occurs at specified places.

Risks of Crime at Places

Opportunities for crime are not equally distributed across places, or "small micro units of analysis" (Weisburd, 2008: 2), and so the analytical approach to studying criminogenic places plays a critical role in the reliability and validity of efforts to assess vulnerabilities and future crime hotspots. Opportunity theorists (for example, Cohen, Kluegel, and Land, 1981; Simon, 1975) have suggested that variations in crime are explained by opportunities to commit crime at locations that are accessible to the offender. Although well developed theoretically, research has been constrained in its ability to operationalize "opportunity" and to develop a metric for assessing it. Cohen and Felson (1979: 595) admitted that, although crime can be more easily facilitated if motivated offenders converge, suitable targets for victimization exist, and an absence of capable guardians occurs, "the risk of criminal victimization varies dramatically among the circumstances and locations in which people place themselves and their property." Cohen, Kluegel, and Land (1981) refashioned the routine activities theory, renaming it "opportunity" theory, to include concepts of exposure, proximity, guardianship, and target attractiveness as variables that increase victimization risk. A common thread among opportunity theorists and related scholarly thinkers is that the unit of analysis for "opportunity" is a place, and that the dynamic nature of that place constitutes opportunities for crime. For example, Eck (2001, 2002), Lee and Alshalan (2005), Mears, Scott, and Bhati (2007), Basta, Richmond, and Wiebe (2010), and Brantingham and Brantingham (1995) all directly state or imply the place-based nature of criminogenic opportunities. Crime control and prevention activities must consider not only who is involved in the criminal events, "but also the nature of the environments in which these activities take place" (Kennedy and Van Brunschot, 2009: 129) because opportunity for crime is an attribute of all places. As an attribute of places, opportunity is not an absolute value, a dichotomous variable, or a static quotient. It is rarely or never zero. Opportunity varies in degrees and changes over space and time as public perceptions about environments evolve, as new crimes occur, as police intervene, or as motivated offenders and suitable targets travel. Assessing spatial criminogenic opportunity requires a conceptual framework that is attuned to incorporating multiple dynamic factors and producing intelligence that serves strategic decisionmaking and tactical action. This intelligence production can be achieved through risk assessment.

Kennedy and Van Brunschot (2009: 4) define risk assessment as "a consideration of the probabilities of particular outcomes." The concept of risk is not new or unique to the criminal justice community (Andrews, 1989; Burgess, 1928; Glueck and Glueck, 1950; Gottfredson and Moriarty, 2006), and risk assessment has a long history of being used to identify, prevent, or control crime (Kennedy and Van Brunschot, 2009). Risk models provide tools for identifying hazards and vulnerabilities that can lead to crime outcomes. Kennedy and Van Brunschot (2009: 11) surmised that risk provides a metric that can help tie different parts of the crime problem together and offers a probabilistic interpretation to crime analysis that enables one to suggest that certain things are likely to happen and others are preventable, based on risk assessments. When "opportunity for crime" is thought of in terms of "risk of crime," places can be evaluated in terms of varying degrees of criminogenic risk relative to certain nearby or far away criminogenic features of the environment.

Although risk assessment provides an efficient way to analyze crime opportunities, challenges appear in the operationalization of crime opportunity in a GIS. The way that criminogenic features have been modeled in a GIS is often contrary to how people experience and conceptualize their environments (Couclelis, 1992; Frank and Mark, 1991). Geographers suggest that regions, such as cities, are learned by humans piecemeal over time, an assertion that is grounded in the view from psychology that "perceptions of space, spatial cognition, and spatial behavior are scale-dependent and experience-based," explained Freundschuh and Egenhofer (1997: 362). (See also Montello, 1993.) So, when assessing the risk of crime to occur at conceivably any location throughout a city, the use of vector points, lines, and polygons in a GIS are poor representations of criminogenic features on a map because they bear no particular relationship to the dynamic surrounding environment. (Couclelis, 1992). "There are difficulties with this view of the world," explained Couclelis (1992: 66), "mainly that points, lines, and polygons that define vector objects do not have naturally occurring counterparts in the real world." The vector objects are approximations of environmental features, but lack any theoretical or empirical link to their geographies (Freundschuh and Egenhofer, 1997). Broad inattention to different spatial conceptualizations of criminogenic features has led to misrepresentations of these urban, suburban, and rural features in GIS and resulting maps (Freundschuh and Egenhofer, 1997). The way people (for example, motivated offenders and suitable victims) conceptualize and operate in space is an important consideration for the mapping of crime risk throughout landscapes. Cartographically modeling these conceptualizations and the spatial influence of criminogenic features using a GIS in a way that reflects the actors' views is an important part of what Freundschuh and Egenhofer (1997: 363) describe as "*Naive Geography*, a set of theories of how people intuitively or spontaneously conceptualize geographic space and time" (see also Egenhofer and Mark, 1995), and can yield more meaningful and actionable spatial intelligence for use by public safety professionals (Frank, 1993; Freundschuh and Egenhofer, 1997; Mark, 1993).

Understanding these crime-prone places, however, requires more than just a snapshot of how offenders and victims interact at a point in space. As shown in the following sections, the best way to map these factors for the articulation of criminogenic "backcloths" (Brantingham and

Brantingham, 1981) is to operationalize the spatial influence of each factor throughout a common landscape rather than atheoretically mapping the factors as points, lines, or polygons in a manner that keeps them disconnected from their broader social and environmental contexts. To succeed at this task, information needs to be incorporated about these places with expected increased crime risks. Fortunately, decades of criminological research have identified a variety of independent variables to be significantly correlated with a variety of crime outcomes that can be used to inform expectations. For example, Caplan, Kennedy, and Miller (2011) studied gang-related shootings and operationalized the spatial influence of known gang members' residences as "areas with greater concentrations of gang members residing will increase the risk of those places having shootings" and depicted this risk factor as a density map created in a GIS from known addresses of gang members' residences. Kennedy, Caplan, and Piza (2010) operationalized the spatial influence of several known correlates of shooting events in Newark, New Jersey, such as public housing. The spatial influence of public housing was mapped to show all places within two blocks from public housing to be at higher than normal risk of shootings compared with all other places throughout the city (for example, Eck, 1994; HUD, 2000; Newman, 1972; Poyner, 2006; Roncek and Francik, 1981). Operationalizing the spatial influence of crime risk factors addresses various theoretical and methodological issues concerning the use of GIS for crime forecasting and assessing place-based victimization risk (Freundschuh and Egenhofer, 1997). The most basic utility of this innovation is that it maximizes the validity of cartographic models and empirical measures used for statistical tests. The next section demonstrates these effects to crime analysis when the same crime correlate is modeled in a GIS according to a variety of spatial influences types.

Operationalizing the Spatial Influence of Criminogenic Features

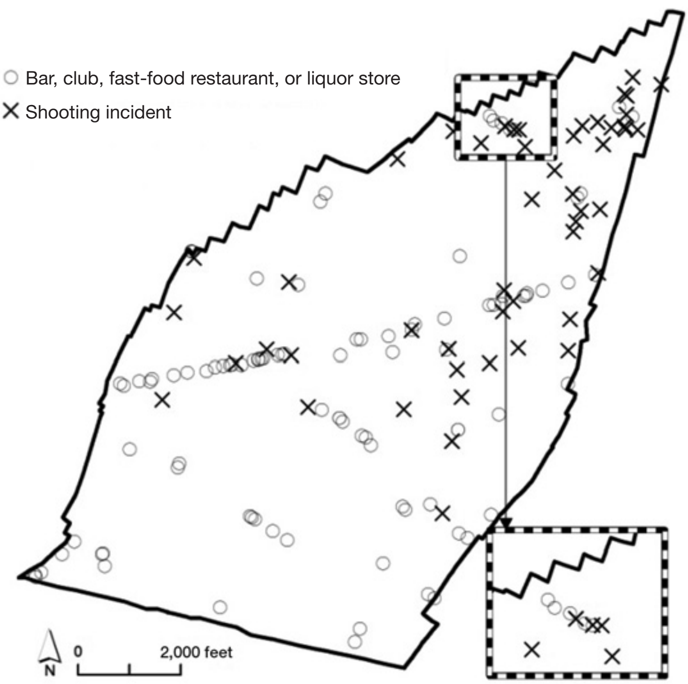
Three primary ways to operationalize the spatial influence of criminogenic features are (1) presence or absence of features, (2) density of features, or (3) distance from features. Each approach is demonstrated in turn. Two general lessons to be learned from the forthcoming discussion: First, it is reasonable to rely on theory and empirical research to identify crime correlates and to operationalize their spatial influence; second, many ways exist to operationalize the spatial influence of crime correlates about their environments, but some methods are more appropriate and efficacious than others. These insights reinforce the notion that approaches to crime analysis, spatial risk assessment, and crime forecasting cannot be atheoretical and must be evidence based. The approaches must be grounded in ways that account for the dynamic interaction of all criminogenic features throughout a landscape.

Presence or Absence of Features

Crime analysis can yield different results when the same crime correlate is modeled in a GIS according to a variety of empirically justified spatial influences. Exhibit 1 shows point symbols representing the locations of shooting incidents (the crime) and bars, clubs, fast-food restaurants, and liquor stores (the crime risk factors) in Irvington. These crime risk factors, or criminogenic features of the landscape, are correlated with shooting incidents in several empirical research studies, both in Irvington and other settings (for example, Block and Block, 1995; Brantingham and Brantingham, 1995; Caplan, Kennedy, and Miller, 2011; Clarke and Eck, 2005; Eck, Clarke, and Guerette, 2007; Kennedy, Caplan, and Piza, 2010). Represented on the map in exhibit 1 are 97 features and 58 shooting incidents. Visual inspection of the map suggests that shooting incidents occur near criminogenic features. Only one shooting incident was at the exact same address as a fast-food restaurant, however, as shown in the extent rectangle at the bottom right of the map. Given the state of knowledge from existing empirical research, it might be said that Irvington as a whole is at greater risk for shootings compared with other municipalities because it has higher numbers of criminogenic features. Short of revoking business licenses and forcibly closing all or some of the most problematic establishments, however, this fact would be less than useful for Irvington's public safety practitioners who must operate at microlevel places within their municipality to suppress and prevent shootings and other violence. Accepting that their city is empirically more crime-prone compared with other cities and doing nothing about it is not an option.

Exhibit 1

Irvington, NJ, 2007: Correlation of Environmental Features Represented as Vector Points

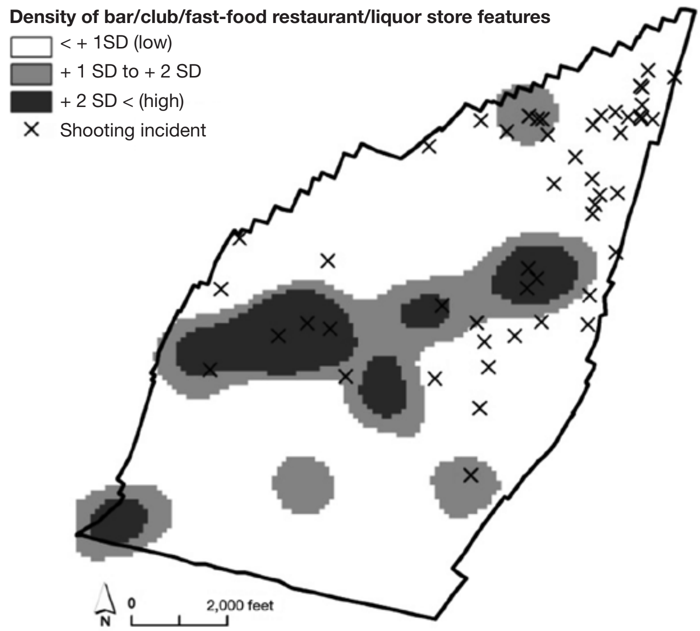


Density of Features

Bars, clubs, fast-food restaurants, and liquor stores are often not the exact locations where associated crimes happen. Rather, shootings occur at places that are in some way defined or influenced by them. As shown in exhibit 2, the spatial influence of these features on shooting incidents is related to their concentration at places throughout the municipality and was operationalized as a raster density map. Shooting incidents are cartographically modeled as more likely to happen at places

Exhibit 2

Irvington, NJ, 2007: Correlation of Environmental Features Represented as Density of Points



SD = standard deviation.

where bars, clubs, fast-food restaurants, and liquor stores are most concentrated. "Places" are defined in the raster map as cells sized 100 feet by 100 feet and the distal limits of nearby features (that is, search radius) used to define the density of each place was set at 1,480 feet. Technically, cell sizes determine how coarse or smooth the raster map will appear: the smaller the cell size, the smoother the map will be (imagine pixels on a television screen). Conceptually, raster cells are the microlevel places for which risk is being assessed and their size should be meaningful for operational purposes. For example, Kennedy, Caplan, and Piza (2010) used a cell size of 145 feet by 145 feet for risk terrain modeling in Newark because that was one-half the median block length in the city. They reasoned that about one block was a meaningful area for crime events to happen within and was small enough for targeted police interventions should risk in these areas be found to be high.[2] In this study, the 100-foot cell (that is, place) size was selected based on the average block length in Irvington (370 feet) so that the microlevel places depicted on the map in exhibit 2

[2] As extreme examples, a cell size of 2 inches would be unreasonable because a person cannot fit in that space and a cell size of 10 miles would not be meaningful for operational policing given the vast area within each cell. Exceptionally large cell sizes could also create problems regarding the phenomenon of "edge effects." Ultimately, the cell size is a subjective decision that should be based on how precise the risk assessment needs to be—the smaller the cell size the better the precision (as long as the risk factor data—for example, point-level data—are also precise). The general rule of thumb is to select a cell size that will enable actionable interpretations of risk terrain maps.

distinguish the spatial influence of criminogenic features as precisely as one corner or the middle of a street block. The 1,480-foot search radius for the density calculation was selected because it equaled approximately four blocks (that is, 370 feet by four blocks), a meaningful sphere of influence for these criminogenic features as attributes of places within the radius. In real terms, and to continue with the example from the introduction section, a person might describe the place where she is standing as the bar district because she observed many bars within a four-block radius.

The density map in exhibit 2 is symbolized according to standard deviational breaks, with all places colored in darker gray having density values greater than +2 standard deviations from the mean density value—which statistically puts these places in the top 5 percent of the most densely populated with criminogenic features. The lighter gray represents places with density values between +1 and +2 standard deviations; white places have density values below +1 standard deviation. As shown on the map, places with greater concentrations of criminogenic features appear to be more frequented by shootings than the bars, clubs, fast-food restaurants, and liquor stores themselves (when compared with exhibit 1). In fact, 20 out of 58 (34 percent) shootings during 2007 occurred at places with density values above +1 standard deviations. It is realized that this result is arguably due to simply identifying a larger "catchment" area to which shootings are aggregated—compared with the feature points themselves. Such an argument is valid and needs to be addressed for statistical tests, as will be done in later sections of this article. For now, however, the intention is to demonstrate operationalizing the spatial influence of criminogenic features in different ways.

Given the state of knowledge from existing empirical literature and the spatial influence of criminogenic features to be operationalized as the concentration of these features throughout the environment, it might be said that places in Irvington with higher concentrations of bars, clubs, fast-food restaurants, and liquor stores are at greater risk for shootings compared with all other places within the municipality. This fact might encourage Irvington police to prioritize and allocate resources to the densest places. In this way, police could preemptively target a few high-density areas of criminogenic features rather than allocating resources to every individual feature in an effort to control and prevent shootings.

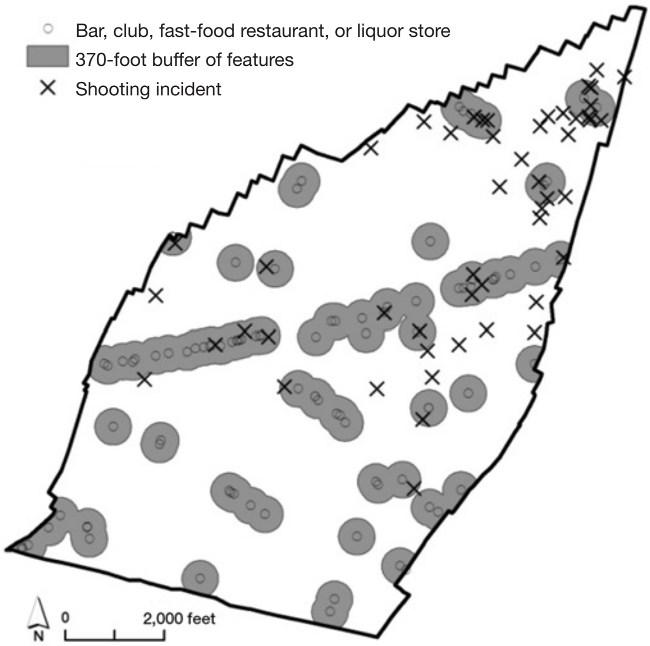
Distance From Features

Bars, clubs, fast-food restaurants, and liquor stores may be considered attractors or generators of shootings (Brantingham and Brantingham, 1995). Perhaps they are the venues where most suitable victims hang out or where the most likely and motivated offenders visit, become intoxicated, or lose self-control (Clarke and Felson, 1993). Due to increased police presence or other capable guardians such as bouncers, witnesses, or closed-circuit television cameras, however, offenders do not shoot their victims inside or directly outside of such facilities. Rather, shootings are more likely to occur at certain distances away. Thought of in this way, the spatial influence of bars, clubs, fast-food restaurants, and liquor stores on shootings is more a function of distance from the closest criminogenic feature rather than the presence or absence of the feature at the shooting incident location. Exhibit 3 shows a map that operationalizes this distal spatial influence with a 370-foot buffer (about 1 block) around all features.

Although only 1 shooting out of 58 during 2007 happened exactly at or in a bar, club, fast-food restaurant, or liquor store, and 20 happened at places defined by high concentrations of these

Exhibit 3

Irvington, NJ, 2007: Correlation of Environmental Features Represented as Distance From Points



criminogenic features, 31 shootings occurred within one block from these features. In fact, 15 out of the 20 shootings that happened at places with high-density values occurred within one block from a criminogenic feature. The average nearest distance of a bar, club, fast-food restaurant, or liquor store to a shooting incident was 424 feet, with a standard deviational distance of 342 feet. Statistically, therefore, about 66 percent of all shooting incidents in Irvington during 2007 could have been expected to occur within +1 standard deviation, or 766 feet, from these criminogenic features. The operationalized spatial influence of the highest risk created by these features to be all places within about one block, or 370 feet—a definition that was grounded in theory and empirical research, identified places with more than one-half (53 percent) of all shooting incident locations.

It is realized that this result is arguably due to identifying a larger catchment area to which shootings are aggregated. Compared with feature points themselves, this argument is true. The coverage area of places with density values above +1 standard deviations (as shown in exhibit 2) is 0.806 square miles, however, and the coverage area of places within one block of a criminogenic feature (as shown in exhibit 3) is 0.725 square miles, which equals about 0.25 percent of Irvington's total area. More shootings occurred in a smaller area that was deemed affected by nearby criminogenic features in a conceptually meaningful way. Although empirical research suggests that bars, clubs, fast-food restaurants, and liquor stores are correlated with shootings, the most meaningful cartographic model of places that are at the greatest risk of shootings is one that operationalizes the spatial influence of these features on shooting incidents to be up to a certain distance away. This cartographic model of the spatial influence of bars, clubs, fast-food restaurants, and liquor stores might not be the case in other jurisdictions or for other crime types, but it is corroborated by existing research (for example, Smith, Frazee, and Davison, 2000; Tilley et al., 2005; Wright and Decker, 1997), and it reinforces the importance of modeling these criminogenic features in commensurate ways on a map.

Modeling the Interaction of Crime Risks Throughout an Urban Landscape

Now consider the role that the interaction of spatial influences of criminogenic features has on increasing the risks that crime will take place. Caplan, Kennedy, and Miller (2011) and Kennedy, Caplan, and Piza (2010) measured the place-based interaction of several criminogenic features using a technique called risk terrain modeling. Risk terrain modeling is an approach to risk assessment whereby separate map layers representing the influence and intensity of each risk factor at every place throughout a landscape is created in a GIS. Then all risk map layers are combined to produce a composite risk terrain map with values that account for all risk factors at every place throughout the landscape. Risk terrain modeling builds on principles of hotspot mapping, environmental criminology, and problem-oriented policing to produce maps that show where conditions are ideal or conducive for crimes to occur in the future, given the existing environmental contexts. Further, it offers a new and statistically valid way to articulate and communicate crime-prone areas at the microlevel according to the spatial influence of criminogenic features.

Risk terrain modeling comprises three concepts. Risk suggests the likelihood of an event occurring given what is known about the correlates of that event, and it can be quantified with positive, negative, low, or high ordinal values. The measures are ordinal because it is not necessarily known whether a risk value of 10 is twice as risky as a value of 5, but it is higher. Using risk as a metric, it is possible to model how risk evolves spatially and temporally, accounting for the different stages of a crime event (Kennedy and Van Brunschot, 2009). A terrain is a grid of the study area made up of equally sized cells that represent a continuous landscape of places where values of risk exist. Raster maps are used to represent terrains in risk terrain modeling because of their ability to model continuous landscapes. Places are defined in raster maps by cells of size x^2 (for example, 100 feet by 100 feet). Modeling broadly refers to the abstraction of the real world at certain places. Specifically within the context of risk terrain modeling, modeling refers to the process of attributing qualities of the real world to places within a terrain, and combining multiple terrains together to produce a single composite map in which the newly derived value of each place represents the compounded criminogenic risk of that place.

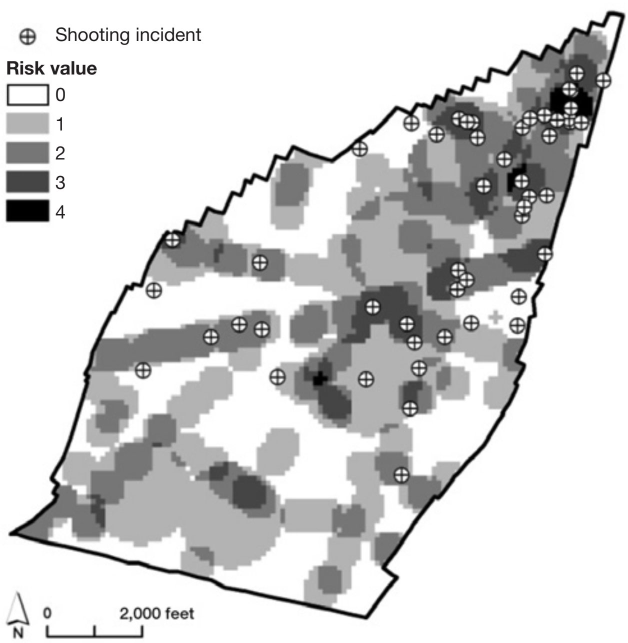
Crime explanations can be accounted for in an RTM by different factors that tie different components of risk together to explain individual, group, and institutional influences and effects on crime events. Risk terrain maps paint a picture, so to speak, of the combined effects of spatial influences of different factors at every place throughout a landscape. Clustering of illegal activity in particular areas is explained in an RTM by the unique combination of criminogenic factors that make these areas opportune locations for crime. This clustering occurs where the potential for, or risk of, crime comes as a result of all the attributes found at these places.

Qualities of places themselves do not create crime. They simply point to locations where, if the conditions are right, the risk of crime or victimization will be high. Risk terrain modeling assumes a step that is basic to the development of GIS in assuming that certain locations can acquire attributes that when combined in prescribed ways can create contexts in which certain outcomes are made more likely. For example, the attributes of open space, presence of children, and proximity to schools may indicate a playground. These attributes combined can be used to anticipate the types of behavior that would be expected in a playground—reducing the uncertainty that forecasts about what would transpire at a playground are wrong. In this way, risk terrain modeling uses the spatial influence of environmental features as a means of assigning likelihood (or risk) that certain events will happen at particular places. Outcomes may be benign (for example, children playing) or they may take on a more sinister character in which a combination of certain types of factors related to crime creates a context in which the risk of crime events can occur.

A key component of risk terrain modeling is to operationalize the spatial influence of crime risk factors, as discussed in the previous section. The objective, explain Caplan and Kennedy (2010), is to create separate maps of the study area, each representing the influence of a risk factor throughout the landscape. At least one raster map is created for each risk factor to represent the intensity of its criminogenic influence at every microlevel place throughout the study area. The resulting raster map shows where crime is most likely to occur as a result of particular conditions within the urban form. Cells within a raster map are the unit of analysis for risk terrain modeling. Exhibit 4 presents a risk terrain map for shootings in Irvington. It was produced according to the steps outlined by Caplan and Kennedy (2010) and includes four risk factors that previous empirical research found

Exhibit 4

Irvington, NJ, 2007: Risk Terrain and Shooting Incidents



to be correlated with shooting incidents: Gang members (Kennedy, Piehl, and Braga, 1996; Topalli, Wright, and Fornango, 2002); bus stops (Loukaitou-Sideris, 1999); schools (Roncek and Faggiani, 1985; Roncek and Lobosco, 1983); and facilities of bars, clubs, fast-food restaurants, and liquor stores (Block and Block, 1995; Brantingham and Brantingham, 1995; Clarke and Eck, 2005; Eck, Clarke and Guerette, 2007; Kennedy, Caplan, and Piza, 2010). Data on gang members were composed of addresses of all known gang members' residences,[3] and was operationalized as a density map because the spatial influence of these features was understood as areas with greater concentrations of gang members residing will increase the risk of those places having shootings. Addresses of all public bus stops were obtained from NJ TRANSIT (New Jersey's public transportation corporation) and operationalized as a distance map up to 555 feet away because the spatial influence of these features was understood as up to one and one-half blocks away from bus stops—transportation resources that motivated offenders and targeted victims frequent and use regularly—are at greater risk for shootings because targeted victims are most vulnerable when they arrive at or leave these destinations (Loukaitou-Sideris, 1999). Addresses of all public and private school buildings were obtained from the New Jersey Department of Education through the New Jersey Geographic Information Network and operationalized as "distances up to three blocks (up to 1,110 feet) are at the greatest risk for shootings" (Xu, Kennedy, and Caplan, 2010). Bars, clubs, fast-food restaurants, and liquor establishments were operationalized in a distance map in accordance with exhibit 3 and the previous related discussion.

The RTM (exhibit 4) of places in Irvington that share the locations and spatial influences of all aforementioned shooting risk factors has high predictive validity. Logistic regression results presented in exhibit 5 suggest that for every increased unit of risk, the likelihood of a shooting more than doubles (Exp(B) = 2.43, $p < 0.01$). Stated another way, the likelihood of a shooting happening at particular 100-foot-by-100-foot places in Irvington during 2007 increases by 143 percent as each additional risk factor affects that place.

Looked at in a different way, as shown in exhibit 6, more than 42 percent of all shooting incidents occurred in the top 10 percent of the highest risk places during calendar year 2007 (Pearson chi square = 55.897; df = 1; $p < 0.01$). The highest risk places were designated as such with a first-tier sorting of the risk values of all cells (N = 3,975) in descending order and then a second-tier sorting

Exhibit 5

Logistic Regressions for Period 1 Risk Value on Period 2 Shooting

	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for Exp(B)	
							Lower	Upper
Risk value	0.888	0.145	37.606	1	< 0.001	2.431	1.830	3.230

B = Beta. C.I. = Confidence Interval. df = degrees of freedom. S.E. = standard error. Sig. = significance. Wald = Wald coefficient.

Nagelkerke R Square = 0.081.

[3] The New Jersey State Police provided data through the Regional Operations Intelligence Center and the many data sets they maintain, validate, and update regularly to support internal crime analysis and police investigations.

Exhibit 6

Shootings in Highest Risk Cells

Place Designated as Top 10% of Highest Risk? (N = 3,975)	Any Shootings Present During 2007 (Yes %, N = 47)
No	57.4
Yes	42.6

Pearson Chi-Square = 55.897; df = 1; p < 0.01.

by random number to randomize the sorting of cells with the same risk values.[4] Then the first 398 cells were designated as "highest risk" and all other cells were designated as "not highest risk."

In sum, this risk terrain map produced with thoughtfully operationalized criminogenic features yielded a valid and reliable forecasting model that was empirically and theoretically grounded. The criminogenic features were selected according to findings from previous empirical research, and they were included in the model in a manner that accounted for their spatial influence at all nearby and faraway places throughout the landscape. The resulting risk terrain map articulates environmental contexts of places that are most likely to attract, enable, and generate criminal shooting incidents as a function of the combined influences of criminogenic features within Irvington. This RTM is deconstructed in the next section to explain why it is valid, and to elucidate the key role that operationalizing the spatial influence of criminogenic features had on its predictive validity.

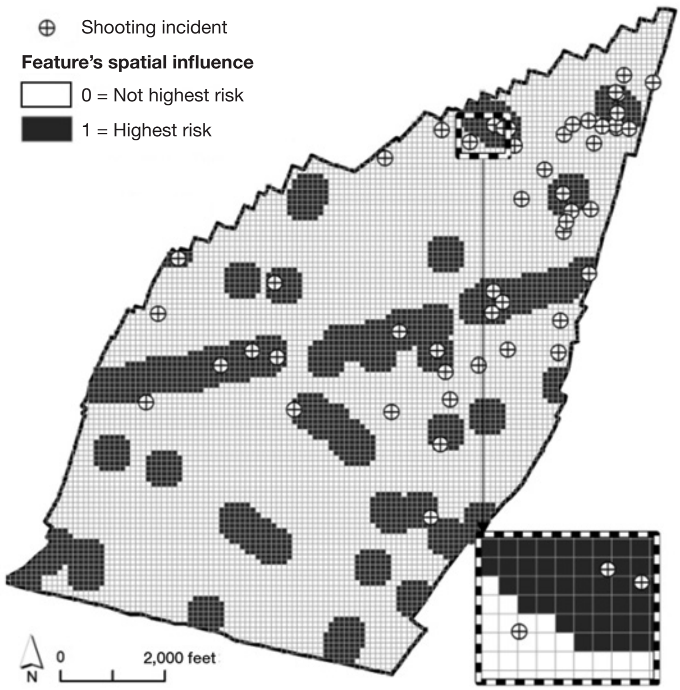
Valid Operationalizations of Spatial Influence Make Risk Terrain Modeling Work

A shooting or other crime incident could conceivably occur at any location in Irvington. That is, criminals do not generally offend with regard to census tract or other geographic units of aggregation. A victim who was shot at 123 Main Street could just as likely been shot at 115 Main Street if he stopped to tie his shoe, walked slower, or was delayed for any number of other reasons. Raster mapping in GIS, specifically developed to model continuous landscapes (Tomlin, 1994, 1991), captures this reality of how people populate, operate within, and travel through a landscape and models how crime can occur at microlevel places better than vector maps (Caplan, Kennedy, and Miller, 2011; Groff and La Vigne, 2002). Cells within a raster map are the standard unit of analysis for statistical testing across individual map layers and the final risk terrain map. For each map layer in the RTM discussed in the previous section, each cell (that is, place) has attributes that account for whether or not it is affected by a criminogenic feature, respectively. For example, exhibit 7 shows the map layer of "spatial influence of bars, clubs, fast-food restaurants, and liquor stores"; all places within one block from any of these features were operationalized as highest risk for shootings to occur. Cells that were located within the spatial influence of these features were given a value of "1"; all other cells were given a value of "0." A second attribute was also assigned to each cell noting the presence ("1") or absence ("0") of one or more shooting incidents during 2007. This

[4] The random number ensured that every cell had an equal chance of being sorted above or below the 10-percent cut point. For example, if 11 out of 100 cells had a risk value of 4, and they were sorted in descending order, the top 10 percent of cells to be designated as "high risk" would all have risk values of 4. The 11-percent cell, however, would be excluded due to a rather arbitrary standard sorting algorithm.

Exhibit 7

Irvington, NJ: Spatial Influence of Bars, Clubs, Fast-Food Restaurants, and Liquor Stores; Operationalized as 370 Feet From Features Is Highest Risk



procedure was repeated for all four map layers of criminogenic features included in the RTM so that the statistical validity of the operationalized spatial influence of each feature could be assessed with 2-by-2 cross tabulation tables and chi-square tests.

As shown in exhibit 8, all four cartographic representations of the spatial influence of criminogenic features in Irvington were statistically significant at $p < 0.05$. Of all shootings that occurred during 2007, 68 percent happened at places defined by their influence from bus stops; 55 percent happened at places defined by their influence from bars, clubs, fast-food restaurants, or liquor stores; 53 percent

Exhibit 8

Statistical Validity of Operationalized Spatial Influence

Criminogenic Feature	Operationalized Spatial Influence of Highest Risk	Any Shootings Present During 2007 (Yes %)	Pearson Chi-Square Value
Schools*	Within 3 blocks	53.2	5.363
Bus stops**	Within 1 block	68.1	7.707
Bars, clubs, fast-food restaurants, and liquor stores**	Within 1 block	55.3	19.318
Known gang members' residences**	Density value greater than +2 standard deviations	38.3	37.813

* $p < 0.05$. ** $p < 0.01$.

happened at places defined by their influence from schools; and 38 percent happened at places defined by their influence from known gang members' residences. Again, "places" are cells sized 100 feet by 100 feet.

Combining the four maps of the spatial influence of criminogenic features into a single composite risk terrain map shows how compounded risk is distributed throughout Irvington and becomes a better predictor of shooting locations. As shown in column 3 of exhibit 9, the compounded risk of shootings gets larger in more confined areas of Irvington with each additional unit value of risk. When the four maps are combined with risk terrain modeling, 74 percent (43 out of 58) of shootings happened at places that were affected by two or more criminogenic features (that is, risk values were 2, 3, or 4). Of the shootings, 48 percent (28 out of 58) happened at places affected by three or more criminogenic features. Only 46 out of 3,975 places (cells) had risk values of 4 and were considered places where shootings could occur.[5] Of all shootings, 14 percent happened at these high-risk places representing barely more than 1 percent of the area of Irvington. Exhibit 4 shows that places with risk values of 4 were quite coalesced into relatively few clusters. Police commanders and other community partners could prioritize these areas (followed by areas with values of 3, 2, and 1, respectively) for targeted evidence-based interventions to prevent shootings with a high level of confidence in the efficaciousness of their resource allocation strategy.

It would appear from column 1 of exhibit 9 that bus stops are the most important feature to affect crime because 68 percent of all shootings happened nearby. Many bus stops are located in Irvington, however, and nearly one-half (48 percent) of the places in the township are cartographically modeled

Exhibit 9

Relative Spatial Influence of Criminogenic Features

Spatial Influence Map of...	Column 1: % of Shootings Present	Column 2: % of Irvington's Area[a]	Column 3: Shootings (Counts) per Square Mile[b]
Bus stops	68	48	57.35
Bars, clubs, fast-food restaurants, and liquor stores	55	27	82.86
Schools	53	37	58.82
Gang members' residences	38	11	146.66
Composite risk value of 2, 3, or 4	74	38	79.63
Composite risk value of 3 or 4	48	10.5	186.66
Composite risk value of 4	14	1	470.59

[a] *Calculated by the number of cells having the attribute of the spatial influence of the criminogenic feature or the risk value, respectively. For example, 3,975 cells were included in the statistical analyses. So, if 46 cells had a risk value of "4," then the area would be 46/3975 = 0.011 or 1.1 percent.*

[b] *Square mile is based on the number of cells having the attribute of the spatial influence of the criminogenic feature or the risk value, respectively. Cells are 100 feet by 100 feet, or 10,000 square feet. So, if 418 cells had a risk value of either 3 or 4, then (418 cells x 10,000 square feet = 4,180,000 square feet) / (5,280 feet per mile x 5,280 = 27,878,400) = 0.15 square mile. 28 shootings in these respective cells / 0.15 square mile = 186.66 shootings per square mile.*

[5] Shootings could be tracked only to street segments because the address level data were geocoded to street segments. So, the number 3,975 represents the number of cells that intersect with a street centerline segment.

as being located within the spatial influence of risk posed by the bus stops. This fact that 'more ground encompasses more shootings' relates to the modifiable area unit problem and requires that relative shooting counts be calculated to control for the square area of features' influences. As shown in column 3 of exhibit 9, places influenced by gang members' residences actually have the most shooting incidents per area and could be a principal feature of the landscape that attracts shootings. To assert that places where gang members reside are definitely places where shootings will happen, however, is like saying the presence of motivated offenders, suitable victims, and no capable guardians always results in crime (that is not true; Cohen and Felson, 1979). What is more accurate, and what risk terrain maps articulate visually, is that places affected by gang members' residences and one or more additional criminogenic features have the greatest likelihood of shootings to occur. As shown in column 3 of exhibit 9, places influenced by all four criminogenic features hosted meaningfully more shooting incidents per square area compared with all other places. Several criminogenic features may influence smaller numbers of places, but as a whole, these places have a very high relative frequency of shootings. Operationalizing the spatial influence of criminogenic features to maps is an important task for maximizing the construct validity of the effect these features have on crimes. Combining these maps with an RTM gives such cartographic modeling practical utility for policing operations by articulating a continuous landscape of compounded risk at all places; resulting maps can be used to efficiently allocate resources and target interventions.

Evaluate Place-Based Interventions While Controlling for Environmental Context

Hindsight is 20/20, as the saying goes. At this point, after analyzing old data, it may seem a bit unfair to say that interventions to suppress and prevent shootings could have been strategically targeted in Irvington to maximize benefits. Police agencies operating in Irvington, however, did in fact have a targeted strategy to suppress and deter shootings. Now with risk terrain modeling and the understanding of the spatial influence of criminogenic features, a spatial analytic method is used for evaluating the shooting suppression strategy. The township of Irvington is relatively small (about 2.9 square miles), sandwiched between a slightly bigger suburban township and the larger city of Newark. Its murder rates for 2007, however, were 38.7 per 100,000 people compared with the national average of 4.9 for similar sized cities across the country (FBI, 2008). Primarily for this reason, Irvington drew a considerable amount of attention from political leaders and law enforcement officials, who set up a special task force to assist the smaller municipal police force with policing this jurisdiction. During 2007, the task force consisted of uniformed state troopers who patrolled targeted areas in both a highly visible saturation capacity and in aggressive undercover operations. Drug arrests at these targeted areas were the task force's principal intervention method; the purpose was to incapacitate likely shooters and likely victims (because shootings were mostly gang and drug related) by means of arrest, conviction, and incarceration. Although this strategy yielded an overall reduction of violence[6] in Irvington since before the task forces' inception and the number of shootings has remained fairly constant since (about 25 biannually), its effect on the spatial distribution of new shootings remained unknown.

[6] According to the New Jersey State Police Uniform Crime Reports, the violent crime rate in 2006—before the task force—was 22.4 per 1,000, with a murder count of 21. In 2009, the violent crime rate was 18.2 per 1,000, with a murder count of 17. The total number of violent crimes in 2006 was 1,321 and in 2009 was 1,024.

Knowing that certain criminogenic features attract and enable shootings above and beyond the routine activities of offenders, victims, or police, Irvington's contextual landscape must be controlled for when evaluating geographically targeted interventions such as the task force's aforementioned drug arrests. A validated RTM of Irvington's fixed criminogenic contexts is especially useful for such an evaluation. The risk terrain map in exhibit 4 was "fixed" because it was produced from criminogenic features that did not change during the year. For example, the count and locations of school buildings did not change during 2007. In Irvington, (probably like many other jurisdictions), schools, bus stops, bars, and so on are not demolished or erected on a regular basis. Therefore, the aforementioned RTM with predictive validity (exhibit 4) articulates the fixed criminogenic contexts for shootings at microlevel places throughout Irvington. Risk terrain modeling has not yet been used to create a contextual control measure of environmental crime risks for the purpose of evaluating police interventions at places, but it could. The fixed context risk terrain map can be used as a base map—a backcloth, so to speak (Brantingham and Brantingham, 1981)—to evaluate the spatial effect of the task force's targeted drug arrests during the first half of 2007 on subsequent shooting locations during the second half of 2007. A reasonable time frame to measure this effect is 6 months because the New Jersey State Police routinely report 6-month crime trends to the public (for example, www.njsp.org/info/stats.html#cit) and revise policing operations and strategies accordingly.

The first step to evaluate the spatial effect of targeted drug arrests on shooting incident locations is to operationalize the intended spatial influence of drug arrests and produce a respective map layer to be added to the fixed context RTM. The basic information sought from evaluating this intervention is whether it was successful, defined by an overall reduction of shooting incidents without displacement or reemergence. This spatial evaluation seeks to answer: What effect did targeted drug arrests during January through June 2007 (Period 1) have on the locations of shooting incidents during July through December 2007 (Period 2)?

Shootings occurred in 32 known locations during Period 1 and 26 locations during Period 2, which was a slight reduction. As shown in exhibit 10, the spatial distribution of shootings during the two time periods changed, with more incidents clustered in northeastern Irvington during Period 2 than had occurred there during Period 1. It is hypothesized that places with higher concentrations of targeted drug arrests had a mitigating effect on the criminogenic contexts at these places and, therefore, shootings would have been less likely to occur. Drug arrest locations were geocoded to street centerline shapefiles and then used to produce the density map in exhibit 11, showing the places with density values greater than +2 standard deviations from the mean drug arrest density value throughout Irvington. These "highest density" places were reclassified with a value of "1" and all other places were assigned a value of "0." Parameters for this map were similar to map layers already included in the fixed context risk terrain map, described previously: "places" were defined by a cell size of 100 feet and density was calculated with a search radius of 1,110 feet, about three blocks.

To test the hypothesis that places with higher drug arrest concentrations deterred future shootings, the drug-density map was subtracted from the fixed context risk terrain map to produce a new risk terrain map with values ranging from -1 to +4. As shown in exhibit 12, this new RTM (hereafter called the "Hypothesis RTM") is statistically significant, although not as much as the original fixed-context RTM. The Nagelkerke R Square of the Hypothesis RTM was 0.032; the fixed-context RTM was 0.081. The Nagelkerke R Square provides a measure of how well future outcomes are likely to

Exhibit 10

Irvington, NJ: Biannual Spatial Distribution of Shooting Incidents

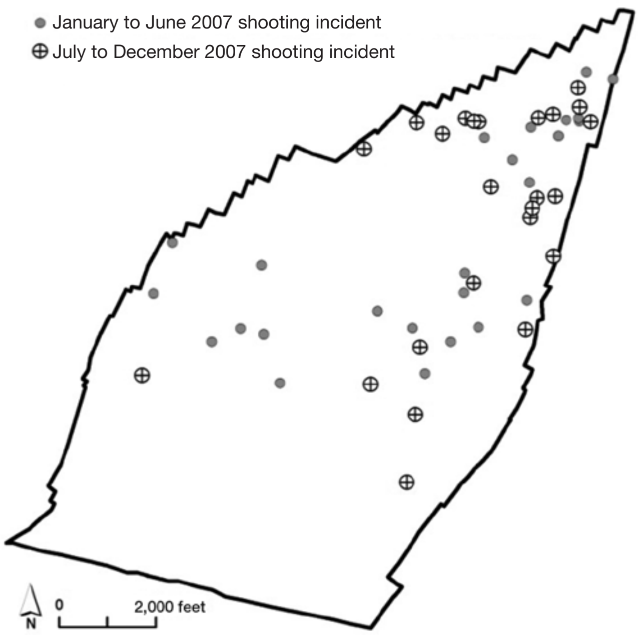
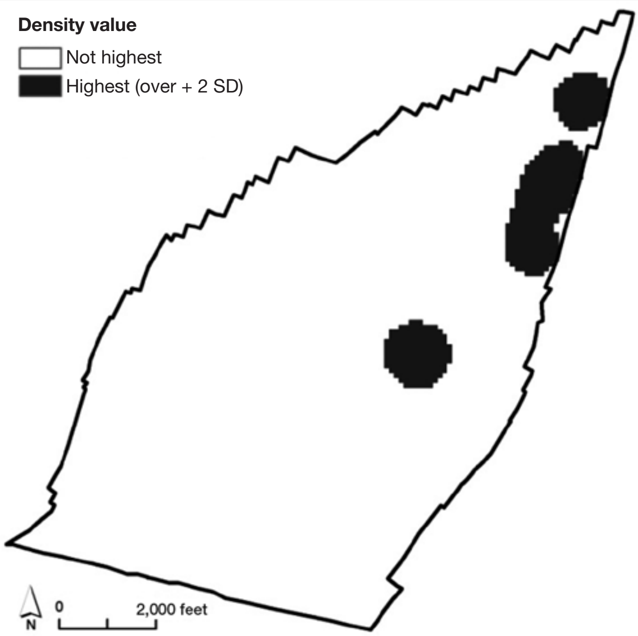


Exhibit 11

Irvington, NJ: January–June 2007, Highest Density Drug Arrest Places



SD = standard deviation.

be predicted by the model. Values of Nagelkerke R Square mean that the Hypothesis RTM only explains about 3 percent of the variance in future shooting locations compared with about 8 percent explained by the fixed-context RTM.

After further reflection, it is apparent that comparing the Hypothesis RTM to the fixed-context RTM is like comparing apples to oranges. As with any other statistical tests, one must consider only the results of the hypothesized model against the alternative, or null, hypothesis. The null hypothesis for the task force's intervention is that places with higher drug arrest concentrations attract future shootings. To adjust to this null hypothesis, the drug-density map was added to the original fixed-context risk terrain map to create a "Null Hypothesis RTM" with values ranging from 0 to 5. As shown in exhibit 12, the Null Hypothesis RTM has statistically significant predictive validity, with a Nagelkerke R Square value of 0.073.

Compared with the Hypothesis RTM, the Null Hypothesis RTM explains the variance of shooting locations much better. Targeted drug arrests at certain areas appear to have actually attracted new shooting incidents to these same places. This result seems counterintuitive and many explanations are likely for this happenstance. Methodologically, a limitation of the RTM is that it does not account for very small increments of time, so it is possible that shootings were deterred when police were in an area, but then ensued shortly after they left. Or perhaps many targeted drug arrests created new open turf that other drug dealers fought to control. Targeted drug arrests may simply not be an appropriate response to gun shooting crimes. Recall that the RTM with the best predictive validity and most explained variance of future shooting locations was the fixed context RTM, which did not include any risk factors directly related to drug arrests. Yet police sought to suppress and deter shootings with targeted drug arrests. A more effective intervention might have been to use evidence-based practices to mitigate one or more of the criminogenic risk factors that were included in the fixed context RTM, thereby reducing the availability of places that are conducive to shootings. Such an intervention might include increasing shooters' apprehension risks through strategic interventions at places within one block from bus stops, bars, clubs, fast-food restaurants, and liquor stores; increasing police patrols along travel routes to and from schools, especially within the immediate three-block areas; or taking civil actions to shut down the most historically problematic bars—giving priority to establishments within places having risk values of 4.

Exhibit 12

Logistic Regressions for Period 1 Hypothesis RTM on Period 2 Shootings

						Risk Value	
	B	S.E.	Wald	Sig.	Exp(B)	95% C.I. for Exp(B)	
						Lower	Upper
Hypothesis RTM: Drug arrests as mitigating factor[a]	0.645	0.222	8.465	0.004	1.906	1.234	2.942
Null hypothesis RTM: Drug arrests as aggravating factor[b]	0.715	0.154	21.608	< 0.001	2.045	1.512	2.764

B = Beta. C.I. = Confidence Interval. df = degrees of freedom. S.E. = standard error. Sig. = significance. Wald = Wald coefficient.

[a] Nagelkerke R square = 0.032; df = 1.

[b] Nagelkerke R square = 0.073; df = 1.

A case was presented for measuring and mapping criminogenic features not as points, lines, or polygons, but as qualities of space throughout a landscape. Thinking about crime correlates not as finite objects, but rather as centers of radiating criminogenic influence across the urban landscape enables cartographically modeling environments in terms of microlevel place-based risks that are more enduring than just the characteristics of the people who frequent these places. Cartographic models of spatial influence are consistent with ideas that were popular among ecologists (for example, Holland, 1998), repeated by environmental criminologists when Brantingham and Brantingham (1995) talked about environmental backcloths, expressed in the key elements of problem-oriented policing (Center for Problem-Oriented Policing, 2010), and are now appearing in terms of risk terrains or opportunity structures (Caplan, Kennedy, and Miller, 2011; Groff and La Vigne, 2002). Individual risk factors are important, such as those owned by motivated offenders or potential victims (Cohen and Felson, 1979), but environmental contexts relative to certain criminogenic features are also very important in assessing crime-prone places. Many places probably abound daily with motivated offenders, suitable victims, and no capable guardians, but crimes do not always occur there. Why? Because these elements must simultaneously exist at enabling places to yield criminal events.

A few researchers have connected environmental factors to crime through simulation models, including recent work by Brantingham and Tita (2008), Tita and Griffiths (2005), and Groff (2007a, b), suggesting that the criminal justice community may be closer in its ability to show not just that certain factors are important in creating criminogenesis, but also to explain how these factors interact to produce the crime outcomes that appear. This article advances these efforts to measure environmental context as an element of criminal events by proposing a technique for operationalizing crime risk factors in cartographic form so that their otherwise intangible influences on places can be statistically tested, used to better inform resource allocation, and controlled for when evaluating place-based interventions. Three operationalizations of spatial influence of criminogenic features within a landscape were presented: presence of features, concentration of features, and distance from features. All are shaped by the urban form or physical layout and design of a city, which is the structural setting for people to interact and commit crimes. The most appropriate operationalization can differ by crime type and research setting, but it should always be derived from theory and expert knowledge.

Cartographically modeling the likelihood of crime at all places throughout a landscape according to the spatial influences that certain criminogenic features have on those places is a more realistic depiction of criminal opportunity (Couclelis, 1992; Frank and Mark, 1991; Freundschuh and Egenhofer, 1997). Operationalizing the spatial influence of criminogenic features considers criminal behaviors as less deterministic and more as a function of a dynamic interaction that occurs at places. Qualities of space themselves do not create crime; they simply point to locations where, if the conditions are right, the risk of crime or victimization will go up. It cannot be assumed, although, that because one or more criminogenic features affect a location that crime will definitely happen. What is more likely is that the likelihood of crime at places that have several criminogenic attributes is higher than at other places because these locations attract motivated offenders (or more likely concentrate them in close locations) and are conducive to allowing certain events to occur. Although physical structure and public activities can have an effect on the ways in which crime occurs (Basta, Richmond, and Wiebe, 2010; Groff 2007a, b), it has been difficult to show empirically how the connection works because of data problems and the complexity of the issue. Measuring and modeling criminogenic features according to their spatial influences addresses the empirical difficulty. Operationalizing spatial influence also lends itself to multilevel modeling in GIS with techniques such as risk terrain modeling, which models the combined influences of criminogenic features at places. When risk terrain modeling is performed with fixed criminogenic features, it can serve as an environmental control measure for evaluating spatial effects from place-based interventions.

The allure of mapping spatial influences of criminogenic features is that doing so can closely tie information to strategic planning. In addition, it provides a means by which police and other community leaders can evaluate interventions. It comports with the idea that the public has anxieties that translate into demands for prevention strategies to reduce crime risks (and crime fears). It also addresses the idea that certain areas can be more dangerous than other areas, even if criminogenic features are not present, and, therefore, that those places justifiably demand greater attention. Combined with risk terrain modeling, it also provides an evaluation approach that can determine a program's effectiveness and efficacy, or wastefulness of certain resource types used.

Author

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