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CRIME AND THE ENVIRONMENTAL OPPORTUNITY STRUCTURE: THE INFLUENCE OF STREET NETWORKS ON THE PATTERNING OF PROPERTY OFFENCES

by

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Crime and the Environmental Opportunity Structure:

The Influence of Street Networks on the Patterning of

Property Offences

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ABSTRACT

This thesis is an empirical study that examines the relationship between property crime and the environmental opportunity structure. The study specifically examines how the accessibility of street networks affects the property offender's search for targets. It is argued that the physical design of street networks influences how people move about within a city and consequently influences their familiarity with specific parts of it. If crimes are committed within the regular activity spaces of criminals, then the areas to which property offenders frequently travel, or with which they are most familiar, should have the highest amounts of property crime. If travel frequency decreases as road complexity increases, then the areas with the most complex street networks and the buildings on the least accessible streets should have the lowest amounts of property crime.

These premises were tested by means of an <u>ex post facto</u> research design that compared the relative amounts of property crime on different types of street segments in the two municipalities of Maple Ridge and Pitt Meadows, B.C. using 1979 crime data. Street segments were differentiated by their structural type (i.e., street layout, length, and curvilinearity), relative accessibility, and by the amount of traffic on them.

The findings of this study showed statistically significant, but substantively weak, relationships between these

independent variables and six different types of property crime. While attempting to control for the confounding influence of different opportunity variables, some strong predictive models were built that accounted for nearly seventy percent of the crime variance on each street segment. Most of the explanatory power of these models was attributed to three opportunity variables: the number of commercial establishments on each street segment, the improvement value of transient accommodations on each street segment, and the presence or absence of a high school on each street segment. The results of this study generally support the theoretical stance that property offenders engage in a spatially patterned search behavior in the selection of their targets.

DEDICATION

To Patricia and Paul Brantingham,

founders of the "Environmental School of Criminology".

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QUOTATION

"What gets into you all? We study the problem and we've been studying it for damn well near a century, yes, but we get no further with our studies. You've got a good home here, good loving parents, you've got not too bad of a brain. Is it some devil that crawls inside you?"

Quote by P.R. Deltoid; the fictional probation officer in Anthony Burgess' book, A Clockwork Orange.

"But brothers, this biting of their toe-nails over what is the cause of badness is what turns me into a fine laughing malchick. They don't go into the cause of goodness, so why the other shop? If lewdies are good that's because they like it, and I wouldn't ever interfere with their pleasures, and so of the other shop. And I was patronising the other shop. More, badness is of the self, the one, the you or me on our oddy knockies, and that self is made by old Bog or God and is his great pride and radosty. But the not-self cannot have the bad, meaning they of the government and the judges and the schools cannot allow the bad because they cannot allow the self. And is not our modern history, my brothers, the story of brave malenky selves fighting these big machines? I am serious with you brothers, over this. But what I do I do because I like to do."

Quote by the mad bad Alex; anti-hero in Anthony Burgess' book, A Clockwork Orange.

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A. LITERATURE REVIEW

I. INTRODUCTION

Traditional attempts to combat crime generally focus on the offender (Jeffery, 1973). Efforts have been made over many decades to improve the effectiveness of many criminal justice system agencies. Law enforcement agencies have expanded their enforcement and investigative strategies, with the goal of deterring crime by increasing the offender's risk of apprehension. Courts have attempted to increase their efficiency in order to ensure treatment and more certain and equitable punishment of offenders. Correctional systems have been modified, time and time again, to improve their ability to rehabilitate offenders. Despite these efforts, it is clear that traditional methods for controlling crime are unable to keep up with the ever increasing crime rate.[1] Jeffery (1977:7), for example, has noted that:

> Deterrence and punishment are failures; treatment and rehabilitation are failures; the criminal justice system is a failure from police to corrections...Nothing that we do today in the criminal justice system is a success.

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[1]Reckless (1973:3) states that "a glance at the statistics of the seven most frequently and uniformly reported offenses...reveals that these crimes have increased much faster both in volume and in rate than has the population of the United States". Other authors (Brantinghams, 1984; Nettler, 1978) have also documented similar crime patterns for Canada, the United States, and Britain.

The apparent failure of the criminal justice system makes it clear that alternative approaches to reducing crime are needed.

Crime Prevention Strategies

One alternative approach to reducing crime is crime prevention. Crime prevention strategies can be differentiated from traditional crime reducing methods in that they are proactive. That is, they attempt to formulate some form of action that will actually prevent a crime from occurring;[2] while the traditional methods react to crime after its occurrence.

A lot of confusion surrounds the concept of crime prevention as it seems to be the professed goal of every criminal justice agency. It seems that any official action taken by criminal justice agencies can be rationalized in terms of prevention rhetoric. Brantingham and Faust (1976) have developed a useful conceptual model of crime prevention that sorts out the wide array of contradictory prevention activities. This model defines three levels of prevention:

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[2] It should be noted that some future author will no doubt argue that it is methodologically impossible to prove that crime can be prevented. The argument can be made that something that has never taken place cannot be measured. Empey (1974:1095) goes so far as to suggest that crime prevention simply involves a particular trivial kind of utopian dreaming. None the less, it is not too unrealistic or problematic to accept the small inferential and inductive leap that a reduction in the official crime rate can, with adequate methodological controls, be attributed to some prevention strategy.

1. primary prevention, directed at modification of criminogenic conditions in the physical and social environment at large;

2. secondary prevention, directed at early identification and intervention in the lives of individuals or groups in criminogenic circumstances; and

3. tertiary prevention, directed at prevention of recidivism.

Many traditional reponses to crime, such as deterrence and rehabilitation, claim to prevent crime but are clearly reactionary in nature. These methods are only "pseudo-crime prevention" techniques because they operate at a tertiary level; after the crime has already occurred.

Conceptual models of crime prevention, when applied to real crime problems by police and others, have evolved into a variety of overlapping programs. Operational crime prevention strategies, while not necessarily mutually exclusive, include some of the following areas:

1. Environmental design - This method of crime prevention manipulates and changes the physical structure of the environment[3] in order to reduce potential criminal

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[3]The term "environment" refers to the external conditions in which people live. One of the primary objectives of this thesis is to study the way in which the physical environment influences behaviour. Of course, it is also essential to consider the influence of behaviour upon environment. Porteous (1977:15) has noted that if the influence of behaviour upon environment is purposive, "it frequently involves some form of design or planning. And if the physical environment does influence our behavior to any extent, then those who control the shaping of that environment also effect our behavior therein.

opportunities (e.g., Angel, 1968; Luedtke et al., 1970; Newman, 1972; Pablant and Baxter, 1975; Gardiner, 1978; Clarke and Mayhew, 1980).

2. Therapeutic intervention - This stategy relies upon the detection of and early intervention with persons having behavioural disorders. Persons attested to have behavioural disorders are directed into programs scientifically designed to change their behaviour, such as behaviour modification, psychosurgery, or chemotherapy (e.g., Mark and Irvin, 1970; Valenstein, 1973).

3. Community and police crime prevention - One method of reducing crime may be through public education. By making the public more aware and self-conscious of potentially criminogenic situations, some forms of crime might be reduced (e.g., not leaving keys in automobiles, locking doors, not jogging alone, or the dangers of drinking alcoholic beverages and driving). When public concern with crime is raised to sufficiently high levels, citizens may hire private police or band together to form vigilante groups (e.g., the Guardian Angels). Since the police are the first line of defence against crime, they have the most to gain through the use of prevention stategies. Many of the public education programs that deal with crime prevention have been instigated by the police. Some prevention

programs, such as "Operation Identification" and "Neighbourhood Watch", were designed to deter burglary, to assist in the apprehension of offenders, and to assist in the recovery of stolen property. Other programs, such as "Neighbourhood Watch" or "Block Parents", were established to raise the public's general awareness of the crime problem and to promote neighbourliness.

4. Law Reform - Since crime is a legal creation, the legalization or decriminalization of certain deviant acts, or behaviours (e.g., homosexuality, prostitution, gambling, or narcotics), can eliminate and in effect prevent crime. The decriminalization of certain crimes does not mean that society is necessarily condoning the deviant acts, or behaviours, that once were criminal. There are many ways of dealing with social problems without making the criminal justice system a repository for all of society's ills. Law reform can be another effective form of crime prevention.

Each of these prevention strategies has its own philosophical origins, and each presents its own set of practical, ethical, and moral problems.[4] When each of these concepts of crime prevention is raised, two distinct questions

[4] It is not the purpose of this thesis to expound these differences but to merely bring to the reader's attention that there are many aspects to crime prevention.

must be asked. First, can crime actually be reduced by one of these methods? Second, if so, do these crime prevention methods have troublesome side effects, or unintended consequences, which offset the social advantages of the reduction in crime that will be realized?

The development of these prevention stategies, particularly crime prevention through enviromental design (CPTED)[5] over the past fifteen years has led to a renewed interest in ecologically orientated studies and the growth of environmental criminology.[6]

Thesis

The general purpose of this thesis is to contribute to the empirical and theoretical growth of environmental criminology. The present study specifically examines how the accessibility of street networks affects the offender's search process for targets. The study was conducted in the two municipalities of Maple Ridge and Pitt Meadows, British Columbia, and used 1979 crime data obtained from the Royal Canadian Mounted Police. The following three premises describe the basic nature of this study.

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[5] Pronounced as "sep-ted".

[6] Environmental and ecological criminology is a form of inquiry that examines the spatial distribution of crime for different areas, in an attempt to provide explanations for any differences in spatial patterning.

1. Street networks can physically influence how people move about within a city. Street networks can also influence the way in which people become familiar with certain sections of a city.

2. Property crime generally occurs within an offender's regular activity space. Property crime should be highest near the areas that offenders are most familiar with or frequently travel through.

3. If travel frequency decreases as road complexity increases, then the areas with the most complex roads and the buildings on the least accessible streets should have the lowest amounts of property crime.

To test these premises an <u>ex post facto</u> research design was developed that compared the relative amount of property crime on different types of street segments. These street segments were differentiated by their structural type (i.e, street layout, curvilinearity, and length), relative ease of accessibility, and volume of traffic. The development of the research design was influenced by a similiar study conducted by Bevis and Nutter (1977) and by the general theoretical and methodological shortcomings of etiological criminological inquiries.

Organization of Thesis

This chapter attempted to provide a brief introduction to the recent development of environmental criminology from the crime prevention movement. The general nature of the empirical study that was undertaken in this thesis was also briefly discussed. Following this introductory chapter is an in-depth examination of the growth of environmental criminology.

The second chapter begins by outlining the development of crime prevention through environmental design (CPTED) and the dispositional bias of etiological criminology. Then, it discusses the architectural approach to crime reduction, developed by Oscar Newman (1972), that has probably been the most dominant force in shaping the direction that CPTED has followed. The chapter concludes by examining why an environmental crime perspective took so long to develop; why it developed in the direction that it did.

The third chapter emphasizes why it is important to identify criminal opportunities before attempting to alter the environment in order to reduce crime. It is argued that the development of environmental and criminological data bases will allow criminal opportunities to be identified so that prevention stategies can be implemented.

Chapter four explores the limitations that the physical environment imposes upon people and how this affects theirstop mobility patterns while committing crimes. The literature pertaining to the influence of street networks and crime is then explored.

The fifth chapter outlines the research design and methodology that was used. The collection and description of the data is also summarized.

Chapter six provides an analysis of the data. The technical aspects of the statistical analysis are contained in an Appendix.

Chapter seven, the conclusion, discusses some of the limitations of this study as well as the implications of the findings.

II. CRIME PREVENTION THROUGH ENVIRONMENTAL DESIGN

Crime prevention through environmental design (CPTED) is the name applied to a cluster of architectural and planning techniques used to reduce crime through manipulations of the social/physical environment. This approach concentrates on reducing the number of criminal opportunities that exist in the environment. Opportunities are identified by studying criminal actions. In order for a criminal action to occur the following three basic elements are necessary:[1]

1. motivation;
2. ability;
3. and an opportunity to commit a criminal act.

While all three elements are necessary for the commission of a criminal act, the latter two elements are relatively ignored in the criminological literature. The etiological methods of reducing crime have usually attempted to alter an offender's motivation to commit crimes.

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[1]This is presupposing that there already exists a potential offender and a criminal law to define the reality of the action.

The Etiological Bias of Traditional Criminology

Mainstream criminology has always been concerned with the causes of crime; however, a distinction must be made between two levels or types of inquiries that can be made when one is studying the etiology of crime: dispositional inquiries and spatial inquiries. The literature bears witness to the traditional form of inquiry which has resulted in a proliferation of biological,[2] psychological,[3] and sociological theories.[4] The main object of these theories is to show how some people are born with, or come to acquire, a "disposition" to behave in a consistently criminal manner. The other form of inquiry has focused on crime rates and patterns, for different areas, in an attempt to provide explanations for the different spatial patterning of crime.

Both of these types of etiological inquiries were first simultaneously addressed by what is called the Chicago School of criminology. During the 1930s, when empirical sociology was emerging in the United States, numerous studies of delinquency were conducted by members of the sociology department at the University of Chicago. The impact from these studies provides the cornerstone for sociological criminology and still remains a

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[2] e.g., XYY syndrome, Lombrosian theory, etc.

[3] e.g., Freudian theory, modelling, containment theory, etc.

[4] e.g., conflict, anomie, social disorganization, differential association, labeling, subcultural, etc.

vital stimulus for research. The "founders" of the Chicago School of criminology, Shaw and McKay (1969), in their ecologically oriented studies, noted that delinquency rates differed markedly among specific neighbourhoods; with the highest delinquency rates found near industrial areas and deteriorated community sections around the city center. They tried to explain this spatial patterning of delinquency by turning to a social-pschological level of analysis. Delinquency was explained in terms of social disorganization, which is produced by "culture conflict".[5] Basically, Shaw and McKay examined the variation in spatial patterning of crime in order to develop a theory of criminal motivation. In this sense the spatial patterning of crime was secondary in terms of the importance placed upon criminal motivation. The Brantinghams (1981:27) have noted that:

> Implicit in most such attempts at explanation is the assumption that variation in motivation leads directly to variation in spatial patterning. Under such an assumption the spatial pattern itself is merely derivative and of little scientific interest.

It is this primary importance placed upon motivation that links almost all criminological theories, including those of a Marxist or radical orientation, to the early work of the Chicago

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[5]The work of Shaw and McKay is summarized and evaluated by Finestone (1976); Morris (1957); Brantingham and Jeffery (1981).

School. The failure of criminological theories to produce strategies that can reduce crime may very well be a consequence of the little scientific interest expressed in the spatial patterning of crime. There is a growing trend in criminology which has started to question the utility of developing etiological based theories (Ohlin, 1970; Gibbon, 1971; Jeffery, 1977; Clarke, 1980). From a utilitarian perspective, the ultimate test of a criminological theory is whether it points to conditions, or events, that can be changed to reduce crime. The continuing high rate of crime makes it self-evident that these well established etiological theories are relatively unsuccessful as a basis for action. The following criticisms point out some of the general weaknesses and assumptions of these theories:

1. Dispositional theories tend to be global in nature. Each theory tries to develop one explanation for all types of crime. Clarke (1980:137) has noted that these theories pay "little attention to the phenomenological differences between crimes of different kinds, which has meant that preventive measures have been insufficiently tailored to different kinds of offence and of offender."

2. Dispositional theories generally neglect individual differences. They cannot account for those persons who have criminal motivation, whether born with it or acquired, yet

remain non-delinquent. The theories also tend to reinforce the view that most crime is largely the work of a small number of criminally disposed individuals; which is contrary to the evidence of self-report studies (Clarke, 1980; Hood and Sparks, 1974).

3. The theories tend to be positivistic in nature in that they study the individual offender and not the offence. Jeffery (1973:464) has noted that:

> the confusion of crime and criminals is commonplace in criminology. The criminologist seeks the answer to crime in the behaviour of the offender rather than in criminal law. Ferri stated that "crime must be studied in the offender." The question "why and how people commit crimes" is an important one; however, a theory of behaviour is not a theory of crime."

4. The theories generally regard criminal opportunities as being constant. Usually the theories are preoccupied with the social normative environment rather than the physical environment. This has meant that impulsive crimes, those that involve low levels of motivation or those that are spontaneous, cannot be explained very well; e.g., many crimes of passion are of this nature.

5. The theories often ignore the skills and abilities that are needed to successfully commit some types of crime.

6. Clarke (1980:137) has further noted that:

> the dispositional bias remains and renders criminological theory unproductive in terms of the preventive measures it generates. People are led to propose methods of preventive intervention precisely where it is the most difficult to achieve any effects, i.e. in relation to the psychological events or the social and economic conditions that are supposed to generate criminal dispositions.

Despite the heavy emphasis by dispositional theories, it may not be necessary to understand criminal motivation in order to reduce crime. There has recently been a renewed interest in the early work of the Chicago School with regards to the patterning of crime; except that this time, spatial patterning is not considered merely a derivative of motivation. It would seem logical that we may help in finding someone commits a crime when we know the "where", "when" and "how" of the act. By understanding the patterning of crime, the processes that account for an individual's involvement in criminality may be uncovered.

> Mapping the contexts of human acts yields clues to human motives. The geographer and his brethren make the psychologist's and sociologist's task easier; they tell us what to look for so we can more sensibly speculate about patterns of human conduct and about the stimuli that occasion them. They tell us where sequences of motives start, and where consequences of actions end. They place humanity in context, and protect us from parochial flights of fancy.
>
> (Toch, 1980:xii)

Taken in this context, the etiology of criminal actions can be considered secondary to the way in which the distribution of opportunities influences the actual commission of crimes. The over-all process of explaining motives may be more akin to Sykes and Matza's (1957) techniques of neutralization in that it is an ex post facto process. Motives can only be ascribed after-the-fact and may therefore have no use as a predictor of criminality. The issue as to "why" people commit crimes may simply be a "red-herring". Nonetheless, with an environmental perspective, criminal motivation is not simply discounted. Instead of rejection, motivation is assumed and the elements of ability and opportunity are emphasized. According to the Brantinghams (1981:18), the development of environmental criminology can be traced to the work of two men who worked independently of one another, but in the same university, during the late 1960s and early 1970s: C. Ray Jeffery[6] and Oscar Newman.[7]

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[6] C. Ray Jeffery, in his book, Crime Prevention through Environmental Design (1971), argued for the need to develop different crime prevention stategies. Beavon (1979) suggests that the impact of his work was vastly overlooked due to a shift in perspectives that Jeffery took between the first and second edition of his book. In the second edition of his book, Jeffery, stressed the role of bioenvironmental criminology, which is the equivalent of therapeutic intervention. The advocacy of this new perspective created such a stir amongst academics that the underlying theme of his work - crime prevention - was lost in the debate.

[7] Oscar Newman, in his book, Defensible Space: Crime Prevention Through Urban Design (1972), argued that the modification of specific features of urban architecture could reduce crime.

The success of CPTED strategies depends upon its ability to anticipate, recognize and appraise criminal opportunities and the initiation of some action to remove or reduce that opportunity (Frisbie, 1977). The ability to identify criminal opportunities is the central tenet that the validity of CPTED relies upon. If this stage in the process is by-passed or taken for granted then any action taken is operating on a haphazard basis. Unfortunately, the evolution of CPTED is analogous to the old cliche of "putting the cart before the horse". The preponderance of work in this field is of the hit-and-miss variety. Solutions and design strategies are often proposed without a thorough understanding of the environmental factors that may provide potential criminal opportunities. The work that best exemplifies this haphazard approach is that of Oscar Newman (1972,1980).

The "Newmanesque" Approach To CPTED

Newman has probably been the most dominant force in shaping the direction that CPTED has followed. The theme of Newman's work is that architectural design can directly effect the amount of crime in residential areas. Therefore, Newman argues that an effective form of crime prevention would be the creation of architectural designs which would be least likely to promote criminal behaviour. Such architectural designs would reflect what Newman calls "defensible space". Newman (1972) outlines four central aspects, that must be maximized, in order to capitalize on defensible space features.

1. Territoriality - the capacity of the physical environment to create perceived zones of territorial influence.

2. Surveillance - the capacity of physical design to provide surveillance opportunities for residents and their agents.

3. Image - the ability of physical design to project the perception of a housing project's uniqueness, isolation, and stigma.

4. Environment - the influence of geographic juxtaposition with "safe zones" in adjacent areas.

According to Newman (1972) these four constituents of good design contribute to the formulation of defensible space "which inhibits crime by creating the physical expression of a social fabric that defends itself." This makes defensible space much more complex than simple target hardening; that is, creating "safe" environments using locks and chains. Defensible space is an environment in which the inhabitants have a sense of community and territoriality. The inhabitants of such an environment will therefore protect and maintain their living space from intruders. In addition, potential criminals will perceive this territorial influence and will, accordingly, be deterred from committing crime in this area.

In his book, <u>Defensible Space</u>, Newman (1972) analysed the occurrence of crime in publicly owned housing estates. It was his contention that public housing projects lacking in defensible space features are particularly vulnerable to crime. To test his theory of crime prevention, Newman compared the amount of crime that occurred in public housing lacking defensible space features and public housing that met his criteria for good defensible space features. From these matched comparisons Newman concluded that the architectural design of buildings can influence the social interaction of people and can reduce the frequency of certain types of crime.

Whether or not Newman's crime prevention theory is successful remains a clouded issue at this time because his work lacks large-scale empirical verification.[8] Many of his concepts, such as territoriality and defensible space, are but unproven concepts waiting to be tested. Yet it may be a long wait because of the many methodological and theoretical shortcomings of Newman's work which may very well deter future empirical verification. Bottoms (1974:206) has stated that "Newman has, in short, drawn our attention to an important theme but by the relative crudity of his treatment of it has run a serious risk of debasing the importance of that theme." The following criticisms point out some of the weaknesses of Newman's work.

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[8]In a recent Canadian study, Newlands (1983) tested several of Newman's concepts. Breaking and entering patterns were analysed in a small forty block area in Vancouver, British Columbia. The results of this study found some limited support for some of Newman's concepts. In another study, Mawby (1977) found no support for Newman's belief that high-rise apartments are more vulnerable to crime than conventional housing.

1. Although Newman offered some empirical support for his findings, that support has been consistently regarded as grossly inadequate throughout the literature (i.e., Adams, 1973; Hillier, 1973; Kaplan, 1974; Bottoms, 1974; Mawby, 1977; Mayhew, 1979b). It has been noted that:

   a. his two main statistical methods, multivariate analysis and comparison of coupled projects, yield surprisingly little support for his conclusions;

   b. there is no justification for the projects that he chose to examine, which means that they may have been selected because they best demonstrate his theory;

   c. there are several errors in his calculations and tables;

   d. Newman seems to have omitted vital data, which may have acted in an extraneous manner, when comparing the two projects (e.g., socio-economic differences);

   e. there are not enough details given about the design differences between projects which may affect territorial feelings;

   f. Newman uses the offence rates of the areas but does not discuss the offender rates, or the extent to which crime is committed by locals as opposed to nonresidents;

g. Newman is uncritical in his use of official criminal statistics and gives no hints that he is even aware of the well-known problems that are associated with their use.

2. Newman has treated the crime phenomenon too simplistically. He puts forth a global theory of residential crime without paying attention to crimes of different kinds that may require differently tailored prevention stategies. Mayhew (1979b:15) has further noted that "Newman has failed to consider that the four key elements might contain contradictions within themselves and might include factors which threaten as well as enhance security." For instance, to enhance surveillance one might provide more window space. While this design feature might deter muggings it could conceivably increase burglaries. Windows might act as an environmental cue that attracts burglars because they provide an easy entry route.

3. Newman treats the criminal as an outsider and the outsider as criminal. Crime is blamed on people who live outside of an area when much of the crime could be perpetrated by neighbours. Conklin (1975:33) believes that this "view of

the criminal as a mysterious, unknown predator may increase anxiety about crime, but it also makes continued residence in the community psychologically possible." Such notions can lead people to fear crime unjustifiably in safe communities or make people feel secure in areas with abnormally high crime rates.

4. Newman failed to consider that his defensible space measures may conflict with life-style preferences or solutions to social problems other than crime. Many people will not be willing to give up their privacy in order to increase surveillance. Neither may they be willing to walk through sterile parks with little or no aesthetic value.[9] Moreover, should society adopt security as a social goal when it cannot yet provide adequate housing for many people?

5. Newman failed to appreciate that architects have certain inherent biases. Porteous (1977:328) has raised the ethical problem of whether planners should plan for people; or with people; or allow the planning to be facilitated by people who live in an environment. People may not want to live in an environment built to defensible space specifications; should we force them to?

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[9] A park designed with defensible space features would appear very spartan. It would contain very few trees or shrubs in order to optimize surveillance potential.

6. The design features advocated by defensible space theory may only change the outer surface of the environment. The environmental changes may be so minor that criminals do not perceive a difference in the environmental cues. It is quite possible that criminals may not perceive, let alone be deterred by, some of the symbolic barriers that Newman has suggested to demarcate territorial boundaries.

7. Newman's notion of creating a social fabric that defends itself may only work for certain groups of people. Different groups of people have different interaction patterns so it might not be feasible to expect every home owner to develop a sense of community or latent sense of territoriality. The best way to develop a cohesive neighbourhood might be to segregate people, which may not be a desirable social goal e.g., keeping the old from the young or by segregating ethnic groups.

8. Newman has also failed to discuss many of the practical problems associated with CPTED. Repetto (1976:284) has identified four of these problems:

    a. the construction costs of remodelling or building various facilities;

    b. the time delays associated with the construction phase will delay any reduction in crime for years;

    c. there will likely be forced dislocation of individuals and businesses or at least a significant alteration in their life patterns in order to accomplish the physical projects that will be required; and

d. there will also be sunk costs associated with the physical changes that were instituted.

Because of these practical problems, architectural design is not likely to be used when other alternative methods are available to reduce crime.

9. Newman has also made some rather questionable assumptions about the nature of criminal acts with regard to the intention and motivation of criminals. He explicitly argues (1972:205) that much of the crime that occurred in the housing projects he studied was of a spontaneous variety (not premeditated). Newman takes this position in order to argue that CPTED will abate crime rather than displace it. If a lot of crime is a spontaneous reaction to an opportunity then Newman suggests that the reduction of opportunities will naturally result in less crime. This is in sharp contrast to opponents of CPTED who argue that if opportunities are reduced or made unattractive, then criminals will seek them in other locations. While the issue of displacement or abatement has not yet been settled, it is naive of Newman to assume that most of the crime in his study was of the opportunistic variety.

10. Because of the prohibitive costs that many CPTED strategies might entail, it is quite likely that many of these measures will only be adopted by those members of our society who have discretionary income. If there is a displacement effect, then those areas without any CPTED measures are going to have an increase in crime. It might be argued that the poor suffer enough without being burdened with the upper classes' share of crime.

11. Perhaps the greatest problem with Newman's work is its lack of construct validity. Many of Newman's key concepts cannot be easily operationalized, if at all. How does one quantify and measure territorality, surveillance potential, or the image of a building? These theoretical abstractions may have no direct relation with the real physical world.

Despite these major shortcomings, the Newmanesque approach has attracted many followers. Basically there are at least three reasons why this Newmanesque approach is so appealing.

First, the shortcomings of Newman's work are not particularly well-known. Reppetto (1976:280) has noted that Newman's "Defensible Space" (1972) received major critical attention in leading magazines and newspapers yet has failed to be reviewed by the major criminological journals.[10] Mayhew (1979b) later gave a very comprehensive and critical review of Newman's work; however, this article was seven years too late in coming and has probably been over-looked by most practioners. Furthermore, it is doubtful whether practioners are concerned with the methodological and theoretical shortcomings of Newman's work; especially when his ideas make such good common sense. One uncritical reviewer stated that:

> The tone of the book is practical, down-to-earth and incremental...All this sounds like good common sense except that Newman is able to back up his message with diagrams and statistics.
>
> (Sommer, 1974:97-8)

It is this common sense approach of Newman's writing that accounts for much of his popular appeal. Sellitz, Wrightsman and Cook (1976:3-7) identified three major problems with modes of thought that depend on common sense.

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[10] Reppetto (1976:282) goes so far as to suggest that the reason that criminologists have ignored Newman's work is due to resentment.

> "Outsiders are never well received in any field and the fact that public attention afforded to ... Newman's ideas about crime prevention far exceeds any similar attention given to ideas of professional criminologists does not make for smooth interaction."

1. Common sense limits people to the familiar. Consequently one's ideas may be limited to a nonconscious ideology.

2. Common sense concern with the immediate often results in coexisting contradictory beliefs.

3. Common sense problems are self-limited since they formulate neither theoretical nor methodological problems. This is because it takes its assumptions and methods as given. Sometimes, of course, common sense solutions are correct, while social science methods lead in the wrong direction.

Another reason why Newman's work is so appealing comes from his production of how-to-do-it manuals on reducing crime. Mayhew (1979b:152) has noted that the fact "that Newman gave detailed instructions for achieving defensible space was an unusual bonus for practitioners normally given only vague suggestions as to how to deal with crime." This has resulted in many ardent supporters of Newman's ideas amongst the policing community. His ideas clearly mesh well with the "lock-and-bolt" mentality of many law enforcement agencies which have simply equated CPTED with target hardening (e.g., better locks for doors and windows, the installation of electronic alarms and surveillance aids, and better forms of lighting). This Newmanesque approach to CPTED has encouraged many police departments to scrutinize architectural and planning designs in order to make recommendations and changes with regard to planning features that may elicit potential criminal opportunities. It is this influx of police interest and expertise that is the actual catalyst in stimulating the growth of CPTED.

Although Newman's work suffers from some severe methodological shortcomings he may have provided some important clues as to the nature of criminogenic settings. If one accepts the premise that the public housing projects that Newman identified as having poor defensible space features are conducive to crime, then the next step is to identify the specific design elements of these projects that account for these criminogenic conditions. From his theoretical outlook, Newman assumed that these criminogenic design features were high-rise apartments, double loaded corridors, poor lighting, etc. These features may be conducive to crime but the conceptual links were not tested by Newman; that is, no evidence was given that these specific physical features were associated with crime. Since this type of <u>ex post facto</u> research lacks controls there is the constant risk of improper interpretation. Kerlinger (1973:39) has noted that if one proceeds from the dependent variable to the independent variable, in <u>ex post facto</u> research, then it is easy to accept the first and most obvious interpretation of an established relation. There may be thousands of environmental cues that people perceive, either consciously or subconsciously, when analysing potential criminal opportunities. Each one of these environmental cues must be empirically tested to verify it's criminogenic effect. It may be questionable as to whether Newman found any statistically significant relationships amongst his environmental variables but this does not undermine the importance of the theme.

While architectural design considerations for the reduction of crime might be welcome by the victims of crime there is the manifest danger that some action might be initiated before the potential criminal opportunities have been identified. While initiating some CPTED strategy could possibly reduce some types of crime, it could likewise conceivably increase the amount of other crimes. A body of knowledge that can identify environmental features that are criminogenic does not yet exist.[11]

It is quite conceivable that somebody (e.g., an architect, a city planner, or a police officer) could make design changes to the environment that are criminogenic as opposed to providing a milieu for defensible space. Those people who attempt to

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[11] This statement does not imply that CPTED assumes environmental determinism. It merely suggests that certain environmental features may provide potential criminal opportunities. The environment does not cause crime but it does affect an offender's choice, whether or not it is made consciously. Many authors find it more useful to think of CPTED in terms of "environmental probabilism". The Brantinghams (1978:106) have noted that "environmental probabilism asserts that lawful relationships between the environment and behaviour exist; but that these relationships are probabilistic rather than certain. At any point in time many paths of action lay open to an individual, and predicting individual behaviour absolutely is impossible; but predicting behaviour within a degree of uncertainty is possible."

prevent crime through environmental design are operating on a haphazard basis until features of the environment can be indentified that are criminogenic. Ex post facto research must be done first, before experimental research, to establish statistical associations. It is this haphazard approach towards CPTED that is so dangerous. It leads to the latent hazard that practioners may lose their interest in this field prematurely. If research in this area starts to show that these haphazard strategies are not working then efforts in this field may be abandoned. So far the few studies that have examined Newman's propositions have not been too supportive (e.g., Mawby, 1977; Newlands, 1983) and there is already an air of pessimism.[12]

Most of this chapter has been highly skeptical and critical of the direction that CPTED has proceeded. If it has ended on a pessimistic note then it has served a functional purpose because the situation does not have to remain this way. The first step in reducing crime is to identify criminal opportunities. It has already been argued that this is the central tenet that the validity of CPTED rests upon. Perhaps it is now time to "put the horse before the cart".

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[12] Mayhew (1979b:157) summarized the little research done in this area and was led to conclude that "defensible space has considerable intuitive appeal, but it may have been oversold."

III. THE IDENTIFICATION OF CRIMINAL OPPORTUNITIES

In order to prevent crime through environmental design it is first necessary to identify the criminal opportunities that are to be changed. The concept of a criminal opportunity is complex. It is not object, but an object interpreted or perceived by a criminal (Rengert, 1981). A criminal opportunity has three elements which must be considered in an integrated fashion: objective site characteristics, spatial attractiveness, and target attractiveness. In a locational sense an inaccessible opportunity is no opportunity at all. Likewise, if an opportunity exhibits no target attractiveness to the potential offender then it cannot be considered as an opportunity.[1] The environment emits many signals, or cues, about its physical, spatial, cultural, legal, and psychological characteristics (Brantingham, 1978:3) which are used by the potential criminal to evaluate opportunities. Research is needed in order to establish the causal relationships between environmental opportunities and criminal behaviour.[2] It has already been

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[1]Target attractiveness has two basic components: lucrativeness and vulnerability. The lucrativeness of a target is the perceived monetary or aesthetic value a criminal sees in an object. The vulnerability of a target is based upon the criminal's perception of how easily the act can be carried out.

[2]Again it must be emphasized that these causal relationships are in terms of environmental probabilism and not to be associated with environmental determinism.

pointed out that very little research has been done in this area due to the etiological bias of traditional criminologists. Another reason why very little research has been done in this area may be due to a lack of criminological data bases at low levels of aggregation.

Level of Aggregation

Census data are a notable example of a data base that is often used by criminologists. Although not created for the study of crime, census data are used by social scientists because they are easily accessible and relatively cheap to obtain. Yet they are a highly questionable as a criminological data base. The types of questions that criminologists would often like to ask of census data cannot be asked unless one is willing to fall into the ecological fallacy.[3] Data at high levels of aggregation cannot answer many of the interesting questions about specific crime sites. The Brantinghams (1976:264) have noted that:

> the mapping of variables into areal aggregates limits comparative analysis to variables which have been mapped into similar levels of aggregation and further limits the questions that can be validly asked of the data to those which are appropriate to such levels of aggregation.

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[3]The ecological fallacy (Robinson, 1950) occurs when one illegitimately shifts from relations among the properties of groups to relations among the properties of individuals. An ecological correlation is not necessarily equal to its corresponding individual correlation.

In order to study the spatial and target attractiveness of criminal opportunities, an environmental data base at least at the street address level of detail is needed. Data are needed at this low level of aggregation to determine what environmental cues contribute to criminogenic conditions. The development of an environmental opportunity data base is a formidable task. Criminologists have never concerned themselves with this problem because they have not yet reached the stage where they can easily produce a complementary data base of criminal events at the address level.

It has only been with the advent of the technological evolution of computers that some police departments are now beginning to record crime at a machine readable address level. Police have usually recorded the location of crimes, victims, and offenders but never in a systematic fashion that could easily be used for research purposes. In order to obtain address information about crimes it is necessary for criminologists to search police files manually in order to extract the needed information.

Contemporary urban police forces are only now beginning to realize the need for improved information handling. Experimental projects in Akron (Pyle, 1974) and Dallas (Makres, 1980) have demonstrated the advantages to police forces in developing in-house data analysis and display systems.[4]

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[4]The advantages that these computerized police records offer are in terms of management purposes (e.g., interdepartment communications, reduction in storage space) and for crime analysis (Sanders, 1980:278). Address based crime files also

The most important element of these computerized systems is that the address of crime occurrences is treated as a variable. This allows the police to respond to areas that are temporarily experiencing high rates of crime. This is not possible using manual records because of the time delay in recording crime (Makres, 1980).

Criminologists also benefit when the police produce data at an address level since this information can be used to analyse the opportunity stucture of the environment. This is something that has only been available to criminologists at a great cost. The expense of obtaining address level data has meant that very few criminological studies have examined the opportunity structure of the environment. As a result, criminological endeavor is mainly confined to easily available aggregated data, such as census data, which only allows criminologists to speculate about the etiology of crimes. From this perspective, the dispositional bias of traditional criminologists can be viewed as an inherent problem tied to the limitations of their data. As criminologists refine their data, they will also refine their theories. Conversely, as criminologists refine their theories, they will also refine their data.

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[4](cont'd) have the potential to provide invaluable information to the police officer on the beat. Before an officer responds to a call, a case history of crime occurrences at the residence or neighbourhood can be obtained before he enters an unknown situation.

The Use of Official Police Statistics

One of the most serious drawbacks in the study of criminology is the enormous cost and time it takes to obtain crime data. Criminologists often rely upon other sources to obtain their data, such as agencies of the criminal justice system. Of course, these agencies gather data to meet their needs as opposed to those of the researchers. For example, police reports are recorded in order to investigate crimes, to document evidence for court, and to report crime totals; purposes which sometimes elude the critics of official statistics. There is often no fault in the way these agencies collect their data but only in the method that researchers use it; usually for purposes for which it was never originally intended.

The use of official crime statisitics has occupied several decades of intense criminological debate. The central issue in this debate revolves around the "dark figure", the amount of crime that goes undetected, unreported, or unrecorded. Hood and Sparks (1974) have noted several common reasons why crimes may go unrecorded:

1. The criminal behaviour may not be perceived as a crime by the victim or other witnesses.

2. The victim may know a crime has been committed but not

report it because he may have sympathy with the offender or may regard the harm done as too trivial in relation to the consequences; he may dislike or not trust the police and the courts; he may live in a community where it is deviant to report a crime; he may fear reprisals; he may fear that his own deviant activity will be exposed; or he may feel that nothing would be achieved by calling the police.

3. There may be a high social toleration of crime.

4. Shrinkage in the number of recorded crimes often occurs because police either did not come when called or failed to regard the incident as a crime and consequently did not record it.

The imperfections of official statistics have led criminologists to devise other ways of counting crime (e.g., self-report studies and victimization surveys) but these methods are not without their own shortcomings. Nettler (1974:96) has noted that "an evaluation of these unofficial ways of counting crime does not fulfill the promise that they would provide a better enumeration of offensive activity". None the less, the extremely high cost of gathering unofficial statistics rules out this type of data for environmental studies at low levels of aggregation.

The use of official police data can invalidate spatial analysis in two ways: differential attention to different neighbourhoods by the criminal justice system (i.e., pro-active policing) or differences in the willingness of residents of different parts of a city to report crime incidences (Brantinghams, 1981). In one of the few studies that has examined the spatial bias of police data, Mawby (1981) found no indication that police data is spatially skewed.

A study by Schneider (1976) found changes in the reporting behavior of residents after the introduction of a neighbourhood-based property identification program. Despite the potential criticisms, the use of police data is not necessarily problematic for some types of spatial analysis. Police only use pro-active policies for specific types of crimes. Police usually only respond to property crimes in a reactive manner, which rules out the possibility of spatial bias on the part of police.

For the purposes of this study, if one assumes that the reporting rate of crimes is constant across the different types of street segments, then the use of police statistics should cause no concern.[5]

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[5] If there was any difference in the reporting rate of crime, one would expect to find a higher reporting rate for victims of commercial establishments. Since commercial establishments would be found on more highly accessible street segments, more crime would be reported on these streets, than on less accessible streets. Consequently, the differential reporting rate could be acting as a confounding variable. To eliminate this possible explanation, a spatial analysis of property crime must be performed separately for commercial and residential crimes. This was done in the current study and no differences in the spatial patterns were observed, of residential and commercial crime, when examining the accessibility of streets. This was taken as

While it is rather easy to suggest that spatial bias may exist in the way people report crimes, it is much more difficult to devise a plausible argument to explain this phenomenon. To make such an argument one would have to believe that certain types of people use street accessibility as a major criterion in their decision to purchase homes. Such an argument is highly implausible and probably merits no serious attention.

Theory Guided Research

The preponderance of criminological research is of an *ex post facto* nature. According to Kerlinger (1973:379):

> Ex post facto research is systematic empirical inquiry in which the scientist does not have direct control of independent variables because their manifestations have already occurred or because they are inherently not manipulable. Inference about relations among variables are made, without direct intervention, from concomitant variation of independent and dependent variables.

Ex post facto research suffers from several severe limitations. Kerlinger (1973:390) has noted that this type of research design has three major weaknesses.

1. The inability to manipulate independent variables.

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[5](cont'd) confirmation that there was no spatial bias in the police data that were used.

2. The lack of power to randomize.

3. The risk of improper interpretation.

The inability to manipulate the independent variable and the lack of power to randomize, stems from the problem that it is inherently impossible to modify the physical environment once an event has already occurred. Any conclusions drawn from an <u>ex post facto</u> research design will always be weak because the results could be due to chance relations or to any number of possible extraneous variables that cannot be experimentally controlled. This inability to control experimentally potential mitigating variables can lead to the acceptance of the first and most obvious interpretation of any chance results.

Since most criminological research is of an <u>ex post facto</u> nature, it is very important to be guided by theory. Without a theory to guide the researcher, it is difficult to find or justify a starting point. For example, in comparing burglarized to non-burglarized houses for differences, the number of variables that could be chosen from the thousands of environmental cues present are virtually limitless. By working without a theory, it is easy to accept the first and most obvious interpretation of an established relation. The more relations one examines, the greater the probability that some chance correlations will be found. Of course, even when guided by a theory, the results are tentatively weak because they may still capitalize on chance relations. Merton (1949:91) noted that because of the flexibility of post factum explanations that whatever the observations, new interpretations can be found to "fit the facts". The retort to this line of logic is that at least when guided by a hypothesis, the researcher has the satisfaction of having the "facts fit the theory". When the facts do not fit the theory then knowledge is advanced through falsification (Popper, 1968). While it is widely acknowledged that the principle of falsification has severe limitations, it does give support to the scientific venture of doing theory guided research (Chalmers, 1976). Another advantage of conducting theory guided ex post facto research is that it eliminates a lot of implausible variables and makes the research job more manageable. With an environmental and crime data base at a street address level, the probabalistic relationships between environmental opportunities and criminal behavior can be more fully explored.

Hirschi and Selvin (1973:38) have identified three criteria of causality which are necessary to establish causal relationships.

1. Association - A and B are statistically associated.
2. Causal order - A is causally prior to B.
3. Lack of spuriousness - The association between A and B does not disappear when the effects of other variables causally prior to both of the original variables are removed.

The first step in identifying criminal opportunities is to show that a relationship, or a statistical association, exists between environmental opportunities and criminal behaviour. If criminal behaviour occurs in a completely random fashion, then no spatial relationships between crime and opportunities should exist. This seems unlikely as the spatial patterning of crime has long been observed. The second step, causal order, means that the the environmental opportunity must attract the criminal to the spatial location and target. It is not necessary to establish causal order for property crimes because it is nonsensical to consider the criminal as being causally prior to the opportunity; that is, the criminal does not attract the opportunity.[6] Whether or not criminals are aware that they are being attracted to an opportunity, makes no difference to the causal order as the process can be either conscious or subconscious. The third criterion of causality is to show that the relationship between environmental opportunities and criminal behaviour is not spurious. There is always the possibility that an or extraneous variable may account for the association. While it is methodologically impossible to test for every extraneous variable, it does strengthen one's argument to consider alternative explanations and to eliminate the more

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[6] For some types of violent crime (e.g., murder, rape, or assault) causal order may have some significance; that is, the criminal may attract the victim.

plausible ones.[7]

In order to document the relationship between environmental opportunites and criminal behaviour there are two possible research strategies. The first is to interview criminals as to the environmental cues that attract them to targets. Research of this kind will no doubt produce many suprising results as criminals' perceptions of targets may differ drastically to what police and researchers think. It is quite possible that perceptions of what constitutes an attractive target are quite varied even amongst criminals for the same types of crime. This kind of research may question the utility of having police provide their expertise to modify the physical environment to eliminate what they perceive to be criminogenic opportunities. Of course, the converse may also be found.

The problem with this type of research is that usually the only criminals available to be interviewed are those who have already been caught and they may not be representative of the criminal population at large. Rengert has suggested that this issue may be a "red-herring" as many offenders are apprehended on the basis of misfortune rather than on the basis of poor criminal skills.[8] The other difficulty with this research

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[7]Blalock (1961:6) points out that causal laws cannot be demonstrated empirically, but that is is helpful for us to think in causal terms.

[8]This is based on Rengert's current research of interviewing professional burglars as to their choice of targets in relationship to their home location. The results of this study have not yet been published but were discussed in a seminar presented at Simon Fraser University.

technique is that criminals may subconsciously respond to environmental cues. If this is the case, then these subconscious environmental cues will not be uncovered in the interview process as the criminal will not be aware of them.

Another research stategy that may uncover relations between environmental opportunities and criminal behaviour is by spatial mapping. The relationships between the home location of property offenders and their targets can be studied. One approach could involve comparisons between those targets that a criminal chose and those that he did not choose. What factors led a burglar to break into one house and leave the neighbours' homes untouched? The differences in the architecture, occupancy, or spatial location of these homes may identify environmental cues that may attract criminals, whether or not it is a subconscious process.[9] This type of research calls for the study of the relationship between the offender and the target or victim. As previously discussed, this type of research can only now be realized with the advent of computerized police files that can provide the spatial coordinates of these relationships.

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[9]Of course this type of research is associational since causality can never be proven.

IV. CRIMINAL MOBILITY PATTERNS AND THE OPPORTUNITY STRUCTURE

Opportunity and Awareness

Much of the current research in environmental criminology has only considered the objective site characteristics of opportunities. While this is important, it still does not explain the cognitive process by which criminals evaluate the suitability of targets or become aware of potential targets. This decision process is shown in Figure 1. This figure pictorially presents the view that etiological criminologists are primarily concerned with the motivation of a criminal while environmental criminologists concern themselves with the entire search process of evaluating the suitability of a target.[1] Whether or not a criminal is highly motivated, some form of a search process must take place in order for a crime to be committed. As depicted in Figure 1 this search process may be affected by the objective site characteristics and by the criminal's perception of

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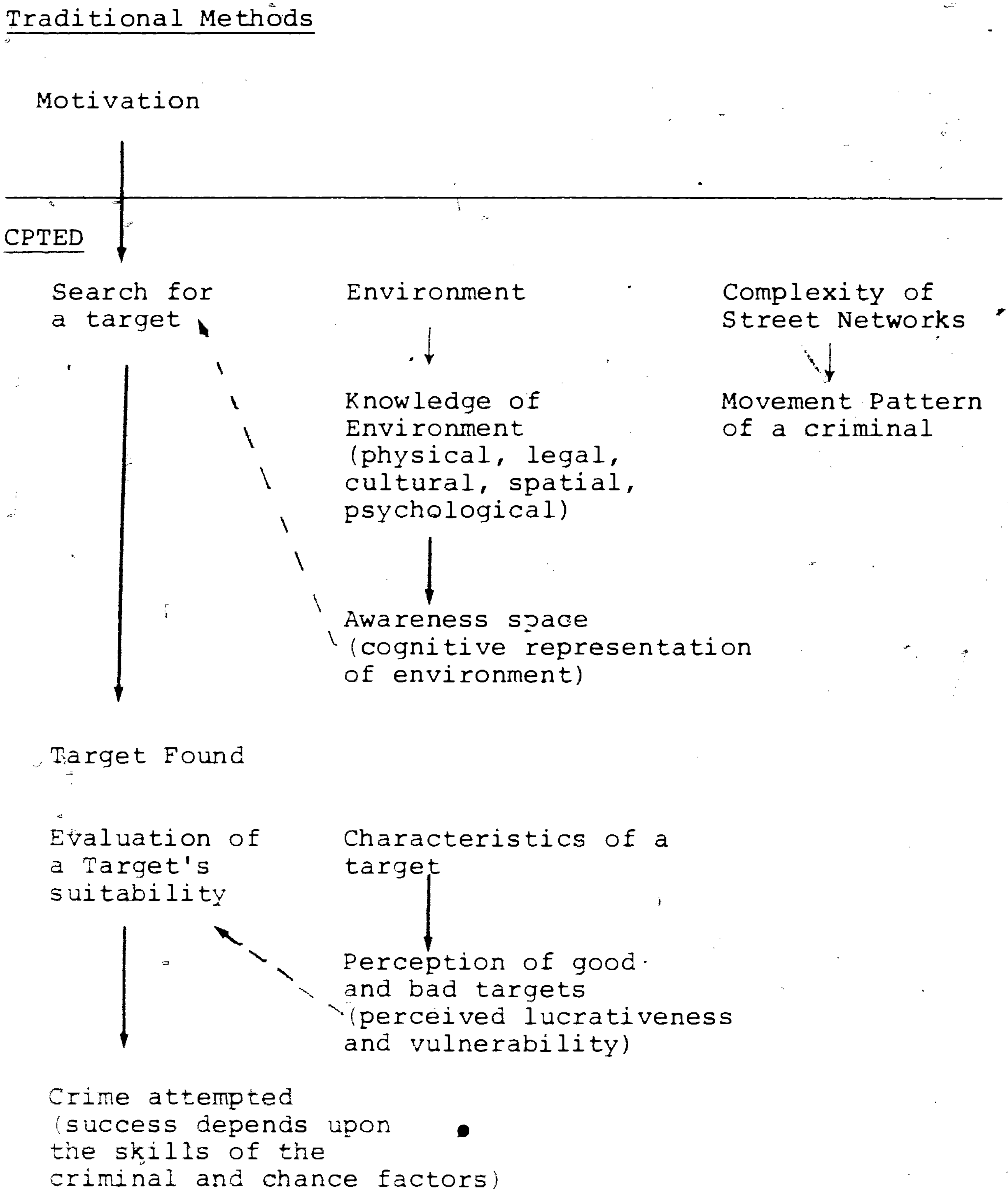
[1]The theoretical underpinnings of this model can be found in the urban research literature pertaining to "human activity systems". This literature examines "activity patterns" of people in terms of the motivation, choice, and action sequence. Chapin (1974) defines an "activity pattern" as a tendency for people in a given population to behave in similar ways.

Figure #1

Flow Chart: Criminal's Decision Process



what is a good or bad opportunity.[2] The search may also be influenced by the limitations imposed by the physical environment and one's knowledge of the environment. The knowledge, or awareness space, that criminals have of the environment and its potential opportunities, should largely depend upon their routine activity patterns. Those areas that criminals frequent probably form the dominant portion of their awareness spaces. Property crimes may occur in the same areas that criminals conduct their routine activity patterns.

From the literature it is clear that the opportunity structure of the environment influences criminal activity patterns (Boggs, 1965; Rengert, 1980, 1981). This influence stems from both the physical limitations that the environment imposes upon the individual and the cognitive representation (awareness space) that the individual has of the environment. It is the polarity of these two forces that has made it difficult to measure a target's probability of being victimized. Two measures are needed: an objective measure of the relative risk and some measure that will account for the subjective component or awareness that criminals have of different opportunities. It was the seminal work of Boggs (1965) that first presented an

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[2]Cohen and Felson (1979) argue that criminal acts require a convergence in space and time of likely offenders, suitable targets, and the absence of capable guardians against crime. They found that the dispersion of activities away from households and families increases the opportunity for crime and thus generates higher crime rates. The absence of capable guardians against crime is probably one variable that influences a criminal's perception of what is a good opportunity.

objective measure of the relative risk of opportunities;[3] but how does one measure or quantify the relative risk due to a criminal's awareness space? It is not sufficient to think of opportunities only in terms of objective realities. For instance, two houses would normally be counted as each representing an equal opportunity to a burglar. If one of these two houses was not in the awareness space of a burglar, then they could not really be considered as representing equal opportunities, as the unknown one would never be exploited. In attempting to define the relative risk of an opportunity, Rengert (1980:201) was led to conclude that:

> the relative magnitude of an opportunity is proportional to its relative degree of accessibility which will partially determine its probability of being exploited.

The street networks of the physical environment, to a large extent, influence the mobility patterns of people. The paths by which criminals regularly travel most likely influence their awareness of potential targets. The next section explores how street patterns can influence the movement patterns of criminals and how these patterns can affect the decision process for

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[3]In her study, Boggs (1965) demonstrated that simple resident population denominators, in crime rate ratios, can produce distorted pictures of crime distributions. She noted that crime rates should form probability statements and should therefore be based on the risk or target group appropriate for each specific crime category.

target selection.

Street Design and Crime

The idea that street design could influence crime was recently expounded by Newman (1976:60). It was his contention that the existing fabric of city streets can be subdivided in order to create territorially defined blocks. As the territorial subdivision of streets in an area increases, the residents are more likely to increase surveillance because they can better recognize who does not belong in the area. With an increase in territorality, surveillance also increases; both of which contribute to a reduction in crime. Empirical support for this contention was provided by Newman (1980) in his most recent book, Community of Interest. This study examined the privatization of streets in St. Louis.

According to Newman, in order to arrest the social decay of their neighbourhoods, a few residents of St. Louis banded together to buy back their streets from the city. The citizens of these private streets legally own and maintain their streets which used to be the responsibility of the city. The distinguishing features of these private streets, as outlined by Newman (1980:126), are:

1. each street is blocked off at one end to prevent through traffic, and

2. ownership of each street right-of-way by the residents is guaranteed by a deed of restriction attached to all property.

The closing off of streets reduces pedestrian and vehicular traffic and apparently creates a psychological effect that encourages residents to think of their own street as their neighbourhood or "home turf".

In order to test whether these private streets had lower crime rates than public streets, Newman examined three matched comparisons. Newman concluded that even though each street showed some idiosyncrasies in the criminal behaviour, the private streets had less crime in almost every crime category. The only exception to this trend was for the crime of burglary.[4] Newman (1980:142) offered two explanations as to why the crime of burglary appears to be an anomaly.

> First, physical closure and institutionalized ownership may make a stranger more obvious and residents more watchful, but it may do little to clandestine entry into a structure from the rear alleys and yards, which, although privately owned, are often only minimally fenced. Second, the very status of the private streets (composed of middle-class single family homes) compared with adjacent public streets (composed of lower-income multifamily homes) may serve to label the private streets as lucrative targets for burglary.

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[4]The other crimes examined were assault, purse snatching, vandalism, theft from auto, and theft of auto accessories.

While this latest study by Newman gives further support for his defensible space arguments, the results must be tempered because of their _ex post facto_ nature. Alternative explanations can be devised to account for his empirical findings.

For example, one of the most serious problems with Newman's latest study was the way in which the crime rates were constructed. The numerator consisted of the number of officially recorded crimes on each block (broken down into the six types of crime) while the denominator was based on the population of residents residing on each block. The population was derived from resident interview responses[5] and the U.S. Bureau of the Census (1970). It is this population figure, of the private and public streets, that may be acting as a statistically confounding variable. One of the requirements of living on a private street is the maintenance of single family residential occupancy. This is not the case for public streets as Newman noted that these streets were deteriorating with many conversions of single family dwellings to multi-family occupancy.

> From a visual perspective, the private streets appear to the potential buyer to be stable and well-maintained residential environments. There is none of the physical

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[5]It was never made clear whether these resident interview responses contributed to the population counts of street blocks. Such data could, if systematically carried out, adjust imperfections or inaccuracies in the census data. However, it would appear that interviews were conducted, mainly with residents of private streets, in order to get their impressions and perceptions of the quality of life in their neighbourhoods.

deterioration prevalent on the surrounding public streets, nor are there any houses which give the unmistakeable sign of having been converted to multifamily occupancy...Recent conversions have made the street a mixture of multifamily and single-family dwellings. The street is occupied by a mixture of middle and lower-income blacks.

(Newman, 1980:131&139)

The net effect of these multi-family conversions is that it may dramatically boost the population of the public streets, which would not be reflected in the census figures.[6] This may result in the denominator of the rate figure for public streets being much too low. Such an under-count could account for the differing crime rates on these two types of streets. Simply because it was difficult to find the current population for each street is no reason to settle for inaccurate and outdated information. Newman's analysis would be more illuminating if he had considered an alternate denominator in the calculation of his rates. Rather than using the conventional population denominator he could have selected ones that would have adjusted for environmental risk or opportunity (e.g., the number of houses or automobiles on each street segment). Many of the crimes that Newman examined are meaningless when expressed in terms of the total population. For instance, burglaries could

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[6] The reason why this population increase will not be reflected in the census figures is that the census was taken over a decade ago, while many of the conversions are recent. Furthermore, there is current debate about the accuracy of the census when it comes to counting illegal suites and their occupants as the landlords are unlikely to report them due to fears of income tax invasion. Only recently, cities in the U.S. were complaining that the recent census (1980) missed counting millions of illegal aliens which meant missed Federal Tax support.

have been examined per units at risk rather using population as the denominator. Harries (1981:148) has noted that:

> population may be conceptually appropriate as a denominator for some offences, but the uncritical application of population as a denominator for all crime categories may yield patterns that are at best misleading and at worst bizarre.

Another serious problem in the way that Newman constructed his crime rates deals with the numerator. There could be a difference in the reporting behaviour between the residents of the two different types of streets. Although both receive patrolling by city police, it is quite possible that people who live on private streets report less crime than people who live on public streets. Since residents of private streets have divorced themselves from the city, in terms of buying back their own streets, they may have become a community unto themselves. The residents of these private streets may have formed close neighbourhood ties with each other to the extent of becoming social elitists. They may feel no need for police intervetion as they are often ineffective in solving property crimes. The territorial feelings they developed about protecting their own community may have displaced the need for bringing in an "outside" police force. Consequently, if the police are not called, then no file can be opened. This explanation offers a different view for the anomaly that Newman found for the burglary rates.

Burglary is one of the only serious crimes that people protect themselves against and this is done through buying houshold insurance. In order to make an insurance claim for burglary, the victim must file a police report of the incident; this is to eliminate fraud and to substantiate the claim. This may account for the high rate of burglaries reported by private street residents because they may be more inclined to purchase insurance than residents of public streets because they are higher in the socio-economic bracket. The other crimes that Newman examined (assault, purse snatching, vandalism, theft from auto, and theft of auto accessories) are either not insurable or are often considered too petty to bother making a claim, especially when there is a deductible that must be paid. It would be more helpful if Newman had examined some other crime such as car theft, which has a high reporting rate because insurance is mandatory. The overall effect of a low reporting rate of crime by the residents of private streets would be the illusion of less crime.

The History of Street Design and Crime

Newman was not the first to express the idea that street design could influence crime. Many authors noticed distinct relationships between these variables while others have hinted at possible connections. Tobias (1972) and Dyos (1957) noted how the rookeries (criminal areas) of early Victorian London were displaced through the placement of new streets. For example, in order to reduce crime, Victoria Street was deliberately run through the infamous Westminster rookery. The purpose of the placement of these major streets was to break up the rookeries and displace their criminal occupants.

> The objects of street improvement in early Victorian London were seldom single, for street improvement during these years provided almost the only effective way of rectifying on a grand scale some of the worst features of urban growth. The disjointed maze of streets in central London was not only inefficient for transport and frustrating for the police but prodigal of human life. Thus, street improvements became not merely a method of increasing the circulation of traffic but a blunt, though seemingly effective, instrument of slum clearance.
>
> (Dyos, 1957:264)

The early positivist, Enrico Ferri, also thought that crime could be dispersed through the introduction of major transportation routes.

> And robbery and brigandage? They withstand the death penalty, and extraordinary raids by soldiers...Wherever the woods are not traversed by railroads or tramways, brigandage carries on its criminal trade. But whenever railroads and tramway visit, brigandage is a form of crime which disappears. You may insist on death penalties and imprisonment, but assault and robbery will continue, because it is connected with geographic conditions.
>
> (Ferri, 1968:98)

Ferri was well aware of the vast importance that the concept of prevention holds in the effort to reduce crime. Many aspects of environmental design can be traced back to this early pioneer in criminology.

> High roads, railways, and tramways disperse predatroy bands in rural districts, just as wide streets and large and airy dwellings, with public lighting and the destruction of slums prevents robbery with violence, concealment of stolen goods, and indecent assaults.
> (Ferri, 1896:123)

Yet the advent of better transportation networks did not always coincide with reduced amounts of crime. For instance, Glyde (1856) found that the highest rates of crime for medium-sized towns, in Sulfolk during the mid-eighteenth century, occurred along the major highways. This finding seems to be a common phenomenon even in today's society. Several authors have found that there are higher crime rates near major arteries (Angel, 1968; Luedtke et al., 1970; Wilcox, 1973; Duffala, 1976). The Brantinghams (1981:50) have suggested that the reason why there tends to be a concentration of criminal events close to major transportation arteries is because:

1. major transportation arteries are likely to become part of the awareness space of many urban residents, including potential criminals, and

2. major arteries offer easy access and escape to criminals.

Relations between streets and crime were also observed by members of the Chicago School. Burgess (1916:726) was led to conclude that one of the most important factors to the understanding of delinquency was the proximity of youths to business streets. This relationship was further expounded by Burgess (1925:152) in his discussion of the triangular relationships between the homes of offenders and the location of delinquent events. Unfortunately this observation, of the spatial patterning between a criminal's residence and the environmental opportunities, was buried under the general rubric of social disorganization. Social disorganization was used to explain the spatial patterns that were uncovered.

> Shaw and McKay concluded that proximity to industry and commerce was really a proxy for the less directly measurable social variable, social disorganization...The spatial characteristics of the crime pattern are reduced to little more than convenient devices for the organization of data bearing on purely social processes of motivation.
>
> (Brantingham and Jeffery, 1981:232)

This shift away from considering aspects of the physical environment as influential forces in shaping crime patterns has meant that in the last half-century there has been virtually no research examining the relationship between streets and crime;

not to mention other environmental variables.

The crime reducing potential of street network systems has for the most part been forgotten by contemporary urban planners. In a study by Appleyard and Lintell (1972:84), they found that "studies of urban streets have concentrated almost exclusively on increasing their traffic capacity with no parallel accounting of the environmental and social costs." Yet these same authors never entertained the notion that streets could alter or affect the crime patterns of cities.

The first contemporary writer to develop a theory linking crime to street use was Jacobs (1961) and this was only by inference. In her theory of crime control she explicitly outlined three coherent themes. First, Jacobs stressed that a clear distinction must be made between public and private space. Second, appreciating that a great deal of crime takes place in public space, Jacobs emphasized the need for surveillance. She argued that citizens must become vigilant and become "the eyes of the street". Third, she recognized that areas with few people around tended to have crimes committed there because there are no witnesses. Consequently, she stressed that the design of cities should be planned so that there is always moderate activity in areas such as sidewalks, parks, and streets. While some of these ideas appeal to common sense, Jacobs never developed the architectural plans to fulfill her ambitions of creating a safe city; this was left for Oscar Newman (1972).

It was the work of Jacobs and Newman that partially inspired Bevis and Nutter (1977) to do the first empirical study of street design and crime. While the previous work of Jacobs and Newman accentuated the importance of street layout, Bevis and Nutter emphasized a different theoretical perspective from the latter authors. Bevis and Nutter postulated that street layout can alter crime in ways other than increasing the territoralitiy and surveillance by residents. From interviews with prisoners, they found that burglars prefer to be familiar with areas they victimize and select targets that are convenient for both access and departure. This would mean that burglars are probably less familiar with, and find less attractive, those areas that are somewhat isolated or inaccessible. Bevis and Nutter also noticed that some of the early cognitive mapping literature (i.e., Moore & Golledge; 1976) pointed to some interesting observations that suggested that less accessible streets are travelled less by nonresidents than are other streets. This led Bevis and Nutter (1977:4) to hypothesize that "houses and apartments along less accessible streets will not be as familiar to nonresident criminals and will not be as frequently burglarized as will housing along more accessible streets."[7] This belief was further supported by interviews with

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[7] This is also another possible explanation for the results of Newman's (1980) study of the privatization of St. Louis streets. The fact that these streets were closed to through traffic would mean that criminals no longer travelled these streets and therefore may not of been aware of the potential opportunities that existed on them.

police who suggested to Bevis and Nutter that there are fewer crimes on cul-de-sacs and dead ends. Rather than redesigning streets in order to test their theory, Bevis and Nutter decided it would be wise to first empirically determine the extent to which existing types of street designs exhibit differing crime rates. They then carried out their study to statistically document the relationship between street accessibility and the rate of burglary.

In their study, Bevis and Nutter developed a typology of six basic types of street segments based upon their accessiblity (see Figure 2). Their findings indicated that there is a noticeable pattern of lower residential burglary rates for housing on those study blocks with lower accessibility and that there is an upward trend that relates increasing street accessibility with rising crime rates.[8] Despite the innovativeness of the Bevis and Nutter study, its impact has been limited because it has remained relatively unknown.[9] Fortunately, it has not been forgotten as the Brantinghams (1978,1981) have considered some of the ideas developed in the Bevis and Nutter study and consequently developed a more sophisticated theoretical underpinning for their findings.

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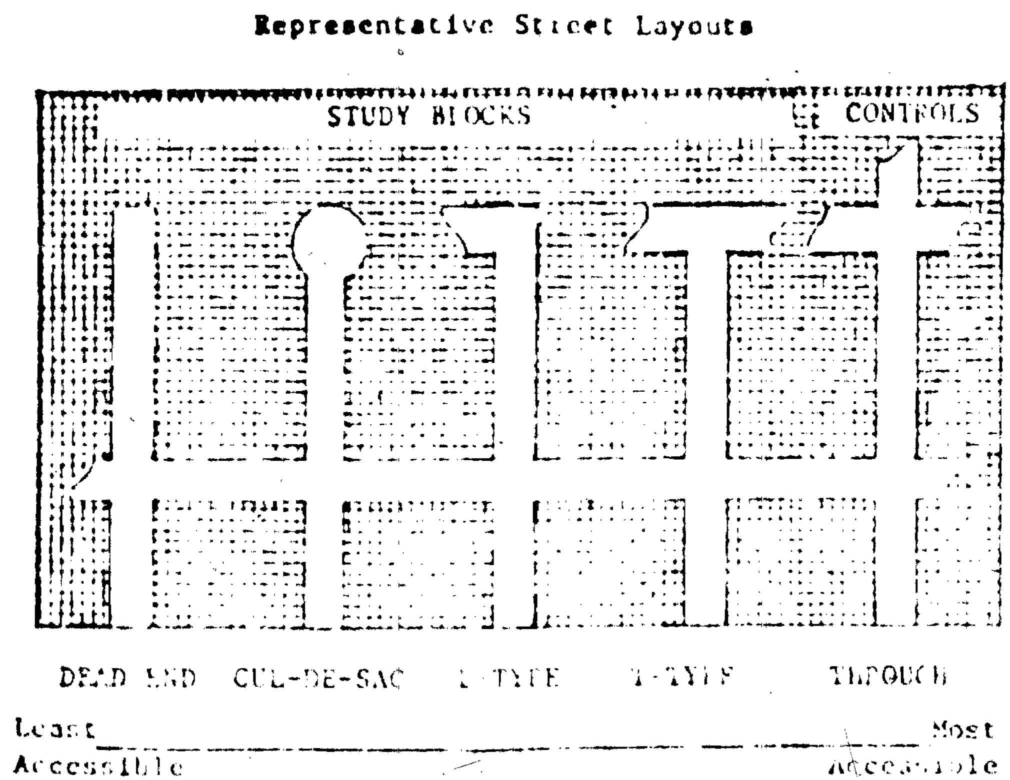
[8]The research design, methodology, and findings of this study will be discussed in the forthcoming section.

[9]Their study won the student paper competition at the annual American Society of Criminology meeting in Atlanta, 1977. A shortened version of their study was published in a relatively obscure publication by Frisbie (1977).

Figure #2

Typology of Street Segments: Bevis & Nutter (1979:8)



The Brantinghams (1978,1981) have developed a theoretical model of crime site selection that uses the concepts of opportunity and motivation and ties them together with the concepts of mobility and perception. Bascially, their theoretical model posits that criminals engage in a search for their targets or victims. The intensity of this search will depend upon how highly motivated they are to commit a crime. In order to evaluate and select targets, criminals will use their previous knowledge of the environment (either learned through experience or through social transmission); this is known as a criminal's awareness space.

Using their own theoretical model, the Brantinghams (1981:51) deductively arrived at some general statements about crime patterns; one of which is a theoretical elaboration of the Bevis and Nutter findings.

> In order for a crime to occur, the criminal has to locate a target or victim in his awareness space. A criminal's awareness space will change with new information and as the result of searching. The expansion of an awareness space will most probably occur in a connnected fashion; the borders or edges of currently known areas will be explored first. In exploring new areas, the potential offender will find it easier to penetrate areas with predictable road networks. Areas with grid street layouts are more predictable than areas with winding roads, cul-de-sacs, or dead ends.

The Bevis and Nutter Study: A Critical Review

The Bevis and Nutter study was divided into two phases. The first phase compared the residential burglary rates of individual blocks representing various layout types (refer back to Figure 2). A sample of eleven to sixteen blocks were randomly selected from the 127 census tracts in Minneapolis for each block type. For each of these study blocks, the nearest "through" block was selected to provide a matched pair as a control. The burglary rate for each of the four types of study blocks was then compared to each of the comparison groups of "through" blocks using a sign test. Their results showed that dead ends, cul-de-sacs, and L-type blocks had lower residential burglary rates than did their more accessible control blocks; however, burglary rates along T-type blocks exceeded the rates for its control blocks. Figure 3 describes their results.

Despite the anomaly presented by the T-type blocks in their matched comparisons, it seems that Bevis and Nutter missed an interesting observation. By averaging the rates of the control blocks together, to form one group, a linear trend can be seen from their data; see Figure 4. This linear trend clearly shows that burglary rates are positively associated with increasing block accessibility and the anomaly represented by the T-type blocks disappears with statistical averaging.

Figure #3

RESIDENTIAL BURGLARY RATES FOR STUDY AND CONTROL BLOCKS
Bevis and Nutter, 1977:9

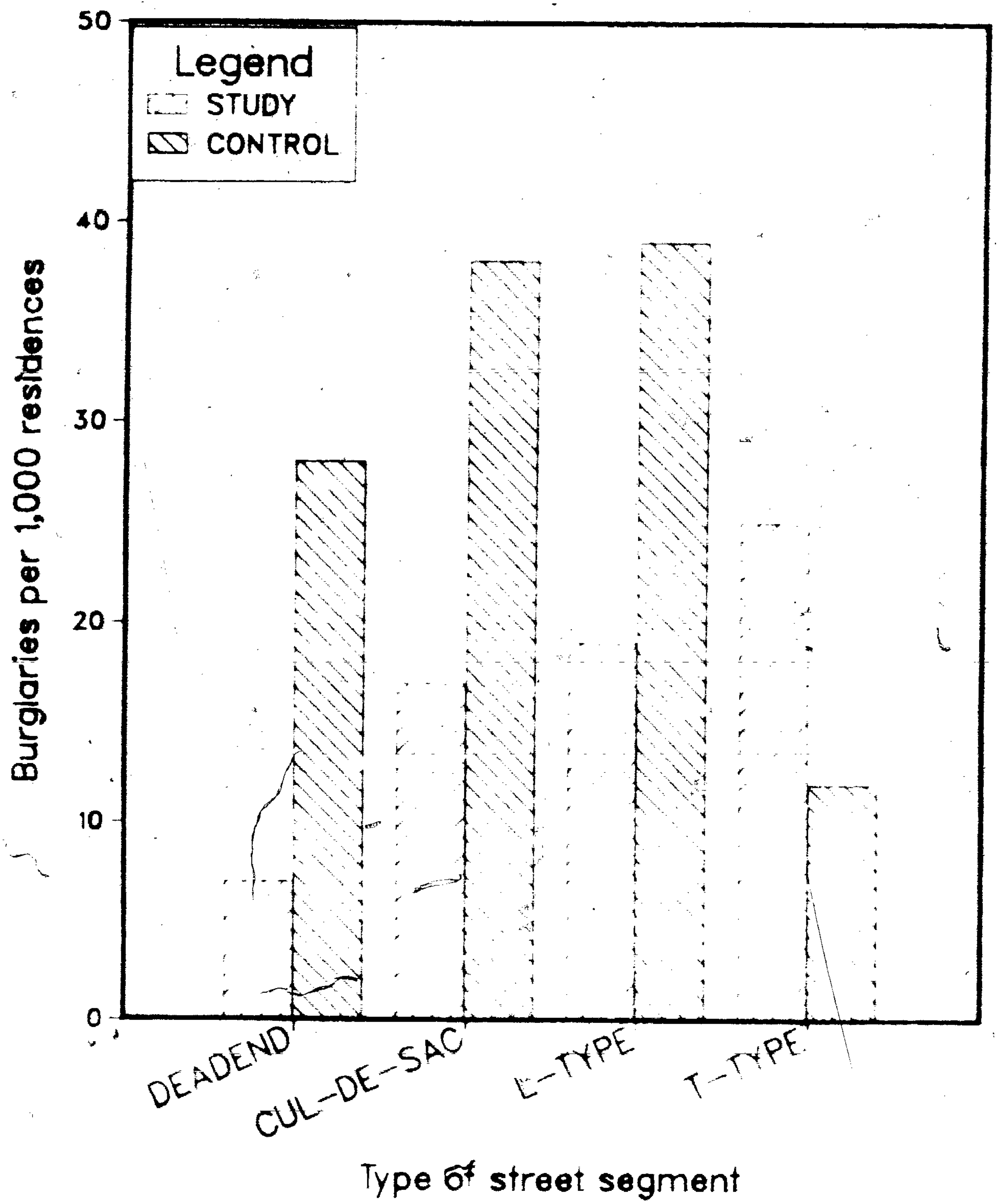
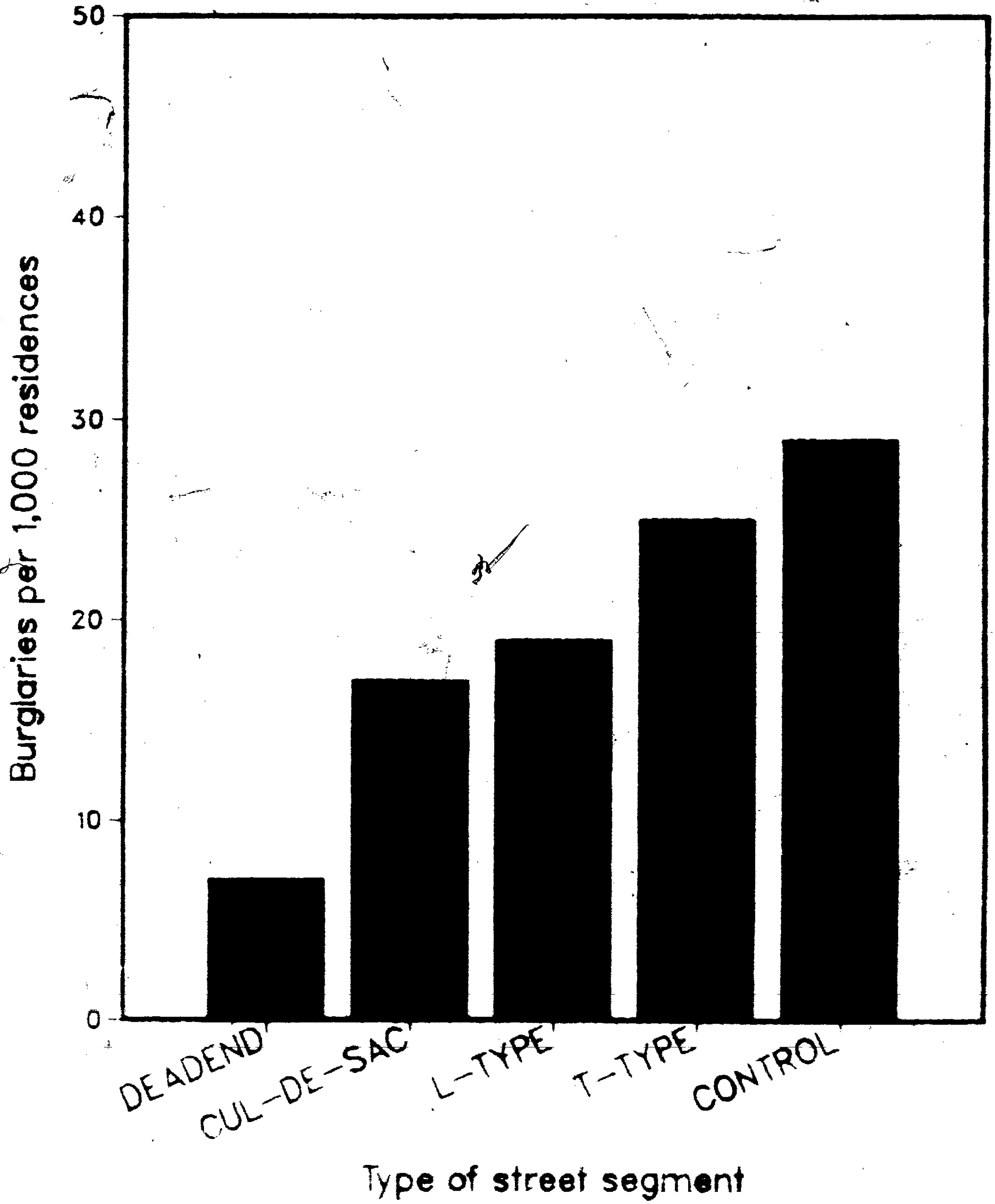


Figure #4

REMODIFICATION OF THE BEVIS AND NUTTER DATA: RESIDENTIAL BURGLARY RATES FOR STUDY AND CONTROL BLOCKS



In the second phase of the Bevis and Nutter study they demonstrated the relationship between burglary rates and street accessibility at another level of aggregation using regression analysis. This phase of the study used census tracts as the unit of analysis rather than types of blocks. Accessibility was measured in terms of the permeability of street layouts, that is, the ease of travelling through an area. They measured permeability at the census tract level by using a graph theory measure.[10] Social variables from the census and the permeability variable were then used in regression models to predict the burglary rates of different census tracts in Minneapolis. They also explored the possibility that street permeability may be conducive to crimes other than residential burglary. Regression models were used to analyse five other types of crime: commercial burglary, commercial robbery, residential street robbery, residential assault by strangers, and residential rape by strangers.[11]

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[10] In graph theoretic terms, a map displaying street layouts is actually a planar (two-dimensional) graph consisting of edges (blocks in the layout) and vertices (intersections in the layout). Bevis and Nutter use "beta", a theoretical graph measure, which is a ratio comparing the number of edges to the number of vertices. For a reference on this subject see Kansky (1963). Beta is a basic measure of permeability in which the greater the value of beta the greater the degree of permeability. The weakness of a graph measure theory of permeability is that it does not take into account aspects of street layout such as the lengths of blocks, the angles at which they meet, or whether blocks are straight, curved, or elevated.

[11] This was a shortcoming of the first phase of the Bevis and Nutter study in that they only analysed residential burglaries. Of course in all fairness to the authors, crime data at this level of aggregation usually does not exist unless one is willing to expend a tremendous amount of time and energy to

The results in the second phase of the study showed that high burglary rates are statistically associated with highly permeable street layouts. After accounting for the variation that was explained by traditional social variables, the permeability variable still accounted for six percent of the variation in residential burglaries (R = .06). Although the contribution to the total variation by the permeability measure is sufficiently large to be statistically significant, it is questionable whether it has any substantive significance; especially in light of the fact that the permeability measure was not statistically significant for any of the other five crimes that were tested.[12]

Of course the major problem with this type of analysis, without entering the arena of causality, is the traditional limitation of the ecological analysis. If Bevis and Nutter had found a substantively high association between the permeability measure and burglaries, this would not necessarily have meant that most of the burglaries were committed on highly accessible blocks. The permeability variable is measuring the general accessibility of large census tracts; not individual blocks. Although the first phase of their study helps in making inferences it is quite conceivable that many of the burglaries in the more accessible census tracts were committed on street

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[11](cont'd) collect it from police records.

[12]It is possible that the statistically significant finding could simply be an anomaly represented by chance, in which case the findings would be spurious.

blocks with low accessibility. The inherent danger of committing the ecological fallacy does not permit one to analyse data at one level and to then draw conclusions at a lower level of aggregation. In converse, the fact that Bevis and Nutter did not find any statistical relationship between the permeability measure and the other five crimes does not preclude the possibility that a substantive relationship does exist between accessibility and various crimes at a block level, as was partially shown in the first phase of their study.

Perhaps the most interesting part of their study was the way in which they applied their results. Based upon the regression model that they developed for residential burglaries they estimated the amount of money that could be saved, in terms of stolen property, by experimentally changing the street layouts of various census tracts. To change the street layouts of census tracts, traffic diverters would be added in order to decrease the permeability of the high crime areas. While this cost benefit analysis was greatly overstated, due to the theoretical shortcomings of their study, it was a very original and thought provoking application of crime prevention concepts.

B. THE STUDY

I. RESEARCH DESIGN

More empirical work is needed to resolve many of the basic issues in environmental criminology. One of these issues that needs development is the understanding of how and where criminals choose their targets. It has been suggested that street networks influence the mobility patterns and choice of targets by criminals. To test this hypothesis this study examines whether or not property crimes are positively associated with street accessibility. Before describing the research design some ambiguities need to be clarified and several operational definitions developed for some of the more important variables.

As can be seen from the Bevis and Nutter study, different units of analysis and/or levels of aggregation can be used to measure street accessibility. This study uses street segments, similiar to the first phase of the Bevis and Nutter study, as the unit of analysis.[1] This leads to the question of how to operationally define a street segment. A street segment or block, for the purposes of this study, was operationally defined

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[1]Census tracts, with the beta measure of permeability, were not used for several reasons: the census tracts in the study area were too large as only three census tracts covered the entire area; the study area is one of rapid growth and the data from the last census would be five years old; and the permeability measure does not measure individual block accessibility or account for structural factors such as length or curvilearity.

as that portion of a street that is between two intersections. This means that intersections can only be end points of a street segment. An intersection was defined as the point where a street ends or where two or more roads meet or cross.

Street segments were differentiated by their structural type, relative accessibility, and by the amount of traffic on them. Bevis and Nutter used a categorical typology to differentiate street segments according to their relative accessibility (refer back to Figure 2). For the purposes of this study, an interval measure of street assessibility was developed based upon the number of "turnings" into each street segment (see figure 5). Figure 5 shows eight examples of different ways in which street segments can be connected.[2] Each direction from which a person can enter or exit a street segment counts as one turning. The turning measure will therefore range from one to six. The accessibility measure used in this study has some distinct advantages over the one used by Bevis and Nutter:

1. It is exhaustive in that it can account for every possible type of street segment.
2. Each category is mutually exclusive.
3. It is universal; it can be applied to any street network system. Minor alterations can also be made to include other means of transportation such as subway systems, trains, pedestrian paths and bicycle trails.

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[2]These eight examples do not exhaust the vast number of ways in which street segments can be interconnected but represent some of the more common situations.

4. It allows accessibility to be measured on a scale that is at an interval level.

From the operational definition of street accessibility that is provided, it can be hypothesized that as street accessibility increases, the amount of property crime should also increase.

To test the appropriateness of the accessibility measure used in this study and to see if structural differences influence the amount of crime on street segments several additional distinctions were made. A distinction was made between three types of street layouts: dead ends, cul-de-sacs, and "grid" (which accounted for all the street segments not in the first two groups). A structural distinction was also made between the length of street segments and whether or not they were straight or curved.[3] The measure of accessibility used in this study was tested against these structural distinctions to see if the structural distinctions are necessary in an overall exploration of accessibility and crime.

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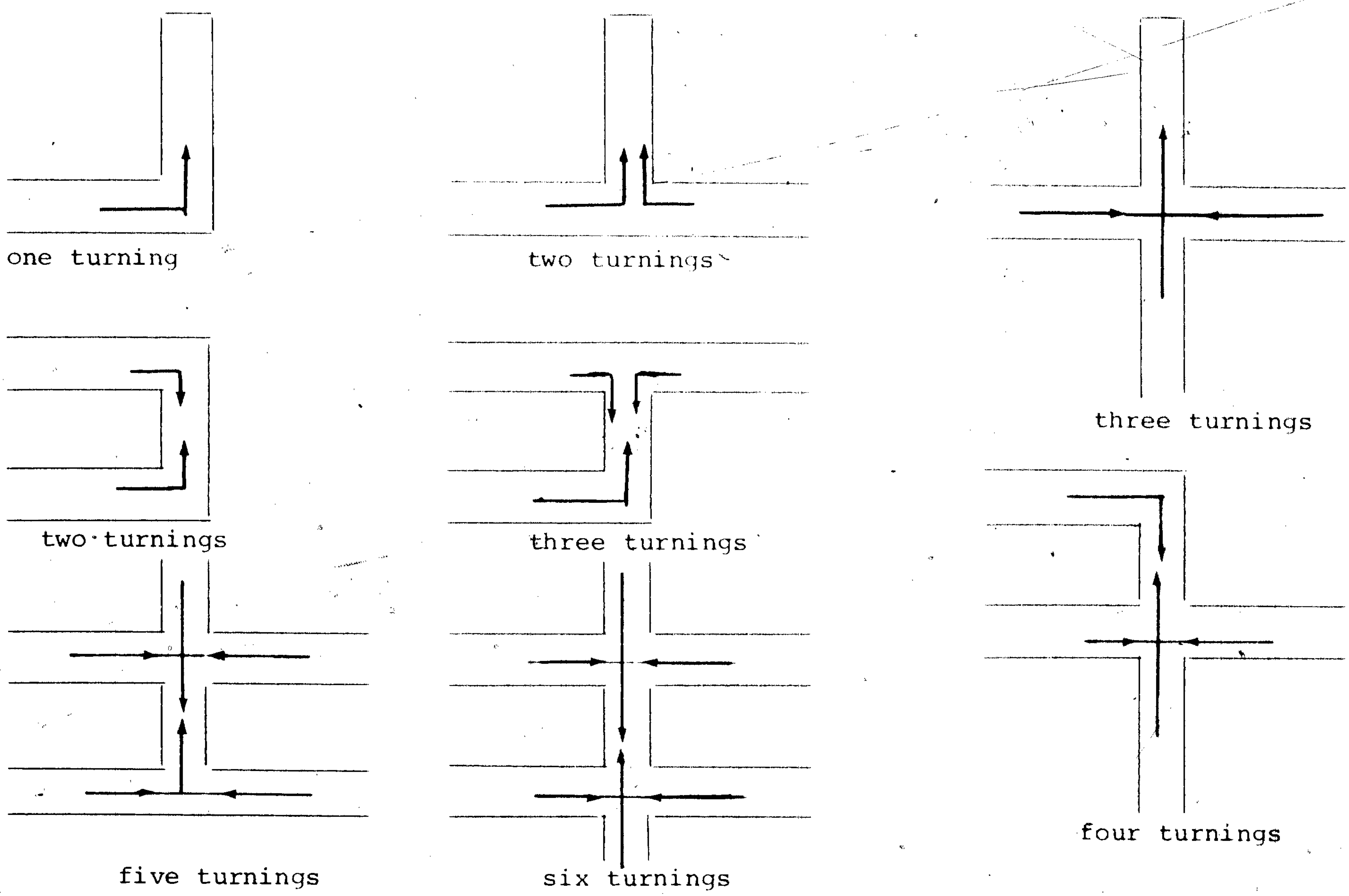
[3]A curvilinear street segment was simply defined as one that was not straight. No effort was made to differentiate amongst the severity of the curves in these non-straight segments as no simple method was available to measure them. Likewise, elevated curves such as hills were also not considered.

Figure #5

Accessibility Measure: Operational Definition



The measure of accessibility (TURNS) categorizes cul-de-sacs and dead ends, by their nature of having only one vertice, as less accessible than segments in the "grid" group. This means, if accessibility influences criminal target choice behaviour, dead ends and cul-de-sacs should have less property crime than grid street segments, because property offenders will not have been as likely to travel on them. If the operational definition of accessibility used in this study proves to be an appropriate measure, there should also be no difference between the amount of crime on dead ends and cul-de-sacs since they are structurally the same according to the accessibility measure.[4] The accessibility measure also does not differentiate between curved and straight streets. If the accessibility measure used in this study proves adequate by itself, the amount of crime on curved and straight street segments should not vary.

The research strategy involved in using an ex post facto design to test the stated hypothesis is basically quite simple. A geographical area is chosen and the various types of street segments within it are identified. Over a specified period of time the number of property crimes on these different types of street segments are then compared. Although experimental control is inherently impossible, with an ex post facto research design,

[4]This suggestion contradicts the findings of the Bevis and Nutter study. Bevis and Nutter believed that cul-de-sacs were more accessible, in terms of entering or leaving, than dead ends because of the turn-around area of cul-de-sacs. However, according to the definition of accessibility as put forth in this study there should be no measurable difference between these two types of street segments.

it is still possible statistically to control for possible mitigating variables. A review of the literature will generally indicate which extraneous variables are relatively important. These theoretically important extraneous variables can be controlled statistically if data is gathered for them. While it cannot be proven that all relevant extraneous variables are controlled, a reasoned selection of control variables can increase the plausibility of findings from an *ex post facto* research design.

Two potentially mitigating variables that should be controlled statistically when examining street accessibility are:

a) Volume of traffic on street segments

A potentially important mitigating variable that should be controlled is the amount of street traffic. This variable is needed to control for the intensity of use for each street segment. If people travel frequently on certain streets then they probably will perceive more criminal opportunities on these blocks then on seldom travelled streets. Opportunities existing on frequently travelled streets are more likely to be a part of a person's awareness space due to their familiarity. Conversely, if a street is never or infrequently travelled, then a criminal is not likely to be aware of any potential opportunities that exist upon it.

b) Potential Opportunities -

Probably the most important extraneous variable that should be controlled is that of the potential opportunities that exist on each block. If a block has no potential criminal opportunities then it is not likely to have any reported crime (e.g., if there are no buildings on a street then this precludes the possibility of a burglary). In attempting to control for potential opportunities it is important to realize that this concept has many components. The components that should be controlled include the following: the number and type of opportunities that exist on each block, the perceived lucrativeness of the targets, and the perceived vulnerability of each target.

While it is relatively easy to list potentially mitigating variables that should be controlled, it is not always so easy operationally to define and measure them. The success of this depends upon more practical matters such as the ease with which data are available and can be collected. The next few sections will discuss the collection of the data and will operationally define the independent variables that have so far only been briefly discussed.

Specific Universe and Time Frame

The specific geographical setting chosen for this study was the two municipalities of Maple Ridge and Pitt Meadows, British Columbia.[5] These two small suburban satellites of Vancouver were selected for many reasons.

1. The local R.C.M.P. were cooperative in allowing access to their crime records and in establishing contacts with the local and regional planning departments.
2. In turn, the planning departments of these two municipalities and the regional planning department were also supportive and supplied many of the maps needed at no cost.
3. This geographical region is isolated from surrounding communities by two major rivers. This feature is important because it minimizes the number of streets that are shared with other municipalities and reduces potential displacement of crimes by offenders.[6] Figure 6 provides a map of the geographical study area.
4. The street network system of this area was sufficently

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[5] A separate analysis of these two municpalities would not be feasible because one R.C.M.P. detachment services both regions. The crime data for the two communities is not kept separate.

[6] Most of the crimes within these two communities are likely to be committed by residents. This assumption was later verified after examining the home locations of offenders who were apprehended.

varied in nature. It provided a diverse sample of "street segment" types. Many municipalities offer no range in street segment types as they are developed in a typical grid-like fashion.

The time frame used in this study was the year of 1979. Every property crime that was reported to the R.C.M.P. during this time period was analysed. A longer time span, from 1979 to 1981, was originally planned at the onset of the study but due to financial and time constraints the study period was shortened.[7]

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[7] Many difficulties in collecting and developing the data for this study were encountered. Although the local R.C.M.P. were very cooperative, unforeseen delays in obtaining screening clearances through the bureaucratic hierarchy of the organization was one of the major drawbacks in the collection of the data. In fact, one of the two students who was hired to collect the crime data never did obtain the necessary police clearance because of difficulties in obtaining information about his family background. Nonetheless, when it came time to collect the crime data, a decision had to be made to either collect as many cases as possible, with minimal detail, or to limit the time span and to extract as much information as possible from each case. The latter method was chosen because it would provide a richer data base for future analysis.

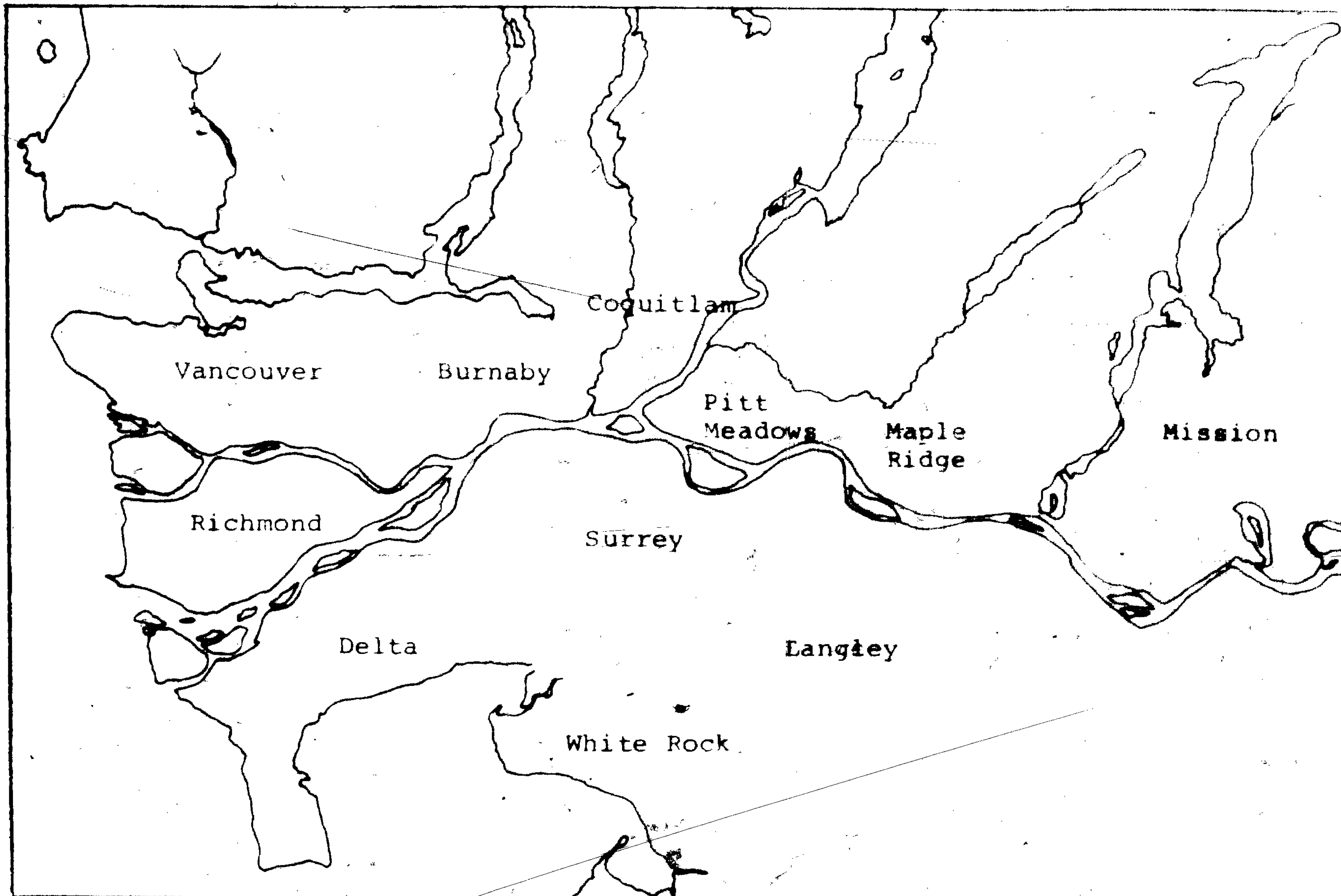

Figure 6: Map of Study Area

The Collection of the Environmental Data

Two separate address specific data sets are needed to examine the relations between crime and the environment. One must contain information about the occurrence of crimes and their specific locations. The other data set must represent environmental opportunities that are available to the criminal population and the accessibility to them via the street network.

All the crime and environmental data were aggregated at a street segment level because this was the unit of analysis for this study. In order to enumerate each street segment it was necessary to obtain two sets of maps. One set of maps, land usage maps, was used to give each street segment a unique identification number (ID). The other set of maps, legal maps, was used to locate the address range (the high and low address) of each street segment. The address range was needed so that the location of crimes and opportunities could later be matched to the street segment ID. In addition to the segment ID, many potential measures of opportunity were collected from the land usage maps. Table A.22 of the Appendix lists the information that was obtained from these maps.

In addition to the environmental data gathered from the land usage maps more data in machine readable form was obtained from the British Columbia Tax Assessment Authorities. From this agency a magnetic computer tape was obtained with tax assessment data on every legal property in Maple Ridge and Pitt Meadows. One of the conditions for the use of this data was that no properties would be singled out or identified in any reports. From an address specific environmental and crime data set it would be fairly easy to identify criminogenic sites or "hot-spots" of criminal activity. While such information might prove to be very useful in prevention efforts, it could also cause embarrassment to the identified property owners or businesses. To ensure the confidential nature of this data, no information or analysis was done for any individual addresses.[8]

Table 1 contains a list of the variables that were selected from the tax assessment. These variables were available for every property in the two study areas.[9] This tax assessment data was also aggregated to a street segment level. Since the land value, improvement value, and lot size were known for each property it was possible to calculate the average land value per square foot for each street segment. These monetary measures might provide an indication of a target's or street segment's general attractiveness to the criminal population. If there were

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[8]It should be noted that the data provided by this agency serves a variety of purposes - valuation, statistical reporting, and administration, as well as the fulfillment of statutory obligations placed on the agency. It was not the purpose of this data to be used or misconstrued as satisfying purposes other than those intended by the Area Assessors.

[9]Only a few criminological studies have taken advantage of automated geographical information systems. Rhodes, Conly, and Schachter (1980) used a similar automated system except that their crime data could not be located at an address level, so it was necessary for them to aggregate their data into larger areal units.

TABLE 1

LIST OF VARIABLES TAKEN FROM THE TAX ASSESSMENT DATA

- Street name.

- Address of property.

- Actual Land Use Code; collapsed into the following categories:

  - single family dwellings,
  - duplexes,
  - multi-family (apartment blocks, row housing, conversion, high rises, residential hotels),
  - mobile homes,
  - civic and insitutional buildings,
  - transient accomodations (hotels, motel and auto courts, campgrounds, seasonal resorts),
  - commercial establishments,
  - farms,
  - industrial sites,
  - vacant lots.

- Lot size (square feet).

- Land value of each property.

- Improvement value of each property (i.e. assessed value of each building on the property).

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street segments or neighbourhoods with relatively affluent homes, then these two measures would reflect this. In addition, by knowing the numbers and types of targets on each street segment, which was provided by the actual land use code[10], some of the objective opportunities that may attract a criminal to a street segment can be identified.

Description of the Environmental Data Set

Altogether there were in excess of 1500 individual street segments identified in the study area. Fourteen of these blocks were excluded from the statistical analysis, because they crossed outside of the boundaries of the study area. Table 2 shows the composition of these street segments according to their accessibility (TURNS) and structural type (TYPE). As seen from this table, only 30 street segments (1.9% of the total) had one turning (accessibilty equal to one). Due to the relatively low number of street segments with just one turning, this group was added to the group of street segments that had only two turnings for the statistical analyses that was done later. This table also shows that there were a total of 60 cul-de-sacs, 266 dead ends and 1249 grid segment types. Of these 1575 street segments, 87.37% were classified as straight (n=1376) while the remaining 12.63% were classified as curved

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[10]Ten general types of properties were differentiated using the actual land use code (see Table 1).

TABLE 2

CROSS-TABULATION OF STREET TYPE BY ACCESSIBILITY (TURNS)

TYPE	TURNS 1	2	3	4	5	6	ROW TOTAL
CUL-DE-SAC (STRAIGHT)	2	35	10	0	0	0	47 3.0%
CUL-DE-SAC (CURVED)	4	5	4	0	0	0	13 0.8%
DEADEND (STRAIGHT)	17	163	46	7	1	0	234 14.9%
DEADEND (CURVED)	7	19	4	1	1	0	32 2.0%
GRID (STRAIGHT)	0	48	166	454	297	130	1095 69.5%
GRID (CURVED)	0	7	38	75	29	5	154 9.8%
COLUMN TOTAL	30 1.9%	277 17.6%	268 17.0%	537 34.1%	328 20.8%	135 8.6%	1575

Number of missing observations = 14

(n=199). Table 3 gives a cross-tabulation of street accessibility (TURNS) by street flow (FLOW). According to the traffic flow variable, 1337 street segments were classified as feeders (84.9%), 126 as minor arteries (8.0%), 68 as major arteries (4.3%) and 44 as highway segments (2.8%). Altogether there was a total of 265 miles of street networks in the study area. The mean length of each street segment 890 feet (.17 miles) with a standard deviation of 1011 feet (.19 miles).

Table 4 gives a breakdown of the data that were obtained from the tax assessment authorities. Ten land use groupings were constructed from the tax assessment land use file as these variables were reported with enough consistency to make empirical analyses possible. Table 4 gives the total number of units for each building type, the average square feet of the lot, the average land value and the average improvement value for each building type. The values given in this table were based upon each individual property. For the purposes of this study, these data were later aggregated to a street segment level. Table 5 gives the results of these aggregated data. Aggregated at a street segment level are the average number of buildings (by each type), the average lot area, the average lot value and and the average improvement value for each building type.

Table 3

CROSS-TABULATION OF STREET FLOW BY ACCESSIBILITY (TURNS)

TYPE	TURNS 1	2	3	4	5	6	ROW TOTAL
1 FEEDER	30	271	258	427	243	108	1337 84.9%
2 MINOR ARTERY	0	4	5	65	41	11	126 8.0%
3 MAJOR ARTERY	0	0	3	28	30	7	68 4.3%
4 HIGHWAY	0	2	2	17	14	9	44 2.8%
COLUMN TOTAL	30 1.9%	277 17.6%	268 17.0%	537 34.1%	328 20.8%	135 8.6%	1575

Number of missing observations = 14

TABLE 4

LAND USE DATA

TYPE OF UNIT	N OF UNITS	AVERAGE SQ. FEET OF LOT	AVERAGE LAND VALUE OF LOT	AVERAGE IMPROVEMENT VALUE
SFD	9642	68,773	$ 29,156	$ 30,221
DUPLEX	97	18,765	27,303	35,647
APARTMENT	428	76,682	26,167	52,622
MOBILE HOME	367	-	-	13,757
CIVIC INST.	114	347,895	95,841	171,013
INDUSTRIAL	74	194,352	109,964	146,059
VACANT	288	192,808	47,371	-
TRANSIENT	11	139,779	189,827	116,404
COMMERCIAL	354	64,642	78,269	91,271
FARM	517	584,182	86,939	49,133

TABLE 5

LAND USE DATA

AGGREGATED TO A STREET SEGMENT LEVEL

TYPE OF UNIT	AVERAGE PER SEGMENT	AVERAGE SQ. FEET OF LOT	AVERAGE LAND VALUE OF LOT	AVERAGE IMPROVEMENT VALUE
SFD	6.12	61,230	$ 29,010	$ 30,010
DUPLEX	.06	16,420	26,740	34,910
APARTMENT	.27	31,860	25,380	64,050
MOBILE HOME	.23	-	-	13,510
CIVIC INST.	.07	315,300	103,770	234,860
INDUSTRIAL	.05	177,470	109,470	513,100
VACANT	.18	170,060	44,580	-
TRANSIENT	.01	114,360	189,830	207,310
COMMERCIAL	.22	281,860	80,650	116,150
FARM	.33	578,900	86,560	48,710

It should be noted that some of these values are dramatically different at this level of aggregation. These differences are simply an artifact of averaging "averages" and demonstrates how careful one must be when interpreting data at varying levels of aggregation.

Collection of the Crime Data

Crime data was only collected for property offences. It made no intrinsic sense to collect data about crimes that were not conceptually related to the environment in terms of the opportunity structure. Crimes can be "crudely" lumped into two categories: violent crime and property crime. Violent crimes, such as murder, assault or rape[11] are conceptually more dependent upon the dyadic relationship between the offender and the victim than between the offender and the crime location. Although personal crimes display spatial patterning, this is probably a consequence of the social interaction of the offender and the victim, as opposed to the influence of the physical opportunity structure. Personal crimes also tend to be more spontaneous in nature as the motivation is often highly affective as opposed to the instrumental motivation (i.e., conscious motivation) that is often involved with property

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[11] An interesting environmental study of rape was conducted by Stoks (1982). This study examined rape at a microspatial level and developed a statistical model that was able to discriminate between the sites of attempted and completed rapes.

crimes.

Property crimes can be classified by using a generic typology or by using their strict legal interpretations. If categories provided in the Canadian Criminal Code are used then legal interpretations must be made for each crime occurrence. The legal categories provided in the Canadian Criminal Code are too artificial for many research purposes.[12] Because of the technical difficulties associated with using legal categories, a loose generic typology was used in this study.[13]. Information regarding the following eight property crimes was collected: bicycle theft, auto theft, theft from auto, shoplifting, robbery, other property theft, burglary, and wilful damage.[14]

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[12]For example, s.294 of the Canadian Criminal Code, arbitrarily distinguishes between theft over two hundred dollars and theft under two hundred dollars. If a legal category was used for classification purposes, the researcher would have to make a decision as to which category the theft belonged for each case. While this seems relatively staightforward, it must be realized that the value of the stolen property is often not recorded, illegible, or at best only an estimate by the attending police officer.

[13]In the collection of the crime data it was also necessary to establish counting rules in order to eliminate idiosyncratic interpretations of criminal events. For example, if a criminal forcibly gains entry into a house, finds some car keys and then steals the home owner's automobile - how should this criminal event be recorded? It could be recorded as a break and enter, an auto theft, a case of wilful damage, or even all three. Fortunately, police departments have procedure manuals on how to "officially" count crime occurrences. Whether or not the investigating officer made the correct decision when recording the crime is irrelevant as the researcher can recode the event when the case is analysed by knowing the correct counting procedures

[14]The shoplifting and robbery categories were eventually deleted from the analysis because of their relatively rare occurrence. Shoplifting was rare in the sense that it was not frequently reported to the police.

For each crime the following information was recorded:

- file number;
- year, month, day and time the complaint was received;
- year, month, day and time the actual crime occurred, if known;
- type of crime (according to the eight categories);
- success of the crime - this was coded in the following manner: (1) successful, (2) attempted, or (3) not sure;[15]
- type of premise in which the crime occurred: residential, commercial, public, or other;
- location of the crime; this includes the address of where the crime occurred, the address of where the crime was reported, the address of where any stolen items were retrieved, and the home location of the offenders if they were apprehended;
- the value of the property loss, if known;
- the number of offenders apprehended, including their age, sex, race, previous criminal record, and court disposition;
- additional information was also gathered about each specific type of crime in terms of a description of the property that

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[15]Often people are not really sure whether a crime has occurred but report it anyway. It is not always easy to tell whether one's home has been entered or whether an item was simply misplaced or lost as opposed to being stolen. Approximately fifteen percent of the property crimes reported to the police were declared unfounded by the police in this study. These cases were not recorded, but for those cases where it was not really clear whether or not a criminal event occurred they were recored as "not sure".

was stolen or damaged.

Description of the Crime Data

During the study, information was gathered for every founded property crime. The frequency of each specific type of crime can be seen in Table 6. In 93.4% of these cases the crime was clearly committed, while in only 4.4% of the cases was the offender interrupted in his attempt to complete the crime. In the remaining 2.2% of the cases there was some doubt expressed either by the police or by the complainant as to whether a crime had actually occurred. Of the 3241 cases, information was available for 73% (n=2368) of them concerning the amount of property loss or damage that was involved. Of these 2368 cases, the approximate monetary loss, in 1979 dollars, was about $862,600.00 or approximately $360 per crime.

Only 310 (9,6%) of the property offences resulted in an arrest being made. From these 310 cases, a total of 485 persons were arrested, but this figure is inflated as the same person was often charged and arrested for several different crimes. Only 332 of these arrested persons went to trial. No official court action was taken in 54.8% of the cases. In the remaining court cases, the accused received the following outcomes: innocent (1.8%), probation (28.3%), jail sentence (2.7%), and other sentences accounted for the remaining 12.3% of the

TABLE 6

FREQUENCY OF PROPERTY CRIMES*

Type of crime	Absolute Frequency	Relative Frequency
Bicycle theft	431	13.3%
Auto theft	128	3.9
Theft from Auto	480	14.8
Burglary	698	21.5
Other property theft	531	16.4
Wilful Damage	973	30.0
TOTAL	3241	100.0%

*Robbery and shoplifting were deleted because of their low counts.

accused.[16] Of the 485 persons that were arrested, 53.3% had a prior criminal record. Most of these arrested persons were males (90.2%), with an average age of about 24.1 years.

i) Bicycle Theft

Of the 431 bicycles reported stolen, 45.7% were stolen from the owner's residence. Another 11.8% were stolen from commercial premises, 23.8% from public premises, and the balance were stolen from other locations (18.7%). The average value for each bicycle was about $111.92, with the following types being stolen: standard (33.7%), three-speeds (6.4%), five-speeds (14.5%), and ten-speeds (45.3%). Only four persons were arrested for stealing bicycles. This suggests that the perpetrators are either very clever or the police view this crime as too petty to fully investigate, in light of other offences that they deem to be more serious.

ii) Auto Theft

Of the 128 cases of auto theft, 37.5% occurred at the victim's residence, 34.4% at commercial establishments, 3.9% at

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[16]The fact that only nine persons were jailed from a total of 3241 property crimes would appear to make crime a very lucrative enterprise. The odds of receiving a jail sentence for committing a property offence would therefore be approximately .28%, hardly the type of statistic that contributes to a deterrent effect.

public institutions, and the balance occurred at other locations (24.2%). The method in which the cars were stolen suggests a high degree of carelessness on the part of the victims as 38.3% of the auto thefts were assisted by the owners having left the keys in the ignition. The remainder of the cars stolen resulted from the victim's keys being stolen (26.2%), the car being hot-wired (32.2%), or the car being forcibly taken (3.3%). The vast majority of the cars stolen were taken from parking lots (49.5%), while 13.6% were stolen from the street, 29.1% from driveways, 6.8% from garages, and only one percent from underground parking lots (there are very few of these in the study area). Of the 128 auto thefts, twenty-four (18.8%) of them resulted in the arrest of a suspect, the highest arrest rate for any of the property crimes analysed in this study.

iii) Theft from Auto

The 480 cases of theft from auto followed a similiar pattern to the auto thefts in that the victim's residence was the usual scene of the crime (36.9%), while 25.2% happened at commercial establishments, 9.4% at public institutions, and the remainder were at other locations (28.5%). The specific location of the car was as follows: parking lots (44.6%), on the street (27.0%), driveways (15.6%), garages (2.1%), and underground parking lots (10.7%). Table A.1 of the Technical Appendix shows the frequency and types of items that were stolen. In addition to these thefts, 21.1% of the cars sustained some form of damage. A suspect was arrested in only 3.7% of these cases.

iv) Break and Enter

Of the 698 cases of burglary, 431 occurred at private residences (61.7%), 186 at commercial premises (26.6%), 80 at public institutions (11.5%), and only one case elsewhere (0.1%). Table A.2 of the Technical Appendix shows the range of goods that were stolen. Only 5.3% of the burglaries resulted in somebody being arrested.

v) Other Property Thefts

Of the 531 cases of property theft, 41.6% occurred at the residence of the victim, 27.3% at commercial establishments, 13.9% at public institutions, and 17.1% at other locations. Table A.3 of the Appendix shows the frequency and types of items that were stolen for this crime. Somebody was arrested in 10.4% of these cases.

vi) Wilful Damage

Of the 973 cases of wilful damage, 40% occurred at the residence of the victim, 32% at commercial establishments, 21.9%

at public institutions and 5.3% occurred elsewhere. Table A.4 of the Appendix shows the frequency and type of damage that occurred. Twelve percent of the cases resulted in somebody being arrested.

vii) Property Crime Data Set

Table A.23 of the Appendix provides a list of all the environmental and crime variables used in the statistical analysis. Although there were originally 3241 property crimes (see Table 6) this figure was reduced to 3100 after eliminating incorrect addresses. The loss of the 141 property crimes was the result of not being able to match the address of the crime location to the geographical framework of the study. This was the result of not being able to determine the location of the crime from the police files or because the location of the crime was outside of the municipal boundaries. Anytime a crime is reported to a detachment, a file must be opened, whether or not it was actually committed within the police jurisdiction.

With 1575 street segments this meant that there was an average of 1.97 property crimes per street segment during 1979. Table 7 gives a breakdown of the frequency in which crimes occurred on different street segments. As can be seen from this table, 50.6% of the street segments had no reported property crime on them. At the extreme end of the scale, one street segment accounted for 110 property crimes by itself.

Table 7

FREQUENCY OF PROPERTY CRIMES ON STREET SEGMENTS

NUMBER OF STREET SEGMENTS	RELATIVE FREQ. OF SEGMENTS	NUMBER OF PROPERTY CRIMES	PERCENTAGE OF PROPERTY CRIMES
797	50.6%	0	0.00%
306	19.4	1	9.87
154	9.8	2	9.93
99	6.3	3	9.58
55	3.5	4	7.10
37	2.3	5	5.97
26	1.7	6	5.03
18	1.1	7	4.06
10	0.6	8	2.58
11	0.7	9	3.19
7	0.4	10	2.26
6	0.4	11	2.13
8	0.5	12	3.10
2	0.1	13	0.84
4	0.3	14	1.81
4	0.3	15	1.94
3	0.2	16	1.55
3	0.2	17	1.65
3	0.2	18	1.74
1	0.1	20	0.65
2	0.1	23	1.48
1	0.1	24	0.77
2	0.1	25	1.61
1	0.1	27	0.87
1	0.1	28	0.90
2	0.1	29	1.87
2	0.1	30	1.94
1	0.1	31	1.00
1	0.1	32	1.03
1	0.1	35	1.13
1	0.1	40	1.29
1	0.1	41	1.32
1	0.1	44	1.42
1	0.1	49	1.58
1	0.1	50	1.61
1	0.1	51	1.65
1	0.1	110	3.55
1575	100.0%	3100	100.00%

II. THE STATISTICAL ANALYSIS OF THE DATA

Theoretical Concerns of Using a Statistical Analysis

In the previous chapter it was hypothesized that there was a positive correlation between property crime and street accessibility. This chapter reports the statistical examination of this relationship. The statistical analysis serves two functions. First, it descriptively summarizes the data. Different forms of multivariate analysis were performed that examined structural interrelationships amongst the many variables. An analysis of the effects that street accessibility has on reported property crime would be incomplete without considering the possible mitigating influences from many of the theoretically important independent variables. The multivariate analysis reported in this thesis attempted to isolate the effects that street accessiblity has on property crime while controlling these other factors. The second function of the statistical analysis was to make inductive generalizations. The purpose of inductive logic is to make generalizations about some population, on the basis of a sample drawn from this population or to formulate general laws on the basis of repeated observations (Blalock; 1979:4).

The use of a statistical analysis in this study such as this is not without debate. Usually statistical inferences are made from a sample to a population. In this study a sample was not used; the entire population was utilized. Every street segment in Maple Ridge and Pitt Meadows was included in the study. Many authors (Blalock; 1979, Greenberg; 1979, Morrison; 1970) in the sociological literature have debated whether or not it is appropriate to use significance tests in instances where one is dealing with the entire population. The argument against significance tests is that, since the entire population is accounted for, there can be no larger population to which one wishes to generalize. If this is so, then tests of significance would be inappropriate since no sampling error would be involved. While the argument against significance tests has some merit, the researchers who argue for the use of significance tests believe that this latter point of view over-simplifies the objectives of nonexperimental research. Some experimenters may be satisfied with generalizations to fixed populations; however, inferences can also be made about the causal processes that may have generated the population data. This second view revolves around the processes that could have generated different subpopulations. If there are varying amounts of reported property crime on different types of street segments, then these differences were either due to some causal influence or to chance or some combination of the latter. Blalock (1972:242) notes that "most social scientists have this more inclusive objective of saying something about causal processes, and therefore they should always make tests in order to rule out the simple 'chance processes' alternative". In addition to testing the levels of significance[1], many of the statistical tests used measure the strength of the relationships amongst the variables. Another argument that is made in defence of significance tests for populations is that it may be the researcher's aim to generalize from the population studied to a larger conceptual universe of populations. Consequently, if some observed pattern between street accessibility and reported property crime is found in Maple Ridge and Pitt Meadows, then conclusions may be drawn about these patterns in other similar cities. The identification of similiar cities is, of course, problematic.

Rather than collect a limited sample of street segments and introduce sampling biases, this study used the entire population of street segments for the two municipalities. While the study area, being suburban, may not be representative of many major urban cities, the results may be similar to results that would be found in other North American cities of similar size and with

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[1]The choice of the significance level is completely arbitrary but by convention a .05 or .01 significance level is most often used as the standard for statistical significance (Morrison; 1970). This means that there is, respectively, one chance in twenty or one chance in a hundred that a Type II error will be made, the failure to reject assumptions when they are actually false. Rather than use some arbitrary conventional level of signifance the actual level of significance will be reported throughout this thesis. Regardless of the level obtained an opinion will be stated as to whether or not it supports the hypothesis using signifance levels of .05 or .01 as guidelines and not as sacred absolutes.

similar characteristics. The major concern with the two suburban municipalities in this study was that there would not be enough property crimes in order to detect any geographical patterns. One must also be concerned about the sample size. As a sample size increases it is statistically easier to obtain significant results. If significance tests are used with large populations care must be taken to look at substantive relationships as well as statistically significant ones.

Statistical Methods For Controlling Opportunities

Despite the use of multivariate statistical techniques, it cannot be over-emphasized that a statistical analysis will not rule out alternative explanations, especially those that introduce additional variables as common causes of the variables under consideration. Theoretically, it would appear from the literature review that the most important additional variable to consider is that of opportunity. If more reported property crime occurs on highly accessible streets, this may simply be due to the fact that there are more opportunities on more highly accessible streets. This raises the issue of how one statistically controls for the number of opportunities in the environment.

It would appear that there are two methods by which one can control for opportunities. One method is to contruct a crime rate (crime per opportunities). For instance, when comparing the number of murders between cities, it is usually more meaningful to express the statistics in terms of a rate (the number of murders per 100,000 people) rather than giving just counts. The other method requires opportunities to be statistically controlled as independent variables. In this latter method the dependent variable is entered just as a count. The argument in favour of this method is that often in environmental criminology the indiscriminate use of denominators has produced rates that can only be described as bizarre (Harries; 1981:147).

A careful analysis of the conceptual difficulties surrounding the concept of opportunity reveals that at least two questions have to be answered before using objective measures of opportunity as denominators: what is an opportunity and are all opportunities equal? In this study six different property crimes are examined. While it might be feasible to use the number of building units[2] as a statistical control, in the analysis of a crime like breaking and entering, it does not make any conceptual sense to use it while analyzing some other crime such as bicycle or auto theft. Since building units were the only type of opportunity in which environmental data could be collected, the number of possible denominators that could be used was very limited. To further complicate matters, there is the question of whether different types of opportunity should be treated equally. Considering different opportunities as

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[2] In an apartment building each single apartment would be considered as a separate unit.

equivalent units (e.g., commercial units and mobile homes) even though they may have different rates of risk, may be tantamount to adding apples and oranges together. Furthermore, even identical opportunities may have different rates of risk depending upon their physical locations or ease of accessibility. It could be hypothesized that apartment units on ground level are more vulnerable to breaking and enterings due to easier accessibility, than are apartments that are located on other levels. If physical location is the only difference amongst these apartments should they be considered equal risks? In the future weighting factors may be produced to create equivalent units for comparative purposes but with the current state of knowledge, it is not possible. For this study opportunity measures were used as independent variables instead of constructing rates with the dependent variable.

Overview of the Multivariate Statistical Techniques

The first series of statistical tests reported in this chapter are one-way analyses of variance. Separate analyses will show the relationship between the dependent variable, the amount of reported property crime, and single independent variables. The single independent variables are the different measures of street accessibility. Despite the findings of any strong relationships, it must be pointed out that the relative strength between any of these variables could be the result of confounding influences. In order to statistically control for some of these confounding influences further analyses were performed using n-way analysis of variance, multiple regression, and analysis of covariance. These latter analyses will be reported in subsequent sections.

The Analysis of Street Segment Types

i) Curved VS. Straight Street Segments

One distinction made about street segments was in relation to their curvilinearity. It was hypothesized that there should be no difference in the amounts of property crime (CR.TOTAL)[3] on these two types of street segments because their accessibility characteristics are similar. In order to test this hypothesis a oneway analysis of variance[4] was performed, comparing the amount of reported property crime that occurred on these two types of street segments. The results of the analysis showed no statistically significant difference (F-ratio = 0.007, F-prob = 0.935, df = 1,1573). This supports the view that there is no difference between the amount of crime on these two types of blocks. See Table A.5 of the Appendix for the technical

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[3] CR.TOTAL is a variable that represents the total number of reported property crimes on each street segment. It is simply a summation of the six crime types used in this study.

[4] The statistical analyses that were performed in this thesis utilized the Statistical Package for the Social Sciences (SPSS).

aspects of this analysis.

ii) Dead ends VS. Cul-de-sacs

Earlier it was discussed whether there should be more crime on dead ends or on cul-de-sacs. In a "Newmanesque" fashion, it could be argued that cul-de-sacs should have less crime on them due to the greater surveillance potential provided by the usual layout of homes on these street segments. On the other hand, Bevis and Nutter (1977:7) expected the direct opposite; that there would be more crime on cul-de-sacs than dead ends. They considered cul-de-sacs as more accessible to criminals because they are easier to enter and leave due to the turnaround areas at the end of these streets.

Despite these two conflicting views, it was argued that there would probably not be any difference in the amount of reported property crime on these two types of street segments because they were both equally accessible according to the turning measure that was employed in this study. A comparison between the amounts of property crime on these two types of street segments provided a good test of the accessibility measure being employed.

A oneway analysis of variance was performed to compare the average amount of crime (CR.TOTAL) on these two types of street segments. The results of the analysis revealed no strong relationship (F-ratio = 0.003, F-prob = .9597, df = 1,324), suggesting that there is no important difference in the amount of property crime on cul-de-sacs and dead ends. See Table A.6 in the Appendix for the technical details of the analysis.

iii) Dead ends and Cul-de-sacs VS. Grid Street Segments

Earlier in this thesis, it was hypothesized that grid street segments should have more crime because of their structurally higher accessibility, than dead ends and cul-de-sacs. Since there was no significant difference between dead ends and cul-de-sacs, these two groups were collapsed. The amount of crime on street segments in this collapsed group was then compared to the amount of crime on the grid street segments. Using a oneway analysis of variance, it was found that there was more property crime (CR.TOTAL) on the grid street segments than on the other group (F-ratio = 16.36, F-prob = 0.0001, df = 1,1573). The technical aspects of this analysis are contained in Table A.7 of the Appendix. Grid street segments averaged 2.24 property crimes per block while dead ends and cul-de-sacs averaged only .91 crimes per block. This result is not only statistically significant but would appear to be of substantive interest in that there is over twice as much crime on grid type streets than dead ends or cul-de-sacs. Of course, this relationship could still be due to some third variable, such as different street segment lengths or the number of buildings on each block. This issue will later be explored in more detail.

Analysis of Street Flow

Earlier in this thesis, it was hypothesized that the volume of traffic could have a pronounced effect on the amount of property crime on street segments. It was argued that street segments with greater traffic volumes should have more property crime on them than those streets that are seldom travelled. People would not be aware of potential crime opportunities on streets that are never or seldom used. As a first test of this relationship a oneway analysis of variance was performed comparing the amounts of crime (CR.TOTAL) on street segments grouped according to their street flow classification. The statistical results strongly support the hypothesis (F-ratio = 73.475, F-prob = 0.0000, df = 3,1571). The technical aspects of the analysis are contained in Table A.8 of the Appendix. As the street flow increased so did the amount of property crime. The street segments classified as feeders averaged 1.36 crimes per block; minor arteries averaged 3.49 crimes per block; major arteries averaged 4.93 crimes per block; and highway blocks averaged 11.59 crimes per block. The substantive difference between the amount of reported crime on different types of street segments is very high. Although no third variables were statistically controlled there was over eight times the amount of reported property crime between two on these subpopulations (highway and feeder street segemnts).

Analysis of Street Accessibility

In order to test the turning measure (TURNS) a series of oneway analyses of variance were done for each of the six property crimes and for the total amount of reported property crime (CR.TOTAL). Table 8 gives a summary of these statistical analyses (Tables A.9 - A.15 of the Appendix contain a technical summary of each statistical analysis). Table 8 shows that the accessibility measure used in this study was related to all of the property crimes except for bicycle theft.

The fact that bicycle theft is an anomaly is not too suprising. The accessibility measure attempts to measure the perceived awareness of potential criminal opportunities on each segment based upon the movement or activity patterns of people. The movement patterns of people are generally restricted to the use of street networks. Since children usually walk and ride bicycles, as well as travel in cars and buses,[5] they likely use more direct routes such as trails and shortcuts, especially in a rural/suburban area as in this study area, rather than relying exclusively on the street network. The different and restricted paths that children travel upon probably results in their having

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[5] Of course there are exceptions to every rule. In one nearby municipality a gang of youths earned the nickname of the "Taxi-cab gang". These youths used taxi cabs to take them to and from the scene of houses that they would break and enter.

Table 8

ONEWAY ANALYSES OF VARIANCE

TESTS FOR THE RELATIONSHIP BETWEEN ACCESSIBILITY AND CRIME

Summary Table

Type of Crime	F ratio	Signifcance
BICYCLE THEFT	1.570	0.1799
AUTO THEFT	6.545	0.0000
THEFT FROM AUTO	7.208	0.0000
PROPERTY THEFT	6.665	0.0000
WILFUL DAMAGE	10.421	0.0000
BREAK & ENTER	9.735	0.0000
TOTAL CRIME	10.483	0.0000

Degrees of Freedom - Between = 4
Within = 1570

an awareness of potential criminal opportunities that may not be influenced by the accessibility of street networks for some types of crime. For a crime like bicycle theft, which is probably committed by very young juveniles, it is not suprising that it displays spatial patterning that is different from other property crimes. The distribution of bicycles in the physical environment may also contribute to this anomaly. Bicycles will tend to be found in areas where children congregate (e.g., parks and schools) and this distribution of targets may bear no direct relation to the accessibility of streets.

Although Table 8 shows statistically significant relationships for all the property crimes studied, except for bicycle theft, the directional relationship between accessibility and crime has not yet been explored. The group means of each property crime (see Tables A.9 to A.15 of the Appendix) again show a distinct pattern, with the exception being bicycle theft. It appears that as street accessibility increases the number of reported property crimes also increases. To show this trend the group means of each property crime were plotted against the number of turnings and Pearson product-moment correlations were calculated. Table 9 summarizes the results of this correlational analysis. As can be seen from Table 9, there is almost a perfect linear relationship between the accessibility measure and property crime. Figure 7 graphically depicts this reationship for the variable CR.TOTAL.

Table 9

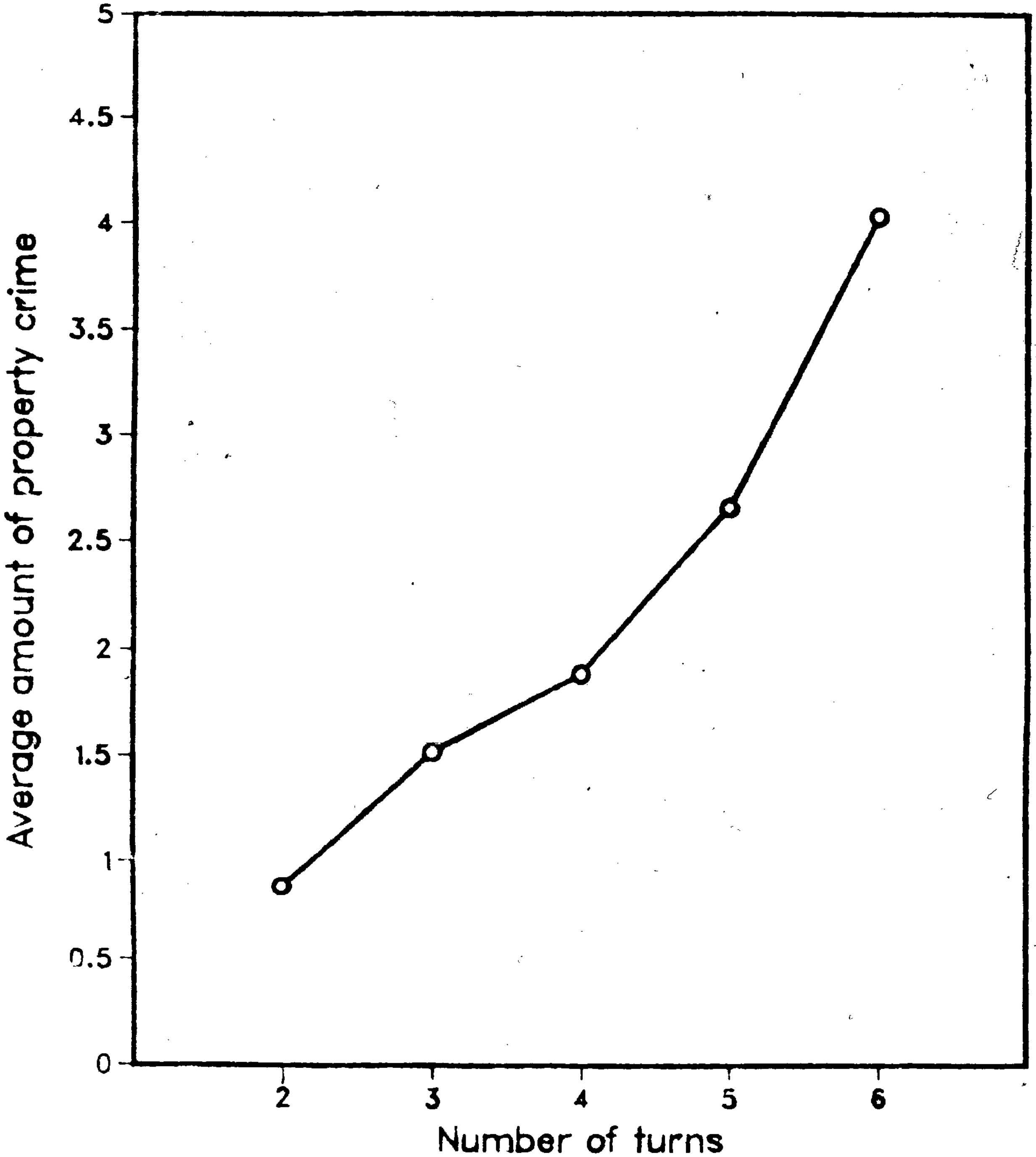
PEARSON CORRELATION

TESTS FOR THE RELATIONSHIP BETWEEN ACCESSIBILITY AND CRIME

Type of Crime	r	R^2	Significance
BICYCLE THEFT	.07510	.00564	.45223
AUTO THEFT	.89466	.80042	.02019
THEFT FROM AUTO	.95327	.90873	.00602
PROPERTY THEFT	.98462	.96947	.00114
WILFUL DAMAGE	.93659	.87721	.00949
BREAK & ENTER	.97030	.94149	.00306
TOTAL CRIME	.97126	.94335	.00291

Figure #7

NUMBER OF TURNINGS BY TOTAL CRIME



Simultaneous Effects of Accessibility and Street Flow

So far the separate statistical analyses have shown that there is a statistically significant association between property crime and the variables of accessibility and street flow. In order to evaluate street accessibility and street flow concurrently, as predictors of property crime at an individual street segment level, a two-way analysis of variance was performed.[6] Tables A.17 and A.18 of the Appendix show the results. Both factors had a statistically significant linear relationship with property crime at a street segment level. In addition there was also a significant two-way interaction between the two factors. Those blocks with both high accessibility and a high street flow volume have a disproportionately greater amount of property crime. The

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[6] In the next section a multiple regression analysis was performed. An examination of the residuals from this analysis showed that its normal distribution was quite leptokurtic. Upon investigation it was discovered that this peakedness was caused by the large number of street segments that had no crime on them (refer back to Table 8). To correct for this peakedness all those segments with no buildings on them were dropped from any future analysis. The rationale for this decision was that street segments with no opportunities should have no crime. A one-way analysis of variance confirmed this hypothesis (F-ratio = 20.346, F-prob = 0.0000) as those blocks with no opportunities averaged only 0.41 crimes per segment while those segments with at least one building average 2.2 crimes per segment. (The technical aspects of this analysis are contained in Table A.16 of the Appendix). The deletion of these 203 segments, that had no buildings on them, greatly reduced the peakedness of the residual distribution. The two-way analysis of variance that is being discussed above was performed after dropping out these buildingless segments.

predictive power of this model is relatively low as very little of the variation in the crime rate is explained at the individual block level by these two factors (R = 0.147). Furthermore, since no other variables were used in this analysis the relative strength of these two factors, limited as it is, could still be the result of other confounding variables.

In order to develop a stronger predictive model and to control for the possible effects of mitigating variables an analysis of covariance was performed. The question that then arises is what variables does one choose as covariates given the large number of independent variables available in the environmental data set? To try every combination of covariates to obtain the best predictive model is not possible.[7] To resolve this problem a stepwise multiple regression analysis was first used to find a strong combination of independent variables that predicted the amount of property crime on each street segment.[8] This combination of variables was then used in an analysis of covariance to assess the influence that these opportunity variables had on the two factors of accessibility and street

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[7]The statistical package that was used, SPSS, has a limitation of accepting up to only five covariates in a single analysis.

[8]The stepwise procedure was used here because there was no a priori reason for ordering the opportunity variables. A forward stepwise procedure was used with inclusion levels. The order of inclusion is determined by the respective contribution of each variable, based upon the partial F's, to the explained variance. The maximum number of independent variables that could be entered into the equation was set at five; a minimum partial F-ratio for any given variable to enter into the equation was set at F=5.0; and a minimum tolerance level was set quite high at t=.75 to reduce the effects of multicollinearity.

flow.[9]

Multiple Regression Model

The use of multiple regression in this study serves several functions. First, it was used to find a strong combination of variables that can be used as covariates in an analysis of covariance. In this sense it contributed to the evaluation of two major factors of interest (accessibility and street flow) by controlling for confounding variables. Second, it was used to find the linear prediction equation that "best" predicts the amount of property crime on any individual street segment using environmental variables. Third, it was used to hopefully uncover some structural relations in the data which might lead to explanations for seemingly complex multivariate relationships. A regression model was developed using five of the independent opportunity variables. The technical aspects of this model are contained in Tables A.19 and A.20 of the Appendix. The model explained almost seventy percent of the variance (R = .687). The five variables that entered into the regression equation were:

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[9]Multiple regression could be used instead of anaylsis of covariance, since the two approaches are statistically equivalent, by converting the two factors of street accessibility and street flow into dummy variables. This procedure was not used because it would require the creation of twenty-nine dummy variables; five for street accessiblity, four for street flow, and twenty for their interaction effect.

1. TAX33 - the number of commercial establishments on each block.

2. TAX32 - the average improvement value of transient accomodations on each block.

3. HI.SCH - a dummy variable: whether or not there was a high school on a street segment.

4. TAX12 - the average improvement value of any apartments on each block.

5. TAX9 - the number of apartment buildings on each block.

Analysis of Covariance

In the two-way analysis of variance it was shown that the independent variables of street accessibility and street flow had a statistically significant linear relationship with reported crime. To assess this relationship using statistical controls a multiple regression analysis was performed to find a strong combination of variables. These five variables (TAX33, TAX32, HI.SCH, TAX12, AND TAX9) were then used in an analysis of covariance to help to statistically control for environmental characteristics in the analysis of accessibility and street flow.

In an analysis of covariance the researcher has the choice of entering into the equation the factors first or the covariates first or both of them simultaneously. In this study since the factors are causally prior to the covariates, on a theoretical level, the two factors were entered into the equation first. Before criminals can select specific opportunities they must first travel to a specific location. The accessibility and street flow variables are indicators of popular routes. Travel along these routes must come causally prior to the selection of opportunities by criminals. Opportunity variables, which reflect the number and attractiveness of potential targets, were entered into the model after the two factors. By entering the factors into the model before the covariates the overall strength of the model does not change. By entering the two factors into the model first they are given the chance to explain as much of the variance as possible. When the covariates are entered into the model these new variables adjust for the variation that was solely attributed to the two factors.

The covariance model that was developed can be seen in Table 10. In this model both street accessibility and street flow are statistically significant at a .000 level. There is also a significant interaction effect between the two factors. Table 11 shows the multiple classification analysis. In this model the two factors account for 14.7% of the variance. While the covariates account for the majority of the variance in the model (54.6%) the two factors cannot be easily dismissed as being unimportant. Overall the covariance model explains 69.3% of the variance which is quite high for a model based upon such a low level of aggregation.

Table 10

ANALYSIS OF COVARIANCE
ACCESSIBILITY VS. STREET FLOW

(factors before the covariates)

SOURCE OF VARIATION	SUMS OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
MAIN EFFECTS	6085.379	7	869.340	99.124	0.000
TURNS	807.312	4	201.828	23.013	0.000
FLOW	4406.695	3	1468.898	167.487	0.000
COVARIATES	22541.297	5	4508.258	514.042	0.000
TAX33	5859.742	1	5859.742	668.142	0.000
TAX32	8640.477	1	8640.477	985.208	0.000
HI.SCH	3390.412	1	3390.412	386.583	0.000
TAX12	1731.163	1	1731.163	197.391	0.000
TAX9	1644.802	1	1644.802	187.544	0.000
2-WAY INTERACTION	863.406	11	78.491	8.950	0.000
EXPLAINED	29490.082	23	1282.177	146.197	0.000
RESIDUAL	11822.242	1348	8.770		
TOTAL	41312.324	1371	30.133		

Table 11

MULTIPLE CLASSIFICATION ANALYSIS
ACCESSIBILITY VS. STREET FLOW

GRAND MEAN = 2.20

VARIABLE AND CATEGORY	N	UNADJUSTED DEV'N	ETA	ADJUSTED FOR INDEPENDENTS DEV'N	BETA	ADJUSTED FOR INDEPENDENTS AND COVARIATES DEV'N	BETA
TURNS							
2	269	-1.25		-0.72		-0.42	
3	229	-0.64		-0.18		-0.11	
4	482	-0.13		-0.26		0.15	
5	289	0.80		0.39		0.15	
6	103	3.07		2.43		0.22	
			0.20		0.14		0.04
FLOW							
1	1143	-0.68		-0.62		-0.15	
2	119	1.46		1.27		0.68	
3	67	2.80		2.50		0.69	
4	43	9.61		9.12		1.12	
			0.36		0.33		0.06
MULTIPLE R SQUARED					0.147		0.693
MULTIPLE R					0.384		0.832

The results of this analysis of covariance are descriptively displayed in Table 11. This multiple classification analysis (MCA) table shows how the mean of each category, for the two factors, was effected when the covariates were used as statistical controls. The mean of each category is expressed as deviations from the grand mean (2.20 property crimes per block). By examining the first column of unadjusted means one can see a distinct pattern. As accessibility and street flow increase, so does the amount of property crime. The street accessibility measure (TURNS) shows that blocks that have only two turnings average .95 reported property crimes (2.20 minus 1.25) while at the other end of the spectrum, blocks with six turnings average 5.27 reported property crimes (2.20 plus 3.07). The volume of traffic measure (FLOW) likewise shows the same linear pattern as the amount of reported property crime ranges from 1.52, for the lowest volume flows, to 11.81 for the highest volume flows. This table is useful in showing the relation between the factors and the covariates in a descriptive fashion but does not provide accurate coefficients for a predictive equation because of the weak interaction effect between the two factors. The effects of the two factors on one another can be seen in the second column that adjusts for the influence of the other factor. Note the changes in these values: the effect of each factor reduces the value of the other factor. Although the variation is reduced, the ordinal pattern produced by both factors is still maintained. That is, as street accessibility or street flow increases so does the amount of reported property crime. This, of course, is consistent with a weak interaction effect.

The third column in the MCA table controls for the effects of the five covariates. The two factors still maintain the same linear pattern although each group's deviation from the grand mean is greatly reduced. The street accessibility measure (TURNS) ranges from 1.78 property crimes, for blocks with two turnings, to 2.42 property crimes, for blocks with six turnings. The street flow measure (FLOW) ranges from 2.05, for the lowest street volume flow, to 3.32, for the highest street volume flow. This third column shows that once the confounding influence of the covariates is controlled that there is little substantial difference between the different street segment types.

Discussion of the Statistical Analysis

The three strongest variables from the covariate and regression models were the number of commercial establishments (TAX33), the average improvement value of transient accomodations on each block (TAX32), and the presence of a high school (HI.SCH). These three variables accounted for 59.6% of the variance in the regression model. Having accounted for these three variables very little of the variance was explained by other variables. As seen from the analysis of covariance, the main factors under study contributed very little to the explanatory power of the model. By examining the nature of these three covariates it is not suprising that the two factors unique contributions to the covariance model was quite small.

Many commercial businesses and transient accomodations[10] are located on highly accessible street segments with high volumes of traffic.[11] The location of these buildings on highly accessible streets is an ultimate confounding problem that cannot be handled in an <u>ex post facto</u> design. By controlling for these covariates the unique contribution, to the overall variance, decreases for the accessibility measures. In essence, high commercial activity is indirectly another measure of accessibility. It is also interesting to note just how strong the dummy variable, HI.SCH, was in the regression and covariate models especially when one considers that there were only four high schools in the study area. The fact that this variable entered so strongly into the models means that there was a lot

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[10]This variable, TAX32, indicates that there is some form of a transient accomodation on the street segment. Since this variable was chosen instead of the number of transient accomodations on each street segment (TAX29) it indicates that the improvement value reflects some value other than the presence or absence of this building type. A correlation of .9518 between the CR.TOTAL and TAX29 (this correlation is only for those blocks that have this building type) shows that the larger the improvement value of the transient accomodation the greater the amount of reported property crime on each segment. Most likely the improvement value of each transient accomodation reflects the size of the building. The more rooms the building has the greater its capacity for billeting transients. The larger hotels also have drinking establishments which may account for the strong correlation between property crime and these transient accomodations.

[11]This is not likely a suprise to most city planners or business entrepreneurs.

of property crime associated with those blocks that have high schools. The ensuing discussion will highlight this observation.

The regression model developed in this study did more than provide variables to act as statistical controls for the analysis of covariance. The fact that a very strong regression model could be built at such a low level of aggregation indicates that property crime follows very distinct patterns. It is the interpretation and explanation of these patterns that will add to the understanding of the crime phenomenon.

By using the three best predictors from the regression model, 59.6% of the variance can be explained. Table A.21 of the Appendix contains the technical aspects of this analysis. To illustrate the linear dependence that property crime has on these three independent variables the following predictive equation was produced.[12]

$$Y' = 1.41 + 2.23(TAX33) + .0000880(TAX32) + 29.0(HI.SCH)$$

*Using the standard error (o = 3.49), a 99 percent confidence interval (t = 2.33) can be constructed around each estimate.

$$Y' + (t \times o) = Y' + 2.33(3.49) = Y' + 8.12$$

The value Y' is the predicted amount of property crime on a street segment in a one year time span. Given the hypothetical composition of street segments, as in Figure 8, the amount of

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[12] The partial regression coeffients are not from the original regression model. The values for the coefficients in this predictive equation come from a model that used only these three variables; see Table A.21 of the Appendix for the technical details.

property crime that will occur on them can be estimated from the predictive equation. The examples provided in Figure 8 point out some interesting observations. If a street segment does not have any commercial units, transient accomodation, or a high school on it, as in examples 5 and 6, then the predicted amount of property crime is 1.41 (the constant in the equation). According to this model, a street segment without these opportunities, such as example 5, is at the same risk as a residential segment, such as example 6. This model predicts that a street segment with a zero value for the three independent variables is at a relatively low risk of having any property crime occur on it. The first four examples give the model predictions of the amount of reported property crime for any street segments containing commercial units, transient accomodations, or high schools.

The results of the regression model show promise for calculating opportunities at risk in the future. However, the data set for the purposes of this study was constructed to examine street segments as the unit of observation and not specific types of opportunities at risk. If an analysis of opportunities was to be done the data should be re-aggregated according to the types of opportunities. Even at this extremely low level of aggregation it is still possible to fall into the ecological fallacy. Although high rates of property crime were associated with blocks that had high schools, transient accomodations or commercial units, this does not mean that the crimes occurred at those specific places.

Figure 8

Example 1 - 1 high school

$$Y' = 1.41 + 2.23(0) + .0000880(0) + 29.0(1) + 8.12$$
$$= 30.41 + 8.12 \text{ property crimes}$$

Example 2 - 1 commercial unit

$$Y' = 1.41 + 2.23(1) + .0000880(0) + 29.0(0) + 8.12$$
$$= 3.64 + 8.12 \text{ property crimes}$$

Example 3 - 9 commercial units

$$Y' = 1.41 + 2.23(9) + .0000880(0) + 29.0(0) + 8.12$$
$$= 21.47 + 8.12 \text{ property crimes}$$

Example 4 - 1 transient accomodation (improvement value = $240,000) and 4 commercial units

$$Y' = 1.41 + 2.23(4) + .0000880(240000) + 29.0(0) + 8.12$$
$$= 31.45 + 8.12 \text{ property crimes}$$

Example 5 - No buildings

$$Y' = 1.41 + 2.23(0) + .0000880(0) + 29.0(0) + 8.12$$
$$= 1.41 + 8.12 \text{ property crimes}$$

Example 6 - 10 mobile homes, 16 single family units and 3 duplexes

$$Y' = 1.41 + 2.23(0) + .0000880(0) + 29.0(0) + 8.12$$
$$= 1.41 + 8.12 \text{ property crimes}$$

The crimes may have occurred at apartments or single family homes on these blocks. The data set was not constructed to identify specific targets although it could be modified to do so at a later stage. In order to avoid the ecological fallacy, one might better consider the opportunity variables as criminogenic magnets rather than as specific targets. These independent variables draw people, including the criminal population, towards them

and any opportunities on those street segments could be acted upon.[13] The importance of the statistical findings will be discussed in light of the theoretical implications drawn from the literature in the concluding chapter.

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[13]When discussing criminals in this thesis it has not been the intention of the author to perpetuate the dualistic fallacy; that there are "good guys" and "bad guys" and never the twain shall meet. It is well recognized from the abundance of self-report literature that we all dabble in some forms of deviance at some points in our lifes. The term "criminal" is only used in the context of identifying those individuals that have the motivation to commit crimes at specific times and locations.

III. CONCLUSIONS

Methodological Considerations

It was pointed out in the discussion of the research design that the greatest limitation of this study was its *ex post facto* nature. This weaknesses has already been discussed; however, there are still a few methodological considerations that need to be expanded.

One of the concerns at the onset of this study was the conceptualization of some of the independent variables. Many of the independent variables used to measure the complexity of street networks were of a very crude nature. Street network complexity was measured at an individual street segment level, without any consideration of the interconnectivity of these units. While such an analysis was beyond the scope of this study, it cannot be overlooked as a major shortcoming. Understanding the interconnectivity of street segments is an important step in tracing the actual paths that property offenders travel, during both their regular activity patterns and during the commission of their crimes. It would be interesting to examine how vulnerable opportunities are in relation to the home location of property offenders. Such a relation would depend on such factors as distance, relative accessibility, and an awareness by the property offender of the opportunity.

It is an encouraging sign that the crude measures of segment accessibility and street flow (volume of traffic) showed significant relationships, although substantively weak, with different types of property crime. The crudity of the measures employed works against the predictive power of the models, as it contributes to the error component. It is likely that the strength of the linear relation between property crime and the two factors, accessibility and street flow, would increase as more sophisticated measures are employed.

General Considerations

The results of this study demonstrated that opportunities are at different risks in the environment depending upon their spatial location. It was shown that opportunities have a greater likelihood of being exploited if they are on relatively accessible street segments and frequently travelled streets. These observations support the theoretical supposition stance that property offenders commit crimes within their regular activity spaces.

In addition, substantively strong relationships were found between property crime and specific types of opportunities located on street segments. The explanatory power provided by the opportunity variables shows great promise for developing crime prevention stategies. In implementing crime prevention stategies, consideration must be given to the cost benifits to be derived. Given limited resources, to implement a crime prevention program, priority should be given to those areas that can receive the greatest benefit. There is no merit in changing the physical structure of potential opportunities, in order to reduce crime, if they are not at risk. A spatial crime-opportunity model can help identify those opportunities or areas that will have a high probability of being exploited. Once these high risk opportunites are identified, architectural design modifications can be attempted. Whether or not design modifications can be implemented that are successful at abating crime remains to be seen. The more interesting theoretical question is whether crime would be displaced, rather than abated. In order to answer this question, any architectural modifications to the environment, for the purposes of crime prevention, should incorporate an evaluation component into the design process.

IV. APPENDIX

TABLE A.1

TYPES OF ITEMS STOLEN FROM AUTOMOBILES

Type of Item Stolen	Absolute Frequency	Relative Frequency
Gas	26	5.0%
Wheels	47	9.0
Tapedeck/radio	113	21.7
Tools	39	7.5
Engine parts	86	16.5
Car accessories	64	12.3
Personal Belongings	58	11.1
License Plates	42	8.1
Other	46	8.8
TOTAL (n=364)	521 *	100.0%

TOTAL VALUE OF ITEMS STOLEN = $78,463.00

AVERAGE VALUE = 215.56

*The total exceeds the actual number of cases as multiple thefts of objects were recorded.

TABLE A.2

TYPES OF ITEMS STOLEN DURING BURGLARIES

Type of Item Stolen	Absolute Frequency	Relative Frequency
Cash	192	22.1%
Jewellery	59	6.8
Electronic Items	117	13.4
Tools	43	4.9
Food or liquor	85	9.7
Other	124	14.2
Nothing	252	28.9
TOTAL (n=428)	872 *	100.0

TOTAL VALUE OF ITEMS STOLEN = $226,101.00

AVERAGE VALUE = 528.00

*The total exceeds the actual number of cases as multiple thefts of objects were recorded.

TABLE A.3

TYPES OF ITEMS STOLEN FOR OTHER PROPERTY THEFTS

Type of Item Stolen	Absolute Frequency	Relative Frequency
Cash	42	7.7%
Jewellery	15	2.7
Electronic Items	29	5.2
Tools	43	7.7
Food or liquor	28	5.0
Wallets	53	9.6
Purses	34	6.1
Pets or animals	18	3.2
Other	293	52.8 *
TOTAL (n=531)	555 **	100.0

TOTAL VALUE OF PROPERTY = $220,991.00

AVERAGE VALUE = 523.68

*As can be seen from the large percentage of items that were classified as "other", the typology clearly needs to be expanded to accomodate the diverse range of items that were commonly stolen.

**The total exceeds the actual number of cases as multiple thefts of objects were recorded.

TABLE A.4

TYPES OF DAMAGES THAT OCCURRED FOR CASES OF VANDALISM

Type of Damage	Absolute Frequency	Relative Frequency
Graffiti	37	3.4%
Windows	366	33.2
Doors	66	6.0
Fences	52	4.7
Arson	19	1.7
Automobiles	337	30.6
Lawns	21	1.9
Lights	49	4.4
Other	155	14.1
TOTAL (n=716)	1102 *	100.0

TOTAL VALUE OF DAMAGE = $156,139.00

AVERAGE LOSS = 218.07

*The total exceeds the actual number of cases as multiple damages were recorded.

Table A.5

ONEWAY ANALYSIS OF VARIANCE

TESTS FOR THE RELATIONSHIP BETWEEN CURVED AND STRAIGHT STREET SEGMENTS

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	F RATIO	F PROB.
BETWEEN GROUPS	1	0.1876	0.1876	0.007	0.9350
WITHIN GROUPS	1573	44378.1699	28.2124		
TOTAL	1574	44378.3555			

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR
CURVED	199	1.9397	4.1931	0.2972
STRAIGHT	1376	1.9724	5.4537	0.1470
TOTAL	1575	1.9683	5.3099	0.1338

Table A.6

ONEWAY ANALYSIS OF VARIANCE

TESTS FOR THE RELATIONSHIP BETWEEN DEAD ENDS AND CUL-DE-SACS

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	F RATIO	F PROB.
BETWEEN GROUPS	1	0.0146	0.0146	0.003	0.9597
WITHIN GROUPS	324	1855.5535	5.7270		
TOTAL	325	1855.5679			

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR
CUL-DE-SAC	60	0.9000	2.1683	0.2799
DEAD END	266	0.9173	2.4403	0.1496
TOTAL	326	0.9141	2.3894	0.1323

Table A.7

ONEWAY ANALYSIS OF VARIANCE

TESTS FOR THE RELATIONSHIP BETWEEN
DEAD ENDS AND CUL-DE-SACS VS. GRID STREET SEGMENTS

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	F RATIO	F PROB.
BETWEEN GROUPS	1	456.8099	456.8099	16.360	0.0001
WITHIN GROUPS	1573	43921.5156	27.9221		
TOTAL	1574	44378.3242			

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR
OTHER	326	0.9141	2.3894	0.1323
GRID	1249	2.2434	5.8057	0.1643
TOTAL	1575	1.9683	5.3099	0.1338

Table A.8

ONEWAY ANALYSIS OF VARIANCE

TESTS FOR THE RELATIONSHIP BETWEEN STREET FLOW AND TOTAL CRIME

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	F RATIO	F PROB.
BETWEEN GROUPS	3	5460.5458	1820.1819	73.475	0.0000
WITHIN GROUPS	1571	38917.9346	24.7727		
TOTAL	1574	44378.4766			

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR
FEEDERS	1337	1.3575	3.3727	0.0922
MINOR ARTERIES	126	3.4921	6.3871	0.5690
MAJOR ARTERIES	68	4.9265	6.8878	0.8353
HIGHWAY	44	11.5909	18.9507	2.8569
TOTAL	1575	1.9683	5.3099	0.1338

SCHEFFE PROCEDURE - RANGES FOR THE 0.05 LEVEL

MEAN	GROUP	GRP 1	GRP 2	GRP 3	GRP 4
1.3575	GRP1				
3.4921	GRP2	*			
4.9265	GRP3	*			
11.5909	GRP4	*	*	*	

(*) Denotes pairs of groups significantly different at the 0.05 level

Table A.9

ONEWAY ANALYSIS OF VARIANCE

TESTS FOR THE RELATIONSHIP BETWEEN ACCESSIBILITY AND BICYCLE THEFT

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	F RATIO	F PROB.
BETWEEN GROUPS	4	8.9939	2.2485	1.570	0.1799
WITHIN GROUPS	1570	2248.9580	1.4325		
TOTAL	1574	2257.9517			

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR
GRP2	307	0.1629	0.6856	0.0391
GRP3	268	0.4104	2.3117	0.1412
GRP4	537	0.2533	0.8826	0.0381
GRP5	328	0.2744	0.7962	0.0440
GRP6	135	0.2519	0.6315	0.0544
TOTAL	1575	0.2667	1.1977	0.0302

SCHEFFE PROCEDURE - ranges for the 0.05 level

- NO TWO GROUPS ARE SIGNIFICANTLY DIFFERENT AT THE 0.050 LEVEL

PEARSON CORRELATION -

- accessiblity by bicycle theft (mean averages)

correlation (r) - 0.07510 R - 0.00564
significance - 0.45223

Table A.10

ONEWAY ANALYSIS OF VARIANCE

TESTS FOR THE RELATIONSHIP BETWEEN ACCESSIBILITY AND AUTO THEFT

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	F RATIO	F PROB.
BETWEEN GROUPS	4	6.1380	1.5345	6.545	0.0000
WITHIN GROUPS	1570	368.0939	0.2345		
TOTAL	1574	374.2317			

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR
GRP2	307	0.0261	0.2543	0.0145
GRP3	268	0.0448	0.2557	0.0156
GRP4	537	0.0596	0.2868	0.0124
GRP5	328	0.1128	0.4095	0.0226
GRP6	135	0.2593	1.3156	0.1132
TOTAL	1575	0.0787	0.4876	0.0123

Table A.10 continued

SCHEFFE PROCEDURE - RANGES FOR THE 0.05 LEVEL

MEAN	GROUP	GRP 2	GRP 3	GRP 4	GRP 5	GRP 6
.0261	GRP2					
.0448	GRP3					
.0596	GRP4					
.1128	GRP5					
.2593	GRP6	*	*	*		

(*) Denotes pairs of groups significantly different at the 0.05 level

PEARSON CORRELATION -
- accessibility by auto theft (mean averages)

correlation (r) - 0.89466 R - 0.80042
significance - 0.02019

Table A.11

ONEWAY ANALYSIS OF VARIANCE

TESTS FOR THE RELATIONSHIP BETWEEN ACCESSIBILITY AND THEFT FROM AUTO

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	F RATIO	F PROB.
BETWEEN GROUPS	4	36.7059	9.1765	7.208	0.0000
WITHIN GROUPS	1570	1998.7529	1.2731		
TOTAL	1574	2035.4587			

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR
GRP2	307	0.1303	0.5852	0.0334
GRP3	268	0.1567	0.6688	0.0409
GRP4	537	0.2235	0.7191	0.0310
GRP5	328	0.4512	0.3582	0.0750
GRP6	135	0.6074	0.5832	0.2223
TOTAL	1575	0.2743	1.1372	0.0287

Table A.11 continued

SCHEFFE PROCEDURE - RANGES FOR THE 0.05 LEVEL

MEAN	GROUP	GRP 2	GRP 3	GRP 4	GRP 5	GRP 6
.1303	GRP2					
.1567	GRP3					
.2235	GRP4					
.4512	GRP5	*	*			
.6074	GRP6	*	*	*		

(*) Denotes pairs of groups significantly different at the 0.05 level

PEARSON CORRELATION -
- accessiblity by theft from auto (mean averages)

correlation (r) - 0.95327 R - 0.90873
significance - 0.00602

Table A.12

ONEWAY ANALYSIS OF VARIANCE

TESTS FOR THE RELATIONSHIP BETWEEN ACCESSIBILITY AND PROPERTY THEFT

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	F RATIO	F PROB.
BETWEEN GROUPS	4	27.2239	6.8060	6.665	0.0000
WITHIN GROUPS	1570	1603.2815	1.0212		
TOTAL	1574	1630.5054			

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR
GRP2	307	0.1531	0.5357	0.0306
GRP3	268	0.2239	0.8536	0.0521
GRP4	537	0.2961	0.8872	0.0383
GRP5	328	0.4756	1.1780	0.0650
GRP6	135	0.5630	1.8228	0.1569
TOTAL	1575	0.3162	1.0178	0.0256

Table A.12 continued

SCHEFFE PROCEDURE - RANGES FOR THE 0.05 LEVEL

MEAN	GROUP	GRP 2	GRP 3	GRP 4	GRP 5	GRP 6
.1531	GRP2					
.2239	GRP3					
.2961	GRP4					
.4756	GRP5	*				
.5630	GRP6	*	*			

(*) Denotes pairs of groups significantly different at the 0.05 level

PEARSON CORRELATION -
- accessiblity by property theft (mean averages)

correlation (r) - 0.98462 R - 0.96947
significance - 0.00114

Table A.13

ONEWAY ANALYSIS OF VARIANCE

TESTS FOR THE RELATIONSHIP BETWEEN ACCESSIBILITY AND WILFUL DAMAGE

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	F RATIO	F PROB.
BETWEEN GROUPS	4	195.3934	48.8483	10.421	0.0000
WITHIN GROUPS	1570	7359.6951	4.6877		
TOTAL	1574	7555.0859			

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR
GRP2	307	0.1824	0.5935	0.0339
GRP3	268	0.4366	1.4763	0.0902
GRP4	537	0.5531	1.6677	0.0720
GRP5	328	0.7927	1.8456	0.1019
GRP6	135	1.5481	5.5081	0.4741
TOTAL	1575	0.5962	2.1909	0.0552

Table A.13 continued

SCHEFFE PROCEDURE - RANGES FOR THE 0.05 LEVEL

MEAN	GROUP	GRP 2	GRP 3	GRP 4	GRP 5	GRP 6
.1824	GRP2					
.4366	GRP3					
.5531	GRP4					
.7927	GRP5	*				
1.5481	GRP6	*	*	*	*	

(*) Denotes pairs of groups significantly different at the 0.05 level

PEARSON CORRELATION -
- accessiblity by wilful damage (mean averages)

correlation (r) - 0.93659 R - 0.87721
significance - 0.00949

Table A.14

ONEWAY ANALYSIS OF VARIANCE

TESTS FOR THE RELATIONSHIP BETWEEN ACCESSIBILITY AND BREAK AND ENTER

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	F RATIO	F PROB.
BETWEEN GROUPS	4	47.6626	11.9157	9.735	0.0000
WITHIN GROUPS	1570	1921.6182	1.2240		
TOTAL	1574	1969.2808			

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR
GRP2	307	0.2182	0.7103	0.0405
GRP3	268	0.2500	0.7747	0.0473
GRP4	537	0.4935	1.0617	0.0458
GRP5	328	0.5488	1.0683	0.0590
GRP6	135	0.8000	2.1676	0.1866
TOTAL	1575	0.4362	1.1372	0.0282

Table A.14 continued

SCHEFFE PROCEDURE - RANGES FOR THE 0.05 LEVEL

MEAN	GROUP	GRP 2	GRP 3	GRP 4	GRP 5	GRP 6
.2182	GRP2					
.2500	GRP3					
.4935	GRP4	*				
.5488	GRP5	*	*			
.8000	GRP6	*	*			

(*) Denotes pairs of groups significantly different at the 0.05 level

PEARSON CORRELATION -
- accessiblity by break & enter (mean averages)

correlation (r) - 0.97030 R - 0.94149
significance - 0.00306

Table A.15

ONEWAY ANALYSIS OF VARIANCE

TESTS FOR THE RELATIONSHIP BETWEEN ACCESSIBILITY AND TOTAL CRIME

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	F RATIO	F PROB.
BETWEEN GROUPS	4	1154.4184	288.6045	10.483	0.0000
WITHIN GROUPS	1570	43225.0254	27.5319		
TOTAL	1574	44379.4414			

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR
GRP2	307	0.8730	2.0147	0.1150
GRP3	268	1.5224	4.8885	0.2986
GRP4	537	1.8790	4.1228	0.1779
GRP5	328	2.6555	4.9622	0.2740
GRP6	135	4.0296	11.7308	1.0096
TOTAL	1575	1.9683	5.3099	0.1338

Table A.15 continued

SCHEFFE PROCEDURE - RANGES FOR THE 0.05 LEVEL

MEAN	GROUP	GRP 2	GRP 3	GRP 4	GRP 5	GRP 6
..1303	GRP2					
.1567	GRP3					
.2235	GRP4					
.4512	GRP5	*				
.6074	GRP6	*	*	*		

(*) Denotes pairs of groups significantly different at the 0.05 level

PEARSON CORRELATION -
- accessiblity by total crime (mean averages)

correlation (r) - 0.97126 R - 0.94335
significance - 0.00291

Table A.16

ONEWAY ANALYSIS OF VARIANCE

TESTS FOR THE RELATIONSHIP BETWEEN
STREET SEGMENTS WITH OPPORTUNITIES AND THOSE WITHOUT

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	F RATIO	F PROB.
BETWEEN GROUPS	1	566.6720	566.6719	20.346	0.0000
WITHIN GROUPS	1573	43811.3821	27.8521		
TOTAL	1574	44378.0508			

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR
NO OPP.	203	0.4089	3.5173	0.2469
OPPORTUNITIES	1372	2.1990	5.4894	0.1482
TOTAL	1575	1.9683	5.3098	0.1338

Table A.17

TWO-WAY ANALYSIS OF VARIANCE
ACCESSIBILITY VS. STREET FLOW

SOURCE OF VARIATION	SUMS OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
MAIN EFFECTS	6085.379	7	869.340	38.772	0.000
TURNS	807.312	4	201.828	9.002	0.000
FLOW	4406.695	3	1468.898	65.513	0.000
2-WAY INTERACTION	4890.578	11	444.598	19.829	0.000
EXPLAINED	10975.957	18	609.775	27.196	0.000
RESIDUAL	30336.367	1353	22.422		
TOTAL	41312.324	1371	30.133		

N = 1372 street segments

Table A.18

MULTIPLE CLASSIFICATION ANALYSIS
ACCESSIBILITY VS. STREET FLOW

GRAND MEAN = 2.20

VARIABLE AND CATEGORY	N	UNADJUSTED DEV'N	ETA	ADJUSTED FOR INDEPENDENTS DEV'N	BETA
TURNS					
2	269	-1.25		-0.72	
3	229	-0.64		-0.18	
4	482	-0.13		-0.26	
5	289	0.80		0.39	
6	103	3.07		2.43	
			0.20		0.14
FLOW					
1	1143	-0.68		-0.62	
2	119	1.46		1.27	
3	67	2.80		2.50	
4	43	9.61		9.12	
			0.36		0.33

MULTIPLE R^2	0.147
MULTIPLE R	0.384

Table A.19

MULTIPLE REGRESSION MODEL

VARIABLE	SIMPLE R	MULTIPLE R	BETA	R^2
TAX32	.54269	.54269	.47713	.29451
TAX33	.54251	.71768	.46132	.51506
HI.SCH	.28380	.77228	.28569	.59642
TAX12	.24585	.80414	.21351	.64664
TAX9	.21916	.82869	.20054	.68673

ANALYSIS OF VARIANCE	SUMS OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
REGRESSION	28371.97	5	5674.394	598.887	0.0000
RESIDUAL	12942.71	1366	9.477		

Table A.19 continued

MULTIPLE REGRESSION MODEL

VARIABLE	B	R^2	F
TAX32	0.883E-04	.29451	972.262
TAX33	2.163	.51506	906.818
HI.SCH	29.077	.59642	355.887
TAX12	0.153E-04	.64664	197.770
TAX9	0.265	.68673	174.815
(constant)	1.223		

Table A.20

MULTIPLE REGRESSION MODEL

(Correlation Matrix)

VARIABLE	CR.TOTAL	TAX32	TAX33	HI.SCH	TAX12
CR.TOTAL	1.00000				
TAX32	0.54269	1.00000			
TAX33	0.54251	0.14323	1.00000		
HI.SCH	0.28380	-0.00265	-0.00037	1.00000	
TAX12	0.24585	0.00111	0.04610	-0.00141	1.00000
TAX9	0.21916	0.00002	0.01554	-0.00073	0.05456

Table A.21

MULTIPLE REGRESSION MODEL

VARIABLE	SIMPLE R	MULTIPLE R	BETA	R^2
TAX32	.54269	.54269	.47548	.29451
TAX33	.54251	.71768	.47452	.51506
HI.SCH	.28380	.77228	.28524	.59642

ANALYSIS OF VARIANCE	SUMS OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
REGRESSION	24641.01	3	8213.670	673.895	0.0000
RESIDUAL	16673.67	1368	12.188		

STANDARD ERROR = 3.49

Table A.21 continued

MULTIPLE REGRESSION MODEL

VARIABLE	B	R^2	F
TAX32	0.880E-04	.29451	750.616
TAX33	2.225	.51506	747.583
HI.SCH	29.032	.59642	275.794
(constant)	1.412		

Table A.22

List of Information Taken From Land Usuage Maps

- TURNS - the accessibility measure which was shown in Figure 5. The number of turnings for each street segment ranged from one to six.
- LENGTH - the length of each street segment was measured in feet. This variable was collected for two reasons. First, to see if the length of a street segment somehow affects a criminal's spatial awareness of targets. Second, this variable was used to develop a density measure (opportunities/length) to see if spatially isolated targets are more vulnerable.
- TYPE - this variable identifies the stuctural type of each street segment: dead end, cul-de-sac, or grid. Since dead ends and cul-de-sacs are structurally less accessible than grids it is expected that there will be less crime on these blocks.
- CURVES - many street segments are structurally different from others because they are curved. This variable was collected to see if the curvilinearity of street segments affect the spatial awareness or mobility patterns of property offenders. Street segments were identified as being either straight or curved.

- SFD - the number of single family dwellings on each street segment. This variable is an objective measure of opportunities.
- DUPLEX - the number of duplexes on each street segment. This variable is an objective measure of opportunities.
- MOBILE - the number of mobile homes on each street segment. This variable is an objective measure of opportunities.
- APTS - the number of apartment buildings on each street segment. This variable is an objective measure of opportunities.
- UNITS - the number of apartment units on each street segment. This variable is an objective measure of opportunities.
- CHANGE - the number of building units built in the last year. This variable was determined by comparing the land usuage maps of the previous year to the present year. This variable was used as an indicator of transition zones which are often associated with high rates of crime.
- FLOW - street flow. This variable was a measure of the amount of traffic that travelled upon each street. It was based on a simple precode that the planning department had defined. Streets were classified as highways, major arteries, minor arteries, or feeders. Each street segment was classified on an ordinal scale from one to four depending upon its predefined street flow status.

- HI.SCH - whether or not there was a high school on each street segment. This variable is an objective measure of opportunities.
- ELEM.SCH - whether or not there was a elementary school on each street segment. This variable is an objective measure of opportunities.
- PARKS - whether or not there was a park on each street segment. This variable is an objective measure of opportunities.

Table A.23

LIST OF VARIABLES IN THE MASTER DATA SET

Variable Names	Definitions
ID	Segment identification number
NAME	Name of street (numeric identification)
LOW	Low address range of block segment
HIGH	High address range of block segment
LENGTH	Length of block segment in feet
TURNS	Accessibility measure
CURVES	Whether or not a street segment was straight
TYPE	Layout of street segment (dead end, cul-de-sac, or grid)
SFD	No. of single family dwellings (land usage maps)
DUPLEX	No. of duplexes (land usage maps)
APTS	No. of apartment buildings (land usage maps)
UNITS	No. of apartment units (land usage maps)
CHANGE	No. of building units built in the last year (land usage maps)
HI.SCH	Dummy variable: high school on segment
ELEM.SCH	Dummy variable: elementary school on segment
PARKS	Dummy variable: park on street segment
TAX1	No. of single family dwellings according to the tax assessment data
TAX2	Average square feet of single family dwellings according to the tax assessment data

Table A.23 continued

LIST OF VARIABLES IN THE MASTER DATA SET

Variable Names	Definitions
TAX3	Average land value of single family dwellings according to the tax assessment data
TAX4	Average improvement value of single family dwellings according to the tax assessment data
TAX5	No. of duplexes according to the tax assessment data
TAX6	Average square feet of duplexes according to the tax assessment data
TAX7	Average land value of duplexes according to the tax assessment data
TAX8	Average improvement value of duplexes according to the tax assessment data
TAX9	No. of apartments according to the tax assessment data
TAX10	Average square feet of apartments according to the tax assessment data
TAX11	Average land value of apartments according to the tax assessment data
TAX12	Average improvement value of apartments according to the tax assessment data
TAX13	No. of mobile homes according to the tax assessment data
TAX14	Average square feet of mobile homes according to the tax assessment data

Table A.23 continued

LIST OF VARIABLES IN THE MASTER DATA SET

Variable Names	Definitions
TAX15	Average land value of mobile homes according to the tax assessment data
TAX16	Average improvement value of mobile homes according to the tax assessment data
TAX17	No. of civic buildings according to the tax assessment data
TAX18	Average square feet of civic buildings according to the tax assessment data
TAX19	Average land value of civic buildings according to the tax assessment data
TAX20	Average improvement value of civic buildings according to the tax assessment data
TAX21	No. of industrial sites according to the tax assessment data
TAX22	Average square feet of industrial sites according to the tax assessment data
TAX23	Average land value of industrial sites according to the tax assessment data
TAX24	Average improvement value of industrial sites according to the tax assessment data
TAX25	No. of vacant lots according to the tax assessment data
TAX26	Average square feet of vacant lots according to the tax assessment data

Table A.23 continued

LIST OF VARIABLES IN THE MASTER DATA SET

Variable Names	Definitions
TAX27	Average land value of vacant lots according to the tax assessment data
TAX28	Average improvement value of vacant lots according to the tax assessment data
TAX29	No. of transient accomodations according to the tax assessment data
TAX30	Average square feet of transient accomodations according to the tax assessment data
TAX31	Average land value of transient accomodations according to the tax assessment data
TAX32	Average improvement value of transient accomodations according to the tax assessment data
TAX33	No. of commercial establishments according to the tax assessment data
TAX34	Average square feet of commercial establishments according to the tax assessment data
TAX35	Average land value of commercial establishments according to the tax assessment data
TAX36	Average improvement value of commercial establishments according to the tax assessment data
TAX37	No. of farms according to the tax assessment data
TAX38	Average square feet of farms according to the tax assessment data

Table A.23 continued

LIST OF VARIABLES IN THE MASTER DATA SET

Variable Names	Definitions
TAX39	Average land value of farms according to the tax assessment data
TAX40	Average improvement value of farms according to the tax assessment data
CRIME1	No. of stolen bicycles at family dwellings
CRIME2	No. of stolen bicycles at commercial establishments
CRIME3	No. of stolen bicycles at public places
CRIME4	No. of stolen bicycles at unknown or other places
CRIME5	No. of auto thefts at family dwellings
CRIME6	No. of auto thefts at commercial establishments
CRIME7	No. of auto thefts at public places
CRIME8	No. of auto thefts at unknown or other places
CRIME9	No. of thefts from autos at family dwellings
CRIME10	No. of thefts from autos at commercial establishments
CRIME11	No. of thefts from autos at public places
CRIME12	No. of thefts from autos at unknown or other places

Table A.23 continued

LIST OF VARIABLES IN THE MASTER DATA SET

Variable Names	Definitions
CRIME13	No. of property thefts at family dwellings
CRIME14	No. of property thefts at commercial establishments
CRIME15	No. of property thefts at public places
CRIME16	No. of property thefts at unknown or other places
CRIME17	No. of wilful damages at family dwellings
CRIME18	No. of wilful damages at commercial establishments
CRIME19	No. of wilful damages at public places
CRIME20	No. of wilful damages at unknown or other places
CRIME21	No. of break & enterings at family dwellings
CRIME22	No. of break & enterings at commercial establishments
CRIME23	No. of break & enterings at public places
CRIME24	No. of break & enterings at unknown or other places

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