THE MODERATING EFFECTS OF VEGETATION ON HUMAN VIOLENT BEHAVIOR CAUSED BY ENVIRONMENTAL STRESSORS

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ABSTRACT

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People experience the environment throughout their entire lives (Stringer, 1975). Its effect, though often imperceptible, is significant, for it can alter human behavior in various ways (Russell and Snodgrass, 1987, Weiss and Baum, 1991). Much research attempts to explain the relationship between the environment and human behavior with the term "environmental stressor." According to studies, environmental stressors have an effect on the behavior and emotion of human beings. Some examples of environmental stressors given in previous studies are temperature, air pollution, noise, and density and crowding (Evans and Cohen, 1987; Weiss and Baum, 1991). The negative effects of these environmental stressors on humans occur in the form of mental

fatigue and lead to increased anger, aggression, and even violence (Baker, 1984; Baum and Koman, 1976; Donnerstein and Wilson, 1976; Rule et al., 1987).

In constrast, a natural environment such as an urban forest, provides a number of benefits for a human beings' quality of life (Grey and Deneke, 1978; Laurie, 1979; Miller, 1988; Robinette, 1972). These benefits include providing clean air, noise reduction, screening, recreational activities, a balanced microclimate, reduced wind velocity, and the like (Tyrväinen, 1997). People who live in vegetated areas experience less fear, and exhibit less aggressive and/or violent behaviors (Kuo and Sullivan, 2001a).

This study design hypothesizes that population density in urbanized areas can function as an environmental stressor to urban residents and lead to a higher crime rate. The study considers both daytime population density and nighttime population density. In addition, the moderating effect of vegetation on aggressive and violent behaviors in human beings caused by environmental stressors is examined. Based on previous studies, here it is hypothesized that vegetated areas in urban settings can moderate environmental stress produced from a high population density, and reduce crime.

For measuring daytime density, the movement of people, including pedestrian and automobiles, and static population density, such as employment density, is considered. Thus, the approximate distance from each block group to the central business district (CBD) of the city of Dallas represents daytime density. Nighttime population density is based on census data. In order to calculate nighttime density, the population in each block group is divided into the area of each block group. For the crime data, the FBI (Federal Bureau of Investigation) Uniform Crime Reports (UCR)

database is used. The amount of vegetation is measured by using multi-spectral satellite imagery. All these data are coordinated and measured by the Geographical Information System (GIS), and analyzed with the Statistical Package for the Social Science (SPSS).

The results of this study show that nighttime and daytime population density have an effect on violent crime, and that vegetation has a moderating effects on the relationship between population density and violent crime.

This study is important to urban planners and landscape architects who develop design criteria in order to provide for a safer urban environment and a better quality of life for human beings.

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CHAPTER 1

INTRODUCTION

1.1 Environment and Behavior Relationship

Humans live and experience the environment temporally and sequentially in their daily lives. In other words, people and the environment interrelate; they interact with each other over time and through space (Stringer, 1975). In several ways human beings and their environment are related. Human beings are prompted, constrained, and shaped in environmental conditions because the environments are the arena in which people live. So, their behaviors are altered, or limited in their environment (Weiss and Baum, 1991).

A new field of study, called "Psychophysiology," has developed models and theories to explain human physiological responses to the environment. These theories and models vary, but they have common principles relating to the study of environment-behavior relationships. First, psychological conditions can be measured by observing the physiological activity that is going on within a person. Second, when things in the environment affect a person, there is a behavioral response along with a physiological change; analyzing this physiological change can help to understand the environmental affect on a human's mood and health (Weiss and Baum, 1991).

Mehrabian and Russell (1974) proposed pleasure, dominance, and arousal as three fundamental responses to environmental stimulation. These aspects were thought to describe cognitive, feeling, and affective responses to external stimuli, and among of

these aspects, pleasure and dominance mainly express feelings which are measured as internal conditions or observations of obvious behaviors (Mehrabian and Russell, 1974). Weiss and Baum (1991) described arousal and stress as two main orientations toward conceptualizing physiological responding. Arousal affects behavior, and human beings perform best at moderate levels of arousal (Broadbent, 1971). Stress is a process which translates environmental demands or threats into psychophysiological responses. These responses include psychological, behavioral, and physiological changes also related with a change of health condition (Rahe, 1975; Schneiderman, 1983), such as harm, or ill health. In addition, environmental events called stressors initiate stress (Lazarus and Cohen, 1978).

Hence, human beings and their environment cannot be separated. The relationships between people and their environmental surroundings are active rather than passive (Krupat, 1985). This interaction results in a person's physical, psychological, and behavioral conditions and responses.

1.2 Environmental Stressors

Certain environmental stressors are categorized by Weiss and Baum (1991) in their study, "Environment-Behavior Relationships" and Evans and Cohen (1987) in their study, "Environmental Stress." The stress-producing factors examined were such things as heat and cold, air pollution, noise, and density and crowding. These environmental stressors, taken in extreme, have a negative affect on human physiology and psychology, including the emotion and behavior.

Human beings are stressed if they are exposed to severe temperatures, and their lives are threatened if such exposure is continued for a long time (Evan and Cohen, 1987; Weiss and Baum, 1991). Goranson and King (1970), in their study of urban and campus riots, noticed that high temperatures were found in the same areas where outbursts of violence were taking place. Certain levels of cold temperatures bring on aggression as well but in their study it was difficult to find subjects who were exposed for long periods of time to these extremely cold temperatures (Bell and Baron, 1977).

Several studies have been done regarding the relationship between pollution and a human beings' health and behavior. Pollution causes a deficiency of oxygen, and can be the cause of physiological damage, loss of health, and psychotic behavior (Beard and Wertheim, 1967; Mehrabian and Russell, 1974; Schulte, 1963).

According to the examination of the interaction between environmental conditions and human behavior, noise has possible negative effects on the quality of human life (Weiss and Baum, 1991). Exposure to continuous noise has been shown to cause increased arousal and stress, and an insufficiency in performance (Cohen, 1980).

Density and crowding are two of the most considerable environmental stressors that have been studied. Most of the early research about the effects of density and crowding were examined by using animal experimentation. The result of this research is expected to be mirrored in humans due to the straightforward conclusion. According to these experiments, high density is connected with organ changes (Myers et al., 1971), aggression, abandonment, sexual disorder (Calhoun, 1970), performance decrements, and slower learning (Goeckner et al., 1974). More recently, studies of crowding and

density have been investigated by many researchers. They found that crowding and density are associated with human beings' physiological arousal such as palm sweat (Bergman, 1971; Saegart, 1974), increases in skin conductance (Aiello et al., 1975), and a rise in heart rate and blood pressure (D'Atri, 1975; D'Atri et al, 1981; Evans, 1979). Density and crowding are related with human beings' behavior such as social problems, delinquency, and crime (Booth and Welch, 1973; Cholden and Roneck, 1975; Levy and Herzog, 1974).

In summary, the environmental stressors presented (heat and cold, pollution, noise, and density and crowding) bring about an increase in arousal and stress. These stressors are associated with physiological, psychological, and social behavior in human beings.

1.3 Functions of Vegetation in the Environment

According to Sommer (2003), vegetation has many more uses than just decorative; hence it is not merely for embellishment. In the past two decades, a number of studies have investigated the benefits vegetation has on humans and on their environment (Dwyer and Schroeder, 1994; Kaplan and Kaplan, 1989; Ulrich, 1993). Scientists have demonstrated that vegetation moderates temperature, reduces wind speed, noise, water overflow, and air pollution, also it conserves energy (Bolund and Hunhammar, 1999; McPherson et al., 1999).

Behavioral scientists and psychologists have shown the various positive effects of vegetation on human beings, such as reducing stress and mental fatigue, lowering the

level of violence and crime in the inner city, and aiding in recovery from surgery (Kaplan and Kaplan, 1989; Kaplan, 1984; Kuo and Sullivan, 2001a; Kuo and Sullivan, 2001b; Kuo et al., 1998; Miles et al., 1998; Ulrich et al., 1991).

Vegetation is also useful in enhancing spaces. It is often used for aesthetic and architectural purposes. For example, plants can soften building edges, provide a decorative background, and screen areas for privacy (Booth, 1983; Cooper Marcus and Sarkissian, 1986).

In urban settings, vegetation provides economic benefits. Vegetation is associated with the increase of property values, and this in turn can result in higher housing prices (Luttick, 2000; Martin et al., 1989; Payne and Strom, 1975). Because vegetation contributes to better health, it can lower the amount of money spent on health care services (Tyrväinen, 1997)

Consequently, vegetation clearly provides benefits, and contributes positively to various areas of people's lives, as well as and their habitats in aesthetic, social, physical, and psychological ways.

1.4 Problem Statement

A number of studies have shown the relationship between human beings and their environment. Various adverse environmental conditions such as temperature, air pollution, noise, and density and crowding are identified as environmental stressors and are associated with the quality of human life as well as health and mood. These factors also affect one's psychology and behavior. Previous studies show the relationship

between the environment and humans, as well as the effect of environmental stressors on a person's behavior. In particular, population density in urban settings is directly associated with urban residents' behavior and psychological state which are theoretically linked to crime. However, there has been limited research into investigating the actual relationship between environmental stressors and crime. The question remains to be answered as to whether there is a relationship between density and crime in a particular area.

Vegetation in an environment has been shown to reduce stress, mental fatigue, and the level of violent behavior and crime in human beings. In addition, how does vegetation affect crime once the relation between density and crime rate has been established in the same area? Little is known about the positive effects vegetation has on the relationship between environmental stressors and crime. This leaves room to investigate the moderation effect of vegetation on this relationship.

1.5 Research Objectives

This thesis examines the relationship between population density and crime. Density is considered an environmental stressor which affects human beings' behavior, it causes aggression and violence. Previous studies have stated the relationship between density and human violent behavior. Thus it has been hypothesized that exposure to high density areas causes more crime in urban settings. For this study, daytime density and nighttime density are respectively considered as main independent variables. The differences between daytime density and nighttime density also is measured in order to

look at the correlation between the variations of density and crime. In addition, this thesis measures the moderating effect of vegetation on this relationship between population density and crime. A positive effect of vegetation on a human beings' psychological states has been shown in previous studies.

In sum, this study investigates the relationship between population density and the number of crimes reported. As well as the moderating effects of vegetation on this relationship between density and crime.

1.6 Research Questions

Theories and experimental studies state that environmental stressors can increase the likelihood of human beings' anger, aggression, and even violence (Baker, 1984; Baum and Koman, 1976; Donnerstein and Wilson, 1976; Rule et al., 1987; Weiss and Baum, 1991) On the contrary, people who live in vegetated areas report feeling lower levels of fear, and show less aggressive and violent behaviors (Kuo and Sullivan, 2001). In this regard, this study aims to test these following questions:

1. Are there more crimes in higher population dense areas?

2. Is there any difference between the effects of daytime density and nighttime density on crime?

3. Is there a moderating effect of vegetation on the relationship between density and crime?

1.7 Importance of the Research

Previous studies have stated that the problematic environmental conditions defined as environmental stressors such as, temperature, noise, air pollution, and crowding and density effect human beings' stress, aggression, and violent behavior. It is hypothesized, that a higher population density leads to higher numbers of crimes, and, that vegetation can moderate the negative impacts of population density on crime. Through this study, knowledge concerning the positive effects of vegetation in urbanized areas can be extended in the field of landscape architecture. These results can help to develop the criteria relating to density in urban areas in the field of new urbanism.

Throughout this study the information gained will help landscape architects and urban planners, those who have roles in dealing with the environment, to have more ideas in developing design criteria. Thus, they will have the tools to design a safer urban environment and a better quality of life for human beings.

1.8 Definition of Terms

Crowding: "an experience of the outcome of the appraisal of physical conditions, situational variables, personal characteristics, and coping assets" (Baum and Paulus, 1987, p. 534).

Daytime Density: the concept of daytime density takes into account the movements of people, including pedestrians, automobiles, as well as static population variables, such as employment density.

Density: "physical conditions associated with numbers of people in given amounts of space" (Baum and Paulus, 1987, p. 534).

Environmental Stressor: a number of conditions, including the effects of physical factors such as temperature, air pollution, noise, and density and crowding, which cause problems with human psychology, physiology, and behavior.

FBI: Federal Bureau of Investigation

GIS: Geographical Information System

Georectify: same meaning as georeference**,** which means "to establish the relationship between page coordinates (x and y) of a planar map of image with known real-world coordinates such longitude, latitude, and UTM. Also referred to as registering." (MacRae, 1998).

LandSAT: "A series of satellites that produce images of the earth. The LandSAT remote sensing satellite program was developed by NASA (National Aeronautics and Space Administration). LandSAT data are provided in BIL (Band Interleaved by Line) or .BIP (Band Interleaved by Pixel) formats. BIL and BIP are supported by ARC/INFO and ArcView" (ESRI, 1995).

Nighttime Density: population density within a block group based on census information.

Psychophysiology: a theory that explains the physiological response to the environment, and common principles to the study of environment-behavior relationship.

UCR: Uniform Crime Reports, the "crime rates are expressed as the number of crimes per 100,000 residents in the population" (Nolan, 2004, p. 547).

Vegetation: all kinds of natural elements (which continuously are growing and changing) such as trees, shrubs, and grass.

Violent crime: potentially violent person-to-person crimes such as murder, rape, robbery, and aggravated assault which are associated with physical resources.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

> "Places are not simply physical locations, mere passive containers of, or background to, human action; instead, they are treated as dynamic productions that acquire meaning in and through discourses."
>
> (Dixon et al., 1997, p. 319)

Generally speaking, the study of the relationship between the environment and human behavior explains the world of everyday experiences; that is what people perform, feel, and perceive, or all that constructs the lives they live (Ittelson, 1987). In other words, people experience the environment, whether they realize or not. In certain environmental conditions, human beings' behaviors are altered or limited, because environments are the arena in which they live (Weiss and Baum, 1991). This chapter examines a number of studies in order to identify the relationships between human beings' behavioral and psychological responses to specific environmental conditions (Cohen, 1978; Frankenhaeuser, 1975; Zubek, 1969).

In this chapter, several studies are described to support basic concepts of this research; namely, the relationships between the environment and the human emotional, psychological, and behavioral responses to environmental conditions.

2.2 Environment and Behavior Relationship

The relationship between people and their environment is complex and difficult to understand, but certainly a key outcome of this relationship is emotion. Emotions are linked to places (Russell and Snodgrass, 1987). People usually consider, before going somewhere, what the experience will be like, whether it will be pleasant or unpleasant. Upon arrival, the affective quality of the new place's atmosphere impresses the person. The affective quality of the place can stimulate emotional changes, such as feelings of stress, depression, peace, or delight. "Affective quality is the bottom line of an accounting of the many features in a place" (Russell and Snodgrass, 1987, p. 245). A person, based on this accounting, decides whether to stay, leave, or ever return to the place again. This affective quality is a key factor in much of a person's later relationship to the place and how the place it affects his or her mood, health, and subjective satisfaction. "Environmental psychologists have found that understanding the relationship between a person and a complex, large-scale environment requires a new view of a person and behavior" (Russell and Snodgrass, 1987, p. 246).

2.2.1 Emotion

The word emotion refers to a "heterogeneous class of different phenomena" (Russell and Snodgrass, 1987, p. 246). In the Russell and Snodgrass (1987) study "Emotion and the Environment," the researchers proposed and informally defined the nature of emotion using four terms: emotional disposition, mood, affective appraisal, and emotional episode. The first, emotional disposition, is long-term, whereas the latter

three are short-term events. Thus, in order to explain the person–environment interaction and how emotion is involved in this relationship, emotion itself needs to be defined and looked at in detail.

Russell and Snodgrass (1987) define emotional disposition as being a long-term phenomenon. It is explained as "a tendency to do or think or feel particular things when the right circumstances occur" (Russell and Snodgrass, 1987, p. 246). The examples are a person's love for family or country, or negative feelings about pollution. These feelings are constant, even if not conscious; they may not be shown outwardly except in certain conditions. This kind of emotional disposition can be viewed as synonymous with attitudes.

The other state of emotion Russell and Snodgrass described is a short-term state or event, because this types of emotion happens over a short span of time, at most a few days. The short-term emotional events, mood, affective appraisal, and emotional episode, are described below.

Mood can be described as "the core emotion-tinged feelings of a person's subjective state at any given moment" (Russell and Snodgrass, 1987, p. 247). People are always in some kind of mood whether it is pleasant or unpleasant; generally, these moods are not directly related to any outward object. Feelings of calmness, depression, anger, excitement, unhappiness, or neutrality are all different moods a person can be in.

Affective appraisal can be described as "an aspect of how someone interprets other persons, places, events, and or things" (Russell and Snodgrass, 1987, p. 247). An affective appraisal is a characteristic placed on "some item, episode, or setting of an

affective quality." A person may interpret something as being pleasant, preferable, or repulsive. Unlike mood (which is not directed toward any particular object), affective appraisal always ties to an object. It is the way an individual inwardly views an object—e.g., as likable or dislikable.

An emotional episode refers to "an emotional reaction to something, with the reaction typically involving coordinated and distinctive physiological, behavioral, and mental changes" (Russell and Snodgrass, 1987, p. 247). The examples of typical emotional episodes Russell and Snodgrass (1987, p. 247) offer are, "falling in love with someone, suffering grief at a death, getting angry at someone, and being frightened by a bear in the woods." These type of things may not happen every day, but they are good examples of what is typically meant by emotion (Fehr and Russell, 1984). Emotional episodes must be linked with affective appraisal and mood, because when a person experiences an emotional episode, mood change and affective appraisal generally are involved. In the typical case of an emotional episode, an external event is affectively appraised, and causing a change in mood, physiology, and behavior; but there are arguments concerning which comes first (James, 1890, 1950; Schachter and Singer, 1962).

Emotion theorists debate over the general elucidation of an emotional episode (Izard, 1977; Lazarus et al., 1980, Schachter and Singer, 1962), yet most agree that it usually consists of three constituents: behavioral, physiological, and mental. The behavioral component is divided into two categories of reactions; expressive, which is shown by crying, laughing, or tone of voice; and, instrumental, which is shown by

running away or aggression. “The physiological component includes changes in, or activity clearly innervated by, the autonomic nervous system. Thus, we attribute emotion to those who blush or tremble. But it also presumably includes more central processes, usually thought to occur in the limbic system” (Russell and Snodgrass, 1987, p. 252). The mental component of emotion is a little more vague, but three things occur typically, all of which have been mentioned previously: (1) people appraise the outward situation or thing according to how it affects them, (2) they find themselves in a certain mood, (3) they notice their own emotional episode. So, individuals recognize that they are happy, sad, upset, or whatever the feeling may be. These three components put together make up an emotional experience (Russell and Snodgrass, 1987). In sum, the configuration of environmental, mental, physiological, and behavioral changes make up an emotional episode.

2.2.2 Effects of the Environment

The environment is not only visual and objective, but it also includes intangibles, everything that people confront in their settings. This means that if some people feel comfortable in certain environments which meet their needs, values, and desires, others may feel uncomfortable in that same environment. The former, who are compatible in the environment will be happy and satisfied. Their levels of happiness and satisfaction correlate with the degree of compatibility (Krupat, 1985). The latter, who are incompatible in the environment, will have a lower level of satisfaction and happiness than the former. People’s emotions are stimulated and influenced by the physical

environment without their being aware of it. Emotions help to explain the entanglement of human beings' relationship to the environment.

2.2.2.1 Invisible Environment

An individual's mood may change when exposed to various imperceptible chemicals. Anderson (1982) in a review of environmental pollutants, described how chemicals affect mood, especially how they are related to unpleasant moods such as nervousness, anxiety, depression, and irritability. In addition, inaudible sounds called infrasound, "sound waves in frequencies below the normal range of human hearing", may also cause psychological changes (Russell and Snodgrass, 1987, p. 259).

A pleasant environment may put people in a pleasant mood, which in turn increases positive or prosocial behavior. On the contrary, an unpleasant environment may cause an unpleasant mood, resulting in more antisocial behavior. This statement is supported by studies about "unpleasant odors (Rotton et al., 1978; Rotton et al., 1979), the pleasantness of an entire room (Gifford, 1980), cigarette smoke (Jones and Bogat, 1978), and noise (Donnerstein and Wilson, 1976; Green and O'Neal, 1969; Konecni, 1975). All of these things are basically invisible, yet all can affect a person's mood and behavior. When people are in a pleasant mood, they may have more of a desire to be with others (Bell, 1978; Gouax and Gouax, 1971; Mehrabian and Rusell, 1974; Tomkins, 1962) and they may behave positively (Moore et al., 1973).

2.2.2.2 Spatial Density

According to Zajonc's 1965 study on the social facilitation effect, a person's arousal increases because of the presence of someone else in the environment. The more people there are in a given environment, the more potential arousal may occur. In like manner, the closer the people are to one another, the more arousal potential may occur (Middlemist et al., 1976). "Closer interpersonal distances can stem from lack of space, a condition now called spatial density" (Russell and Snodgrass, 1987, p. 266). The terms spatial density and interpersonal distance are usually used interchangeably in most research studies. However, Worchel and Teddlee (1976) noted that human behavioral effects are attributable to interpersonal distance, rather than spatial density.

Regardless, it is difficult to predict the specific distance between people that causes behavioral or emotional changes, because reactions differ from person to person (Russell and Snodgrass, 1987). The effects of density and interpersonal distance are not always purely positive or negative, but depend on circumstance and person (Baron, 1978; Freedman, 1975; Storms and Thomas, 1977). Despite this, people generally feel unpleasant when others invade their personal space, such as someone sitting in a nearby seat without asking. This violation of personal space increases arousal "which constitutes the key ingredient in stress, anger, fear, and similar states" (Russell and Snodgrass, 1987, p. 266), and it can sometimes lead to withdrawal or conflict. On the other hand, depending on the environment, an individual may feel happy when another person enters their personal space (Russell and Snodgrass, 1987).

2.3 Environmental Stressors

Evan and Cohen (1987) state that analyzing appropriate environmental conditions for best possible human performance is one way to understand the relationship between the environment and human behavior. Several studies have examined how stress has been used to designate environmental stressors such as extreme temperatures, air pollution, noise, and density and crowding that may bring on problems in a person's physical or psychological condition (Evan and Cohen, 1987; Weiss and Baum, 1991). Stress is accessed by individual appraisals and responses to actual environmental conditions (Baum et al., 1982; Magnusson, 1982). The conditions of the physical environment are important in the stress and coping process. Some particular environmental conditions are more capable than others for a human being's best performance. Understanding the variation of environmental conditions provides more insight into the stress and coping process (Forsman, 1983; Magnusson, 1982).

2.3.1 Density and Crowding

Today, more than ever, human beings are constantly irritated by environmental problems such as extreme temperatures, air pollution, noise, and density and crowding. There has been for some time more concern in the general public about overpopulation and crowding (Baum and Paulus, 1987, Calhoun, 1970, Ehrlich and Ehrlich, 1970; Zlutnick and Altman, 1972). Zlutnick and Altman (1972) stated that the phenomena related to crowding and physical density is connected with a variety of social problems such as deteriorating quality of life in cities, crime, and the breakdown of families.

The terms density and crowding were formerly used equivalently. Stokols (1972) discriminated "between the physical condition of density and the subjective experience of crowding"(Baum and Paulus, 1987, p. 534). On the one hand, "density refers to physical conditions associated with numbers of people in given amounts of space" (Baum and Paulus, 1987, p. 534). But, "crowding refers to an experience—the outcome of appraisal of physical conditions, situational variables, personal characteristics, and coping assets" (Baum and Paulus, 1987, p. 534). People interpret and evaluate stressors differently; stress depends on the person reporting or experiencing it. Under certain circumstances a person may not experience crowding but another person in the same spatially dense place may experience crowding (Lazarus, 1966).

The way settings are evaluated results in crowding. Two ways density can be categorized are social and spatial density. Social density represents the changing number of people in certain areas, and spatial density refers to the changing amount of space while the number of people is constant. (Loo, 1972; McGrew, 1970; Zlutnick and Altman, 1972).

Early studies of crowding used laboratory animals and investigated their behavior. These studies evaluated the effect of density on behavior rather than the experience of crowding because there is no way to understand how animals feel in given settings. In high density conditions, there were negative effects on the animals' physiology such as organ damage and dysfunction, and aggressive behavioral responses

(Baum et al., 1981; Christian, 1963; Henry and Stephens, 1977; Henry et al, 1967; Henry, 1971; Myers et al., 1971).

There are some weaknesses in using animal studies to approach human behavior because humans have more coping abilities than animals, and there are additional possibilities of environmental variables. However, the outcomes of the animal studies have provided information useful to studying human responses in urban density (Baum and Paulus, 1987). Several research studies focus on the relationship between urban density and human social or physical pathology. Some of the studies have proposed that density is related to delinquency, social, and psychological problems (Booth and Welch, 1974; Levy and Herzog, 1974; Schmit, 1966).

Other studies have stated that exposure to crowding in small spaces increased aggression among people (Aiello et al., 1979; Ginburg et al., 1977; Hutt and Vaizey, 1966). There was a variation in the response to high density according to ages and gender. Rohe and Patterson (1974) reported that children have more conflict in high density. Also, males have more aggressive responses to crowding in spatial limitation than females (Baum and Koman, 1976; Freedman et al., 1972; Schettino and Borden, 1976; Stokols et al., 1973). “Thus decreasing amounts of space may be more aversive to men because they are more likely to appraise spatial restriction as threatening, because their style of coping with it is more aggressive, or because they simply require more personal space” (Baum and Paulus, 1987, p. 546).

Overload is one perspective of what happens socially when people are confronted with high density situations (Baum and Paulus, 1987). This results from an

individual's perception of the environmental stimulation and his or her coping level (Rapoport, 1975). People seek to have a certain balance of stimulation; a person does not want to be overloaded with stimulation but neither do they want to be isolated (Rapoport, 1975). This balance is contingent on circumstances and a person's characteristics. Individuals attempt to find this balance by changing their behavioral and psychological way of coping. When experiencing crowding people try to get away from the crowded areas or act standoffish. On the contrary, when experiencing isolation people put themselves around other people to increase social interaction (Rapoport, 1975). Baum and Paulus (1987) say, when experiencing overload a person may behave in stereotypical ways. "One may also make decisions on the basis of less information and analysis and, hence, be more responsive to salient social cues such as gender or race" (Baum and Paulus, 1987, p. 552).

In urban life, overload is the cause of much of the unfriendly interactions between city residents (Baum and Paulus, 1987). Unfriendly behavior is essentially a reaction to high social demands, and it causes individuals to separate themselves from unimportant people and place. Stressed urbanites tend to pay attention to the pertinent aspects of their environment and stay away from the impertinent. A person perceives the stimuli in the environment and decides how to cope with it, resulting in mental fatigue and withdrawal from the excessive stimuli (Cohen, 1978).

People want to use space in a certain way, but when others invade anther's space, it causes frustration and the experience of crowding occurs (Brehm, 1966; Stokols, 1972,

1976). As a result, the individual tries to occupy additional space by changing their behavior in order to accomplish the original goals.

2.3.2 Noise, Heat, and Air Pollution

Noise is referred to as "unwanted sound" (Evan and Cohen, 1987, p. 586). Generally noise is described by "intensity (e.g., dBA), frequency (e.g., pitch), periodicity (continuous or intermittent), and duration (acute or chronic)" (Evan and Cohen, 1987, p. 586). An elevated blood pressure, heart rate, and skin conductance are all results of exposure to loud (usually > 90 dBA) and unpredictable noise (Cohen and Weinstein, 1982; Glass and Singer, 1972; McLean and Tarnopolsky, 1977).

There are more injurious effects physiologically and psychologically to residents who live in communities with high noise levels (Tarnopolsky et al., 1978; Weinstein, 1978). In experimental settings exposure to severe noise causes self-reports of stress, tension, and annoyance (Evan and Cohen, 1987, p. 586). Some studies have stated that there is greater aggression and hostility under noise (Cohen and Spacapan, 1984; Rule and Nesdale, 1976). All these things show noise to be an environmental stressor.

Temperature is also an environmental stressor. Human body temperature is perceived through the relationship between the environmental temperature and the core body temperature. The human body regulates its core temperature, keeping it within the range of 37°C (Evan and Cohen, 1987). When this core temperature is disrupted due to an increase in temperature from external environment, high risk of heat stroke and heat exhaustion occurs, which can eventually lead to death (Bell and Greene, 1982). In

addition, not only external environmental temperature but also other outward factors influence surrounding temperature which in turn can affect human health (Evan and Cohen, 1987).

Studies have shown that human behavior is influenced by various levels of ambient heat exposure. For example, performance in response tasks and rapid signal detection tasks improves when individuals are initially exposed to heat. The performance level then progressively declines as the person remains in the heat (Bell and Greene, 1982; Poulton, 1970).

Griffiths (1975) mentions that thermal comfort relates to ambient temperature, humidity, and clothing insulation properties. The average range of thermal comfort for most people is usually 24 to 27°C with 45% relative humidity and moderate clothing. However, when temperature rises people usually experience discomfort or irritability and later fatigue. According to Baron's 1978 study there is a direct relationship between human hostility and aggression and increase in temperature. Yet, when hot temperature continues, the aggressive behavior is withdrawn and people choose to escape from the hot environment. There are filed studies that actually support this idea; these show that the violent acts increased along with the rise of temperature, up to approximately 32°C, but later decreased with prolonged high temperature (Baron, 1978; Bell and Greene, 1982).

Third, among defined environmental stressors, air pollution has been less researched than other stressors mentioned. The health cost related to air pollution alone is approximately $240 million dollars per year in the United States (Evans and Jacobs,

1982). Air pollution is a serious problem that affects not only the majority of the population of the United States but also world wide (Evans and Jacobs, 1982).

The two categories of air pollutants are indoor air pollutants and heavy metals, such as lead, mercury, cadmium, and other compounds. These two categories which contribute to ambient pollutants have not been analyzed and documented enough, and these should be taken seriously in the health community. Few studies have been made on human behavior in relation to ambient air quality (National Academy of Science, 1981).

Research has shown that bad odors and cigarette smoke cause annoyance and negative performance (Rotton, 1983). Furthermore, chronic exposure to air pollution eventually results in feelings of helplessness and increased hostility (Evans and Jacobs, 1982).

Finally, there are studies that link air pollution levels to poor mental health. Recent studies, with thorough controls and research designs, have found evidence of a correlation between pollution levels and psychological health (Briere et al., 1983; Strahelivitz et al., 1979). The study by Evans et al. (in press) found that people who had negative psychological impacts as a result of air pollution were those who had recently experienced a stressful life event. Still, labeling air pollution as an environmental stressor is not confirmed; thus far only negative affect data supports the theory of linking air pollution to stress.

2.4 Environmental Psychology of Disorder

Morris (1957), the first social ecologist correlated data relating crime to environmental characteristics. Crime, delinquency, and fear are not distributed equally. Crime and delinquency are related issues; within a community these are found to be a large part of societal problems which the populace has to deal with. (Podolefsky, 1983; Podolefsky and DuBow, 1981). Among different social groups such as lower, middle, and upper-class, crime and delinquency are viewed differently. In a society there are generally three different groups of people: lower, middle, and upper-class, all three have problems with crime. Interestingly enough in Ralph Taylor's (1987) study, he claims that among the lower class, one of the reasons there is criminal and delinquent activity is due to a lack of recreational facilities.

Regardless of where one lives, be it within the city or in the suburbs, people come across all kinds of disorder, from the small things such as beggars and vandalism to more serious crimes such as robbery, assault, and murder (Fisher and Baron, 1982; Rainwater, 1966). There are more crimes, delinquency, and fear of crime in some places than other places (Baum and Paulus, 1987; Taylor, 1987), and these are related with human territoriality (Newman, 1972; Jeffrey, 1977). The concept of territoriality refers to "An interlocked system of attitudes, sentiments and behaviors, regarding small-scale or delimited spaces of the environment, concerned with who has access to the spaces in question and what activities go on there, and with the expression of the occupants linkage to the space" (Russell and Snodgrass, 1987).

Environmental conditions such as litter, graffiti, and evidence of vandalism in a space make people feel unsafe and causes some people have the desire to commit crime in these same areas (Newman, 1972).

Hence, crime, delinquency, and fear, which can be called environmental psychological disorders are within a continuum. In other words, these three items are a continuous whole, in which no part is distinguishable from the other. These are associated with human territoriality, which is the result of the delimitation of spaces in the environment.

2.4.1 Human Territorial Functioning

Human territorial functioning refers to a combination of a person's feelings, emotions, and behaviors related to a space they claim as their territory, along with who they allow in the space, what goes on in the space, and how the space expresses the person (Taylor, 1987). Human territorial functioning expresses the context of sociology, physiology, and culture, and is linked with aggression, dominance, and even good relationships within groups. "Territorial functioning is also place-specific" (Taylor, 1987, p. 954). In specific areas, territorial behavior essentially relies on the perceived quality of an area and what it means to an individual (Taylor, 1987).

The territorial functioning is stronger in the spaces where individuals spend most of their daily lives. In other words, an episode happening in the front or backyard is more significant than an episode happening on the sidewalk or street, and these are more important than outside the neighborhood. "Thus territorial control is weakest

surrounding locations such as playgrounds, alleys (Brower, 1980), small corner shops, commercial strips or nodes (McPherson et al., 1983), institutional land use (Suttles, 1968), or even heavily trafficked streets (Appleyard, 1981)" (Taylor, 1987, p. 955).

2.4.2 Disorder and Territoriality

Along with the previous statement, territorial functioning provides a good view for understanding why the disorder continuum such as crime, delinquency, and fear of crime are more dominant in some spaces than others. In some places there are two groups who share a common neighborhood; because they both want territorial control some kind of balance or equilibrium must be reached. The equilibrium is reached through a temporal and spatial response in their territory (Taylor, 1987). For example, one group hangs out one the streets corner after 8 p.m. whereas the other group gathers in the ally after dark; these two groups control these areas at those times. If these spaces are invaded by the other group, the equilibrium is disrupted.

There are two ways this equilibrium can be disrupted. First, people wish to extend their territorial control. This results in the possibility of people attempting to execute too much territorial control. Second, the equilibrium between order and disorder can be disturbed, "when an area experiences a change in the composition of its population, as in the case of gentrification or racial succession, or when an area experiences significant physical or other land use changes such as the building of a shopping mall or highway, demolition or construction of other buildings, or increased

vacant units" (Taylor, 1987, p. 958). Hence, some areas have more opportunities for disorder, because of the location, type of land use, and traffic patterns.

2.4.3 Physical Environment and Crime

Previous studies have sought to find the reason why more delinquency or criminal acts are generated in certain places of urban settings than others (Taylor, 1987). An early study of Shaw (1929) reports that the concentration of delinquent and adult offenders is higher in places that are physically deteriorated, and these places are mostly in the transition zone of nearby central business districts and industrial areas. City growth usually brings out the expansion of central business districts to increase services and jobs go along with population growth. Shaw (1929) concludes that physical deterioration is best interpreted as evidence of an area encountering transition, on account of a city's growing pattern, from residential to commercial or industrial land use.

> It has been quite common in discussions of delinquency to attribute causal significance to such conditions as poor housing, overcrowding, low living standards, low educational standards and so on. But these conditions themselves probably reflect a type of community life. By treating them one reflect a type of symptoms of more basic processes. (Shaw, 1929, p. 205)

Spaces are classified by land uses, such as private or semiprivate, and public or open for the community, such as stores, churches, or playgrounds. These land uses explain different behavior settings and opportunity areas where disorder may be. Some public places are less likely to have disorder as a result of territoriality for some of the following reasons: First of all, public spaces are generally not close to homes and

residential areas where more territoriality occurs. Second, in public spaces all different kinds of people gather, from all different areas making it difficult for any one to understand the territorial boundaries giving less control to any particular group (Taylor, 1987).

O'Donnell and Lydgate (1980) concluded that some crime correlated with land uses in Honolulu. For example, while robbery and larceny usually happen in retail, restaurant, and entertainment areas, fraud is associated with tourist business. In addition, some crimes associated with physical resources are related to potentially violent crimes such as robbery, assault, and disorderly conduct. Katzman (1981), using a "density potential model" (Taylor, 1987, p. 969) in Dallas, came to the conclusion that property crime was greater in neighborhoods with higher property values. He also found that there is a higher crime rate in neighborhoods near poorer populations.

2.5 Functions and Effects of Vegetation in the Environment

2.5.1 Functions of Vegetation in the Environment

Vegetation is an exceedingly significant element in designing and managing external environments (Booth, 1983). Vegetation serves as a structural element in outdoor spaces creating beautiful overall spaces. Vegetation is not merely an important element for the visual quality of an outdoor environment; it has more possible and potential functions (Booth, 1983). Sommer (2003) states that vegetation has many more uses than just decorative, hence it is not merely for embellishment but also it executes a number of roles in environment.

Instead of vegetation, Booth (1983) uses the term “plant material” which is “to present native and cultivated woody plants of all types, from groundcover to trees” (Booth, 1983, p. 66). Robinette (1972) classifies the functional uses of plant materials into four categories: architectural uses, engineering uses, climate control, and aesthetic uses. With the different characteristics of plant materials such as shape and height, they are used architecturally to screen unpleasant views, control privacy, and create spaces and outdoor rooms. (Booth, 1983). The engineering use of plant materials include purifying air, keeping moisture in soil, and preserving erosion and loss of soil (Booth, 1983; Grey and Deneke, 1986; Schroeder, 1989; Tyrväinen, 1997). Climate control means modifying air temperature by blocking exposure to sun and wind (Booth, 1983). The use of plant material aesthetically is to “emphasize or accentuate certain points in exterior environments” (Booth, 1983, p. 112) and to soften or lessen a building’s shape and form. Consequently, plant materials have various functions and roles in outdoor environments.

In addition, vegetation is refer to as “natural,” because it is “growing, and changing” (Robinson, 2004, p. 10). This characteristic of vegetation contributes to the enhancement the visual quality of its surroundings; it provides potential recreational activities in wooded areas (Tyrväinen, 1997), as well as a pleasant and enjoyable nature for people in urban areas (Booth, 1983).

2.5.2 Effects of Vegetation on Humans

Previous studies well stated the various environmental and social benefits of vegetation in urban settings (Grey and Deneke, 1978; Laurie, 1979; Miller, 1988; Robinette, 1972). These benefits include providing an amiable nature, shading, screening, clean air, erosion prevention, wind velocity reduction, and a balanced microclimate (Booth, 1983; Tyrväinen, 1997).

Several studies examined numerous positive effects of vegetation on human psychology and physiology. One theory named, "Attention Restoration Theory" proposed by S. Kaplan (1995) suggests that exposure to natural environments such as landscapes help to reduce mental fatigue, that is, directed attention fatigue. Other studies propose that this reduction of mental fatigue in natural environments support and assist in public health, and even reduce the levels of violence and crime in the inner city (Kaplan, 1984; Kaplan and Kaplan, 1989; Kuo and Sullivan, 2001; Miles et al., 1998). In addition, it has been found that natural settings have a sedative effect giving an innoxious incitement that brings out positive emotion and mood, and block negative feelings (Ulrich, 1979, 1984). These positive effects on human psychology lead to an affect on human physiology as well. Ulrich's 1979 study looks at the relationship between natural settings and recovery from surgery. According to his study, patients who have view of a natural setting have a faster recovery from surgery than patients who have a view of an urban setting. Even photographic simulation of natural views has an affect on recovery from surgery (Ulrich, 1984).

Peterson (1976) reports that generally people look for neighborhoods that are well-vegetated, have trees, small parks, and walking paths. People who lives in such an area have higher satisfaction and social interaction in their community (Kweon et al., 1998). But, when these same people want to get away and find privacy they leave their homes and seek out an urban forest (Hammitt, 2002).

In addition, there are studies regarding the effects of plants indoors on people's performance and mood. One way to change an office space is to arrange foliage plants (Shibata and Suzuki, 2002). Interestingly enough, people bring plants to work because they hope to reduce their stress and mental fatigue (Asaumi et al., 1994, 1995a; Kondo and Toriyama, 1989). There are similar researches suggesting that looking at plants in work environments bring out creative tasks (Stone and Irvine, 1994). Also, Asaumi et al. (1995b) reports that people feel more pleasant and lively when plants are in their environment. Tennessen and Cimprich (1995) stated that students who see more vegetation from their dormitory windows had better performance on their attention, and their studies.

In summary, a number of studies have investigated the effects of vegetation on human psychology and physiology. These effects occur not only in community parks (Canin, 1991; Cimprich, 1993) and natural areas (Hartig et al., 1991; R. Kaplan, 1984), but also in natural settings viewed through windows (Ovitt, 1996; Tennessen and Cimprich, 1995), as well as rooms with interior plants (Asaumi et al., 1995b; Lohr et al., 1996).

2.6 Summary

The literature shows that people are always being affected by the environment whether they are aware of it or not. The environment is not merely visual and objective, but also everything that humans confront in their settings. The relationship between people and their environment is complex and difficult to understand. Human emotion is a key aspect in understanding this relationship, because emotions are linked to places. When people stay in a certain place, the atmosphere's affective quality impresses them. The affective quality of places gives them emotional changes such as feelings of stress, depression, peace, or delight.

The literature also states that the environmental condition ties to human emotion, behavior, and health. It also shows that there are problematic environmental stressors which affect a person's psychology, physiology, and behavior. These environmental stressors are mainly categorized into density and crowding, temperature, noise, and air pollution. When people are exposed to these environmental stressors, their psychological and physical behavior change. These changes include stimulation, stress, mental fatigue, organ damage, increased heart rate, aggression, and violence. The literature review reveals that space, crowding, and territoriality shape a person's emotion and behavior. People generally have their own territoriality, but it is difficult to understand the territorial boundaries in public spaces. The delimitation of spaces in the environment is associated with environmental psychological disorders such as crime, delinquency, and fear. It has also been reviewed that some places have more opportunities for disorder, due to their location and types of land use.

In addition, the literature proves that vegetation has various functions and benefits. It is not merely for embellishment but also executes a number of roles in environment. The functions of vegetation include purifying air, keeping moisture in soil, modifying air temperature, and so on. There are also numerous positive effects of vegetation on human psychology and physiology. In inner city environment, vegetation helps reduce metal fatigue, the level of violence, and crime.

Based on literature reviews, this research will reveal whether there is any relationship between environmental stressors, specifically density, and human violent behavior. Any moderating effect on this relationship will also be shown.

CHAPTER 3

RESEARCH METHOD AND DATA

3.1 Introduction

This chapter describes study rationale, study flow, and variables. Specifically, the second sub-chapter describes study rationale, including the relationship between density and crime and the effects of vegetation on their relationship. The third sub-chapter develops the moderation model of vegetation on the relationship between population density and crime. The fourth sub-chapter discusses the study flow and data. In particular, the fourth sub-chapter characterizes the study site, study design, and variables used in the study as well as the variables and their measurements. In addition, this sub-chapter discusses the methods used to measure both the dependent and independent variables including daytime density, nighttime density, and the amount of vegetation. The fifth sub-chapter summarizes the study method and data.

3.2 Study Rationale

3.2.1 Density and Crime

Numerous studies find strong ties between environmental conditions and humans' behavior and emotion. In particular, population density has been shown to be relevant to a variety of social problems and crime (Booth and Welch, 1974; Levy and Herzog, 1974; Schmit, 1966; Zlutnick and Altman, 1972). Baum and Paulus (1987)

define population density as, “physical conditions associated with the number of people in a given amount of space.” Under some conditions and for some people, a given level of population density in a setting can lead to crowding and function as an environmental stressor. It is evident that exposure to crowded environments in small spaces can increase aggression among people (Aiello et al., 1979; Ginburg et al., 1977; Hutt and Vaizey, 1966). Thus it is presumable that high density in urbanized areas can results in increased aggression of urban residents and lead to violent crimes. Figure 1 illustrates the relationship between density, crowded environments, aggression, and crime, based on previous studies.

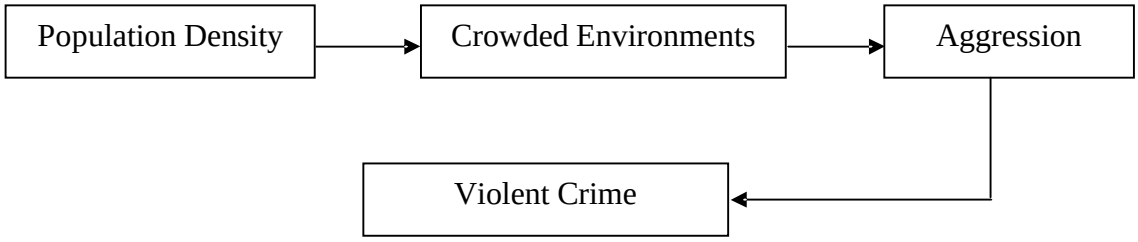

Figure 1. The hypothesized mechanism showing how population density can lead to crime based on previous studies

3.2.2 Moderation Effects of Vegetation

Vegetation has been shown to have numerous benefits for humans in several different ways, such as purifying air (Tyväinen, 1997; Schroeder, 1989), modifying air temperature (Booth, 1983), and offering an aesthetic experience (Booth, 1983). Vegetation in urban settings also brings on psychological effects. Kweon et al. (1998) find that spending time in green outdoor spaces is related to making stronger social interaction among residents. Ulrich et al. (1991) report that vegetation can speed

recovery from surgery as well as aid in stress reduction. More importantly, vegetation in urban environments can reduce levels of violence and crime in urbanized areas by aiding in recovery from mental fatigue (Kaplan, 1984; Kaplan and Kaplan, 1989; Kuo and Sullivan, 2001a; Kuo and Sullivan, 2001b; Miles et al., 1998). Thus it is very clear from previous studies, that vegetation in urban environments has positive psychological effects on urban residents' behavior and mental condition, and can reduce the level of violence in urbanized areas.

As stated earlier, population density functions as an environmental stressor and potentially leads to an increase of crime in urban environments. Vegetation can reduce the level of violence in urban settings. It is therefore presumable that vegetation may reduce the impact of population density on violent crime. Figure 2 summarizes the hypothetical negative effects of population density and the moderation effects of vegetation.

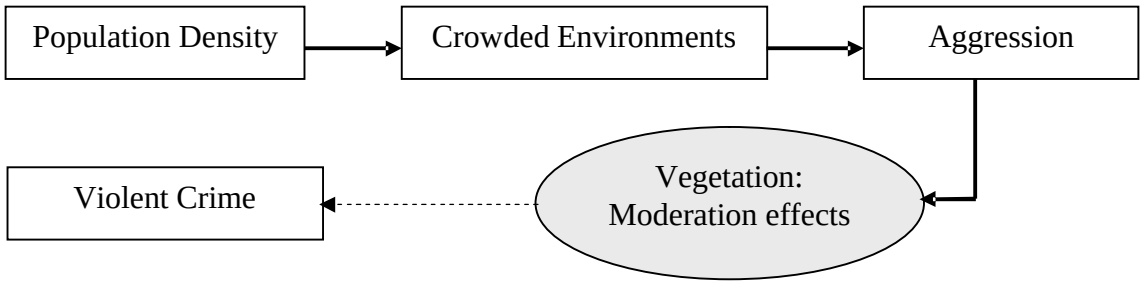

Figure 2. Hypothetical negative effects of population density and moderation effects of vegetation.

In Figure 2, the hypothesized negative effect of population density is considerably reduced by the moderation effects of vegetation. Development of the

moderating effects of vegetation on the relationship between population density and crime is discussed in the next chapter in detail.

3.3 Moderation Model of Vegetation

3.3.1 Moderation Model

A moderator can be considered as a third variable that affects the direction or strength of the relationship between an independent variable and a dependent variable. Specifically, a moderator effect would be said to occur if a relationship is substantially reduced instead of being reversed (Baron and Kenny, 1986). In statistical terms, moderation can be considered as an interaction between an independent variable and a factor (i.e., moderator) of a dependent variable. Baron and Kenny (1986) provide some examples of moderation framework types and different statistics showing different dependent, independent, and moderator types. If both the independent variable and moderator are categorical, then simple 2 3 2 ANOVA should be used. If a moderator is a dichotomous measure and the independent variable is continuous, then it tests the difference between the two correlation coefficients and then the slopes of two regression coefficients. However, regardless of the types of variables, a moderation model can be represented by a dependent variable, independent variable, moderator, and the interaction between moderator and independent variable, as shown in Figure 3. Figure 3 depicts the hypothetical relationship between density and vegetation with violent crimes; the three causal paths feed into the outcome variable of the dependent variable in the model. The moderator hypothesis is supported if the interaction (Path c)

is significant. There may also be significant main effects for the predictor and the moderator (Path a and b), but these are not directly relevant conceptually to testing the moderator hypothesis.

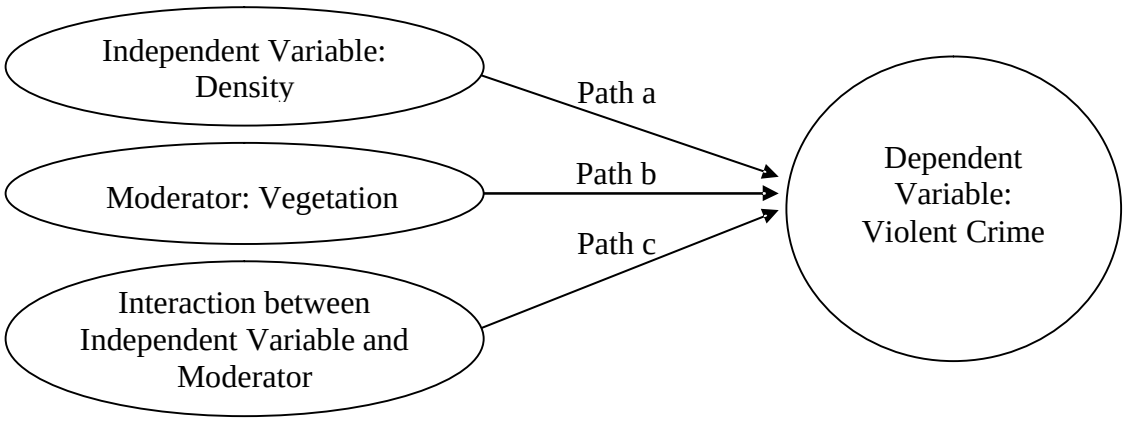

Figure 3. Hypothesized moderation model of vegetation showing the relationship between density and crime.

3.3.2 Moderation Models of Vegetation for Daytime Density and Nighttime Density

The hypothesized moderation model of vegetation represented in equation 1 is that the proximity to a central business district (CBD) of a census block group may positively affect violent crime. This hypothetical relationship suggests that vegetation may moderate the effects of the approximate a census block group to a CBD on violent crime. The study measures proximity in distance of the CBD from the geographical center of each census block group boundary. Therefore the expected sign of b_1 is negative. In other words, the further the census block group from the CBD, the less number of violent crimes are expected.

(1) $Y_v = a + b_1X_d + b_2X_v + b_3X_dX_v + e,$

where Y_v = violent crime,

X_d = distance to CBD,

X_v = amount of vegetation,

X_dX_v = product of distance to CBD and amount of vegetation,

a = constant, b_1, b_2, and b_3 = coefficients, and e = error term

In equation 1, if a moderator—amount of vegetation in a block group—is dichotomized at a certain point and labeled as low vegetation (LV, $X_v = 0$) / high vegetation (HV, $X_v = 1$), the equation 1 could be broken into two separate equations. First, in low-vegetated (LV) areas, there exists only a constant and the distance to the CBD term in the equation, because the vegetation term (X_v) and interaction term (X_dX_v) drop out from the equation due to $X_v = 0$ (equation 2). Second, the vegetation term becomes a constant in the high-vegetation (HV) areas because $X_v = 1$ as shown in equation 3. Now two regression models contain a constant and an independent variable respectively. The moderation effect can be tested by examining whether or not the slopes of the LV and the HV models are significantly different. More specifically, it is indicative that there is a moderation effect of vegetation if b_1 (i.e., an estimated slope in equation 2) is significantly different from b'_1 (i.e., $b_1 + b_3$, an estimated slope in equation 3). Also, t-statistics can be used to test a significance level of two slopes as given in equation 4 with $df = n_0 + n_1 - 4$, where n refers to number of observations of each group (Cohen & Cohen, 1983, p.56). From the hypothesis of this study, it is expected that b'_1 (i.e., $b_1 + b_2$) is significantly smaller then b_1 by the moderation effect of trees.

(2) $Y_{lv} = a_l + b_1 X_d + e$, *when* $X_v = 0$,

(3) $Y_{hv} = (a + b_2) + b_1 X'_d + e'$, when $X_v = 1$, and

$= a'_1 + b'_1 X'_d + e$,

where $a'_1 = (a + b_2)$ and $b'_1 = b_1 + b_3$

(4) $$t = \frac{b_l - b'_1}{\sqrt{\frac{\sum (y_l - \hat{y}_l)^2 + \sum (y_t - \hat{y}_t)^2}{n_l + n_t - 4} \times \frac{\sum X_d^2 + \sum X_d^{t\,2}}{\sum X_d^2 \times \sum X_d'^2}}}$$

where n = number of observations in LV and HV

Similarly, the moderation of vegetation for nighttime density can be transformed into equation 6 and 7 from equation 5.

(5) $Y_v = a + b_1 X_d + b_2 X_v + b_3 X_d X_v + e$,

where Y_v = violent crime,

X_d = nighttime density,

X_v = amount of vegetation,

$X_d X_v$ = product of nighttime density and amount of vegetation,

a = constant, b_1, b_2, and b_3 = coefficients, and e = error term.

(6) $Y_{lv} = a_l + b_1 X_d + e$, *when* $X_v = 0$,

(7) $Y_{hv} = (a + b_2) + b_1 X'_d + e'$, when $X_v = 1$, and

$= a'_1 + b'_1 X'_d + e$,

where $a'_1 = (a + b_2)$ and $b'_1 = b_1 + b_3$

3.4 Study Flow and Data

3.4.1 Study Site

Dallas County, Texas was selected as the study site. The county includes Dallas, the largest city in the North Texas region. The study site is bordered by Kaufman and Rockwall counties to the east, Tarrant County to the west, Denton and Collin counties to the north, and Ellis County to the south. The city of Dallas is the county seat and largest city. The county's size is 908.7 square miles composed of thirty-seven major cities in North Texas including Dallas, Irving, Coppell, Euless and Grand Prairie. The county is drained by the Trinity River in the middle of the boundary in Figure 4. Total population is more than 2 million, and the average household income is $63,417. Between 1950 to the 1990's, the population of the county rapidly increased. By 1950, 89.8 percent of Dallas County was considered urban, and in 1950, the whole county was officially classified as the Dallas Metropolitan Statistical Area by the census bureau (The Handbook of Texas Online, 2005). The population tripled between 1950 and 1990, from 614,799 to 1,852,810 people. One of the considerable characteristics of the population changes in the county was the rapid increase of Hispanic population. In 1980 the Hispanic population made up 9 percent of the population, but by 1990 it was 17 percent, and it keeps increasing (US Census Bureau, 1990, 2000).

According to the 11th Annual America's Safest and Most Dangerous Cities Survey by Morgan Quitno Awards (2005), the city of Dallas, the largest city in the county, is the fifth most dangerous city among 32 cities with a population of 500,000 or more.

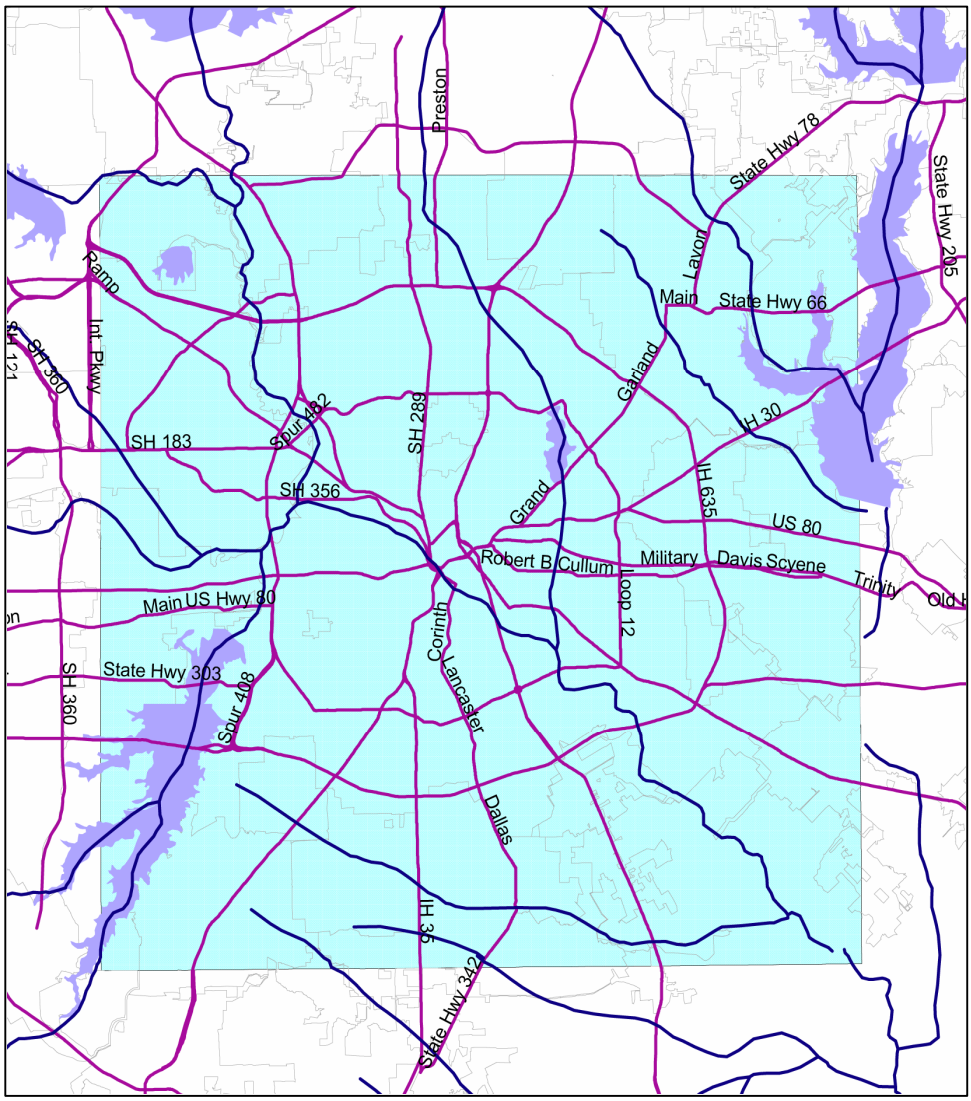

Figure 4. The study site including major cities in North Texas Region. The Trinity River and well-structured transportation provide natural and economic dynamics.

3.4.2 Study Flow and Measurement

3.4.2.1 Study Flow

Figure 5 illustrates the overall process of the study. In order to test moderation effects of vegetation on the relationship between density and crime, the study process

incorporates density analysis, crime analysis, and vegetation analysis. The density analysis study differentiates between daytime and nighttime density; the daytime moderation model and nighttime moderation model will be test respectively with the results of crime and vegetation analysis. The definitions and analysis process of density, crime, and vegetation for the census block group are discussed in the next sub-chapter.

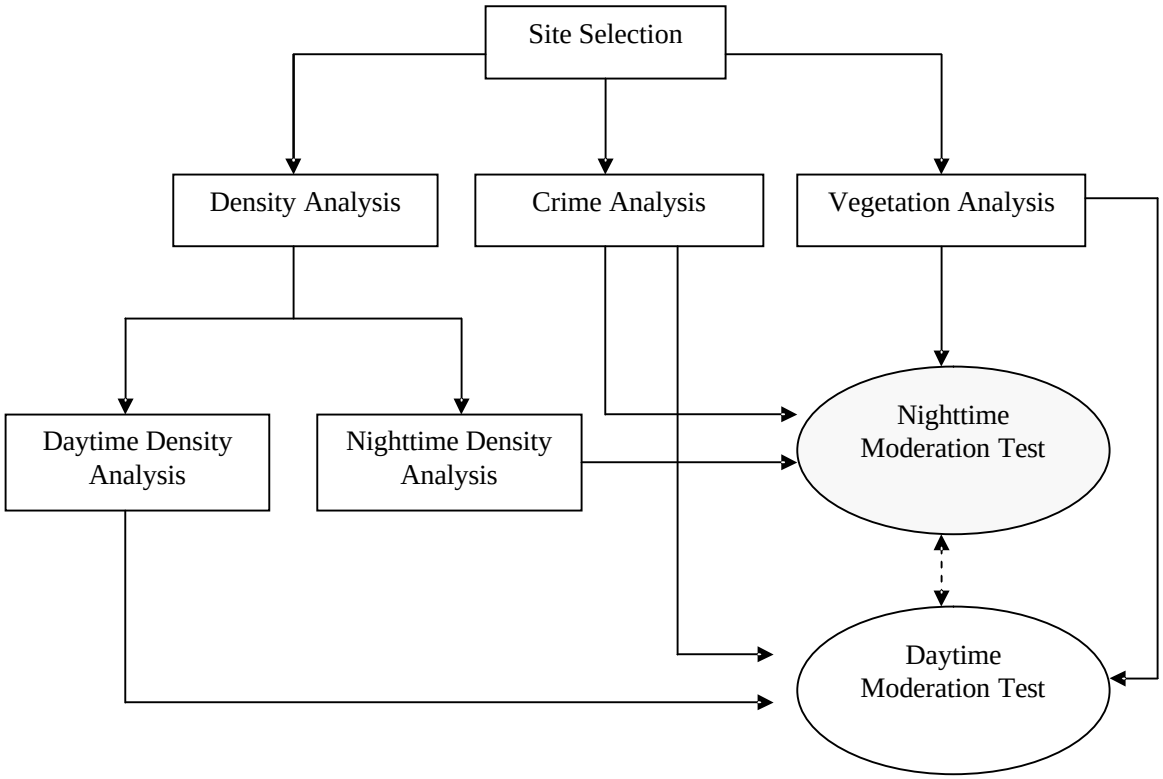

Figure 5. Study process to test moderation effects of vegetation on the relationship between density and crime.

3.4.2.2 Measuring Violent Crime

In order to measure the number of violent crimes reported within the 1683 block groups in the study site, the Crime Risk data of Spatial Insight, Inc. was analyzed. This

data are based on the crime rate of the Federal Bureau of Investigation's Uniform Crime Reports (UCR) which name known as "Index Crimes". UCR is considered as a popular resource of crime statistics in the United States (Regoli and Hewitt, 2000; Schmallerger, 1999; Siegel and Semma, 2000). Index Crimes represents seven categories of crime: four violent offenses (murder, rape, robbery, and aggravated assault) and three nonviolent crimes (burglary, larceny theft and motor-vehicle theft) (Texas Almanac, 2005). As defined in chapter 3.2.2, violent crime includes murder, rape, robbery, and assault. "Crime rate is generally expressed as the number of crimes per 100,000 residents in the population" (Nolan, 2004, p. 547). From the first method of Nolan's 2004 study, the following simple equation was derived and used to calculate the crime rate:

(8) $CR = NC \times 100{,}000 / POP$

where CR = crime rate in uniform crime report

NC = the total number of crime reported

POP = the total number of population

In this study, the number of violent crimes which occurred in each block group were found by substituting variables for crime rate and population in the above equation. The resultant equation is as follows:

(9) $VC = POPCY \times CR / 100{,}000$

where VC = the number of violent crime reported within each block group,

POPCY = current year (2004) population

CR = crime rate in uniform crime report

There is a possibility of a minor difference between the results in Nolan's study and this study. However, this result still provides useful crime data for a given population in each block group of the study area.

The average number of violent crimes a year is 8.9 per block group, with a minimum number of 0 and a maximum number of 85 a year. Figure 6 shows that overall distribution of violent crimes is skewed toward zero, and that the violent crimes are not evenly distributed over the study site. In other words, there are a few block groups where violent crimes are concentrated. Figure 6, showing the spatial distribution of violent crimes within the study site, also confirms that violent crimes are not evenly distributed over areas.

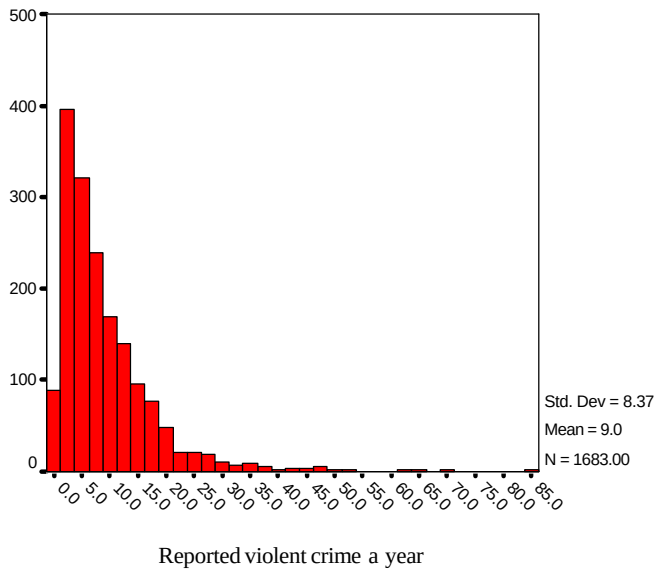

Figure 6. Histogram of reported violent crimes in the Dallas county

Overall distribution pattern of violent crimes in Dallas County can be characterized as having centralized tendencies. Most high crime block groups are

located inside of the circle composed of Loop 12 to the west, IH-20 to the south, and IH-635 to the east and north. Interestingly enough, block groups on the west and east of the county show relatively less violent crime compared to block groups on the south and north.

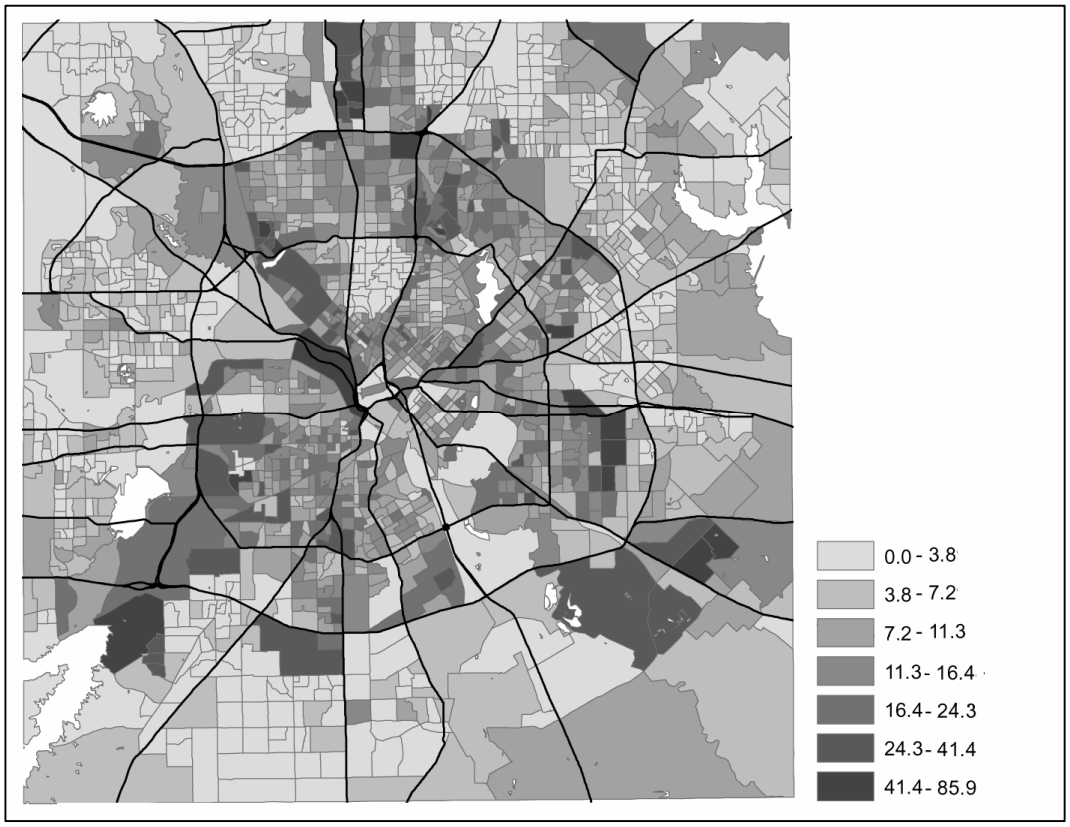

Figure 7. Distribution of violent crimes within the study areas.

3.4.2.3 Measuring Daytime Density

The study design differentiates between daytime and nighttime density by investigating the relationship between population density and violent crime. In capturing the daytime density of the study areas, some aspects need to be considered. Unlike nighttime density, the concept of daytime density takes movements of people,

including pedestrian and automobiles, as well as static population density, such as employment density, into account. In order to capture these complex entities of daytime density within a block group, this study used the proximity concept to the central business districts (CBD). It is not a perfect measure of daytime density, but it is the closest available way of measuring daytime density. Dallas County includes many cities and jurisdictions varying in size and economic volume. However, most cities are dependent on economic activities or activity density. Proximity to the CBD is measured in distance and represents daytime density in Figure 8.

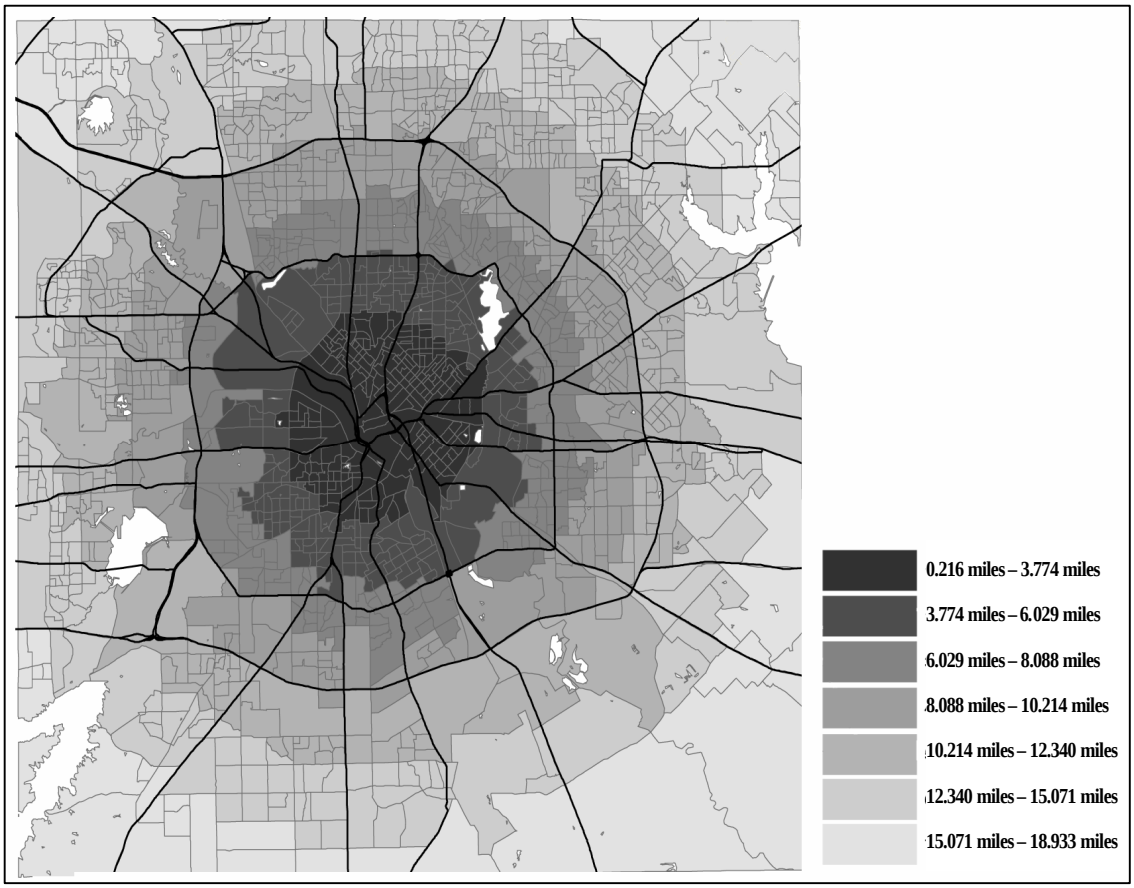

Figure 8. Proximity to Dallas CBD from each census block group. The proximity is measured in distance between geographical center of each block group to the CBD and represents daytime density.

In order to measure the approximate distance of the block groups to the CBD of Dallas, geographical centers were identified for the CBD of Dallas and the census block groups in the Geographic Information System (GIS). The distance between the geographical center of each block group to the center of the CBD was calculated in GIS.

3.4.2.4 Measuring Nighttime Density

Nighttime density was found by using the 2004 demographic estimates and projections data of Spatial Insight, Inc. These data are based on the Census information from the 2000 Census of U.S. Census Bureau. Census information represents the population within block groups as shown in Figure 9.

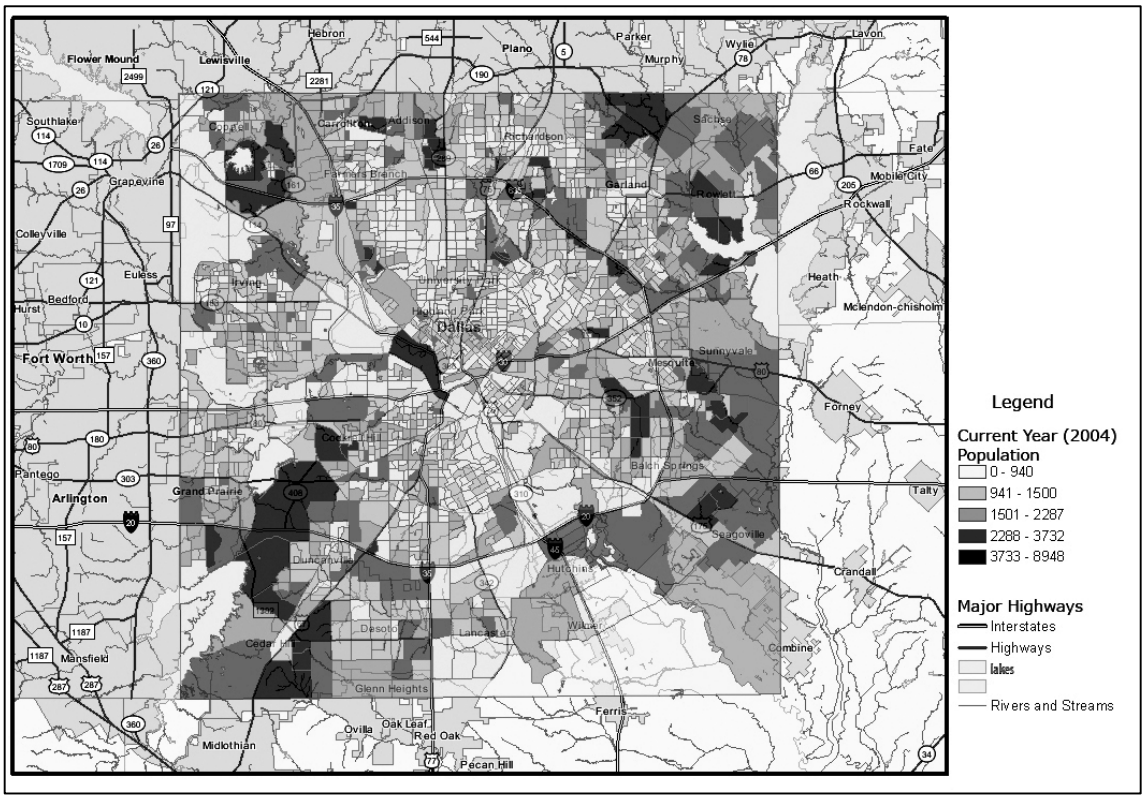

Figure 9. Population within each block group

Figure 9 shows the highway system and how it surrounds and converges in the downtown Dallas area. There is a higher population outside of this major highway area including I-20, I-35, and IH-635, which is outside of the City of Dallas. To estimate the nighttime density, population was divided into the area of each block and these results are shown in Figure 10. Even though the population is higher outside of the major highway area, nighttime population density of the downtown Dallas area is higher.

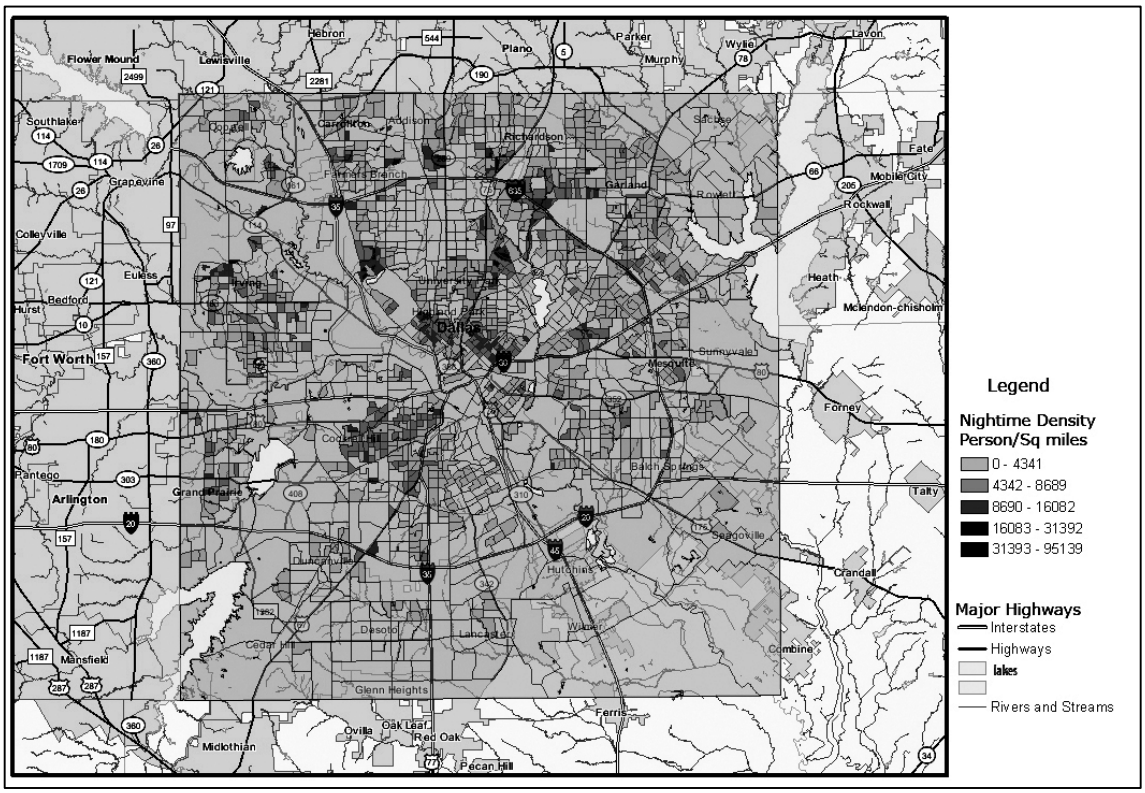

Figure 10. Nighttime density of study area

3.4.2.5 Measuring Vegetation

In order to calculate the amount of trees within each block group, the study used a LandSAT multispectral image with 30m × 30m resolution. The satellite image is

georectified to block group GIS shape data. The color compositions of tree areas, grass areas, developed areas, water areas, and others are sampled from the satellite image. Based on the sampled color composition, the satellite image was classified into five landcover types in an image processor software. The five landcover types are 1) tree areas, including urban forests and shrubs, 2) grass areas, 3) developed areas, 4) water areas, and 5) others including croplands, wetlands, and natural grass lands.

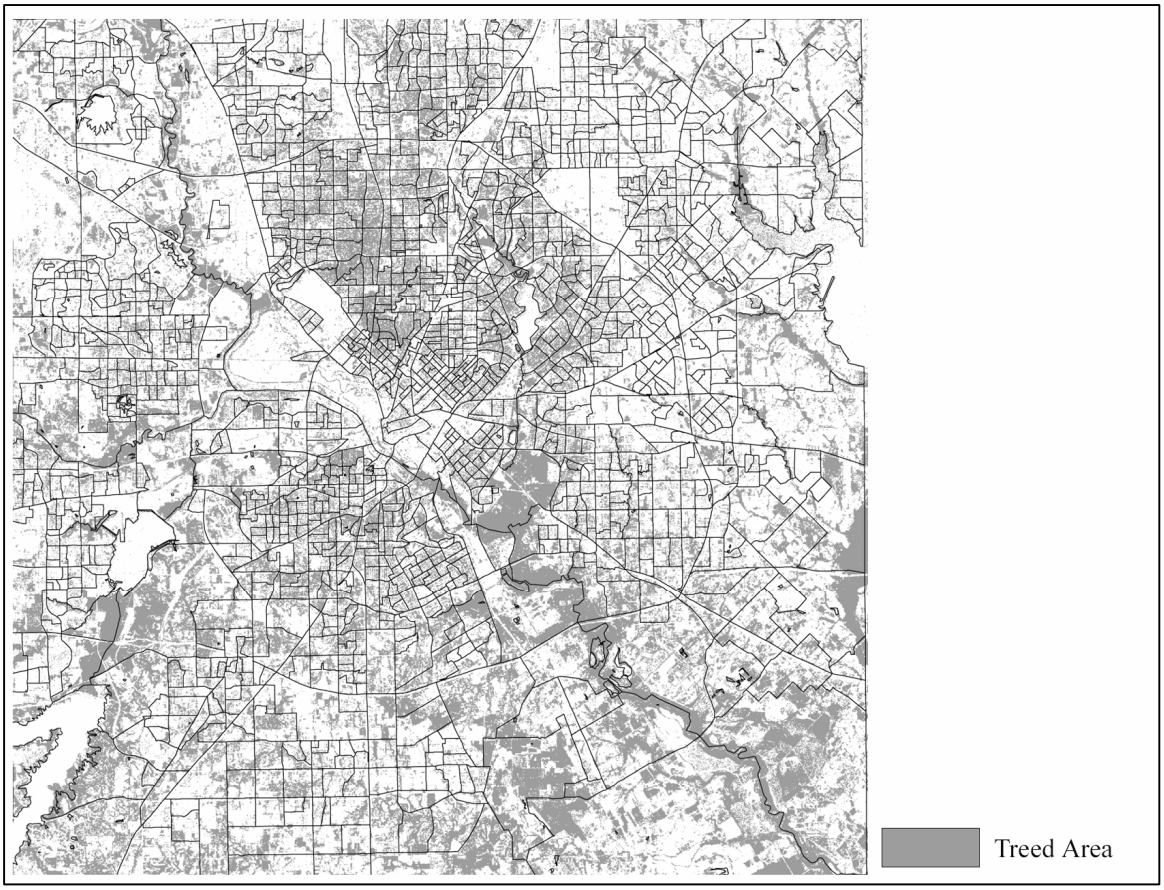

Figure 11. Landcover map. Shaded areas represent treed areas within the study site.

The land cover map was then refined by a 3 × 3 neighborhood algorithm in order to minimize false classifications. Neighborhood algorithm (NA) is, “a direct

search method of inversion that preferentially samples those regions of a multidimensional parameter space that have acceptable data fit. It has the ability to search efficiently by sampling simultaneously in different regions of parameter space." (Marson-Pidgeon, et al., 2000). The landcover map was recoded into two categories; 1) trees and 2) others as shown in Figure 11 (refer to page 49). Based on this dichotomized landcover map, the amount of trees within each block group was then calculated in the GIS.

3.5 Summary

This thesis, based on previous research, studied how population density is related to violent crime, and how vegetation may moderate that effect. For this study Dallas County was selected as the study site. The study required much data collection. First of all, Census 2000 data were collected and was used to calculate nighttime density. Taking many things into consideration, daytime density was found by using the proximity from each block group to the CBD. To determine the amount of vegetation within each block group, a LandSAT mulispectral image was measured though the GIS. The primary method of data analysis was the GIS, and the quantitative data were analyzed using the Statistical Package for the Social Sciences (SPSS).

CHAPTER 4

RESULTS

4.1 Introduction

The purpose of this study was to investigate the moderating effect of vegetation on the relationship between density and crime. For this study daytime density and nighttime density were collected, and the numbers of violent crimes was obtained. These data were used to investigate three research questions as given in Chapter one. This chapter reports the results of the investigation. Section 4.2 discusses a broader view of the relationship between crime and other various factors. In further detail, sections 4.2.1 and 4.2.2 describe (1) the relationship between demographic factors and crime (Demographic factors include age, gender, education level, and income.), (2) the relationship between land use and crime (Land use represents the actual used spaces in each block.). The most important portion of this study comes out in section 4.3. It is here the outcome of this study is reviewed. Sections 4.3.1 and 4.3.2 report the empirical results, showing (1) the correlation among study variables, and (2) the moderation model of daytime and nighttime density with few trees and many trees.

4.2 Correlation between Crime and Various Factors

4.2.1 Demographic Factors and Crime

Here, the relationship between several demographic factors and crime is reviewed. The final data of demographic factors includes age, gender, education level, and income in the 1683 block groups of Dallas County.

The age groups are distributed into age groups shown in Table 1. Crime data are classified into total crime, violent crime, and property crime within each block group. Interestingly enough, it was found that the age group 20 to 29 had the highest correlation to all three categories of crime, namely, total crime (r = 0.264), violent crime (r = 0.335), and property crime (r = 0.129). This correlation represents merely the numerical relationship; it does not explain the causal relationship between age groups and crime, such as who is the victim or who is the offender. The age group of 70 and above has the lowest correlation to all three categories of crime data. These results are shown in Table 1.

Table 1: Correlation of Age Groups and Crime

Crime / Age	Total Crime	Violent Crime	Property Crime
0 to 9	.264**	.335**	.116**
10 to19	.245**	.308**	.113**
20 to 29	.273**	.340**	.129**
30 to 39	.254**	.315**	.122**
40 to 49	.216**	.273**	.098**
50 to 59	.181**	.225**	.085**
60 to 69	.133**	.157**	.074**
70 and above	.084**	.093**	.053*

* $p < 0.05$, ** $p < 0.01$

There is a difference in the correlation between gender and crime. Males have a higher correlation than females among all three categories of crime shown in Table 2. This correlation is significant above the level of 0.01.

Table 2: Correlation of Gender and Crime

Crime / Gender	Total Crime	Violent Crime	Property Crime
Male	.272**	.337**	.347**
Female	.246**	.311**	.110**

** $p<0.01$

The education levels are distributed into less than 9^{th} grade, 9^{th} to 12^{th} grade with no diploma, high school graduate, college with no diploma, associate degree, bachelor's degree, and graduate or professional school degree in ages 25 and above. In looking at the different education levels, the population group 9^{th} to 12^{th} grade with no diploma has the highest correlation to all three categories of crime. These correlations are shown in Table 3.

Table 3: Correlation of Education Level and Crime

Crime / Education Level	Total Crime	Violent Crime	Property Crime
Less than 9^{th} grade	.009	.020	-.007
9^{th} -12^{th} grade with no diploma	.296**	.349**	.161**
High school graduate	.185**	.240**	.076**
College with no diploma	.094**	.133**	.026**
Associate degree	.049**	.174**	.115**
Bachelor's degree	.035	.136**	.113**
Graduate or prof. school degree	.038	.134**	.135**

* $p < 0.05$, ** $p<0.01$

The correlation between the income levels and crime are divided into four classifications of the population, including various household income levels. Household income refers to the amount of income received in a year of all persons who occupy a single housing unit (U.S. Census Bureau). The average household income in the study area was $66,776.88. The population according to income levels are distributed into a household income of less than $29,999, $30,000 to $59,999, $60,000 to $99,999, and more than $100,000. The correlation to total crime is highest in the population group with a household income level of $60,000 to $99,999. The population group with a household income level less than $29,999 has the highest correlation to violent crime. The correlation between income level and property crime is highest in the population group with a household income level more than $100,000. The results of the correlations between household income levels and crime are as shown in Table 4.

Table 4: Correlation of Household Income Level and Crime

Crime / Income Level	Total Crime	Violent Crime	Property Crime
Less than $29,999	.220**	.277**	.100**
$30,000 to $59,999	.190**	.212**	.119**
$60,000 to $99,999	.223**	.248**	.138**
More than $100,000	.155**	.055*	.234**

* P<0.05, ** P<0.01

4.2.2 Land Use and Crime

The literature review indicates a relationship between land use and crime; that the types of crime differ according to land use. In order to examine this relationship, the

GIS was used to tabulate land use shape file and block group shape file together. Various categories of land use exist within each block; these land uses are distributed and calculated within each block group. There are twenty-three categories of land use, but only nine of these categories were looked at in this study, including single residential, multi-family residential, mobile residential, commercial office, commercial retail, commercial hotel or motel, industrial, roadway, and parks. Looking at the results, the multi-family residential area has the highest correlation (r = 0.301) with violent crime and total crime. In other words, when the multi-family residents occupy more areas within a block group, the number of violent crime rises. The correlation between retail, commercial, and property crime was higher than others (r = 0.100). The results of this correlation between land use and crime are shown in Table 5.

Table 5: Correlation of Land Use and Crime

Land Use \ Crime	Total Crime	Violent Crime	Property Crime
Single residential	.014	.013	.013
Multi-family residential	.244**	.301**	.088**
Mobile residential	.062**	.074**	.026
Office commercial	.006	-.009	.028
Retail commercial	.100**	.083**	.100**
Hotel / Motel	.058*	.037	.075**
Industrial	.033	.033	.023
Roadway	.061*	.056*	.053*
Parks	.108**	.118**	.061*

* P <0.05, ** P <0.01

4.3 Empirical Results

4.3.1 Correlation between Variables

One of the purposes of this study is to investigate the correlation between density and crime. In order to examine this correlation, nighttime and daytime densities are measured. Nighttime density is the population density gathered from census data within each block group.

As stated in chapter 3.4.2.3, unlike nighttime density, daytime density is identified by measuring the proximity to the CBD; this represents movements of people during the daytime. Through the GIS, the proximity in distance to the CBD from the geographical center of each census block group boundary is measured. In order to test the moderation model, the amount of trees within each block group is calculated. The descriptive statistics of these variables are summarized in Table 6. The unit of distance to the CBD is miles, and the amount of trees in each block group is calculated per square foot.

Table 6. Descriptive Statistics of Variables

Variable	Min.	Max.	Mean	Std. Deviation
Nighttime Density	0	95,139	6,454.65	6,489.889
Distance to CBD	.000	85.901	8.96605	8.373175
Violent Crime	.22	18.93	8.9936	4.02823
Trees	0	371,918,547	4,533,093.5	16,596,765.114

N =1683

The correlation between these study variables indicates that the seemingly independent variables have a significant relationship with violent crime. There is a positive correlation between nighttime density and violent crime of r = 0.329. In other words, the higher the density, the more crime occurs. This correlation is significant at the level of 0.01.

Interestingly enough, there is a negative correlation between crime and the distance to the CBD. In order words, the closer to the CBD, the more crime occurs. These results confirm previous studies that suggest the negative effect of density on human violent behavior and the concentration of delinquent and adult offenders is higher in places that are near a CBD area. These correlations are shown in Table 7.

Table 7. Correlation among Variables

	Nighttime Density	Distance to CBD	Violent Crime	Trees
Nighttime Density	1	-.178**	.329**	-.179**
Distance to CBD	-.178**	1	-.296**	.156**
Violent Crime	.329**	-.296**	1	.022
Trees	-.179**	.156**	.022	1

** $p < 0.01$

Prior to testing the moderation effect of vegetation on the relationship between daytime and nighttime density and violent crime, this study examines the mean difference between low vegetation (LV) and high vegetation (HV) in each block. The units used in the results are square feet; these are shown in Table 8.

Table 8. Mean Difference between LV and HV and T-Test Statistics

	N	Mean	Std. Deviation	Mean Difference
(LV) Low Vegetation	836	784,982.72	437,167.142	-7,447,544.85**
(HV) High Vegetation	847	8,232,527.6	22,800,797.909	

4.3.2 Standard Model and Moderation Model

In this study, the moderating model was developed as previously stated in chapter 3.3.2. The moderating effect of vegetation on the relationship between nighttime density and violent crime was estimated. The moderation model was divided into two equations according to the moderator—the amount of vegetation in a block group, such as low vegetation (LV) and high vegetation (HV). The results of standard model and moderation model of nighttime density are shown in Table 9.

Table 9. Standard Model and Moderation Model of Nighttime Density

	Standard Model		Moderation Models			
			LV Model		HV Model	
	b	b	b	b	b	b
Constant	5.909**		3.320**		5.866**	
Nighttime Density	.000**	.344	.001**	.533	.001**	.334
F	109.305**		330.641**		111.635**	
R^2	.115		.284		.119	

** $p < 0.01$

As hypothesized, the moderation model shows that vegetation had a positive contribution on the relationship between nighttime density and violent crime. The •-value of the LV model (b = 0.533) and the HV model (b = 0.334) indicate that the

moderating effect of vegetation is higher and the effect of density on violent crime is less in the HV model. In Table 9, the F-value of a standard model and the two moderation models indicate that model estimations are valid at a $p < 0.01$ level. The LV model explains about 28% and the HV model explains 12% of the moderating effect of vegetation.

In the same way the moderation model was used with nighttime density, so also it was used in finding the moderating effect of vegetation on relationship between distance to CBD and violent crime. In Table 10, the F-value of a standard model and two moderation models describe that the model estimation are valid at $p < 0.01$ level. The distance to the CBD appears to have a negative impact on the violent crime rate, but the vegetation has a positive contribution on this impact. This result shows that vegetated areas lesson the impact that the approximate distance to CBD has on violent crime. The •-values in the LV model (b = -.393) and HV (b = -.222) model indicate that there is a higher moderating effect of vegetation in the HV model.

Table 10. Standard Model and Moderation Model of Daytime Density

	Standard Model		Moderation Models			
			LV Model		HV Model	
	b	b	b	b	b	b
Constant	14.541**		14.571**		14.439**	
Distance to CBD	-.638**	-.307	-.737**	-.393	-.498**	-.222
F	85.348**		152.438**		43.823**	
R^2	.091		.155		.048	

** $p < 0.01$

Two main points are brought out through comparing the regression coefficient variables in these two moderation models. First, the results show that the higher nighttime density is the more violent crime raises; in addition, the closer the distance to the CBD is the more violent crime raises. Second, the vegetation has a moderating effect on these two correlations, and this effect is higher in the HV model than the LV model.

CHAPTER 5

CONCLUSION

5.1 Summary of Findings

The study has a dual purpose. The first purpose is to investigate the relationship between density, which is one of the most significant environmental stressors, and human violent behavior, which is represented by violent crime. For this study part of this study, the difference between daytime and nighttime density was considered. Nighttime density was measured using census data of block groups in Dallas county. The distance from each block group to the central business district (CBD) in the city of Dallas represents daytime density which shows the movement of the population during the daytime. The second purpose is to discover how the vegetation affects the relationship between these two densities and violent crime.

As a first step, the relationship between nighttime density and crime was examined. There is a positive correlation between violent crime and nighttime density. In other words, the higher the density, the more crime occurs. The correlation between nighttime density and violent crime is statistically significant. The results indicate that nighttime density plays a part in increasing violent crime. This study can show initial evidence of increased aggression among people exposed to highly dense areas (Aiello et al., 1979; Ginsburg et al., 1977; Hutt and Vaizey, 1966) as reviewed in section 2.3.1, in

the literature review portion. It also shows that increasing density brings out negative interactions among people, and thus can cause more violence and crime.

Next, the relationship between the distance to the CBD, which represents daytime density, and violent crime was investigated. This reveals that the approximate distance to the CBD has a negative effect on violent crime. In other words, the closer to the CBD a group block is, more crime occurs. The result of this finding is statistically significant. This study confirms the early study of Shaw (1929); the concentration of delinquency is higher in places near central business districts and industrial areas, because these places are associated with high population density.

Finally, the moderating effect of vegetation on the relationships between two different densities and violent crime was tested. The moderation model is dichotomized according to the amount of vegetation within each block group (LV model and HV model). The moderation models show that vegetation has a moderating effect on the interrelation of nighttime density and violent crime, as well as the correlation between the distance to the CBD and violent crime. As hypothesized, the moderating effect of vegetation is higher in the HV model than in the LV model. The impact of density on violent crime was less in the HV model. The negative effect of the distance to the CBD decreased in the HV model. The results of the moderation test gives significant evidence that the psychological effect of vegetation plays a role in reducing the levels of human violent behavior as stated in previous studies (Kaplan, 1984; Kaplan and Kaplan, 1989; Kuo and Sullivan, 2001a; Kuo and Sullivan, 2001b; Miles et al, 1998). And the

amount of vegetation is also important, because the more vegetation there is, the more positive effect there is.

In conclusion, the collected and analyzed data for this study support the hypothesis mentioned in the literature review, which says density leads to more violent crime in the study site. It also confirms that the distance to the CBD, which represents daytime density, has a negative effect on violent crime. In addition, it was found that vegetation has a moderating effect on the interrelation of environmental stressors and violent crime.

5.2 Relevance of Findings to Landscape Architecture

The findings of this study help to understand previous studies on the effect of environmental stressors, especially density, on human violent behavior. It is important to understand the relationship between density and human behavior because density is one of the significant issues in the professions of landscape architecture and urban planning. In order to provide a better life for human beings, new urbanism, a new planning movement in these professions, has emerged (Ellis, 2002). New urbanism reforms the design of an existing built environment into the form of a complete city, town, or neighborhood community. New urbanism promotes the restoration of diversity, compactness, and vibrancy in human society. Increasing density is one of the principles in new urbanism (Montgomery, 1998). It includes more buildings and residences that are serviced closer together for ease of walking, in order to create convenient and enjoyable places; this encourages higher population density. However, it should be

considered that density increases aggression of urban residents and leads to violent crime. The finding of this study causes others to consider the impact density has on human violent behavior.

The finding of this study provides landscape architects and urban planners a base of knowledge about the moderating effect of vegetation on the correlation between density and crime. This base gives people an understanding of the psychological effect of vegetation, especially the way it can help to prevent violent behavior. If density causes an increase in violent crime, then providing vegetation is a potentially significant solution to reducing this impact. This study demonstrates a link between vegetation and less crime in an empirical design and provides clear support for the hypothesized mechanism. For example, in areas that are already highly dense and have a high crime rate, the city can go in and add vegetation to these neighborhood to improve the quality of life. Also, when building new neighborhoods preventative action can be taken by adding the vegetation before the areas become highly dense and violent crime occurs. Therefore, this study is important to urban planners and landscape architects who are developing design criteria, because this research affects factors which density affect quality of life and safety in urban environments.

In addition, this study demonstrates how the Geographical Information System (GIS) can be a useful tool for applying statistical information to a large study site; it helps visualize the information. Especially, this study shows that it is good for landscape architects and urban planners to investigate primary information, such as demographics, through the GIS.

5.3 Recommendation for Further Study

This study found a direct relationship between environmental stressors, density, and violent crime. It also found the moderating effect of vegetation on this relationship. However, there is a limitation in this study; only one environmental stressor–density–was examined. Previous studies indicate that exposure to other environmental stressors, such as noise, heat, and air pollution, cause aggression and violent behavior. Further study should examine whether these other environmental stressors lead to violent crime.

Although this study provides only initial evidence of a positive relationship between density and violent crime. Further study is needed to consider more experimental designs such as observation and survey. In addition, previous studies have stated that crime, delinquency, and fear of crime are not distributed equally. It would be useful to examine the difference between the number of crime occurrences and the perception of human beings' fear of crime in a highly dense area.

Moreover, future studies should investigate whether there is a long-term reduction of aggression and violent behavior because of the moderating effect of vegetation. Examining the moderating effect of vegetation on crime in different demographic areas such as age, income level, education level, and gender would also be beneficial.

APPENDIX A

DESCRIPTIVE STATISTICS

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Daytime Density	1683	1	102692	2079.53	5306.269
Daytime Population	1683	1	52195	784.06	2892.176
Nighttime Density	1683	0	95139	6454.65	6489.889
Nighttime Population	1683	0	8948	1368.78	888.247
Number of Violent Crimes	1683	.0000	85.9008	8.966047	8.3731754
Number of Total Crimes	1683	0	158	15.83	12.161
Few Trees	836	0	1577961	784982.72	437167.142
Many Trees	847	1587762	371918547	8232527.57	22800797.909
Distance to CBD (miles)	1683	.216325783	18.934003358	8.993591293	4.02823400062
Age 0 to 9	1683	0	1659	226.48	179.144
Age 10 to 19	1683	0	1281	197.66	145.056
Age 20 to 29	1683	0	2214	200.83	205.655
Age 30 to 39	1683	0	3027	229.33	189.973
Age 40 to 49	1683	0	2023	204.06	141.400
Age 50 to 59	1683	0	875	147.25	91.310
Age 60 to 69	1683	0	423	83.93	49.677
Age 70 and above	1683	0	829	79.24	67.455
Gender - Male	1683	0	6437	687.80	472.340
Gender - Female	1683	0	3738	680.98	432.603
Education Level less than 9^{th} Grade	1683	0	1314	102.45	137.397
9^{th} – 12^{th} Grade with no Diploma	1683	0	1751	112.64	108.110
High school graduate	1683	0	2412	185.81	147.301
College with no Diploma	1683	0	1246	181.11	146.867
Associate Degree	1683	0	336	42.66	44.719
Bachelor's Degree	1683	0	1576	150.68	171.708
Graduate or Prof. School Degree	1683	0	1066	75.22	93.380
Household Income less than $10,000	1683	0	1427	114.28	115.052
$ 30,000 to $ 59,999	1683	0	1736	168.10	144.651
$ 60,000 to $ 99,999	1683	0	922	114.01	103.435
More than $ 100,000	1683	0	973	62.69	81.347
Single Residential	1683	.000	43035312.859	3404754.57419	3608703.978906
Multi-family Residential	1683	.000	6004927.376	402885.55134	768024.229893
Mobile Residential	1683	0	14511908	54709.18	495008.971
Commercial Office	1683	0	25520941	315767.15	1341714.418
Commercial Retail	1683	.000	15512729.054	488814.64680	1089294.474951
Commercial HOTEL/MOTEL	1683	0	3002464	19921.29	144541.675
Industry	1683	.000	92575963.709	748088.59565	4304222.888781
Roadway	1683	.000	43035312.859	2001939.79117	2876271.022921
Parks	1683	.000	40533259.786	519142.56280	2406842.735736
Valid N (listwise)	0				

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