Urban Greening and Criminal behavior: A Geographic Information System Perspective

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SUMMARY. A geographic information system (GIS) was used to create an interface to evaluate the relationship between the amount of greenness and the crime level within the city of Austin, Texas. Results indicated a statistically significant negative correlation between the incidence of crime committed in the Austin greater metropolitan area for the year 1995 and the amount of vegetation within the area in which those crimes occurred. Areas with less than the average mean greenness level in Austin had an increased amount of crime. Results indicated no statistically significant relationship between the level of greenness of the crime sites and the severity of the crimes committed, and income level appeared to have no statistically significant effect on the severity of crimes committed.

In the United States today, thousands of dollars are spent each year for research on crime prevention and criminal motivation (Beck and Gilliard, 1995). In 1995, the Federal Bureau of Investigation (FBI) reported 13.9 million crimes to law enforcement agencies of which 21,597 were murders. In addition, property valued at $15.6 billion was stolen during 2.6 million burglaries. Victims produced from these crimes were averaging 685 for every 100,000 inhabitants in city areas. Crime rates have dropped since 1990, but the number of crimes remaining is significant (FBI, 1998).

Green areas within urban environments have been shown to alleviate some of the problems linked with crime, including promoting social communication among residents and greater feelings of safety (Kuo and Sullivan, 2001; Waliczek et al., 1996), and reducing mental fatigue (Kuo, 2001). However, in poor inner-city areas the amount of vegetation is generally minimal (Kuo, 2001), and within inner-city areas there are higher incidences of crime (Monmonier, 1997). While historically, vegetation has been cleared from crime-ridden areas because of the potential for these areas to become hiding places for criminals, research has suggested that the opposite may be true: vegetation may lead to safer environments (Kuo and Sullivan, 2001).

The main objective of this study was to determine whether a statistical relationship existed between the incidence of crime and the amount of green vegetation in areas of Austin, Texas. Additionally, comparisons were made to evaluate whether there were correlations between varying levels of vegetation and the severity of crimes. Demographic considerations within analyses included income levels within the areas of the inner-city of Austin.

Methods and materials

To conduct the data analysis, four layers of information were generated and incorporated using a GIS. These layers included a city limit boundary, income levels within the city, city crime information and levels of greenness.

GEOGRAPHIC INFORMATION SYSTEM. A GIS is described as "an organized collection of computer hardware, software, geographic data and personnel designed to efficiently capture, store, update, manipulate, analyze and display all forms of geographically referenced information" [Environmental Systems and Research Institute (ESRI), 1996]. The GIS was used to 1) spatially locate crime scenes, 2) attach attributes describing the crime, 3) generate percent greening for an area, and 4) analyze data. Each type of information used was placed into a separate layer. The GIS software used in this study was the ArcInfo suite of products developed by ESRI (Redlands, Calif.).

CITY LIMITS. The researched area included the intersected city limit area

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Table 1. Severity values and definitions[z] for crimes obtained from the Austin, Texas, Police Department for August and September 1995.

Crime	Severity value[z]	Crime	Definition of crime[z]
Most severe			
1	Capital murder	Perpetrator intentionally or knowingly causes a death	
1	Murder	Perpetrator intentionally or knowingly causes a death	
2	Manslaughter	Recklessly causes a death	
3	Aggravated robbery (deadly weapon)	Serious bodily injury or use of a deadly weapon	
3	Attempted aggravated robbery (deadly weapon)	Serious bodily injury or use of a deadly weapon	
3	Aggravated robbery by assault	Serious bodily injury or use of a deadly weapon	
4	Robbery by assault	Bodily injury	
4	Attempted robbery by assault	Bodily injury	
5	Burglary of a residence	Burglary of a person's home	
5	Attempted burglary of a residence	Burglary of a person's home	
6	Burglary of a nonresidence	Burglary of a business or building	
Least severe			
6	Attempted burglary of a nonresidence	Burglary of a business or building	

[z]Values and definitions based on classification levels and degree of punishment for each crime according to the 16th edition of the Texas Penal Code (Texas Legislative Council, 2002).

of Austin, Texas between 1980 and 1995. Austin was chosen primarily due to the size, the varied levels of vegetation within the city, an established urban forestry program, varied crime levels within the city and the availability of aerial photography and crime data. It has been reported that, on average, crime in suburbs is lower than crime within larger city areas (Monmonier, 1997). Therefore, a constraint was placed on the study area to ensure that no suburbs were included. The study area was established using city limit boundaries that existed in both 1980 and in 1995, ensuring that the study area has been considered inner-city Austin for an extended number of years.

Income levels. Income data was required for the study in order to determine the effects greening had on crime at various income levels. Generally low and middle-income areas tend to have higher crime rates compared to higher income levels [U.S. Bureau of the Census (USBC), 1990)]. Income level data was acquired from the 1990 USBC population and housing surveys and was limited to residential housing information. The census data was divided into usable block number areas in tracts for Travis County. Once the census tracts were collected, an income level value was attached to each tract according to its block number. Census data provided the mean income per household by tract number. Each tract was then assigned the mean household income level. The mean annual income levels for each block level were grouped into high (>$50,001), middle ($20,001 to $50,000) and low (0 to $20,000) incomes using Duncan's new multiple range test which separated the income level data into three statistically different ranges.

Crime data. Crime data was obtained from the Austin Police Department for the months of August and September 1995. These were the months in 1995 in which the most crimes occurred in the area (M. Grant, personal communication), ensuring the most data points for the study. Approximately 1,170 crimes were committed during this time frame. Data received contained an offense description, offense code, date and time the crime occurred as well as an X,Y coordinate (latitude/longitude) for the location of the crime. The X,Y coordinates were collected using a global positioning system (GPS) mounted in the police vehicle at the scene. The crimes were assigned a severity level according to their degree of seriousness. This classification was determined by the degree of punishment for each crime according to the 16th edition of the Texas Penal Code (Texas Legislative Council, 2002.). All attempted crimes were given the same severity level as the actual crime because the criminal's intentions were the same (V. Baker, personal communication) (Table 1). Each crime point was then assigned a 1 if it was the most severe or violent crime, and a 6 if it was the least severe or violent crime.

Greenness. The amount of vegetation or greenness of the entire Austin city study area was measured using color infrared aerial photography. Vegetation considered in the greenness value included grass, trees, shrubs, groundcover and other plants. Both formal landscaped areas and naturally occurring vegetation were considered within the greenness index. The percent green in a given area was analyzed using a normalized difference vegetation index (NDVI) (Ray, 1994), a well-established measure used in small and large scale greenness studies (U.S. Global Change Research Program, 2003). The NDVI calculated the amount of greenness with an index that ranged from –1 to 1 for color infrared images. A value of –1 indicated little to no vegetation and received a 0% on the greenness scale, while areas that calculated a 1 on the NDVI received a 100% on the greenness scale. Ranges of greenness levels in between 1 and –1 values were considered and calculated with a percentage accordingly.

Data analysis. The GIS provided an interface to incorporate and analyze the spatial data for the greening and the attribute data for the crime. By overlapping the dates of the aerial vegetation photographs and the dates of the crime data, there was temporal consistency, meaning that, at the point in time when a crime was committed, there was also an accurate measure of the surrounding vegetation. Data was analyzed for statistical significance using Pearson's correlation coefficients (Ott, 1993).

Results

Crime activity and greenness. Once all areas included in the Austin city study area were analyzed using the NDVI, the results indicated that the average greenness value for the total area within the Austin city limits

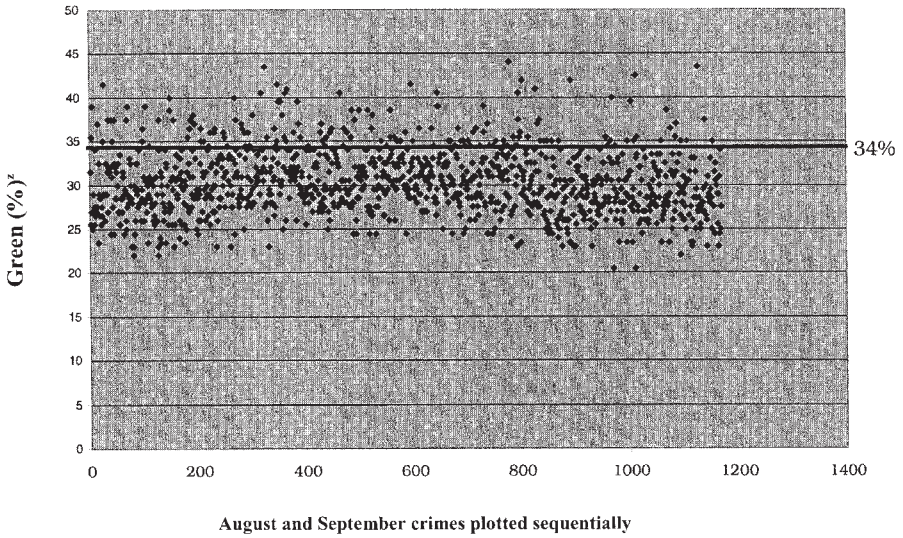

Fig. 1. Committed or attempted crimes that occurred within the Austin, Texas, inner-city area in August and September 1995, plotted sequentially based on their percent green values. Analyzed using a normalized difference vegetation index (NDVI) (Ray, 1994) which calculated the amount of greenness with an index that ranged from –1 to 1 for color infrared images. A value of –1 indicated little to no vegetation and received a 0% on the greenness scale, while areas that calculated a 1 on the NDVI received a 100% on the greenness scale.

boundary to be about 34%. The value (34%) will be referred to as the mean greenness value throughout the remainder of the results and discussion. Each crime point's greenness value was then plotted on a scatterplot sequentially by when they occurred in August or September. Once plotted, 83% (972 of 1170) of all crimes occurred in areas that had greenness values below 34% (Fig. 1).

Individual crimes occurred primarily at greenness levels that ranged between 20.5% and 44% (Table 2). Results of Pearson's correlation analysis indicated a statistically significant negative correlation (P = 0.0467) between the number of crimes committed and the amount of greenness present in the area in which the crimes occurred. This result is similar to results reported in a smaller-scale study (Kuo and Sullivan, 2001) that found that Chicago inner-city apartment buildings with more greenery tended to have reduced amounts of crime compared to similar apartment buildings with less vegetation. Often, trees and shrubs in cityscapes are removed because of the widely held belief that the removal will help to deter crime (Pluncknett, 1960). More recent research, however, supports the argument that higher levels of vegetation may promote less criminal activity (B. Funches, personal communication; Kuo, 2001; Sullivan and Kuo, 2001;).

Green spaces have been known to increase coping mechanisms and reduce stress and violence in urban areas (B. Funches, personal communication; Kuo, 2001; Waliczek et al., 1996). Therefore, researchers felt that it would be worthwhile to evaluate the relationship between the amount of greenness within the crime scene area of Austin and the severity of the crime committed within these crime sites. These analyses showed no significant correlation (P = 0.1531). Also, in contrast to past studies and empirical data that indicate that income level influenced crime in an urban area (Becker, 1968; USBC, 1990), there were no significant differences in any of the three income areas and the severity of crimes committed in Austin given the amount of greenness present (Table 3).

Conclusions

In this time of growing urbanization, green spaces within city environments should be a consideration beyond aesthetic value. Most people recognize the value of an urban forest beyond its beauty, including environmental effects such as purifying air, modifying extremes in temperature and reducing noise pollution and glare. However, when expenses are cut in public or private budgets, landscaping monies are often seen as merely for beautification, and not as a necessity. In addition, because of the maintenance costs, trees and shrubs are sometimes omitted from environments and replaced with concrete. This

Table 2. The number of crimes that occurred within the Austin, Texas, inner-city area and the percentage of greenness measured within those areas.

Green (%)z	Crimes (no.)
20.5	2
22	3
23	14
23.5	15
24	4
24.5	22
25	22
25.5	23
26	46
26.5	26
27	53
27.5	59
28	60
28.5	77
29	72
29.5	64
30	52
30.5	60
31	68
31.5	57
32	44
32.5	51
33	49
33.5	28
34	37
34.5	26
35	32
35.5	17
36	13
36.5	14
37	8
37.5	12
38	4
38.5	6
39	6
39.5	4
40	3
40.5	5
41	2
41.5	3
42	2
42.5	1
43.5	2
44	1

zAnalyzed using a normalized difference vegetation index (NDVI) (Ray, 1994) which calculated the amount of greenness with an index that ranged from –1 to 1 for color infrared images. A value of –1 indicated little to no vegetation and received a 0% on the greenness scale, while areas that calculated a 1 on the NDVI received a 100% on the greenness scale.

Table 3. Results of Pearson's correlation coefficient for the evaluation of the severity of crimes committed in the study area for each income level and the percent green in which they occurred.

Income level[z]	Crime severity value[y]	Green (%)[x]	*P*
Low income	Crime severity	–0.034	0.5082
Middle income	Crime severity	–0.036	0.3185
High income	Crime severity	–0.127	0.4305

[z]The mean income levels for each block level were grouped into high (>$50,001), middle ($20,001 to $50,000) and low (0 to $20,000) incomes using Duncan's new multiple range test.
[y]Values and definitions based on classification levels and degree of punishment for each crime according to the 16th edition of the Texas Penal Code (Texas Legislative Council, 2002).
[x]Analyzed using a normalized difference vegetation index (NDVI) (Ray, 1994) which calculated the amount of greenness with an index that ranged from –1 to 1 for color infrared images. A value of –1 indicated little to no vegetation and received a 0% on the greenness scale, while areas that calculated a 1 on the NDVI received a 100% on the greenness scale.

neglect of greening may not only be environmentally detrimental, but results from the Austin study, in addition to others, provides evidence that the vegetation within city environments can reduce crime and promote safer communities.

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