

## A REFEREED PAPER

# DO DESIGNED LANDSCAPES DETER CRIME?

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**Abstract.** The relationship between the amount of vegetation and the level of property crime within the City of Tallahassee was evaluated. Results indicated a statistically significant negative relationship between the incidence of property crime committed in the city and the amount of vegetation as measured using Normalized Difference Vegetation Index (NDVI) within the area in which those crimes occurred. Areas with less than the average mean NDVI level had an increased frequency of crime. Results indicated statistically significant relationships between the amount of vegetation and traditional social-economic variables (i.e., income level, unemployment, housing density), and level of property crimes committed. Results also indicated that the amount of vegetation could predict the likelihood of a household becoming a victim of property crime.

Nationwide, law enforcement agencies reported 11.9 million crimes, of which 12% were violent crimes and hate crimes, and 59.4% were property crimes (FBI, 2002). Victims from these crimes averaged 4,118.8 for every 100,000 inhabitants in city areas.

Nationally, crime rates have dropped since 1990, but the number of crimes remains high (FBI, 1998). This might be attributed to the thousands of dollars spent each year for research on crime prevention and criminal motivation. The decline in crime rates can also be the result of increased and improved neighborhood crime watch programs and vigilantism. In addition, landscaping and green/open areas within urban environments have been shown to alleviate some of the problems linked with crime, including promoting social communication and stronger ties among neighbors, greater sense of safety and adjustment (Kuo and Sullivan, 2001), and recovery from urban-associated mental fatigue (Kaplan and Kaplan, 1989). However, in poor inner-city areas the amount and quality of vegetation is generally minimal, and within these areas there are higher incidences of crime (Kuo, 2001). Vegetation has been cleared from crime-ridden areas because of the potential for these areas to become refuges for criminals (Kuo et al., 1998). On the contrary, research has suggest-

ed that the opposite may be true: vegetation may lead to safer environments (Kuo and Sullivan, 2001).

The objectives of this study were twofold. The first was to determine whether a relationship existed between the incidence of property crime and the amount of vegetation in areas of Tallahassee, Florida. Additionally, a logit model was developed to predict the likelihood of a given dwelling becoming the victim of property crime. Demographic factors considered in the analyses included populations, income levels, density, and other characteristics for the census tracts where the studied subdivisions were located.

## Materials and Methods

In order to accomplish the objectives of this study, ten subdivisions within a three-mile radius from the center of the City of Tallahassee were randomly selected. These subdivisions are located in 10 different census tracts and are primarily residential areas consisting of single family houses, townhouses, and/or apartment complexes. The property crimes that occurred in these subdivisions in 2000 were delineated and analyzed.

Three sets of primary data/information were analyzed using a geographic information system (GIS): crime reports, amount of vegetation measured by Normalized Difference Vegetation Index (NDVI), and variables related with census tracts and blocks within the city.

*Crime Reports.* Tallahassee Police Department (TPD) 2000 year-end crime reports were analyzed. These crime reports summarize the specific crimes (i.e., aggravated assault, and strong-armed robbery) for each address reported during the year. These reports include both citizen-initiated complaints and those filed by an officer without a citizen complaint. Citizen-initiated complaints occur when a crime is reported to the police and an officer is dispatched to interview the victim or victims and any witnesses. The officer then files a report about the incident describing the specific crime or crimes, the date, the address where the crime(s) occurred, and other pertinent information. Details from this report are then summarized in the year-end crime reports. From the 2000 crime reports, property crimes were delineated. Property crime is the sum of the offenses of burglary, larceny-theft, motor vehicle theft, and arson. Violent crimes, on the other hand, included assaults, batteries, robberies, and homicides; and total crimes is the sum of all crimes reported.

*Vegetation.* The amount of vegetation for the entire City of Tallahassee, including the census tracts in which the study subdivisions were located, was measured using color infrared aerial photography. Vegetation considered in the "greenness" value included grass, trees, shrubs, groundcover and other plants. Both constructed landscaped areas and naturally occurring vegetation were considered. Using ERDAS Imagine®, the percent green in a given area was analyzed using NDVI. NDVI, a well-established measure used in small and large-scale greenness studies (U.S. Climate Change Science Program, 2003), calculates the amount of greenness with an

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Table 1. Values of selected variables assigned to census tracts wherein study subdivisions were located.

Census tract	Unemployment rate (%)	Median family income (\$)	Total dwelling units	Percent owned (%)	Total population
2	5.4	56,618	2,417	32.5	3,811
3.01	5.7	66,146	852	55.8	1,526
5	63.2	11,500	913	2.4	4,569
6	20.4	20,750	1,522	24.8	2,900
8	1.8	61,950	1,558	43.0	2,937
13	93.1	N.A.	4	0.0	2,591
14	10.7	20,028	3,347	19.3	6,870
15	3.0	52,588	1,905	55.2	4,041
17	1.5	85,280	3,150	72.2	7,104
21.01	4.0	56,029	1,778	60.9	3,847

index ranging from -1 to +1 for color infrared images. A value of -1 indicated little to no vegetation, while areas that calculated a +1 on the NDVI indicated full vegetation.

The amount of vegetation (trees, shrubs, grass and groundcover) was assessed at two levels: census tract level and household level where crime occurred. The mean NDVI, median NDVI, and range for each census tract were determined. The average NDVI of each property where property crime was committed and reported were also determined.

*Other factors likely to affect property crime.* To determine the effects vegetation had on crime at various socio-economic variable levels, data including total population, income, housing density, percent unemployment, and percent home ownership were required. Table 1 contains data for these five additional variables attached to each census tract where property crime occurred which were obtained from the 2000 U.S. Bureau of the Census Population and Housing surveys.

*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 were analyzed for statistical significance using Pearson's correlation, simple regression and logistic regression (Cody and Smith, 1997).

*Geographic Information Systems.* GIS is "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" (ESRI, 1996). The GIS was used to: 1) spatially locate crime scenes; 2) attach attributes describing the crime; 3) generate NDVI values for study areas; and 4) analyze data. Each type of information used was placed into a

separate layer or theme. The GIS software used in this study was the ArcView 3.3 suite of products developed by Environmental Systems and Research Institute.

## Results and Discussion

*Crime Activity and Census Tracts Variables.* In contrast to past studies and empirical data that indicate income level influenced crime in urban areas (U.S. Bureau of the Census, 2000), there was no significant association between the number of property crimes and median income level ( $p = 0.1363$ ). We felt that it would be worthwhile to evaluate the relationship between the number of property crimes committed and other primary census tracts variables of unemployment, density, and percent ownership. These analyses showed no significant correlation in any of the census tracts variables and the number of property crimes committed given the amount of vegetation.

*Property Crime Activity and Vegetation.* Once all subdivisions included in the study area were analyzed using the NDVI, the results indicated that the average NDVI value for the total area within the study area to be approximately 0.395. This value (0.395) will be referred to as the "mean NDVI value" throughout the remainder of the results and discussion. Each crime location's NDVI value was then plotted on a scatterplot; 43% of all property crimes occurred in areas that had NDVI values below 0.395 and 57% of all property crimes occurred in areas that had NDVI values higher than 0.395.

Individual crimes occurred primarily at NDVI levels that ranged between 0.0 and 1.00 (Table 2). To test the hypothesis that vegetation deters crime, we conducted simple regression with NDVI as the independent variable and the frequency of property crime as the dependent variable. Results from this regression analysis indicated that NDVI was significantly and negatively related to the number of property

Table 2. NDVI values and number of property crimes reported by census tracts.

Census tract	Mean NDVI	Median NDVI	Minimum NDVI	Maximum NDVI	Number of property crimes reported
2	0.37	0.40	-0.01	0.60	289
3.01	0.49	0.50	0.10	0.64	104
5	0.24	0.23	-0.03	0.55	127
6	0.38	0.39	0.09	0.56	229
8	0.45	0.47	0.03	0.61	99
13	0.20	0.20	-0.06	0.47	85
14	0.40	0.42	0.07	0.63	361
15	0.46	0.48	0.05	0.66	169
17	0.49	0.50	0.12	0.67	76
21.01	0.44	0.45	0.12	0.68	92

Table 3. Simple regression showing the relationship between NDVI and the frequency of property crimes in Tallahassee, Florida.

Variable	Parameter estimate	Standard error	t-value	P	R <sup>2</sup>
Intercept	252.8576	16.2774	15.53	<0.0001	0.1566
NDVI	-134.0358	29.9326	-4.48	<0.0001	

crimes (Table 3 and Fig. 1). This implies the more the abundant vegetation around a house is, the less frequently property crimes occur. Moreover, NDVI accounts for 15.66% of the variance in the frequency of property crimes that occurred and were reported.

*Census Tracts Variables and NDVI.* Pearson correlation analyses were conducted between NDVI and the following census tracts related factors that might be associated with property crimes: percent unemployment, median family income, percent ownership, total dwellings, and total population. Results of these analyses indicated vegetation is not related to total dwellings, but is strongly and negatively related to percent unemployment ( $p < 0.0002$ ). Moreover, results indicated strong positive correlation between vegetation and median family income ( $p = 0.0002$ ), percent ownership ( $p < 0.0001$ ), and total population ( $p = 0.0048$ ). These findings suggest that NDVI

predicts crime by virtue of its shared variance with some of the variables associated with census tracts. We felt it would be worthwhile to determine if the level of vegetation measured by NDVI and some of the census tracts variables reported can be used to predict if a given dwelling has been the victim of property crime in the past.

To accomplish this, we conducted a logistic regression in which all census tracts related predictors and NDVI were entered, and dependent variable were coded as 1 for victim of property crime and 0 for non-victim of property crime. Logistic regression is a regression method that uses a transformation (called logit) which forces the prediction equation to predict between 0 and 1 (Cody and Smith, 1997). The parameter estimates for the logistic regression model are shown in Table 4. The logistic regression equation predicts the natural log of the odds for a given dwelling being the victim of prop-

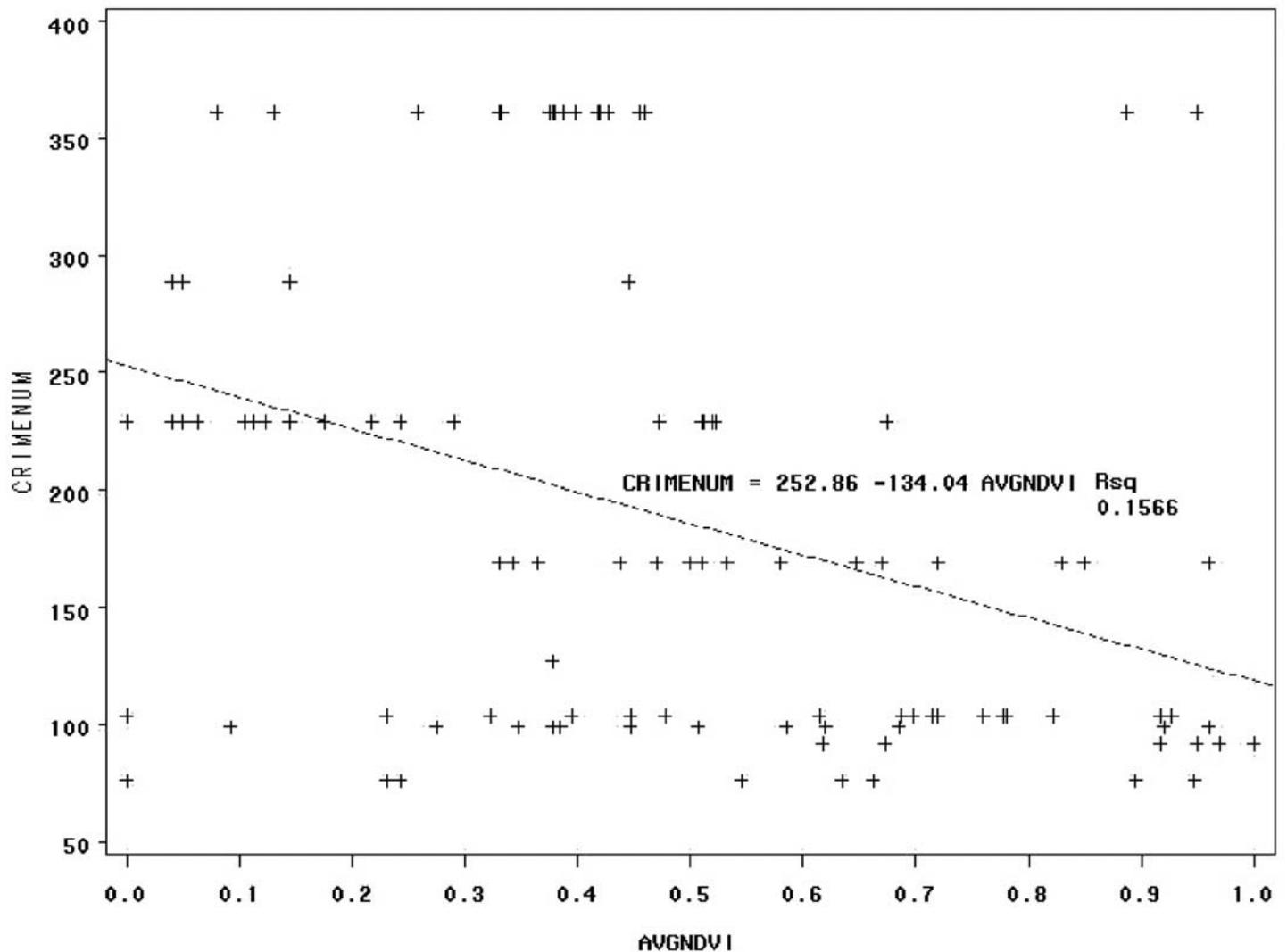


Fig. 1. Relationship between NDVI and number of property crime ( $R^2 = 0.1566$ ).

Table 4. Parameter estimates for the logistic regression model.

Variable	Estimate	Standard error	$\chi^2$	p
Intercept	0.4731	0.7116	0.4420	0.5062
NDVI	-0.9224	0.5466	2.8474	0.0915**
Median family income	-0.00003	0.000016	4.1709	0.0411*
Percent ownership	0.0431	0.0169	6.5067	0.0107*

\*Significant at  $\alpha = 0.05$ ; \*\*significant at  $\alpha = 0.10$ .

erty crime using NDVI, Median Family Income, and Percent Ownership as predictors. Hence, the logistic regression equation is:

$$\log(\text{odds of property crime occurring}) = 0.4730 - 0.9224 * \text{NDVI} - 0.00003 * \text{Median Family Income} + 0.0431 * \text{Percent Ownership}$$

And the

Probability (P) of victim of property crime = Odds/1 + Odds.

### Conclusion

In this day of forest fragmentation and urban sprawl, open green space within city environments should be a consideration beyond aesthetic value. Most people increasingly recognize the value of open green space beyond its beauty, including increasing property values and environmental effects such as purifying air, modifying extremes in temperature and reducing noise pollution and glare. However, in times of budget cuts, funds for landscaping and protection of open green spaces are often seen as merely for beautification, and not as a necessity. In addition, because of high maintenance costs and liabilities, trees and shrubs are often removed from urbanizing environments and replaced with concrete. This minimal level of concern for preserving green space may not only be environmentally detrimental, but results from this Tallahassee study, in addition to others, provides evidence that the vegetation within city environments can reduce crime and promote safer communities.

The level of vegetation associated with NDVI is a potential addition to our crime fighting arsenal. Moreover, together with some attributes assigned to census tracts (median family income and percent ownership), the likelihood of a given dwelling for being the victim of property crime can be predicted using NDVI values.

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