ENVIRONMENT AND CRIME IN THE INNER CITY
Does Vegetation Reduce Crime?

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ABSTRACT: Although vegetation has been positively linked to fear of crime and crime in a number of settings, recent findings in urban residential areas have hinted at a possible negative relationship: Residents living in "greener" surroundings report lower levels of fear, fewer incivilities, and less aggressive and violent behavior. This study used police crime reports to examine the relationship between vegetation and crime in an inner-city neighborhood. Crime rates for 98 apartment buildings with varying levels of nearby vegetation were compared. Results indicate that although residents were randomly assigned to different levels of nearby vegetation, the greener a building's surroundings were, the fewer crimes reported. Furthermore, this pattern held for both property crimes and violent crimes. The relationship of vegetation to crime held after the number of apartments per building, building height, vacancy rate, and number of occupied units per building were accounted for.

> The highway from one merchant town to another shall be cleared so that no cover for malefactors should be allowed for a width of two hundred feet on either side; landlords who do not effect this clearance will be answerable for robberies committed in consequence of their default, and in case of murder they will be in the king's mercy.
> —Statute of Winchester of 1285, Chapter V, King Edward I

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There is a long tradition of addressing crime in problem areas by removing vegetation. As early as 1285, the English King Edward I sought to reduce highway robbery by forcing property owners to clear highway edges of trees and shrubs (Pluncknett, 1960). Today, that tradition continues as park authorities, universities, and municipalities across North America engage in active programs to remove vegetation because it is thought to conceal and facilitate criminal acts (Michael & Hull, 1994; Nasar & Fisher, 1993; Weisel, Gouvis, & Harrell, 1994).

One of the settings in which crime is of greatest concern today is the inner-city neighborhood. To combat crime in this setting, should vegetation be removed? This article suggests the opposite. We present theory and evidence to suggest that far from abetting crime, high-canopy trees and grass may actually work to deter crime in poor inner-city neighborhoods.

COULD THERE BE EXCEPTIONS TO THE RULE?

As a rule, the belief is that vegetation facilitates crime because it hides perpetrators and criminal activity from view. Here, we review the evidence in support of this "rule" and suggest conditions under which it might not apply.

Although no studies to date have examined whether crime rates are actually higher in the presence of dense vegetation, a variety of evidence links dense vegetation with fear, fear of crime, and possibly crime itself.

It is certainly the case that many people fear densely vegetated areas. In research on urban parks, densely wooded areas have consistently been associated with fear. In one study, safety ratings for 180 scenes of urban parks showed that individuals felt most vulnerable in densely forested areas and safest in open, mowed areas (Schroeder & Anderson, 1984). And in another study, individuals who were asked for their open-ended responses to photo-

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graphs of urban parks indicated that heavily vegetated areas seemed dangerous (Talbot & Kaplan, 1984). Although neither of these studies specifically probed fear of crime (as opposed to more general fear), it was clear that at least some participants had crime in mind; one respondent specifically suggested that weedy areas gave muggers good hiding places (Talbot & Kaplan, 1984).

Dense vegetation has also been linked specifically to fear of crime. In safety ratings for 180 scenes of parking lots, the more a photo was covered by vegetation, the lower the perceived security (Shaffer & Anderson, 1985). And in research examining fear of crime on a university campus, dense understories that reduced views into areas where criminals might hide were associated with fear of crime (Nasar & Fisher, 1993). In these and other studies, view distance seems to be an important factor. Fear of crime is higher where vegetation blocks views (Fisher & Nasar, 1992; Kuo, Bacaicoa, & Sullivan, 1998; Michael & Hull, 1994).

Not only has dense vegetation been linked to general fears and to fear of crime in particular, but two studies have pointed more directly at a facilitative role of vegetation in crime. In the first study, park managers and park police indicated that dense vegetation is regularly used by criminals to conceal their activities (Michael & Hull, 1994). In the second, burglars themselves lent support to this notion. In this study, automobile burglars described how they used dense vegetation in a variety of ways, including to conceal their selection of a target and their escape from the scene, to shield their examination of stolen goods, and finally, in the disposal of unwanted goods (Michael, Hull, & Zahm, 1999). At the same time, Michael and his coauthors made it clear that vegetation was neither necessary nor sufficient for a crime to take place.

The clear theme in all these studies is that dense vegetation provides potential cover for criminal activities, possibly increasing the likelihood of crime and certainly increasing the fear of crime. Large shrubs, underbrush, and dense woods all substantially diminish visibility and therefore are capable of supporting criminal activity.

But, not all vegetation blocks views. A well-maintained grassy area certainly does not block views; widely spaced, high-canopy trees have minimal effect on visibility; and flowers and low-growing shrubs seem unlikely to provide cover for criminal activities. We suggest that although the rule that vegetation aids crime may hold for visibility-decreasing forms of vegetation, there are systematic exceptions to this rule. To wit, we propose that widely spaced, high-canopy trees and other visibility-preserving forms of vegetation do not promote crime.

MIGHT VEGETATION DETER CRIME? THEORY

Furthermore, we propose that in some settings, visibility-preserving forms of vegetation may actually deter crime. Specifically, we propose that in poor inner-city neighborhoods, vegetation can inhibit crime through the following two mechanisms: by increasing surveillance and by mitigating some of the psychological precursors to violence. Let's look at each of these in turn.

Increasing surveillance. Surveillance is a well-established factor in criminal activity. Jane Jacobs (1961) suggested that the simple presence of more "eyes on the street" would deter crime, and this concept was prominent in Oscar Newman's (1972) classic *Defensible Space* and appeared in Jeffery's (1971) *Crime Prevention Through Environmental Design*. Since then, many studies have shown that perpetrators avoid areas with greater surveillance and greater likelihood of intervention (e.g., Bennett, 1989; Bennett & Wright, 1984; Cromwell, Olson, & Avary, 1991; Poyner & Webb, 1992). And, substantial research has shown that criminals avoid well-used residential areas where their activities might easily be observed (Coleman, 1987; Macdonald & Gifford, 1989; Merry, 1981; Rhodes & Conley, 1981).

There is some evidence to suggest that in inner-city neighborhoods, vegetation might introduce more eyes on the street by increasing residents' use of neighborhood outdoor spaces. A series of studies conducted in inner-city neighborhoods has shown that treed outdoor spaces are consistently more well used by youth, adults, and mixed-age groups than are treeless spaces; moreover, the more trees in a space, the greater the number of simultaneous users (Coley, Kuo, & Sullivan, 1997; Kuo, Sullivan, Coley, & Brunson, 1998; W. C. Sullivan, Kuo, & DePooter, 2001). Not surprisingly then, a recent study found that children were twice as likely to have adult supervision in green inner-city neighborhood spaces than in similar but barren spaces (A. F. Taylor, Wiley, Kuo, & Sullivan, 1998). Thus, in these settings, higher levels of vegetation not only preserve visibility but may also increase surveillance.

Perhaps just as important as actual surveillance in deterring crime is implied surveillance. Newman (1972) suggested that criminals might be deterred by environmental cues suggesting that surveillance is likely even when no observers are present (also see Jeffery, 1971; R. B. Taylor, 1988). Consistent with this, territorial markers have been empirically linked to lower rates of incivilities and crime (Brown & Altman, 1983; Perkins, Brown, & Taylor, 1996; Perkins, Wandersman, Rich, & Taylor, 1993; R. B. Taylor, 1988). (And even those *E&B* readers who are not criminals may have

experienced the power of implied surveillance—on the highway after passing an empty police car.)

There is some evidence to suggest that residential vegetation can act as a territorial marker. Chaudhury (1994) showed front views of houses to students and examined how a host of environmental features affected their ratings of *territorial personalization*. He found that the presence and maintenance of vegetative features was the strongest predictor of territorial personalization, with an *R*-squared of .65. Similarly, Brown and colleagues (Brown & Altman, 1983; Brown & Bentley, 1993) found evidence suggesting that plants and other territorial markers make properties less attractive for burglary. We suggest that well-maintained vegetation may constitute a particularly effective territorial marker. Well-maintained vegetation outside a home serves as one of the *cues to care* (Nassauer, 1988), suggesting that the inhabitants actively care about their home territory and potentially implying that an intruder would be noticed and confronted.

Mitigating psychological precursors to violence. Another mechanism by which vegetation might inhibit crime is through mitigating mental fatigue. S. Kaplan (1987) suggested that one of the costs of mental fatigue may be a heightened propensity for "outbursts of anger and potentially . . . violence" (p. 57), and three proposed symptoms of mental fatigue—irritability, inattentiveness, and decreased control over impulses—are each well-established psychological precursors to violence. Irritability is linked with aggression in numerous studies (e.g., Caprara & Renzi, 1981; Coccaro, Bergeman, Kavoussi, & Seroczynski, 1997; Kant, Smith-Seemiller, & Zeiler, 1998; Kavoussi & Coccaro, 1998; Stanford, Greve, & Dickens, 1995). Inattentiveness has been closely tied to aggression in both children (Stewart, 1985) and adolescents (Scholte, van Aken, & van Leishout, 1997). And, impulsivity is associated with aggression and violence in a variety of populations (for reviews, see Brady, Myrick & McElroy, 1998; Markovitz, 1995; Tuinier, Verhoeven, & Van Praag, 1996).

A considerable body of studies indicates that vegetation aids in the recovery from mental fatigue. Contact with nature in a variety of forms—wilderness areas, prairie, community parks, window views, and interior plants—is systematically linked with enhanced cognitive functioning as measured by both self-report and performance on objective tests (e.g., Canin, 1991; Cimprich, 1993; Hartig, Mang, & Evans, 1991; R. Kaplan, 1984; Lohr, Pearson-Mimms, & Goodwin, 1996; Miles, Sullivan, & Kuo, 1998; Ovitt, 1996; Tennessen & Cimprich, 1995). To the extent that irritability, inattentiveness, and impulsivity are symptoms of mental fatigue, as first proposed in

S. Kaplan (1987) and recently elucidated in Kuo and Sullivan (in press), reductions in mental fatigue should decrease violent behavior.

In sum, we propose that vegetation can deter crime in poor urban neighborhoods in any or all of the following ways: by increasing residents' informal surveillance of neighborhood spaces, by increasing the implied surveillance of these spaces, and by mitigating residents' mental fatigue, thereby reducing the potential for violence. Next, we review empirical work pointing at a negative relationship between vegetation and crime.

MIGHT VEGETATION DETER CRIME? CIRCUMSTANTIAL EVIDENCE

There are a number of scattered hints in the empirical literature that vegetation might have a negative relationship to crime in residential settings.

A few studies have used images to examine the relationship between vegetation and sense of safety in residential settings. The findings from residential settings are in direct contrast to those obtained in studies of nonresidential settings: In residential settings, the more vegetation there is, the less fear of crime. One study used photographs of residential sites to examine effects of architectural and landscape features on fear of crime and found that higher levels of vegetation were associated with less fear of crime (Nasar, 1982). Another study used drawings of residences and found that properties appeared safer when trees and shrubs were included than when they were not (Brower, Dockett, & Taylor, 1983). And, similar results were obtained from an experiment using computer-based photo simulations. In that study, an inner-city courtyard was depicted with varying densities of trees: The more dense the tree planting was, the greater the sense of safety (Kuo, Bacaicoa, et al., 1998).

One study used controlled comparisons of real residential settings to examine the relationship between vegetation and sense of safety. In a public housing development where residents were randomly assigned to architecturally identical apartment buildings with varying levels of vegetation immediately outside, those residents who lived in buildings with more trees and grass gave systematically higher endorsements to the statement "I feel safe living here" than did their counterparts living in relatively barren buildings (Kuo, Sullivan, et al., 1998). That is, not only do images of green residential settings evoke a greater sense of safety, but individuals living in such settings report a greater sense of safety as well.

There is some indication that this greater sense of safety is warranted. A few studies have examined the relationship between vegetation and "incivilities." R. B. Taylor, Gottfredson, and Brower (as cited in R. B. Taylor, 1988) compared street blocks with higher and lower levels of high-maintenance

gardening and found fewer problems reported on street blocks with higher levels of high-maintenance gardening. And in another study, Stamen (1993) surveyed landscaped and nonlandscaped areas in a community and found that the incidence of vandalism or graffiti in sites without plantings was 90% as compared to 10% in sites with plantings. Similarly, Brunson (1999) examined both physical and social incivilities in public housing outdoor spaces with trees and grass versus in similar spaces without vegetation. Resident reports indicated that graffiti, vandalism, and littering were systematically lower in outdoor spaces with trees and grass than in comparable, more barren spaces (Brunson, 1999). Furthermore, resident reports indicated that social incivilities, such as the presence of noisy, disruptive individuals, strangers, and illegal activity, were also systematically lower in the greener outdoor spaces (Brunson, 1999).

Additional evidence that vegetation may reduce crime comes from two studies that examined the relationship between residential vegetation and residents' levels of aggression and violence. Mooney and Nicell (1992) compared violent assaults by Alzheimer patients during two consecutive summers in five long-term care facilities—three without gardens and two in which exterior gardens were installed. In Alzheimer patients, increases in the number of aggressive assaults each year are typical because of the progressive deterioration of cognitive faculties; and indeed, in the facilities without gardens, the incidence of violent assaults increased dramatically over time. By contrast, the incidence of violent assaults in the other facilities stayed the same or decreased slightly after gardens were installed.

Another study compared levels of aggression and violence in an urban public housing neighborhood where residents played no role in planting or maintaining the vegetation outside their apartments and were randomly assigned to levels of greenness. Levels of aggression and violence were systematically lower for individuals living in green surroundings than for individuals living in barren surroundings; moreover, lack of nature significantly predicted levels of mental fatigue, which in turn significantly predicted aggression. Mediation testing indicated that the relationship between vegetation and aggression was fully mediated through attention (Kuo & Sullivan, in press).

In sum, there is a variety of evidence suggesting that vegetation may be linked to lower levels of crime in residential neighborhoods, particularly poor inner-city neighborhoods. Residential vegetation has been linked with a greater sense of safety, fewer incivilities, and less aggressive and violent behavior. Of these findings, the most direct evidence of a negative link between vegetation and crime comes from residents' reports of illegal

activities in the space outside their apartment building and from residents' self-reports of (criminally) aggressive behavior.

The study presented here is the first to examine the relationship between vegetation and crime in an inner-city neighborhood using police crime reports. Although police crime reports are far from infallible (O'Brien, 1990), one advantage of such reports is that they are based on actual counts of crimes reported over the course of a year and thus are less subject to the distortions introduced by having residents estimate the frequencies of such events from memory. Thus, the convergence of findings from resident reports and police reports would lend confidence to a negative link between vegetation and crime. In this study, we examined the relationship between the vegetation outside of apartment buildings and the number of police crime reports for those buildings over a 2-year period. We collected police data on property crimes, violent crimes, and total crimes for 98 apartment buildings in one inner-city neighborhood and used the amount of tree and grass cover outside each building to predict crime.

METHOD

Data presented here were collected as part of the Vital Neighborhood Common Spaces archive, a multistudy research effort examining the effects of the physical environment on the functioning of individuals, families, and communities residing in urban public housing.

POPULATION, SETTING, AND DESIGN

Ida B. Wells is a large public housing development in Chicago. Wells provides housing for approximately 5,700 individuals, of which 65% are female, 97% are African American, and 44% are children younger than 14 years old (Chicago Housing Authority, 1995). Ida B. Wells is one of the 12 poorest neighborhoods in the United States (Ihejirika, 1995). At the time of this study, approximately 93% of the people living at Wells were officially unemployed, and roughly 50% of the families received Aid to Families with Dependent Children (Chicago Housing Authority, 1995).

The amount of nature outside apartment buildings at Ida B. Wells varies considerably. When the development was originally built in the 1940s, trees and grass were planted around each of the low-rise buildings. Over time, many of these green spaces have been paved in an effort to keep dust down and maintenance costs low; this paving has killed many of the original trees,

Figure 1: Ground Level View at Ida B. Wells Showing Apartment Buildings With Varying Amounts of Tree and Grass Cover

leaving some areas completely barren, others with small trees or some grass, and still others with mature high-canopy trees (see Figure 1). Because shrubs were relatively rare, vegetation at Ida B. Wells was essentially the amount of tree and grass cover around each building.

A number of apartment buildings at Wells were excluded from this study. First, the high-rise and midrise (seven-story) buildings were excluded to keep the buildings sampled similar in size, number of residents, and amount of outdoor common space. Second, of the 124 low-rise (one to four stories) apartment buildings, those buildings adjacent or nearly adjacent to the police station within the development were excluded because the presence of police officers would be expected to be a significant deterrent to crime. And finally, a small cluster of low-rise buildings was excluded because the buildings' irregular placement with respect to each other and the street made it unclear where the common space associated with one building ended and the next began. The final sample included 98 buildings.

Ida B. Wells offers a number of rare methodological advantages for investigating the relationship between residential vegetation and crime. Although levels of vegetation outside the apartment buildings vary considerably, the residents are strikingly homogeneous with respect to many of the individual characteristics that have been shown to increase vulnerability to crime—income, education, and life circumstances. This similarity among residents coupled with the consistent low-rise architecture decreases the sources of extraneous variability in crime. This increases the power to detect differences in the amount of crime associated with differences in the level of vegetation outside each apartment building.

Perhaps more important, the apartment assignment procedures and landscaping policies of public housing work to ensure that there are no systematic

relationships between the vegetation outside an apartment building and the characteristics of its residents. Applicants for public housing at Ida B. Wells (and elsewhere in Chicago public housing) are assigned to individual apartments without regard for the level of nearby vegetation. And although residents have some choice in accepting or rejecting a particular apartment in theory, in practice the level of nearby vegetation is not a significant factor in residents' choices, and most residents simply accept the first available apartment (Kuo, Sullivan, et al., 1998). Moreover, residents play little or no role in decisions to introduce or remove trees. Thus, in this study, there were no a priori reasons to expect a relationship between the level of vegetation outside an apartment building and the characteristics of its inhabitants—more "responsible" residents might just as likely live in barren buildings as in green buildings.

MEASURES

Crime reports. Chicago Police Department year-end Uniform Crime Reports were analyzed for this study. These crime reports summarize for each address at Ida B. Wells the specific crimes (e.g., aggravated assault and strong-armed robbery) that were reported during the year. These reports include both citizen-initiated complaints and those filed by an officer without a citizen complaint.

When a crime is reported to the police, 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 2 years of crime reports, we created three summary variables indexing crime for each low-rise apartment building at Ida B. Wells, following the classification scheme used by the Department of Justice (Bureau of Justice Statistics, 1999). In this scheme, property crime is the sum of simple thefts, vehicle thefts, burglaries, and arson; violent crime includes assaults, batteries, robberies, and homicides; and total crimes is the sum of all crimes reported.

Vegetation. To assess the density of trees and grass around each of the low-rise buildings, we took dozens of 35mm slide photographs of the development by helicopter, passing over each cluster of buildings from a number of vantages (see Figure 2). We also took ground-level photographs of many of the outdoor spaces. All the slides were taken in June when the tree canopy

Figure 2: Aerial View of a Portion of Ida B. Wells Showing Buildings With Varying Amounts of Tree and Grass Cover

was full and the grass was green. For each building, the aerial slides were put together with slides taken at ground level; there were at minimum three different views from aerial and ground-level photos of each space (front, back, left side, and right side) around each building. Five students in landscape architecture and horticulture then independently rated the level of vegetation in each space. Each of the individuals rating the spaces received a map of the development that defined the boundaries of the specific spaces under study. The raters viewed the slides and recorded their ratings on the maps. A total of 220 spaces was rated, each on a 5-point scale (0 = no trees or grass, 4 = a space completely covered with tree canopy). Interrater reliability for these ratings was .94.[1] The five ratings were averaged to give a mean nature rating for each space. The nature ratings for the front, back, and side spaces around each building were then averaged to produce a summary vegetation rating. Ratings of vegetation for the 98 buildings ranged from 0.6 to 3.0.

Other factors likely to affect crime. Four additional variables possibly related to vegetation and the number of crimes reported per building were assessed through (a) on-site analysis, (b) Chicago Housing Authority floor

TABLE 1
Simple Ordinary Least Squares Regressions
Using Vegetation to Predict Crimes Per Building

	Total Crimes			*Property Crimes*			*Violent Crimes*		
Predictor	R^2	β	p *Value*	R^2	β	p *Value*	R^2	β	p *Value*
Vegetation	.08	–2.2	< .01	.07	–1.0	< .01	.07	–1.3	<.01

plans of each building type in the development, and (c) Chicago Housing Authority apartment vacancy records.

Number of units is the number of apartment units in a building; the range was from 4 to 20.

Number of occupied units is the average number of units rented in a particular building during the 2 years of the study; the mean was 7.8, and the range was from 0.5 to 15. We were able to obtain data on 84 of the 98 buildings in this sample.

Vacancy is the 2-year average of the number of vacant apartments divided by the number of units in the building; the mean was 13%, and the range was from 0% to 92%. We were able to obtain data on 84 of the 98 buildings in this sample.

Building height is the number of floors in a building; the range was from 1 to 4.

RESULTS

If vegetation reduces crime, then we would expect to find that the greener a building's surroundings are, the fewer crimes reported. Perhaps the most straightforward test of this possibility is to conduct simple regressions with vegetation as the independent variable and the three summary crime indices as dependent variables (see Table 1). Results from these ordinary least squares regressions indicate that vegetation is significantly and negatively related to each of the measures of crime. The greener a building's surroundings are, the fewer total crimes; this pattern holds for both property crimes and violent crimes. For each of the three indices, vegetation accounts for 7% to 8% of the variance in the number of crimes reported per building.

Figure 3 provides a more concrete sense of the amount of crime associated with different levels of vegetation. For this figure, the continuous vegetation variable was recoded into the following three categories: low (ratings from

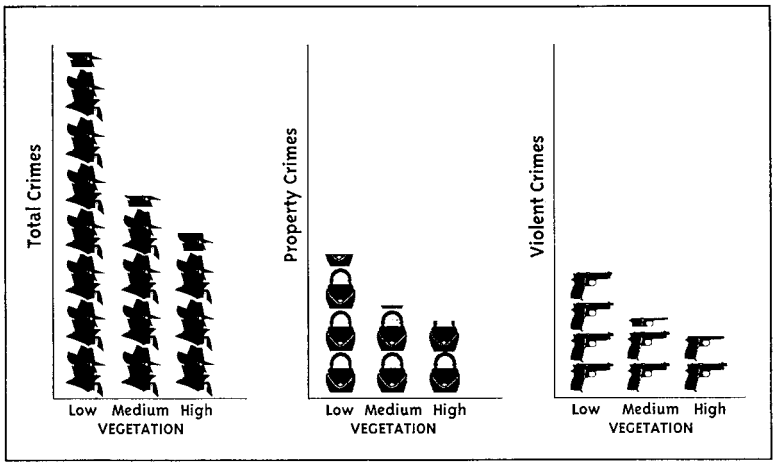

Figure 3: Mean Number of Crimes Reported Per Building for Apartment Buildings With Different Amounts of Vegetation (each icon represents one reported crime)

0.0 up to 1.0), medium (from 1.0 up to 2.0), and high (from 2.0 up to 3.0, inclusive). Figure 3 shows the average number of total, property, and violent crimes reported for buildings with low, medium, and high levels of vegetation. Compared to buildings with low levels of vegetation, those with medium levels had 42% fewer total crimes, 40% fewer property crimes, and 44% fewer violent crimes. The comparison between low and high levels of vegetation was even more striking: Buildings with high levels of vegetation had 52% fewer total crimes, 48% fewer property crimes, and 56% fewer violent crimes than buildings with low levels of vegetation. Fisher's protected least significant difference analyses indicate that for each measure of crime, low and medium buildings were significantly different at $p < .05$. The same pattern held for comparisons between low and high buildings. Although buildings with high levels of vegetation had 17% fewer total crimes, 13% fewer property crimes, and 21% fewer violent crimes than buildings with medium levels of vegetation, these differences were not statistically significant.

These data reveal a clear negative relationship between vegetation and crime and hint that this relationship is strongest when comparing buildings with low levels of vegetation to buildings with either medium or high levels. Although these findings are exciting and intriguing, they do not control for other important variables. The analyses that follow provide a closer look at

TABLE 2
Multiple Regressions Using Number of Units and Vegetation to Predict Crimes Per Building

	Total Crime		*Property Crimes*		*Violent Crimes*	
Predictors	β	p *Value*	β	p *Value*	β	p *Value*
Number of units	0.70	< .0001	0.31	< .0001	0.39	< .0001
Vegetation	–1.44	< .05	–0.63	< .05	–0.81	< .05

NOTE: The multiple regressions for total crimes: adjusted R^2 = .52 (N = 98, p < .0001); for property crime: adjusted R^2 = .45 (N = 98, p < .0001); for violent crime: adjusted R^2 = .44 (N = 98, p < .0001).

the relationship between vegetation and crime, taking into account other factors likely to affect the number of crimes per building.

TESTING POTENTIAL CONFOUNDS

Controlling for number of apartments. Perhaps one of the most important variables to control for in predicting the amount of crime in a setting (e.g., a building, neighborhood, or city) is the number of people in that setting. Because more apartments per building mean more potential perpetrators and more potential victims, one would expect more crimes in buildings with more apartments. Indeed, previous research has shown the number of units in a building to be related to the number of reported crimes (Newman & Franck, 1980). Thus, it is not surprising that in this sample, strong positive linear relationships exist between the number of units and the number of property crimes (r = .62, p < .0001), violent crimes (r = .63, p < .0001), and total crimes (r = .67, p < .0001). That is, the more apartments in a building, the more crimes reported for that building.

To examine whether the relationship between vegetation and crime still held when the number of apartments in a building was controlled, a series of multiple regressions were conducted in which both vegetation and number of units were used to predict the number of crimes reported per building. As Table 2 shows, when the number of units per building is controlled, vegetation continues to be a significant negative predictor of total crime, property crime, and violent crime. In other words, the level of greenness around a building at Ida B. Wells predicts the number of crimes that have occurred in that building even after the number of apartments in the building has been accounted for.

TABLE 3
Intercorrelations Among Possible Predictors of Crime and Three Crime Scales

	Vegetation	*Number of Units*	*Vacant Rate*	*Number of Occupied Units*	*Building Height*	*Property Crime*	*Violent Crime*
Vegetation							
Number of units	–.15						
Vacancy rate	–.02	.26					
Number of occupied units	.12	.82**	–.31**				
Building height	–.48**	.67**	.40**	.35**			
Property crime	–.27**	.62**	.01	.38**	.53**		
Violent crime	–.27**	.63**	.25**	.30**	.58**	.72**	
Total crime	–.29**	.67**	.16	.38**	.60**	.91**	.95**

**$p < .01$.

Other potential confounds. To identify other potential confounds between vegetation and crime, correlations were conducted between vegetation and the following three factors that have been shown in other studies to be associated with crime: vacancy rate (R. B. Taylor, Shumaker, & Gottfredson, 1985), the number of occupied apartments per building (Newman & Franck, 1980), and building height (Newman, 1972; Newman & Franck, 1980). As the first column in Table 3 shows, vegetation is not related to either vacancy rate or number of occupied units but is strongly and negatively related to building height; the taller the building is, the lower the level of vegetation. The fourth column in Table 3 indicates that building height has a strong positive relationship to total crime, property crime, and violent crime. Thus, the relationship between vegetation and crime is confounded by building height: Taller buildings are both less green and have more reported crimes than shorter buildings. These findings raise the possibility that vegetation predicts crime only by virtue of its shared variance with building height.

To test for this possibility, we examined whether vegetation still predicts crime when building height and number of units are controlled. Table 4 provides the results of a series of multiple regressions in which vegetation, building height, and number of units were used to predict crime. If vegetation predicts crime by virtue of its relationship with building height, then vegetation should no longer predict crime when building height is controlled, and building height should predict crime with vegetation controlled. As Table 4

TABLE 4
Multiple Regression Using Three Independent Variables (number of units, vegetation, and building height) to Predict Crimes Per Building

	Total Crime		*Property Crimes*		*Violent Crimes*	
Predictors	β	p *Value*	β	p *Value*	β	p *Value*
Number of units	0.69	.0001	0.33	.0001	0.34	.0001
Vegetation	–1.41	< .05	–0.69	< .05	–0.55	.07
Building height	0.05	*ns*	–0.13	*ns*	0.18	*ns*

NOTE: The multiple regressions for total crimes: adjusted $R^2 = .51$ ($N = 98$, $p < .0001$); for property crime: adjusted $R^2 = .44$ ($N = 98$, $p < .0001$); for violent crime: adjusted $R^2 = .43$ ($N = 98$, $p < .0001$).

shows, however, this is not the case; vegetation remains a significant or marginally significant predictor of crime with building height and number of units controlled. Moreover, building height has no predictive power when vegetation and number of units are controlled. These findings indicate that although building height is confounded with vegetation, it cannot account for the link between vegetation and crime.

Thus far, the analyses have established that (a) there is a reliable association between the amount of vegetation outside a building and the number of crimes recorded for that building by the police, (b) these relationships are independent of the number of units in a building, and (c) these relationships are independent of building height. These analyses show that vegetation predicts crime and that this relationship cannot be accounted for by these other confounding variables.

DOES ADDING VEGETATION IMPROVE THE CURRENT ARSENAL OF CRIME PREDICTORS?

To determine whether vegetation makes any unique, additional contribution to the current arsenal of predictors, we conducted a multiple regression in which all available significant predictors of crime were entered (i.e., vegetation, other predictors that were confounded with vegetation, and other predictors that were not confounded with vegetation). This kitchen-sink multiple regression, in which vegetation and number of units, building height, vacancy rate, and number of occupied units were entered as predictors, indicated that vegetation does make a unique contribution to the current arsenal of predictors. Vegetation was a significant predictor of total crime ($\beta = -1.1$, $p = .05$) even when all other crime predictors have been accounted for. Moreover, the relatively low variance inflation factor for vegetation in this regression (1.31) indicates that vegetation is relatively independent of the

other predictors. In addition, comparison of the adjusted R^2s of the kitchen-sink multiple regressions with and without vegetation indicated that the additional predictive power gained by adding vegetation outweighs the loss of degrees of freedom incurred in increasing the total number of predictors. The adjusted R^2 for the model with only the current arsenal of predictors was .23; the adjusted R^2 for the model with the current arsenal of predictors plus vegetation was .26. Although this increase represents only 3% of the total variance in crime, it represents a sizable proportion of the current predictive power (13%). Together, these findings indicate that adding vegetation improves the current arsenal of predictors, adding unique explanatory power.

A Cuthbert plot (Cp) analysis yielded additional evidence of the predictive power of vegetation. Cp analysis is a technique for determining the most powerful, most parsimonious model out of a set of multiple predictors (SAS Institute, 1998). Essentially, given a set of predictors, Cp analysis tests all possible combinations of predictors and selects the best model. An alternative to comparing adjusted R^2s, Cp analysis is particularly helpful when there is multicollinearity between predictors, as was the case here. Cp analysis indicated that the best model for predicting total crime, selecting from the entire set of available predictors (number of units, building height, vacancy rate, number of occupied units, and vegetation), comprises only two predictors—number of units and vegetation (Cp = 1.32). Thus, in these data, the best possible model of crime comprises only vegetation and one other predictor.

DISCUSSION

This study examined the relationship between vegetation and crime for 98 apartment buildings in an inner-city neighborhood. Analyses revealed consistent, systematically negative relationships between the density of trees and grass around the buildings and the number of crimes per building reported to the police. The greener a building's surroundings are, the fewer total crimes; moreover, this relationship extended to both property crimes and violent crimes. Levels of nearby vegetation explained 7% to 8% of the variance in the number of crimes reported per building. The link between vegetation and crime could not be accounted for by either of the two confounding variables identified. Vegetation contributed significant additional predictive power above and beyond four other classic environmental predictors of crime. And out of all possible combinations of available predictors, vegetation was identified as one of the two predictors in the best possible model of crime.

The findings contribute to our understanding of the relationship between vegetation and crime and suggest opportunities for intervention and future research.

CONTRIBUTIONS TO THE UNDERSTANDING OF VEGETATION AND CRIME

One contribution of this work is to propose a systematic exception to the rule that vegetation promotes crime. The rule in both folk theory and environmental criminology has been that vegetation promotes crime by providing concealment for criminals and criminal activities. If the mechanism by which vegetation affects crime is indeed concealment, then one implication of this rule is that vegetation should not promote crime when it preserves visibility. The contribution here is simply to point out that many forms of vegetation preserve visibility and therefore ought not promote crime. Indeed, we found that in this sample of inner-city apartment buildings, buildings with widely spaced, high-canopy trees and grassy areas did not experience higher rates of crime. These findings suggest that at the very least, crime prevention concerns do not justify removing high-canopy vegetation in inner-city neighborhoods. They demonstrate that one of the classic suspects in environmental criminology does not always promote crime.

Moreover, the findings indicate a large and systematically negative link between levels of vegetation and police reports of crime in this setting. Although this is the first study to demonstrate such a link, the findings are consistent with previous work linking vegetation with lower levels of incivilities (Brunson, 1999; Stamen, Yates, & Cline, as cited in S. Sullivan, 1993) as well as previous work linking vegetation with lower levels of aggression and violence (Kuo & Sullivan, in press). The results obtained here were based on police crime reports, whereas the Brunson (1999) and the Kuo and Sullivan (in press) findings were based on residents' memories and self- reports. The convergence of findings from such different measures lends confidence that in inner-city residential settings, the relationship between vegetation and crime is negative—the more vegetation, the less crime.

A third contribution of the work here is to help resolve a puzzle in previous work on residential vegetation and sense of safety. A number of studies have found that residential vegetation is associated with greater sense of safety (Brower et al., 1983; Kuo, Bacaicoa, et al., 1998; Kuo, Sullivan, et al., 1998; Nasar, 1982). In combination with the old rule that vegetation promotes crime, such findings raised the disturbing possibility that residents systematically misperceive green areas as safe. And yet other research has found good concurrent validity between measures of fear, perceptions of disorder, and media reports of crime (e.g., Perkins & Taylor, 1996). The finding here that

vegetation is systematically linked with lower levels of crime suggests that individuals are accurate in their perception of green areas as safer.

A final contribution of this work is to propose two mechanisms by which vegetation may deter crime in inner-city neighborhoods. Specifically, we propose that vegetation may deter crime both by increasing informal surveillance and by mitigating some of the psychological precursors to violence. Although neither of these mechanisms—nor the more general question of causality—can be addressed in these data, there is clear empirical support for these mechanisms in other work. Substantial previous research has shown that surveillance deters crime and that in inner-city neighborhoods, greener outdoor spaces receive greater use, thereby increasing informal surveillance. Moreover, Kuo and Sullivan's (in press) work showed that for residents randomly assigned to apartment buildings with different levels of vegetation, higher levels of vegetation systematically predicted lower levels of aggression, and mediation analyses indicated that this link was mediated via attentional functioning. In addition, we can address a number of alternative interpretations for the findings here. Public housing policies in this setting are such that levels of income, education, and employment among residents are largely held constant; residents are randomly assigned to varying levels of vegetation; and the amount of trees and grass outside an apartment is not under residents' control. And the confound analyses conducted here indicate that the link between vegetation and lower crime could not be explained by a number of classic environmental predictors of crime—vacancy rates, building height, the number of apartments, and the number of occupied apartments in a building.

POSSIBILITIES FOR INTERVENTION AND FUTURE RESEARCH

The findings in this study set the stage for more ambitious explorations of the relationship between urban residential vegetation and crime. Now that there is good reason to think that visibility-preserving vegetation does not necessarily promote crime and may even inhibit crime in inner-city neighborhoods, it seems appropriate to attempt an intervention study or two. Intervention studies employing true experimental designs might be used to answer a number of important questions with regard to the effects of vegetation on crime. Urban public housing communities might be especially amenable sites for such research as housing authorities tend to have centralized control over landscaping for dozens and even hundreds of identical buildings.

A study in which identical or matched apartment buildings in a poor urban area were randomly assigned to receive different levels of vegetation could help address the question of causality and the question of the shape of the

relationship between vegetation and crime. Would crime rates decrease linearly or curvilinearly with increasing vegetation? In this sample, the difference between low and moderate green cover buildings was 3.1 crimes, but the difference between moderate and high green cover buildings was only 0.7 crimes. One possible interpretation of this pattern is that the relationship between vegetation and crime is nonlinear with diminishing returns. Another is that the 0.7 crime difference between the moderate and high vegetation conditions is a poor estimate because of the relatively low number of high-vegetation buildings in the sample, and the relationship between vegetation and crime is actually linear across the entire range of vegetation.

Future studies might systematically vary the arrangement and maintenance of vegetation and examine the rates of crime associated with these factors. The vegetation in this study was not configured to provide symbolic barriers or to mark the territory of particular apartment buildings. Would arrangements that create symbolic barriers and delineate the territory of particular residences (e.g., with small hedges) be more effective in decreasing crime than other arrangements? Brown and colleagues (Brown & Altman, 1983; Brown & Bentley, 1993) found evidence suggesting that plants and other territorial markers may make a property less attractive for burglary, but no study has yet randomly assigned different planting arrangements to different buildings and compared the resulting rates of property crime. Analogously, well-maintained vegetation seems to be a particularly effective territorial marker (Chaudhury, 1994), but research has yet to systematically examine the effect of different levels of maintenance on crime.

Future research might also look more closely—and more broadly—at the outcomes of planting interventions. In this sample, vegetation predicted levels of both property crime and violent crime. This is noteworthy given that studies in environmental criminology often find that the relationship between the physical environment and crime depends on the specific category of crime (e.g., Brantingham & Brantingham, 1993). It would be interesting and useful to examine the relationships between vegetation and more specific categories of crime or other categories altogether. For instance, does vegetation have more of an effect on impulsive crimes than on "rational" crimes? We might expect impulsive crimes committed out of frustration or rage to be reduced through the beneficial effects of vegetation on mental fatigue. And to the extent that perpetrators consciously calculate risks in selecting their targets, more "rational," premeditated crimes might be reduced through the beneficial effects of vegetation on informal surveillance.

In examining the outcomes of planting interventions, it will be important to address the possible displacement of crime. One of the standard concerns in efforts to combat crime is that although interventions may reduce crime in

targeted locations, the effect may be to simply displace crime to other areas, yielding no overall decrease in crime (Gabor, 1981). Would adding vegetation and decreasing crime in one part of an inner-city neighborhood simply increase crime in another part of the neighborhood? The answer may depend on the type of crime in question. By reducing the irritability, impulsivity, and cognitive deficits associated with mental fatigue and hence preventing minor conflicts from spiraling out of control, vegetation might inhibit violent crimes in some residences without increasing violent crimes in others. On the other hand, by increasing informal surveillance of some outdoor spaces without reducing the actual impetus for burglary and other premeditated crimes, vegetation might serve to simply shift such crimes to more vulnerable targets. Future research should examine rates of crime both in and around the intervention areas.

Such comparisons might shed light on the mechanisms by which vegetation affects crime. To further address the question of mechanism, levels of informal surveillance and mental fatigue might be measured in buildings receiving the planting intervention and in matched buildings selected as controls. Mediation analyses could then be conducted to examine the joint links between vegetation, crime, and the proposed mediators. Does vegetation affect crime only when it increases residents' use of outdoor spaces and levels of informal surveillance?

Finally, one exciting possibility for future work would be to compare the outcomes from intervention studies in which residents were either involved or uninvolved in the greening process. The question here would be whether the process of tree planting could enhance residents' territoriality, thereby deterring crime over and above the direct effect of the presence of vegetation. Active involvement in tree-planting programs has been claimed to enhance a community's sense of territoriality (Dwyer, McPherson, Schroeder, & Rowntree, 1992), and the community greening lore is replete with stories in which greening efforts have been accompanied by dramatic decreases in crime and incivilities (e.g., Hynes, 1996; Lewis, 1980; Littman, 1996; Trust for Public Lands, 1996). Previous research in inner-city neighborhoods suggests that residents would be willing to help plant and care for trees (Kuo, Bacaicoa, et al., 1998). As planting is the single largest cost associated with the care and maintenance of the urban forest (McPherson, Nowak, & Rowntree, 1994), involving residents would substantially defray the already low costs associated with a planting intervention.

Ultimately, the largest reductions in crime will come from strategies that address the factors underlying crime (e.g., intense poverty and the availability of guns). In the meantime, this study offers a ray of hope by identifying an easily manipulable environmental feature that has a systematic, negative

relationship with property crimes, violent crime, and total crimes. The work presented here suggests the exciting possibility that in barren inner-city neighborhoods, planting a few trees may work to inhibit crime, creating safer neighborhoods for poor families and their children.

NOTE

1. In these data, agreement between raters is analogous to the reliability of items in a scale; the hope is that different raters will respond to a particular building in a similar fashion. Thus, to assess interrater agreement, a Cronbach's alpha was calculated with individual raters treated like individual items in a scale and individual buildings treated like individual respondents.

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