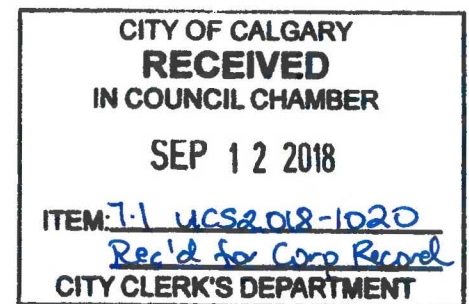


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Good morning, Mr Chair and committee members, thank you for this opportunity to speak,

My name is Mike Bingley and I am the Education Director for the Canadian Wildlife Federation. CWF is Canada's largest conservation charity, reaching more than 2.5 million people each year who join us in maintaining a bright future for wildlife from coast to coast to coast. We do this through programming like the WILD Family Nature club, which reaches more than 45,000 people each year in unstructured play in nature, or the Canadian Conservation Corps, a program that we offer in conjunction with the Canada Service Corps, launched by the Prime Minister this past spring, which sees young adults engaged in expeditionary learning, meaningful service learning with a community partner and finally delivering a project of their own design, in their own community, when they return home. Of course, we have a variety of other



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programs across the country, but we have limited time this morning.

I'm also a citizen of Calgary, living in Citadel with my wife and two children and, as a Calgarian, I have a vested interest in the community that we live in.

It should be of no surprise to any of you that Albertans love the outdoors – nature is a 5 Billion dollar industry here in Alberta where more than 75% of Albertans spending some time in a natural area each year and more than half say that they choose where to live based on their proximity to the natural world. This is good news because people who are connected with the natural world are more likely to protect these natural spaces that support wildlife in our communities. Put simply: connection builds constituency for the natural world.

The bad news is that people who spend time in nature are a species at risk and, like the peregrine falcon in the 1960s, it's the youth numbers that are plummeting. Having a strong connection to an outdoor place is the first step to ensuring any kind of conservation ethic, and it is an essential component of our Canadian identity. We must act decisively to reverse this trend or we will soon find ourselves in the position where it is too late.

We know through peer reviewed science that a connection with nature is a key indicator of current and future conservation ethic. That's why we at CWF care about it. That's only one reason why you, as our city council should care. A connection with nature has been shown to increase community social capital, reduce violence across communities, raise property values and has a host of health and education benefits. People who spend time outdoors on a daily basis are healthier, more likely to vote, more likely to shovel a neighbours walkway and more likely to graduate from

university that those who don't, regardless of their socioeconomic background. Any nature is good, but wild nature, like Nose Hill Park, are even better.

The City of Calgary has done admirable work in setting aside land for future generations to experience through its park program. My colleagues in other parts of the country are impressed with the urban wildlife that we live with daily in our city and we have an opportunity to do more.

I'd like to suggest a few things to help Calgary become an even greener city:

- First – the city needs to understand that partnerships with NGOs, like CWF, are an essential part of conservation. We would like to partner with the city through programs like our

Canadian Conservation Corps and our Wild Family Nature club, but we find it difficult to do so.

- Second – the city has an opportunity to pilot some best practices that will help make Calgary an even better place for all wildlife. Programs like habitat offsets, riparian waterway enhancement or encouraging the use of native species over non-native species will help enhance our shared environment.
- Finally, the city should expand the opportunities for young people to get their hands dirty in a natural environment and to learn about that environment through formal, non-formal and informal learning programming. It should be careful not to use a "look, but don't touch" philosophy that will not allow young people to really experience the natural world. Where it is appropriate, young people should be able to flip over rocks, dig, climb trees and build forts in our natural places.

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I have one more suggestion for each of you as you move through this process. I'd like you to spend a few minutes over the next week in one of our city's fantastic natural areas and consider how we can ensure that future generations of Calgarians get the same opportunities, no matter what their socioeconomic background and no matter where they live in our growing city. Our predecessors were very forward thinking in making sure that we have these precious natural spaces and I want to make sure that we have even more of them in the future.

Thank you very much, I'd be happy to answer any questions that you might have.

VIEWS OF NATURE AND SELF-DISCIPLINE: EVIDENCE FROM INNER CITY CHILDREN

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Abstract

Children growing up in the inner city are at risk of academic underachievement, juvenile delinquency, teenage pregnancy, and other important negative outcomes. Avoiding these outcomes requires self-discipline. Self-discipline, in turn, may draw on directed attention, a limited resource that can be renewed through contact with nature. This study examined the relationship between near-home nature and three forms of self-discipline in 169 inner city girls and boys randomly assigned to 12 architecturally identical high-rise buildings with varying levels of nearby nature. Parent ratings of the naturalness of the view from home were used to predict children's performance on tests of concentration, impulse inhibition, and delay of gratification. Regressions indicated that, on average, the more natural a girl's view from home, the better her performance at each of these forms of self-discipline. For girls, view accounted for 20% of the variance in scores on the combined self-discipline index. For boys, who typically spend less time playing in and around their homes, view from home showed no relationship to performance on any measure. These findings suggest that, for girls, green space immediately outside the home can help them lead more effective, self-disciplined lives. For boys, perhaps more distant green spaces are equally important.

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Introduction

Children growing up in the inner city are at risk of academic underachievement (Brooks-Gunn, 1986), juvenile delinquency (Berrueta-Clement, 1984), teenage pregnancy (Furstenberg, 1976), and other important negative outcomes, with profound consequences for themselves, those around them, and society. Outcomes such as these often reflect failures of self-regulation, or self-discipline (Baumeister *et al.*, 1994). Could a feature of the physical environment affect inner city children's capacity for self-discipline, and as a consequence, play a role in these outcomes?

This paper explores whether children's self-discipline might be enhanced by contact with nature. Previous research suggests that natural settings and views can help renew the psychological resource used in deliberately directing attention. It has been proposed that self-discipline draws on this same resource (Kuo, 2000); if so, we would expect self-discipline to decline when this resource is depleted or fatigued, and we would expect self-disci-

pline to improve when this resource is renewed. Thus, regular contact with natural settings and views might be expected to enhance children's capacity for self-discipline on a day-to-day basis.

To test this possibility, this study tested for links between the view from home and three forms of self-discipline in children. Specifically, it examined whether, in an inner city neighborhood, children with 'greener' views from home were better able to concentrate, inhibit initial impulses, and delay gratification.

Three forms of self-discipline

Concentrating, inhibiting initial impulses, and delaying gratification are each distinct and important forms of self-discipline. They are distinct forms of self-discipline in that each involves overriding different, unhelpful tendencies. And they are important in that each seems likely to play a pivotal role in the course of a young person's life. More specifically, each seems likely to play an important role in negotiating the risks faced by inner city children:

academic underachievement, juvenile delinquency, and teenage pregnancy.

Concentrating requires overcoming the tendency for the mind to wander, and sustaining attentional focus despite distractions, boredom, frustration, or fatigue. As it involves directing one's thoughts to the topic at hand, concentration is the form of self-discipline that most clearly draws on our capacity to deliberately direct attention. The ability to concentrate is important because it enables an individual to mentally 'buckle down' and stay on a task long enough to make progress and be effective. It also seems to enable an individual to complete tasks more quickly. In children, chronic or acute deficits in concentration could result in valuable time spent in less-than-effective ways. A child too mentally fatigued to concentrate might spend countless hours in front of books and assignments, yet learn very little due to their inability to focus on the task at hand. Indeed, inattentiveness is a significant predictor of academic underachievement (e.g. Mantzicopoulos, 1995; Rowe, 1992).

Inhibiting initial impulses¹ requires overcoming the tendency to jump to conclusions or to act on impulse. It involves overriding one's initial response to a problem or situation, in order to consider alternatives or consider the potential costs and benefits of a course of action. The ability to inhibit initial impulses is important because it gives rise to more prudent and cautious choices, and consequently, more prudent and cautious actions. Chronic or acute deficits in a child's ability to inhibit impulses can have serious, negative long-term repercussions. For example, a child too mentally fatigued to inhibit impulses is more likely to give in to repeated offers of a lit cigarette or other dangerous substance. A diminished capacity to inhibit impulses could also cause a child to accept a dare to jump from one balcony to the next, or to snatch an elderly woman's purse. Consistent with this, impulsivity is consistently linked with risky behavior (Donohew *et al.*, 2000; McCoul, 2000), aggression and violence (e.g. Hynan & Grush, 1986; Markovitz, 1995), and delinquency (Lynam, 2000; Rigby, 1989; White, 1994).

Delaying gratification requires overcoming impatience and the tendency to favor short-term rewards over long-term goals. It involves internalized standards and morals. The ability to delay gratification is important because reaching future goals often requires postponing immediate rewards. It assists the individual in persisting at goal-oriented behaviors for the good of their future. Even a temporary deficit in the ability to delay gratification can have ma-

jor repercussions. For example, a temporary inability to delay gratification might lead a young couple to give in to immediate desires and engage in unprotected sex, rather than wait until they are better prepared. Consistent with this, poor ability to delay gratification is a significant predictor of unplanned pregnancy (Donoghue, 1993; Shaffer *et al.*, 1978).

In sum, concentration, impulse inhibition, and delay of gratification may play pivotal roles in the course of a young person's life. How might these vital forms of self-discipline be enhanced by the presence of natural elements immediately outside the home? We suggest that each of these forms of self-discipline draws on a resource which can be renewed by contact with nature — the capacity for deliberate or self-directed attention. In the next section, we review the literature on how natural settings and views can renew directed attention; we then consider why self-discipline might draw on this resource.

How natural settings and views restore directed attention

Both theory and evidence suggest that the resource underlying our capacity to direct attention can be renewed by contact with nature. Attention Restoration Theory (Kaplan, 1995; Kaplan & Kaplan, 1989) builds on William James' description of attention to provide an explanation for why natural settings and views might be expected to renew this resource. James observed that certain elements in the environment are effortlessly engaging, and draw on what he called involuntary attention: 'strange things, moving things, wild animals, bright things...' (James, 1962, p. 231). For those stimuli and situations that do not effortlessly engage us, he proposed, we draw on a voluntary form of attention, or what S. Kaplan (1995) calls directed attention.

The mechanism underlying directed attention appears to behave like a mental muscle. With prolonged or intense use, the capacity to deliberately direct attention becomes fatigued and performance declines (Cohen & Spacapan, 1978; Glosser & Goodglass, 1990). In *Attention Restoration Theory*, S. Kaplan proposed that stimuli that draw primarily on involuntary attention give directed attention a chance to rest. Further, he noted that natural settings and views appear to draw on involuntary attention; as a consequence, contact with nature should assist in recovery from the fatigue of directed attention.

Evidence in Adults. A number of studies in adult populations support Attention Restoration Theory. Several studies have shown that nature draws upon involuntary attention (e.g. Kaplan, 1973, 1983; Kaplan & Talbot, 1983, Ulrich, 1981). In addition, a number of other studies have shown that exposure to natural environments can be effective in restoring directed attention from fatigue (Canin, 1991, Cimprich, 1990, Hartig *et al.*, 1991; R. Kaplan, 2001; Kuo, 2001; Lohr *et al.*, 1996; Miles *et al.*, 1998; Ovitt, 1996, Tennessen & Cimprich, 1995).

Of the previous empirical studies linking nature and directed attention, three are particularly relevant to the study presented here. These studies focus on residential nature and residential views of nature. In one study, residents randomly assigned to relatively 'green' high-rise apartment buildings scored significantly higher on an objective measure of attention than did residents assigned to relatively 'barren' buildings (Kuo, 2001). In another study, university students with 'all natural' or 'mostly natural' views from their dormitory room windows scored significantly higher on two objective measures of directed attention than did residents with 'mostly built' or 'all built' views (Tennessen & Cimprich, 1995). And in a third study, residents of low-rise apartment buildings with window views of natural elements or settings rated themselves as functioning better on several indices thought to be related to attention restoration (Kaplan, 2001). Thus, there is some reason to think that residential views of nature might prove restorative in this study.

Evidence in children. Numerous studies have linked directed attention to nature and near-home nature in adults; very little research has been conducted with children. Although Attention Restoration Theory does not exclude children and it has been suggested nature might support directed attention in children (Trancik & Evans, 1995), only two empirical studies have examined this possibility. Wells (2000) examined children who moved from poor quality housing to better quality housing in better neighborhoods. Among these children, those whose move involved the greatest increase in nature had the highest rated levels of attentional functioning post-move. Another study provides three additional pieces of evidence about the link between nature and directed attention in children. That study revealed that exposure to nature through green activity settings was related to better attentional functioning (reduced attention deficit symptoms) in a population of children with Attention

Deficit Disorder (Faber Taylor *et al.*, 2001). In that study, parents rated a variety of leisure activities with respect to whether those activities left their child's attention deficit symptoms better than usual, worse than usual, or the same as usual: results indicated that children function better than usual after activities in green settings. Moreover, ratings were higher for those activities conducted in green settings than for those conducted in built outdoor or indoor settings. In addition, the greener a child's usual play setting, the less severe their attention deficit symptoms were rated in general. And most relevant to the current study, several measures of residential greenness were significantly and negatively linked to overall severity of symptoms — but only for girls and not for boys. Multiple potential confounds were evaluated; none could explain the relationships between green settings and better attentional functioning.

In sum, not only do theory and evidence suggest that nature supports directed attention in adults, but there is some evidence that it does so in children as well. Moreover, there is evidence to suggest that near-home nature and residential views of nature can help renew directed attention.

Does self-discipline draw on directed attention?

Might self-discipline draw on directed attention, and hence, be renewed by contact with nature? More than one investigator has proposed that the capacity for self-discipline is a limited but renewable resource (Kuo, 2000; Muraven & Baumeister, 2000). Perhaps it is no coincidence that both what personality psychologists call 'self-control strength' (Muraven & Baumeister, 2000) and what environmental psychologists call 'directed attention' (Kaplan, 1995) are subject to the same patterns of decline and restoration — decline with overuse and renewal with rest. Kuo (2000) has proposed that the mental mechanism that underlies self-discipline and the mental mechanism that underlies directed attention are one and the same.

Although directed attention has been operationalized primarily in terms of effective cognitive performance (e.g. maintaining focus or paying attention, resisting distractions, planning, decision making, remembering things), it is clear from Kaplan's description that the mechanism he proposes may be involved in much more (Kaplan & Kaplan, 1989; Kaplan, 1995). In essence, Kaplan proposes a general control mechanism for directing any of a variety of different forms of mental activity, including thoughts, images, sensations, and

impulses. Thus, the mechanism for directing attention may be involved in the inhibition of any strong-but-unhelpful mental activity in favor of any weak-but-helpful mental activity.

Each of the three forms of self-discipline examined here could plausibly draw on this proposed mechanism. Concentration involves both inhibiting distractions and other task-irrelevant thoughts, and supporting on-task thoughts. Similarly, inhibition of impulses may involve inhibiting initial impulses, blocking out the stimuli that give rise to those impulses, and supporting the consideration of alternatives. And delay of gratification may involve inhibiting impulses, inhibiting unhelpful thoughts and sensations that fan one's desire for immediate gratification (e.g. warm chocolate cake), and supporting thoughts about long term goals (e.g. weight loss).

Consistent with this conception, a number of studies and reviews have linked voluntary or controlled aspects of attention to forms of self-discipline and self-regulation. Mischel and colleagues have shown that children's ability to direct attention away from immediate rewards is pivotal in their ability to delay gratification (Mischel *et al.*, 1972), and that adolescents' attentiveness and ability to concentrate is predicted by their ability to delay gratification as pre-schoolers (Shoda *et al.*, 1990). Two studies have independently linked aspects of attention to more disciplined ways of dealing with anger or conflict (Eisenberg *et al.*, 1994; Kuo & Sullivan, 2001b). In factor analyses of questionnaire data, Rothbart *et al.* (2001) have found a broad effortful control factor, in which attentional focusing clusters with inhibitory control. Posner & Rothbart (2000) review literature suggesting that high-level attentional networks provide the neural basis for self-regulation. And finally, in their review of over 500 books and articles on self-regulation failure, Baumeister *et al.* (1994) conclude that loss of control over attention is a key factor in self-regulation failure.

This study

If nature renews directed attention in children, and if directed attention is indeed involved in self-discipline, as we suggest, then children's self-discipline should be strengthened by contact with nature. This study examined whether near-home nature is related to three forms of self-discipline in both girls and boys. Specifically, we asked

- *Do residential views of nature enhance children's concentration?*

- *Do residential views of nature enhance children's inhibition of initial impulses?* and
- *Do residential views of nature enhance children's delay of gratification?*

This study breaks new ground in two respects. First, previous research has linked concentration to nature empirically, but only in adults with normal attentional functioning and in children with compromised attentional functioning. This study is the first to examine the relationship between nature and concentration in a sample of children with normal attentional functioning. And second, although nature and concentration have been linked in some populations, neither impulse inhibition nor delay of gratification have been linked to nature in any population. The findings of two studies (Kuo & Sullivan, 2001b; Kuo, 2001) are consistent with a link between nature and self-discipline, but neither of these studies directly examined impulse inhibition or delay of gratification.

To examine the relationship between residential views of nature and concentration, impulse inhibition, and delay of gratification in children, we conducted one-on-one tests and interviews with a sample of inner city girls and boys and their mothers. Objective performance measures were used to assess children's concentration, inhibition of initial impulses, and delay of gratification. Mothers' ratings were used to assess the naturalness of views from home.

Methods

Site and design

The site was Robert Taylor Homes, a large public housing development in Chicago, Illinois, USA. At the time of this study, Robert Taylor Homes (RTH) comprised 28 16-story buildings. It had over 12,000 official residents, of whom 31% were children between 5 and 14 years old (CHA, 1995). Almost all of the heads of household (99.7%) were African-American and most (75%) received Aid to Families with Dependent Children (CHA, 1995).

The physical characteristics of RTH help make it an optimal site for studying the effects of near-home nature. When the development was built in the 1960s, trees and grass were planted in the common spaces next to every building. Over the years, for reasons of reducing maintenance and dust, grass in most of the spaces was replaced with pavement, causing many of the trees to die and subsequently be removed. This attrition has left some buildings

barren and others with pockets of green. While the amount of nearby nature varies from building to building, the buildings themselves are nearly identical in architecture, layout, size, and number of residential units. Thus, many would-be confounds are held constant at RTH, allowing for clean comparisons of the effects of near-home nature.

The social characteristics of RTH also help make it an optimal site for studying the effects of near-home nature. The housing assignment practices of Chicago Housing Authority result in *de facto* random assignment of residents to buildings, and residents are not involved in landscaping decisions or maintenance. Previous research at this site with a different sample of residents found no systematic relationships between levels of vegetation outside apartment buildings and residents' age, education, marital status, work status, income, Aid to Families with Dependent Children status, number of children at home, length of residence, or numerous other factors (Kuo & Sullivan, 2001a).

Participants and procedures

To boost rapport between the participants and interviewers, we hired and trained residents of RTH as interviewers. The four interviewers were African-American women between 30 and 45 years old. Each had achieved at least a high school diploma. The interviewers received 40 hours of training in interviewing and administering objective performance measures from our staff and the National Opinion Research Center.

In order to minimize distractions to interview participants during the interview, we also hired and trained residents to serve as child-care providers. Child care providers accompanied the interviewers to the interviews and kept any children in the apartment who were not being interviewed safe and entertained. All child care providers were at least 18 years old and were completing or had completed high school.

Twelve apartment buildings with varying amounts of vegetation were sampled; we excluded buildings adjacent to parks, police stations or other relatively unique features. Within the selected buildings, sampling was limited to the 2nd, 3rd, and 4th floors because those floors provide residents maximal views of the trees and grass outside their building; there are no residences on the ground floor.

To recruit participants, flyers were posted and interviewers canvassed door-to-door. Interviewers did not canvas or interview in the building in which they lived, and they were instructed not to inter-

view anyone with whom they were acquainted. Parent-child pairs were invited to participate in a University of Illinois study about 'the physical environment of the neighborhood and how it affects mothers and children.' Any 7-12 year old child and their mother or primary caregiver was eligible to participate, so long as they had been residents of RTH for at least a year. Potential participants were told that they could refuse to answer any question, and could stop the interview at any time. Adults received \$10 and children received a small gift at the completion of the interview.

Of the eligible adult-child pairs approached, 169 of 174 agreed to participate — a 97% response rate. Ninety one of the child participants were boys; 78 were girls. Both the boys' and girls' mean ages were 9.6 years old (ranges 7.7-11.7 and 7.7 to 12.2 years old, respectively). All participants were African-American.

Interviews and testing were conducted in participants' apartments at the kitchen table. Adult interviews and testing typically lasted a little more than an hour. Child interviews and testing typically lasted 45 minutes.

Measures

We measured near-home nature and three types of self-discipline: concentration, inhibition of initial impulses, and delay of gratification.

Near-home nature. Near-home nature was assessed by asking the adult participants to rate the views from their apartment windows. Ratings in response to two items were combined: 'How much of the view from your window is of nature (trees, plants, water)?' and 'How much of your view from your window is man-made (buildings, street, pavement)?' (reverse-scored). Each item was rated on a five-point scale, from 0 'not at all' to 4 'very much'. Figure 1 shows barren and green areas immediately outside RTH apartment buildings.

Concentration. Concentration was assessed using four tasks. These tasks have previously been used as measures of attention or concentration: Symbol Digit Modalities Test (Cimprich, 1992, Lezak, 1983; Smith, 1968), Digit Span Backwards (Cimprich 1992; Wechsler, 1955), Alphabet Backwards (Cimprich, 1992), and Necker Cube Pattern Control (Cimprich, 1990; Schwartz, 1994; Tennessen & Cimprich, 1995). Phenomenologically, each of these tasks is characterized by the effortful use of attention or paying attention.



FIGURE 1. Views of near-home nature vary from apartment to apartment at Robert Taylor Homes.

In Symbol Digit Modalities (SDM), the participant substitutes numbers for nine geometric symbols, including three mirror image pairs, as quickly as possible (Smith, 1973). Scores on SDM were the number of correct substitutions in a 90-s period. One participant's score was more than 2 S.D. higher than the next highest score; this outlier was excluded from further analysis.

In Digit Span Backwards (DSB), the participant listens to a sequence of numbers two to eight digits long and then repeats the sequence aloud in reverse order (Wechsler, 1955). Scores on DSB were the longest number of digits repeated correctly before two consecutive failed trials.

In Alphabet Backwards (ABK), the participant recites the alphabet backwards beginning with a specified letter (e.g. the letter u) (Cimprich, 1992). In this study, three trials were given; scores were the average number of letters recited in correct (reverse) sequence divided by the average time spent reciting them (i.e. the average speed with which the participant could recite the alphabet backwards).

In Necker Cube Pattern Control (NCPC), the participant attempts to mentally 'hold on to' one interpretation of an ambiguous stimulus (Tennessen & Cimprich, 1995). First, the participant stares at a three-dimensional line drawing of a cube for 30 s, signaling each time the front and back faces appears to reverse. Then, the participant tries to mentally 'hold the cube still' or inhibit it from reversing for 30 s, signaling each time the faces reverse. Scoring for this measure was the percent reduction in the number of reversals from the first task — letting the cube reverse freely — to the second task — holding the cube still. Scores were based on performance of the two tasks after a practice trial.

Scores on SDM, DSB, ABK, and NCPC were standardized and averaged to create a summary index of

concentration. Z-scores were used because the four tasks were scored on very different scales.

Inhibition of initial impulses. Inhibition of initial impulses was assessed by combining scores on three established measures of impulsivity or impulse inhibition: Matching Familiar Figures Test (e.g. Welsh *et al.*, 1991; Brown & Quay, 1977; Kagan, 1966), Stroop Color-Word Test (Boucugnani & Jones, 1989; Davies *et al.*, 1984; Dyer, 1973), and Category Matching (Melnik & Das, 1992). Each of these tasks tends to evoke an initial response that is incorrect or very likely to be incorrect. In each of these tasks, good performance requires avoiding the initial incorrect response in order to discern the correct response.

In Matching Familiar Figures (MFF), the participant is presented with a target figure and a set of six alternatives; the task is to select the single alternative that exactly matches the target figure (Kagan, 1966). Because all the alternatives all look the same at first glance, participants must be careful in evaluating them. For each trial, the number of erroneous choices a participant makes before selecting the correct alternative is recorded. In this study, a participant's score on the measure was the total number of errors over 12 trials. MFF has been found to be a reliable measure: reliability for total number of errors ranges from 0.62 (Block *et al.*, 1974) to 0.78 (Cairns & Cammock, 1978). Matching Familiar Figures has also been found to be a valid measure of impulsivity (Brown & Quay, 1977; although *cf.* Block *et al.*, 1974).

In the Stroop Color-Word Test (Stroop), the participant is given a sheet of paper with 50 color names presented in rows (Dodrill, 1978). Each color name is printed in incongruent ink colors; e.g. the word *red* might be printed in green ink. The participant is first asked to read each of the words on the page aloud, and then asked to name the *ink color* of each

word on the page. The challenge of this task is to avoid the initial impulse to read the words rather than name the ink colors. In this study, a participant's score was the number of ink colors named correctly on first attempt.

In Category Matching (CM), the participant is presented with a sheet containing 84 pairs of icons (Schwartz, 1994; adapted from Melnyk & Das, 1992). The participant evaluates pairs of icons, attempting to circle only those pairs in which the two icons belong to the same conceptual category. Twenty-one of the pairs are target pairs, while the remaining 63 are distractor pairs. The challenge of this task is in resisting the impulse to circle pairs in which the icons are similar in form but not in conceptual category. A participant's score was the number of pairs evaluated in 30 s less any errors.

We created a summary index of inhibition of initial impulses by averaging the *z*-scores of MFF (reverse-scored), Stroop, and CM.

Delay of gratification. A version of Rodriguez *et al.*, (1989) task was used to assess children's capacity to delay gratification. In this task, the challenge is to resist an immediate, smaller reward in favor of a delayed but larger reward. The participant is first asked which of two kinds of candy they prefer. Then, they are shown a very large and a very small bag of their preferred candy, and told that if they can wait long enough, they can have the larger bag; otherwise, they will receive the smaller bag. The test administrator then instructs the child to wait quietly with their eyes closed and leaves the room, taking the candy with her (*cf.* Rodriguez *et al.*, 1989). Scores on this task were the total time waited, with a maximum score of 15 min.

Results

Results are presented in four parts. We begin by presenting preliminary analyses suggesting that the relationship between near-home nature and self-discipline should be examined separately by gender. We then examine relationships between near-home nature and self-discipline for girls and boys. Finally, we address the potential role of age differences in the relationship between nature and self-discipline.

Preliminary analyses: should girls and boys be analyzed separately?

Previous research has hinted at gender differences in the effects of near-home nature on children (Faber Taylor *et al.*, 2001). To determine whether the effects of near-home nature on self-discipline would best be analysed separately for girls versus boys, we conducted a number of preliminary analyses.

First, we used independent *t*-tests to examine gender differences in self-discipline. Did the girls and boys in this study differ in their performance on the three forms of self-discipline? As Table 1 shows, there are gender differences on each of the three forms of self-discipline tested, with girls outperforming boys on two forms and boys outperforming girls on the third. Girls' scores are significantly higher on concentration and marginally significantly higher on impulse inhibition ($p=0.08$); boys' scores are significantly higher on delay of gratification.

These findings suggest that it would be prudent to take gender into account in testing for links between nature and self-discipline. To do so, we conducted 2×2 factorial ANOVAs examining the

TABLE 1
Means, standard deviations, and mean comparisons between girls and boys on measures of self-discipline

	Means		Standard Deviations		<i>t</i>	<i>p</i>
	Girls [†]	Boys ^{**}	Girls	Boys		
Concentrating*	0.15	-0.12	0.58	0.52	3.24	<0.01
Inhibiting impulses [‡]	0.09	-0.09	0.69	0.62	1.79	0.08
Delay of gratification [‡]	358	454	309	325	-1.95	0.05
Self discipline [§]	0.03	-0.02	0.53	0.48	0.65	ns

*Concentration summary=average of *z*-scores on four constituent measures

[†]Inhibition of impulses summary=average of *z*-scores on 3 constituent measures

[‡]Delay of gratification scores=total time waited in seconds

[§]Self-discipline summary=average of three *z*-scores: concentration summary, inhibition summary, and delay of gratification.

[†]*n*=78

^{**}*n*=91

effects of gender and nature on self-discipline. In particular, we were interested in whether any effects of nature might be moderated by gender. Indeed, consistent with previous research, gender by nature interactions emerged for each of the three forms of self-discipline. Findings indicated that girls differed from boys significantly in the effect of near-home nature on concentration, $F(1,165)=5.7$, $p<0.05$, and delay of gratification, $F(1, 165)=5.4$, $p<0.05$. Girls differed from boys marginally significantly in the effect of nature on impulse inhibition, $F(1,165)=3.6$, $p=0.06$.

Accordingly, we examined the relationships between near-home nature and each of the three forms of self-discipline separately for girls and for boys.

Near-home nature and self-discipline in girls

Concentration. If near-home nature enhances this form of self-discipline in girls, we might expect girls with greener views to perform better, overall, at Symbol Digit Modalities, Alphabet Backwards, Necker Cube Pattern Control, and Digit Span Backwards. We used a simple OLS regression to examine the relationship between parent-rated naturalness of apartment view and a summary index of these four measures of concentration.

Do girls with greener views perform better at tests of concentration? Yes. On average, the greener a girl's view from home, the better she concentrates. As Figure 2 shows, there is a strong positive linear relationship between naturalness of apartment view and girls' performance on the summary index of concentration, $F(1,76)=10.9$, $p<0.01$, and each of the constituent measures echo this pattern. For each

scale point difference in rated greenness of view (for example, from 0 'not at all' to 1 'a little'), performance increases by roughly a quarter of a standard deviation, $\beta=0.233$. Greenness of view explains approximately one-eighth of the variance in concentration scores, $R\text{-squared}=0.126$.

Inhibition of initial impulses. If near-home nature enhances this form of self-discipline in girls, we might expect girls with greener views from home to perform better, overall, at Matching Familiar Figures Test, Stroop Color-Word Test, and Category Matching. We used a simple OLS regression to examine the relationship between naturalness of apartment view and a summary index combining these three measures of impulse inhibition.

Do girls with greener views perform better at tests of impulse inhibition? Yes. On average, the greener a girl's view from home, the more effective she is at inhibiting impulses. As Figure 3 shows, there is a positive relationship between naturalness of view and girls' performance on the summary index of these three measures; and again, the constituent measures echo this pattern. Naturalness of apartment view significantly and positively predicts impulse inhibition, $F(1, 76)=3.8$, $p=0.05$. Greenness of view explains roughly 5% of the variance in impulse inhibition scores, $R\text{-squared}=0.048$, with a β of 0.172.

Delay of gratification. If near-home nature enhances this form of self-discipline in girls, we might expect girls with greener views from home to perform better on the Mischel delay of gratification task.

Are girls with greener views more able to resist the temptation of an immediate-but-smaller reward?

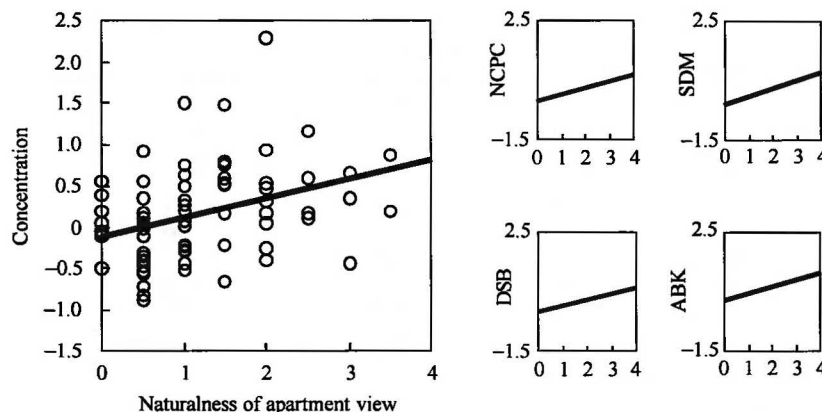


FIGURE 2. OLS regression of naturalness of view on the summary measure of girls' concentration (left) and its four constituent measures. All scores are standardized.

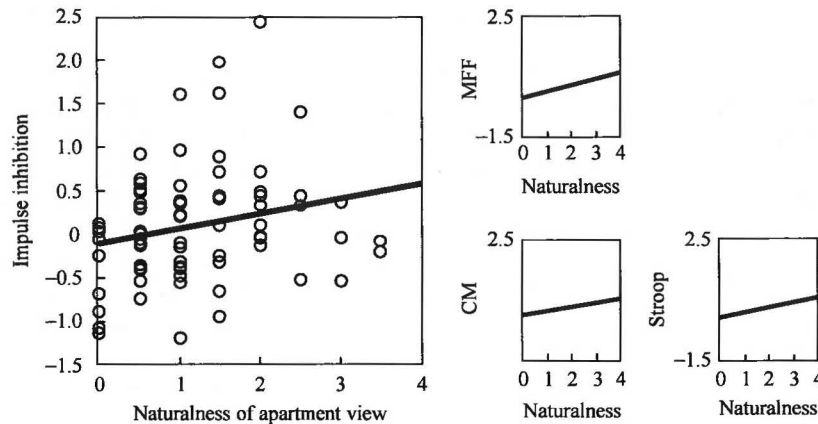


FIGURE 3. OLS regression of naturalness of view on the summary measure of girls' impulse inhibition (left) and its three constituent measures. All scores are standardized.

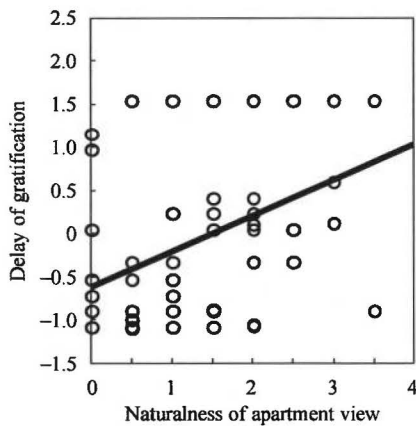


FIGURE 4. OLS regression of naturalness of view on girls' delay of gratification. Delay of gratification scores are standardized.

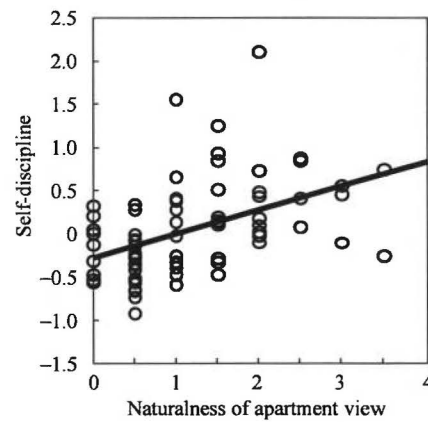


FIGURE 5. OLS regression of naturalness of view on the summary measure of girls' self-discipline. Self-discipline scores are standardized.

Yes. On average, the greener a girl's view from home, the longer she is able to delay gratification. As Figure 4 shows, there is a strong positive relationship between naturalness of view and performance on this task. Naturalness of apartment view significantly and positively predicts delay of gratification, $F(1, 76) = 12.7$, $p < 0.001$. For each point difference in rated greenness of view (for example, from 0 'not at all' to 1 'a little'), performance increases by almost half of a standard deviation, $\beta = 0.417$. Greenness of view explains roughly one-seventh of the variance in impulse inhibition scores, $R^2 = 0.143$.

Combined self-discipline measure. To further test the relationship between near-home nature and girls' self-discipline, we created a single index combining scores on the three forms of self-discipline. Do girls

with greener views perform better, overall, on these three forms of self-discipline? Yes. As Figure 5 shows, view from home strongly and positively predicts girls' scores on this combined measure, $F(1, 76) = 19.4$, $p < 0.0001$. On average, the greener a girl's view from home, the better she scores overall on different forms of self-discipline; for each point difference in greenness of view, scores increase by roughly a quarter of a standard deviation, $\beta = 0.274$. Greenness of view explains roughly one-fifth of the variance in self-discipline scores, $R^2 = 0.203$.

Near-home nature and self-discipline in boys

Table 2 summarizes the findings for the relationship between near-home nature and self-discipline by

gender. As a comparison between the left and right halves of the table shows, the findings for boys stand in startling contrast to the findings for girls. Whereas girls show consistent and often strong links between near-home nature and various forms of self-discipline, boys show only the barest hint of such a link. Beta coefficients for boys hover around zero for concentration, delay of gratification, and the combined self-discipline measure. For impulse inhibition, boys' scores show a slight tendency to increase with naturalness of the view from home, $\beta = 0.116$, but this relationship is not significant, $p = 0.13$.

Age, near-home nature, and self-discipline

To address the potential role of age in this study, we conducted 2×2 factorial ANOVAs (age \times nature) for concentration, impulse inhibition, and delay of gratification. Girls' scores and boys' scores were analysed separately. Findings for girls showed, not surprisingly, a main effect for nature view for each of the three forms of self-discipline. Girls' concentration showed a main effect of nature view, $F(1, 74) = 17.3$, $p < 0.0001$, as did girls' impulse inhibition, $F(1, 74) = 4.9$, $p < 0.05$ and girls' delay of gratification, $F(1, 74) = 8.6$, $p < 0.01$. There was no significant main effect for age, nor was there a significant interaction between age and nature for any of the three forms of self-discipline.

Findings for boys showed, again, no main effect for nature view for any of the three forms of self-discipline. There was a hint of a main effect of age on concentration, $F(1, 74) = 2.8$, $p = 0.10$, but there were no other significant effects for age on other forms of self-discipline, and no significant interactions between age and nature for any of the measures.

These results indicate that the basic findings of the study do not change when age is taken into account: for girls, near-home nature is consistently linked to self-discipline; for boys, near-home nature is not linked to self-discipline.

Discussion

This study tested for possible links between near-home nature and children's self-discipline, more specifically their capacities for concentration, impulse inhibition, and delay of gratification. Because preliminary analyses indicated gender differences — and, more importantly, interactions between gender and nature — for each of these three forms of self-discipline, we examined the relationship between nature and self-discipline separately for girls and boys.

For girls, views of near-home nature were systematically related to each of these three forms of self-discipline. Girls' performance on each of the following measures was significantly and positively related to nature: a summary measure of concentration (based on Symbol Digit Modalities, Alphabet Backwards, Necker Cube Pattern Control, and Digit Span Backwards); a summary measure of impulse inhibition (based on Matching Familiar Figures, Stroop Color-Word Test, and Category Matching); Mischel's delay of gratification measure; and an index combining the three forms of self-discipline. Differences in girls' near-home nature explained 20% of the variance in overall self-discipline scores.

Findings for boys stood in striking contrast to those for girls. Whereas girls showed significant, positive relationships between near-home nature and each of the outcome measures, boys showed no significant relationships between near-home nature and any of the outcomes. What might account for these gender differences?

One possibility seems promising at first, but becomes less plausible on further inspection — that nature restores directed attention in girls but not boys. First, there is no a priori theoretical reason to expect these effects to be limited to girls. Attention Restoration Theory (Kaplan & Kaplan, 1989; Kaplan, 1995) would suggest that nature supports directed attention in any individual with an intact attentional system. And consistent with this, the empirical work with adults suggests that the

TABLE 2
OLS regression summaries for naturalness of apartment view on measures of self-discipline for girls and boys.

	Girls (78)				Boys (91)			
	R^2	beta	F	p	R^2	beta	F	p
Concentrating	0.13	0.23	10.9	0.001	0.01	0.07	1.2	ns
Inhibiting impulses	0.05	0.17	3.8	0.05	0.01	0.12	2.3	0.13
Delay of gratification	0.14	0.42	12.7	<0.001	0.00	-0.03	0.6	ns
Self discipline	0.20	0.27	19.4	<0.0001	0.01	0.05	0.7	ns

nature-directed attention relationship is true for both males and females (Canin, 1991; Cimprich, 1990; Hartig *et al.*, 1991; Lohr *et al.*, 1996; Miles *et al.*, 1998; Ovitt, 1996; Tennessen & Cimprich, 1995). It is difficult to imagine why nature would affect directed attention in women, men, and girls, but not boys.

Another possible explanation for the lack of relationship between near-home nature and self-discipline in boys seems more promising. That is, perhaps boys are affected by contact with nature in just the way that girls are, but boys have relatively less contact than girls with the nature immediately outside their homes. Studies that have geographically mapped children's play have found that boys typically play farther from home than girls (Hart, 1979; Sobel, 1993); for reviews see Moore & Young, (1978), Wohlwill and Heft (1987). Perhaps boys are unaffected by near-home nature simply because they spend time elsewhere. Consistent with this, findings from a previous study indicated that boys' attentional functioning was not related to the level of nature immediately around their home, but was related to the level of nature in their usual play space (Faber Taylor *et al.*, 2001). Future research should examine the relationship between levels of nature in boys' most typical play spaces and their self-discipline.

The findings in boys notwithstanding, the overall pattern of findings in this study strongly suggests a link between near-home nature and concentration, impulse inhibition, and delay of gratification in girls.

Alternative interpretations

To what extent do the links between near-home nature and these forms of self-discipline reflect a causal relationship between nature and self-discipline? While definitively showing a cause and effect relationship requires a true experimental design, we can begin to address some possible alternative interpretations here.

One possible alternative interpretation for the current findings might be that self-discipline is linked to near-home nature, but not because nature enhances self-discipline. That is, perhaps some form of self-selection is operating: perhaps more effective, more self-disciplined parents find ways to be assigned to greener apartments, or they find ways to create greener surroundings, or the Chicago Housing Authority assigns 'better' prospective tenants to greener buildings. Chicago Housing Authority policies work against each of these possibilities. Apart-

ment assignment policies result in de facto random assignment of residents with respect to levels of nearby nature at RTH. Furthermore, on-going landscape maintenance at RTH is handled by a small landscaping crew; residents are not involved in maintenance and funds are inadequate to fulfill special requests from residents. Thus it seems unlikely that any of these forms of self-selection are taking place. Moreover, it is not clear why, if 'better' parents self-select into, or create, or are assigned to greener apartments, their superior qualities would be reflected only in their daughters.

Another possible interpretation might be that more self-disciplined children actually have the same levels of near-home nature as their less self-disciplined counterparts, and the link between self-discipline and high greenness ratings is an artifact. For example, perhaps more self-disciplined, more effective parents tend to have better lives and be in more positive moods than their less effective counterparts, and these positive moods lead them to be more agreeable, thus leading them to endorse items more highly – including their greenness ratings. Consistent with this, previous research has found links between mood and suggestibility (Tata & Gudjonsson, 1990). However, two considerations render this possibility implausible. First, the measure of naturalness of view in this study was composed of two items, one of which was reverse-scored. To the extent that positive moods induced residents of greener buildings to endorse all items more highly, the inflation in the reverse-scored item should balance the inflation of the positively scored item. And second, again, it is not clear how this explanation could account for the mothers of girls, but not boys, giving higher greenness ratings.

A third possible alternative interpretation might involve some form of experimenter demand. Might the interviewers have somehow influenced mothers with high-performing children to give greener ratings? Alternatively, might they have influenced children from greener buildings to score higher? Although these possibilities cannot be ruled out entirely, neither seems likely. The test administrators did not know the hypothesis of the study and thus would not know which mothers or children to influence, or in what direction to influence them. And yet again, it is not clear how this interpretation could account for the lack of relationship between nature and self-discipline for boys.

In sum, the links between nature and self-discipline found here do not appear to be simple artifacts of self-selection, systematic biases in assignment of participants to conditions, mood-

elevated nature ratings, or experimenter demand. Nonetheless, a causal relationship between nature and enhanced self-discipline — even for girls — remains to be substantiated.

Contributions to the literature

By documenting a systematic, positive link between near-home nature and three forms of self-discipline in girls, this work contributes to the research on the benefits of nature in three ways.

First, the results underscore the potential importance of views of nature. Previous research has shown that a variety of positive outcomes are associated with views of nature in adults in a variety of settings. In residential settings, views of nature have been linked to residential satisfaction, enhanced well-being, more effective patterns of coping, and greater day-to-day effectiveness (Kaplan, 1985, 2001; Kuo, 2001; Tennessen & Cimprich, 1995) respectively. In workplaces, views of nature have been linked to job satisfaction and well-being (Kaplan, 1993); in prisons, to decreased demand for health care services (Moore, 1981); and in hospitals, to faster recovery from surgery (Ulrich, 1984). The findings here add to a growing body of evidence suggesting that views of nature are no mere amenity.

Second, this work contributes to our understanding of the benefits of nature for children. Specifically, the findings from this study combine with the findings from a previous study to suggest that attentional restoration may be an important and universal benefit of nature for children. The current study links nature and superior attentional functioning in a sample of extremely low-income, attentionally normal African American children. The previous study linked nature and better attentional functioning in a primarily middle and upper-income, predominantly European American sample of children with Attention Deficit Disorder (Faber Taylor *et al.*, 2001). Together, the two sets of findings suggest the possibility of a nature-attention link that generalizes across socioeconomic status, race, and attentional status, as well as different levels of residential greenness — from the most barren of public housing grounds to the lushest of backyards in wealthy neighborhoods.

Perhaps the most important contribution of this work is to identify two new benefits of nature. Previous research on a nature-directed attention relationship has focused primarily on cognitive outcomes, especially the capacity to pay attention or concentrate. Although previous findings linking nature and reduced aggression are certainly consis-

tent with the hypothesis that nature enhances self-discipline (Kuo & Sullivan, 2001b), to our knowledge, this is the first study to systematically document a link between nature and less cognitive forms of self-discipline, specifically impulse inhibition and delay of gratification. Failure to inhibit impulses can have both immediate consequences and important long-term implications for an individual; similarly, a pattern of failure in the delay of gratification may substantially alter the course of an individual's life and their chances of success in a variety of domains. For example, previous research has indicated that children's ability to delay gratification predicts their academic achievement, social competency, and ability to cope with frustration and stress in adolescence (Mischel *et al.*, 1988). If near-home nature can provide a daily, easily accessible means of supporting impulse inhibition and delay of gratification in a setting where individuals are likely to be chronically mentally fatigued (Kuo, 1992), the implications for individuals, families, and society may be enormous.

This study underscores the potential importance of views of nature, extends previous research on attentional restoration in children to a very different population and setting, and introduces two potential new benefits of nature: enhanced impulse inhibition and delay of gratification. The findings have a number of implications for practice.

Implications for practice

These findings help reinforce the importance of incorporating trees and grass in spaces for children. One implication of this research concerns the design of public housing developments. As a large proportion of urban public housing residents are children (in Chicago family housing in 1995, for example, roughly 60% of residents were 19 years old or younger; roughly 50% were 14 or younger, CHA, 1995), these findings argue for the potential importance of incorporating trees and grass around public housing apartment buildings. Moreover, these findings suggest that designers of public housing should consider more than just ground-level views of common spaces when placing trees and grass; it may be helpful to place trees and grass strategically within view from the surrounding apartments. Along the same lines, the findings here suggest that, in suburban areas and on the urban-rural fringe, the practice of constructing treeless residential developments may have important unintended costs. Previous work has suggested that the urban forest may be a vital part of children's

living environments (Faber Taylor *et al.*, 2001; Faber Taylor *et al.*, 1998); the work here reinforces that notion.

Another implication of this research concerns the design of schoolyards. These findings raise the possibility that incorporating trees and grass in schoolyards could play an important role in the classroom. Perhaps after spending breaks in green schoolyards, children return to their classrooms better prepared to pay attention, to suppress disruptive impulses, and to wait patiently for future breaks. Again, strategic placement may be important here. It may be that an occasional long glance out a classroom window helps support a child's capacity for self-discipline throughout the school day. Perhaps greater benefits from a given investment in landscaping can be obtained by placing vegetation to maximize views of trees and grass through classroom windows.

We close by noting the implications of this study for helping inner city children negotiate the many risks of urban poverty. The findings here suggest that the barrenness of inner city neighborhoods may contribute to lower levels of self-discipline and, potentially, to higher rates of negative outcomes in inner city children. In this study, the greener a girl's view from home, the better her performance on measures of concentration, inhibition of impulses, and delay of gratification. These three forms of self-discipline may play key roles in the likelihood of such negative outcomes as academic underachievement, juvenile delinquency, and teenage pregnancy. Perhaps when housing managers and city officials decide to cut budgets for landscaping in inner city areas, they deprive children of more than just an attractive view. Neglecting landscaping may deprive inner city children of a much needed resource for self-discipline – for the psychological capacities that lead to a brighter future.

Notes

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¹'Inhibiting initial impulses' has also been labeled 'inhibiting prepotent responses' (Logan *et al.*, 1997).

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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,

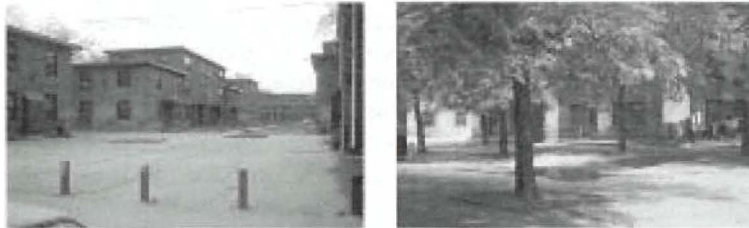


Figure 1: Ground Level View at Ida B. Wells Showing Apartment Buildings With Varying Amounts of Tree and Grass Cover

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

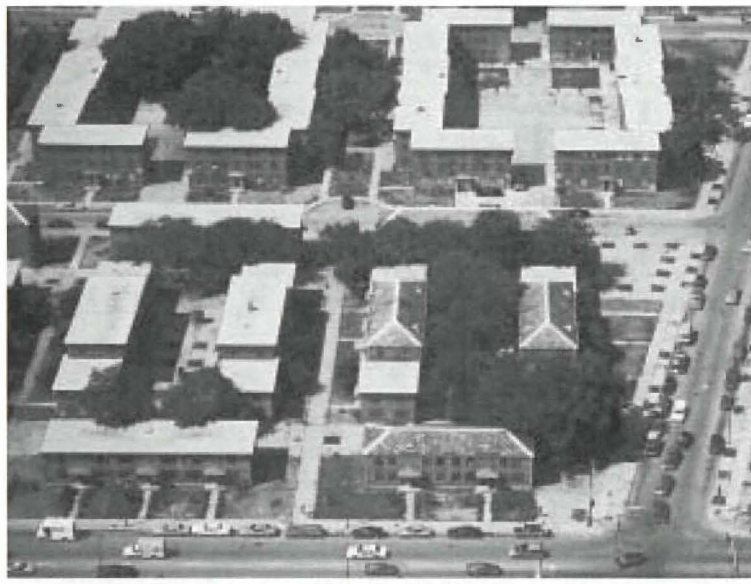


Figure 2: Aerial View of a Portion of Ida B. Wells Showing Buildings With Varying Amounts of Tree and Grass Cover

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

<i>Predictor</i>	<i>Total Crimes</i>			<i>Property Crimes</i>			<i>Violent Crimes</i>		
	<i>R²</i>	<i>β</i>	<i>p Value</i>	<i>R²</i>	<i>β</i>	<i>p Value</i>	<i>R²</i>	<i>β</i>	<i>p Value</i>
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

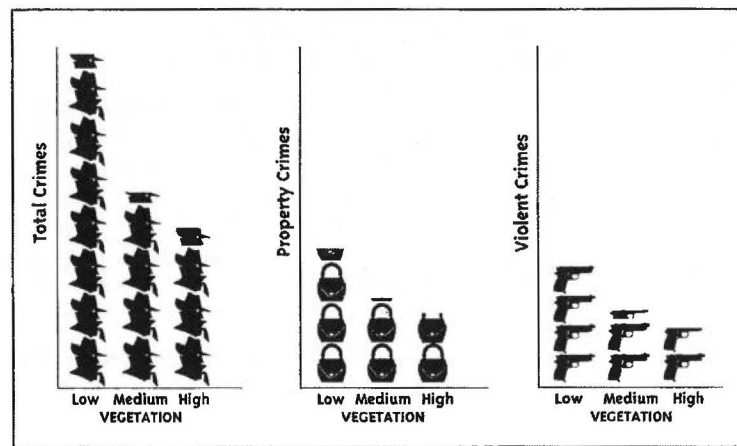


Figure 3: Mean Number of Crimes Reported Per Building for Apartment Buildings With Different Amounts of Vegetation (each icon represents one reported crime)

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

Predictors	Total Crime		Property Crimes		Violent Crimes	
	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

<i>Predictors</i>	<i>Total Crime</i>		<i>Property Crimes</i>		<i>Violent Crimes</i>	
	β	<i>p Value</i>	β	<i>p Value</i>	β	<i>p Value</i>
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	<i>ns</i>	-0.13	<i>ns</i>	0.18	<i>ns</i>

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^2 's 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 (C_p) analysis yielded additional evidence of the predictive power of vegetation. C_p 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, C_p analysis tests all possible combinations of predictors and selects the best model. An alternative to comparing adjusted R^2 's, C_p analysis is particularly helpful when there is multicollinearity between predictors, as was the case here. C_p 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 ($C_p = 1.32$). 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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