HIGH SCHOOL LANDSCAPES
AND
STUDENT PERFORMANCE

by

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I wish to dedicate this dissertation to the memories
of my father, mother, and stepmother.

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Abstract

High school students today are experiencing unprecedented levels of school related stress. At the same time, a growing body of research has linked views of and access to natural features with stress reduction and restoration from mental fatigue. How important are such views and access to students while they are at school? This study investigated 101 public high schools in southeastern Michigan to examine the role played by the availability of nearby natural environments in the academic achievement and behavior of high school students. All analyses controlled for student socio-economic status, racial/ethnic makeup, building age, and size of enrollment. The results reveal that nature exposure beneficially affects student performance. Specifically, views with greater quantities of natural features (e.g., trees, shrubs) from classroom as well as cafeteria windows were associated with higher standardized test scores, graduation rates, and percentages of students planning to attend college, and lower occurrences of criminal behavior. In addition, school policies of allowing students to eat lunch outdoors and to leave campus during lunch were related to enhanced test scores and college plans.

This study also investigated the influences that specific features of the high school and surrounding landscapes can have on students. Greater quantities of viewable natural features near student lunch sites were found to be positively related to test scores, graduation rates, and intentions to attend college. In addition, the results suggest that the trees and shrubs viewed from the lunch sites and classroom windows need to be close to the viewer to be of greater benefit. Finally, large expanses of landscape lacking in natural features had a negative influence on test scores, intentions to attend college, and college plans. Such landscapes included large areas of lawn, parking lots, and bordering farmlands.

Prior research concerning the relationships between school physical environments and student performance has concentrated mainly on indoor characteristics of the school building and kindergarten or elementary school playscapes. This study's results, however, demonstrate that campus landscape features that are primarily looked at rather than more directly experienced can have just as much influence on high school students' academic achievements and behaviors.

Chapter I
Introduction

Teenagers throughout the United States spend a substantial amount of time in high schools. How important are views of nature from high school classrooms and cafeterias and access to nature during the school day to student performance? Surprisingly, there appears to be little information to answer this question.

In other contexts, research has shown the important role played by views of and access to nearby nature. These studies have linked such views and access with a wide variety of beneficial effects, including greater work productivity and mental functioning, improved health and sense of well-being, and enhancements in social interactions and socially acceptable behaviors. In light of this evidence it would seem reasonable to expect that contact with landscape features and more natural sites, including trees, shrubs, lawns, and woodlands should enhance student performance in terms of both scholastic achievement and behavior.

This chapter provides a brief introduction to the problem and an overview of the study. A more extensive review of the literature with respect to the role played by nearby nature and the issues that have been studied in the school context are provided in the next chapter.

Study Background

The physical environment of schools has received attention with respect to student performance. Most of these studies, however, have concentrated on the indoor

characteristics of school buildings and classrooms. For example, research has addressed indoor features including lighting, noise, indoor air quality and temperature, building age, and the maintenance of indoor facilities (Earthman & Lemasters, 1996; Evans, 2006; Weinstein, 1979; Woolner, Hall, Higgins, McCaughey, & Wall, 2007). The role played by natural features of the outdoor campus environment has been examined in a handful of studies, but most of these have looked at how more natural playscapes positively influence the development of elementary school students (Herrington & Studtmann, 1998; Neville, 1994; Owens, 1997). Of the two studies that have investigated the effects of viewing natural landscape features from campus building windows, one focuses on dormitories at a university (Tennessen & Cimprich, 1995), while the other took place at elementary schools (Heschong Mahone Group, 2003a). Results of both of these studies show that greater levels of vegetation in the views are linked with better student academic achievement and mental functioning. Neither study, however, examined the specific composition of the natural features contributing to the outcomes, nor was the distance to the natural elements considered, leaving many questions unanswered. For example, are views of trees, shrubs, and lawn equivalent in the benefits they provide? Are the effects of the view affected by how distant the natural environment is? Answers to questions such as these could be useful in designing high school campuses.

Study Overview

The purposes of this study are both to gain an understanding of the role played by views of nearby nature with respect to high school students' performance, and to look more specifically at the effects that certain natural features of high school landscapes can have. This investigation into student potential exposure to nature consisted of two parts. First, the landscape features that exist on each campus and in the surrounding neighborhood were inventoried. Tree density, areas of shrubs and lawns, the sizes of parking lots and athletics fields, and the presence of more natural landscapes bordering each campus are among the landscape elements that were assessed. Second, student potential access to these landscape features was investigated. This access was measured by calculating the window areas of classrooms and school cafeterias, analyzing the sites

provided for students to eat lunch in, and inspecting school policies associated with student contact with the outdoor environment.

The influences of both student exposure and access to nature were assessed with respect to student performance. These performance variables were examined at the school level, relying on publicly available information about students' scholastic achievement as well as their conduct. To the extent that access to nearby nature is beneficial for this age group, one would expect nature availability to be reflected in higher achievement and reduced misbehavior.

High schools were chosen for this study rather than elementary and middle schools for a variety of reasons. They tend to be larger in scale, thus incorporating a greater variety of landscape features and layouts. In addition, most of the prior research concerning the outdoor physical environments of schools has involved elementary schools. The findings of this study will provide information about a much less researched student age group and campus environment. Furthermore, given that high school dropout rates are substantial in so many American cities and satisfaction with the high school experience is quite low (Campbell & College, 2003; Freeman, 2004; Thomas, 2008), exploring the potential of the high school landscape as a factor in student performance would seem constructive.

How much influence can we realistically expect the outdoor environment to have on students? Insights into this question can be obtained by analyzing the findings of studies concerned with indoor characteristics of school buildings. For example, researchers have found that students in substandard buildings score 5-10% lower on standardized tests than students in functional buildings. Other studies have found that building conditions could also account for about 3-6% of the variance in test scores in multiple regression analyses (Earthman, 2004; Mayer, Mullens, & Moore, 2000; National Research Council, 2006; Schneider, 2002; Woolner et al., 2007).

Studies have suggested that the influence of the physical environment on students is less than that of other factors such as student socio-economic status and ethnic/racial background, teacher quality, and peer group characteristics (Woolner et al., 2007). Researchers, nevertheless, contend that building characteristics will "reliably affect hundreds or thousands of students over the life of the building, typically fifty years. Since the design of classrooms is entirely within the control of the school district, much more so than student or teacher demographics, optimized design of schools should be a central concern for all new school construction" (Heschong Mahone Group, 2003a, p. xi).

Following this same logic, campus landscapes will also be experienced by thousands of students during the life of the school building. In fact, elements of the landscape may last longer than the buildings themselves. In addition, the cost to improve landscapes is usually much less than that to renovate buildings. If an increase comparable to the 5-10% improvement in student performance due to better buildings can also be demonstrated for better landscapes, improving the latter may indeed be worth consideration by school administrators.

Chapter II
Physical Environments and Student Performance

This chapter opens with a review of the benefits that contact with nature can provide for people. The emphasis in examining this literature is on the benefits provided by viewing rather than more directly interacting with nature (e.g., gardening, camping, climbing trees). During the course of a typical school day, a view is the only type of nature contact that most high school students will likely experience. The second section of the chapter examines school related stresses and anxieties that many high school students are currently experiencing. In light of these negative situations, contact with nature may be of great importance for today's high school students. The third section of the chapter reviews work on student background and social dimensions, as well as school resource factors, to highlight the substantiated important role that these issues play in student performance. In light of their strong impact, the effects of these factors were controlled for in the statistical analyses that were used in this study to explore the relationships between nature contact and student performance. This chapter closes with a discussion of the study's hypotheses which were based on the findings of past research. These hypotheses served as the foundation for the methods used to investigate school landscapes.

Benefits of Contact with Nature

The many benefits that views of and access to natural features in the landscape can have on people has been revealed primarily in contexts other than the school environment. The findings in these nonschool settings are presented first to provide an overview of these positive effects. Studies have been conducted in places where people work and reside, as well as where individuals are hospitalized and imprisoned. Next, the

small number of studies that have taken place at schools are examined. This is followed by a discussion of the nature contact that students may experience while commuting to and from school. Lastly, the explanations proposed by various researchers for the benefits provided by viewing and experiencing nature are looked at.

Nonschool Settings

Within the workplace, researchers have documented that views of nature are associated with increased employee productivity, enhanced feelings of job and life satisfaction, greater psychological and physical well-being, and reduced levels of frustration and stress (Heerwagen & Wise, 1998; Heschong Mahone Group, 2003b; R. Kaplan, 1993; Leather, Pyrgas, Beale, & Lawrence, 1998). Views out of an office or factory window with greater vegetation content and/or size of the view available have been associated with a corresponding increase in many of these benefits for workers (Heschong Mahone Group, 2003b; R. Kaplan, 1993; Leather et al., 1998). Indirect evidence of the importance of views of nature from the workplace for worker productivity and well-being is provided by other research. First, a large body of research has established that the ability to see out of the building is desired by office employees and is an important factor in their working environment (Brill, 1984; Collins, 1975; Manning, 1965; B. W. P. Wells, 1965; Wotton & Barkow, 1983; Young & Berry, 1979). Distant views or views with natural elements (e.g., sky, natural vegetation, water) are preferred to those lacking these features (Ludlow, 1976; Markus, 1967).

Second, workers with a window view are more productive (Collins, 1975; Figueiro, Rea, Stevens, & Rea, 2002; Hedge, 1995; Young & Berry, 1979) and possess greater satisfaction with their jobs and physical working conditions (e.g., visual appearance, lighting, temperature, comfort) (Brill, 1984; Cuttle, 1983; Farrenkopf & Roth, 1980; Finnegan & Solomon, 1981; Hedge, 1995; B. W. P. Wells, 1965; Wyon & Nilsson, 1980) than their windowless counterparts. Increased sense of well-being has also been reported for employees who have a window view (Collins, 1975; Cuttle, 1983; Hedge, 1995; Ludlow, 1976; Young & Berry, 1979).

Third, studies have revealed that office workers favor daylight as the primary source of illumination (Cuttle, 1983; Heerwagen & Heerwagen, 1986; Langdon, 1966; Manning, 1967; Markus, 1967; Veitch & Gifford, 1996; B. W. P. Wells, 1965). Furthermore, daylight has positive impacts on work attitudes and experiences (Heerwagen & Heerwagen, 1986; Heerwagen & Wise, 1998) as well as feelings of relaxation (Boubekri, Hull, & Boyer, 1991). Nonetheless, Ne'eman (1974) found that workers prefer a pleasant view (e.g., nice park) through their windows more than indoor sunshine.

Fourth, employees occupying windowless offices were found to have more pictures of natural scenes on their walls than occupants of windowed spaces, possibly as a way of compensating for the lack of real natural scenes (Heerwagen & Orians, 1986; Sommer, 1974).

In the residential context, studies have revealed that views of and exposure to nearby natural features can increase resident's cognitive abilities (Kuo, 2001; Taylor, Kuo, & Sullivan, 2002; Tennessen & Cimprich, 1995; N. M. Wells, 2000), sense of well-being (R. Kaplan, 2001), and satisfaction with their neighborhood and residences (R. Kaplan, 2001; Kearney, 2006; Talbot & Kaplan, 1991). In addition, Wells and Evans (2003) report that exposure to nearby nature buffer the impact of life stress on children. Among residents of an inner-city public housing complex, higher levels of nearby vegetation (e.g., trees, grass) have been associated with greater social interaction, and a reduction in aggression, violent behaviors, and crime (Coley, Kuo, & Sullivan, 1997; Kuo & Sullivan, 2001a, 2001b; Kuo, Sullivan, Coley, & Brunson, 1998).

Within diverse settings, views of nature through a window or in a painting have been associated with benefits to physical health. These benefits include a reduction in health care needs by prison inmates (Moore, 1981), shorter postoperative hospital stays (Ulrich, 1984), and a decrease in pain experienced both during a medical procedure and after surgery (Diette, Lechtzin, Haponik, Devrotes, & Rubin, 2003; Ulrich, Lundén, & Eltinge, 1993).

In summary, a growing body of research results suggests that views of and experiences with nearby nature may provide many social, psychological, and physical health benefits. Although most of these studies have taken place in workplace, residential, and hospital settings, one might reasonably expect the benefits to also apply in other settings, particularly in schools.

School Settings

Research concerning the physical environment of schools has focused primarily on building features and interior spaces. Only a handful of studies have directly investigated how features of the natural environment in the campus landscape can influence student behavior. "The periodical review suggests [that there has been] limited interest in improvements to the design of exterior spaces at high schools" (Owens, 1997, p. 158). Alternative outdoor settings have received some empirical attention, but these studies have examined playgrounds in preschool, kindergarten, and elementary school. In these contexts natural playscapes have been found to benefit children's creative play and social, emotional, cognitive, and motor development (Fjørtoft, 2004; Fjørtoft & Sageie, 2000; Herrington & Lesmeister, 2006; Kirkby, 1989; Lindholm, 1995). The number of even these studies, though, is small (Herrington & Studtmann, 1998; Neville, 1994).

Heschong Mahone Group (2003a) conducted the only previous study that looked at the effects of classroom window views on student performance. They examined the attributes of 500 elementary school classrooms in thirty-six schools. Ample views (i.e., 100 sq ft of window area or greater per classroom) that included vegetation (i.e., primarily trees or bushes) or human activity (e.g., playground, lunch area, parking lot), and objects in the far distance were found to be associated with higher scores on standardized tests.

While I did not find any research that examines nature contact in the high school context, the Tennessen and Cimprich (1995) study offers confirmation of the benefits of nature views in a school setting. Their investigation of the effects of view content from

dormitory windows on college students showed that more natural views were associated with better mental concentration abilities.

Other than these two studies, there has been very little investigation concerning how views of nature from school campus buildings might affect student performance. While not considering the contents of the views, some studies have examined the related topics of the effects of windowed versus windowless classrooms (Cooper & Ivey, 1964; Demos, Davis, & Zuwaylif, 1967; Douglas & Gifford, 2001; Heschong, Wright, & Okura, 2002; Larson, 1965) and daylighting (Heschong et al., 2002; Heschong Mahone Group, 1999; Küller & Lindsten, 1992; Nicklas & Bailey, 1997). The results of investigations into the effects of windowless classrooms and daylighting on student scholastic achievement, behavior, mental health, and attitudes towards school have been conflicting (Collins, 1975; Edwards & Torcellini, 2002; National Research Council, 2006; Weinstein, 1979). Benefits of windowless classrooms reported by students and teachers include freedom from outside noise and distractions, more wall space for bulletin boards and bookcases, and more even lighting and thermal levels. Advantages of windowed classrooms include the provisions of a view, natural lighting, and knowledge about the weather, and student self-reports of greater productivity and less stress. In her review of the research, Weinstein (1979) concluded that "evidence supports neither the claim that windowless classrooms will allow increased concentration, leading to higher achievement, nor the fear that the absence of windows will have harmful psychological and physical effects" (p. 592). Similarly, Collins (1975, p. 18) assessed that "some students like the situation [windowlessness], others, possibly a majority, would prefer to have windows. The most striking conclusion seems to be the absence of significant findings, either pro or con."

Concerning daylighting, some researchers claim that students in daylit classrooms demonstrate enhanced scholastic achievement, better sociability, higher concentration levels, and lower sick leave rates as compared to students in windowless classrooms (Heschong et al., 2002; Heschong Mahone Group, 1999; Küller & Lindsten, 1992; Nicklas & Bailey, 1997). However, other researchers contend that some of these studies

suffer from methodological flaws or are statistically unreliable (Boyce, 2004; Evans, 2006). Reviewers of daylight research have concluded that "because of inconsistent results and the small number of well-designed studies, there is insufficient evidence at this time to determine whether or not an association exists between daylighting and student performance" (National Research Council, 2006, p. 40).

Nature Exposure while Commuting to School

Studies indicate that viewing and experiencing more natural environments promote feelings of general well-being, and reduction and recovery from stress and mental fatigue (Berto, 2005; Cimprich & Ronis, 2003; Hartig, Evans, Jamner, Davis, & Gärling, 2003; Hartig, Mang, & Evans, 1991; Herzog, Black, Fountaine, & Knotts, 1997; R. Kaplan & Kaplan, 1989; S. Kaplan, 1995; Parsons, Tassinary, Ulrich, Hebl, & Grossman-Alexander, 1998; Ulrich, 1981; Ulrich et al., 1991). The percentage of quality green space (e.g., urban green space, agricultural space, natural green space) in residential environments has also been found to have a positive association with the perceived general health of residents. This relation is stronger for residents with lower socio-economic status as compared with people of high socio-economic status, for the elderly and youth than adults, and for housewives (De Vries, Verheij, Groenewegen, & Spreeuwenberg, 2003; Maas, Verheij, Groenewegen, De Vries, & Spreeuwenberg, 2007; Mitchell & Popham, 2007). While these studies have not specifically addressed the teen years, it is reasonable to expect that the findings would apply to this age group as well. High school students experience different levels of nature in their neighborhoods during their daily commute to school, while they walk, cycle, drive, or ride in a car or bus.

Explanations for these Nature Benefits

Researchers have advanced varied explanations for why contact with nature results in improvements to work performance, mental functioning, health, general well-being, social interactions, child behaviors, and residential satisfaction. Two of the most widely cited explanations are the attention restoration theory and the psycho-evolutionary theory. In addition, preference for natural features may play a role in enhancing student performance and satisfaction with the school physical surroundings.

Attention restoration theory proposes that contact with nature has the potential to restore the directed attention capabilities of the brain (R. Kaplan & Kaplan, 1989; S. Kaplan, 1995). Directed attention fatigue, or mental fatigue, occurs when the capacity to focus or concentrate is reduced by overuse. This fatigue can be the result of a stress response, can lead to a stress response, or then again can occur simultaneously with stress. An individual experiencing such fatigue not only may have a decreased ability to concentrate, but also may become more irritable, distractible, impulsive, antisocial, and accident prone. The theory contends that recovery from directed attention fatigue is a prerequisite for an individual to be able to function effectively. A decrease in mental fatigue has been proposed as an explanation for increases in test scores (Heschong Mahone Group, 2003a) and cognitive functioning (Kuo, 2001; Taylor et al., 2002; Tennessen & Cimprich, 1995; N. M. Wells, 2000), satisfaction with work and residential settings (R. Kaplan, 1993, 2001), senses of well-being of both adults (R. Kaplan, 1993, 2001; Leather et al., 1998) and children (N. M. Wells & Evans, 2003), and social interactions and socially acceptable behaviors (Coley et al., 1997; Kuo & Sullivan, 2001a, 2001b).

In addition to sleep, recovery from directed attention fatigue can take place within environments that support mental restoration. As proposed by the attention restoration theory, such settings possess the characteristics of fascination, a sense of being away, extent, and compatibility (S. Kaplan, 1995). Fascination is an alternative form of attention that does not require effort and allows directed attention to rest. Many forms of fascination exist and are derived from a variety of sources. One important characteristic of fascination involves the continuum from "soft" to "hard." Soft fascination occurs, for example, when an individual is viewing natural features or strolling in a natural setting. This type of attention is effortless, permits an individual to rest his or her directed attention, and allows one to think about other things and reflect on unresolved issues. Hard fascination takes place, for example, when one is viewing television, attending a basketball game, or watching people at a shopping mall. Similar to soft fascination, hard fascination is effortless and allows directed attention to rest. However, hard fascination fills the mind with alluring distractions and does not allow the individual to think about

and reflect on unresolved issues. In addition, to be softly fascinating setting, a setting must be beautiful and, as a result, pleasurable to the individual experiencing it. This beauty-based pleasure helps one to reflect about confusing, discomforting, fearful, or otherwise painful (i.e., opposite of pleasurable) issues. Thus, a softly fascinating setting is beautiful, promotes the reflection process, and lessens any pain that may be involved (S. Kaplan, 1993). The ability to reflect is a key provision of mentally restorative environments.

A sense of being away allows an individual to escape from a mental activity involving the fatiguing use of directed attention. Extent requires that the restorative experience has enough scope "to engage the mind" and "be rich enough and coherent enough so that it constitutes a whole other world" (S. Kaplan, 1995, p. 173). Finally, attention restoration theory hypothesizes that the environment must be compatible with an individual's goal of being mentally restored. Compatibility involves a match between one's inclinations or purposes and the demands of the environment. In other words, a particular surrounding needs to "fit what one is trying to do and what one would like to do" (S. Kaplan, 1995, p. 173).

The psycho-evolutionary theory postulates that immediate, subconscious emotional responses play a key role in an individual's initial reaction to the environment. This initial reaction is affective, innate, cross-cultural, and mostly automatic without extensive cognition and information processing. The visual properties of the environment influence this response. These properties involve gross structural components, gross depth properties, and general classes of environmental content (e.g., vegetation, water). The emotional response influences psychophysiological arousal, cognition, and motivation and is central to subsequent thoughts, memory, meaning, and adaptive behavior or functioning. Depending on the characteristics of the environment and an individual's affective, cognitive, physiological state immediately before the encounter, adaptive responses can range from stress and avoidance behaviors to restoration and approach behaviors (Ulrich, 1983; Ulrich et al., 1991).

Psycho-evolutionary theory posits that natural settings, unlike urban sites, have a calming and restorative effect on an individual. Nature provides a visually pleasant physical surrounding that reduces stress by producing positive emotions, sustaining nontaxing attention, and restricting negative thoughts. Neurophysiological arousal is returned to more moderate levels, fostering an overall sense of well-being (Hartig et al., 1991; Ulrich et al., 1991).

In summary, attention restoration and the psycho-evolutionary theories attribute the restorative effects of contact with nature to different processes. Nevertheless, both theories support the idea that nature functions well as a restorative environment (Hartig et al., 2003).

Lastly, preference for natural elements in the landscape may be a factor in the restorative quality of and levels of satisfaction with these environments. Both of these factors, in turn, have been linked with enhanced student performance. First, a large body of past research outside the context of schools has consistently revealed that outdoor environments with higher levels of nature present are more preferred than those dominated by built features (Anderson & Schroeder, 1983; Brush & Palmer, 1979; Herzog, Kaplan, & Kaplan, 1982; R. Kaplan, 1985; R. Kaplan & Kaplan, 1989; Nasar, 1987; Thayer & Atwood, 1978; Ulrich, 1983). One can argue that if a student prefers a certain environment, he or she is likely to spend more time in or viewing that environment. This may result in a student spending more time in an environment that has also been found to be more mentally restorative and stress reducing. In addition, preliminary investigations have been conducted on the direct relationships between restoration and preference. Some researchers contend that surroundings with high nature content are preferred partly because of their restorative value (Staats, Kieviet, & Hartig, 2003; Van den Berg, Koole, & Van der Wulp, 2003). However, the bulk of these findings are based on perceived levels of fatigue and restoration. Additional studies are needed to demonstrate that these perceived levels are correlated with actual ones.

Second, views of more preferred landscapes in the context of residential neighborhoods have been associated with higher levels of satisfaction with these surroundings and greater feelings of overall well-being (R. Kaplan, 2001; Kearney, 2006). One can argue that views from school buildings with higher levels of nature content may similarly lead to greater senses of satisfaction with the school environment and overall well-being. In addition, student psychological well-being and satisfaction with the learning environment have been positively associated with greater levels of student performance and productivity (Chambel & Curral, 2005; Chow, 2007; S. J. Cotton, Dollard, & De Jonge, 2002).

In conclusion, the direct associations between preference and the restorative qualities of a given environment are still being explored. Nevertheless, greater preference for an environment that has high nature content may indirectly affect student performance by encouraging students to spend more time in a setting that can also be restorative, and by increasing students' satisfaction with school and feelings of overall well-being.

High School Stress

High school students have a great need for restorative and stress reducing environments, and this need may be growing. Research dealing with life events and stress has cited school related issues as not only a major contributor to adolescent stress (Burnett & Fanshawe, 1997; De Anda et al., 2000; Elias, 1989; Jones & Hattie, 1991; Stuart, 2006), but also the leading source of stress for this age group (Ainslie, Shafer, & Reynolds, 1996; Armacost, 1989; Kaiser Family Foundation, 2005; Stuart, 2006). A recent nationwide survey revealed that 63% of teenagers, between fourteen and eighteen years of age, feel that school is the greatest cause of stress, and that 27% of teenagers frequently experience stress in their daily lives (Kaiser Family Foundation, 2005). Stress has been linked with increases in mood disorders among teenage students, such as aggression, anxiety, anger, and resignation, bullying, classroom disruptions, unexcused absences, and other disorderly student behaviors (Barnes, Bauza, & Treiber, 2003;

Hampel, 2007; Hampel & Petermann, 2005; Moulds, 2003; Natvig, Albrektsen, & Qvarnstrøm, 2001). A stressful school environment can also lead to decreases in student attendance, grades, satisfaction with school, and overall sense of psychological well-being (Chambel & Curral, 2005; Chow, 2007; S. J. Cotton et al., 2002; Leonard, Bourke, & Schofield, 2000; Needham, Crosnoe, & Muller, 2004). Studies have discovered, though, that the deleterious effects of stress on scholastic performance can be reduced by enhancing student satisfaction with academic life. Some of the ways that such satisfaction can be promoted involve reducing academic demands, and increasing peer support and student control over their academic work (Chambel & Curral, 2005; S. J. Cotton et al., 2002).

Researchers, counselors, and parents feel that there is more stress in high school students' lives today than ever before. Students state that the primary causes are schoolwork and the college application process (Aratani, 2007; Mundy, 2005; Sexton, 2005). Research findings substantiate many of these beliefs. First, high schools and parents have of late been encouraging students to undertake increasingly demanding course work and to participate in additional extracurricular activities (College Admission Info, 2007; Ginsburg, 2007). In 2005, high school graduates earned approximately three credits more than those in 1990, which represents about 360 additional hours of instruction during their high school careers (U.S. Department of Education, 2005). Second, the college admission process has become more competitive in recent years due to record numbers of applicants. This growth in applicants is largely due to the children of Baby Boomers reaching college age. The number of high school graduates has increased every year since 1996 and is not expected to peak until the year 2009 (College Admission Info, 2007; Ginsburg, 2007; E. W. Green, 2006). Finally, indirect evidence of the increasingly stressful nature of the school environment is provided by the sharply dropping percentage of high school seniors reporting positive feelings toward school. In 1980, 46.1% of seniors reported that they liked high school either very much or quite a lot. In 2001, only 29.5% reported these same beliefs. The proportion of seniors feeling that the schoolwork assigned to them is meaningful and important has also decreased.

The percentage has dropped from 42.2% to 28.8% during this same time period (Freeman, 2004).

In summary, studies have revealed that the leading sources of stress for today's high school students involve school related issues, and that these students may be experiencing increased levels of anxiety. A reduction in stress and an increase in the level of student satisfaction with school should lead to happier, and better performing and behaving students.

School Factors that Affect Student Performance

Most studies analyzing the influence of school factors on high school student performance have looked at issues other than those involving a school's physical environment. Factors found that have the most effect on student performance include the following:

- Student socio-economic status and family background
- School size
- Class size
- Teacher quality
- Peer group effect

Student socio-economic status – Studies have concluded that student socio-economic status and family background are among the strongest predictors of student performance including scholastic achievement (Coleman et al., 1966; Hanushek, 1997; Hedges, Laine, & Greenwald, 1994; Rouse & Barrow, 2006; Sirin, 2005), graduation rates (Fowler & Walberg, 1991; Rouse & Barrow, 2006; Rumberger & Palardy, 2005), and school disorder or student misbehavior (Gottfredson, Gottfredson, Payne, & Gottfredson, 2005; Welsh, 2001). Some researchers contend that school resources and expenditures on students have negligible effects on a student's achievement after family inputs are accounted for (Coleman et al., 1966; Hanushek, 1997). Socio-economic status and family background have been measured by student participation in free or reduced

lunch programs and student ethnicity/race (Blatchford, Bassett, Goldstein, & Martin, 2003; Borman & Kimball, 2005; Bradley & Taylor, 1998; Finn, Gerber, & Boyd-Zaharias, 2005; K. B. Green, Pasternack, & Shore, 1982; Kuziemko, 2006; Lewis, 2000; Nye, Konstantopoulos, & Hedges, 2004; Rivkin, Hanushek, & Kain, 2005). Researchers have noted that the use of the proportion of pupils who are eligible for free school meals as a proxy for student socio-economic and family background is supported by the high correlation of this indicator with neighborhood unemployment rate, and proportions of households which are single parent families or have many children (Bradley & Taylor, 1998; Sirin, 2005).[1]

School size – Most studies agree that smaller schools (i.e., 400-800 total students in a four-year high school) are beneficial for student academic achievement, graduation rates, attendance, social behavior, extracurricular participation, attitudes toward school in general and toward particular school subjects, self-esteem, and sense of belongingness. Smaller schools especially benefit low-socio-economic status and minority students (K. Cotton, 1996; Ready, Lee, & Welner, 2004; Schneider, 2002; Williams, 1990). Grade schools in the United States, nevertheless, continue to grow larger. Despite a 70% increase in the nation's population between 1940 and 1990, the total number of elementary and secondary public schools has declined 69%. High school enrollments of 2,000 to 3,000 students are commonplace in many urban and suburban locations (K. Cotton, 1996; Schneider, 2002).

Class size – The evidence linking class size to student performance is much less conclusive as compared to school size (Ecalle, Magnan, & Gibert, 2006; Pedder, 2006; Schneider, 2002). "There are still too many conflicting results in the literature for any consensus to have been reached regarding whether decreasing class size has any significant effect on achievement" (Lindahl, 2005, p. 375). Research has indicated,

[1] Bradley and Taylor (1998) noted that the correlation coefficients (r) between the proportion of pupils eligible for free meals and the unemployment rate, proportion of households which are single parent families, and proportion of household with four or more children were respectively 0.90, 0.90, and 0.72. Their investigation was based on data obtained from 363 local authority districts in England in 1996.

though, that very small classes (i.e., 8 to 15 pupils) are beneficial for younger students (i.e., kindergarten through third grade), especially those who are economically disadvantaged, have special needs, or are minorities. These benefits include enhanced test scores, reduced class disciplinary problems, improved student self-concept and peer relationships, and increased likelihood that students take either the ACT or SAT college-entrance exam by the end of high school (Egelson, Harman, & Achilles, 1996; Krueger & Whitmore, 2000; Molnar et al., 1999; Nye, Hedges, & Konstantopoulos, 2000).

Teacher quality – Research has revealed that teacher quality has a significant influence on student scholastic achievement. Students learn more from teachers with more than a few years of experience, high academic skills, and proper training in the field in which they teach (Barton, 2003; Borman & Kimball, 2005; Coleman et al., 1966; Mayer et al., 2000; Nye et al., 2004). In addition, teacher quality has been found to vary in consistent patterns. Most importantly, classrooms with higher concentrations of minority, poor, and lower-achieving students are more likely to be taught by teachers of lower quality (Barton, 2003; Coleman et al., 1966; Mayer et al., 2000).

Peer groups – Peer groups have a significant influence on student performance. Students have higher scholastic achievement (Betts, Zau, & Rice, 2003; Chen, 1997; Coleman et al., 1966; Rouse & Barrow, 2006), graduation rates (Battin-Pearson et al., 2000; Chen, 1997), and lowers levels of misbehavior (Welsh, 2001) in those classes and schools with greater concentrations of richer and higher achieving students. Some researchers have concluded that the influence of peer groups on achievement can be greater than that of teacher quality (Lamb & Fullarton, 2002).

Researchers have also looked at the effects of school building and classroom features on student performance, although these are much less studied than the five factors discussed above. Some have noted that "students spend thousands of hours in classrooms, and therefore classrooms automatically are among the most important physical structures in society" (Douglas & Gifford, 2001, p. 295). Reviewers have classified the areas of study of this research into the following four major categories:

- Lighting
- Noise
- Indoor air quality and thermal comfort
- Building age and condition

Lighting – "There have been more studies concerning the quality of lighting in the classroom than with any other single building component" (Earthman, 2004, p. 34). The consensus of this research is that appropriate lighting is important for optimal student performance. In addition, researchers have concluded that the illumination in American schools from both electric lighting and daylighting is adequate for most children (Evans, 2006; National Research Council, 2006).

Noise – Chronic noise from aircraft, elevated trains, and road traffic has been found to impair reading comprehension, speech perception, and long-term memory (Bronzaft, 1981; Bronzaft & McCarthy, 1975; Evans & Maxwell, 1997; Haines et al., 2001; Haines, Stansfeld, Head, & Job, 2002; Hygge, Evans, & Bullinger, 2002; Stansfeld et al., 2005). Some studies did not find significant impairment from road noise (Clark et al., 2006; Shield & Dockrell, 2004). Researchers are also concerned with noise from sources internal to school buildings and poor classroom acoustics (Earthman, 2004; Higgins, Hall, Wall, Woolner, & McCaughey, 2005; Schneider, 2002).

Air quality and temperature – Poor indoor air quality, and low and high relative humidity levels and temperature have been associated with increased student absenteeism and decreased scholastic achievement (Earthman, 2004; Environmental Protection Agency, 2000; Evans, 2006; Mendell & Heath, 2005; National Research Council, 2006).

Building age – Newer, modernized, better maintained, or more attractive school buildings have been connected with superior student scholastic achievement, health, attendance, self-esteem, attention, motivation, and behavior, and peer and student-teacher interactions (Earthman & Lemasters, 1996; Kumar & O'Malley, 2008; McGuffey, 1982; National Research Council, 2006; Schneider, 2002; Uline, 2000). Studies have revealed

that building age can be used as a surrogate for a number of specific building characteristics. These features include the condition and quality of the lighting, acoustics, indoor air, thermal control, science laboratories, and support facilities (e.g., auditorium, cafeteria, gymnasium, library, instructional resource center), and the aesthetic condition of the environment (Earthman & Lemasters, 1996; McGuffey, 1982). In addition, building cosmetics (e.g., recent painting, presence of graffiti, cleanliness) have been found to be more strongly associated with student achievement than the condition and quality of many of these building features (Al-Enezi, 2002; Earthman, Cash, & Van Berkum, 1996; Earthman & Lemasters, 1996; Evans, 2006; National Research Council, 2006).

Summary

A growing body of research outside the context of the school environment has revealed that contact with nature can provide many emotional, mental, and health benefits for individuals while at work, at home, in the hospital, or imprisoned. Although research in the context of the school environment has been minimal, it seems reasonable to expect that contact with nature would also benefit high school students. The majority of the studies investigating student academic achievement and problem behaviors have only considered student background, social, and school resource factors. Some studies have investigated the physical environment of schools, but most of these have concentrated solely on indoor conditions. At the same time, high school students today are experiencing unprecedented levels of stress and anxiety. In many ways, the benefits provided by viewing nature may be needed by students today more than ever before.

Key Research Questions

In light of the limited prior research, this study is necessarily exploratory. Many of the school characteristics that are utilized to assess student exposure and access to nature have not been taken into consideration in past studies. The important issues that were investigated are largely based on findings in contexts other than school settings.

The overarching supposition is that increased opportunities to experience nature in the course of the school day will have modest positive effects on student performance. More specifically, such opportunities in certain situations may be achieved by:

- A higher percentage of classrooms with windows
- Classrooms or cafeterias with larger window areas
- A greater amount of vegetation (e.g., trees, shrubs, lawn) and more natural settings (e.g., woodland and prairie remnants, streams) in or bordering the school campus
- Policies that grant student permission to eat lunch outdoors or to leave campus during lunch time
- Greater exposure to natural features while commuting to school due to the location of the school in an urban-fringe or rural setting, as compared to an urban site

Chapter III
Method

High Schools Studied

The high schools studied consisted of 101 public schools located throughout the southeastern region of the state of Michigan. They were chosen from schools situated in six counties, Lenawee, Livingston, Monroe, Oakland, Washtenaw, and Wayne (Figure 3.1). The names and addresses of these schools are listed in Appendix A. The schools were chosen from one region of this state to minimize differences in campus layouts and

FIGURE 3.1
The Locations of Lenawee, Livingston, Monroe, Oakland, Washtenaw, and Wayne Counties in the State of Michigan (highlighted in gray)

(Source of Base Map: Michigan Start Pages 2004)

building designs, school district policies, and regional cultures and climate conditions. To obtain a more homogenous sample of students, private high schools, public high schools offering alternative educational or magnet programs, and public high schools that were combined with elementary or middle schools were excluded from the study.

Letters introducing the study were mailed to the principals of 137 schools. Three to four follow-up telephone calls were made starting a week after the mailings. Two of the schools were eliminated because of the timing of the study. One of these, an urban school, was undergoing extensive renovations, while the other, an urban-fringe school, had just moved into new facilities for the 2005-2006 school year, the time of the data collection. Twenty schools requested approval from their five corresponding school districts. Permission was obtained from two of these school districts. Two school districts denied permission, and the application process to obtain approval from the fifth school district was too lengthy to be completed in the time period allocated for data collection. Of the 137 schools originally contacted, thirty-six (26%) were thus not included in the final database. Fourteen of the excluded schools were located in inner-city Detroit, eight in other urban settings, eight in rural areas, and six were urban-fringe schools. Definitions for the terms urban, urban-fringe, and rural are provided in the next section.

Constructs and Measures

Information about each facility was obtained from a variety of sources. Each school was contacted and an appointment was requested with the principal or vice-principals. If an appointment could not be made, information was obtained from front office personnel at each school through telephone interviews and unscheduled drop-in questioning. Site visits were used for inventorying physical features of the school campus, and the interior and exterior of the buildings. Floor plans and aerial photographs and Geographic Information Systems (GIS) data were used to corroborate these assessments. The aerial photographs and the GIS data were obtained from the United States Geological Survey (USGS), the Counties of Wayne and Livingston, and the

Michigan Department of Information Technology internet web sites. The ArcMap software program was used to determine the lengths and areas of different parts of the campus. Further information, especially with respect to student performance measures, was obtained from statewide and nationwide public information databanks. These databanks included the web sites of the Michigan Department of Education, Standard and Poor's School Matters, and Public School Review. All of the information collected was for the academic school year of 2004-2005.

School Demographics and General Characteristics

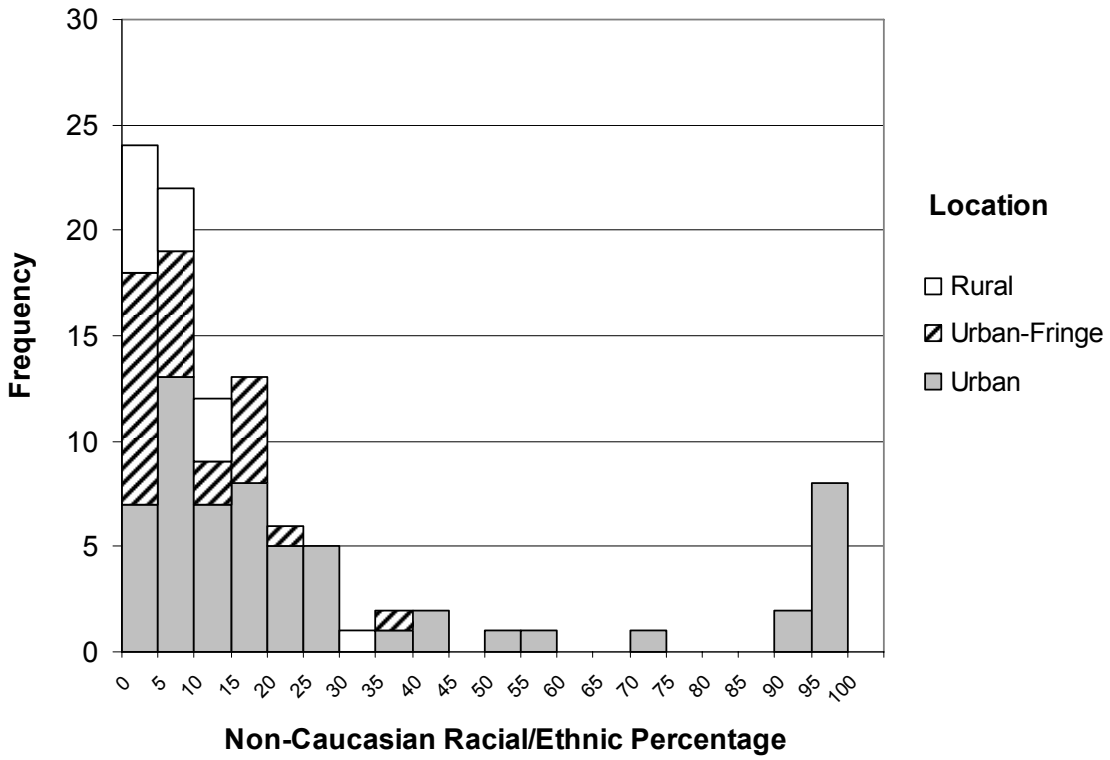
As discussed in Chapter II, a number of previously studied variables have strong connections with student academic achievement and behavior. These include school socio-economic status, racial/ethnic makeup of the student body, age of the main classroom building, and size of the enrollment at each school. To identify the unique effect that nature has on student performance, these four variables were included in the study as a way of controlling for the effect of social and physical factors.

School socio-economic status – the average socio-economic background of the students at each school was measured by the percentage of students who participate in the National School Lunch Program. The mean participation rate for the 101 schools studied was 21.50% (standard deviation 20.37%), with the average for the state of Michigan being 35.0% (School Matters, 2005). As used in this study, the school socio-economic status variable reflects the degree of non-participation in the program, thus the higher the socio-economic status, the lower the percent of students in the National School Lunch Program. As mentioned in Chapter II, this variable also provides some insight into peer group influence and teacher quality.

Ethnicity – the Michigan Department of Education lists racial/ethnic composition for the student body of each school using the following categories: Caucasian, African/American, Hispanic, Asian/Pacific Islander, American Indian/Alaska Native, and Multi-Racial (School Matters, 2005). The mean enrollment of non-Caucasian groups for the 101 schools was 25.36% (standard deviation 29.97%), with the average for the state of Michigan being 27.9%. Figure 3.2 shows several characteristics with respect to racial/ethnic composition of the sample. Most of the schools have a less than 15% non-

FIGURE 3.2

Non-Caucasian Student Population Shown by Geographic Location (2004-2005)



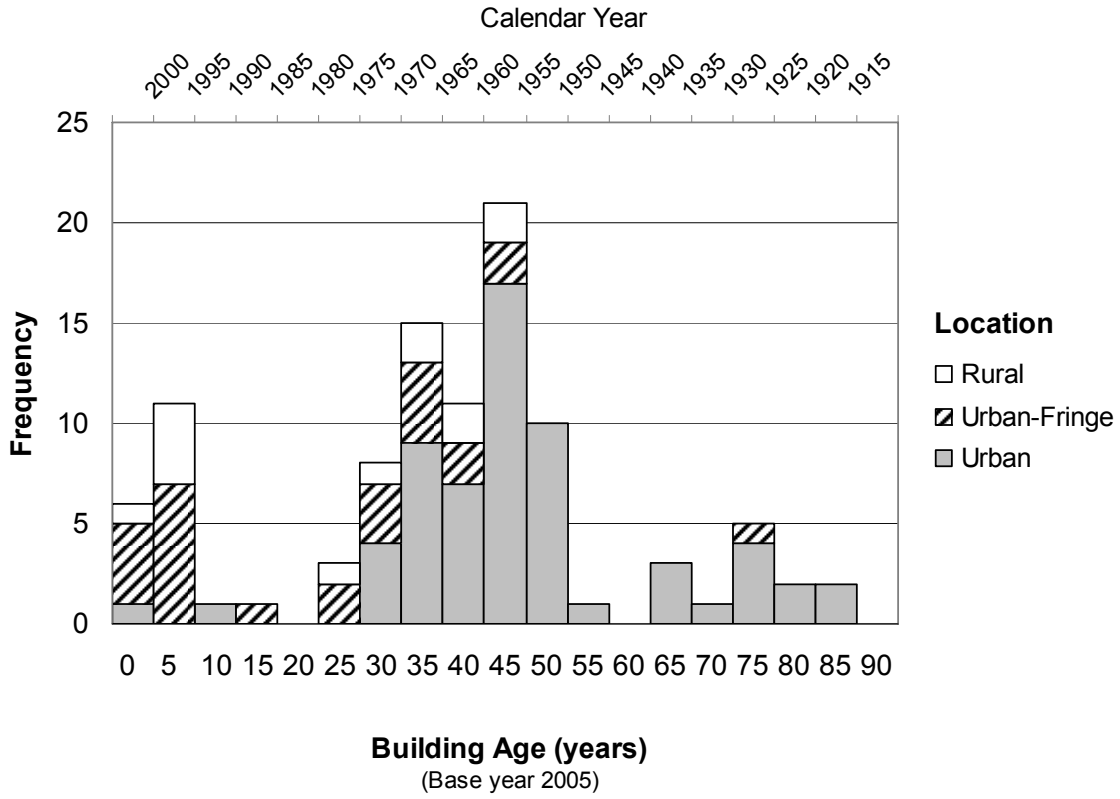
Note: The smaller the percentage of non-Caucasian (minority) students, the more likely the school was located in an urban-fringe or rural location. Schools with greater than 40% non-Caucasian students were located exclusively in urban areas.

Caucasian enrollment (as shown by the first four bars in the figure). The figure also indicates whether the school is located in a rural, urban-fringe, or urban setting. While the urban schools range widely in ethnic composition (from 0% to 95% non-Caucasian), almost all the rural and urban-fringe school have low ethnic/racial diversity. In addition, the schools with 40% or greater non-Caucasian enrollment are all urban schools.

Building age – the age of the main classroom building as of the year 2005 ranged from 2 to 88 years, with a mean of 39.72 years (standard deviation 21.10 years). Building age was used as a surrogate for the condition and quality of the lighting, acoustics, indoor air, thermal control, science laboratories, and support facilities, and the aesthetic condition of the interior environment. Figure 3.3 displays the distribution of the age of the school facility by the location of the school. The school buildings varied

greatly in age, with 16.8% opening within the past ten years and 12.9% older than sixty years. With relatively few exceptions, the older schools – those built before 1955 (i.e., fifty years old) – are in urban areas. In fact, only two urban schools are relatively new, while almost all the urban-fringe and rural schools have been built since 1955.

FIGURE 3.3
Distribution of Schools by Age of Buildings and Geographic Location



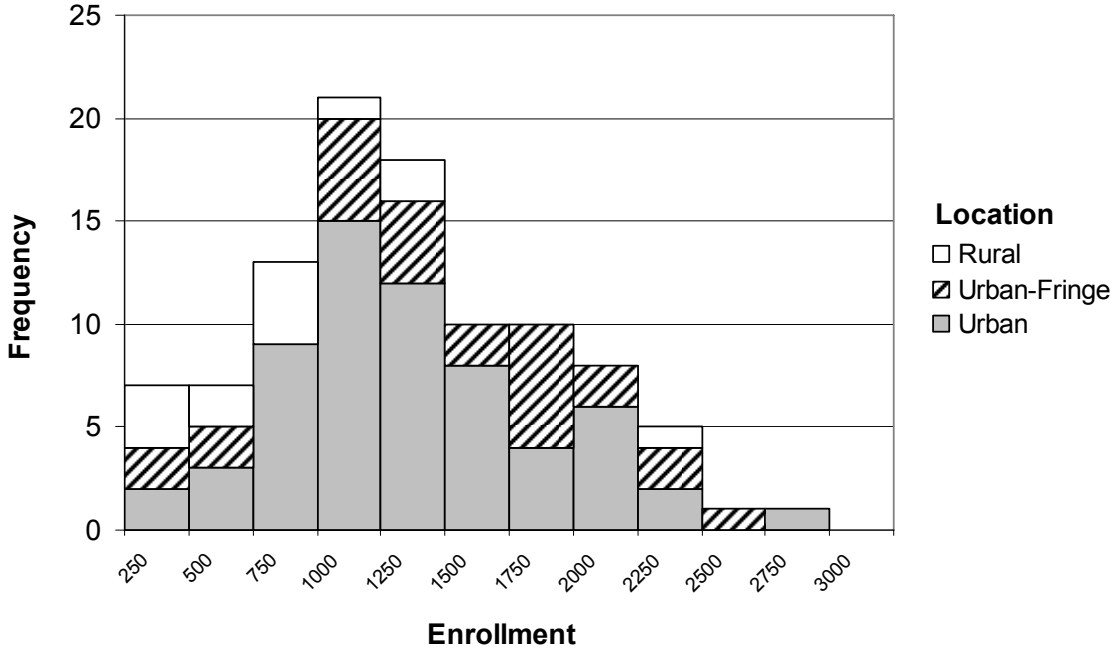
Note: The newer schools (i.e., less than thirty years old) are primarily located in urban-fringe or rural areas. Schools older than fifty years are almost all located in urban areas.

Enrollment – the total number of students in the schools ranged from 253 to 2,864 students, with a mean of 1,357.86 and a large standard deviation of 565.89 students (School Matters, 2005). Figure 3.4 displays the distribution of school enrollment by the location of the school. The smallest schools (i.e., less than 625 students) are fairly equally distributed in urban, urban-fringe, or rural areas. In contrast, most of the larger

schools (i.e., greater than 1,375 students) are located in urban or urban-fringe locations. Rural schools, in general, are much smaller than urban and urban-fringe schools

FIGURE 3.4

School Enrollment by Geographic Location (2004-2005)



Note: Most of the rural schools are smaller than those in urban and urban-fringe areas. The larger schools (i.e., greater than 1,375 students) are almost all located in urban or urban-fringe locations.

Students' Potential Exposure to Nature

The focus of this study was on the effects of exposure and access to nature on student performance. Exposure was measured in a variety of ways and at different scales, including the amount of nature found in the surrounding neighborhood and on the high school campus as well as the amount of access students had to these natural elements. These different scales of the physical environment are discussed in the next three sections.

A. Regional and Neighborhood Characteristics

Urban/rural context – of the schools included in the study, 61.4% were located in urban areas, 25.7% in the urban-fringe, and 12.9% in rural locales. These designations

are based on the classification reported by the Public School Review organization (Public School Review, 2005). In general terms, an urban area is defined as consisting of a large central place that has a minimum of 50,000 people, the urban-fringe as being comprised of contiguous territory having a density of at least 1,000 persons per square mile, and rural locales as territory not classified as urban or urban-fringe (U.S. Census Bureau, 2008).

The amount of nature surrounding a school was measured by noting the location of the school (i.e., urban, urban-fringe, rural) and determining how the land bordering each school was utilized. Regional differences may provide students with different exposures to natural landscape features (e.g., farmland, forest remnants) as they travel between home and school each day.

Land utilization around each school was measured by calculating the percentage of the total linear distance of the outer campus boundary that was occupied by each of the land use types listed in Table 3.1. These classifications are based on land uses found around the schools studied during the site survey. The land use variables were placed into two groups, differentiated in terms of their natural characteristics. The order of the listings within each group was determined by how common each type of land use was in the bordering neighborhood (i.e., based on the mean percentages that each site type occupied among the 101 schools). Great differences existed in the neighboring sites.

1. More Natural Bordering Sites:

   Natural settings – forest, wetland, and prairie remnants, rivers, lakes, and nature parks

   Farmlands – land either under cultivation or capable of being cultivated, and land with greenhouses

   Parks – recreational parks and golf courses

   Cemeteries –park-like setting burial grounds

TABLE 3.1

Bordering Neighborhood Sites (N = 101 High Schools)

	Mean Percentages of the Borders	Schools Bordered by this Setting Type	Standard Deviation	Range
More Natural Bordering Sites				
Natural Settings	11.8	49	17.9	0-74
Farmlands	5.1	17	14.2	0-66
Parks	3.0	19	7.5	0-42
Cemeteries	0.3	2	2.5	0-23
Less Natural Bordering Sites				
Residential Homes	50.2	98	24.0	0-100
Schools	9.6	44	12.9	0-52
Commercial	4.8	42	8.6	0-49
Civic Buildings	3.4	27	6.8	0-34
Vacant Lots	2.9	20	9.9	0-66
Churches	2.2	27	4.8	0-30
Industrial	1.9	10	6.9	0-44
Railroads	1.5	7	5.6	0-29
Freeways	1.1	6	4.7	0-26
Power Lines	0.6	3	4.0	0-29
Medical Offices	0.6	10	2.3	0-11
Recreational Facilities	0.5	7	1.8	0-9
Hospitals	0.2	2	1.6	0-16
Utilities	0.1	2	0.6	0-4
Noise Sources				
	Mean Rating	Schools Bordered by this Setting Type	Standard Deviation	Range
Street Usage Level	1.7	101	0.8	1-3

2. Less Natural Bordering Sites:

Residential homes – residential homes, apartment complexes, and nursing homes

Schools – public or private elementary and middle schools

Commercial – retail businesses and professional office complexes

Civic buildings – city halls, community centers, fire stations, historical homes, libraries, police stations, post offices, public works facilities, school district offices, and county welfare offices

Vacant lots – vacant and abandoned lots with and without structures present

Churches – churches of all religious denominations

Industrial – factories, warehouses, etc.

Railroads – railroad tracks in current use

Freeways – interstate express highways

Power lines – high-voltage power lines

Medical offices – doctor's and dentist's offices

Recreational facilities – indoor recreation centers

Hospitals – public or private hospitals

Utilities – electrical power substations

3. Noise Sources: Airplane and automobile traffic noises were noted at each high school. The variables measuring these noise sources were defined as follows:

   Aircraft noise – was the school located directly underneath the arrival and departure flight paths of large jet aircraft. None of the schools was.

   Street usage – the level of usage of the street in front of each school was rated on a 3- point Likert scale where 1 = nonbusy residential street, 2 = two-lane moderately busy road, 3 = four-lane very busy road. Differences existed among the schools (Table 3.1).

B. Campus Characteristics

The campuses of the schools studied differed greatly in terms of total acreage and the amount of area devoted to landscape, athletic fields, and parking lots (Table 3.2). For each campus, four areas defined below were calculated using the GIS data noted above. Figure 3.5 provides an example of the portions of the campus denoted as landscaped areas, parking lots, and athletic fields.

1. Campus Site Areas

   Campus area – total area of each high school campus

   Landscaped areas – the areas between the school buildings and athletic fields, parking lots as defined below, and the edge of the school property, and outdoor courtyards totally surrounded by schools buildings

   Athletic fields – football, soccer, and baseball fields, tennis courts, and other outdoor sport facilities

   Parking lots – parking lots, roadways, driveways, and alleyways within school boundaries, including all areas of vegetation surrounded by or contained within

these features and located between these features and bordering neighborhood streets and sites

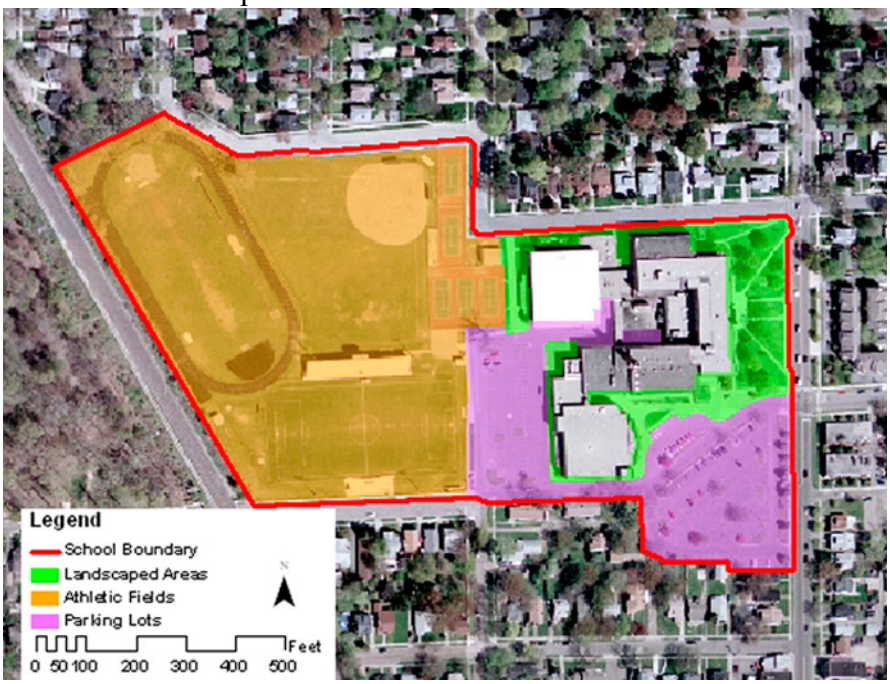
TABLE 3.2

Campus Site Areas (N = 101 High Schools)

	Mean Areas	Standard Deviation	Range
Campus Area (acres)	48.5	25.8	3-130
Landscaped Area (acres)	5.1	2.9	1-13
Athletic Field Area (acres)	20.0	9.0	0-41
Parking Lots (acres)	10.5	6.5	0-31
Landscaped Area/Student (sq ft/student)	193.4	149.7	33-863
Parking Lot Area/Student (sq ft/student)	360.0	210.1	37-1070
Athletic Field Area/Student (sq ft/student)	806.0	706.4	0-3801

FIGURE 3.5

Campus Boundaries and Areas Measured



Landscaped, parking lot, and athletic field areas were included both in terms of their absolute size, and also divided by the enrollment of the corresponding school

to determine for each school the *landscaped area/student*, *parking lot area/student*, and *athletic field area/student*.

2. Campus Natural Features

Additional and more detailed features of the amount of nature at each school were measured and found to differ greatly among the facilities studied (Table 3.3). These involved the density of trees, areas of shrubs and lawns, naturalness of views provided to students from school building windows, distances to viewable natural settings, and how well maintained the landscape was on each campus. The information needed for these measurements were obtained through site visits and from the GIS data used above. Five of the campus nature variables were defined with respect to the landscaped area (as defined previously):

Tree density – the number of trees per acre of landscaped area

Parking lot tree density – the number of trees per acre of parking lot

Shrub area – the area of the landscaped area consisting of shrubs and groundcover

Shrub/landscaped area – the percentage of the landscaped area consisting of shrubs and groundcover

Lawn area – the area of the landscaped area consisting of mowed grass

Lawn/landscaped area – the percentage of the landscaped area consisting of mowed grass

Cafeteria view naturalness level – the degree of naturalness in the view from each school's primary cafeteria window. A 4-point Likert scale was used, with 1 for 'no view' or 'all built,' 2 for 'mostly built,' 3 for 'mostly natural,' and 4 for 'all natural.' These terms were defined as follows:

1. "No view" consisted of cafeterias without any window to the outdoors and the all built view consisted of buildings, roads, and walkways without any vegetation[2].

[2] Note: "No view" and "all built" were originally separate categories. However, because only two of the schools were found to have an "all built" cafeteria window view, these two categories were combined during the statistical analyses.

2. If the majority of what could be seen was built, including school buildings, paved school courtyards, parking lots, roads, and surrounding homes and buildings, but with natural elements such as a few trees and shrubs, or if the majority of what could be seen was athletic fields or large expanses of lawn devoid of trees and shrubs, such a view was mostly built.
3. The mostly natural view included evidence of human presence such as sidewalks, courtyards, parking lots, and roads along with a mostly natural setting.
4. The all natural view consisted of trees, shrubs, and forest remnants without any evidence of human influence.

Nearness to woodlands – the distance from the approximate center of the classroom buildings to the closest woodland remnant on or viewable from the school grounds (e.g., a tall wall or building bordering a school does not block the view of this particular landscape). This distance was rated on a 5-point Likert scale, where 1 = no woodland remnant is visible, 2 = 1500 – 1999 feet, 3 = 1000 – 1499 feet, 4 = 500 – 999 feet, and 5 = 0 – 499 feet.

TABLE 3.3

Campus Natural Features (N = 101 High Schools)

	Mean Areas	Standard Deviation	Range
Tree Density (trees/acre)	12.4	6.6	0-35
Parking Lot Tree Density (trees/acre)	4.5	3.7	0-19
Shrub Area (sq ft)	4,567.9	14,998.1	0-150,653
Shrub/Landscaped Area (%)	2.0	4.5	0-45
Lawn Area (acres)	3.8	2.5	0-10
Lawn/Landscaped Area (%)	70.5	14.7	17-92
Cafeteria View Naturalness Level (rating)	1.9	0.8	1-4
Nearness to Woodlands (rating)	2.8	1.7	1-5
Landscape Maintenance (rating)	3.2	0.7	1-5

Landscape maintenance – the level of maintenance and upkeep evident in the landscape. The landscapes were rated on a 5-point Likert scale, where 1 represented a very disorderly, unmaintained landscape and 5 corresponded to a pristine, well-maintained landscape. The level of care rather than aesthetic

considerations was the basis of this rating. For example, a campus rated as a 3 had landscapes where the lawns, and shrub and perennial groupings that were roughly 80% intact, very little litter was present, and some pruning of shrubs and trees was in evidence. A campus landscape rated as a 5 had lawns, and shrub and perennial groupings that were almost 100% intact, almost no litter present, and extremely well pruned hedges, shrubs, and trees.

C. Student Potential Access to Nature

In addition to the amount of nature present on each campus, the ability of students to access nature was measured and found to differ among the schools (Table 3.4). Nature access involved determining how easily students could view or come into direct contact with nature during the school day. These measurements involving school building window sizes and heights, and school lunch policies were defined as follows:

1. Building Features

Windowed classroom percentage – the percentage of classrooms that had windows of any size at each school, not including rooms that had only skylights or windows that did not extend below door height. Classrooms used for shop classes (e.g., auto, wood, metal) and other specialized classrooms (e.g., planetariums, greenhouses) were not included in the computation.

Classroom window area – the average total window area of regular classrooms (e.g., history, literature, math, science) at each school. The window areas of all of these classrooms were measured and then averaged. Only windows that provided a view at eye level while sitting for at least some of the students were considered. The areas of skylights and windows that did not extend below door height were not added to the classroom total. The window areas of art, computer, home economics, and shop classes (e.g., auto, wood, metal), and other specialized classrooms (e.g., planetariums, greenhouses) were not included in the calculation.

Cafeteria window area – the area of the cafeteria windows were categorized on a 0 to 5 scale where: 0 = no windows, 1 = windows make up approximately 25% of the primary outward facing wall, 2 = windows make up approximately 50% of the primary outward facing wall, 3 = windows make up approximately

75% of the primary outward facing wall, 4 = windows make up 100% of the primary outward facing wall, 5 = windows make up 100% of a greater than one story tall primary outward facing wall.

Building height – the height of the majority of the classroom building or buildings of each school. The extent of the view and viewing angles from classroom windows depend on the height of the building.

2. School Policy

Eat lunch outdoors – a dummy variable where 0 = students are not allowed to eat lunch outdoors, 1 = students are allowed to each lunch outdoors

Open campus – a dummy variable where 0 = students are not allowed to leave campus during lunch without prior permission, 1 = students are allowed to leave campus during lunch without prior permission (Table 3.4)

TABLE 3.4

Student Potential Access to Nature (N = 101 High Schools)

	Mean	Standard Deviation	Range
Building Features			
Windowed Classrooms (%)	76.6	25.4	0-100
Classroom Window Area (sq ft)	87.6	48.4	0-254
Cafeteria Window Area (rating)	2.2	1.8	0-5
Building Height (stories)	1.8	0.7	1-3
School Policy			
Eat Lunch Outdoors (%)[1]	51.5	-	-
Open Campus (%)[1]	9.9	-	-

[1] The mean for this dummy variable is being reported as a percentage (e.g., .099=9.9%).

Student Performance Measures

The student performance measures included both student academic achievement and behavior and made up the dependent or outcome variables in this study. Scholastic achievement was measured by use of the following variables (Table 3.5):

Michigan Merit Award – the percentage of Michigan Merit Award winners at each school determined by student performance on the Michigan Educational Assessment Program (MEAP) test. This standardized test was taken by all public high school students in the state of Michigan from the year 1969 to 2006. Usually this test was taken during a student's junior year (Michigan Department of Education, 2006).

Graduation rates – the graduation rates as reported by each school to the Michigan Department of Education.

Four-year college plans – the percentage of seniors at each school who stated that they planned to attend a 4-year college upon graduation. Only seventy-eight of the high schools studied polled their outgoing seniors during the academic year 2004-2005 on this issue.

TABLE 3.5

Student Scholastic Achievement for the Academic School Year 2004-2005
(N = 101 High Schools)

	Mean	Standard Deviation	Range
Michigan Merit Award (%)	34.6 *n* = 99[1]	17.9	0-71
Graduation Rates (%)	89.0 *n* = 97	11.4	40-100
Four-Year College Plans (%)	56.4 *n* = 78	17.1	20-94

[1] Data for some of the high schools were either missing from the Michigan Department of Education annual report or not reported by the high school.[3]

Student behavior was measured with the following variables:

Student disorderly conduct – each school was required to file a report on eleven types of student discipline problem that occurred at school (Note: "Misbehaviors on bus" was removed from consideration since this problem occurred off campus) (Michigan Department of Education, 2006). The relative frequencies of these misbehaviors were reported to the state of Michigan on a 6-point Likert scale where 0 = no occurrences or 0 per 100 students, 1 = low or 1-3 per 100 students, 2 = low-medium or 4-7 per 100 students, 3 = medium or 8-11 per 100 students, 4 = medium-high or 12-15 per 100 students, 5 = high or over 15 per 100 students. Factor analysis was conducted and seven types of problems formed a factor with a Cronbach's alpha reliability value of 0.84 (Table 3.6). The relative frequencies of these seven types of school discipline problems

[3] No patterns in the missing data were found for the Michigan Merit Award and graduation rates measures. Concerning four-year college plans, 97.2% of most economically advantaged schools, as defined in Chapter IV, or 96.2% of the urban-fringe schools surveyed their outgoing senior students. Rural schools (92.3%), moderately advantaged schools (71.4%), urban schools (66.1%), or the least advantaged schools (62.2%) were less likely to survey their students.

were averaged to represent student disorderly conduct at each high school (Table 3.7). These seven problems were student social tensions, bullying, verbal abuse of teachers, insubordination, acts of disrespect for teachers, physical attacks or fighting, and truancy. The remaining four disorders were not examined further due to very low occurrence rates. Unlike the other seven problems where 61.2-81.6% of the schools reported relative frequencies of either 0 or 1, over 90% of the schools reported relative frequencies of either 0 or 1 for these five types. These disorders were extortion, widespread disorder in classrooms, undesirable gang activities, and undesirable cult or extremist group activities.

TABLE 3.6

Factor Analysis of the Eleven Types of Student Disorder

Rotated Component Matrix(a)

	Component Factor Loading		
	Student Disorderly Conduct	2	3
Student Insubordination	0.80		
Physical Attacks or Fighting	0.79		
Student Bullying	0.65		0.50
Student Acts of Disrespect for Teachers	0.62	0.55	
Truancy	0.59	0.48	
Student Verbal Abuse of Teachers	0.55	0.52	
Student Social Tensions	0.48		0.49
Undesirable Gang Activities		0.84	
Widespread Disorder in Classrooms		0.67	
Undesirable Cult or Extremist Group Activities			0.71
Student Extortion			0.68
Cronbach's alpha	0.84	0.78	0.59
Means	1.37	1.02	0.72

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 9 iterations.

Student criminal activity – each school was required to file a report on twenty-two types of student criminal activities (Michigan Department of Education, 2006). Four of these activities had zero occurrences. These included hostage taking, homicide, drive by shooting, and suicide. Twelve criminal activities had very low occurrence rates, with over 90% of the schools reporting frequencies of less than 0.5 per 100 students. These twelve activities were gang activity, trespasser, sexual assault, armed subject, weapon, bomb threat, explosion, arson, robbery, unauthorized removal (i.e., burglary and theft),

suicide attempt, and drug use. These sixteen criminal behaviors were not examined further. The number of occurrences of the remaining six types of activities were averaged together to represent student criminal activity at each high school. These six behaviors were physical violence, illegal possession, vandalism, verbal assault, larceny, and minor in possession (Table 3.7). Definitions of these crimes are provided in Appendix B.

TABLE 3.7

Student Behaviors for the Academic School Year 2004-2005
(N = 101 High Schools)

	Mean	Standard Deviation	Range
Student Disorderly Conduct (relative frequency rating)	1.4 $n = 98$[1]	0.7	0-4
Student Criminal Activity (number of incidents)	8.6 $n = 98$	11.8	0-84

[1] Data for some of the high schools were missing from the Michigan Department of Education annual report.

Chapter IV
The High School Campuses of Different Socio-Economic Groups

The 101 schools in the sample, though in the same geographic area (southeastern Michigan), differ in terms of socio-economic dimensions as well as their physical facilities. These two considerations are likely to be related to each other, with the affluence of the students likely to be reflected in the school's site and facilities. This chapter examines these relationships, particularly focusing on the relationship between the schools' economic advantage and characteristics of the surrounding neighborhoods, the campus natural features, and student access to nature while spending the day at school.

School Demographics and Location

The index of socio-economic status used in this study is the rate of the schools' participation in the National School Lunch Program. The schools were divided into three categories based on the percentage of the students receiving free or reduced lunches. The most economically advantaged schools (n = 36) were those with fewer than 10% participation rate in this federal program. The least economically advantaged (n = 37) included at least 20% of their students in the program. The remaining schools (n = 28), moderately advantaged, fell between these rates, with 10-19% participation.

The schools in the three economic groups differed with regard to percentage of minority students, age of the facility, and enrollment size (Table 4.1). The schools in the least advantaged group had significantly greater percentages of minority students and were housed in much older buildings than those in the two more advantaged groups. On the

other hand, the most advantaged schools had much larger student enrollments as compared to the two less advantaged groups.

TABLE 4.1

School Demographics and Location by Economic Advantage

	Least Advantaged High Schools (n = 37)	Moderately Advantaged High Schools (n = 28)	Most Advantaged High Schools (n = 36)	ANOVA or Chi-Square Analyses
School Demographics and General Characteristics				
Ethnicity [1] (% of students)	49.7 [a]	12.0 [b]	10.8 [b]	30.82***
Age of Main Building (years)	49.1 [a]	37.3 [b]	32.0 [b]	7.07**
Enrollment (# of students)	1264.0 [a]	1171.04 [a]	1599.9 [b]	5.84**
School Location				
Rural (%)	8.1 [a]	25.0 [a]	8.3 [a]	$\chi^2 = 5.08$
Urban-Fringe (%)	5.4 [a]	25.0 [ab]	47.2 [b]	$\chi^2 = 16.70$***
Urban (%)	86.5 [a]	50.0 [b]	44.4 [b]	$\chi^2 = 15.73$***

* p < 0.05. ** p < 0.01. *** p < 0.001.

[a] Means sharing a superscript are not significantly different from one another using Tukey's HSD bivariate comparisons or Chi-Square analysis.

[1] Total percentage of all of the minority racial/ethnic groups for the academic school year 2004-2005.

The schools' economic advantage was also related to whether they were located in rural, urban-fringe, or urban settings (Tables 4.1 and 4.2). The schools in the least advantaged group were most often sited in urban locations as compared with the other two school groups and comprised 52% of the urban schools in the sample. The preponderance of the schools located at the urban-fringe (65%) were in the most advantaged economic category, while over half the schools in rural locations were in the moderately-advantaged category. However, some of the schools in each economic advantage category were located in each of the urban/rural settings.

TABLE 4.2

School Location by Economic Advantage Crosstabulation

		Economic Advantage			Total
		Least Advantaged High Schools	Moderately Advantaged High Schools	Most Advantaged High Schools	
School Location	Rural	3	7	3	13
	Urban Fringe	2	7	17	26
	Urban	32	14	16	62
Total		37	28	36	101
		Value	Degrees of Freedom	Asymp. Sig. (2-sided)	
Pearson Chi-Square		22.90 [a]	4	< 0.001	

[a] 3 cells (33.3%) have expected count less than 5. The minimum expected count is 3.6.

The School Campus and Its Surroundings

Surrounding Neighborhood Characteristics

The adjacent areas near the high school campuses differed not only with respect to their location in urban, urban-fringe or rural contexts, but also in terms of the nearby land uses. Some of these characteristics varied by category of economic advantage (Table 4.3).

Most notable are the differences in natural settings bordering on the school campuses. The least advantaged schools were far less likely to have natural environments such as forest, prairie, and wetland remnants, nature parks, lakes, and rivers in the bordering neighborhood as compared with the other two groups of schools, which did not differ significantly from each other.

The most advantaged schools were surrounded by residential homes and apartments, and indoor recreational facilities to a greater degree than moderately advantaged schools, perhaps because relatively more of the latter group were in rural settings. The least advantaged schools were surrounded by more vacant lots than the more advantaged school groups.

TABLE 4.3

Land Uses Bordering Schools by Economic Advantage

	Least Advantaged High Schools (n = 37)	Moderately Advantaged High Schools (n = 28)	Most Advantaged High Schools (n = 36)	ANOVA or Chi-Square Analyses
More Natural Bordering Sites				
Natural Settings (%)	3.3 [a]	16.3 [b]	17.0 [b]	7.46***
Farmlands (%)	6.6 [a]	7.2 [a]	2.0 [a]	1.37
Parks (%)	1.7 [a]	4.3 [a]	3.5 [a]	1.03
Cemeteries (%)	0.0 [a]	0.8 [a]	0.3 [a]	0.88
Less Natural Bordering Sites				
Residential Homes (%)	51.7 [ab]	39.9 [a]	56.6 [b]	4.19*
Schools (%)	10.7 [a]	12.9 [a]	5.9 [a]	2.59
Commercial (%)	5.1 [a]	4.5 [a]	4.9 [a]	0.04
Civic Buildings (%)	4.9 [a]	2.9 [a]	2.2 [a]	1.56
Vacant Lots (%)	6.7 [a]	0.1 [b]	1.0 [b]	4.70*
Churches (%)	2.1 [a]	1.5 [a]	2.8 [a]	0.59
Industrial (%)	2.2 [a]	3.8 [a]	0.0 [a]	2.53
Railroads (%)	2.2 [a]	1.7 [a]	0.5 [a]	0.90
Freeways (%)	1.3 [a]	2.3 [a]	0.0 [a]	1.94
Power Lines (%)	0.0 [a]	2.0 [a]	0.3 [a]	2.28
Medical Offices (%)	1.0 [a]	0.0 [a]	0.6 [a]	1.61
Recreational Facilities (%)	0.2 [ab]	0.0 [a]	1.1 [b]	3.99*
Hospitals (%)	0.1 [a]	0.0 [a]	0.4 [a]	0.71
Utilities (%)	0.0 [a]	0.0 [a]	0.2 [a]	1.86
Noise Sources				
Street Usage Level (rating)	1.9 [a]	1.6 [a]	1.7 [a]	0.73

* $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

[a] Means sharing a superscript are not significantly different from one another using Tukey's HSD bivariate comparisons or Chi-Square analysis.

It is also important to note the many ways in which the schools' economic category did not relate to physical characteristics. The three school groups did not differ in terms of the presence of farmland, parks, cemeteries, elementary and intermediate schools, commercial businesses (e.g., retail stores, professional offices), civic buildings (i.e., city halls, community centers, county welfare offices, department of public works facilities, fire stations, historical homes, libraries, post offices, police stations, school

district offices), churches, industrial complexes, railroad tracks, freeways, high voltage power lines, medical offices, hospitals, and electrical power substations in the bordering neighborhood. The schools in the three groups also did not differ concerning the size and traffic level of the street in front of the school. They were equally likely to be bordered by a quiet residential street or a busy boulevard.

Campus Site Characteristics

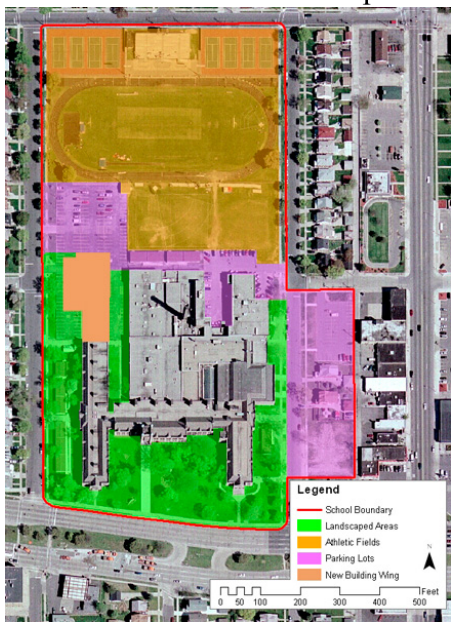
To provide a better sense of the diversity of physical settings across the high schools in the sample, aerial views of six schools are shown in Figures 4.1-46. The landscaped areas, athletic field, and parking lot areas are highlighted. The six schools are shown in pairs with each pair representing one category of the economic advantage variable. Schools were selected to closely match the mean participation rate in the National School Lunch Program for their respective category.

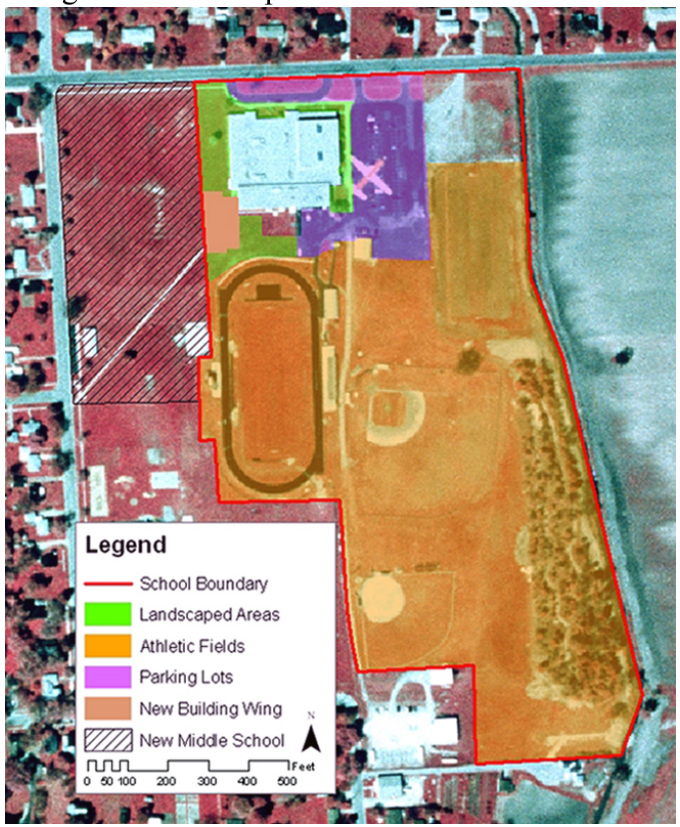
While the most advantaged schools were, on average, 25% larger than the least advantaged in terms of student enrollment, they were almost twice as large in terms of the size of the school site (Figures 4.5 and 4.6). Table 4.4 shows the substantial differences in school site characteristics with far larger campuses for the most- and moderately advantaged schools compared to the lowest economic category. The differences in campus size are particularly reflected in the acreage devoted to athletic fields and parking. For example, on a per student basis, almost twice the campus area was devoted to athletic fields and parking at the moderately advantaged schools compared to the least and most advantaged (Figures 4.1-4.4).

The proportion of the campus that was devoted to landscaping was greater for the least advantaged schools (13%) as compared to the moderately (9.9%) and most advantaged (9.4%). However, it is noteworthy that the per student allocation of landscaped area as well as the acreage that was landscaped did not differ in terms of the economic distinction (Table 4.4 and Figures 4.1-4.6).

FIGURE 4.1 **FIGURE 4.2**

Examples from the Least Advantaged High School Group

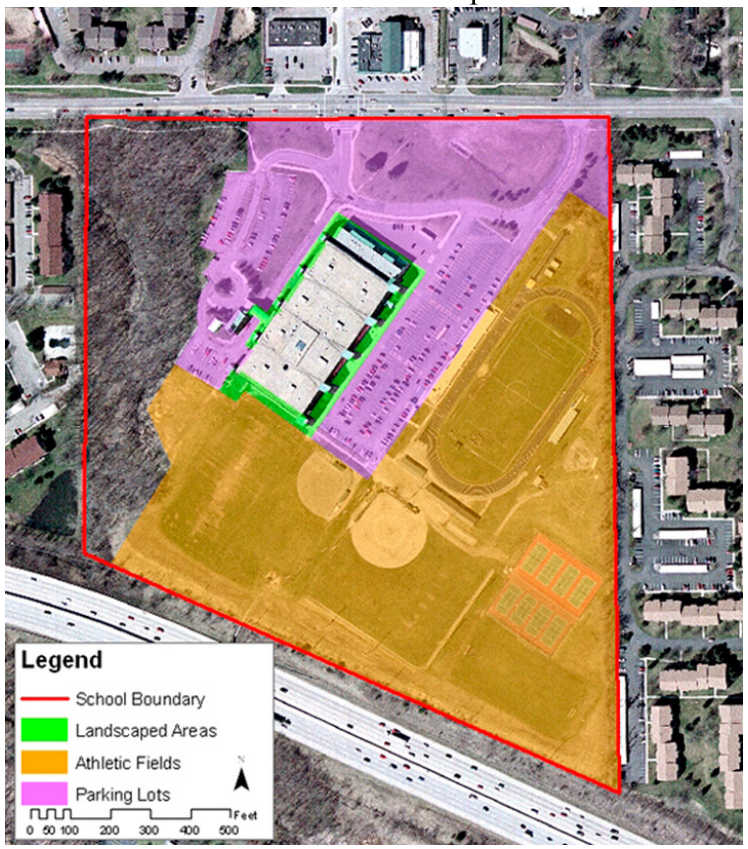


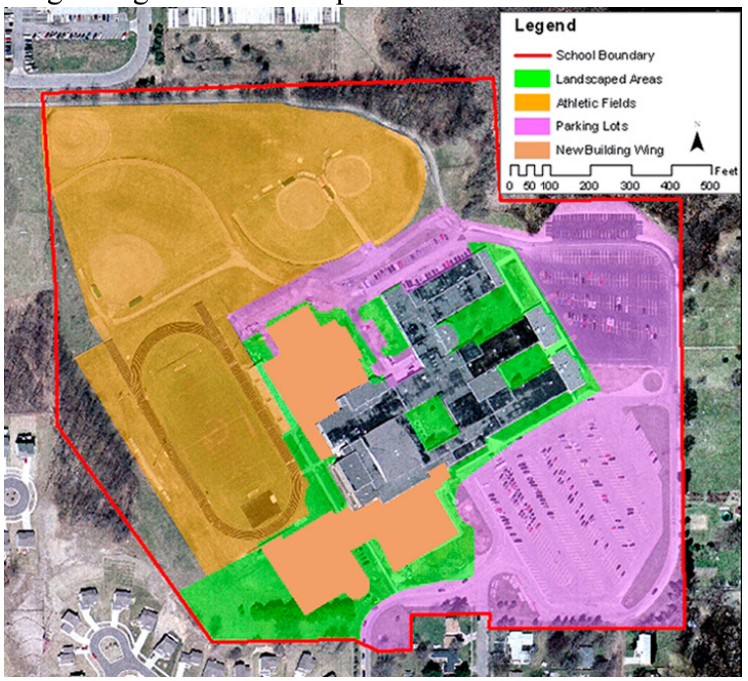


Note the compact size of the school campus area in Figure 4.1 as compared with all of the other schools displayed (Figures 4.2-4.6). Figure 4.1 is a representative example of many of the older urban schools in this least advantaged group, with smaller parking lots and athletic fields. Figure 4.1 differs from the other campuses (4.2-4.6) in its compact total acreage. Most of the schools in least advantaged category are located in urban areas; Figure 4.2, however, is at the urban-fringe, and some of the other schools in the category are in rural locales.

FIGURE 4.3 **FIGURE 4.4**

Examples from the Moderately Advantaged High School Group

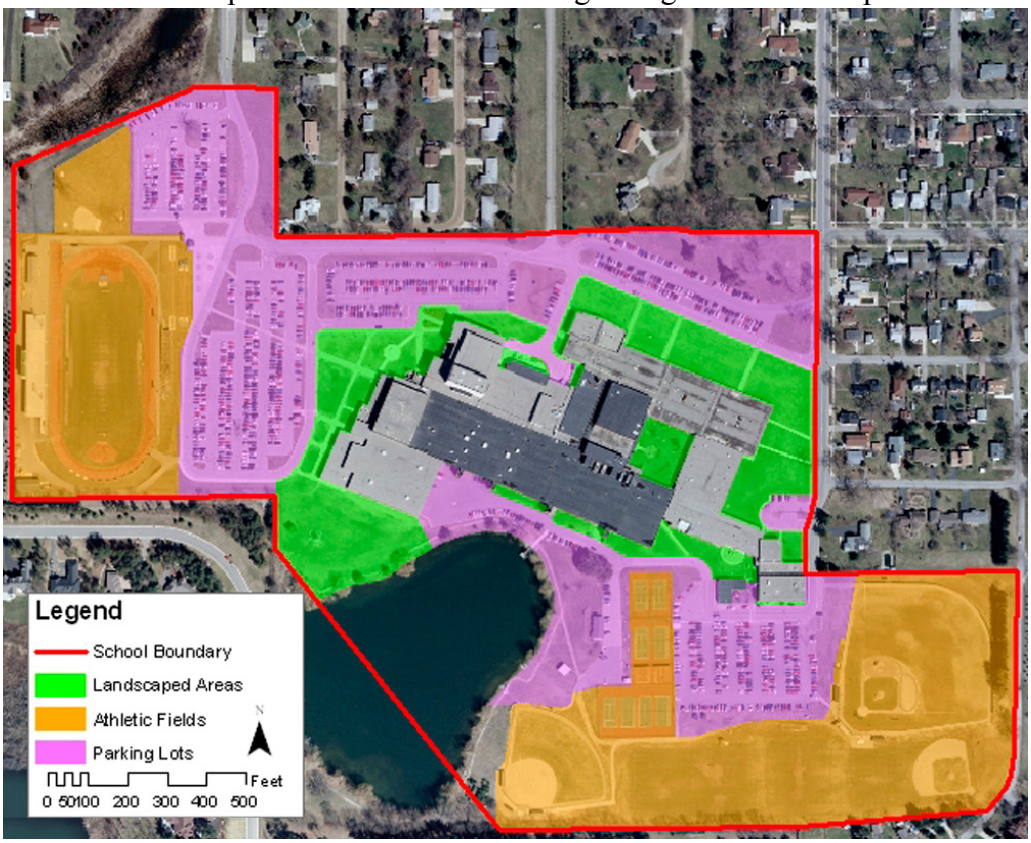




From an aerial perspective, the campuses of the moderately advantaged schools as seen here have a greater similarity with respect to features such as size of parking lots and athletic fields, and type of surrounding neighborhood with those of the most advantaged (Figures 4.5 and 4.6) than with the least advantaged schools (Figures 4.1 and 4.2). These similarities are also shown in the statistical analyses (Table 4.4).

FIGURE 4.5

Example from the Most Advantaged High School Group



The most advantaged schools often have larger campuses, particularly evident in the large and numerous parking lot and athletic fields, as compared with those of the least advantaged group (Figures 4.1 and 4.2). In addition, their urban-fringe surroundings are more likely to include lakes, forest remnants, or other natural features than the urban schools of the least advantaged group (Figure 4.1). Also note that the sizes of the landscaped areas adjacent to the school buildings (highlighted in green) are very similar among the three economic groups (Figures 4.1-4.6).

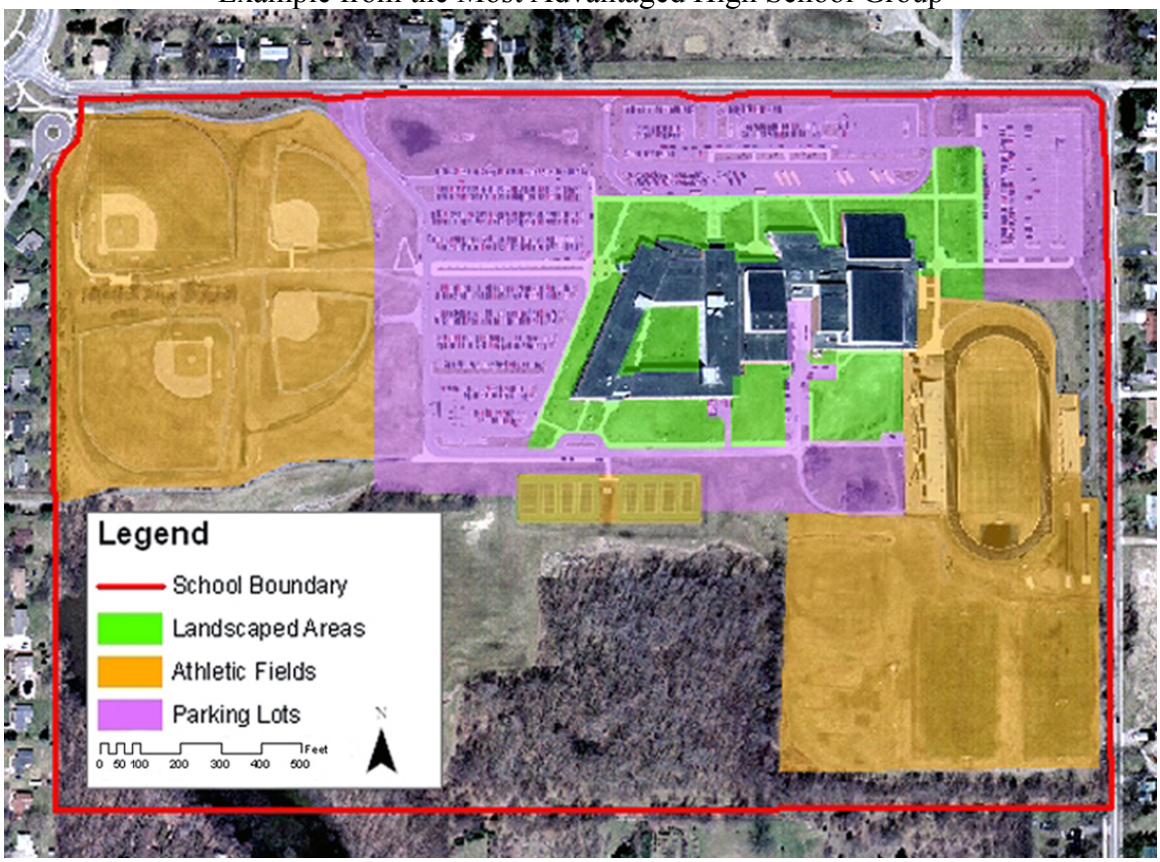
Student Potential Exposure to Nature on Campus

The three school economic groups varied on many of the student exposure to nature measurements used in this study, with many of the differences favoring the most advantaged schools (Table 4.4). For example, the most advantaged schools had forest remnants nearby more often than the least advantaged. In addition, while the size of the landscaped, lawn, and shrub-covered areas were not significantly different, tree density was far greater at the most advantaged schools as opposed to the moderately advantaged, with the least advantaged falling in between. Tree density in the parking lots was by far

greatest at the most advantaged schools. These schools also had superior level of landscape maintenance.

FIGURE 4.6

Example from the Most Advantaged High School Group



Concerning student access to nature, while the percentage of classrooms with windows, the average classroom window area, and building height did not differ among the three economic groups, the most advantaged schools had the larger cafeteria window area with views consisting of greater nature content as compared to the less economically-advantaged. And the students on campuses providing the most nature opportunities also had the highest likelihood of being permitted to eat their lunch outdoors.

TABLE 4.4

Campus Site Characteristics by Economic Advantage

	Least Advantaged High Schools (n = 37)	Moderately Advantaged High Schools (n = 28)	Most Advantaged High Schools (n = 36)	ANOVA or Chi-Square Analyses
Campus Site Areas				
Campus Area (acres)	33.3 [a]	52.8 [b]	60.7 [b]	13.56***
Landscaped Area (acres)	4.5 [a]	5.3 [a]	5.7 [a]	1.81
Athletic Field Area (acres)	16.0 [a]	23.2 [b]	21.4 [b]	6.47**
Parking Lots (acres)	6.8 [a]	11.5 [b]	13.4 [b]	12.16***
Landscaped Area/Student (sq ft/student)	175.6 [a]	245.4 [a]	171.2 [a]	2.41
Parking area/student (square feet/student)	262.5 [a]	484.6 [b]	363.4 [a]	10.64***
Athletic Field Area/Student (sq ft/student)	676.1 [a]	1188.7 [b]	641.9 [a]	6.31**
Natural Features				
Tree Density (trees/acre)	12.2 [ab]	9.9 [a]	14.5 [b]	4.17*
Parking Lot Tree Density (trees/acre)	3.2 [a]	3.7 [a]	6.6 [b]	10.81***
Shrub Area (sq ft)	3350.4 [a]	2840.0 [a]	7163.0 [a]	0.84
Shrub/Landscape Area (%)	1.9 [a]	1.1 [a]	2.8 [a]	1.11
Lawn Area (acres)	3.3 [a]	4.1 [a]	4.1 [a]	1.44
Lawn/Landscaped Area (%)	68.6 [a]	75.7 [a]	68.4 [a]	2.52
Cafeteria View Naturalness Level (rating)	1.9 [ab]	1.6 [a]	2.1 [b]	3.61*
Nearness to Woodlands (rating)	2.2 [a]	3.0 [ab]	3.2 [b]	3.66*
Landscape Maintenance (rating)	2.9 [a]	3.3 [ab]	3.5 [b]	7.57***
Student Access to Nature				
Building Features				
Windowed Classrooms (%)	83.2 [a]	73.6 [a]	72.3 [a]	1.96
Classroom Window Area (sq ft)	96.7 [a]	74.3 [a]	88.5 [a]	1.74
Cafeteria Window Area (rating)	2.1 [ab]	1.5 [a]	2.8 [b]	4.12*
Building Height (stories)	1.9 [a]	1.6 [a]	1.8 [a]	1.23
School Policy				
Eat Lunch Outdoors (%)	29.7 [a]	53.6 [ab]	72.2 [b]	$\chi^2 = 13.26$**
Open Campus (%)	5.4 [a]	10.7 [a]	13.9 [a]	$\chi^2 = 1.50$

* $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

[a] Means sharing a superscript are not significantly different from one another using Tukey's HSD bivariate comparisons or Chi-Square analysis.

Summary

School socio-economic status was a major factor in determining the types of high school social and physical environments with which a student interacted. Concerning the social environment, the students in the most advantaged schools interacted with larger number of peers at school and fewer minority students than those in the less advantaged schools.

Concerning the physical environment, the students in the most advantaged schools attended more modern facilities and were exposed to greater levels of nature both on campus and in the bordering neighborhood than students in many of the less advantaged schools. During lunch time, students from the most advantaged schools were able to view and directly experience these more natural landscapes to a greater degree than their less advantaged peers.

Students in the moderately advantaged schools experienced social and physical environments that were in many ways more similar to their most advantaged peers. Even so, their schools had fewer trees in the landscape adjacent to the buildings, fewer natural features in the cafeteria window views, and smaller cafeteria window areas.

The least advantaged schools were located on much smaller campuses in terms of area than the other two school groups. Most of the extra area in the more advantaged schools was devoted to larger athletic fields and especially much larger parking lots. It was fascinating, however, that the size of the campus landscaped area and the ratio of landscaped area per student did not vary among the three groups.

Chapter V
Natural Landscape Features and Student Performance

The previous chapter was devoted to gaining an overview of the high school campuses in terms of the sites themselves and the surrounding areas, especially as these relate to opportunities for students to be exposed to nature. The socio-economic status of the student body was found to play an important role not only with respect to the demographics of the student body, but particularly with respect to the physical environment including campus location and size as well as nature affordances.

The focus of this chapter is to relate the physical characteristics of the high school campuses to student performance. Here again the concentration is on the characteristics that relate to contact with nature opportunities. Four other variables (i.e., school socio-economic status, ethnic/racial makeup, age of main building, enrollment) also are included in the analysis, to control for their separate effects on student performance.

Student Performance

Student performance was evaluated in terms of both academic achievement and behavior, all measured at the aggregate school level. Academic achievement was assessed in three different ways, through the investigations of the percentages of students who were recipients of the Michigan Merit Award, graduation rates, and the percentages of graduating seniors planning to continue their education at a four-year college (Table 3.5 of Chapter III). Student behaviors were measured in two ways, by examining the relative frequency of student disorderly behavior and the occurrences of student criminal behavior at each school (Table 3.7 of Chapter III).

As shown in Table 5.1 these performance measures were strongly related to school socio-economic status (i.e., percent of students participating in the National School Lunch Program). Students in the three different school groups performed very differently on all of the academic achievement and behavior measures used in this study. All of the differences favored the students in the more economically advantaged schools relative to the least advantaged high schools. The moderately advantaged schools were similar to the most advantaged schools with respect to graduation rate and the behavior measures, more similar to the least advantaged schools with respect to four-year college plans, and in-between the two other groups with respect to Merit Award winners.

TABLE 5.1
Student Performance Grouped by Economic Advantage

	Least Advantaged High Schools (n = 37)	Moderately Advantaged High Schools (n = 28)	Most Advantaged High Schools (n = 36)	F-value
Student Academic Achievement				
Merit Award Winners (%)	17.8 [a] n = 37^	35.9 [b] n = 28	51.9 [c] n = 34	92.24***
Graduate Rates (%)	80.3 [a] n = 36	92.6 [b] n = 28	95.3 [b] n = 33	26.07***
Four-year College Plans (%)	48.1 [a] n = 23	47.2 [a] n = 20	67.0 [b] n = 35	17.45***
Student Behavior				
Student Disorderly Conduct (relative frequency rating)	1.8 [a] n = 36	1.2 [b] n = 28	1.0 [b] n = 34	18.05***
Student Criminal Activity (number of incidents)	13.9 [a] n = 36	5.5 [b] n = 28	5.6 [b] n = 34	6.31**

* $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.
[a] Means sharing a superscript are not significantly different from one another using Tukey's HSD bivariate comparisons or Chi-Square analysis.
^ Data for some of the high schools were either missing from the Michigan Department of Education annual report or not reported by the high school.

Benefits of Increased Landscape Naturalness

Explanation of Regression Models

Regression analyses were used to explore the effects that physical characteristics (i.e., school landscape, building features) and school policies have on the five

performance outcome variables mentioned above. Separate analyses were conducted to investigate these effects on each outcome variable.

In each regression analysis, the first independent variables entered were the four control variables. These variables consisted of school socio-economic status, ethnic/racial makeup of the student body, age of the main building, and enrollment. These four variables were introduced into the models to control for factors known to be strongly related to student performance. These variables were kept in the model regardless of whether they were significant predictors of a particular outcome variable. These control variables are shown for all of the results.

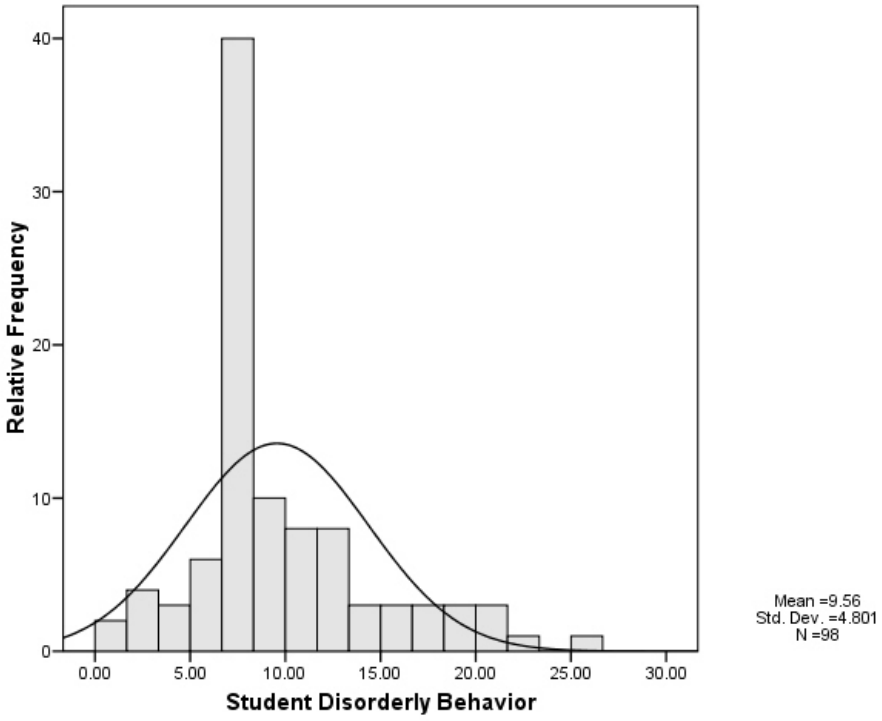
Four sets of independent variables, or models, were examined. In the first model, the candidate predictors consisted of the regional and neighborhood variable group. This group included both school location and the amount of nature in the areas bordering the school site (Table 3.1 of Chapter III). The second model consisted of campus nature features as the predictors, including campus site areas and natural elements (Tables 3.2 and 3.3 of Chapter III). In the third model, building features that potentially affected student exposure to nature were entered as the candidate predictors (Table 3.4 of Chapter III). Finally, the fourth model was composed of school policies that influenced students' direct contact with nature both on and off campus (Table 3.4 of Chapter III).

For each of the four models, the candidate predictors were entered individually, although always with the control variables, to determine which were separately significant. The significant predictors discovered during this first stage were then, in the second stage, entered together using stepwise-type regression procedures (including forward selection, stepwise, and backward elimination methods). Researchers have "recommended that all the procedures be applied in the hopes of either seeing some agreement or learning something about the structure of the data that might be overlooked by using only one selection procedure" (Montgomery, Peck, & Vining, 2001, p. 316). Thus the results reported in Tables 5.2 through 5.5 below include only those candidate

predictors that were found to be significant in all three stepwise-type selection procedures for each respective model.

There is one further complication that needs to be mentioned before looking at any of the results. For the academic achievement measures, linear regression models were used. The student behavior measures, however, required alternative approaches. Disorderly behaviors and student criminal activity occur relatively rarely, and thus generate highly skewed distributions. This type of data has a distribution that is not normal. As a consequence, these two behavior measures are not well estimated by linear regression models (Figures 5.1 and 5.2).

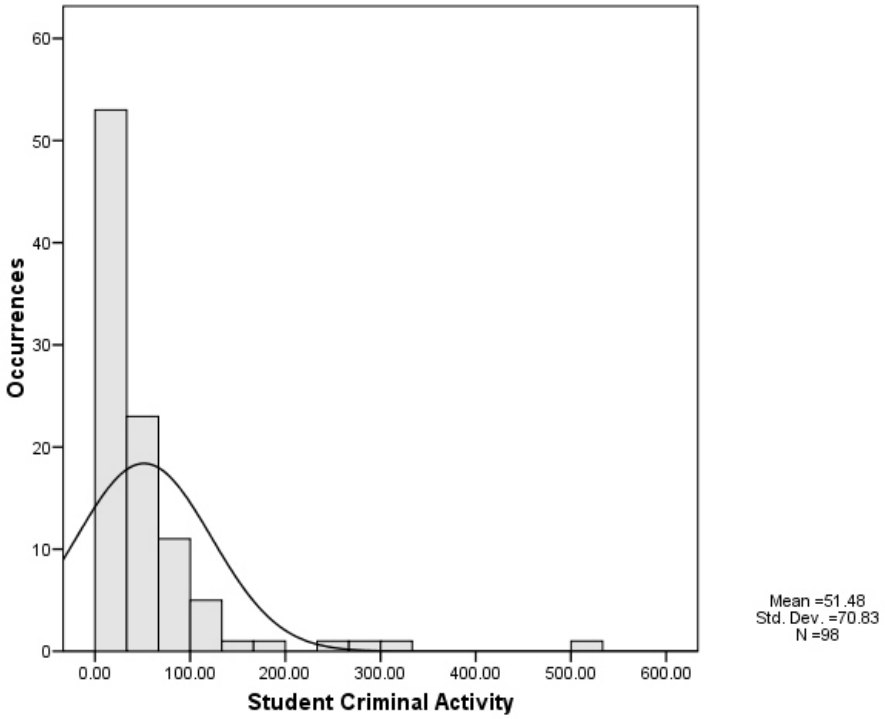
FIGURE 5.1
Distribution of Student Disorderly Behavior



For the student disorderly behavior, the Poisson generalized linear regression model was used. This model is specifically suited for many types of count data (Gujarati, 2003). However, the Poisson regression model could not be used for the other behavior

measure, student criminal activity. The data distribution for this variable was over-dispersed, which means that the variance was much larger than the mean. For this variable, the mean was 51.48 occurrences with a standard deviation of 70.83 (i.e., variance = 5016.93). In this situation, the negative binomial generalized linear regression model provides better estimates and, therefore, was used to analyze student criminal activity (Gujarati, 2003)[4].

FIGURE 5.2
Distribution of Student Criminal Activity



[4] Note that for both the Poisson and negative binomial regression models pseudo R-squared changes are being reported. An equivalent statistic to the linear regression R-squared does not exist for generalized linear regression models. The model estimates from generalized linear models are maximum likelihood estimates calculated with an iterative process. These estimates are not calculated to minimize variance, so the linear regression method to judge goodness-of-fit does not apply. However, several pseudo R-squared measurements have been developed. The Cox and Snell's pseudo R-squared was used in this study. These measurements are called "pseudo" R-squared because they look like R-squared in that their values range from 0 to 1 and higher values indicate a better model fit. However, pseudo R-squareds should not be interpreted in the same manner as R-squared. A pseudo R-squared "only has meaning when compared to another pseudo R-squared of the same type, on the same data, predicting the same outcome. In this situation, the higher pseudo R-squared indicates which model better predicts the outcome" (UCLA Academic Technology Services, 2008, para. 12). In addition, in generalized linear models, "goodness of fit is of secondary importance. What matters is the expected signs of the regression coefficients and their statistical and/or practical significance" (Gujarati, 2003, p. 606).

Model 1 – Regional and Neighborhood Characteristics

Students attending schools situated near farmland or in close proximity to other public or private schools have a lower likelihood of planning to continue to four year colleges (Note here and in subsequent analyses that the number of observations for this dependent variable is much lower than for the other student performance measurements. A number of schools did not survey their outgoing students, particularly many of the less economically advantaged ones). In addition, schools bordered by medical offices, such as a doctor's or dentist's office, have higher graduation rates as compared with the other schools (Table 5.2).

Two other neighborhood characteristics played a significant role, relating to student behavior outcomes. Greater usage levels of the street in front of a given school are related to fewer occurrences of student criminal activities. The results also show that the presence of churches in the bordering neighborhood is associated with fewer incidences of student disorderly behaviors.

Model 2 – Campus Natural Characteristics

The availability of a view of nature from the cafeteria window is a strong positive predictor with respect to each of the academic achievement measures (Table 5.3). It helps to explain the variances of Michigan Merit Award winner percentages, graduation rates, and indications of continuing to four-year colleges.

Achievement measures are also related to how the campus area is used. The percentage of the campus landscaped areas devoted to lawns, the parking lot area to student ratio, and the size of the athletic fields are all associated with a lower likelihood of students continuing on to four year colleges. Furthermore, the percentage of the landscaped area on the school grounds that was devoted to lawns is also negatively related to students receiving Merit Awards and positively related to student criminal behavior (Table 5.3).

TABLE 5.2

Student Performance Regressed onto
Regional and Neighborhood Characteristics

	Dependent Variables				
	Student Academic Achievement			*Student Behavior*	
Independent Variables	Michigan Merit Award	Graduation Rates	Four-Year College Plans	Student Disorderly Conduct	Student Criminal Activity
Control Variables					
School SES	0.78	0.53	0.38	-0.01^	-0.05^
Ethnicity (% of students)		-0.37	0.27		-0.02^
Building Age (years)					
Enrollment (# of students)					
Adjusted R Square – Control Variables	0.68	0.67	0.17		
Pseudo R-squared – Control Variables				0.36^^	0.42^^
Candidate Predictors: Regional and Neighborhood Characteristics					
Farmlands (%)			-0.40 (15.5%)		
Schools (%)			-0.30 (7.5%)		
Churches (%)				-.03^ (9.2%)	
Medical Offices (%)		0.16 (2.4%)			
Street Usage Level (rating)					-0.44^ (5.9%)
Observations	98	96	77	98	98
Adjusted R Square – Entire Model	0.68	0.69	0.40		
Pseudo R-squared – Entire Model				.45^^	0.48^^

Note: Beta results that appear are significant at the .05 level. For each significant predictor variable of a dependent variable, the corresponding percentage of the variance explained is listed below the Beta.

^ Nonstandardized B values reported for Poisson and negative binomial generalized linear regression models.

^ ^ Pseudo R-squared values are reported for the Poisson and negative binomial generalized linear regression models.

TABLE 5.3

Student Performance Regressed onto Campus Natural Characteristics

	Dependent Variables				
	Student Academic Achievement			*Student Behavior*	
Independent Variables	Michigan Merit Award	Graduation Rates	Four-Year College Plans	Student Disorderly Conduct	Student Criminal Activity
Control Variables					
School SES	0.74	0.46	0.56	-0.01^	-0.05^
Ethnicity (% of students)		-0.41	0.29		-0.02^
Building Age (years)			-0.27		
Enrollment (# of students)					
Adjusted R Square - Control Variables	0.68	0.67	0.17		
Pseudo R-squared – Control Variables				0.36^^	0.42^^
Candidate Predictors: Campus Natural Characteristics					
Athletic Field Area (acres)			-0.24 (3.6%)		
Parking Area/Student (sq ft/student)			-0.32 (6.6%)		
Lawn/Landscaped Area (%)	-0.13 (1.5%)		-0.29 (13.6%)		0.02^ (3.4%)
Cafeteria View Naturalness Level (rating)	0.19 (3.7%)	0.17 (2.8%)	0.27 (8.7%)		
Observations	98	96	77	98	98
Adjusted R Square – Entire Model	0.73	0.69	0.49		
Pseudo R-squared – Entire Model				0.36^^	.46^^

Note: Beta results that appear are significant at the .05 level. For each significant predictor variable of a dependent variable, the corresponding percentage of the variance explained is listed below the Beta.

^ Nonstandardized B values reported for the Poisson and negative binomial generalized linear regression models.

^ ^ Pseudo R-squared values are reported for the Poisson and negative binomial generalized linear regression models.

Model 3 – Building Characteristics

All three of the significant building characteristic predictors (Table 5.4) may have their effect through altering views of nature afforded from within the school. Larger cafeteria windows are positive predictors with respect to Michigan Merit Award, while the window area in classrooms added significantly to the variability in explaining both four-year college plans and student criminal activity. Furthermore, taller high school buildings – possibly affording more distant views – also predict students' inclinations to continue to four-year colleges.

TABLE 5.4

Student Performance Regressed onto Building Features

	Dependent Variables				
	Student Academic Achievement			*Student Behavior*	
Independent Variables	Michigan Merit Award	Graduation Rates	Four-Year College Plans	Student Disorderly Conduct	Student Criminal Activity
Control Variables					
School SES	0.78	0.49	0.60	-0.01^	-0.05^
Ethnicity (% of students)		-0.40	0.45		-0.02^
Building Age (years)					
Enrollment (# of students)					
Adjusted R Square - Control Variables	0.68	0.67	0.17		
Pseudo R-squared – Control Variables				0.36^^	0.42^^
Candidate Predictors: Building Characteristics					
Classroom Window Area (sq ft)			0.28 (9.7%)		-0.01^ (8.5%)
Cafeteria Window Area (rating)	0.17 (2.6%)				
Building Height (stories)			0.26 (5.7%)		
Observations	98	96	76	98	97
Adjusted R Square – Entire Model	0.70	0.67	0.32		
Pseudo R-squared – Entire Model				0.36^^	0.51^^

Note: Beta results that appear are significant at the .05 level. For each significant predictor variable of a dependent variable, the corresponding percentage of the variance explained is listed below the Beta.

^ Nonstandardized B values reported for the Poisson and negative binomial generalized linear regression models.

^ ^ Pseudo R-squared values are reported for the Poisson and negative binomial generalized linear regression models.

Model 4 – School Policies

The two school policies included in the study – those that might impact students' opportunities to have nature opportunities during the course of the school day – both relate to student achievement. In fact, both the policy permitting students to eat lunch outdoors and the "open campus" policy are significantly related to the number of Michigan Merit Award recipients. The open campus policy is also associated with four-year college plans (Table 5.5). While over half (51.5%) of the schools allowed students to eat lunch outdoors, the open campus policy was far more restrictive, with only 9.9% of

TABLE 5.5

Student Performance Regressed onto School Policies

	Dependent Variables				
	Student Academic Achievement			*Student Behavior*	
Independent Variables	Michigan Merit Award	Graduation Rates	Four-Year College Plans	Student Disorderly Conduct	Student Criminal Activity
Control Variables					
School SES	0.74	0.49	0.52	-0.01^	-0.05^
Ethnicity (% of students)		-0.40	0.50		-0.02^
Building Age (years)					
Enrollment (# of students)					
Adjusted R Square - Control Variables	0.68	0.67	0.17		
Pseudo R-squared – Control Variables				0.36^^	.42^^
Candidate Predictors: School Policies					
Eat Lunch Outdoors (%)	0.13 (1.3%)				
Open Campus (%)	0.20 (4.6%)		0.29 (7.8%)		
Observations	98	96	77	98	98
Adjusted R Square – Entire Model	0.74	0.67	0.25		
Pseudo R-squared – Entire Model				0.36^^	.42^^

Note: Beta results that appear are significant at the .05 level. For each significant predictor variable of a dependent variable, the corresponding percentage of the variance explained is listed below the Beta.

^ Nonstandardized B values reported for the Poisson and negative binomial generalized linear regression models.

^ ^ Pseudo R-squared values are reported for the Poisson and negative binomial generalized linear regression models.

the schools permitting students to leave campus during the lunch break without prior permission (Table 3.4 of Chapter III). Further analysis also revealed that over 80% of the outdoor lunch areas in the schools studied are situated just outside the primary cafeteria windows. In addition, all of these lunch sites are located in the campus landscaped areas.

Combining Environmental Characteristics

For each of the student performance measures, a final model was developed. This model was formulated by entering all of the significant predictors from the corresponding four separate models together. Stepwise-type regression procedures were used to select the predictors for the final model. Only the predictors that were found to be significant in

all three stepwise-type selection procedures are discussed below. Table 5.6 shows the correlations among all of the predictors from the four models.

Table 5.7 shows the results for each of the student achievement and behavior outcome variables. For two of these, graduation rates and student disorderly behavior, each of the predictors from their respective four models remained significant. For the other three performance measures, on the other hand, some of the predictors that had been significant in the four separate models were not significant in this final stage and were dropped in the final models. In these instances, when potentially confounding variables are controlled for, the unique contributions of the some of these predictors are no longer significant at the .05 level (L. Zhang, personal communication, April 7, 2008). The predictors selected in the final models in all cases are significantly correlated with the dropped variables (Tables 5.6 and 5.7). These selected predictors can be considered for this set of data as better predictors of the corresponding dependent variables (K. Welch, personal communication, May 2, 2008).

For example, for the performance measure involving Michigan Merit Award recipients, the cafeteria window area and the policy of eating outdoors were not significant in the final model. In this case, the level of naturalness in the cafeteria window view is correlated with both cafeteria window area ($r = 0.68$, $p < .01$) and the policy of eating outdoors ($r = 0.49$, $p < .01$). Cafeteria view naturalness level is perhaps a more effective measure than building features and school policies.

For student college plans, the presence of other schools in the bordering neighborhood, athletic field area, and building height were no longer significant predictors in the final model (Table 5.7). In this instance, the presence of bordering farmland is correlated with bordering schools ($r = 0.26$, $p < .01$) and athletic field area ($r = 0.34$, $p < .01$). Parking area per student is also correlated with athletic field area ($r = 0.34$, $p < .01$). In addition, lawn percentage of the landscape is correlated with building height ($r = -0.29$, $p < .01$). Thus, one can argue that the presence of farmland, parking area per student, and lawn percentage of the landscape are better predictors of

TABLE 5.6

Correlations among Predictors from the Four Regression Models

	Farmlands (%)	Schools (%)	Churches (%)	Medical Offices (%)	Street Usage Level (rating)	Athletic Field Area (acres)	Parking Lot Area (acres)	Lawn/ Landscaped Area (%)	Cafeteria View Nature Level (rating)	Classroom Window Area (sq ft)	Cafeteria Window Area (rating)	Building Height (stories)	Eat Lunch Outdoors (%)	Open Campus (%)
Farmlands (%)	1													
Schools (%)	.261(**)	1												
Churches (%)	-0.147	-0.097	1											
Medical Offices (%)	-0.101	0.128	0.147	1										
Street Usage Level (rating)	-.299(**)	-0.140	.255(*)	.215(*)	1									
Athletic Field Area (acres)	.339(**)	0.151	-0.158	-0.067	-0.052	1								
Parking Lot Area (acres)	0.012	-0.082	-0.171	0.077	0.033	.542(**)	1							
Lawn/Landscaped Area (%)	.221(*)	0.184	-0.083	-0.092	-.280(**)	.352(**)	0.153	1						
Cafeteria View Nature Level (rating)	0.022	-.224(*)	-0.088	0.025	0.024	0.126	0.070	0.016	1					
Classroom Window Area (sq ft)	-0.167	-0.189	0.135	-0.023	0.187	-0.154	-0.088	-0.179	0.036	1				
Cafeteria Window Area (rating)	-0.014	-0.041	-0.068	0.100	0.119	0.137	.213(*)	-0.066	.679(**)	0.195	1			
Building Height (stories)	-.258(**)	-.318(**)	0.015	0.073	0.104	-.215(*)	-0.007	-.290(**)	.197(*)	.235(*)	0.055	1		
Eat Lunch Outdoors (%)	0.136	-0.026	-0.133	-0.056	-0.050	0.172	0.194	-0.045	.490(**)	0.109	.421(**)	0.009	1	
Open Campus (%)	-0.042	-0.033	0.145	0.111	0.027	-0.076	-0.099	0.029	.297(**)	0.123	.284(**)	0.056	0.189	1

** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed).

TABLE 5.7

Student Performance Regressed onto All Four Categories of School Characteristics

	Dependent Variables				
	Student Academic Achievement			*Student Behavior*	
Independent Variables	Michigan Merit Award	Graduation Rates	Four-Year College Plans	Student Disorderly Conduct	Student Criminal Activity
Control Variables					
School SES	0.75	0.50	0.46	-0.01^	-0.05^
Ethnicity (% of students)		-0.37	0.29		-0.02^
Building Age (years)			-0.29		
Enrollment (# of students)					
Adjusted R Square - Control Variables	0.68	0.67	0.17		
Pseudo R-squared – Control Variables				0.36^^	0.42^^
Candidate Predictors: Regional and Neighborhood Characteristics					
Farmlands (%)			-0.32 (15.4%)		
Schools (%)			– [a]		
Churches (%)				-.03^ (9.2%)	
Medical Offices (%)		0.15 (2.2%)			
Street Usage Level (rating)					-0.43^ (5.0%)
Candidate Predictors: Campus Natural Characteristics					
Athletic Field Area (acres)			–		
Parking Lot Area/Student (sq ft/student)			-0.23 (2.2%)		
Lawn/Landscaped Area (%)	-0.13 (1.5%)		-0.25 (10.0%)		–
Cafeteria View Naturalness Level (rating)	0.14 (1.7%)	0.16 (2.8%)	0.21 (4.1%)		
Candidate Predictors: Building Features					
Classroom Window Area (sq ft)			0.24 (3.8%)		-0.01^ (8.5%)
Cafeteria Window Area (rating)	–				
Building Height (stories)			–		
Candidate Predictors: School Policies					
Eat Lunch Outdoors (%)	–				
Open Campus (%)	0.18 (4.6%)		0.19 (7.7%)		
Observations	98	96	76	98	97
Adjusted R Square – Entire Model	0.76	0.71	0.59		
Pseudo R-squared – Entire Model				0.45^^	0.56^^

Note: Beta results that appear are significant at the .05 level. For each significant predictor variable of a dependent variable, the corresponding percentage of the variance explained is listed below the Beta.

[a] A dash indicates that a predictor was dropped from the final model.

^ Nonstandardized B values are reported for the Poisson and negative binomial generalized linear regression models.

^ ^ Pseudo R-squared values are reported for the Poisson and negative binomial generalized linear regression models.

college plans than the presence of adjacent schools, athletic field area, and building height.

Lastly, for student criminal activity, lawn percentage of the landscape was no longer a significant predictor in the final model. Lawn percentage of the landscape ($r = -0.28$, $p < .01$) is correlated with street usage level. The latter is perhaps the more important predictor of criminal behavior than the size of the campus lawn areas.

Table 5.7 shows that for four of the five student performance measures the added contribution of the environmental variables, beyond the control variables, is between 4-14% of the variance. For the four-year college plans the pattern is substantially different. The control variables account for only 17% of the variance, and an additional 42% is attributable to environmental considerations (Recall that this analysis excludes many of the less advantaged schools).

In summary, all three of the achievement measures are significantly and positively impacted by having cafeteria view of natural areas. Two of the achievement measures – Merit Award recipients and students planning to attend four year colleges – are also positively related to having less area devoted to lawns and to having an open school policy. Intention to attend a four year college is positively predicted by a lack of farmland nearby, a lower amount of per student parking, and larger classroom window areas. Lastly, student criminal behavior is negatively associated with larger classroom windows and greater street usage.

Summary

For each of the student performance measures used in this study, four separate linear regression models were developed. The results reveal that a predictor from each of the four sets of independent variables is significantly associated with one or more performance measure. These sets correspond to different facets of student potential exposure to nature, namely regional and neighborhood characteristics, campus natural

elements, building features, and school policies. All of the significant predictors from these four separate models were then entered together in a final combined model for each respective performance measure. In the next chapter, patterns both in the ways that these predictors affect student performance, and in the ways that some of these predictors were dropped from the final model for each performance measure are explored.

Chapter VI
Beneficial and Non-Beneficial Campus Landscape Features

The regression analyses presented in the previous chapter provide consistent evidence for the importance played by the natural environment on student performance. A variety of measures support this conclusion. This chapter examines the pattern of results by focusing on specific ways in which the natural environment impacts student performance.

The Importance of Student Background

The school socio-economic status, measured by participation in the National School Lunch Program, is a strong predictor in each of the analyses presented in the previous chapter. Furthermore, the racial/ethnic makeup accounts for significant variance in explaining high school graduation rates, plans to continue to four-year colleges, and student criminal activity. Building age and size of high school, however, have minimal impact on the outcome variables.

Across the various regression analyses, the four background variables accounted for as much as two-thirds of the variance in explaining Michigan Merit Award recipients and graduation rates and 36-42% of the variance with respect to student behavior. With respect to students' plans to continue on to four-year colleges, the control variables explained only 17% of the variance. However, for this dependent variable, almost one-fourth of the sample could not be included in the analyses as not all schools report this information. Generally speaking, the poorer schools are less likely to be included in the analysis for this outcome measure, possibly accounting for this unexpected result.

The focus of this research, however, is on the role played by environmental variables. The findings of the regression analyses suggest that landscape features of the high school campus and bordering neighborhood do significantly influence student performance. These effects remain significant even after controlling for the influences of school socio-economic status, ethnic/racial makeup of the student body, age of the school facilities, and enrollment. While economic and demographic variables are well documented as being related to student academic achievement, the role played by environmental characteristics has received far less attention. Predictors from each of the four categories of independent characteristics were found to explain a significant additional portion of the variance for each outcome variable.

The Benefits of Views of Nature

Lunch Time

The most prominent findings center on student exposure to more natural landscapes during their lunch time. Three different but related predictors were associated with all three student achievement measures, particularly the percentage of Merit Award recipients.

The most consistent result involves the view content from each school's main cafeteria window. Views with higher nature content are positively associated with each of the three measures of student academic achievement, explaining between 3.7% and 8.7% of their variance (Table 5.3 of Chapter V).

Second, the area of the primary cafeteria windows is positively associated with Merit Award recipients in the building features model (Table 5.4 of Chapter V). Additional analysis revealed that cafeteria windows are also significantly correlated with cafeteria window naturalness levels ($r = 0.68$, $p < .01$). Therefore, the schools with larger cafeteria windows provide their students not only with larger views of the outside environment, but also with views containing greater quantities of natural features.

Third, the policy of allowing students to eat lunch outdoors is positively related to higher percentages of Merit Award winners in the school policy model (Table 5.5 of Chapter V). Further examination found that a significant correlation exists between schools that allow students to eat outdoors and both higher levels of naturalness in the cafeteria view ($r = 0.49$, $p < .01$) and greater tree densities in the campus landscaped areas ($r = 0.21$, $p < .05$). Over 80% of the outdoor eating areas in these schools are situated just outside the primary cafeteria windows and all of these areas are sited in the campus landscaped areas. Therefore, students who are able to eat outside are being provided with landscapes views that have greater quantities of trees and other natural elements.

Classroom Views

The positive effects of viewing more natural landscapes are not limited just to lunch time. Having larger classroom window areas, on average, is associated with greater percentages of students planning to attend four-year colleges and fewer occurrences of student criminal behaviors, explaining 9.7% and 8.5% of the variance respectively (Table 5.4 of Chapter V). While data were not collected on the types of views provided by these classroom windows, there is a significant correlation between window area and tree density in the landscaped areas, ($r = 0.27$, $p < .01$). Thus, the view from classrooms with larger window area is more likely to include greater concentrations of trees in the landscapes surrounding the classroom buildings and in the interior courtyards.

It is worth noting that the percentage of classrooms with windows was not a predictor of any of the student performance measurements. Others (e.g., Collins, 1975; Weinstein, 1979) have commented on the inconsistent findings with respect to the relationship between the availability of windows in classrooms and student performance. An explanation for such a lack of consistent association may be due to the failure to examine what is available in the view. A view devoid of high levels of natural features may be only slightly better than not having any view at all. Specifically, with regard to the student performance measures used in this study, such a view may not benefit

students to a measurable level when compared to a lack of a view. Additional support for this contention is provided by the final regression model for Merit Award recipients. In this model, all of the significant predictors from the four separate models were entered together (Table 5.7 of Chapter V). This analysis indicated that both cafeteria window area and the school policy of allowing students to eat outdoors no longer remain significant predictors. The content of the view from the lunch area is perhaps a more important statistical predictor than the size of this view or more direct access to these lunch area landscapes.

The Importance of a View

The findings of this study suggest that greater quantities of natural features in the landscape adjacent to school buildings do not benefit the students unless they can be easily viewed from the building windows or the outdoor lunch area. None of the measures concerning trees and shrubs in the landscape adjacent to the school buildings (i.e., tree density in the landscaped or parking lot areas, shrub area, shrub percentage of the landscaped area) is directly associated with any of the student performance measures. Instead, the benefits of these landscape elements are revealed only by examining the effects of the view content provided by a school's cafeteria and classroom windows, and the school policy of allowing students to eat lunch outdoors.

Explanation

The results from this study indicate that larger views of more natural landscapes from the cafeteria, outdoor eating area, and classrooms are associated with improved student scholastic achievement and behavior. These findings most directly support those of past studies investigating the beneficial effects of views of nature on school campuses (Heschong Mahone Group, 2003a; Tennessen & Cimprich, 1995). If one accepts the proposition that the school and office workplace environments are similar, the findings of this study also support the workplace studies documenting the many beneficial effects of nature views on office worker performance, morale, and feelings of well-being (Heerwagen & Wise, 1998; Heschong Mahone Group, 2003b; R. Kaplan, 1993; Leather et al., 1998).

Both attention restoration and the psycho-evolutionary theories provide explanations for why greater quantities of natural features in classroom and cafeteria window views are positively related to greater student performance. As proposed by attentions restoration theory, higher levels of natural features would provide more softly fascinating elements that would aid the processes of resting an individual's direct attention and recovery from mental fatigue. In accord with the psycho-evolutionary theory, greater nature content will provide a more visually pleasing physical surrounding that will in term reduce stress. As reviewed in Chapter II, a reduction in mental fatigue and stress should lead to better student academic achievement, lower occurrence of disorderly behavior, and greater overall student satisfaction with school.

The results from this study suggest, moreover, that the landscape views that students are exposed to at lunch time may be as important as those they experience while in the classroom. While both attention restoration and psycho-evolutionary theories provide an explanation for the benefits of higher levels of viewed nature content, as discussed above, the propositions of attention restoration theory offer additional explanations (R. Kaplan & Kaplan, 1989; S. Kaplan, 1995). Lunch time may provide students with one of the best opportunities during the school day to take a break from the learning process. During this time, one or more of the proposed four sequential stages of mental restoration can take place. These stages represent deepening levels of restorativeness, and each stage requires both more time and higher quality restorative settings. Students may have an opportunity during lunch to "clear their head" of miscellaneous thoughts from previous events of the school day, rest their directed attention, deal with unresolved concerns, and reflect on their respective lives, priorities, possibilities, values, actions, and goals. Reflection represents the final level of restorativeness, and "is the most demanding of all in terms of both the quality of the environment and the duration required" (R. Kaplan & Kaplan, 1989, p. 197). Higher nature levels in the views available from the lunch areas would aid in the number of restorative stages each student may be able to attain. Although the nature content of classroom window views is important, students may not have adequate periods of time for the latter of the four stages of restoration during class time. While in class, students

are under a teacher's constant supervision and are busy concentrating on the lessons being presented. Indeed, the reflection process may be equated with daydreaming, a behavior that is definitely frowned upon by most teachers.

Of the five student performance measures used in this study, the percentage of Merit Award winners is the only one associated with all three predictors connected with the lunch area of each school. The level of naturalness of the view afforded by the primary cafeteria window, cafeteria window area, and the school policy of eating outdoors are all positive predictors of this outcome variable. The Merit award is presented to students based on their performance on a required standardized test. As suggested above, lunch time may provide students with one of the better opportunities to restore their fatigued mental faculties. The ability to concentrate on the information being presented during class time is a vital component of the learning process. One could argue, therefore, that of the five measures of student performance utilized in this study, Merit Award percentages is the one most closely appraising the ability of students to concentrate during class.

Landscapes Features with Non-beneficial Effects

Landscapes Lacking in Natural Features

The regression results suggest that large expanses of landscapes lacking in natural features both within a campus and in the bordering neighborhood are not favorable to student performance. Greater percentages of lawns in the campus landscaped areas are associated with fewer students receiving Merit Awards and planning to attend four-year colleges, and an increase in student criminal behavior. Further analysis revealed that lawn percentage is negatively correlated with tree density in the landscaped areas of the schools investigated in this study ($r = 0.49$, $p < .01$). Higher percentages of farmland in the bordering neighborhood and larger campus parking lots, and athletic fields, are also related to fewer students planning to attend four-year colleges. In addition, greater percentages of public and private schools in the bordering neighborhood are negatively

associated with student college plans. One can argue that an adjoining school equates with additional nearby parking lots, athletic fields, and large expanses of featureless lawns (Tables 5.2 and 5.3 of Chapter V).

Further evidence of the negative influence of large areas of landscapes lacking in natural features can be found by reviewing how the levels of naturalness in a school's main cafeteria window view were defined. As discussed in the method chapter, to receive the highest rating, 3, the view had to be "mostly natural," in other words dominated by trees, shrubs, and natural features other than lawns. Views made up primarily of large expanses of lawns without many trees, or with athletic fields, were given a rating of "mostly built" or 2. Higher levels of naturalness in these views, as discussed above, are positive predictors of all three measurements of student academic achievement.

Lastly, more indications of the negative influence of featureless landscape are shown in the final regression model for the four-year college plans outcome variable (Table 5.6 of Chapter V). In this model, where all of the predictors from the four separate models are entered together, the percentage of the bordering neighborhood made up of farmlands, the lawn percentage of the landscape, and the amount of parking area per student are all strong negative predictors of student college plans, accounting for 15.4%, 10.0%, and 7.7% of the variance, respectively. Farmlands, lawns, and parking lots represent landscapes that are particularly lacking in distinctive features, to an even greater extent than the presence of neighboring school landscapes and campus athletic fields – environmental characteristics that were eliminated in the final regression model. Athletic fields, in many instances, contained bleachers, baseball backstops, tennis courts, football goal posts, and were surrounded by fences. One could speculate, therefore, that the greater level of featurelessness present in farmlands, lawns, and parking lots is the underlying reason for their greater predictive powers.

Explanation

In the context of work settings and dormitories, prior research has shown increased employee frustration and stress as well as decreased performance and satisfaction with the environment when nature was unavailable or less available in the immediate view (Heschong Mahone Group, 2003a, 2003b; R. Kaplan, 1993; Leather et al., 1998; Tennessen & Cimprich, 1995). None of these past investigations, though, help to explain the deleterious influences of large expanses of featureless lawns or farmlands on student academic achievement and behavior being reported here. After all, these featureless settings are made up primarily of natural elements, including mowed grass and farm crops. Yet, as the findings reported here document, the mere presence of natural elements is not sufficient. An explanation for these apparently contradictory results is available by linking the findings of studies in the diverse fields of landscape preference, residential neighborhood satisfaction, and student productivity.

Landscape preference research has consistently shown that large, flat landscapes lacking in natural features are often aesthetically less preferred, as compared to other natural settings (R. Kaplan & Kaplan, 1989; Schroeder, 1987; Ulrich, 1986). Studies have also revealed that views of less preferred landscapes are associated with lower levels of neighborhood satisfaction and senses of well-being (R. Kaplan, 2001; Kearney, 2006). In addition, researchers have determined that student psychological well-being and satisfaction with academic life are positively related to measures of school performance and productivity (Chambel & Curral, 2005; Chow, 2007; S. J. Cotton et al., 2002). View preference and senses of well-being and satisfaction have not, however, been studied in the school context. Nonetheless, the effect of these variables in school settings could be expected to be similar to their effect in other environments in which people live, study, and work. Further study would help to test the appropriateness of this explanation for the negative relationships that exist in this study between views of landscapes lacking in natural features and student performance.

The Importance of Proximity

The findings of this study indicate that in addition to the ability of students to view natural features in the landscape (e.g., trees, shrubs), the proximity to these features is also an important factor. Only when natural features in the landscape are adjacent to the school buildings (e.g., cafeteria view naturalness level, density of trees in the landscape) are there direct or indirect positive effects on student performance. None of the measures concerning natural features that existed farther away from the school buildings is a significant positive predictor of performance. These ineffective measures include density of trees in the parking lots, distance to forest remnants either on campus or in adjacent properties, and the percentages of the bordering neighborhood consisting of woodlands and parks (e.g., recreational parks, golf courses). One might speculate that natural features fade into the background out of the viewer's mind, becoming ineffective, as their distance from the viewer increases.

Explanation

The propositions of attention restoration theory furnish an explanation for this outcome (R. Kaplan & Kaplan, 1989; S. Kaplan, 1995). Some natural features that are softly fascinating, and which allow directed attention to rest and provide an opportunity for reflection, may only be effective in relatively close proximity to the viewer. For example, the "motion of leaves in the breeze," "the play of light on foliage" (R. Kaplan & Kaplan, 1989, pp. 192-193), or the movement of small animals (e.g., squirrels, small birds) may not be noticeable if the observer is too far away. In other words, there may be a distance restriction on the restorative effects that certain natural features can afford.

In contrast, many of the landscapes lacking in natural features that are negatively associated with student performance are located farther from the school buildings. These include athletics fields, parking lots, and farmland. The effects of these featureless settings remain detrimental even at great distances. It is the very lack of distinctiveness and structure that makes these settings ineffective at aiding restoration and thus improving student performance. What is lacking in such settings is unlikely to be

replaced as their distance from the viewer is increased. This too is an area requiring further research.

Influences from Beyond the Campus Border

While interesting to note, regional differences are less likely to play a direct role with respect to student performance since the students only encounter the adjacent land uses while traveling to and from school. Furthermore, school administrations have little control over these land uses and changes that might occur to adjacent land. Some of the characteristics of the bordering neighborhood, though, were found to influence student performance. As already mentioned, greater percentages of farmland and schools bordering a given school are related to a decrease in students planning to attend a four-year college.

The open campus policy is also potentially pertinent to the regional scale issues as it permits students to leave campus during the lunch period. Open campus policy was found to be related to both higher percentages of Merit Award recipients and students planning to attend a four-year college. Perhaps some of these students use this opportunity to eat lunch in more natural settings in the nearby neighborhood. Of course, a number of other factors can also explain this positive relationship between this school policy and student performance. Such a policy may reflect the presence of a greater sense of trust between the students and the school administrators. This trusting relationship could be the reason students perform better at these schools. Likewise, this policy may be producing students who are more responsible. Students who are given the responsibility to leave and return to school during lunch may become more accountable in other aspects of life as well. Nonetheless, the findings of other studies suggest that any opportunity to view or directly experience more natural surroundings can result in many psychological, social, and behavioral benefits (Hartig et al., 2003; R. Kaplan, 1993; Ulrich et al., 1991).

Furthermore, higher percentages of the bordering neighborhood occupied by medical or dental offices and churches are associated with superior graduation rates and fewer incidences of student disorderly behaviors, respectively. In addition, greater usage levels of the street in front of a given school are related to fewer occurrences of student criminal activities. These findings do not relate to the level of landscape naturalness, and explanations for them are necessarily speculative. Perhaps a medical center that is visible from school grounds provides a tangible representation of rewarding careers that are achievable only by graduating from high school and continuing on to higher education. Likewise, a church adjacent to a school may provide a visible symbol of religious admonitions concerning how one should treat fellow humans. In addition, the student criminal activities measure involves such observable deeds as physical violence, vandalism, and verbal assault. These are behaviors that can be noticed by the general public if undertaken outside of the school buildings. A busy street in front of the school equates with more people potentially watching student outdoor activities both during and after school hours. Such surveillance may discourage the occurrence of some of these criminal behaviors (Jacobs, 1961; Newman, 1972).

Lastly, differences due to the regional location of the schools, that is whether the school was situated in an urban, urban-fringe, or rural area, are not associated with student performance. The explanation may center on what is viewable from the school buildings. Regional differences cannot be viewed during the bulk of the school day, but only while traveling to and from school. Therefore, these differences may have much less influence on the students.

Summary

The findings of the regression analyses conducted in this study are consistent with those of related past studies and while providing new insights into the benefits of viewing nature. First, in agreement with prior school research, student background, involving socio-economic status and racial/ethnic background, remains a very important predictor of academic achievement and problem behaviors. Second, in accord with the two past

studies concerning campus window views, larger classroom and cafeteria window areas and greater vegetation content in the views provided are associated with higher student academic achievement.

The results also add to our understanding of the benefits of viewing natural landscape features. First, permitting students to spend lunch time where they can experience nature nearby may provide them an exceptionally beneficial opportunity to recover from mental fatigue and stress. Higher levels of natural features at school lunch sites may significantly support the process of reflection, and provide a more restorative experience for the students. Past studies examining the physical environment of schools have neglected to consider the possible effects of lunch site features on student achievement and behavior.

Second, the findings of this study suggest that trees and shrubs need to be in close proximity to the viewer to be of more benefit. Natural features that are far away from the observer may not provide the softly fascinating elements needed for reflection and recovery from mental fatigue.

Third, large expanses of vegetated landscapes lacking in natural features (i.e., lawns, athletic fields, farmlands) are associated with poorer student performance. The viewing and experience of some forms of vegetation may not be as beneficial as others. Prior studies have not investigated the effects that different types of vegetation have on individuals. In many cases, researchers have grouped trees, shrubs, and grass together into a general, all-inclusive category of vegetation.

Fourth, higher levels of natural features near school buildings do not benefit the students if they cannot be easily viewed from the classroom or lunch area. To truly benefit students, therefore, views of the landscape from inside school buildings should be given as much consideration as those from important viewing positions outside the building.

Lastly, natural features of the campus landscapes explained 5.2% of the variance in the test scores required to be a recipient of the Michigan Merit Award (Table 5.3 of Chapter V). This is comparable to the reported 3-6% of the variance in test scores explained by school building features in prior research (Earthman, 2004; National Research Council, 2006). The often overlooked outdoor physical environment of schools can perhaps have as much influence on student performance as the more intensely examined indoor features.

Chapter VII
Conclusions

This chapter begins with an overview of the study and its major findings. Before turning to the implications of these findings for the design of high school campuses, some limitations inherent in this kind of research are discussed. The chapter ends with suggestions for future research as well as concluding thoughts.

Overview of the Study

High school students may be under more stress today than ever before. The competition that students face in the college application process and school work loads have increased to unprecedented levels in recent years. Students have a great need for restorative and stress reducing environments. In addition, high school dropout rates in major urban areas throughout the country are high and student satisfaction with the high school experience has decreased significantly in recent years. At the same time, a growing body of research outside the context of schools has documented the many benefits to human well-being provided by views of and access to natural features. Attention restoration and psycho-evolutionary theories provide widely cited explanations for why nature contact results in improvements to work performance, mental functioning, physical and emotional health, socially acceptable behaviors, and satisfaction with one's social and physical environment. It is conceivable, therefore, that high school landscapes have an effect on student achievement and behavior.

The purpose of this study was to investigate the relationships between specific campus landscape features and diverse measures of student performance. Although adolescents spend a major portion of their waking hours in their school building, there

has been little attention paid to the potential effect of this physical setting on their behavior and academic achievement. Even less attention has been paid to the potential effect of nearby nature on student performance. The insights provided by the findings can aid school administrators and designers in building and renovating campus landscapes in ways that may reduce student mental fatigue and stress levels, increase satisfaction with the school environment, and enhance overall performance.

High schools were chosen for this study because they tend to be larger, with greater diversity of landscape features and layouts than elementary or middle schools. In addition, high school outdoor environments have been much less studied than those of elementary schools. This study investigated 101 public high schools located in the southeastern region of the state of Michigan. The schools selected were restricted to one region in an effort to reduce differences in campus layouts and building designs, school district policies, and regional cultures and climate.

The independent variables consisted of four control variables and four categories of potential predictors. The control variables were introduced to address differences among the schools concerning aggregate student socio-economic status, racial/ethnic makeup of the student body, building age, and size of enrollment. The categories of predictors consisted of regional and neighborhood characteristics, campus natural elements, and building features and school policies related to student access to the outdoor physical environment. The dependent variables were five measures of student performance. Student academic achievement was measured with the percentage of Michigan Merit Award recipients, graduation rates, and the four-year college plans of graduating seniors at each school. Student behavior at a given school was measured with annual reports required by the state of Michigan concerning incidents of student disorderly behavior and criminal activity.

The findings of the descriptive analyses revealed that school socio-economic status is related to many differences among the schools studied. These disparities involve school demographics, location, types of adjacent land uses, campus site elements, and

building features and school policies affecting student access and direct exposure to the outdoor environment. Most of these differences favor the higher status schools.

The results of the linear regression analyses revealed that school socio-economic status is very strongly related to all five measures of student performance used in this study. This finding is in agreement with a large body of research concerning student achievement that has explored the influence of factors other than the school physical environment (e.g., school enrollment, class size, teacher quality, peer group effect). School socio-economic status along with racial/ethnic composition, building age, and enrollment were controlled for in all of the regression models used in this study. Nevertheless, even after controlling for these factors, the regression analyses uncovered significant effects from environmental characteristics and school policies. In particular, features of the campus outdoor environment, as well as building characteristics and school policies related to the students' potential access to these features, influence student academic achievement and behavior. First, larger cafeteria and classroom window views and higher levels of nature content in these views are associated with higher standardized test score, graduation rates, and percentages of students planning to attend college, and lower occurrences of student criminal behavior. Second, natural landscape elements must be in relatively close proximity to the viewers to achieve these beneficial effects. Third, large expanses of landscapes lacking in natural features are detrimentally related to test scores, college plans, and student disorderly and criminal behavior rates. Lastly, school lunch policies related to student potential exposure to the outdoor environment during the school day, namely eating outdoors and having an open campus policy, are associated with enhanced test scores and college plans.

Both attention restoration and psycho-evolutionary theories provide explanations for the beneficial effects that views of and access to natural features in the campus landscape can have on student performance. Psycho-evolutionary theory focuses on the affective response to the environment. While attention restoration theory is thought of as concentrating exclusively on the qualities of the environment that support mental restoration, this theory also focuses on an affective response to beauty to explain what it

refers to as "soft fascination." This is important in the present context since attention restoration theory also offers insights into why the landscape views that students experience at lunch time may be as important as, if not more important than, those from classroom windows. In addition to the characteristics of the physical environment, both a sufficient amount of time and the process of reflection may be needed to more fully recover from mental fatigue. The lunch break may provide students with the time required as well as soft fascination, both of which support reflection. In addition, attention restoration theory provides an explanation for why natural landscape features need to be in close proximity to students to be of most benefit. A distance restriction may exist for the softly fascinating restorative qualities of natural features. Lastly, landscape preference research, in combination with studies concerning satisfaction with residential neighborhood landscapes and the connections between student satisfaction with academic life and productivity, provides an explanation for the non-beneficial influences of large expanses of featureless campus lawns and bordering farmlands. These landscapes are not aesthetically preferred, and this quality may detrimentally affect students' satisfaction with their school physical surroundings and ultimately their productivity.

Study limitations

Given the geographical context of the study, it is difficult to determine whether the results would apply to areas with distinctly different weather, natural settings, or more spread out campus configurations. Before turning to these limitations with respect to external validity, however, some other potential weakness of the study need to be discussed. These concern the focus on aggregate information for entire schools, the consequences of highly skewed distributions with respect to some of the variables, the quality of the available information about student performance and conduct, and limitations with respect to campus variables.

School as Unit of Measure

The unit of measure utilized in this study was individual schools rather than the students themselves. Although there is likely to be substantial variation in student

academic achievement, behavior, and socio-economic and ethnic/racial backgrounds at each school, concentrating on the level of the entire school offered many advantages. First, the schools showed vast variation with respect to their physical characteristics. At the same time, however, it is virtually impossible to determine the extent of contact each student has with the diversity of physical characteristics at the school. Second, high school students move about the building and campus during the school day. To track the characteristics of the classrooms each student used during the school day would have been a daunting if not an impossible task. Third, the student performance measures were readily available only at the school level. Accessing such information for each student would have required the permission of the school district, school, and parents or guardians of each student. The process of obtaining this permission would not only have been time consuming, but would have likely yielded a biased sample especially with respect to student conduct. Therefore, due to these theoretical and practical considerations, this study was performed at the school rather than individual student level.

Outlier Considerations

The schools included in the study ranged widely in terms of many potentially pertinent variables. This readily leads to outliers, a few cases that are distinct from the rest with respect to some issue. The inner city schools were a source of many outliers in the independent and dependent variables, particularly for all five of the dependent variables measuring student performance. As a result, the regression analyses for each dependent variable were conducted twice, once with all 101 schools sampled and again without the inner city schools. A conservative stance was adopted in this study. Only those potential predictors that remained significant in both analyses were reported. In addition, the outliers for each independent variable, involving both the control and potential predictor variables, were closely examined. In all instances, a strong case could not be established for the removal of any of these outliers, and none was omitted in the regression results reported.

Performance Measures

The dependent variables used in the study – MEAP test scores, graduation rates, and student disorderly and criminal behavior rates – are all required by the state of Michigan. Nonetheless, there are many causes for inaccuracies in these publicly available data. Since these data are used for accountability purposes, leading to funding outcomes for the schools, administrators may provide inaccurate records. Critics contend that these centralized educational policies have resulted in widespread dishonest reporting on all three of these school performance measures (Uzzell, 2005). In addition, researchers have reported that disciplinary reports may reflect school and district policies more than they do actual incident rates. Some schools may have stricter supervision and disciplinary measures than others. Moreover, disincentives to report student behavior problems include the fear of appearing incompetent and the loss of potential local and state political and financial support (Fisher, 2001; Welsh, Greene, & Jenkins, 1999). Thus, although these are reasonable and appropriate measures, their accuracy is difficult to verify.

Classroom and Campus Boundary Designations

Classroom use was based on school maps provided by each school. The percentage of classrooms that had windows and the average area of the classroom windows at each school were calculated only for the standard classroom (e.g., history, literature, math, science). Classrooms used for teaching art, computer skills, home economics, and shop (e.g., auto, wood, metal), and other specialized classrooms (e.g., planetariums, greenhouses) were not included in these computations. However, some of the school maps were poorly labeled and in other instances a given classroom was used for multiple purposes or had recently shifted in use. Thus, there are likely to be inaccuracies in the variables used to indicate classroom window percentages and area.

The locations of the school boundaries were estimated through the use of aerial photographs. Due to time constraints during the data collection period, the exact locations of the property lines were not obtained from county offices. Additional difficulties were encountered when a high school was bordered by a public elementary or

middle school. These adjoining schools had athletic fields and parking lots that were sometimes shared or connected. In these circumstances, the exact boundary of the high school property could only be roughly approximated.

External validity

While there was a substantial variation in size of schools and campus layouts represented within the study sample, the basic high school footprint in the study region is based on a single building. In warmer parts of the country (e.g., southern California), by contrast, a high school may consist of a series of buildings with outdoor walkways connecting them. These considerations can have direct consequences in terms of students' exposure to the outdoors during the school day.

Even the opportunity to eat lunch outdoors – available in about half of the schools in the study – is unlikely to lead to exposure to the outdoors. Southeastern Michigan experiences extended winters that discourages students from leaving the school building for about half of the school year. Students in warmer regions of the country are exposed to the outdoor environment as they walk from class to class, during breaks, and at lunch time. The results of this study, then, may not be fully applicable to schools in locales with a drastically different climate. Additional investigations involving schools from diverse regions of the country are needed to substantiate the claims made from the findings of this study.

Implications

Despite these limitations, this study provides insights that are likely to be broadly pertinent. This may be the first study that provides evidence of the impact of exposure to nearby nature on student behavior and on the life course plans of young people. The study also is unique in providing information regarding particular landscape characteristics that may contribute to these patterns in adolescents' behavior and plans. The findings thus point to some concrete high school campus design guidelines that are

applicable both with respect to new or planned schools and to improvements of existing campuses.

New Campus Landscapes

A school district may wish to build a new high school campus for this region of the country. What types of building and landscape features should be promoted? First, the findings of this study suggest that large classroom and cafeteria window areas should be provided. Such features would maximize students' views to the outdoors during the school day. This might be especially important for students attending high schools in regions of the country with climates similar to that of southeastern Michigan. During the extended winters of this area, a view through a window is the primary contact with nature that many of these students will have. In fact, to protect the students from the harsh climate, 86.1% of the high schools studied consisted of one large building or connected smaller buildings. The students do not have to walk outside to move among classrooms. In addition, due to the climate, students who are allowed to eat lunch outdoors will probably choose to do so only during the warmer months of the school year.

Second, it matters what is in the view. The views from classroom and cafeteria windows should be filled with natural features such as trees and shrubs. Many schools place the bulk of the trees and shrubs by the front door to the main building. While these features may be pleasant for visitors to the school to look at, in many instances only the school administrators in the front offices are able to view this vegetation during the school day. Rather than planning the landscape only from important viewpoints outside the school building, the designers should also consider the types of views students will have from the building. In addition, distance seems to affect how influential natural features are to student performance. Hence, this vegetation should be planted relatively close to the classroom and cafeteria windows. If there are concerns about safety and blocked sightlines, lower growing shrubs can be used and trees can be pruned so that their trunks branch at a height above six feet.

Third, views from classroom and cafeteria windows of large expanses of lawns, parking lots, and athletic fields lacking in natural features (e.g., shrubs, trees) should be minimized. For example, large lawn areas can be reduced in size through the use of flower beds, groundcovers, and shrubs in lieu of mowed grass. Detention ponds instead of lawns offer an additional option. In Michigan and other states throughout the country, building codes are requiring the construction of on-site retention ponds to handle storm water runoff in large-scale developments. Instead of hiding these ponds on the back edges of the school property, they could be redesigned with native wetland vegetation and placed near the school buildings. Such settings could be used to increase student awareness of ecological processes and incorporated into the lesson plans of science classes. Furthermore, these areas could provide pleasant outdoor environments where students can eat lunch. One of the newer schools investigated in this study successfully designed their retention ponds for just these purposes. In addition, if large parking lots and athletic fields must be included in the design, these features can be located as far away as possible from the school buildings and strategically located outside the views from the majority of classroom and cafeteria windows. In addition, both parking lots and athletic fields can be further hidden through the use of hedges, trees, and mounds of earth.

Fourth, sightlines from the streets surrounding the schools should not be blocked by vegetation or other landscape features. The findings of this study suggest that such views are associated with fewer incidents of student criminal activity. Criminal activity by nonstudents on high school campuses may also be deterred. Low growing shrubs and groundcovers and high branching trees can provide both the benefits of having natural features in close proximity to the students and maintaining additional surveillance from the surrounding neighborhood.

Lastly, designers of a new school may believe that student performance can be positively affected by natural features of the campus landscape, but may have a very limited landscape budget. The findings of this study suggest that the designers should first concentrate on improving the area where students eat lunch. Large cafeteria

windows should be built and the views provided should be filled with large amounts of closely planted trees and shrubs. There are two reasons for adopting this strategy. First, as discussed in Chapter V, the lunch period may provide one of the best opportunities during the school day for students to restore their fatigued mental states. This period of the day offers one of the few opportunities that students have to relax, take a short break, and reflect on important issues of the day. Second, almost all of the schools investigated in this study (i.e., 91.9%) require their students to eat lunch at school. Although these students may not share the same classrooms during the school day, they do share the same lunch sites. Hence, vegetation planted by the eating areas will be experienced by a greater percentage of the students than those placed anywhere else on campus.

Existing Campus Landscapes

A school district may wish to renovate the landscape of an existing high school campus. If the budget of the school district is limited or if the school district wishes to prioritize which part of the outdoor environment to work on first, the landscapes that can be viewed from the lunch areas should be at the top of the list, for the reasons discussed above. Trees and shrubs should be planted near the cafeteria windows and outdoor eating areas. Next, trees and shrubs should be planted close to the classroom buildings so that they are easily viewed from the classroom windows. In the schools studied, the density of trees in the campus landscaped areas averaged 12.4 trees per acre, with the greatest density at 35.0 trees per acre (Table 3.3 of Chapter III). These densities correspond to overall tree spacings of about 59 feet and 35 feet respectively. In comparison, municipal parks and recreation departments typically recommend a spacing for public parks and streets of at least 35 feet for large trees (i.e., mature size over 60 feet), 25 feet for medium sized trees (i.e., mature size from 30-60 feet), and 15 feet for small trees (i.e., mature size of less than 30 feet) (Los Angeles Department of Recreation and Parks, 2008; Portland Parks & Recreation, 2008). Many more trees can be planted on the public high school campuses studied since their average tree densities are well below these guidelines.

After improving the landscape views from the cafeteria and classroom windows, the next phase of the renovation might concentrate on altering large areas of lawns,

parking lots, and athletic fields. If these features exist, large sections of mowed grass can be reduced through the introduction of additional plantings of perennials, groundcovers, shrubs, and trees. Large areas of lawns, parking lots, and athletic fields can also be broken up into visually smaller spaces with the strategic placement of vegetation. In addition, views of parking lots and athletic fields from classroom windows can be blocked with trees and hedges.

The entrances at most of the schools examined in this study were adequately landscaped. Unfortunately, for almost all of these same schools, this area was the only part of the campus that had been adequately landscaped. In addition, for almost all of the schools studied, the views from the majority of the classrooms and both indoor and outdoor lunch areas do not look out at this front area. Finally, most of the students drive, arrive on the school bus, or are driven to school by their parents. At most of the schools examined, students who drive or are driven to school enter and leave the school building from a side entrance rather than the front door. These students may rarely view the vegetation located at the front entrance during the entire school day. These patterns of existing landscaping and building arrangements may or may not represent the norm throughout most of the country, and each school should be examined on a case-by-case basis.

School Policies

Schools should be encouraged to allow students to eat outdoors during lunch and to have an open campus. Both of these policies are significantly associated with enhanced student academic achievement.

Future Directions and Conclusions

The results of this study provide insights into the effects that campus landscape elements, as well as policies concerning student access to these elements, have on student performance. While some of the findings are congruent with prior research (e.g., Heschong Mahone Group, 2003a), many of the issues the study raises have not been

previously investigated. As such the findings here serve as a first step and point to the importance of further studies.

The Lunch Venue

Features of the lunch area were found to be associated with all three measures of student academic achievement. Greater levels of naturalness in cafeteria window views, larger cafeteria window area, and the policy of allowing students to eat outdoors are related to higher test scores, graduation rates, or percentages of students planning to attend a four-year college. These results suggest that the physical makeup of the lunch setting can be an important factor in student performance. Researchers have commented on the inconsistent findings with respect to the relationship between windowed versus windowless classrooms, or daylit versus nondaylit+ classrooms, and student performance (Collins, 1975; Heschong Mahone Group, 2003a; National Research Council, 2006; Weinstein, 1979). It is likely that these studies did not consider the nature of the school lunch area, and this omission may help to explain some of the inconsistencies.

The findings of this study support the notion that lunch time may provide students with a valuable break from the learning process. Students can recover from mental fatigue and stress, and reflect on events that occurred during the first portion of the school day. Future studies examining the effects of the school physical environment on student academic achievement or behavior should take into account differences in the physical characteristics of lunch areas.

Seeing Nature Nearby

The beneficial effects of greater densities of trees and shrubs in classroom and cafeteria window views appear to decrease the farther these features are from the viewer. At a certain distance these features may no longer provide an effective restorative environment. In addition, higher levels of natural features benefit students only if they can be easily viewed from the classroom or lunch areas. In the schools examined in this study, a view through a window is the primary contact that most of these students will have with nature during a typical school day. It would be appropriate for future studies

on the role of windows to include not only the amount of nature in the view but its proximity as well.

Non-Beneficial Landscape Elements

It is also important to realize that not all forms of campus vegetation are associated with benefits to student performance. While greater densities of trees and shrubs were found to be related to increases in all three measures of student academic achievement, greater areas of lawn and athletic fields are associated with a decrease in the percentages of students planning to attend a four-year college and an increase in student criminal activities. Here again, there are direct implications for campus planning as well as future research opportunities. For example, future studies could determine the most effective means of negating the detrimental effects of large expanses of landscapes lacking natural features. Perhaps these negative influences can be decreased simply by blocking the views of these areas from classroom and student lunch areas. Or, maybe these large expanses should be divided to create smaller areas. Trees, shrubs, or flowering perennials, or perhaps a certain combination of all three of these elements, may negate the negative effect of large parking lots and lawn areas.

Offsetting Student Stress and Mental Fatigue

The benefits provided by contact with nature during the school day for the students may operate through decreasing mental fatigue, stress, or another as yet unidentified factor. Today's high school students may be experiencing unprecedented levels of school related stress. Both attention restoration and the psycho-evolutionary theories provide possible explanations for why nature contact is restorative. Attention restoration theory also supplies rationales for why nature contact at lunch time may be just as important as during class time, and why natural features may have to be in close proximity to the viewer to be of benefit. An explanation for the negative associations that exist in this study between large expanses of landscapes devoid of natural features and better student performance is not as straightforward. Research findings concerning landscape preference, residential neighborhood satisfaction, and student productivity studies can be linked to explore this issue. Further studies will be needed, though, to

confirm that the findings concerning view preference and satisfaction in the context of residential neighborhoods can be extended to the school environment.

Conclusions

High school students today are experiencing unprecedented levels of school related stress. A growing body of research outside the context of schools has attributed the many benefits of nature contact to a reduction in stress and restoration from mental fatigue. Perhaps more than ever before, these troubled and stressed students are in need of the proverbial "walk in the woods." Although providing such an opportunity during the course of the school day may not feasible, some forms of nature can still be brought directly to the students.

The findings of this study suggest that larger views offering greater quantities of natural landscape features (i.e., trees, shrubs) from classrooms and lunch areas can benefit student academic achievement and behavior. The presence of more trees and shrubs in the campus landscape has been connected with higher test score, graduation rates, and percentages of student planning to attend a four year college, and lower occurrences of problem behaviors. In addition, the magnitude of the benefits provided by greater student exposure to nature was found to be as substantial as those associated with better school building and classroom features.

These results, as well as those of similar studies investigating the relationships between campus landscape elements and student performance, call for action on the part of school administrators, school boards, and designers of high school campuses. Natural landscape features are often valued only for their aesthetic qualities and considered as luxuries rather than as necessities. Given the relative low cost of providing nearby trees and shrubs and the high potential benefit in terms of student performance and behavior, it is hard to justify such an amenity perspective. This study's findings have linked the benefits of greater nature contact not only to the current performance of students, but also to their future college plans. Regardless of the socio-economic level of the school, high

school students seem to benefit from visual access to nearby nature during their school day. The students as well as society as a whole, have much to gain from properly designed high school landscapes. Current students attending such schools will benefit and the returns on the funds spent will continue throughout the lifetimes of both these landscapes and the graduates themselves.

Appendices

APPENDIX A
The Public High Schools Examined in this Study

Lenawee County School Districts	
Addison Community Schools	*Onsted Community Schools*
Addison High School 219 North Comstock Street Addison, Michigan 49220	Onsted Community High School 10109 Slee Road Onsted, Michigan 49265
Adrian City School District	*Tecumseh Public Schools*
Adrian High School 785 Riverside Avenue Adrian, Michigan 49221	Tecumseh High School 760 Brown Street Tecumseh, Michigan 49286
Morenci Area Schools	
Morenci High School 788 East Coomer Street Morenci, Michigan 49256	

Livingston County School Districts	
Brighton Area Schools	*Howell Public Schools*
Brighton Area Schools 125 South Church Street Brighton, Michigan 48116	Howell Public Schools 411 North Highlander Way Howell, Michigan 48843

Monroe County School Districts	
Bedford Public Schools	*Jefferson Schools*
Bedford Senior High School 8285 Jackman Road Temperance, Michigan 48182	Jefferson High School 5707 Williams Road Monroe, Michigan 48162
Dundee Community Schools	*Monroe Public Schools*
Dundee High School 130 Viking Drive Dundee, Michigan 48131	Monroe High School 901 Herr Road Monroe, Michigan 48161
Ida Public School District	*Summerfield School District*
Ida High School 3145 Prairie Street Ida, Michigan 48140	Summerfield High School 17555 Ida West Road Petersburg, Michigan 49270

Oakland County School Districts	
Avondale School District	*Novi Community School District*
Avondale High School 2800 Waukegan Road Auburn Hills, Michigan 48326	Novi High School 24062 Taft Road Novi, Michigan 48375
Berkley School District	*Oak Park City School District*

Berkley High School
2325 Catalpa Drive
Berkley, Michigan 48072

Birmingham City School District

Earnest W. Seaholm High School
2436 West Lincoln Road
Birmingham, Michigan 48009

Wylie E. Groves High School
20500 West 13 Mile Road
Beverly Hills, Michigan 48025

Bloomfield Hills School District

Andover High School
4200 Andover Road
Bloomfield Hills, Michigan 48302

Lahser High School
3456 Lahser Road
Bloomfield Hills, Michigan 48302

Clarenceville School District

Clarenceville High School
20155 Middlebelt Road
Livonia, Michigan 48152

Clarkston Community School District

Clarkston High School
6093 Flemings Lake Road
Clarkston Michigan 48346

Clawson City School District

Clawson High School
101 John M Avenue
Clawson, Michigan 48017

Farmington Public School District

Farmington High School
32000 Shiawassee Street
Farmington, Michigan 48336

Harrison High School
29995 W. 12 Mile Road
Farmington Hills, Michigan 48334

North Farmington High School
32900 West 13 Mile Road
Farmington Hills, Michigan 48334

Ferndale Public Schools

Ferndale High School
881 Pinecrest Street
Ferndale, Michigan 48220

Oak Park High School
13701 Oak Park Boulevard
Oak Park, Michigan 48237

Oxford Area Community Schools

Oxford High School
745 North Oxford Road
Oxford, Michigan 48371

Pontiac City School District

Pontiac Central High School
300 West Huron Street
Pontiac, Michigan 48341

Rochester Community School District

Rochester High School
180 South Livernois Road
Rochester Hills, Michigan 48307

Stoney Creek High School
575 East Tienken Road
Rochester Hills, Michigan 48306

School District City of Royal Oak

George A. Dondero High School
709 North Washington Avenue
Royal Oak, Michigan 48067

Clarence M. Kimball High School
1500 Lexington Boulevard
Royal Oak, Michigan 48073

South Lyon Community Schools

South Lyon High School
1000 N. Lafayette
South Lyon, Michigan 48178

Southfield Public School District

Southfield High School
24675 Lahser Road
Southfield, Michigan 48034

Southfield-Lathrup High School
19301 West 12 Mile Road
Lathrup Village, Michigan 48076

Troy School District

Athens High School
4333 John R Road
Troy, Michigan 48085

Troy High School
4777 Northfield Parkway
Troy, Michigan 48098

Hazel Park City School District
Hazel Park High School
23400 Hughes Avenue
Hazel Park, Michigan 48030

Holly Area School District
Holly High School
6161 East Holly Road
Holly, Michigan 48442

Huron Valley Schools
Lakeland High School
1630 Bogie Lake Road
White Lake, Michigan 48383

Lake Orion Community Schools
Lake Orion Community High School
495 East Scripps Road
Lake Orion, Michigan 48360

Lamphere Public Schools
Lamphere High School
610 West 13 Mile Road
Madison Heights, Michigan 48071

Madison Public Schools (Oakland)
Madison High School
915 East 11 Mile Road
Madison Heights, Michigan 48071

Walled Lake Consolidated Schools
Walled Lake Central High School
1600 Oakley Park Road
Commerce, Michigan 48390

Walled Lake Northern High School
6000 Bogie Lake Road
Commerce Township, Michigan 48382

Walled Lake Western High School
600 Beck Road
Walled Lake, Michigan 48390

Waterford School District
Waterford Kettering High School
2800 Kettering Drive
Waterford, Michigan 48329

Mott High School
1151 Scott Lake Road
Waterford, Michigan 48328

West Bloomfield School District
West Bloomfield High School
4925 Orchard Lake Road
West Bloomfield, Michigan 48323

Washtenaw County School Districts

Ann Arbor Public Schools
Huron High School
2727 Fuller Road
Ann Arbor, Michigan 48105

Pioneer High School
601 West Stadium Blvd.
Ann Arbor, Michigan 48103

Chelsea School District
Chelsea High School
740 North Freer Road
Chelsea, Michigan 48118

Dexter Community School District
Dexter High School
2200 North Parker Road
Dexter, Michigan 48130

Lincoln Consolidated School District
Lincoln High School
7425 Willis Road
Ypsilanti, Michigan 48197

Milan Area Schools
Milan High School
200 Big Red Drive
Milan, Michigan 48160

School District of Ypsilanti
Ypsilanti High School
2095 Packard Road
Ypsilanti, Michigan 48197

Whitmore Lake Public Schools
Whitmore Lake High School
8877 Main Street
Whitmore Lake, Michigan 48189

Wayne County School Districts

Dearborn City School District
Dearborn High School
19501 Outer Drive

Huron School District
Huron High School
32044 Huron River Drive

Dearborn, Michigan 48124

Edsel Ford High School
20601 Rotunda Drive
Dearborn, Michigan 48124

Fordson High School
13800 Ford Road
Dearborn, Michigan 48126

Dearborn Heights School District

Annapolis High School
4650 Clippert Street
Dearborn Heights, Michigan 48125

Detroit City School District

Chadsey High School
5335 Martin Street
Detroit, Michigan 48210

Communications & Media Arts High School
14771 Mansfield Street
Detroit, Michigan 48227

Finney High School
17200 Southampton Street
Detroit, Michigan 48224

Mackenzie High School
9275 Wyoming Street
Detroit, Michigan 48204

Murray-Wright High School
2001 W. Warren Avenue
Detroit, Michigan 48208

Northern High School
9026 Woodward Avenue
Detroit, Michigan 48202

Osborn High School
11600 E. 7 Mile Road
Detroit, Michigan 48205

Southeastern High School
3030 Fairview Street
Detroit, Michigan 48214

Southwestern High School
6921 W. Fort Street
Detroit, Michigan 48209

Ecorse Public School District

Ecorse Community High School
New Boston, Michigan 48164

Lincoln Park Public Schools

Lincoln Park High School
1701 Champaign Road
Lincoln Park, Michigan 48146

Livonia Public Schools

Churchill High School
8900 Newburgh Road
Livonia, Michigan 48150

Franklin High School
31000 Joy Road
Livonia, Michigan 48150

Adlai E. Stevenson High School
33500 W. Six Mile Road
Livonia, Michigan 48152

Melvindale-Northern Allen Park Schools

Melvindale High School
18656 Prospect Street
Melvindale, Michigan 48122

Northville Public Schools

Northville High School
45700 Six Mile Road
Northville, Michigan 48168

Plymouth-Canton Community Schools

Canton High School
8415 Canton Center Road
Canton, Michigan 48187

Salem High School
46181 Joy Road
Canton, Michigan 48187

Plymouth High School
8400 Beck Road
Canton, Michigan 48187

Redford Union School District

Redford Union High School
18499 Beech Daly Road
Redford, Michigan 48240

Riverview Community School District

Riverview Community High School
12431 Longsdorf Street
Riverview, Michigan 48193

Romulus Community Schools

Romulus High School
9650 S. Wayne Road
Romulus, Michigan 48174

South Redford School District

Lee M. Thurston High School

27385 West Outer Drive
Ecorse, Michigan 48229

Flat Rock Community Schools

Flat Rock Community High School
28100 Aspen Drive
Flat Rock, Michigan 48134

Garden City School District

Garden City High School
6500 Middlebelt Road
Garden City, Michigan 48135

Gibraltar School District

Oscar A. Carlson High School
30550 W. Jefferson Avenue
Gibraltar, Michigan 48173

Grosse Ile Township Schools

Grosse Ile High School
7800 Grays Drive
Grosse Ile, Michigan 48138

Grosse Pointe Public Schools

Grosse Pointe North High School
707 Vernier Road
Grosse Pointe Woods, Michigan 48236

Grosse Pointe South High School
11 Grosse Pointe Boulevard
Grosse Pointe Farms, Michigan 48236

Hamtramck Public Schools (no web site)

Hamtramck High School
11410 Charest Street
Hamtramck, Michigan 48212

26255 Schoolcraft Road
Redford, Michigan 48239

Southgate Community School District

Southgate Anderson High School
15475 Leroy Street
Southgate, Michigan 48195

Taylor School District

John F. Kennedy High School
13505 Kennedy Drive
Taylor, Michigan 48180

Trenton Public Schools (no web site)

Trenton High School
2601 Charlton Road
Trenton, Michigan 48183

Van Buren Public Schools

Belleville High School
501 West Columbia Avenue
Belleville, Michigan 48111

Wayne-Westland Community Schools

John Glenn High School
36105 Marquette Street
Westland, Michigan 48185

Woodhaven-Brownstown School District

Woodhaven High School
24787 Van Horn Road
Brownstown, Michigan 48134

Wyandotte City School District

Roosevelt High School
540 Eureka Road
Wyandotte, Michigan 48192

APPENDIX B
Definitions of the Six Public High School Student Criminal Activities Used in this Study

(Michigan Department of Education, 2006)

Illegal Possession – the number of incidents that occurred during the past school year that involved the illegal use, possession or sale of a controlled substance, prescription drug or narcotic on school property or at a school-sponsored activity.

Larceny – the number of larcenies or thefts that occurred on school property or at a school-sponsored activity over the past school year. An incident requiring mandatory reporting involves one of the following: theft in excess of $100 or numerous events of minor theft (less than $100).

Minor in Possession – number of incidents of a minor in possession of alcoholic liquor or when law enforcement was called as a result of a minor in possession of alcoholic products on school property or at a school-sponsored activity over the past school year.

Physical Violence – the number of incidents of physical assaults between a student and another person(s) that were reported to law enforcement or that resulted in suspension or expulsion. These incidents must have occurred over the past school year on school property or at a school-sponsored activity. A physical assault means intentionally causing or attempting to cause physical harm to another through force or violence.

Vandalism – the number of incidents of vandalism or destruction of school property over the past school year. Other property crimes to be reported include, but are not limited to, theft and graffiti. Incidents of arson that result in property damage should be reported as arson. An incident requiring mandatory reporting involves one of the following: damage in excess of $100, numerous events of minor damage (less than $100), or damage that is gang related.

Verbal Assault – a verbal assault such as name-calling, racial or ethnic slurs, or derogatory statements addressed to others designed to precipitate disruption, incite violence, or impede the school program.

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