



## Research Paper

## Green urban landscapes and school-level academic performance



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## HIGHLIGHTS

- Represented student environments with school attendance areas.
- Found positive relationship between urban intensity and school reading performance.
- Observed positive relationship between tree cover and school reading performance.
- No significant relationships between environment and school math performance.
- Results support idea that urban nature is related to academic success.

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## ABSTRACT

The growing disconnect between humans and nature has implications for human well-being. Research has linked exposure to nature with various benefits including improved focus, vitality, productivity, and reduced stress, factors that may enhance the academic performance of individual students. In intensively-urbanized landscapes with few natural elements this effect could, via aggregated population-level impacts, influence the academic performance of entire populations, negatively affecting educational attainment and propagating urban poverty. Designing urban environments to provide increased interaction with natural landscape elements such as vegetation could mitigate this effect, benefiting the academic growth and future success of urban students. Recent studies support this idea; however, this effect is poorly understood, hindering the management of urban environments to improve educational outcomes. This study explores relationships between urban nature and the academic performance of urban schools using the Twin Cities Metropolitan Area of Minnesota, USA as a case study area. We used regression analysis to identify relationships among environmental variables on and around school campuses (i.e., tree cover, vegetated land covers, water) and four measures of population-level third-grade reading and mathematics success, accounting for school socioeconomic and demographic characteristics. Contrary to expectations, we found a positive relationship between impervious surfaces and reading performance, while relationships between two vegetated land covers (grass, shrub) and water bodies and both mathematics and reading academic success were non-significant. We found a significant, positive relationship between tree cover and reading performance, suggesting that initiatives aimed at increasing tree cover in student environments could support academic success.

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## 1. Introduction

Today's populations inhabit increasingly urban environments. Over half of the world's population is now urban, a number that is projected to grow to 70% by 2050 (UNPD, 2012). This progressively more urban population is increasingly disconnected from the natural world, given the shift in the typical person's daily environment from largely natural (i.e., vegetated) to built. "Nature-deficit dis-

order" (Louv, 2008), a phrase used to describe the costs to human well-being associated with separation from the natural world, is of particular concern for the development of children in this urban world. The relationship between children and natural systems is recognized as critical to their development, influencing spiritual and cognitive growth, and mental and physical well-being (Kahn & Kellert, 2002; Kellert, 2005, 2009). The current disconnect between urban children and natural systems thus has major implications for their present and future well-being (Kellert, 2009; Kimball, Schuhmann, & Brown, 2009). Of particular concern are impacts on cognitive functioning and development associated with reduced contact with nature in urban settings that could limit academic performance and success in life. In intensively-urbanized land-

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scapes, settings where most children have little to no contact with nature, this could affect not only individual students, but entire populations, propagating urban poverty via negative impacts on cognitive development and educational attainment. Remedying this disconnect by designing and managing urban landscapes to increase opportunities for interaction with nature (e.g., through the provision of parks and vegetation) could serve to enhance academic success and the overall well-being of urban populations. Very little empirical evidence exists to support this notion, however, reducing our ability to plan and design urban landscapes to enhance educational success.

Present research supports the idea that urban blue and green environments, waterways, and vegetated environments in urban settings benefit human well-being. Existing studies indicate that these environments enhance physical health (Kardan et al., 2015; Wheeler et al., 2015; White, Alcock, Wheeler, & Depledge, 2013a), mental health (Bratman, Hamilton, Hahn, Daily, & Gross, 2015; Berman et al., 2012; Ryan et al., 2010), and cognition as well as attentive capabilities (Dadvand et al., 2015; Faber-Taylor & Kuo, 2011). Research has linked exposure to urban vegetated environments with improved focus, increased vitality, and reduced stress levels (Bratman, Hamilton, & Daily, 2012). These findings imply that spending time in or around nature or natural landscape elements could indeed positively affect educational outcomes for individual students through improvements to cognitive and emotional well-being, as stress (Mathewson et al., 2012), in addition to reducing ability to direct attention thereby negatively impacting executive functioning (Kaplan & Berman, 2010), may thus lead to diminished academic performance.

Since the academic performance of individual students attending the same school aggregates to determine the academic performance of that school, access to green environments on school grounds or in school attendance areas (SAA) could thus enhance both student and school-level academic success while lack of such access could hinder success. This in turn could influence the future well-being of urban populations via impacts on employment and socioeconomic status associated with poor educational outcomes (e.g., failing to complete high school). This notion is particularly interesting in the context of intensively-developed urban environments with little vegetation or green space; environments where student academic performance, particularly that of disadvantaged groups, is often poor (Blanchett, Mumford, & Beachum, 2005). The limited evidence that exists in this area indicates that nature on and around school campuses can indeed impact the academic performance of entire student bodies. For example, high schools with views of trees and shrubs have been found to have higher average standardized test scores and graduation rates, more students going to college, and lower delinquency rates than other schools (Matsuoka, 2010). Additionally, levels of vegetation around schools have been found to exhibit a positive association with third-grade reading and mathematics scores on standardized tests (Wu et al., 2014). The connection between urban nature and school-level academic performance, however, is currently under-explored, and defining relationships between urban vegetation and school performance will require considerably more research. Key questions that remain center on identifying the locations in which natural landscape elements impact student performance (i.e., on-campus, near campus, in the home environment), how different natural landscape elements influence academic performance, and the levels and types of exposure to nature that relate to student academic performance. Answering these questions will help us better understand relationships between urban nature and academic performance and thus benefit urban populations via design and management of urban landscapes.

In order to improve our understanding of the relationship between academic performance and exposure to nature in urban

landscapes, this study sought to identify associations between school-level reading performance and levels of vegetation on school campuses and in SAA. SAA are exhaustive spatial partitions of school districts delineated by district administrators. The relationship between school, student, and SAA is such that a student attends the school associated with the SAA in which they live. Although these boundaries usually ensure that students attend the school closest to their residence, school districts may manipulate them with the goal of impacting segregation (Richards, 2014). Utilizing SAA over open enrollment can reduce commute lengths thereby potentially reducing student stress (Masouleh, Murayama, & Rho'Dess, 2009); furthermore, living in close proximity to school may encourage students to walk or bike to class, creating opportunities for exercise. We deemed this unit of geographical analysis appropriate for this study because it provides an indicator of the environment in which elementary school students spend their time away from campus (i.e., their residence and immediate neighborhood).

We focused on urban schools in the Minneapolis-St. Paul metropolitan area of Minnesota, USA and examined relationships between academic performance as indicated by mean standardized test scores for individual schools and measures of urban nature (tree cover, impervious surfaces, and waterways) for school campuses and SAA. We focus on reading test scores at the third-grade level as third-grade reading ability predicts odds of high school graduation and college enrollment (Lesnick, Goerge, Smithgall, & Gwynne, 2010). Based upon past studies, we hypothesized that a positive association would exist between mean school test scores and the levels of tree cover and areas of waterbodies on campus and in SAA given that evidence exists to suggest that these features reduce student stress and enhance focus. We further hypothesized that a negative relationship would exist between urban intensity as indicated by imperviousness and test scores as these environments would likely offer fewer opportunities to interact with nature. In this way, we sought to elicit relationships between urban environmental characteristics and school-level academic performance. Identification of these relationships will not only improve our understanding of the relationship between school performance and urban nature, but will also enhance our ability to plan and manage green environments to support well-being.

## 2. Urban green environments and academic performance

### 2.1. Theoretical frameworks for interpreting relationships between exposure to nature and academic performance

Understanding the links between urban green environments and the performance of individual schools requires us to consider the mechanisms through which green environments may enhance the academic performance of individual students. Past studies of the relationships among exposure to nature, cognitive ability, and emotional well-being indicate that green environments may impact academic performance through mechanisms explained by two existing theories, Attention Restoration Theory (ART, see review by Kaplan & Berman, 2010) and Stress Recovery Theory (SRT; Ulrich et al., 1991). The first explains how nature and cognition may interact to influence academic performance. The second suggests that humans have evolved a psycho-physiological response to nature such that spending time in natural environments lowers stress. We summarize these theories and their implications for academic performance below.

#### 2.1.1. ART: nature and the ability to direct attention

ART holds that the mechanism necessary to voluntarily direct attention, an ability crucial to higher-level cognitive functioning

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