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Exploring the Relationship Between Green Space and Academic Performance

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by

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Abstract

A growing body of literature is exploring the possibility that the presence of green spaces near schools can work to improve academic performance. Research to date on the relationship between green space and academic performance has shown mixed results. However, some see incorporating green spaces into school layouts as a key alternative strategy for improving academic achievement in the United States. This paper adds to the emerging discourse on the relationship between green space and academic achievement by using open-source data to conduct a regression analysis exploring the possible relationship between green space near K-12 schools and SAT scores in both Los Angeles and Fresno, CA. After controlling for socioeconomic factors, a positive and significant relationship is found between SAT scores and green space near K-12 schools in Los Angeles. In Fresno, after controlling for socioeconomic factors, a statistically insignificant positive relationship is found between SAT scores and green space near K-12 schools. Additionally, evidence of diminishing returns to the benefit of green space is found in both Los Angeles and Fresno. Green space near schools is found to be a positive predictor of academic performance especially in areas with limited green space. The findings of this paper will hopefully encourage policymakers and school planners to consider indulging green space in school design.

Introduction

Academic performance has been shown to be a strong predictor for future earnings (French et al, 2015), political engagement (Milligan et al, 2004; Dee et al, 2004), criminal involvement (Martins et al, 2022), health (Kern & Friedman, 2008) and life satisfaction (Tabbodi et al, 2015). Although criticisms have been brought against measures of academic performance including test scores and grades for not fully capturing a student's true learning and understanding (Popham, 1999; Kohn, 2011) it has been repeatedly shown that academic success is linked to future success and even happiness (Tabbodi et al, 2015). Working to better measures of academic performance including test scores should be seen as an integral part of improving the future success and happiness of students. Even though the United States is one of the countries with the highest spending on education internationally, test performance in the U.S is poor relative to other rich nations (OECD 2016). New avenues through which to improve academic performance in the U.S. should be explored.

A growing body of literature is exploring the possibility that the presence of green spaces or areas containing trees, shrubs, grasses, and other vegetation near schools can work to improve academic performance. Incorporating green space into school layouts could be a key alternative strategy for improving academic achievement in the U.S. (Kuo et all, 2021). Research to date exploring the impact of green space on academic performance is relatively small and shows mixed results (Browning, 2019). It is the authors hope that this paper will add to the emerging discourse on the relationship between green space and academic achievement by using open-source data to conduct a regression analysis exploring the possible relationship between green space near K-12 schools and SAT scores in both Fresno and Los Angeles, CA.

This paper will first provide an explanation of the mechanisms through which green space is thought to improve academic outcomes. Then a short summary of relevant works

exploring the relationship between green space and academic performance will be presented. The methods and results of the regression analysis will finally be presented and briefly discussed. In Los Angeles a positive and significant relationship is found between SAT scores and green space near K-12 schools. For Fresno an insignificant positive relationship is found between SAT scores and green space near K-12 schools. Evidence of diminishing returns to the benefit of green space is found in both Los Angeles and Fresno. It is the purpose of this paper to add to the information available to policy makers and school planners looking to better support student academic success.

Background

Mechanisms

Green spaces are thought to improve academic outcomes by lowering stress and supporting mental restoration. Stress reduction theory, SRT, suggests that exposure to landscapes with abundant vegetation can moderate states of arousal and reduce negative thoughts through unconscious psychophysiological pathways (Bratman et al, 2012). Chronic stress can be detrimental to learning and memory processes (Vogel & Schwabe, 2016; Schwabe, 2012; Joels, 2006). Following SRT, simply being exposed to the vegetation in green spaces can reduce stress and moderate stress responses leading to potentially improved learning and memory processes. This improvement in learning and memory processes can in turn lead to higher academic achievement. Additionally, attention restoration theory, ART, states that green spaces can help people recover from directed attention fatigue. Directed attention fatigue, DAF, results from the overuse of the brain's ability to process background information while staying focused on current tasks. Symptoms of DAF include feeling distractible, impatient, forgetful, or irritable. DAF can

also contribute to increased stress levels (Bratman et al, 2012). ART claims that green space immersion allows the brain to replenish the attention mechanisms that support cognition, mood, and attention. Improved cognition, mood, and attention can boost a student's ability to learn and achieve academic success. Green spaces near schools may support academic success by reducing stress and facilitating mental restoration.

Green spaces are also thought to support academic performance by improving overall physical health. It has been established that "healthier students are better learners" (Basch, 2011). Green spaces can improve overall physical health by lowering urban temperatures (Feyisa et al, 2014; Akbari, 2002), filtering harmful pollutants out of the air (Nowak et al., 2014; Nowak et al, 2018; Amorim et al, 2013), reducing noise pollution (Dimitrova & Dzhambov, 2017; Van et al, 2012; Veisten et al, 2012), and providing a desirable place to engage in physical activity (West et al, 2012; Lee et al, 2015; Dadvand et al, 2016; Roemmich et al, 2006; Cohen et al, 2006; Thompson et al, 2011). The impact green spaces have on physical health may be dependent on the type of green space and the location of the green space. Green spaces can impact temperatures by disrupting an existing urban heat island effect (Feyisa et al, 2014). An urban heat island occurs when an urban area experiences higher temperatures as a result of the abundance of materials such as asphalt, concrete, and roofing tile that absorb and re-emit much more thermal energy than natural materials (Stone & Rodgers, 2001). If a green space is outside of the effects of an urban heat island it is unlikely to have a significant impact on temperature. Similarly, if a green space is located in an area that is not exposed to air pollutants or harmful noise levels the pollutant filtering and noise shielding effects of the vegetation in green spaces will probably not significantly impact health outcomes. The level to which green space supports physical activity is also likely dependent on the type of green space (Brown et al, 2014; Spengler

et al, 2011). Not all green spaces are suitable for the same level of physical activity. Additionally, it may not be safe to engage in outdoor activities in all green spaces. If a green space is located near a pollution source, unsafe highway, or lacks certain amenities, exercise in the space could be perceived as dangerous or undesirable. Given that the relevance of key mechanisms is likely different in different areas it may be important to investigate the relationship between green spaces and academic performance in multiple settings.

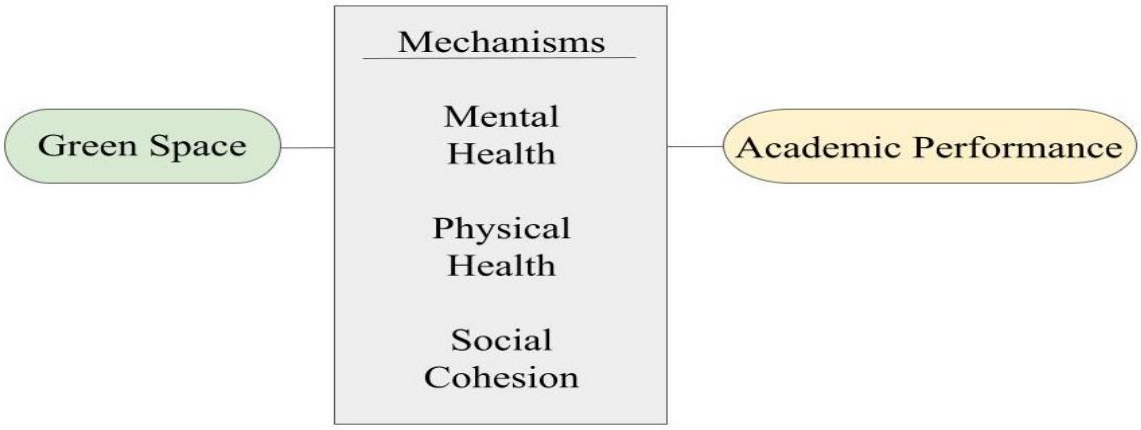

Figure 1: Conceptual framework showing link between Green Space and Academic Performance

Green spaces promote classroom engagement and overall social cohesion. Social cohesion refers to the strength of the relationships that hold a community together (Kawachi et al, 2000). A community with strong social cohesion will have good social networks that provide community members with "social capital" or shared community resources (Kawachi et al, 2000). Strong social cohesion can support academic success (Yoon & Leem, 2021; Harun & Chin, 2015). Social cohesion also works to prevent social isolation (Tomaka et al, 2006). Feelings of social isolation have been shown to limit academic performance (Harun & Chin, 2015). Green spaces can strengthen social cohesion by providing a structured place for social gatherings and

community member interaction (Fan et al, 2011). Additionally, studies have found neighborhood greenness to be positively associated with social cohesion (De Vries et al, 2013; Maas et al. 2009; Sugiyama et al, 2008). Green spaces near schools may improve academic performance by supporting social cohesion and engagement in the classroom.

Related Literature

The author of this paper is aware of only one 2019 literature review (Browning, & Rigolon, 2019) that summarizes the body of work exploring the possible relationship between green space and academic performance. The 2019 review identifies thirteen peer-reviewed articles that examined the possible associations between academic outcomes and green space. The discourse surrounding the relationship between academic performance and green space is relatively recent with the earliest identified article published in 2010 (Browning, & Rigolon, 2019). The majority of identified papers measured green space using aerial imaging to assess green space in a radial buffer zone around schools (Browning, & Rigolon, 2019). Academic performance was assessed using college preparatory exam scores, standardized test scores, and grades (Browning, & Rigolon, 2019). Common confounders controlled for included income, racial composition, gender, student teacher ratio and school attendance (Browning, & Rigolon, 2019). Overall, the findings of the thirteen articles are mixed. The 2019 review found that, of the 122 findings reported by the identified articles, 28% are significantly positive, 8% are significantly negative, and 64% are non-significant. Reported positive findings are associated with green space measured within 2000 m of schools (Browning, & Rigolon, 2019). College preparatory exam scores and grades are found to show predominantly greater positive associations compared to other measures of academic success (Browning, & Rigolon, 2019).

Conversely, writing test scores are found to have non-significant associations with green space (Browning, & Rigolon, 2019). The 2019 review concludes that, although small in number and limited in research design, the thirteen identified articles provide sufficient evidence to justify further research exploring the possible relationship between academic achievement and green space near schools.

Following the methods presented in the 2019 review this paper has identified six additional articles published since 2019 that explore the relationship between green space and academic performance. Standardized test scores are used by five of the six articles as a measure of academic performance with one article observing graduation rates (Rakowska et al, 2023; Requia et al, 2022; Requia & Adams 2022; Hodson & Sander, 2021; Kuo et al, 2021; Donovan et al, 2020). Remote imaging is used to identify multiple measures of green space, most commonly normalized difference vegetation index results. Of the six articles five found some positive association between their measures of green space and academic performance (Requia et al, 2022; Requia & Adams 2022; Hodson & Sander, 2021; Kuo et al, 2021; Donovan et al, 2020). One article reports a negative and significant association between green space and standardized test scores (Rakowskal et al, 2023). Another article reports a significantly negative association between green space and only science assessment scores (Requia et al, 2022). Additionally, a 2022 investigation in Brazil finds that the distance between green spaces and schools is significantly negatively associated with academic achievement (Requia & Adams, 2020). A 2021 study sampling schools from across thirty six U.S. states found evidence suggesting that social and environmental context influences the relationship between green space and academic performance (Hudson, 2021). The strength of the relationship between green space and academic performance, although generally positive, was found to differ depending on social

and environmental context (Hudson, 2021). More research is needed to define the relationship between green space and academic performance in different contexts. Research to date provides a small pool of mixed, yet promising and intriguing results. The motivation behind this paper is to help expand the exploration of the relationship between green space and academic performance.

Data and Methods

Data Collection

To investigate the relationship between green space and academic outcomes I need to collect data on some measure of green space and academic outcomes. Open-source data on the level of green space near K-12 schools was obtained from the Enviro Atlas data bank provided by the U.S. Environmental Protection Agency. Enviro Atlas provides data for areas all over the U.S on the number of K-12 schools in each 2010 census block group that have less than twenty five percent green space within a 100-meter radius around the central school building (EnviroAtlas, 2020). The level of green space in each 100-meter radius is assessed using aerial photography through remote-sensing methods (EnviroAtlas, 2020). Enviro Atlas also reports the number of K-12 schools within each census block. Through subtracting the number of schools with less than twenty five percent of green space from the total number of schools, this paper found the number of schools with greater than twenty five percent green space in view for each census block. This resulting data on the number of K-12 schools with a green view in a census block is the green space measure used in this analysis. Census blocks without schools were removed. For Fresno data from census blocks outside of Fresno city limits were removed resulting in 139 remaining census blocks (See Table 4). For Los Angeles the sample was limited

to two regional groups (see figures 2-3). This was done to reduce the Los Angeles sample to a feasible size. The first group was selected from a central Los Angeles region bounded from west to east by the Harbor Freeway and East San Bernardino Freeway and bounded from north to south by the Santa Monica-Santa Ana Freeway and the Imperial Highway. The second group was taken from a northeast Los Angeles region bounded from west to east by the Rosemead Boulevard and the San Gabriel River Freeway and bounded from north to south by the Foothill Freeway and the El Monte Busway Road. In total 351 census blocks were included for Los Angeles (see Table 4).

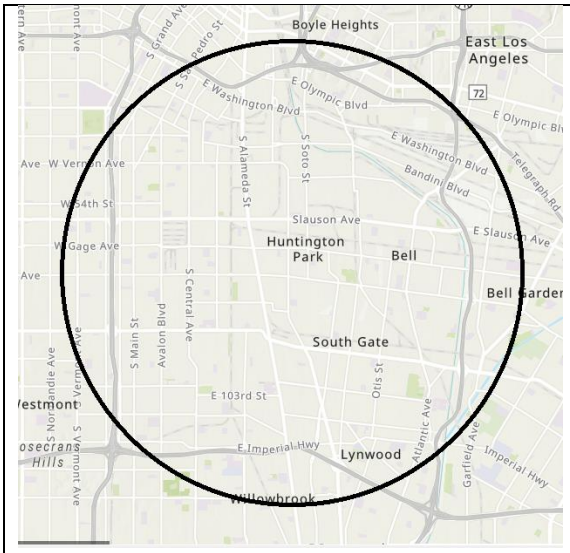

Figure 2: LA central sample area

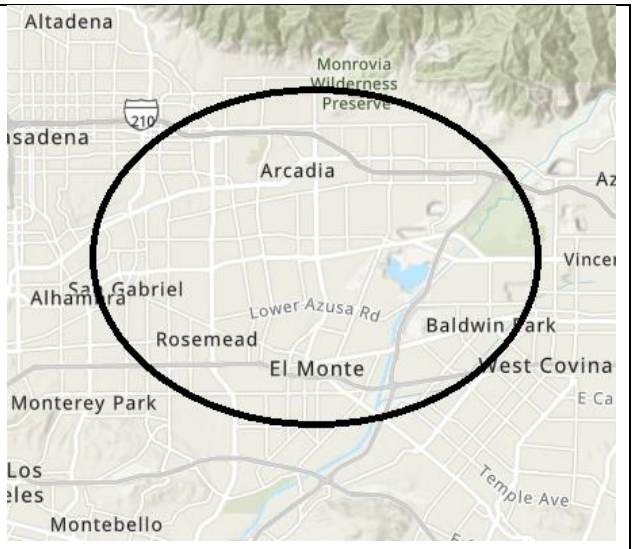

Figure 3: LA northeast sample area

Enviro Atlas additionally provides data on population with income below twice the U.S. poverty level, population identifying as other than white and non-hispanic, and population under the age of thirteen for each census block. This data on income, racial composition, and number of children is used to account for important covariates in this analysis. Enviro Atlas data on demographics and socioeconomic factors are reported along with green views near schools for 2010 census blocks. As a result, data on key covariates and green views from schools were

downloaded from Enviro Altles already matched to census block groups for both Fresno and Los Angeles.

Average Scholastic Assessment Test, SAT scores for schools within selected areas were obtained from EdGap data provided by the Memphis Teacher Residency, MTR. MTR provides open access data on average composite SAT scores for high schools in a number of U.S states including California. The SAT composite scores are based on the reading and mathematics tests only, excluding the writing test that is optional in some states (EdGap.., 2023). As the unit of this analysis is a census block and not an individual high school the score from the closest high school to each census block was used to measure academic performance in this analysis. When matching SAT scores to clusters of nearby census blocks, judgment calls had to be made. Ideally the SAT score given to each census block represents the average SAT score of the students that passed through schools located in that census block.

VARIABLE	Los Angeles	Fresno
	N=351	N=139
SAT Score	964.80	968.77
Schools with Green View	0.62	0.96
Non-White Population	1423.97	65.63
Low-Income Population	784.39	47.26
Population < 13	293.14	416.60
Number of K-12 Schools	1.34	1.37

Mean values for each variable for both Los Angeles and Fresno census blocks.

Table 4: Summary statistics for collected open-score data

Model Specification

This analysis will run a regression looking at SAT scores versus green space near schools. When constructing a regression model, it is important to control for confounding factors that may be correlated with both the response variable and explanatory variable of

interest. Income is a key socioeconomic factor that has been shown to be related to academic performance (Lacour & Tissington, 2011) and abundance of green space (Astell-Burt, 2014; Wen, 2013). Wealthier areas often have more parks, gardens, grass lawns, and green school yards. Due to the common correlation between green spaces and high income areas, it is crucial to control for income when exploring the relationship between green space and academic achievement.

When examining the data retrieved from Enviro Atlas, low income is found to be slightly negatively correlated with green space in both the Fresno and Los Angeles data sets (see Table 5-6). A moderate correlation between low incomes and SAT scores is also found for both Fresno and Los Angeles (see Table 5-6). This finding supports the suspected necessity to control for income in the model. Income is included as a control variable in this model (see Figure 7).

Racial composition is also a key socioeconomic factor shown to be related to academic performance (Lee, 2007) and abundance of green space (Wen, 2013). Evidence supporting an acute racial disparity in access to green space has been identified by a growing body of exploring the correlation between racial composition and green space (Wen, 2013; Kephart, 2022; Cassini, 2020). These disparities are thought to originate from our county's history of “redlining” practices and historic under investment in BIPOC communities (Kephart, 2022; Cassini, 2020). Today this common disparity is perpetuated by continued modern day racial injustice and underinvestment. Due to this identified correlation between racial composition and green space, it is crucial to control for racial composition when exploring the relationship between green space and academic achievement.

Examining the data on racial composition sourced from Enviro Atlas reveals a small negative correlation between population identifying as other than white and green space in both

the Fresno and Los Angeles data sets (see Table 5-6). Additionally, negative correlations are found between population identifying as other than white and SAT scores in both locations (see Table 5-6). This finding supports the need to control for racial composition. In this analysis racial composition is controlled for in the model (see Figure 7).

	SAT	Green-View	Non-white	Low-Income	Population < 13	K-12 School
SAT	1.0000					
Green-View	0.0278	1.0000				
Non-White	-0.5760	-0.1106	1.0000			
Low-Income	-0.5415	-0.1355	0.8495	1.0000		
Population < 13	0.0229	-0.0906	0.2568	0.0364	1.0000	
K-12 Schools	0.0308	0.4230	-0.0802	-0.0313	-0.0767	1.0000

Table 5: Correlation table for Fresno, CA

	SAT	Green-View	Non-white	Low-Income	Population < 13	K-12 School
SAT	1.0000					
Green-View	0.2803	1.0000				
Non-White	-0.1889	-0.1144	1.0000			
Low-Income	-0.3526	-0.1698	0.8020	1.0000		
Population < 13	-0.2518	-0.1465	0.8825	0.7898	1.0000	
K-12 Schools	-0.0151	0.4283	-0.0131	-0.0475	-0.0407	1.0000

Table 6: Correlation table for Los Angeles, CA

Variables representing neighborhood characteristics that might impact both SAT scores and green space were also included as covariates in the model. The number of schools in a

census block could indicate the level of resources available to a student and as a result be correlated with SAT scores. Additionally, the number of children in a census block could indicate how many children share resources which could impact SAT scores. Areas with more schools could have more school yards, sport fields and playgrounds resulting in more green spaces near schools. Areas with more children could be more urban and have less natural areas. Additionally, both the number of schools and the number of children under the age of thirteen in a census block could indicate how crowded or densely populated an area is. Overcrowding in schools has been shown to negatively impact academic performance (Earthman, 2002). Both the number of K-12 schools and population under thirteen are included in the model specification as covariates (see Figure 7).

Data from Enviro Atlas on the number of schools in each census block shows a moderate positive correlation between the number of schools and green space for both Fresno and Los Angeles (see Table 5-6). In Los Angeles a moderate positive correlation is also found between the number of schools and SAT scores (see Table 6). However, in Fresno a small negative correlation is found between the number of schools and SAT scores (see Table 5). In Los Angeles the number of children under thirteen is slightly negatively correlated with both green space and moderately negatively correlated with SAT scores (see Table 6). In Fresno the number of children under thirteen is very slightly positively correlated with SAT scores and very slightly negatively correlated with green space (see Table 5). These findings support the decision to include both the number of K-12 schools and population under thirteen in the model.

The relationship between green space and academic achievement is suspected to be nonlinear. Evidence has been found to suggest that some of the benefits from green views may be subject to diminishing returns (Nowak et al, 2014). Additionally, in areas that already have

sufficient vegetation adding additional green space is found to be associated with a smaller positive impact on academic success (Tallis, 2018). In areas with limited vegetation, such as urban areas, the addition of green space has been shown to have a larger positive impact on academic success (Tallis, 2018). To allow for this possible nonlinear relationship a squared term for green views is included in the model specification (see Figure 7).

Interaction terms are included in the model in order to investigate the partial effect of green views on SAT scores at different levels of socioeconomic factors. Green spaces may provide an alternative avenue through which to combat historic underinvestment and improve academic outcomes in low income and predominantly BIPOC communities (Browning & Rigolon, 2019). Including interaction terms between green views and measures of both income and racial composition will allow the impact of green views on SAT scores to be examined at different levels of both income and racial composition. If green spaces are to be seen as a viable way to improve academic outcomes in historically disadvantaged communities, it would be desirable for green views to have a larger positive impact on SAT scores in areas with larger low income and BIPOC populations. An interaction term between schools with green views and size of population with income below twice the U.S. poverty level is included in the model (see Figure 7). Additionally, an interaction term between schools with green views and population identifying as 'other than white' and non-hispanic is included (see Figure 7).

$$SAT = \beta_0 + \beta_1 GreenView + \beta_2 GreenView^2 + \beta_3 NonWhite + \beta_4 LowIncome + \beta_5 Children + \beta_6 Schools + \beta_7 GreenView * NonWhite + \beta_8 GreenView * LowIncome$$

Figure 7: Final regression model equation used in this analysis

Results

Los Angeles

For the Los Angeles data, a statistically significant relationship was found between green views near schools and SAT scores after controlling for socioeconomic factors. At 5 percent significance, the addition of one school with a green view in a census block without a school with green views increased the average SAT score of the nearest high school by about 92.2 points (see Table 8). The coefficient for green view squared is negative indicating that the benefit of green views decreases at higher levels of green space. However, the coefficient for the squared term is not statistically significant (p-value > 0.05). Excluding the squared term from the regression model results in a smaller but still positive and significant relationship between green views near schools and SAT scores. The Los Angeles data provides strong evidence that green views near schools could improve SAT scores.

The interaction term between green views and income is significant, but the interaction term between green views and racial composition is not significant. The significant coefficient for the interaction term between green views and population with income under twice the U.S poverty line is negative (see Table 8). This result indicates that in lower income areas the positive effect of green views near schools on SAT scores is smaller. As expected, low income was found to have a statistically significant and negative relationship with SAT scores (see Table 8). The statistically insignificant coefficient for the interaction term between green views and population identifying as ‘other than white’ and non-hispanic is positive. This suggests that in areas with a larger population identifying ‘as other than white’ and non-hispanic the positive effect of green views on SAT scores is larger. The term for population identifying as ‘other than

white' and non-hispanic was found to have a statistically insignificant and positive relationship with SAT scores.

	(1) SAT score
Green-view	97.20***
	(23.93)
Green-view^2	-0.311
	(7.195)
Non-white	0.0752***
	(0.0280)
Low-income	-0.0669**
	(0.0294)
Population < 13	-0.181**
	(0.0884)
K-12 schools	-24.86**
	(10.17)
Green-view*Non-White	0.0122
	(0.0225)
Green-view*low-income	-0.0730**
	(0.0295)
Constant	957.4***
	(25.91)
Observations	351
R^2	0.250
Adjusted R^2	0.233

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Regression results for Los Angeles, CA

The number of K-12 schools and the number of children under the age of thirteen were both found to negatively impact SAT scores. Both the coefficients for the number of K-12 schools and population of children under the age of thirteen had a significant and negative

relationship (see Table 8, p-value < 0.05). Notably, results suggest that the addition of a child under the age of thirteen to a census block lowers the average SAT score of the nearest high school by 24 points (see Table 8). This large impact likely captures the negative effect of overcrowding on SAT scores.

Fresno

After controlling for key covariates including socioeconomic factors, this analysis found no significant relationship between views of green space and SAT score (see Table 9). Regression results suggest that increased views of natural environments have a positive and decreasing impact on SAT scores, but this relationship is not statistically significant. The coefficients for both green views from the central school building and its squared term are statistically insignificant (p-value > 0.05, see Table 9). Even before controlling for key covariates, the relationship between green views near schools and SAT scores is found to be statistically insignificant. The data collected for Fresno, CA does not strongly suggest the existence of a positive causal effect between green views near schools and SAT scores.

The interaction terms between green views near schools and both socioeconomic covariates also revealed no statistically significant relationship (p-value > 0.05, see Table 9). Although statistically insignificant, the interaction term coefficient between green views and racial composition suggests that green views near schools positively impact SAT scores more in areas with a higher population that identifies as ‘other than white’ and non-hispanic (see Table 9). The statistically insignificant interaction term coefficient between green views and income suggests that green views near schools positively impact SAT scores less in low income areas (see Table 9). However, the coefficient for income on its own, although statistically insignificant,

suggests that low-income areas are related to higher SAT scores. This finding is counterintuitive and could suggest income is correlated with some other factor affecting SAT scores in Fresno that is not included in the model.

	(1) SAT score
Green-view	12.06
	(47.75)
Green-View	-6.586
	(10.85)
Non-white	-2.761**
	(1.191)
Low-income	0.0658
	(1.010)
Population < 13	0.0626**
	(0.0297)
K-12 schools	6.687
	(15.67)
Green-view*low-income	-0.442
	(0.889)
Green-view*Non-White	0.287
	(1.000)
Constant	1110.8***
	(54.71)
N	139
R^2	0.369
Adjusted R^2	0.330

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9: regression results for Fresno, CA

The only variables found to be significantly related to SAT scores in Fresno are for racial composition and number of children under thirteen years of age. The addition of one more

individual identifying as other than white and non-hispance in a census block is found to decrease the average SAT score of the nearest high school by about 3 points at 5 percent significance level (p-value < 0.05 see Table 9). An increase in the population of children under the age of thirteen in a census block is found to increase the average SAT score of the nearest high school by about 0.06 points at 5 percent significance level (p-value < 0.05, see Table 9). The number of schools in a census block is also found to be positively correlated with SAT scores, but this relationship is not statistically significant.

Discussion

The results of this paper suggest that green space near schools positively impacts SAT scores at a decreasing rate. Although insignificant for Fresno, coefficients for green views near schools were positive for both Fresno and Los Angeles. Decreasing returns to green space were found in both the Fresno and Los Angeles data sets, although both squared term coefficients were insignificant. The green space coefficient was also smaller for Fresno. This smaller positive relationship between green space and academic performance in Fresno could be brought on by the larger surrounding agricultural green spaces. Given decreasing returns to green space, areas with more surrounding green should have a smaller positive relationship between additional green space and academic performance. Overall, the results of this investigation support the existence of a positive yet decreasing relationship between green space near schools and SAT scores. The addition of green spaces near K-12 school buildings may work to support academic success in urban areas. Efforts to improve academic outcomes for students should consider the addition of green space initiatives in school planning and policy.

This analysis did not find clear evidence suggesting that green space is more beneficial in low-income areas. In both Fresno and Los Angeles green space was found to have a smaller positive association with SAT scores in more low-income areas. The coefficient for the green space and income interaction term was significant for Los Angeles but insignificant for Fresno. This finding could indicate that low-income areas might benefit less from green initiatives in schools. It is also possible that green spaces in low-income areas are of poorer quality and as a result positively impact academic outcomes less. This paper did not control for green space quality such as upkeep, safety, and diversity in vegetation. Future papers exploring the impact of green space on academic performance in areas with different income levels should consider controlling for green space quality.

No statistically significant evidence was found to suggest that green space is more beneficial in communities with larger BIPOC populations. In both Fresno and Los Angeles, the positive relationship between green space and SAT scores was greater in areas with larger BIPOC populations. However, coefficients for green space and racial composition interaction terms were statistically insignificant for both Fresno and Los Angeles. Although insignificant, these findings suggest that green space initiatives may be more beneficial to academic success in BIPOC communities. More research is needed to determine if the addition of green space is more beneficial to academic outcomes in predominantly BIPOC communities.

Results for Fresno were more statistically insignificant compared to Los Angeles. Analysis of the Fresno data set produced only two statistically significant coefficients while the Los Angeles data set produced only two insignificant coefficients. This difference in significance of findings could be a result of sample size and sample selection. The Los Angeles sample consists of 341 data points. Comparatively, the Fresno sample has only 139 data points.

Additionally, the Los Angeles data set includes greater variation in most variables. Unfortunately, the sample that can be drawn from Fresno is limited by the city's size. Future studies exploring the possible benefits of green space in smaller more rural locations might consider pooling data from multiple small cities in order to increase the size of rural samples.

It is important to note some key limitations of this analysis. Measures of crucial variables in this analysis may report an incomplete or inaccurate representation of reality. In this analysis green space is measured as the number of schools with greater than twenty five percent green space in view per census block. This measure of green space does not discriminate between schools with 30 percent green space in view and schools with 90 percent green space in view. Similarly, income is measured as the population with income below twice the U.S. poverty level and does not fully represent differences between different income levels above twice the U.S. poverty level. This lack of precision in measures of key variables could lower the accuracy of this analysis. Additionally, the matching of SAT scores to census blocks relies on judgment. SAT scores may be poorly matched to census block groups leading to inaccuracies in this analysis. As this analysis is carried out on the census block level and not the school level some possibly influential school level factors are left out of the model specification. If time permitted, this paper would have considered including measures of school attendance, student teacher ratio, and school enrollment in the analysis. Despite limitations, this paper has used open-source data to conduct a regression analysis exploring the possible relationship between green views near K-12 schools and SAT scores in both Fresno and Los Angeles, CA. This paper hopes that the findings of this analysis will encourage policy makers and school planners to better support student academic success through the addition of green space.

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