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Does Naturalness Influence Positive Learning Outcomes During Environmental Education Field Trips?

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DOES NATURALNESS INFLUENCE POSITIVE LEARNING OUTCOMES DURING ENVIRONMENTAL EDUCATION FIELD TRIPS?

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by
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ABSTRACT

Environmental education (EE) field trip programs in the United States often take place in outdoor, natural settings. Such natural environments provide ample opportunity for hands-on and immersive learning to occur, which may allow for positive cognitive and moral development in children. However, recent research on the impact of more natural settings on youths' academic success has produced mixed outcomes, suggesting that the relationship between levels of naturalness and student success is more complex than previously assumed. Utilizing student surveys collected during 283 EE field trip programs and remotely sensed land cover data, this study examines the relationship between levels of naturalness and student learning outcomes for students in grades 5-8. This study also examined whether differences in levels of naturalness between students' day-to-day environment and the field trip setting influences student learning outcomes while also controlling for grade level, race of participants, and socioeconomic status (SES). Findings indicate a significant, positive relationship between levels of naturalness and positive student learning outcomes during EE field trip programming. Additionally, novel levels of naturalness also had a positive relationship with student learning outcomes. However, only a small percentage of variance is explained by these two variables, suggesting that many other EE field trip program characteristics likely drive positive student outcomes.

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INTRODUCTION

Every year, thousands of middle school-aged (roughly, ages 10-14) children participate in environmental education (EE) field trip programs throughout the United States. Many of these EE field trip programs seek to meet curriculum-based standards while also creating an environmentally literate student population with the knowledge, skills, dispositions, and ability to address current and future environmental challenges (Gillett, 1977; Hofstein & Rosenfeld, 1996; Powell et al., 2019; Stern et al., 2014). A hallmark of EE field trip programs is that they often occur in natural settings and provide immersive hands-on experiences (e.g., McCrea, 2006; NAAEE Guidelines for Excellence, 2021; Simmons, 2018). Researchers suggest that exposure to nature and natural settings during middle childhood and early adolescence (ages 10-14, roughly middle school-aged) can positively impact youths' academic performance and cognitive and moral development (Kellert, 2005; Kahn & Kellert, 2002; White & Stoecklin, 2008). Thus, it is assumed that an important component of a successful EE field trip program is immersive and interactive experiences in natural environments. However, recent research specifically focused on cognitive development, student learning, and exposure to green or natural settings has shown mixed or inconclusive results, suggesting that the relationship may be more complex than previously thought (Browning & Rigolon, 2019; Browning & Locke, 2020).

Our research focuses on assessing whether the level of naturalness of an EE field trip setting, as measured by the percentage of natural land cover, influences middle school-aged students' learning outcomes across a large sample of EE field trip program sites in the United States.

Additionally, researchers have also suggested that novelty, or the exposure to new and unique experiences, may enhance students' learning outcomes in field trip settings (e.g., Berman & Davis-Berman, 1995; Dale et al., 2020; Garst et al., 2011). However, some researchers have suggested that too much novelty may impede or distract students' learning in educational field trip settings (Falk et al., 1978). We explore these hypotheses by examining the potential influence that novel levels of naturalness may have on student learning outcomes during EE field trip programs. To do so, we calculated the difference in naturalness between students' day-to-day environments, as represented by their school attendance zone (SAZ), and the EE field trip setting. We then analyzed the relationship between learning outcomes and this difference in relative naturalness.

LITERATURE REVIEW

Naturalness & Positive Learning Outcomes: Theoretical Underpinnings

Research on exposure to nature and associated positive learning outcomes have traditionally been underpinned by several related theories: Biophilia, Attention Restoration Theory (ART), and Stress Reduction Theory (SRT) (Kaplan et al., 1998; Kellert, 2005; Kellert & Wilson 1993; Ulrich, 1983; Ulrich et al., 1991; White & Stoecklin, 2008).

Biophilia, based in sociobiology, suggests that people have a genetic predisposition and an innate tendency to bond with the natural world (Kellert, 2005; Kellert & Wilson 1993; White & Stoecklin, 2008). Biophilia also suggests that because humans evolved in nature, interacting with the natural world underpins children's healthy physical, emotional, and intellectual development (e.g., Kahn & Kellert, 2002; Van Dijk-Wesselius et al., 2018). While conceptualized as a genetic predisposition, the theory also emphasizes the need to properly nurture biophilia throughout childhood (Kellert, 2005; Kahn & Kellert, 2002; White & Stoecklin, 2008). Regular opportunities to learn about and have positive experiences in natural environments can nurture biophilia and promote its associated benefits in children (Chawla et al., 2014; Kellert, 2005; Kellert 1997; Sobel 2002; White & Stoecklin, 2008).

Related to biophilia, Stress Reduction Theory (SRT) suggests that, based on human evolutionary history and personal experiences, certain natural environments that are familiar and non-threatening can alleviate stress (Browning & Locke, 2020; Ulrich, 1983; Ulrich et al., 1991; Hodson & Sander, 2017). Humans have evolved to have immediate, positive responses in familiar and beautiful natural settings (Bowler et al., 2010; Ulrich, 1983). In these natural settings, individuals experience emotional and psychological restoration that is considered automatic, which allows for rapid, short-term recovery from stress and an increased sense of well-being and ability to learn (Ulrich et al., 1991; Hartig et al., 1991).

Attention Restoration Theory (ART) explains how certain natural environments can lessen the typical effort required for directed attention, thus restoring attentional capacity (Kaplan, 1995; Kaplan et al., 1998). These environments (1) allow for thoughtful reflection and attract involuntary attention; (2) are non-threatening and welcoming; (3) encourage exploration; and (4) create separation from stressful environments and normal attention demands (Kaplan et al., 2998; Hodson & Sander, 2017). Increased exposure to these natural environments can positively impact children's working memory and attention (Bagot, 2004; Bagot et al., 2015; Dadvand et al., 2015; Kelz et al., 2015; Larson et al., 2018; Li & Sullivan, 2016; Taylor et al., 2002; Tennessen & Cimprich, 1995; Wells, 2000). Additionally, research suggests that even after brief exposure to nature, cognitive capacity and the ability to focus attention are increased (Larson et al., 2018; Kaplan, 1995; Li & Sullivan, 2016). EE field trips often take place in these types of natural environments, thus potentially restoring attention in students and positively impacting students' learning outcomes. However, more recent research investigating the effect of exposure to nature on students' academic success in formal educational settings has produced inconsistent results (Browning & Rigolon, 2019).

Naturalness & Learning Outcomes in Formal Education

Studies investigating the effects that naturalness/green space may have on academic achievement have produced mixed results. The variable ways in which green space and naturalness have been operationalized add complexity to interpreting and comparing results (Browning et al., 2018; Browning & Rigolon, 2019; Browning & Locke, 2020; Kuo et al., 2019; Taylor & Hochuli, 2017). For example, some studies focus on green space, which is considered a subset of naturalness and is often operationalized as remotely sensed tree and shrub cover or vegetation in urban environments (Browning & Locke, 2020; Taylor & Hochuli, 2017). Others conceptualize naturalness more broadly to include most or all of the non-built environment

(Dallimer et al., 2011; Taylor & Hochuli, 2017), and sometimes use remotely sensed measures like the percentage of an area with developed impervious surface coverage (Larson et al., 2018). For the purposes of this study, 'naturalness' is being operationalized instead of 'green space' because of the wide variation in land cover considered natural across the United States. Places that have natural land cover may not always be "green" (deserts, for example). Additionally, studies focused on naturalness and academic performance have been primarily conducted in two ways: (1) through direct observation by means of case studies and experiments where researchers attempt to understand student perceptions of naturalness and the impact it may have on student learning, and (2) through indirect research where researchers use remotely-sensed data and assess the impacts of naturalness on student academic achievement through standardized academic testing metrics (Browning & Rigolon, 2019; Browning & Locke, 2020).

Both direct and indirect studies have found positive relationships between naturalness, as represented by green space, and students' academic success. For example, studies in which students are exposed to naturalness/green space through a window during class appear to have better performance on cognitive tasks as well as better grades (Li et al., 2019; Benfield et al., 2015). Research on classroom engagement following outdoor teaching has also found positive relationships between engagement and lessons spent outdoors (Kuo et al., 2018). Studies using geospatial technologies and remotely sensed data have found that youths' exposure to naturalness/green space correlates with positive standardized testing scores, suggesting the importance of nature to students in formal learning environments (Donovan et al., 2020; Kweon et al., 2017; Leung, et al, 2019; Spero et al., 2019; Tallis et al., 2018; Wu et al., 2014). However, more recent research suggests that the relationship between the level of naturalness surrounding a classroom and student learning outcomes is more complex (Browning & Rigolon, 2019; Browning & Locke, 2020).

Other studies have found null or even negative relationships between naturalness and student learning outcomes. For example, a study conducted by Beere and Kingham (2017) using a measure of greenness based on New Zealand's national land cover database found that students' academic success negatively correlated with naturalness around New Zealand schools. Browning et al. (2018), also found a statistically significant negative relationship between student academic performance and normalized difference vegetation index (NDVI) derived measures of greenness in an area around Chicago public schools. Additionally, a study conducted in Germany using NDVI, tree cover, and proportion of agricultural land, forest, and urban green space found no significant relationships between naturalness around students' schools and academic performance (Markevych et al., 2019).

The relationship between student learning outcomes and naturalness exposure also appears to be influenced by sociodemographic and contextual factors including urbanity, socioeconomic status (SES), gender, and student-teacher ratio, among others (Browning & Rigolon, 2019; Browning & Locke, 2020). Schools and neighborhoods in urban areas with high degrees of poverty tend to also have less vegetation cover, fewer natural areas, and parks are not funded as well compared to parks in wealthier areas (Kou et al., 2018; Rigolon et al., 2018a; Rigolon et al., 2018b). A recent study addressing the relationship between academic performance and naturalness (using tree cover, total vegetation cover, agricultural cover, and urban intensity) in the United States found that the impact of certain vegetation types (e.g., tree cover, grass) on student success varies based on socioeconomic context as well as urbanity (Hodson & Sandar, 2019). Such findings allude to the importance of considering populations' demographic and social context when investigating the influence of naturalness on students' academic performance (Browning et al., 2018; Browning & Rigolon, 2019; Browning & Locke, 2020; Hodson & Sandar, 2019).

Naturalness, Novelty, & Environmental Education

Based on this prior research (e.g., Browning et al., 2018; Browning & Rigolon, 2019; Browning & Locke, 2020) as well as our own research (Stern et al., 2021), similar sociodemographic factors may influence student learning outcomes during EE field trip programs. Variables such as the grade level, racial identity, and SES of students influence learning outcomes in both formal education and EE settings, and need to be accounted for in order to understand the specific influence that naturalness has on student learning outcomes.

While research on naturalness/green space and learning outcomes in formal education have produced mixed results, very limited research has been conducted to explicitly assess the relationship between naturalness and student learning outcomes during EE field trips. Dale et al. (2020) found that there was a significant, but weak, positive association between the naturalness of EE sites (as measured by researchers' observations) and positive learning outcomes for middle school children in the United States. Research conducted by Ballantyne and Packer (2009) on different pedagogical approaches during EE field trip programs using observational data and in-depth interviews of educators, teachers, and students, emphasizes the importance of natural environments during experience-based programs for learning outcomes. A similar study surveying students on environmental attitudes and behavior change during EE field trip programming indicates that natural environments are attractive to students and that they appreciate the opportunity to engage in environments outside of the classroom (Ballantyne & Packer, 2002).

Though very few studies have quantitatively assessed the role that naturalness plays in EE field trip programming, and, to our knowledge, no studies have used remote sensing to assess naturalness, the field of EE is undergirded by a strong assumption that naturalness is an essential component of successful EE programs and is linked to positive learning outcomes. As such, this study empirically examines this assumed linkage while accounting for the potential influence of students' grade level, race, and SES.

Some researchers argue more specifically that being exposed to *novel* levels of naturalness may enhance outcomes during EE field trips (Dale et al., 2020; Garst et al., 2009; Garst et al., 2011). Novelty can be defined as an individual perception of something that is unique, unfamiliar, or new (Garst et al., 2009). Novel natural EE field trip settings are those whose environmental features are different from a students' everyday environment and traditional classroom settings (Dale et al., 2020; D'Amato & Krasny, 2011; Simmons, 2018). Some have argued that such environments may be important for inspiring learning in children (Dale et al., 2020; White & Stoecklin, 2008). Researchers suggest that novel, natural environments can reduce stress and anxiety (e.g., Berman & Davis-Berman 1995; Garst et al., 2011), increase intrinsic motivation, inspire collective action, and challenge people's perceptions (DeWitt & Storksdieck 2008; De Waal 2008; Orion 1989; Orion & Hofstein 1994). Thus, exposure to novel levels of naturalness during EE field trips may positively influence learning for students (Dale et al., 2020).

However, there is also research suggesting that some familiarity and prior exposure to a setting can reduce distraction and improve cognitive learning outcomes (Falk, 1983; Falk et al., 1978; Falk & Balling, 1982; Orion & Hofstein, 1991). Many children lack exposure to wild or natural settings (Orion & Hofstein, 1991; Simmons, 2018) and when these children are immersed in natural environments, a sense of disequilibrium can form that may potentially negatively influences learning outcomes (Falk, 1983; Falk et al., 1978; Falk & Balling, 1982; Orion & Hofstein, 1991). Such research suggests an alternative hypothesis – that smaller differences in novel levels of naturalness between EE field trip sites and student's day-to-day environments may lead to better learning outcomes. As such, our second research question focuses on understanding whether or not novel levels of naturalness during EE field trip programs influence student learning outcomes when controlling for the potential influence of grade level, race, and SES of participating student groups.

METHODS

The purpose of this study is to explore the relationship between the level of naturalness at EE field trip programs in the United States and student learning outcomes. We do so by pursuing two specific research questions: (1) Controlling for grade, race, and SES, what is the relationship between the level of naturalness of an EE field trip setting, as measured by the percent of natural land cover, and middle school-aged students' learning outcomes? and (2) Controlling for grade, race, and SES, what is the relationship between student learning outcomes and novel levels of naturalness, as measured by the difference in the percent natural land cover at EE field trip program sites and student's school attendance zones (SAZs)?

This study is part of a larger research effort designed to examine EE field trip programs and the linkages between a range of program characteristics, pedagogical approaches, and positive student learning outcomes. This involved the observation of over 70 programmatic characteristics at 345 EE field trip programs across the United States (see: Dale et al., 2020; Lee, et al., 2020; O'Hare et al., 2020).

Site Selection

We collaborated with the North American Association of Environmental Education (NAAEE), the National Park Service (NPS), and the Association of Nature Center Administrators (ANCA), to identify a broad range of organizations that offered EE programs. We identified over 300 potential program providers, including national parks, state and local parks, nature centers, botanical gardens, wildlife reserves, farms, public forests, science museums, and other environmental organizations. Our selection criteria dictated that potential organizations must offer programs that were: (1) field trips taking place away from school; (2) EE-focused; (3) a single day or less in duration; (4) served grades 5-8; (5) and offered by providers that expressed a willingness to participate. Ultimately, 345 programs provided by 90 unique organizations (Figure

1) were observed between January and June 2018 (see Dale et al., 2020; Lee et al., 2020 for more information).

Figure 1: A map of sampled program providers (n = 90).

Survey Design & Administration

Immediately following each program, all attending students were invited to complete a retrospective survey to assess student learning outcomes (see Appendix A). For all programs, researchers attempted a census of all eligible attendees. No time limit was given for the students to complete the survey, but the average completion time was around 8 minutes. The student survey was composed of the Environmental Education Outcomes for the 21st Century (EE21) scales, which were developed with extensive collaboration and review by the EE field and followed scale development procedures recommended by DeVellis and Thorpe (2021) and others (see Powell et al. 2019 for details). EE21 is comprised of 10 sub-scales that measure outcomes identified by the field as relevant and important (Place Attachment, Learning, Interest in

Learning, 21st Century Skills, Self-Identity, Self-Efficacy, Environmental Attitudes, Environmental Behaviors, Cooperation/Collaboration Behaviors, and School Behaviors) (Table 3). All but two of these sub-scales were measured using retrospective questions asking students to reflect on how much the program influenced them. All items were scored on an 11-point Likert-type scale (see Appendix A for details). The remaining two sub-scales, Self- Efficacy and Environmental Attitudes, used retrospective pre/post questions to ask students to, first, reflect on how they felt about given statements before the program, and then, how they felt after as a result of the experience. The mean scores for these two subscales represent the difference between pre and post responses.

Data Cleaning

Data from the 345 observed programs were entered into Microsoft Excel and then transferred to SPSS for data screening and analysis. We first removed any EE field trip programs with a response rate below 50%. We then screened and removed individual surveys missing responses to more than 25% of items along with those demonstrating clear patterns of invalid responses, such as a lack of variability in answers, strings of consecutive numbers, or the use of a single circle to indicate responses for multiple items (Dale et al., 2020; Lee et al., 2020; O'Hare et al., 2020). Survey data was then screened for multivariate outliers using Mahalanobis Distance (Field, 2018). This produced a sample of 334 usable programs and 4,376 valid surveys.

To develop the sample for our first research question, we then removed any programs that were attended by multiple schools or grade levels, occurred entirely indoors, or did not have an identifiable location (EE field trips occurred on a moving bus or took place on water,). These inclusion criteria were developed to remove programs that occurred at sites whose relative naturalness could not be readily assessed and compared using our methodology. 283 programs met these criteria and constituted our sample for our first research question (Table 1).

Table 1: Program inclusion criteria for research question 1

Criteria	Programs Removed	Programs remaining
Stating point	N/A	334
Removed programs attended by multiple schools or grades	3	331
Removed any programs that occurred entirely indoors	9	322
Removed programs without an identifiable location	39	283

The sample for our second research question was winnowed using the same inclusion criteria, but with the additional removal of programs that were not attended by a public-school group. This is because SAZs only exist for public schools. We removed 64 additional programs based on this criterion. Because we are investigating the difference in the percent natural land cover between the SAZ and EE field trip site, we then aggregated data to the school level (i.e., mean EE21 score for all programs from a school) instead of the program level. Thus, our unit of analysis is the 106 public schools representing 219 programs from which we collected survey data.

Grade, Race, & SES of Participating Students

Previous studies (e.g., Browning et al., 2018; Browning & Rigolon, 2019; Browning & Locke, 2020) as well as our research (Stern et al., 2021) show that students' sociodemographics can impact learning outcomes in formal education and EE settings. As such, we group mean centered the EE21 outcome by grade and race and used linear regression models to control for SES for each research question.

Grade levels were reported by the on-site educators, but were also collected on student questionnaires. Most groups were comprised of a single grade.

Although student surveys contained a question about racial identity using standard Census Bureau categories, we observed that students often experienced discomfort or misunderstood this question. Many left the question blank or wrote in invalid responses. Because of these problems, we took steps to verify the racial majority of each participating school group.

We began by determining the overall racial make-up of the school of each attending group using various internet sources (www.elementary schools.org; www.greatschools.org; www.schooldigger.com, and individual school websites). We recorded the racial majority of students (> 50%) as: majority White, majority Black, majority Hispanic, or no majority. We then compared self-reported racial demographics on the student surveys to these school figures to determine mismatches. The school-wide data matched self-reported data in 88% of the cases. We examined each mismatched case where school-wide data did not match the attending group data. In most cases, the mismatch could be explained by low response rates on the surveys (it would still be possible that the majority of the group could match the majority of the school). In cases of mismatch with higher response rates, we recorded the group as "missing data," rather than assigning a specific racial make-up to the group. We did this to be as conservative as possible and avoid misclassification. This only happened in four cases. In some cases (n = 35), school-wide data was not available. In these cases, we coded the majority of the student group using self-reported racial data only when a clear majority (>50% of all students in the group, regardless of the response rate) identified as a specific race. Other cases (n = 4) were coded as missing data. This resulted in eight cases in which the racial majority was not clear enough to use in our analyses.

We use the percentage of students with access to free and reduced lunch prices within a school as a single indicator of SES. These data were collected from the publicly available National Center for Education Statistics database in 2018. While SES encompasses a far broader array of characteristics, percent free and reduced lunch reflects the general context of a school's attendance zone in terms of the concentration of low-income students (NCES, 2020). Nationwide, approximately 58% of public-school students participated in the National School Lunch program that provides free and reduced lunch prices (Bauman & Cranney 2020; USDA Food and Nutrition Service, 2020).

Mapping & Data Analysis

Natural Land Cover

We used the 2016 National Land Cover Database (NLCD) Percent Developed Imperviousness dataset for the continental United States as our measure of relative land cover naturalness. The 2016 NLCD Percent Developed Imperviousness dataset is a raster dataset derived from 30-meter Landsat imagery created by the USGS and the Multi-Resolution Land Characteristics consortium (MRLC, 2020). This is a continuous metric that represents the continental United States as a grid of 900-m^2 pixels with values ranging from 0-100, indicating the estimated percent of each area that is covered with built impervious surfaces. The inverse of this metric is the operational measure of naturalness used for this study, which allowed us to calculate the percent of natural land cover at EE sites and SAZs.

'Naturalness' can be considered a loaded term with many different definitions and ways to measure it. We acknowledge this, and made the decision to use the 2016 NLCD Percent Developed Imperviousness dataset for this study as it has been used in previous naturalness literature, and is a continuous measurement that provides a more nuanced representation of naturalness (e.g., Larson et al., 2018; Kuang, 2019). However, we know that 'imperviousness' and 'naturalness' are not necessarily synonyms, so we conducted a sensitivity analysis using reclassified 2016 NLCD categorical land cover dataset, to ensure that our metric for naturalness was both accurate and valid.

Sensitivity Analysis for Naturalness

Like the Percent Developed Imperviousness dataset, the 2016 NLCD categorical land cover dataset is also a raster dataset that represents the continental United States as a grid of 900-

m² pixels. Unlike the imperviousness dataset, this dataset categorically classifies the land cover of each pixel into 16 unique land cover types (e.g., deciduous forest, grassland, cultivated crops, high intensity development) (MRLC, 2020). For our research purposes, we collapsed and reclassified the 16 land cover classes into unnatural and natural land cover (Akpinar et al., 2016). This allowed us to calculate the percent of natural land cover at EE sites and SAZs, and compare the naturalness for these locations.

However, the reclassification of the 2016 NLCD categorical land cover dataset was complicated by three of its cover classes: *developed open space, developed, low intensity*, and *barren land*. The land cover categories *developed open space* and *developed low intensity* are transitional cover classes that contain land cover that has been developed by humans as well as land cover that is considered natural. *Barren land* is a complex cover class as a result of how it is defined and its application in NLCD. Certain pixels contained in this cover class are naturally occurring (e.g., volcanic material, dunes, glacial deposits), while others are not considered natural in this study (e.g., mines, gravel pits). To determine how each of these cover classes were treated, we used purposive sampling of ten sites (five EE sites and five SAZs) for each cover class where there was a high number of pixels with one of the land cover class present. We then cross-checked these pixels against 2016 satellite imagery and determined their naturalness.

Developed open space is defined by the MRLC as mostly vegetated land with 20% or less impervious surface coverage. Places like parks, lawns, and golf courses are often included in this class. In our sample, we found that pixels of this type were 60-90% natural ($\bar{x}$ = 75%, n = 10). As a result, we chose to classify developed open space as natural.

Low intensity developed space is defined by the MRLC as a mix of vegetation and constructed materials with 20-49% impervious surface coverage. Single-family houses are the places most often included in this class. In our sample, we found that sites were highly variable, with pixels of this cover type ranging from 13% to 67% natural ($\bar{x}$ = 39%, n = 10). How we choose to reclassify this cover type matters a lot because, in some of our study sites, as much as 68% of pixels are of this class. As a result, we do not feel that this class can be neatly or confidently collapsed into either natural (1) or unnatural (0). Instead, we assigned pixels of this class a value of 0.5 natural.

Barren land is defined by the MRLC as accumulations of earthen material with <15% vegetation cover. Land cover often found in this class include both natural areas, such as exposed bedrock, scarps, glacial debris, and dunes, as well as areas of intense human disturbance, like mines and gravel pits. In our sample, we found that pixels of this type are generally natural in EE sites (87-100%, $\bar{x}$ = 92%, n =5) but unnatural in SAZs (21-100% unnatural, $\bar{x}$ = 52%, n =6). Barren land represents only 0.4% of pixels in SAZs but 5.13% of pixels in EE sites overall (with one EE site having almost 80% of its area covered by this class). Consequently, how we choose to reclassify barren land would most likely have little or no meaningful effect on our estimates of naturalness within SAZs, but could dramatically alter our estimates of naturalness in EE sites. As a result, we chose to treat pixels of this class as natural within EE sites and unnatural within SAZs.

What we discovered is that the percentage of natural land cover as measured by both the 2016 NLCD Percent Developed Imperviousness dataset and our reclassified 2016 NLCD land cover dataset were almost perfectly correlated with each other (r (281) = .963, $p < .01$). This sensitivity analysis supports our use of the 2016 NLCD imperviousness dataset as our metric for naturalness in this study.

Site & SAZ Boundaries

We mapped the spatial extent of each EE field trip site where students engaged in activities. Researchers who observed programs used ArcGIS Survey123 to outline the specific areas where students engaged in activities during the EE field trip program (Figure 2). This was important because some EE field trip destinations (like national parks) occupy very large areas, but a single field trip program only actively uses a small portion of that area. It is for this reason that we did not simply use parcel data to represent the spatial extent of each field trip site.

Figure 2: An outline created by one of our researchers on ArcGIS Survey123 depicting the approximate location where they observed an EE program occurring.

The shapefiles generated through this mapping exercise were then loaded into ArcGIS Pro version 2.8.1, and we applied a 25-meter "visual buffer" around each site following recommendations by Browning et al., (2018) and Browning and Rigolon (2019). This visual buffer is intended to account for any features outside of the direct site that may have influenced students' perception of naturalness, as the students may have seen features beyond that boundary that could have influenced their experience (Browning & Rigolon., 2019; Browning et al., 2018).

For our second research question, we mapped public school groups' day-to-day environments using their respective SAZs (Figure 3). SAZs are local political boundaries that represent the "catchment area" for a single public school (NCES, 2020). SAZs were chosen because they encompass both the school that students attend as well as all of their homes and neighborhoods (Browning et al., 2018; Hodson & Sander, 2017; Hodson & Sander, 2019). SAZ data was gathered from the publicly available 2020 National Center for Education Statistics dataset (NCES, 2020).

Figure 3: A map of visiting student groups' school locations (n = 106).

Data Analysis

The same analyses were conducted for each of our research questions. As grade and race are factors that impact EE21 outcomes (Stern et al., 2021), we began by group mean centering

EE21 outcomes to control for these variables (Enders & Tofighi, 2007). We then calculated bivariate Pearson correlations and conducted a series of linear regression models for each of our research questions: (1) Controlling for grade, race, and SES (percent free and reduced lunch), what is the relationship between the level of naturalness at an EE field trip site, as measured by percent natural land cover, and middle school-aged students' learning outcomes? and (2) Controlling for grade, race, and SES, what is the relationship between student learning outcomes and novel levels of naturalness, as measured by the difference in percent natural land cover at EE field trip program sites and students' SAZs?

RESULTS

Research Question 1:

A diverse population of students attended the 283 programs included in the sample for our first research question (Table 2). A plurality of programs were attended by student groups from majority-White schools (43.7%) and fifth grade groups (44.1%). The average eligibility for free and reduced lunch was 59.3% across the sample (Table 2).

Table 2: Demographic & descriptive data

S	**N**	**Percentages & Frequencies**			
Grade Level	263	**5**	**6**	**7**	**8**
		44.1% (116)	31.6% (83)	19.4% (51)	4.9% (13)
Racial Majority	277	**White**	**Latinx**	**Black**	**No Majority**
		43.7% (121)	33.2% (92)	8.7% (24)	14.4% (40)
% Free & Reduced Lunch	239	M = 59.3 (SD = 24.1)			

Table 3 displays the means and standard deviations for each item and each sub-scale that composes the EE21 composite measure. Our analysis uses the composite EE21 score, where each variable is equally weighted and aggregated to the program level (the mean of all students that attended a given program).

Table 3: EE21 means & standard deviations

Constructs	RQ1 (n=283) M(SD)	RQ2 (n=219) M(SD)
Connection/Place attachment	7.76 (1.23)	7.91 (1.18)
Learning	7.56 (1.04)	7.67 (1.02)
Interest in Learning	6.53 (1.39)	6.66 (1.38)
21st Century Skills	6.43 (1.38)	6.57 (1.38)
Meaning/Self Identity	6.87 (1.32)	6.99 (1.31)
Self-Efficacy	.98 (.58)	1.03 (.58)
Environmental Attitudes	1.04 (.50)	1.04 (.49)
Actions: Environmental Stewardship	7.42 (1.14)	7.53 (1.08)
Actions: Cooperation/Collaboration	7.06 (1.26)	7.16 (1.25)
Actions: School	7.34 (1.43)	7.48 (1.43)
EE21 Composite (Cronbach's alpha=.962)	**5.90 (.98)**	**6.01 (.96)**

The average area of the EE field trip site was 8.52 hectares. The smallest area utilized for a field trip program was 0.61 hectares and the largest area was 55.66 hectares. EE sites contained on average 85.21% natural land cover, ranging from 6.88% to 100% natural (Table 4).

Table 4: Descriptive statistics for EE site area & naturalness (n=103)

	Area (Hectares)	2016 NLCD Impervious Surface Naturalness %
Mean (SD)	8.52 (8.71)	85.21 (17.78)
Median	5.87	91.21
Minimum	.61	6.88
Maximum	55.66	100

Correlations:

There was a positive, significant relationship between EE21 outcomes and land cover naturalness at EE sites (*r* (254) = .187, $p < .01$)[1]. There is also a significant, positive correlation between percent free and reduced lunch and EE21 outcomes (*r* (221) = .316, $p < .01$) (Table 7). However, there is not a significant correlation between percent free and reduced lunch and land cover naturalness at EE sites (*r* (254) = -.054, $p = .40$).

Table 5**:** Research question 1 bivariate correlations

	N	1	2	3
1. EE21 Outcome (GMC for Grade & Race)	256	---	---	---
2. 2106 NLCD Impervious Surface Naturalness %	256	.187**	---	---
3.% Free & Reduced Lunch	223	.316**	-.054	---

** Correlation is significant at the .01 level (2-tailed).

Regression Models:

The first linear regression model (F (1, 254) = 9.24, $p < .003$; $R^2 = .035$) examined the relationship between EE21 and land cover naturalness. The results suggest that a significant, positive relationship between land cover naturalness of EE sites and EE21 exist (*B* = .187, *p* = .003) (Table 6). The second linear regression model (F (2, 220) = 16.981, $p < .001$; $R^2 = .134$), examining the relationship between EE21 outcomes, land cover naturalness, and SES found a significant, positive relationship between land cover naturalness at EE sites and EE21 outcomes (*B* = .184, *p* = .004), and between SES and EE21 outcomes (*B* = .322, $p < .000$) (Table 7). While both percent free and reduced lunch and land cover naturalness were found to be significant

[1] In addition to conducting a correlations analysis in which the 283 student groups were the unit of analysis, we conducted a correlations analysis in which we aggregated the group mean centered EE21 outcomes to the sites where the EE field trip programs occurred (n=93). This analysis revealed a significant, positive correlation between EE21 outcomes and land cover naturalness at the EE sites (*r* (93) = .262, $p < .05$) (Appendix C). However, we use the sample of 283 programs as our unit of analysis for our first research question, as we controlled for SES using percent of students on free and reduced lunch.

predictors of positive EE21 outcomes, percent free and reduced lunch is a much stronger predictor of positive EE outcomes than land cover naturalness at EE sites.

Table 6: Regression model research question 1 results without controlling for SES

Variable	Standardized Beta Coefficients	t	Sig.
(Constant)		-3.00	.003
% Naturalness	.187	3.04	.003

a. Dependent Variable: GMC EE21 Outcome

Table 7: Regression model research question 1 results controlling for SES

Variable	Standardized Beta Coefficients	t	Sig.
(Constant)		-4.56	.000
% Naturalness	.184	2.93	.004
% Free & Reduced Lunch	.322	5.12	.000

a. Dependent Variable: GMC EE21 Outcome

Research Question 2:

Research question 2 investigates the relationship between student learning outcomes and the difference in the percent natural land cover between the SAZ and EE field trip site. To examine this question, we aggregated data to the school level (n = 106 schools attended 219 EE field trip programs). A plurality of programs were attended by student groups from majority-White schools (44.8%) and 50% were fifth grade groups. The average eligibility for free and reduced lunch was 60.48% (Table 8).

Table 8: Sociodemographics for sampled schools

S	N	Percentages & Frequencies			
Grade Level	102	**5**	**6**	**7**	**8**
		50% (51)	31.4% (32)	12.7% (13)	5.9% (6)
Racial Majority	105	**White**	**Latinx**	**Black**	**No Majority**
		44.8% (47)	37.1% (39)	4.8% (5)	13.3% (14)
% Free & Reduced Lunch	104	M = 60.48 (SD = 24.34)			

SAZs on average were 12,648 hectares and contained on average 67.6% natural land cover, with SAZs ranging from 13.4% to 99.6% natural (Table 9). EE sites were 87.04% natural and almost 20% more natural than the average SAZ.

Table 9: Descriptive statistics for SAZ area, SAZ naturalness, EE field trip site naturalness, & SAZ-EE site naturalness difference

	SAZ Area (n=106) (hectares)	**SAZ Naturalness %**	**EE Site Naturalness %**	**Naturalness Difference %**
Mean	12648.70	67.61	87.04	19.43
(SD)	(45703.97)	(23.39)	(15.15)	(24.52)
Median	1065.33	64.86	94.77	17.04
Minimum	94.10	13.40	34.05	-33.33
Maximum	368580.61	99.60	100	80.05

Correlations:

We conducted Pearson bivariate correlation analysis and the results suggest that there is a positive, significant relationship between EE21 outcomes and the difference in land cover naturalness between students' SAZs and EE sites (r (98) = .203, $p < .05$). There is also a significant, positive correlation between percent free and reduced lunch and EE21 (r (96) = .311, $p < .01$) (Table 10). However, there is a significant relationship between percent free and reduced lunch and land cover naturalness between students' SAZs and the EE sites they visited (r (102) =.311, $p < .01$).

Table 10: Research question 2 bivariate correlations

	N	1	2	3
1. EE21 (GMC for Grade & Race)	100	---	---	---
2. Novel Levels of Naturalness Difference %	100	.203*	---	---
3. % Free & Reduced Lunch	98	.311**	.311**	---

** Correlation is significant at the .01 level (2-tailed).
* Correlation is significant at the .05 level (2-tailed).

Regression Models:

The linear regression model 1 (F (1, 98) = 4.197, $p < .043$; $R^2 = .041$) suggests a significant, positive relationship between EE21 and novel levels of naturalness $B = .203$, $p = .043$ (Table 11). Controlling for SES by including the percentage of students eligible for free and reduced lunch in the regression equation, linear regression model 2 (F (2, 95) = 5.799, $p = .004$; $R^2 = .109$), indicates that novel levels of naturalness was not a significant predictor of EE21 ($B = .115$, $p = .263$) and only percent free and reduced lunch was significant in this model ($B = .276$, $p = .008$), with an R^2 of .109 (Table 12).

Table 11**:** Research question 2 linear regression results without controlling for SES

Variable	**Standardized Beta Coefficients**	**t**	**Sig.**
(Constant)		-.809	.421
Novel Levels of Naturalness % (Difference between SAZ & EE field trip site)	.203	2.05	.043

a. Dependent Variable: GMC EE21 Outcome

Table 12**:** Research question 2 regression results controlling for SES

Variable	**Standardized Beta Coefficients**	**t**	**Sig.**
(Constant)		-2.762	.007
Novel Levels of Naturalness % (Difference between SAZ & EE field trip site)	.115	1.126	.263
% Free & Reduced Lunch	.276	2.710	.008

a. Dependent Variable: GMC EE21 Outcome

DISCUSSION

We investigated the relationship between naturalness of EE field trip sites and student learning outcomes. Controlling for grade and race, we began by conducting a bivariate correlations analysis to explore the simple relationship between land cover naturalness at EE sites and EE21 outcomes. Our results from this analysis indicate a positive, significant, but weak relationship between the percentage of natural land cover of an EE field trip site and positive EE21 outcomes. We then ran a series of linear regression models to explore the impact of naturalness on student learning outcomes and found that the naturalness of the setting at an EE field trip site is a significant predictor of positive EE21 outcomes, both with and without controlling for SES – a factor known to influence EE21 outcomes during field trip programming (Stern et al., 2021).

To assess an alternative hypothesis – that novel levels of naturalness, rather than site naturalness itself, may positively influence student learning outcomes during EE field trip programs – we first calculated the difference in the percentage of natural land cover between the EE field trip sites and visiting school groups' SAZs. We then ran a bivariate correlations analysis that revealed a significant, positive relationship between novel levels of naturalness experienced during an EE field trip program and positive EE21 outcomes. We followed up by conducting a series of regression models to investigate the relationship between positive EE21 outcomes and novel levels of naturalness, while controlling for SES (percent free and reduced lunch). We found that novel levels of naturalness weakly contribute to positive EE21 outcomes during EE field trip programming, although when controlling for SES, novel levels of naturalness was not a significant predictor of EE21 outcomes. This result suggests that the percentage of students receiving free and reduced lunch is a covariate of novel levels of naturalness and accounts for shared variance in EE21 outcomes. This result is supported by other research that suggest that higher levels of percent free and reduced lunch are associated with urban schools (e.g., Berman et al., 2018; Kuo et al., 2018; Logan & Burdick-Will, 2017).

What we observed in both our analyses is that when controlling for grade level of students and the racial majority of students' schools, the naturalness of EE field trip sites are weakly but positively correlated with positive EE21 outcomes. However, when we also controlled for SES, as measured by percent free and reduced lunch, we found that SES is a stronger, more significant predictor of positive EE21 outcomes during EE field trip programs. This is not to say that the naturalness of the setting and novel levels of naturalness don't contribute to positive EE21 outcomes, but rather many other factors also contribute to outcomes during EE field trip programming.

For example, in our regression model for our first research question, only 3.5% of the variance was explained by naturalness. Novel levels of naturalness only explained 4.1% of the variance in the regression model, while SES explains 9.7% of the variance for our second research question. Again, such findings suggest that natural settings and novel levels of naturalness contribute to positive EE21 outcomes during EE field trip programming, but that there are many different pedagogical approaches and program characteristics that influence positive EE21 outcomes (e.g., Dale et al., 2020; DeWitt & Storksdieck, 2008; Stern et al., 2021; Storksdieck, 2001; Lee et al., 2020; O'Hare et al., 2020). These results suggest that practitioners in novel, natural settings (e.g., the Grand Canyon, Yellowstone, Acadia, Crater Lake) should continue to emphasize and use such features in EE programming but recognize that being reliant on such features is not enough to produce positive student learning outcomes. For program practitioners in urban or less novel natural environments, our findings indicate that a successful EE program is still entirely possible, and it is best to focus on effective pedagogy and teaching strategies to promote positive learning outcomes (DeWitt & Storksdieck, 2008; Storksdieck, 2001). This means that EE field trip programs can essentially occur anywhere, which is especially important for access and equality. Students may not need to travel hours into extremely novel, natural locations to receive the benefits of an incredible EE program. EE programs could occur in students' neighborhoods, at local nature centers, in familiar environments and be just as impactful on learning outcomes as programs in novel, highly natural settings.

While our research highlights the effects of naturalness during EE field trip programs on EE21 outcomes, there are some limitations to this study. We used outlines created by researchers who observed EE programs to identify the areas where field trips occurred. This was done after researchers had observed the EE field trips. In the future, researchers could carry GPS units and track the areas where programs occurred. Doing so may yield more precise outlines and estimated areas of EE field trip program sites.

While we ultimately used the 2016 NLCD Percent Developed Imperviousness dataset, which has been used in past naturalness research (Larson et al., 2018), it may be advantageous in the future to use this dataset in tandem with other imagery (NDVI, for example) or observational data, to help address any error in land cover classification (Wickham et al., 2021). The pixel size of the 2016 NLCD Percent Developed Imperviousness dataset is 900m^2, which is quite large, and as this is a raster dataset, each individual pixel is assigned one value of relative imperviousness. This means that our metric for naturalness was considered coarse grained, and it would be best to pair this remotely sensed data with metrics of student perception of naturalness and novel levels of naturalness in future studies. Previous EE research has been reliant on expert observations to understand naturalness and novelty of settings (Dale et al., 2020), and although this study was the first of its kind to use remotely sensed data to understand the relationship between naturalness student learning outcomes, the students' perception of naturalness is still missing. The addition of students' perceptions would allow for a more holistic sense of the role that natural and novel environments play during an EE field trip program. Adding questions to existing surveys would provide an opportunity to gain a deeper understanding of novel and natural environments.

Additionally, we used imperviousness of built surfaces as a proxy measurement for naturalness. Naturalness is a very complex term, and while we did conduct a sensitivity analysis and ensured that the imperviousness classification was correlated with natural land cover, the quality of the natural environment was not measured. In the future, it could be advised to use imagery with a higher resolution as well as direct observational data to better understand nuances of naturalness that could be associated with quality.

While some of the EE programs and SAZs were located in non-coastal states in the interior United States, our sample of EE programs and SAZs used in this study focused on predominantly coastal locations. Our study of EE programs and SAZs is also post hoc in nature, as such sites were not selected and sampled for the purpose of this study. This resulted in a sample of sites that may not be as diverse in natural attributes, and includes a student audience that is reflective of a primarily coastal population. Future sampling efforts should focus on other states and other student populations to increase diversity.

While these limitations exist, this research offers compelling evidence to counter the common assumption in the field that simply having an EE lesson outside, in a natural environment, will automatically produce life-changing experiences and positive learning outcomes. Natural environments and novel natural environments during EE field trip programming contribute positively to learning outcomes, but must be paired with effective pedagogical approaches and program implementation in order to create truly impactful experiences for students (Dale et al., 2020; Duerden & Witt, 2012; Durlak & DuPre, 2008; Morgan et al., 2016).

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APPENDICES

Appendix A

Student Survey

CLEMSON UNIVERSITY VirginiaTech

POST-EXPERIENCE SURVEY

This survey asks questions about your recent program. Your answers will help to us to improve future field trips. This is not a test. There are no right or wrong answers. Answer with your honest opinions. Your participation is voluntary. Thanks for your time!

1. **Your initials** ____________________ **Your birthday** ____________________

2. **Your school's name** ____ **Your grade level** _____

3. **How would you rate this experience on a scale from 0 to 10?** ***Circle a number.***

Terrible										Excellent
0	1	2	3	4	5	6	7	8	9	10

4. **Write three words or short phrases below that best describe how the program made you feel.**

1. ________________________ 2. ________________________ 3. ________________________

5. **As a result of this experience, do you intend to do anything differently in your life?**

Circle one: **Yes** **No**

If yes, what will you do? ***Write your answer in the space below.***

6. **How much do you feel you learned from this experience, on a scale from 0 to 10?** ***Circle a number.***

Nothing at all										A huge amount
0	1	2	3	4	5	6	7	8	9	10

7. **To what extent do you agree with the following statements?** ***Circle a number for each statement.***

	Not at all			→		Somewhat agree		→			Strongly agree
I believe in myself.	0	1	2	3	4	5	6	7	8	9	10
I feel it is important to take good care of the environment.	0	1	2	3	4	5	6	7	8	9	10
Humans are a part of nature, not separate from it.	0	1	2	3	4	5	6	7	8	9	10
I have the power to protect the environment.	0	1	2	3	4	5	6	7	8	9	10
I feel confident that I can achieve my goals.	0	1	2	3	4	5	6	7	8	9	10
I can make a difference in my community.	0	1	2	3	4	5	6	7	8	9	10

Turn over to continue . . .

CLEMSON UNIVERSITY   VirginiaTech

How much did you learn about each of the following things as a result of this experience? ***Circle a number for each.***

How much did you learn about . . .	Nothing at all					A fair amount					A huge amount
How different parts of the environment interact with each other.	0	1	2	3	4	5	6	7	8	9	10
How people can change the environment.	0	1	2	3	4	5	6	7	8	9	10
How changes in the environment can impact my life.	0	1	2	3	4	5	6	7	8	9	10
How my actions affect the environment.	0	1	2	3	4	5	6	7	8	9	10

8. How interested are you in each of the following things? ***Circle a number for each.***

	Not at all					Somewhat interested					Extremely interested
Science.	0	1	2	3	4	5	6	7	8	9	10
How to research things I am curious about.	0	1	2	3	4	5	6	7	8	9	10
Learning about new subjects in school.	0	1	2	3	4	5	6	7	8	9	10
Learning more about nature.	0	1	2	3	4	5	6	7	8	9	10

9. How good are you at each of the following things? ***Circle a number for each statement.***

	Not good at all					OK					Extremely good
Solving problems	0	1	2	3	4	5	6	7	8	9	10
Using science to answer a question	0	1	2	3	4	5	6	7	8	9	10
Listening to other people's points of view	0	1	2	3	4	5	6	7	8	9	10
Knowing how to do research	0	1	2	3	4	5	6	7	8	9	10

10. Did this experience do any of the following things for you? ***Circle a number for each row.***

The field trip . . .	Not at all					A fair amount					A huge amount
Taught me something **that will be useful to me** in my future.	0	1	2	3	4	5	6	7	8	9	10
Made me curious about something.	0	1	2	3	4	5	6	7	8	9	10
Really made me think.	0	1	2	3	4	5	6	7	8	9	10
Made me realize something I never imagined before.	0	1	2	3	4	5	6	7	8	9	10
Made me think differently about the choices I make in my life.	0	1	2	3	4	5	6	7	8	9	10

Continue on the next page . . .

11. How likely are you to do any of the following things within the next year?

	Not likely →					Somewhat likely →					Extremely likely
Help to protect the environment.	0	1	2	3	4	5	6	7	8	9	10
Spend more time outside.	0	1	2	3	4	5	6	7	8	9	10
Make a positive difference in my community.	0	1	2	3	4	5	6	7	8	9	10
Listen more to other people's points of view.	0	1	2	3	4	5	6	7	8	9	10
Talk with others about ways to protect the environment.	0	1	2	3	4	5	6	7	8	9	10
Cooperate more with my classmates.	0	1	2	3	4	5	6	7	8	9	10
Work harder in school.	0	1	2	3	4	5	6	7	8	9	10
Pay more attention in class.	0	1	2	3	4	5	6	7	8	9	10

12. How much do you agree with the following statements about the location you've just visited for this program? *Circle a number for each statement.*

How much do you agree?	Not at all →					Somewhat agree →					Strongly agree
I want to visit this place again.	0	1	2	3	4	5	6	7	8	9	10
Knowing this place exists makes me feel good.	0	1	2	3	4	5	6	7	8	9	10
I care about this place.	0	1	2	3	4	5	6	7	8	9	10

13. Are you a girl or a boy? *(Directions: circle one)* **Girl** **Boy** **Transgender or other**

14. Which of the following best describes your racial or ethnic background? *(Check all that apply)*

☐ White ☐ Hispanic/Latino ☐ Mixed (two or more races) ☐ American Indian or Alaskan Native

☐ Black ☐ Asian ☐ Native Hawaiian or other Pacific Islander ☐ Other_______________

Stern, Marc J. and Robert B. Powell 2018. EE21 Survey.
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Appendix B

NLCD 2016 Land Cover Naturalness

Table 13 and Table 14 depict the break-down of how land cover was classified for EE sites and SAZs in our sample. It is important to note that categories considered natural and unnatural are almost identical, aside for the classification of Barren Land. This land cover type is considered natural at EE sites, but unnatural in SAZs.

Table 13: Land cover composition of EE sites derived from 2016 NLCD land cover data

Land Cover Category	**# Of Sites Category is Present (n=103)**	**Average%**	**% Composition range**	**Natural (1) Unnatural (0)**
Open Water	40	5.27	0 - 61.54	1
Developed, Open Space	70	11.24	0 - 91.67	1
Developed, Low Intensity	79	10.71	0 - 66.67	.5
Developed, Medium Intensity	62	7.57	0 - 68.42	0
Developed, High Intensity	29	2.86	0 - 100	0
Barren Land	21	3.77	0 - 84.87	1
Deciduous Forest	44	16.11	0 - 100	1
Evergreen Forest	32	4.67	0 – 54.24	1
Mixed Forest	26	3.86	0 – 70.59	1
Shrub/Scrub	39	11.24	0 – 100	1
Herbaceous	24	2.55	0 – 46.30	1
Hay/Pasture	22	3.58	0 – 81.58	1
Cultivated Crops	12	2.47	0 – 67.53	1
Woody Wetlands	34	8.75	0 – 96.43	1
Emergent Herbaceous Wetlands	33	5.35	0 – 44.55	1

Table 14: Land cover composition of SAZs derived from 2016 NLCD land cover data

Land Cover Category	**# Of Sites Category is Present (n=106)**	**Average %**	**% Composition Range**	**Natural (1) Unnatural (0)**
Open Water	74	1.97	0 – 47.22	1
Developed, Open Space	103	11.66	.71 – 50.80	1
Developed, Low Intensity	103	22.03	.48 – 63.28	.5
Developed, Medium Intensity	103	19.97	.06 – 67.43	0
Developed, High Intensity	103	8.59	02 – 74.30	0
Barren Land	70	.31	0 – 5.61	0
Deciduous Forest	52	5.32	0 – 60.07	1
Evergreen Forest	53	3.75	0 – 47.28	1
Mixed Forest	50	3.15	0 – 35.12	1
Shrub/Scrub	75	5.86	0 – 84.64	1
Herbaceous	84	1.70	0 – 31.47	1
Hay/Pasture	63	3.25	0 – 38.28	1
Cultivated Crops	78	5.99	0 – 71.18	1

Woody Wetlands	67	3.64	0 – 54.28	1
Emergent Herbaceous Wetlands	64	2.81	0 – 85.67	1

Tables 15 and 16 depict descriptive statistics for land cover naturalness for EE sites and SAZs in our research questions. These tables compare the naturalness of our reclassified 2016 NLCD land cover dataset to the 2016 NLCD Urban Imperviousness dataset. These two metrics are highly correlated to each other.

Table 15**:** EE site naturalness comparison (n=103)

	Area (Hectares)	**2016 NLCD Naturalness %**	**2016 NLCD Impervious Surface Naturalness %**
Mean (SD)	8.52 (8.71)	83.73 (22.30)	85.21 (17.78)
Median	5.87	92.57	91.21
Minimum	.61	0	6.88
Maximum	55.66	100	100

Table 16**:** Comparison of naturalness composition for EE sites & SAZs

	SAZ Area (n=106) (hectares)	**EE Site Area (n=77) (hectares)**	**SAZ 2016 NLCD Naturalness %**	**EE Site 2016 NLCD Naturalness %**	**2016 NLCD Naturalness Difference %**	**SAZ Impervious Surface Naturalness %**	**EE Site Impervious Surface Naturalness %**	**Impervious Surface Difference %**
Mean (SD)	12648.70 (45703.97)	7.84 (7.43)	60.53 (28.88)	85.57 (20.57)	25.04 (29.82)	67.61 (23.39)	87.04 (15.15)	19.43 (24.52)
Median	1065.33	5.54	57.91	96.35	21.28	64.86	94.77	17.04
Minimum	94.10	.85	6.47	9.52	-47.30	13.40	34.05	-33.33
Maximum	368580.61	46.09	99.56	100	90.42	99.60	100	80.05

Appendix C

Additional Correlations for Research Question 1

Table 17 presents a correlations matrix for research question 1 where students' group mean centered EE21 outcomes were aggregated to the site.

Table 17**:** Research question 1 correlations

	N	**1**	**2**
1. GMC EE21 Outcome	93	---	---
2. 2106 NLCD Impervious Surface Naturalness %	103	.262*	---

* Correlation is significant at the .05 level (2-tailed).