ASSESSING PUBLIC PERCEPTION OF GREEN INFRASTRUCTURE IN ACADEMIC SETTINGS: USING THE UNIVERSITY OF GEORGIA AS AN EXAMPLE

by

YUWEN YANG

(Under the Direction of Ron Sawhill)

ABSTRACT

Green infrastructure has been increasingly recognized for its potential to reduce and treat stormwater on site while delivering environmental, social, and economic benefits. Widespread use of green infrastructure in academic settings requires public acceptance of various best management practices. Green Infrastructure practices such as rain gardens and pervious pavement have been implemented on the University of Georgia Campus, but the public perception of these sustainable practices remains unknown among the university community. Two visual preference surveys designed to understand landscape preference were distributed to 2,000 UGA students. The results showed that students have a positive visual response toward campus landscapes containing green infrastructure practices. Based on the rating scores of thirteen landscape images, the results showed that additional environmental education information improves student positive perception of green infrastructure practices. Multiple regression analysis was used to test the influential variables upon people's preferences, including gender, age, academic major, education level, familiar environment and campus living status.

KEY WORDS: Visual Preference; Green Infrastructure; Campus Landscape; Landscape Perception

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DEDICATION

This thesis is dedicated to my beloved family, who has supported me in the past 25 years. Most importantly, I dedicate this thesis to my father, who has influenced me the most and made me become who I am.

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CHAPTER 1

INTRODUCTION

The Urbanization and Stormwater Problem

As cities have expanded over the past decade, the global citizenry has shifted from a predominantly rural population to a predominately urban population. According to the United Nation's World Population Prospect Report, the world's urban population continues to grow faster than the total population of the world. Consequently, about 3 billion people or 48 percent of human beings, were living in urban settlements in 2003. The United Nations has also recently projected that "nearly all global population growth from 2017 to 2030 will be absorbed by cities, about 1.1 billion new urbanites over the next 13 years." In addition, it is predicted that by 2050 about 64% of the developing world and 86% of the developed world will be urbanized.

With urbanization and all the developments that has occurred in cities, human activities have altered our landscape greatly, producing all manner of adverse environmental effects. One such effect that has had tremendous impact is the alteration of the natural cycle of water due to the increase in impervious surfaces, blocking the infiltration process. When rain falls in natural, undeveloped areas, the water is absorbed and filtered by soil and plants. In this situation, stormwater runoff is cleaner and less of a problem. However, urbanization transforms natural landscape into impervious land cover, producing stormwater runoff and water pollution, which in turn affecting the ecosystem health of receiving water bodies and downstream communities. The earliest documentation of increased runoff from urban areas was in the late 1800s (Kuichling

1889), and urban runoff continues to be a leading cause of impairments in the nation's waterways (EPA 2002).

The term *Urban Stream Syndrome* perfectly describes the urbanization effect on waterbody. By definition, urban stream syndrome is a consistently observed ecological degradation of streams draining urban land (Christopher 2005). The factors contributing to the syndrome are complex and interactive, but most impacts can be ascribed to urban stormwater runoff delivered to streams. Urban area streams are particularly important because they are the ecosystems that sustain urban population. Human depend on the ecological service streams provide, including safe water supply, water recharge, flood risk reduction, recreational use, and the provision of habitat for diverse wildlife (Christopher 2005).

As of 2000, an estimated 83,749 km^2 of impervious surface covered the United States, and the impervious cover will expand to 114,070 km^2 by 2030. About 7% of eight-digit Hydrologic Unit Code (HUC) watersheds (4.3 % of the conterminous United States) were stressed or degraded (exceeding 5% IS) in 2000, and it is estimated that this will nearly double to 8.6% of watersheds by 2030 (David *et al*., 2000). Eight-digit Hydrologic Unit watersheds is analogous to medium-sized river basins. There is a direct relationship between the amount of impervious cover and the biological and physical condition of downstream receiving waters (EPA).

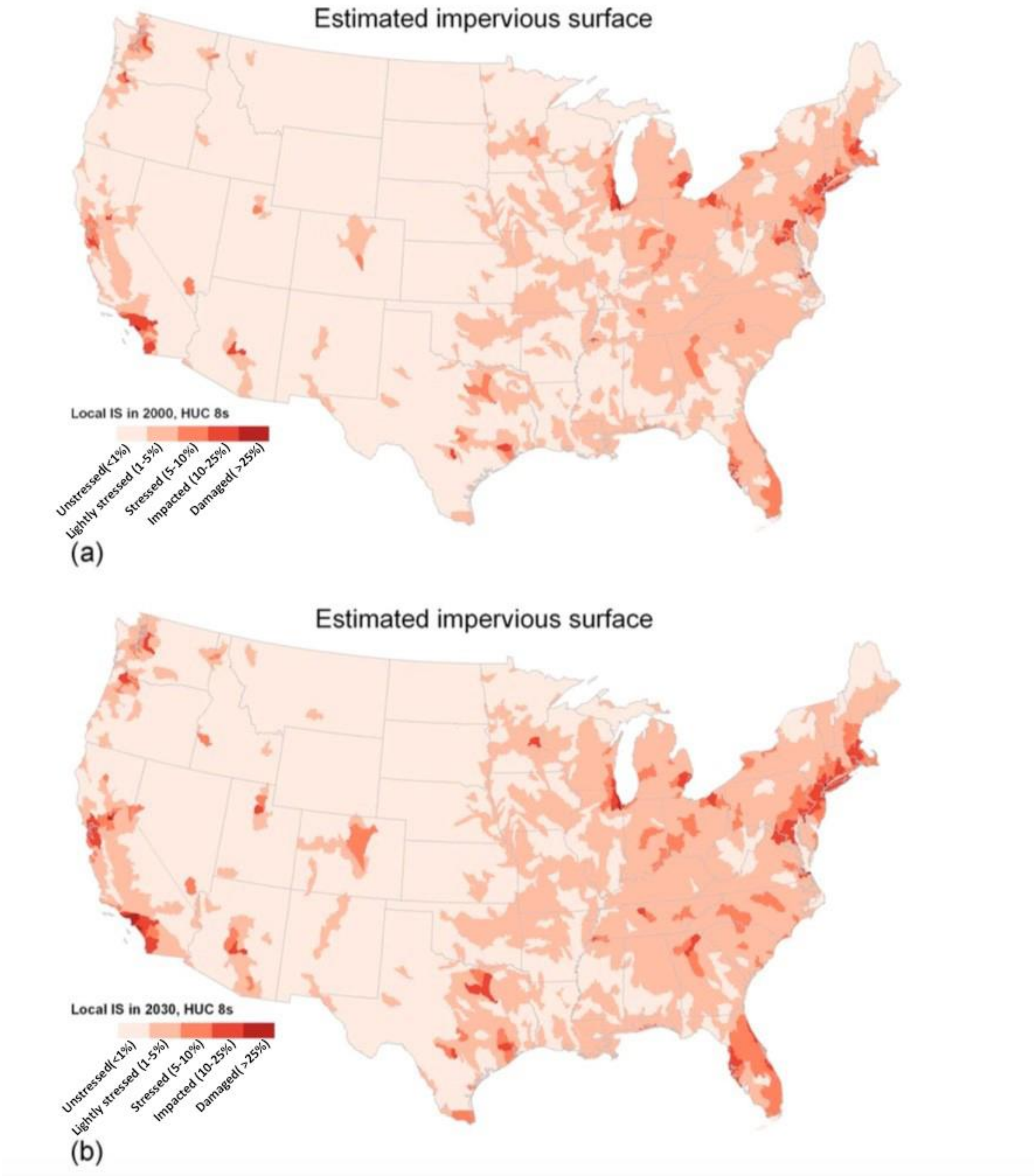

Figure 1: Estimated impervious surface summarized by eight-digit HUCs for 2000 (a), 2030 (b)

Every year, an estimated 10 trillion gallons of untreated stormwater generated from paved surfaces enter sewer systems and waterways. More than 750 cities in the U.S. experience sewage system overflows into nearby waterways during large rainstorms. Raw sewage, motor oil, and other pollutants can contaminate drinking water supplies, increase health risks, degrade ecosystems, and damage tourist economies (NRDC).

Green Infrastructure as a Remedy

Green infrastructure(GI) is increasingly recognized for its potential to reduce and treat stormwater on site while delivering environmental, social, and economic benefits (EPA). According to Claudia (2015), "Green infrastructure includes but is not limited to, green roofs, downspout disconnection, trees and tree boxes, rain gardens, vegetated swales, pocket wetlands, infiltration planters, vegetated median strips, curb extensions, permeable pavements, reforestation, and protection and enhancement of riparian buffers and floodplains." EPA defines green infrastructure as, "a cost-effective, resilient approach to managing wet weather impacts that provides many community benefits." Compared to the traditional single-purpose gray stormwater infrastructure used to transport urban stormwater away from the built environment by pipes, storm drains, and concrete storage tanks, green infrastructure adopts a de-centralized means to reduce and treat stormwater at the source.

The concept of GI grew out of the discipline of ecological planning (Zhang 2013). Ecological planning uses the principles of ecology to guide planning decisions. Dramstad (1996) stated that "Ecology is generally defined as the study of the interactions among organisms and their environment." The basic principles of ecology helped to shape the fundamental concept of green infrastructure, which is that "nature reserves/green spaces can provide multiple different functions for human being and other species (Zhang 2013)." Within the field of landscape architecture, Ian McHarg was a leader who advocated ecological planning in his famous book *Design with Nature*. He believed that “by using natural processes as the framework for developing our cities, public and private benefits could be maximized by safeguarding and enhancing land, water, air, and biotic resources (McHarg 1969).”

Green infrastructure pilot projects have shown that this innovative approach has the potential to capture, retain, infiltrate and evapotranspire 90 percent or more of the precipitation from a storm delivering an inch or less of rain (EPA 2017). Research on GI practices such as bio-retention, pervious pavements, and grassed swales has increased in recent years. (Michael 2007) Bio-retention cells have been effective in retaining large volumes of runoff and pollutants on site and have consistently reduced concentrations of certain pollutants such as metals. Porous pavements have been extremely effective in infiltrating stormwater runoff. Green roofs have been found to retain a large percentage of rainfall (63% on average) in a variety of climates (Michael 2007). An EPA report summarizes 17 case studies of developments that include GI practices and concludes that applying those techniques can reduce project costs and improve environmental performance. In most cases, green infrastructure practices were shown to be both financially and environmentally beneficial to communities (EPA, 2007).

The Environmental Protection Agency(EPA) has a long history of supporting GI development. According to Claudia (2015), “Since the 1990s, the agency has provided both technical assistance and information and developed policies to facilitate and encourage green infrastructure solutions and incorporate green infrastructure practices in Clean Water Act permits.” The EPA also provided grants and funding for projects in different communities in 23 states to identify green infrastructure opportunities and solutions for overcoming implementation barriers (Claudia 2016). In the United States, Philadelphia and New York City are leading the way with innovative green infrastructure plans. They have set up performance standards or provided incentives to promote green infrastructure while others have built demonstration projects (EPA). Also, many communities are experiencing the benefits of GI.

Barriers to the Adoption of GI

Even though an enormous amount literature exists that examines GI and its potential benefits in improving the physical environment of cities in the United States, and many cities have implemented GI Programs such as Chicago, Cincinnati, Milwaukee, New York City, Philadelphia, Portland, and Seattle, there are barriers to wide adoption of GI (Barnhill et al. 2012). Such barriers may relate to concern about the costs, doubts as to the benefits of GI, and public perception of GI as messy and ugly practices. "Some people think the facilities like rain gardens are ugly," reported a survey contributor while offering a solution(EPA). They also noted that property owners dislike any standing water, even during or just after rain events because of concern over mosquitoes (EPA). This kind of rejection is not uncommon. Research suggests that the most critical barriers to the adoption of GI are cognitive barriers and lack of socio-institutional mindset and policies. As Dhakal (2017) stated, "To overcome such barriers, it requires not only developing a new socio-institutional mindset through education and awareness, but also improving socio-institutional arrangements such as governance and policies." Other barriers are essentially the result of these two barriers. Social acceptance is very important and effective driver of a new technology or idea. Enhancing the knowledge of GI through education and increasing public awareness can resulting in the removal of cognitive barriers, which can facilitate social acceptance. Nassauer pointed out in her research that improved ecological quality may not be appreciated if recognizable landscape language that communicates human intention is not part of the landscape (Nassauer 1995). If the general public does not recognize the intention and benefit of GI, it is unlikely that landscape that features GI practices will be appreciated and properly maintained. Once the general public accepts the look of GI practices and understands how GI functions in the landscape, other pro-GI policies and programs at any level can becomes easier. Collectively, Americans prefer a manicured and orderly environment, with little room for nature and natural landscaping (Clean Water America Alliance Report). While there has been some growing awareness with the environmental movement, nonetheless, most cultural values are slow to change, and producing change requires long-term education efforts. Adjusting cultural values and public perception to allow appreciation of GI aesthetics and characteristics remains a challenging task (Clean Water America Alliance Report).

Assessing GI in an Academic Setting

Existing landscape perception research has shown that landscape preference may be the result of a combination of psychological (Ulrich 1981), cultural (Nassauer 1995b; Kaplan, R. and Herbert 1987), and possibly evolutionary values (Balling and Falk 1982; Kaplan, S. 1987). This thesis explores the cultural influence on people's landscape preferences. Since cultural values are one of the contributors to the preference for highly-ordered and well-maintained landscapes, it is possible that this preference can be affected by changes in cultural values.

Universities, as institutions of higher education, have the resources and personnel to communicate, and provide education regarding the various benefits of GI to students and other community members. Green Infrastructure practices such as rain gardens, disconnected downspout, and pervious pavement have been implemented on the University of Georgia campus, but the public perception of those sustainable practice remains unknown among the university community. This thesis aims to bridge a gap in the landscape preference literature pertaining to landscape preferences in an academic campus setting by using the UGA campus as an example. In this study, the following research questions will be addressed:

1. What aesthetic perception do students have of the Green Infrastructure practices on the UGA Campus?
2. Will informing students of GI's ecological benefits alter student perception of their surrounding sustainable landscape?

Purpose

As Nassauer (1995) states, "The appearance of landscapes communicates cultural values; culture changes landscapes and culture are embodied by landscapes." Landscape is essentially the cultural manifesto of human activity on the ecosystems. This thesis examines if introducing a new value to the respondents alters their aesthetic perception of the surrounding sustainable landscape.

Significance

A review of the literature has identified a conspicuous gap in research pertaining to landscape perception on an academic campus. This study adds to the research pertaining to landscape preference and addresses an area (the academic setting) not widely investigated in the past. Campuses of higher learning institutions are dynamic and ever-changing place; they can serve as vehicles of cultural changes (Sniff 2011). For centuries, American campuses have been developed based on the classical Jeffersonian campus, using it as a prototype and producing in many modified versions. (Bormann *et al*. 2001). The prototypical college campus contains a central lawn for social activity and public gatherings, and the lawn serves simply as a statement piece for the institution itself. This research acknowledges the importance of the central lawn as generative spaces for campus life; however, it asks on a broader level if the aesthetic look of GI is also acceptable and attractive to students. This study also adds to the research pertaining to the evaluation of aesthetic preference with regard to GI and the question of whether public perception changes after people understand the function of and the purpose behind the ecological look of GI. The outcomes provide parameters for future research.

CHAPTER 2

LITERATURE REVIEW

This chapter explains what GI is, the foundation of landscape perception studies, landscape perception paradigms, evolutionary and cultural perspectives, landscape perception theories, the validity of using online visual survey as the major research method, and existing landscape perception studies in academic settings.

Definition of Green Infrastructure

Green infrastructure is a term that can encompass a wide array of specific practices, and several definitions exist. The EPA defines GI as "A cost-effective, resilient approach to managing wet weather stormwater runoff impacts that provides many community benefits."

Stormwater runoff is a major contributing factor to water pollution in urban areas. In the past, traditional grey stormwater infrastructure focused on using engineered solutions to move runoff away from site to stream as quickly as possible. The common engineered practices include gutters, storm drains, sewers, etc. (EPA 2017). This traditional way of stormwater management is mainly aimed controlling urban flooding issues and does not address stormwater quantity nor runoff quality. Due to the fact that impervious surfaces in cities replace the natural vegetation and eliminate the natural infiltration process, untreated runoff generated from all manner of impervious surfaces in cities flows directly into streams. As a result, streams are filled with trash, bacteria, heavy metals, and other pollutants (EPA 2017). During heavy rain events, high velocity runoff can cause erosion and flooding in urban streams, in turn causing damage to habitat for aquatic organisms, decreasing biodiversity, and possibly damaging adjacent existing infrastructure (EPA GI Technical Assistant Program 2012).

To mitigate the negative impact of stormwater on streams, GI practices serve as innovative solutions to solve different problems. Green infrastructure practices restore the natural hydrologic process by removing impervious surfaces and reincorporating different elements such as soil and vegetation to promote infiltration. It has been estimated that GI costs 5% to 30% less than conventional grey infrastructure on initial installation and costs about 25% less over its life cycle than traditional grey infrastructure (Copeland 2016). According to the EPA website, "At the site scale, GI refers to stormwater management systems that mimic nature to reduce runoff volume, to promote infiltration, and to remove certain kinds of pollutants" (EPA 2017). This thesis focuses on the site scale stormwater management practices on the UGA campus, which includes green roofs, rain gardens, pervious pavement, cisterns, etc.

Landscape perception

Research on landscape preference and perception is not new. It dates to the 1960s and has expanded over the years within landscape architecture and allied professions (Zube et al. 1982). Studies have been conducted to investigate people's perception regarding landscapes, landscape preferences and ecological aesthetics through different lenses including psychological theory, evolutional theory, and cultural theory (Rosenberger 2012). However, there are limited landscape preference studies within urban academic campus settings. The literature search revealed only a few such studies (e.g., Zhang 2006; Johnson and Castleden 2011; Ewert and Baker 2001; Saksa 2011; Zheng *et al*. 2011; Rosenberger 2012; Zhang 2013; Rumao 2016).

Landscape perception studies started under the context of environmental management and policy making (Daniel 2001). Systematic analyses and studies of landscape beauty and amenity occurred in the 1960s and early 1970s in the United States and focused on the identification and management of scenic resources and scenic beauty (Zube et al. 1982). As Zube stated, “Landscape perception and assessment research has engaged the interests of individuals from a variety of disciplines and professions including: forestry, geography, landscape architecture, psychology, environmental studies and recreation.” These professions and disciplines have developed their own different methods of evaluating landscape perceptions and generated different collections of findings (Zube et al. 1982). From a review of over 160 articles published in 20 journals during the period 1965-1980, Zube identified four paradigms: expert paradigm, psychophysical paradigm, cognitive paradigm and experiential paradigm (Zube et al. 1982).

Expert Paradigm

The Expert paradigm focuses on asking professionals to assess landscape beauty or value. Research in this category usually involves the evaluation of landscape quality by trained experts such as landscape architects and planners (Zube et al. 1982). This paradigm is based on the assumption that some abstract design parameters are relevant to landscape aesthetics, such as form, line, texture, color, etc. This approach has been widely applied in environmental management practices (Daniel 2001). Some researchers believe that professionals are more sensitive to the surrounding environment and more capable of making judgements than lay people because experts are usually proficient in both natural sciences and fine arts (Carlson 1997; Chenoweth 1984). However, the expert paradigm was later considered inefficient because experts do not the value general public’s perception, resulting in low reliability of the paradigm with regard to public perception. Substantial evidence has shown that experts read landscape differently than lay people; therefore, they are not a valuable source for an objective judgement of public perception of landscapes (Kaplan 1979). Zube (1984) stated that “the expert paradigm has low reliability but high utility.” This was because much of the research in this category focused on natural resource management, and experts were used to make recommendations for environmental management. When used appropriately, experts’ perspectives are an invaluable resource with high applicability (Kaplan 1979).

Psychological Paradigm

The Psychological/ Cognitive paradigm focuses on exploring what the term *landscape* means to people. Zube et al. (1982) suggested that the meaning of landscape has a strong correlation to people’s past experiences and cultural background. People do not only respond passively to environment stimuli; they value certain landscapes over others (Taylor *et al*. 1987). The cognitive approach has been applied in many preference studies for different landscapes. The method of this paradigm analyzes people’s perceptions based on people who experience or use the landscape. Thus, landscape aesthetic is based on the feelings and perceptions of people (Zhang 2006). If positive feelings such as relaxation and happiness are evoked when viewing a landscape, this landscape is considered high quality. In contrast, a low-quality landscape can evoke negative feelings (Daniel and Vining 1983.) Kaplan’s studies revealed that different psychological constructs can be used as important predictors of people’s landscape preferences, such as “complexity”, “mystery”, “legibility” and “coherence” (Kaplan 1979). A common method used in this paradigm is asking members of the general public to score photographs based on their personal preferences on quantitative scales (Zhang 2006) The psychological paradigm is supported by empirical study, so it has high validity and reliability (Daniel and

Vining 1983). This thesis falls into the psychological paradigm because it involves assessing a selected population's evaluations (UGA students) of everyday surrounding campus landscapes based on their aesthetic perception.

Psychophysical Paradigm

The psychophysical paradigm focuses on determining a mathematic relationship between landscape physical features and the perceptual judgement of people, such as landscape perception, aesthetic value, scenic beauty, etc. (Daniel and Vining 1983). Research in this paradigm uses a statistical method such as regression analysis to determine the relationship between landscape physical elements and people's perceptions. It evaluates the landscape quality by testing the general public or interested groups rather than experts. The most direct way is to ask the lay public about what they find appealing (Taylor et al. 1987). This paradigm includes studies focused on forest landscape planning and management (Shafter and Brush, 1977). Participants are usually asked to rate their preferences with interval scales of measurement (Zhang, 2006). In this way, landscape quality is transformed into quantitative values. Photographs were frequently used as a surrogate for the actual environment in different studies. Recently, other techniques have been developed to represent or simulate the actual landscape by researchers, such as computer simulations and 3D modeling (Zhang 2006).

Experiential Paradigm

The experiential paradigm focuses on the personal interaction between humans and landscape. Research in this category emphasizes individual experience and subjective feelings with everyday landscapes (Zube et al. 1982). Personal, experiential and emotional factors are used to interpret the surrounding landscape instead of ranking the landscape based on scenic beauty (Daniel and Vining 1983). The experiential approach is usually combined with other research paradigm methods such as the cognitive paradigm or the psychophysical paradigm to provide valid and reliable quantitative and qualitative data (The Macaulay Land Use Research Institute 2005). Most studies within this paradigm focus on landscape development and the perception of landscape hazards. Only a few studies focus on assessing the natural landscape. Bishop (2001) used the experiential approach in his study to predict path choices in virtual environment. Research in this paradigm mainly uses personal interview, content analysis and verbal questionnaires. Content analysis is used to identify common experiences based on the collected data (Daniel and Vining 1983).

Comparing the four paradigms identified above, the expert paradigm regards participants as passive observers of the landscapes, and landscapes are viewed dimensionally; the cognitive paradigm focuses on the meaning of physical landscape features associated with people's perception; the psychophysical paradigm focuses on finding the relationship between landscape features and the observer's perception; and the experiential paradigm concentrates on the interaction of humans and the landscape, treating humans as active participants and viewing the landscape as a whole. Zube et al. (1982) states that there is no individual paradigm that can meet all of the needs of landscape assessment. Table 1 depicts the spectrum of perception provided by these paradigms.

Table 1: Spectrum of Paradigm (Zube et al. 1982)

Paradigms	Expert	Psychophysical	Cognitive	Experiential
Human	Passive → Active			
Landscape	Dimensional → Holistic			

Predictors of Landscape Perception

Complexity

The beginning of aesthetics study had been dominated by a single approach: the analysis of some index of preference in response to stimuli. For example, Berlyne's (1960) study focused on different "collative variables" such as novelty and surprise. Most of the research emphasis has been placed on the complexity of the stimulus array. Complexity refers to the amount of the diversity of the visual elements presented in a scene that researchers are interested understanding (Kaplan1979). Some research identified an inverted-U relationship between complexity and preference. There appeared to be an optimal value of complexity that was most preferred (Day 1967; Vitz 1966). However, in other studies the inverted-U relationship was weak. Wohlwill (1968) tested public preference for works of art and to photographs of the outdoor environment and the inverted-U failed to reach an acceptable level of significance. The limitation of this research is that only two scenes per seven complexity levels are tested, ranging from urban settings to arctic tundra.

Emphasis on complexity as a sufficient basis for predicting preference implies that the content of the landscape is not an important distinction. In other words, there are no distinctions between nature and the built environment when evaluating public perception. In response to Wohlwill 's study, Kaplan *et al*. (1972) conducted research to test the role of content in preference. They included more scenes representing a smaller range of environments. The central focus was to compare reactions to scenes of natural and built environments. The results showed that natural scenes are uniformly preferred over scenes of the built environment. Only one built environment scene of an urban park was as preferred as the lowest rated natural scene. Complexity showed no predictive role in Kaplan's research, and this study also inspired further research to find other predictors of preference. Wohlwill (1976) conducted a follow-up research, incorporating similar content distinction, with scenes carefully selected to represent a wide spectrum of complexity level. The results showed a weak relationship between complexity and preference in urban scenes at the two highest complexity levels. In other scenes, however, complexity and preference were linear and positively related. These results showed that the role of content is still substantial and that natural scenes were vastly preferred to the urban scenes. A series of subsequent studies searched for other predictors of preference and examined reactions to scenes representing both the built and natural environments (e.g., Kaplan 1979; Gallagher 1977; Ulrich 1977; Anderson 1978; Lee 1979; Ellsworth 1982; Herzog 1982).

Mystery and Coherence

Mystery is defined as the "promise of learning more information in the scene by further walking into it." Coherence refers to the order and level of direction of attention and how the scene hangs together (Kaplan 1979). Kaplan explained that a scene identified as coherent may include repeated elements, smooth texture, or readily identifiable components (Kaplan 1979). R. Kaplan (1973) demonstrated that both coherence and mystery are important predictors of preference. This study analyzed the preference of designers for different scenes, revealing that designers weighted coherence more heavily than others do in their preferences; a similar study was replicated by Grant (1979). Gallagher (1977) conducted research on preference for a prairie restoration landscape surrounding a corporate headquarters building. Ulrich (1977) focused on the roadside environment. These studies found strong support for the role of mystery in the prediction of preference.

Anderson (1978) looked at forest management practices in a national forest area. Lee (1979) studied preferences for scenes of Louisiana wetlands. Ellsworth (1982) compared the effectiveness of a traditional landscape architectural approach with the informational approach in the context of the rivers and marshes of Idaho. The latter method proved to be superior in predicting preference. Herzog (1982) focused on forest environment; Herzog et al. (1976) examined preference for scenes of familiar urban settings. These studies provided strong support for the predictive roles of both mystery and coherence, although they focus on different environmental types.

Legibility

Legibility is defined as "how the environment can be functioned and whether people can understand the environment immediately and explore it without getting lost" (Kaplan 1979). Kaplan explained that legibility is a prediction of finding one's way to go into a space and finding the way back. Legibility suggests a strong spatial orientation and the ability to navigate easily in the setting. Herzog and Leverich (2003) tried to show that legibility was an effective predictor of landscape preference. However, the result showed that legibility had been an ineffective predictor of environmental preference. Although Ellsworth (1982) also found that legibility is not an effective predictor, spatial definition was shown to be an important factor in preference.

In general, all four predictors — complexity, mystery, legibility and coherence provide information allowing people to understand why they prefer certain types of environments.

Information Processing Theory

S. Kaplan (1975, 1979) arrived at two effective informational outcomes: understanding and exploration. Understanding is comprehending or making sense of a place or a scene, and coherence falls into this category. Exploration is being held by the setting, being attracted by the sources of additional information; mystery and complexity belong to this category.

Kaplan (1979) stated that there were two underlying purposes that lead researchers to understand people's preferences: "making sense" and "involvement". Making sense concerns the need to comprehend the immediate environment. People prefer certain landscapes based on how well they can immediately understand what is going on in the scene. Ulrich (1977) stated that "to be preferred, a scene should not only present information, but it should also be identifiable and easily grasped. Conversely, a scene that is ambiguous and resists identification, or which places very high processing demands on the observer, should be less preferred". Involvement refers to the willingness to figure out, to learn, to be stimulated. The more involving an environment is, the greater the preference will be. Kaplan (1979) suggested that if the environment can both making sense and produce involvement, then this kind of environment would be preferred.

Furthermore, Kaplan (1979) identified different ways people relate to the visual information. One is called the "Visual Array", which refers to the immediate visual information that can be seen in a two-dimensional photograph. Another way is the "Three-dimensional Space", which predicts or infers the unknown information of a given scene. Four predictors of preferences — Coherence, Complexity, Legibility and Mystery were summarized by Kaplan (1979) in the following 2x2 Preference Matrix.

Table 2: Information Processing Theory Preference Matrix, Kaplan (1937)

Level of interpretation	**Making sense** (Understanding)	**Involvement** (Exploration)
The Visual array	Coherence	Complexity
Three-dimensional space	Legibility	Mystery

Kaplan and Kaplan (1982) critically integrated many of the theories and developed the theory of information processing. The four important environmental preference predictors (Coherence, Complexity, Legibility and Mystery) provide the information to understand why people like certain landscape environments. This theory contributes to explaining the ability of humans to cope with stress in the environment and human landscape preferences.

Evolutionary/Biological Theories

Biological theories consider landscape aesthetics as a genotypic phenomenon, whereas the aesthetic appreciation of landscape images results from the accumulation of a long human evolutionary history (Appleton 1975). The term biophilia was coined by Edward O. Wilson in his 1984's book *The Biophilia Hypothesis* to describe what he believes that human has a tendency to affiliate with nature, and there is a partly genetic basis for human's positive response to nature (Kellert et al. 1993). According to Robert Thayer, "even though people no longer rely on the landscape cues for survival, they respond to and appreciate landscape as if they still did"

(Thayer 1994). Interpretations of findings repeatedly suggest parallels with the environment under which humans evolved. People should be enticed by new information, by the prospect of updating and extending their cognitive maps (Barkow 1983). However, they cannot stray too far from the familiar, caught in a situation in which they are helpless because they lack necessary knowledge (Kaplan and Kaplan 1982). Among the vertebrates, habitat selection is a widespread tendency (Woodcock 1982); animals show a preference for the kind of environments in which their species prospers.

In many preference studies, participants are unable to explain their choices. Research suggests that there is an evolutionary bias in humans favoring a preference for certain kinds of environments (Balling and Falk 2010). However, some scholars disagree with this kind of statement; they believe that aesthetic reactions to landscape are largely or even a completely learned cultural patterns (Lyons 1983; Tuan 1971) Many studies support the hypothesis that evolutionary factors play an important role in human preference patterns, and humans have demonstrated an innate preference for savanna-like (pastoral lawn and trees) settings. Appleton (1975) stressed the evolutionary advantages of landscape views that simultaneously afford prospect (wide, open views from which approaching predators could be seen) and refuge (protected settings that prevent the viewer from being seen or that protect the viewer’s back). He analyzed the enduring cultural value of prospect and refuge views as portrayed in Western landscape painting since the 18th century. Balling and Falk (1982) studied the preferences of individuals of different ages for various kinds of environments. A variety of settings had been studied; but this was the first study to systematize the range of environments: 5 biomes including desert, rainforest, savanna, mixed hardwoods, and boreal forest. Balling and Falk inferred an innate preference for landscapes that exhibit the characteristics of the African savanna from their investigation of preferences for different biomes. While young children in the forested northeastern United States preferred savanna over forested landscapes, adults preferred the more familiar forest environment. Bourassa (1990, 1991) interprets these and numerous other empirical studies that show high preference for canopied landscapes with an open floor as evidence of biological influence on human preference for natural landscapes. Biological theories further support the fundamental validity of aesthetics in human life and suggest that some aesthetic preferences remain stable despite societal and environmental changes.

Cultural Theory

Cultural theories posit that various factors such as societal, religious, racial, and historical factors can affect people's aesthetic reactions (Bourassa 1990). From the 1980s to 1990s, research transitioned toward being less subdivided and more holistic. Nassauer (1995) combined the cultural and psychological into a theoretical framework that purposes a new idea called "ecological aesthetic." She pointed out that "improved ecological quality may not be appreciated or maintained if recognizable landscape language that communicates human intention is not part of the landscape. Ecological function is not readily recognizable to lay people who are not educated to look for it." Even for an educated landscape architect, ecological function might not be visible. Additionally, the appearance of many native ecosystems and wildlife habitats do not fit the cultural norms favoring the neat appearance of landscapes.

Nassauer used "Cues to Care" to advocate for designs that use cultural values and norms related to the appearance of landscape to make ecological function become recognizable to the general public. She believes that in North American culture, a neat and ordered landscape is read as a sign of care, and it is probably preferred when people were asked to assess its landscape beauty. Nassauer suggests that “neatness of vegetation contributes to a positive perception and aesthetic perception of an ecological design. But at the same time, a neat, orderly landscape usually does not enhance the ecological function of a landscape.” Nassauer, J. I. (1995b) ‘s research assumes that “culture and landscape interact in a feedback loop in which culture structures landscapes and landscapes inculcate culture.” She proposed four principles:

1. *Human landscape perception, cognition, and values directly affect the landscape and are affected by the landscape.*
2. *Cultural conventions powerfully influence landscape pattern in both inhabited and apparently natural landscapes.*
3. *Cultural concepts of nature are different from scientific concepts of ecological function.*
4. *The appearance of landscapes communicates cultural values.*

People who value natural landscape tend to assume that natural landscapes are equal to high ecological quality, while the cultural concepts of “nature” and the scientific concepts of “ecological function” have no necessary relationship (Nassauer 1992). In other words, a landscape that looks like beautiful nature might be a polluted former landfill, and what looks like a neglected abandoned landscape may be a rich and healthy ecosystem. Nature, to lay people, in western culture usually means a tidy, mowed lawn (Crandell 1993). Even though ecological consciousness has begun to challenge the conventional mowed lawn landscape, the look of healthy ecosystems may still not have been widely accepted by the public, because the cultural perceptions of naturalness are so deeply confused with ecological health (Bormann *et al*. 1993; Stein 1993).

However, the cultural perception of nature is not wrong. What is mistaken is the confusion of cultural perception with ecological function. This mistake tends to lead people into the common misunderstanding that a landscape that looks natural is ecologically good. People tend to object to ecological landscapes simply because these kinds of landscapes do not look natural culturally. Nassauer *et al.* (2007) outlined a model for "ecological aesthetic" and proposed three claims:

1. Humans view the environment at a specific scale (perceptible realm);
2. Interactions give rise to an "aesthetic experience"
3. Context affects aesthetics.

In essence, Nassauer is stating that landscapes perceived as aesthetically pleasing are more likely to be appreciated and protected.

Expert vs Perceptual-based approaches

Two opposing approaches appeared when systematic visual landscape quality assessment was developed in the last half of the 20th century: the expert approach and the perception-based approach. They occupy a large portion of landscape assessment studies and played an important role in both environmental management practice and the field of scientific research (Daniel, 2001). The perception-based approach has its foundation in philosophical studies. It is based on the assumption that the physical features in the landscape serve as stimuli to evoke a human observer's aesthetic response through sensory-perceptual process or cognitive construct. The perception-based approach has been applied in environmental perception and landscape assessment research (Daniel 2001). Many studies using this approach incorporate scaling methods to obtain a quantitative data in order to transform the qualitative landscape into measurable landscape aesthetic quality (e.g., Kaplan 1975; Kaplan et al. 1972; Ulrich 1977; Zube 1974). Assessing landscape quality is based on rankings or ratings of landscapes photographs. Perception-based assessments have generally achieved high levels of reliability compared to the expert approach. As Daniel (2001) stated, the "The perception-based approach emphasizes the human viewer side of the landscape quality interaction, but the essential contribution of the biophysical landscape is also acknowledged."

Validity of Visual Survey

This thesis uses a Visual Preference Survey as the main research method. A visual preference survey uses photographs of built environment to provide alternatives for participants to choose. By collecting participant's responses, public vision can be incorporate into future landscape projects (Local Government Commission, 2013).This image surveying methodology was patented by Anton Nelessen and Associates in the 1990s and is now known as the Visual Preference Survey™ (Local Government Commission 2013). Nelessen and Constantine applied this technique to several projects such as planning for the downtown area of Metuchen in central New Jersey and community plan for North Bend in east Seattle. These projects were successful in informing the public and incorporate diverse groups' preferences and visions (Robert et al. 2017) Thus, this technique was shown to be a valuable tool for informing the public of design options and collecting data on the public's relative preferences for the different options (Nelessen and Constantine 1993). After Zube et al. (1982) indicated a need to unify and produce a theoretical base to justify future human-environment perception research, the VPS™ became the predominant tool among planners, architects, forest managers, landscape architects and environmental psychologists. VPS has applications in visioning projects, design charrettes, and other physical planning activities with heavy public involvement (Ewing et al. 2005).

This Thesis

This study adopts VPS by using photographic images of UGA campus GI practices as a substitute for real-place experience and ask students to rate the landscape images. Many research studies support this approach. Ulrich (1977) explains, "the fact that feelings and responses related to visual properties of environments are of salient concern supports the validity of using photo as a simulation technique." Kaplan (1974) in his study demonstrated the reliability of using black and white photography to convey visual landscape scenes across a wide range of environments and user groups. Shuttleworth (1979) reviewed the results of previous studies and reported a case study which provides further evidence for the validity and effectiveness of photographs in representing landscapes.

The Internet survey has proved to be an objective and reliable instrument for gathering valid data on landscape perception and visual landscape assessments. Roth (2006) support this method stating that "scenic quality assessment is fully independent of the technical and methodological configuration of the Internet questionnaire." The results of his study showed that scenic quality categories of visual variety, beauty, and visual naturalness as well as overall scenic quality can be validly recorded on the Internet (Roth 2006).

Landscape Perception in Academic Settings

The literature review of relevant research identifies some existing environmental perception research in academic settings, but there is a need to expand. Zhang (2006) conducted an empirical study of preference for campus open space around the drill field on the Mississippi State University (MSU) campus. This study aimed to determine how certain landscape features can contribute to landscape preference patterns for campus open space. The study found that factors such as gender, educational and cultural background can heavily affect these patterns.

The results indicated that “vegetation” including trees, seasonal flowers and open grassland, was the most preferred landscape feature on campus open space.

Johnson and Castleden (2011) examined how undergraduate students in geography perceive and value water conservation initiatives on an urban Canadian campus. The focus of this paper was to examine how participants evaluated and ranked photographs of prospective campus landscape images, how they perceived their value; and how student values, identified through the use of alternative landscape imagery, can be integrated into traditional landscape development and campus planning. One limitation of this research is that the subject students were in a course that would have attracted students interested in sustainable resource management on campus. However, the same survey could be distributed to different student groups. Ewert and Baker (2001) measured differences between academic major and reported attitudes and beliefs about the environment. Other variables investigated included sex, age, and place of residence. Their research found significant differences in variables of academic major, gender and age. The results of this study also suggest that females and older students will generally respond in a more pro-environmental fashion than students who are younger and male. Whether an individual perceives himself or herself as coming from an urban or rural location appeared to play an inconsequential role in how he or she responded to the items on the study instrument.

Saksa (2011) examined student perception of the sustainable landscape on the Laird Campus and the impact of education signage on students’ perception of the landscape. Signage explaining landscape sustainability was installed on campus combined with an educational campaign improved student awareness and acceptance of sustainable landscaping practices. Students’ awareness and acceptance of sustainable landscaping practices increased with greater levels of engagement with the campaign. However, students' aesthetic perception of the landscape's as appealing did not significantly improve after the campaign.

Zheng et al. (2011) explored students' preferences toward "natural and wild" versus "clean and neat" landscapes with regard to their study major, level of education, and previous experience. This study found that senior students and students from large cities prefer well-maintained and artificial landscapes. This study focused specifically on residential landscapes.

Rosenberger (2012) examined a range of three surface treatments: manicured grass (control), unmanaged early successional (rough), and managed early successional (prairie) conditions. These surface treatments were tested in four settings typical on an academic campus: paths, forecourts, quads, and open spaces. A survey was conducted to test the hypothesis that sustainable landscape surface treatments are acceptable in an academic campus. Collected data showed that the result supported the hypothesis.

Rumao (2016) assessed users' perceptions of the UT Arlington campus landscape. Data collection methods included online surveys of campus users, passive observations, and a review of archival and secondary data. The findings from this research indicate that design characteristics such as gathering areas, sitting areas, trees and vegetation affect users' experience on campus the most.

Zhang (2013) studied student perceptions of stormwater treatment areas in the city of Gainesville, Florida. This study found that appearance is important in GI design and management because the perception of beauty largely determines the perception of ecological significance. Most conventional aesthetic principles remain valid for design and management of GI. While a new aesthetic appreciation of GI is emerging, it is not yet the dominant aesthetic.

Educational background influences the acceptance of the “new aesthetics”; however, conventional aesthetics have more weight in determining the common perception of beauty in many populations.

CHAPTER 3

GREEN INFRASTRUCTURE PRACTICES

This chapter introduces different categories of GI practice, how individual category of GI practice works in the landscape, and their performance in different studies.

Green Infrastructure Practices

As mentioned in previous chapter, EPA states that "At the city or county scale, green infrastructure is a patchwork of natural areas that provides habitat, flood protection, cleaner air, and cleaner water; at the site scale, stormwater management systems that mimic nature soak up and store water." Green infrastructure practices at site scale include but not limited to rain gardens, rain barrels and cisterns, green roofs, permeable pavements, bioswales/vegetated swales (Norman, 2008). For the purpose of this thesis, I focus on the different site scale GI practices. This chapter discuss the different GI practices individually and their environmental benefits compared to the conventional way of managing stormwater.

Downspout Disconnection

According to the EPA definition, downspout disconnection is "a simple practice that reroutes rooftop drainage pipes from draining rainwater into the storm sewer to draining it into rain barrels, cisterns, or permeable areas." It is used to store stormwater during rain events and allow stormwater to infiltrate into the soil. Downspouts installed in the past were directly connected to the sewer system thus the surface runoff generated from the roof is entering the sewer system without any treatment (Becker 2016). As a result, untreated runoff from the roof goes into the combined sewers system quickly, resulting in a combined sewer overflow (CSO) and polluted runoff discharged into local waterways (Southwest Florida Water Management Report). This problem can be largely reduced by disconnecting the downspouts from the sewer system and directing the water to an infiltration surface. Carmen (2016) studied four paired downspout disconnection sites in a residential setting in Durham, North Carolina. To test the effectiveness of the disconnection practice, volume and peak flow reduction was quantified by calculating volume reduction with and without direct rainfall on the lawn, resulting in cumulative runoff volume reduction ranges of 57–99% and 49–99%, respectively. The findings indicate that this simple and inexpensive stormwater control measure (SCM) can be an effective tool to mitigate runoff. Downspout disconnection could be especially beneficial to cities with combined sewer systems. Even if combined sewer overflow is not a problem for a city, this practice is still worth implementing because the infiltration process can largely reduce runoff volume and improve rainwater quality.

Figure 2: *Disconnected Downspout.* http://eavestroughrepairstoronto.com/#!mandatory-downspout-disconnection

Rainwater Harvesting

Rainwater harvesting is a system that collect and store rainfall for later use (EPA). The main component of each RWH system is the rainwater collection tank, which allows for storage and treatment of the collected rainwater. During rain events, storm runoff is directed to the tank through a collection system, usually a system of gutters and downspouts, and rainwater is temporarily stored for different building uses. A separate piping system with multiple pumps is usually required to connect the rainwater collection tank to appliances and taps for rainwater use. The pumps are used to assure there is enough pressure head for the various uses (Campisano 2017).

In urban settings, RWH provide functions such as concentration, collection, storage and treatment of rainwater from different impervious surfaces (rooftops, terraces, courtyards, etc.) for on-site use (Campisano 2017). Studies from Australia showed that installing rainwater harvesting tanks could return the rainwater runoff level to close to the pre-development condition (Burns et al., 2012a) When combined with other infiltration practices, excess overflow from RWH systems can be further infiltrated for groundwater recharge (Dillon 2005). This practice is particularly valuable in arid and semi-arid regions, where water scarcity is a significant issue, and recycling of rainwater can reduce the demand for water supplies.

A large quantity of research exists on the performance of RWH systems, most of it conducted in arid or semi-arid regions or in places where potable water is considered a limited resource (DeBusk 2013).However, the practice of rainwater harvesting has recently been implemented in humid and well-developed regions in response to severe drought, increased water demands, public awareness of the environmental impacts of stormwater runoff, and increased interest in green building practices, which support smart water use(Jones et al. 2010). A monitoring study evaluated three rainwater cisterns in North Carolina in the Southeastern United States. A computer model was developed to simulate system performance, and simulations were conducted for 208 rain barrels and larger cisterns. Results of the monitoring study showed that the rainwater harvesting systems were underutilized, which was suspected to have resulted from poor estimation of water usage and public perception of the harvested rainwater. Also, simulation results showed that a rain barrel was frequently depleted when used to meet household irrigation demands and overflowed during most rainfall events. Simulations also illustrated the improved performance of large systems while providing an indication of diminishing returns for increased cistern capacity (Jones et al. 2010).

Figure 3: *Rainwater Harvesting Cistern*. http://www.geise.net/portfolio_vine_de.html

Rain gardens and Bioretention Cells

Rain gardens are versatile practices that can be installed in almost any unpaved space. They are shallow vegetated depressions in which the native soil has been removed and replaced with a bio-retention media comprised primarily of sand and compost or mulch. The sand is used to promote infiltration while the organic compost or mulch is used to enhance plant growth. (Paus et al., 2014) Rain gardens receives runoff generated from nearby impervious surfaces and infiltrates it back into the soil (Autixier 2014). This practice mimics natural hydrology by infiltrating, evaporating and transpiring stormwater runoff. Rain gardens also improve the runoff quality to some extend by settling, infiltration, adsorption, decomposition, ion exchange, and volatilization processes. Rain garden vegetation can also remediate nitrogen and phosphate from polluted stormwater (Read *et al*. 2008). Rain gardens exist in a wide range of sizes, but they are commonly used as a way to retrofit existing urban areas, and they are used where larger structure are not allowed due to the condition of the land (Palla 2017).

Schlea et al. (2014) conducted a rain garden study in the Brook Run neighborhood of Westerville, Ohio to test the hydrologic performance of terraced, street-side rain gardens by monitoring inflow and outflow volumes and water tables during simulated runoff events. The street-side rain gardens reduced storm water volume by an overall total of 37% with mean individual simulation values for volume reduction, peak flow reduction, and peak delay of 52%, 62%, and 16 min, respectively. The results of this study suggest that rain gardens can benefit existing developments by reducing runoff volume and peak flow with the potential for water quality benefits.

Bio-retention cells are urban rain gardens with vertical walls and either open or closed bottoms. They collect and absorb runoff from sidewalks, parking lots, and streets(EPA). Bio-retention cells reduce runoff volume and improve water quality by substantially reducing pollutant loading to surface water bodies, lessening stream erosion rates, recharging groundwater and providing base flow to urban streams, and helping to reduce the water quality impacts of combined sewer overflows (Winston et al. 2016). Bio-retention cells can temporarily store and treat a certain amount of rainwater from highly impervious catchments. Typically, bio-retention cells pond 22–30 cm of stormwater in their surface storage, have 60 to 120 centimeters of bio-retention media and, when underlying soils are poorly drained, have an underdrain surrounded by a gravel layer to allow for drainage. Once the surface storage fills, an overflow structure conveys flow to the storm drain or combined sewer network (Winston et al. 2016).

Shakya (2017) investigated the performance of planter boxes (bio-retention cells) and rain gardens for volume reduction of stormwater in combined sewers in two residential areas of St. Louis, Missouri. Six planter boxes and twelve rain gardens were installed at the site with a control site where no GI was installed. The study found that volume reductions of stormwater between the test and control sites was 62%. Planter boxes are ideal for space-limited sites in dense urban areas and as a streetscaping element.

Figure 4: *Rain Gardens*. http://www.sitelines.org/webatlas/victoria/trent-raingarden.htm

Bioswale

Bioswales are vegetated, mulched, or xeriscaped (do not need supplemental water from irrigation) channels that provide treatment and retention as they move stormwater from one place to another. Vegetated swales slow, infiltrate, and filter stormwater flows (EPA).

Leroy et al. (2016) focused on evaluating the effectiveness of vegetated swales in improving water quality. Two types of vegetated covers were compared and examined— grasses and macrophytes. The result shows that the swales planted with macrophyte performed better than grass covered swales. The vegetated swale led to reductions of concentrations from 17% to 45% for trace elements such as lead, zinc and copper in infiltrated waters. The grass cover performed poorly due to lower retention of soil, while macrophytes is more capable of retaining soil particles due to their deeper root system. Xiao et al. (2011) conducted research to evaluate the ability of a bioswale with engineered soil and trees to reduce storm runoff, pollutant loading, and support tree growth. The bioswale reduced runoff by 88.8% and total pollutant loading by 95.4%. The engineered soil provided a better aeration and drainage for tree growth than did the control's compacted urban soil. The superior performance of the bioswale demonstrated its potential use for large-scale application in parking lots and roadsides to reduce runoff and support tree growth. As linear features, bioswales are particularly well suited to placement along streets and parking lots.

Figure 5: *Bioswale*. https://www.rivercityusa.com/bioswale-remediation/

Permeable pavements

Permeable pavements manage stormwater through infiltration, treatment, and storage of rainwater. When compared to conventional impervious asphalt, permeable pavements can reduce runoff quantity, lower peak runoff rates, and delay peak flows (Collins 2010). They can be made of pervious concrete, porous asphalt, plastic grid pavers, or permeable interlocking pavers (PICPs). In addition to reducing the runoff from the rain that falls on them, permeable pavements can help filter out pollutants that contribute to water pollution. Permeable pavements can also reduce the need for road salt and reduce construction costs for residential and commercial development by reducing the need for some conventional drainage features (EPA).

Many studies have demonstrated the effectiveness of pervious pavement in reducing runoff, improving runoff quality and delaying the peak rate of runoff (Collins et al. 2010; Kumar et al. 2016; Luke et al. 2011; Winston et al. 2016.) Several studies examined and compared the hydraulic and environmental performance of different types of pervious pavements. The finding demonstrated that PC, PA, and PICPs are all effective in mitigating storm runoff in a wide range of climate and through all seasons. Additionally, little difference exists in the ability of these pavement types to remove heavy metals (Huang et al. 2016; Collins et al. 2010). The infiltrated water had significantly lower levels of copper and zinc than the direct surface runoff from the asphalt area. Motor oil was detected in 89% of samples from the asphalt runoff but not in any water sample infiltrated through the permeable pavement. Neither lead nor diesel fuel were detected in any sample (Benjamin et al. 2003). Another important finding is that pollutant concentrations were greatest during the first few months after construction and declined rapidly over the course of the study (Drake 2014). Research focused on sediment accumulation in pervious pavement found that while this process resulted in reduced permeability over time, the overall infiltration performance of the pervious pavement system was satisfactory after eight years of continuous service (Luke et al. 2011; Kumar et al. 2016). This practice could be particularly cost effective where land values are high and flooding is a problem.

Figure 6: *Pervious Pavements.* http://pavementconstructors.com/porous-asphalt/

Vegetated Roofs

Vegetated roofs, as one of the GI practices, are considered an innovative and effective way to manage stormwater runoff while also providing significant benefits to the urban environment. Vegetated roof, also called green roofs, provide a possible means for roofs to be used beneficially in a dense urban environment rather than contributing to stormwater problems. Vegetated roofs utilize engineered soil as growing media, select drought tolerant plants, and specialized roofing materials installed on existing structures (Peck *et al.* 1999). The substrate depth of extensive green roofs is relatively thin compared to intensive green roofs, usually between 2 to 15cm (0.8-6 inch). During storm events, extensive green roofs reduce runoff by absorbing rainwater into pore spaces in the substrate, through uptake by plant material, and by transpiration. Green roofs have been used not only to control runoff volume but also to improve air and water quality and promote conservation of energy (Muhammad 2015).

Many large cities in the U.S. have established stormwater management policies to encourage the implementation of green roofs. For example, in Portland, Oregon, developers who install impervious surfaces exceeding an area of 46.5 m^2 must allow for onsite stormwater management. If conditions onsite do not meet the policy standard, the developer must either build an offsite facility to reduce the impact or pay a fine for municipal stormwater management (Liptan 2005).

Many studies have shown that green roofs are efficient in reducing the amount of water runoff compared to conventional roofs. Some study results indicate that green roof systems significantly reduced storm-water runoff and that system design, growth media depth, and presence of plants impacted storm-water retention. (Morgan et al. 2103; Vijayaraghavan. 2016; Versini et al. 2014). Versini (2014) found that at the building scale, the use of green roof has shown a positive impact on urban runoff (decrease and slow-down in peak discharge, decrease in runoff volume). When they are widely implemented, green roofs can affect urban runoff in terms of peak discharge and volume and prevent flooding in several cases. The green roofs investigated seem useful in mitigating the effects of usual rainfall events but are less helpful for in the more severe events. Therefore, Versini suggest combining green roofs with other infrastructures. One green roof study conducted on the UGA campus has demonstrated that green roof implementation can significantly reduce peak runoff rates, particularly for small storm events (Timothy, C. 2006). Carter and Jackson (2007) investigated the potential influence of the hypothetical establishment of vegetated roofs in the Tanyard Branch watershed in Athens, Georgia, USA. The authors conclude that green roofs alone cannot be relied upon to provide complete stormwater management at the watershed scale. Green roofs are particularly cost-effective in dense urban areas, where land values are high, and on large industrial or office buildings, where stormwater management costs are likely to be high.

Green infrastructure practices use two mechanisms to reduce stormwater runoff: infiltration and evapotranspiration. In the case of green roofs, stormwater runoff reduction is accomplished using only evapotranspiration because the water infiltrates into underlying substrates instead of native soil. The size and type of vegetation determines a green roof's interception storage (water storage on the plant surfaces) and actual evapotranspiration. Therefore, the effectiveness of green roofs in reducing annual runoff volume is independent of the native soil infiltration rate (Beyerlein 2012). More precisely, the effectiveness of a green roof is dependent on the difference between the precipitation and the potential evapotranspiration during the wet season. This is when a green roof receives most of its precipitation and is most likely to produce stormwater runoff. In a GI/LID modeling study, green roofs in Atlanta, Philadelphia, and Los Angeles all show similar annual runoff volume reductions in the range of 38% to 44%. However, in this study Seattle has only 22% reduction. The reason for Seattle's lower reduction rate is the relatively low potential evapotranspiration of only 3.5 inches total for the winter period of November through March; the corresponding total precipitation for this period is 25 inches. The other three regional sites do not have a comparably large difference between the precipitation and evapotranspiration (Beyerlein 2012).

Figure 7: *Vegetated Roof*. https://www.apartmenttherapy.com/the-benefits-of-a-green-roof-170607

Urban Tree Canopy

Trees reduce and slow stormwater by intercepting precipitation in their leaves and branches, removing water from the soil via transpiration, enhancing infiltration, and bolstering the performance of other GI technologies (Berland et al. 2017) Many cities have set tree canopy goals to restore some of the benefits of trees that were lost when the areas were developed (EPA). Research has shown that trees can play a substantial role in reducing stormwater runoff, and trees can combine with other GI technologies such as bioswales and structural soils (Berland et al. 2017).

Studies modeling the hydrologic influence of the urban forest have been done and are varied in complexity. Sanders (1986) showed that the tree canopy cover (22%) in Dayton, OH, lowered potential stormwater runoff by approximately 7% for a 6-hr, 1-year storm event. By increasing tree canopy cover over non-paved, permeable areas from 37% to 50%, Sanders (1986) claimed that potential stormwater runoff could be further reduced to 12%. Wang *et al*. (2008) conducted an analysis that led to an assessment reporting that increasing canopy cover from 12% to 40% over permeable surfaces decreased stormwater runoff by 2.6% in a Baltimore, MD, watershed. These modeling studies provide further evidence that increasing tree canopy cover over impervious surfaces may help reduce stormwater, and tree canopy can be thought of as part of the treatment train of GI in an urban watershed.

CHAPTER 4

STORMWATER MANAGEMENT AT UGA

This chapter introduces the three UGA campus watersheds, along with their historical development and current problems; different categories of extant GI practices; location and size of individual practices, and how they function in the campus landscape.

The University of Georgia main campus is located in Athens, Georgia. It was founded in 1785 and the campus includes 475 buildings for a total of 17,733,878 square feet. There were 18,22 full-time professional faculty and 37,606 students for the fall 2017(UGA Factbook 2017). The University of Georgia possesses three watersheds - Lilly Branch, Tanyard Creek, and the Physical Plant Drainage (PPD) watershed. The headwaters of Lilly Branch and Tanyard Creek begin in Athens-Clarke County to the west of the campus, while the PPD watershed in entirely contained within UGA's main campus. All the watersheds have been adversely impacted by the urbanization process in terms of both stormwater quality and hydrological cycle (Flaute 2012). To be clear, here we adopt the EPA definition of watershed, which is "the area of land where all of the water that is under it or drains off of it goes into the same place." Watersheds can range from only a few acres to a few million acres, but everyone in the United States lives in a watershed.

In the fall of 2012, Office of Sustainability Intern Jack Spalding researched the history of UGA's campus watersheds (Watershed UGA). Tanyard Branch and Lilly Branch are the two most prominent streams running through the University Campus. As of 2012, these streams for the most part have been altered and have failed to retain their original, natural courses and appearance. This alteration of the streams did not occur only in recent decades; it dates back to 1700s, when Athens and the University were founded (Watershed UGA). In the early days of the University, the streams were much more heavily incorporated into the daily lives of students, faculty, and citizens.

Lilly Branch

Lilly Branch is part of Carlton Branch that has commonly been referred to as "Stinky Creek" (Beth Gavrilles 2014). The name Lily Branch was a name added to improve on "stinky creek". It is an impaired urban stream affected by intensive cotton farming around a century ago, and by watershed urbanization in recent years (Watershed UGA). According to the Watershed UGA website, "Over forty percent of the 409-acre Lilly Branch watershed is impervious, with limited riparian zones." The urbanization process transformed the natural vegetated area into impervious surfaces and generated a large volume of polluted storm water flows into Lilly Branch, and in turn filling the North Oconee River with sediment and pollutants. (Watershed UGA). Approximately two-thirds of Lilly Branch is in culverts, with only two day-lit sections. Lilly Branch has a shallow dry-weather depth in most areas. It deepens to over 5 feet towards its confluence with the North Oconee River. In both the day-lighted and piped reaches, storm drains run directly into Lilly Branch. Biotic sampling in 2002, 2003, 2004, 2005, and 2010 all indicate poor water quality. Because of the resulting wet-weather increases in flow, bank erosion, bank instability, and sediment-loading damage the day-lit portions of Lilly Branch (Watershed Management Plan).

Tanyard Creek

Tanyard Creek Watershed is one of the watersheds that directly cut through the UGA campus. It bisects the UGA campus and drains a 499-acre watershed with seventy-four percent impervious surface (Watershed UGA). Near Sanford Stadium, the branch is funneled into a pipe under the stadium and eventually falls into the North Oconee River. Approximately 50% of Tanyard Creek runs through culverts and pipes. Impervious surface in this watershed includes parking lots and buildings, which forces more water and polluted runoff into the waterway (Watershed UGA). Over the years, Tanyard Creek has tested for high levels of fecal coliform, bacteria that indicate the presence of animal waste. It is listed on Georgia's 303(d) list because of high levels of fecal coliform, resulting in the failure of Tanyard Creek to meet its designated use as a fishing site (Watershed UGA). Macroinvertebrate sampling in Tanyard Creek indicates the stream water quality is very poor. There are also signs of chemical presence and other pollutants caused by stormwater runoff from parking lots (Watershed UGA).

The history of the Tanyard Creek watershed is similar to that of Lilly Branch. It was originally used for agriculture, and then underwent urbanization in the 1930s because of downtown Athens development and the expansion of the University (Watershed UGA). According to the Watershed UGA website, "In 1831, the first botanical garden in the state was created along Tanyard Creek. There were also several tanneries along the creek near present-day Lumpkin Street." Most of the land in this watershed is commercial or University use with some residential areas and transportation corridors (Watershed UGA).

Physical Plant Stream

The Physical Plant Stream is entirely contained within the UGA campus. It is piped for most of its reach, daylighting a few hundred meters before entering the Oconee River (Watershed UGA). It includes several UGA buildings and parking lots as well as the steam plant and Facilities Management staging areas. The Physical Plant Stream is 0.09 miles in length, originating near Boyd Hall and the Ecology Building and flowing past the UGA Steam Plant and Facilities Management staging areas (Watershed UGA). Headwaters are culverted near the Facilities Management parking lot. The infrastructure failed in 2010, and the culverts had to be re-constructed at significant depth. Historic maps show a livestock pond in this area, which may explain the depth. The stream enters a culvert under East Campus Road and then daylights at River Road (Watershed UGA). This day-lighted portion is heavily infested with invasive plant species. The Physical Plant Stream watershed is much smaller than the Lilly Branch or Tanyard Creek watersheds. It was originally cleared for agricultural uses, the rest of the watershed is now covered by roads, parking lots, university buildings, and lawns.

Existing Green Infrastructure Practices on UGA Campus

Due to development of the campus, impervious surfaces have caused damages to the campus watershed, contributing to different environmental problems. To mitigating the adverse impact in the campus watershed related to stormwater, various GI practices have been installed on the UGA campus such as pervious pavement, rain gardens, vegetated roofs and rainwater harvesting cisterns. Coordinated projects between the City of Athens and UGA, such as the Lumpkin Street Project, have been carried out to improve water quality for the campus watershed; they also provide functional and educational opportunities.

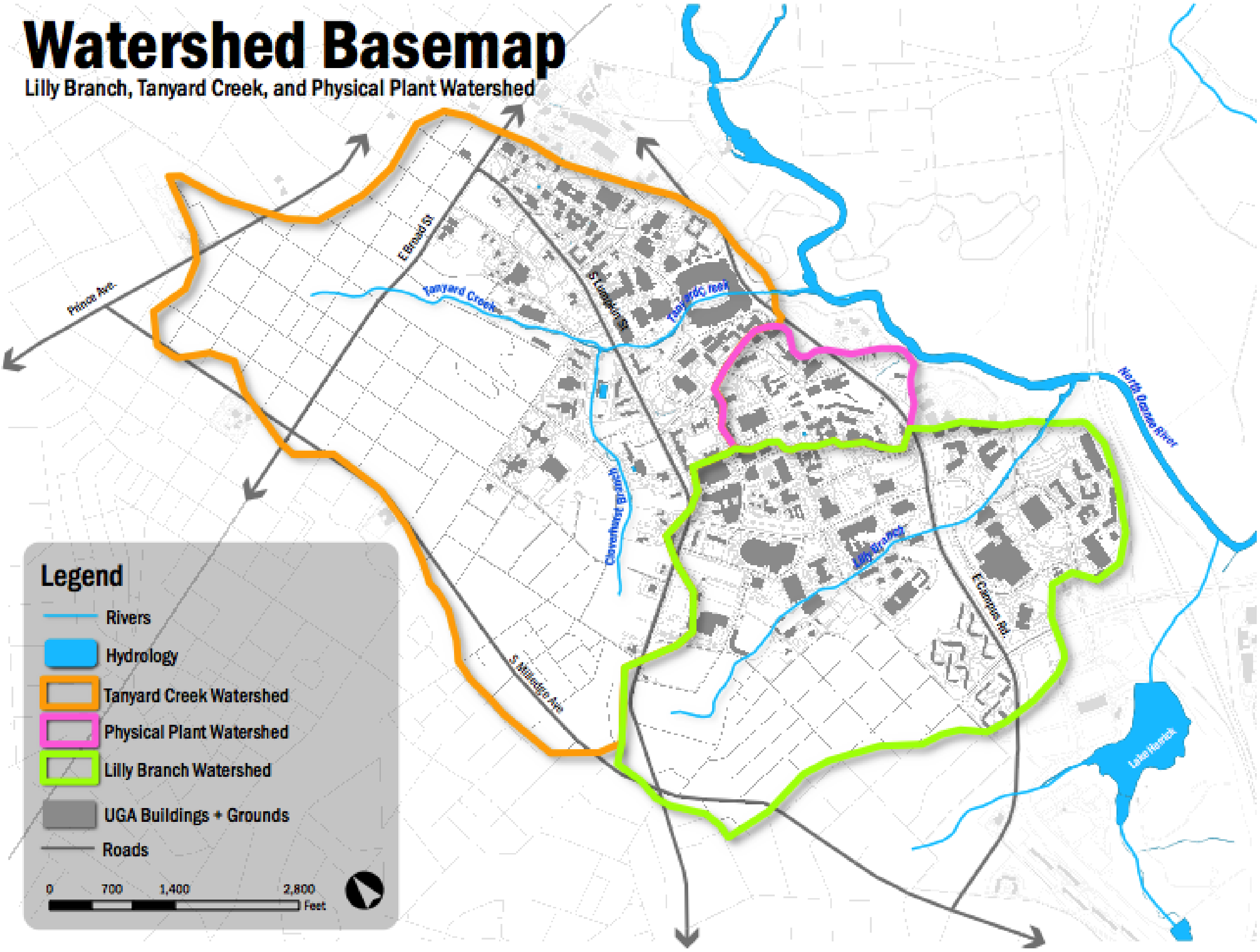

Figure 8: UGA Campus Watershed Map

Through their installation at highly visible places on campus, GI practices become a series of landscape elements of the UGA campus. They can reveal how rainwater moves through landscape as a natural phenomenon that might otherwise be ignored. Furthermore, these elements can provide valuable research opportunities for students and faculty studying urban ecosystems. Stormwater projects in academic settings not only mitigate environmental problems, but also provide potential outdoor learning space for college students.

Rain Gardens

UGA has installed over 70 rain gardens throughout the UGA Athens Campus. The first rain garden was installed at the UGA Recreation Sports Complex on college station road in 1998. Other major campus rain gardens include those at Lumpkin Woods, the Tate Center, the Special Collections Library and the Lamar Dodd School of Art (Sustainable UGA 2015).

Lumpkin Street

Rain gardens on Lumpkin Street were part of the Lumpkin Street Drainage Improvements project installed in 2003 to improve the health of Tanyard Creek (Sustainable UGA 2015). There are 15 rain gardens along Lumpkin Street designed to treat 90 percent of rainfall in the project area, collectively creating the largest roadside water quality improvement project of its kind in the country when it was constructed (Discover UGA 2015). Water from streets and parking lots is directed toward these raingardens, and pollutants in the runoff are filtered by plants to encourage infiltration. Water that infiltrates into the ground helps to create healthy campus streams during dry periods. This project won the AUA Sustainability Award in 2004 and is a collaborative effort between Athens-Clarke County and the University of Georgia (Sustainable Design Projects).

Figure 9: Lumpkin Woods Rain Garden

Special Collections Library

Five rain gardens (bio-retention areas) and one enhanced swale using engineered soil mixture are installed around the special collection library and they infiltrate stormwater on site. Pollutants are removed through both soil and plant absorption.

Figure 10: Special Collections Library Rain Garden

Lamar Dodd Art School

One MLA class focused part of their project on the restoration of Lilly Branch located just south of the Lamar Dodd School of Art in East Campus. They have planted rain gardens in front of Lamar Dodd to clean up the run-off coming down the hill and into the stream (Discover UGA 2015). The stormwater runoff from the Art buildings flows into a series of rain gardens and swales where it is filtered and cleansed before flowing into the nearby Lily Branch.

Figure 11: Lamar Dodd Art School Rain Garden

Permeable Pavements

There are also porous pavements installed at UGA, which act like normal pavements, but allow stormwater to drain into the underlying soil instead of contributing to runoff. Their aesthetic value to the public remains unknown.

Brooks Mall

At Brooks Mall in South Campus, impervious roadway and parking areas that experienced heavy vehicular traffic were eliminated and replaced with pervious pavement. The

Mall now provides a safe and pleasant greenspace and at the same time increased stormwater infiltration and improved water quality (Discover UGA 2015).

Figure 12: Brooks Mall Pervious Pavement

Jackson Street Building and Denmark Hall

At the rear of the Jackson Street Building in North campus, porous concrete was installed. Near Denmark Hall, permeable pavers were installed. Both were designed to reduce stormwater runoff, allow water to infiltrate into the soil, enhance water quality, and serve as a demonstration for students in the College of Environment and Design and the broader community.

Figure 13: Jackson Street Building Pervious Pavement(left); Denmark Hall Pervious Pavement(right)

Vegetated Roofs

Four vegetated roofs have been installed at UGA. They are located on the Lamar Dodd School of Art Building, at the Climate Research Lab on top of the Geography building, on the expansion to the Tate Center, and at the trial green roof on the Science Library (Flaute 2012). According to the Sustainable UGA website, the vegetated roof (approximately 3000 sq. ft) on top of the UGA Geography-Geology building was installed to serve as a temperature buffer for the Climatology Laboratory in the 1960s. Since 2007, different groups of people such as professors, students and volunteers have further used this green space by planting and maintaining a fruit and vegetable garden (Sustainable UGA 2015). Produce from the fruit and vegetable garden is donated to Campus Kitchen at UGA, and also delivered to Athens families, as well as the Food Bank of Northeast Georgia and other institutions working toward food security (Martin 2015). The fruit and vegetable garden help to lower the rooftop temperature by retaining storm water, absorbing heat and releasing the water vapor back to the atmosphere.

Figure 14: Geography-Geology Building Rooftop Garden

The rooftop garden at the Tate west lawn was constructed on a previously paved parking structure. After completion, the entire site had a significant net increase of permeable surface and green space (Sustainable Design Projects). The vegetated roof at Lamar Dodd Art school is a 3,400-square-foot “green roof” carpeted with plants. It is part of the building design to fit into an overall greenspace and stormwater management plan for the East Campus arts complex.

Tim Carter, a PhD student who established the trial green roof on the Science Library-Boyd Hall Graduate Studies building on the campus of the University of Georgia, conducted a green roof study on UGA campus. The study site is located on the ground floor roof of the Boyd Graduate Studies Building. The roof was installed during the period of September 30 to October 1, 2003 with assistance from the Office of the University Architect, the UGA Physical Plant and the Institute of Ecology (UGA Green Roof Project). Monitoring was conducted between November 2003 and November 2004 at this trial green roof, with two test plots and one control plot to test the effectiveness of the green roof in reducing stormwater flows. The test and control plots were identical in size and shape at 5.2 m by 8.2 m for a total of 42.64 m^2. Stormwater mitigation performance was monitored for 31 precipitation events, which ranged in depth from 0.28 to 8.43 cm. The result showed that runoff from the green roof was decreased and delayed. Runoff decrease ranged from 90 percent for small storms events (<2.54 cm) to slightly less than 50 percent for larger storms (> 7.62 cm). The average runoff lag times increased from 17.0 minutes for the normal roof to 34.9 minutes for the green roof, an average increase of 17.9 minutes. Also, with precipitation depth decrease, the precipitation retention of the green roof decreased as well.

Rainwater Harvesting Cisterns

The University of Georgia has approximately 16 cisterns varying in size and volume—totaling over 530,000 gallons according to the Office of Sustainability—that collect rainwater and redistribute it as non-potable sources (Cannon 2015). Some cisterns are used for rainwater harvesting only, while others collect water from other sources, such as air conditioner condensate (Flaute, 2012). This means the water is not consumed but is used for other things such as irrigation, flushing toilets, and cooling buildings. The first cistern was installed in 2005 underneath the Memorial Garden. "At the time it was perceived as an unnecessary and an extravagant use of dollars for a tank that was used to store rainwater when we had plenty of water," said Office of Sustainability Director, Kevin Kirsche. When an outdoor watering ban was issued in 2007 because of a drought, the campus was still able to keep the Memorial Garden alive by using the water from the cistern (Cannon 2015). This circumstance changed how many people at UGA viewed water conservation and was a catalyst for more cistern installations. Most of the water held in a cistern comes from rainwater, but according to the UGA Extension's website, only 62 percent of rainwater striking a roof will be collected. Water can also come from condensation resulting from cooling buildings. The following table lists the location and size of the 16 cisterns:

Table 3: UGA Rainwater Collection Cisterns

#	**Location**	**Size**	**Above/Under Ground**
1	Georgia Museum of Art	30,000-gallon	Underground cistern
2	Residence 1516 Building	30,000-gallon	Underground cistern
3	Special Collection Library	105,000-gallon	Underground cistern
4	UGArden	3,000-gallon	Above-ground cistern
5	Georgia State Botanical Garden	10,000-gallon	Underground cistern
6	Founders Memorial Garden	600 gallons	Above-ground cistern
7	Grounds Department Maintenance Shops	10,000-gallon	Above-ground cistern
8	Double Bridges Farm	54,000-gallon	Two separate above-ground cisterns
9	Memorial Garden	5,100-gallon	Underground cistern
10	Paul D. Coverdell Center	40,000-gallon	Underground cistern
11	Tate Center under the Georgia Quad	75,000-gallon	Underground cistern
12	PPD Grounds Shop	10,000-gallon	Above-ground cistern
13	Lamar Dodd School of Art	35,000-gallon	Underground cistern
14	Pharmacy South	10,000-gallon	Underground cistern
15	Butts-Mehre Expansion	200,000 -gallon	Underground cistern
16	Jackson Street Building	28,000-gallon	Above-ground cistern

<u>Jackson Street Building Cistern</u>

The Jackson Street Building was constructed in 1962 to house the University of Georgia's visual arts program. It has been renovated with innovative LEED features after five years of use. Re-opened in 2012, the building had a complete interior renovation; the new facility aimed for LEED Gold in New Construction and Major Renovations. Air conditioner condensate and rainwater runoff is stored in a 28,000-gallon above-ground cistern and then filtered, treated, and reused within building to flush toilets and provide make-up water for the cooling tower.

Figure 15: Jackson Street Building Above-ground Cistern

Special Collections library Cistern

The Special Collections Library cistern provides water for site irrigation and reclamation water for the neighboring UGA Central Utility Plant. Underground cistern storage of approximately 105,000 gallons has been used to store stormwater runoff and settle pollutants from the building roof and surrounding landscapes. Stormwater runoff is reduced by a net decrease of 1.23 acres of impervious surfaces and encouraging surface infiltration through the use of mulched landscaped beds and mild sloping sod green space (Sustainable Design Projects). Prior to construction, there was only 18% vegetation on site, while afterward, the project site was 55% vegetated. There were also 75,000 SF of new vegetation: 50,000 SF consisting of native and adapted plants and 25,000 SF of turf. Drought tolerant plant material was selected, and sod areas were minimized to reduce total irrigation water demand.

Tate Center Cistern

A 75,000-gallon cistern is used to collect precinct rainwater from the Miller learning Center and Tate roofs, and condensate from the Tate mechanical system to provide gray water for flushing toilets and urinals throughout the building and irrigation for adjacent landscapes.

Lamar Dodd Art School Cistern

In 2009, the Office of University Architects completed work on the new Lamar Dodd School of Art landscape. This project was awarded a 2008 Stormwater Steward Award by Athens-Clarke County (ACC), and includes a 32,000-gallon cistern for collecting rainwater from the building's roof and condensate from the art school's HVAC system.

CHAPTER 5

RESAERCH DESIGN

Survey was the primary research method used for gathering data on student perception in this study. The key component and focus of this research was to conduct visual surveys with photos of selected GI on the UGA campus and ask subjects to rate a series of landscape images of selected practices to help determine student perception of these sustainable landscapes. Two visual surveys were administered to volunteer participants on the campus of the University of Georgia to understand their perception of thirteen landscape images of selected GI practice sites. This chapter explains the selection of representative GI sites, creation of survey images, the structure of the visual survey, the survey distribution, the data collection process, and the data analysis.

To answer the first research question, a survey with thirteen photos of selected GI practices was distributed to a group of students to explore their aesthetic response to those practices. To answer the second research question, which is whether informing students of the environmental values of GI will alter their perception of UGA campus GI practices, another survey was conducted to test the impact of the educational information. Unlike the first survey, which consists of only photos of the selected GI sites, the second survey uses the exact same images from the first survey but with additional educational information — that is, a list of bullet points of the GI environmental benefits of each site was provided in the survey before participants rated the landscape photos. Students were encouraged to imagine they were experiencing the scenes and ranked photographs solely based on their visual preference on a five-level Likert scale, ranging from very attractive to very unattractive, with neutral at the midpoint. For the purpose of this study, each option was assigned a score in order to calculate the average score of each survey image (Very attractive=5, Somewhat attractive=4, Neutral=3, Somewhat unattractive=2, Very unattractive=1.) However, these scores were not presented to the participants. To avoid leading the respondent and skewing the result, when introducing the benefit of GI practices, the wording used was as value free as possible.

Site Selection

As revealed by initial investigation and communication with the Grounds Department, Campus Architects Office and Office of Sustainability faculty, the existing GI practices on the UGA campus include rain gardens, vegetated roofs, permeable pavements, cisterns/rainwater harvesting system and disconnect downspouts. A series of GIS inventory maps of existing cisterns, rain gardens, and vegetated roofs were obtained from Carol Flaute's practicum Stormwater Management: A Plan for the Basins from Tanyard Creek to Lilly Branch on the North Oconee River. Based on the inventory map location and multiple campus walks with both Professor Ronald Sawhill and Professor Danny Sniff, representative sites of different categories of GI practices were identified. The major criteria for selection include high visibility and easy public access. Other criteria include vegetation type when selecting rain gardens, pervious pavement type, vegetated roof types, and above or underground when selecting cisterns.

The following sites were selected:

Figure 16: Site A, Rain Garden, near the Lamar Dodd Art School.

This is a photo taken in front of the Lamar Dodd Art School in Fall 2017, featuring a series of rain gardens designed to clean up the runoff before it enters the Tanyard Creek. Including a rain garden photo taken in the Fall, when vegetation in the rain garden is partially missing or has different leaf color, provides a chance to show students the visual seasonal differences of rain gardens and test their preference for rain gardens in less thriving seasons. This site was selected because the rain garden had no vegetation when the photo was taken.

Figure 17: Site B, Pervious Pavement, at the back of Jackson Street Building.

This is a photo taken at the rear of the Jackson Street Building in Spring 2018, featuring a pervious pavement designed to infiltrate runoff into the underlying subgrade before it drains into the stream. This site was selected because it is highly visible to the public and has a relatively prominent pattern in the landscape.

Figure 18: Site C, Green Roof, at rooftop of the Geology Building.

This is a photo taken at the rooftop garden of the Geology/Geography Building in Spring 2018, featuring a vegetated roof originally designed to monitor climate change and now transformed into an urban rooftop vegetable garden. Including a rooftop garden from Spring, when vegetation is partially missing and not directly accessible to all students and faculty due to its location, provides an opportunity for comparison with the Site H vegetated roof since the photo of the Tate Center West Lawn was taken in the Summer, and the location is highly public.

Figure 19: Site D, Rain Water Harvesting Cistern, at the Special Collections Library.

This is a photo taken in front of the Special Collections Library in winter 2017, featuring a 105,000-gallon cistern hidden underground. Without the existence of the cistern, the traditional lawn landscape could cause adverse environmental impacts including pesticide and herbicides flow into waterways, greenhouse gas release caused by lawn maintenance, or even just intensive water use in the summer. The cistern has been used to filter and store runoff from surrounding landscapes, which is reused for irrigation, toilet flush, etc. Including a cistern that is not visible to the public provides an opportunity to test whether informing people of the existence of the cistern and its environmental impact will change their perception of this landscape.

Figure 20: Site E, Rain Garden, at the Lamar Dodd Art School.

This is a photo taken in front of the Lamar Dodd Art School in Winter 2017, featuring a rain garden that was designed to clean up the runoff before it enters the Lily Branch. Including a rain garden photo taken in the winter, when no vegetation was visible, provides a chance to show students how rain gardens look in the winter and test their preference for them.

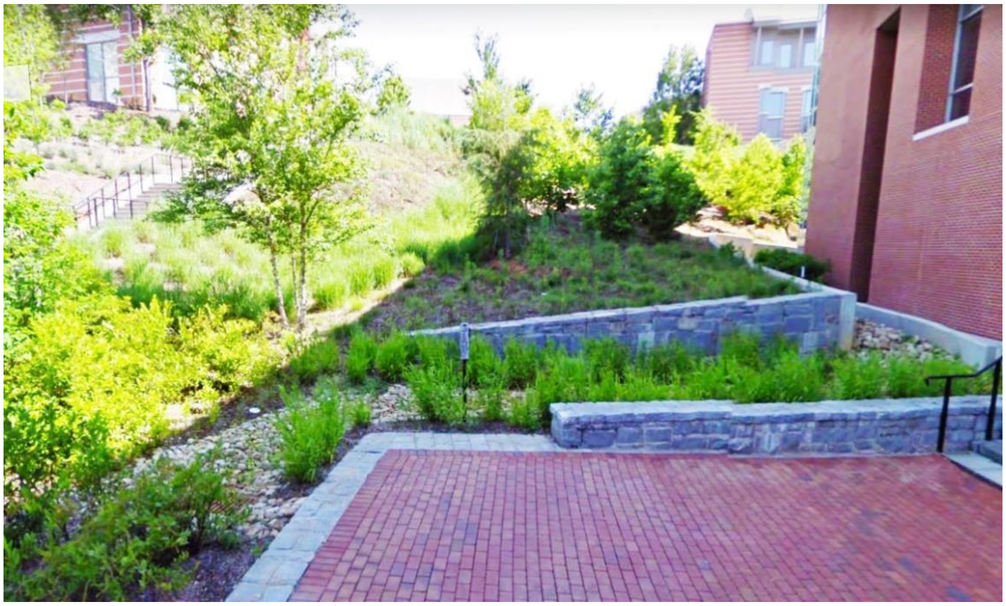

Figure 21: Site F, Rain garden, at the Lamar Dodd Art school.

This is a photo taken in front of the Lamar Dodd Art School in Summer 2017, featuring a rain garden that was designed to clean up the runoff before it enters the Lily Branch. Including a rain garden photo taken in the summer, when vegetation was luxuriant, provides a chance for comparison with Site E and test the effect of seasonality on students' preference for rain gardens.

Figure 22: Site G, Pervious Pavement, at the Meyers Community Parking Lot

This is a photo taken at the Myers Community Parking Lot in Spring 2018, featuring a permeable concrete grid with grass growing in-between designed to infiltrate runoff from the parking lot. Including a permeable concrete grid photo in the survey provides a chance for comparison with Site B, which features porous concrete, and test the public's preference for different kinds of pervious pavement.

Figure 23: Site H, Vegetated Roof, at the West Lawn near the Tate Center.

This is a photo taken at the Tate Center West Lawn in Summer 2017, featuring a vegetated roof on a parking deck to decrease impervious surface, add to the site's comfort by reducing the heat island effect, and reduce the quantity of stormwater coming from the site. Including a vegetated roof photo from the summer, when vegetation is luxuriant and highly accessible to the public, provides an opportunity for comparison with the Site E vegetated roof and test the effect of seasonality.

Figure 24: Site I, Rainwater Harvesting Cistern, at the back of Jackson Street Building.

This is a photo taken at the rear of the Jackson Street Building in Spring 2017, featuring an above-ground 28,000-galon cistern designed to store, filter, and treat rainwater and facilitate its reuse within the building. This site was selected because the cistern is prominent in the landscape and forms a strong contrast with other hidden cisterns. Additionally, it is highly public because of its location near the entrance/exit of the North Parking Deck, which people drive by on a daily basis.

Figure 25: Site J, Rain Garden, at the Tate Center parking deck.

This is a photo taken at the parking lot at the Tate Center in Spring. It features a rain garden that relies on runoff water to irrigate plant material. Including a rain garden from the spring when vegetation was becoming green, and the edge of the rain garden was well-defined compared to other rain gardens, provides an opportunity to test students' preference for different rain gardens. This site was selected for its prominent public location as well.

Figure 26: Site K, Rain Garden, at the Myers Community.

This is a photo taken at the parking lot at the Tate Center in Spring. It features a rain garden that collects runoff from surrounding landscapes. Including a rain garden from the spring, when vegetation was becoming green and blending in with the landscape without a clear edge compared to other rain gardens, provides an opportunity to test students' preference for different rain gardens.

Figure 27: Site L, Rain Garden, at the Lumpkin Woods.

This is a photo taken along Lumpkin Street in Spring 2018. It features a rain garden that collects runoff from the walkway and street. Including a rain garden with vegetation that is completely green and blends in with the landscape without a clear edge compared to other rain gardens provides an opportunity to test students’ preference for different rain gardens.

Figure 28: Site M, Pervious pavement and disconnected downspout, at Denmark Hall.

This is a photo taken near the Denmark Hall in Spring 2018, featuring a permeable interlocking concrete paver combined with a disconnected downspout. Including a photo with permeable interlocking concrete paver and disconnected downspout, provides an opportunity to test students' preference for different kind of pervious pavement and disconnected downspouts.

In chapter 3, other categories of GI were mentioned but not included in the visual preference survey, such as urban tree canopy, disconnected downspout and bioswale. This is due to the fact that when presented in the photo, they were not very prominent feature or do not stand out in the photo. For example, disconnected downspout in site M image is not discernable to viewer; trees were presented in every image. Therefore, those categories were not included in the final survey images.

Survey Images

The initial photo collection process began with taking photos of all inventory sites. By walking to and identifying GI practice sites, some of the sites were found to be very hidden or even not visible to the public, such as the cisterns buried underground at the Tate Center and the rain gardens located at the rear of the Special Collections Library, where people seldom notice that stormwater management practices exist. Access to some of the sites is limited, such as the vegetated roofs at the Lamar Dodd Art School and the Geology Building. After filtering out less appropriate sites and comparing available inventory photos, thirteen GI practice images were selected as final survey sample images. All thirteen survey images were taken with an iPhone 7 during different seasons and under different weather conditions at the University of Georgia campus. By showing GI practices in different seasons and under different weather conditions, the participants received a more complete image of different GI practices in terms of color(seasonality) and vegetation change(seasonality). Since seasonal change can affect the visual quality of some these practices (vegetated roof, permeable pavement and rain garden), photos representing these categories taken in different season were provided, making it possible to test whether seasonality plays a role in affecting people’s aesthetic response to different GI practices. Only minor adjustments were made using Photoshop to establish continuity of quality between images.

Survey Structure

The survey consists of four sections:

- Section one is an introductory paragraph to welcome respondents and explain the purpose, location (UGA campus) and process of completing the survey and approximate time of completion. Participants were informed that their involvement in the study is voluntary, and that they may choose not to participate or to stop at any time without penalty. They were also informed that their participation will be confidential, and no personal information will be collected, and that only the research team will have access to data, and data will not be exposed to others.
- Section two collects respondent's background information such as age, gender, academic major, education level, etc. In order to test whether familiarity with the landscape has an influence on people's perception, the respondents were asked if they live on campus or off campus and what kind of environments they are most familiar with.
- Section three asks respondents to indicate the level of attractiveness of each representative GI practice images. However, they are not told what any of the images contain with regard to GI. Images are rated on a five-Likert scale with decreasing visual quality, ranging from *Very Attractive* to *Very Unattractive*. In the second survey, additional educational information was provided in the form of bullet points. The participants were asked to read the text and rate each landscape image.

  For the control group, the following question was asked for each GI practice image in section three:

  Please rate the landscape based on the following visual preference scale:

    - Very Attractive
    - Somewhat Attractive

- Neutral
- Somewhat Unattractive
- Very Unattractive

For the study group, a list of benefits was provided for participants to read before rating each landscape image. For example:

This landscape contains a series of **Rain Gardens** designed to

- Infiltrate rainwater/reduce runoff
- Slow runoff rate
- Clean rainwater
- Improve stream health
- Recharge groundwater

Please rate this landscape based on the following visual preference scale:

- Very Attractive
- Somewhat Attractive
- Neutral
- Somewhat Unattractive
- Very Unattractive

- Section four is an open-end question for any comments and suggestions.

(The two full surveys are available in the Appendix A.)

After participants rated each image, the results from control group were collected and analyzed to determine students' initial aesthetic responses to landscapes containing GI practices. The results of the study group were then compared with those of the control group to determine if students' preferences were significantly altered by knowing the environmental benefits provided by GI practices in these landscapes.

A list of benefits is provided for each category of GI practices.

Table 4: Environmental benefits of GI practices

Green infrastructure/ Benefits	Rain Garden	Vegetated Roof	Rainwater Harvesting Cistern	Disconnected Downspout	Permeable Pavement
1	Infiltrate rainwater/reduce runoff	Retain rainwater in the plants and growing medium	Collect and store rainfall for later use (flush toilet, irrigation, etc.)	Reduce runoff volume	Reduces or eliminates stormwater runoff
2	Slow runoff rate	Slow runoff rate	Conserve water	Decrease runoff peak discharge	Filters out pollutants, purifying runoff
3	Clean rainwater	Reduce the amount of storm water	Slow and reduce runoff	Reduce pollutants from rooftop	Protect streams and groundwater
4	Improve health of stream	Improve air quality		Improve water quality	
5	Recharge groundwater	Reduce urban heat island effect			

- Section four is an open-end question for any comments and suggestions.

(The two full surveys are available in the Appendix A.)

Previous studies indicate a strong causal relationship between different factors and a subject's landscape preference patterns. As discussed in the previous chapter, studies have found that factors such as gender, and educational and cultural background can heavily affect landscape preference patterns (Zhang 2006). Ewert and Baker (2001) found significant differences in the variables of academic major, gender and age. Therefore, these variables were addressed in questions one, two and four:

1. Gender
    - Female
    - Male
    - Transgender
    - Prefer not to respond

2. Age
    - Under 18
    - 18-19
    - 20-21
    - 22-24
    - 25 and above

Zheng *et al*. (2011) found that senior students prefer well-maintained and artificial landscapes. Thus, this thesis hypothesized that graduate student will have lower ratings compared to undergraduate students. Based on the literature, the following question was asked:

4. Education Level
    - Freshman
    - Sophomore
    - Junior
    - Senior
    - Graduate student
    - Professional student

As was noted in an earlier chapter, Zheng et al. (2011) identified academic major as an influential factor on people's preference. He found statistically significant results showing that students in anthropocentrically focused programs are more inclined to choose a neat, well-kept environment; whereas, students in ecologically focused programs prefer more natural landscapes. To examine this relationship, this thesis hypothesized that student from different academic major have different attitude toward GI practices. Therefore, question three was asked:

3. Academic Major: ___________________

Previous studies investigated judgments of aesthetic quality in a familiar environment. Merrill and Baird (1980) conducted two experiments asking students to make judgements of aesthetic quality in a familiar environment. One group made judgements at the site, and another group made judgement from memory. The result suggested that participants have detailed mental representations of their familiar environment. In both experiments the relative ratings were stable across the seasons of the year. Therefore, this thesis hypothesized that participants' familiarity with campus landscape settings will not create difference in their visual preference ratings. The following question was asked:

5. Do you live on-campus or off-campus?
   - On campus
   - Off-campus

A study by Kaplan (1990) indicated that familiarity (one's knowledge of and experience with a landscape) affects perception (the way one sees a landscape) and this perception may affect preference (how much one likes a landscape), Kaplan found that familiarity has a positive effect on preference. Daniel (1990) found that familiarity is positively related to preference for the prairie landscape that was studied. Therefore, this thesis hypothesized that participants claiming to be most familiar with an urban environment should rate all the landscape images higher since all the sites are located in an urban campus setting. To test this factor, question six was asked:

6. Which of the following environments do you consider yourself most accustomed to?
   - Urban
   - Suburban
   - Rural

Informed Consent

This survey adopts the method of consent without signature. An informed consent form was provided at the beginning of the survey. Sufficient information was provided in order to allow the participants make an informed decision about whether or not they wanted to participate. A drawing of a 25-dollar incentive was provided by the researcher to improve the participation rate. By clicking on *Yes* after reading the consent information, the participants were assumed to have agreed to participate in this study (Please see the consent in the Appendix A.)

Incomplete disclosure

In the consent form of both surveys, no information about GI was provided because this study’s aim was to discover what students think about a landscape's beauty without causing them to presuppose that I was evaluating GI. Because the control group (survey 1) were not informed about GI, given the aim of the study, it was necessary that the study group (survey 2) not know ahead of time what I was evaluating and teaching them about. Therefore, participants were not informed that I was evaluating the effect of education information on their aesthetic preference in survey 2.

At the end of both surveys, the participants were provided with a debriefing form stating that in order to make the study valid, part of the survey was not fully disclosed at the beginning of the survey. Participants were informed that this survey was about assessing their aesthetic preference for GI; additionally, participants in the study group will be informed that this study attempted to discover the effect of educational information on their aesthetic preference for GI (Please see the debriefing form at Appendix A.)

Respondent Selection

Students who were registered at the University of Georgia were invited to participate in this survey. This study hypothesizes that students in different academic departments have differing understandings and perceptions of stormwater management practices. Therefore, random distribution was selected to include students from all academic majors. The email list of UGA students was obtained through an online request from the Office of the Registrar.

Survey Distribution

Before distributing the surveys to UGA students, the finished surveys were submitted to the University of Georgia Institutional Review Board through the IRB E-research Portal. The IRB is the research oversight committee ensuring that human subjects research is conducted in compliance with the applicable federal, state, and institutional policies and procedures. The researcher received permission to distribute the survey from the Institutional Review Board on April 17, 2018. Given the benefit of online surveys: high efficiency, low cost of distribution, consistency of representation and the relatively short length of time of this study, I chose to create and distribute the surveys through the Qualtrics system. This survey was distributed on April 25, 2018.

Data Collection

After a week of data collection from the online survey, the respondent information was extracted into a Microsoft Excel spreadsheet. Any surveys with missing values (unanswered questions) were eliminated from the dataset in order to simplify the analysis.

Data Analysis

As mentioned at the beginning of this chapter, each option was assigned a value in order to calculate an average score for each landscape image. In this study, the option *Very attractive* is assigned a value of five, *Somewhat attractive* four, *Neutral* three, *Somewhat unattractive* two, *Very unattractive* one. In this way, after collecting responses from all participants, average scores were generated for each landscape image (for both the study and the control groups). The higher the score, the more preferred the landscape is, and the more aesthetically pleasing people consider it to be. This researcher equates that preference as meaning people consider it more aesthetically pleasing. For instance, a landscape image with an average score of 4.5 is considered more beautiful and attractive than a landscape image with an average score of 2.9. By comparing the study groups scores with those of the control group, patterns can be discovered to determine whether the introduction of educational information can alter students' perception of sustainable landscapes. This thesis used the IBM SPSS Statistics software package to analysis the rating scores to determine if there is a significant difference between results from the study group and control groups (Mann Whitney U Test). A Multiple Regression Model was used to analyze the potential variables in the survey.

CHAPTER 6

RESULT AND DISCUSSION

This chapter includes descriptive information about the participants and analytic results from the survey. There are two sets of sampling data; 112 participants are from the control group and 115 participants are from the study group, resulting response rate of 11.2% and 11.5% respectively. However, 3 participants from the study group were disqualified and removed from the final data due to incompletion of their surveys, so study group data came from 112 participants in the end. The data from the control group is presented first, followed by the study group data. An overall representation of the survey participants is included: age, gender, education level, academic major, residency status, and familiar landscape environment. The data were then compared and analyzed to answer the two research questions. Finally, a series of statistical analyses were conducted to determine if any of the variables had a significance impact on the preference pattern.

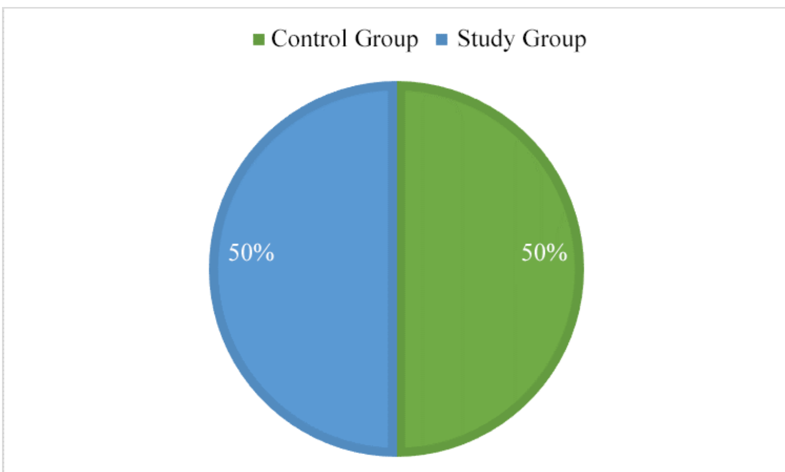

Figure 29: Distribution of Study/Control Group Participants

Sample Characteristics

<u>Control Group</u>

The participants were selected from the random sample of 1,000 student email addresses obtained from the University of Georgia Office of the Registrar and consisted of 50% graduate students and 50% undergraduate students. The responses comprise a total of 112 participants from 1,000 recruits, resulting in a 11.2% response rate. The participants are sorted by six independent variables. Four of them are demographics variables — including gender, age, academic major, and education level; two of them are non-demographics variables, campus living status and familiar landscape type. The final dataset from the control group contained 1,456 scores (13 images scored by 112 participants).

- Gender

  The distribution of the participants is almost 2:1 in favor of females, with 71 female participants (63.39%) and 41 male participants (36.61%) responding.

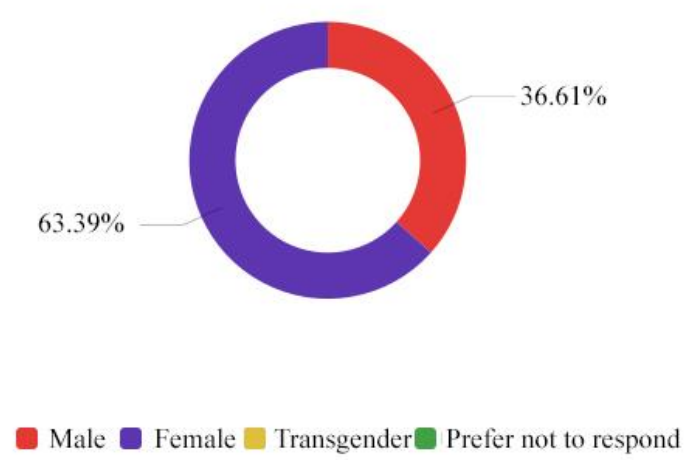

Figure 30: Distribution of Gender by Percentage

- Age

  Age distribution is also not balanced, with 11 subjects in the 18-19 range (9.82%), 22 subjects in the 20-21 range (19.64%), 22 subjects in the 22-24 range (19.64%), and 57 subjects over 25 years old (50.89%). Around half of the participants 25 years old and older.

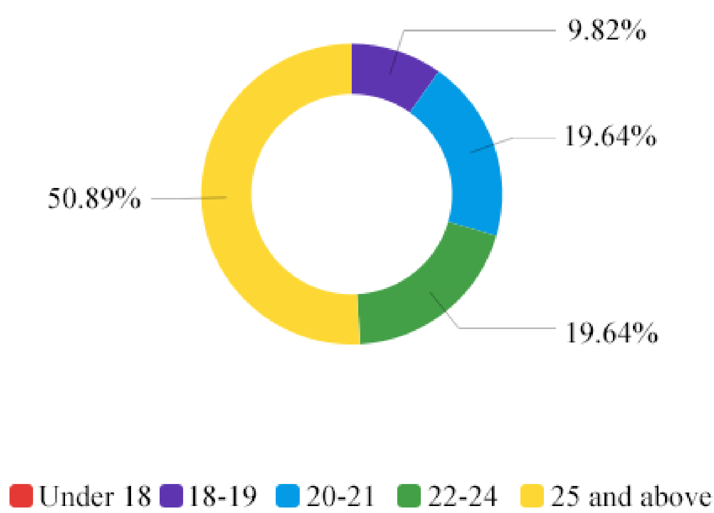

Figure 31: Distribution of Participants' Ages by Percentage

- Academic Major

  The following figure presents the educational background of the 112 survey participants. Their majors are included in the following table:

Table 5: Participants' Academic Majors, Control Group

Academic major	Count
Accounting	5
Advertising	1
Agriscience	1
Animal science	3
Art	3
Biochemistry	2
Biology	8
Business	5
Chemistry	3
Computer science	3
Ecology	1
Economics & Finance	5
Education	8
Engineering	5
Entomology	1
Environmental Planning and Design	1
Exercise and Sports Science	2
Fabric design	1
Food Science	5
Forestry	1
Genetics	2
Health Promotions & Outcomes	2
History	1
Human Development and Family Science	1
Infectious Disease	1
Journalism	1
Landscape architecture	1
Learning, Design, and Technology	1
Management Information System	2
Marketing	1
Microbiology	1
Middle grades education	2
Music education	4
plant Biology	2
Poultry Science	1
Psychology	3
Public administration	6
Risk Management & Insurance and Political Science	1
Sociology	8
Sport Management	3
Veterinarian	1

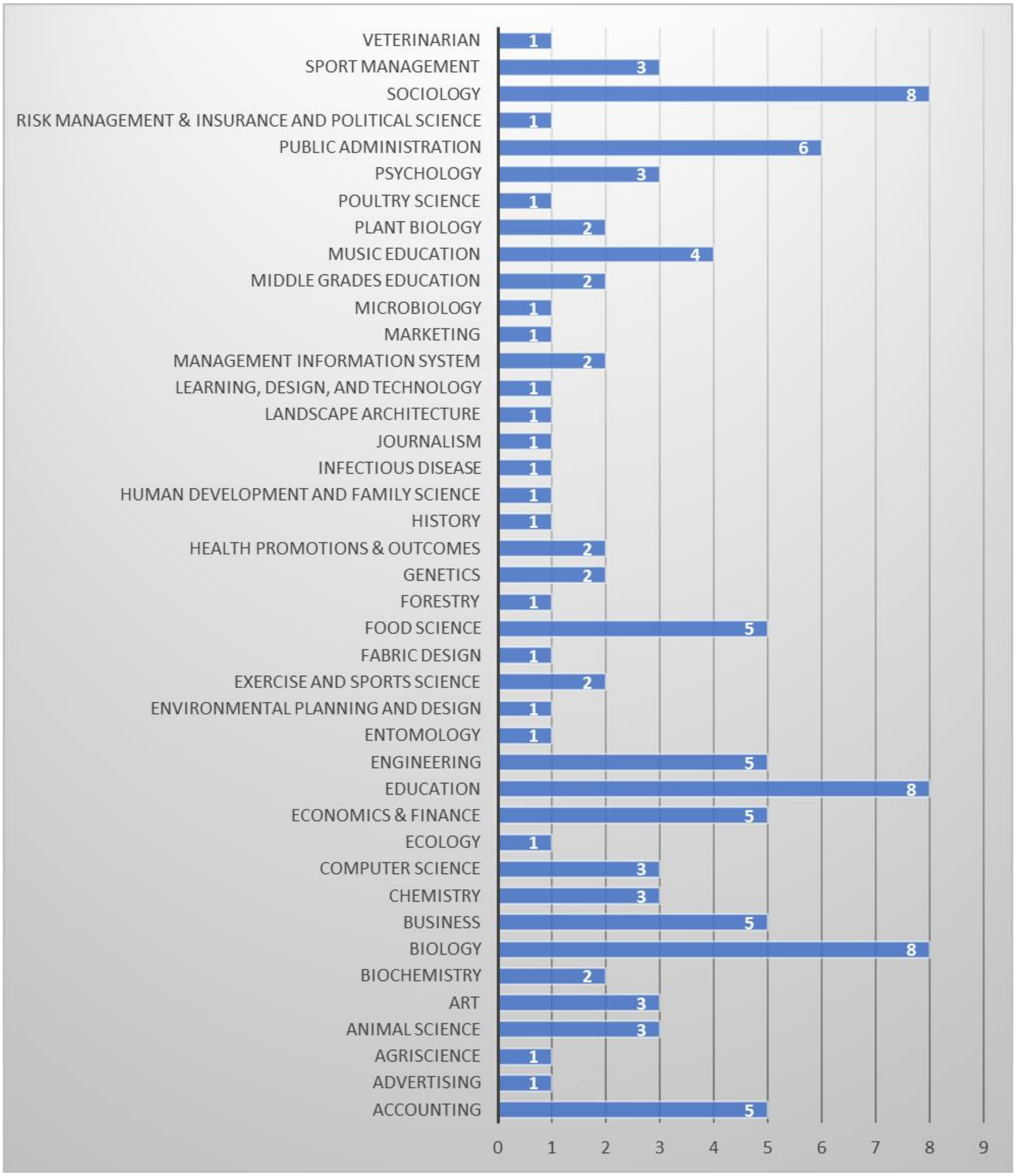

Figure 32: Participants’ Academic Majors, Control Group

- Education level

  The majority of the participants were graduate students, representing 59.82% (n=67) of the total study population, followed by junior students with 11.61% (n=13); sophomore students, with 9.82% (n=11); senior students, with 8.04% (n=9); freshman students, with 7.14% (n=8); and professional students, with 3.57% (n=4).

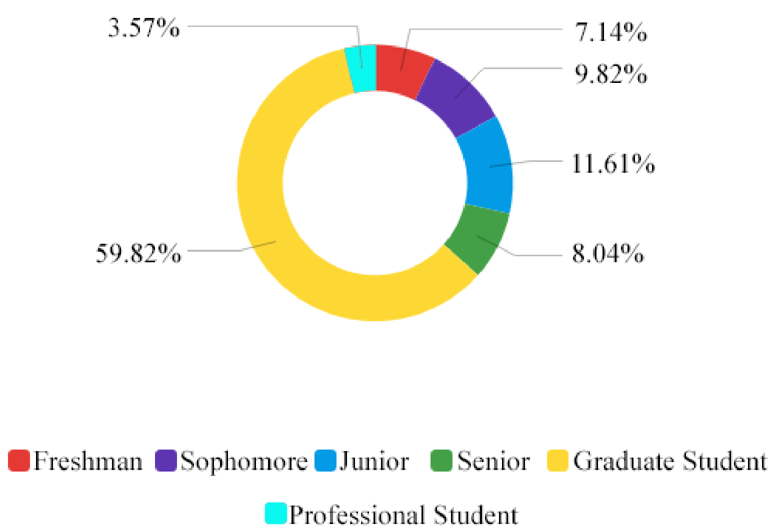

Figure 33: Distribution of Participants Education Level by Percentage, Control Group

- Residency Status

  Student residency status is not distributed evenly. Most of the participants (83.93%, n=94) lived off-campus, with only 16.07% (n=18) living on campus.

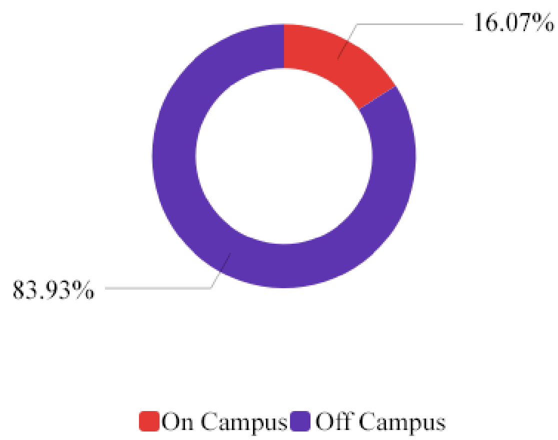

Figure 34: Distribution of Participants' Residency Status, Control Group

- Familiar environment

  The majority of the participants claimed they are most familiar with suburban settings, representing 56.25% (n=63) of the total study population. Those most familiar with urban environments represented 32.14% (n=36), followed by those most familiar with rural environments, at 11.61% (n=13).

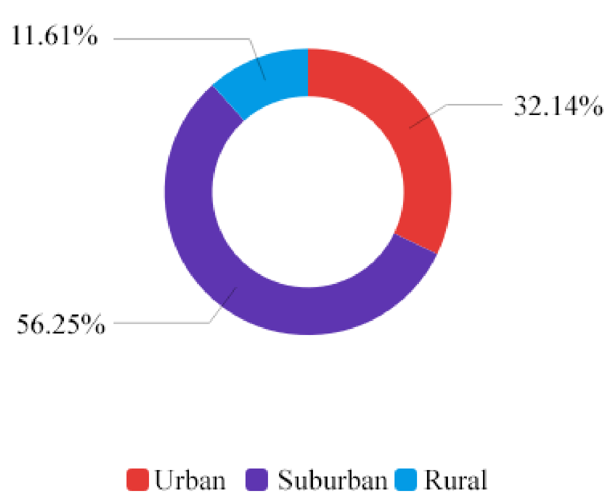

Figure 35: Distribution of Participants' Familiar Environment, Control Group

<u>Study Group</u>

The final dataset from the study group contained 1,456 scores (13 images scored by 112 participants). The participants were selected from the random sample of 1,000 student email addresses obtained from the University of Georgia Office of the Registrar, consisting of 50% graduate students and 50% undergraduate students. The responses comprise a total of 115 participants from 1,000 recruits, resulting in a 11.5% response rate. However, 3 of the participants with incomplete surveys were eliminated from the final data.

- Gender

  The distribution of the participants gender is around 2:1 in favor of females, with 83 female participants (74.11%) and 28 male participants (25%) responding. One of the respondent chose to not reveal gender.

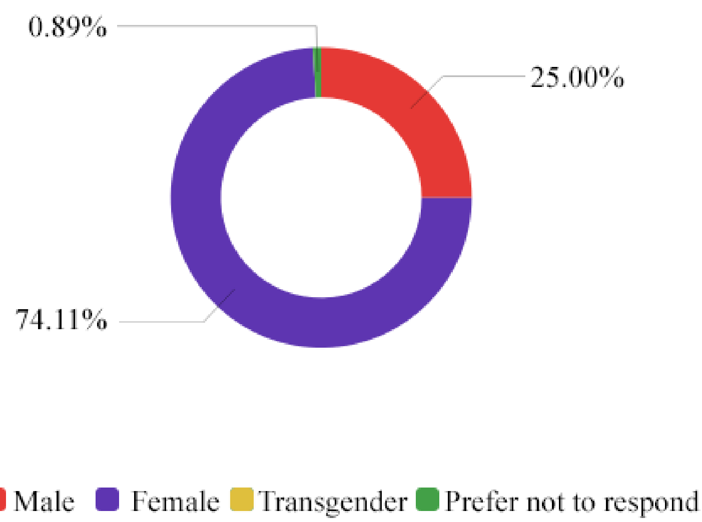

Figure 36: Distribution of Gender by Percentage, Study Group

- Age

Age distribution is also not balanced, with 14 subjects in the 18-19 range (12.5%), 18 subjects in the 20-21 range (16.07%), 24 subjects in the 22-24 range (21.43%), and 56 subjects over 25 years old (50%). Around half of the participants are 25 years old or older.

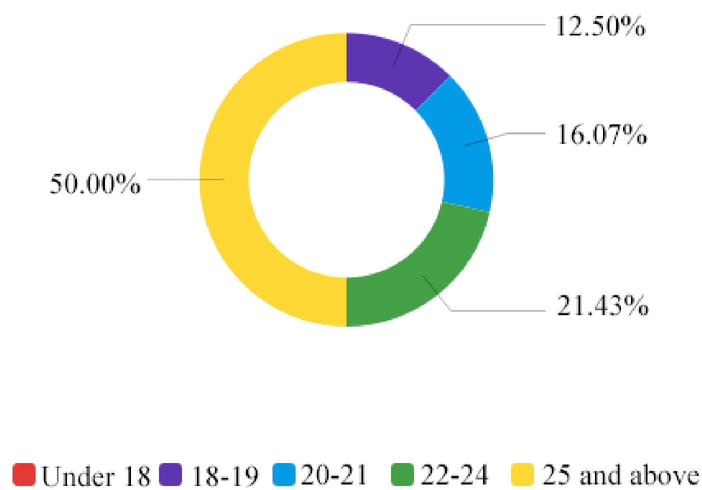

Figure 37: Distribution of Participants Age by Percentage, Study Group

- Academic Major

The following figure presents the educational backgrounds of the 112 survey participants. Their majors are included in the following table:

Table 6: Participants' Academic Majors, Study Group

Academic major	Count
Accounting	3
Advertising and Public Relation	1
Agriculture	2
Animal Science	1
Animation	1
Anthropology and Spanish	1
Art History	1
Biochemistry	1
Biochemistry and Molecular Biology	3
Biology	4
Business	4
Chemistry	2
Communications	3
Comparative Biomedical Sciences	2
Computer Science	4
Conservation Ecology and Sustainable Development	1
Counseling	1
Dietetics	1
Early Childhood Education	2
Ecology	2
Economics	1
Education	4
Engineering	6
Entertainment and Media Studies	1
Environmental Health Science	2
Exercise sports science	1
Finance	2
geology	2
Health	2
Human Development and Family Science	4
Human Resources and Organizational Development	1
Journalism	2
Kinesioogy	2
Landscape Architecture	2
Learning, Leadership and Org Development	2
Linguistics	4
Marine Sciences	1
Marketing	4
Music Education	1
Neuroscience	1
Nonprofit management and leadership	1
Nutrition	4
Pharmaceutical Sciences	1
Physics	1
plant biology	2
Political Science	1
poultry science	1
Psychology	4
Public Relations & Policy	3
Risk Management and Insurance	1
Sociology	5
Sport Management	1
Theatre Set Design	1
Toxicology	1
Wildlife Sciences	2

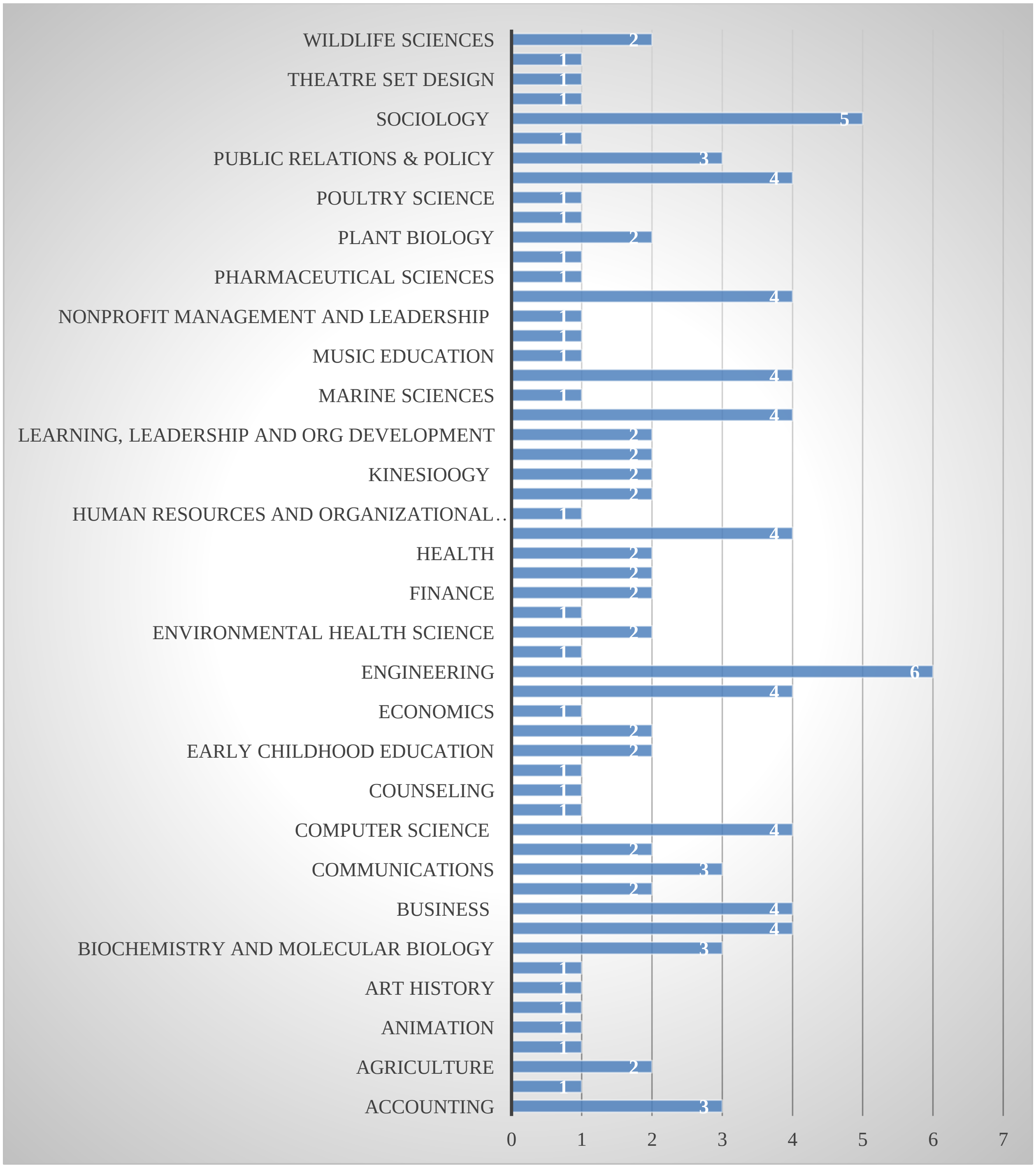

Figure 38: Participants' Academic Majors, Study Group

- Education level

The majority of the participants were graduate student, representing 65.18% (n=73) of the total study population, followed by senior students, with 11.61% (n=13); freshman student, with 9.82% (n=11); sophomore student, with 7.14% (n=8); junior students, with 6.25% (n=7); and no professional students.

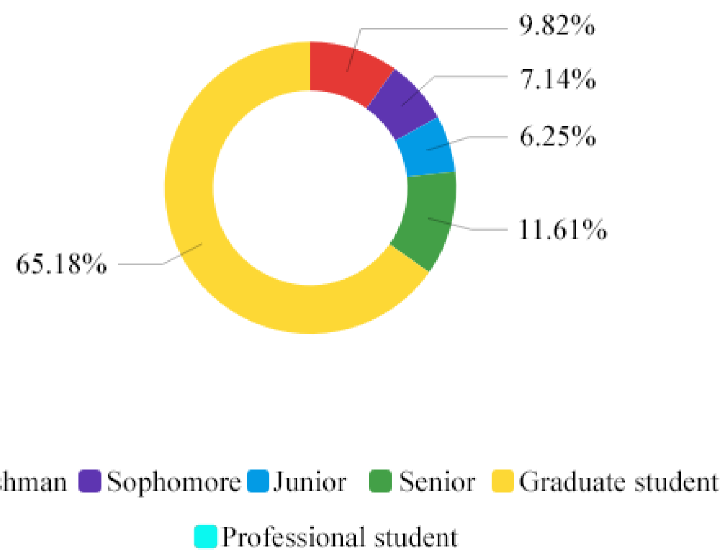

Figure 39: Distribution of Participants Education Level, Study Group

- Residency Status

Student residency status is not distributed evenly, with 77.68% of participants (n=87) living off-campus and only 22.32% (n=25) of participants living on campus.

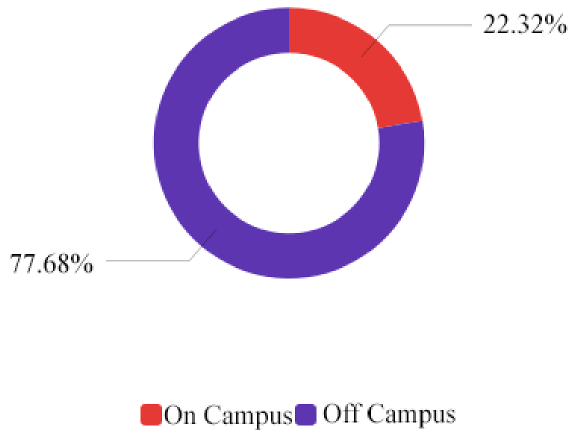

Figure 40: Distribution of Participants' Residency Status, Study Group

- Familiar environment

The majority of the participants claimed they are most familiar with suburban settings, representing 66.07% (n=74) of the total study population. Those most familiar with urban environments represented 17.86% (n=20), followed by those most familiar with rural environments at 16.07% (n=18).

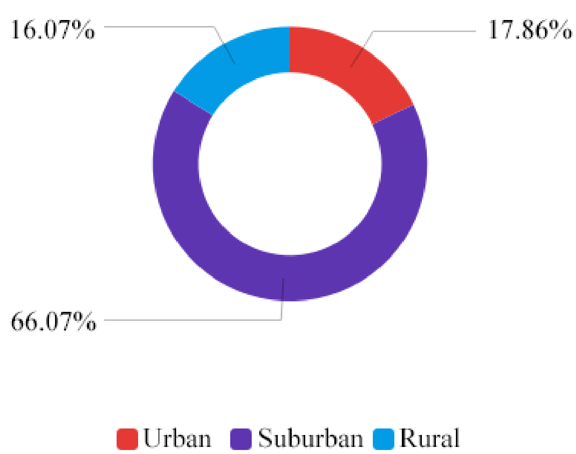

Figure 41: Distribution of Participants' Familiar Environment, Study Group

Research Question Results

To understand the overall visual preference of UGA students regardless of the amount of environmental knowledge they might or might not have, data from the control and study groups were combined, and average scores were calculated based on the combined data (Table 7). The following table presents the average rating of each of the landscape images from all 224 participants. As mentioned in chapter 5, an average score for each survey image was calculated from the received ratings to indicate its visual attractiveness to students. Preference scores were rated on a five-point Likert Scale, where visual attractiveness increases as the mean value increases (e.g., a landscape image with a score of 2.5 is less attractive compared to a landscape image with a score of 3.5). An average score of 3 or above indicates the survey image containing GI is considered attractive. In the total of 13 survey images, 10 out of 13 images received positive ratings, or 77% of total image ratings. Within all the landscape images, Site H Tate Center west lawn vegetated roof, has the highest score.

Table 7: Survey Image Average Score by Site

Site	A	B	C	D	E	F	G	H	I	J	K	L	M
Average Score	3.89	3.04	2.57	3.63	3.15	4.13	2.15	4.36	3.54	3.72	3.42	4.13	1.98

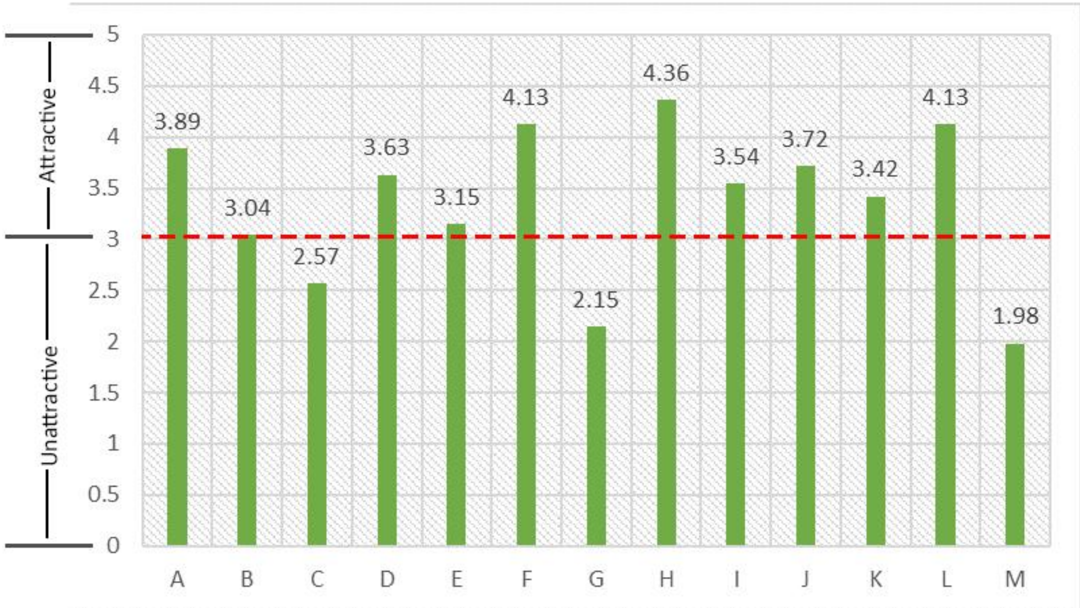

Figure 42: Survey Image Average Score by Site

A photo collage was combining all 13 survey images appears on the next page (Figure 37).

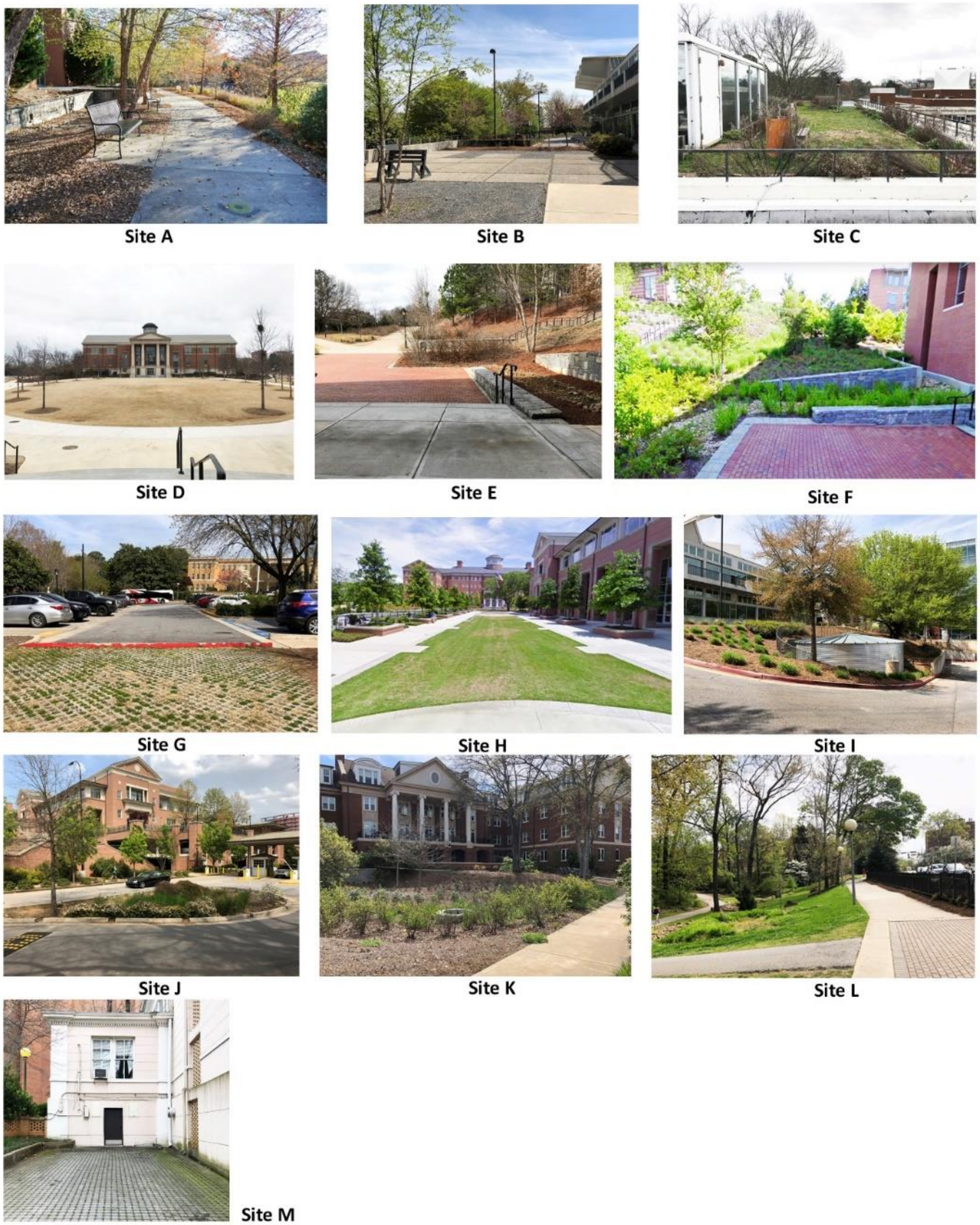

Figure 43: All survey sample images

To understand how UGA students perceive each individual category of GI practice, the ratings for 13 landscape images were grouped into four categories (rain garden, pervious pavement, cistern, vegetated roof) and the average score of each category was calculated. The table below shows the average of the mean scores of each category of GI practice. Based on comparing the ratings of each category of GI practices, Rain Gardens have the highest average score, 3.74, among the practices, followed by Cisterns, with a score of 3.58; Vegetated Roofs, with a score of 3.46; and Pervious pavements, with a score of 2.39. Disconnected Downspout was omitted because it is not very visible in the survey image compared to the pervious pavement in photo M. In these four categories, pervious pavement was considered unattractive since its score dropped below 3 (three corresponds to the "Neutral" option in both surveys). The other three categories were considered varying in degree of attractiveness.

Table 8: Mean of Mean by Green Infrastructure Categories

Category	Mean of Mean
Rain garden (Site A, E, F, J, K, L)	3.74
Pervious pavement (B, G, M)	2.39
Cistern (D, I)	3.58
Vegetated Roof (C, H)	3.46

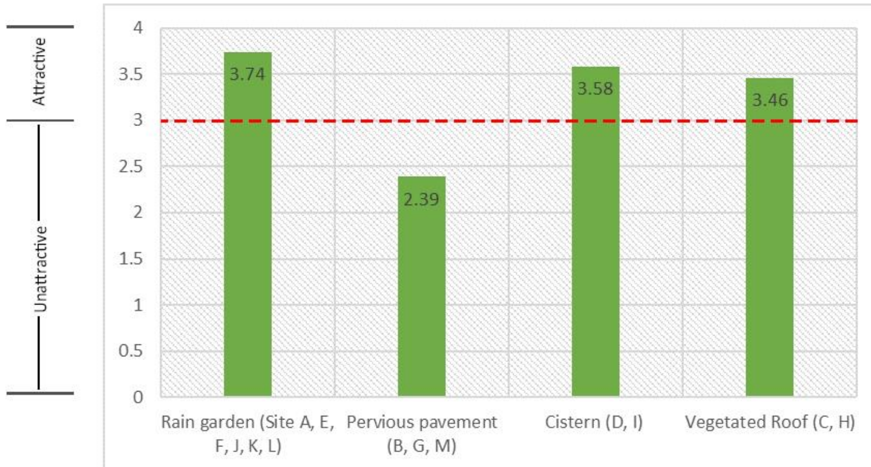

Figure 44: Mean of Mean by Green Infrastructure Categories

To evaluate students' overall perception of GI practices, the average score of the four categories' means was calculated. The resulting score of all GI practices is 3.29, which suggests that even though students found pervious pavement unattractive, when considered in the context of these GI practices, students have a positive attitude overall toward GI practices and consider rain garden the most attractive of all.

Research Question 2: Will informing students of GI's ecological benefits alter student perception of their surrounding sustainable landscape?

The summarized table below presents the mean values of each survey image from both the uninformed control group and the informed study group. If a landscape image score is 3 and above, it is considered attractive and visually pleasing; if the score is between 2 to 3, it is considered neutral; and if the score is equal to or below 2, it is considered unattractive and visually unpleasing.

Table 9: Control Group Mean of Landscape Images

Site	A	B	C	D	E	F	G	H	I	J	K	L	M
Mean	3.92	2.94	2.32	3.54	3.05	4.03	1.96	4.33	3.48	3.56	3.36	3.94	1.87

Table 10: Study Group Mean of Landscape Images

Site	A	B	C	D	E	F	G	H	I	J	K	L	M
Mean	3.86	3.13	2.81	3.71	3.25	4.22	2.35	4.39	3.60	3.88	3.48	4.33	2.10

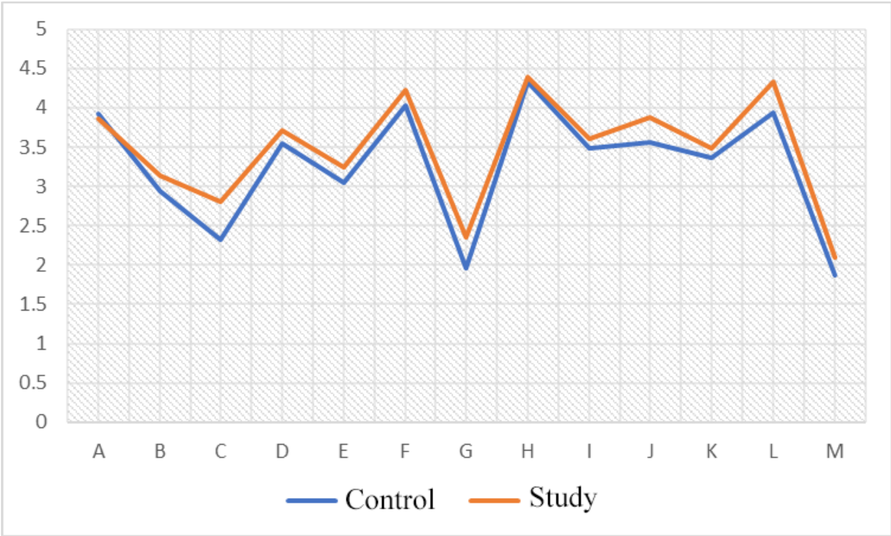

Figure 45: Comparison of Means: Control vs Study Group

Comparing the average score of each landscape image from the control and study group, there is an overall increasing trend in ratings, with Site A, the Lamar Dodd Art School rain gardens, the only exception. The orange line above indicates ratings for all the sites from the study group, which contains the participants who received additional education information. The blue line indicates ratings received from the uninformed control group, which contains the participants who received the survey image only. As can been seen in Figure 39, the orange line is above the blue line from Site B to Site M. This result suggests that educational information helped improve students' visual preference, and it is positively related. The average of mean value increased from 3.25 for the control group to 3.47 for the study group, a seven percent increase in overall score.

In order to answer research question two, a Mann-Whitney U test was performed to determine if there were significant differences in ratings for GI practices between the study group and the control group. Distributions of the rating scores for the study and control group were similar, as assessed by visual inspection of Figure 40. The median rating score was statistically significantly higher in the study group (3.40) than in the control group (3.17), *p* = .000. From the results, we can conclude that additional education information does alter students' visual preference, improving students' perception of UGA GI practices.

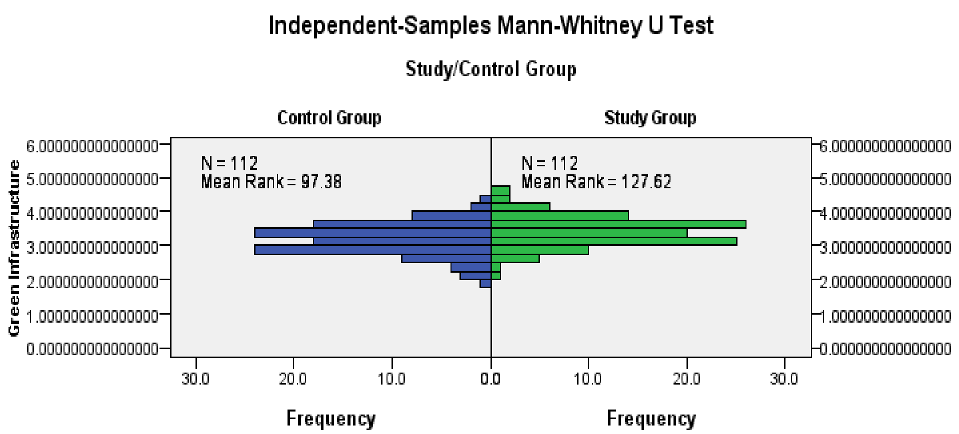

Figure 46: Study /Control Group Distribution Shape

Table 11: Mann Whitney U Test Summary

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Green Infrastructure is the same across categories of Study/Control Group.	Independent-Samples Mann-Whitney U Test	.000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Table 12: Study/Control Group Median of Ratings

Median

Study/Control Group	Green Infrastructure
Control Group	3.167500000
Study Group	3.395000000
Total	3.292500000

To understand if ratings for each category of GI practice have statistically significant difference, 13 landscape images were combined into 4 categories to facilitate the analysis process. They were grouped together based on the GI practices categories, including rain gardens (A, E, F, J, K, L), pervious pavement (B, G, M), rainwater harvesting cisterns (D, I) and vegetated roofs (C, H). Again, disconnected downspout was not included here because the it was not obvious in the landscape photo (M) compared to pervious pavement. A Mann-Whitney U test was performed to determine if there were differences in rating score for each category of GI practices between the study and control groups. Distributions of the rating scores for the study and control groups were similar, as assessed by visual inspection of the distribution diagrams below. The median rating score for rain gardens and pervious pavement was statistically significantly higher in the study group than in the control group. From the results, we can conclude that additional education information does alter students' perception of rain gardens, pervious pavements and vegetated roofs, but not cisterns.

Table 13: Mann Whitney U Test Summary for Individual Categories of GI

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Rain garden is the same across categories of Study/Control Group.	Independent-Samples Mann-Whitney U Test	.014	Reject the null hypothesis.
2	The distribution of Pervious Pavement is the same across categories of Study/Control Group.	Independent-Samples Mann-Whitney U Test	.002	Reject the null hypothesis.
3	The distribution of Cistern is the same across categories of Study/Control Group.	Independent-Samples Mann-Whitney U Test	.091	Retain the null hypothesis.
4	The distribution of Vegetated Roof is the same across categories of Study/Control Group.	Independent-Samples Mann-Whitney U Test	.006	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

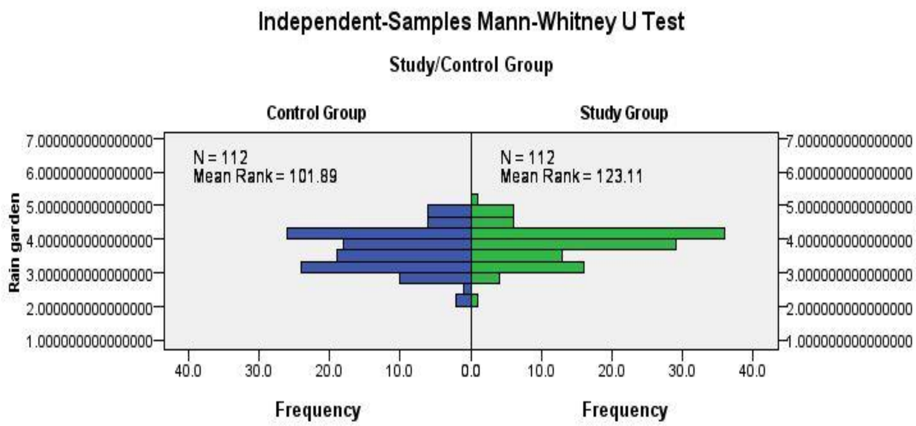

Figure 47: Rain Garden Rating Distribution Shape

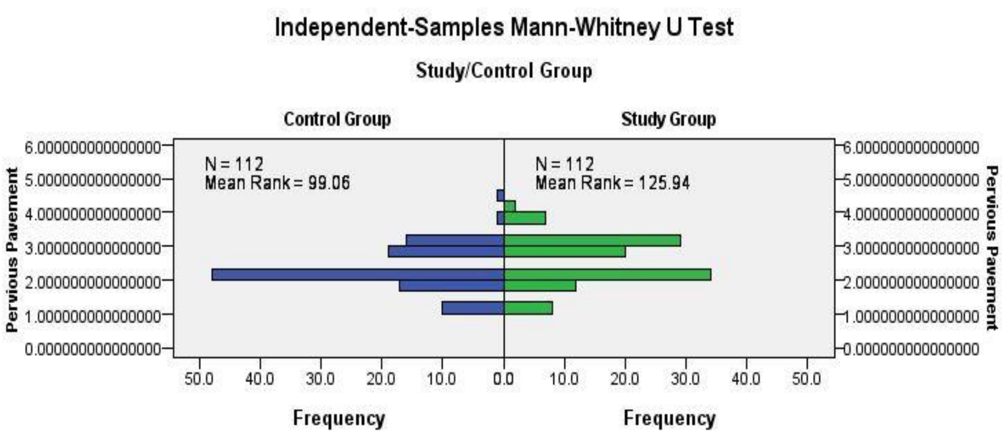

Figure 48: Pervious Pavement Rating Distribution Shape

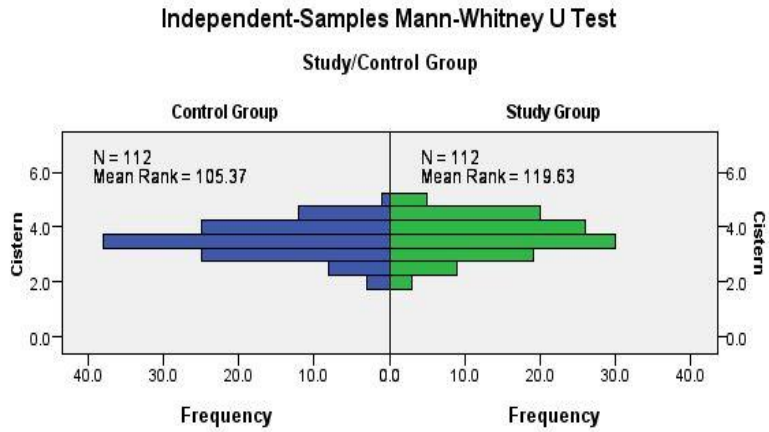

Figure 49: Cistern Rating Distribution Shape

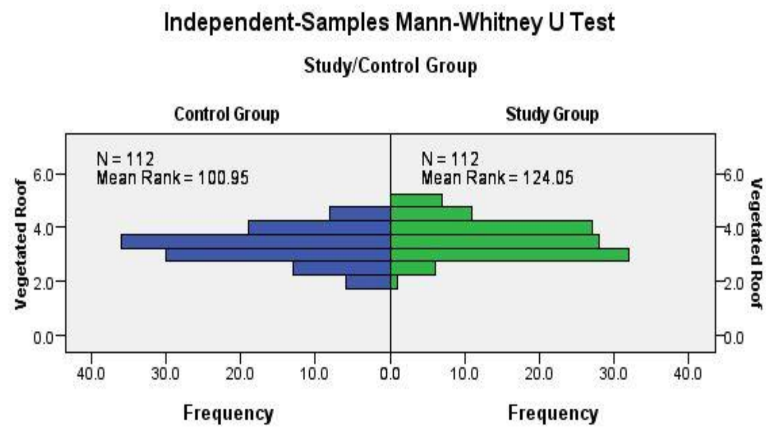

Figure 50: Vegetated Roof Rating Distribution Shape

Independent Variables

1. Gender

Table 14: Survey Image Average Score by Gender

Site	A	B	C	D	E	F	G	H	I	J	K	L	M
female	3.95	3.08	2.7	3.67	3.1	4.2	2.2	4.37	3.53	3.75	3.44	4.21	1.73
male	3.76	3.06	2.34	3.58	3.2	3.94	2.07	4.37	3.54	3.68	3.41	3.97	2.09

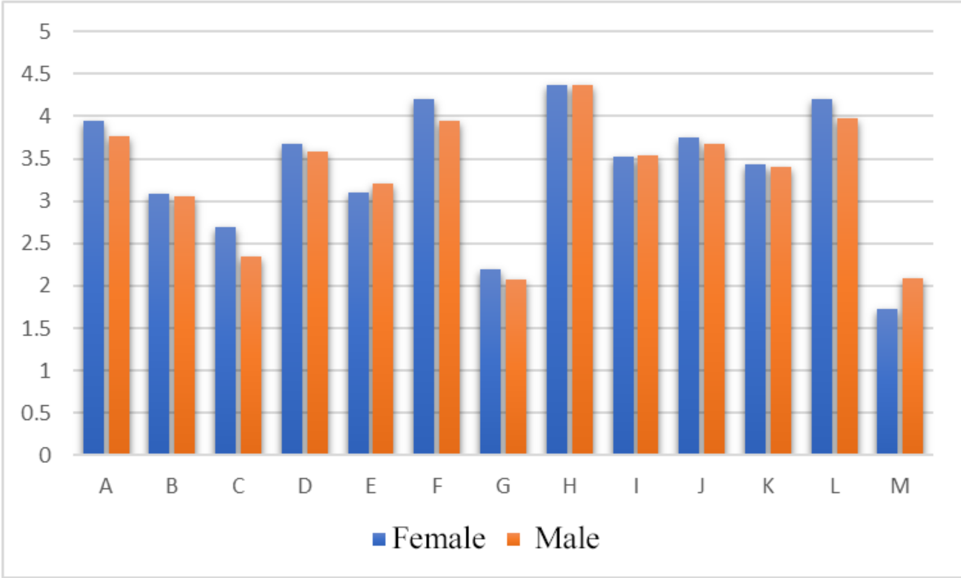

Figure 51: Survey Image Average Score by Gender

There were 69 male participants and 154 female participants in this study, with one participant preferring not to reveal his/her gender. A review of ratings by gender for each survey image shows a trend of female participants awarding higher rating scores. Female rating scores were higher for nine out of thirteen images (Sites A, B, C, D, F, G, J, K, L), representing 69.23 percent of the total images.

2. Age

Table 15: Survey Image Average Score by Age

Site	A	B	C	D	E	F	G	H	I	J	K	L	M
18-19	3.85	3.22	2.67	3.59	3.19	4.19	2.19	4.26	3.52	3.70	3.37	3.93	2.00
20-21	3.73	3.15	2.56	3.63	2.95	4.12	1.95	4.56	3.46	3.51	3.34	4.17	1.85
22-24	3.91	3.00	2.5	3.72	3.11	4.11	1.98	4.43	3.70	3.89	3.48	4.13	2.02
25+	3.94	2.97	2.56	3.58	3.21	4.13	2.29	4.28	3.51	3.73	3.42	4.16	2.01

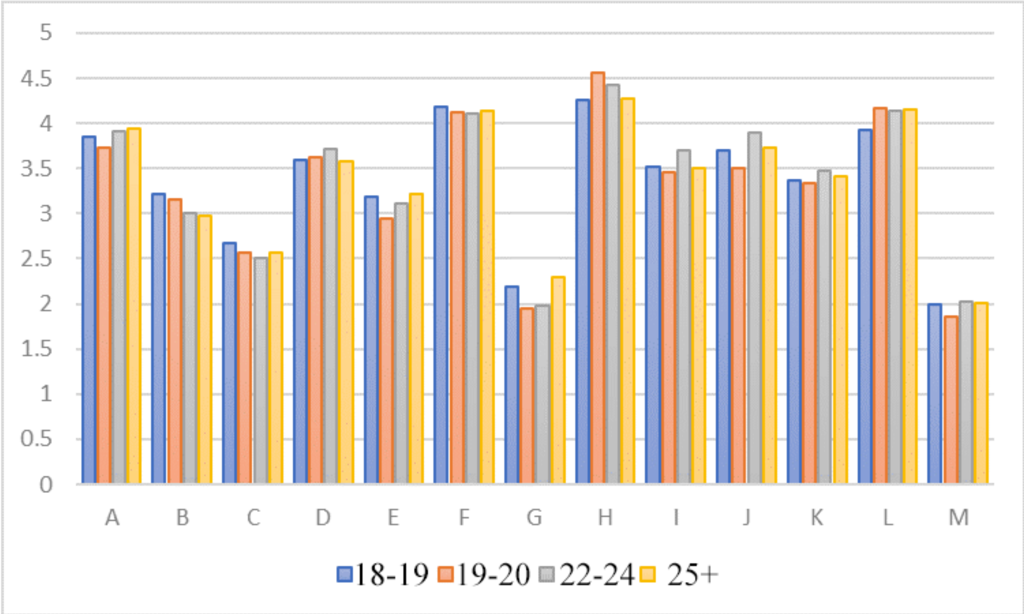

Figure 52: Survey Image Average Score by Age

Participants were classified into four age groups: 18-19 years old (*n* = 25), 20-21 years old (*n* = 40), 22-24 years old (*n* = 46) and 25+ (*n* = 113). Based on reviewing average scores from Table 15 and Figure 46 above, there was no clear preference pattern observed in the ratings of different age groups.

3. Academic Major

To simplify the analysis, academic majors were combined from the two data sets and 3 majors with the highest participants numbers were selected for comparison. Their majors are Biology (n=8), Computer Science (n=7), and Social Work (n=10). There is a clear difference, in that students from social work have higher scores for the survey images.

Table 16: Survey Image Average Score by Academic Major

Academic Major	Mean
Biology	2.96
Computer Science	3.22
Social Work	3.4

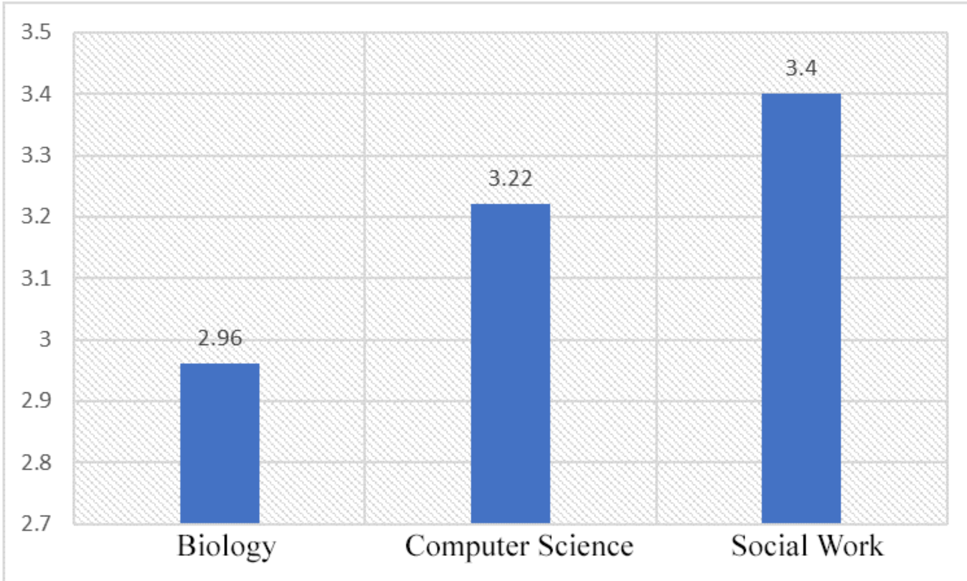

Figure 53: Survey Image Average Score by Academic Major

4. Education Level

The analysis of educational level categorizes all the data (freshman, sophomore, junior, senior, graduate student, professional student) into two different categories: undergraduate students (n=80) and graduate students & PHD students (n=144). No clear preference rating pattern was found between undergraduate and graduate students.

Table 17: Average Score by Education Level: Undergraduate vs. Graduate

Site	A	B	C	D	E	F	G	H	I	J	K	L	M
Undergraduate student	3.82	3.13	2.64	3.66	3.05	4.11	2.05	4.45	3.52	3.65	3.41	4.08	1.89
Graduate student	3.92	2.99	2.51	3.59	3.19	4.15	2.22	4.31	3.56	3.76	3.41	4.15	2.03

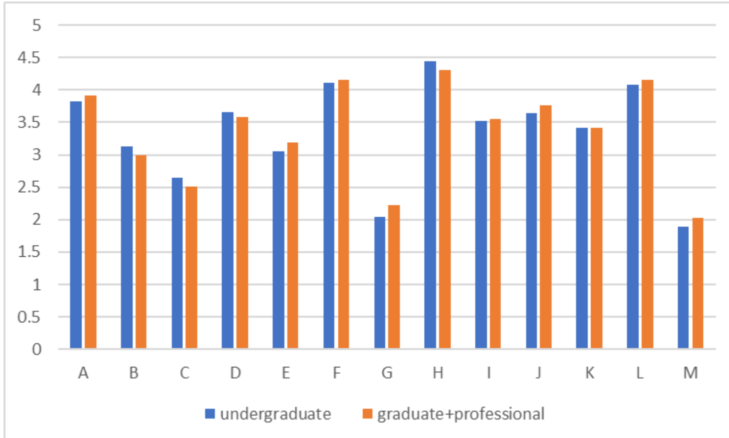

Figure 54: Survey Image Average Score by Education Level: Undergraduate vs. Graduate

5. On/off Campus

Table 18 shows ratings by participants who live on and off campus. Only 43 participants indicated they live on-campus, while 181 participants live off-campus. Based on a review of the ratings of each survey image, students who live off-campus gave eight out of the thirteen images higher scores (Sites A, B, E, F, H, I, L, M), which equals 61.54 percent of the total number of images.

Table 18: Survey Image Rating by Residency Status

Site	A	B	C	D	E	F	G	H	I	J	K	L	M
On campus	3.86	3.02	2.67	3.63	3.07	3.88	2.23	4.23	3.42	3.72	3.88	4.09	1.81
Off campus	3.91	3.08	2.57	3.63	3.15	4.18	2.15	4.4	3.57	3.72	3.46	4.15	2.01

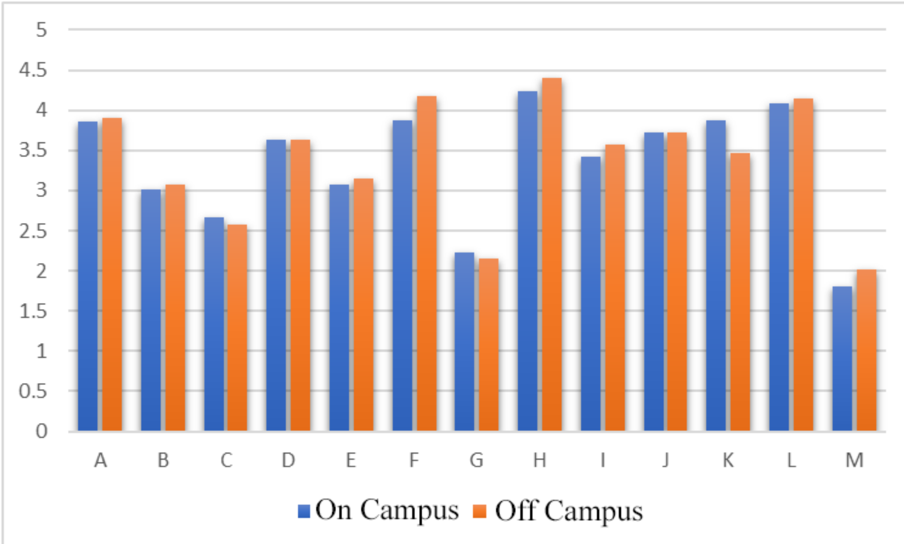

Figure 55: Survey Image Rating by Residency Status

6. Familiar environment

Participants were classified into three groups: urban (*n* =56), suburban (*n* =137), and rural (*n* = 31).

Table 19: Survey Image Average Score by Familiar Environment Category

Site	A	B	C	D	E	F	G	H	I	J	K	L	M
Urban	3.77	3.02	2.40	3.58	3.02	4.07	2.3	4.37	3.53	3.61	3.51	4.07	1.79
Suburban	3.93	3.08	2.61	3.56	3.22	4.19	2.12	4.37	3.52	3.72	3.37	4.12	2.02
Rural	3.90	2.90	2.61	3.94	3.03	4.00	2.03	4.29	3.68	3.94	3.42	4.29	2.16

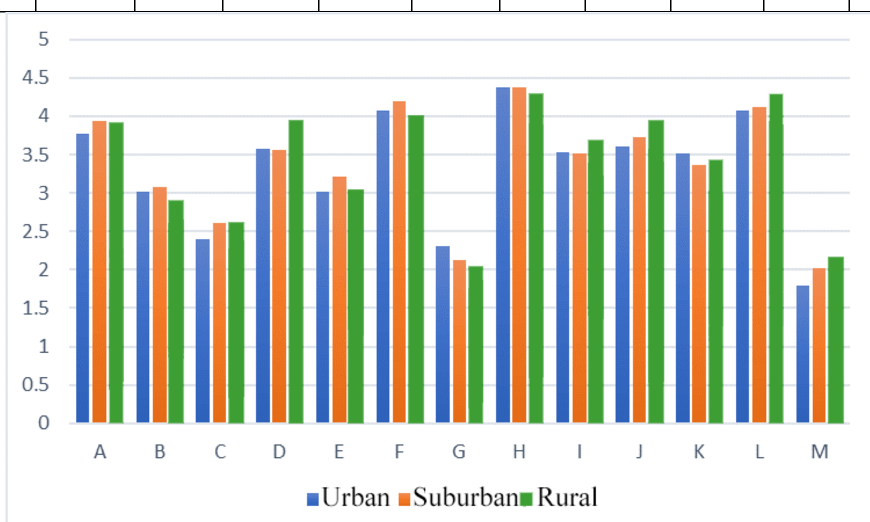

Figure 56: Survey Image Average Score by Familiar Environment Category

To determine if all these independent variables have statistically significant differences as compared to the overall student rating, a multiple regression analysis was performed to examine all the variables including gender, age, education level, campus living status, and familiar environment. There was independence of residuals, as assessed by a Durbin-Watson statistic of 1.930. There was homoscedasticity, as assessed by visual inspection of a plot of studentized residuals versus unstandardized predicted values. There was no evidence of multicollinearity, as assessed by VIF values less than 10. The assumption of normality was met, as assessed by a Q-Q Plot. The multiple regression model suggests that there is no statistically significant difference for all variables since all of their *p* values (Sig. in the table) are greater than 0.05. The regression coefficients table is presented below (Table 20), and all other above-mentioned figures/tables can be found in Appendix B.

Table 20: Multiple Regression Coefficients Table for Independent Variables

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
3	(Constant)	2.831	.349		8.101	.000
	Gender	.097	.068	.096	1.417	.158
	Education Level	-.094	.134	-.097	-.703	.483
	Campus	.112	.095	.094	1.173	.242
	Study/Control Group	.214	.063	.229	3.378	.001
	Suburban	-.045	.093	-.047	-.488	.626
	Urban	-.063	.106	-.058	-.591	.555
	18-19	-.023	.178	-.016	-.130	.897
	20-21	-.124	.157	-.102	-.790	.430
	22-24	.001	.087	.001	.010	.992

a. Dependent Variable: Green Infrastructure

To determine if different academic majors have a significant difference with regard to students' ratings, a separate multiple regression analysis was conducted. Participants' academic majors were combined from the two data sets and 3 majors with the highest participants numbers were selected and their data were used in the analysis. The multiple regression model suggests that there is no statistically significant difference for different academic majors since their *p* value (Sig. in Table 21) is greater than 0.05.

Table 21: Multiple Regression Coefficients Table for Academic Major

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	4.111	1.511		2.720	.018
	Control/Study Group	.179	.227	.195	.792	.443
	Gender	.097	.415	.102	.234	.819
	education	-.622	.658	-.634	-.945	.362
	campus living	.290	.303	.270	.958	.356
	Biology	-.647	.347	-.659	-1.866	.085
	CS	-.204	.430	-.200	-.476	.642
	Urban	-.563	.504	-.552	-1.117	.284
	SubUrban	-.260	.511	-.264	-.508	.620
	18-19	-.691	.767	-.296	-.901	.384
	20-21	-.388	.636	-.361	-.609	.553
	22-24	-.323	.330	-.282	-.978	.346

a. Dependent Variable: GI Rating

Discussion

The findings of this thesis are contradictive to studies conducted by Saksa (2011), Zheng (2011), Ewert and Baker(2001) and Zhang(2013) studies in that: students' aesthetic perception of the landscape's appeal did significantly improve in this thesis, whereas in Saksa's study students' perception did not improve after an educational campaign; no significant difference was found between students from different academic majors and education levels in this thesis, while Zheng's study indicated significant differences in preference among students from four different majors and different education levels; Zhang's study found that educational background influences the acceptance of the aesthetic look of stormwater treatment areas while this thesis found educational background had no influence on aesthetic rating; and Ewert and

Baker (2001) found significant differences in the variables of academic major, gender and age, while this thesis did not.

This thesis did not support studies from Kaplan (1990) and Daniel (1990) finding that familiarity affects perception and has a positive effect on preference. The reason for this difference might be that there is no clear boundary between urban, suburban, and rural environments or these categories/terms are too vague for students to understand and choose. Students who live in the Athens area may consider themselves to live in urban or rural environments based on their understanding of these terms. The hypothesis that familiarity of campus setting can create a significant difference in student's ratings was not validated in this thesis, which might suggest that living on or off-campus does not significantly impact one's familiarity with the campus in general. The question could be rewritten as: "How many hours do you spend outdoor on the UGA campus each week?" or "How often do you use the UGA campus landscape?" This thesis adds support to Rosenberger's 2012 study showing that sustainable landscape is acceptable in an academic campus and that landscapes containing sustainable stormwater practices are considered attractive by students in academic campuses. Students from the social work major have higher scores than computer science and biology majors, this is probably because each academic major is corresponding to some specific knowledge and this knowledge acted as a variable in the preference-shaping process.

Comparing the overall GI average score between study and control group, it increased from 3.25 for the control group to 3.47 for the study group. The difference between the two average scores is relatively small and they both fall under the somewhat attractive range (3-4). This suggests that the overall visual perception of student did not improve greatly. This might have resulted from the method used in this thesis to educate student. A list of descriptive bullet points highlighting the environmental benefits of GI from an ecological perspective might not be the best way to educate or inspire students. Students from majors that do not address environmental issues often may not comprehend the provided information completely. This can impede the educational information being conveyed. As a landscape architect student, knowing how to use design to educate people effectively about the ecological benefit of our surrounding sustainable landscapes is important. One method to improve the approach to education is to add an explanatory diagram next to the landscape image to help students understand the hydrological process and what is occurring in different scenes. Since this study only focused on the environmental aspect of GI, future studies can also incorporate other aspects such as economic information.

Pervious pavement images received lower scores among the GI practices and it was considered unattractive. Compared to other GI treatment images, there is very little vegetation in the pervious pavement images. This might have directly influenced students' perception. Ulrich (1986) found that liking for urban scenes usually increases when trees and other vegetation are present. This might explain why pervious pavement were consider unattractive among GI practices. As landscape architects, when placing pervious pavements, it would be wise to combine pervious pavement with other attractive GI treatment to provide a more aesthetically pleasing solution.

The Site F rain garden photo was taken in the early Summer, exhibiting low shrubs with a clear edge. The Site E rain garden in front of the Lamar Dodd Art School has the lowest average score, 3.14. This photo was taken at the same location as that of the Site F rain garden photo, but in a different season and from a different angle. Although the average scores of Site E and Site F (3.14 versus 4.13) differ, the photos were taken at the same location planted with shrubs having a well-defined edge, and the major difference between them is the season. The photo taken in the summer has a higher score compared to the photo taken in the winter. Therefore, this suggests that seasonality does appear to play a role in impacting people's perception of GI practices. Although the average scores of Site K and Site L (3.41 vs 4.13) differ, photos of both were taken in spring, and were without a clear boundary, and the difference between them is vegetation type. Rain gardens with only grass have a higher score compared to those with only shrubs.

Table 22: Average Rain Garden Scores

Rain Garden	**Defined Shape**	**Season**	**Vegetation Type**	**Average Score**
A Lamar Dodd Art school	Y	Fall	Missing	3.89
E Lamar Dodd Art school	Y	Winter	Shrub	3.14
F Lamar Dodd Art school	Y	Summer	Shrub	4.13
J Tate Center Parking Deck	Y	Spring	Grass, Shrub	3.72
K Myers Community	N	Spring	Shrub	3.41
L Lumpkin Wood	N	Spring	Grass	4.13

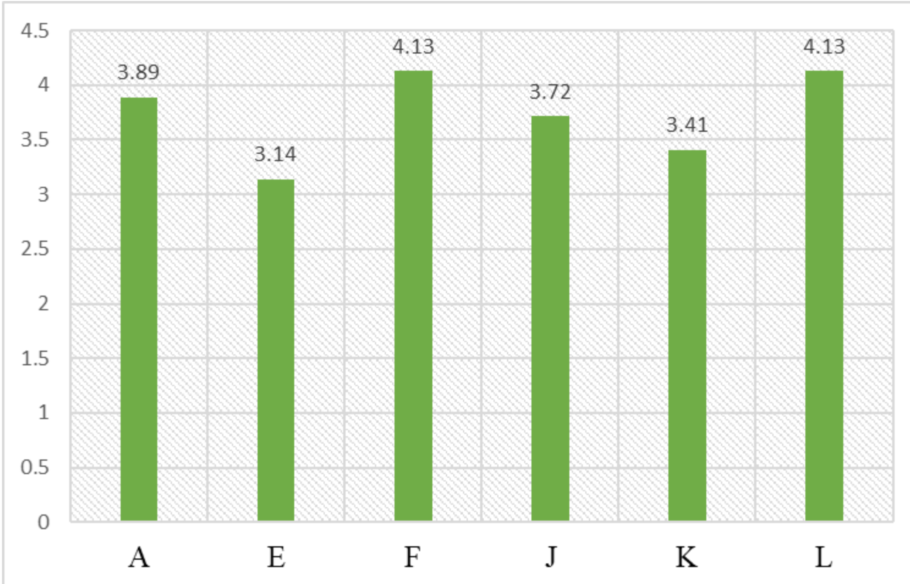

Figure 57: Average Rain Garden Scores

A comment received from of the participants states, “I think the time of day matters in the taking of the photos as well as the season. A sunny spring day on campus can make any space pretty even the non-attractive ones.” This is in accord with the survey data trend and our assumption that weather influences the overall attractiveness of the practices. Another comment states, “I chose images based on how much green I saw, I think.” This comment, again, suggests that seasonality impacts students’ perception of those landscapes because in warm seasons green is the dominate color, and in cool seasons there is less green.

Potential Limitations

Based on observation and comments from participants, each survey image differs in terms of lighting conditions, weather, composition, color, etc. All of these factors can influence how the landscape looks. Since the result from this thesis has shown that season and weather condition did influence students’ perception for GI. To avoid skewed results, future studies can take photos of GI under the same weather conditions and in the same seasons to eliminate these factors. However, it is difficult to maintain continuity in color photo with regard to color, texture, and lighting. Color as a psychological influence on preference was also a concern in other studies; thus, some research adopts black and white photography only (Rosenberger 2012). Therefore, other possible solutions would be use black and white images to eliminate different lighting, color conditions and provide a uniform image quality.

As mentioned in chapter 2, predictors such as mystery and coherence were found to influence people's preference for landscapes. In this thesis, some of the survey images clearly demonstrate these predictors. For example, site A contents evoke the feeling of mystery and site H conveys the idea of coherence. Both sites received relatively high scores among the 13 survey images. Whereas in some other images, no predictor was clearly presented. This might have influenced students' judgement. Future studies can improve on this by incorporating the predictors into the survey images to compare whether it is education or predictors that are influencing the visual perception of students. In addition, future studies can also try to use a similar composition for all survey images to eliminate the potential effect of these predictor.

Another problem that potentially influenced the result was the inability to control the environment where respondents viewed these images. The survey location might have produced different effects on respondents. For example, a comfortable and quiet place is likely to make participants feel pleasant and induce them to give better scores. It is difficult to conclude whether ratings were affected by respondents' surveying environments.

This research adopted the VPS technique, which included selecting survey images. The representative survey images were chosen from sample images of selected GI sites taken by the author. Both the site selection and sample images selection processes can potentially increase threats to Internal Validity(IV) because bias might have been present when selecting the sites or survey images. This study aimed to measure the visual pleasantness of each GI landscape. However, images have many elements in addition to the GI practices, such as vehicles, people, and buildings, that could affect people's perception.

This study acknowledges the IV threat of scene selection bias, but both the study group and the control group were tested with the same set of images. Therefore, the comparison of data from both group should produce valid result. As mentioned previously, this study avoids sample selection bias by using a randomized sample of student email addresses from the Registrar's Office at the University of Georgia.

As mentioned earlier, color photos are difficult to equalize in terms of color continuity. Even though the literature demonstrates that using color photographs as surrogates for landscapes is valid, it would be beneficial for a future study to split surveys between one group receiving color images and another group receiving black and white images.

CHAPTER 7

CONCLUSION

Summary of Findings

The results from this study indicate that GI practices on the UGA campus received overall positive aesthetic scores from students. Ten out of thirteen landscape images containing GI photos were considered attractive. Rain Gardens received the highest average score among these practices, followed by cisterns, vegetated roofs and pervious pavements. Within rain gardens, due to the variation in the appearance of vegetation related to seasonal changes and vegetation types, some differences in perceptions of landscape preference were produced. Photos taken in the summer and of grass as the main vegetation in rain gardens received higher scores. The results from statistically comparing the study and the control group ratings indicate that additional education information does alter students' perception and it is positively related. Statistically significant difference was found by using the Mann Whitney U Test comparing the study and the control group, and the results support the hypothesis that educational information improves student's perception of GI practices on campus.

The multiple regression analysis suggests the hypothesis that gender influences preference pattern is not valid statistically. Also, there was no statistically significant difference found between undergraduate and graduate students. The hypothesis that graduate students will have no significantly different ratings compared to undergraduate students is valid in this study. The statistical analysis showed that there was no significant difference between the landscape ratings given by students living on or off campus. The hypothesis that participants' familiarity with the campus landscape setting will not create significant differences in their visual ratings is valid in this thesis. The results failed to support the hypothesis that participants claiming to be most familiar with urban environments will give higher ratings for the landscape images.

Implications

Environmental education is proved to be effective for improving students' visual perception of campus GI practices in this thesis. Therefore, how to better educate college student through campus practices is important for Universities to consider. Universities as institutes of higher education have the responsibility and opportunity to educate students in environmental knowledge and to cultivate their cultural values to appreciate sustainable/ecological landscapes before they assume their places in the society. Intentional dissemination of environmental knowledge to shape young adult values can suffuse and influence future society development in the long run. Through the campus GI practice inventory process, this thesis found that University of Georgia has not done a great job in effectively educating their students about campus GI practices. Some common ways universities could adopt to educate students about GI includes supplying educational material, hosting educational activities, and placing educational signage on campus. Beyond all these, we as landscape architects, have many exciting ways to explore educating the public. Design has always been our strongest and most powerful tool to convey our ideas and values. Design can incorporate the concept that a well-designed stormwater management facility in itself possesses educational opportunity. One innovative book named *Artful Rainwater Design* focused on promoting GI practices as urban amenities which can offer other benefits in addition to their stormwater management function (Wilasinee 2017). According to Echols and Pennypacker (2015), “Innovative rainwater design can be used to create places recognized as beautiful, meaningful, and educational—from lush rain gardens to plazas that artfully expose how rain water flows across and infiltrates into land.” In short, this emerging idea suggests stormwater facilities can be designed in a way that engages and educates the public. To achieve this educational goal, making the stormwater management features visible and legible in the landscape so people notice them is the keystone (Echols and Pennypacker 2015). Echols and Pennypacker conducted extensive analysis of case studies and identified two basic ways to learn: one way is to provide simple signage or exhibits; another way is to design the treatment system in such a way as to enable public engagement through educational games or activities (Echols and Pennypacker 2015). Other techniques that can be used in design include but are not limited to

1. Making stormwater trials visible and legible;
2. Creating stormwater narratives;
3. Making the stormwater system playful, intriguing or puzzling;
4. Providing a variety of visible plant types and communities;
5. Creating a variety of spaces for groups to explore, gather, or sit near the stormwater treatment system.

In their case studies, many of the stormwater treatment systems have intentionally provided learning opportunities for people with the aim of enhancing public knowledge of stormwater management. However, the efficacy of these design techniques in terms of encouraging stormwater education through the experience of landscapes still remains unknown.

Another powerful tool that could be possibly applied in campus settings to educate the community is the idea of eco-revelatory design. Eco-revelatory design is defined as “design that reveals and interprets ecological phenomena, process and relationships" (Eco-Revelatory Design Proposal 1998). Eco-revelatory design focuses on using design and management strategies to convey the ecological benefit beyond the actual boundaries of the site. It is about influencing the way people think about and care about their relationship to their environment (Liverman 2007).

Future research should explore better ways to educate students and to test the effectiveness of different educational methods in order to expand the idea of education influence upon perception. This study compared student age with a very small breakdown interval; future studies should adjust the age break down and include faculty to see if a larger age interval can produce a significant preference pattern. Future studies should also improve upon the method for testing the relationship of familiar environments on preference patterns. Only three academic majors were selected and tested in this thesis, future studies should intentionally select and compare participants from ecologically focused majors and anthropocentrically focused majors.

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APPENDIX A: SURVEY SLIDES

Section 1

UGA Campus Landscape Survey- Control Group

This survey is conducted by Yuwen Yang, a graduate student from the College of Environment and Design under the direction of Professor Ronald Sawhill at The University of Georgia. I invite you to participate in a research study entitled *Assessing Public Perception of Landscape Spaces: Using the University of Georgia Campus as An Example.* This survey is intended to discover your aesthetic preference for different UGA campus landscapes.

Your participation will involve filling out the basic background information at the beginning, then rating a series of landscape images, and adding comments or any suggestions at the end of the survey. The survey should only take approximately 5-10 minutes to complete. In order to make the study valid, part of the survey is not completely disclosed here. Your involvement in the study is voluntary, and you may choose not to participate or to stop at any time without penalty. Participation is not required to be able to enter the drawing for a 25$ gift card. If you do not want to participate but still want to enter the drawing, please go to the end of the survey and click submit.

Your participation will be confidential and no personal information will be collected. Only the research team will have access to the data, and data will not be exposed to others. The result of the research study maybe published, but your name or any identifying information will not be used. In fact, the published result will be presented in summary form only.

The findings from this project may provide information to better understand public perception of landscape spaces in academic settings. There are no known risks or anticipated discomfort associated with this research.

If you have any questions about this research project, please feel free to call me at (706)206-0552 or send an email to yyy81810@uga.edu. Questions or concerns about your rights as a research participant should be directed to the Human Subjects Office at 212 Tucker Hall, 310 E. Campus Rd. Athens, GA 30602; telephone 706-542-5318; email address irb@uga.edu.

By clicking YES, you are agreeing to participate in the above described research project.

Section 2

3. Gender
    - Female
    - Male
    - Transgender
    - Prefer not to respond

4. Age
    - Under 18
    - 18-19
    - 20-21
    - 22-24
    - 25 and above

5. Academic Major: ___________________

6. Education Level
    - Freshman
    - Sophomore
    - Junior
    - Senior
    - Graduate student
    - Professional student

7. Do you live on-campus or off-campus?
    - On campus
    - Off campus

8. Which of the following environments do you consider yourself most accustomed to?
    - Urban
    - Suburban
    - Rural

Section 3

Please view the following images and try to imagine them as if you are in these scenes. Please rate each landscape images based on their **VISUAL PLEASING LEVEL**. There are no right or wrong answers since preference is subjective, and everyone’s opinion is appreciated.

Site A

Location: This photo was taken near the Lamar Dodd Art school.

1. Please rate this landscape base on the following visual preference scale:
   - Very Attractive
   - Somewhat Attractive
   - Neutral
   - Somewhat Unattractive
   - Very Unattractive

Site B

Location: This photo was taken near the Jackson Street Building.

2. Please rate this landscape base on the following visual preference scale:
    - Very Attractive
    - Somewhat Attractive
    - Neutral
    - Somewhat Unattractive
    - Very Unattractive

Site C

Location: This photo was taken at roof top of the Geology Building.

3. Please rate this landscape base on the following visual preference scale:
   - Very Attractive
   - Somewhat Attractive
   - Neutral
   - Somewhat Unattractive
   - Very Unattractive

Site D

Location: This photo was taken at the Special Collections Library.

4. Please rate this landscape base on the following visual preference scale:
   - Very Attractive
   - Somewhat Attractive
   - Neutral
   - Somewhat Unattractive
   - Very Unattractive

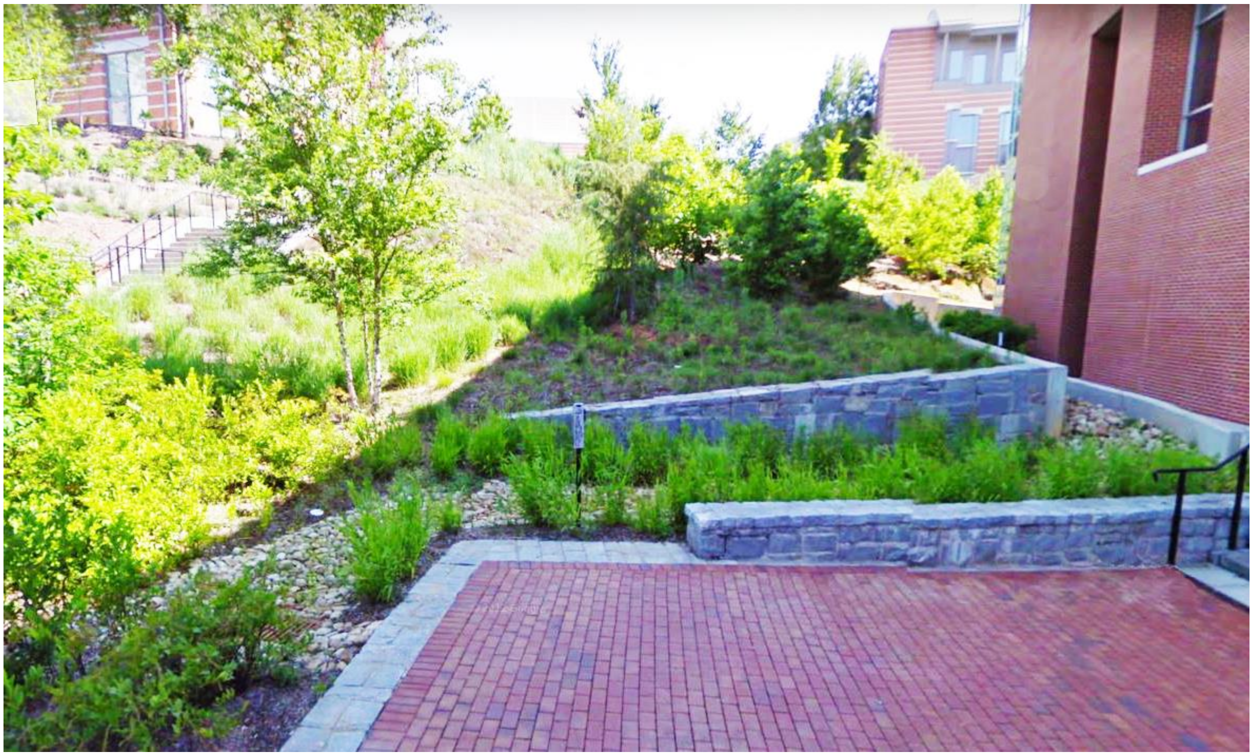
Site E

Location: This photo was taken near the Lamar Dodd Art school.

5. Please rate this landscape base on the following visual preference scale:
   - Very Attractive
   - Somewhat Attractive
   - Neutral
   - Somewhat Unattractive
   - Very Unattractive

Site F

Location: This photo was taken near the Lamar Dodd Art school.



6. Please rate this landscape base on the following visual preference scale:
    - Very Attractive
    - Somewhat Attractive
    - Neutral
    - Somewhat Unattractive
    - Very Unattractive

Site G

Location: This photo was taken at the Myers Community Parking Lot.

7. Please rate this landscape base on the following visual preference scale:
   - o Very Attractive
   - o Somewhat Attractive
   - o Neutral
   - o Somewhat Unattractive
   - o Very Unattractive

Site H

Location: This photo was taken at the West Lawn near the Tate Center.

8. Please rate this landscape base on the following visual preference scale:
    - Very Attractive
    - Somewhat Attractive
    - Neutral
    - Somewhat Unattractive
    - Very Unattractive

Site I

Location: This photo was taken at the Jackson Street Building

9. Please rate this landscape base on the following visual preference scale:
    - Very Attractive
    - Somewhat Attractive
    - Neutral
    - Somewhat Unattractive
    - Very Unattractive

Site J

Location: This photo was taken at the Tate Center parking deck.

10. Please rate this landscape base on the following visual preference scale:
    - o Very Attractive
    - o Somewhat Attractive
    - o Neutral
    - o Somewhat Unattractive
    - o Very Unattractive

Site K

Location: This photo was taken at the Myers Community.

11. Please rate this landscape base on the following visual preference scale:
    - Very Attractive
    - Somewhat Attractive
    - Neutral
    - Somewhat Unattractive
    - Very Unattractive

Site L

Location: This photo was taken at Lumpkin Woods.

12. Please rate this landscape base on the following visual preference scale:
    - Very Attractive
    - Somewhat Attractive
    - Neutral
    - Somewhat Unattractive
    - Very Unattractive

Site M

Location: This photo was taken near Denmark Hall

13. Please rate this landscape base on the following visual preference scale:
    - Very Attractive
    - Somewhat Attractive
    - Neutral
    - Somewhat Unattractive
    - Very Unattractive

Section 4

Thank you again for participating this survey!

If you have any comments or questions, please write in the following blank.

UGA Campus Landscape Survey - Study Group

Section 1

UGA Campus Landscape Survey

This survey is conducted by Yuwen Yang, a graduate student from the College of Environment and Design under the direction of Professor Ronald Sawhill at The University of Georgia. I invite you to participate in a research study entitled *Assessing Public Perception of Landscape Spaces: Using the University of Georgia Campus as An Example.* This survey is intended to discover your aesthetic preference for different UGA campus landscapes.

Your participation will involve filling out the basic background information at the beginning, then rating a series of landscape images, and adding comments or any suggestions at the end of the survey. The survey should only take approximately 5-10 minutes to complete. In order to make the study valid, part of the survey is not completely disclosed here. Your involvement in the study is voluntary, and you may choose not to participate or to stop at any time without penalty. Participation is not required to be able to enter the drawing for a 25$ gift card. If you do not want to participate but still want to enter the drawing, please go to the end of the survey and click submit.

Your participation will be confidential and no personal information will be collected. Only the research team will have access to the data, and data will not be exposed to others. The result of the research study maybe published, but your name or any identifying information will not be used. In fact, the published result will be presented in summary form only.

The findings from this project may provide information to better understand public perception of landscape spaces in academic settings. There are no known risks or anticipated discomfort associated with this research.

If you have any questions about this research project, please feel free to call me at (706)206-0552 or send an email to yyy81810@uga.edu. Questions or concerns about your rights as a research participant should be directed to the Human Subjects Office at 212 Tucker Hall, 310 E. Campus Rd. Athens, GA 30602; telephone 706-542-5318; email address irb@uga.edu.

By clicking YES, you are agreeing to participate in the above described research project.

Section 2

9. Gender
    - Female
    - Male
    - Transgender
    - Prefer not to respond

10. Age
    - Under 18
    - 18-19
    - 20-21
    - 22-24
    - 25 and above

11. Academic Major: ___________________

12. Education Level
    - Freshman
    - Sophomore
    - Junior
    - Senior
    - Graduate student
    - Professional student

13. Do you live on-campus or off-campus?
    - On campus
    - Off campus

14. Which of the following environments do you consider yourself most accustomed to?
    - Urban
    - Suburban
    - Rural

Section 3

Please read the text and view the following images and try to imagine them as if you are in these scenes. Please rate each landscape images based on their **VISUAL PLEASING LEVEL**. There are no right or wrong answers since preference is subjective, and everyone's opinion is appreciated.

Site A

Location: This photo was taken near the Lamar Dodd Art school.

This landscape contains a series of **Rain Gardens** designed to

- Infiltrate rainwater/reduce runoff
- Slow runoff rate
- Clean rainwater
- Improve stream health
- Recharge groundwater

1. Please rate this landscape base on the following visual preference scale:
   - Very Attractive
   - Somewhat Attractive
   - Neutral
   - Somewhat Unattractive
   - Very Unattractive

Site B

Location: This photo was taken near the Jackson Street Building.

This landscape contains **Pervious Pavement** designed to

- Reduce or eliminate stormwater runoff
- Filter out pollutants, purifying runoff
- Protect streams and groundwater

2. Please rate this landscape base on the following visual preference scale:
   - Very Attractive
   - Somewhat Attractive
   - Neutral
   - Somewhat Unattractive
   - Very Unattractive

Site C

Location: This photo was taken at the roof top of the Geology Building.

This landscape contains a **Vegetated Roof** designed to

- Retain rainwater in the plants and growing medium
- Slow runoff rate
- Reduce the amount of storm water
- Improve air quality
- Reduce urban heat island effect

3. Please rate this landscape base on the following visual preference scale:
    - Very Attractive
    - Somewhat Attractive
    - Neutral
    - Somewhat Unattractive
    - Very Unattractive

Site D

Location: This photo was taken at the Special Collections Library.

This landscape contains a **Rainwater Harvesting Cistern** below the lawn that is designed to

- Collect and store rainfall for later use (flush toilet, irrigation, etc.)
- Conserve water
- Slow and reduce runoff

4. Please rate this landscape base on the following visual preference scale:
    - Very Attractive
    - Somewhat Attractive
    - Neutral
    - Somewhat Unattractive
    - Very Unattractive

Site E

Location: This photo was taken near the Lamar Dodd Art school.

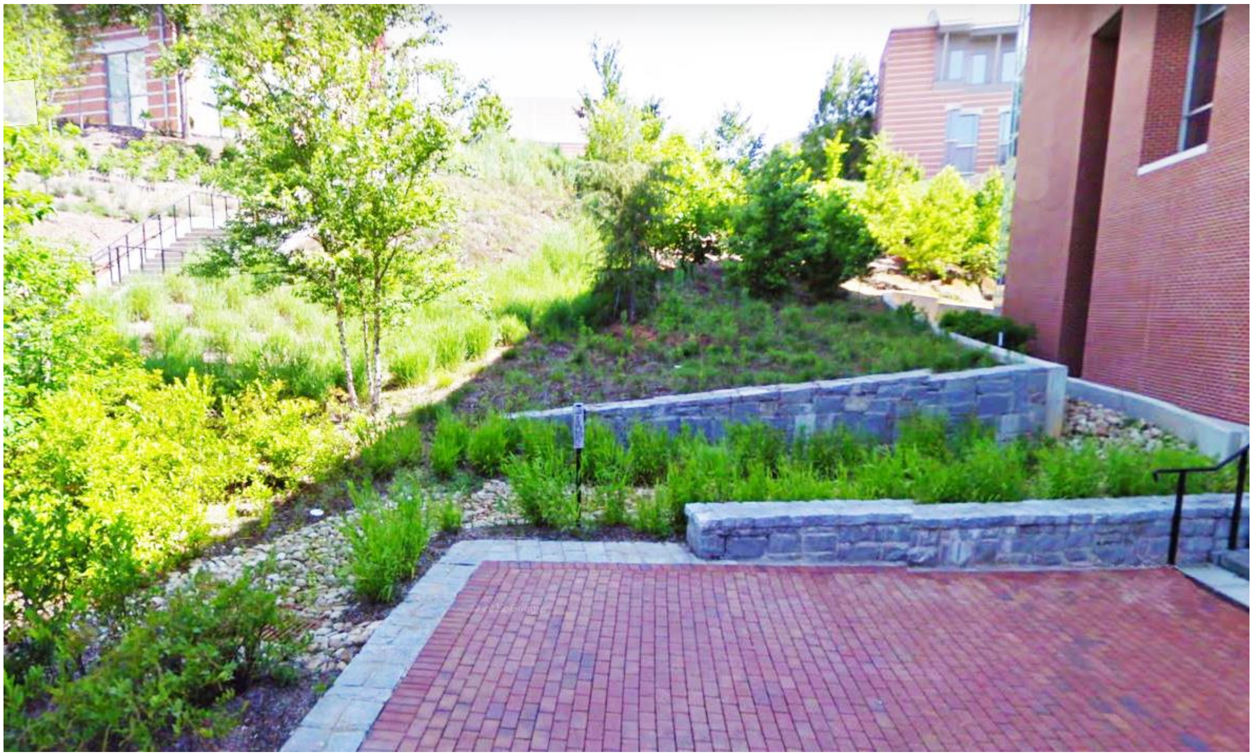
This landscape contains a **Rain Garden** designed to

- Infiltrate rainwater/reduce runoff
- Slow runoff rate
- Clean rainwater
- Improve stream health
- Recharge groundwater

5. Please rate this landscape base on the following visual preference scale:
   - Very Attractive
   - Somewhat Attractive
   - Neutral
   - Somewhat Unattractive
   - Very Unattractive

Site F

Location: This photo was taken near the Lamar Dodd Art school.



This landscape contains a **Rain Garden** designed to

- Infiltrate rainwater/reduce runoff
- Slow runoff rate
- Clean rainwater
- Improve stream health
- Recharge groundwater

6. Please rate this landscape base on the following visual preference scale:
    - Very Attractive
    - Somewhat Attractive
    - Neutral
    - Somewhat Unattractive
    - Very Unattractive

Site G

Location: This photo was taken at the Myers Community Parking Lot.

This landscape contains a **Pervious Pavement** designed to

- Reduce or eliminate stormwater runoff
- Filter out pollutants, purifying runoff
- Protect streams and groundwater

7. Please rate this landscape base on the following visual preference scale:
    - Very Attractive
    - Somewhat Attractive
    - Neutral
    - Somewhat Unattractive
    - Very Unattractive

Site H

Location: This photo was taken at the West Lawn near the Tate Center.

This landscape contains a **Vegetated Roof** designed to

- Retain rainwater in the plants and growing medium
- Slow runoff rate
- Reduce the amount of storm water
- Improve air quality
- Reduce urban heat island effect

8. Please rate this landscape base on the following visual preference scale:
   - o Very Attractive
   - o Somewhat Attractive
   - o Neutral
   - o Somewhat Unattractive
   - o Very Unattractive

Site I

Location: This photo was taken at the Jackson Street Building

This landscape contains a **Rainwater Harvesting Cistern** designed to

- Collect and store rainfall for later use (flush toilet, irrigation, etc.)
- Conserve water
- Slow and reduce runoff

9. Please rate this landscape base on the following visual preference scale:
    - Very Attractive
    - Somewhat Attractive
    - Neutral
    - Somewhat Unattractive
    - Very Unattractive

Site J

Location: This photo was taken at the Tate Center parking deck.

This landscape contains a **Rain Garden** designed to

- Infiltrate rainwater/reduce runoff
- Slow runoff rate
- Clean rainwater
- Improve stream health
- Recharge groundwater

10. Please rate this landscape base on the following visual preference scale:
    - o Very Attractive
    - o Somewhat Attractive
    - o Neutral
    - o Somewhat Unattractive
    - o Very Unattractive

Site K

Location: This photo was taken at the Myers Community.

This landscape contains a **Rain Garden** designed to

- Infiltrate rainwater/reduce runoff
- Slow runoff rate
- Clean rainwater
- Improve stream health
- Recharge groundwater

11. Please rate this landscape base on the following visual preference scale:
    - Very Attractive
    - Somewhat Attractive
    - Neutral
    - Somewhat Unattractive
    - Very Unattractive

Site L

Location: This photo was taken at Lumpkin Woods.

This landscape contains a **Rain Garden** designed to

- Infiltrate rainwater/reduce runoff
- Slow runoff rate
- Clean rainwater
- Improve stream health
- Recharge groundwater

12. Please rate this landscape base on the following visual preference scale:
    - Very Attractive
    - Somewhat Attractive
    - Neutral
    - Somewhat Unattractive
    - Very Unattractive

Site M

Location: This photo was taken near Denmark Hall

This landscape contains **Pervious Pavement** and a **Disconnected Downspout** designed to

- Reduce or eliminate stormwater runoff
- Decrease runoff peak rate
- Filter out pollutants, purifying runoff
- Improve water quality
- Protect streams and groundwater

13. Please rate this landscape base on the following visual preference scale:
    - Very Attractive
    - Somewhat Attractive
    - Neutral
    - Somewhat Unattractive
    - Very Unattractive

Section 4

Thank you again for participating this survey!

If you have any comments or questions, please write in the following blank.

UGA Campus Landscape Survey-Debriefing Form

Thank you for your participation in this research study. For this study, it was important that I withhold some information from you about some aspects of the study. Now that your participation is completed, I will describe the withheld to you, why it was important, answer any of your questions, and provide you with the opportunity to decide on whether you would like to have your data included in this study.

What you should know about this study

(1) This study is about assessing your aesthetic preference of green infrastructure practices on UGA campus. This study trying to discover the effect educational information on your aesthetic preference of green infrastructure.

(2) This information is not provided because this study wants to discover what you think about a campus landscape's beauty without causing to presuppose I am evaluating and teaching you about green infrastructure.

Right to withdraw data

You may choose to withdraw the data you provided prior to debriefing, without penalty or loss of benefits to which you are otherwise entitled. Please click No below if you do not give permission to have your data included in the study:

If you have questions

The main researcher conducting this study is Ranold Sawhill, a Professor from College of Environment and Design and Yuwen Yang, a graduate student at the University of Georgia. If you have questions later, you may contact Yuwen Yang at yyy81810@uga.edu or at (706)-2060552. If you have any questions or concerns regarding your rights as a research participant in this study, you may contact the Institutional Review Board (IRB) Chairperson at 706.542.5318 or irb@uga.edu.

Click Yes below indicates that you have been debriefed and have had all your questions answered.

Appendix B: Survey Data

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.278[a]	.077	.038	.4600542468	1.930

a. Predictors: (Constant), Study/Control Group, Education Level, 22-24, Suburban, Gender, Campus, 18-19, Urban, 20-21

b. Dependent Variable: Green Infrastructure

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.786	9	.421	1.987	.042[b]
	Residual	45.081	213	.212		
	Total	48.867	222			

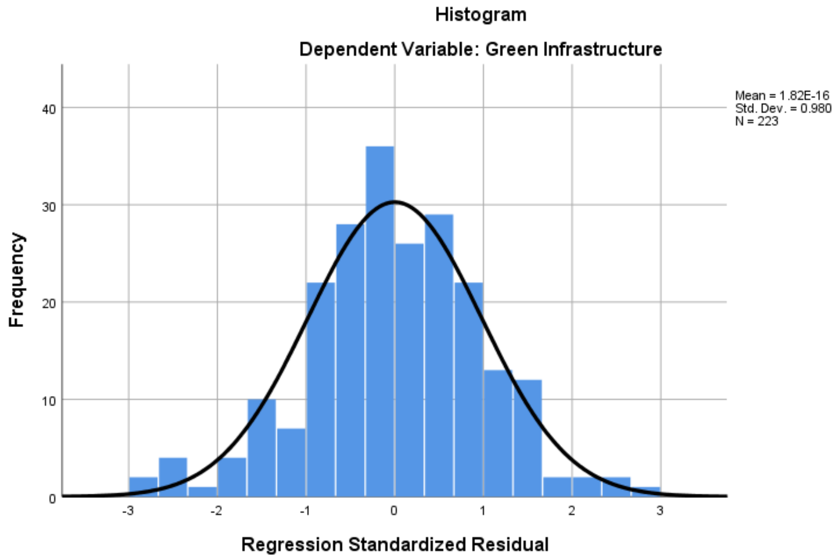
a. Dependent Variable: Green Infrastructure

b. Predictors: (Constant), Study/Control Group, Education Level, 22-24, Suburban, Gender, Campus, 18-19, Urban, 20-21

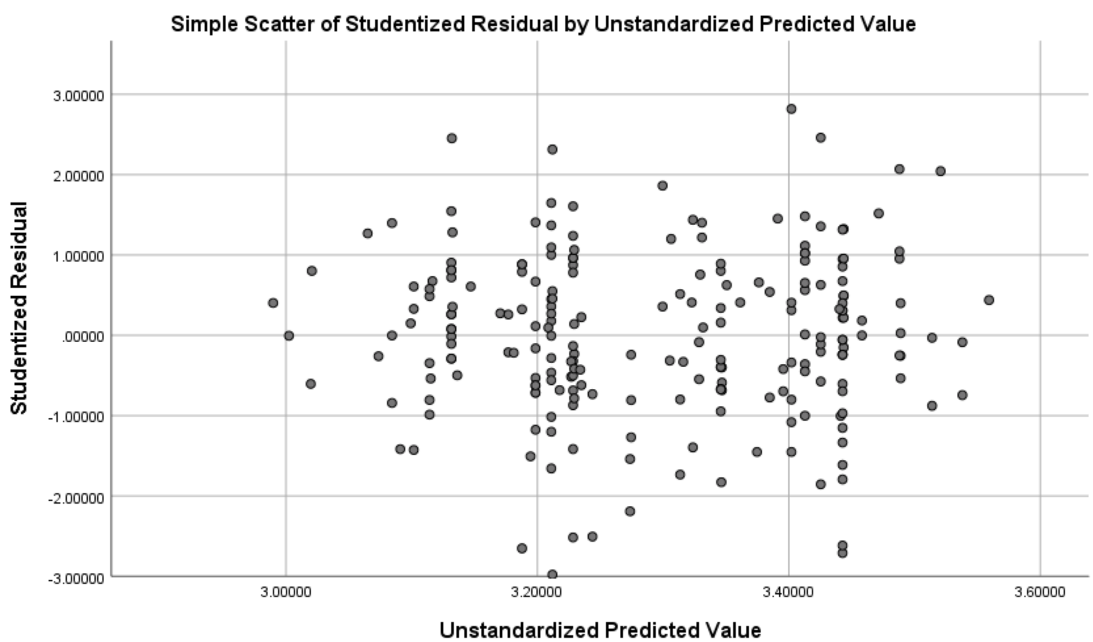
Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	2.831	.349		8.101	.000	2.142	3.520					
	Urban	-.063	.106	-.058	-.591	.555	-.271	.146	-.059	-.040	-.039	.450	2.221
	Suburban	-.045	.093	-.047	-.488	.626	-.228	.138	.021	-.033	-.032	.464	2.157
	18-19	-.023	.178	-.016	-.130	.897	-.375	.329	.014	-.009	-.009	.299	3.341
	20-21	-.124	.157	-.102	-.790	.430	-.434	.186	-.026	-.054	-.052	.261	3.838
	22-24	.001	.087	.001	.010	.992	-.171	.173	.027	.001	.001	.758	1.319
	Gender	.097	.068	.096	1.417	.158	-.038	.231	.128	.097	.093	.952	1.051
	Campus	.112	.095	.094	1.173	.242	-.076	.300	.047	.080	.077	.670	1.492
	Education Level	-.094	.134	-.097	-.703	.483	-.359	.170	-.009	-.048	-.046	.229	4.374
	Study/Control Group	.214	.063	.229	3.378	.001	.089	.339	.240	.226	.222	.943	1.060

a. Dependent Variable: Green Infrastructure



Normal Distribution



Studentized Residuals Versus Unstandardized Predicted Values (Homoscedasticity)

APPENDIX C: IRB APPROVAL

UNIVERSITY OF GEORGIA

Tucker Hall, Room 212
310 E. Campus Rd.
Athens, Georgia 30602
TEL 706-542-3199 | FAX 706-542-5638
IRB@uga.edu
http://research.uga.edu/hso/irb/

Office of Research
Institutional Review Board

EXEMPT DETERMINATION

April 17, 2018

Dear Ronald Sawhill:

On 4/17/2018, the IRB reviewed the following submission:

Type of Review:	Initial Study
Title of Study:	Assessing Public Perception of Green Infrastructure Practice in Academic Settings: Using the University of Georgia Campus as An Example
Investigator:	Ronald Sawhill
Co-Investigator	Yuwen Yang
IRB ID:	STUDY00005870
Funding:	None
Grant ID:	None
Review Category	Exempt UGA Flex Category 7

The IRB approved the protocol from 4/17/2018 to 4/16/2023.

Please close this study when it is complete.

In conducting this study, you are required to follow the requirements listed in the Investigator Manual (HRP-103).

Sincerely,

Angela Bain, CIP, CIM
University of Georgia
Human Subjects Office

Commit to Georgia | give.uga.edu
An Equal Opportunity, Affirmative Action, Veteran, Disability Institution