EVALUATING VISUAL PREFERENCE OF A BIOSWALE IN AN URBAN SETTING

by

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(Under the Direction of JON CALABRIA)

ABSTRACT

Green Infrastructure (GI) is increasingly adopted across many landscapes; however, barriers to its implementation and acceptance still exists such as visual appearance. This thesis explores visual preferences of bioswales, one of the components of GI. Respondents participated in a web-based survey using a Choice Based Conjoint (CBC) method to indicate their preferred bioswale design with attributes such as material use, check dams, and vegetation types. Based on the Hierarchical Bayesian (HB) analysis, the results suggest that mulch and gravel materials, and high diversity and high and medium density for vegetation types hold significant preferences ($p<0.01$). While preferences vary with individuals, results from this thesis may provide guidance for better design and management of bioswales to improve appreciation of the designed landscape. Further research is needed to determine if the finding is consistent with a large sample group and across other regions.

KEYWORDS: Bioswale, Choice Based Conjoint (CBC) Analysis, Green Infrastructure (GI), Landscape Architecture, Visual Aesthetics, Visual Preference Survey

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DEDICATION

I would like to dedicate this thesis to my husband, Suraj Shrestha and my family, especially my mom, dad, and my sister, for their unconditional support and motivation to complete this thesis. And to my dear friend, Adedamola, for never giving up on the idea of doing it by summer!

To all who believe it is possible to make the world cleaner, greener, and a better place through this profession.

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CHAPTER 1

INTRODUCTION

During the fall of 2019 and spring of 2020, I observed some green infrastructure (GI) on campus that promotes sustainable stormwater management, such as permeable pavements, rainwater harvesting, green roof, bioswales, rain gardens, and bioretention areas. Some of them were not functioning as intended because of sediments filling up such systems. Though green stormwater infrastructure has been designed and installed in various parts of the campus, it seems that it is not maintained well to promote campus sustainability efforts. This may be because of the lack of proper information about GI and the perception people have towards such infrastructures. Studies show that lack of proper information on GI and its aesthetics are some of the reasons that hinder implementation and maintenance of GI (Clean Water America Alliance [CWAA] 2011; Dunn 2010; Nir 2017; Everett et al. 2016; Rainer 2017).

However, perception differs according to people; therefore, it is essential to know where people's preferences lie. With an understanding of these preferences, designers may be able to achieve what they intend to through clear and concise design. If not designed according to their preferences, people do not seem to pay much attention, and the landscape seems to be neglected. People tend to value less what they are not familiar with and what they do not like (Drobney 1994). Therefore, in the case of green infrastructure, too, it is essential to establish GI attributes that people prefer before implementing GI and plan for its long-term performance and management beforehand to preserve its intended value.

Objectives

In the last few decades, much research on landscape design and perception has been done based on various professionals' perspectives towards the design of landscape and layman's perspectives towards visual aesthetics of landscape (Junge et al. 2011; Hwang et al. 2017). Similarly, since the 2000s, many researchers have focused on the visual preferences of GI and raising awareness, but there is limited research on the design of GI in terms of preferences of various socio-demographic groups. We need to understand which elements of landscape design would increase awareness and willingness to implement and manage the landscape for its long-term performance and resilience. This thesis is a first step towards understanding design characteristics that guide people's preferences for better design and management. It explores whether general knowledge of GI and bioswales influences people's preferences and perceptions about these sustainable stormwater management practices. Hence, further research is needed if certain design interventions will motivate people to acknowledge the landscape or improve their willingness to implement GI and ensure proper management for a resilient GI.

Overview

The profession of landscape architecture is ever evolving. A rise in the acknowledgment of environmental justice and the benefits of nature has led to changes in the way land is being developed. Designing a landscape is not enough; it has yet become another role for professionals in this field to help convey information to people about the green strategies used for environmental and human health through design. Although GI is a relatively new term, the concept of integrating green spaces with the built environment, especially in an urban context, can be traced back to the 19th century (Newell et al. 2013). With the examples of New York's Central Park and Boston's Emerald Necklace, the works of landscape architect Frederick Law

Olmsted included green spaces as an integral part of urban design (Eisenman 2013). The Back Bay Fens in the Emerald Necklace Park system, which is a first known example of a constructed wetland for the city's sewage management, is considered as a predecessor to modern green infrastructure (Eisenman 2013; Simons 2017). Landscape architect Ian McHarg emphasized scientific facts to consider natural factors for land development while making a case for an "ecological approach to design" (McHarg 1992; Arisoy 2013). His neighborhood design for The Woodlands in Houston utilized less permeable soils for development and permeable soils as open spaces to preserve the natural hydrological processes in the sites, and it survived 100-year storms in 1970 and 1994 with less property damage than the surrounding areas (Yang and Li 2013; Simons 2017). Therefore, it can be said that sustainable design practices have been applied to land development since the mid-19th century. The term GI came into existence only after its first use in 1994 in a report to the Florida governor on "land conservation strategies," stating that the "natural systems are equally…important components of our infrastructure" (Benedict and McMahon 2002; Firehock 2010).

Revisions made to the Federal Water Pollution Control Act in 1972, then recognized as the Clean Water Act, to regulate the pollution of surface waters in the US urged designers to develop new strategies other than gray infrastructure to manage stormwater on site (U.S. EPA 2020b; Echols and Pennypacker 2015). The main objective then became to treat the first flush of rainwater through "retention, infiltration, biofiltration, or bioretention" that help remove pollutants from the rainwater, and thus controlling the quality and quantity of water flowing to nearby streams (Echols and Pennypacker 2006; 2008; 2015). Research suggests that such stormwater management systems provide many added "positive values," such as "aesthetic, biological, cultural, ecological, economic, technical, educational, environmental, historical, recreational, and public relations" (Wade and McLean 2014; Stahre 2006). Experts acknowledged that green infrastructure could provide more than stormwater management; therefore, adding amenity to its benefits, more creative designers took it a step further, transforming stormwater management into a thoughtful design feature (Echols and Pennypacker 2006; 2008; 2015).

The thoughtful design of GI may evoke acceptance and appreciation among people towards low-impact designs. It might be difficult for them to understand whether a rain garden has some hidden hydrological process, i.e., natural management of stormwater, with ecological benefits or if it is just another vegetation area that is different from the manicured lawn that people are used to. Intended design with visual aesthetics has the possibility to incite "cues to care" (Nassaeur 1988; 1995a). "Cues to care" refers to the cultural language of "perceived care of the landscape" that employs recognizable context in an unfamiliar landscape (Nassauer 1988; 1995a; 1995b). Such recognizable context may be incited by the neatness of the landscape, such as "evenness of turf…, placement of ornamental plants, use of fences and borders, and freedom from weeds or litter" (Nassauer 1988) and have the potential to be acknowledged as human intervention and care. The absence of recognizable human interventions and lack of knowledge of ecological functions among people may lead to underappreciation and under-management of the landscape (Gobster et al. 2007; Nassauer 1995a; Mozingo 1997).

Landscape architects who believed in landscape design that could reveal ecological functions to the public came together in August of 1997 to compile design works that represented such theory, and there, they coined the term "Eco-revelatory design" (Brown, Harkness, and Johnston 1998). It is defined as "a design strategy that attempts to enhance site ecosystems as well as engage users by revealing ecological and cultural phenomena, processes, and relationships affecting a site” (Arisoy 2013; Brown, Harkness, and Johnston 1998). The group worked towards organizing an exhibition with designs that could communicate such ecological and cultural processes to the broader public. They hoped to bridge the gap between the creative design language of landscape architecture and “promote ecological awareness” by making people aware of the landscape processes and its complexities as it has been referred to as “educational and enlightening” (Brown, Harkness, and Johnston 1998; Liverman 2007). Therefore, to raise awareness among people about sustainable stormwater management, it is necessary to reveal how stormwater is integrated into the landscape, where it is heading, and how sustainable practices are used for its treatment through conveyance and infiltration to the ground. Revealing natural hydrological process and stormwater management can be achieved through familiarity in the landscapes and act of human intention and care.

While information and awareness on GI are essential factors for communities to understand its importance and benefits, visual appearance can improve acceptance from the community. Inferior design standards and implementation, lack of maintenance, and inability to gain support from the community aid to the GI’s failure (Rainer 2017). Studies show that community engagement can make its implementation more effective and successful (Baptiste, Foley, and Smardon 2015; Barclay 2016; Everett et al. 2016; Shandas and Messer 2008). It has been more than four decades since the implementation of GI and more than a decade of studies on barriers to its implementation, and there are still issues on its execution and long-term management (Copeland 2016; CWAA 2011; Southwest Michigan Planning Commission [SWMPC] 2010; U.S. EPA 2016). Though few studies indicate that information on GI motivate people to adopt it for stormwater management, there is limited research on whether the knowledge will also increase its visual appreciation (Dogmusoz 2019; Everett et al. 2016;

Shandas and Messer 2008). Understanding preferences and perceptions of GI, in this case, bioswales, can help cross the barrier of visual aesthetic issues and lack of community support related to GI, especially in public spaces. The following research questions can inform professionals about people's visual preferences and if those preferences are guided by their knowledge on GI and bioswales and thus act accordingly for successful implementation of GI.

Research Questions

This study addressed the following research questions to help determine the visual preferences of bioswale design:

1. What are the characteristics of bioswale design that people visually prefer, such as the use of turf, mulch, or gravel, presence or absence of check dams, vegetation types including diversity, density, and height?
2. Does knowledge on GI and bioswale influence visual preferences?

Outcomes

There have always been barriers to the implementation of GI, which include technical, physical, legal, financial, and community barriers (CWAA 2011); however, with the growing body of literature on the health and environmental benefits of GI, stakeholders such as municipal officers, professionals, developers, and communities are willing to dedicate their resources on the implementation of GI. Even though people are crossing some of those barriers, some remain, and a couple of those are "insufficient or inaccessible information about GI and its benefits," visual appearance, and maintenance of installed GI (CWAA 2011). This study may aid in better understanding of whether certain design features for GI, in this case, bioswales, increase its acceptance across different socio-demographic groups and if knowledge about GI and bioswales influences their visual preferences. This, in turn, may guide better design and management of bioswales in the long run.

Limitations and Delimitations

This study is limited to the Athens, GA region. The use of a web-based survey and convenience sampling method for collecting responses limits the ability of this research to represent the general population. Though the study was intended to test the visual preference for bioswale design in one Choice-Based Conjoint (CBC), some restrictions did not allow that. First, the number of images to be generated for one CBC exercise, including all five attributes (characteristics) of the bioswale design, was huge. Second, some of the attributes could not be combined in one conditional relationship to generate images; for instance, Material Use could not be combined with different vegetation types because to determine their preferences, they had to be presented as standalone characteristics without using vegetation. Third, Sawtooth does not allow the use of two conditional relationships in one CBC. Therefore, two CBC studies were created in one survey that presented Material Use and Check dams design features in one CBC and vegetation types such as Vegetation Diversity, Density, and Height in another CBC. Therefore, results of the visual preferences from one CBC cannot be compared to that of another CBC. This is explained further in Chapter 3.

One of the delimitations of the study is the use of only herbaceous perennials during peak bloom time. The study did not take planting design and seasonality into consideration but did test visual preferences of Vegetation Diversity, Density, and Height. The design did vary vegetation height, groupings, or spacing of plants.

CHAPTER 2

LITERATURE REVIEW

Since last decade, there has been a growing number of studies on GI ranging from its definition and history (Beauchamp and Adamowski 2013; Firehock 2010; Thomson, Bartley, and Shipper 2008; Youngquiest 2009), its benefits (Anderson et al. 2008; Dietz and Clausen 2008; Molla 2015; Thomson, Bartley, and Shipper 2008; Yang et al. 2005) to the barriers to its implementation (Keeley et al. 2013; Barnhill and Smardon 2012). Some define it on a broader term as "a strategically planned and managed network of wilderness, parks, greenways, conservation easements…. that supports native species, maintains natural ecological processes, sustains air and water resources, and contributes to the health and quality of life…." (Benedict and McMahon 2006; Firehock 2010; McDonald et al. 2005; Moon 2011; Rowe and Bakacs 2017; U.S. EPA 2020a). Though its definition varies with different sources, it refers to sustainable design strategies or low impact development (LID) practices to naturally manage and improve the quality of stormwater runoff from impervious surfaces. Overall, as a sustainable practice, green infrastructure provides environmental, social, and economic benefits (Dunn 2010; Kim 2019; Rowe and Bakacs 2017; U.S. EPA 2020b; Wolch, Byrne, and Newell 2014).

Emergence of GI

Stormwater runoff is one of the major problems contributing to the pollution of nearby streams and rivers due to impervious surface runoff from rainfall events. As urban runoff increased due to an increase in impervious surfaces, this caused flooding and erosion in streams, waterways, and local watersheds. Therefore, experts in this field had to develop a new strategy for stormwater management mimicking the underlying natural processes so that stormwater will be managed naturally and more effectively than the conventional drainage system, also known as gray infrastructure. Gray infrastructure uses pipes and drainage systems to convey stormwater runoff from impervious surfaces to local streams and waterways. This has led to the pollution of water bodies, destruction of infrastructure and damage to wildlife habitat, and disturbance of ecosystem. To prevent pollutant discharges into the water bodies and regulate surface water quality, the Clean Water Act was revised and implemented (U.S. EPA 2020c). After the revisions made to the Clean Water Act, green infrastructure system was introduced by experts in the field to mitigate the problems caused by gray infrastructure (Echols and Pennypacker 2006).

Earlier, the term GI was used to refer to a large-scale stormwater management system, such as in a watershed scale, that included natural land conservation, interconnected green spaces, and green or habitat corridors (Benedict and McMahon 2006; Firehock 2010). For instance, according to the American Society of Landscape Architects (ASLA), GI is referred to as infrastructure for sustainable practices that help mitigate climate changes, including green energy, habitat restoration, and sustainable stormwater management (Moon 2011). However, since 2007, the USEPA has defined the term as sustainable practices to manage stormwater on site, including both vegetated and non-vegetated methods (Firehock 2010; U.S. EPA 2020a). Therefore, there is no one definition for GI, and it differs with sources and studies; nevertheless, they all refer to design practices adopted to naturally improve stormwater management (Benedict and McMahon 2006; Dunn 2010; Firehock 2010; Rowe and Bakacs 2017; U.S. EPA 2020a).

Through the Clean Water Act, EPA defines green infrastructure (GI) as the measures that utilize “plant or soil systems, permeable pavement or other permeable surfaces or substrates, stormwater harvest and reuse, or landscaping to store, infiltrate, or evapotranspirate stormwater and reduce flows to sewer systems or to surface waters" (U.S. EPA 2020c). GI involves the use of permeable materials such as soil and vegetation, gravel/stone, and man-made permeable surfaces such as permeable concrete pavers. The system mimics the natural processes of improving water quality and minimizing the volume of stormwater runoff by collecting and infiltrating stormwater (CWAA 2011; Dunn 2010; Rowe and Bakacs 2017; U.S. EPA 2020a). It helps to improve water quality by reducing pollutant loads, stream bank erosion and sedimentation, reduces water quantity through infiltration and evapotranspiration, and recharges groundwater table in the process.

Green infrastructure differs in size and scales too, and thus, at a larger scale, such as "city or county scale," green infrastructure is a network of connected natural areas providing "habitat, flood protection, cleaner air, and cleaner water," whereas at a small scale, such as "neighborhood or site scale," it is a stormwater management system that soaks up and stores water (U.S. EPA 2020a). It is also considered part of a city's "organizing framework" that helps to create a cleaner, healthier, and greener urban infrastructure (Eisenman 2013). Recent findings on GI prove that, apart from ecological services, even a small-scale project provides wildlife habitat as well as improves health and well-being of people by providing a cleaner environment and creating educational and recreational opportunities, thus, enhancing the quality of life (Dunn 2010; Rowe and Bakacs 2017; U.S. EPA 2020b; Wolch, Byrne, and Newell 2014). According to USEPA (2020a), there are several small-scale components of GI, such as rainwater harvesting, rain gardens, planter boxes, bioswales, permeable pavements, green parking, green roofs, and urban tree canopy, among others.

Bioswales

One of such small-scale components of GI is a bioswale. USEPA (2020) defines bioswales as “vegetated, mulched, or xeriscaped channels that provide treatment and retention as they move stormwater from one place to another.” They are similar to rain gardens except that bioswales are usually linear in shape and are suitable for installation near sidewalks, roads, or parking lots. Though bioswales do not hold stormwater for a longer period, they slow down the flow and help in its infiltration and purification. Studies show that bioswales can effectively remove some contaminants associated with toxic urban stormwater runoff (Anderson et al. 2016; Purvis et al. 2018; Xiao et al. 2017). When installed in bioswales, check dams, known as weirs, can improve the stormwater holding capacity of bioswales by retaining water in one section, and creating pools until it is filled out and directed to another section. Thus, check dams help to hold water in bioswales for a longer period and increase stormwater infiltration to the ground, decreasing the water quantity and improving the water quality until it is directed to natural water sources.

Challenges to GI implementation and management

Based on an online survey in 2011, the Clean Water America Alliance (CWAA) identified four categories for GI barriers from people and institutions involved in green infrastructure such as “municipal employees, government agencies, non-profit organizations, academia, consulting firms,” and people in private sectors. The study found out that one of the greatest barriers in the installation and long-term maintenance of GI is lack of or inaccessible information on GI associated with unfamiliarity with the new concept and its related risk and uncertainty (CWAA 2011). Furthermore, few studies show that inaccessible information on GI makes the public wary of unfamiliar concepts and may create reluctance among municipal employees, developers, and business owners to implement them (CWAA 2011; Dunn 2010).

Other barriers include technical barriers, legal, financial, and community and institutional barriers (CWAA 2011). According to a study carried out in 2008 by the National Resource Council, "institutional, technological, and perceptual barriers" are the major barriers to implementing of GI projects (Baptiste, Foley, and Samardon 2015). Lack of adequate knowledge on GI and its benefits and insufficient technical data on "design standards, best management practices, codes and ordinances" hinder the implementation of green infrastructure. In terms of legal barriers, conflicting and restrictive local and federal rules, and lack of incentives for the establishment of GI limits regulatory guidance required for people and organizations to successfully implement them (CWAA 2011; Dunn 2010).

Financial barriers that most people and organizations are concerned with include lack of adequate data on upfront installation and long-term maintenance costs. The environmental and social benefits of GI as well as financial benefits, in the long run, is difficult to measure; therefore, people seem reluctant to install GI because of the high establishment cost and price differences based on site conditions such as soil type for infiltration, and vegetation use (Montalto, Behr, and Yu 2011). As GI is a relatively new concept for many, they do not understand its ability to purify air and water, conserve resources, save maintenance costs as opposed to conventional infrastructure, increase in property value, and promote the local economy; there is still a lack of adequate grants, funding, incentives, and political support available to encourage the establishment of GI (CWAA 2011; Dunn 2010). Additionally, in terms of maintenance of GI, information and training of the maintenance crew is limited, leading to unintentional damage to them that results in poor maintenance and functioning of GI (CWAA

2011). For instance, as GI filters pollutants, it is essential to regularly clean up the sediments to ensure long-term performance, and if not well-equipped, the maintenance workforce may be unaware of such maintenance strategy (U.S. EPA 2016; Taguchi et al. 2020). Nowadays, organizations have been aware of the importance of proper maintenance and are striving to create better maintenance checklist especially for GI and its different components (American Rivers 2016; Feehan 2013; Marine Extension and Georgia Sea Grant 2020; Oregon State University Stormwater Solutions 2013; Philadelphia Water Department [PWD] 2014).

Reluctance to incorporate GI is not only limited to technological and financial barriers but extends to community resistance in terms of insufficient information on GI to the public and aesthetic preferences. This is also true for political leaders, administrators, developers, business owners, and landscapers. Because of the cultural aesthetics of manicured lawn, clean-cut edges, and trimmed vegetation, sometimes natural vegetation is deemed to be messy and ugly and thus are not acknowledged by the community (CWAA 2011; Gobster et al. 2007; Nassauer 1993; 1995; Nassauer et al. 2009; Yang and Li 2013). CWAA (2011) reports that this may be because of inaccessible information to the public about green infrastructure and its benefits. Some New York residents protested that the rain gardens in their streets built by the city were established poorly, not well maintained, and installed without community discussion or engagement (Nir 2017). Similarly, Portland, Oregon residents were concerned about the maintenance of bioswale and uncertain about its purpose and effectiveness (Everett et al. 2016). These examples illustrate that public awareness and information about green infrastructure, GI aesthetics aligned with that of the community, and community participation can help to improve public acknowledgment (Baptiste, Foley, and Smardon 2015).

The commonalities between the barriers mentioned above are mainly the lack of sufficient information on GI to the communities and various organizations. Insufficient information on design standards and implementation to the concerned parties, lack of maintenance, and inability to gain support from the community aid to the failure of GI (Rainer 2017), while studies show that stakeholder outreach, awareness, and community participation can make its implementation more effective and successful (Baptiste, Foley, and Smardon 2015; Barclay 2016; Everett et al. 2016; Shandas and Messer 2008).

Visual Aesthetics and Ecological Aesthetics in Landscape Design

Ecological and aesthetic preferences have always been considered two different perspectives leading to conflicts (Parsons 1995). Ecological aestheticians argue that visual aesthetics value only superficial appearances and lack ecological benefits, while the ecological landscape may not always exhibit physical beauty (Thayer 1989; Meyer 2008). This has somewhat been proven by many studies on visual preferences of North American landscape, showing that manicured lawns providing pleasing visual aesthetics are preferred over untrimmed and messy vegetation (Gobster at al. 2007; Nassauer 1993; 1995; Nassauer et al. 2009; Yang and Li 2013). Several works of ecological restoration are often met with community resistance as people do not understand the importance of such restoration projects and are more concerned about the aesthetics and recreational aspects of the landscape. Gobster (2000) argues that it is essential to take both views regarding landscape aesthetics into account. Though daunting, it is best to incorporate ecology and aesthetics by striving to create a balance between them (Gobster 2000).

Many researchers now emphasize on “new ecological aesthetic” that incorporates visual aesthetics and knowledge (Howett 1987). Visual aesthetics have the ability to attract viewers’ attention and inform them of the intentional design of the landscape. For instance, manicured lawns and clean-cut edges and planting areas inform people of the intended design and the act of care to the landscape (Nassauer 1995). In the absence of such visual characteristics and the knowledge of ecological benefits, there may be an absence of appreciation of the landscape, too, resulting in negligence (Gobster et al. 2007; Nassauer 1995). When people do not understand the value of something, they tend to care less, or when they do not know what to do with the landscape may unknowingly make changes that will hamper the ability of GI to perform well for its intended use (CWAA 2011; Drobney 1994). Therefore, it is essential for them to understand the importance and benefits of GI so that it will incite "cues for care" and will be willing to invest in its implementation and management (Nassauer 1988; 1993).

To improve the acceptance of GI, it is essential to normalize the use of GI and associate it with the natural stormwater management process as manicured lawns are associated with that of cultural landscape and care. One way to do that would be to investigate people's preferences for landscape design and align their preferences with the ecological benefits of GI so that it would be acceptable to them.

Choice Based Conjoint (CBC) Analysis

Preference research, especially in landscape design, is difficult to analyze when images are used instead of words as in market research; however, CBC methods make it much more convenient to analyze these preferences than just rating or ranking preferences (Johnson et al. 2013; Gobster, Ribe, and Palmer 2019). CBC is designed to assess consumer behavior and preferences in marketing, and it has been successfully used to assess landscape preferences even though it is not without limitations in landscape research (Louviere, Flynn, and Carson 2010; Molin 2011). Therefore, this study utilized a discrete choice experiment based on conjoint analysis to determine the visual preferences of bioswale design. Discrete choice experiment (DCE) is a preference survey method that employs attributes of different levels determining preferences of those attributes and levels, and provides preference relationships and interactions (Louviere, Flynn and Carson 2010; Schirpke et al. 2019).

CBC method effectively predicts consumer choices by presenting choice tasks combining various attributes and levels and tests which attribute and level carry the most weight. Measuring individual or group preferences and analyzing factors influencing the preferences also make it an effective method for choice studies. This methodology also calculates utility scores of attributes and levels predicting customer choices (Sawtooth Software, Inc. 2017). Based on these qualities, CBC has the potential to predict features for landscape preferences as well, and though it is not without limitations can help in providing a better understanding of people's preferences for various landscapes and study factors controlling those preferences (Hurtubia, Guevara and Donoso 2015; Schirpke et al. 2018).

Some of the analyses carried out to compute preferences for the study are Counts, Hierarchical Bayesian (HB), and Logit. Counts and Logit analysis are helpful in providing quick summary results, while HB provides a detailed evaluation of the collected survey data, including individual utility scores. CBC's Counts analysis provides information about the number of times a particular feature of a product was preferred to the number of times it actually occurred in the survey. It calculates percentages regarding preferences based on the number of times a concept, including a level of an attribute, was chosen divided by the number of times that level occurred in the choice task. Counts provides quick calculation of the "main effects and joint effects" for the data. "Main effects" measure the impact of an individual attribute level on product choice, independent of other attributes and levels, whereas "joint effects" generate data regarding the interaction of different attributes and levels. Interactions of different attributes and levels provide the most and the least preferred combinations.

Hierarchical Bayesian (HB) analysis provides a utility score that determines which attribute and level are most preferred, which proves to be helpful in analyzing visual preference of different landscape characteristics. It is the most commonly used method and an effective way for developing utilities in market research that generates individual part-worth utilities based on only a few choices given by each individual. Logit is useful in calculating average preferences for the sample group, which provides information about the importance of each attribute with respect to the others. CBC's logit analysis calculates all the main effects providing utility scores to each attribute. Both logit and HB estimate utility values for the level of an attribute that measures the worth for that level. With these analyses, every level of different attributes is provided with a utility value, known as part worth. Higher utility represents higher desirability of the attribute level, and the levels that have higher utility scores have a "larger positive impact" on influencing respondents' choices (Sawtooth Software, Inc. 2017). However, Sawtooth recommends using HB for producing final and accurate results. Because of the potential of part-worth utilities in measuring preferences, these analyses mentioned above are applied in this study.

CHAPTER 3

METHODOLOGY

Overview

This study implemented a Choice-Based Conjoint (CBC) Analysis to determine visual preferences. CBC is used to study "respondents' preferences for the combinations of various features" that drive their decisions. It is suitable for this research in which preferences for bioswale characteristics are determined through combinations of those characteristics represented by an image (Sawtooth Software, Inc. 2017). A web-based survey collected data from the sample group on demographics, general knowledge on GI and bioswales, and visual preferences of bioswales ("Sawtooth Software"). Images with a constant base image of downtown Athens Street were modified with a bioswale alongside the street to test visual preferences for a combination of a various characteristics that are generally employed in a bioswale design.

Study Process

To determine the visual preferences of bioswale with CBC, 39 images in total were generated that included bioswale characteristics, such as Material Use, Check dams, and vegetation types, which is explained further in this chapter. A questionnaire was developed with three sections regarding socio-demographic factors, general knowledge on GI and bioswales, and two CBC exercises ("Sawtooth Software"). To conduct the pilot study for a visual preference survey, the survey had to be sent out to potential respondents. For human subjects' research, it is required by the Institutional Review Board (IRB) to submit an application with all the necessary documents used in conducting the survey. IRB also requires the researcher to complete Collaborative Institutional Training Initiative (CITI) certifications. The CITI certification consists of basic courses for Social & Behavioral Research for Human Research. After completing the CITI certification, application was submitted to the IRB along with recruitment letter, consent form, and survey questionnaire (Appendix B). After approval from the IRB on June 11, 2021 (Appendix A), a recruitment email was sent out to the College of Environment + Design programs at the University of Georgia through convenience sampling. Convenience sampling, or availability sampling, is a method in which sample population is selected based on their easy accessibility (Frey 2018). For instance, Facebook polls are one of the examples of this method. Frey (2018) provides an example of student population in "researcher's own college" being readily available to the researcher for conducting a study as a primary source of data.

After responses were received for the pilot study, the data was collected and then analyzed in Lighthouse Studio ("Sawtooth Software"). This study addressed the question of analyzing visual preferences of bioswale design; therefore, to calculate the preferences and estimate the part-worth utilities, the analyses methods included Counts, Hierarchical Bayesian (HB), and Logit Analyses. Results from the three analyses complement each other and increase the reliability of the findings. For this research, counts analysis was used to calculate the "proportion of wins" for each level of attributes based on the number of times a particular level, such as mulch, was chosen to the number of times it actually appeared in the choice task. It was also used to generate data regarding the interaction of different attributes and levels, which provided results on the most and the least preferred combinations. While logit provided utility scores for each attribute, HB provided utility scores for each level of an attribute. HB was used to calculate the individual part-worth and generate box and whisker plots that helped to determine which level of an attribute was the most and the least preferred, as summarized (Figure 1).

Counts

- Calculates proportion of "wins" for each level
- Provides quick calculation of the "main effects and joint effects"
- Interaction provides the most and the least preferred combinations

Logit

- Calculates average preferences for the sample group
- Estimates all "main effects" providing utility scores to each attribute
- Higher utility represents higher desirability

Hierarchical Bayesian (HB)

- Provides utility scores to each level of an attribute to determine which is the most preferred and the least preferred level of that attribute
- Calculates importance of each attribute present in a CBC exercise

Figure 1. Similarities and Differences between Counts, Logit, and HB Analysis

Study Area

The site for this study was chosen based on the presence of a green strip, approximately 8' wide, alongside a sidewalk that could be used for the bioswale design as bioswales are best used alongside streets (Figure 2). The street view resembles a typical medium-sized downtown area and thus can represent a picture of a downtown street of any US city similar to Athens, GA. The background image required for the visual preference survey was taken of Downtown Athens Street from the sidewalk on a bright sunny day during April 2021 at around 4:00 PM EST (Figure 3). The image was captured with an iPad Air (4^{th} generation) from an eye-level height of 5' (160 cm) approximately so that it is viewed normally by people with average height (Center for Disease Control and Prevention [CDC] 2018). Passersby were not included in the image because they are likely to create a distraction (Herzog et al. 1976; Herzog 1989; Herzog and Gale 1996). To direct viewers' attention to the sidewalk and intended bioswale design, views with trees or tree branches in the foreground were excluded to eliminate any bias based on the presence of trees or flowers. Several studies have shown that people tend to value trees in urban nature, and in a street view, either in a residential or commercial zone, they highly prefer flowering trees, or big canopy trees with large trunk diameter (Herzog et al. 1976; Brush and Palmer 1979; Getz, Karow, and Kielbaso 1982; Palmer 1986). Therefore, presence of trees and shrubs in the line of sight of the bioswale was excluded from the base photo.

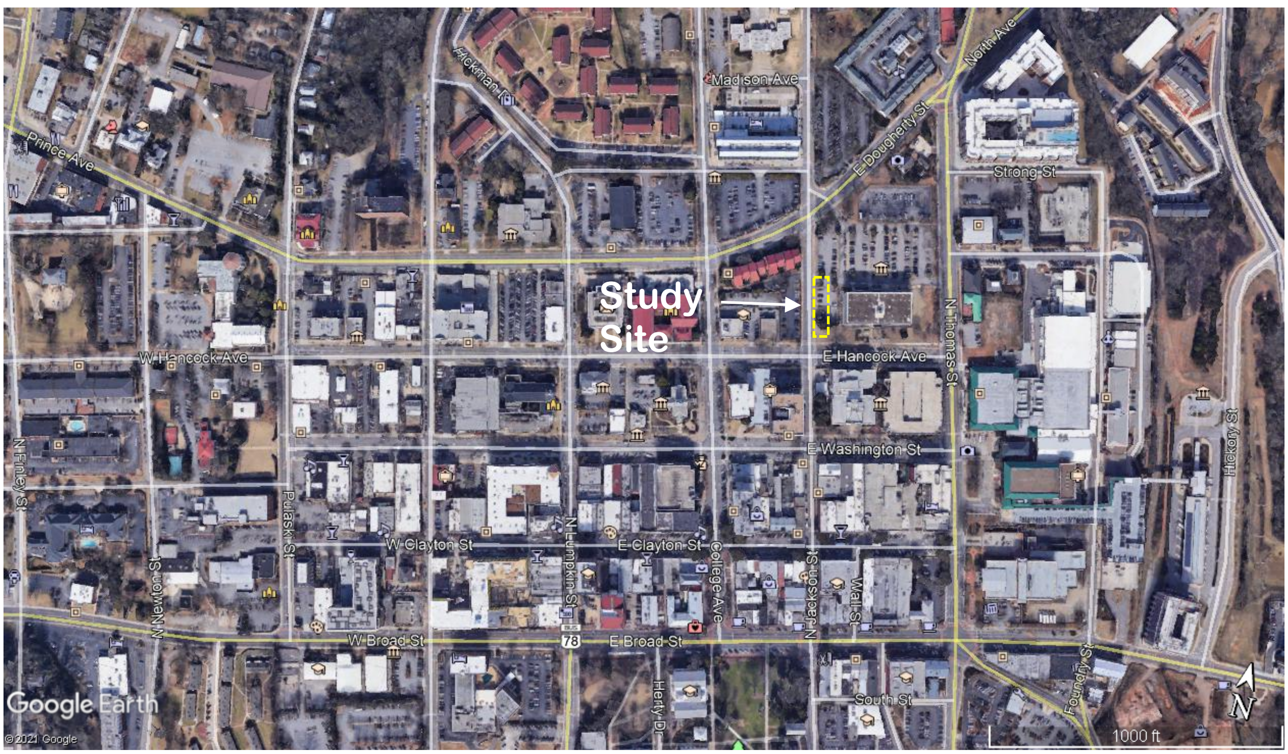


Figure 2. Map of Study Area. (Source: Google Earth Pro). Accessed May 26, 2021.

Figure 3. Site Image – View towards Hancock Ave. (Photo by P. Karmacharya, April 2021)

Sample Group

The main objective of this study is to determine visual preferences of bioswale through material uses and vegetation. A convenience sampling method was used to collect responses from the College of Environment and Design at the University of Georgia. Most of the respondents were students from Landscape Architecture, Urban Planning and Design, and Historic Preservation programs. There has been an ongoing debate on whether it is appropriate to include student samples representing the general population. Nevertheless, numerous studies have employed students as a sample population for conducting environmental preference surveys (Herzog and Gale 1996; Herzog et al. 2000; Herzog, Chen, and Primeau 2002). Studies indicate that it is acceptable to include student sampling “with more moderation” (Henry 2008). Because of the convenience of student sampling (Henry 2008), this study also selected student population; however, caution should be taken as the results cannot be generalized to other populations

(Herzog and Gale 1996; Peterson 2001). Studies on environmental preferences also suggest that "college students do not always represent other age groups" (Balling and Falk 1982; Herzog et al. 2000; Herzog 2002; Zube, Pitt, and Evans 1983).

Study Variables

The visual preference survey examined the different visual perceptions of bioswale design through material uses and vegetation types. The most important factors of a landscape design that can influence preferences are the type of vegetation used, signs of human interference, and how neat or well-maintained the landscape is (Beck, Heimlich, and Quigley 2002; Gobster et al. 2007; Helfand et al. 2006; Herzog 1989; 1992; Junge et al. 2011; Nassauer 1988; 1993; Nassauer et al. 2009; Ryan 2005; Ulrich 1986). Therefore, the aspects of a bioswale design included in this study are:

- Material uses in a bioswale such as a turf, gravel/stone, mulch
- Human intention such as the use of Check dams
- Vegetation types such as Vegetation Diversity, Density, and Height

In CBC design, features of a product are labeled as 'Attributes,' and different elements within those features are labeled as 'Levels.' Therefore, in this study, the variables for bioswale design mentioned above are referred to as attributes and various elements representing those variables are referred to as levels. Table 1 illustrates the attributes and their different levels used to establish this preference study.

Table 1. Attribute and Levels

Attribute	Levels
Combination 1	
1. Material Use	a. Turf b. Gravel and Stones c. Mulch
2. Check dam	a. No Check dam b. Concrete Check dam c. Stone Check dam d. Masonry Check dam
Combination 2	
3. Vegetation Diversity	a. Low diversity (One plant species) b. Medium diversity (3-5 plant species) c. High diversity (more than 5 plant species)
4. Vegetation Density	a. Low density (10-30%) b. Medium density (30-70%) c. High density (More than 70%)
5. Vegetation Height	a. Low height (Up to 1' tall) b. Medium height (1-3 ft tall) c. Tall height (4-6 ft tall)

Material Use

The most common type of pervious materials used in bioswales are turf, gravel/stone, and mulch. Therefore, these three material types were used for the bioswale design to determine which material people prefer the most (Figure 4).

Figure 4. Images with Turf, Gravel, and Mulch, respectively

Check dams (Weirs)

Check dams are often used in bioswales to prevent continuous flow of stormwater by holding stormwater behind the dams and creating pools of water until the stormwater spills over from one pool into the next one through a cut designed in the check dams usually created in the center. Use of check dams increase stormwater infiltration to the ground as it helps to hold water in bioswales for a longer period. This reduces the quantity of stormwater flowing downstream and provides better filtration from pollutants, thus improving the stormwater quality as well. In this study, three types of Check dams were used that are commonly found in bioswales which are concrete, stone, and masonry Check dam (Figure 5).

Figure 5. Images with Concrete, Stone, and Masonry Check dam, respectively

Vegetation Diversity

This attribute consists of three levels ranging from low diversity to high diversity (Figure 6). Low diversity includes only one plant species. In many bioswale designs, we can see the use of only one species, for example, grasses. Therefore, in this bioswale design, River Oats (*Chasmanthium latifolium*) was used to determine whether people preferred it over the use of other diverse species or not. The intention for the use of River Oats was to limit bias based on the use of color. The medium diversity level includes three to five species ranging from fewer ornamental grasses and shrubs to several herbaceous perennials. Similarly, high diversity included a range of species with more than six plant species for the design. The use of native plants in bioswale design provides resilience and thus making bioswales more effective and successful (Dunnett and Clayden 2007). They also tend to exhibit ecological benefits by managing stormwater runoff, improving water quality and promoting wildlife habitat as well (Helfand et al. 2006; Rainer and West 2015). Plants were selected based on their native range in the Southeastern United States (Clemson Cooperative Extension 2016; Dunnett and Clayden

2007; Kraus 2013; North Carolina State University 2017; Seymour 2010). Refer to Appendix C for a full list of plant species used in this bioswale design.

Figure 6. Images showing Low, Medium, and High diversity vegetation, respectively

Vegetation Density

This vegetation type is used to determine how dense planting design people prefer or can tolerate visually in a bioswale (Figure 7). The low density covers 10-30% of the bioswale that is visible in the base image. Similarly, medium density covers 30-70%, while high density covers more than 70% of the visible bioswale.

Figure 7. Figure: Images showing Low, Medium, and High-density vegetation, respectively

Vegetation Height

Similar to the vegetation diversity and density, this characteristic includes low height, medium height, and tall height (Figure 8). Low height includes young plants up to 1' tall, while medium and tall height include plants with height 1-3ft and 3-6ft, respectively. The intention with this attribute is to assess if people prefer a visible line of sight over tall plantings that obstruct clear sight.

Figure 8. Images showing Low, Medium, and Tall height vegetation, respectively

Different combinations of these attributes and levels are generated to determine which bioswale design people prefer over another. The attributes used in different combinations with all of their levels that make up complete combination sets are shown below:

Combination	**Attributes**
Combination 1	Material Use and Check dam
Combination 2	Vegetation Density, Diversity, and Height

There were a couple of different factors that regulated the combination of different attributes. For instance, to determine whether people preferred bioswale with turf, stone, or mulch along with the presence or absence of Check dams, the Material Use attribute was combined with one other attribute, i.e., Check dams producing 3x4=12 images in total. For instance, the combination of Turf Material (Attribute 1 Level 1) with No Check dam (Attribute 2 Level 1) formed one image (Figure 4). Similarly, the combination of Turf Material (Attribute 1 Level 1) with Stone Check dam (Attribute 2 Level 2) formed another image and so on (Figure 5). These two attributes were not combined with the attributes corresponding to vegetation type to limit the number of images generated (Figure 10).

Similarly, the three attributes related to vegetation type: Vegetation Diversity, Vegetation Density, and Vegetation Height, were used to generate thirty-six images. Each attribute consists of three levels, thus creating 3x3x3=27 images in total. As mentioned above, to limit the number of images produced, a combination of these vegetation type attributes was shown with the combination of mulch and concrete check dam only, and thus in this study, Material Use and Check dam attributes do not play a vital role in the preference of vegetation type. On top of that, it would not have been feasible to show the different materials or check dams with taller or overgrown vegetation; that is why the combination of the vegetation types with attributes Material Use and Check dam were excluded completely.

The following table lists the complete set of images generated and the attributes and the levels of attributes represented in each of those images:

Table 2. Combination 1

Image	Material Use	Check dam
	Turf	No Check dam
	Turf	Concrete Check dam
	Turf	Stone Check dam
	Turf	Masonry Check dam

Image	Material Use	Check dam
	Gravel and Stones	No Check dam
	Gravel and Stones	Concrete Check dam
	Gravel and Stones	Stone Check dam
	Gravel and Stones	Masonry Check dam

Image	Material Use	Check dam
	Mulch	No Check dam
	Mulch	Concrete Check dam
	Mulch	Stone Check dam
	Mulch	Masonry Check dam

Table 3. Combination 2

Image	Vegetation Diversity	Vegetation Density	Vegetation Height
	Low	Low	Low
	Low	Medium	Low
	Low	High	Low
	Low	Low	Medium

Image	Vegetation Diversity	Vegetation Density	Vegetation Height
	Low	Medium	Medium
	Low	High	Medium
	Low	Low	Tall
	Low	Medium	Tall
	Low	High	Tall

Image	Vegetation Diversity	Vegetation Density	Vegetation Height
	Medium	Low	Low
	Medium	Medium	Low
	Medium	High	Low
	Medium	Low	Medium

Image	Vegetation Diversity	Vegetation Density	Vegetation Height
	Medium	Medium	Medium
	Medium	High	Medium
	Medium	Low	Tall
	Medium	Medium	Tall

Image	Vegetation Diversity	Vegetation Density	Vegetation Height
	Medium	High	Tall
	High	Low	Low
	High	Medium	Low
	High	High	Low

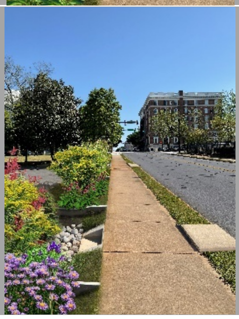
Image	Vegetation Diversity	Vegetation Density	Vegetation Height
	High	Low	Medium
	High	Medium	Medium
	High	High	Medium
	High	Low	Tall

Image	Vegetation Diversity	Vegetation Density	Vegetation Height
	High	Medium	Tall
	High	High	Tall

Image Production

The base image was kept consistent as a background across all pictures created (Figure 9). Then, the image was digitally manipulated for generating various bioswale designs using Adobe Photoshop v22.4 for Windows desktop and Adobe Photoshop for iPad. Research indicates that though manipulated photos provide an effective way to control the representation of desired features, they may not present the same effects as realistic photos do as even a slight difference in lighting and objects may generate a different response (Hurtubia, Guevera, and Donoso 2015). Therefore, a constant base image was used for all manipulated photos, and adjustments were made to all imported layers, such as plant images, to represent similar lighting and color. To minimize the glare coming from hardscapes, such as road, sidewalk, and the parking lot, reducing distraction from those and emphasizing on the bioswale design (green strip on the left side of the original image; Figure 9), layers were created on top of those hardscapes according to their shapes in the Photoshop (Broich 2021). Then, the individual layers were painted using the

‘Paint Bucket’ tool with the base color of certain components creating a solid color. For instance, for the road, a color was picked from a point on the road that gave a greyish color to its newly created layer on the top. That way, each layer created matched with their respective base components. The layers were then modified with the ‘Multiply’ option on the layers panel, and the opacity was changed, which in this case, was between 20% to 50%.

Figure 9. Images before and after modification (Image modified using Adobe Photoshop v22.4)

Images of components required for the post-production were searched online and downloaded (“Google,” Appendix D). Some elements such as turf, mulch, gravel, check dams, and drainage inlets were selected with the polygonal lasso tool on Photoshop on the Windows desktop from the original image and copied to the base image as layers for manipulation. Then, a layer mask was created for each of those layers and edited accordingly to blend in with the existing green patch on the base image to create different bioswale designs. Individual plants were also downloaded through Google browser and carefully edited through the lasso tool on the iPad Air using Apple Pencil for precision around the leaves, flowers, and branches. The coloration of plant images and other elements such as turf, check dams, and drainage inlets were modified to fit that of the base image with adjustments such as Hue/Saturation, Color Balance, and Brightness/Contrast on the Photoshop.

Questionnaire Design

A survey questionnaire with three sections was developed in the Lighthouse Studio ("Sawtooth Software"). The first section included socio-demographic questions. The second section asked questions about people's understanding of green infrastructure and bioswales. The third section was composed of the visual images generated above and asked respondents to choose between two images of the bioswale design they would visually prefer.

Section 1: Socio-Demographic Questions

To understand correlations between various socio-demographic categories and visual preferences, the survey included questions on the following:

- Age
- Sex
- Race and ethnicity
- Formal education level
- Employment
- Income level
- Job details
- Environmental group affiliation
- Gardening activities
- University System of Georgia (USG) affiliation

This provided a base for developing a correlation between visual preferences and different groups that can help in the bioswale design targeting a certain population group.

Section 2: General Knowledge on GI and Bioswales

In this section, general questions on GI and Bioswales were asked to assess people's familiarity and understanding of those terms, which was then used to determine whether knowledge of those components influenced people's visual preferences. The questions included the following:

- Familiarity with the term Green Infrastructure (skip logic)
    - Definition of GI
    - Components of GI
- Familiarity with the term Bioswale (skip logic)
    - Definition of Bioswale
    - Agree/Disagree statements about the successful implementation of bioswales

Section 3: Visual Preference Questions

The CBC exercise designed for this preference study consisted of two sets of questions. The questions asked respondents to select their preferable image between two images of bioswale design with the choice of selecting a "None" option. CBC exercise utilizes conditional relationships when using images for preference study ("Sawtooth Software"). One set of CBC design included images for combination 1, i.e., Material Use and Check dams, while another set had images for combination 2, i.e., Vegetation Diversity, Density, and Height (refer to Chapter 3 study variables pg. 24). Therefore, there were two conditional relationships for this study. Though the intention was to analyze all the attributes in one CBC, doing so generated hundreds of possible combinations for one conditional relationship, i.e., 3x4x3x3x3=324 combinations, which would not have been feasible for this study (Figure 10). Furthermore, Sawtooth does not allow the use of two conditional relationships in one CBC; therefore, two CBC exercises had to be created.

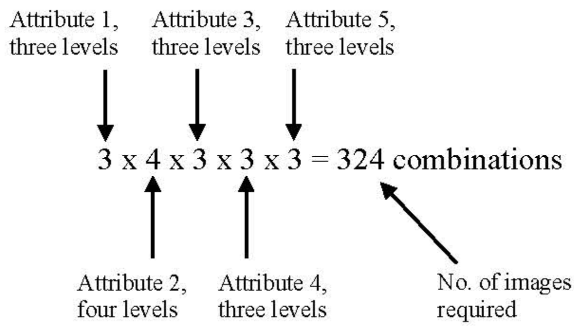


Figure 10. Attribute Combinations

The first set had four questions (choice tasks) in total and the second set had ten questions in total. Lighthouse Studio suggests that the CBC design be limited to 8 to 15 choice tasks to prevent respondent fatigue (Johnson and Orme 1996; "Sawtooth Software"). In addition, people tend to answer later questions differently if more choice tasks are included, thus posing the threat of generating less accurate data (Herzog and Bachman 1981). With the use of more internet surveys these days, respondents seem to be less patient; thus, it is recommended to have fewer choice tasks if there is an opportunity for large sample sizes, which is possible when web surveys are employed (Dillman et al. 2014; Johnson and Orme 1996; Kato and Miura 2021; "Sawtooth Software").

Data Analysis

Data collected through an online survey for preference study was analyzed through Counts analysis, Logit, and Hierarchical Bayesian analysis (HB) to calculate the part-worth utilities. Counts provided a percentage for the number of times a concept featuring an attribute level was chosen. Interaction produced through counts also helped to determine the most and the least preferred combinations. Logit estimated utility scores for each attribute while HB estimated utility scores for individual respondents with respect to the attribute levels, such as turf and concrete check dam or high diversity and tall height vegetation. Furthermore, the analysis also estimated which attributes carried the most weight through the importance graph and thus helped to reveal the most and least important attributes.

CHAPTER 4

RESULTS AND DISCUSSION

Overview

An online survey was distributed on June 16, 2021, to programs in the College of Environment + Design at the University of Georgia through a listserv email. A second reminder email was sent out on June 21, 2021. Convenience sampling was used to include sample groups from the programs Landscape Architecture, Historic Preservation, and Urban Planning and Design. The web survey consisted of socio-demographic questions, questions on general knowledge of GI and bioswales, and two CBCs for preference study. Out of 51 respondents, 45 completed the survey.

Results

Socio-Demographics

Respondents were 27 females (n=27, 60%), 17 males (n=17, 38%) and one other (n=1, 2%), with an age range from 19 to 68. 40% respondents fall within an age range of 18-24, 29% in age range 25-34, 14% in 35-44, 5% in 45-54, 10% in 54-65, and 2% above 65 (n=42). The sample group was composed mostly of the White ethnicity with 76%, followed by Asian with 16%, Black or African American with 7%, and American Indian or Alaskan Native with 2% (n=45). Other than respondents having 2% some high school and 2% high school, all other had some level of a college degree with 11% some college, 4% associate degree, 38% bachelor's and master's degree each, 2% professional and doctorate degree separately (Table 4).

Out of 42 respondents, 36% were related to the profession of landscape architecture, 12% landscape design, 7% landscape management, 10% environmental science, 2% horticulture, and 33% others such as historic preservation, urban planning, construction management, legal, administrative, and restaurant employee (Table 4). Only 16% of respondents mentioned that they were involved in environmental groups such as Society for Ecological Restoration, Institute for Sustainable Infrastructure, and Soil and Water Conservation Society, whereas 84% of respondents were not involved in any environmental groups, while 73% were involved in some gardening activities and 23% were not.

Table 4. Summary of Socio-demographic responses

Q1Gender

Value	Label	Count	Percent
1	Male	17	38
2	Female	27	60
3	Other	1	2

Q4Ethnicity

Value	Label	Count	Percent
1	American Indian or Alaskan Native	1	2
2	Asian	7	16
3	Black or African American	3	7
4	Native Hawaiian or Other Pacific Islander		
5	White	34	76

Q5Education

Value	Label	Count	Percent
1	None		
2	< High School		
3	Some High School	1	2
4	High School degree or equivalent	1	2
5	Some College	5	11
6	Associate degree	2	4
7	Bachelor's degree	17	38
8	Master's degree	17	38
9	Professional degree	1	2
10	Doctorate	1	2

Q9ProfessionDetails

Value	Label	Count	Percent
1	Landscape architecture	15	36
2	Landscape design	5	12
3	Landscape management	3	7
4	Ecology		
5	Environmental Science	4	10
6	Horticulture	1	2
7	Other	14	33

General Knowledge on GI and Bioswales

96% of the respondents answered that they had heard about the term GI, while only 4% responded that they had never heard of the term before (Table 5). However, only about 70% of the participants correctly answered the question related to GI definition, and 19% incorrectly answered that GI is related to piped drainage and water treatment system. Similarly, more than 80% of the participants correctly answered the question related to GI components, while 63% checked detention pond as a component of GI, 16% checked piped drainage system and storm sewer separately, and 5% and 7% included gutter and impervious pavement respectively (Table 5).

Though 95% of the respondents thought bioswale was a component of GI, only 87% of them mentioned that they had heard of the term bioswale before. When asked about the terms related to GI, 90% of the participants answered correctly about bioswale being "linear, vegetated, mulched, or xeriscaped channels…", around 50% answered correctly all the terms related to a bioswale, while 3% incorrectly mentioned that bioswale is a "feature that transports stormwater to water sources without infiltration" (Table 5). Around 80% of the respondents highly agreed, and 46% somewhat agreed to most of the correct statements when asked to agree/disagree with certain statements about the implementation of a successful bioswale, and 3% somewhat disagreed with them, while 15% approximately remained neutral. Similarly, in the case of incorrect statements, around 80% highly disagreed with most of them, with 21% approximately somewhat disagreeing, and around 18% remaining neutral. 3% of the respondents highly agreed with some of the incorrect statements, while around 10% somewhat agreed.

Table 5. Summary of Responses on General Knowledge on GI and Bioswales

Q13GI

Value	Label	Count	Percent
1	Yes	43	96
2	No	2	4

Q14GIDefinition

Value	Label	Count	Percent
1	Patchwork of natural areas providing flood protection and healthier environment	30	70
2	Piped drainage and water treatment system	8	19
3	Sustainable stormwater management system	37	86
4	System that mimics the natural hydrological cycle	36	84

Q15GIComponents

Value	Label	Count	Percent
1	Rain garden	41	95
2	Permeable Pavement	36	84
3	Detention Pond	27	63
4	Bioswale	41	95
5	Piped Drainage System	7	16
6	Green Roof	40	93
7	Bioretention	42	98
8	Gutter	2	5
9	Impervious Pavement	3	7
10	Storm sewer	7	16

Q16Bioswale

Value	Label	Count	Percent
1	Yes	39	87
2	No	6	13

Q17BioswaleDefinition

Value	Label	Count	Percent
1	Linear vegetated, mulched, or xeriscaped channels that collect, absorb, and convey stormwater runoff	35	90
2	Shallow, vegetated basin that collect and absorb stormwater runoff	23	59
3	Feature that infiltrates, evaporates, and transpires stormwater	19	49
4	Feature that transports stormwater to water sources without infiltration	1	3

Visual Preference for Bioswales

The Hierarchical Bayesian (HB) analysis generated importance graphs revealing attributes carrying the most weight and box and whisker plots revealing attributes and levels preferred the most for combinations 1 and 2. For combination 1 of Material use and Check dam, the importance graph revealed that Material Use was more important than Check dams (Figure 11).

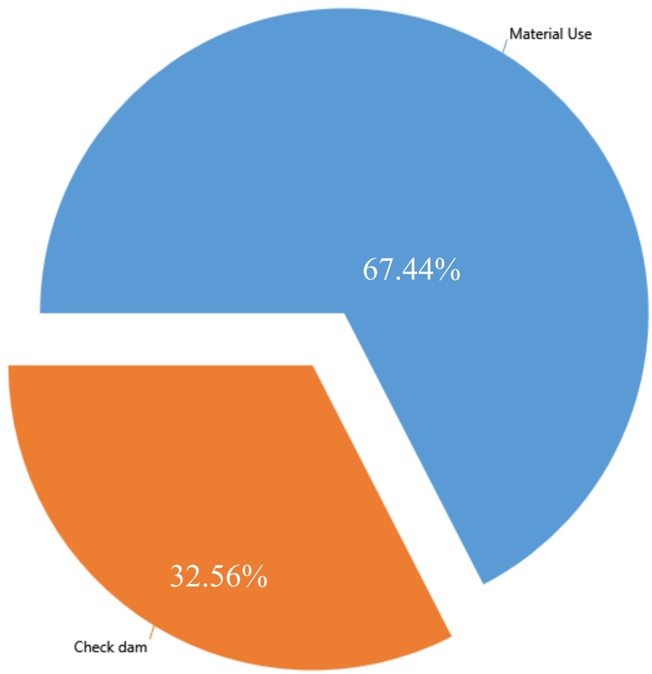


Figure 11. Importance Graph for Combination 1

The box and whisker plots generated show that the three materials used were preferred differently (Figure 12), gravel/stone and mulch being highly preferred than turf, which had a very low preference rate (X2 (2, n=46) =15.519, p<0.01).

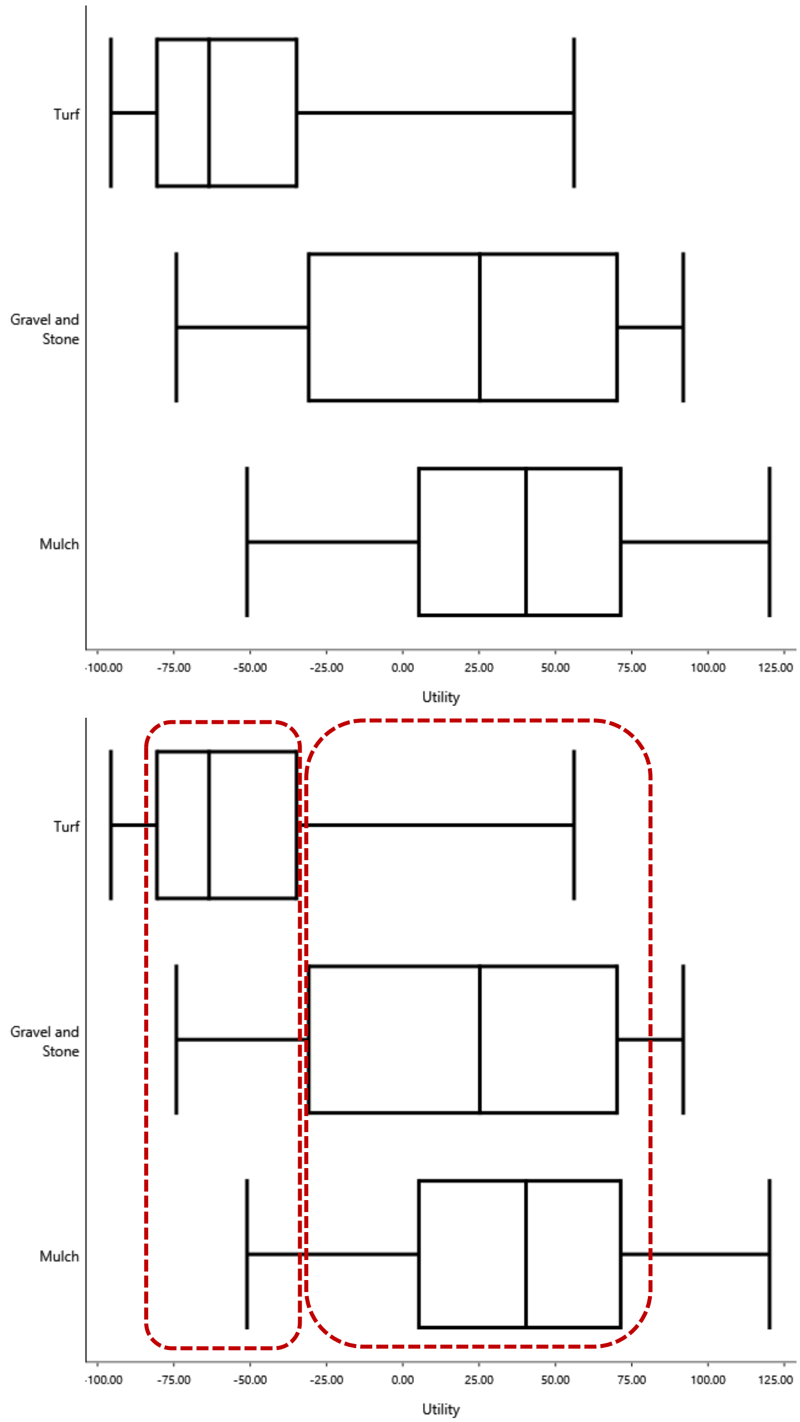


Figure 12. Box and Whisker Plot for Material Use (n=46)

In box and whisker plots, when the boxes are aligned in a perpendicular line or a box, it indicates that those levels of an attribute have similar preferences, and when they are delineated from each other, it suggests that they are preferred differently. For example, in the box and whisker plots for Material Use, the box for turf is clearly delineated from that of the gravel/stone and mulch, represented by red boxes, and the utility bar below shows the negative value for turf (Figure 12). This suggests further investigation on the statistical significance that turf was less preferred than gravel/stone and mulch, while gravel/stone and mulch had no significant difference in their preferences.

For Check dams, the box and whisker plots do not show a significant difference in the preference of absence or presence of any Check dams as all the boxes are lined up in a single column (Figure 13), and thus, all three Check dams, concrete, stone, and masonry were equally preferred revealing no significant difference (X2 (3, n=46) = 0.37).

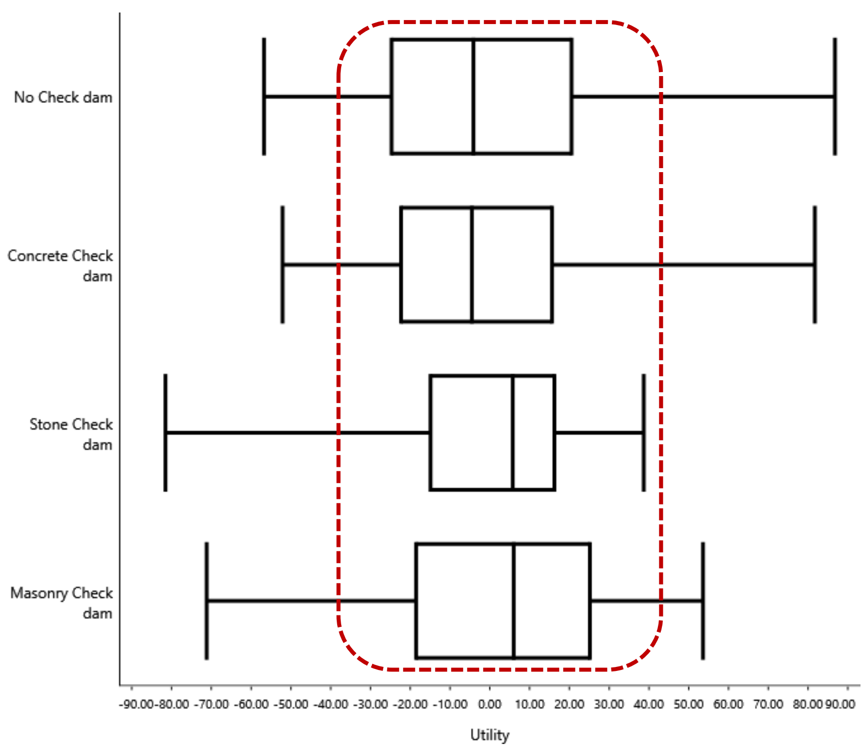


Figure 13. Box and Whisker Plot for Check dams (n=46)

In the case of combination 2 of vegetation types, the importance graph revealed that the Vegetation Diversity was the most important for visual preferences, followed by Vegetation Density, and Vegetation Height was the least important (Figure 14).

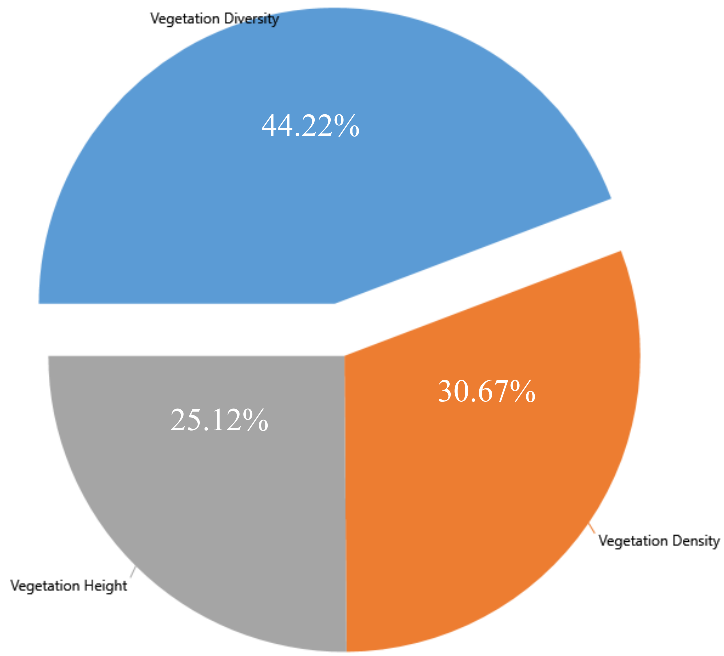


Figure 14. Importance Graph for Combination 2

The box and whisker plots for the vegetation types showed that the three levels of the Vegetation Diversity and Vegetation Density were preferred differently while that of the Vegetation Height had similar preferences. Low Vegetation Diversity was not preferred, whereas high Vegetation Diversity was highly preferred, followed by medium Diversity ($X2$ $(2, n=47) = 46.301$, $p<0.01$, Figure 15).

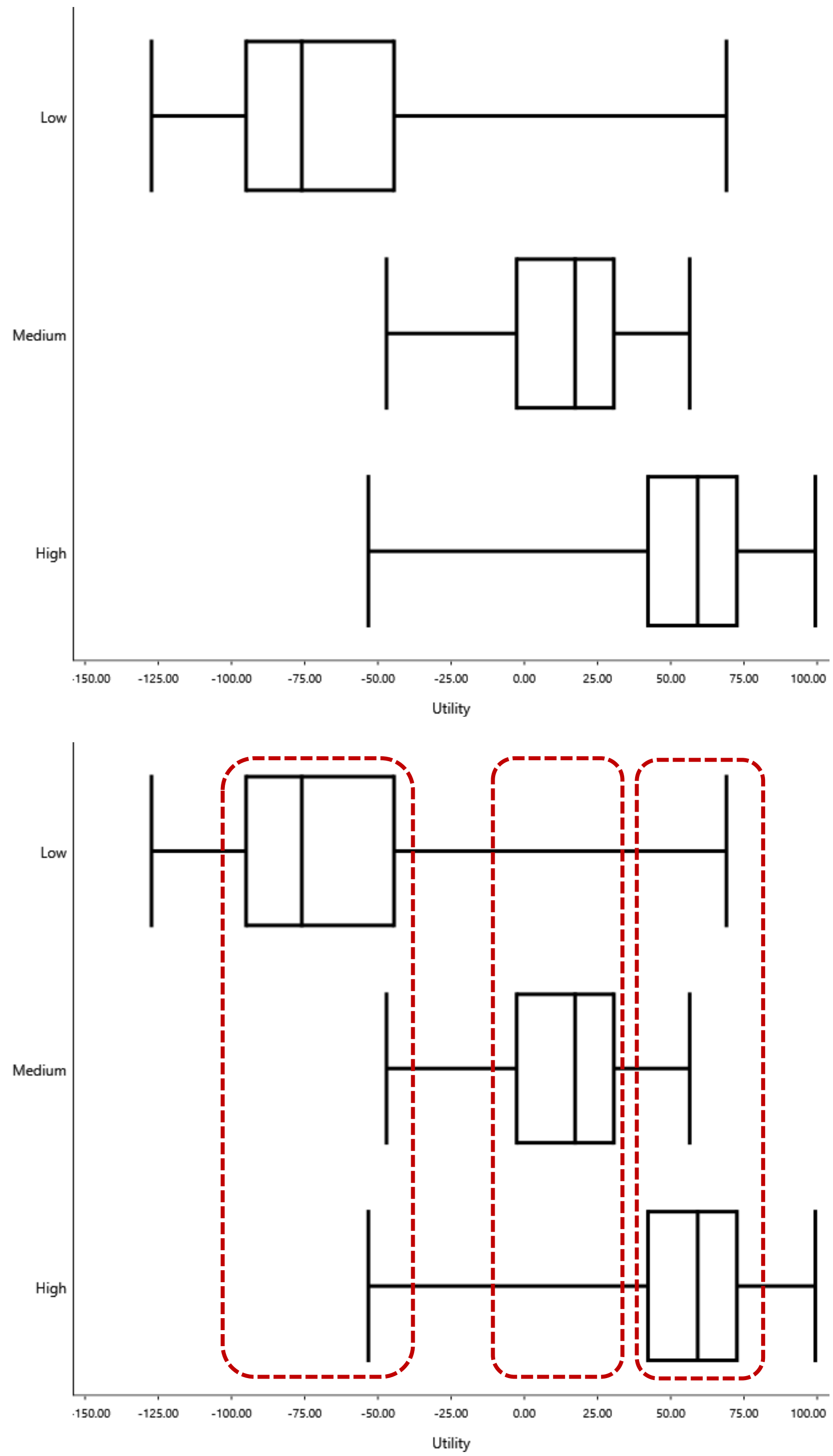


Figure 15. Box and Whisker Plot for Vegetation Diversity (n=47)

Similarly, low Vegetation Density was the least preferred and high Density the most preferred, followed by medium Vegetation Density (X2 (2, n=47) = 16.291, $p<0.01$, Figure 16).

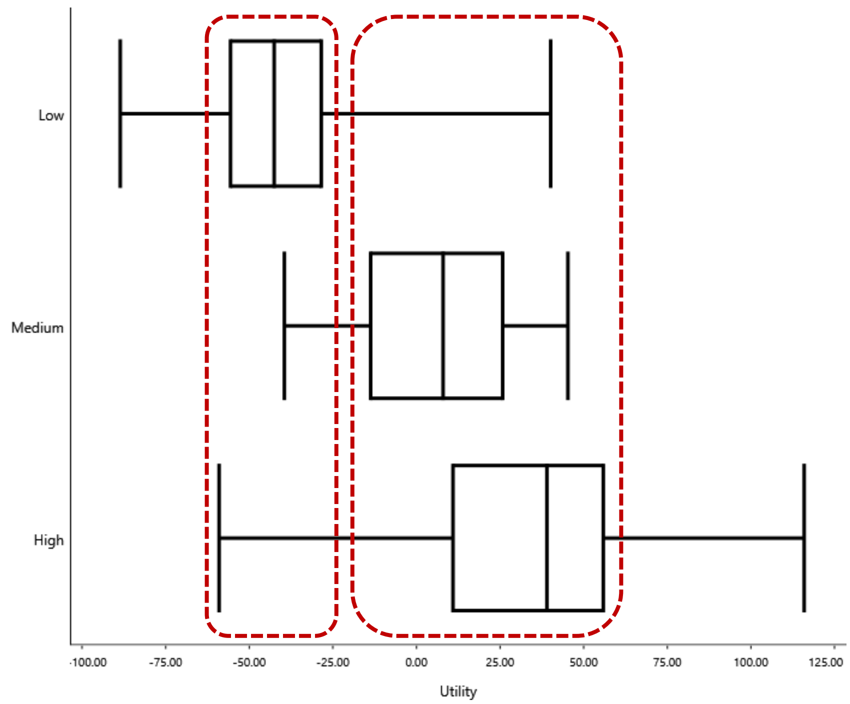


Figure 16. Box and Whisker Plot for Vegetation Density (n=47)

However, in the case of Vegetation Height, all levels of height were equally preferred, i.e., there was no significant difference in the height preferences (X2 (2, n=47) = 2.49, Figure 17).

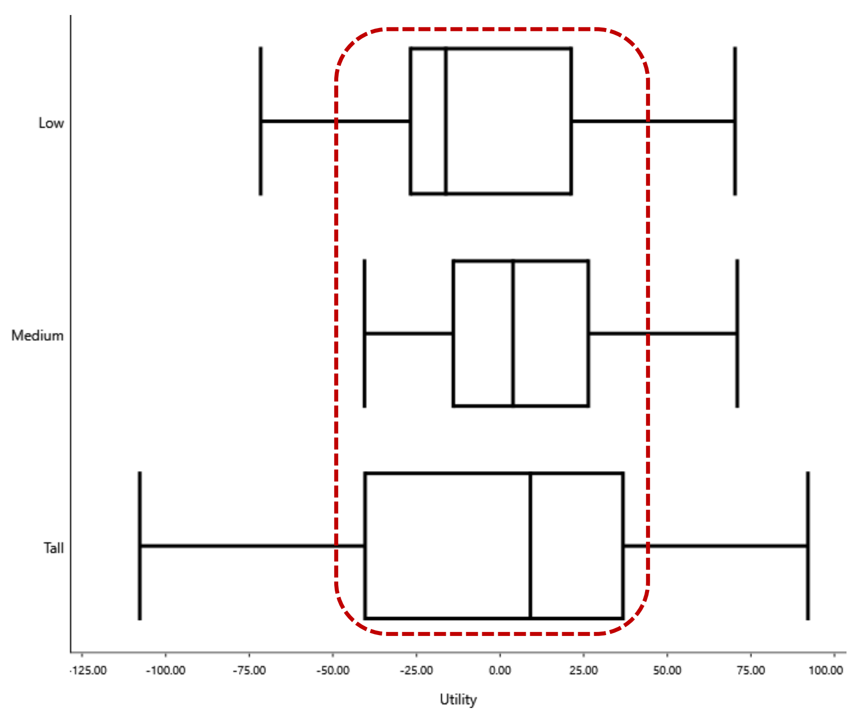


Figure 17. Box and Whisker Plot for Vegetation Height (n=47)

The negative value of both Confidence Interval (CI) for turf indicates that it was the lowest preferred material, while the positive value for gravel/stone and mulch refer that they were highly preferred with the overlapping CI values showing they had similar preferences (Table 6). This supports the utility scores provided by the box and whisker plots. For Vegetation Diversity, the table shows a distinct CI interval. High negative values of CI for low Vegetation Density indicate that it was not preferred in comparison to medium diversity, which has low positive value and high diversity having the highest positive values of CI.

Table 6. Average Utility Values Zero-Centered Differences using HB analysis

Average Utility Values

Utility Scaling Method: Zero-Centered Differences

Respondent Count: 46

Label	Utility	Std Deviation	Lower 95% CI	Upper 95% CI
Material Use				
Turf	-55.63	31.37	-64.69	-46.56
Gravel and Stone	19.09	53.56	3.62	34.57
Mulch	36.53	42.58	24.23	48.84
Check dam				
No Check dam	-0.56	31.64	-9.70	8.58
Concrete Check dam	-0.79	29.59	-9.34	7.76
Stone Check dam	-1.32	26.67	-9.03	6.39
Masonry Check dam	2.67	29.31	-5.80	11.14

Average Utility Values

Utility Scaling Method: Zero-Centered Differences

Respondent Count: 47

Label	Utility	Std Deviation	Lower 95% CI	Upper 95% CI
Vegetation Diversity				
Low	-65.42	44.65	-78.18	-52.65
Medium	14.49	22.45	8.08	20.91
High	50.92	33.22	41.43	60.42
Vegetation Density				
Low	-39.24	25.66	-46.57	-31.90
Medium	5.66	22.96	-0.90	12.23
High	33.58	38.07	22.69	44.46
Vegetation Height				
Low	-4.11	33.70	-13.74	5.53
Medium	8.73	26.28	1.22	16.24
Tall	-4.62	48.32	-18.43	9.19

Similar to Vegetation Diversity, CI values for the three levels of Vegetation Density are distinct and do not overlap, which conveys that the preferences for these three levels are significantly different. Low-density vegetation has both negative values of CI showing that it was the least preferred, medium density has a negative value for lower CI and positive value for higher CI, indicating that they were both liked and disliked by respondents, while high-density vegetation has positive values of CI that reveal it as the highest preferred level of Vegetation Density. However, in the case of Vegetation Height, the values of CI for all levels are not distinct, revealing both positive and negative values. Therefore, preference for the three levels of Vegetation Height is not significantly different.

The average utility values with logit analysis reveal corresponding results with that of the HB analysis. For Material Use, turf has a high negative utility score indicating that it was preferred the least, gravel/stone was preferred more than turf, and mulch having the highest utility score was preferred the most (Table 7). For Check dams, no check dam and stone check dam possess negative values, whereas concrete check dam and masonry check dam possess lower positive values. However, Table 7 shows that there are no significant differences between the utility scores. In terms of Vegetation Diversity, low diversity has the highest negative value, and high diversity has the highest positive value, which, as in other analyses, shows that high Vegetation Diversity was highly preferred, and low Vegetation Diversity was not preferred. Similar is the case with Vegetation Density, where the results show the highest and the lowest utility score for high and low Vegetation Density, respectively. However, for Vegetation Height, the preference level is non-distinguishable, with a very short interval between the utility score of three levels. Medium height is the only level having a positive utility score, which is indeed very low, while the other two levels show negative scores.

Table 7. Average Utility Values Zero-Centered Differences using Logit analysis

Average Utility Values

Utility Scaling Method Zero-Centered Differences

Label	Utility
Turf	-101.96
Gravel and Stone	33.83
Mulch	68.13
No Check dam	-0.70
Concrete Check dam	1.46
Stone Check dam	-15.34
Masonry Check dam	14.58
None	-420.63

Average Importances

Attribute	Importance
Material Use	85.04
Check dam	14.96

Average Utility Values

Utility Scaling Method Zero-Centered Differences

Label	Utility
Low	-90.88
Medium	17.56
High	73.32
Low	-53.37
Medium	0.02
High	53.34
Low	-7.24
Medium	18.17
Tall	-10.93
None	-302.21

Average Importances

Attribute	Importance
Vegetation Diversity	54.73
Vegetation Density	35.57
Vegetation Height	9.70

Counts Analysis

Counts provide information about preferences for an attribute level considering the number of times a concept (image) with that attribute level, for instance, high vegetation density, was chosen based on the number of times it appeared within a task (CBC question) in the survey.

In this study, for CBC1, gravel & stone and mulch was chosen more than 50% of the times they appeared with gravel and stone selected 55.2% of the times and mulch 62%, while turf only 28.7% of the times showing a distinct gap in the preferences than the other two (X2 (2, n=46) =15.519, p<0.01, Appendix E). In terms of Check dams, the absence or presence of any type of check dams did not result in a significant difference for determining preferences (X2 (3, n=46) =0.37).

In the case of CBC2, high diversity vegetation was more preferred, with image consisting of this level of Vegetation Diversity chosen 65.7% of the times it occurred, medium diversity 52.1% of the times, and low diversity 28.1% (X2 (2, n=47) =46.301, p<0.01, Appendix E). For Vegetation Density, high density vegetation was selected 59.3% of the times it appeared, medium density 49.5%, and low density 36.7% (X2 (2, n=47) =16.291, p<0.01). However, the three levels were not significantly different for Vegetation Height in terms of their preferences (X2 (2, n=47) =2.49). This shows that high diversity and high and medium density vegetation were the most preferred for Vegetation Diversity and Vegetation Density attributes, respectively, whereas all levels of Vegetation Height were almost equally chosen.

Interaction

The Counts analysis for Combination 1 did not provide any significant result for the interaction of Material Use and Check dams (X2 (6, n=46) =4.659, p=0.121). In the case of Combination 2 (Vegetation Diversity, Vegetation Density, and Vegetation Height), for Vegetation Diversity x Vegetation Density, high diversity with high-density vegetation were selected 77.8% of the times the combination occurred, medium diversity with high-density vegetation 69.9% of the times, high diversity with medium density vegetation 64.7% (X2 (4, n=47) =3.795, p=0.024). All other combinations occurred below that, with the lowest being low diversity and low-density vegetation at 23.3% (Appendix E). However, for Vegetation Diversity x Vegetation Height, the results were not significant (X2 (4, n=47) =6.566, p=0.094) as was the case with Vegetation Density x Vegetation Height (X2 (4, n=47) =0.751, p=0.91).

While the results from the Counts, Logit, and HB analysis provide different sets of values, data from each analysis produce similar results and support each other regarding the preferences and importance of attributes and levels. While HB provides a robust and complete set of data that can solely be used to determine preferences, Counts and Logit provide further support to make the study more reliable. Also, Counts provides the interaction of different attributes and their levels, which prove to be effective in analyzing preferences of combinations of those attributes and levels.

Future Research Direction

This study revealed the significance of the use of mulch and gravel and stones (Material Use), and high vegetation diversity and high vegetation density over other characteristics for bioswale design; however, there are some limitations as it employed a pilot study. For instance, because of the low responses from male participants, it was not feasible to analyze the significant difference for preferences between males and females that otherwise could have provided guidance for bioswale design targeting a specific population. Similar is the case with other socio-demographic factors such as ethnicity, education, profession, involvement in environmental groups, and gardening activities as well as with the general knowledge on GI and bioswales. To find notable results considering such factors, it is essential to move forward by employing a large sample group and see if the findings are consistent with this pilot study and across other regions as well. Because community involvement in GI is said to be valuable in its acceptance (Baptiste, Foley, and Smardon 2015), the research may be taken further to new directions to determine if this preference changes people's perception of GI, raising their willingness to implement as well as care for it.

Studies on vegetation preferences in residential and commercial areas have indicated that dense vegetation and tall height vegetation come across as unaesthetic, messy, untended, and safety risks among the public and therefore are not well-preferred (Gobster et al. 2007; Nassauer 1993; 1995a; 1995b; Nassauer et al. 2009; Yang and Li 2013). As this research found the results contrast to these findings, there may be a few factors influencing these preferences. First, the sample group involved in this study are people who have education in the environmental background, and most of them had greater knowledge on GI and bioswales, and second, the site involves a bioswale in an urban street. There have been very few studies on preferences and perception of GI and its components such as bioswales, bioretention, and rain gardens (Broich 2019). Therefore, it would be interesting to learn if the information on GI played any crucial role in directing people's preferences and how they would react if the study were done on other components of GI or a different site such as a residential street or a school zone or in front of a mall. Additional research on these could provide better understanding and guidance in designing and managing such sustainable stormwater infrastructures targeting specific populations and regions.

Though unintentional, the use of herbaceous perennials during the high flowering season may have been another great regulating factor for people's preference towards high diversity, high density, and tall height vegetation (Herzog et al. 1976; Brush and Palmer 1979; Getz, Karow, and Kielbaso 1982; Palmer 1986). Broich (2019) found out that people prefer late summer season over dormant seasons, such as winter, indicating that people may have preference for high flowering and greener season. However, one study on vegetation preferences shows that green vegetation is also preferred during the non-flowering season (Jorgenson, Hitchmough, and Calvert 2002). Future studies can be conducted on seasonal preferences for specific GI components comparing between herbaceous perennials and see if people equally prefer high diversity, high density, and tall height vegetation during the non-flowering season as in flowering season. As flowering plants have shown to have high preferences in other study areas, additional comparisons could be the use of evergreen and seasonal plants and see the differences between them in terms of GI components such as bioswales and rain gardens. Plant selections play a vital role in the effectiveness of GI (Bratieres et al. 2008; Henderson, Greenway, and Phillips 2007; Lucas and Greenway 2008; Read et al. 2008); therefore, further research on planting design and selection can inform professionals about better design recommendations.

Results from this study indicate that high diversity and high and medium density vegetation have the highest preferences. Although high diversity and dense vegetation are beneficial in effective pollutant removal, they require regular maintenance. Regular maintenance and long-term management of GI have been identified as few barriers to implementation and proper functioning of GI (CWAA 2011). Few studies talk about the maintenance issues of GI (Kraus, Riley, and Neal 2016), and fewer organizations provide maintenance guidelines for different GI components such as bioswales, rain gardens, and bioretention (American Rivers; Feehan 2013; Marine Extension and Georgia Sea Grant 2020; Oregon State University Stormwater Solutions 2013; PWD 2014). According to a sixty-six rain gardens' survey, Kraus et al. (2016) indicate that most of the rain gardens were not adequately maintained. Even if some of them were, lack of proper maintenance guidance resulted in people unknowingly hampering the effectiveness of the gardens, such as the use of herbicides for weed control though no products are specifically labeled for its use in such landscape. The use of vegetation such as certain herbaceous perennials or some woody trees also results in weed growth, and if not controlled, they can outgrow the ornamental plants resulting in an unpleasing view. Other maintenance issues include the accumulation of sediments and pollutants in the garden beds, which is evident from the study of the rain gardens in which approximately half of the sixty-six rain gardens had sediment accumulation (Kraus, Riley, and Neal 2016). Appropriate techniques in the removal of weeds, as well as sediments from the garden beds, can ensure proper management of GI for its long-term efficiency and resilience.

The vast literature on "cues to care" show that people prefer neat and well-maintained landscapes such as manicured lawns, trimmed vegetation, crisp edges, and colorful plants (Li and Nassauer 2020; Nassauer 1995b; 2011). However, these studies were done in a different context than that of GI, and it is essential to understand the varying preferences people have for various landscapes. GI components such as bioretention are designed to have a low area of mowed lawn, diverse vegetation increasing biodiversity, and untrimmed vegetation (Oudolf and Kinsbury 2013) that may not always show that they are cared for. The results of this study support these qualities of GI, showing that "cues to care" may not always be applicable. For instance, results indicate that mowed turf is not always preferred across all the landscapes as the turf was the least preferred feature in this bioswale design. Besides that, vegetation height did not play any remarkable role in defining preferences as tall vegetation was not less preferred than low height vegetation, which indicates that trimmed vegetation may not always be preferable than the untrimmed one. Again, this might be because of the small sample group as well as the professional background of the people involved in this study. Therefore, more research with a large sample group will help to provide robust data on this matter.

Most of the respondents involved in this study had much better knowledge of GI and bioswales; however, due to the low sample size, it could not be determined if that helped influence any of the preferences towards different bioswale characteristics. Studies have shown that community involvement aids in successful project implementation, and when provided with information on GI, they tend to be more willing to implement it in their property even though they have some concerns about its appearance and long-term maintenance (Dogmusoz 2019). Sometimes, it is more effective to visually show what the landscape process is rather than explain it to the people who are unfamiliar with the term, as aesthetics tend to draw people's attention (Curtis 2011). Eco-revelatory design in landscape architecture advocates that landscape processes be revealed through design enriching human experiences (Brown, Harkness, and Johnston 1998; Liverman 2007). Recently, there have been numerous examples of revealing sustainable stormwater management process through artful interventions called artful rainwater design, which claims to provide educational value and awareness through design (Echols 2007; Echols and Pennypacker 2006; 2008; 2015). The use of educational signs and/or artful structures conveying the stormwater management process may exhibit signs of human intention and care (Nassauer 2011), and future studies could explore these further.

CHAPTER 5

CONCLUSION

This study addressed the question of visual preferences for various characteristics that can be employed in the design of a bioswale and found out that people prefer mulch and grave/stone over turf in terms of Material Use and high diversity and high and medium density vegetation in terms of vegetation types. Though significant differences could not be found between different levels of Vegetation Height, people preferred all vegetation heights equally. Similarly, because of the small sample group, no comparisons could be made in visual preferences between various socio-demographic groups and preferences on knowledge people have on GI and bioswales; however, the study can be replicated, and the findings may prove to be essential in carrying out further research.

Interaction of several features such as Material Use with absence and presence of Check dams, Vegetation Diversity with Vegetation Height, Vegetation Density with Vegetation Height, and Vegetation Diversity with Vegetation Height provide valuable insights for bioswale design. For combination 1, the results suggest no particular preference for the presence or absence of Check dams with respect to the Material use. The preference of mulch and gravel/stone over turf may be based purely on aesthetic reasonings, or it may be guided because the participants were more knowledgeable in terms of GI and bioswales, and they were the most chosen components as they have higher infiltration capacity than turf. As in the case of findings on Material Use, it could have been said that the presence of check dams was more important than the absence of check dams because check dams provide better stormwater management, but the differences were not remarkable enough to deduce that. Therefore, further research will help provide insights to prove these hypotheses.

Likewise, in the case of Combination 2 (Vegetation Diversity, Vegetation Density, and Vegetation Height), for Vegetation Diversity x Vegetation Density, high diversity with high-density vegetation was the most preferred combination followed by medium diversity with high-density vegetation, and high diversity with medium density vegetation, while low diversity and low-density vegetation received the lowest preference. For Vegetation Diversity x Vegetation Height, and Vegetation Density x Vegetation Height, the interaction did not produce any significant results. Here, it can also be inferred that Vegetation Diversity carried the most weight and importance in determining preferences, with Vegetation Density being the second most important and vegetation height carrying the least importance.

Use of three different methods to evaluate preferences provided comprehensive data for this study that support each other and improve its reliability. While Counts produced a different set of data, such as the proportion of “wins” and interactions for different attributes and levels, Logit and HB provided similar utility scores for the attributes and levels and importance of one attribute over another. However, HB is a newer and more effective way to produce results, and it is recommended that HB be used for final accurate results. Overall, HB presents a robust set of data, including utility scores for each level of an attribute, box and whisker plots, and importance graphs, and therefore is a powerful analysis method.

Results for this study suggest that using mulch and gravel/stone instead of turf may provide better visual aesthetics as people preferred them more over the turf in the bioswale design. This is also supported by the fact that turf has a lower infiltration rate than the other two materials, and thus, mulch, and gravel/stone would be more effective in stormwater management. Other than that, if vegetation is used in a bioswale, giving priority to more diverse vegetation, especially herbaceous perennials, may ensure acceptance from the public. Bloom times of those species should also be kept in mind, and species with different flowering periods should be considered. A balance between Vegetation Density and Height with respect to Vegetation Diversity may be essential in establishing successful bioswale design to improve the acceptance of bioswales in terms of visual aesthetics. However, the use of high diversity and high-density vegetation comes with the issue of maintenance because of weed growth and sediment accumulation. Therefore, care should be taken during plant selection and planting design for bioswales and other components of GI.

Future research including a larger sample group and/or other settings, such as residential streets in a suburban area, a commercial zone, or an industrial area, may provide more robust data regarding the visual preferences of bioswales. Determining whether information and knowledge on GI help guide people's preferences and their willingness to implement and properly manage GI may yet be another area of future studies. Other studies may include testing preferences for seasonality or different planting design. Further research may include some additional characteristics for the bioswale design, such as educational signage and artful interventions, or study on other components of GI such as rain gardens and green roofs. Besides that, advancing studies on the maintenance of GI with recommendations and step-by-step guidelines on its proper management could address the management issues. The possibilities are endless, and this study is one of the few steps taken towards understanding landscape preferences for GI.

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APPENDICES

A. IRB Approval Letter

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/

Human Research Protection Program

EXEMPT DETERMINATION

June 11, 2021

Dear Jon Calabria:

On 6/11/2021, the Human Subjects Office reviewed the following submission:

Title of Study:	Evaluating Visual Preference of Bioswale in an Urban Street
Investigator:	Jon Calabria
Co-Investigator:	Pranisha Karmacharya
IRB ID:	PROJECT00004157
Funding:	None
Review Category:	DHHS Exempt 3B

We have determined that the proposed research is Exempt. The research activities may begin 6/11/2021.

Since this study was determined to be exempt, please be aware that not all future modifications will require review by the IRB. For more information please see Appendix C of the Exempt Research Policy (https://research.uga.edu/docs/policies/compliance/hso/IRB-Exempt-Review.pdf). As noted in Section C.2., you can simply notify us of modifications that will not require review via the "Add Public Comment" activity.

A progress report will be requested prior to 6/11/2026. Before or within 30 days of the progress report due date, please submit a progress report or study closure request. Submit a progress report by navigating to the active study and selecting Progress Report. The study may be closed by selecting Create Version and choosing Close Study as the submission purpose.

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

B. Online Survey

Start

Welcome!

Dear Participant,

My name is Pranisha Karmacharya and I am a graduate student in the College of Environment + Design at the University of Georgia under the supervision of Dr. Jon Calabria. I am inviting you to take part in a research study as a part of my master's thesis.

I am doing a research on the visual preference of bioswales which are installed for sustainable stormwater management to treat stormwater runoff. I am interested in your opinion on how you would prefer the bioswales to look so that it is acceptable and acknowledged by all.

Your responses will help us understand various characteristics of bioswales affecting visual preference and can provide guidance in better design and management of these bioswales, especially in public spaces. Therefore, your participation is very important and much appreciated.

You must be **18 years or older and a U.S. resident** to participate in this study. If you agree to take part in this study, you will be asked to fill in an online visual preference survey with three sections. The first section includes questions about yourself. The second section will ask you questions about your understanding of Green Infrastructure and Bioswales. The third section will ask you to choose between two images of bioswale design that you would visually prefer, but you will have the option to choose neither. The survey should take no longer than 15 minutes.

Participation is voluntary. You can refuse to take part or stop at any time without penalty. If you are a student, your decision to participate or not to participate will have no impact on your grades or class standing. If there are questions that make you uncomfortable and do not wish to answer them, then you can skip these questions.

Results from this survey can be used or shared, after identifiers have been removed, with other researchers for future research without your further consent. This research involves transmission of data over the internet. Every reasonable effort has been considered to ensure the effective use of technology; however, we cannot guarantee confidentiality during online communication.

If you have questions about this research, please feel free to contact me at **pk44293@uga.edu**. If you have any complaints or questions about your rights as a research volunteer, contact the IRB at **706-542-3199** or by email at **IRB@uga.edu**.

Please keep this letter for your records.

Sincerely,
Pranisha Karmacharya
Master of Landscape Architecture Candidate
University of Georgia
College of Environment + Design
285 South Jackson Street

Consentquestion

You must be 18 years or older and a U.S. resident to participate in this study. Are you 18 years or older and a U.S. resident?

Consentquestion=1 Yes ○

Consentquestion=2 No ○

Next

Section1

Section 1

In this section we would like to ask you a few questions about yourself. All of your answers are confidential.

Click "Next" to begin the section.

Back Next

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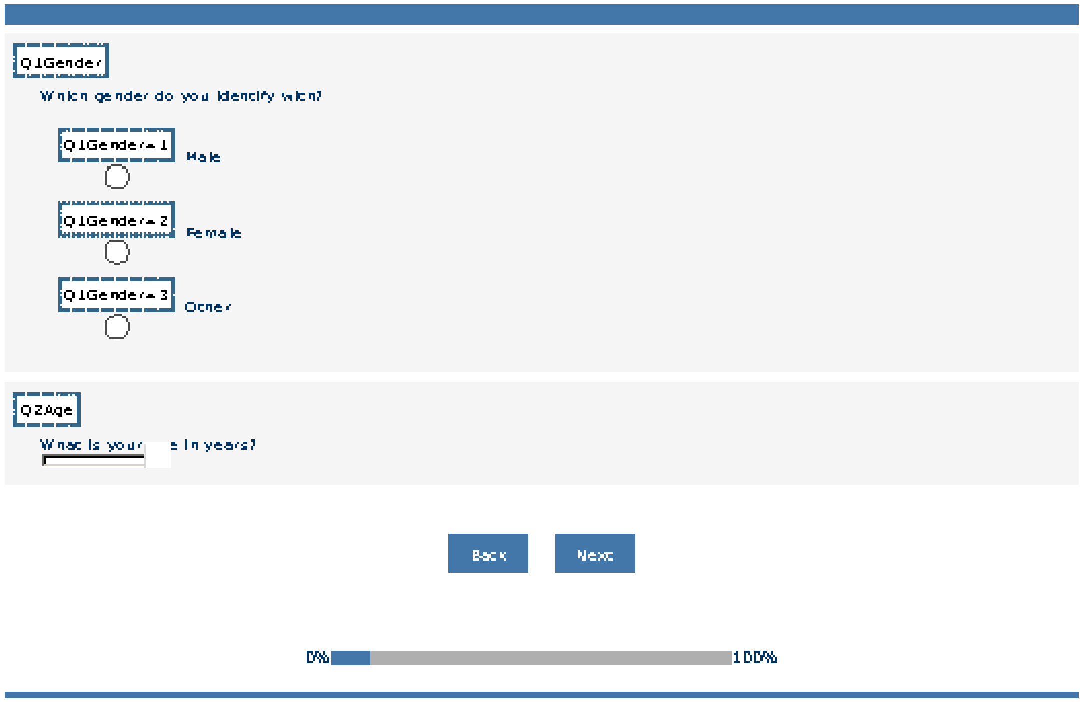

Q1Gender
Which gender do you identify with?
Q1Gender=1 Male
Q1Gender=2 Female
Q1Gender=3 Other
Q2Age
What is your
e in years?
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Q3Ethnicity

Are you of Hispanic, Latino, or of Spanish origin?

Q3Ethnicity=1 ◯ Yes

Q3Ethnicity=2 ◯ No

Q4Ethnicity

How would you describe yourself? Please select all that apply.

Q4Ethnicity_1 ☐ American Indian or Alaskan Native

Q4Ethnicity_2 ☐ Asian

Q4Ethnicity_3 ☐ Black or African American

Q4Ethnicity_4 ☐ Native Hawaiian or Other Pacific Islander

Q4Ethnicity_5 ☐ White

Back Next

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Q5Education

What is the highest level of education you have completed?

- Q5Education=1 None
- Q5Education=2 < High School
- Q5Education=3 Some High School
- Q5Education=4 High School degree or equivalent
- Q5Education=5 Some College
- Q5Education=6 Associate degree
- Q5Education=7 Bachelor's degree
- Q5Education=8 Master's degree
- Q5Education=9 Professional degree
- Q5Education=10 Doctorate

Back Next

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Q6EmploymentStatus

What is your current employment status? Please select all that apply.

Q6EmploymentStatus_1 ☐ Employed or self-employed full-time

Q6EmploymentStatus_2 ☐ Employed or self-employed part-time

Q6EmploymentStatus_3 ☐ Unemployed (currently looking for work)

Q6EmploymentStatus_4 ☐ Unemployed (not currently looking for work)

Q6EmploymentStatus_5 ☐ Student

Q6EmploymentStatus_6 ☐ Retired

Q6EmploymentStatus_7 ☐ Unable to work

Back Next

0% 100%

Q7HouseholdIncome

What was your total household income last year, before taxes?

- Q7HouseholdIncome=1 ○ < $25K
- Q7HouseholdIncome=2 ○ $25 – $50K
- Q7HouseholdIncome=3 ○ $51 – $100K
- Q7HouseholdIncome=4 ○ $101 – 150K
- Q7HouseholdIncome=5 ○ > $150K

Back   Next

0% 100%

Q8Job

Is your job related to landscape/environment/horticulture?

Q8Job=1 Yes

Q8Job=2 No

Q9ProfessionDetails

Which of the following profession best describes your work?

Q9ProfessionDetails=1 Landscape architecture

Q9ProfessionDetails=2 Landscape design

Q9ProfessionDetails=3 Landscape management

Q9ProfessionDetails=4 Ecology

Q9ProfessionDetails=5 Environmental Science

Q9ProfessionDetails=6 Horticulture

Q9ProfessionDetails=7 Q9ProfessionDetails_7_other

Other

Back Next

0% 100%

Q10EnvironmentalGroups

Do you belong to any environmental organization?

Q10EnvironmentalGroups=1 ○ Q10EnvironmentalGroups_1_other Yes (Please specify) [ ]

Q10EnvironmentalGroups=2 ○ No

Q11GardeningActivities

Do you personally take part in any gardening activities?

Q11GardeningActivities=1 ○ Yes

Q11GardeningActivities=2 ○ No

Back Next

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Q12USGAffiliation

Are you affiliated to the University System of Georgia (USG) in any way? If yes, please specify.

Q12USGAffiliation=1 ○ Q12USGAffiliation_1_other Yes [ ]

Q12USGAffiliation=2 ○ No

Back Next

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Block2

Section 2

In this section, you will asked some general questions on Green Infrastructure and Bioswales that help us know your understanding of these terms.

Click "Next" to begin the section.

Back Next

0% 100%

Q13GI

Have you heard of the term Green Infrastructure before?

Q13GI=1 Yes

Q13GI=2 No

Back Next

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Q14GIDefinition

What do you think the term Green Infrastructure relate to? Please select all that apply.

Q14GIDefinition_1 ☐ Patchwork of natural areas providing flood protection and healthier environment

Q14GIDefinition_2 ☐ Piped drainage and water treatment system

Q14GIDefinition_3 ☐ Sustainable stormwater management system

Q14GIDefinition_4 ☐ System that mimics the natural hydrological cycle

Back Next

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Q15GIComponents

Which of the following components do you think is a Green Infrastructure? Please select all that apply.

- Q15GIComponents_1 ☐ Rain garden
- Q15GIComponents_2 ☐ Permeable Pavement
- Q15GIComponents_3 ☐ Detention Pond
- Q15GIComponents_4 ☐ Bioswale
- Q15GIComponents_5 ☐ Piped Drainage System
- Q15GIComponents_6 ☐ Green Roof
- Q15GIComponents_7 ☐ Bioretention
- Q15GIComponents_8 ☐ Gutter
- Q15GIComponents_9 ☐ Impervious Pavement
- Q15GIComponents_10 ☐ Storm sewer

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0% 100%

Q16Bioswale

Have you heard of the term Bioswale before?

Q16Bioswale=1 Yes

Q16Bioswale=2 No

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0% 100%

Q17BioswaleDefinition

What do you think the term Bioswale relates to?

Q17BioswaleDefinition_1 ☐ Linear vegetated, mulched, or xeriscaped channels that collect, absorb, and convey stormwater runoff

Q17BioswaleDefinition_2 ☐ Shallow, vegetated basin that collect and absorb stormwater runoff

Q17BioswaleDefinition_3 ☐ Feature that infiltrates, evaporates, and transpires stormwater

Q17BioswaleDefinition_4 ☐ Feature that transports stormwater to water sources without infiltration

Q18BioswaleFamiliarity

Have you ever seen one?

Q18BioswaleFamiliarity=1 ○ Yes

Q18BioswaleFamiliarity=2 ○ No

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0% 100%

Q19BioswaleStatements

Do you agree or disagree with the following statements?

Implementation of a successful Bioswale would:

	Highly Agree	Somewhat Agree	Neutral	Somewhat Disagree	Highly Disagree
Help in stormwater management	Q19BioswaleStatements_r4=1	Q19BioswaleStatements_r4=2	Q19BioswaleStatements_r4=3	Q19BioswaleStatements_r4=4	Q19BioswaleStatements_r4=5
Help to connect with nature in urban areas	Q19BioswaleStatements_r8=1	Q19BioswaleStatements_r8=2	Q19BioswaleStatements_r8=3	Q19BioswaleStatements_r8=4	Q19BioswaleStatements_r8=5
Help to mitigate the effects of climate change	Q19BioswaleStatements_r7=1	Q19BioswaleStatements_r7=2	Q19BioswaleStatements_r7=3	Q19BioswaleStatements_r7=4	Q19BioswaleStatements_r7=5
Promote wildlife habitat	Q19BioswaleStatements_r5=1	Q19BioswaleStatements_r5=2	Q19BioswaleStatements_r5=3	Q19BioswaleStatements_r5=4	Q19BioswaleStatements_r5=5
Improve the aesthetics of a locality	Q19BioswaleStatements_r1=1	Q19BioswaleStatements_r1=2	Q19BioswaleStatements_r1=3	Q19BioswaleStatements_r1=4	Q19BioswaleStatements_r1=5
Degrade air quality	Q19BioswaleStatements_r2=1	Q19BioswaleStatements_r2=2	Q19BioswaleStatements_r2=3	Q19BioswaleStatements_r2=4	Q19BioswaleStatements_r2=5
Help to increase temperature of surrounding areas	Q19BioswaleStatements_r3=1	Q19BioswaleStatements_r3=2	Q19BioswaleStatements_r3=3	Q19BioswaleStatements_r3=4	Q19BioswaleStatements_r3=5
Deteriorate health of water bodies	Q19BioswaleStatements_r6=1	Q19BioswaleStatements_r6=2	Q19BioswaleStatements_r6=3	Q19BioswaleStatements_r6=4	Q19BioswaleStatements_r6=5

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0% 100%

CBCintro

Section 3

In this section, you will be presented with two different images of bioswale design and you will be asked to indicate your preference for the photos. Please select the image you prefer the most. You will also have the option to choose "Neither".

Click "Next" to begin the section.

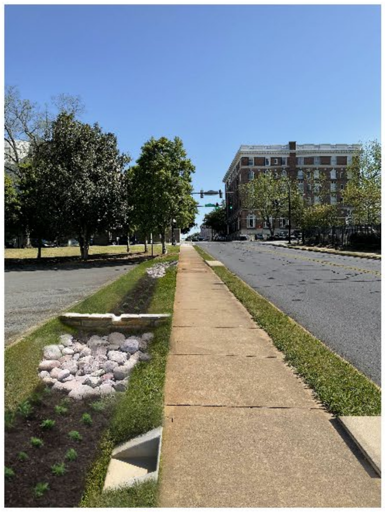
Back Next

0% 100%

CBC1_Random1

Imagine that you are walking down an urban street. Which of the following images would you prefer visually?

(1 of 4)



CBC1_Random1

Select

CBC1_Random1

Select

NONE: I wouldn't choose any of these.

CBC1_Random1

Select

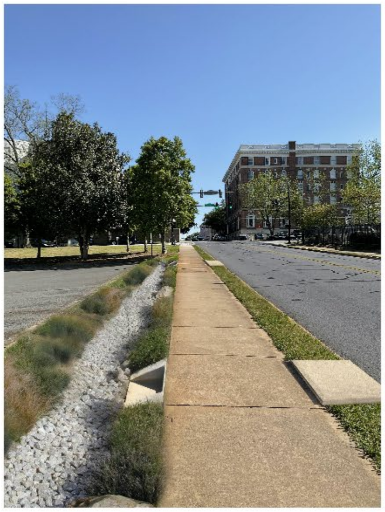
Back Next

0% 100%

CBC1_Random2

Imagine that you are walking down an urban street. Which of the following images would you prefer visually?

(2 of 4)



CBC1_Random2

Select

CBC1_Random2

Select

NONE: I wouldn't choose any of these.

CBC1_Random2

Select

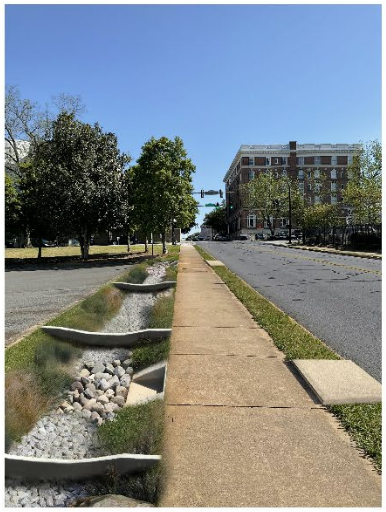
Back Next

0% 100%

CBC1_Random3

Imagine that you are walking down an urban street. Which of the following images would you prefer visually?

(3 of 4)



CBC1_Random3

Select

CBC1_Random3

Select

NONE: I wouldn't choose any of these.

CBC1_Random3

Select

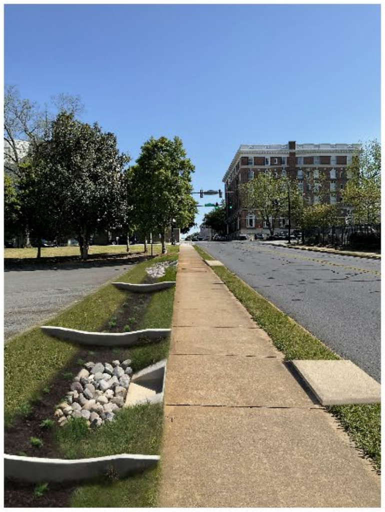
Back Next

0% 100%

CBC1_Random4

Imagine that you are walking down an urban street. Which of the following images would you prefer visually?

(4 of 4)



CBC1_Random4

Select

CBC1_Random4

Select

NONE: I wouldn't choose any of these.

CBC1_Random4

Select

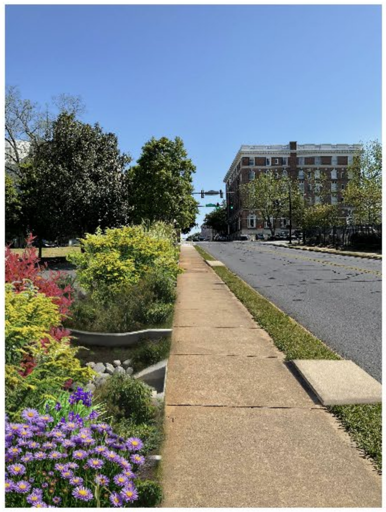
Back Next

0% 100%

CBC_Random1

Imagine that you are walking down an urban street. Which of the following images would you prefer visually?

(1 of 10)



CBC_Random1

Select

CBC_Random1

Select

NONE: I wouldn't choose any of these.

CBC_Random1

Select

Back Next

0% 100%

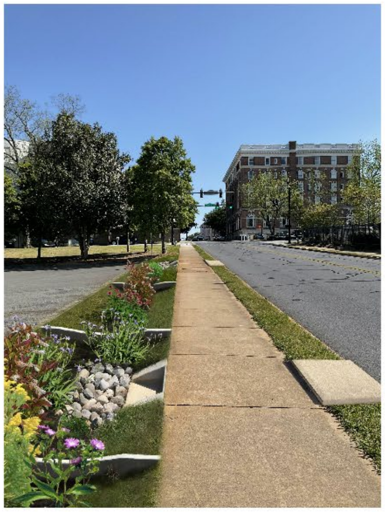
CBC_Random2

Imagine that you are walking down an urban street. Which of the following images would you prefer visually?

(2 of 10)

CBC_Random2

Select



CBC_Random2

Select

NONE: I wouldn't choose any of these.

CBC_Random2

Select

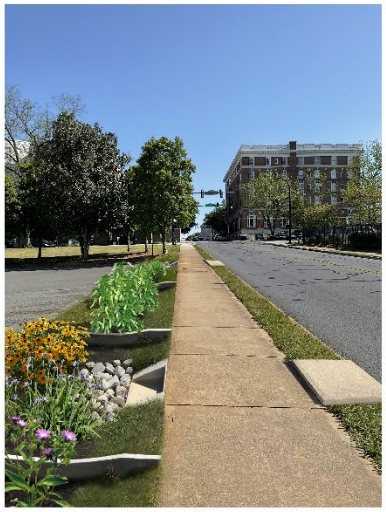
Back Next

0% 100%

CBC_Random3

Imagine that you are walking down an urban street. Which of the following images would you prefer visually?

(3 of 10)



CBC_Random3

Select

CBC_Random3

Select

NONE: I wouldn't choose any of these.

CBC_Random3

Select

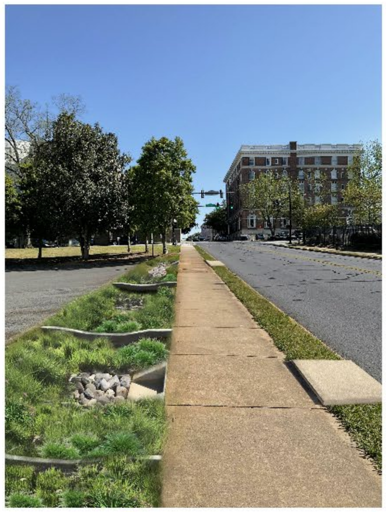
Back Next

0% 100%

CBC_Random4

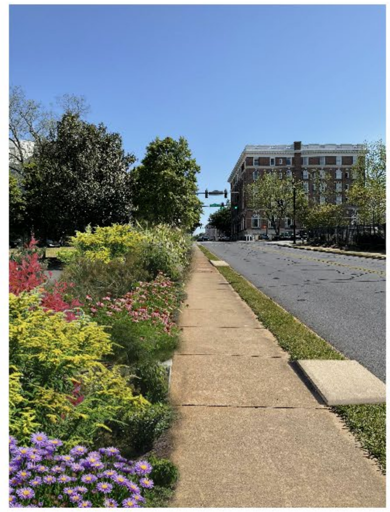
Imagine that you are walking down an urban street. Which of the following images would you prefer visually?

(4 of 10)



CBC_Random4

Select



CBC_Random4

Select

NONE: I wouldn't choose any of these.

CBC_Random4

Select

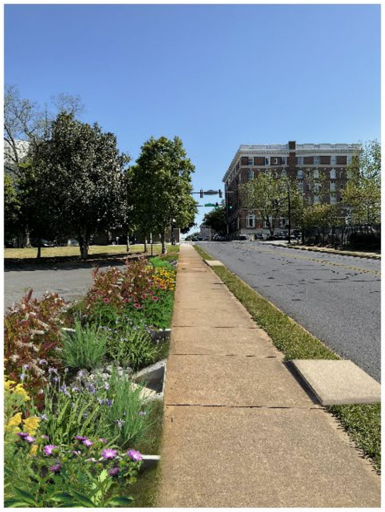
Back Next

0% 100%

CBC_Random5

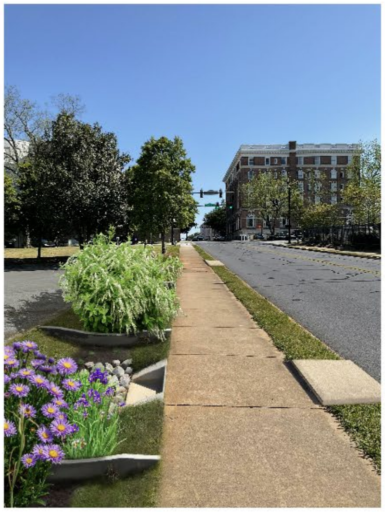
Imagine that you are walking down an urban street. Which of the following images would you prefer visually?

(5 of 10)



CBC_Random5

Select



CBC_Random5

Select

NONE: I wouldn't choose any of these.

CBC_Random5

Select

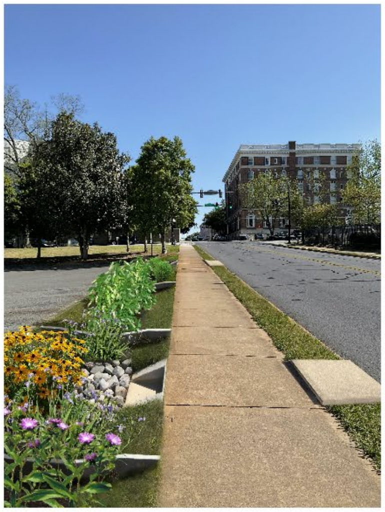
Back Next

0% 100%

CBC_Random6

Imagine that you are walking down an urban street. Which of the following images would you prefer visually?

(6 of 10)



CBC_Random6

Select

CBC_Random6

Select

NONE: I wouldn't choose any of these.

CBC_Random6

Select

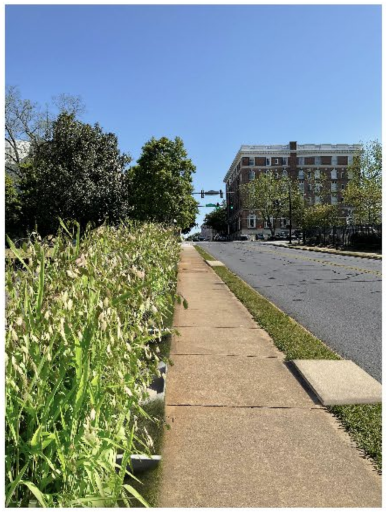
Back Next

0% 100%

CBC_Random7

Imagine that you are walking down an urban street. Which of the following images would you prefer visually?

(7 of 10)



CBC_Random7

Select

CBC_Random7

Select

NONE: I wouldn't choose any of these.

CBC_Random7

Select

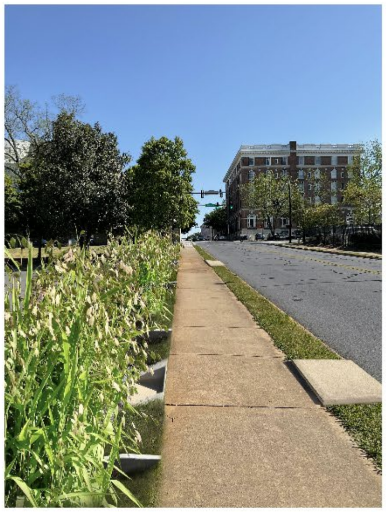
Back Next

0% 100%

CBC_Random8

Imagine that you are walking down an urban street. Which of the following images would you prefer visually?

(8 of 10)



CBC_Random8

Select

CBC_Random8

Select

NONE: I wouldn't choose any of these.

CBC_Random8

Select

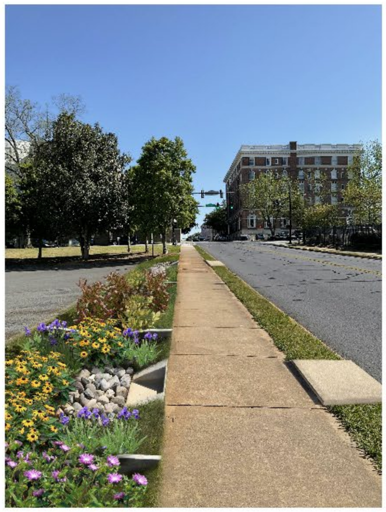
Back Next

0% 100%

CBC_Random9

Imagine that you are walking down an urban street. Which of the following images would you prefer visually?

(9 of 10)



CBC_Random9

Select

CBC_Random9

Select

NONE: I wouldn't choose any of these.

CBC_Random9

Select

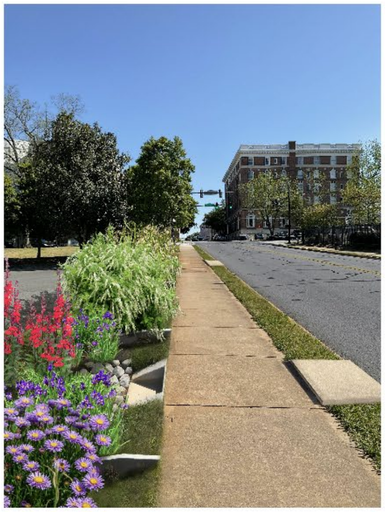
Back Next

0% 100%

CBC_Random10

Imagine that you are walking down an urban street. Which of the following images would you prefer visually?

(10 of 10)



CBC_Random10

Select

CBC_Random10

Select

NONE: I wouldn't choose any of these.

CBC_Random10

Select

Back Next

0% 100%

Terminate

This concludes the survey. Thank you very much for your time and participation!

0% 100%

C. Plant List

Ornamental Grass

- River Oats (Chasmanthium latifolium)

Shrub

- Virginia Sweetspire (Itea virginica)

Herbaceous Perennials

- Black-eyed Susan (Rudbeckia fulgida)
- Blue-flag Iris (Iris versicolor)
- Cardinal Flower (Lobelia cardinalis)
- Cinnamon Fern (Osmundastrum cinnamomeum)
- Common Rush (Juncus effusus)
- Goldenrod (Solidago canadensis)
- Purple Aster (
- Purple Coneflower (Echinacea purpurea)

D. Image Reference Websites

Table 8. Image Reference Websites

Image	Website
Material Use	https://slidetodoc.com/stormwater-management-presented-by-olmsted-township-building-department/ https://i.pinimg.com/originals/79/76/44/79764448099c6463226a799d0161c640.jpg
Check dams	https://www.susdrain.org/case-studies/case_studies/queen_maryrs_walk_llanelli.html https://www.flickr.com/photos/mocobio/11074050904
Plants	https://www.flickr.com/photos/44594806@N05/5100271908/ https://content.yardmap.org/learn/bioswales-for-stormwater-management/ Greendale_GrangeAve_2010_07_12 | Bioretention / bioswale in … | Flickr https://www.hgtv.com/outdoors/flowers-and-plants/new-england-asters https://www.outsidepride.com/seed/flower-seed/aster/aster-blue.html https://www.peacetreeorganix.com/#/blackeyed-susan/ https://david-szalay-plants.blogspot.com/2018/04/lobelia-speciosa-fan-burgundy.html https://hinsdalenurseries.com/products/cinnamon-fern/ https://edgeofthewoodsnursery.com/goldenrods-they-dont-make-you-sneeze-really https://memphisherbsociety.org/gardening-gone-herbs-september-2019/ https://commonsensehome.com/weekly-weeder-9-canada-goldenrod/ http://plants.blumengardens.com/12120027/Plant/7550/Prairie_Fire_Red_Switch_Grass/ https://www.netpsplantfinder.com// https://www.quia.com/jg/2718861list.html http://plants.beechwood-gardens.com/12130013/Plant/16833/Nicolas_Hakone_Grass/ https://davesgarden.com/guides/pf/showimage/4485/ https://www.wildflower.org/gallery/result.php?id_image=19378 https://nativeplantherald.prairienursery.com/2016/09/native-grasses-the-tall-and-short-of-it/ https://plantlust.com/plants/chasmanthium-latifolium/images/49106/

	https://plantlust.com/plants/10294/chasmanthium-latifolium/ https://www.clemson.edu/cafls/demo/plant_profiles/echinacea-purpurea.html https://hanaleikauaivacation.com/perennial-landscaping/ https://alchetron.com/Echinacea-purpurea

E. Statistical Analysis

Table 9. Counts Analysis for Combination 1

	A	B	C
1	Choice Tasks Included	All	
2		Random1, Random2, Random3, Random4	
3			
4	**Material Use**		
5		Total	
6	Total Respondents	46	
7	Turf	0.287	
8	Gravel and Stone	0.552	
9	Mulch	0.620	
10			
11	Within Att. Chi-Square	15.519	
12	D.F.	2	
13	Significance	p < .01	
14			
15			
16	**Check dam**		
17		Total	
18	Total Respondents	46	
19	No Check dam	0.479	
20	Concrete Check dam	0.484	
21	Stone Check dam	0.461	
22	Masonry Check dam	0.522	
23			
24	Within Att. Chi-Square	0.370	
25	D.F.	3	
26	Significance	not sig	
27			

28	**Material Use x Check dam**		
29			Total
30	Total Respondents		46
31	Turf	No Check dam	0.313
32	Turf	Concrete Check dam	0.323
33	Turf	Stone Check dam	0.179
34	Turf	Masonry Check dam	0.323
35	Gravel and Stone	No Check dam	0.531
36	Gravel and Stone	Concrete Check dam	0.645
37	Gravel and Stone	Stone Check dam	0.581
38	Gravel and Stone	Masonry Check dam	0.452
39	Mulch	No Check dam	0.600
40	Mulch	Concrete Check dam	0.484
41	Mulch	Stone Check dam	0.600
42	Mulch	Masonry Check dam	0.800
43			
44	Interaction Chi-Square		4.659
45	D.F.		6
46	Significance		not sig
47			
48			
49			
50	**None**		
51		Total	
52	Total Respondents	46	
53	None Chosen	0.027	

Table 10. Counts Analysis for Combination 2

	A	B	C
1	Choice Tasks Included	All	
2		Random1, Random2, Random3, Random4, Random5, Random6, Random7, Random8, Random9, Random10	
3			
4	**Vegetation Diversity**		
5		Total	
6	Total Respondents	47	
7	Low	0.281	
8	Medium	0.521	
9	High	0.657	

10			
11	Within Att. Chi-Square	46.301	
12	D.F.	2	
13	Significance	p < .01	
14			
15			
16	**Vegetation Density**		
17		Total	
18	Total Respondents	47	
19	Low	0.367	
20	Medium	0.495	
21	High	0.593	
22			
23	Within Att. Chi-Square	16.291	
24	D.F.	2	
25	Significance	p < .01	
26			
27			
28	**Vegetation Height**		
29		Total	
30	Total Respondents	47	
31	Low	0.463	
32	Medium	0.535	
33	Tall	0.455	
34			
35	Within Att. Chi-Square	2.490	
36	D.F.	2	
37	Significance	not sig	
38			
39	**Vegetation Diversity x Vegetation Density**		
40			Total
41	Total Respondents		47
42	Low	Low	0.233
43	Low	Medium	0.295
44	Low	High	0.314
45	Medium	Low	0.310
46	Medium	Medium	0.550
47	Medium	High	0.699
48	High	Low	0.552
49	High	Medium	0.647
50	High	High	0.778

	A	B	C
51			
52	Interaction Chi-Square		3.795
53	D.F.		4
54	Significance		not sig
55			
56			
57	**Vegetation Diversity x Vegetation Height**		
58			Total
59	Total Respondents		47
60	Low	Low	0.311
61	Low	Medium	0.333
62	Low	Tall	0.196
63	Medium	Low	0.452
64	Medium	Medium	0.646
65	Medium	Tall	0.470
66	High	Low	0.636
67	High	Medium	0.632
68	High	Tall	0.703
69			
70	Interaction Chi-Square		6.566
71	D.F.		4
72	Significance		not sig
73			
74			
75	**Vegetation Density x Vegetation Height**		
76			Total
77	Total Respondents		47
78	Low	Low	0.336
79	Low	Medium	0.406
80	Low	Tall	0.362
81	Medium	Low	0.475
82	Medium	Medium	0.569
83	Medium	Tall	0.434
84	High	Low	0.583
85	High	Medium	0.619
86	High	Tall	0.576
87			
88	Interaction Chi-Square		0.751
89	D.F.		4
90	Significance		not sig

91			
92			
93			
94	**None**		
95		Total	
96	Total Respondents	47	
97	None Chosen	0.030	