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Assessing Visual Preference among Fourth Grade Students for Habitat Components on Educational Green Roofs in Starkville, Mississippi

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By

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As urbanization grows wildlife habitat is displaced and fragmented. Vegetative roofs offer an innovative alternative to provide animal food and habitat in urban environments. This research study investigates how wildlife needs in a green roof ecosystem are interpreted through children's visual perception. A visual preference survey was administered to fourth-grade students in Starkville, Mississippi which offered paired photographs displaying basic vertebrate and invertebrate needs. The responses from 85 students (n=85) were compared to identify preferences for legible habitat components. The results of this survey showed that fourth-grade students could readily identify the basic habitat needs for birds but were less able to with insects. Students were intrigued with utilizing a green roof for learning and play. Green roofs have potential to be designed as innovative teaching tools to enhance science education in K-12 schools.

DEDICATION

I would like to dedicate this to my family who continuously encouraged me to pursue this passion. I never would have been able to complete this process without all of their support and encouragement.

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CHAPTER I

INTRODUCTION

Background

Green roofs are defined as building roofs that are covered with shallow soil and vegetative cover (Braaker, Ghazoul, Obrist & Moretti, 2014). The addition of green roofs provide many urban benefits that include storm water treatment, building energy conservation, and wildlife habitat (Oberndorfer et al., 2007). Green roofs intercept rainfall that occurs upon building rooftops, and in the process they collect, retain and cleanse storm water which reduces water pollution and flooding at drainage systems (Oberndorfer et al., 2007). They reduce structural heating and cooling costs as they add additional layers of drainage, impermeable barriers, soil, and plants; all which serve to better insulate rooftops. The addition of plants to building roofs also increases green urban infrastructure which provides more food sources and shelter for insects and birds.

The addition of green infrastructure in urban areas is invaluable as wildlife habitat loss and vegetative fragmentation are common products of increasing development (Theobald et al., 1997). An area's biodiversity is depleted as habitat, nesting areas, and foraging potential is displaced; and as a result, plants and animal species decline. Due to these concerns, there is potential for green roofs to create wildlife refuge and increase biodiversity upon rooftops in urban areas (Kadas, 2006, Dunnett & Kingsbury, 2004).

Biodiverse green roof design (Lundholm, 2006) can also incorporate a variety of different habitat types to add potential for increased plant biodiversity and urban wildlife.

Green roofs can serve to educate the public about the values of green infrastructure. As the idea of a vegetated building is still new in the United States, it is important for these biotechnologies to also include public education. Green roof design can include a variety of educational components that address ecological topics ranging from wildlife habitat to storm water infiltration.

Public education is important for wildlife needs on green roofs as many birds and mammals often require dense areas of shrubs and trees, which can be perceived as unmanaged to visitors. Previous research has shown high levels of preference for landscapes similar to African savanna habitat (Balling & Falk, 1982). This means that openly-viewed landscapes are more generally preferred as opposed to dense, structured thickets. This suggests that as wildlife habitat is decreased in cities, that species requiring dense habitat for nesting and shelter will also be decreased, unless the public understands and accepts the value of various landscape typologies. As mentioned by Thayer (1994), sustainable landscape and sustainable technology are necessary for environmental management and in order to have successful ecological design it must contain expression along with interpretation to be legible (Thayer, 1994).

Research Objectives

To explore how green roofs can serve as teaching laboratories, the objective of this research study is to investigate how wildlife habitat components in a green roof ecosystem are understood and viewed by fourth-grade students in Starkville, Mississippi.

This was assessed by distributing paper surveys to students that contain photographs of basic wildlife needs, and asked to record their understanding and preference of various habitat types using a Likert scale. These images exclusively contain green roof habitat in order to limit the scale down to the size of a miniature food web and focus on the space defined by the constraints of a green roof area. This constrained habitat model helps to focus attention on the four habitat components: food, water, cover and breeding space, while also limiting the variety of urban wildlife that would be expected to utilize these spaces concentrating on creatures with wings or accessibility to the roof. The data was then analyzed in order to determine student comprehension and preferences for visible habitat components. All four essential habitat requirements-- food, water, shelter and nesting space -- were represented in the survey. Comments and responses were collectively compared to determine preference and to establish recommendations for the design of green roof wildlife habitat for wildlife education purposes.

Organization of Thesis

This thesis contains four chapters which is organized by a literature review, a description of the research methodology, the data analysis, and discussion and results.

CHAPTER II

LITERATURE REVIEW

The following literature review chapter begins with a review of the loss of biodiversity in cities due to development encroachment. Second, it contains a discussion on how pocket greenspaces, including the role of green roofs, can create additional landscape connectivity and habitat. Third, it addresses potential green roof landscape ecological models, and prior research conducted for bee and butterfly responses to green roofs. Lastly, it describes prior visual studies on landscape preference and environmental education.

Habitat Loss, Connectivity and Urban Green Infrastructure

Habitat loss and fragmentation are common products of increasing urban development. As development and impervious surfaces increase and more wildlife habitat is lost, efforts to preserve biodiversity and re-create habitat must be increased. Wildlife habitat is most prevalent in rural settings or along buffer or edge zones of urban development. As noted by Tonietto, biodiversity is being directly impacted as certain pollinators have been declining in abundance (Tonietto, 2011). Biodiversity is important for ecological health and agricultural viability both in and around urban areas. Urban wildlife habitat, including valuable pollinator nesting and foraging habitat is being depleted within rapidly urbanized areas.

Green infrastructure in urban and suburban areas provides a viable option to increase wildlife habitat by acting as microhabitats that provide potential for connectivity. Connectivity is defined as the degree to which the landscape provides for animal movement (Brooker, Brooker, & Cale, 1999). Wildlife corridors and habitat patches can play an important role in ecosystem health and management. Reconciliation ecology, which is the modification of the anthropogenic environment to encourage non-human use and the preservation of biodiversity, is being encouraged and implemented in innovative ways (Francis, 2011). Reconciliation ecology projects can serve as links between large habitat patches and green spaces, providing and re-creating network connections where they previously existed.

Green Roofs as Part of Urban Green Infrastructure

Sprinkled amongst the hard surfaces of urbanized areas, patches of existing vegetation and habitat remain, often as fragmented remnants of a once-diverse ecosystem. The existing patches, coupled with planted greenspaces where people, work, live and play; are part of the overall green infrastructure of a city. Since space for green infrastructure comes at a premium cost in urbanized areas, communities often focus upon the creation of small patches of green wherever possible. Green roofs can provide a viable option for habitat re-creation in both rural and urban settings and can serve as connectors between existing habitat patches (Oberndorfer et al., 2007). Corridors and habitat patches can be linked with green roof habitat by strategic placement throughout an urban area to create green links and connections (Benvenuti, 2014).

Green roofs help to provide ecosystem services creating venues for this important urban wildlife habitat and increase the rich biodiversity of associated plants and insects.

Environmental benefits of green roofs come directly from their function as the ecosystems they mimic such as storm water treatment, energy conservation, and urban wildlife habitat (Oberndorfer et al., 2007). Ecosystem elements are interconnected and green roof function and potential can be increased through utilization of these relationships.

Roof Garden History and Context

Roof gardening dates back to ancient civilizations originating in Mesopotamia (Tian & Jim, 2011). Most recently, many European countries have made dramatic advancements and improvements to green roof technology. Germany and The Netherlands are two notable nations in recent green roof technological advancements. Green roofs act as living machines absorbing and transpiring storm water in addition to reducing runoff (Snodgrass & Snodgrass, 2009). Roof gardens have been increasing in scope and popularity around the world (Dunnett & Kingsbury, 2004). European municipalities are incorporating green roofs as a standard item in developments. The biodiversity potential of green roofs has been recognized in Basel, Switzerland and there are mandatory green roof requirements on newly constructed flat roofs (Brenneisen, 2003). Other biodiversity preservation tactics such as the utilization of natural soil materials can enhance ecological value and create habitat for rare and endangered species that have been displaced due to urbanization.

Extensive and Intensive Green Roofs

"Extensive green roof" describes a shallow depth of growing medium and is mainly used for environmental benefits such as insulating properties and storm water management (Weiler & Scholz-Barth, 2009). Greater plant diversity usually requires greater soil depth. Low growing horizontal spreading water storing alpine plants also known as succulents are hardy and suitable for green roofs (Weiler and Scholz-Barth 2009). Some sedums, proven effective green roof plants, are butterfly host plants. Wildflowers are a common seeding material upon green roofs (Benvenuti, 2014).

Vegetation with less vigorous root and resource requirements are better suited for extensive habitat. Intensive green roof systems describe greater depth of growing medium allowing for greater diversity of vegetation and normally require irrigation and more intensive maintenance (Weiler & Scholz-Barth, 2009). Differences between extensive and intensive roof types have various requirements in regard to structural integrity, plant communities, irrigation and maintenance (Oberndorfer et al., 2007). Semi-extensive green roofs hold great potential for diversification of roof plantings and could create more biodiversity at a roof level. Trees can be grown in containers or planters and placed strategically around to create dynamic rooftop gardens. Sun, wind, and water resources can be captured at rooftop locations as well.

Dependent upon the type of plant material, the height of roof vegetation may also contribute to roof shading and cooling effects. Whether intensive or extensive, green roofs are consistently comprised of some or all of the following layers: Vegetation, Growing media, Filter layer, Drainage layer, Protection fabric, Root barrier, Insulation, Waterproofing membrane, and a Roof deck (Weiler & Scholz-Barth, 2009).

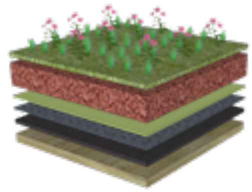

Figure 2.1 Green Roof Schematic

Graphic showing the different layers contained within a green roof (Counterman, 2016)

Green roofs create many benefits and enhancements in the quality of urban life. Green roofs help to slow, treat and retain storm water while shading the roof surface and provide an evaporated cooling effect that lowers local air temperature, reduces the urban heat island effect, provides storm water storage and treatment, creates urban habitat and increases aesthetics. Cumulative positive effects of increased habitat can be seen through groupings of green roofs and large-scale effects are noticed from sizable sites over time (Oberndorfer et al., 2007). Water runoff from vegetated roofs are subsequently cooled, slowed, reduced and overall watershed health is improved.

Similar to water quality, air quality improves through green roofs as well (Weiler & Scholz-Barth, 2009). Plants help to filter the air and reduce harmful pollutants. Green roofs act as extra insulation on buildings reducing heat loss in the cooler months and retaining cool interiors in warmer temperatures. Green roofs provide an external evaporative-cooling effect which reduces local urban heat island effects (Weiler & Scholz-Barth, 2009).

Green Roof Habitat Types

Ecological design and surrounding conditions must be considered when designing suitable habitat. Ecological design can be defined as the minimization of environmental impacts and integration with living processes, in other words "design resulting from humans constructive engagement with nature" (Van der Ryn & Cowan, 2007, p. 23). This type of design can provide greater visibility for natural processes and can allow a variety of opportunities for habitat interaction within urban areas. Increasing visibility of the natural world within the urban context creates opportunities for observing urban wildlife and considering the consequences of our human actions on the natural world. As Ian McHarg stated in his book Design with Nature, "Our eyes do not divide us from the world, but unite us with it. Let this be known to be true. Let us then abandon the simplicity of separation and give unity its due. Let us abandon the self-mutilation which has been our way and give expression to the potential harmony of man-nature. (McHarg, 1969, p. 5)."

Native vegetation can prove successful on green roofs and can help improve wildlife usage. Modern development has destroyed many existing habitat templates that were present within our urban areas (Lundholm, 2006). Growing interest and potential environmental and economic benefits of the utilization of entire plant communities on green buildings helps to create a better understanding of the habitat templates we design and how they function to improve the relationships between community structure, environmental conditions, and ecosystem functions (Lundholm, 2006). Jeremy Lundholm in his 2006 article entitled "*Green Roofs and Façades"* examines the implications of using natural ecosystems as templates for green roof design. While green roof plant selection has historically targeted drought-tolerant species, the incorporation of other features of rocky habitats may improve green roof functions and increase desirable habitat benefits.

Additionally, diversity in the planning and construction phase of a green roof leads to greater diversity in plants and animal presence on the respective green roof. Diversity is produced from the dynamic use of locally sourced waste materials, native soils and seeding or planting of native plant communities (Werthmann, 2007). This results in the successful re-creation of habitat and brownfield areas where that habitat has been displaced. Re-creation of the original pre-development conditions of the building footprint can recreate destroyed habitat and allow for species to thrive that would have otherwise been displaced.

Green Roofs Can Provide for Urban Wildlife Habitat

Urban wildlife is at risk in many regions of the United States as their habitat is being rapidly depleted (Tonietto, 2011). Wildlife habitat is considered suitable when the basic elements that are required to sustain life are present. These basic elements include access to food, water, cover from weather and predators, and protected space for nesting and resting/breeding (Leedy et al., 1978).

It has been observed that some mobile wildlife, in particular birds, will utilize green roofs primarily for foraging (food collection behavior), more often than nesting behavior (Gedge, 2003). Green roof habitat can contain many properties required for life, however some wildlife have specific requirements that must be met in order for the space to serve as a suitable and preferred habitat (Gedge & Kadas, 2005).

Benvenuti investigated the habitat potential of wildflower roofs in 2014. Wildflower roofs can work to connect ecological corridors and help to create habitat and opportunities for ecological observation in urban areas (Rugh & Liu, 2014). These roofs are able to be inserted into existing spaces within urban areas where there is lack of vegetation in order help to create habitat and opportunities for ecological observation in urban areas (Benvenuti, 2014). Rooftop gardens, green roofs, or eco-roofs as they are collectively called, all create opportunities to increase green space within our urban environment.

Native plants prove successful on green roofs and provide wildlife usage (Werthmann, 2007). A case study of the American Society of Landscape Architects Headquarters green roof in Washington D.C. was conducted in 2007, which was found to provide thriving insect communities, bird and other wildlife usage (Werthmann, 2007). Green roofs can also be designed to serve as various habitat types and functions. A landscape project entitled “Stunted Growth Pattern” at the Elsässertor office building in Basel, Switzerland by Vogt Landscape Architects and Herzog and de Meuron Architects features a grove of trees on the roof. Due to constricted root space the trees are dwarfed, and this bonsai-like rooftop garden is an example of design utilizing green infrastructure into unique forms. “Stunted Growth Pattern” is an example that unique habitats and environments can be created within green roof environments (Margolis, 2007). Jeremy Monsma emphasizes the importance roof ecosystems that contain large amounts of native vegetation and increased biodiversity to provide wildlife habitat and diverse ecosystem services (Monsma, 2011). Many wildlife preferred plants including various types of prairie vegetation have proven successful on green roofs (Weiler & Scholz-Barth, 2009). No evidence was found that native plants upon green roofs are any more pollen limited than when present at ground level.

Green roofs have the potential to serve as wildlife habitat hotspots, connecting wildlife habitat throughout urban areas. Pollinator populations on green roofs may contribute to more sustainable green roofs allowing for natural seeding and a more stable plant community (Colla, Willis, & Packer, 2009). Pollinators are good indicators of a healthy ecosystem meaning the survival of a large amount of other species depends on them. They provide an important ecological service pollinating over 85% of flowering plants, which is essential for agricultural viability (Xerces Society, 2011). Over one hundred agricultural crops in the United States require assistance from pollinators to be successful food producing species (Vaughan & Black, 2006). Pollinators often require specific plants and habitat conditions to successfully exist. Incorporation of native materials and vegetation has proven successful on green roofs and green wall structures and helps to attract a diverse range of wildlife, including pollinators (Werthmann, 2007). Urban rooftops are an underutilized asset in our communities that can be managed to provide wildlife habitat and additional ecosystem services (Dunnett & Kingsbury, 2004).

The idea introduced by Jeremy Lundholm about utilizing ecosystems as templates for green roof design is a great example of endless opportunities that are present in the growing green roof industry (Lundholm, 2006). Building upon this research, Jeremy Monsma has further explored the incorporation of native soils and plant communities to create a more dynamic biodiverse green roof ecosystem (Monsma, 2011). Utilizing a comprehensive process of spatial analysis and careful considerations for urban biodiversity, green roof networks, or urban habitat patches can be created throughout our urban areas (Carter & Fowler, 2008). With proper planning and effective policies in place green roofs can help to re-create lost habitat without utilizing any additional valuable urban space (Kadas, 2006).

Research gaps exist in regards to living roof and wall design along with their benefits and implications at a landscape scale where biodiversity can be maximized (Francis, 2011). Additionally, further research is needed regarding suitable plants for living roofs in various climate regions; as well as plants that provide benefits such as storm water contaminant removal and insect and wildlife resources like pollen. More interdisciplinary research is needed to maximize the benefits of these constructed ecosystems and their role and function within the urban environment (Oberndorfer et al., 2007).

Green Roofs and Butterfly Habitat

Plants and animals can establish successful communities within these rooftop ecosystems and species diversity can be found as more dynamic on the roof than in a semi-rural location (Brenneisen, 2003). Butterflies and their historical movement between habitat fragments imply that they do not require corridors and that they can sustain in habitat patches. Stoner and Joern (2004) suggest the construction of tower-like green butterfly garden materials to place within a garden area to create various diverse butterfly fragment habitat. These materials may help to increase butterfly visits to green roof habitat (Stoner & Joern, 2004).

Related recent research has shown invertebrate presence on green roofs to be similar to invertebrate presence in the surrounding landscape. In 2011, Jeremy Monsma surveyed a variety of green roofs for insect diversity across a region of Northern Michigan. Thriving bee communities were found upon the green roofs surveyed in Jeremy Monsma's study and several other recent green roof studies. Specific host plants should be incorporated when targeting butterflies and other individual pollinators. Pollinators are attracted to specific vegetation types and patterns within plantings, grouping plants of the same species has also been found to be beneficial in attracting more pollinators (Stoner & Joern, 2004).

Green Roofs and Bee Habitat

In a study by Colla, Willis, and Packer (2009), green roofs were found to successfully provide habitat for many urban bee species. The green roofs were surveyed for bee diversity and abundance and the researchers compared counts with ground level sites (Colla, Willis, & Packer, 2009). Kadas examined various green roofs in London and found that a high abundance of invertebrates, some determined to be rare or scarce, were found on the roofs. These green roofs studied in London contain a tremendous amount of biodiversity in a small region (Kadas, 2006). Biodiversity composition of bee communities on green roofs was found to be similar at ground level as measured by a variety of biodiversity measures (Colla, Willis, & Packer, 2009). Green roofs are potential bee conservation habitat within urban areas and can see great success if planted diversely with natives providing foraging and nesting habitat requirements of a variety of species (Tonietto, 2011). The potential for green roofs as habitat seems limitless when planted with desirable host plants, and foraging materials, along with the inclusion of other functional habitat requirements.

There have been close links determined between plant species and habitat or vegetation types being used as a model for the green roof (Lundholm, 2006). Rooftop habitats experience seasonally dry conditions, contain shallow soil and resilient vegetation. Extensive green roofs that are not designed for people to walk upon may provide excellent habitat areas. Some non-vegetated rooftops naturally support lichen and mosses and may provide premium habitat for birds who prefer cliff or open grassy habitats. These roofs that are described as brown roofs include roofs covered in loose material or substrate that have not been purposefully planted. These roofs re-create brownfield conditions through use of nearby byproducts sometimes resulting in spontaneous vegetation. These non-vegetated loose substrates can provide habitat for many invertebrate and bird species serving to increase biodiversity in urban areas (Werthmann, 2007). Depending upon local climate conditions green roofs can provide insect habitat islands and habitat reconstructions up to 20 stories high in the air (Ksiazeka, 2012). As discussed by Dunnett and Kingsbury, recent studies have shown that insect diversity on rooftops is similar to insect diversity at the same location on the ground level (Dunnett & Kingsbury, 2004). Additionally, conservation of rare or endangered species can be improved through the utilization of these unique habitat locations (Brenneisen, 2006).

Landscape Visual Preference

Most people in the United States now live in urban areas and they are often removed from sources of natural environments in their daily lives (Louv, 2005). As a result, most Americans comprehension of the natural world and wildlife needs are reduced and result in a “nature deficit disorder” (Louv, 2005). This contributes to a lack of understanding how the natural world works and how it can be perceived. Visual perception of ecological habitats is often influenced by the viewer’s personal aesthetics of what they observe (Balling & Falk, 1982).

Paul H. Gobster, USDA Forest Research Social Scientist, (2007) wrote that most people do not know how to assess ecological quality. He states that “humans cannot directly sense ecological quality, though there may be a tendency based on evolutionary processes and cultural expectations to assume that good ecological quality is associated with good aesthetic quality (Gobster, 2007, p. 962).” This suggests that more organized and aesthetically pleasing spaces are often perceived as the most desirable and effective habitat for wildlife. However, some suitable wildlife habitats can be perceived as disorderly, messy and not aesthetically pleasing, which can lead to significant problems for utilizing natural habitats as urban models (Mozingo, 1997).

Anderson notes that there is a visual preference for habitats resembling natural landscapes that appear absent of human influence (Anderson, 1981). This suggests that when a landscape appears to be in a natural state and untouched by anthropogenic influences it may be viewed as preferred habitat regardless of order, organization or aesthetics. An orderly and aesthetically pleasing environment may be perceived by humans to be suitable habitat, however while containing some positive ecological qualities, it may not possess all the required components of food, water, cover, and space to be an effective habitat for wildlife.

Landscape - Orderly (human preference)
Image Credit Counterman

Landscape - Natural (wildlife preference)
Image Credit Counterman

Visual perception is used to evaluate the visual characteristics and sensory perceptions of images (Kaplan & Herbert, 1987). Public perception of these visual characteristics is an effective tool for researchers to help determine the factors that contribute to aesthetic quality and functionality of landscapes. One common model that is utilized to determine visual preference, is termed *knowledge acquisition theory*. Knowledge acquisition theory includes four categories that determine a viewer's comprehension and preference of landscape scenes (Kaplan, 1975). These four categories consist of coherence, complexity, legibility and mystery.

Landscape – Coherence (planted strawberry field)
Image Credit Counterman

Coherence encompasses the orderliness or organization within the landscape (Kaplan, 1975). This focuses on the distribution of patterns, textures and shadows throughout the landscape. Landscapes can be composed of many different elements, which can influence the perception of complexity within the landscape. In general, the more elements that are visibly present, the more complex the landscape is perceived.

Landscape – Complexity (pitcher plant bog surrounded by pine savannah)
Image Credit Counterman

Mystery pertains to the concealing and revealing of all elements within the landscape (Kaplan, 1975). This includes both what can be seen and what is perceived or implied throughout the landscape. What aspects of the landscape are visible for viewing can affect what the viewer expects to find within the landscape that may be out of sight. For instance, a specific element in the landscape may be partially visible, which will require some inference from the viewer for complete landscape visualization. The perception of mystery encourages the viewer to look further into the scene, or the hiker to push further down the trail, searching for what may be concealed behind that next curve.

Landscape – Mystery (winding stream ecosystem)
Image Credit Counterman

Legibility refers to the visualization of the landscape as a three dimensional space (Kaplan, 1975). Legibility is concerned with the interpretation of the structure and function of the landscape and the conditions for movement within the space. Landscape elements that provide a variety of textures and identifiable landmarks can assist in defining the legibility of a place. Studies that utilize photographs to query visual preference among subjects must be selected wisely to prevent researcher bias or confusing images. Visual perception studies are capable of capturing social, cultural, economic and ecological features that can produce valuable information from participants who view those images (EPA, 2002). Participants provide feedback based on their visual preference choices about what they view and can assess from the provided landscape images.

Bishop and Leahy make a variety of suggestions for controlling variable comparisons and reducing noise in the background imagery (Bishop & Leahy, 1989). Their study found visual preference for digitally-enhanced images to be lower than original images. However some image criteria were developed that influence higher ratings. They suggest varying images for only one variable, such as a habitat component, while equalizing the remainder of the images to control for background distractions like topographic relief and elements located in the foreground and middle ground areas of the images. Additionally, Bergen suggested that digital images should represent all elements of the landscape as accurately as possible (Bergen, 1995). This will help prevent background details and other discrepancies to cause variation in preference rating. A stronger visual comparison can be made when there is a cohesive system in place to evaluate and edit those images.

The Importance of Visual Interpretation for Ecological Models

Interpretive education tools can be developed based on the perception of these successful landscape images, and unsuccessful images can be eliminated. Zube discusses the importance of accurately simulating the landscape image in order to recreate the actual experience of the landscape while influencing participant's perceptions of the landscape (Zube, 1988). It is important that the digital images are perceived as real images and the participant can develop perceptions accordingly. Landscape images that effectively convey successful habitat features can be utilized to develop learning tools for science education as well as public outreach education programs. This information can be utilized to help inform ecological design, and improve the educational demonstration potential of landscapes.

Thayer describes the concept of visual ecology, as a feedback system between organisms and habitat that requires transparency (Thayer, 1989). Actually viewing ecological processes can help to make complex natural processes visible and more understandable. When we can see and experience actual habitat upon a roof we can better understand and envision the wildlife that may utilize this habitat. When we have clear imageability we have full visibility. In addition this transparency can further emphasize our connections to nature.

Mozingo discusses the potential for merging ecology and aesthetics, stating that ecological values should be expressed in a meaningful and visible manner (Mozingo, 1997). Ecological landscapes should engage the public to promote widespread acceptance and longevity. Landscape architects have potential to contribute to overall ecological health by focusing on landscape ecology and regional implementation (Mozingo, 1997).

Environmental Education

Information obtained through visual perception studies can help to protect existing environmental features and inform the future development of additional educational tools. Images that successfully conveyed important habitat features through a visual perception study can have a lasting effect on participants. The benefits of some habitat features, such as stick bundles for insect habitat, may not have been previously understood by participants and may now receive proper respect and protection.

Place responsive pedagogy combines outdoor experience and environmental education techniques to teach through personal experience of the outdoor environment. Place responsive pedagogy theory incorporates human-environment interaction and attempts to improve human environmental understanding therefore resulting in positive environmental impact (Mannion, 2013). Environmental appreciation is fostered through outdoor education experiences. These outdoor education experiences can be enhanced through thoughtful development and implementation of comprehensive education tools that encourage exploration and understanding of the surrounding landscape.

Mississippi has recently been ranked in the bottom 10 states for 4th grade science education (USDOE, 2005). An emphasis is being placed on the development of research-based science standards and improvement of planning and instruction. The need for innovative science education tools has been identified and a new framework for science education is being embraced statewide. Learning objectives are being made more measurable and the state of Mississippi has adopted specific science standards for each grade level (USDOE, 2005). A place responsive pedagogy approach in Mississippi would create more opportunity for outdoor education experiences and foster a greater appreciation for the environment. Green roofs can provide opportunities to view and experience a variety of wildlife habitat types. Green roofs can be utilized as innovative science education tools in many climates, including Mississippi, and for a variety of habitat types. Outdoor learning can be experienced directly upon the rooftop of the school and students do not have to travel far to participate in place responsive pedagogy. For instance a prairie ecosystem could be recreated on the rooftop and wildlife habitat could be experienced directly above the classroom. Unique habitat types such as green roofs provide an innovative opportunity for science education with an emphasis on human environment interaction.

Mississippi Science Standards

The Mississippi Science Framework, MS Science 2010, establishes the educational content and standards for science education in all schools within the state of Mississippi. For life sciences basic environmental concepts are presented in kindergarten and more complex material is spiraled in progressive implements with each grade level. In the state of Mississippi, first grade science introduces the basic components that are required to sustain life, which include the need for food, water and shelter. Whereas in third grade, the science emphasis is on environmental conditions that organisms require (MS Science, 2010). The Mississippi state science standard for third grade (3.e) states that students shall "recall that organisms can survive only when in environments (deserts, tundras, forests, grasslands, taigas, wetlands) in which their needs are met and interpret the interdependency of plants and animals within a food chain, including producer, consumer, decomposer, herbivore, carnivore, omnivore, predator, and prey" (MS Science, 2010, p. 30). In the fourth grade an emphasis on human and habitat interaction is discussed in detail in science courses. Fourth grade science standard (4.d) states that students will "describe how human activities have decreased the capacity of the environment to support some life forms" (MS Science, 2010, p. 35). Also, the focus of learning promotes human-environment interaction and the effect humans have had on the environment; including air emissions and wildlife habitat displacement (MS Science, 2010). Students in the public school system are introduced to basic science concepts beginning in Kindergarten through the Youth Environmental Science (YES) program that encourages them to experience environmental interaction through a range of activities that may include walking in the woods, planting vegetables and even planting trees (MS Science, 2010). This first-hand environmental interaction teaches students about the impacts that humans have on the environment.

As a result of the emphasis the science standards place on human interactions with nature, fourth grade is an appropriate level to explore how natural resources are impacted through usage. Fourth graders are learning about cause and effect relevant to their immediate surroundings as well as the surrounding environment (MS Science, 2010). This is a great time to demonstrate how water quality can be significantly impacted both regionally and locally. Innovative storm water management tools and best management practices such as green roofs, green walls or biofilters can serve as a powerful teaching tool to demonstrate positive human environment interaction (Carter & Fowler, 2008). Green roofs are layered vegetated roof systems and can provide urban wildlife habitat and enhance biodiversity (Gedge & Kadas, 2005). Green walls are vegetated or modular systems that allow for vertical plant installations (Brenneisen, 2006). A biofilter is a pollution control device containing living material that functions to capture and biologically reduce or control pollutants. Green roofs and green walls can both function as biofilters (Dunnet, 2004). When installed together green roofs and green walls have potential to create habitat islands or urban wildlife habitat patches (Lundholm, 2006).

Storm water demonstration areas including green roofs can be observed and studied by students in order to witness actual storm water treatment and efficacy. For example, a science class could conduct an experiment to measure the amount of storm water runoff from a green roof versus the amount of runoff from an asphalt-shingled roof. This would provide a tangible example of storm water infiltration on the green roof and conversely storm water runoff from the asphalt roof. The students could measure the exact amount of rainwater that was absorbed by the green roof and compare it to the amount of runoff from the asphalt roof. Similarly, water quality testing of the same roof runoff has potential to inform students of the water quality benefits of green roofs.

Best management practices such as green roofs can also provide an accessible habitat for urban wildlife. Many species of birds and insects have been observed to utilize green roofs for feeding and even nesting opportunities (Brenneisen, 2003). Green roof surfaces could provide a space for urban wildlife observation and education while teaching about basic science concepts including components required to sustain life and human environment interaction. Very few research studies have been conducted to understand how green roofs and other storm water practices can be designed to teach students about wildlife habitat and their visual preferences.

The Future of Green Roof Education

The North American green roof industry has dramatically grown in the past decade. Increases have been noted in green roof scientific research, demonstration sites, and international conferences related to the green roof industry. An increase in industry leads to an increase of policies governing these practices. Carter and Fowler discuss multi-faceted and spatially focused green infrastructure policy instruments that have potential to provide planning and regulatory framework for regional implementation of storm water management practices policy (Carter & Fowler, 2008). Financial incentives in the form of density and storm water credits can help to overcome barriers of construction costs and activities related to the implementation of innovative technology. Additionally, green roof demonstration projects are emphasized for their relevance to increasing education, experience and awareness of the industry all of which influence related policy (Carter & Fowler, 2008). These education and outreach opportunities are crucial in influencing public opinion and support of green roof habitats (Carter & Fowler, 2008).

Green infrastructure provides a viable option to increase wildlife habitat by acting as microhabitats that provide many ecological benefits including improved air quality, air temperatures, and storm water management within a watershed (Snodgrass & Snodgrass, 2009). Wildlife habitat, including valuable nesting and foraging habitat is being depleted within these urbanized areas. Green roofs can help to provide venues for displaced urban habitat and the rich biodiversity of associated plants and insects. These biodiverse roofs can then serve as living classrooms for interactive learning and observation education.

In conclusion, green roofs provide valuable ecosystem services in our urban environment, while also providing wildlife habitat and visual greenery to be enjoyed by all. Green roofs are full of additional underutilized opportunities to harness available rooftop wind, water and solar energy (Dunnett & Kingsbury, 2004). There is also major potential for green roofs to serve as wastewater treatment areas and become incorporated into a grey water system for the building (Weiler & Scholz-Barth, 2009). A comprehensive solution can be attained that includes integrating local and regional planning and policies to support sustainable development practices through green infrastructure incorporation and habitat re-creation. These policies should be supported by incentives and actual tangible benefits that are immediately available to the general public. There are a variety of opportunities available to help shape and influence these policies and the growing green roof industry. Green roofs are likely to contribute to pollinator conservation efforts (Tonietto, 2011). There are opportunities to create more biodiverse green roofs and increase habitat expansion in the urban environment. Pollinator and wildlife friendly green roofs could even incorporate bee hives on the rooftops and honey production on the ground floor, effectively utilizing resources while producing more usable resources. These sustainable and biodiverse green roofs can be utilized as places of engagement and demonstration education. The potential for what can be grown and shown on a green roof is only limited by the resources available to create these unique spaces.

CHAPTER III

METHODOLOGY

The objective of this research study is to investigate how wildlife habitat components in a green roof ecosystem are understood and preferred by fourth-grade students in Starkville, Mississippi. Green roofs can provide an outdoor classroom experience and are being utilized for instructional purposes in a variety of international locations. As green roofs become more popular for student learning there is opportunity to increase wildlife legibility as part of the experience. An increase in wildlife habitat legibility can provide teaching tools within these outdoor classroom spaces and encourage active learning through wildlife observation. These rooftop learning labs can be designed to maximize wildlife habitat and increase biodiversity.

Survey Logistics

In order to better understand how green roof design can impact student learning of complimentary wildlife habitats, a visual preference survey was administered to fourth grade students at Henderson Ward Stewart Elementary School and Starkville Academy in Starkville, Mississippi. The Starkville Area Schools include 8 public schools and 2 private schools. Henderson Ward Stewart Elementary, a public school with grades second through fourth, and Starkville Academy, a private school with grades Pre-K through twelfth, were chosen due to the diverse representation of students from a variety of backgrounds. Utilizing an inclusive sample from both the public and private schools in Starkville allowed for a representative sampling of all population demographics present in town. In addition, many of the teachers at these facilities were enthusiastic about science education and willing to allow their students to participate in this study. Fourth grade subjects were chosen due to their grade level understanding of basic science concepts and experience regarding environmental conditions and habitat requirements. Additionally, fourth graders are old enough to be diversely opinionated but still young enough to maintain their original ideas from their surrounding peers (Wigfield, 1997). Often, by the time a student has reached the fourth grade in the Starkville area schools, the structured curriculum has allowed them to participate in a variety of outdoor learning experiences through field trips as well as on-campus learning activities (MS Science, 2010).

Administration and faculty at Henderson Ward Stewart Elementary and Starkville Academy were contacted November 1, 2016, and permission to administer the survey was requested through a letter by the researcher. A request for permission to utilize human subjects was submitted to the Institutional Review Board (IRB) at Mississippi State University and approval was confirmed on December 5, 2016 (IRB #16-244). The approval letter can be viewed in Appendix B. Student and parent consent documents that comply with the IRB approval for work with human subjects were distributed to participants prior to distribution of the visual preference survey that can be viewed in Appendix A.

Survey Instrument

A visual preference survey was selected as the preferred instrument for this study. This type of survey was preferred due to its accessibility and proven success of engaging participants that are not already experts in the subject matter (Al-Kodmany, 2002). Visual preference surveys can be easily modified to include a range of material and a variety of participants. Photographs are one of the most frequently used visual support tools to help determine users landscape preferences (Pinto-Correia, 2011). Utilizing digital photos provides for greater control of the landscape viewing experience, and provides the researcher with endless opportunity to display a variety of scenes. Additionally, past participants have reported this type of visualization tool as enjoyable (Kaplan & Herbert, 1987). This simple landscape preference survey method was selected as the proper tool to effectively engage fourth grade students.

Digital photo media was selected to create the images for the visual preference survey. Photographs have been found to be acceptable substitutes for the landscapes they represent (Bergen, 1995). Digital photography can produce high quality realistic images. Real color photos were selected as the base images for the survey in order to utilize photo manipulation to create realistic looking scenes (Pinto-Correia, 2011). The presence of color in the images allowed for specific details to be enhanced and highlighted within the realistic green roof scenes. The digital images were manipulated with light control, and layering was used to construct the scenes with legible habitat components (Al-Kodmany, 2002). This photo manipulation provided control over variables present and absent in the images. For example, the background could be controlled in each image to reduce visual distraction from the green roof scenes, and habitat components were easily added or modified within the scenes. The survey images were manipulated to include a variety of elements in order to simulate the green roof landscape as accurately as possible (Bergen, 1995). These manipulated images provide a realistic green roof scene that participants can comprehend even though many of them have never seen an actual green roof. Once the best representative green roof images were compiled, the green roof images containing legible habitat components were paired with green roof images without legible habitat components. Questions for each of the images state for participants to use a Likert scale ranging from one to five, in order to rank their preference for images. In this survey, one represents the respondent's perception as least likeable, and five as the most likeable. Respondents also have the opportunity to explain why they preferred one image to another, and they may circle where a legible habitat element can be found on the image.

Baseline Wildlife Knowledge

The survey instrument was constructed to assess baseline levels of student understandings of urban wildlife habitat and then record their visual preference of wildlife habitat. The survey is composed of the following sections: 1) introduction with wildlife knowledge content, and 2) visual preference survey. The introduction section begins with brief introductory statements and has seven questions about urban wildlife habitat requirements that will help determine the student's existing knowledge of basic wildlife requirements.

The first four wildlife content questions request a response of Yes or No to be circled. The first question reads: Do you think birds or bugs could live on the roof? This question is paired alongside an image of a dog house with a green roof. This image is intended to capture the participants attention and engage them with the material at a scale they can imagine viewing, the top of a dog house (Nicholson-Cole, 2005).

The second question reads: Would you agree with the following statement: Building more houses and apartments means less wildlife lives in town. This question is intended to encourage understanding of urban wildlife habitat.

The third question asks if wildlife habitat requirements are present at home or school it reads: Does your home or school have all the requirements for wildlife habitat? This question encourages the participants to consider the requirements for wildlife habitat and evaluate surrounding environments.

The fourth question asks about wildlife sightings at home or school, it reads: Do you ever notice wildlife around your home or school? This question is intended to help participants focus on past wildlife sightings and possibly encourage future urban wildlife observation.

The fifth question asks participants to fill in the blank, it reads: How many times have you seen wildlife in town during the last week? This question is intended to highlight the existence of urban wildlife, and allow the participants to realize they are already familiar with many of these creatures (Nicholson-Cole, 2005).

The sixth question talks about habitat features and asks participants to chose all the required features from a list. This question is intended to ensure that the participant has a complete understanding of the four features required for successful wildlife habitat.

The final wildlife content question reads: What type of wildlife do you think you could find on a green roof? This question is followed by a list of 12 types of wildlife ranging from a beetle to a deer and was intended to inspire creative thinking while answering the remaining visual preference questions. This brief introduction section helped to immediately engage the students and ignite their interest about green roof habitat, a subject matter most students are unfamiliar with as a topic.

Highlighting this information at the beginning of the visual preference survey provided an opportunity to connect the green roof urban wildlife habitat information to current science concepts that fourth graders are familiar with. Additionally, the wildlife context allowed an opportunity for questions prior to beginning the visual preference survey, ensuring that all participants had sufficient understanding of the subject matter (Presser, 2004). Following this baseline portion of the assessment, students were then presented with a visual preference survey component, which contains images of green roofs and the presence or absence of wildlife habitat requirements. The images are presented in pairs in the survey. Photomontage images for this research survey were compiled through image layering in Adobe Photoshop to represent a variety of green roof scenes that contain or do not contain legible habitat features and components. The tools within Photoshop were utilized in order to effectively highlight key habitat components while providing realistic looking images for the survey (Pinto-Correia, 2011). For example brightness and contrast were adjusted on some images in order to highlight some habitat elements. Additionally, some components like vegetation and nesting spaces were added or manipulated in some of the images. These images were paired together carefully every effort was made to ensure that the images were significantly similar in order for them to be comparable (Bergen, 1995).

The visual survey is structured so that respondents can record their preference ratings for each of the images—those that reflect green roof habitat with habitat features as well as those that lack visible or legible habitat features (Martin, 2004). For instance, when the survey lists a question about specific green roof habitat components, such as if a bird nest could be found there, respondents were expected to rank the highest score for the image that reflects the greatest nesting properties of green roof habitat, and the lowest score for the image that reflects the lowest frequency of nesting components. This preference score should reflect qualitative visibility of nesting sites in the image, meaning the scenes with more legible nesting properties score higher than the ones with less visible nesting components.

Questionnaire Creation

The survey instrument includes a total of 20 green roof images in order to show a wide diversity of habitat requirements. The basic wildlife needs of food, water, cover, and breeding areas are addressed within these images. Landscape elements were assessed based on their habitat potential and their legibility (Steinitz, 1990). The images are displayed in pairs, with one image having a green roof with a visible legible component requirement, and the other paired image contains a green roof without a legible habitat component visible.

Figure 3.1 Green Roof Habitat Legibility

The left image depicts butterfly food as flowering vegetation and where the image on the right depicts a more homogenous terrain lacking flowers and other butterfly vegetation.

The digital images used in the survey were mainly selected from the researchers personal digital image library. Five images were obtained through a Google search for biodiverse and dynamic green roofs. These images include Question 1.A, 2.A, 2.B, 3.B, and 4.B. The images were then digitally enhanced where necessary through a photomontage procedure so that each image contained background, middle ground and foreground elements (Shafer, 1969). This helped to provide continuity and context within the images. It is believed that visual preference choices are based on an individuals cultural makeup and collective life experiences, therefore a variety of scenes were selected for representation (Steinitz, 1990). The legibility of habitat elements within the photos is an important component for ease of student use; therefore easily recognizable habitat elements and features were selected. Legibility is the visual quality that creates understanding and comprehension of a place; landscape elements that provide a variety of textures and identifiable landmarks can assist in defining the legibility of a place (Kaplan, 1975). Determining legibility is related to how easily the viewer can determine orientation and readability of the environment (Balling & Falk, 1982).

All the photographs were chosen with intent to represent existing green roof habitat and contain features to help simulate a true green roof visitation (Nassauer, 1983). For example, horizon lines were left visible in order to ensure the viewer understood the image was taken on a rooftop. Questions regarding the habitat potential associated with each individual green roof image directly precede the images. This simple strategy provided clarity and organization for the participants (Steinitz, 1990).

The first two image pairs, Questions 1 and 2, ask about overall visual preference of the green roofs and inquire about a desire to visit and play on the roofs. These images were placed in the beginning of the survey to connect the participants to the subject matter and were selected for their aesthetic and visually engaging qualities (Nicholson-Cole, 2005). Image 1A was selected for the colorful and diverse vegetation that is both aesthetically pleasing and attractive for wildlife. Image 1B was selected for the interesting pathway and water feature, both factors were expected to interest and engage the participants.

Image 1A

Image 1B

Figure 3.2 Green Roof Habitat Engagement

The left image depicts flowering vegetation where the image on the right depicts a more organized terrain and water feature.

Image 2A was selected for the colorful ground markings, interesting walkways and diverse garden areas. Image 2B was selected for the diversity of vegetation and the unique stump features for climbing or relaxing.

Image 2A

Image 2B

Figure 3.3 Green Roof Habitat Usability

The left image depicts a colorful path and planted vegetation, where the image on the right depicts a less organized pathway and climbing features.

The next two pairs of images, Questions 3 and 4, inquire about the potential of a bird to locate food and water on the pictured green roofs. Participants are then asked to circle on the image where food or water may be found in the image respectively. Image 3A was selected for the diversity of vegetation including the easily recognizable corn plant in the foreground. Image 3B was selected for the homogenous, or similar, vegetation and the absence of fruits or flowers.

Image 3A

Image 3B

Figure 3.4 Green Roof Habitat Component Bird Food

The left image depicts vegetation including corn plants with edible food, where the image on the right depicts a homogenous ground cover and gravel.

Image 4A was selected for the large water feature in the foreground. Image 4B was selected for the small pond depression surrounded by vegetation on the green roof. The areas containing water were labeled as such to avoid confusion for the participants.

Image 4A

Image 4B

Figure 3.5 Green Roof Habitat Component Bird Water

The left image depicts a large water feature, where the image on the right depicts a small water depression.

The next two image pairs, Questions 5 and 6, inquire about the potential for cover and breeding space within the green roofs pictured. Participants are then asked to circle on the image where the cover or space may be found in the image respectively. Image 5A was selected for the diverse vegetation and bird boxes in the foreground. Image 5B was selected for the more homogenous vegetation and absence of manmade bird structures.

Image 5A Image 5B

Figure 3.6 Green Roof Habitat Component Bird Cover

The left image depicts bird house structures, where the image on the right depicts a variety of vegetation.

Image 6A was selected for the presence of nesting structures both on the roof and in the background trees. Image 6B was selected for the more homogenous vegetation and absence of manmade bird nesting structures.

Image 6A Image 6B

Figure 3.7 Green Roof Habitat Component Bird Breeding Space

The left image depicts bird nesting structures, where the image on the right depicts a more homogenous ground cover and gravel.

The remaining four image pairs inquire about habitat components for insects. The next two questions, Questions 7 and 8, ask participants to locate food and water sources for insects on the images and to determine the image they prefer that contains the legible habitat component. Participants are also asked to circle on the image where food or water for an insect may be found respectively in the image. Image 7A was selected for the flowering vegetation. Image 7B was selected for the more homogenous and less colorful vegetation.

Image 7A

Image 7B

Figure 3.8 Green Roof Habitat Component Insect Food

The left image depicts flowering vegetation, where the image on the right depicts a more homogenous ground cover and herbaceous material without flowers.

Image 8A was selected for the large water feature in the foreground. Image 8B was selected for the rock depressions creating small puddling areas located in between the vegetation.

Image 8A

Image 8B

Figure 3.9 Green Roof Habitat Component Insect Water

The left image depicts a large water feature, where the image on the right depicts a small water depressions.

The final two image pairs, Questions 9 and 10, inquire about cover and breeding space for insects on green roofs. Participants are also asked to circle on the images where the cover or space may occur. Image 9A was selected for the insect hotel structure in the scene. Image 9B was selected for the visible seat wall and the tall trees.

Image 9A

Image 9B

Figure 3.10 Green Roof Habitat Component Insect Cover

The left image depicts an insect housing structure, where the image on the right depicts a large seat wall and tall trees.

Image 10A was selected for the visible wood pile in the foreground and along the wall. Image 10B was selected for the homogenous groundcover and flowering vegetation.

Image 10A

Image 10B

Figure 3.11 Green Roof Habitat Component Insect Breeding Space

The left image depicts wood and stick piles, where the image on the right depicts a more homogenous ground cover and flowering vegetation.

All 20 of these images were selected based on their content, their presentation quality value, and their ability to be digitally manipulated. The image pairs were organized and digitally manipulated to present a legible habitat feature next to an image with out a legible habitat feature. Different images were paired next to each other and digital enhancements were made to calibrate the quality of the side-by-side images as well as to highlight legible habitat requirements.

Before habitat enhancement

After habitat enhancement

Figure 3.12 Green Roof Habitat Enhancement

The left image depicts vegetation, a pathway and a wall, where the image on the right has wood and stick piles added along the wall.

Survey Distribution

The survey was distributed over a period of twelve weeks to 60 students in three classes at Starkville Academy as well as 126 students in six classes that attend Henderson Ward Stewart in Starkville Mississippi. The students at Starkville Academy were presented the surveys in their classroom by the researcher. These surveys were presented to two classes of students at Starkville Academy on December 12, 2016 and to the third class on December 19, 2916. The introduction about green roof habitat was read aloud to the class and then the survey was completed. Students were permitted to ask questions while taking the survey and had time to ask additional questions upon completion of the survey. In conclusion some brief information about the green roof in Starkville at the Oktibbeha County Heritage museum was presented to the class. The students at Henderson Ward Stewart had the surveys delivered via USPS to their home addresses. These surveys were mailed out to Henderson Ward Stewart students on December 15, 2016 with a requested return date of January 15, 2017, surveys were collected through February 28, 2017. The same brief introduction about green roof habitat accompanied the mailed survey along with the researcher's contact information in case of questions.

The complete survey can be viewed in Appendix A.

CHAPTER IV

DATA ANALYSIS

Data Introduction

Question responses to the survey are analyzed to determine which images and habitat components are most often visually preferred by student respondents. For each question with a photograph accompaniment, the arithmetic means were calculated from the Likert scale results. The means for all photo pair questions were compared to find the most preferred images by students in order to determine their effectiveness of legible habitat requirements upon green roofs. Participants are expected to assign the highest ranking to the images that display the most legible habitat components.

Survey Analysis Process

Surveys completed by Starkville Academy students were collected on December 12th and December 19th by the researcher in the classroom at the conclusion of the presentation. The surveys completed by Henderson Ward Stewart students were distributed on December 15th and returned to the researcher via USPS beginning December 20th until February 28th. All 60 fourth grade students at Starkville Academy were presented the opportunity to complete the survey. A total of 54 Starkville Academy students were able to participate and successfully completed the survey, for a completion rate of 85%. One hundred and twenty six fourth grade students at Henderson Ward Stewart were sent surveys on December 15th. A total of 31 Henderson Ward Stewart students successfully completed and returned the survey, for a completion rate of 25%. From a total number of 186 surveys distributed 85 (n=85) surveys were successfully completed by Starkville area fourth grade students and collected by the researcher resulting in a response rate of 45.7%, which is within acceptable response standards by Dillman (2009). As displayed in Table 4.1 below, the surveys distributed and completed in the classroom at Starkville Academy received a significantly higher successful completion rate than the surveys distributed to Henderson Ward Stewart students via USPS.

Table 4.1 Survey Distribution

Date Distributed	**Number of students**	**Completed surveys**
12/12/2016 Starkville Academy	22	20
12/12/2016 Starkville Academy	18	17
12/19/2016 Starkville Academy	20	17
12/15/2016 Henderson Ward Stewart	126	31
Total	186	85

A table displaying the number of surveys distributed and completed during the survey period. The surveys distributed in the classroom had a much higher completion rate.

Once all 85 completed surveys were collected the data was compiled in an Excel spreadsheet. Data from each question on the survey was entered into the spreadsheet. Wildlife content questions and photograph pair Likert rankings were all entered as individual data points (Martin, 2004). The open-ended questions requesting narrative comments were coded for similar content and entered as individual data points in the spreadsheet. For the photograph pair questions the areas circled on the images were categorized and coded for similar content, and entered as individual data points in the spreadsheet (Bergen, 1995). This spreadsheet was then formatted for calculations and translation into SPSS. This formatting included simplifying variable names and assigning numerical codes to narrative data entries. Means were calculated and frequency distributions of Likert ratings were determined (Steinitz, 1990). Graphs and tables were then generated in Excel to clearly display the relevant data. When formatting and calculations in Excel were complete the dataset was opened in SPSS. Once the dataset was accessible in SPSS the relevant variables were coded for content and a variety of analyses were run. Arithmetic means of the Likert scale results and standard deviations were calculated and compared for each photographic pair. Frequency distributions were determined for the coded narrative comments and the areas circled on the images (Presser, 2004). Tables and graphs were generated in SPSS to display the relevant data.

Images that represent obvious legible habitat components were expected to produce the highest visual preference ratings among Starkville Mississippi fourth graders. These results can help to determine what types of images are most effective to identify legible habitat requirements upon green roofs (Nicholson-Cole, 2005). Through this assessment, visual preference for a variety of habitat components will be analyzed for an educational landscape.

Survey Results

The first two visual preference questions are intended to help connect the participants to the subject matter and engage them in visualizing a green roof visitation. The first question reads: *Would you like to visit these green roofs?* Two diverse green roof images depicting legible environments for learning are displayed directly below the question. The image on the left, Image 1A, displays a variety of colorful vegetation and background trees. The image on the right, Image 1B, has an interesting walkway and a large water feature.

Question 1: Visual Preference

Would you like to visit these green roofs?

Image 1A

Image 1B.

Both Image 1A and Image 1B produced a total of 85 responses. Participants were expected to respond with a stronger visual preference for the diverse and colorful vegetation presented in Image 1A. This expected outcome was confirmed as summarized in Figure 4.1 below, 57 out of 85 total responses (67%) indicated a stronger visual preference for Image 1A and selected the highest levels of visual preference (4 or 5) for Image 1A. Whereas Image 1B resulted in only 41 out of 85 responses (48%) that selected the highest levels of visual preference (4 and 5) for Image 1B.

Figure 4.1 Question 1 Compare Means

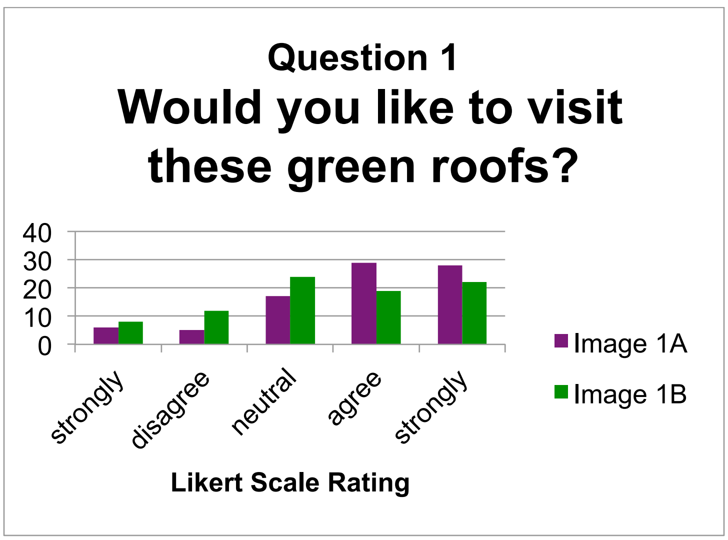

	Image 1A	Image 1B
N	85	85
Mean	3.80	3.41
Std. dev	1.173	1.275

A bar graph showing visual preference regarding visiting either green roof. Image 1A had a mean preference rating of 3.80 and was slightly preferred to image 1B with a mean of 3.41.

The results, summarized in Tables 4.2 and 4.3 below, indicate that both images convey a positive visual preference. Both images produced a high percentage of preference for visitation. This suggests that respondents would prefer to visit both green roofs presented in the Images. Image 1A had a total of (67%) of respondents selecting the highest levels of visual preference, where Image 1B had a total of (48%) of respondents selecting the highest levels of visual preference. Image 1A produced slightly higher Likert ratings with a mean of 3.8 while Image 1B Likert ratings produced a mean of 3.4. This suggests that Image 1B with the pathway and water features is slightly less preferred by students than Image 1A with the diverse colorful vegetation.

Table 4.2 Image 1A Frequency Distribution

Image 1A

	Frequency	Percent	Cumulative Percent
strongly disagree	6	7.1	7.1
disagree	5	5.9	12.9
neutral	17	20.0	32.9
agree	29	34.1	67.1
strongly agree	28	32.9	100.0
Total	85	100.0	

A table showing the visual preference results for Image 1A displays the frequency and percentage of responses.

Table 4.3 Image 1B Frequency Distribution

Image 1B

	Frequency	Percent	Cumulative Percent
strongly disagree	8	9.4	9.4
disagree	12	14.1	23.5
neutral	24	28.2	51.8
agree	19	22.4	74.1
strongly agree	22	25.9	100.0
Total	85	100.0	

A table showing the visual preference results for Image 1B displays the frequency and percentage of responses.

Question 1: Open Ended Comments

The first photographic pair question also provided the opportunity for participants to explain why they would or would not like to visit the green roofs displayed in the images. Directly beneath Images 1A and 1B respondents were asked: *Why or why not?* Not all participants wrote a response to these open-ended questions. This first open-ended question produced 58 written responses regarding Image 1A and 60 written responses regarding Image 1B from the 85 participants. There were a variety of responses recorded and these were individually coded into ten different categories displayed in Table 4.4 below.

Table 4.4 Question 1 Open Ended Comments

	Description	% Selected
Question 1A	beauty	17.2%
	wildlife	17.2%
	size	12.1%
	positive aesthetic	12.1%
	flowers	12.1%
	awesome/cool	8.6%
	unknown	6.9%
	negative aesthetic	5.2%
	vegetation	5.2%
	learning	3.4%
Question 1B	negative aesthetic	21.7%
	wildlife	21.7%
	positive aesthetic	16.7%
	size	11.7%
	water	8.3%
	vegetation	8.3%
	awesome/cool	6.7%
	unknown	3.3%
	beauty	1.7%
	learning	0.0%

A table showing the coded written responses for Question 1A and 1B displays the percentage of responses written in for each question.

The most common responses for Image 1A mentioned beauty (17.2%), wildlife (17.2%), size (12.1%) and positive aesthetics (12.1%). The open-ended comments that received the least attention regarded learning potential (3.4%), negative aesthetics (5.2%), and vegetation (5.2%). The most common responses for Image 1B mentioned negative aesthetics (21.7%), wildlife (21.7%), and positive aesthetics (16.7%). The open-ended comments that received the least attention included learning potential (0%), beauty (1.7%), and unknown (3.3%). These results displayed in Figure 4.2 below suggest that respondents considered aesthetics and wildlife as important while viewing both Images 1A and 1B.

Figure 4.2 Question 1 Compare: Why or Why not to visit this green roof

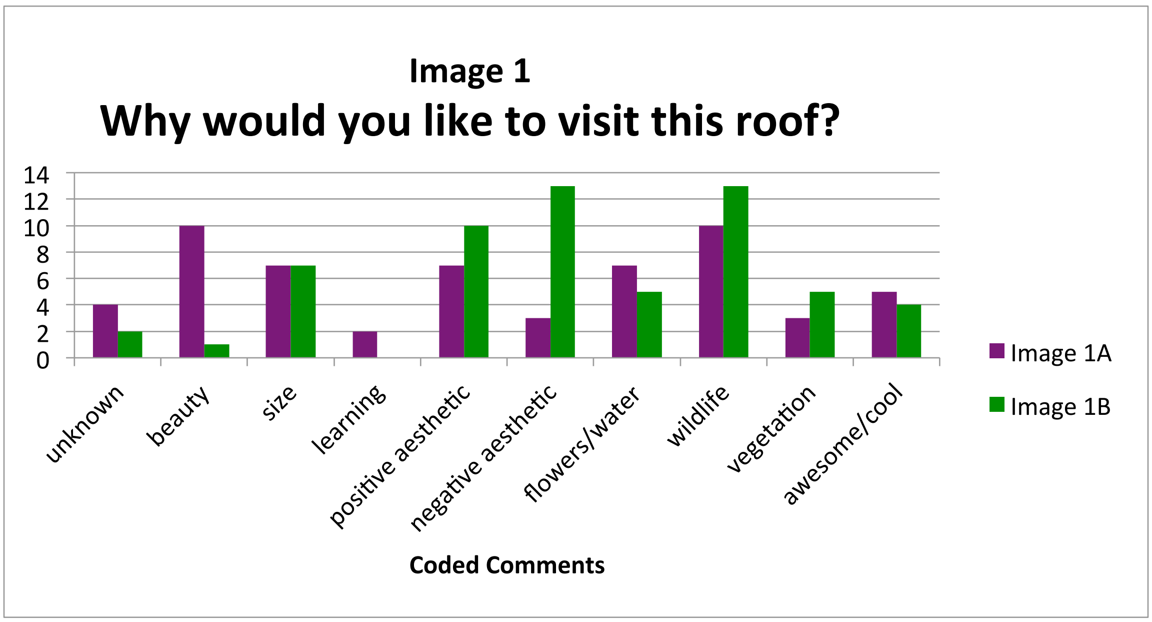

Figure 4.2 A bar graph showing reasons to visit these green roofs. The most common responses for image 1A were 1) beauty and 2) wildlife. The most common responses for image 1B were 1) negative aesthetics and 2) wildlife.

Question 2: Visual Preference

Would you like to have recess here?

Image 2A **Image 2B.**

Both Image 2A and Image 2B produced a total of 85 responses. Participants were expected to respond with a stronger visual preference for the diverse terrain and variety of vegetation presented in Image 2B. This expected outcome was confirmed as summarized in Figure 4.3 below, 59 out of 85 total responses (69%) indicated a slightly stronger visual preference for Image 2B and selected the highest levels of visual preference (4 or 5) for Image 2B. Whereas Image 2A resulted in only 53 out of 85 responses (62%) that selected the highest levels of visual preference (4 and 5) for Image 2A.

Figure 4.3 Question 2 Compare Means

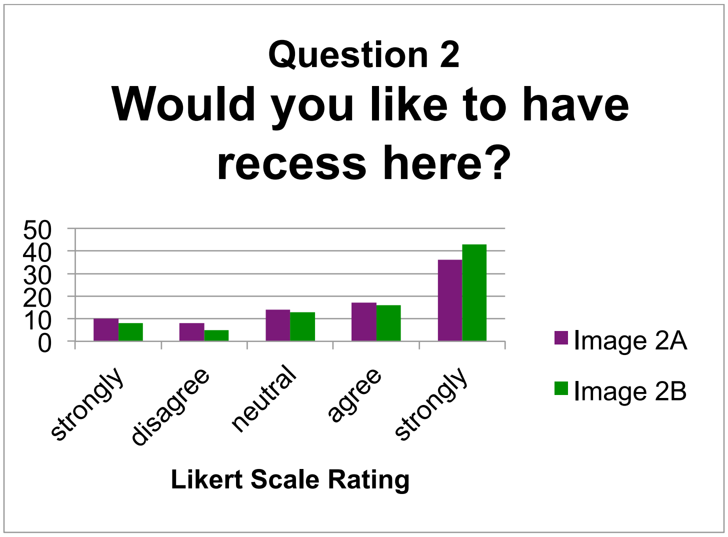

	Image 2A	Image 2B
N	85	85
Mean	3.72	3.95
Std. dev	1.402	1.327

Figure 4.3 A bar graph showing visual preference regarding having recess on either green roof. Image 2B had a mean preference rating of 3.95 and was slightly preferred to image 2A with a mean of 3.72.

The results summarized in Tables 4.5 and 4.6 below, indicate that both images convey an overall positive visual preference. Both images produced a high percentage of preference for recess playtime on the green roofs. This suggests that respondents would prefer to enjoy recess on both green roofs presented in the Images. Image 2B had a total of (69%) of respondents selecting the highest levels of visual preference, where Image 2A had a total of (62%) of respondents selecting the highest levels of visual preference. Image 2B produced only slightly higher Likert ratings with a mean of 3.95 while Image 2A Likert ratings produced a mean of 3.7. This suggests that Image 2B with the diverse vegetation and variety of play spaces is slightly more preferred by students than Image 2A with the bright painted pathway and colorful vegetation.

Table 4.5 Image 2A Frequency Distribution

Image 2A			
	Frequency	Percent	Cumulative Percent
strongly disagree	10	11.8	11.8
disagree	8	9.4	21.2
neutral	14	16.5	37.6
agree	17	20.0	57.6
strongly agree	36	42.4	100.0
Total	85	100.0	

A table showing the visual preference results for Image 2A displays the frequency and percentage of responses.

Table 4.6 Image 2B Frequency Distribution

Image 2B			
	Frequency	Percent	Cumulative Percent
strongly disagree	8	9.4	9.4
disagree	5	5.9	15.3
neutral	13	15.3	30.6
agree	16	18.8	49.4
strongly agree	43	50.6	100.0
Total	85	100.0	

A table showing the visual preference results for Image 2B displays the frequency and percentage of responses.

Question 2: Open Ended Comments

The second photographic pair question also provided the opportunity for participants to explain why they would or would not like to have recess on the green roofs displayed in the images. Directly beneath Images 2A and 2B respondents were asked: *Why or why not?* Not all participants wrote a response to these open-ended questions. This second open-ended question produced 58 written responses regarding Image 2A and 59 written responses regarding Image 2B from the 85 participants. There were a variety of responses recorded and these were individually coded into ten different categories displayed in Table 4.7 below.

Table 4.7 Question 2 Open Ended Comments

	Description	% Selected
Question 2A	size	29.3%
	positive aesthetic	15.5%
	awesome/cool	13.8%
	beauty	12.1%
	wildlife	8.6%
	flowers	6.9%
	negative aesthetic	5.2%
	unknown	3.4%
	learning	3.4%
	vegetation	1.7%
Question 2B	playspace	27.1%
	negative aesthetic	16.9%
	positive aesthetic	15.3%
	wildlife	15.3%
	size	10.2%
	unknown	5.1%
	awesome/cool	5.1%
	learning	3.4%
	beauty	1.7%
	vegetation	0.0%

A table showing the coded written responses for Question 2A and 2B displays the percentage of responses written in for each question.

The most common responses for Image 2A mentioned size (29.3%), positive aesthetics (15.5%), awesome/cool (13.8%), and beauty (12.1%). The open-ended comments that received the least attention regarded vegetation (1.7%), learning potential (3.4%), and unknown (3.4%). The most common responses for Image 2B mentioned playspace (27.1%), negative aesthetics (16.9%), and positive aesthetics (15.3%). The open ended comments that received the least attention included vegetation (0%), beauty (1.7%), and learning potential (3.4%). These results displayed in Figure 4.4 below suggest that respondents considered the size of the roof top and available playspace as extremely important while viewing both Images 2A and 2B.

Figure 4.4 Question 2 Compare: Why or Why not to visit this green roof

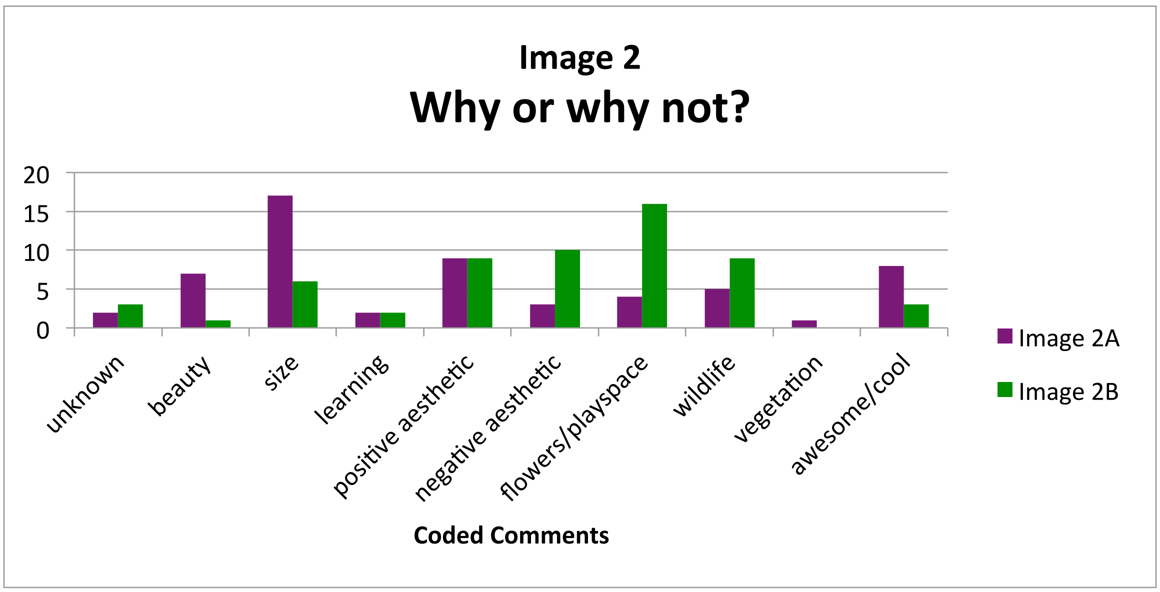

Figure 4.4 A bar graph showing reasons to visit these green roofs. The most common responses for image 2A were 1) size and 2) positive aesthetics. The most common responses for image 2B were 1) playspace and 2) negative aesthetics.

Question 3: Visual Preference

How likely would a bird find food on these green roofs?

Image 3A

Image 3B.

Both Image 3A and Image 3B produced a total of 85 responses. Participants were expected to respond with a stronger visual preference for the variety of vegetation presented including corn plants, a potential bird food source in Image 3A. This expected outcome was confirmed as summarized in Figure 4.5 below, 54 out of 85 total responses (64%) indicated a stronger visual preference for Image 3A and selected the highest levels of visual preference (4 or 5) for Image 3A. Whereas Image 3B resulted in only 25 out of 85 responses (29%) that selected the highest levels of visual preference (4 and 5) for Image 3B.

Figure 4.5 Question 3 Compare Means

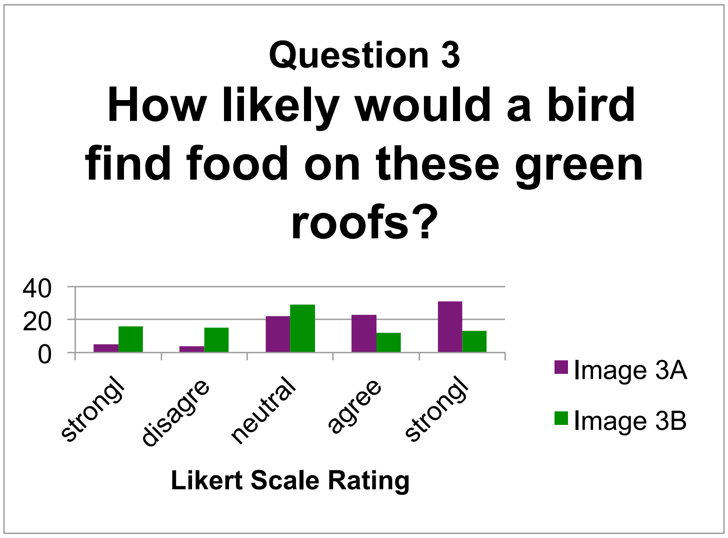

	Image 3A	Image 3B
N	85	85
Mean	3.84	2.89
Std. dev	1.153	1.300

Figure 4.5 A bar graph showing visual preference regarding where a bird may find food on either green roof image. Image 3A had a mean preference rating of 3.84 and was preferred to image 3B with a mean of 2.89.

The results summarized in Tables 4.8 and 4.9 below indicate that only one image conveys a positive visual preference. Image 3A produced a high percentage of preference for bird food potential. Image 3B produced the highest preference for the neutral category. This suggests that respondents prefer the green roof image containing the legible habitat component, edible vegetation, displayed in the Image 3A. Image 3A had a total of (54%) of respondents selecting the highest levels of visual preference, where Image 3B had a total of only (25%) of respondents selecting the highest levels of visual preference. Image 3A produced much higher Likert ratings with a mean of 3.8 while Image 3B Likert ratings produced a mean of 2.9. This suggests that Image 3A with the diverse and edible vegetation is greatly preferred by students than Image 3B with the homogenous vegetation and terrain.

Table 4.8 Image 3A Frequency Distribution

Image 3A

	Frequency	Percent	Cumulative Percent
strongly disagree	5	5.9	5.9
disagree	4	4.7	10.6
neutral	22	25.9	36.5
agree	23	27.1	63.5
strongly agree	31	36.5	100.0
Total	85	100.0	

A table showing the visual preference results for Image 3A displays the frequency and percentage of responses.

Table 4.9 Image 3B Frequency Distribution

Image 3B

	Frequency	Percent	Cumulative Percent
strongly disagree	16	18.8	18.8
disagree	15	17.6	36.5
neutral	29	34.1	70.6
agree	12	14.1	84.7
strongly agree	13	15.3	100.0
Total	85	100.0	

A table showing the visual preference results for Image 3B displays the frequency and percentage of responses.

Question 3: Open Ended Comments

The third photographic pair question also provided the opportunity for participants to clarify why they would or would not expect a bird to find food on the green roofs displayed in the images. Directly beneath Images 3A and 3B respondents were asked: *Circle where a bird may find food on the image above?* Not all participants circled an area on the image. This interactive question produced 58 circled responses regarding Image 3A and 66 circled responses regarding Image 3B from the 85 participants. There were a variety of responses recorded and these were individually coded into the different categories displayed in Table 4.10 below.

Table 4.10 Question 3 Image Response

	Description	% Selected
Image 3A	around corn plants	80.3%
	background rooftop area	12.1%
	all plant material	4.5%
	foreground vegetation	1.5%
	plants around cistern	1.5%
	entire surface area	0.0%
Image 3B	foreground vegetation	58.3%
	on ground between plants	16.7%
	entire surface area	12.5%
	background rooftop area	8.3%
	all plant material	2.1%
	vegetation clusters foreground and background	2.1%

A table showing the coded areas circled on the images for Image 3A and 3B displays the percentage of coded areas circled on each image.

The most common areas circled for Image 3A were around corn plants (80.3%), background rooftop area (12.1%), and all plant material (4.5%). The areas on the image that received the least attention were foreground vegetation (1.5%), and plants around cistern (1.5%). The most common areas circled for Image 3B were foreground vegetation (58.3%), on ground between plants (16.7%), and entire surface area (12.5%). The areas on the image that received the least attention included clusters of plant material foreground and background (2.1%), and all plant material (2.1%). These results displayed in Figure 4.6 below suggest that respondents considered food sources and vegetation as important while viewing both Images 3A and 3B.

Figure 4.6 Question 3 Compare: Image Response

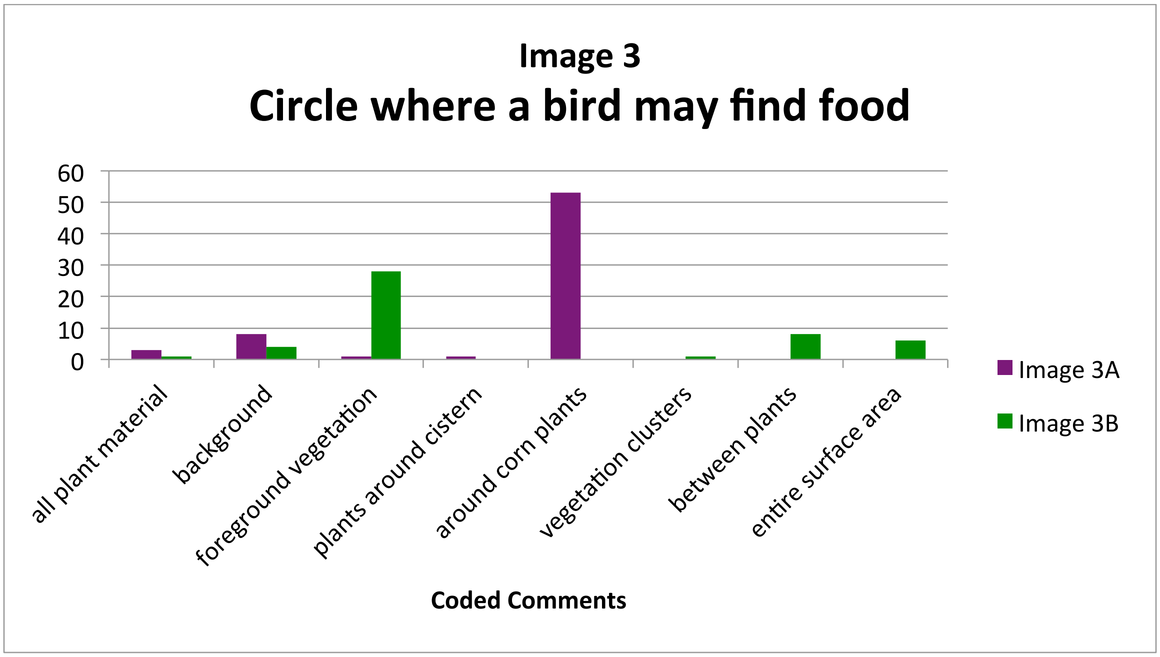

Figure 4.6 A bar graph showing where insects may find breeding space. Highest responses for image 3A were 1) around corn plants and 2) background. Highest responses for image 3B were 1) foreground vegetation and 2) between plants.

Question 4: Visual Preference

How likely would a bird find water on these green roofs?

Image 4A

Image 4B.

Both Image 4A and Image 4B produced a total of 85 responses. Participants were expected to respond with a stronger visual preference for the pond depression, an appropriately sized water feature for a bird, presented in Image 4B. This expected outcome was not confirmed as summarized in Figure 4.7 below, 73 out of 85 total responses (86%) indicated a stronger visual preference for Image 4A and selected the highest levels of visual preference (4 or 5) for Image 4A. Whereas Image 4B resulted in only 54 out of 85 responses (64%) that selected the highest levels of visual preference (4 and 5) for Image 4B.

Figure 4.7 Question 4 Compare Means

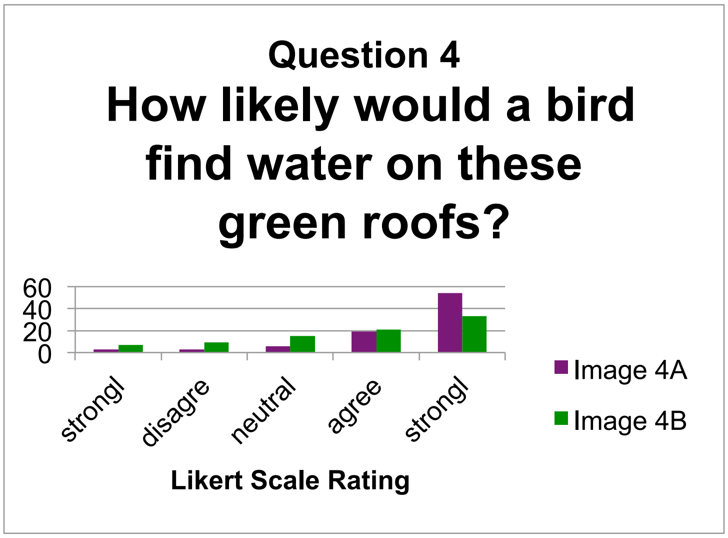

	Image 4A	Image 4B
N	85	85
Mean	4.39	3.75
Std. dev	1.013	1.299

Figure 4.7 A bar graph showing visual preference regarding where a bird may find water on either green roof image. Image 4A had a mean preference rating of 4.39 and was preferred to image 4B with a mean of 3.75.

The results summarized in Tables 4.11 and 4.12 below indicate that both images convey a positive visual preference. Both images produced a high percentage of preference for bird water potential. This suggests that respondents would consider bird water sources to be present in both green roof images. Image 4A had a total of (86%) of respondents selecting the highest levels of visual preference, where Image 4B had a total of (64%) of respondents selecting the highest levels of visual preference. Image 4A produced higher Likert ratings with a mean of 4.4 while Image 4B Likert ratings produced a mean of 3.8. This suggests that respondents slightly prefer the green roof image containing the legible habitat component, a large bird water source, displayed in the Image 4A.

Table 4.11 Image 4A Frequency Distribution

Image 4A

	Frequency	Percent	Cumulative Percent
strongly disagree	3	3.5	3.5
disagree	3	3.5	7.1
neutral	6	7.1	14.1
agree	19	22.4	36.5
strongly agree	54	63.5	100.0
Total	85	100.0	

Table 4.11 A table showing the visual preference results for Image 4A displays the frequency and percentage of responses.

Table 4.12 Image 4B Frequency Distribution

Image 4B

	Frequency	Percent	Cumulative Percent
strongly disagree	7	8.2	8.2
disagree	9	10.6	18.8
neutral	15	17.6	36.5
agree	21	24.7	61.2
strongly agree	33	38.8	100.0
Total	85	100.0	

A table showing the visual preference results for Image 4B displays the frequency and percentage of responses.

Question 4: Open Ended Comments

The fourth photographic pair question also provided the opportunity for participants to clarify where they would or would not expect a bird to find water on the green roofs displayed in the images. Directly beneath Images 4A and 4B respondents were asked: *Circle where a bird may find water on the image above?* Not all participants circled an area on the image. This interactive question produced 63 circled responses regarding Image 4A and 60 circled responses regarding Image 4B from the 85 participants. There were a variety of responses recorded and these were individually coded into the different categories displayed in Table 4.13 below.

Table 4.13 Question 4 Image Response

	Description	**% Selected**
Image 4A	water feature	95.2%
	background	1.6%
	flowering vegetation	1.6%
	turf	1.6%
Image 4B	pond depression	96.7%
	background	3.3%
	flowering vegetation	0.0%

A table showing the coded areas circled on the images for Image 4A and 4B displays the percentage of coded areas circled on each image.

The most common area circled for Image 4A was the water feature (95.2%). The water feature was circled as a water source for birds by almost every participant that circled something on Image 4A. The areas on the image that received the least attention were turf (1.6%), flowering vegetation (1.6%), and background features (1.6%). The most common area circled for Image 4B was the pond depression (96.7%). The pond depression was circled as a water source for birds by almost every participant that circled something on Image 4B. The areas on the image that received the least attention included flowering vegetation (0%), and background features (3.3%). These results displayed in Figure 4.8 below suggest that respondents considered visible water sources or potential water sources as important while viewing both Images 4A and 4B.

Figure 4.8 Question 4 Compare: Image Response

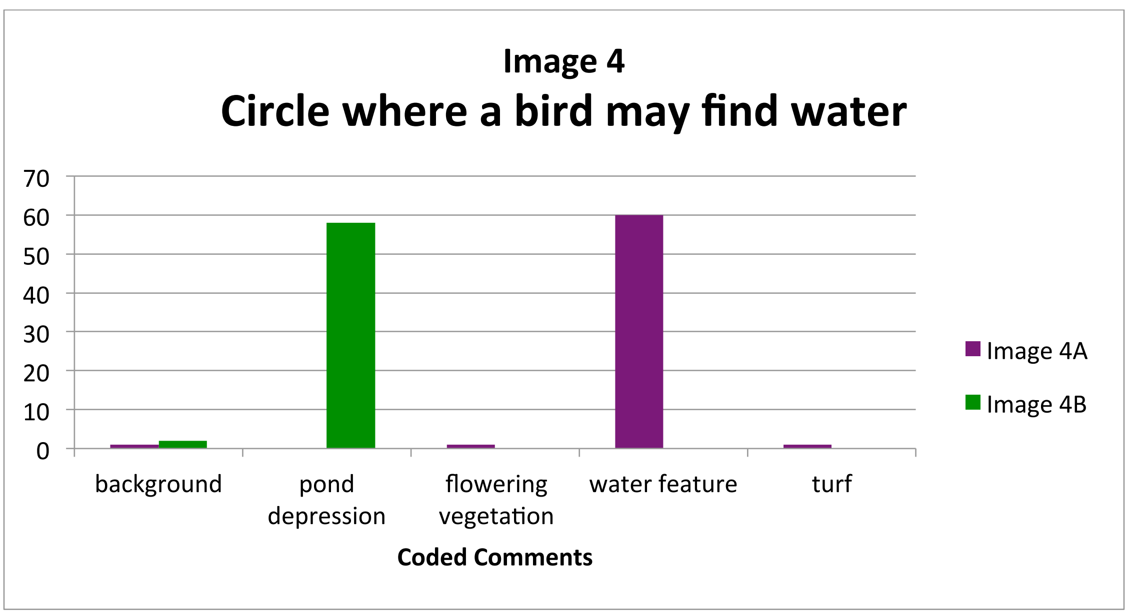

Figure 4.8 A bar graph showing where a bird may find water. The highest response for image 4A was 1) water feature. The highest responses for image 4B was 1) pond depression.

Question 5: Visual Preference

How likely would a bird find cover on these green roofs?

Image 5A

Image 5B.

Both Image 5A and Image 5B produced a total of 85 responses. Participants were expected to respond with a stronger visual preference for the bird house structures, presented in Image 5A. This expected outcome was confirmed as summarized in Figure 4.9 below, 64 out of 85 total responses (78%) indicated a stronger visual preference for Image 5A and selected the highest levels of visual preference (4 or 5) for Image 5A. Whereas Image 5B resulted in only 28 out of 85 responses (33%) that selected the highest levels of visual preference (4 and 5) for Image 5B

Figure 4.9 Question 5 Compare Means

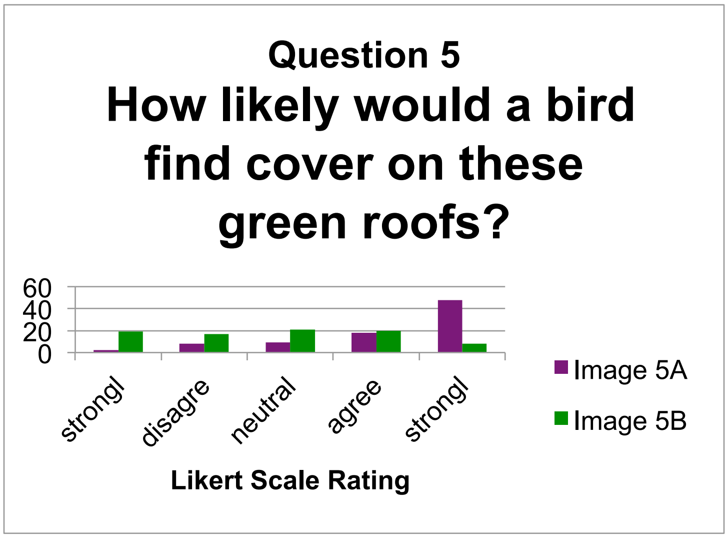

	Image 5A	Image 5B
N	85	85
Mean	4.20	2.78
Std. dev	1.111	1.294

Figure 4.9 A bar graph showing visual preference regarding where a bird may find cover on either green roof image. Image 5A had a mean preference rating of 4.20 and was preferred to image 5B with a mean of 2.78.

The results summarized in Tables 4.14 and 4.15 below indicate that only one image conveys a positive visual preference. Image 5A produced a high percentage of preference for bird cover potential. Image 5B produced the highest preference for the neutral category. This suggests that respondents prefer the green roof image containing the legible habitat component, bird house cover, displayed in the Image 5A. Image 5A had a total of (78%) of respondents selecting the highest levels of visual preference, where Image 5B had a total of only (33%) of respondents selecting the highest levels of visual preference. Image 5A produced much higher Likert ratings with a mean of 4.2 while Image 5B Likert ratings produced a mean of 2.8. This suggests that Image 5A with the bird house structures is greatly preferred by students than Image 5B with the variety of vegetation.

Table 4.14 Image 5A Frequency Distribution

Image 5A

	Frequency	Percent	Cumulative Percent
strongly disagree	2	2.4	2.4
disagree	8	9.4	11.8
neutral	9	10.6	22.4
agree	18	21.2	43.5
strongly agree	48	56.5	100.0
Total	85	100.0	

A table showing the visual preference results for Image 5A displays the frequency and percentage of responses.

Table 4.15 Image 5B Frequency Distribution

Image 5B

	Frequency	Percent	Cumulative Percent
strongly disagree	19	22.4	22.4
disagree	17	20.0	42.4
neutral	21	24.7	67.1
agree	20	23.5	90.6
strongly agree	8	9.4	100.0
Total	85	100.0	

A table showing the visual preference results for Image 5B displays the frequency and percentage of responses.

Question 5: Open Ended Comments

The fifth photographic pair question also provided the opportunity for participants to clarify where they would or would not expect a bird to find cover on the green roofs displayed in the images. Directly beneath Images 5A and 5B respondents were asked: *Circle where a bird may find cover on the image above?* Not all participants circled an area on the image. This interactive question produced 73 circled responses regarding Image 5A and 44 circled responses regarding Image 5B from the 85 participants. There were a variety of responses recorded and these were individually coded into the different categories displayed in Table 4.16 below.

Table 4.16 Question 5 Image Response

	Description	**% Selected**
Image 5A	birdhouses	94.5%
	all vegetation	2.7%
	background	2.7%
	aloe plant	0.0%
	foreground vegetation	0.0%
	shaded areas between vegetation	0.0%
Image 5B	background	59.1%
	foreground vegetation	13.6%
	shaded areas between vegetation	13.6%
	all vegetation	6.8%
	aloe plant	6.8%
	birdhouses	0.0%

A table showing the coded areas circled on the images for Image 5A and 5B displays the percentage of coded areas circled on each image.

The most common areas circled for Image 5A were the birdhouses (94.5%), all vegetation (2.7%), and background (2.7%). The areas on the image that received the least attention were aloe plant (0%), foreground vegetation (0%), and shaded areas between vegetation (0%). The most common areas circled for Image 5B were background features (59.1%), foreground vegetation (13.6%), and shaded areas between vegetation (13.6%). The areas on the image that received the least attention included birdhouses (0%), aloe plant (6.8%), and all vegetation (6.8%). These results displayed in Figure 4.10 below suggest that respondents considered birdhouse structures and background features as important while viewing both Images 5A and 5B.

Figure 4.10 Question 5 Compare: Image Response

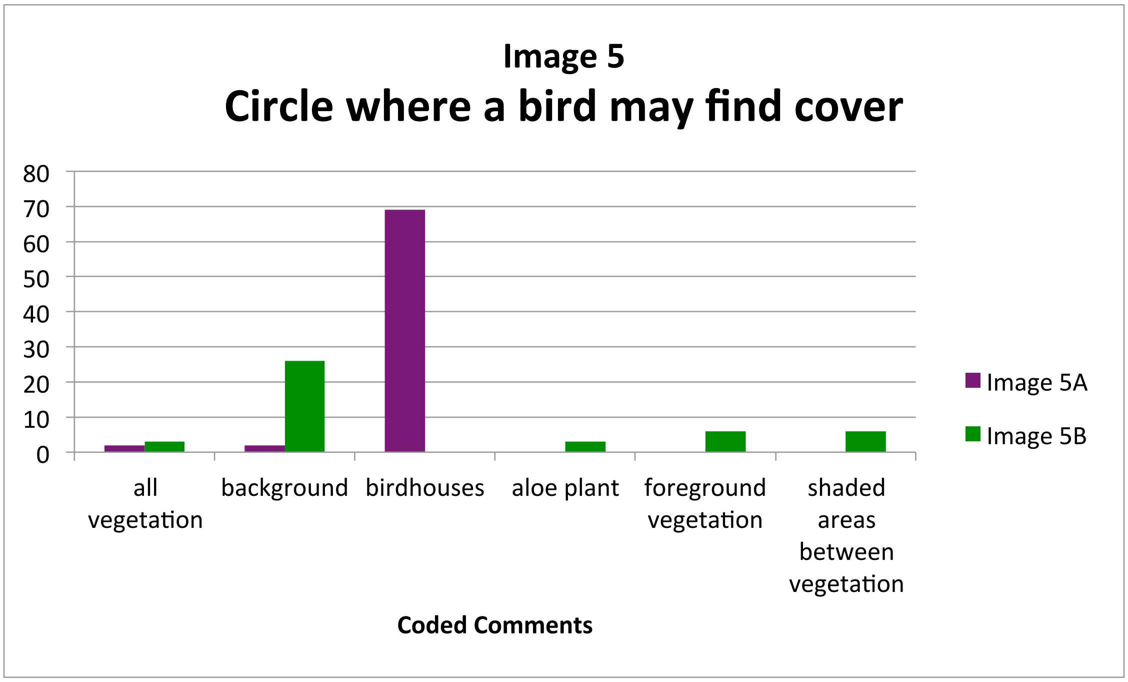

Figure 4.10 A bar graph showing where a bird may find cover. Highest responses for image 5A were 1) birdhouses 2) all vegetation and background. Highest responses for image 5B were 1) background 2) foreground vegetation and shaded areas between vegetation.

Question 6: Visual Preference

How likely would a bird find breeding space on these green roofs?

Image 6A **Image 6B.**

Both Image 6A and Image 6B produced a total of 85 responses. Participants were expected to respond with a stronger visual preference for the bird nesting structures, presented in Image 6A. This expected outcome was confirmed as summarized in Figure 4.11 below, 58 out of 85 total responses (68%) indicated a stronger visual preference for Image 6A and selected the highest levels of visual preference (4 or 5) for Image 6A. Whereas Image 6B resulted in only 53 out of 85 responses (62%) that selected the highest levels of visual preference (4 and 5) for Image 6B.

Figure 4.11 Question 6 Compare Means

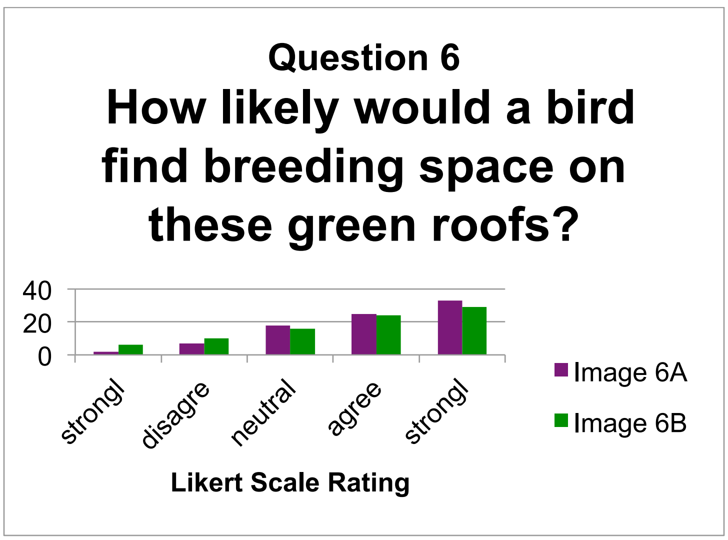

	Image 6A	Image 6B
N	85	85
Mean	3.94	3.71
Std. dev	1.073	1.252

Figure 4.11 A bar graph showing visual preference regarding where a bird may find breeding space on either green roof image. Image 6A had a mean preference rating of 3.94 and was slightly preferred to image 6B with a mean of 3.71.

The results summarized in Tables 4.17 and 4.18 below indicate that both images convey a positive visual preference. Image 6A produced a slightly higher percentage of preference for bird breeding space potential. Both images produced a high percentage of preference for bird breeding space potential. This suggests that respondents would consider bird breeding spaces to be present in both green roof images. Image 6A had a total of (68%) of respondents selecting the highest levels of visual preference, where Image 6B had a total of only (62%) of respondents selecting the highest levels of visual preference. Image 6A produced slightly higher Likert ratings with a mean of 3.9 while Image 6B Likert ratings produced a mean of 3.7. This suggests that Image 6A with the bird nesting structures is only slightly preferred by students than Image 6B with the variety of vegetation and background trees. This suggests that respondents slightly prefer the green roof image containing the legible habitat component, bird nesting space, displayed in the Image 6A.

Table 4.17 Image 6A Frequency Distribution

Image 6A

	Frequency	Percent	Cumulative Percent
strongly disagree	2	2.4	2.4
disagree	7	8.2	10.6
neutral	18	21.2	31.8
agree	25	29.4	61.2
strongly agree	33	38.8	100.0
Total	85	100.0	

A table showing the visual preference results for Image 6A displays the frequency and percentage of responses.

Table 4.18 Image 6B Frequency Distribution

Image 6B

	Frequency	Percent	Cumulative Percent
strongly disagree	6	7.1	7.1
disagree	10	11.8	18.8
neutral	16	18.8	37.6
agree	24	28.2	65.9
strongly agree	29	34.1	100.0
Total	85	100.0	

A table showing the visual preference results for Image 6B displays the frequency and percentage of responses.

Question 6: Open Ended Comments

The sixth photographic pair question also provided the opportunity for participants to clarify where they would or would not expect a bird to find breeding space on the green roofs displayed in the images. Directly beneath Images 6A and 6B respondents were asked: *Circle where a bird may find space on the image above?* Not all participants circled an area on the image. This interactive question produced 69 circled responses regarding Image 6A and 60 circled responses regarding Image 6B from the 85 participants. There were a variety of responses recorded and these were individually coded into the different categories displayed in Table 4.19 below.

Table 4.19 Question 6 Image Response

	Description	% Selected
Image 6A	bird nesting structures	59.4%
	background	29.0%
	tallest trees	4.3%
	foreground vegetation	4.3%
	entire image	1.4%
	midground vegetation	1.4%
	gravel border	0.0%
Image 6B	background	73.3%
	midground vegetation	11.7%
	foreground vegetation	8.3%
	entire image	3.3%
	gravel border	1.7%
	tallest trees	1.7%
	bird nesting structures	0.0%

A table showing the coded areas circled on the images for Image 6A and 6B displays the percentage of coded areas circled on each image.

The most common circled areas for Image 6A regarded bird nesting structures (59.4%), background (29.0%), tallest trees (4.3%) and foreground vegetation (4.3%). The areas on the image that received the least attention included gravel border (0%), midground vegetation (1.4%), and entire image (1.4%). The most common circled areas for Image 6B were background (73.3%), midground vegetation (11.7%), and foreground vegetation (8.3%). The areas on the image that received the least attention included foreground vegetation (0%), tallest trees (1.7%), and gravel border (1.7%). These results displayed in Figure 4.12 below suggest that respondents considered bird nesting structures and background features as important while viewing both Images 6A and 6B.

Figure 4.12 Question 6 Compare: Image Response

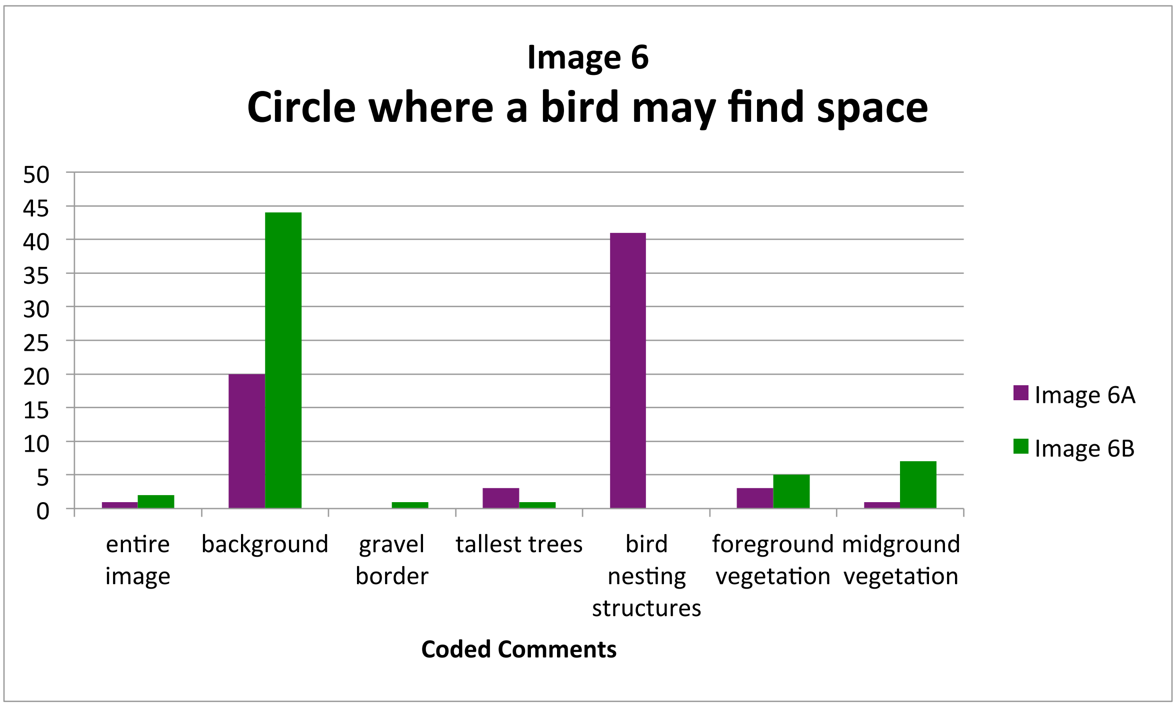

Figure 4.12 A bar graph showing where a bird may find breeding space. Highest responses for image 6A were 1) bird nesting structures and 2) background. Highest responses for image 6B were 1) background and 2) midground vegetation.

Question 7: Visual Preference

How likely would a butterfly find food on these green roofs?

Image 7A

Image 7B.

Both Image 7A and Image 7B produced a total of 85 responses. Participants were expected to respond with a stronger visual preference for the variety of vegetation presented including flowering plants, a potential butterfly food source in Image 7A. This expected outcome was confirmed as summarized in Figure 4.13 below, 69 out of 85 total responses (81%) indicated a stronger visual preference for Image 7A and selected the highest levels of visual preference (4 or 5) for Image 7A. Whereas Image 7B resulted in only 22 out of 85 responses (26%) that selected the highest levels of visual preference (4 and 5) for Image 7B.

Figure 4.13 Question 7 Compare Means

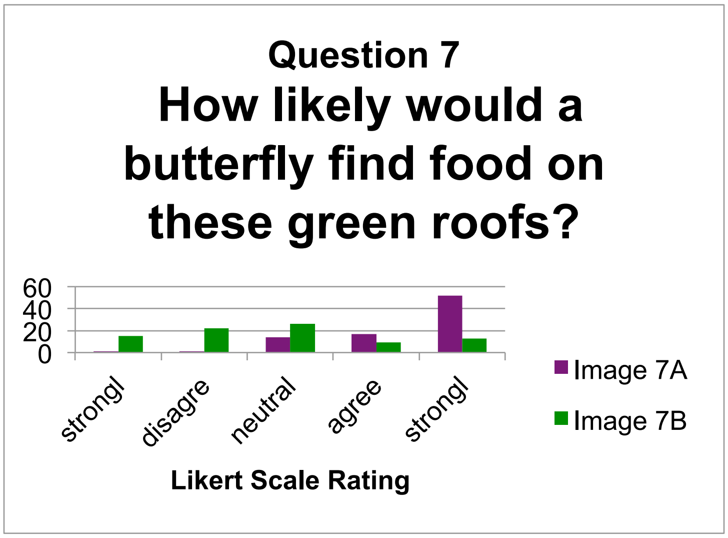

	Image 7A	Image 7B
	85	85
Mean	4.39	2.80
Std. dev	.888	1.289

Figure 4.13 A bar graph showing visual preference regarding where insects may find breeding space on either green roof image. Image 7A had a mean preference rating of 4.39 and was preferred to image 7B with a mean of 2.80.

The results summarized in Tables 4.20 and 4.21 below indicate that only one image conveys a positive visual preference. Image 7A produced a high percentage of preference for butterfly food potential. Image 7B produced the highest preference for the neutral category. This suggests that respondents prefer the green roof image containing the legible habitat component, flowering vegetation, displayed in the Image 7A. Image 7A had a total of (81%) of respondents selecting the highest levels of visual preference, where Image 7B had a total of only (26%) of respondents selecting the highest levels of visual preference. Image 7A produced much higher Likert ratings with a mean of 4.4 while Image 7B Likert ratings produced a mean of 2.8. This suggests that Image 7A with the diverse and flowering vegetation is greatly preferred by students than Image 7B with the homogenous vegetation and terrain.

Table 4.20 Image 7A Frequency Distribution

Image 7A

	Frequency	Percent	Cumulative Percent
strongly disagree	1	1.2	1.2
disagree	1	1.2	2.4
neutral	14	16.5	18.8
agree	17	20.0	38.8
strongly agree	52	61.2	100.0
Total	85	100.0	

A table showing the visual preference results for Image 7A displays the frequency and percentage of responses.

Table 4.21 Image 7B Frequency Distribution

Image 7B

	Frequency	Percent	Cumulative Percent
strongly disagree	15	17.6	17.6
disagree	22	25.9	43.5
neutral	26	30.6	74.1
agree	9	10.6	84.7
strongly agree	13	15.3	100.0
Total	85	100.0	

A table showing the visual preference results for Image 7B displays the frequency and percentage of responses.

Question 7: Open Ended Comments

The seventh photographic pair question also provided the opportunity for participants to clarify why they would or would not expect a butterfly to find food on the green roofs displayed in the images. Directly beneath Images 7A and 7B respondents were asked: *Circle where a butterfly may find food on the image above?* Not all participants circled an area on the image. This interactive question produced 64 circled responses regarding Image 7A and 66 circled responses regarding Image 7B from the 85 participants. There were a variety of responses recorded and these were individually coded into the different categories displayed in Table 4.22 below.

Table 4.22 Question 7 Image Response

	Description	**% Selected**
Image 7A	flowering vegetation	90.6%
	background	6.3%
	all vegetation	1.6%
	mulch	1.6%
	midground vegetation	0.0%
	turf	0.0%
Image 7B	background	60.4%
	all vegetation	12.5%
	midground vegetation	12.5%
	turf	10.4%
	flowering vegetation	4.2%
	mulch	0.0%

A table showing the coded areas circled on the images for Image 7A and 7B displays the percentage of coded areas circled on each image.

The most common areas circled for Image 7A were flowering vegetation (90.6%), and background features (6.3%). The areas on the image that received the least attention were all vegetation (1.6%), and mulch (1.6%). The most common areas circled for Image 7B were background features (60.8%), all vegetation (12.5%), and midground vegetation (12.5%). The areas on the image that received the least attention included flowering vegetation (4.2%), and turf (10.4%). These results displayed in Figure 4.14 below suggest that respondents considered flowering vegetation and background features as important while viewing both Images 7A and 7B.

Figure 4.14 Question 7 Compare: Image Response

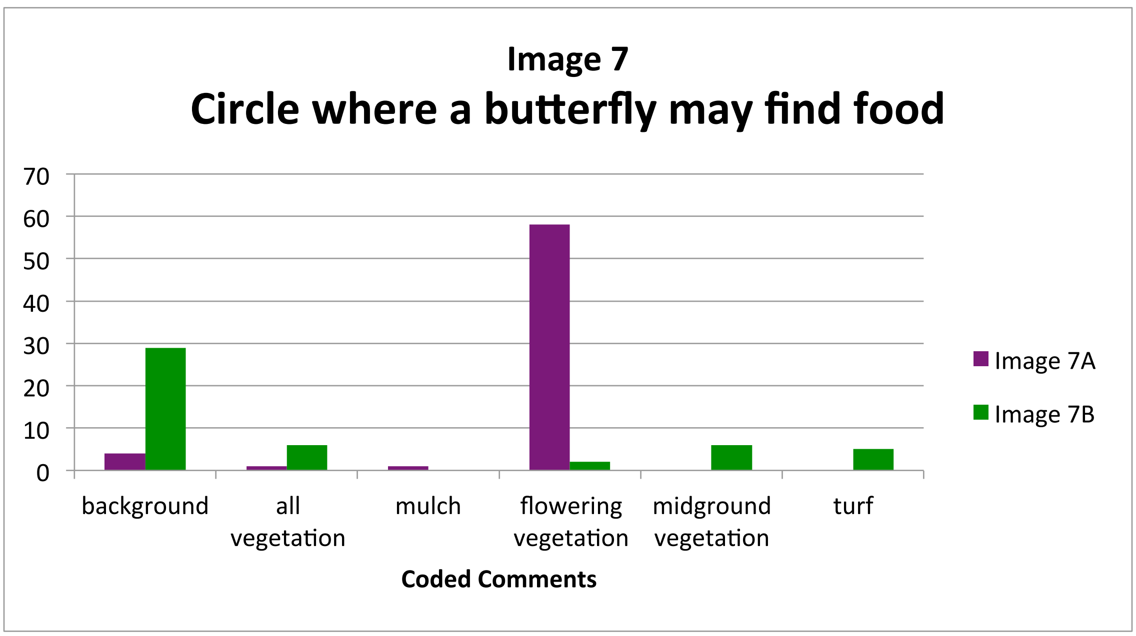

Figure 4.14 A bar graph showing where a butterfly may find food. Highest responses for image 7A were 1) flowering vegetation and 2) background. Highest responses for image 7B were 1) background 2) all vegetation and midground vegetation.

Question 8: Visual Preference

How likely would a butterfly find water on these green roofs?

Image 8A

Image 8B.

Both Image 8A and Image 8B produced a total of 85 responses. Participants were expected to respond with a stronger visual preference for the rock depressions, an appropriately sized water source for a butterfly, presented in Image 8B. This expected outcome was not confirmed as summarized in Figure 4.15 below, 69 out of 85 total responses (86%) indicated a stronger visual preference for Image 8A and selected the highest levels of visual preference (4 or 5) for Image 8A. Whereas Image 8B resulted in only 47 out of 85 responses (64%) that selected the highest levels of visual preference (4 and 5) for Image 4B.

Figure 4.15 Question 8 Compare Means

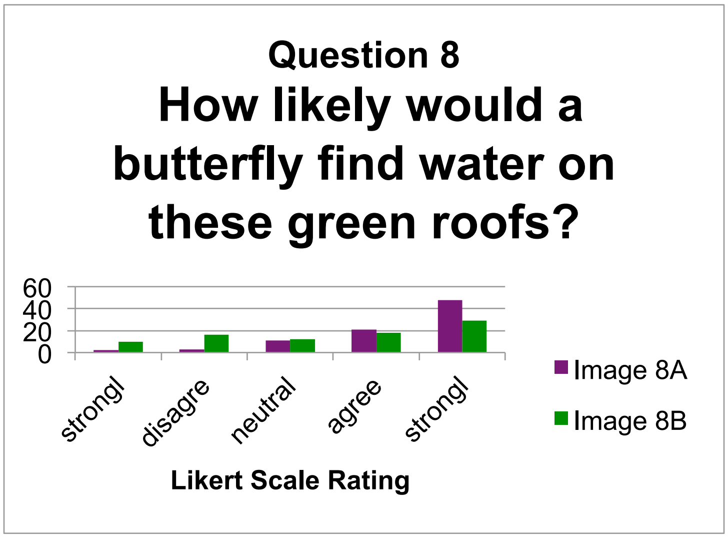

	Image 8A	Image 8B
N	85	85
Mean	4.29	3.47
Std. dev	.986	1.428

Figure 4.15 A bar graph showing visual preference regarding where a butterfly may find water on either green roof image. Image 8A had a mean preference rating of 4.29 and was slightly preferred to image 8B with a mean of 3.47.

The results summarized in Tables 4.23 and 4.24 below indicate that both images convey a positive visual preference. Both images produced a high percentage of preference for butterfly water potential. This suggests that respondents would consider butterfly water sources to be present in both green roof images. Image 8A had a total of (86%) of respondents selecting the highest levels of visual preference, where Image 8B had a total of (64%) of respondents selecting the highest levels of visual preference. Image 8A produced higher Likert ratings with a mean of 4.3 while Image 8B Likert ratings produced a mean of 3.5. This suggests that respondents slightly prefer the green roof image containing the large water source, displayed in the Image 8A.

Table 4.23 Image 8A Frequency Distribution

Image 8A			
	Frequency	Percent	Cumulative Percent
strongly disagree	2	2.4	2.4
disagree	3	3.5	5.9
neutral	11	12.9	18.8
agree	21	24.7	43.5
strongly agree	48	56.5	100.0
Total	85	100.0	

A table showing the visual preference results for Image 8A displays the frequency and percentage of responses.

Table 4.24 Image 8B Frequency Distribution

Image 8B			
	Frequency	Percent	Cumulative Percent
strongly disagree	10	11.8	11.8
disagree	16	18.8	30.6
neutral	12	14.1	44.7
agree	18	21.2	65.9
strongly agree	29	34.1	100.0
Total	85	100.0	

A table showing the visual preference results for Image 8A displays the frequency and percentage of responses.

Question 8: Open Ended Comments

The eighth photographic pair question also provided the opportunity for participants to clarify where they would or would not expect a butterfly to find water on the green roofs displayed in the images. Directly beneath Images 8A and 8B respondents were asked: *Circle where a butterfly may find water on the image above?* Not all participants circled an area on the image. This interactive question produced 66 circled responses regarding Image 8A and 62 circled responses regarding Image 8B from the 85 participants. There were a variety of responses recorded and these were individually coded into the different categories displayed in Table 4.25 below.

Table 4.25 Question 8 Image Response

	Description	**% Selected**
Image 8A	water feature	98.5%
	background vegetation	1.5%
Image 8B	rock depression	48.4%
	foreground water feature	45.2%
	rock & plant material	4.8%
	flowering vegetation	1.6%

A table showing the coded areas circled on the images for Image 8A and 8B displays the percentage of coded areas circled on each image.

The most common area circled for Image 8A was the water feature (98.5%). The water feature was circled as a water source for butterflies by almost every participant that circled something on Image 8A. The area on the image that received the least attention was background vegetation (1.5%). The most common areas circled for Image 8B were the rock depressions (48.4%), and the foreground water feature (45.2%). The areas on the image that received the least attention included flowering vegetation (1.6%), and rock & plant material (4.8%). These results displayed in Figure 4.16 below suggest that respondents considered visible water features or potential water sources as important while viewing both Images 8A and 8B.

Figure 4.16 Question 8 Compare: Image Response

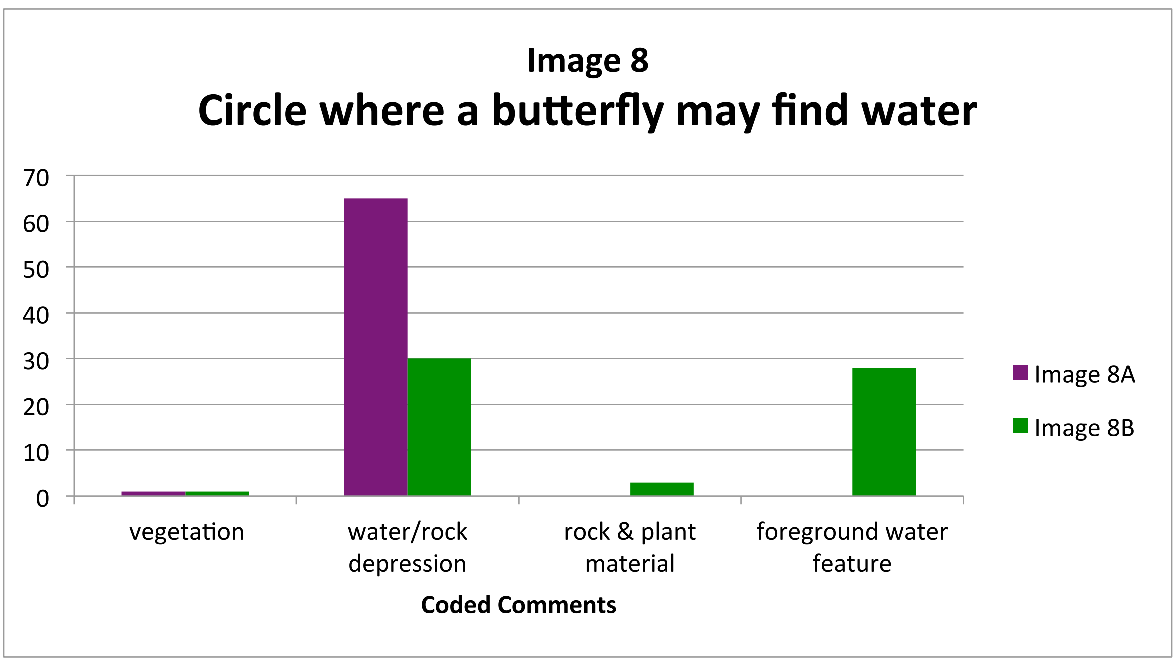

Figure 4.16 A bar graph showing where a butterfly may find water. Highest responses for image 8A were 1) water feature and 2) vegetation. Highest responses for image 8B were 1) rock depression and 2) foreground water feature.

Question 9: Visual Preference

How likely would a bee find cover on these green roofs?

Image 9A

Image 9B.

Both Image 9A and Image 9B produced a total of 85 responses. Participants were expected to respond with a stronger visual preference for the insect hotel structure, presented in Image 9A. This expected outcome was not confirmed as summarized in Figure 4.17 below, only 41 out of 85 total responses (48%) indicated a stronger visual preference for Image 9A and selected the highest levels of visual preference (4 or 5) for Image 9A. Whereas Image 9B resulted in 65 out of 85 responses (76%) that selected the highest levels of visual preference (4 and 5) for Image 9B.

Figure 4.17 Question 9 Compare Means

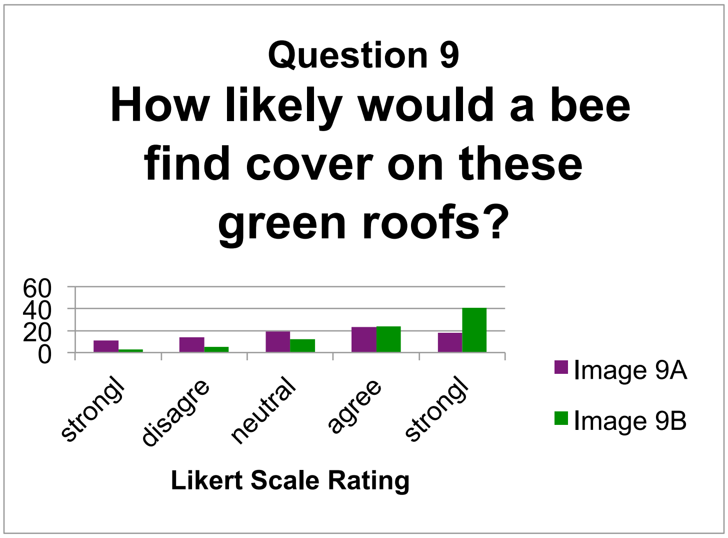

	Image 9A	Image 9B
N	85	85
Mean	3.27	4.12
Std. dev	1.322	1.085

Figure 4.17 A bar graph showing visual preference regarding where bees may find cover on either green roof image. Image 9B had a mean preference rating of 4.12 and was preferred to image 9A with a mean of 3.27.

The results summarized in Tables 4.26 and 4.27 below indicate that only one image conveys a positive visual preference. Image 9B produced a high percentage of preference for bee cover potential. Image 9A produced the highest preferences for both agree and neutral categories. This suggests that respondents prefer the green roof image containing the variety of vegetation and shaded seat wall, displayed in the Image 9B. Image 9B had a total of (76%) of respondents selecting the highest levels of visual preference, where Image 9A had a total of only (48%) of respondents selecting the highest levels of visual preference. Image 9B produced higher Likert ratings with a mean of 4.1 while Image 9A Likert ratings produced a mean of 3.3. This suggests that Image 9B with the shaded seat wall and variety of vegetation was more preferred for insect cover by students than Image 9A with the insect hotel.

Table 4.26 Image 9A Frequency Distribution

Image 9A			
	Frequency	Percent	Cumulative Percent
strongly disagree	11	12.9	12.9
disagree	14	16.5	29.4
neutral	19	22.4	51.8
agree	23	27.1	78.8
strongly agree	18	21.2	100.0
Total	85	100.0	

A table showing the visual preference results for Image 9A displays the frequency and percentage of responses.

Table 4.27 Image 9B Frequency Distribution

Image 9B			
	Frequency	Percent	Cumulative Percent
strongly disagree	3	3.5	3.5
disagree	5	5.9	9.4
neutral	12	14.1	23.5
agree	24	28.2	51.8
strongly agree	41	48.2	100.0
Total	85	100.0	

A table showing the visual preference results for Image 9B displays the frequency and percentage of responses

Question 9: Open Ended Comments

The ninth photographic pair question also provided the opportunity for participants to clarify where they would or would not expect a bird to find cover on the green roofs displayed in the images. Directly beneath Images 9A and 9B respondents were asked: *Circle where a bee may find cover on the image above?* Not all participants circled an area on the image. This interactive question produced 73 circled responses regarding Image 9A and 44 circled responses regarding Image 9B from the 85 participants. There were a variety of responses recorded and these were individually coded into the different categories displayed in Table 4.28 below.

Table 4.28 Question 9 Image Response

	Description	% Selected
Image 9A	insect hotel	76.7%
	background tall vegetation	10.0%
	shaded foreground vegetation	3.3%
	vegetation right side	3.3%
	all vegetation	1.7%
	background trees	1.7%
	foreground plant material	1.7%
	on ground between plants	1.7%
Image 9B	tallest tree	77.8%
	under seat wall	7.9%
	under tree canopy	4.8%
	background trees	3.2%
	plant material behind seat wall	3.2%
	all vegetation	1.6%
	light post	1.6%

A table showing the coded areas circled on the images for Image 9A and 9B displays the percentage of coded areas circled on each image.

The most common areas circled for Image 9A were the insect hotel (76.7%), background tall vegetation (10%), and shaded foreground vegetation (3.3%). The areas on the image that received the least attention were on ground between plants (1.7%), foreground plant material (1.7%), and background trees (1.7%). The most common areas circled for Image 9B were tallest tree (77.8%), under seat wall (7.9%), and under tree canopy (4.8%). The areas on the image that received the least attention included light post (1.6%), all vegetation (1.6%), and plant material behind seat wall (3.2%). These results displayed in Figure 4.18 below suggest that respondents considered insect hotel structures and tall trees as important while viewing both Images 9A and 9B.

Figure 4.18 Question 9 Compare: Image Response

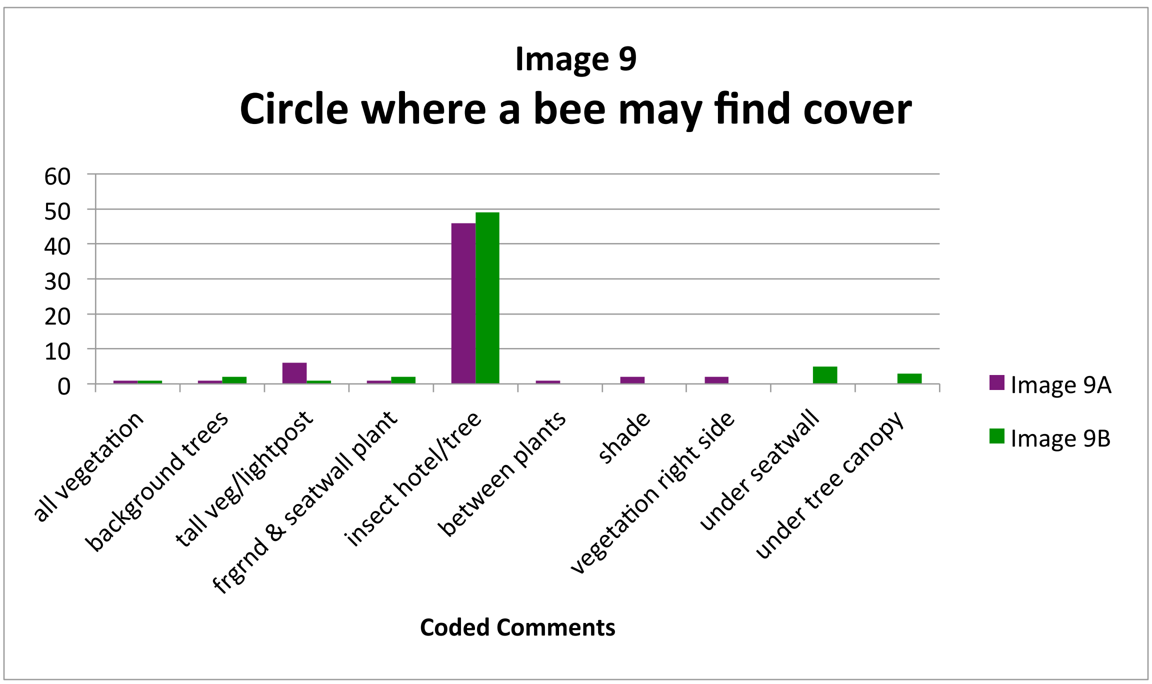

Figure 4.18 A bar graph showing where a bee may find cover. Highest responses for image 9A were 1) insect hotel and 2) tall vegetation. Highest responses for image 9B were 1) tallest tree and 2) under seat wall.

Question 10: Visual Preference

How likely would an insect find breeding space on these green roofs?

Image 10A

Image 10B.

Both Image 10A and Image 10B produced a total of 85 responses. Participants were expected to respond with a stronger visual preference for the wood pile and vertical wood structures, presented in Image 10A. This expected outcome was not confirmed as summarized in Figure 4.19 below 55 out of 85 total responses (64%) indicated a stronger visual preference for Image 10A and selected the highest levels of visual preference (4 or 5) for Image 10A. Whereas Image 10B resulted in 64 out of 85 responses (75%) that selected the highest levels of visual preference (4 and 5) for Image 10B.

Figure 4.19 Question 10 Compare Means

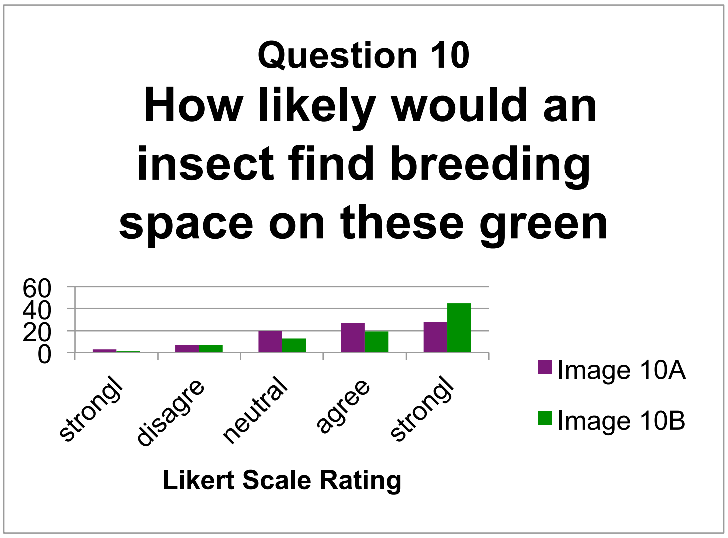

	Image 10A	Image 10B
N	85	85
Mean	3.82	4.18
Std. dev	1.093	1.049

Figure 4.19 A bar graph showing visual preference regarding where insects may find breeding space on either green roof image. Image 10B had a mean preference rating of 4.18 and was slightly preferred to image 10A with a mean of 3.82.

The results summarized in Tables 4.29 and 4.30 below indicate that both images convey a positive visual preference. Image 10B produced a slightly higher percentage of preference for insect breeding space potential. Both images produced a high percentage of preference for insect breeding space potential. This suggests that respondents would consider insect breeding spaces to be present in both green roof images. Image 10A had a total of (64%) of respondents selecting the highest levels of visual preference, where Image 10B had a total of only (75%) of respondents selecting the highest levels of visual preference. Image 10B produced slightly higher Likert ratings with a mean of 4.2 while Image 10A Likert ratings produced a mean of 3.8. This suggests that Image 10B with the variety of flowering vegetation is only slightly preferred by students than Image 10A with the insect hotel and background wood piles. This suggests that respondents slightly prefer the green roof image containing various flowering vegetation displayed in the Image 10B.

Table 4.29 Image 10A Frequency Distribution

Image 10A

	Frequency	Percent	Cumulative Percent
strongly disagree	3	3.5	3.5
disagree	7	8.2	11.8
neutral	20	23.5	35.3
agree	27	31.8	67.1
strongly agree	28	32.9	100.0
Total	85	100.0	

A table showing the visual preference results for Image 10A displays the frequency and percentage of responses.

Table 4.30 Image 10B Frequency Distribution

Image 10B

	Frequency	Percent	Cumulative Percent
strongly disagree	1	1.2	1.2
disagree	7	8.2	9.4
neutral	13	15.3	24.7
agree	19	22.4	47.1
strongly agree	45	52.9	100.0
Total	85	100.0	

A table showing the visual preference results for Image 10B displays the frequency and percentage of responses.

Question 10: Open Ended Comments

The tenth photographic pair question also provided the opportunity for participants to clarify where they would or would not expect an insect to find breeding space on the green roofs displayed in the images. Directly beneath Images 10A and 10B respondents were asked: *Circle where an insect may find space on the image above?* Not all participants circled an area on the image. This interactive question produced 64 circled responses regarding Image 10A and 56 circled responses regarding Image 10B from the 85 participants. There were a variety of responses recorded and these were individually coded into the different categories displayed in Table 4.31 below.

Table 4.31 Question 10 Image Response

	Description	% Selected
Image 10A	vertical wood wall	35.9%
	wood pile	26.6%
	foreground	10.9%
	background	9.4%
	turf	4.7%
	walkway	4.7%
	entire image	3.1%
	flowering vegetation	3.1%
	all vegetation	1.6%
	shade by flowering plants	0.0%
Image 10B	background	35.7%
	flowering vegetation	26.8%
	all vegetation	14.3%
	foreground	8.9%
	shade by flowering plants	7.1%
	entire image	3.6%
	turf	1.8%
	walkway	1.8%

A table showing the coded areas circled on the images for Image 10A and 10B displays the percentage of coded areas circled on each image.

The most common circled areas for Image 10A included vertical wood wall (35.9%), wood pile (26.6%), and foreground (10.9%). The areas on the image that received the least attention included all vegetation (1.6%), flowering vegetation (3.1%), and entire image (3.1%). The most common circled areas for Image 10B were background (35.7%), flowering vegetation (26.8%), and all vegetation (14.3%). The areas on the image that received the least attention included walkway (1.8%), turf (1.8%), and entire image (3.6%). These results displayed Figure 4.20 below suggest that respondents considered bird vertical wood wall and background features as important while viewing both Images 10A and 10B.

Figure 4.20 Question 10 Compare: Image Response

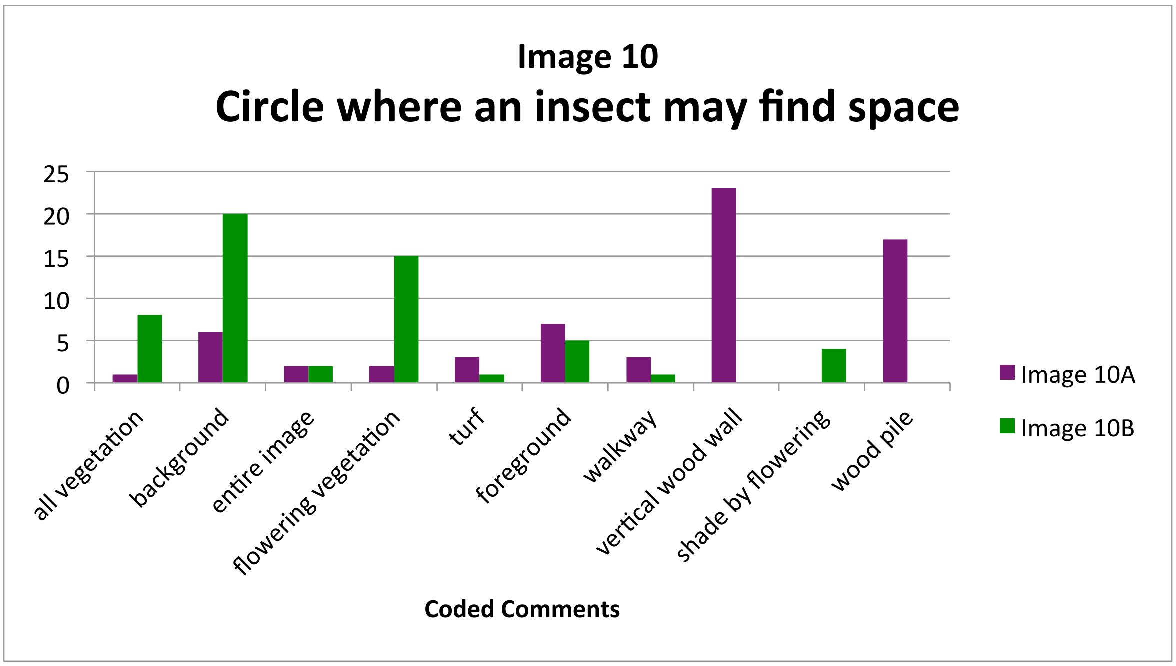

Figure 4.20 A bar graph showing where insects may find breeding space. Highest responses for image 10A were 1) vertical wood wall and 2) wood pile. Highest responses for image 10B were 1) background and 2) flowering vegetation.

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CHAPTER V

DISCUSSION AND CONCLUSION

Introduction

This chapter discusses the findings that were presented in chapter IV. The participants in this study were expected to assign the highest rankings to the images that displayed the legible habitat components in each image. Previous research by Bergen (1995) has shown computer enhanced images can be an effective tool to determine visual preference for legible educational landscape components. The images utilized in this survey were enhanced in order to highlight the visibility of the habitat or educational landscape components. The expected visual preferences and actual visual preferences are displayed in Figure 5.1 below. Participants were asked a variety of questions about the habitat components in order to obtain diverse responses similar to Presser (2004). Participants were asked to evaluate each image using a provided Likert scale in order to rank their preference for all twenty images within the visual preference survey.

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Figure 5.1 Expected Versus Actual Outcome

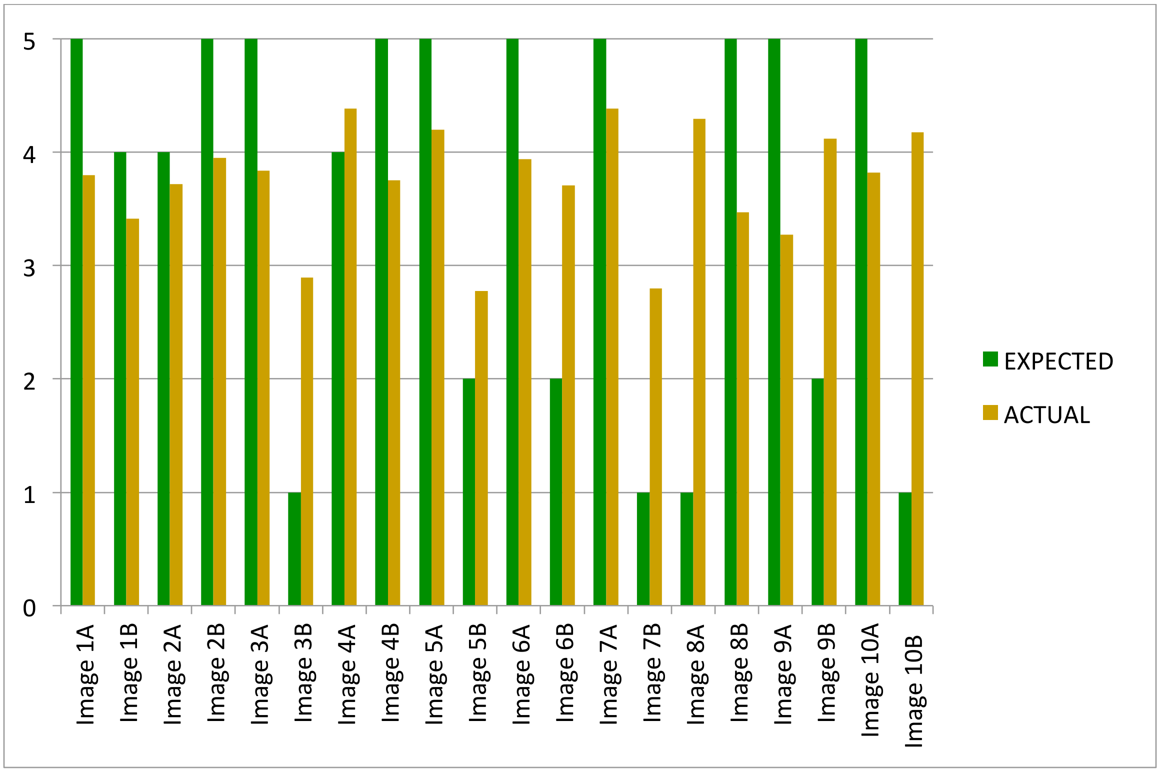

Figure 5.1 A bar graph showing the expected visual preference and the actual recorded visual preference for each image. Most of the expected visual preference ratings were similar to the participants recorded visual preference ratings. Only three images measured a visual preference mean difference greater than 2. This suggests that most of the images displayed resulted in the expected visual preference ratings.

Image Comparisons

This study utilized a comparison of digitally enhanced images and meaningful associated text to rank a variety of legible habitat components for visual preference. As Mozingo states ecological values should be expressed by making them “visible and

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meaningful" (Mozingo, 1997, p. 50). Meaning was assigned to each image through the meaningful text descriptions, while visibility or legibility of habitat components was enhanced digitally in each image pair

The first two images, Image 1A and Image 1B were displayed to determine the participants preference of diverse and colorful vegetation versus an interesting pathway and water feature. While the participants did prefer the colorful vegetation more than the pathway and water feature the mean preference response was only slightly higher for the diverse colorful vegetation. These results suggest that both images were preferred, and while the colorful image mean preference response was slightly higher, the exciting possibility of visiting either green roof produced a high preference rating for both images.

When presented with the option to visit the green roofs the majority of participants selected the highest levels of visual preference for all green roof images. This means that when presented with the potential opportunity to visit any green roof the overwhelming consensus is "yes please". Most participants have likely never seen a green roof before and would be enthusiastic about an opportunity to visit one regardless of unique features and overall aesthetics.

Image 1A

Image 1B

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The next two images, Image 2A and Image 2B were displayed to further engage the participants in the survey process and determine a preference for types of play spaces upon green roofs. As Mozingo emphasized, in order for ecological landscapes to be accepted and promoted they must engage participants and encourage public interest (Mozingo, 1997). Participants were expected to have a stronger visual preference for the diverse terrain displayed in Image 2B versus the colorful pathway and organized vegetation in Image 2A. While the participants did prefer the diverse terrain to the colorful pathway and vegetation the mean preference response was only slightly higher for the diverse terrain. These results suggest that both images were preferred and while the image with the diverse terrain was slightly more preferred, the idea of having playtime on any green roof produced a high preference rating for both images. The preference rating may have been different if the images displayed had been compared against a more homogeneous type of green roof. However, since both images contained diverse and exciting play elements participants displayed a strong preference for both green roofs. Many written comments contained references to the potential for play on these roof tops. The comment that stood out the most for Image 2B was "Parkour!" This means that the participants displayed an overwhelming positive response when presented with the opportunity to play on either green roof.

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Image 2A **Image 2B**

Images 3A, 3B, 7A and 7B were selected to determine visual preference for the legible habitat component of food. Question 3 asks about birds finding food on the green roofs and question 7 asks about butterflies finding food on the green roofs. Participants were expected to have a stronger visual preference for the legible food sources present in Images 3A and 7A. This expected outcome was realized as participants preferred Image 3A over 3B and Image 7A over 7B. Image 3A produced a much higher preference rating than Image 3B. However, Image 7B produced a high rating of neutral, suggesting that the participants may not have completely understood where butterflies find food.

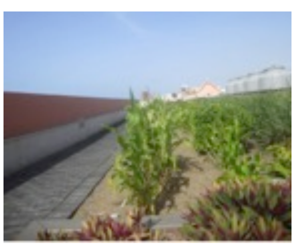

Image 3A **Image 3B**

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Image 7A **Image 7B**

Images 4A, 4B, 8A and 8B were selected to determine visual preference for the legible habitat component of water. Question 4 asks respondents about birds finding water on the green roofs and question 8 asks students about butterflies finding water on the green roofs. Participants were expected to have a stronger visual preference for the legible water sources present in Images 4B and 8B. This expected outcome was not realized as participants displayed a higher mean preference response for Image 4A over 4B and Image 8A over 8B. All Images 4A, 4B and Images 8A and 8B produced positive visual preference ratings. These results suggest that the participants may not have completely understood appropriate sized bird water sources and how butterflies find water.

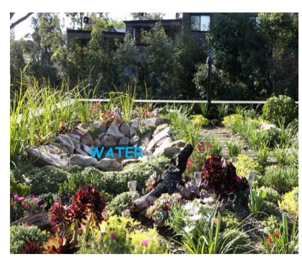

Image 4A **Image 4B**

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Image 8A **Image 8B**

Images 5A, 5B, 9A and 9B were selected to determine visual preference for the legible habitat component of cover. Question 5 asks about birds finding cover on the green roofs and question 9 asks about bees finding cover on the green roofs. Participants were expected to have a stronger visual preference for the legible cover sources present in Images 5A and 9A. This expected outcome was realized for question 5 but not for question 9. Image 5A produced a much higher preference rating than Image 5B. However, Image 9B produced a higher preference rating than 9A, suggesting that the participants may not have completely understood where bees find cover. These results suggest that the participants understood the concept of cover from a structured birdhouse but may not have completely understood how bees find cover. Educational landscapes could highlight a variety of habitat components for different species of birds as well as small habitat details such as bee cover with interesting and informative displays and signage. For example, a series of signs could be placed throughout the landscape that allow participants to "follow the bee" utilizing a common graphic while displaying appropriate example bee habitat all around the green roof.

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Image 5A

Image 5B

Image 9A

Image 9B

Images 6A, 6B, 10A and 10B were selected to determine visual preference for the legible habitat component of space. Question 6 asks about birds finding breeding space on the green roofs and question 10 asks about insects finding breeding space on the green roofs. Participants were expected to have a stronger visual preference for the legible cover sources present in Images 6A and 10A. This expected outcome was realized for question 6 but not for question 10. Image 6A produced a slightly higher preference rating than Image 6B. However, Image 10B produced a higher preference rating than 10A, suggesting that the participants may not have completely understood what types of habitat features insects utilize for breeding space. These results suggest that the participants understood the concept of breeding space for birds utilizing a bird nesting structure but may not have completely understood how insects utilize space for breeding.

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Educational green roofs should highlight all the habitat features present, including the critical and small areas that insects can use for breeding. Natural areas including mulch, nesting spaces, leaf litter and wood piles can be featured along with carefully constructed insect housing components.

Image 6A

Image 6B

Image 10A

Image 10B

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Impacts for Designers of Educational Green Roofs

Designers of green roofs can make informed design decisions in order to help guide the general public to recognize and appreciate sustainable landscapes. As Robert Thayer states, "The small steps taken to build sustainability into the local landscape in discreet, manageable chunks which people can observe, try out, experience, and improve are actually large steps for humankind. (Thayer, 1994, p. 94)." Even minor exposure to sustainable landscapes allows for observation and experiential learning that could lead to improved sustainable practices. Educational green roofs could serve as individual small and diverse areas for people to experience a localized piece of sustainable landscape.

Educational landscapes can be designed to maximize learning objectives while also maintaining positive aesthetic qualities. Ecological landscape design is essential to create functional and sustainable educational landscapes Clearly stated by Dramstad, landscape architects can contribute to regional ecological health through the utilization of a landscape ecological approach in their designs (Dramstad, 1996). In order to preserve regional ecological balance and widespread ecological health, individual landscapes should be treated as a contributing part of the whole ecosystem. This means that the overall ecological health of the surrounding environment can be altered by one small part within the larger ecosystem. This includes rooftop habitat patches as well as the surrounding green spaces. Comprehensive landscape ecology should be considered when developing these green roof habitats (Dramstad, 1996). In order for green roof parcels to improve regional ecological health they must be treated as an extension of the landscape found on the ground below.

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Green roof landscapes can be designed to mimic natural habitat. For example a wildflower meadow habitat can be simply recreated on a rooftop and include habitat features to encourage wildlife usage. Interpretive signage and other educational components can be added to enhance the natural looking landscape and provide experiential learning benefits. Thayer states that sustainable landscapes require both conspicuous expression and visible interpretation, emphasizing that the creativity and artistic skills employed by landscape architects are critical for successful development and implementation (Thayer, 1989). Elements must be creatively designed in order to both capture interest and convey meaning.

Thayer maintains that ecological design cannot be evaluated by aesthetics (Thayer, 1989). Where as Mozingo contends that for ecological design to successfully display environmental vision ecological processes and aesthetics must display positive human environment interaction (Mozingo, 1997). Both Thayer and Mozingo make strong points. Currently, modern ecological design must be evaluated by both ecological function and aesthetics success. It is true that is difficult to objectively evaluate ecological design by the aesthetic qualities portrayed. However, it is necessary that the general public experience and accept the current aesthetics of modern ecological design in order for the design to be successful. For example, if people think an urban wildlife habitat green roof is unsightly, they will not want them on their roof tops or in their urban areas.

In an educational landscape the legible components must be visible in order to be effective. The legible habitat components that demonstrated success in the preference

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survey include the following: colorful vegetation, diverse terrain, food sources, cover materials, and bird breeding space. These components were highly visible in the images and there was a successful connection made between the images, previous knowledge, and the associated text. As Thayer states, "Sustainable landscapes need conspicuous expression and visible interpretation, and that is where the creative and artistic skills of the landscape architect are most critically needed (Thayer, 1989, p. 89)." Landscape architects must utilize creativity to effectively convey legible habitat components upon an educational green roof.

Considerations should be made regarding what is best for wildlife in the surrounding area, and habitat modifications should be made upon the roof in order to mimic the habitat on the ground below (Monsma, 2011). These habitat components should be strategically designed to mimic natural occurring habitat. The legibility of each component should be visible to the observer. The design should display an active heterogeneous landscape in order to captivate both aesthetics and function of the space.

The results of this study suggest that design choices may have an effect on the legibility of habitat components on green roof ecosystems. Food source legibility produced successful results in this study. Question 3 asked participants to identify the presence of bird food within the green roof images. These images produced successful results as the majority of the participants were able to identify the presence of a food source in the foreground corn plants in Image 3A. Question 7 asked participants to identify the presence of butterfly food within the associate images. These images produced successful results as the majority of the participants were able to identify the

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presence of a butterfly food source in the flowering vegetation present in Image 7A. This suggests that the legible food sources of corn plants and flowering vegetation can be effective legible habitat components for green roof ecosystems. Legible food source visibility could be expanded by utilizing additional common row crop vegetation for bird food potential as well as brightly colored flowering vegetation coupled with common butterfly host plant materials such as milkweed for insect food potential.

The questions regarding water source legibility did not produce successful results in this study. Question 4 asked participants to identify the presence of a water source for birds within the green roof images. These images did not produce the expected results as the majority of the participants did not identify the preferable size of the water source in Image 4B. Question 8 asks participants to identify the presence of a water source for butterflies within the associated image. Both of these images produced unexpected results as the majority of the participants identified the inappropriate sized water source as the preferred water source for both birds and butterflies. This suggests that the green roof water sources should be specific to the targeted wildlife. Legible water sources included on green roofs should include a large variety of types and sizes of designed water sources.

The questions regarding legible nesting and bird cover components did produce successful results in this study. Question 5 asked participants to identify the presence of bird cover within the green roof images. These images produced successful results as the majority of the participants were able to identify the presence of a cover source, the bird houses, in the foreground in Image 5A. Question 6 asks participants to identify the

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presence of bird nesting space within the associate images. These images produced successful results as the majority of the participants were able to identify the presence of the bird nesting structures present in Image 6A. This suggests that the legible cover source of bird boxes, as well as the legible nesting source of nesting boxes can be effective legible habitat components for green roof ecosystems. Cover and nesting sources will be different for different types of birds and designers should consider the local species and include a variety appropriate of habitat types.

The questions regarding legible insect nesting and bee cover components did not produce successful results in this study. Question 9 asked participants to identify the presence of a cover source for bees within the green roof images. These images did not produce the expected results as the majority of the participants did not identify the legible insect hotel structure source in Image 9A. Many participants selected Image 9B as the preferred insect nesting habitat image, Question 10 asked participants to identify the presence of insect breeding space within the associated images. Both of these images produced unexpected results as the majority of the participants identified the Image 10B as the preferred breeding space for insects. This suggests that the green roof habitat cover and nesting sources should be specific to the targeted wildlife. Legible cover and nesting sources included on green roofs should include a large variety of materials in order to accommodate a large variety of insects..

In order to be constructed a roof that is legible habitat education for elementary school children, all four required habitat components should be addressed: food, water, shelter and cover. These should be addressed at the appropriate scale for each individual

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green roof habitat. Food sources for wildlife should be present and legible to the observer. Water sources should be appropriate in size for the targeted wildlife type and should be visible to the observer. Sources of shelter should be present and also easy for observers to identify. Cover material must be present on green roof habitat and should be legible for observation. For example, a habitat component for insect cover should not just be a pile of mulch on the ground. The space within and surrounding must be cohesive and aesthetically pleasing. This may take the form of a carefully designed planted area that contains vegetation and surrounding undisturbed mulch piles for insect usage. This means the area containing the insect cover should be successfully surrounded with other types of vegetation or groundcover helping to create a balanced designed green roof. The observer should be able to understand what the insect cover material is, mulch, or leaf litter, and understand why it is there. Educational signage should be included when the space is to be utilized as a learning laboratory. Following these basic guidelines and strategies will allow Landscape Architects to effectively design green roof habitats that captivate aesthetics and function while also serving as a teaching tool for a variety of user groups. Educational green roofs are an underutilized resource for both landscape architects and educators as well. This resource potential should be explored and expanded helping to create more educational green roofs that are both suitable for urban wildlife and informative for observers.

A successfully designed educational green roof would optimally contain a mixture of both extensive and intensive vegetated green roof areas. This would allow for the maximum habitat potential and possibility for human visitation without wildlife

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disruption. Additionally, a variety of habitat types should be represented. A representative woodland area could be developed in the intensive green roof portion where tree roots can become established. Appropriate sized water, cover and nesting components should represented in order to attract both local and migratory species. A grassland or prairie habitat can then be constructed in the surrounding extensive green roof portion. Less human disturbance will be expected upon this extensive green roof grassland habitat since there is less opportunity for human activity upon extensive green roof designs. Allowing for a human use space, the intensive portion of the roof, along with an extensive portion of the roof that can not be utilized by humans, would provide for undisturbed habitat potential.

An example of an educational green roof that creatively displays a natural looking ecosystem while simultaneously informing the public about the habitat components present is the California Academy of Sciences. This green roof built upon constructed rooftop hills that mimic the surrounding terrain can be viewed from the ground level below as well as an outside observation deck. Visitors can visit the green roof while learning about green infrastructure benefits and the native plants that help create habitat on the roof. Habitat components are legibly displayed on this green roof and educational signage provides interpretation. A rolling wildflower meadow garden populated with pollinators can be viewed from the observation deck upon the green roof.

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California Academy of Sciences Green Roof

Image credit: http://www.ranacreekdesign.com/projects/california-academy-of-sciences

Public and private elementary schools have potential to incorporate educational landscapes into the existing curriculum. A great example of this is the green roof found at Sidwell Friends School that is part of an outdoor learning laboratory. Here students grow herbs on the roof for the cafeteria, watch and measure the water flow from the roof through the terraced wetland into the habitat pond below, and learn about sustainable practices. These students have the opportunity to experience a remarkable educational landscape that is incorporated into the current curriculum. It would have been a great addition to this study if students from a school with access to a green roof could have been included as participants. With the help of grant funding Public School number 41 in New York City added a green roof. This roof top addition adds green space to the region, provides outside educational space for the students and also increases energy efficiency

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within the building. This public school green roof provides opportunity to combine the existing curriculum with outdoor education resulting in influential experiential learning.

Sidwell Friends School Green Roof

Image Credit: https://www.asla.org/sustainablelandscapes/sidwell.html

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Public School Number 41 New York City

Image Credit: http://www.mbbarch.com/work/public-school-41-green-roof

Legible habitat components should be included in the design of green roofs and school garden areas and can be utilized as multidisciplinary teaching tools. Landscape architects and designers of green roofs should include legible components that represent a variety of habitat elements when designing educational landscapes. At a minimum the four basic required components for habitat should be included in green roof habitat design. This means a food source, a water source, an area for resting or nesting, and appropriate breeding space. Including these habitat components could be as simple as planting the appropriate vegetation, supplying a depression for water collection and providing materials upon the rooftop for nesting and breeding spaces. As seen from the results of

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this study, pacing and sizing of these components should be appropriate for the type of habitat being created. For example, when designing a rooftop butterfly habitat a small water source is all that is required and in fact can be more effective for attracting butterflies than a large water source. This was unclear to some participants in this study and could be clarified through the use of interpretive signage and educational literature.

Five Borough Technical Services Division Green Roof

Image Credit: http://www.greenroofs.com/blog/2011/06/21/gpw-nyc-parks-five-borough-5-boro-administrative-building/

There are many inspiring examples of green roofs designed to provide habitat and encourage biodiversity. An impressive example of a green roof habitat can be found on the Chattahoochee Nature Center green roof in Roswell Georgia. This green roof includes two tiers and is mainly planted with native plants that occur regionally in

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Georgia Piedmont rock outcroppings. The top tier is also heavily vegetated with plants to encourage butterflies. There is an observation area and interpretive signage to educate the public on the advantages of green roofs. Thayer states that people who can comprehend the logistics behind a functional sustainable landscape will have a different response to that landscape from those who are uninformed. He cites evidence that the National Park Service spends millions of dollars on facilities and interpretive programs each year in order to improve positive visitor experiences (Thayer, 1989). This suggests that visitors to educational green roofs can obtain a more meaningful experience when they are educated and informed about green roof resources and habitat requirements. This educational and informational factor can be directly related to this visual preference study. Some of the images in this preference study that may have been misunderstood could have been more clearly presented with the addition of educational components. For example, the images of water sources could have contained additional information related to the appropriate size of a water source for a particular type of wildlife. Including interpretive signage and educational opportunities will help to ensure that educational landscapes are better understood and utilized to the fullest potential.

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Chattahoochee Nature Center Green Roof

Image Credit: http://www.greenroofs.com/blog/2016/08/08/project-week-august-8-2016-chattahoochee-nature-center-discovery-center/

Limitations to Study

Many limitations to this study focus on the difficulties concerning selecting children as participants. The rules and regulations regarding children as survey participants in the public school system created logistical barriers and made it difficult to effectively work with the public school students. The superintendent of the public school informed me that no surveys could be distributed to the students in the classroom in order to prevent distraction from instructional time. However, I was provided a list of student's home addresses and was allowed to mail the surveys to their homes. The fact that

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surveys had to be mailed, completed, and returned at the discretion of these student participants and their parents resulted in a very low response rate of 25% for the public school students. The response rate for the private school students was much higher at 85%. It is expected that the public school response rate would have been much higher if the surveys could have been completed in the classroom like at the private school. These logistical barriers contributed to the small sample size of participants that successfully completed the survey. While this small sample size produced usable results for this study a small sample size may have larger negative impacts on a more detailed study.

A comprehensive wildlife habitat component review for both the public and private school students before completing the survey could have eliminated some confusion for survey participants. Each participant was presented with the same introductory material before completing the survey. It could have clarified some confusion about habitat components if a comprehensive review of habitat requirements, including legible images, was included in the introductory material provided to the participants. This confusion could have been addressed during the survey introduction with a brief review of required habitat components including: food sources for birds and butterflies, appropriate sized water sources for birds and butterflies, appropriately sized bee cover habitat components, and insect breeding space habitat components. Images could have been shown to participants to ensure their comprehension of these habitat components. This would have helped to clarify the material being presented and allow participants to make educated choices about wildlife habitat components. Educational green roofs should be designed to contain appropriate sized habitat features and

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corresponding interpretive signage that describes these features, their presence in nature and adaptations to green roof habitat.

It is possible that some of the images presented in the survey caused confusion for some of the participants. As Bergen suggests images are subject to a variety of individual interpretation that cause variation in preference rating (Bergen, 1995). Therefore, all computer modified images utilized for visual preference should be simulated as realistically as possible while clearly displaying all landscape elements present (Bergen, 1995). When reviewing the written comments produced in this visual preference survey it is evident that some habitat details were difficult to comprehend for some individuals. It is possible that this difficulty influenced the preference ratings for some of these images. The images presented in the survey could have been edited further in order to prevent confusion and to more effectively highlight the habitat elements being discussed. For example, the images displaying the habitat component of water features could have been more clearly constructed. Image 4B could have shown visible water in the pond depression area, this may have encouraged more participants to choose this water source as the preferred or more suitable water source for birds on a green roof. Image 8B could have been further edited to eliminate the visible portion of the water source in the bottom right hand corner. This visible water source caused some confusion for participants as many students circled the barely visible portion of the rooftop water source as a place for a butterfly to find water on a green roof.

To further understand visual preference of legible habitat components this research could be expanded to include a more detailed study that includes specific habitat element

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introduction material and images that clearly convey multiple habitat components. A more lengthy visual preference survey containing more images to rank for each habitat element in question could produce more comprehensive results. Additionally, a follow up study within a year's time for the previous participants would be a great way to test the validity of the legible habitat components presented. For example, ask the students who participated similar questions regarding habitat elements and have them evaluate a new set of images for visual preference. This could help to clarify some of the results and would be useful since the participants would already be familiar with the subject material.

Opportunities for Future Research

A suggestion for future research includes performing a related survey requesting input from visitors to existing educational green roofs. This survey would ask specific questions about what the visitors were viewing and how they perceived habitat requirements were being achieved and how they could be improved. A survey for visitors to the Chattahoochee Nature Center green roof would be a great start to refining green roof educational components. This would allow for the assessment of existing legible habitat components as well as an evaluation of the interpretive signage that exists on an educational green roof. This could help to provide suggestions and improvements for educational green roof design as well as environmental education.

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Green roof education should be included and improved in existing environmental education curriculum. Current academic standards specify the importance of human environment interaction and habitat degradation, which are directly related to potential green roof habitat. The American Society of Landscape Architects has developed a green roof education program for students in the 6th through the 8th grade. This program called "The Roof is Growing" consists of teacher and student resources, an interactive website, and a field trip guide. It is aimed at students in the Washington D.C. area, but can be adapted for students anywhere. This education program is a great start for green roof education, however it should be expanded to include both younger and older grade levels. The 4th graders that participated in this research study have shown intense interest and enthusiasm for the unique habitats and environments found upon green roofs. Older students, high school aged, should be included in this program as well. High school students could further expand upon this topic. An enhanced an expanded green roof education program could even include a design build portion where older students help to construct an actual green roof.

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APPENDIX A

GREEN ROOF HABITAT VISUAL PREFERENCE SURVEY

GREEN ROOF HABITAT

Human – Environment Interaction

Human activities and the growth of cities where many people live reduces the amount of space where wildlife can live. Human-environment interaction and population growth can result in wildlife habitat displacement. This means the wildlife is forced to search for new space to find food and other resources they need to survive. These creatures will be forced to leave the cities or they will have to adapt to use different habitat in town.

Does building more houses and apartments mean fewer animals in town? **YES** **NO**

Do you think birds or bugs could live on the roof? **YES** **NO**

Urban Wildlife

We live in an urban area here in Starkville Mississippi and there are many opportunities to observe wildlife throughout town. Everyone has seen squirrels, birds, frogs, lizards and many types of insects. You may even have deer, a fox or even an alligator pass through your back yard. All these creatures that share space with us in town are considered urban wildlife.

Do you ever notice wildlife around your home or school? **YES** **NO**

How many times have you seen wildlife in town during the last week? ________

Did you notice any wildlife on the way to school this morning? **YES** **NO**

Habitat Requirements

There are certain requirements for successful wildlife habitat. Regardless of habitat location wildlife require food, water, cover and protection in order to survive and thrive.

Select the Habitat Features from the list that are required for wildlife to survive
(Circle all that apply)

Food	**Candy**
Music	**Cover**
Pillows	**Electronics**
Nesting Space	**Water**

Green Roof Habitat

A green roof is a special type of layered roof built to support plant life. Many types of plants can be grown on green roofs. A variety of wildlife has been observed using different types of green roofs for many essential habitat requirements. Green roof habitat could provide a usable space for urban wildlife that has suffered natural habitat loss.

What type of wildlife do you think you could find on a green roof?
(Circle all that apply)

Spider	**Snail**	**Bee**
Lizard	**Alligator**	**Bat**
Squirrel	**Butterfly**	**Fox**
Deer	**Beetle**	**Bird**

GREEN ROOF HABITAT

1. Given the chance how likely would you be to visit these green roofs?

Rate each image below on a scale of 1 -5 with 1 being the lowest and 5 being the highest
(1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree)

1 2 3 4 5

1 2 3 4 5

2. Given the chance would you like to have recess here?

Rate each image below on a scale of 1 -5 with 1 being the lowest and 5 being the highest
(1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree)

1 2 3 4 5

1 2 3 4 5

GREEN ROOF HABITAT

3. How likely would a bird find food on these green roofs?
Rate each image below on a scale of 1 -5 with 1 being the lowest and 5 being the highest
(1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree)

1 2 3 4 5

1 2 3 4 5

4. How likely would a bird find water on these green roofs?
Rate each image below on a scale of 1 -5 with 1 being the lowest and 5 being the highest
(1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree)

1 2 3 4 5

1 2 3 4 5

GREEN ROOF HABITAT

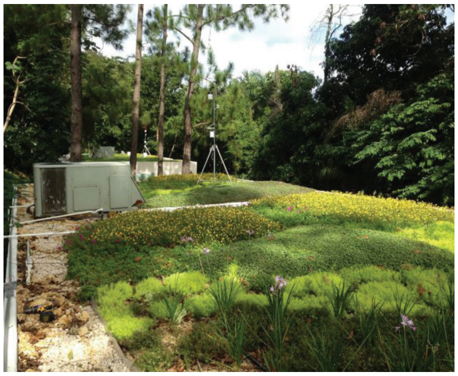
5. How likely would a bird find cover on these green roofs?
Rate each image below on a scale of 1 -5 with 1 being the lowest and 5 being the highest
(1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree)

1 2 3 4 5

1 2 3 4 5

6. How likely would a bird find breeding space on these green roofs?
Rate each image below on a scale of 1 -5 with 1 being the lowest and 5 being the highest
(1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree)

1 2 3 4 5



1 2 3 4 5

GREEN ROOF HABITAT

7. How likely would a butterfly find food on these green roofs?
Rate each image below on a scale of 1 -5 with 1 being the lowest and 5 being the highest
(1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree)

1 2 3 4 5

1 2 3 4 5

8. How likely would a butterfly find water on these green roofs?
Rate each image below on a scale of 1 -5 with 1 being the lowest and 5 being the highest
(1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree)

1 2 3 4 5

1 2 3 4 5

GREEN ROOF HABITAT

9. How likely would a bee find cover on these green roofs?
Rate each image below on a scale of 1 -5 with 1 being the lowest and 5 being the highest
(1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree)

1 2 3 4 5

1 2 3 4 5

10. How likely would an insect find breeding space on these green roofs?
Rate each image below on a scale of 1 -5 with 1 being the lowest and 5 being the highest
(1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree)

1 2 3 4 5

1 2 3 4 5

APPENDIX B

IRB APPROVAL LETTER

MISSISSIPPI STATE UNIVERSITY

Office of Research Compliance

Institutional Review Board for the Protection of
Human Subjects in Research
P.O. Box 6223
53 Morgan Avenue
Mississippi State, MS 39762
P. 662.325.3294

www.orc.msstate.edu

NOTICE OF APPROVAL FOR HUMAN RESEARCH

DATE:	December 05, 2016
TO:	Amy Counterman, Business & Industry
FROM:	Kari Reeves, Assoc Dean/Assoc Prof, MSU - Expedited
PROTOCOL TITLE:	Visual preference for legibility of wildlife habitat on green roofs
PROTOCOL NUMBER:	16-244
APPROVAL PERIOD:	Approval Date: December 05, 2016 Expiration Date: November 15, 2017

Under an expedited review procedure, the research project identified above was approved for one year on December 05, 2016 by the Mississippi State University Institutional Review Board (MSU IRB). The application qualified for expedited review under CFR 46.110, Category 7.

This memorandum is your record of the IRB approval of this study. Please maintain it with your study records.

Please note that the MSU HRPP accreditation for our human subjects protection program requires an approval stamp for consent forms. The approval stamp will assist in ensuring the HRPP approved version of the consent form is used in the actual conduct of research. **You must use the stamped consent form for obtaining consent from participants.**

The MSU IRB approval for this project will expire on November 15, 2017. If you expect your project to continue beyond this date, you must submit an application for renewal of this HRPP approval. HRPP approval must be maintained for the entire term of your project.

If, during the course of your project, you intend to make changes to this study, you must obtain approval from the HRPP prior to implementing any changes. Upon becoming aware of an unanticipated problem that suggests participants or others are at greater risk of harm than was previously known or recognized, a problem report must be submitted to the HRPP as soon as possible, but always within 10 days. Serious problems must be reported verbally within one business day, in addition to the submission of the written Problem Report.

You are required to maintain complete records pertaining to the use of humans as participants in your research. This includes all information or materials conveyed to and received from participants as well as signed consent forms, data, analyses, and results. These records must be maintained for at least three years following project completion or termination, and they are subject to inspection and review by the HRPP and other authorized agencies.

Please notify this office when your project is complete. Upon notification, we will close our files pertaining to your project. Reactivation of the HRPP approval will require a new HRPP application.

If you have any questions relating to the protection of human research participants, please contact the HRPP by phone at 325.3994 or email irb@research.msstate.edu. We wish you the very best of luck in your research and look forward to working with you again.

Kari Reeves

Approval Period:	December 05, 2016 through November 15, 2017
Review Type:	EXPEDITED
IRB Number:	IORG0000467

APPENDIX C

EDUCATIONAL GREEN ROOF GUIDELINES

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Educational Green Roof Design Guidelines

- Diverse colorful vegetation
- Varied terrain
- Focus on heterogeneity to ensure both aesthetics and function of the space
- Address all four habitat components at the appropriate scale for each individual green roof habitat: food, water, shelter and cover
- Include visible food sources
- Distinct cover sources and materials
- Specific breeding space area
- Include a mixture of both extensive and intensive vegetated green roof areas.
- Create a variety of habitat types with similar conditions to surrounding area that are suitable for existing wildlife

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APPENDIX D

EDUCATIONAL GREEN ROOF SCHEMATICS