Perceptions of Pollinators: Knowledge, Attitudes, and Behaviors Among University Faculty, Students, and Staff

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Abstract

Native bee declines are a significant concern worldwide because of the potential impact on ecosystem functioning, affecting human well-being. There are 20,000 native bee species worldwide, of which approximately 4,000 are in North America. Native bees are the most important pollinators because of their diversity and specificity to many flowering plant species. Decreased crop yield and possible economic collapse, food shortages, and floral plant declines would follow a significant decline in native bees. Since pollinators are so critical, organizations such as the Xerces Society and Obama Administration's National Strategy to Promote Honeybees and Other Pollinators are aiding in educating the public and enlisting the people's assistance in support of pollinators. As these critical initiatives promote pollinators the public knows little about how important these tiny insects are to their well-being. To understand the knowledge, attitudes, and behaviors of undergraduate students, graduate students, professors, and staff at a university in the Southeastern U.S., a bee questionnaire was administered online through Qualtrics. The survey contained three sections that measured knowledge and attitudes using a drop-down selection or a Likert Scale of 1 to 5. This was followed by 16 images identified as a bee or non bee. Finally, the participant was asked to select which bee was a honeybee from the images. Analysis of the results included a binomial comparison, ANOVA statistical analysis between the groups, and a comparison of means. The results showed that only 27% of the participants knew that there were 4,000 species of bees, 53% of participants could identify a honeybee, 40% of participants were afraid of bees, 79% were concerned about bees, 82% agreed pollinators were important, and 96% thought that bees were essential to humans. In conclusion, it was determined that almost half the participants did not know what a honeybee looked like, and only one-fourth of participants knew that 4000 species of native bees were in the U.S. Overall, there was a lack of knowledge about pollinators, even though most participants believed pollinators to be important. It is interesting to note that there was no statistical difference between the different groups (staff, students, faculty). Future implications from this study to support bee conservation education for the public and Universities such as this one in becoming a U.S. Bee Campus through a certification program.

Keywords: native bee, pollinators, conservation, environmental behavior

Chapter 1: Introduction

Rational

The Theory of Planned Behavior (Ajzen, 1991) was used to investigate attitudes, subjective norms, and behaviors to determine intentions toward pollinators and pollinator conservation. Understanding attitudes toward environmental behaviors is important to determine how humans feel toward the behavior. Subjective norms tell of the perceived pressure toward the behavior. Behavior determines how well one believes one can do a behavior. Due to declines in the number of bees worldwide (Rasmussen et al., 2022) resulting in a possible ecosystem collapse, it has become evident that something needs to be done. The first step is to survey the public to determine their knowledge, attitudes, and behaviors toward pollinators. One will not conserve what one does not understand. Previous research has determined a gap between public interest and understanding (Campbell & Hagevik, 2019; Wilson et al., 2017).

Purpose

The decline in native bees populations worldwide is due to habitat loss, pesticides, farming, climate change, and disease (Rasmussen et al., 2022). The decline of native bee populations affects almost all flowering plants and trees that support human well-being through pollinating. Pollinator conservation aims to increase bee populations by practicing simple fundamental behaviors such as planting native flowers or pollinator gardens as a food resource, creating native habitats, and studying bees and overall bee health through research. Multiple studies have shown that the public lacks an understanding of the importance of bees even though they are highly interested in pollinator conservation (Wilson et al., 2017).

This study aims to determine if there are differences between students, professors, and staff attitudes toward conservation practices and the knowledge of pollinators. The Theory of Planned Behavior (TPB) and its framework (attitudes, subjective norms, and controlled behaviors) were used to determine intention toward behaviors accurately or, in other words, whether humans will participate in pollinator conservation practices. Determining behaviors toward pollinator conservation practices provide a baseline of understanding for the planning of future pollinator conservation activities to help improve the knowledge of pollinators' importance to the ecosystem and increase participation in environmental practices supporting pollinators.

Multiple studies have used TPB to determine knowledge among primary and secondary students and attitudes toward the environment (Wilson et al., 2017; Penn et al., 2020). This study aims to find differences between STEM and non-STEM students' intentions toward pollinator conservation and knowledge of pollinators with a modified bee survey. Professors from the same university were added to this study to help determine if experiences were a factor between differences, and the researcher interviewed the public at a campus function to obtain their attitudes towards conservation practices as a comparison group to the student, professors, and staff. Age and ethnicity groups were investigated to determine if there were any differences between the groups.

This research study addressed the following questions: What are students, professors, and staff at a large comprehensive master's degree university in the Southeastern US knowledge about and attitude toward bees and pollinator conservation? Is there a difference in willingness to support bees between STEM and non-STEM students? Is there a difference in age, ethnicity, or years of education? Is there a difference in professors, students, and staff's knowledge of bees? How does this compare to the community's attitudes towards bees and pollinator conservation? The findings from this study can be used to determine ways to support the public and the University in becoming a U.S. Bee campus through a certification program.

Limitations

There were minimal limitations to this study. This study occurred at a medium size minority-serving master's level University in the Southeastern United States. The sample size was small, especially with the public interviews, because of the lack of access due to the continued health impacts of the pandemic. With greater participation in the survey, possibly through more significant incentives, patterns may have been found among groups. This is an initial study, and in a longitudinal study over time, perhaps if conservation practices were implemented on campus, there would be a change in results. It would be interesting to compare these results with similar Universities in the U.S.

Chapter 2: Literature Review

Introduction

There are an estimated 20,000 bee species worldwide and 4000 bee species in North America which have declined by more than 60% due to multiple factors such as agriculture and pesticide use, climate change, habitat loss, and decreased floral diversity (Bruno et al., 2009; Ferreira et al., 2022; Penn et al., 2020; Rasmussen et al., 2022; Wilson et al., 2017). Pollinating insect species declines are problematic for countries worldwide because of their importance to many agricultural crops and the valuable ecosystem services they provide.

The European honeybee is a non-native bee species found throughout the U.S. Honeybees are raised as a cash crop for honey and loaned to farmers to support the pollination of crops such as almonds, cherries, peaches, and strawberries (Campbell & Hagevik, 2019; Caviglliasso et al., 2021; Penn et al., 2020). Crops cover over 50% of the arable land in the US, and about 40% globally (USDA FDA, 2020). Mallinger et al. (2021) found that pollinators benefited 47 food crops in Florida, including blueberries, mangoes, melons, squashes, and tangelos, and pollination contributed from 75% to 100% of crop productivity. Pollinators support crop yields which supply food for humans and other animals (Habel & Ulrich, 2022). Loss of bee diversity will affect human well-being overall due to the many necessary ecosystem services provided by pollinators (USDA FDA, 2020).

Habitat loss significantly contributes to native bee declines due to minimal or no floral diversity to support different bee species. Bee diversity depends upon floral diversity because bees are attracted to different flowers, and some bees have a preference, such as cactus bees, pear orchard bees, and squash bees (Felker & Bunch, (2016). Bees are unique because their diet consists of nectar and pollen housed inside flowers, and this is the bee's only food supply and nutritional resource for themselves and their bee larvae growing in the nest. Bees coevolved with angiosperms and are critical to the reproduction of plants through the transfer of pollen from their hairy bodies to other plants while foraging.

Another factor that has contributed to the decline of these pollinators includes diseases and invasive predators. Giant Asian Hornets (*Vespa mandarinia*) prey on honeybees and have an appetite for them that is unparalleled by any other. Giant Asian Hornet can cause hive collapse due to the high quantity of honeybees that can be consumed in one sitting because a single wasp can kill enough honeybees so that the hive will not be sufficiently supported. Varroa mites are pests that carry diseases and are one of the leading causes of hive failure (Smart et al., 2016). Varroa mites ride the backs of honeybees to the hive, where the disease is spread, and Varroa mites feed and lay eggs on the honeybee larvae (Piou et al., 2022).

To help fight the battle over the possible crisis that could occur from the possible extinction of pollinators, it is important that everyone value them and work together to support an increase in their populations. However, fear and lack of knowledge impede participants' intentions and behavior from involvement in critical environmental practices (Wilson et al., 2017). To help understand how to combat these fears, Ajzen's Theory of Planned Behavior (TPB) can be used to determine participant willingness to get involved by their attitudes, subjective norms, and their controlled behavior toward practices such as raising honeybees, caring about native bees, creating natural habitats, building nesting sites, and planting native floral vegetation along with herbs, crops, flowering trees, and small gardens (Ajzens., 1991; Schonfelder & Bogner, 2017; Stout, 2022).

Native bee conservation is restoring diverse floral habitats for native bees and increasing bee species richness through conservation practices, policy, and public awareness (Law, 2015;

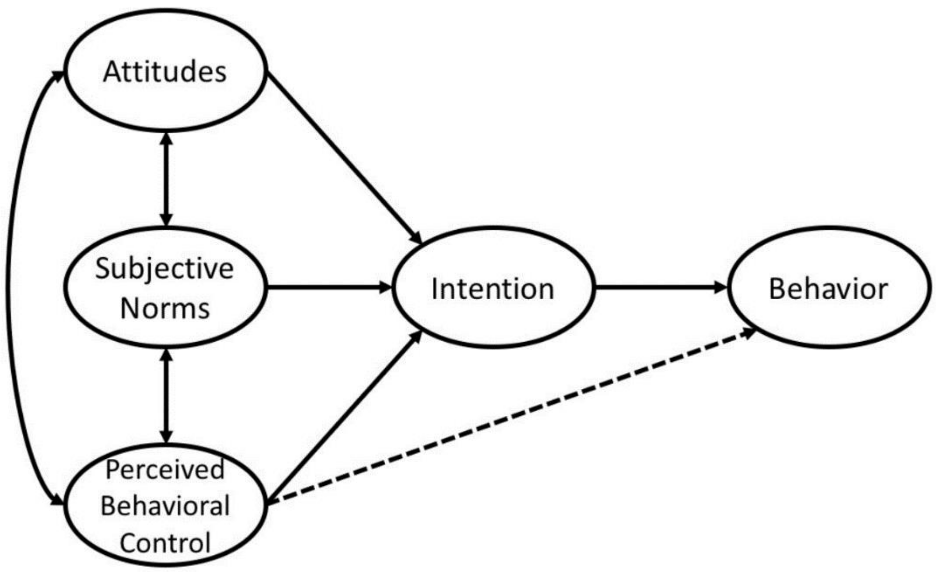
USDA FDA, 2020). Honeybees grab much of the media's attention, but native bees have greater or equal importance in pollinating plants (Penn et al., 2020; Wilson et al., 2017). Ferreira and others (2022) stated that 35% of global crop production requires pollination. Bumble bees as well as carpenter bees need large quantities of nectar and pollen for sustainable food supplies as they work all day long, visiting miles of flowers and foraging for nectar and pollen. Some small bees, such as sweat bees, fairy bees, and smaller species of carpenter bees, tend to stay closer to home when they forage, but a honeybee can travel up to 5 miles or more. Some native bees are plant-specific, which is why some species of bees have become extinct when their food source disappeared or became too few to support them (Bately & Hagandoem, 2009; Bruno et al., 2009; Rasmussen et al., 2022). Pollinator conservation awareness is more important than ever and therefore, public understanding of the potential impacts of pollinator decline and extinction and what can be done to support pollinators are of public interest.

Theoretical Framework

Theory of Planned Behavior (TPB)

The Theory of Planned Behavior (TBA) was constructed from another similar framework, the Theory of Reasonable Action, in the mid-1980s by Icek Ajzen and has been widely used to determine intentions to do a behavior from attitudes towards the behavior, subject norms, and perceived behavior control (Ajzen, 1985). However, intentions with perceptions of behavior control account for intentional variances because many factors affect decision-making such as age, knowledge, and importance (Ajzen, 1991). LaMorte (2019) of the Boston University School of Public Health described the TPB as a way to predict an individual's intention to engage in a behavior at a place or time as determined by an attitude which refers to the degree to which an individual has a positive or negative evaluation of the behavior; behavior intent which refers to what motivates a given behavior; social norms which refer to the expected behaviors in a group or cultural complex; perceived power which refer to the perceived presence of factors that may affect the performance of behavior; and perceived behavioral control which refers to a person's perception of the difficulty performing a behavior (See Figure 1).

Figure 1. Diagram of the Conceptual Framework of the Theory of Planned Behavior (adapted from Ajzen, 2005)



Linder et al. (2018) used the TPB and an exercise questionnaire to determine why traditional and nontraditional students are not involved in vigorous exercises. The exercise questionnaire showed that intentions and descriptive norms significantly affected whether traditional students would exercise and indicated whether nontraditional students would participate in vigorous exercises (Linder et al., 2018).

Likewise, pro-environmental behavior is defined as behavior that seeks to decrease the adverse effects of one’s actions on the natural world (Cosquer, 2012). Karapandžin & Rodić (2017) indicated that the TPB was the most used theoretical framework to determine environmental behaviors, environmental decision-making, and agroecological practices that surrounded sustainability. For example, Mulwanda et al. (2022) examined the perceived benefits of insect pollinators to Mufulira farming communities using a questionnaire, a focus group discussion, and interviews. The researchers found that farmers knew that insects pollinated their crops and understood that the crops supported the insects with food. Knowledge was influenced by age, farming experience, and education level (Mulwanda et al., 2022). Matzek & Wilson (2021) surveyed 1,092 adult Australians to determine if an ecosystem service approach would broaden support for ecological behaviors. They found that pro-environmental behavior of supporting ecosystem restoration was subjected to pro-use (utilizing) and anti-use (preserving). The public's preference supported pro-use rather than anti-use. Attitudes predicted behavioral intentions more than core values (Matzek & Wilson, 2021). These results supported that an ecosystem service approach might appeal more to nontraditional supporters that had a more egocentric viewpoint of the environment. Using the TPB considers restraints as well as affordances which is important to consider when implementing environmental programs. Considering knowledge, attitudes, and behaviors, as well as social norms and behavioral controls are all a part of how an individual chooses to act or not. Measures that consider these variables should be a part of conservation programs that encourage the support and preservation of pollinators as well (Bosone et al., 2022).

Effects of Agricultural Practices on Pollinators

Studies have shown that human interference with abiotic and biotic ecosystem functions, such as intense agriculture practices, strongly reduces pollination due to deforestation and floral diversity loss (Habel & Ulrich, 2022). Natural and near-natural habitat loss due to increased agricultural farmlands, housing, and commercial development has negatively impacted pollinating insects such as native bees, butterflies, and honeybees and these practices caused a significant decrease in floral diversity (Habel & Ulrich, 2020).

Habel & Ulrich (2020) showed that in areas where bees declined, so did the plants that need bees to pollinate them. This showed that plants associated with specific insects decline if the pollinator associated with them declines (Stokstad, 2006). Ferreira (2022) studied three different habitats (soybean crop, Amazon Forest, and vegetation between soybean fields) and found that bee diversity was more significant in the vegetation between soybean fields and the Amazon Forest. Still, the Amazon Forest had the highest bee populations, while soybeans had the lowest bee diversity (Ferreira, 2022). Agriculture practices, such as clearing the Amazon Forest for cropland, have decreased bee diversity and specific crops like soybeans have had adverse effects on native bee habitats and diversity (Ferreira, 2022).

Insect density and diversity have declined due to increases in the land that is tilled or plowed before the planting season. The soil disturbance raises nutrients from the ground before planting, and fertilizers are added to the ground, which becomes saturated with nitrogen and phosphorus that kill beneficial insects and affect bees that live in the ground (Lajos et al., 2021). As a result of such agricultural practices in sub-Saharan Africa, soil fertility has decreased, water quality has declined, and ecosystem stability among plants and pollinators has deteriorated (Rukondo, 2018). Pollinator declines cause a negative feedback loop as surrounding natural vegetation such as flowering plants and trees are also affected since they too depend on pollinators for reproduction. This then causes other animals in the ecosystem that rely on those plants to be affected. Therefore, pollinators are crucial to ecological function that support most of the world's plant diversity and the associated organisms (Rukondo, 2018).

Agroecology applies environmental concepts and principles that involve mobilizing practitioners and academics to find innovative ways to increase food productivity and sustainability while ensuring quality of life (Belain et al., 2019). Agroecology should address all factors in food systems involving total energy flow, materials from their source to production, and return of nutrients to soils (Belain et al., 2019). Delaine et al. (2019) stated that climate-smart-agriculture (CSA) is adapting and building resistance to climate change, sustainable agricultural productivity, and income growth by reducing or eliminating greenhouse gasses. CSA is mandatory to ensure food supplies for nine billion people on this planet by the year 2050 (Delain et al., 2019).

Invasive Predators and Diseases

Predators and diseases can significantly impact populations of organisms at all ecological levels. Unfortunately, while there are many studies about honeybee's predators, parasites, and diseases there is not enough research to confirm any native bee declines are due to parasites and diseases. Leza et al. (2019) said that honey bees are vital in pollinating, allowing humans to take advantage of a natural process that supports food supplies. Like most other insects or animals, honeybees have enemies such as wasps and mites. Mertz (2021) and Piou et al. (2022) noted that parasites and predators significantly impact honeybees and can cause hive collapse if not properly managed. *Vespa velutina,* a species of hornet, has a diet that can consist of up to 70% honeybee just before the wintering season in October (Require et al., 2018).

There have been 70 viruses associated with honeybees, but only three have symptoms, and deformed wing virus (DWV) is the leading cause of colony collapse in North America (Piou et al., 2022). Parasitic *Varroa mites* vector DWV and has at least four different viral strains (DWV-A, B, C, D); DWV-B devastates Europe, and DWV-A kills millions of honeybees in North

America (Piou et al., 2022). Piou et al. (2022) stated that *Varroa* mites injected viral particles into the hemolymph, allowing faster replication. *Varroa* mites are better known to beekeepers as *Varroa destructor* as they ride on honeybees' backs feeding on their fat body and enter the developing worker cells to feed on the larvae (Ramsey et al., 2019). As soon as females hatch, they start reproducing again, and honeybees become susceptible to viral and bacterial diseases, which can cause colony collapse (Mertz, 2021; Piou et al., 2022).

The small hive beetle is a honeybee parasite that originated in Africa's southern regions and has now manifested in many other parts of the world through human introduction (Mustafa et al., 2013). Small hive beetles feed on brood, honey, and pollen stored in the comb. Infestations on small honeybee hives by small hive beetles can result in hive collapse because the small hive beetles will steal all resources for survival (Mustafa et al., 2013). Mustafa et al. (2013) used a total of 24 small hives (12 small hives with screens and 12 small hives without screens) over a four-week time frame to determine how small hives would be affected by hive beetle infestations and found that small hives without screens were susceptible to small hive beetle infestations compared to large honeybee colonies that were not infested.

Use of Pesticides and the Effects on Bees

In addition to disease and predation from introduced species, native bees and non-natives are affected by the use of pesticides on crops (Tosi et al., 2017). Pesticides and their effects on honeybees and native bees have been shown to affect cellular function, organ function, body part dysfunction, and loss in honey production due to energy loss in honeybees (El-Din et al., 2022; Tosi et al., 2017). Declines due to pesticides from agricultural landscapes increased susceptibility to bacterial and viral diseases causing adverse effects on many bee species and populations (Tosi et al., 2017). Chlorpyrifos and Imidacloprid caused damage to the body, mouthparts, leg shrinkage, and abdomen length in bees, and Imidacloprid blocks synaptic signaling in the brain and affects adult honeybees' motor and sensory systems (Manorway, 2021). Tosi et al. (2017) said that with pesticides and low food supplies, the mortality rate of the bees increased to 50%, and food consumption was reduced by 48%. Endurance, strength, velocity, memory, larvae production, queen production, drone production, hive production, a decline in adult bees (28%), pollen collection (19%), and honey production (29%) were all reduced in honeybees (Sandrock, 2022). Decelerated growth was significant, and readiness to swarm in springtime decreased (Sandrock, 2022). When honeybees swarm, they are looking for a new home to start the colony. One study on blue orchard bees exposed to pesticides and low food supplies found that these stressors together decrease reproduction (Stuligross & Williams, 2020). There are an overwhelming number of scientific studies linking bee declines to pesticide use and illustrating the far-reaching impacts of toxic chemicals on a wide range of environments.

Effects of Pesticides on Beneficial Insects

Agriculture has contributed significantly to the decrease in natural predatory insects and microbial insects such as parasitic wasps, hoverflies, spiders, beetles, and bacteria that naturally aid in stabilizing pest infestations, pollination processes, and small ecosystems (Tosi et al., 2017). Beneficial insects, including pollinators, have declined over decades of agricultural development because of the loss of habitat, increased pesticide use, and decline of food resources from wildflowers. Gut et al. (2022) said that using pesticides increased the mortality rate of insects that meet pesticide residues from contaminated nectar and pollen. Disrupting the natural balance between predator and prey, such as using pesticides, resulted in infestations (Gut et al., 2022). For example, using pesticides in a pear orchard reduced the natural enemies of Pear psylla (a sap sucking pest), such as the brown and green lacewing and minute pirate bugs, which caused less fruit yield (Gut et al., 2022). Planting wildflowers every two rows in monoculture crops would increase crop production because natural predator numbers are high, maintaining pest infestations that help to increase fruit yield (Pecenka et al., 2021).

Sustainable Agriculture

No-Till

No-till farming helps keep the destruction of ground-dwelling pollinators to a minimum. Increasing food supplies worldwide while combating climate change through innovative agriculture is the main objective of sustainable agriculture, and there are some examples showing promising results. In 1999 no-till farming was adopted across nations and covered about 45 million ha of farmland, where 1 ha is equal to 100 acres of land (Derpsh et al., 2019). Over time no-till land has grown to 72 million ha in 2003 and to 111 million ha in 2009, an increase of 6 million ha per year (Derpsh et al., 2019). Derpsh et al. (2019) said South America has the most non-tilled farmlands at 70%, which will never be tilled again. No-till practices are adaptable to different climates and cropping conditions and are being practiced from the Arctic Circle, in areas 3000 m above sea level, in stormy areas that receive up to 2500 mm of rain a year, and in areas that receive less than 250 mm of rain per year (Derpsh et al., 2019). No-till offers ways to increase productivity and optimize ecosystem services, increasing the range of economic, environmental, and social benefits, which allows agriculture to respond to global challenges such as climate change, land and environmental degradation, and increased food, energy, and production costs. Agriculture needs pollinators to maintain sustainable food sources for an ever-growing population that is set to reach 9 billion people by 2050 (USDA, 2020). To feed the world and maintain ecosystem functioning, innovative and sustainable practices must continue to be developed.

Sustainable Agriculture and Pollinators

Sustainable agriculture aims to support the human population with healthier foods, stable food systems, and a healthier environment and well-being. Sustainable agriculture includes landscapes that promote pollination and minimize pesticide use. In a three-year study, alyssum which supports hoverflies that are beneficial insects was planted between rows of broccoli to see how well the broccoli produced from the first to second harvest. It was shown that planting alyssum on both sides of a bed would produce bigger broccoli shoots (Brennan, 2016). Perrot et al. (2022) discussed oilseed rape crops and how these crops are grown extensively to produce biofuels and are highly profitable for farmers. Native pollinators increased oilseed rape crop yields by up to 35% (Perrot et al., 2022). Perrot et al. (2022) studied oilseed rape crops for six years to determine if pollinators also affected other beneficial insects in fields as well. When pollinator species were high, so were the beneficial predatory insects. In another study on blueberries in Vermont with low intensified managed landscapes (pesticide use is minimal and the landscape supports native bees), it was found that native bees improved seed sets by 92%, increased fruit sets by 12%, increased fruit mass by 12%, and reduced harvest time by almost three days. Incorporating suitable native habitats for native pollinators within or alongside crops can increase crop yield, decrease the use of pesticides, and decrease pests.

Honeybees

Honeybees are social bees that survive in large colonies with one queen, many non-reproductive females called workers, and some fertile males called drones and are on all continents except for Antarctica (Holzschuh et al., 2012). Holzschuh et al. (2012) found that honeybees forage on many different plant species collecting pollen and nectar, and while native bees pollinate more efficiently than honeybees, a higher number of bees could possibly be better dependent upon the floral source. Honeybees can be managed by artificial hives quickly moving from place to place. Stanghellini et al. (1998) compared two honeybees (Asian and Western) on watermelon crops to determine if there would be any positive effects on seed production. Western honeybees (*Apis mellifera*) were found to be 2-10 times more productive than Asian honeybees (*Apis cerana*) because Western honeybees are hairier, which allows for more pollen to stick to the bee body and spread abroad through foraging (Cavigliasso et al., 2021; Stanghellini et al., 1998). Fruit crops benefit honeybees with high amounts of nectar and pollen. Blueberries are thirty-nine percent of Argentina's crops and supply the United States and Europe (Cavigliasso et al., 2021). Cavigliasso et al. (2021) observed the effectiveness of honeybees on three blueberry farms. Using conventional methods on six plots and precision methods on three plots, it was found that honeybees accounted for 99% of the flower visits in a 50-hour time frame, and the number of bee visits was 1050 from both methods (Cavigliasso et al., 2021). Fields that were precision managed had a 70% increase in bee visitations than those of conventionally managed blueberry crops. Increased visitations from honeybees also increased fruit sets by 13% using precision management methods that also caused 10% more flowers to become fruit (Cavigliasso et al., 2021). Shanahan (2021) reviewed multiple studies about pollinator habitats and floral diversity and showed that most studies did not indicate the correlations between pollinators and floral diversity. He stated that agricultural systems pose a major problem by not recognizing the capabilities of pollinators and the effects of decreases in floral diversity on pollinators and crop production (Shanahan, 2021).

Native Bee Declines

Bruno et al. (2009) emphasized that deforestation, agriculture intensification, and introduced invasive species have contributed to the decline of bees. In Denmark, the differences in diversity over a one-hundred-year span showed a decline in native bee species and diversity, and a loss of floral diversity (Rasmussen et al., 2022). For example, 174 species were reported from 1900-1919, and from 2000-2019, 121 species of native bees were reported.

Temperature increases and landscape changes have significantly harmed native bee species (Keleman & Rehan, 2021). Keleman & Rehan (2021) studied the effects of temperature over 45 years (1974-2019) and landscape change over 118 years (1902 to 2019) on small carpenter bees, *Ceratina calcarata*, and found that temperature caused female carpenter bees to decrease in size by 0.42% and male carpenter bees to decrease in size by 0.45% for every degree of increased temperature. Worldwide there are an estimated number of 20,000 native bee species with over 4,000 living in North America alone (Penn et al., 2020). The largest number of native bees occur in diverse habitats, such as in California and Utah, where over 30% and 25% (Utah Pests Extension, 2022) of North American bees are found. According to a recent global survey of bees (Orr et al., 2021), worldwide hotspots occurred in the southwestern USA, the Mediterranean Basin into the Middle East, and Australia, with a weaker signal in South Africa. However, bees live in every ecosystem and content except Antarctica, signifying their significance to all ecosystems in the world.

What is Native Bee Conservation?

Native bee conservation is the preservation of all wild bees and their habitats. Conservation practices include planting flowers, providing additional food resources such as nectar, and promoting bee populations and diversity by adding different housing structures such as bee housing. Conservation involves learning about what makes something a bee, why bees are important, their life cycles, where they live, and what they need to be healthy and happy. Since bees are found worldwide, the declines are global. Therefore, everyone needs to get involved to support bee conservation practices.

Public Connections with Pollinators

The public connections to pollinators and bees are minimal because the public has a lack of understanding in general about what bees do, the relationship between bees and plants, the consequences of pollinator declines, and the importance of bees to the entire ecosystem (Caine, 1977; Penn et al., 2020; Wilson et al., 2017). Multiple surveys of the public have shown knowledge gaps while at the same time a willingness to support pollinators. One survey asked 1427 participants about bee importance and then used multiple pictures of ten insects (6 were bees) to see if participants could identify bees (Penn et al., 2017). The results showed that almost 80% of participants misidentified the number of bee species in the U.S. and over twenty participants said that there were between 1 million and a billion bee species which indicates that these participants might have mistaken species for the population. Wilson et al. (2017) also showed that from the images of insects, 74% could identify bees but when the bumble bee and honeybee were removed the participants could only identify just over 50% of the bees. Penn et al. (2020) used similar questions asking participants if they strongly agreed (5) or strongly disagreed (1) with honeybees being native to North America, honeybees are more connected to wildlife than livestock, and if they were afraid of bees. The average for these three questions was unsure or 3, showing a knowledge gap between humans and bee importance. This knowledge gap could be due to a lack of knowledge about pollinators and fear of bees (Penn et al., 2020). The survey also asked participants to identify the honeybee from multiple insects, and the results showed that only 50% could identify a honeybee (Penn et al., 2020). Schönfelder & Bogner (2017) used questionnaires to compare experienced beekeepers to primary, secondary, and college students to see how they perceived bees, thought about bee conservation, and how dangerous bees are to them. The study showed that students had the willingness to protect bees and that their perception of danger was mediocre. Getting stung was the most significant fear factor, but educational programs can reduce human fears by getting rid of misinformation and supporting interest in pollinators (Schönfelder & Bogner, 2017). They recommended using honeybees as a model organism to reduce fears that hinder participation (Schönfelder & Bogner, 2018). References from myths, stories, and idioms found throughout many cultures can be very informative as well (Meyer-Rochow, 2021). Schönfelder & Bogner (2017) said that negative emotions such as fear often lead to a lack of support for conservation, appropriate curriculum, and activities for protection.

Schönfelder & Bogner (2018) addressed these fears using an online beehive for students to observe honeybees in action, hard at work. The students showed greater interest, lower perceived danger, and higher willingness to protect bees after program participation. The students could get close to a virtual hive without fear and see and hear the bees up close, which helped them build confidence. Stout (2022) proposed that the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) work to improve the understanding of the status and trends of pollinator populations, direct and indirect stressors of decline, including their interactions, risks, and benefits of pollinator conservation practices on ecosystems, pollinators benefits to society, the effectiveness of specific, tailored, actionable solutions and correlations that link benefits and values with actions to reverse declines. Eighty-eight articles were used to help formulate the United Nations Sustainable Development Goals (SDG). It was found that life on land (SDG 15) and partnerships (SDG 17) were the most outstanding in the collection of articles from 1992-2020 which correlated to biodiversity, sustainability, and restoration, and establishing multi-stakeholder partnerships (Sustainability, 2021).

Lack of Public Understanding of Pollinators

Multiple studies have shown a lack of knowledge about pollinators' importance, which could account for the general public's lack of interest and participation in pollinator conservation practices (Wilson et al., 2017; Campbell & Hagevik, 2019; Penn et al., 2020; Meyer-Roehow, 2021). A study conducted at four universities found that, on average, 50% of the students could identify a honeybee, and of six pictures of pollinators, only two were correctly identified (Penn et al., 2020). The university students did not know that beetles were pollinators (33.7%) and that only about 40% of students knew that a moth was a pollinator. Marseille & Colléony (2021) found that the driving factor was a lack of understanding in changing people's perception of bees. In a study using 32 conservation practitioners and 16 pollinating insect scientists from different industry sections, researchers discovered that the policy was inadequate (Dicks et al., 2013) and that public understanding was necessary. Understanding people's behaviors toward animals allows for better decision-making (Marseille & Colléony, 2021; Penn et al., 2020).

Penn et al., (2020) found that students lacked knowledge of pollinators but were interested in supporting conservation practices, such as pollinator campuses. An average of 95% of students from three large public Universities that were designated pollinator campuses supported conservation practices (Penn et al., 2020). We can interpret from the results that by introducing pollinators and conservation practices, students became interested in learning about pollinators and pollinator conservation practices (Penn et al., 2020). The general public's views and interests have been used to start initiatives such as “SAVE THE BEES" and government incentive programs such as paying homeowners to raise bees. Elicante et al. (2019) surveyed owners of small farms to determine the level of knowledge of bees and pollinators. From the survey, the farmers did know what honeybees were but did not know their role as pollinators and did not know that native bees also had a significant role in pollinating farm crops (Elisnate et al., 2019). After presenting information on pollinators and bees, the farmers were given a survey one year later, and the results showed that the farmer's knowledge of pollinators had increased while also learning about bio-pesticides.

Alverez-Garcia et al. (2018) surveyed teachers' training at two universities in Spain and compared their students' environmental understanding by introducing environmental and sustainability content to the students. One of the classes had more environmental information than the other class. The classes showed no difference in the amount of information retained but did show that the teachers had high enthusiasm for the environmental curriculum (Alverez-Garcia et al., 2018). In a survey by Nurwidod et al. (2020), students were analyzed to show the relevance of eco-school programs by scoring the students' environmental literacy. The study showed that students' environmental literacy increased in environmental effects, ecological knowledge, cognitive skills, and behavior (Nurwidod et al., 2020).

Johnson (2014) used a lesson plan to assess elementary students' knowledge of bees and taught for five days about bees pollinating, bee communication, bee anatomy, and bee communities in a one-week program to help students gain an understanding of the importance of bees. After a week of introduction to pollinators, students' knowledge increased in areas about bee anatomy by learning the three body parts (abdomen, thorax, and head) and an understanding of pollination. Johnson (2014) also taught the students about bee conservation such as building native habitats, planting flowers, building bee homes, and not using pesticides. At the end of the lesson, students were asked to name their favorite fruit and then discuss what would happen with bees, and this question helped students understand the importance of bees.

Public Programs to Support Bee Conservation

Governmental agencies and non-profit organizations have put forth efforts through funds for information awareness sessions or booths, education curricula or educational activities, policymaking (USDA-FSA, 2020), growing bees, and pollinator habitats. “Save the Bees” was a campaign widely seen by many across the country through a television network or on some billboard. The Xerces Society (2020) is a non-profit organization specializing in supporting conservation programs. The Xerces Society aids other organizations that support pollinator conservation practices through informational packages and monetary support (The Xerces Society, 2020). The Obama Administration also voted into law in 2015 a multi-year plan to help support pollinators by supporting building or maintaining native habitats (Law, 2015). Programs, including Bring Back the Pollinators, the 2018-2030 Pollinator Initiative, and the National Pollinators Garden Network’s Million Pollinator Garden Challenge, are all examples of partnerships to help combat pollinator declines. The primary goal of these organizations is to bring awareness to the public regarding bee declines due to habitat loss and other factors. Cosquer (2012) studied how repetitive interactions with nature aid in the development of knowledge and beliefs, and the results showed that (1) conservation efforts should be added to a broader spectrum of social relationships, (2) observing everyday nature causes humans to think about how nature works, (3) scientific knowledge seems much needed to help humans understand ecosystems. Cosquer et al. (2018) later added to this study by concluding that the public would play a vital role in reaching the goals set to increase biodiversity by increasing public awareness of conservation and how the public can get involved with conservation practices. Laws (2015) said that since 2014 the objectives as stated by the Obama Administration on The National Strategy to Promote the Health of Honeybees and Other Honeybees have been to increase bee diversity by implementing better farming practices, including native bee landscape, and increasing public knowledge. However, the objective has not been met to this date due to increased managed areas of people and non-involvement of stakeholders (Cosquer et al., 2012) such as national and local authorities, elected representatives, non-profit agencies, and the public.

Knapp et al. (2021) said three areas must be addressed for conservation programs to operate smoothly. First, the operation must be low-cost conservation practices such as not cutting the grass or clearing a small portion of land for ground nesting bees. Second, barriers that halt conservation practices, such as money and time, should be monitored closely, or plants with lots of nectar and seeds should be used instead. And third, knowledge and awareness to raise interest in pollinators are needed (Knapp et al., 2021).

Bee Conservation Efforts

Schönfelder & Bogner (2018) said that education was essential for increasing student willingness to support pollinators. By implementing pollinators and pollinator conservation practices and curricula, students learn about ecosystems that support the reproduction of plants and trees. Elementary school students' knowledge and understanding of plants were assessed with a pre/post survey, where students learned about flowers, their parts, and their functions using two methods: some students used mobile devices to collect data, and other students used the traditional methods such as drawing pictures or sketches. The results showed that the students gained more knowledge and understanding using mobile devices than traditional data collection methods. Bokor et al. (2014) used four activities in a week-long STEM program to assess student knowledge of plants: students learned about pollinators and plants, molecular biology, morphological phylogenetic, and molecular phylogenetics to help students gain an understanding of different plant species and plant characteristics. After assessing the pre/post surveys, the students showed increased learning at 0.643, showing more than minimal knowledge gained from 0.5 (Golick et al., 2018). Golick et al. (2018) used a survey to analyze students' knowledge of pollinator systems to build a framework to support the student's knowledge. The framework included lessons on plants and pollinators, conservation behaviors, and pollinating functional systems (Golick et al., 2018). Golick et al. (2018) said that with this curriculum, the students could add new information that helps them understand the ideas and practices that support pollinator conservation. Wells et al. (2021) used planting pollinator gardens to enhance student learning. Westlake (2019) planted gardens in an urban setting to enhance student knowledge of plants and pollinators in a non-ordinary educational setting. Students planted pollinator-friendly food gardens, and Westlake (2019) used a gymnasium to teach lessons on pollinators and conservation practices. Givot et al. (2015) used hummingbirds, which are pollinators and have also been on the decline. In this research study, Givot had students investigate whether the loss of trees and plants had an impact on hummingbirds. Ozer-Keskin & Aksakal (2020) surveyed seventh-grade students' interests by showing images of pollution in the environment and giving them four skills tests to assess their thoughts while drawing an image of a polluted environment. From the students' thoughts and images, the researchers concluded that images are a great way to assess students' thoughts about the environment (Ozer-Keskin & Aksakal, 2020). Information with images helps students put concepts together more efficiently and helps students retain information better because images are used for memory and knowledge enhancement.

The University of North Carolina at Pembroke, every summer for six years, has offered a bee camp to middle school and high school students through multiple grants. The camp occurred at the Garden and Apiary at UNCP. Students at the summer bee camp were introduced to multiple conservation practices through the learning of native bees, honeybees, other pollinators, research, plants, plant/pollinator correlation, gardening, sustainability, native habitats, and the many factors that affect bee species and populations (Campbell & Hagevik, 2019). These are up-to-date conservation practices that help increase scientific knowledge and allow students to gain a scientific understanding of pollinators and plants, bee morphology, and the effects of pollinators on the ecosystem. The researchers found that the students in the program gained a better understanding of pollinators, could correctly identify native bees and a honeybee, and that the students became bee ambassadors, educating others about bees and bee conservation.

Summary

The continued decline in pollinators from farming and pesticide use, habitat loss, introduced invasive predators, and diseases have caused a problem worldwide. Pollinator declines decrease food production, decrease pollination, decrease floral diversity, and decrease bee diversity, resulting in monetary losses (Cavigliasso et al., 2021). Native bees are generalists and specialists, supporting a diverse world of flowering plants and trees. Delaine et al. (2019) said climate-smart-agriculture (CSA) adapts and builds resistance to climate change and sustainable agricultural productivity and income growth by reducing or eliminating greenhouse gases and is mandatory for the food security of 9 billion people. However, current agricultural practices and pesticide use contribute to pollinator declines. Agriculture's increased use of pesticides and increased farmlands decrease bee diversities by demolishing habitats without regard to the benefit of pollinators such as native bees. Pesticides are detrimental to bees and beneficial insects, causing many different negative morphological changes that increase bee mortality rates. At the same time, many crops depend on bees, especially honeybees for pollination. Honeybees are some of the most productive pollinators because hives can have up to 150,000 bees and are mobile, so the hives are moved from farm to farm. Farmers can contact beekeepers to help aid in pollination across farms to help increase product yields. The *Varroa mite*, the Asian hornet, and small hive beetles have the potential to cause hive collapse due to viral infections, predation, and food loss. Honeybees are being affected negatively by the same pressures facing native bee populations.

The best way to introduce pollinators and their importance is to help students and their families to become familiar with the scientific language that better explains pollination processes. Knowledge of specific pollinators and their importance is lacking in and outside of the classroom. Educational institutions, non-profits like the Xerces Society, and governmental agencies are in the fight to help promote pollinator conservation for the sake of saving these species. Implementing courses or programs that would help students learn about pollinators and their importance could help close the gap between humans and nature. Information booths and camps are an excellent way to support the public and students with knowledge of the consequences of continued bee declines.

The Theory of Planned Behavior is used to determine an individual's intentions to perform a behavior. Attitude, subjective norms, and behavior control can adequately be used to determine the intention of behaviors by multiple methods. Surveys and questionnaires can be composed of questions that can be analyzed to show an individual’s interests and knowledge levels. Intentions, age, and knowledge content compared across stem vs. non-stem can help determine gaps between the two groups. The current study used knowledge, attitudes, and intentions to investigate the following research questions:

1. What are students, professors, and staff at a large comprehensive master's degree university in the Southeastern US knowledge about and attitude toward bees and pollinator conservation?
2. Is there a difference between STEM and non-STEM groups?
3. Is there a difference in age, ethnicity, or years of education?
4. Is there a difference in professors, students, and staff?
5. How does this compare to the community's attitude towards bees and pollinator conservation?

Chapter 3: Methodology

Introduction

Despite multiple efforts by a variety of conservation groups, governments, and non-profit organizations, there is a persistent lack of understanding about pollinators and the ecosystem services they provide. To determine what University students, faculty, and staff at a public University in the Southeast thought about pollinators and pollinator conservation, meaning their knowledge and attitudes, a bee survey was designed, validated, and distributed. In addition, as a comparison, a sample of convenience was used among community members at an outreach event. It was hypothesized that there would be a difference between STEM and non-STEM students. It was hypothesized that there would be differences in knowledge between levels of education, but there would be a lack of knowledge overall as a group, compared to other studies. This study may find evidence of differences between students, professors, staff, age, ethnicity and education levels, and the public, and compare similar studies results.

This study determined participants' intentions to perform pollinator conservation behaviors by comparing STEM and non-STEM participants based on knowledge, attitudes, and intended behaviors. This study received IRB approval # 31-21 on October 5, 2022 (see Appendix G).

Setting

The study occurred at a 4-year Comprehensive Master's University in Southeastern U.S. This non-tribal institution consists of 7,666 students and 425 faculty and 925 full-time employees (Fast Facts, 2022). Table 1 below shows the overall student demographics with non-white students (61%) being greater than white students (39%). Table 2 below shows that there are almost as many faculty on a tenure track (54%) as those not on a tenure track (46%). The employee demographics (see Table 3) shows that 53% are white with 47% are non-white which is different from that of the overall student population.

Table 1: Student Demographics

White or Caucasian	African American or Black	American Indian or Native American	Asian	Native Hawaiian or Pacific Islander	Hispanic	Two or more Ethnicities
39%	29%	12%	2%	1%	12%	6%

Table 2: Faculty Demographics

Permanent Tenure	Not Tenured but on Tenure Track	Not on Tenure Track	Total
135	95	195	425

Table 3: Employee Demographics

White or Caucasian	African American or Black	American Indian or Native American	Asian	Native Hawian or Pacific Islander	Hispanic	Two or more Ethnicities	Total
47.2%	9.8%	33%	3.9%	0.1%	3.4%	1.1%	925 FTE

The faculty to student ratio is 14:1 and the institution prides itself on providing a personalized, low-cost education. The institution is non-selective with a 92% acceptance rate (U.S. Department of Education, 2022).

Participants

The participants in this study were the students, professors, and staff at the University. There were 493 respondents to the bee survey, 69 of the 493 respondents had incomplete surveys and were not used in this study. The final number of surveys for data collection was n=423. The demographics of the participants were twice as many STEM and non-STEM and a small number of staff respondents (see Table 4). Participants were of different age levels and educational levels (see Tables 5 and 6).

Table 4: Participant Type

STEM	Non-STEM	Staff
270	130	23

Table 5: Participant Type by Age

18-24	25-34	35-44	45-over	Prefer not to say
201	66	62	91	3

Table 6: Participant Type by Education Level

Doctorate	Graduate	Senior	Junior	Sophomore	Freshman	High school +	High School
51	92	97	80	45	42	10	6

At a STEAM-day function, twenty interviews were conducted of public volunteers who answered the three questions to compare their thoughts about pollinators to that of the University population. The interviewees were a sample of convenience with twice as many being females (see Table 7).

Table 7: Interviewees and Interview Questions

Male	Female	Total Interviewees
6	14	20
1. Are you afraid of bees?		
2. How important do you think bees are to us?		
3. How important do you think pollinators are to us?		

Description of Measures

A modified bee survey (based on Campbell and Hagevik, 2019) was administered through the survey software tool Qualtrics (Qualtrics XM, 2022). The survey had four parts consisting of part one, eight demographic questions which consisted of education level, age, and ethnicity (see Appendix D), part two was two drop-down knowledge questions, part three had a 5-point Likert scale, with Strongly Agree a 5 and Strongly Disagree a 1, measuring attitudes and one knowledge question about honey bees, part four had 16 images of pollinators, native bees, and a honey bee and used a dichotomous yes or no scale in bee identification, part six showed all 16 images and asked for the one honey bee to be identified. The 16 images in part four were presented one at a time and participants could not go back once they had answered a question and participants could not go forward unless all the questions were answered. Participants could quit the survey at any time if they chose not to complete it, but they could not go back to it again. Participants could complete the survey one time only. Incomplete surveys were eliminated from the study.

The survey was sent out to both graduate and undergraduate students. The survey was also sent out to professors across all departments (biology, math, physics, psychology, etc.) and staff (administration) working at the University. The university administrative support sent the survey out by recruitment email to the students, professors, and staff. A survey reminder was sent out two weeks after the initial email to the students, professors, and staff (Appendix A). All emails had a Qualtrics link (Appendix A). A consent form was at the beginning of the survey for participants over the age of eighteen to read and sign (Appendix D). The survey remained available for three more weeks.

A chance to win a $20.00 e-gift card was provided at the end of the survey to help encourage participation. This voluntary question was located after the rules of the survey (Appendix D). When the survey closed, each participant that provided a name and email was numbered 1-25. A number generator was used to randomly select five participants. Electronic gift cards were sent via email to the five randomly chosen participants, then the emails that informed the five participants of their winnings were deleted. The survey was anonymous, and no identifying information was collected.

Interviews were collected while the survey was ongoing. Interviewees were asked if they would like to voluntarily answer three questions. These questions were open-ended so that the interviewee could express their answers. Question one asked the interviewee if they were afraid of bees to help determine a fear factor towards bees and compare the interviewee answers to the survey participants. Question two asked interviewees if native bees were important and why. Lastly, question number three asked if pollinators were important and why. Interviewees had to read and sign a consent form to participate in the study (Appendix C). The interviewees were asked to express their thoughts about questions concerning bees (Appendix E). The interview was conducted by the researcher, and answers were recorded in approximately 15 minutes per interview. The answers were recorded in a notebook before being transferred to an electronic device. The answers were analyzed and then compared to other groups, such as public vs students.

The researcher recorded any unexpected issues, changes, or conflicts that affected survey participation or interviewee participation. The journal also helped the researcher keep up with the types of participants when to send emails and the number of professors participating in the survey. When the study was finished, all notes were analyzed and added as needed.

Data Analysis

This was a mixed methods study with self-reported data (bee survey for students, professors, and staff) and descriptive observational data (public interviews and research journals). The survey was first analyzed to determine significant differences between the participant groups. These groups included students, STEM, non-STEM, professors, staff, educational level, age, and ethnicity. Pivot tables and pivot charts were used to analyze data in Excel to search for any significant differences between groups.

The first part of the data analysis was to determine the knowledge content from survey questions 9 and 10. These questions were multiple choice with one correct answer. The answers were then compared in groups using a simple binomial test and a comparison of means between groups. Questions 13-29 were identification questions for 16 images of insects and were analyzed using a binomial test to help determine the knowledge content of the participants from the survey. These questions were analyzed by binomial tests to determine any differences between groups, such as the professors versus students.

Secondly, data analysis to determine attitudes toward pollinators and conservation practices was analyzed by a Likert scale (Penn et al., 2020; Wilson et al., 2017). The Likert scale ranged from Strongly Agree (5), Agree (4), Neutral (3), Disagree (2), and to Strongly Disagree (1).

STEM vs non-STEM, professors vs. students, each age group, and each ethnicity group were compared using averages compiled from the Likert scale (Wilson et al., 2017). Interview questions 2 and 3 were also scored by the same Likert scale from the survey, and the answers were compared to other groups.

Finally, ANOVA one tailed t-tests were used to analyze any significant differences between STEM and non-STEM groups on bee identification from the 16 images of insects (questions 13-28) and honeybee identification (question 29) to help determine if there were differences between the groups (Wilson et al., 2017).

The interview data were analyzed by creating general themes for the text and were then compared to the results from the survey. Categories included fear of bees and bee conservation. Answers were analyzed to determine any differences or similarities in knowledge and attitudes between the groups, such as public versus students and public versus professors.

Lastly, the research journal text was analyzed for any missing similarities or differences to determine any correlations. This is a sequential exploratory design (Ivankova et al., 2006) with the survey being analyzed first, followed by the interview data (see Appendix E), and finally the personal journal. The sources of data and analysis for the study are summarized in Table 8 below:

Table 8: Data Sources and Analysis

Data Source	Quantitative / Qualitative	Research Questions	When Collected	Analysis
Survey to students, professors & staff	Quantitative, Likert Scale	Are there any differences in intentions to perform conservation behaviors between STEM and non-STEM students?	After three weeks	Mean or average of each question, percentages of the group, search for significant differences, ANOVAS, t-tests

		Are there differences between student's vs professor's attitudes? Are there differences in knowledge levels between groups?		to obtain p-values, binomial test
Interview Questions	Qualitative	Are you afraid of honey? Do you believe that bees are important? Do you believe that honeybees are important?	During STEAM Day at the University	Text analysis for similarities and differences
Research Journal	Participant observer	What factors influence students, professors, staff, and the public intentions to perform conservation behaviors?	Throughout the study, every day	Text analysis to find patterns, differences, similarities, and changes

Summary

A medium-sized public University in the Southeastern part of the U.S. began efforts to promote bee and pollinator conservation through the establishment of a Campus Garden & Apiary and outreach efforts to schools and the community through school gardens, outreach programs, and summer camps. To determine the overall campus and community's knowledge, attitudes, and intended behaviors toward pollinators and pollinator conservation a bee survey was administered, and data were collected and analyzed and then compared to interviews of community members. The overall purpose of this study was to determine if there was interest in pollinator conservation to work towards the establishment of a U.S. Bee Campus certification at the University. The results of the bee survey and the interviews follow in Chapter 4: Results.

Chapter 4: Results

This research study determined differences between students, professors, staff, and the public's knowledge and attitudes toward pollinators and behaviors related to pollinator conservation. Other variables explored included age, ethnicity, educational level, and STEM vs. non-STEM and their impacts on pollinator knowledge, attitudes, and behavior. Results from the Bee Campus survey will be discussed followed by the community interview questions. From the research questions, it is hypothesized that: 1) there will be a lack of knowledge among participants about pollinators and pollinator conservation, 2) attitudes towards pollinators and pollinator conservation will be positive with a willingness to support bees, 3) there will be a level of fear of bees among the participants, 4) there would be significant differences among STEM vs. non-STEM, students, professors, and staff, 5) there would be significant differences between age, ethnicity, and education levels, 6) the public attitudes towards pollinators and pollinator conservation would be positive and correlate with those of the survey participants.

Bee Campus Survey

A Bee Campus Survey based on a survey by Campbell & Hagevik (2019) consisted of 24 multi-part questions that were administered by email through Qualtrics in the fall semester of the academic year. These questions were used to gather participants' knowledge about bees (questions 9 and 10) and (question 29) assessed by the average percentages for the correct answers among the group (staff=23; professors = 51; students = 349) by the number of total participants (N=423). See Table 9 below.

Table 9: Knowledge of Pollinators by Percentage of Groups That Were Correct

Questions	STEM N=130	Non-STEM N=270	Students N=349	Professors N=51	Staff N=23	All Survey Participants (N=423)
9. How many bee species are in the US?	28%	27%	29%	25%	0	21% correctly answered the number of bee species in the U.S.
10. How many honeybee species are in the US?	6%	5%	5%	6%	0	4% knew how many honeybee species were in the U.S.
29. Identify the honeybee	60%	49%	52%	56%	39%	51% correctly identified the honeybee

Table 9 shows the percent averages for different groups and the overall survey results for questions 9, 10, and 29, respectively. Question 9 showed no significant differences among the groups using a one-tailed T-test and a p-value of >0.05. As a group, only 28% of the participants knew how many bee species are in the U.S. Question 10 was very similar across groups, with an average percentage of about 26% that know how many honeybee species are in the U.S. Only 5% of the survey participants knew the correct number of honeybee species in the U.S. Question 29 asked survey participants to identify a honeybee; only 52% could do so. Question 29 also shows no significant difference between STEM participants identifying a honeybee with a p-value >0.05 and the non-STEM group. The data indicate that there is no difference in knowledge of pollinators between students, professors, staff, STEM, and non-STEM groups. Tables 10 and 11 report knowledge of pollinators by ethnicity group and age, respectively. There were no significant differences found between the groups by age or ethnicity groups.

Table 10. Knowledge of Pollinators by Ethnicity

Ethnicity	Question 9. How many honeybee species in the U.S.?	Question 10: How many bee species in the U.S.?	Question 29: Identify the honeybee.
White or Caucasian	5.0%	26%	53%
African American or Black	1.5%	21%	50%
American Indian or Alaskan Native	5.3%	32%	50%
Asian or Pacific Islander	12.5%	12%	62%

Ethnicity not listed	N/A	50%	75%
Multi-ethnicity	15%	41%	53%
Latin X	3.3%	20%	46%

Table 11. Knowledge of Pollinators by Age

Age	Question 9. How many honeybees in the U.S.?	Question 10. How many bee species in the U.S.?	Question 29. Identify the Honeybee.
18-24	29%	4%	47%
25-34	16%	4.5%	54%
35-44	22%	6.4%	66%
45-over	32%	8.7%	59%
Prefer not to say	33%	N/A	50%

A Likert scale ranging from 5=Strongly Disagree, 4=Disagree, 3=Not Sure, 2=Agree, 1=Strongly Agree analyzed questions 11-1 through 11-6 to determine attitudes towards pollinators and pollinator conservation. The mean percentages for each group were calculated and then the overall percentages of those that agreed or strongly agreed were determined. There were no significant differences found between the groups (P-value >0.05). See Table 12 below.

Table 12: Percentages of Positive Attitudes Towards Pollinators

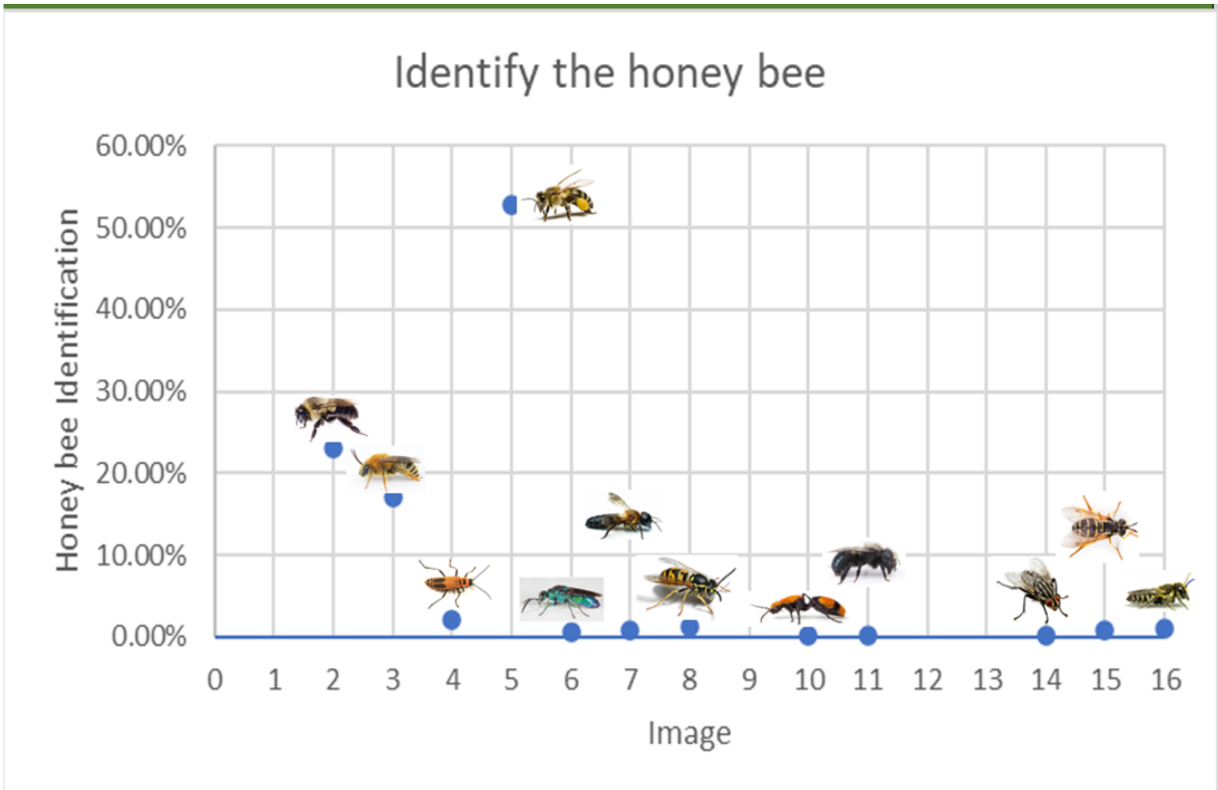
Questions	STEM	non-STEM	Students	Professors	Age	Overall
11-1. Bees are important to humans.	81%	78%	87%	94%	96%	95%
11-2. I am afraid of insects.	40%	40%	40%	31%	37%	41%
11-3. I am concerned about protecting bees.	97%	95%	79%	94%	77%	79%
11-4. I am afraid that bees might sting.	33%	43%	29%	41%	40%	31%
11-5. Wildlife and pollinators are very important to me.	82%	70%	85%	80%	83%	83%

11-6. Honeybees are an endangered species.	82%	77%	88%	80%	80%	80%

Questions 11-1 to 11-6 were multi-part questions used to determine attitudes towards pollinators and pollinator conservation (See Table 12). Question 11-1 shows that STEM and non-STEM groups found bees and pollinators to be equally important to humans at 81% and 78%, respectively. Overall, 95% of participants agreed that bees are important to humans. Question 11-2 shows that 40% of all participants were afraid of bees but 31% of professors were afraid of bees. Question 11-3 shows that the overall concern for protecting bees is 79%. Question 11-4 and Question 11-2 supported the level of fear associated with being stung by bees. Question 11-5 shows that 83% of all survey participants believed that pollinators are important to them. Question 11-6 showed that 80% of survey participants believed honeybees to be endangered, when in fact they are not endangered nor a native bee.

16 images of insects, with seven insects being bee species, were shown to participants one at a time. Participants had to determine if the image of each insect was a bee or non-bee. Then the participants determined which one of the 16 images was a honeybee. Figure 2 below shows results from identifying a honeybee.

Figure 2. Percentage of Identify the Honeybee by Image



A binomial test was used to determine any significant differences between the knowledge of pollinators (questions 13-28 and question 29), and the p-values are reported for each question for the survey participants (See Table 13). The total number of participants (423), the number of correct answers for each question (n), and 0.05 probability rate determine if the answer supports the null hypothesis.

Table 13: Knowledge of Pollinators from Images of Insects

Survey Question Number	P value
Questions 13-19 Questions 21-24 Questions 26-28	P<.0001 P<.0001 P<.0001
Question 20. Image of yellow jacket.	P<0.4366 Participants were misidentifying the yellow jacket as a bee

Question 25. Image of sweat bee.	P<.0001 Students were classifying the sweat bee wrong as non-bee more than 50% of the time.
Question 29. Identify the honeybee.	P<.2432 Students can't identify the honeybee better than guessing (50/50 chance).

Table 13 displays the p-values for questions 13-29. Questions 13, 14, 15, 16, 17, 18, 19, 21, 22, 23, 24,26, 27, and 28 had p-values of <0.0001, showing that students knew each of these insects from the images or the correct answer was chosen at a higher rate than they would have achieved if they had been guessing. Question 20 asked if a yellow jacket was a bee or non-bee and participants misidentified it with a bee and a p<0.4366. P<0.0001 for question 25 shows that students select the sweat bee as a non-bee more than 50% of the time, meaning the students don't know this is a bee, possibly because to them, it may look more like a wasp. Question 29 showed a p-value of <0.2432 and was interpreted that participants can't identify the honeybee by guessing, demonstrating a lack of knowledge about honeybees. Although the honey bee was correctly selected 52% of the time, other bees were also selected including the bumble bee (22%), followed by a squash bee (18%) (see Figure 2). In other studies, it has been shown that participants may confuse the aggressive yellow jacket wasp (Image 8) with bees because of the yellow and black honeybee association, however, in this study the yellow jacket was only selected 1.8%.

Question 29 was analyzed using an ANOVA and t-test to determine any significance between STEM and non-STEM groups identifying a honeybee, and the p-value is reported (See Table 14).

Table 14. Identify the Honeybee Results

Question	Groups	p-value
Question 29. Identify the honeybee.	STEM vs non-STEM	p<.2518

Table 14 shows no significant difference between STEM and non-STEM abilities to identify the honeybee with a $p>0.05$. We hypothesized that there would be differences between groups and their ability to identify a honeybee, but no differences were found between the groups.

Interview questions to the public were analyzed using the same Likert scale (5=strongly disagree, 4=disagree, 3=neutral, 2=agree, 1=strongly agree) and percentages of means that agreed or strongly agreed were reported and compared to the survey participants (See Table 15).

Table 15: Results of the Questionnaire Compared to Survey Participants

Questions	Interviewee	Survey Participants
How afraid would you say you are of bees?	45%	41%
How important would you say native bees are to you?	90%	83%
How important would you say honeybees are to you?	90%	95%

Table 15 shows that results from a questionnaire and similar questions from the survey were reported and compared. The results show that 45% of the interviewees fear bees compared to similar results from the survey participants at 41%. 90% of interviewees said that native bees were important to them, mainly because of knowing that bees pollinate, and 83% of the survey participants agreed that native bees are important to them. Of the interviewees, 90% said that honeybees were important or very important to themselves because they pollinate and make honey, compared to 95% of the survey participants.

Summary

The survey results showed no significant differences between groups' knowledge of pollinators or differences in attitudes towards pollinators and pollinator conservation. STEM compared to non-STEM and students compared to professors showed no significant differences in the knowledge of pollinators with $p>0.05$ (Questions 9, 10, 29). Interesting data to report about knowledge of pollinators is that there is a knowledge gap or a lack of understanding about native bees and honeybees because only one-third of participants did not know the number of bee species in the U.S. From the total number of participants (423) only 5% knew the number of honeybee species in the U.S. There were no significant differences between age and ethnicity and knowledge of pollinators. The survey participants' attitudes toward pollinators were positive with a willingness to support pollinator conservation. All groups showed an interest in the importance of pollinators and pollinator conservation, with 83% agreeing wildlife and pollinators are important, 95% agreeing that bees are important, and 79% agreeing they are concerned about bees. Interviewees also showed similar results from the questionnaire compared to the survey participants' attitudes toward pollinators and pollinator conservation.

Chapter 5: Discussion and Conclusions

The decline of native bees and other pollinators has received attention from the science community recently (Wilson et al., 2017) due to the critical importance of bees to ecosystem functioning and biodiversity, yet these small insects remain largely misunderstood to the public. The results of this study confirmed the conclusions of Wilson and others, with no significant differences found between groups regarding their knowledge and attitudes towards bees, pollinators, or pollinator conservation. All groups acknowledged the importance of bees and pollinators and that they should be conserved. The researcher hypothesized that knowledge would be insufficient about pollinators though there would be a desire to protect and conserve them. What was a surprise to me was that there were no significant differences among any of the groups nor was there a significant difference based on the demographic variables of age, ethnicity, or level of education. Demographic variables may not show a difference because everybody learns about bees in the same manner which is from others' experiences and not in education or academics. People's knowledge and understanding of bees comes from their own self interactions and others' stories of their encounters with bees.

Knowledge of Bees

The first two questions of the survey asked participants about bee diversity to determine their knowledge of pollinators. The first question asked participants to determine the number of bee species in the U.S. with an overall average of 28% correctly answering. Wilson et al. (2017) claimed that a media focus on the non-native honeybee for the past 15 years excluding the 2,000 species of native bees in the U.S. was a part of the problem. The second question asked participants to identify the number of honeybee species in the U.S. with only 5% of participants answering correctly. This agrees with other studies that showed a lack of knowledge about bee species (Penn et al., 2020: Wilson et al., 2017). This is a concern because participants consistently overestimated the number of bee species (four instead of one) and underestimated the number of native bee species, with 100 (instead of 2000) being the most common answer. It is important to understand the scale of biodiversity for the taxa that is being conserved.

The 16 images of insects presented to participants asked if the image was a bee. This section of the survey demonstrates a general knowledge of the differences between different types of insects, pollinators, and bees. The yellow jacket was mistaken for a bee most often by the participants even though they are not a bee but instead an aggressive predator. In addition, yellow jackets are much larger than many native bees. Since yellow jackets do sting and the sting is painful, this may explain why the participants are somewhat afraid of bees. The yellow and black striations of the yellow jacket may explain the confusion with a bee, particularly a bumble bee for example. Sweat bees were misidentified as a non-bee, probably because of their resemblance to wasps. Other studies using images of insects asked participants to identify pollinators. They found that only 54% identified moths, 40% identified wasps, 34% identified flies, and 35% identified beetles, showing that knowledge of insects that are pollinators other than bees is also not known to the public (Penn et al., 2020).

Participants were asked to identify a honeybee from pictures of the sixteen insects. Penn et al. (2020) found that on average, 48% of the participants correctly identified the honeybee from three major universities (LSU-55%, UK-46%, and OSU-44%). The participants in this study identified a honeybee correctly 53% of the time. Honeybees, bumble bees, and squash bees were often misidentified as non-bees. All three of these bees are frequent visitors to crops, thereby supporting crop yields, a necessity for food sustainability. However, honeybees are raised like livestock due to the monetary value of selling queen bees, renting to farmers, and honey production. Despite a media focus on honeybees, participants in general misidentify honeybees for other insects approximately half of the time. Our findings demonstrate that though there is a broad focus on protecting honeybees in the media, there is little education about what exactly makes something a honeybee and what exactly to protect or promote. Additionally, our findings demonstrate an overemphasis on honeybees, neglecting the important role that native bees play in the pollination of flowers, including many food crops.

Attitudes Towards Pollinators and Conservation

Multiple questions were asked to determine participants' attitudes toward pollinators and pollinator conservation practices. Most participants agreed that bees were important, acknowledging that bees play an important role in the ecosystem. Similar studies have shown that participants rated bees highly important to themselves and the environment, just as this study which showed that 95% of participants considered bees to be important. Wilson et al. (2017) said that raising awareness of bee diversity and their needs could benefit those concerned for bees, and the bees would benefit as well. Of participants, 83% agreed that bees should be saved, despite an overall lack of knowledge about them. It may be known that pollinators are important, but there is a distance between understanding just how important bees are to pollinating and understanding anything about the bees and what they need to thrive. Bees are the ultimate pollinator because their diversity allows them to be generalists pollinating all plants, and some are specialists only foraging on specific plants. They are also the only insects that specifically visit flowers to collect pollen, rather than collecting it by accident. The importance of bee diversity to humans should be a top priority for closing knowledge gaps about bees so that there is an understanding of just how much we depend on bees as do the ecosystems of the world.

Attitudes were affected by the fear of bees. Participants' fear of bees arises from fear of being stung by bees and other stinging insects like wasps. Fear was apparent in all groups; on average, 40% of participants said they feared bees. Attitudes towards stinging bees can come from one's encounter with bees and being stung. It is important that the fear of bees be diminished through the learning of bee habits and behaviors. Bees will only sting if they feel threatened, such as when one gets too close to the bees' home or when someone swings at a bee to scare it away. Bees are harmless to humans except those allergic to a bee sting which can be overcome by introducing safety when being around bees. Additional knowledge about what insects are not bees can also help reduce fear of bees. For example, people who classify yellow jackets as bees may feel differently about bees once they realize that yellow jackets are not bees.

Lastly, the questionnaire revealed that the public supported bees and agreed that pollinators were important, and honeybees were important to them. Interviewees said that both honeybees and pollinators were important because bees support food sustainability, and honey is a desired product for many uses. When compared, the interviewees and survey participants shared similar interests by strongly agreeing at 90% for both the importance of honeybees and the importance of pollinators.

Implications

The survey results show that knowledge of bees is lacking on a public level, even among different levels of education. It was revealed that bee diversity was largely unknown and that many participants believed that honeybees were native and endangered, of which neither is true. Introducing the diversity of pollinators and pollinator conservation practices will support an understanding of the importance of bees to the ecosystem and redirect interest and resources toward native bees. This survey provided information to support on-campus initiatives to support bee conservation practices and education. Off-campus activities such as information booths should be used to introduce the public to pollinator conservation practices. Knowledge of the importance of pollinators should be emphasized in classes suitable to teach about pollinators and plants associated with pollinators. Students, professors, staff, and the public participated in this study because initiatives to become a bee campus will involve the public and all campus community members. All conservation practices should be under a conservation umbrella that can be supported by different ethnicities, ages, and knowledge levels, to support upcoming pollinator conservation programs.

Limitations

Although the survey was administered online it could have been inconvenient for some participants to find time to participate. This study was limited to students, professors, staff, and the public but could have included groundskeepers, environmental control, and the landscaping crew where the study was conducted. Another aspect that could be taken into consideration would be to have a better incentive to get more participation from the rest of the campus. When there is a need for participation, monetary gifts such as gift cards or gifts can be used to encourage greater participation. This study did not look at gender differences due to the disproportionate number of females that took the survey. Reaching out to a broader and more diverse pool of participants might affect the results.

Future Research

This study may be used to promote further research on pollinators and pollinator conservation practices. The researcher has determined that there is a lack of understanding of the importance of bees and that there is a willingness to support pollinators and pollinator conservation practices. Additional research into the media coverage and scientific communication to the public regarding native bees and bee and pollinator conservation should be further investigated. Why does society see wildflower murals and cards without a bee on them or a pollinator for example when without these small insects the plant nor the flower would be possible? Why does the public so misunderstand bees and how can these misconceptions be addressed? How can the public and farmers understand ways to implement best practices around supporting pollinator conservation? How can one leverage the interest in honeybees to promote all bees? There are many questions that remain to be addressed by the research and education community.

Future research should try and close the gap between humans and pollinators. Conservation practices should be used in research to help determine which practices are suitable for campus participation in support of and conservation of pollinators in general. Which pollinator conservation practices should be implemented on and off campus to help participants gather information and learn about bee diversity? Floral diversity and native bees are both important to understand, but how do we determine which native wildflowers could support bee diversity and populations? Understanding beekeeping could be an important step in learning about honeybees' social habits and the value of honeybees as a cash crop and reducing fears associated with bees. Connections to food production and sustainability should be considered in future research. Future research on pollinators and the promotion of pollinator conservation will help aid in this University and others in becoming a U.S. Bee Campus.

Reflections

This research study was fun and interesting to conduct. Being trained in Alzheimer's research helped me appreciate just how important research is to our everyday lives. The bee campus survey was a good way to do this. I expected greater participation in the survey, but the results were sufficient for the study. I was surprised that so many people wanted to support pollinators and pollinator conservation practices, but that the participants' knowledge of bees and pollinators was so limited and controlled by media promotion. For myself, I have learned a great deal about the importance of bees to the ecosystem. I learned that continual work and tireless efforts are needed to implement pollinator conservation practices due to the constraints of time and funding. Promotion to become a U.S. Bee Campus should be an important goal to work toward at the University. Educating the public about the crisis that could occur due to further bee declines should be a priority of the University and of conservation and educational groups overall. Much more needs to be done and can be done to promote these worthwhile efforts to “save the bees” and “save the pollinators”.

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Appendix A: Survey Recruitment Email

Good afternoon BraveNation,

Graduate student James Locklear, Science Education, Biology Department, under the supervision of Dr. Rita Hagevik is conducting a study on the UNCP campus and the surrounding community views on pollinator conservation.

Understanding what people know or do not understand about bees and bee conservation is the first step in planning and developing effective science education programs. The results of this research study will be used to inform pollinator conservation education on the campus of UNCP and in the surrounding community.

Participation is completely voluntary and should take approximately 10 minutes. Those who complete the survey will have a chance at the end to voluntarily enter their email into a random drawing for one of several $20 Amazon e gift cards.

Please complete the survey by clicking the following link:

https://uncp.co1.qualtrics.com/jfe/form/SV_1Mn8O9D2eDF2yLs

If you have any questions or difficulties with the survey, please contact James Locklear at

jpl024@bravemail.uncp.edu

Thank you for your valuable time!

Regards, James Locklear

Survey Reminder Email

Good afternoon BraveNation,

This is just a reminder email to please consider completing the UNCP Campus Bee Survey. If you already have, please disregard this email!

Graduate student James Locklear, Science Education, Biology Department, under the supervision of Dr. Rita Hagevik is conducting a study on the UNCP campus and the surrounding community views on pollinator conservation.

Understanding what people know or do not understand about bees and bee conservation is the first step in planning and developing effective science education programs. The results of this research study will be used to inform pollinator conservation education on the campus of UNCP and in the surrounding community.

Participation is completely voluntary and should take approximately 10 minutes. Those who do complete the survey will have a chance at the end to enter their email into a random drawing for one of five $20.00 Amazon e gift cards.

Please complete the survey by clicking the following link:

https://uncp.co1.qualtrics.com/jfe/form/SV_1Mn8O9D2eDF2yLs

If you have any questions or difficulties with the survey, please contact James Locklear at jpl024@bravemail.uncp.edu.

Thank you for your valuable time!

Regards, James Locklear

Appendix B: Survey Consent

University of North Carolina at Pembroke

Consent to Participate in a Research Study

Adult Participants

IRB Study Number: #31-22

Consent Form Version Date: 9/25/2022

Title of Study: Perceptions of Bee Conservation at a NC University Campus

Principal Investigator Contact Information: James Locklear jpl024@bravemail.uncp.edu 910-740-0634

Institutional Review Board: **irb@uncp.edu** or 910-775-4512

Message to Participants-

Welcome to the UNCP Bee Campus survey. This survey will take approximately 10 minutes to complete and all responses will be kept confidential. The questions will help others to understand what people know or do not understand about bees and bee conservation so that effective pollinator conservation education programs can be designed and sustained. Please answer the questions as honestly as possible. Participants must complete the survey to enter a drawing for one of five $20.00 Amazon e-gift cards. Participants must be at least 18 years of age. Participation is completely voluntary. You may withdraw your participation at any time for any reason, without penalty. Your information will not be shared at any time; results will only be reported in an aggregate form. You may contact the principal investigator at any time with questions or concerns.

Upon completion of the survey, you will have the option to put your email address at the end to be entered in a random drawing for a $20 Amazon gift card. Your email address will not be used for any other reason than the drawing. This information will not be reported or connected to your survey answers. Entering the drawing is voluntary; you do not have to enter to finish this survey. Thank you for your participation and time!

I have read the information provided above. I have asked all the questions I have at this time. I voluntarily agree to participate in this research study survey

__ I am over the age of 18

__ Yes I Consent

__ No I do not Consent

Appendix C: Interview Informed Consent

Good afternoon,

Introduction

You are invited to participate in a study conducted by James Locklear, a UNCP graduate student. The purpose of this study is to determine the public's attitudes towards bees and knowledge of pollinator conservation practices. Understanding these two aspects (attitudes & interests) among the community would help determine and promote programs such as UNCP’s Bee Camp and information booths (Pembroke Day, STEAM Day) needed to support community engagement and awareness in pollinator conservation practices.

On this form you will find specific information on the research study to decide if you would like to participate. Please read carefully before you sign and agree to participate.

Procedures

Adults in the surrounding Southeast region of North Carolina will be asked if they would like to voluntarily answer four questions in an informal 15-minute interview as they visit a bee outreach booth at a STEAM day event sponsored by the School of Education on a Saturday from 9 AM to 1PM. The researcher will take notes on the interviewees responses. No demographic or name information will be recorded. The responses are to hear what the broader community thinks about bees and pollinator conservation to be compared to the results on the online bee survey. The interview questions were conducted by the researcher, James Locklear during the event.

Risks

There is no risk to the participants other than 10 minutes of the participants' time.   And there is no risk other than breach of confidentiality.

Benefits

There are no direct benefits to participants except that participants can contribute their experience and knowledge. Students and community members could benefit in the future by improving pollinator conservation practices.

Confidentiality

Procedures and protocols are in place to minimize breach of confidentiality. Participant information will be kept in a locked office in a locked cabinet for the duration of the study. Once the study is complete participant information will be destroyed or deleted.

Voluntary Participation or Withdrawal

As a participant you have the right to voluntarily participate in this study. You also have the right to withdraw from the interview at any time without penalty.

Findings and Future Participation

The participants' information will not be used in the results of this study nor will they be used in future studies at the University of North Carolina at Pembroke.

IRB Review

The Institutional Review Board for the protection of human research participants at the University of North Carolina Pembroke has reviewed and approved this study. The email for The Institutional Review Board at UNCP is irb@uncp.edu and can be called directly at 910-775-4512. If you have questions about the research study itself, please contact the Principal Investigator at 910-740-0634 or jpl024@bravemail.uncp.edu. If you have questions about your rights or would simply like to speak with someone other than the principal investigator about concerns, please contact the Professor and Director of the Graduate Science Education program at UNCP at 910.521.6652 or rita.hagevik@uncp.edu.

James P Locklear	Dr. Rita Hagevik	The Institutional Review Board
Principal Investigator	Professor, UNCP	IRB Approval Committee
910-740-0634	910-521-6652	910-775-4512
jpl024@bravemail.uncp.edu	rita.hagevik@uncp.edu	irb@uncp.edu

Informed Consent

By signing below, you agree to allow your student to participate in this study. You indicate that you understand the risks and benefits of participation by your student, and that you know what your student will be asked to do. You also agree that you have asked any questions you might have and are clear on how to stop your participation in the study if you choose to do so. Please be sure to retain a copy of this form for your records.

____________________________ ______________________________ _________

Participant's Signature Participant's Name, Printed Date

Appendix D

UNCP Campus Bee Survey

Welcome to the Pollinator Conservation Survey, which should take about 10 minutes to complete.

The questions will ask about your attitudes and beliefs regarding bees and pollinator conservation.

Participation is completely voluntary. You may withdraw your participation at any time for any reason without penalty. Your information will not be shared at any time, results will only be reported in an aggregate form.

Survey participants must be at least 18 years of age. There are no direct benefits to you as a participant in this research study; however, this research will contribute to the knowledge of beliefs and attitudes about pollinator conservation.

The risk to the participants is no greater than what is experienced in everyday life.

I have read the information provided above. I confirm that I am 18 years or older and a part of the UNCP campus community (student, professor, staff). I voluntarily agree to participate in this research survey.

__YES, I consent

__NO, I do not consent

Are you a STEM major (Science, Technology, Engineering, and Math) or do you work in a STEM field or are you a non-STEM major (Social Sciences such as Psychology, English, History, Religion, Social Work or others) or work in a non-STEM field?

__STEM major or work in STEM field

__non-STEM major or work in a non-STEM field

What is your current level of education?

_High School plus other courses

_Freshman (year 1) in college

_Sophomore (year 2) in college

_Junior (year 3) in college

_Senior (year 4) in college

_Graduate (post undergraduate work)

_Docatorate (PhD or EdD or related such as MD

Gender

_Male

_Female

_Non-binary/Third gender

_prefer not to say

Age

_18-24

_25-34

_35-44

_45 and over

_prefer not to say

What race or ethnicity best describes you?

_White

_American Indian or Alaskan native

_African American or black

_Latin X

_Asian or Pacific Islander

_Multi ethnicity or races

_Ethnicity/Race not listed above

Do you identify as Hispanic?

_yes

_no

Approximately how many bee species live in the US?

_100

_400

_1000

_4000

How many honey bee species live in the US?

_1

_4

_10

_20

Please indicate how much you disagree or agree with each of the following statements by picking the choice in the appropriate column.

Strongly Agree / Agree / Neutral / Disagree / Strongly Disagree

Bees are important to humans

I am afraid of insects

I am concerned about protecting bees

I am afraid of bees because they might sting me

Wildlife and pollinators are very important to me

Honeybees are an endangered species

The next several questions will include images followed by multiple-choice questions. Please view each of the 16 images, and after selecting your answer, click the arrow at the bottom right to move through the images. Please remember to answer the question beneath each image.

IMAGE 1

Is this a bee?

_yes

_no

IMAGE 2

Is this a bee?

_yes

_no

IMAGE 3

Is this a bee?

_yes

_no

IMAGE 4

Is this a bee?

_yes

_no

IMAGE 5

Is this a bee?

_yes

_no

IMAGE 6

Is this a bee?

_yes

_no

IMAGE 7

Is this a bee?

_yes

_no

IMAGE 8

Is this a bee?

_yes

_no

IMAGE 9

Is this a bee?

_yes

_no

IMAGE 10

Is this a bee?

_yes

_no

IMAGE 11

Is this a bee?

_yes

_no

IMAGE 12

Is this a bee?

_yes

_no

IMAGE 13

Is this a bee?

_yes

_no

IMAGE 14

Is this a bee?

_yes

_no

IMAGE 15

Is this a bee?

_yes

_no

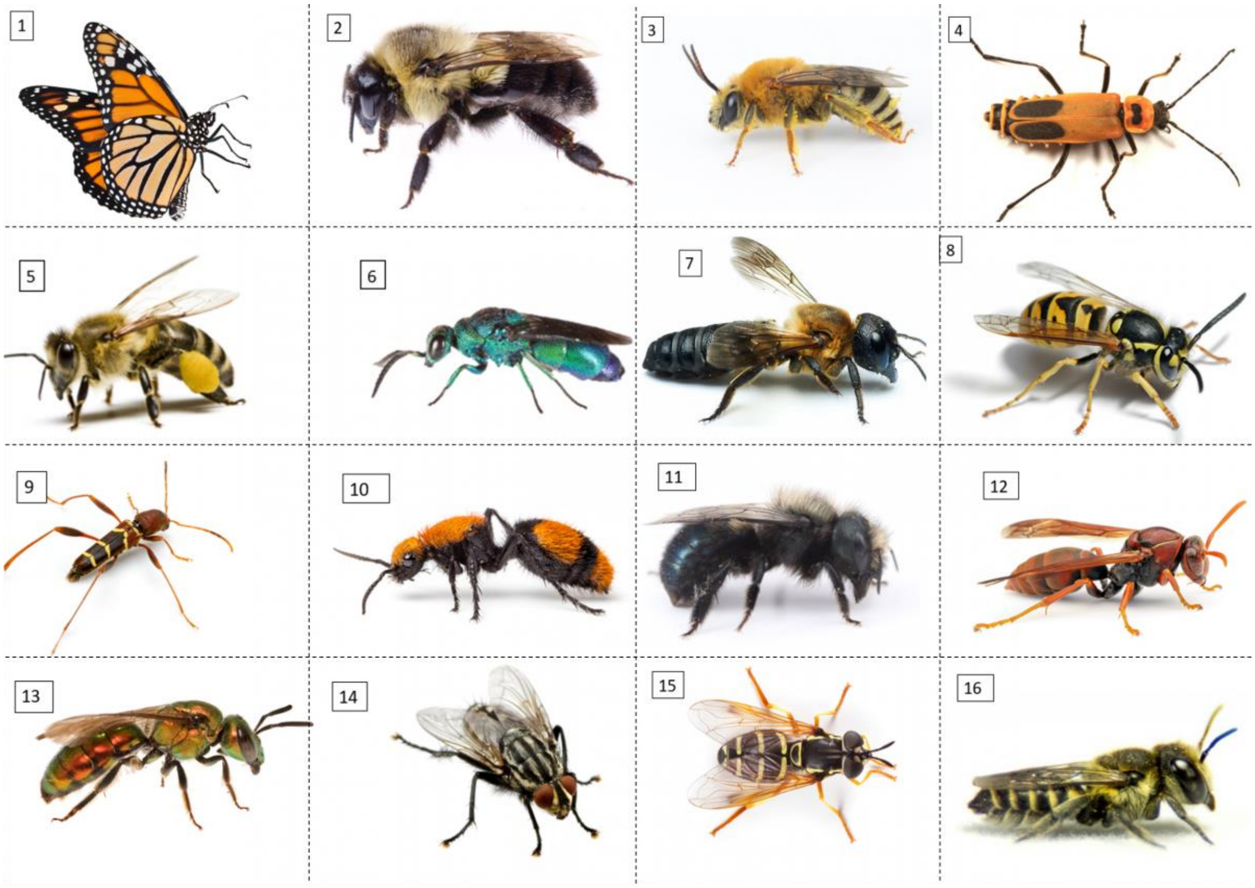
IMAGE 16

Is this a bee?

_yes

_no

Which image shows a honeybee? (Please choose the number from the drop-down menu that corresponds to the image of the honeybee from the diagram below.)



If you would like to be entered in a drawing for a chance to receive a $20.00 Amazon e-gift card (one of five possible gift cards) please place your email address here. If not just type the words no thank you. Thank you for taking this survey.

Enter Email Address:___________________________________

Appendix E: Interview Questions and Protocols

Protocols

1) Ask the participants if they would like to voluntarily be interviewed.
2) Ask the participants if they would sign a consent form.
3) If the participant signs the consent form they may continue to be interviewed, but if the participant does not sign the consent form they will not be interviewed.

Interview Questions

1. What are your thoughts about pollinators in general?
2. Are you afraid of bees?
3. How important do you think bees are to us?
4. How important do you think pollinators are to us?
5. What do you think can be done to help out pollinators?

The participants' answers to the questions will be written down by the interviewer James Locklear. The answers will be typed on a computer, kept under password protection and under lock and key in an office for the duration of the study. No identifiable information will be used in the results of this study. After the study has stopped all information on paper pertaining to this study will be destroyed.

Appendix F: The Planned Behavior Theory and Approaches

Perceptions of Bee Conservation on a NC University Campus

Human intentions towards specific behaviors can be determined accurately from attitudes toward the behavior, subjective norms, and perceived behavior control and attitudes have shown to correlate with these three aspects of the planned behavior theory (Ajzen, 1991). Agan et al. (2022) said that physical activity preferences and belief in ability to perform such activities will determine whether they will participate or not. LaMonte (2019) said that attitude was the degree of favorability towards a behavior, that behavior intention is the motivating factors that instigate a given behavior, and that perceived behavior control referred to the easy or difficult to perform an activity.

The Planned Behavior Theory

Approaches	Description	Examples
Attitudes toward behavior	The degree of favorability towards a behavior (LaMonte, 2019)	For example, if you like being out in nature then your attitude towards doing a duty in nature is highly positive, but if you do not like being out in nature then you will not be as willing to participate in doing that duty
Behavior intent	The motivation factors that instigate a given behavior (LaMonte, 2019)	For example, the fear of, the love for, the ability to do or not, how fun is it, will I get hurt, are all motivational factors that influence behaviors.
Perceived behavior control	Refers to the easiness of difficultness to perform a duty (LaMonte, 2019)	For example, if you know that you can perform a duty then you might see it as easy, where someone else might have never performed that same duty and will think that it is difficult.

How does this relate to your study?

Learning can be difficult at any level of education, to encourage student and community engagement it is best to discover if they will participate (intent), the level of willingness to participate (attitude), and then determine projects to incorporate for learning that everyone can benefit from on future projects.

References

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Ajzen, I. (1991). The theory of planned behavior. Organizational behavior and human decision processes. *Elsevier*. *50*(2). 179-211. https://doi-org.proxy181.nclive.org/10.1016/0749-5978(91)90020-T

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Appendix G: Approval Letter

One University Drive

P.O. Box 1510

Pembroke, NC 28372

Institutional Review Board

FWA 00005281

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October 5, 2022

James Locklear

Department of Biology

UNCP Campus

Title of Study: Perceptions of Bee Conservation at a University of NC Campus; IRB Protocol #31-22

Dear Mr. Locklear:

The IRB has completed review of your protocol titled: Perceptions of Bee Conservation at a University of

NC Campus and it is EXEMPT.

Please note that if significant changes are made to the protocol, you must submit these changes to the IRB

prior to their implementation in your study, as they may change the status of your review. Also, if any unanticipated or adverse events occur during this research, you must notify the IRB immediately.

Please include your protocol number (#31-22) on any future correspondence. This protocol expires in October

2025. If you should need to extend the research study beyond October 2025, please submit a new protocol to

the IRB.

Due to the coronavirus, please be mindful of the university's policies concerning masking and social distancing in your experiment. You will need to follow all university guidelines when conducting your research.

Sincerely,

Erik C. Tracy, Ph.D.

Associate Professor of Psychology

IRB Chair