4-1-2019

Flourishing the Urban Environment: How Urban Gardens Affect Pollinators

Emily Ann Rickert

Flourishing the Urban Environment: How Urban Gardens Affect Pollinators

Honors Thesis

Emily Ann Rickert

Department: Biology

Advisor: Patrick Kelly Williams, Ph.D.

April 2019

Flourishing the Urban Environment: How Urban Gardens Affect Pollinators

Honors Thesis
Emily Ann Rickert
Department: Biology
Advisor: Patrick Kelly Williams, Ph.D.
April 2019

Abstract
The order of Hymenoptera is classified as bees, wasps, and ants and are widely recognized as pollinators. Some species of bees (family Apoidea) and hoverflies tend to focus on certain types of flowers and are attracted to patterns and colors. Native plants and crops that are specifically bee-friendly can encourage bees and other pollinators that are decreasing in biodiversity and population to come back. Urban gardens work to provide vegetables and organic produce to its communities and subsequently are also growing pollinator-friendly food. This study focuses on whether the biodiversity of Hymenoptera, hoverflies, and other significant pollinators are affected by these types of land use and resource availability. Urban gardens are an interesting way to gauge how human influence can possibly change how pollination occurs with either organic or artificial urging. The results of this thesis could lead to evolving the diversity of urban gardens, to include pollinator-friendly crops and plants, and promoting the implementation of urban gardens in cities in order to increase biodiversity of pollinators in those settings. This will lead to both healthier human and plant communities. Through examining three different communities of plants, visual surveys focused on Hymenoptera and Diptera observed differences in the species distribution.

Table of Contents

Introduction

Bees have had an interesting relationship with humans throughout time. There are quite a few misconceptions within the public's mind as to how they look at bees. Many people see bees without knowing the difference between bees, wasps, and flies. There are species of flies like the Hoverfly (family Syrphidae) which can mimic bees and wasps down to their wing sound and are often mistaken for bees or wasps at first glance. However, upon closer examination, there are some key differences in the position of their eyes, resting position of their wings when not in flight, and their flight patterns and behaviors. Hoverflies even feed on pollen and nectar as adults but are not vegetarians like their counterpart in bees. One of the more common ways to differentiate between the mimics includes the one pair of fully developed wings flies have while bees and wasps have two pairs. The wings of flies also protrude from different body parts and do not have stingers [3].

Stingers in *Hymenoptera* demonstrate another common public misconception as well as an evolutionary modification. The ovipositor, an organ used to lay eggs with, became adapted into the stinger for protection. As it originated with an egg-laying mechanism, only females of some species can sting. Honey bees have a barbed stinger that can become lodged in the victim and get caught and pulled out of the honey bee. This leads to them usually only using it to protect the nests. The stinger in other species of bees or wasps are not barbed so they are known to sting more than once [2].

Honey bees are a common bee, the *Apis mellifera* being a frequently seen one in Ohio, and are called "social bees". This means they live in hives with large reproduction numbers and bees dedicated to specific functions like a worker bee or a male that reproduces with the queen. Most other bees are what is called a "solitary bee" and are carpenter bees like *Xylocopa* spp. or *Ceratina* spp.. While they do not always live on their own like the name suggests, this type of bee usually burrows in the ground or makes their nests in places like trees and stems of plants. They can live together to avoid predation of species including flower crab spiders, a bird species called bee-eaters, and even some wasps. However, as they are not attached to a hive, they are free to roam and find environments with their needed resources in exchange for less protection of a swarm and a hierarchy that spreads the work out among the hive [2,4].

An identifying feature between two groups of bees is the mouthparts. The division is between long-tongued bees (families Megachilidae and Apidae) and short-tongued bees (families Andrenidae, Collectidae, Halictidae, and Melittidae). They are often divided by this because of the role that mouthparts play in assisting in nesting, communication, taste, and senses. Long tongues aid bees in collecting nectar when flower morphology has the nectaries harder to reach; usually with long sympetalous corollas or tubular corollas. The morphology causes the bee to have to pass the reproductive parts of the flower to get to the nectar to eat. Thus, as the bee moves to get the nectar, the male sperm of the flower is in the pollen within the anthers and is caught by the hair on the bee while the female reproductive parts throughout the stamen obtains pollen from other flowers that bee has already visited. Short-tongued bees, and other insects that do not have a long tongue, can get around having to pass the reproductive parts by chewing the base of the flower and taking a short-cut to the nectar [2, 6].

Since the nectar is what attracts the bees to the flowers, the flowers have adapted to increase their visitation from pollinators. Nectar is usually made of water, sugars, amino acids, lipids, and proteins. There are certain concentrations of nectar that attract different pollinators and the thickness of the nectar can vary depending on the type of plant and its main pollinator. Factors that affect the production of nectar with the perfect blend of concentrations is the amount of rain, genetics of the flower, and temperature. Plants have the different structures that make it easier or harder for pollinators to feed on the nectar depending on the mouth parts of the pollinator and where the flowers produce it as aforementioned [2].

Besides tongue length, bees also differ in whether they are generalists or specialists. Generalists are bees that visit a wide range and diversity of plants and are thought to be able to forage longer as they are not restrained to the flowering period of a certain category of plants like specialists are. Specialists visit certain plant species and are constrained by the abundance of flowers in an area. This supports a theory that these types of bees are more in danger of habitat fragmentation and climate change as they rely on that particular type of plants to forage. The pollen and nectar composition can encourage specialization as flowers can have a composition that is more enticing and addicting to certain species to ensure they have a better chance at having their genes spread [2, 6, 7].

Most often, pollinators are usually associated with bright flowers and not generally vegetables or fruits as some vegetables are self-pollinating so they do not rely on the pollinators to spread their pollen. However, this is a public misconception as there are species of bees that can pollinate plants like strawberries, blackberries, and herbs. The possibilities of pollinators benefitting an urban garden's biodiversity by spreading the pollen of these plants is high compared to the benefit of increasing bee population and diversity with urban gardens [4,8].

The innovation of urban gardening began in response to food deserts, which make it challenging for people in poverty and low income housing to find fresh vegetables and healthy options within their neighborhood and pricing. Urban gardens support a variety of vegetables and fruits along with fresh items like eggs. In urban cities like Dayton, small areas of land are either bought or rented in places that once were abandoned lots or reclaimed by the government. Usually these areas are not in use and tend to be areas that were subject to disasters like fires or foreclosures.

Organizations like non-profits take the land and turn it into a garden that gives back to the community. The community protects and helps with the garden and in turn, the garden's produce is sold at affordable prices supported by community dinners and memberships that alleviate impeding or current food crisis. While these urban gardens have an impact on the community, they also lead to providing the community with education on the environment, opportunities for jobs and internships, and restoring the urban environment. The type of developing they do on land can range from expanding vegetable patches, laying down fertilizer and wood chips to repair soil damage, building greenhouses that protect more sensitive plants, and building eco-friendly infrastructure to provide more room for plants in an urban environment [5]. From these, it repairs some of the damage done to the environmental loss caused by building development and urbanization and brings opportunities for increased biodiversity. Pollinators like bees and butterflies and hummingbirds are used to measure biodiversity of urban habitats and can lead to affecting the mood and health of people [5]. Even people's front yard can make a difference in the habitat recovery. Most habitat fragmentation has moved to the residential yards of urban places.

Pollinators like bumble bees (*Bombus* spp.) tend to prefer small areas with inland water when compared to other habitats within an urban environment and unmanaged vegetation. This could be one reason why the urban gardens may not demonstrate a significant difference as the gardens are tended to daily and abandoned lots may provide more of an accurate environment [4]. As well, urban gardens tend to create the garden based on needs of the community and not the needs of the environment. While it does benefit the environment positively for the most part, there could be unintended consequences to not attempting to return it to its environmental baseline. There are studies that show there are negative as well as positive impacts to planting bee-specific plants on the native ecosystem. The native plants can endure pathogens they are susceptible to and increased competition while also potentially increasing their pollinator diversity and, therefore, increasing genetic diversity [9].

If urban gardens were to add wildflowers to attract more floral pollinators, there is the chance that if they are invasive to the area or escape outside of the garden due to pollination they could negatively alter the composition of nearby land and choke out important native plants [4]. Altering the habitat even further with the development of urban gardens could be a cause in decreasing pollinator population since the environment is being used for human purpose rather than attempting to move it to the ecosystem baseline. Wildflower species can change the habitat by increasing the soil strength [4,8]. Urban gardens can favor native species with diverse functions and wildflower gardens can attract pollinators. However, they can also lead to the spread of pathogens, especially when introduced by humans. This is not confirmed and currently undergoing further research [8].

There are some plants like dandelions (*Taraxacum officinale*), blackberries (*Rubus fruticocus*), open-flowered asters (*Aster spp.*), purple loosestrife (*Lythrum* spp.), goldenrod (*Solidago*), Sunflowers (*Helianthus annus)*, dahlia (*Dahlia)* , dogwood (*cornus)*, and wisteria (*Wisteria floribunda)* that all attract certain bee populations and as they are popular, can be found in many residential gardens and community gardens already. There are also harmful species inserted in the environment like Honeysuckle, which is popular among honey bees and bumblebees yet it is highly invasive and choking out native plants in Ohio. Careful consideration as to what plants are being planted if going outside of the native plants is important due to this reason [2].

Urban flower gardens are another tactic used that are designed specifically to bring pollinators to urban environments with plants that generate food for pollinators, one of the reasons for a decrease in pollinator population in urban climates. Studies have been done that show plants that increase biodiversity and how they attract pollinators in different areas. As previously mentioned, there can be good responses to increasing pollinator-specific plants and also negative consequences that end up affecting the composition of the urban garden and its surroundings. Studies that delve into which plants can best perform to create food for pollinators as well as how they affect the environment are thus crucial when deciding how to improve the conditions of gardens for the pollinators. However, there can be indirect causes and influences that are delayed past the positive changes [10, 11].

Despite this, all in all, pollinators have been shown to positively affect humans just as urban habitats have demonstrated to be able to create a value in pollinators diversity [11]. But urban development has been proven to be negatively impacting the pollinator's access to food and shelter [12]. Where urban gardens do not exist, plant species compete to survive and thrive over other plant species. The plants have to be resilient to habitat fragmentation and competition that end up reducing the diversity of plants. There has been research that suspects that the fragmentation of habitat also creates a divide in the number of pollinators that will visit that site which greatly cuts down the diversity in pollinator. This, in turn, affects the outreach of diversity in the plants which already have a decreased diversity. The disturbance of the urban environment can lead to an affect on more than just pollinators or just plant diversity [13].

Urban gardens and urban flower gardens can lead to correcting this problem where the diversity of both are achieved and maintained. Some community gardens, however, have little to no native plants. When considering urban gardens which focus on more vegetation, there could be a lack of flowering vegetation that provides nectar for bees but many still plant bee-attractive flowers. Abandoned lots can hold higher insect biodiversity because of its varied resource availability. There were findings to support the theory that community gardens can hold resources to support bee populations that have high biodiversity and there needs to be an investigation into what plants can thrive together while bringing pollinators like bees to the community or sustaining their lifestyle [14].

Materials and Methods

Sites

Three main sites were investigated. The first was a floral garden called Wegerzyn that is a part of a park service. It had a wide variety of plants and opportunities for a diversity of pollinators. The front portion of the entrance to the garden where native Ohioan prairie plants were mixed in with common pollinator plants was surveyed. The plants were planted with the dual intention of bringing pollinators to the garden and the education of the community. Gardeners with the park service tended to the plants. Early summer had Sea Holly (*Eryngium* spp.), Catmint (*Nepeta* spp.), and a yellow aster as the most visited flowers while the late summer had Yellow Coneflower (*Ratibida pinnata*), a pink mint, Bergamot (*Monarda fistulosa*), and Compass plant (*Silphium laciniatum*) as the most visited.

The next site was a native prairie site called the Labyrinth on Mount Saint John property with the help and permission of the Marianist Environmental Education Center that was planted with the intention of restoring the habitat to its original composition and to be a place of reflection. The MEEC's Labyrinth was tended to via planting, mowing, and weeding and was more maintained than the aforementioned site. Wingstem (*Verbesina alternifolia*), Purple Coneflower (*Echinacea purpurea*), Common Milkweed (*Asclepias syriaca*), and then later in the season Bergamot (*Monarda fistulosa*) and Rattlesnake Master (*Eryngium yuccifolium*) were the more commonly visited

The last site was the Lincoln Hill community garden ran by the Mission of Mary. It holds three greenhouses and planting plots that can be rented by the community. The site was often mowed and the plants within the greenhouse like peppers were maintained. On the contrary, the sides of the greenhouse that could not be reached by the mower were not. White and Red Clover (*Trifolium repens* and *pratense,* respectively) were the most commonly visited along with Wild Carrot (*Daucus carota)* and later in the season included Narrowleaf Plantain (*Plantago lanceolata*). The flowers of the vegetables at the site attracted a few species, but the flowers were short-lived and the species seemed sparse compared to the other parts of the site.

Survey

Observations of the pollinators were done with visual surveys and photographs. Approximately ten minutes at the beginning of every survey was dedicated to observing and documenting the flowering phrenology, weather patterns, and visible species. The temperature, wind speed, humidity, and time were recorded from the official Dayton Airport for the most accurate readings. Visual surveys were conducted by following the selected species and recording flower species visited, the time the chosen pollinator spent foraging before disappearing from view, any interactions had with other pollinators, and other notable observations made. Time was recorded from first spotting to disappearance from view. A total of approximately twenty minutes of usable data was collected for each survey. A total of 30 surveys were taken with ten from each site spread out from June 19th, 2018 to August 8th, 2018.

Identification process

If not immediately identified when observed, a photograph was taken on a Nikon DSLR to ensure later identification could be made down to the last possible level. To prevent further decimation of species and hindering the overall purpose of the research, photographs were taken of nearly all species observed to qualify correct identification in field rather than other methods that can harm or kill the species. Identification was accomplished through a variety of methods and cross-checked across a variety of sources to ensure best possible identification [2, 3, 6, 9, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24].

Analysis

The pollinator species richness for each site was analyzed. Since there were multiple surveys done for each site, the alpha diversity (comparison within each site) was computed to gauge individual site composition with the Shannon diversity index. This method involves abundance and can indicate the evenness of the community. To ensure sample size and species dominance were properly represented, the Simpson's Diversity Index was also calculated [24].

$$\text{Shannon diversity index (H)} = -\sum_{i=1}^{s} p_i \ln p_i$$

Where s = total number of species in survey

p_i = number of individuals of a species divided by the total number of individuals in the survey

Theoretically, at H = 1 is community evenness. Higher values of H correlates to a potential high diversity [24, 25].

$$\text{Simpson's diversity index (D)} = \frac{\Sigma ni(ni-1)}{N(N-1)}$$

Where ni = the number of individuals of a species

N = the total number of individuals of the survey

D was then inputted into the equation: 1-D to get allow for the

In order to examine beta diversity (comparison between two sites), the Sorenson's similarity index was also used. This compared the species of pollinators surveyed between two sites at a time [24, 26].

$$\text{Sorenson's similarity index (SI)} = \frac{a}{a+b+c} \times 100$$

Where a = number of species in both sites

b = number of species in the first site but not in the second

c = number of species in the second site but not in the first.

The value ranges between 0 to 100 with 100 meaning the sites have more in common [24, 27].

Results

As seen in Fig. 8, Bumble bees (*Bombus* spp.) were the top surveyed species between the three sites followed by Carpenter bees (*Xylocopa* spp.) and then sweat bees (Family Halictidae). The most common bee species at Lincoln Hill were bumble bees (*Bombus* spp.) and Western Honey Bees (*Apis mellifera*) [Fig. 4]. Also found there were Cabbage White butterflies, skippers, crickets, and grasshoppers [Table 5]. There were more crickets and grasshoppers found at this site than others. The most common bee species found at Wegerzyn were bumble bees (*Bombus* spp.) and Eastern Carpenter bees (*Xylocopa virginica*) with sweat bees (Family Halictidae) close behind [Fig. 2]. There were also a wide variety of wasps, especially on the planted Sea Holly (*Eryngium* spp.) [Table 1 and Fig. 1]. The most common bee species surveyed at the Labyrinth were bumble bees *(Bombus* spp.), Western Honey bees (*Apis mellifera*), and flies (Order *Diptera*) were next commonly recorded with Eastern Carpenter bees (*Xylocopa virginica*) following those [Fig. 6].

The alpha diversity within each site computed with the Shannon diversity index and the Simpson's diversity index. In table 2, Wegerzyn's computed values are listed. Over the ten days surveyed, there was a variable range from ~1.08 to ~2.35 for the H value. The average showed a value closer to 2 than 1 so it could indicate a higher diversity but lower evenness. The Simpson's diversity index value was closer to 0 than 1.

Lincoln Hill's alpha diversity from the Shannon diversity index and Simpson's diversity index as shown in table 4. There was a wide range on some of the days but remained fairly close to 1. This could mean a high evenness within the composition of the community. The Simpson's diversity index was closer to 0 than to 1.

As seen in table 6, the Labyrinth only showed a value close to 1 for one day with the rest of the values closer to 2. This could indicate a higher diversity but lower species evenness. The same day showed a high Simpson's diversity index (D) value while the rest were low and close to 0.

Table 7 demonstrates the comparisons between the communities statistically with the Sorenson's index. The closer to 100, the more community overlap. Only two sites could be compared at a time with this method but the value for each comparison is between 0 and 100 showing there is overlap but not completely. Wegerzyn and Lincoln Hill were closest in overlapping at 40, Wegerzyn and the Labyrinth with 35.135, and lastly, Lincoln Hill and the Labyrinth with 34.375.

Discussion

Through observing *Hymenoptera* and other pollinators foraging habits over the course of the summer months, differences between the species and also the overall composition of the sites were more noticable. Flowering phrenology between the months can be seen in Fig. 9-12. Some flowering plants were quick to bloom and then become unvisited by pollinators as it wilted. The Catmint was a plant that was very heavy in pollinators at the end of June by a short few weeks later and only an occasional bumble bee and Cabbage White butterfly foraged on them. However, they stayed in the same spot for the entirety of the study. Other plants that wilted and were no longer visited by pollinators were either cut back or died quickly like Butterfly weed. Yellow Coneflower and Bergamot bloomed in later July and took up the space and pollinators that Sea Holly had attracted before. Wasp species were especially prevalent around the Sea Holly that was bloomed near the beginning of July, but as it wilted the abundance of wasps and other species it had attracted were observed as lower and more spread out if the species was still spotted near the site.

The labyrinth had a more gradual change. Common Milkweed and Wingstem were attracting a significant amount of the pollinators and then as they faded back, Purple Coneflower gradually bloomed more and became the more visited spot. Then as it began to wilt, Bergamot bloomed and became the main attractor. On the other hand, Lincoln Hill remained consistent in its most popular flowers. Observations showed the Red Clover, White Clover, and Prairie Fleabane were in most of the surveys and multiple times. Narrowleaf plantain appeared in late July as a prominent attractor as well. Early in the study the flowers of the vegetables also had species spotted on it, but as August came, there was a decrease in the abundance inside the greenhouses. The mowing of the site also appeared to detract from the foraging habits of the pollinators. The mowing disturbed clover populations and the populations on the sides of the greenhouses were observed to have a greater number of pollinators attracted there.

While the composition for the Labyrinth, as shown in table 6, may not be even it is described as having a high diversity in both indices. The Labyrinth had the highest Shannon diversity index value of the three sites when averaged with Wegerzyn next and Lincoln Hill last. The average Simpson's diversity index values showed Wegerzyn as having a higher diversity followed by the Labyrinth and then Lincoln Hill. The former two are close in values, however.

There are some overlaps between each community but overall each site has its own niche which supports a different composition of species of pollinators. Table 7 demonstrates the comparisons between the communities statistically with the Sorenson's index. The closer to 100, the more overlap. Since the values are close to the middle between 0 and 100, the overlap is not complete for any of them but there is some. With the different species of plants that were at the sites and common species for this area, some overlap is to be expected. There were plants at

Wegerzyn and the Labyrinth that were highly attractive to pollinators and at both sites like Bergamot. There were plants that were of similar families that were highly attractive to pollinators at all the sites like those in the Aster family. There was still a lack of a complete overlap of species. So, the lack of overlap in community can indicate the importance of choosing plants that are pollinator-attractive, however, different variables like placement and nesting possibilities for pollinators can also alter these outcomes.

Common *Hymenoptera* in this study:

Bumble bee (*Bombus* spp.)

In Ohio, bumble bees are common and beloved. Most active throughout a wide range in the summer season, these long-tongued social bees are usually large and extremely fuzzy with hair covering most of their body. The species are differentiated by the color patterns on their back as seen in Fig. 14 and have a unique pollination method through buzzing. As generalists, they can feed on a large range of plants from long tubular corolla species like Catmint (*Nepeta* spp.) to vegetable and berry plants. Observations about them included that they tended to be slower and focus on collecting from one plant before moving on. They also tended to be seen after rainfall but were visibly lethargic [1, 6].

Western Honey bee *(Apis mellifera)*

The Western Honey bee is a nonnative species introduced from Europe that has become integrated into the United States as a highly recognizable bee that support the U.S. commercial crop and food production industry. *Apis mellifera* are the most common spotted species of *Apis* and can be seen in Fig. 15. This social generalist species visits a large diversity of plants, produces honey, and pollinates a good portion of the agriculture in America. They are active at a certain temperature range which is unique for bee species and are a species of concern as they have been noticed to be suffering from what is classified as colony collapse disorder, the reason only theorized about [6]. Observations of this species included their appearance consistently at all sites, their focus on a wide diversity of flowers, and their lack of care if other pollinators landed on the flower they were foraging on.

Polyester bees (*Colletes* spp.)

Solitary bees that may burrow in groups, the commonly spotted Polyester bees (*Colletes* spp.) were medium-sized bees with a heart-shaped head and a black and white striped abdomen. [15]

Carpenter bees (*Xylocopa* spp.)

The two types of carpenter bee observed was the Eastern Carpenter bee (*Xylocopa virginica*) and an all black variation with lighter visible pollen collecting hairs on the back legs (*Xylocopa* spp.). The Eastern Carpenter bee is very common bee that is prevalent in gardens and parks and chew wood. They behave aggressively but usually lack action. Eastern Carpenter bees have a similar body type to the *Bombus* spp. but have a short-tongue and often chew the base of flowers to get nectar as seen in Fig. 16 and their short tongue visible in Fig. 13. They also lack the distinct hairy abdomen that Bumble bees are known for and instead having a dark and shiny one that is clearly hairless up close. The other species of Carpenter bee is a fast medium-sized species that resembles a few other species but lacks a hairy body with the exception of its legs [6, 15].

Paper Wasp

The most common paper wasp in Ohio is the Northern Paper Wasp (*Polistes fuscatus*), a native that eats nectar and honeydew so they visit a variety of flowers. The other commonly spotted paper wasp in Ohio was the European Paper Wasps (*Polistes dominula*), which are often mistaken for Eastern Yellowjackets (*Vespula maculifrons*) due to the similarities in their coloring. They have visible differences in their body shape and when they are active as the latter usually first appears closer to fall. They appeared at Lincoln Hill and Wegerzyn mostly and were unbothered by other pollinators when they were foraging [15].

Sweat bees

The Halictidae family encompasses the great variety of sweat bees that can range from the genus *Halictus, Augochloropsis, Lasioglossum, Augochlora,* to *Agapostemon*. They all tend to forage in gardens and parks and most visit a large range of flowers. Some species within the genus of *Augochlora* can be differentiated from other genus of sweat bees with their coppery undertones while those within *Agapostemon* contains uniquely colored species of males with a white and black striped abdomen. Other differences are hard to spot in the field and require closer examination. Common observations were their abundance around certain flowers and tiny size [6, 15].

Hover flies

For the purpose of this experiment, hover flies in the family of Syrphidae were grouped as one due to difficulty in identifying individual species and to prevent removing the focus from *Hymenoptera*. Many hoverflies use mimicry to gain similar benefits to bees. The importance of Hover flies and other species commonly found from *Diptera* in the field is significant in relation to pollination. Observations recorded about the Hoverflies were focused on their prevalence on certain days and overall abundance [1, 6, 15].

Conclusion

Each site has its differences and impact on the environment. Wegerzyn serves to educate the community, Lincoln Hill alleviates some of the food crisis and brings together the community, and the Labyrinth helps restore the native plants as they create a safe space for people to reflect. Juxtaposing the three sites together created a better picture of the flower species that overlapped between the sites and what native plants bring to the environment. The highest attractive plants for each site included native plants and the composition of species included a large portion of *Apis mellifera* and *Bombus* spp., between all sites. There would need to be a longer study done on Lincoln Hill over the course of a few seasons to more accurately gauge the change in pollinator composition the urban garden has caused. However, this study is a starting point for seeing how it differs from the potential landscape it could have. While it ended up not being as diverse as Wegerzyn or the Labyrinth, it did have an even composition and a high abundance of *Apis mellifera* and *Bombus* spp., which are important.

In researching pollinators, there are many variables that are still not understood. There are also many variables that can affect pollinators habits; some that may not be seen from the researcher perspective. Choosing certain methods that seem to work to attract pollinators can help while research into why some are disappearing continues. This study can also be applied here with the data shown in the overlap between the communities and the plants with the highest traffic.

This research can be extended by choosing more specific species to survey. Pollinators are a vast category and narrowing down the surveys to specific species. If still examining the impact urban gardens may be making then choosing the most abundant species at Lincoln Hill (*Apis mellifera* and *Bombus* spp.) and studying the differences in them between sites is a direction to take this study. Surveying a greater variety of sites and pursuing it for a longer time over multiple seasons would potentially allow for a more distinct and accurate study. There is plenty more to be done for the *Hymenoptera*, especially if we want to prevent species loss. Beginning by planting more bee-attractive plants and supporting organizations like the ones surveyed would be a good start.

Acknowledgements

Thank you to Dr. Patrick Kelly Williams for his support and guidance. Thank you to Michele Banker and the Marianist Environmental Education Center at Mount Saint John for the use of their facilities and help. Thank you to the Mission of Mary Urban Gardens and the people with Five Rivers MetroPark's Wegerzyn for the use of their land. Thank you to the University of Dayton's Biology Department and Honors Program.

Figures

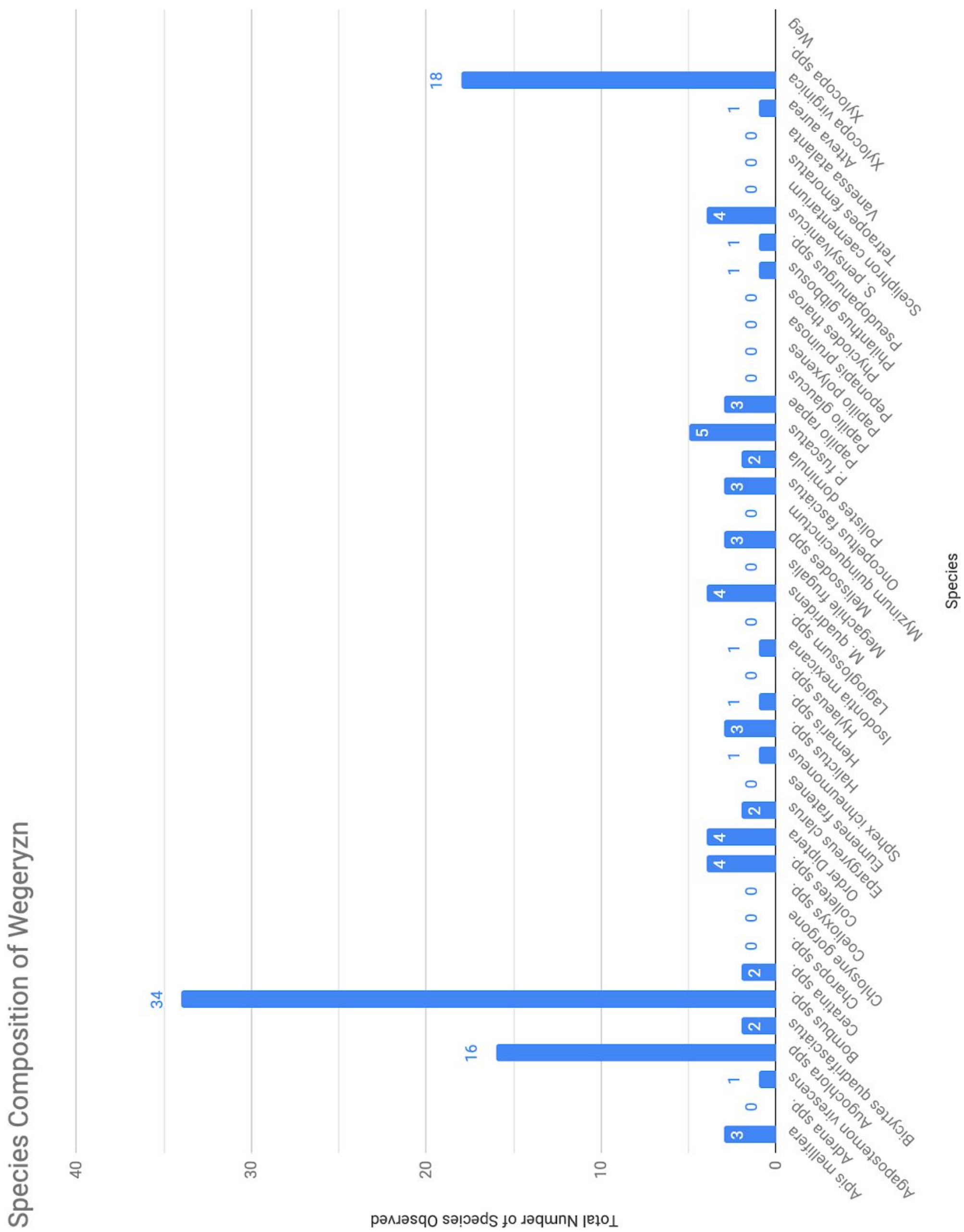

Fig. 1- Graph of the species observed and recorded at Wegerzyn over ten days.

Wegeryzn	6/19	6/21	6/28	7/3	7/5	7/12	7/19	7/21	7/25	8/1	Total
Apis mellifera	2					1					3
Adrena spp.											
Agapostemon virescens									1		1
Augochlora spp			1	1	2	4	2	3	1	2	16
Bicyrtes quadrifasciatus			1		1						2
Bombus spp.	1	2	2	1		5	3	8	7	5	34
Ceratina spp.	1		1								2
Cheraps spp.											
Chlosyne gorgone											
Coelioxys spp.											
Colletes spp.			1			1	1	1			4
Order Diptera		3						1			4
Epargyreus clarus						2					2
Eumenes fraternes											
Sphex ichneumoneus			1								1
Halictus spp.	1		1						1		3
Hemaris spp.								1			1
Hylaeus spp.											
Isodontia mexicana						1					1
Lagioglossum spp.											
M. quadridens			1	1	1	1					4
Megachile frugalis											
Melissodes spp								1	1	1	3
Myzinum quinquecinctum											
Oncopeltus fasci	3										3
Polistes dominul	2										2
P. fuscatus		3	1			1					5
Papilio rapae				1	1	1					3
Papilio glaucus											
Papilio polyxenes											
Paponapis pruinosa											
Phyciodes tharos											
Philanthus gibbo.	1										1
Pseudopanurgus spp.								1			1
S. pensylvanicus			2	1	1						4
Sceliphron caementarium											
Tetraopes femoratus											
Vanessa atalanta											
Atteva aurea										1	1
Xylocopa virginic	3		1	1	1	2	4	1	3	2	18
Xylocopa spp.											

Table 1 - Number of species surveyed at Wegerzyn and the total number observed over ten days.

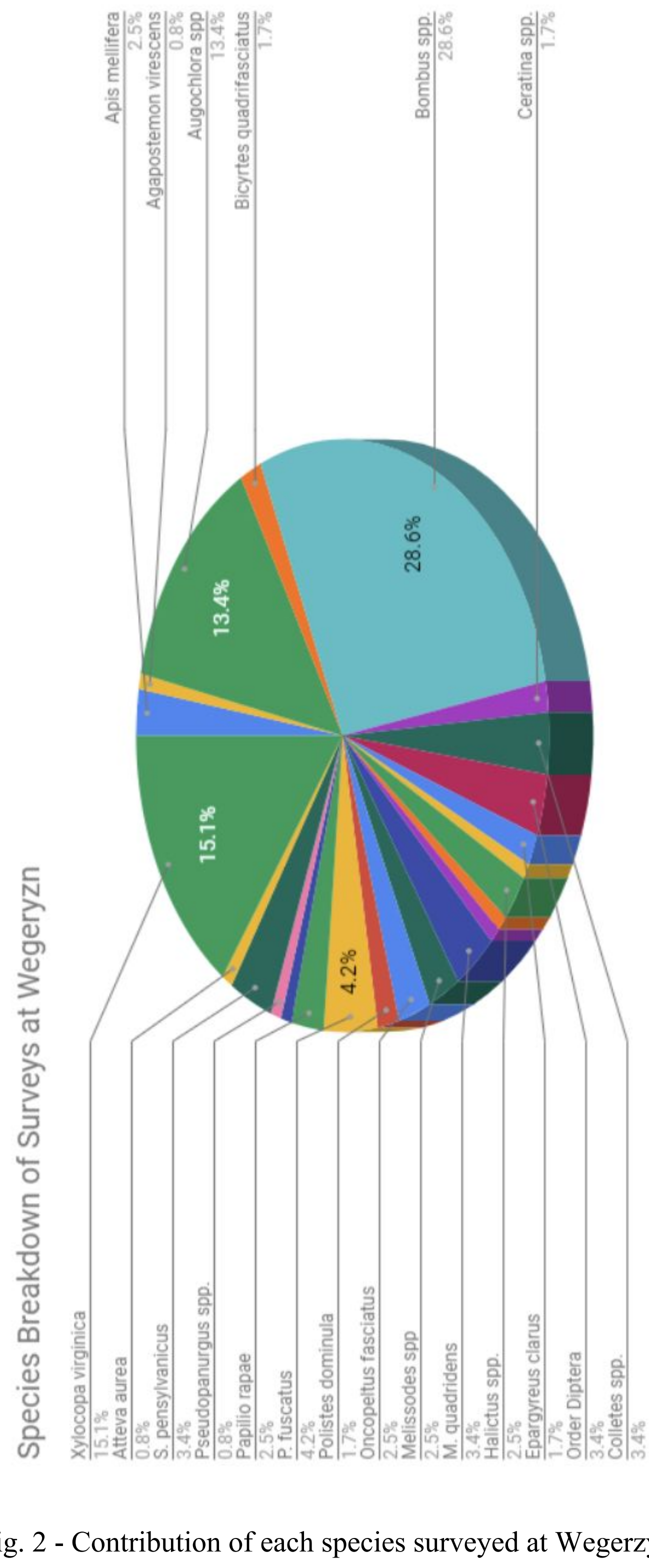

Fig. 2 - Contribution of each species surveyed at Wegerzyn.

Date	6/19	6/21	6/28	7/3	7/5	7/12	7/19	7/21	7/25	8/1	Average
No. of Species	8	3	11	6	6	6	4	8	6	5	
Individuals	14	8	13	6	7	7	10	17	14	11	
H	1.692194276	1.08219553	2.351673302	1.493132891	1.747868097	1.747868097	1.279854226	1.660779862	1.430685336	1.414279065	1.590053068
1-D	0.912	0.75	0.9743589744	1	0.9523809524	0.9523809524	0.7777777778	0.7720588235	0.7362637363	0.7818181818	0.8609039399

Table 2 - Alpha diversity indices for the ten dates at Wegerzyn.

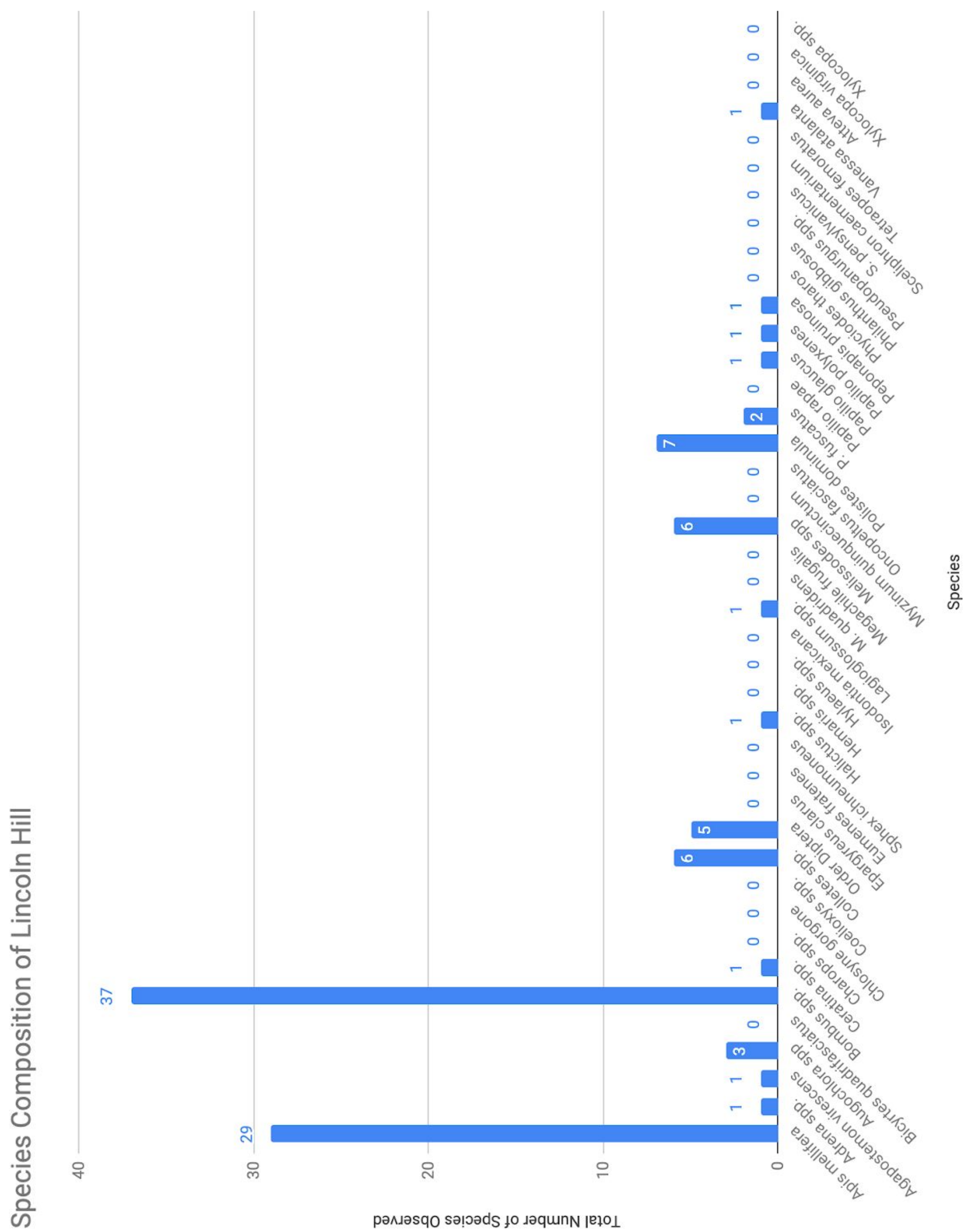

Fig. 3 - Graph of the species observed and recorded at Lincoln Hill over ten days.

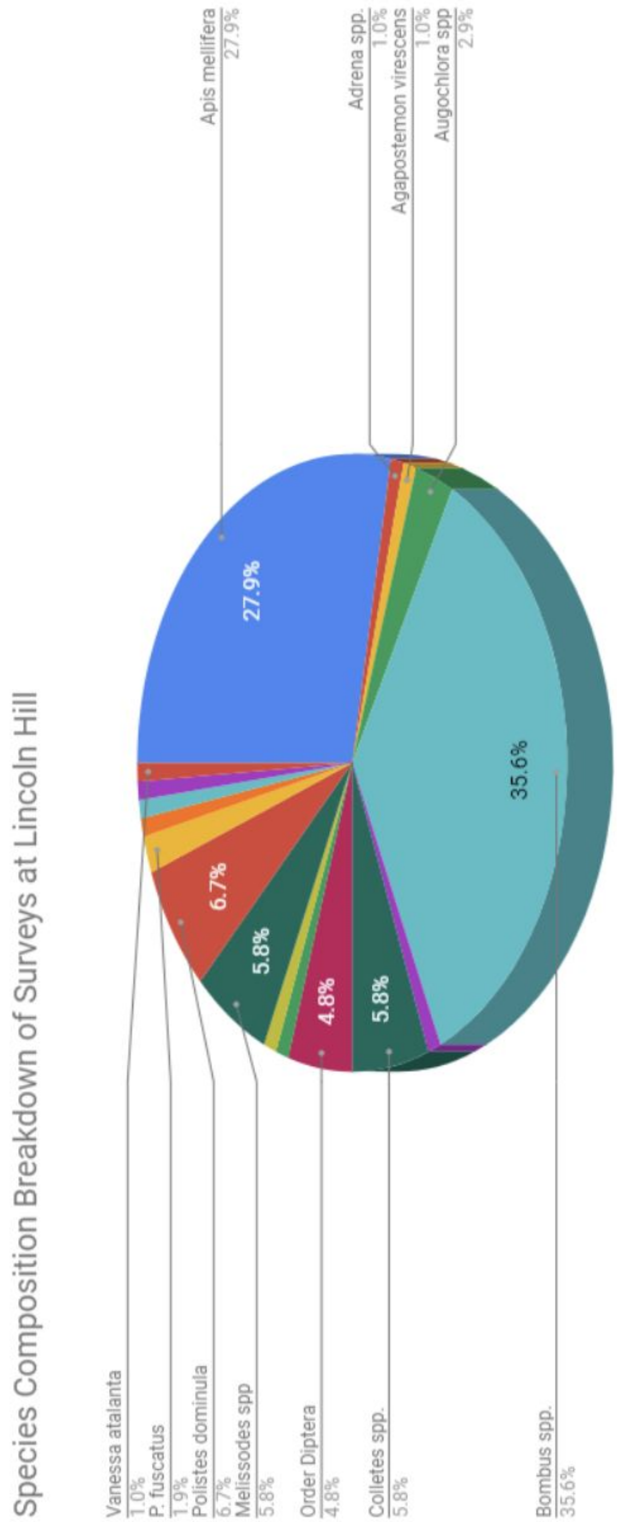

Fig. 4 - Breakdown of species contribution to composition of surveys at Lincoln Hill.

LH	6/20	6/22	6/28	7/5	7/12	7/21	7/23	7/25	8/1	8/8	Total
Apis mellifera	3	3	2	7	1	1	3		5	4	29
Adrena spp.					1						1
Agapostemon virescens								1			1
Augochlora spp						1				2	3
Bicyrtes quadrifasciatus											0
Bombus spp.	2	6	6	5	5	3	6	1	3		37
Ceratina spp.			1								1
Chalcops spp.											
Chlosyne gorgone											
Coelioxys spp.											
Colletes spp.		3					2			1	6
Order Diptera			1	1	1			1	1		5
Epargyreus clarus											0
Eumenes fratenes											
Sphex ichneumoneus											0
Halictus spp.								1			1
Hemaris spp.											0
Hylaeus spp.											
Isodontia mexicana											0
Lasioglossum spp.								1			1
M. quadridens											0
Megachile frugalis											
Melissodes spp			1		3				2		6
Myzinum quinquecinctum											
Oncopeltus fasciatus											0
Polistes dominul	3	3	1								7
P. fuscatus	1		1								2
Papilio rapae											0
Papilio glaucus				1							1
Papilio polyxenes								1			1
Peponapis pruinc	1										1
Phyciodes tharos											
Philanthus gibbosus											0
Pseudopanurgus spp.											0
S. pensylvanicus											0
Sceliphron caementarium											
Tetraopes femoratus											
Vanessa atalanta			1								1
Atteva aurea											0
Xylocopa virginica											0
Xylocopa spp.											

Table 3 - Number of species recorded at Lincoln Hill and the total number observed over ten days.

Date	6/20	6/21	6/28	7/5	7/12	7/21	7/23	7/25	8/1	8/8	Average
No. of Species	5	4	8	4	5	3	3	6	4	3	
Individuals	10	15	14	14	11	5	11	6	11	7	
H	1.50478824	1.332179	1.772139388	1.091303001	1.366711052	0.9502705392	0.9949236326	1.791759469	1.240684292	0.9556998911	1.30004585
1-D	0.84444	0.7714285714	0.8241758242	0.6593406593	0.7636363636	0.7	0.6545454545	0	0.7454545455	0.6666666667	0.6629688085

Table 4 - Alpha diversity indices for the ten dates at Lincoln Hill.

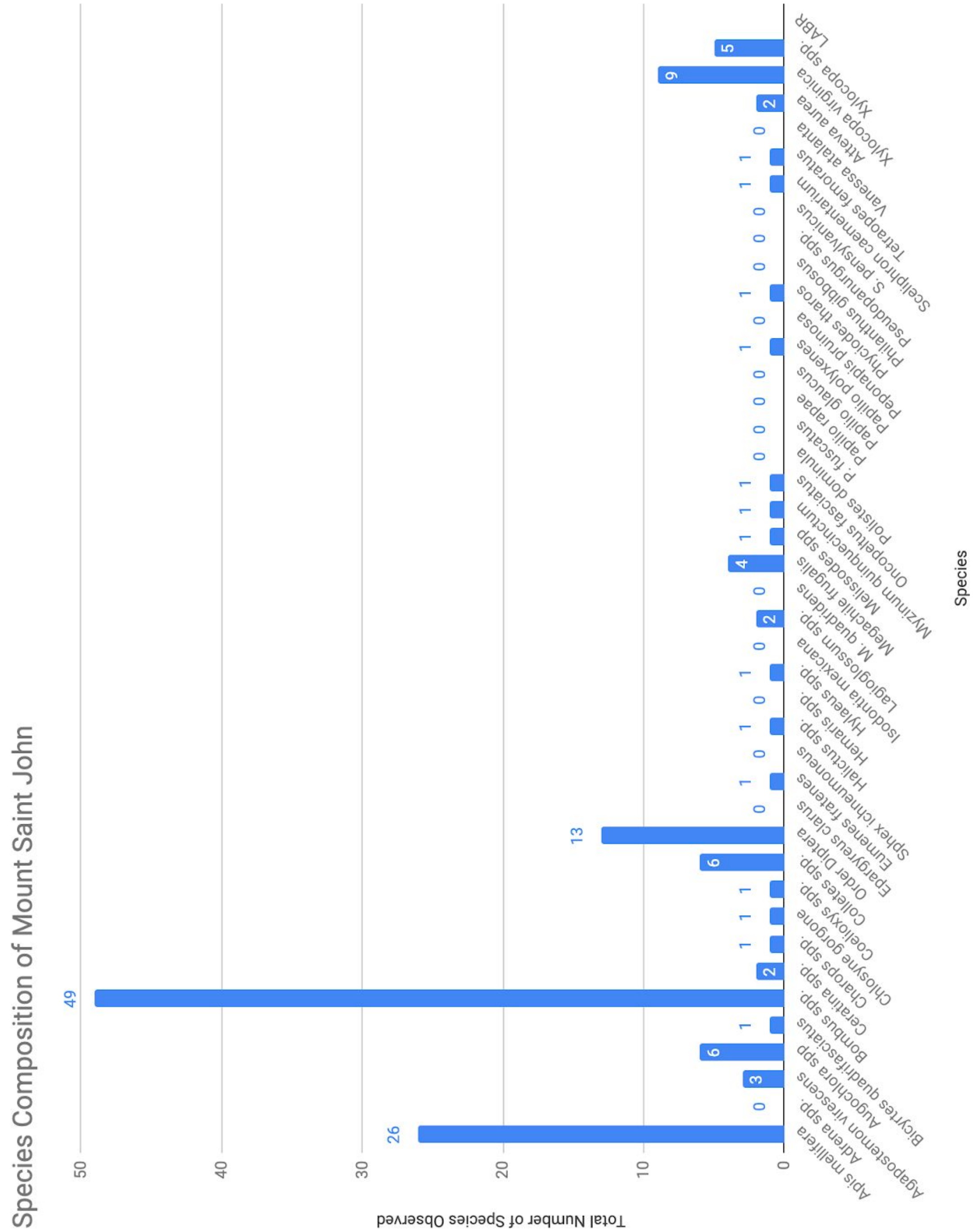

Fig. 5 - Graph of the species observed and recorded at the Labyrinth over ten days

MSJ	6/21	6/22	6/25	6/28	7/3	7/5	7/19	7/21	7/25	8/8	Total
Apis mellifera	2	3	5	2	3		3	1	5	2	26
Adrena spp.											0
Agapostemon virescens					1	1				1	3
Augochlora spp	1			2		1				2	6
Bicyrtes quadrifasciatus							1				1
Bombus spp.	2	4	10	5	6	7	4	5	3	3	49
Ceratina spp.			1						1		2
Charops spp.								1			1
Chlosyne gorgone					1						1
Coelioxys spp.									1		1
Colletes spp.	1			1			1		2	1	6
Order Diptera	1	6			1			4		1	13
Epargyreus clarus											0
Eumenes fraternes									1		1
Sphex ichneumoneus											0
Halictus spp.						1					1
Hemaris spp.											0
Hylaeus spp.						1					1
Isodontia mexicana											0
Lasioglossum sp	1					1					2
M. quadridens											0
Megachile frugalis					2	1				1	4
Melissodes spp		1									1
Myzinum quinquecinctum							1				1
Oncopeltus fasciatus				1							1
Polistes dominula											0
P. fuscatus											0
Papilio rapae											0
Papilio glaucus											0
Papilio polyxene	1										1
Paponapis pruinosa											0
Phyciodes tharos							1				1
Philanthus gibbosus											0
Pseudopanurgus spp.											0
S. pensylvanicus											0
Sceliphron caementarium		1									1
Tetraopes femoratus		1									1
Vanessa atalanta											0
Atteva aurea						1				1	2
Xylocopa virginic	1			1			1	2	3	1	9
Xylocopa spp.							1	3	1		5

Table 5 - Number of species observed at the Labyrinth and the total number observed over ten days

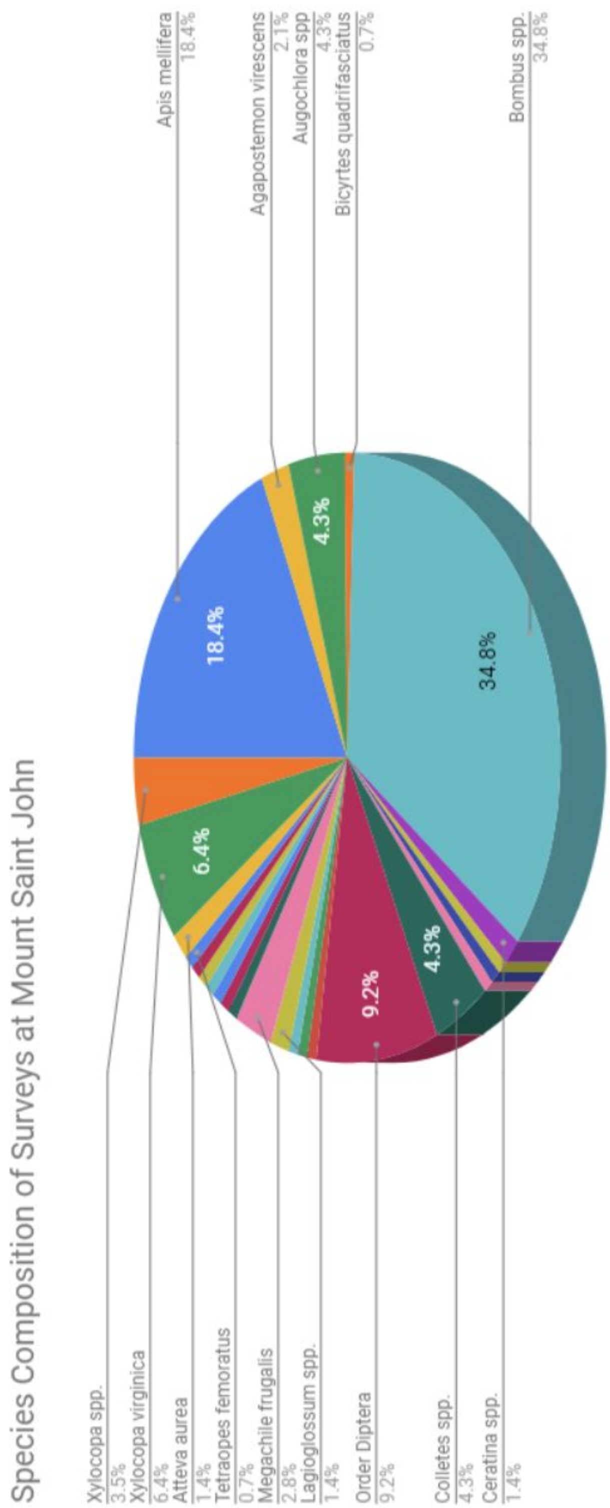

Fig. 6 - Breakdown of species at the Labyrinth from surveys

Date	6/21	6/22	6/25	7/28	7/3	7/5	7/19	7/21	7/25	8/8	Average
No. of Species	8	6	3	6	6	8	8	6	8	9	
Individuals	10	16	16	12	14	14	13	16	17	13	
H	2.025326221	1.548115527	0.8305236915	1.583258459	1.536722469	1.666102255	1.884871334	1.630432583	1.890557011	2.098147389	1.669405694
1-D	0.9555555556	0.8	0.5416666667	0.8181818181	0.7912087912	0.7692307692	0.8846153846	0.833333333	0.875	0.9358974359	0.8204689754

Table 6 - Alpha diversity indices for the ten dates at the Labyrinth.

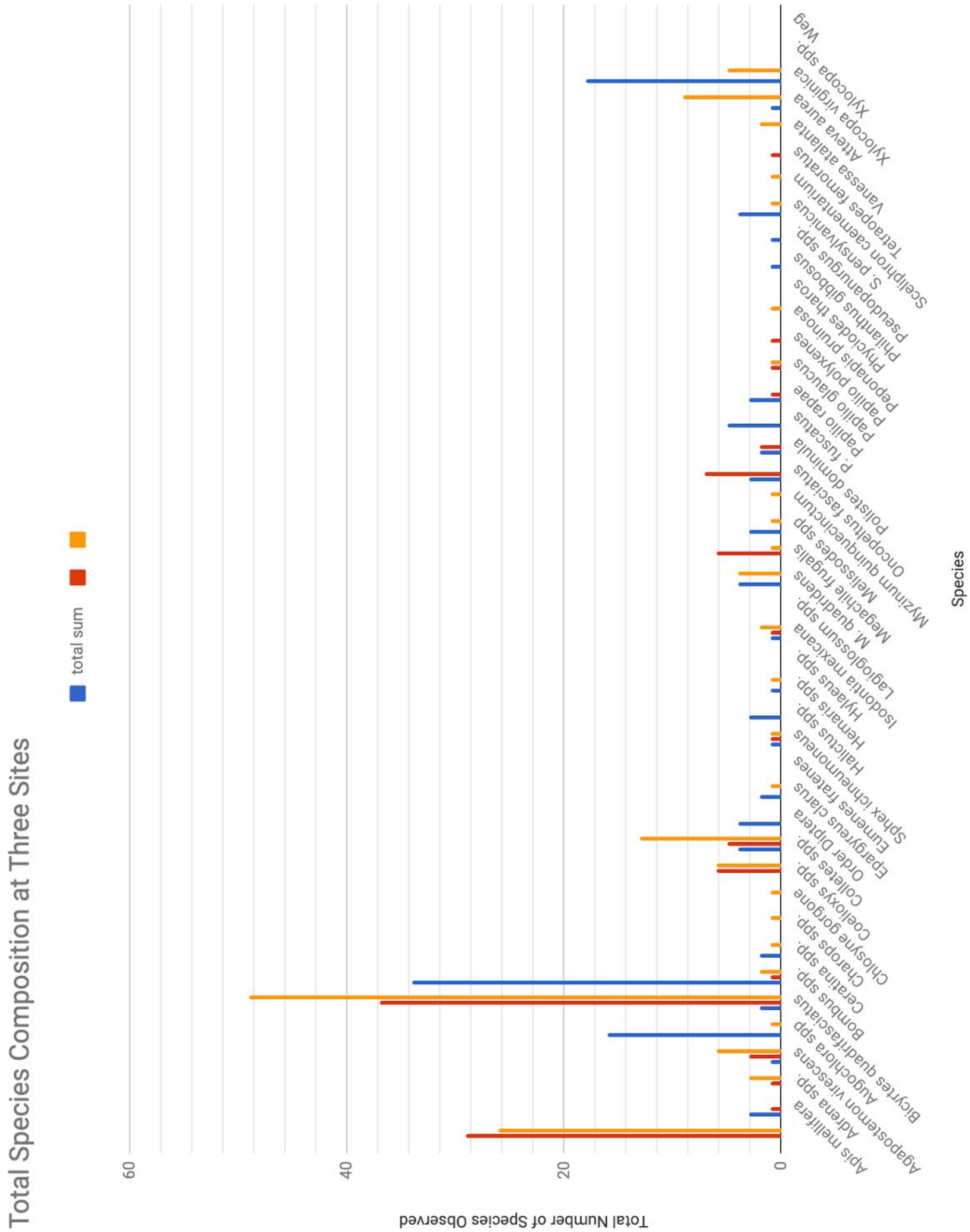

Fig. 7 - Graphical comparison of the total number of each species at the three sites.

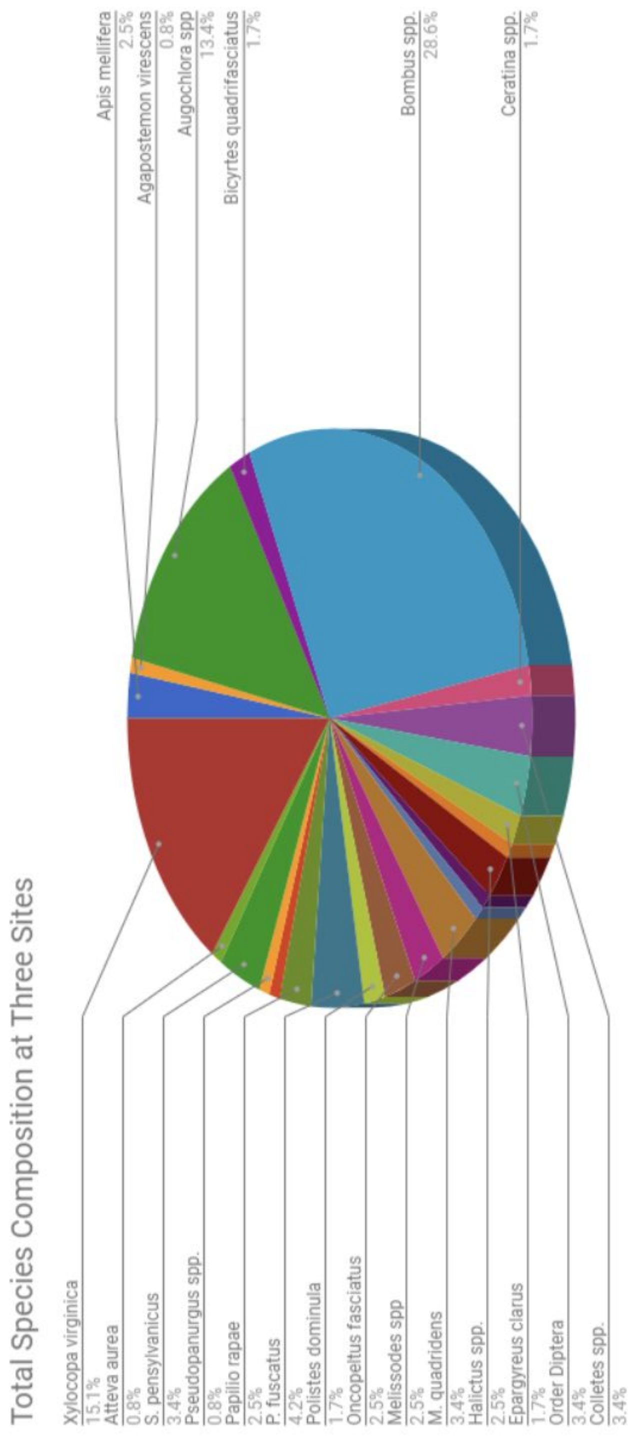

Fig. 8 - Species contribution breakdown over the three sites.

	Lincoln Hill	Wegerzyn	Labyrinth
Lincoln Hill	*	40	34.375
Wegerzyn		*	35.135
Labyrinth			*

Table 7 - Sorensen's similarity indices for the sites.

Fig. 9 - Example of the flowering phrenology of the plants at the Labyrinth from the end of June to Early August.

Fig. 10 - Example of the flowering phrenology of Common Milkweed. Late June, early July, late July, to early August demonstrate how the plants change over time and have a peak period they flourish.

Fig. 11 - Example of the flowering phrenology at Lincoln Hill between late June to early August.

Fig. 12 - Example of the flowering phrenology present at Wegerzyn from Late June to Early August.

Fig. 13 - Carpenter bee (*Xylocopa* spp.) attempting to feast on nectar from Bergamot.

Fig. 14 - The pattern differences between *Bombus* spp. along with the variety in plant species this generalist tends to forage on.

Fig. 15 - A Western Honey bee (*Apis mellifera)* on Wingstem. The abdomen is a distinct orange to black interlaced with white stripes that define this nonnative common pollinator.

Fig. 16 - Carpenter bee (*Xylocopa* spp.) on Thistle. The lack of hair on the abdomen is clear in this picture. It looks shiny and hairless compared to a Bumble bee.

Bibliography

1. Mission of Mary [Internet]. 2014. (Dayton): Mission of Mary; [updated 2017; cited 2018]. Available from: “http://www.missionofmary.org/about-2/”

2. Chadwick F, Alton F, Tennant E.S, Fitzmaurice B, Earl J. 2016. The Bee Book. New York (NY): Dorling Kindersley Penguin Random House.

3. Walliser J. 2014. Attracting Beneficial Bugs to Your Garden. Portland (OR): Timber Press.

4. Burra A, Schaega N, Hall DM. (2018). Assessing residential front yards using Google Street View and geospatial video: A virtual survey approach for urban pollinator conservation. Applied geography 92 (2018): 12-20

5. Bellamy CC, van der Jagt APN, Barbour S, Smith M, Moseley D. (2017). A spatial framework for targeting urban planning for pollinators and people with local stakeholders: A route to healthy, blossoming communities. Environmental Research 158: 255-268. Available: https://journals.ohiolink.edu/pg_99?111447066601176::NO::P99_ENTITY_ID,P99_ENTITY_TYPE:272458429,MAIN_FILE&cs=3LdwzuKyLQJt8OvmQ2J0HSvUCPyXdYXoK5hPUBB9DkCR32aFXzIXazdVaw14t5aAuJ8PccOeRWBeGOBAEos0h-g

6. Wilson J.S., Carril O.M. 2016. The Bees in Your Backyard: a Guide to North America's Bees. Princeton (NY): Princeton University Press.

7. Martins KT, Gonzalez A, Lechowicz. PATTERNS OF POLLINATOR TURNOVER AND INCREASING DIVERSITY ASSOCIATED WITH URBAN HABITATS. Urban Ecosyst (2017) 20: 1359-1371. DOI: DOI 10.1007/s11252-017-0688-8

8. Johnson AL, Fetters AM, Ashman TL (2017) Considering the unintentional consequences of pollinator gardens for urban native plants: is the road to extinction paved with good intentions? New Phytologist 215: 1298-1305. Available: https://journals.ohiolink.edu/pg_99?105798304955674::NO::P99_ENTITY_ID,P99_ENTITY_TYPE:271533180,MAIN_FILE&cs=3fHYEfYoiRIlLOzBRdX-30M2WLHFV39pXYMiLFL97UOiM4am5ZXffGwNhxvjvxpeBp0J1csLcPnAI1kabKCbBEA

9. Walliser J. 2014. Attracting Beneficial Bugs to Your Garden. Portland (OR): Timber Press.

10. Hicks DM, Ouvrard P, Baldock KCR, Baude M, et al. (2016) Food for pollinators: Quantifying the nectar and pollen resources of urban flower meadows. PLoS ONE 11(6): 1-37. doi: 10.1371/journal.pone.0158117Available: http://europepmc.org/backend/ptpmcrender.fcgi?accid=PMC4920406&blobtype=pdf

11. Normandin E, Vereecken NJ, Buddle CM, Fournier V. (2017) Taxonomic and functional trait diversity of wild bees in different urban settings. PeerJ 5: 1-35. doi: 10.7717/peerj.3051. Available: https://www-ncbi-nlm-nih-gov.libproxy.udayton.edu/pmc/articles/PMC5344019/

12. Ushimaru A, Kobayashi A, Dohzono I. (2014) Does urbanization promote floral diversification? Implications from changes in herrkogamy with pollinator availability in an urban-rural area. The American Naturalist 184 (2): 258-268. Available: http://eds.a.ebscohost.com.libproxy.udayton.edu/eds/pdfviewer/pdfviewer?vid=1&sid=67c62029-8238-4c1a-918c-cb18bd090cab%40sessionmgr4009

13. Hennig EI, Ghazoul J. (2011) Plant-pollinator interactions within the urban environment. Perspectives in Plant Ecology, Evolution and Systematics 13 (2): 137-150. doi: 10.1016/J.PPEES.2011.03.003. Available: https://journals.ohiolink.edu/pg_99?104381089917442::NO::P99_ENTITY_ID,P99_ENTITY_TYPE:2735342,MAIN_FILE&cs=3kp6PdzOBns4lfjshxb-pS2nUYYBFStYq3dY1sVrwFHquI6Hu1Zm_P3wBk_uzdz6b1a5Fpuj-2FTVMlDZgeEMRw

14. Makinson JC, Threlfall CG, Latty T. (2017). Bee-friendly community gardens: impacts of environmental variables on the richness and abundance of exotic and native bees. Urban Ecosystems 20 (2): 463-476.

15. Reader's Digest. 2016. Gardening for Birds, Butterflies, and Bees. New York (NY): Reader's Digest

16. Eaton E.R. Common Bees and Wasps of Ohio Field Guide. Ohio Division of Wildlife. Available: http://wildlife.ohiodnr.gov/portals/wildlife/pdfs/publications/id%20guides/Pub5488_Bees%20and%20Wasps%20of%20Ohio.pdf

17. Ohio Division of Wildlife. Spring Wildflowers of Ohio Field Guide. Available: http://wildlife.ohiodnr.gov/education-and-outdoor-discovery/conservation-education-project-wild/education-materials

18. Ohio Division of Wildlife. Common Spiders of Ohio Field Guide. Available: http://wildlife.ohiodnr.gov/education-and-outdoor-discovery/conservation-education-project-wild/education-materials

19. Ohio Division of Wildlife. Dragonflies & Damselflies of Ohio Field Guide. Available: http://wildlife.ohiodnr.gov/education-and-outdoor-discovery/conservation-education-project-wild/education-materials

20. Ohio Division of Wildlife. Moths of Ohio Field Guide. Available: http://wildlife.ohiodnr.gov/education-and-outdoor-discovery/conservation-education-project-wild/education-materials

21. Ohio Division of Wildlife. Common Butterflies and Skippers of Ohio Field Guide. Available: http://wildlife.ohiodnr.gov/education-and-outdoor-discovery/conservation-education-project-wild/education-materials

22. National Audubon Society. 1980. Field Guide to Insects and Spiders: North America. New Hampshire (NH): Knopf.

23. Evans A. 2007. National Wildlife Federation Field Guide to Insects and Spiders & Related Species of North America. Sterling Publishing.

24. Chima UD, Oladele AT, Okorie CF. (2013). Ecological and Ethnomedicinal Survey of Plants within Homesteads in Abia State, Nigeria. Journal of Forest Science 29, (4): 257-274. http://dx.doi.org/10.7747/JFS.2013.29.4.257

25. Simpson EH. (1949). Measurement of diversity. Nature 163: 688

26. Oloyo. (2001). Fundamentals of Research Methodology for Social and Applied Sciences, ROE Educational Press, Federal Polytechnic, llaro Nigeria.

27. Odum EP. (1971). Fundamentals of Ecology. W.B. Saunders Company, Philadephia.