Native Plant Pollinator Diversity in a Small Suburban Yard

Independent Study Project
Native Plant Studies Certificate,
North Carolina Botanical Garden

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As part of the *Pollination* course I completed at the NC Botanical Garden in late summer 2015, I recorded all the floral visitors I observed over a three-week period on the Tall Ironweed (*Vernonia gigantea*) in my yard. Amazed by the diversity of pollinators that visited this one species, I wondered what other pollinators are present in my yard in spring and summer. Although I have not purposely created a pollinator garden, I became aware of the importance of native plants about 10 years ago, and have been removing exotic invasive plants and adding native plants to my yard for the past decade. For this independent study project, I observed the floral visitors to native plants in my small, suburban yard for 16 weeks between the first week of April and the last week of August, 2016. Through my observations I aimed to discover which types of pollinators and floral visitors are attracted to the native plants in my yard, whether the types of pollinators vary by season, and which native plants attract the greatest diversity of pollinators. I also planned to investigate whether I observed the pollinators I expected to see, based on the types of native plants in my yard.

Materials and Method

Native plant inventory and expected pollinators

First I made a spreadsheet of the native plants in my yard as of January 2016, including the scientific name, common name, family, growth habit, flower color, number of plants, location, and source (See Appendix 1 for the list of common and scientific names of the 128 native plants that were present during the study period.) I created a diagram showing the different areas of my yard (A - K) that are listed on the spreadsheet in the “Location” column; a second diagram indicates the approximate location of native and non-native plants in the yard (see Appendix 2).

To determine which pollinators I might expect to see, I gathered information about the bees, butterflies, and moths that are associated with specific native plants in my yard. I used information from *Pollinators of Native Plants* (Holm, 2014) to create a pollinator-native plant interactions spreadsheet showing which genera of bees Holm observed at particular plant species in Minnesota which I also have in my yard. If Holm observed a close relative of a plant that I have, I added the name of the plant she observed as “Related Species Data” and included the bee genera data for that plant. I reviewed Holm’s descriptions of plant-insect interactions for each of the species she observed that I have in my yard, and made notes about which moths and butterflies the plant is host to, and which butterflies and skippers she observed visiting the plant. These notes are recorded in the pollinator-native plant interactions spreadsheet, along with a few notes about fly visitors. Additionally, I used informational flyers from the Xerces Society to supplement the bee data, and *The Kaufman Guide to Butterflies of*

North America (2003) to add information about which of the native plants in my yard are larval food plants for butterflies found in North Carolina.

After recording information about likely bee visitors, I tallied the number of plants in my yard that attract each of the 18 bee genera that Holm listed. Holm observed pollinators in Minnesota, so some of the bees present in the upper Midwest and Great Lakes region may not be seen in North Carolina. If my results are similar to Holm's, I would expect to see *Bombus* and *Lasioglossum* bees at many plants. Although I have expected bee data for only a quarter of the native plants in my yard, it appears that all 18 genera of bees studied by Holm are attracted to some of the native plant species in my yard.

I included bloom period for each plant on the pollinator-native plant interactions spreadsheet. I found bloom periods for 112 of the 130 native plant species on my January 2016 list using *Wildflowers of North Carolina* (Justice, Bell, & Lindsey, 2005) and the *FloraQuest* phone app (University of North Carolina, 2015). The remaining plants are mostly cultivars not listed in either of these two sources.

Description of the study site

The study site, located in Greensboro, NC, is a 0.30-acre lot in a suburban subdivision with mature hardwood trees on many of the lots. Within a half-mile radius of this property is a large shopping center, a four-lane boulevard, a natural area (The Bog Garden) with a stream and pond, and a more formal garden (Tanger Bicentennial Gardens). The vegetation in my yard is a mix of native and non-native plants, with two large native trees in the front yard and several smaller native trees along the edge of the backyard on the north side. There are non-native shrubs along the foundation on two sides of the house, a mix of native perennials along the south side of the house, and native perennials, shrubs, and vines in the backyard, as well as two raised beds for vegetables and herbs. The soil in the yard is a typical Piedmont clay soil in the Cecil series. The yard has some areas of turf, mostly Bermuda grass and weeds, and some patches of bare soil; in the past, Cicada-Killer Wasps have nested in the yard. (Appendix 2 provides a diagram of the site.)

Data collection: Systematic observations

I began data collection the first week of April, 2016. I observed floral visitors each week for 10 consecutive weeks. After a one-week interim, I collected data for two consecutive weeks in June, then every other week for four more weeks of observation in July and August, 2016. I conducted systematic observations at four times on one day for 14 of the weeks in the study. Due to weather constraints, during the third week the first two observation periods were conducted on a different day of the week than the second two periods, and during the seventh week observation was limited to two periods. Before beginning the observations, I conducted an inventory of all the native plants in the yard that were in bloom on the observation day, with notes on bloom stage and how many flowers were open. I constructed a list of 12 selected plant species in bloom and divided them into two groups (A, B) of six plants each. The number of plants in bloom during the weeks of observation ranged from 14 to 31, with an average of 22 native plants in bloom on observation days. Because were more than 12 plants in bloom on a given day, I chose to observe plants that had more flowers open and those that I had not previously observed. Each day of observation I spent two hours observing floral visitors to

native plants that were in bloom. The time was divided into four 30-minute observation periods which began at 10:30 am, 12:30 pm, 2:30 pm, and 4:30 pm. Within a 30-minute period I observed six different native plants for five minutes each. I alternated groups by observation period: group A at 10:30 am and 2:30 pm, group B at 12:30 pm and 4:30 pm.

I created a Pollinator Diversity Observation Data sheet to use during each 30-minute observation period (see Appendix 3). I listed the six target plant species for a given observation period at the top of the sheet. For each observation period I recorded the date, observation period number (1 - 4), start and end times, temperature, cloud cover, and wind speed. I recorded the type of each floral visitor, its size, a description of its appearance, its behavior at the flower (e.g., foraging for nectar, collecting pollen, resting, mating), and which plant species it was visiting. Based on the behavior of floral visitors, I recorded information about the availability of nectar and pollen for each plant. I set a 5-minute alarm to time the intervals for observation. While observing, I scanned the flowers with my naked eye, and then used close-focus butterfly binoculars to view details of floral visitors. When the five minutes elapsed, I completed my descriptions of floral visitors and occasionally took photos of them before beginning the next 5-minute observation interval. To consolidate the data across the four observation periods, I constructed a weekly summary that listed all the distinct floral visitors (beginning with the smallest bees, followed by larger bees, wasps, flies, beetles, butterflies and moths, and other floral visitors), then a list of all the plants species observed that week and which floral visitors were attracted to each of the plants.

Data collection: Photography and identification of floral visitors

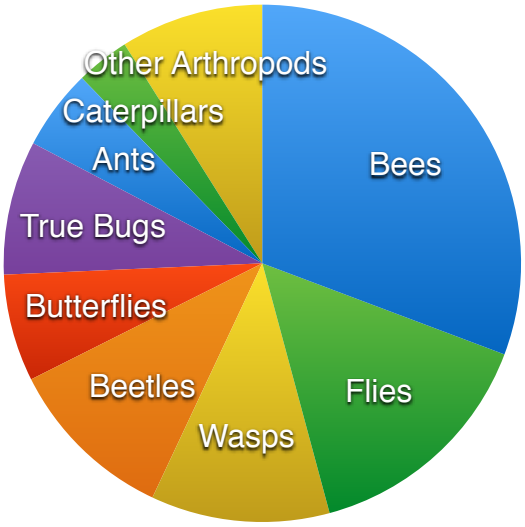
During the course of the study, I took many photographs of pollinators and other floral visitors on both observation and non-observation days. If I observed floral visitors on non-observation days that were not previously seen during systematic observations, I made a note of the floral visitors and added the information to the appropriate weekly summary. On three occasions I captured small bees, chilled them, and brought them inside to take 10x macro photos of the bees.

I used several resources to identify floral visitors: *Pollinators of Native Plants* (Holm, 2014), the Xerces Society Guide *Attracting Native Pollinators* (Mader et al., 2011), and *The Bees in Your Backyard* (Wilson & Carril, (2016). I also used several field guides to insects and butterflies, as well as online guides to butterflies and moths. For additional help in identifying the floral visitors that I photographed, I sent photos to my advisor Anne Lindsey, BugGuide.net, and iNaturalist.org. Although it is not always possible to identify bees and wasps to species level from photographs, with assistance I was able to identify the genus of many pollinators. Most other floral visitors were identified at the level of family or order. Ninety photographs of 55 different floral visitors were of sufficient quality to upload to iNaturalist.org; these are included in the iNaturalist project, “Pollinator Diversity at Home” which I created to document the floral visitors observed in my yard (see Appendix 4). As of September 14, 2016, I have submitted photographs of 27 species to BugGuide.net for identification help.

Results and Discussion

1. Did the native plants in my yard attract a diversity of pollinators and other floral visitors?

Figure 1: Floral Visitors



During the 16 weeks of systematic observation I observed 181 distinct floral visitors to the native plants in my yard. All the major types of pollinators — bees, wasps, flies, beetles, butterflies and moths — were observed, as well as ants, caterpillars, true bugs, and other arthropods (e.g., leafhoppers, insect larvae, mites, spiders). One bird, a Ruby-throated Hummingbird, was observed visiting flowers. Figure 1 shows the proportion of different types of floral visitors (excluding the bird). Bees were the most abundant floral visitors. Table 1 shows the number of species observed and the average number of species seen each week for each category of floral visitor.

Table 1: Floral Visitor Species by Category

Floral Visitor Type	Number of Species	Weekly Average
Bees	55	9.4
Flies	27	2.1
Wasps	20	1.8
Beetles	19	1.3
True Bugs	15	1.3
Butterflies and Moths	13	1.4
Ants	9	1.9
Caterpillars	6	0.3
Other arthropods	16	1.6
Birds	1	0.1
TOTAL	181	21.1

Figure 2: Major Pollinators by Category

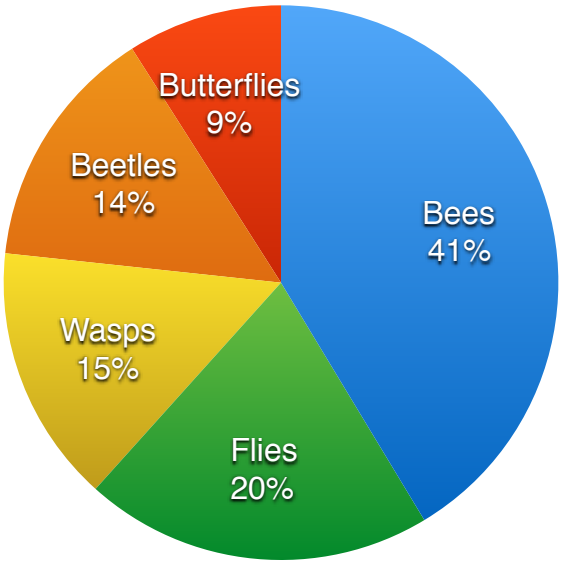
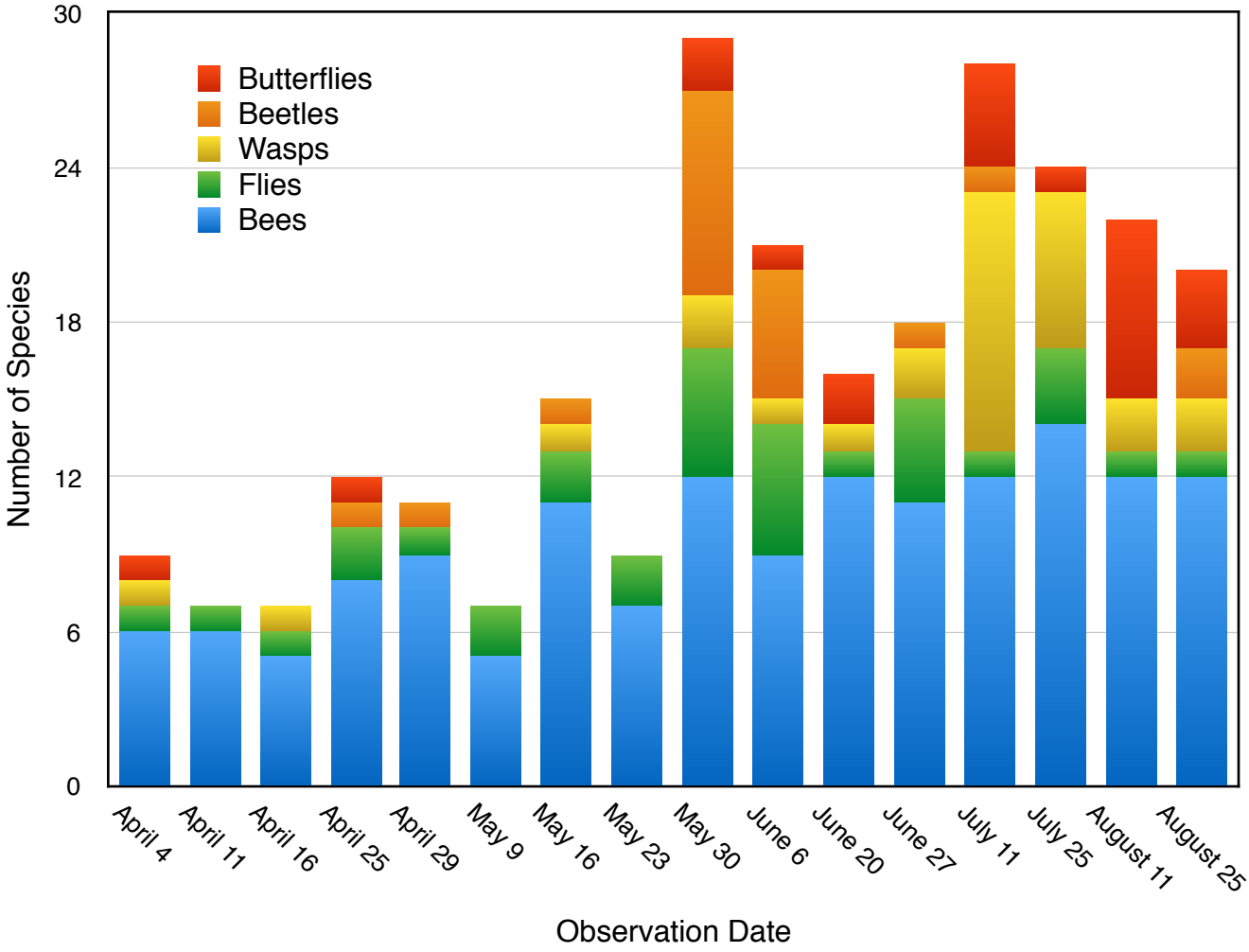


Figure 2 shows the percentage of 133 species observed in each of the five major classes of pollinators. Bees constituted the largest group (41%) of major pollinators. Of the 55 bee species observed, 34 were very small bees (2-10 mm) such as sweat bees, 18 were small to medium bees (11-16 mm) such as honey bee workers, and three were large bees (17- 30 mm), such as carpenter bees. Among the fly species, 17 of 27 were hover-flies (family *Syrphidae),* also known as flower-flies. In the butterflies and moths category, there were six butterflies, three skippers, and four moths.

Figure 3: Total Pollinators by Week

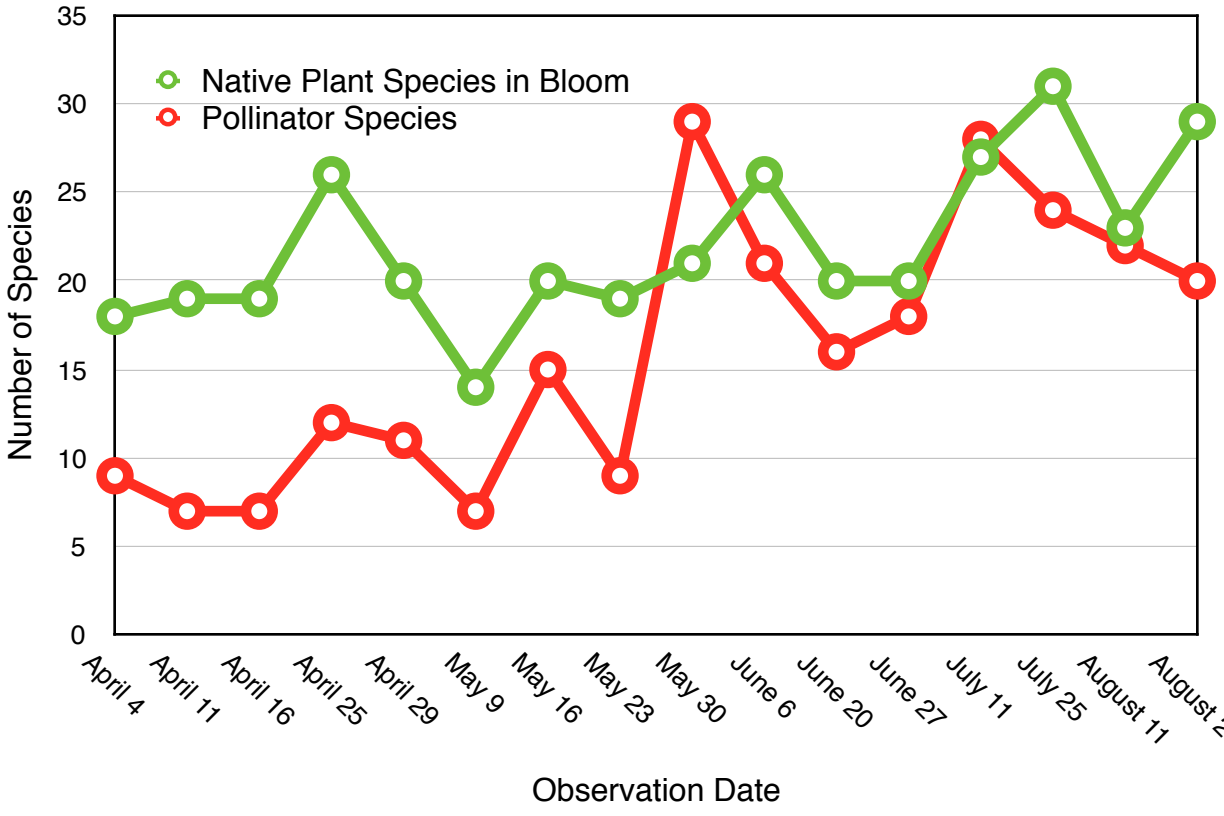


2. Did the types of pollinators vary by season or across time?

As shown in Figure 3 above, the number and type of pollinator species vary over time, with fewer species present in the spring and increasing numbers in late spring and summer. Beetle species were present eight of the 16 weeks, with the highest number of species at the end of May (week 10). Flies were observed every week of the study; the greatest number of fly species was observed in late May and early June (weeks 10 and 11). Wasps were present in 11 of 16 weeks, with the number of species observed peaking in mid-July (week 13). Like flies, bees were observed in every week of the study; the number of bee species peaked in late July (week 14). Butterfly and moth species were observed in 9 of 16 weeks, with the greatest abundance of species in mid-August (week 15).

Bees and other pollinators have typical flight seasons. For example, bees in the genus *Lasioglossum* are usually seen in spring, summer, and fall, whereas bees in the genus *Agapostemon* are typically seen in summer and fall. Differences in flight season may explain some of the variation in numbers of species observed. Other factors that likely bear some relationship to the numbers and types of pollinators observed over the course of the study are daily temperatures and the number and type of native plants in bloom. Cooler temperatures contribute to less activity; on mornings when the temperature was below 60° F., the first (and sometimes only) bees I saw were bumblebees, which have the ability to use their flight muscles to warm their bodies. The relationship between number of pollinators observed and the number of plant species in bloom at the study site is shown in Figure 4 below. The

Figure 4: Pollinators and Plants in Bloom by Week



correlation between the two variables is not perfect, but it is clear that the number of pollinator species observed tends to increase as more native plant species are in bloom. Greater masses of flowers can attract more pollinators, and for generalists, having a variety of plants in bloom at the same time may also be attractive.

3. Which flowering plants attracted the most pollinators and floral visitors?

The number of floral visitors to individual plant species each week ranged from zero to 16. For each week, I calculated the two most "popular" plants: Popularity was defined as attracting the greatest number of floral visitor species; in weeks 15 and 16, there was a tie for second place. The most popular plants for each week of the study are shown in Table 2. The number of floral visitors to popular plants each week ranged from three to 16; the average number of floral visitors attracted to popular plants in a given week was 6.77. Other plants that attracted a minimum of five floral visitors in one week were *Asclepius incarnata, Asclepius tuberosa, Eutrochium fistulosum, Physostegia virginiana, Rudbeckia fulgida*, and *Vitus*

Table 2: Popular Plants by Week

Week No.	Observation Date	Most Popular Plant	Second Most Popular
1	April 4	*Fothergilla gardenii*	*Aquilegia canadensis*
2	April 11	*Aesculus pavia*	*Cornus florida*
3	April 16	*Cornus florida*	*Aquilegia canadensis*
4	April 25	*Nyssa sylvatica*	*Wisteria frutescens*
5	April 29	*Nyssa sylvatica*	*Oenothera speciosa*
6	May 9	*Oenothera fruticosa*	*Oenothera speciosa*
7	May 16	*Nyssa sylvatica*	*Coreopsis auriculata*
8	May 23	*Ceanothus americana*	*Coreopsis auriculata*
9	May 30	*Ceanothus americana*	*Coreopsis auriculata*
10	June 6	*Ceanothus americana*	*Erigeron strigosus*
11	June 20	*Coreopsis auriculata*	*Echinacea purpurea*
12	June 27	*Eryngium yuccifolium*	*Coreopsis auriculata*
13	July 11	*Apocynum cannabinum*	*Eryngium yuccifolium*
14	July 25	*Rudbeckia triloba*	*Rudbeckia laciniata*
15	August 11	*Rudbeckia subtomentosa*	*Rudbeckia hirta,* *Vernonia gigantea,* *Eutrochium purpurea*
16	August 25	*Rudbeckia subtomentosa*	*Rudbeckia hirta,* *Pycnanthemeum incanum*

aestivalis. Among the plants that attracted the most floral visitors were those that attracted the greatest number of bee species. Nine plant species were visited by five or more species of bees: *Ceanothus americana, Echinacea purpurea, Eryngium yuccifolium, Fothergilla gardenii, Pycnanthemeum incanum, Rudbeckia laciniata, Rudbeckia subtomentosa,* and *Rudbeckia triloba.*

The most popular plant of all, *Ceanothus americana* (New Jersey Tea), attracted 16 different floral visitors in one week: six bee species, five beetle species, three fly species, one wasp, and one species of ant. Another popular plant, *Eryngium yuccifolium* (Rattlesnake Master) attracted 12 species of floral visitors in a single week.

3a. What are the floral characteristics of the plants that attracted the most floral visitors?

Plants that had many flowers open at the same time were very popular. As seen on the list above, some of these were trees or shrubs, and some were perennials, especially those in the Aster family, which have composite flowers in addition to having many inflorescences in bloom at the same time. One exception to the popularity of asters was *Chrysogonum virginianum*; although it has many inflorescences they don't bloom at the same time. Instead the plant flowers over a long period of time (15 of the 16 weeks in this study) with a few scattered blooms open each week. I saw some pollinators and floral visitors on these plants, but never more than two or three. Bright-colored flowers with landing platforms, such as *Coreopsis auriculata*, *Cornus florida*, *Echinacea purpurea, Erigeron strigosus*, *Oenothera spp.*, and *Rudbeckia spp. are* attractive to many pollinators, especially butterflies. Bees prefer flowers that are at the blue-violet end of the color spectrum, or yellow or white. In my yard, 15 of the 21 most popular flowers are blue, yellow, or white.

3b. Why did some flowers fail to attract any floral visitors?

One unexpected finding was that I did not observe any pollinators or other floral visitors at some native plants that appeared to be blooming. Of the 86 different species of native plants that I observed between April and August, 11 attracted no floral visitors during the time I was observing them. These were *Fothergilla* "Blue Shadow", *Polemonium reptans, Podophyllum peltatum, Thalictrum thalictroides*, *Viola sororia, Mainanthemum racemosum, Eurybia divaricata, Arisaema triphyllum, Rhexia virginica, Parthenocissus quinquefolia*, and *Lobelia siphilitica*. With the exception of the last three, these native plants bloom early in the spring season when there are fewer pollinators about. So it is possible that they attracted pollinators, but floral visitation in the spring is rare enough that the sampling schedule was less likely to capture their visits. Some of these plants, such as *Viola sororia*, have back-up mechanisms for self-pollination in cleistogamous flowers, so attracting pollinators is less critical. Others, such as *Arisaema triphyllum* have hidden flowers (behind the spathe) so it would be difficult to observe pollinators (although I did find fungus gnats trapped inside the spathe of a female plant). And plants such as *Podophyllum peltatum* do not produce nectar, so they may be less likely to attract a variety of floral visitors. *Lobelia siphilitica* was just beginning to bloom in week 16 of the study; it may have attracted pollinators in subsequent weeks.

4. Did I see the types of bees and butterflies I expected to see?

To determine whether the bees and butterflies I observed might be expected based on the particular native plants that I have in my yard I compared my observations to those of Holm (2014). Holm studied pollinators of native plants and their interactions with plants in a suburban setting and in restored and remnant plant communities in Minnesota over a period of ten years. Among bee visitors, she focused on common native bee genera. All of the 18 genera Holm included in a chart of "Bee - Native Plant Interactions" (p. 244) have been collected in North Carolina, according to the *Discover Life* website (2017). During my study, I observed 16 genera of bees, distributed across the five major families of bees found in eastern North America: *Colletidae, Andrenidae, Halictidae, Megachilidae,* and *Apidae* (see Table 3 below). Twelve of the genera I observed were ones Holm reported in Minnesota. In addition, I observed native bees in two genera not listed by Holm, *Augochlorella* (sweat bees) and *Xylocopa* (large carpenter bees). Two other genera I observed were non-native bees: one unexpected species, *Anthidium manicatum* (European Wool Carder Bee), and the expected non-native *Apis mellifera* (Western Honey Bee).

Table 3: Expected and Observed Bee Genera

Family	Genera	Common Name	Observed in MN (Holm, 2014)	No. of Target Plants Visited in MN	Observed at Study Site in NC
Colletidae	*Colletes*	Cellophane bees	yes	10	no
	Hylaeus	Yellow-faced bees	yes	14	yes
Andrenidae	*Andrena*	Mining bees	yes	6	yes
Halictidae	*Agapostemon*	Green sweat bees	yes	13	yes
	Augochlora	Sweat bees	yes	7	yes
	Halictus	Sweat bees	yes	22	yes
	Augochlorella	Sweat bees	—	—	yes
	Lasioglossum	Sweat bees	yes	30	yes
	Sphecodes	Cuckoo bees	yes	5	no
Megachilidae	*Anthidium*	Wool carder bees*	—	—	yes
	Coelioxys	Cuckoo bees	yes	9	yes
	Heriades	Small resin bees	yes	6	no
	Megachile	Leafcutter bees	yes	18	yes
	Osmia	Mason bees	yes	9	no

Family	Genera	Common Name	Observed in MN (Holm, 2014)	No. of Target Plants Visited in MN	Observed at Study Site in NC
Apidae	*Anthophora*	Digger bees	yes	10	no
	Apis	Honey bees*	—	—	yes
	Bombus	Bumblebees	yes	29	yes
	Ceratina	Small carpenter bees	yes	22	yes
	Melissodes	Long-horned bees	yes	16	yes
	Nomada	Cuckoo bees	yes	7	no
	Triepeolus	Cuckoo bees	yes	5	yes
	Xylocopa	Large carpenter bees	—	—	yes
		*** Not native to North America**			

As noted in Table 3, the number of target plants — native plants I have in my yard which were also studied by Holm — that attracted particular genera of bees in Minnesota ranges from five to 30. As expected based on the large number of target plants, I saw bees in the genera *Bombus* and *Lasioglossum* visiting many native plants in my yard. *Bombus impatiens* (Common Eastern Bumblebee) was the most frequently seen species, observed in 15 of 16 weeks of the study. Bees in the genus *Lasioglossum* were observed in all 16 weeks of the study. Notable absences were six common bee genera observed by Holm for which there were between five and 10 target plants in my yard: I did not observe any bees in the genera *Anthophora, Colletes, Heriades, Nomada, Osmia,* or *Sphecodes.*

In descriptions of specific native plant-insect interactions within prairie, woodland edge, and wetland edge communities, Holm (2014) refers to eight genera of butterflies that are attracted to native plants that grow in my yard. In the 16 weeks between April 4 and August 25, I observed four of those eight genera of butterflies visiting flowers of native plants in my yard: *Celestrina* (Summer Azure was observed ovipositing on *Ceanothus americana*), *Colias* (Orange Sulphur), *Papilio* (Eastern Tiger Swallowtail), and *Strymon* (Gray Hairstreak). I also observed butterflies in two genera not mentioned by Holm in connection with my target plants, *Junonia* (Common Buckeye) and C*upido* (Eastern Tailed Blue). I continued to photograph new floral visitors to native plants in my yard during September and October, and observed three more genera of butterflies referred to by Holm: *Phyciodes* (Pearl Crescent), *Speyeria* (Variegated Fritillary), and *Vanessa* (American Lady). The only butterfly genus referred to by Holm in connection with my target plants that I did not observe is *Danaus*, the milkweed butterflies. Despite having four different *Asclepias* species in my yard, I observed no Monarch

butterflies visiting them. There are only two small patches of *Asclepius syriaca* in the yard, but in previous years this was sufficient to attract female Monarchs which laid eggs on the plants.

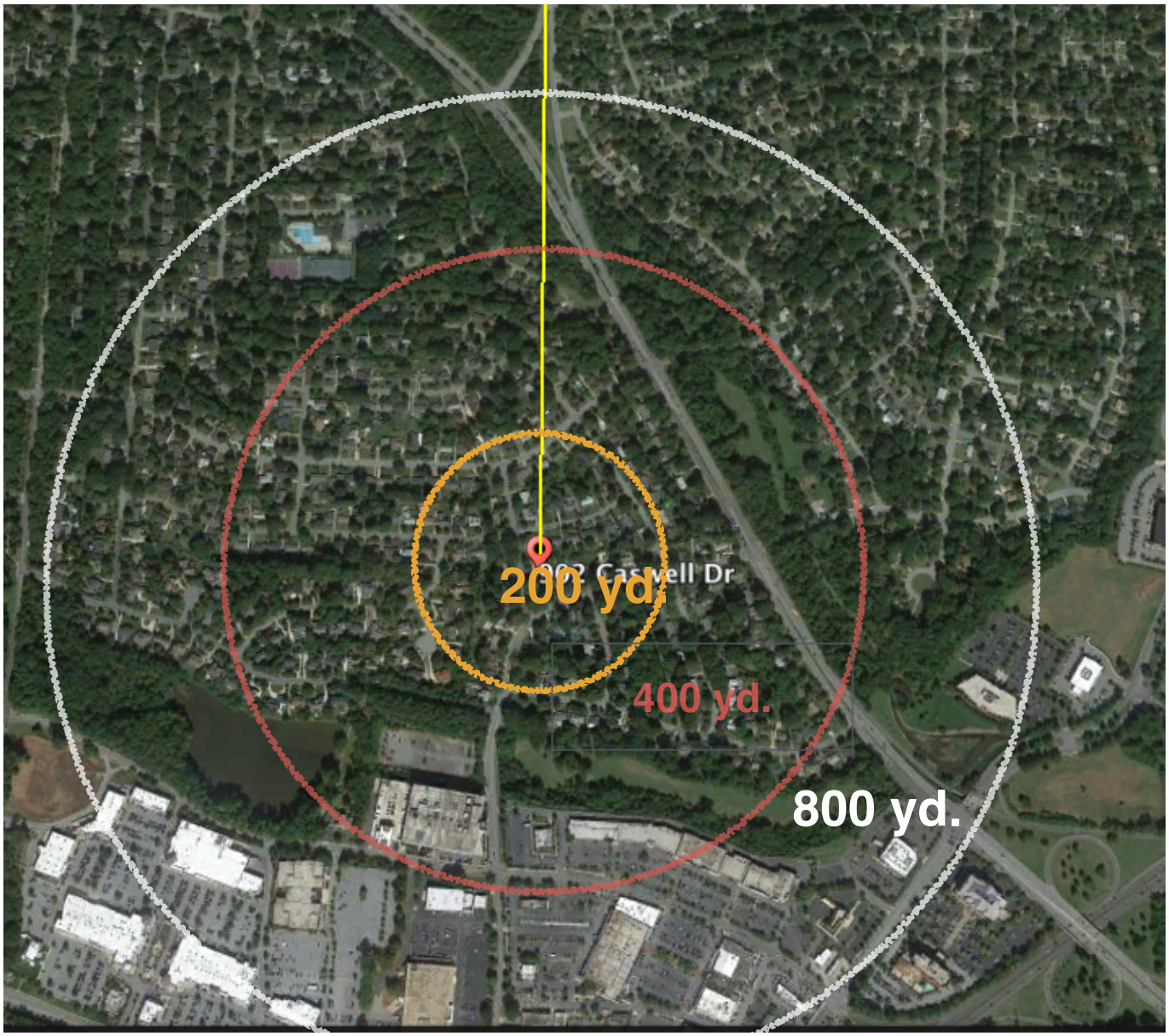
Based on information in Kaufman (2003), 24 of the native plants in my yard are larval host plants for butterflies and skippers found in North Carolina. Between April and August I observed four species of butterflies and skippers associated with one or more of those 24 native host plants. During September and October I observed two more butterfly species associated with native host plants found in my yard. The plants hosting the greatest number of butterfly and skipper species were *Wisteria frutescens* (American Wisteria) which hosts seven species, and *Baptisia australis* (Blue Wild Indigo) which hosts four species.

Overall, there were more bee, wasp, and moth species than I expected, and fewer butterflies. As noted, the diversity of butterflies visiting native plants in the yard increased in September and October, after the 16-week study was completed. I was surprised by the number of day-flying moths and wasps I observed foraging for nectar; I am more familiar with night-flying moths and with wasps that rely on food sources other than nectar. I also discovered that bumblebees are very important pollinators: They were present every week of the study, they forage earlier in the morning and later in the evening than other bees, and they are quite numerous.

5. What accounts for the diversity of pollinators I observed?

Pollinators need good places to nest as well as foraging habitat. Without specifically gardening for pollinators, I have provided many of the features that promote success of pollinators. As seen in a map of my neighborhood (Figure 5), there are natural areas within a 800 yard radius of the study site that might provide nesting habitat, and thus enhance pollinator diversity. The majority (62%) of bees I observed were very small bees (2-10 mm) which typically fly up to 200 yards from their nests to forage for food. Small to medium-sized bees (11-16 mm) may fly up to 400 or 500 yards, and large bees (17-30 mm) have foraging distances of a mile or more. There are relatively ungroomed patches along the back fences of my yard and three adjacent properties that include areas of bare soil and probably abandoned rodent burrows created by chipmunks. Bare soil, especially sandy or loamy soil, provides nesting habitat for the 70% of native bees that are ground nesters. My back yard also has two snags (one 12-foot tall trunk and one 8-foot log) and a section of trunk from a tree that was removed. Such snags are likely to have abandoned beetle tunnels that are used by the 30% of native bees that are tunnel-nesters. The hollow stems of plants such as *Eutrochium fistulosum* may also provide nesting sites.

Figure 5: Foraging Distances from the Study Site



Pollinators benefit from pesticide-free foraging habitat that includes a diverse range of native plants providing pollen and nectar, with several plant species flowering at once and a sequence of plants flowering through the growing season. Although I use the herbicide glyphosate to control some exotic invasive plants, I do not use any insecticides in my yard. The vast majority of native plants have been grown from seed and/or acquired from sources that do not use neonicotinoids, so floral visitors to my yard enjoy pesticide-free native plants for foraging. With between 14 and 31 different species of native plants in bloom each of the 16 weeks of the study, my yard clearly surpasses the pollinator garden recommendation for at least three bloomers in each season. The diversity of plants in the yard exhibit different flower

shapes, colors, and sizes, appealing to pollinators of varying size and with different tongue lengths. Flowers in the aster family have a simple structure with an open platform, making nectar easily available and thus attracting many bee species. My yard has 26 species in the aster family, 20 of which were in bloom at some point between the beginning of April and the end of August. Bumblebees (*Bombus*) and some other bees have long tongues or are big enough to push petals aside. These bees sometimes prefer more complex flowers such as lupines and salvias; nectar is hidden deep inside these flowers, often with a higher concentration of sugar (Mader et al., 2011). Of the 16 plant species that I observed *Bombus* species visiting in my yard, six had flowers with a complex structure: *Dicentra eximia, Wisteria frutescens, Scutellaria incana, Pycnanthemum incanum, Penstemon digitalis,* and *Penstemon smallii.*

The plants in my yard are of different heights and growth habits, including ground covers, herbaceous perennials from one to 12 feet in height, vines, shrubs, understory trees, and canopy trees. The inclusion of different structural layers of plants makes the study site attractive to diverse types of pollinators.

While bees need places to nest as well as pollen and nectar for provisioning brood cells, butterflies and moths need host plants on which to lay their eggs, so that the emerging larvae have the appropriate plant food. Many of the native plants in my yard serve as host plants for butterflies and moths. For example, *Lindera benzoin* (Spicebush) is the host plant for the Spicebush Swallowtail, and *Parthenocissis quinquefolia* (Virginia Creeper) hosts the Eight-spotted Forester Moth. Most notable in my yard as a host plant for butterflies and skippers is *Wisteria frutescens* (American Wisteria), which supports the Silver-Spotted Skipper, Clouded Sulphur, Orange Sulphur, Gray Hairstreak, and Eastern Tailed Blue. All of these butterflies were observed visiting native plants in my yard at some point during the observation period or in the two months after the study.

Conclusion

Native plants are the base of the food web for thousands of insects and other arthropods. It is clear from the results of this study that many types and species of floral visitors, including five classes of pollinators, were attracted to the native plants in my yard. I observed seasonal variation in the types of pollinators present, with more butterflies appearing in late summer, and a different peak week for the number of species observed among each of the five major classes of pollinators. Most of the bee and butterfly genera that I expected to see were observed during the study, in addition to some unexpected species. Bees and flies were observed every week of the study, pointing to their importance as pollinators of native plants.

The diversity of pollinators I observed is remarkable, considering the relatively short time span for observation (two hours a week for 16 weeks spread over spring and summer). The variety of plant species in my yard with their differing sizes, growth habits, and flower colors, shapes, and bloom periods helped attract a diversity of pollinators. Characteristics of the study site and surrounding neighborhood also provided features attractive to pollinators, especially places to nest and availability of host plants.

Floral visitors are attracted to plants for a variety of reasons, and they interact with the flowers and with each other. Bees and flowers have evolved a complex relationship that benefits the flowers through pollination, and the bees through food provisions for adult bees and their offspring. Numerous other floral visitors benefit from the rewards that flowers offer: nectar, pollen, oils and resin, and places to meet conspecifics, hunt for prey, or lay eggs. During the study, I observed mating beetles and flies, insects predators, and pollinators foraging for nectar and gathering pollen. I witnessed larger bees displacing skippers, moths, and smaller bees foraging on flowers, and a non-native bee patrolling a patch of flowers and attempting to drive off a much larger, native bee foraging for nectar. Some bees robbed nectar from flowers, while others foraged for nectar and pollen in ways that made cross-pollination of flowers more likely. These observations underscored the realization that there is a world of activity happening within the flowers of native plants. Adding native plants to one's landscape stands to benefit many organisms, and thus support biodiversity.

To document the floral visitors observed in my yard I created the iNaturalist project, "Pollinator Diversity at Home" at iNaturalist.org (see Appendix 4). For each photograph I uploaded, I included information about the native plant being visited as well as the identification of the floral visitor. In this way, I hope to encourage others to observe and help sustain the vast array of organisms dependent upon native plants. Pollinators need native plants, and native plants need pollinators to create the next generation.

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APPENDIX 1: Native Plants at the Study Site

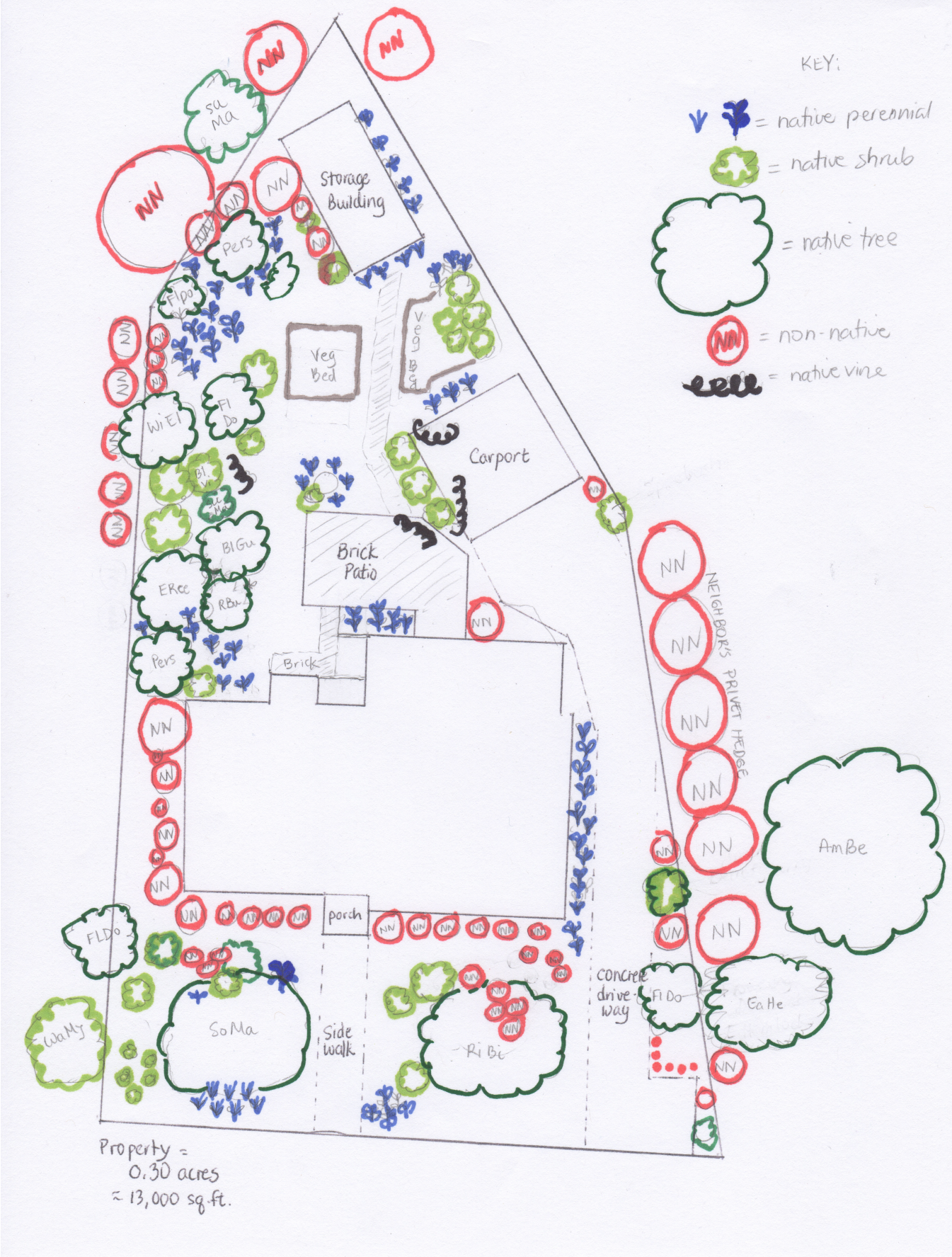
Native Plants at the Study Site in Greensboro, NC in 2016 (N= 128)

Scientific Name	Common Name	Scientific Name	Common Name
Acer floridanum	S. Sugar Maple	*Impatiens capensis*	Jewelweed
Aesculus pavia	Red Buckeye	*Iris cristata*	Dwarf Crested Iris
Amsonia tabernaemontana	Common Blue-star	*Juniperus virginiana*	Eastern Redcedar
Anemone americana	Round-lobed Hepatica	*Liatris spicata*	Sessile Blazing Star
Anemone virginiana	Tall Thimbleweed	*Liatris squarrosa*	Blazing Star
Apios americana	American Groundnut	*Lindera benzoin*	Spicebush
Apocynum cannabinum	Dogbane/Indian Hemp	*Lobelia cardinalis*	Cardinal Flower
Aquilegia canadensis	Eastern Columbine	*Lobelia inflata*	Indian Tobacco
Arisaema triphyllum	Jack-in-the-Pulpit	*Lobelia siphilitica*	Great Blue Lobelia
Artistolochia tomentosa	Woolly Pipevine	*Lonicera sempervirens*	Coral Honeysuckle
Asarum canadense	Deciduous Wild Ginger	*Magnolia grandiflora*	Southern Magnolia
Asclepias incarnata	Swamp Milkweed	*Maianthemum racemosum*	Solomon's Plume
Asclepias syriaca	Common Milkweed	*Manfreda virginica*	False Aloe/ Agave
Asclepias tuberosa	Butterfly Milkweed	*Marshallia obovata var. obovata*	Piedmont Barbara's Buttons
Asclepias verticillata	Whorled Milkweed	*Melothria pendula*	Mouse Melon
Baptisia alba x australis 'Purple smoke'	Hybrid Wild Indigo	*Nyssa sylvatica*	Black Gum
Baptisia australis	False Indigo	*Oenothera fruticosa*	Sundrops
Betula nigra	River Birch	*Oenothera specieosa*	Showy Evening Primrose
Callicarpa americana	American Beautyberry	*Parthenocissis quincefolia*	Virginia Creeper
Calycanthus floridus	Sweet Shrub	*Passiflora lutea*	Yellow Passionflower
Carex flaccosperma	Blue Wood Sedge	*Penstemon digitalis "Huskers Red"*	Foxglove Beardtongue
Ceanothus americanus	New Jersey Tea	*Penstemon smallii*	Small's Beardtongue
Centrosoema virginianum	Spurred Butterfly Pea	*Phlox sp.*	Phlox

Scientific Name	Common Name	Scientific Name	Common Name
Cephalanthus occidentalis	Common Buttonbush	*Phlox stolonifera*	Creeping Phlox
Cercis canadensis	Eastern Redbud	*Phytolacca americana*	American Pokeweed
Chionanthus virginicus	White Fringetree	*Podophyllum peltatum*	Mayapple
Chrysogonum virginianum	Green and Gold	*Polemonium reptans*	Jacob's Ladder
Claytonia virginica	Eastern Spring-Beauty	*Polygonatum biflorum*	Solomon's Seal
Clematis virginiana	Virgin's Bower	*Prunus caroliniana*	Carolina Cherry Laurel
Cornus florida	Flowering Dogwood	*Pseudognaphalium obtusifolium* ssp. *obtusifolium*	Blunt-leaved Rabbit Tobacco
Cornus stolonifera, "Farrow"	Red Twig Dogwood "Arctic Fire"	*Pycnanthemum incanum*	Hoary Mountain Mint
Dicentra cucullaria	Dutchman's breeches	*Rhexia virginica*	Virginia Meadow Beauty
Dicentra eximia	Bleeding Heart	*Rudbeckia fulgida*	Orange Coneflower
Diospyros virginiana	Persimmon	*Rudbeckia laciniata*	Green-headed Coneflower
Echinacea purpurea	Purple Coneflower	*Rudbeckia hirta*	Black-eyed Susan
Erigeron annuus	Common Fleabane	*Rudbeckia subtomentosa*	Sweet Coneflower
Erigeron strigosus	Rough Fleabane	*Rudbeckia triloba*	Brown-eyed Susan
Eryngium yuccifolium	Rattlesnake Master	*Sanguinaria canadensis*	Bloodroot
Erythronium americanum	Northern Trout Lily	*Scutellaria hyssopifolia*	Hyssop Skullcap
Erythronium umbilicatum	Dimpled Trout Lily	*Scutellaria incana var. punctata*	Hoary Skullcap
Euonymus americanus	Strawberry Bush	*Silphium astericus*	Starry Rosinweed
Eupatorium "Phantom #1"/ (Eutrochium maculatum)	Dwarf Joe Pye Weed	*Solidago sempervirens*	Goldenrod
Eupatorium perfoliatum	Common Boneset	*Solidago caesia*	Wreath Goldenrod
Eurybia divaricata	White Wood Aster	*Spigelia marilandica*	Indian Pink
Eutrochium fistulosa	Joe Pye Weed	*Stylophorum diphyllum*	Wood Poppy
Eutrochium purpureum	Sweet-scented Joe Pye Weed	*Symphyotrichum georgiana*	Georgia Aster

Scientific Name	Common Name	Scientific Name	Common Name
Fothergilla x intermedia 'Blue Shadow'	Fothergilla Blue Shadow	*Symphyotrichum lavae*	Smooth Aster
Fothergilla gardenii	Coastal Fothergilla	*Teucrium canadense*	American Germander, Cananda Germander
Franlkinia alatamahaw	Franklin tree	*Thalictrum thalictroides*	Rue Anemone
Gelsemium sempervirens	Carolina Jessamine	*Tiarella 'Jeepers Creepers*	Foamflower
Geum canadense	White Avens	*Tiarella cordifolia var. collina*	Foamflower
Helianthus angustifolium	Swamp Sunflower	*Trillium cuneatum*	Toad Trillium
Helianthus schweinitzii	Schweinitz's Sunflower	*Ulmus alata*	Winged Elm
Heuchera americana 'Purple Palace'	American Alumroot	*Vaccineum corymbosum*	Highbush Blueberry
Heuchera spp.	Coral Bells	*Vaccinium ashei/ Vaccinium virgatum*	Rabbiteye Blueberry
Heuchera villosa	Alumroot	*Vernonia gigantea*	Tall Ironweed
Heuchera villosa 'Autumn Bride'	Alumroot	*Viburnum dentatum*	Arrowwood Virburnum
Hexastylis arifolia	Arrowleaf Ginger	*Viburnum prunifolium*	Black Haw Viburnum
Hexastylis minor	Little Heartleaf Ginger	*Viburnum trilobum 'Red Wing' **	Vibernum
Hydrangea quercifolia	Oak-leaf Hydrangea	*Viola sororia*	Common Violet
Hydrastis canadensis	Goldenseal	*Vitis aestivalis*	Summer Grape
Ilex decidua 'Midas'	Deciduous Holly (male)	*Wisteria frutescens*	American Wisteria
Ilex decidua 'Warren's Red'	Deciduous Holly (female)		
Ilex verticillata 'Southern Gentleman'	Winterberry (male)		
Ilex verticillata 'Winter Red'	Winterberry (female)		
Illicium parviflorum	Yellow Anise Tree		

APPENDIX 2: Diagram of Plant Locations at Study Site



APPENDIX 3: Pollinator Data Collection Sheet

Pollinator Diversity Observation Data

Date: _____ / ___ / 2016 Obsv: 1 2 3 4 **Start time** ____:____ AM/PM **End time**: ____:_____ AM/PM
Temperature ____ F. **Cloud Cover:** Sunny ___ Partly cloudy ___ Overcast ___ **Wind** :_____ mph

	PLANT SPECIES	BLOOM STAGE	NECTAR AVAILABLE	POLLEN AVAILABLE
1				
2				
3				
4				
5				
6				

VISITOR TYPE	SIZE	APPEARANCE	BEHAVIOR AT FLOWER	EFFECTIVE POLLINATION

APPENDIX 4: iNaturalist.org Project Link

Pollinator Diversity at Home
iNaturalist.org project with photos of floral visitors observed during this study.
www.inaturalist.org/projects/pollinator-diversity-at-home