

**Pollination Ecology at Loyola University Retreat and
Ecology Campus and at other Monarch Waystations,
McHenry County, IL 2017**

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Mentor: Stephen Mitten, S.J.

*Institute of Environmental Sustainability
Loyola University Chicago
Summer 2017*

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ABSTRACT

A preliminary survey was conducted to identify floral visitors and their host flowers at Loyola University Retreat and Ecology Campus in McHenry County, Illinois over the summer of 2017. Pollen samples were gathered from 65 species of flowers and from 49 pollinators. Biological slide references of known pollen species were created for a database to compare with pollen samples collected from pollinators. The results allude to relationships between flowers and their insect pollinators. The Rusty Patched Bumble Bee (*Bombus affinis*), a newly enlisted endangered species, was documented for the first time. In addition, monarch butterfly (*Danaus plexippus*) information was gathered from five different monarch butterfly waystations dispersed throughout McHenry County. Data was collected on a weekly basis to obtain information on local monarch butterfly populations. Information gathered included monarch individuals per site with observed stages of monarch development. 83 monarch eggs and 25 caterpillars were documented. 30 combined eggs and caterpillars were raised in the lab and 25 adult monarchs were released outdoors. Fifteen other species of butterflies and moths were also observed at these waystations. The results revealed that LUREC had the highest number of monarch individuals while Dean Street and Triangle Prairie had the most Lepidoptera species observed. As the summer progressed, the number of monarchs observed increased. Pollination ecology is at its infancy and has great potential for assisting both specialist in ecosystem restorations and ecologist in determine the effects of climate change on pollination efficacy. Identifying the focal plants that would provide forage for the majority of pollinator taxa would be fruitful future research that could assist restoration specialists to select the main species of flora to plant.

INTRODUCTION

BACKGROUND

Global food security demands healthy pollinator populations. The current global decline in pollinators and the associated loss of pollination services is a widespread concern among agriculturalist and ecologist. A vast array of species serve as pollinators, including 20,000

species of bees as well as birds, bats, flies, and butterflies (Intergovernmental Platform on Biodiversity and Ecosystem Services, 2016). Despite the importance of pollination to ecological systems, the pollination ecology of many plants is poorly known. Pollination ecology is at its infancy and has great potential for assisting specialist in ecosystem restoration. The study of pollinators is particularly important as Loyola University Retreat and Ecology Campus (LUREC from now on) implements a restoration plan for its degraded prairie, oak woodlands and wetlands. An evaluation of pollinator's at the Loyola University Retreat and Ecology Campus can allow for more efficient and effective conservation efforts to maintain the biodiversity of the campus. Understanding pollination ecology can also assist in determining whether or not the restorations efforts applied are successful in effectively promoting biodiversity across the campus.

The Monarch Butterfly (*Danaus plexippus*) population has plummeted in the last decade, making this butterfly species a target for federal listing, and for cross-border collaboration with Mexico. A migratory butterfly species, monarchs' bridge two nations' borders in its fall journey to California and Mexico and are being utilized for citizen outreach. USFWS focused on Monarch Butterfly conservation in 2015-2016. Target audiences for this project included all citizens of McHenry County, including faith-based communities, schools, and the Hispanic community. "Charismatic species" such as the monarch can be used to provide basic "conservation value education" to all age levels, and across all land uses from private backyards to public lands. In the summer of 2016, eight monarch waystations were planted with funds obtained from the US Fish and Wildlife Service at locations across McHenry County, IL. by the Friends of Hackmatac's (FOH) Monarch Coalition; a group of twenty conservation agencies and educational organizations in McHenry County and neighboring Wisconsin that came together to work towards the conservation of the monarch butterfly. Fourteen plant species consisting of Butterfly weed (*Asclepias tuberosa*), Common milkweed (*Asclepias syriaca*), Swamp milkweed (*Asclepias incarnata*), Wild bergamot (*Monarda fistulosa*), New England aster (*Symphyotrichum novae-angliae*), Smooth blue aster (*Symphyotrichum laeve*), Tickseed (*Coreopsis verticillata*), American pokeweed (*Phytolacca americana*), Rough blazing star (*Liatris spicata*), Little bluestem (*Schizachyrium scoparium*), Prairie dropseed (*Sporobolus heterolepis*), Stiff goldenrod (*Oligoneuron rigidum*), Cardinal flower (*Lobelia cardinalis*), and False indigo (*Baptisia australis*) were planted in these waystations. As a rule, a waystation must include at least 2 types of milkweed, the 'host' plant for Monarchs. One such monarch waystation was planted at Loyola University and Retreat and Ecology Campus in the summer of 2016. 396 host and nectar plants were installed. This study is the first to document the success or failure of these waystations in attracting monarchs. Comparisons between waystation utilization by monarchs were observed.

Thus this study is threefold: 1) to construct a pollen reference slide library of LUREC's flowers; 2) to investigation the pollinator-flora relationship found there; and 3) to begin a preliminary survey of the monarch butterfly activity at five new monarch waystations across McHenry County, IL.

STUDY AREA DESCRIPTION

The five monarch butterfly waystations monitored in this study were located in McHenry County, IL and were visited weekly (Figure 1). Their name and size is as follows:

Triangle Prairie (Figure 2): 6626.47 m² | 1.64 acres | 0.66 hectares | 71326.72 feet²

McHenry County Fairgrounds (Figure 3): 61.02 m² | 0.02 acres | 0.01 hectares | 656.77 feet²

Dean St. (Figure 4): 9603.36 m² | 2.37 acres | 0.96 hectares | 103369.68 feet² |

Crystal Lake (Figure 5): 177.33 m² | 0.04 acres | 0.02 hectares | 1908.72 feet²

LUREC (Figure 6): 301.65 m² | 0.07 acres | 0.03 hectares | 3246.94 feet² |

The monarch/pollinator installations were planted in the spring of 2016. So that they were truly effective, they were all at least 100 square feet and they varied in the numbers of individuals of each of the 14 plant species installed (see above). The majority of these plants were different kinds of milkweed; the common milkweed (*Asclepias syriaca*), swamp milkweed (*Asclepias incarnata*) and butterfly weed (*Asclepias tuberosa*). They were all located in an area that received at least six hours of sun a day. As the summer progressed, common milkweed plants grew to heights over five feet.

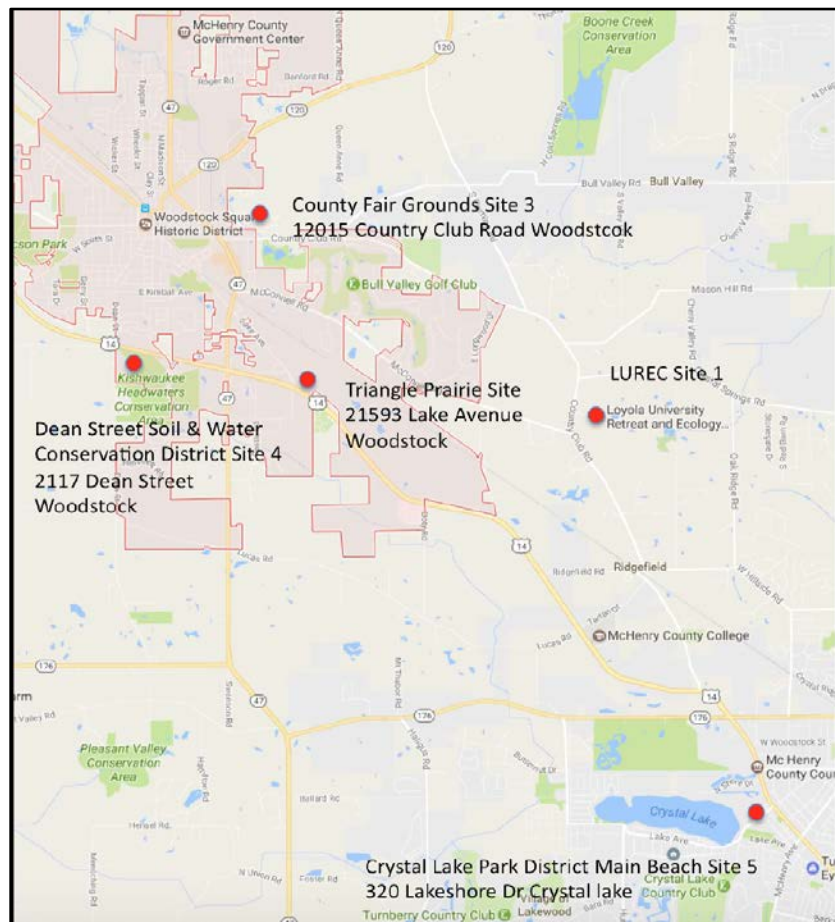


Figure 1. An overhead view of each of the five sites where monarch waystations were located.



Figure 3. McHenry County Fairgrounds monarch waystation site.



Figure 4. Dean Street Soil & Water Conservation District monarch waystation site.

Crystal Lake Park District Main Beach Garden Style planting Site 5

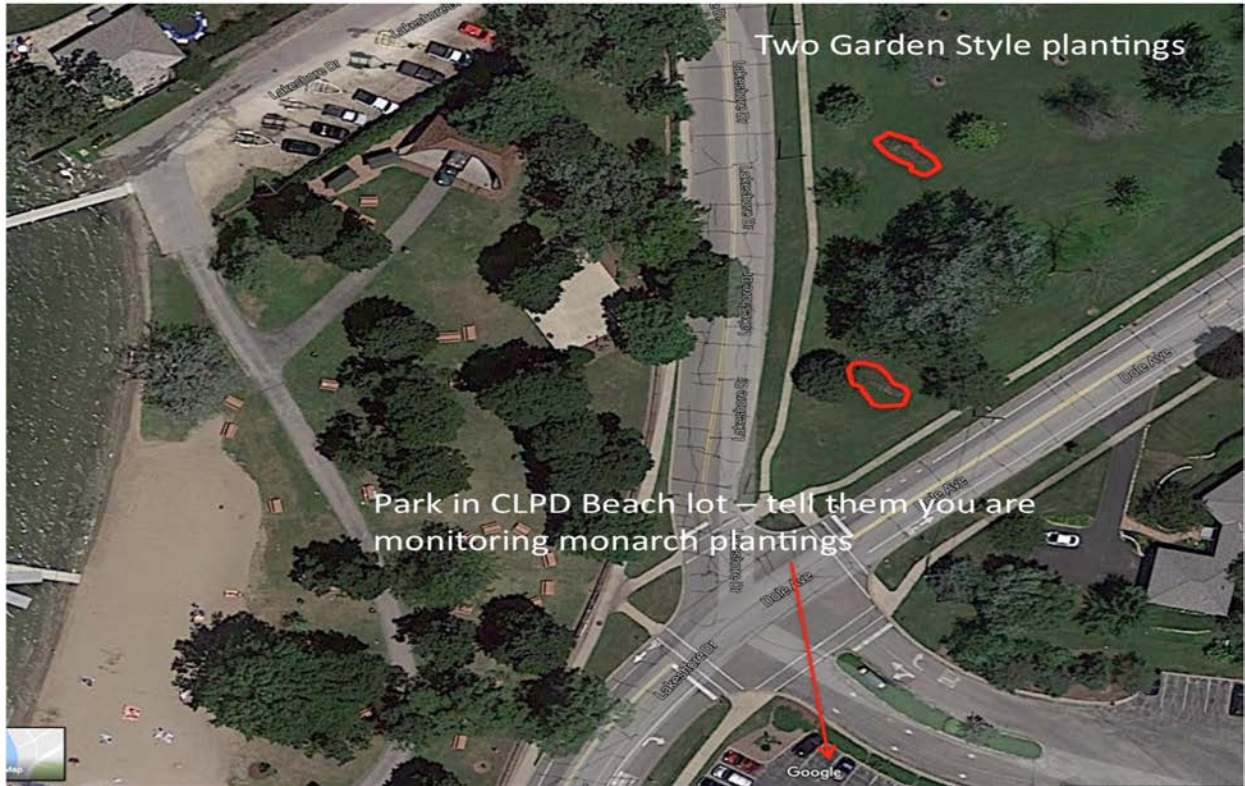


Figure 5. Crystal Lake Park District monarch waystation site.

Loyola University Chicago Retreat & Ecology Campus

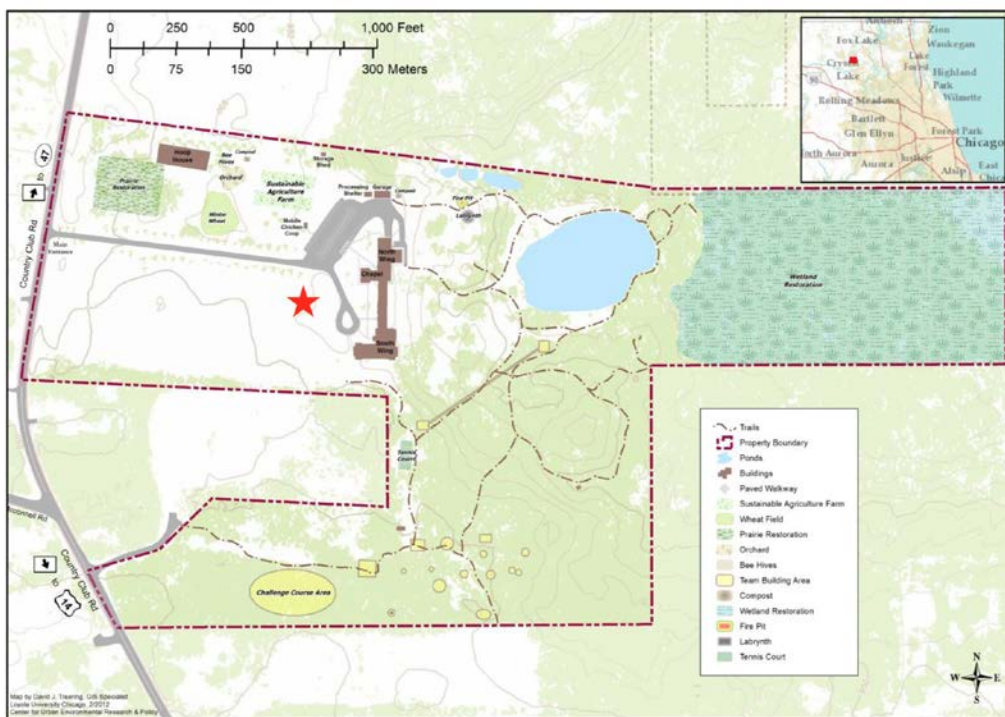


Figure 6. Top image is an overhead view of LUREC with habitat descriptions. The red star denotes the LUREC monarch butterfly waystation. Below photo is LUREC's monarch butterfly waystation.

Loyola University Chicago Retreat and Ecology Campus (LUREC) is located at 2710 S. Country Club Road in Bull Valley, McHenry County, IL. Its total size is 98 acres (39.7 hectares) and varies in habitats across the campus. Geographically, LUREC is located in Section 13, Township 44, North, Range 7, and East of the Third Meridian. The campus includes a large

academic and retreat building, landscaped grounds, an organic farm and greenhouse, nature trails, oak and pine forests, shrub lands, a small restored prairie, three small retention ponds, and a stream that feeds into a degraded fen that is currently being restored (Perez and Mitten, 2012) (Figure 6). Parker Fen, an Illinois Nature Preserve, borders directly northeast of LUREC's property.

METHODOLOGY

Investigation of the Pollinator-Flora Relationship at LUREC

Pollen reference slides were collected to determine pollinator-flora relationships at Loyola University Retreat and Ecology Campus. These reference slides were used to identify the specific types of flowers visited by individual insect pollinators from the pollen grains collected off the insect's body. They will also serve as reference material for future pollinator-flora studies.

POLLEN GRAIN SLIDE SAMPLING

Flower species were identified by using *Illinois Wildflowers* by Don Kurz. Once identified the anthers of a particular flower species were placed in a vial of isopropyl alcohol (IPA). The specific amount of IPA was around 1.5mL but varied depending on the amount of collectible pollen. Once the pollen was soaked in IPA, the solution was vigorously mixed to separate anthers from pollen grains and create more separation between individual grains. After allowing the solution to sit for at least fifteen minutes, one drop of IPA pollen solution was placed at each end of the microscope slide and subsequently given roughly ten minutes to dry.

The gel used to set and stain the pollen grains on the microscope slides was created using 35mL of distilled water, 30mL of glycerol reagent, and 10g of gelatin. Half of the gel was placed in a separate beaker and 3-5 drops of Safranin stain was added in order for the pollen grains to be more distinguished. Once dried, a small drop of the stained and unstained gel were each placed on their own slide cover. The dried slide was then lowered slowly onto the slide covers with a slight tilt in order to decrease the number of air bubbles. The slide was then immediately placed on a hot plate for five minutes and then subsequently placed into a refrigerator for fifteen minutes to allow the gel to set. Once set, the slides were removed and the slide cover edges were lined with clear nail polish to increase their durability and permanency. Once the nail polish dried, they were ready for inspection under a microscope. Some flora species were sampled more than once to see the difference in orientation of individual pollen grains or to create a more concentrated sample.

POLLINATOR SAMPLING

Pollinators were collected with the use of insect nets or jars from off of identified flowering plants and then transferred to small sample jars. Jars were stored in the freezer long

enough to induce a temporary torpor of the organism. Once incapacitated, insects were removed from the jar and placed onto a weigh boat for identification and pollen removal. The lowest taxonomic level of each organism was determined with the use of the following reference materials; *The bees in your backyard: a guide to North America's bees* by Wilson and Carril; *An Identification and Native Plant Forage Guide* by Heather Holm; and *Kaufman Field Guide to Insects of North America* by Eaton, Bowers, and Kaufman. The use of a stereoscope was used as an aid for identification. Images were taken of some of the species (See Appendix 1). Once the organism was identified, pollen grains were separated for analysis by use of a dissecting needle, scalpel, and tweezer and in some cases isopropyl alcohol. Visible pollen was removed with tweezers and then placed in a weigh boat where drops of IPA were added. The insects may have also been flushed with isopropyl alcohol to help remove any unseen pollen. Following pollen removal, organisms were transferred to a holding jar and placed under a heat lamp and then returned to the wild once revived.



MONARCH BUTTERFLY MONITORING METHODOLOGY

Each of the five monarch waystation were visited once a week, between 9:00am and 5:30pm; weather permitting. Weather conditions varied between sixty and eight-seven degrees Fahrenheit and consisted of predominantly clear skies with low wind. Sites visitation order varied to limit confounding variables. Milkweed plants at each site were checked for any monarch activity, and eggs and caterpillars were recorded. Time spent at each site depended on the size of the patch and the number of milkweed plants there and therefor time varied from site to site, depending on how long it took to examine every milkweed plant in each patch. All adult monarch butterflies visiting the patch were also recorded. Opportunistic observations of other butterfly species that happened to be present were also recorded. Monarch eggs were brought back to the laboratory so as not to be predated. Caterpillars were also taken back to the laboratory; however, 4th and 5th instars were less likely to survive because of earlier parasitism from the tachinid fly. 5th instars nearing the chrysalis process were not disturbed because doing so decreases the chance of their completion. Since survival rates of monarch eggs and instars are extremely low in the wild (10%) (Prysby and Oberhauser 2004), removing them to the lab increased their survival rate to 85%. All stages of the monarch's life from egg to newly emerged adults were filmed and the documentary video was put on the LUREC Biodiversity and Restoration Facebook page at https://www.facebook.com/Loyolawoodstock/?ref=notif¬if_id=1519417717374366¬if_t=page_user_activity

RESULTS

POLLEN GRAIN RESULTS

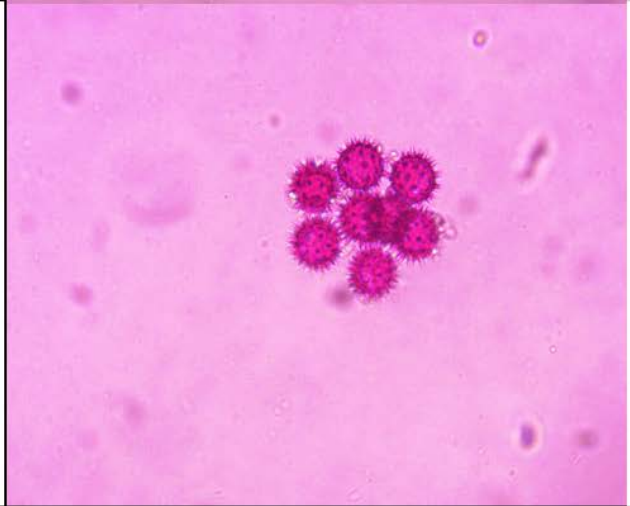
65 pollen reference slides were created from onsite plant species to determine pollinator-flora relationships. These reference slides were used to identify the specific types of flowers visited by individual insect pollinators from the pollen grains collected off the insect's body. The pollen grains of the various species vary in size and shape (oval, rod, disc or bean-shaped) and may form a more or less solid surface bearing little pores or have ornamentations like points, spikes or ribs which allow for adherence to different types of pollinators of which 80% of the plant families pollen is dispersed by animals, mostly by insects such as bumblebees, bees, butterflies and hoverflies. The 65 reference slides are shown below (**Table 1**).

Pollen Grain	Picture
Bee Balm	
Black Cherry Tomato Flower	

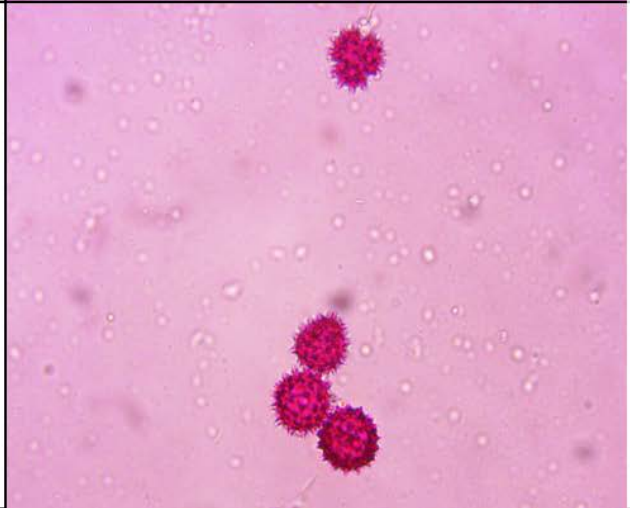
Black Medic



Blackeyed Susan



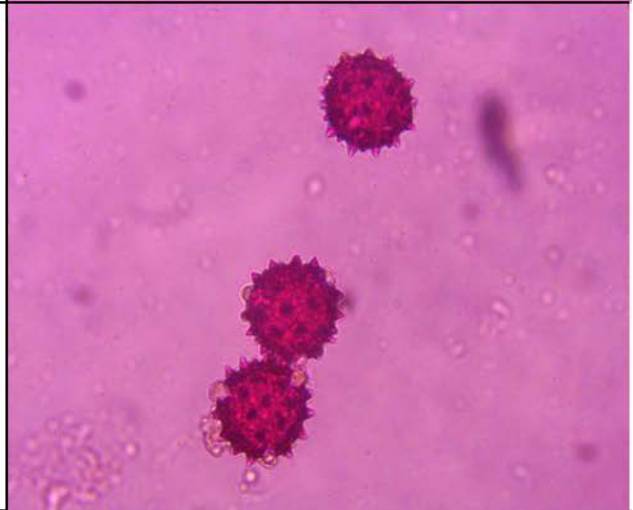
Blazing Star



Blue Mistflower

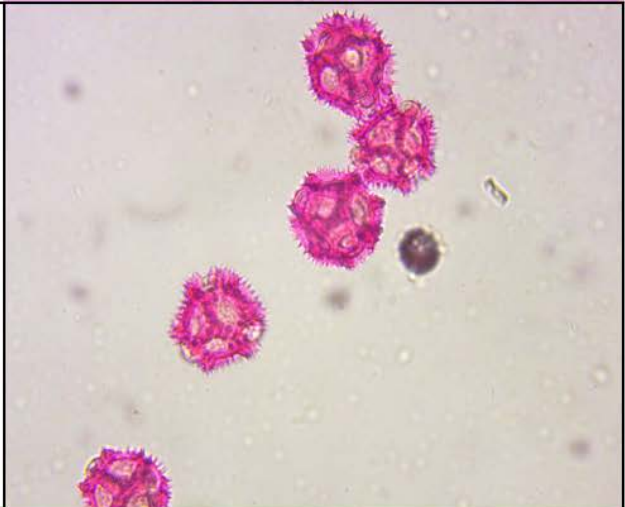




Canada Thistle



Canary Grass

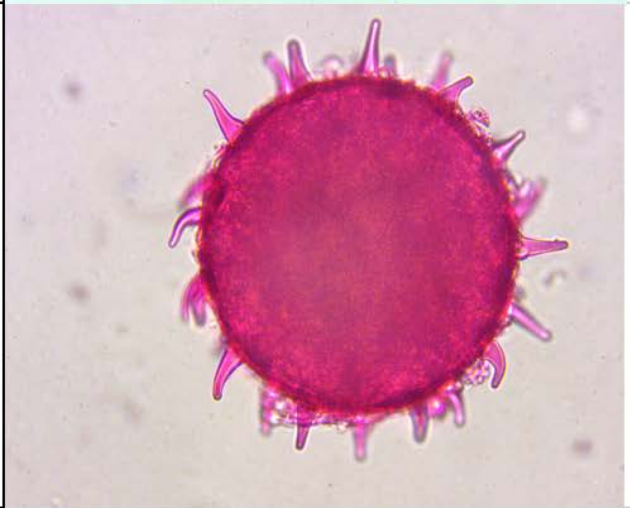


<p>Chicory</p>	
<p>Cleavers</p>	
<p>Clustered Black Snakeroot</p>	

Common Dayflower



Common Hibiscus



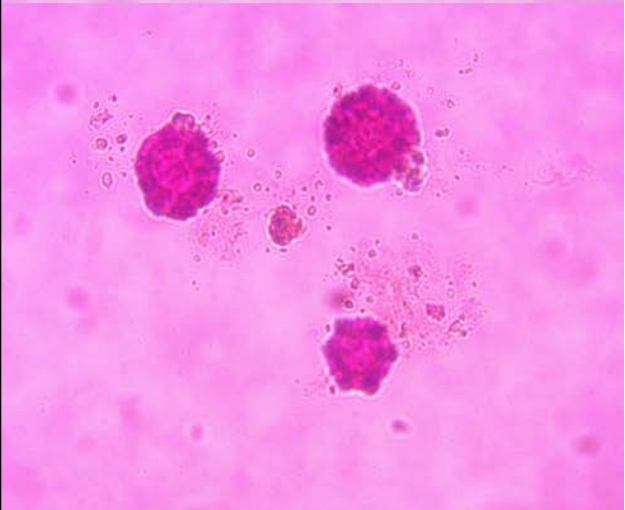
Culver's Root



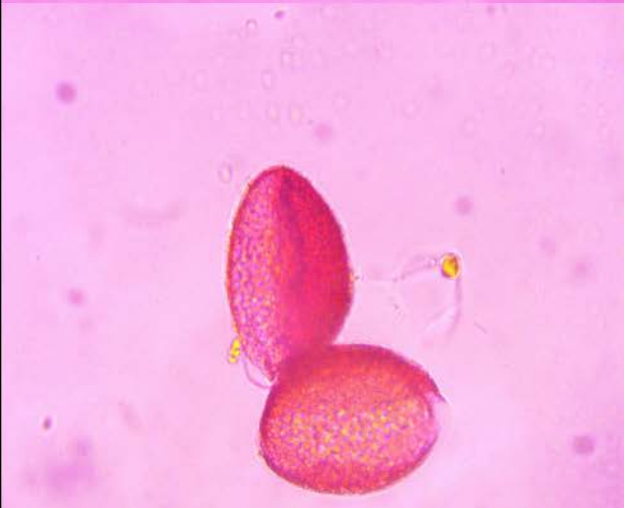
Dame's Rocket



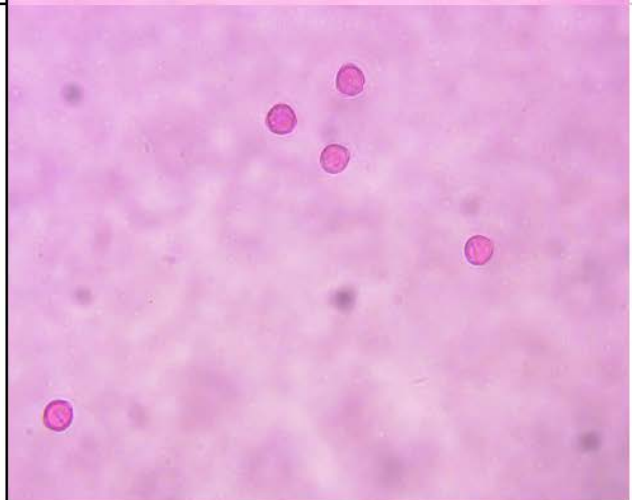
Dandelion



Daylily



Deadly Nightshade



Dill



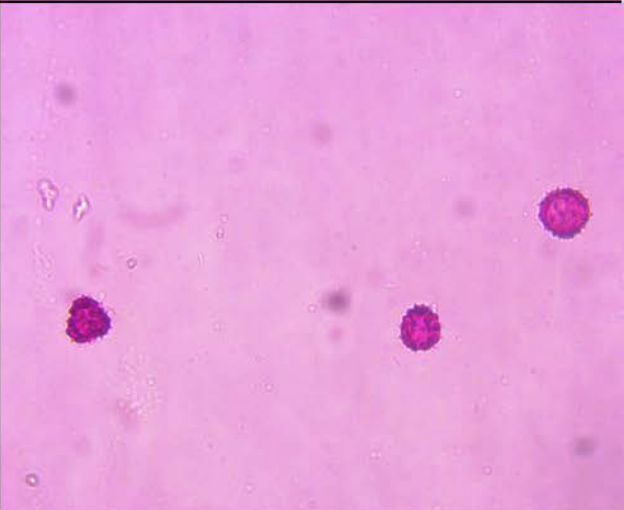
Drumstick Allium



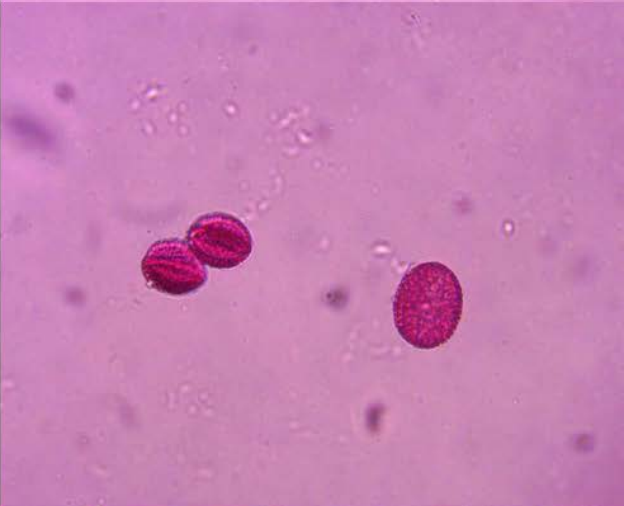
Evening Campion



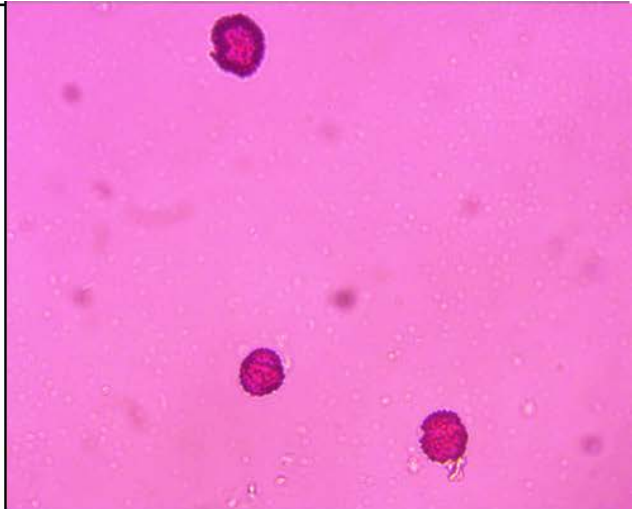
Feverfew



Field Mustard



Fleabane



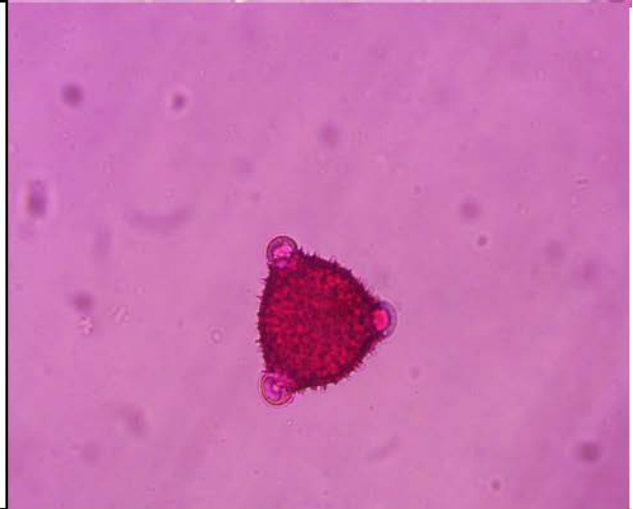
Great Angelica



Hawkweed



Honeysuckle



Hostas



Jewelweed



Lady's Thumb



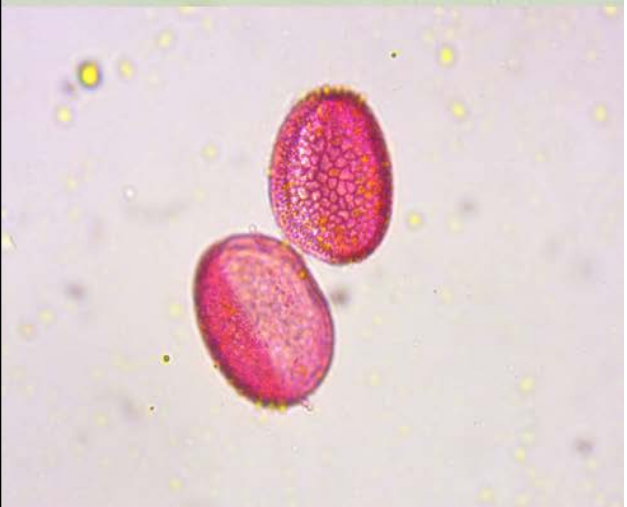
Lance-Leaced Coreopsis



Late Figwort



Michigan Lily



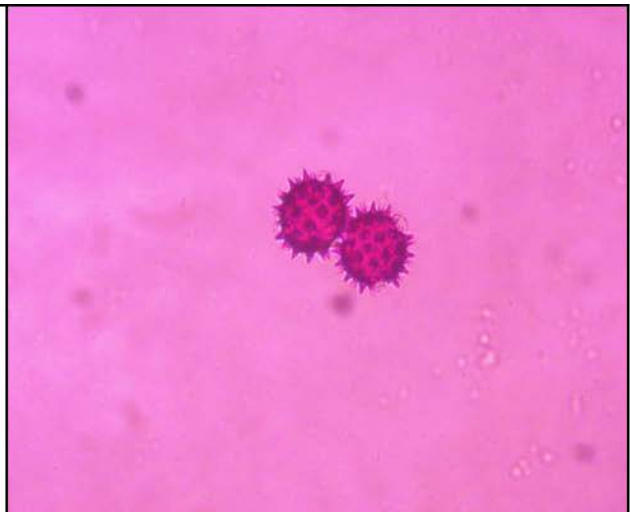
Multiflora Rose



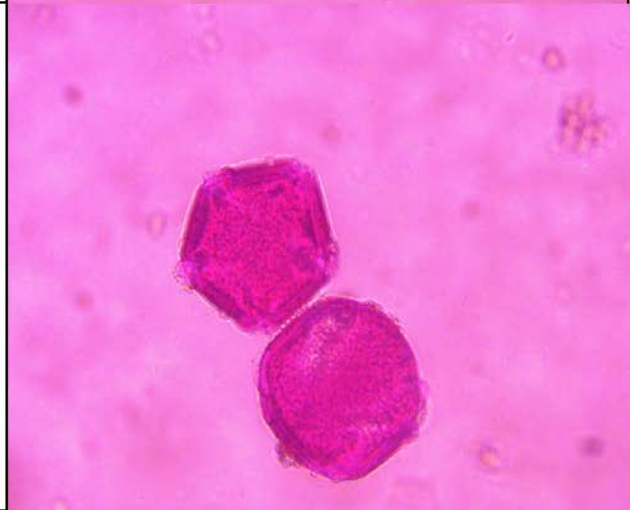
Ohio Spiderwort



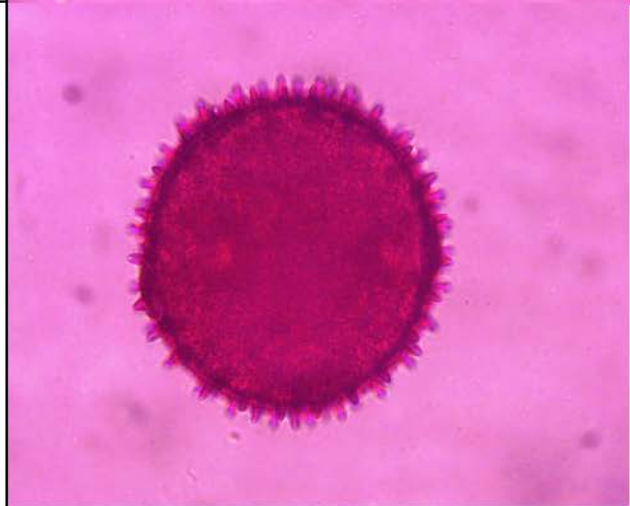
Pale Purple Coneflower



Pansy



Patty Pan



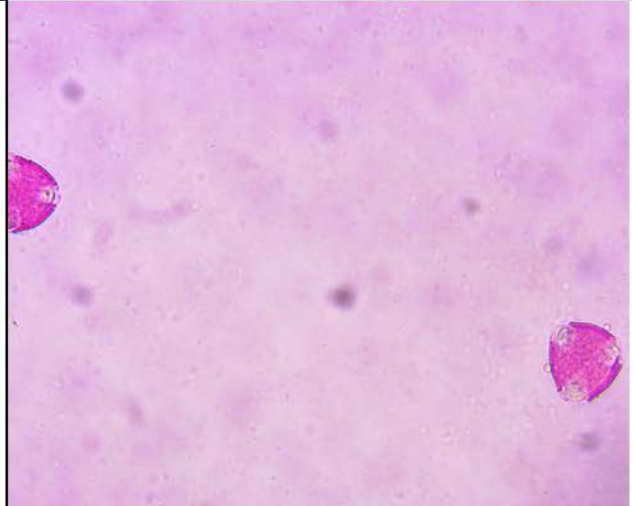
Penstemon Digitalis


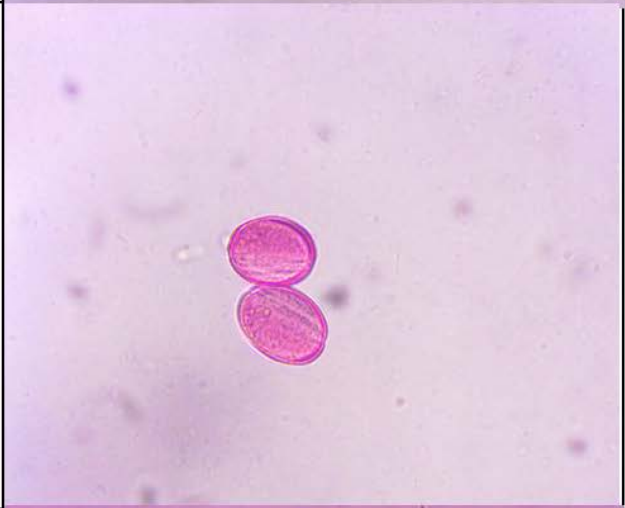
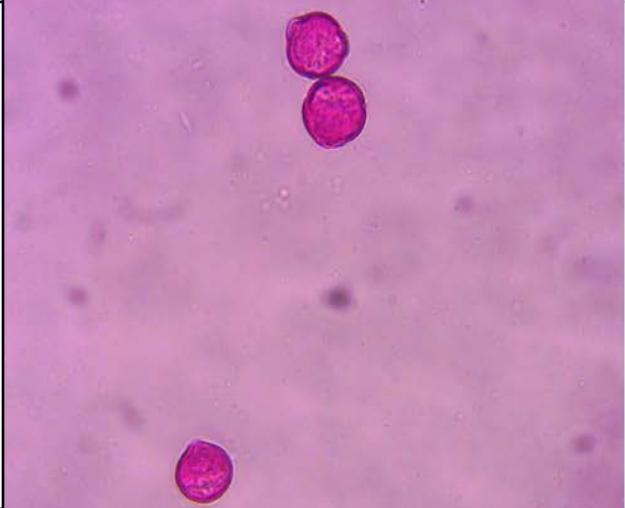


Perforate St. John's Wort

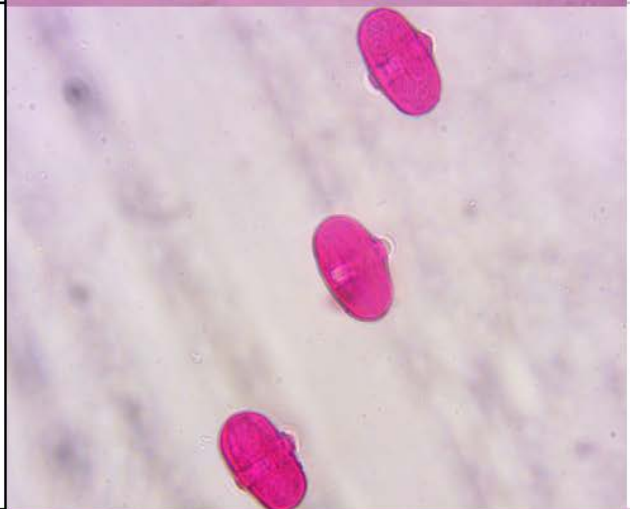


Pokeweed



<p>Purple Joe Pye Weed</p>	
<p>Purple Prairie Flower</p>	
<p>Raspberry Flower</p>	

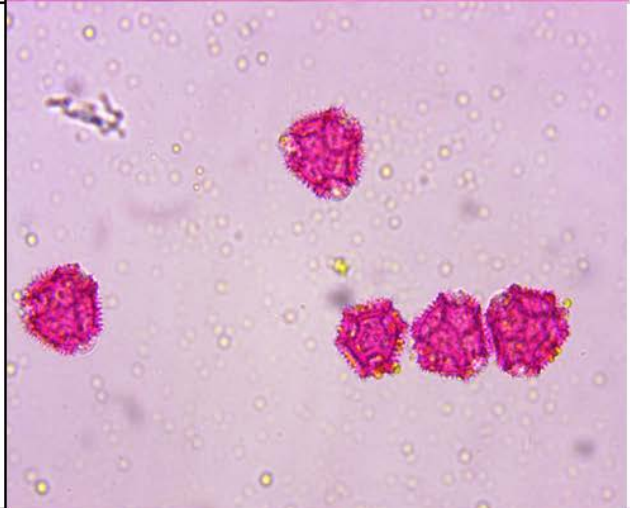
Rattlesnake Master



Red Clover



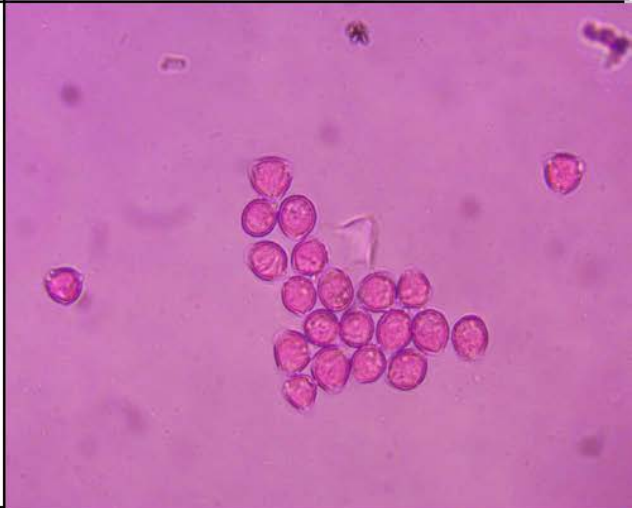
Sow Thistle



Spiderwort



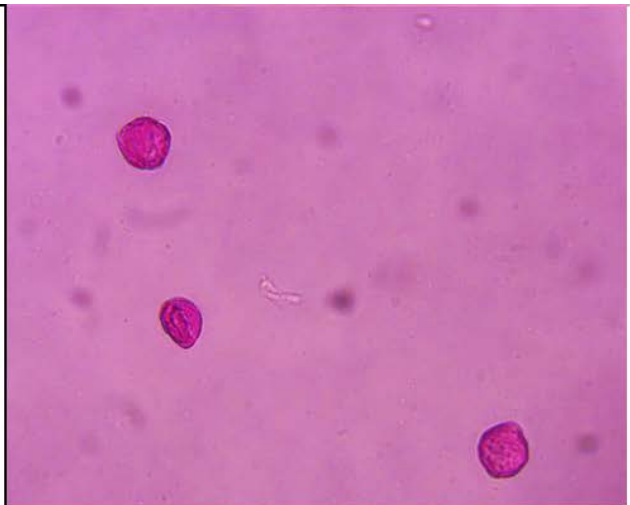
Spirea



Stinging Nettles



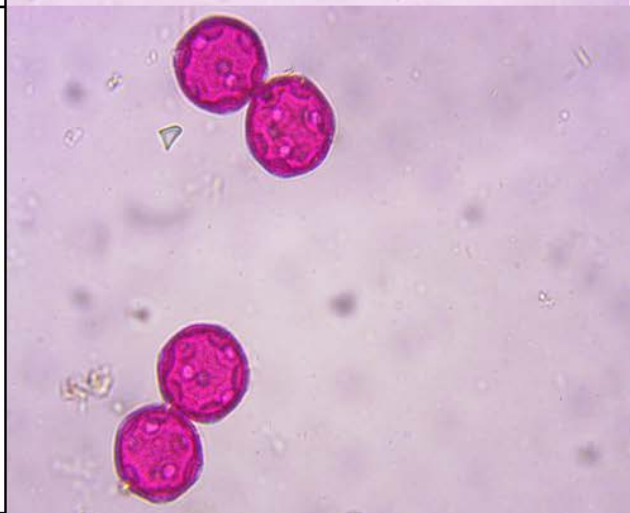
Strawberry Flower



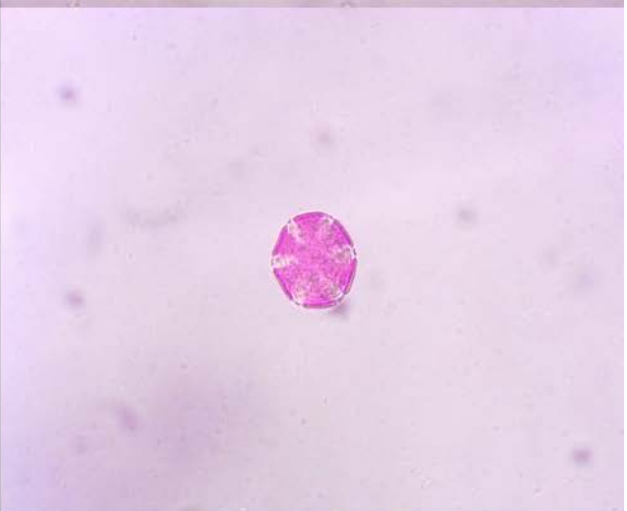
Sunflower



Tall Blue Bell



Virginia Mountain Mint



White Avens



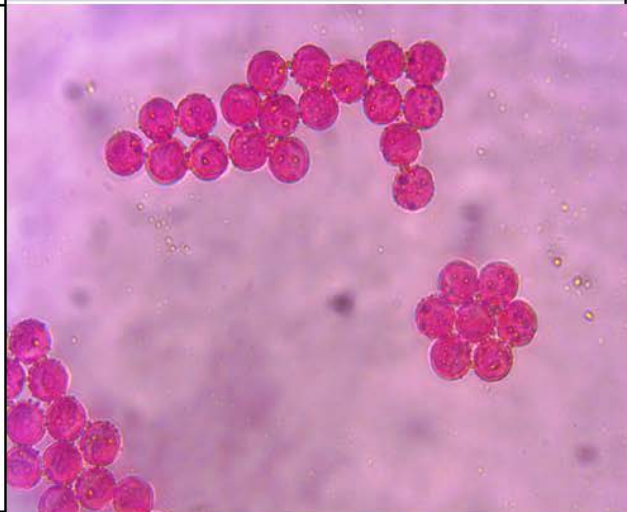
White Campion



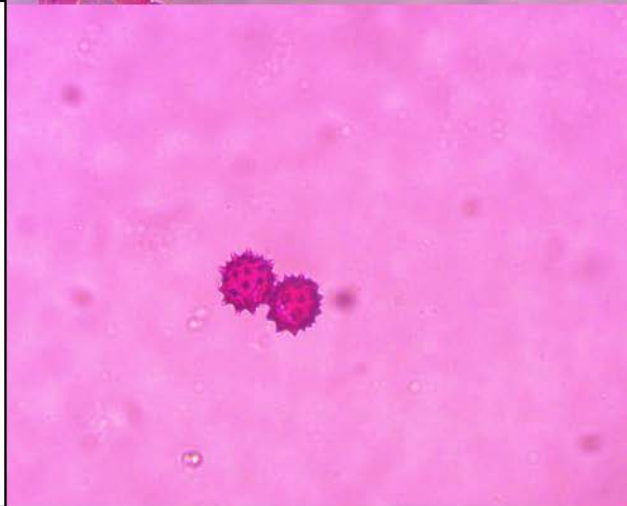
White Sweet Clover



White Wild Indigo



Wild Quinine



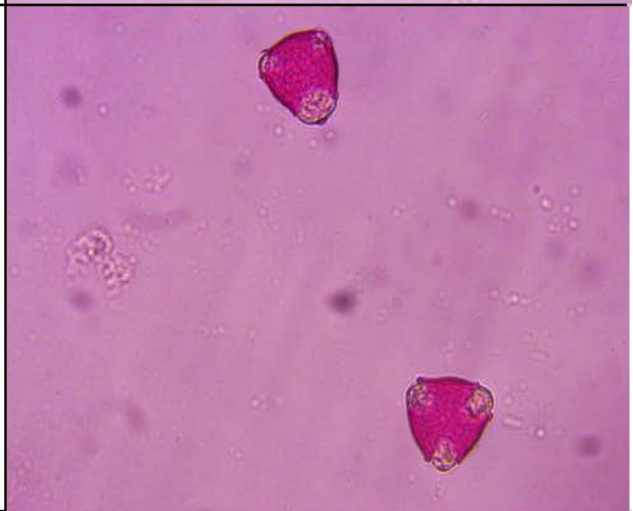
Wild Senna



Yarro



Yellow Oxalis






<p>Yellow Squash Flower</p>	
<p>Yucca</p>	
<p>Zinnia</p>	

Table 1. Pollen grain reference slides. Magnification, scale and aspect ratio of the photographs are kept constant for ease of comparison.

POLLINATOR RESULTS

49 insect pollinators were directly sampled. This analysis revealed the specific insect pollinator to its plant host. **Figure 7** is a representative slide of pollen removed off a Green Sweat Bee (Tribe *Augochlorini*) that was found on a Rattlesnake Master (*Eryngium yuccifolium*). It had pollen from the Rattlesnake Master and the Prairie Blazing Star (*Liatris pycnostachya*), which it had obviously visited. **Figure 8** illustrates pollen from Canada Thistle (*Cirsium arvense*) and Red Clover (*Trifolium pratense*) that was obtained off of a Common Eastern Bumble bee (*Bombus impatiens*) found on a Canada Thistle. A Green Sweat Bee (Tribe *Augochlorini*) captured off a Fleabane (*Erigeron strigosus*) had pollen from Fleabane, Lady's Thumb (*Persicaria maculosa*) and Pale Purple Coneflower (*Echinacea pallida*) (**Figure 9**).



Figure 7. Green Sweat Bee (Tribe *Augochlorini*) found on a Rattlesnake Master (*Eryngium yuccifolium*) with pollen from Rattlesnake Master and Prairie Blazing Star (*Liatris pycnostachya*).

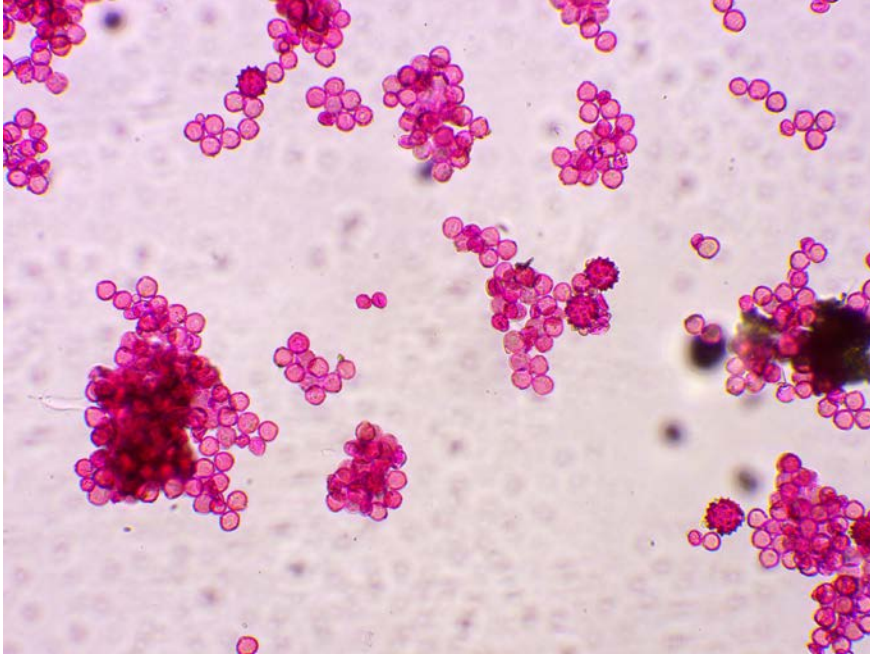


Figure 8. Common Eastern Bumble Bee (*Bombus impatiens*) found on Canada Thistle (*Cirsium arvense*) with pollen from Canada Thistle and Red Clover (*Trifolium pratense*).

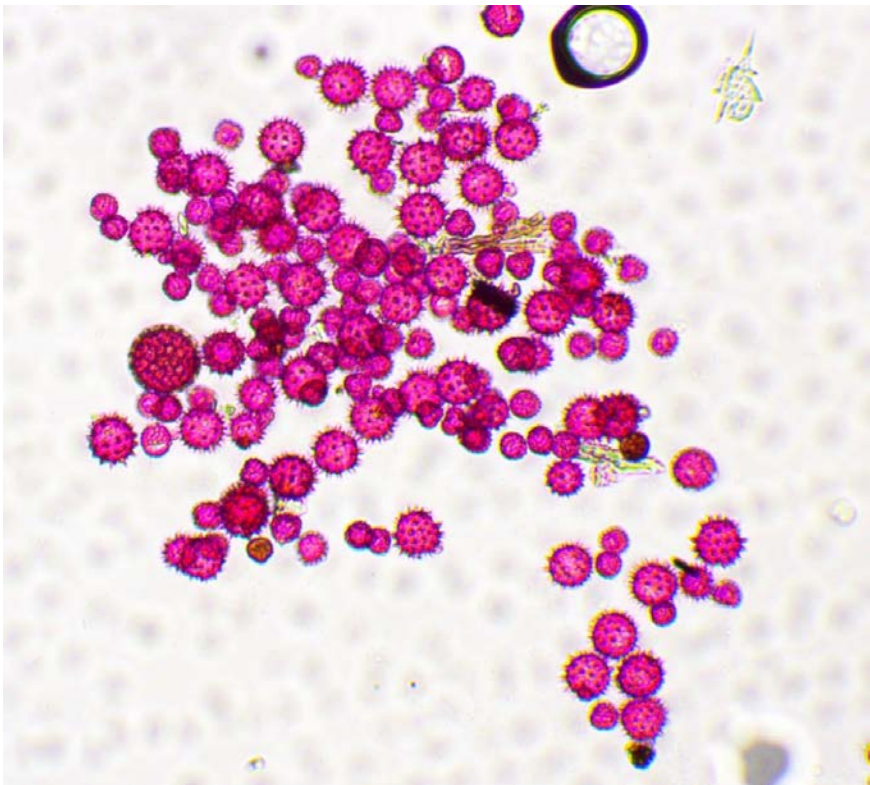


Figure 9. Green Sweat Bee (Tribe *Augochlorini*) on Fleabane (*Erigeron strigosus*) with pollen from Fleabane, Lady's Thumb (*Persicaria maculosa*), and Pale Purple Coneflower (*Echinacea pallida*).

Observational data of nearly 100 pollinator visits shown in **Appendix 2** corroborated the pollen information off the insects.

MONARCH WAYSTATION RESULTS

Five monarch waystations were monitored throughout McHenry County. The sites were located at the Loyola University Retreat and Ecology Campus, Triangle Prairie (Woodstock, IL), the McHenry County Fairgrounds, the Dean Street Soil & Water Conservation District, and the Crystal Lake Park District. Each site’s observational data for monarchs are shown in **Tables 2 -6** below. Eggs, instars from first through fifth, and adult butterflies were recorded. No chrysalides were found during the monitoring.

	5/31	6/7	6/14	6/21	6/27	7/6	7/12	7/17	7/25	7/31	8/8	Total Individuals
eggs	1					1	3	2	10	1	15	33
1st instars									1			1
2nd instars		1							2		4	7
3rd instars						3	1					4
4th instars										1	1	2
5th instars					2							2
butterflies	1			1		2	1	3	3	3	5	19

Table 2. Monarch eggs and instars found at Loyola University Retreat and Ecology Campus.

	5/31	6/7	6/14	6/21	6/27	7/6	7/12	7/17	7/25	7/31	8/8	Total Individuals
eggs		1				2				11	3	17
butterflies						2	3	1				6

Table 3. Monarch eggs and instars found at the Triangle Prairie site.

	5/31	6/7	6/14	6/21	6/27	7/6	7/12	7/17	7/25	7/31	8/8	Total Individuals
eggs						3				1	2	6
2nd instars					1							1
butterflies									1			1

Table 4. Monarch eggs and instars found at the McHenry County Fairgrounds site.

	5/31	6/7	6/14	6/21	6/27	7/6	7/12	7/17	7/25	7/31	8/8	Total Individuals
eggs			1	1	1			1		4	17	25
2nd instars				1								1
5th instars				5								5
butterflies		1			1	1	3	3	1	3	1	14

Table 5. Monarch eggs and instars found at Dean Street Soil & Water Conservation District site.

	5/31	6/7	6/14	6/21	6/27	7/6	7/12	7/17	7/25	7/31	8/8	Total Individuals
eggs									1		1	2
5th instars										2		2
butterflies								1			1	2

Table 6. Monarch eggs and instars found at Crystal Lake Park District site.

The most productive monarch waystation was located at the Loyola University Retreat and Ecology Campus. The least productive monarch waystation was located at the Crystal Lake Park District (**Figure 10**). This was somewhat correlated to the site size. As the summer progressed, monarch activity increased (**Figure 11**). A total of 83 monarch eggs and 25 instars were documented. Of these, 30 combined eggs and caterpillars were raised in the lab and 25 adult monarchs were pupated and released outdoors throughout the summer. An additional 21 monarch adults were tagged and released in the fall (See Appendix 3).

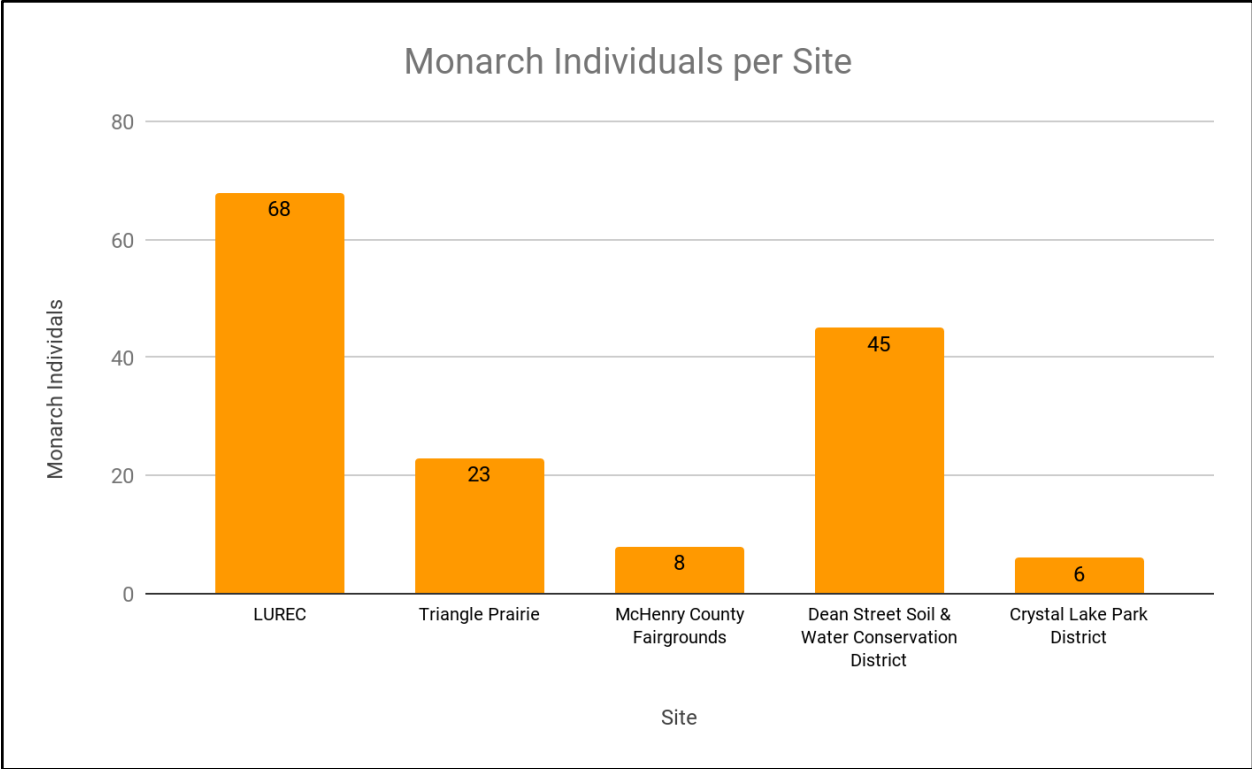


Figure 10. Monarch Individuals found at each site while monitoring.

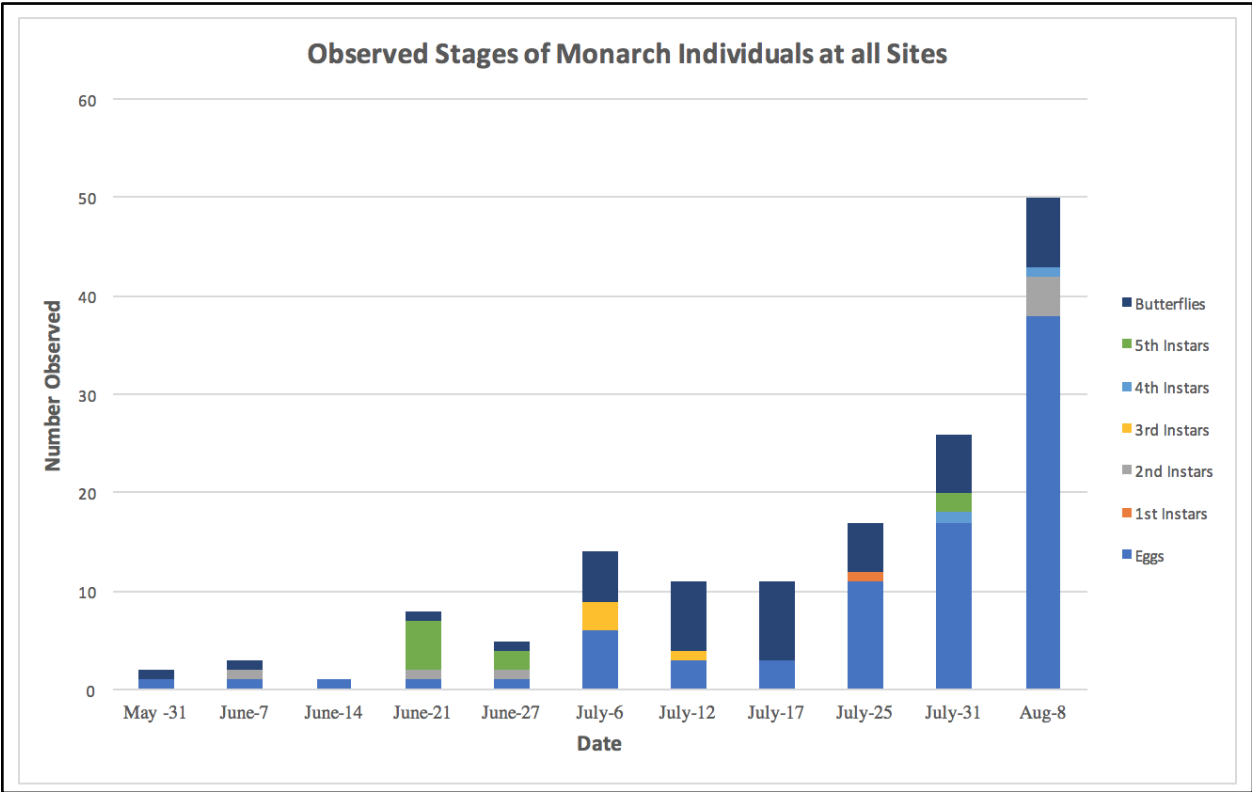


Figure 11. Data collected per day at monarch waystations.

Butterfly/Moth Species	LUREC	Triangle Prairie	MC Fairgrounds	Dean Street	Crystal Lake Park District
Azure butterfly	4	1	1	3	
Black Swallowtail	1	3		3	
Buckeye				1	
Cabbage White	5	9	5	5	2
Clouded Yellow		1			
Common Wood-nymph		10			
Eight-spotted Forester				1	
Grass Skipper		1			
Painted Lady				1	
Pearl Crescent	1	4		3	
Red Admiral		2		2	1
Silver-spotted Skipper	3		1		
Clouded/Orange Sulfur	3			2	
Tiger Swallowtail	2	1			
Zabulon Skipper				1	

Table 7. Opportunistic observation of other butterflies/moths recorded at each site.

There were 15 other butterfly/moth species that were observed opportunistically during site visits. Dean Street and Triangle Prairie had ten and nine species respectively while LUREC had seven species observed. Crystal Lake Park had only two other species reported. Species list and total individuals are recorded in **Table 7**.

DISCUSSION

POLLEN GRAIN DISCUSSION

Pollen is the male gamete cell of a plant. They vary in size and some are difficult or nearly impossible to see with the naked eye. We had hoped to use the Loyola University electron microscope for this research but it was not working. When examining the pollen under a microscope, it becomes apparent that each grain has a particular structure varying in size, shape, and density. The variation in pollen grains corresponds to the evolution of a particular plant species. Each plant species has co-evolved with a particular vector for pollination. Most flowering plants rely on insect pollinators to transfer genetic material, but some plant species rely on wind or water for pollination. Each pollen grain contains both an intine and an exine, or an inner layer and outer layer, respectively. The intine is composed of primarily cellulose while the exine is the more durable layer with its contents being more uncertain.

The creation of a reference pollen grain database for plant species found at LUREC combined with the knowledge gained from sampling pollinators provides valuable information

for appropriate management of the property. In this case, scientific discoveries can be used in management to promote a particular pollinator or plant species. For example to attract more native *Halictidae* (Sweat bees) and specialist *Megachilidae* (Resin bees); more purple prairie clover (*Dalea purpurea*) could be seeded. This pollinator-flora relationship information also can be used in the fight against invasive species at LUREC because once the relationship between plant and pollinators is identified, the plant species phenology can be examined to reduce the impact any eradication of that invasive species may have on native pollinators. An example of this could be adjusting when Canada thistle (*Cirsium arvense*), a nonnative species is sprayed to avoid native pollinator casualties, or provide a more attractive/nutritious substitute for pollinators when Canada thistle is in bloom. Besides the benefits provided to management at LUREC, the reference database can be used in the future for education in other field courses. Continued pollinator-flora relationship researchers can add to the collection. Identifying the focal plants that would provide forage for the majority of pollinator taxa would be fruitful future research that could assist restoration specialists to select the main species to plant.

Rusty Patched Bumble Bee (*Bombus affinis*)

Today pollinators are under threat from habitat loss, disease, parasites, and pesticides such as neonicotinoids. Conservationists are becoming ever more concerned about their decline. Recently the Rusty Patched Bumble Bee (*Bombus affinis*) was added to the endangered species list. In the past 20 years, the Rusty Patched Bumble Bee population has dropped by about 87% and the species now occupies only .1% of its former range (USFWS 2018). While conducting research on pollinators, we happened to find, identify and photograph on four separate occasions a Rusty Patched Bumble Bee (**Figure 12 and 13**). Since Loyola obtained the property, native habitat restoration has been a priority, thus providing a refugia for a diverse pollinator community. It is likely due to this initiative to plant native pollinator-friendly plants, coupled with the many abandoned thirteen-lined ground squirrel (*Ictidomys tridecemlineatus*) holes which the bumble bee uses to overwinter that LUREC is home to one of the few remaining Rusty Patched Bumble Bee populations left in the world.

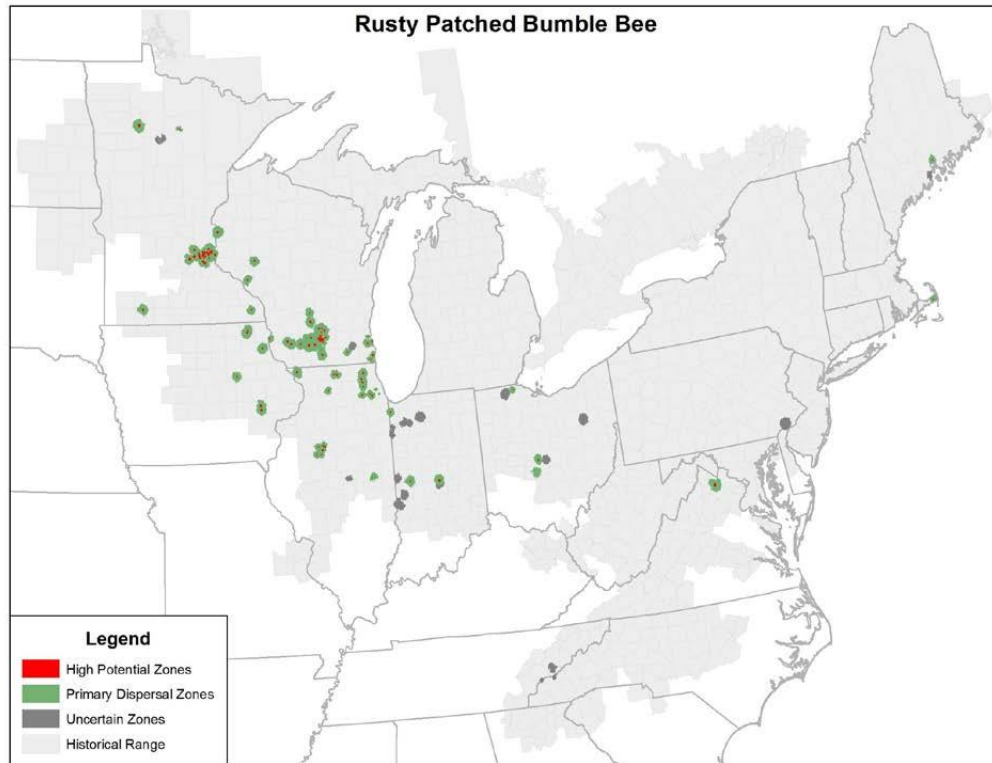


Figure 12. Known Rusty Patched Bumble Bee locations. Source: USFWS July 6, 2017

This discovery was so significant that the USFWS featured LUREC on their website. See link to USFWS article <https://www.fws.gov/FieldNotes/regmap.cfm?arskey=37716>

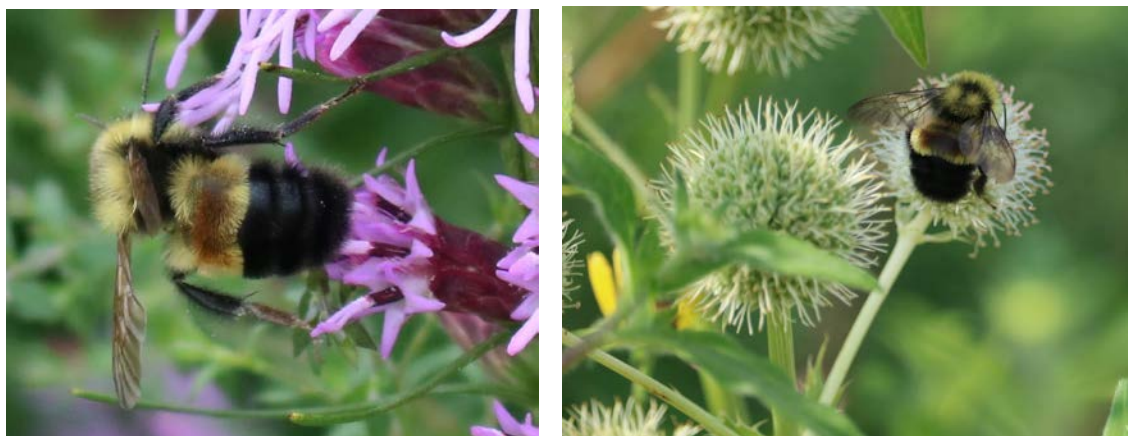


Figure 13. A Rusty Patched Bumble Bee found on a Blazing Star (*Liatris sp.*) and Rattlesnake Master (*Eryngium yuccifolium*).

MONARCH WAYSTATION DISCUSSION

In recent years the Monarch butterfly population has declined rapidly. There has been a ninety percent decrease in the population over the last 20 years. The population dropped from 150 million individuals in 2016 to 109 million in 2017 (Mizejewski, 2017). There are two main

reasons for the monarch decline: (1) loss of breeding habitat in the U.S. and (2) degradation of overwintering habitat in Mexico. The lack of availability of milkweed that feeds the caterpillars and native flowering plants that supply the adult monarch butterflies with nectar has led to their general decline throughout their entire range. The butterflies are also negatively impacted by insecticide and herbicide used by the agricultural industry.

Because monarchs travel such great distances, they are in urgent need of conservation efforts all along their migratory routes. The monarch waystations that were established throughout McHenry County in 2016 were set up for that purpose. This was the first year that data was collected and our data will be useful for future researchers studying the population of monarchs in the area. As the summer progressed, from late May to early August, the monarch butterfly population increased in the gardens that we were monitoring (**Figure 11**). There are two reasons for this, the first being that it took the monarch most of the summer to reach the sites this far north. The eastern population travels all the way from Mexico to Canada and then all the way back just in time to overwinter. However, it is not the same individual monarchs making this long journey. There are between four and five generations per year in each population—the first couple generations begin the journey, and two or three more generations are produced before the population makes the return trip to their overwintering sites. It is these last two generations that probably reached McHenry County and it is these monarchs bred in late summer and early fall that return to Mexico. As the summer progressed, the monarch population increased. Lastly, it is possible that our skill in locating eggs and instars improved and we were able to locate individuals more easily as the summer progressed.

Monarchs progress to adulthood from an egg through five instar caterpillar stages. After the fifth instar a chrysalis is formed and finally an adult butterfly emerges. Monarchs mortality rates are documented to be over 90% in the wild (Borkin, 1982). Due to this detrimental statistic, we took the monarch eggs and instars back to our laboratory at Loyola University Retreat and Ecology Campus. We provided them a safe environment to grow. This included a steady supply of milkweed leaves and a heat lamp during the daytime to foster their growth. The survival rate of monarchs raised in our lab was roughly eighty-five percent, vastly higher than in the wild. The main cause of deaths inside the laboratory was from parasites that the monarchs already had before being brought in. We raised and released an estimated twenty-five adult butterflies at Loyola University Retreat and Ecology Campus throughout the summer. Many of the eggs and instars were brought in from other gardens and it is likely that a higher amount of monarch individuals found at LUREC's garden (**Figure 10**) could be attributed to the early release of adults who laid eggs nearby. Although this garden was not large in size (0.07 acres), there were many other milkweed plants and flowering plants located throughout the 98-acre campus. This probably had a positive impact on the monarch's survival rate and a reason for them to stay in the area. All of the other gardens were closer to busy roads and the milkweed plants were often secluded within the garden.

Dean Street Soil & Water Conservation District's monarch garden had the second most monarch individuals, 45 were found throughout our study. The area comprising of 2.37 acres (if

one includes the surrounding area around the designated planted garden) was considerably larger and no doubt contributed to the higher number of monarchs. Triangle Prairie's garden was the second largest with 1.64 acres and 23 individuals were found. This site was located at the intersection Route 14 and Lake Avenue, which was often very busy. Even though the acreage was fairly large, the busy intersection likely caused a decrease in monarch activity. While not completely surprising, the number of other species of Lepidoptera species observed correlated somewhat to size of the patches. While LUREC had the highest number of monarch individuals Dean Street and Triangle Prairie had a slightly higher number of Lepidoptera species observed. The last two sites, McHenry County Fairgrounds and Crystal Lake Park District, were the smallest areas; 0.02 and 0.04 acres, respectively. The small area with such a small number of milkweed plants was likely the reason for the small number of monarchs as well as overall species of Lepidoptera.

While city properties like recreation centers, public parks, median strips and libraries can provide monarch habitat and host monarch waystations, we would recommend that the size of these patch be increased for greater effectiveness. If patches are small, they would be more effective if a higher number of these smaller patches were installed with shorter distances between them for increased connectivity.

ACKNOWLEDGEMENTS

Special thanks are extended to Dr. Roberta Lammers-Campbell for her assistance in plant identification and to Nancy Schietzelt of the Environmental Defenders of McHenry County and Nancy Williamson of the Illinois Department of Natural Resources who created the maps of the locations of the Monarch Waystations and who also procured our access onto the properties for monitoring purposes. We are grateful to Mike Redmer of the Chicago Ecological Services Field Office of the US Fish and Wildlife Service who was instrumental in getting a positive ID for the Rusty Patched Bumble Bee. It was he who first proposed that we keep an eye out for it. We would like to also thank the Monarch Coalition of the Friends of Hackmatac for their enthusiastic support and for giving us a platform to share our work. Financial support was provided as a biodiversity internship by the Institute of Environmental Sustainability, Loyola University Chicago.

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Appendix

Appendix 1 Pollinator Images



Stereoscope used to identify pollinator species.



A Mining bee belonging to the genus *Andrena*. Identifiable by the tufts of fur high up on the hind leg along with a relatively long and rounded marginal cell in the wings. Mining bees are solitary and nest in the ground, and they are one of the first bees to emerge in the spring.



Ceratina or small carpenter bee collects pollen on its hind legs. These bees are relatively small, nest in pithy stems or wood, and usually has a white/yellow patch on the face. This bee has a white spot, but it is not visible from this angle.



This bee belongs to the genus *Colletes* because the diagnostic “s” shaped recurrent vein (indicated by the red arrow).



Small Resin Bee (Genus Heriades). This type of bee collects pollen on its abdominal scopae and usually the abdomen has a strong curl at the end. You can tell it's a female because of that pristine stinger.



Native bees like this one typically cover their hind legs scopae and abdomen in pollen making them more effective pollinators than non-native honeybees which are more effective at holding onto the pollen and bringing it back to the hive.



Above: Wool Carder bee pollinating Bee Balm. Below: Honey bee pollinating Common Milkweed.



Appendix 2 Pollinator Observations

Date	Plant Species	Relative Location	Time	Temp (F)	Pollinator Species	Captured	Notes
6/15	Lance-leaved Coreopsis	Behind big evergreen (Just north of church parking lot)	5:50 PM	84	Soldier Beetle (2)	Observed	Sunny not windy
6/15	Red Clover	Past bluebird box Kevin put up	5:56 PM	85	Tiger Swallowtail	Observed	Sunny not windy
6/16	White Clover	Past bluebird box Kevin put up	10:57 AM	73	Common eastern Bumble bee	Observed	Clear slight breeze
6/19	Pale Purple Coneflower	Front of LUREC	2:30 PM	77	Common eastern Bumble bee	Captured not tested	Cloudy Windy Storm coming
6/21	White Wild Indigo	Front of LUREC	9:28 AM	72	Common eastern Bumble bee	Observed	Sunny not windy
6/21	Zinnia	Front of LUREC	9:30 AM	72	Bicolored Agapostemon	Observed	Sunny not windy
6/21	Pale Purple Coneflower	Front of LUREC	11:05 AM	77	Common eastern Bumble bee	(Z1)	Sunny not windy
6/21	Pale Purple Coneflower	Front of LUREC	11:20 PM	77	Bicolored Agapostemon	(Z2)	Sunny not windy
6/21	Butterfly Weed	Rocks near the Monarch Garden	5:46 PM	73	Brown-belted Bumble bee	Observed	Scattered Clouds
6/21	Common Milkweed	Rocks near the Waystation	5:46 PM	73	Brown-belted Bumble bee	Observed	Scattered Clouds
6/26	Butterfly Weed	Behind LUREC	10:20 AM	66	Japanese Beetle	Observed	Cloudy
6/26	Yucca	Corner of parking lot	5:30 PM	68	Tegeticula yuccasella	Observed	Partially Cloudy
6/26	Yucca	Corner of parking lot	5:30 PM	68	Common eastern Bumble bee	Observed	Partially Cloudy
6/26	Lance-leaved Coreopsis	Waystation	5:30 PM	70	Lasioglossum	(Z3)	Partially Cloudy
6/26	Black-eyed Susan	Waystation	5:30 PM	70	Halictidae	Observed	Partially Cloudy
6/27	Common Milkweed	Rocks near the Waystation	10:00 AM	68	Honey bee	Captured not tested	Sunny not windy
6/27	Lance-leaved Coreopsis	Waystation	9:50 AM	68	Lasioglossum	(Z4)	Sunny not windy
6/30	Black-eyed Susan	Waystation	11:45 AM	77	Syrphid Fly Eristalis	Captured not tested	Overcast
6/30	Black-eyed Susan	Waystation	12:30 PM	78	Syrphid Fly Eristalis	(Z6)	Overcast
6/30	(walking)	Between the Waystation and the Farm	12:35 PM	78	Andrena (Mining Bee)	(Z5)	Overcast
6/30	Hydrangea	Front of LUREC	1:13 PM	78	Red Admiral	Observed	Overcast
7/6	Marsh Blazing Star	Front of LUREC	11:25 AM	85	Silver-spotted Skipper	Observed	Sunny
7/9	Drumstick Allium	Front of LUREC	3:00 PM	80	Yellow Jacket	Observed	Sunny
7/11	Drumstick Allium	Front of LUREC	11:10 AM	82	Two-spotted Longhorn bee	Observed	Overcast
7/11	Drumstick Allium	Front of LUREC	11:10 AM	82	Augochlora	(Z7)	Overcast
7/11	Canada Thistle	Fen	11:35 AM	82	Common eastern Bumble bee	(Z8)	Overcast

7/19	Fleabane	Fen	11:00 AM	80	Augochlorini tribe	(Z9)	Clear
7/19	Sunflower	Front of LUREC	2:30 PM	80	Halictus	Captured not tested	Scattered Clouds
7/19	Drumstick Allium	Front of LUREC	2:30 PM	80	Lasioglossum	(Z13)	Scattered Clouds
7/19	Marsh Blazing Star	Front of LUREC	2:30 PM	80	Halictus	(Z14)	Scattered Clouds
7/19	Dill	Herb Garden	2:30 PM	80	Lasioglossum	(Z15)	Scattered Clouds
7/19	Marsh Blazing Star	Front of LUREC	4:00 PM	78	Common eastern Bumble bee	(Z12)	Scattered Clouds
7/19	Dill	Herb Garden	2:30 PM	80	Black Ant	(Z16)	Scattered Clouds
7/19	Dill	Herb Garden	2:30 PM	80	Black Ant	Captured not tested	Scattered Clouds
7/20	Marsh Blazing Star	Front of LUREC	11:10 AM	77	Honey bee	(Z18)	Sunny
7/20	Marsh Blazing Star	Front of LUREC	11:10 AM	77	Halictus	(Z19)	Sunny
7/20	Bee Balm/Rattlesnake Master	Front of LUREC	3:00 PM	80	Common eastern Bumble bee	(Z20)	Cloudy
7/20	Field Mustard	Farm	5:00 PM	79	Cabbage Butterfly (2X)	(Z20&Z21)	Cloudy
7/21	Pale Purple Coneflower	Front of LUREC	6:00 PM	79	two-spotted Longhorn bee (5X)	Observed	Post rain
7/24	Rattlesnake Master	Front of LUREC	1:30 PM	72	Euodynerus (Mason Wasp)	Captured not tested	Sunny
7/24	Marsh Blazing Star	Front of LUREC	1:30 PM	72	Large Milkweed bug	Observed	Sunny
7/25	Marsh Blazing Star	Front of LUREC	10:30 AM	77	Carpenter Bee	Observed	Clear
7/25	Bee Balm	Prairie	5:00 PM	79	Snowberry Clearwing	Observed	Clear
7/25	Hibiscus	Front of LUREC	4:30 PM	79	Japanese Beetle (2X)	(Z25)	Clear
7/25	Hibiscus	Front of LUREC	10:30 AM	77	Black Ant	(Z22)	Clear
7/25	Hibiscus	Front of LUREC	10:30 AM	77	Two-spotted Longhorn bee(2X)	(Y1)	Clear
7/25	Hibiscus	Front of LUREC	10:30 AM	77	Ptilothrix	(Z24)	Clear
7/25	Rattlesnake Master	Front of LUREC	11:00 AM	78	Common eastern Bumble bee	(Z23)	Clear
7/25	Common Dayflower	Front of LUREC	10:00 AM	74	Agapostemon	(Y2)	Clear
7/26	Canada Thistle	Behind LUREC	2:15 PM	83	Aphrodite Fritillary	Captured not tested	Cloudy
7/26	Dandelion	Behind LUREC	2:15 PM	83	Aphrodite Fritillary	Observed	Cloudy
7/26	White Sweet Clover	Behind LUREC	2:30 PM	83	Common eastern Bumble bee	(Y3)	Cloudy
7/26	White Sweet Clover	Behind LUREC	2:30 PM	83	Halictus	(Y4)	Cloudy
7/26	Marsh Blazing Star	Front of LUREC	2:30 PM	83	Syrphid Fly Eristalis	(Y6)	Cloudy
7/26	Spotted Bee Balm	Front of LUREC	2:30 PM	83	Common eastern Bumble bee	(Y5)	Cloudy

7/27	Canada Thistle	Fen	10:00 AM	80	Monarch	Observed	Cloudy
7/27	Mist Flower	Front of LUREC	9:35 AM	77	Augochlorini tribe	(Y7)	Cloudy
7/27	Purple Prairie Clover	Front of LUREC	9:35 AM	77	Lasioglossum Dialictus	(Y12)	Cloudy
7/27	Mist Flower	Front of LUREC	11:00 AM	77	Augochlorini tribe	(Y10)	Cloudy
7/27	Marsh Blazing Star	Front of LUREC	11:00 AM	77	Honey bee	(Y8)	Cloudy
7/27	Sow Thistle	Next to Maintenance Shed	11:20 AM	77	Ceratina	(Y13)	Cloudy
7/27	Sow Thistle	Next to Maintenance Shed	11:20 AM	77	Halictus	(Y11)	Cloudy
7/27	Canada Thistle	Next to Maintenance Shed	11:20 AM	77	Common eastern Bumble bee	(Y9)	Cloudy
7/27	Purple Prairie Clover	Front of LUREC	11:45 AM	77	Lasioglossum Dialictus	(Y14)	Cloudy
7/27	Rattlesnake Master	Front of LUREC	11:45 AM	77	Augochlorini tribe	(Y15)	Cloudy
7/27	Marsh Blazing Star	Front of LUREC	6:15 PM	76	Rusty-patched Bumble Bee	Observed	Clear
7/31	Bee Balm	Monarch Garden	1:00 PM	81	snowberry Clearwing	Observed	Partially Cloudy
7/31	Bee Balm	Monarch Garden	1:00 PM	81	Carpenter Bee	(Y16)	Partially Cloudy
7/31	Bee Balm	Monarch Garden	1:00 PM	81	American Bumble bee	(Y19)	Partially Cloudy
7/31	Bee Balm	Monarch Garden	1:00 PM	81	Heriadese (Resin Bee)	(Y17)	Partially Cloudy
7/31	Swamp Milkweed	Monarch Garden	4:40 PM	82	Carpenter Bee	(Y20)	Clear
7/31	Swamp Milkweed	Monarch Garden	4:40 PM	82	Carpenter Bee	(Y21)	Clear
7/31	Swamp Milkweed	Monarch Garden	4:40 PM	82	American Bumble bee	Captured not tested	Clear
7/31	Bee Balm	Monarch Garden	4:50 PM	82	Heriadese (Resin Bee)	(Y18)	Clear
7/31	Bee Balm	Monarch Garden	4:50 PM	82	Great Black Wasp	Observed	Clear
8/1	Hibiscus	Front of LUREC	10:40 AM	78	Two-spotted Longhorn bee	Captured not tested	Scattered Clouds about to rain
8/1	Hibiscus	Front of LUREC	10:40 AM	78	Japanese Beetle	Captured not tested	Scattered Clouds about to rain
8/1	Rattlesnake Master	Front of LUREC	1:30 PM	82	Brown-belted Bumble bee	Captured not tested	Partly Cloudy (Post rain)
8/1	(none)	Flowers in Front of Patty's office	1:40 PM	82	Two-spotted Longhorn bee	Captured not tested	Partly Cloudy (Post rain)
8/1	(none)	Flowers in Front of Patty's office	1:45 PM	82	Colletes	Captured not tested	Partly Cloudy (Post rain)
8/1	(none)	Flowers in Front of Patty's office	1:45 PM	82	Colletes	Captured not tested	Partly Cloudy (Post rain)
8/1	Hostas	Front of LUREC	2:30 PM	82	Two-spotted Longhorn bee	Captured not tested	Partly Cloudy (Post rain)
8/1	(none)	Monarch Garden	2:30 PM	82	Agapostemon	Captured not tested	Partly Cloudy (Post rain)

8/1	Daylily	Flowers in Front of Patty's office	3:05 PM	82	Japanese Beetle	Captured not tested	Partly Cloudy (Post rain)
8/1	(none)	Flowers in Front of Patty's office	3:05 PM	82	Hummingbird Clearwing	Observed	Partly Cloudy (Post rain)
8/1	(none)	Flowers in Front of Patty's office	4:05 PM	82	Agapostemon	Observed	Partly Cloudy (Post rain)
8/7	Hostas	Front of LUREC	9:20 AM	69	Two-spotted Bumble bee	Captured not tested	Partly Cloudy
8/7	Hostas	Front of LUREC	9:20 AM	69	Two-spotted Bumble bee	(X1)	Partly Cloudy
8/7	Hibiscus	Front of LUREC	9:20 AM	69	Peponapis Prainosa	Captured not tested	Partly Cloudy
8/7	Hibiscus	Front of LUREC	9:36 AM	69	Peponapis Prainosa	(X2)	Partly Cloudy
8/7	Purple Prairie Clover	Front of LUREC	9:36 AM	69	Lasioglossum Dialictus	(X3)	Partly Cloudy
8/7	Hydrangea	Front of LUREC	9:55 AM	69	Common eastern Bumble bee	(X4)	Partly Cloudy
8/7	Sow Thistle	Monarch Garden	9:55 AM	69	Syrphid Fly Eristalis	(X5)	Partly Cloudy

Appendix 3 Monarch Tagging



Above: Examples of tagged Monarchs. Below: Data sent into Monarch Watch.

TagCode	Tag Date	Male (M) / Female (F)	Reared (R) / Wild (W)	TagCity	TagState	TagZip
XEY700	8/31/17	M	R	Chicago	IL	60660
XEY701	9/4/17	F	R	Chicago	IL	60660
XEY702	9/10/17	M	W	Chicago	IL	60660
XEY703	9/16/17	F	R	Chicago	IL	60660
XEY704	9/19/17	M	R	Chicago	IL	60660
XEY705	9/19/17	F	R	Chicago	IL	60660
XEY706	9/19/17	M	R	Chicago	IL	60660
XEY707	9/19/17	F	R	Chicago	IL	60660
XEY708	9/19/17	M	R	Chicago	IL	60660
XEY709	9/19/17	M	R	Chicago	IL	60660
XEY710	9/19/17	F	R	Chicago	IL	60660
XEY711	9/19/17	F	R	Chicago	IL	60660
XEY712	9/19/17	F	R	Chicago	IL	60660
XEY713	9/21/17	F	R	Chicago	IL	60660
XEY714	9/21/17	M	R	Chicago	IL	60660
XEY715	9/23/17	F	R	Chicago	IL	60660
XEY716	9/23/17	M	R	Chicago	IL	60660
XEY717	9/24/17	M	R	Chicago	IL	60660
XEY718	10/11/17	F	R	Chicago	IL	60660