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Pollinator Surveys at Illinois Nature Preserve Sites in West-Central Illinois

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Abstract: From 2018-2020 insect pollinators and their plant associations were surveyed on 18 protected prairie, wetland, and forest natural areas in west-central Illinois with the use of photographic documentation. The goals of the survey were to establish baseline taxonomic lists of potential pollinators, determine floral associations, assess the impacts of invasive species, find specialist pollinators associated with rare community types, evaluate insect preference for high-quality remnants, and obtain new ideas to guide management for the benefit of the pollinating insect community. Six sites were sampled each year, with the goal of surveying each site on a five-year rotation. Each site was surveyed every 1-2 months (April – September), for 60-80 minutes per visit following pre-established meandering transects. Personal experience was used to identify plant and many insect species. Photographs for most taxa (over 90%) were submitted to the websites BugGuide.net and I-Naturalist.org for documentation and to provide additional assistance for identification of insects. Potential pollinators and their floral associations were recorded to species level when possible. Three years of surveys (18 sites) have identified about 673 potential pollinators on 209 species of plants. Taxonomic richness was similarly high (20-22%) for flies, bees, and beetles, followed by wasps (16%). Bees had the highest abundance followed by beetles, flies, and butterflies. There was little difference in the richness and abundance of insects on sites receiving moderate-to-low intensity management and those which received no management. The replication of these surveys every five years will be important to note changes in the communities of pollinators and the impacts of management.

Introduction

Little data exists statewide on insect pollinators and their floral associations, especially for taxa other than bees. Goals of the Illinois Wildlife Action Plan (Illinois Department of Natural Resources, IDNR 2005) call for the collection of more data on pollinators in Illinois for the purpose of improving pollinator-friendly land management. Photo pollinator surveys were established in west-central Illinois to contribute towards these goals. The study was designed to focus on six key points: 1) diversity and abundance of insect pollinators; 2) floral associations; 3) impact of invasive species; 4) insect diversity within natural community types; 5) insect preference for high-quality remnants versus lower quality degraded sites; and 6) effects of management on insect diversity and abundance.

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Methods

From 2018 to 2020 a repeatable pollinator monitoring program was established in west-central Illinois natural areas. Each year six sites were selected with the goal of revisiting sites on a five-year rotation (Table 1). All sites chosen were larger than 10 acres and permanently protected by the Illinois Nature Preserves Commission (INPC), either as dedicated nature preserves (NP) or registered land and water reserves (LWR). To increase efficiency and reduce travel time, surveys were conducted in pairs, sampling two sites/day. Most sites are owned and managed by the IDNR; others are owned by private individuals, municipalities, or land trusts.

To establish survey methods the US Fish & Wildlife Service (FWS) Bombus Survey procedures were reviewed (https://www.fws.gov/midwest/endangered/insects/rpbb/pdf/Bumble_ Bee Survey Field Data Sheet April2019.pdf). The FWS methods focus on catch and release with photos taken of all *Bombus* species (bumble bees) along with recording the abundance of domesticated honeybees (*Apis mellifera*). The survey also provides for recording management practices and any stressors or threats. The

Table 1: Schedule of pollinator survey sites visited (years 1-3) or with planned visits (years 4-5) in west-central and central Illinois nature preserves and land and water reserves.

	County	Site Names
Year 1	Hancock	Mississippi River Sand Hills NP, Samuel Barnum Mead Savanna NP, Cecil White Prairie LWR
	Fulton	Harper-Rector Woods NP
	McDonough	Short Fork Seep NP
	Rock Island	Josua Lindahl Hill Prairie NP
Year 2	Adams	Allendale Springs LWR
	Hancock	Stony Hills NP
	Henderson	Ellison Creek Sand Prairie NP
	Knox	Haw Creek Sedge Meadow LWR
	Peoria	Jubilee College Forest NP
	Schuyler	Williams Creek Bluff LWR
Year 3	Adams	Fall Creek Gorge LWR, Burton Cave NP
	Adams/Brown	Robert A. Evers LWR
	Peoria	Singing Woods NP, Robinson Park Hill Prairies NP
	Pike	Grubb Hollow Hill Prairie NP
Year 4	Cass	Cox Creek Hill Prairies LWR
	Hancock	Cedar Glen NP
	Knox	Forever Fields LWR
	McDonough	Argyle Hollow Barrens NP
	Morgan	Meredosia Hill Prairie NP
	Stark	Harper's Woods NP
Year 5	Hancock	Crystal Glen LWR
	Henderson	Harry N. Patterson Savanna LWR
	Fulton	Kedzior Woodlands LWR
	Mason	Sand Prairie Scrub Oak NP, Long Branch Sand Prairie NP
	Rock Island	Black Hawk Forest NP

Xerces Society's Upper Midwest Pollinator Survey (https://www.xerces.org/publications/id-monitoring/upper-midwest-citizen-scientist-pollinator-monitoring-guide-native) also was consulted. Both surveys involve recording specifics on observers, location, date, time, duration, cloud cover, temperature, wind speed, habitat type, and floral species. The Xerces survey has participants record bees, either based on type assigned by size, color and notable features or genus, as well as non-bees (birds, spiders, and other insect groups). Data collection methods for both surveys were adopted along with the addition of photographing and recording all potential pollinator insects and floral associations to species level when possible.

Individual site survey visits were made four times during the year (April/May, June, July, and Aug/Sept) to account for phenological variation and to capture the most species diversity. Survey duration ranged between 60-90 minutes during each site visit. Counts were conducted between late morning and early afternoon (generally 10am – 3pm) and, when possible, under favorable conditions: above 70°F, little to no winds, sunny skies. On a few occasions the temperatures were around 60°F. At times winds were gusting to 20 mph when insect pollinators were present, challenging photo documentation.

Insect Diversity and Abundance

All bees, butterflies, and skippers were recorded regardless of whether they were visiting flowers at the time of observation. Flower-visiting wasps, beetles, flies, moths, true bugs, along with a few other insect groups were recorded if observed with pollen; also recorded were insects determined to be closely associated with pollen and nectar feeding or gathering based on previous experience and photo observations (Figure 1). Flower-visiting insect numbers were recorded along with their plant associations. Extensive personal experience and training facilitated recognition of insect groups

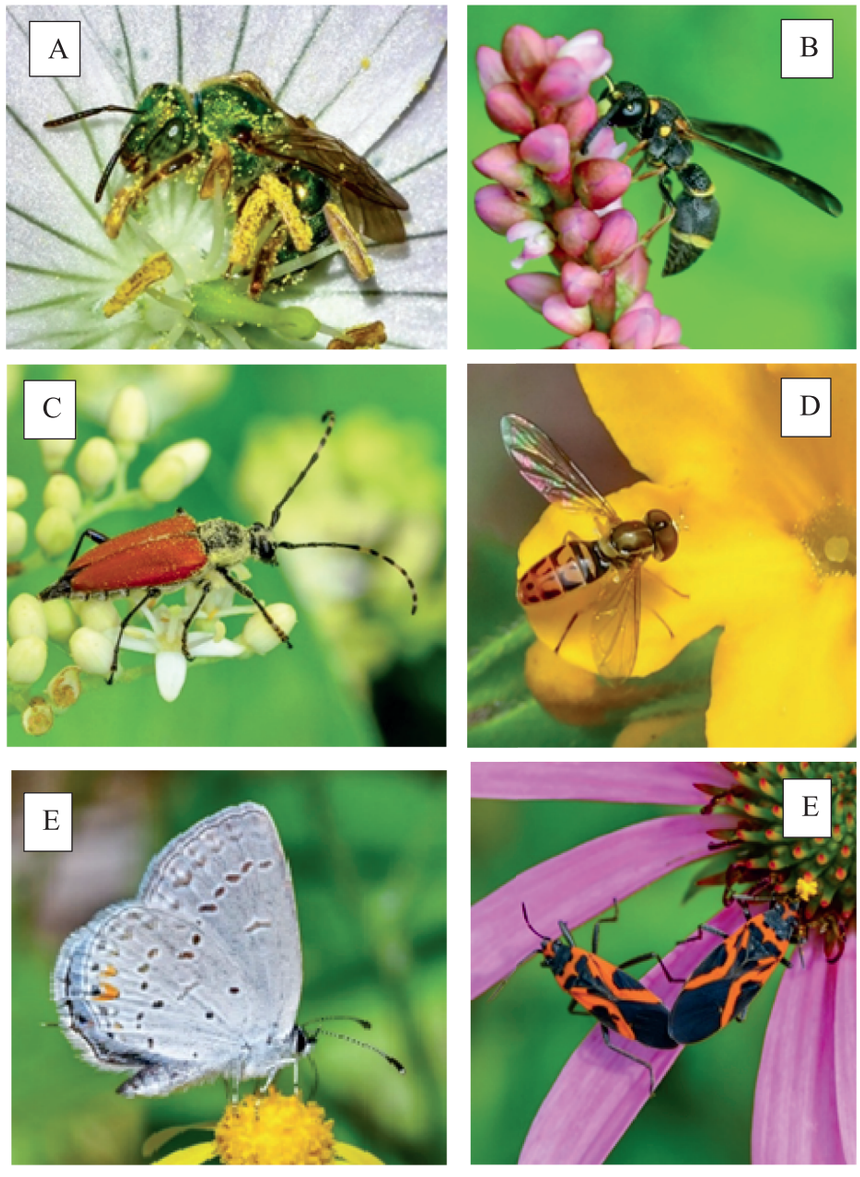

Figure 1. Photos of different types of pollinators surveyed: A) green sweat bee (*Agapostemon* sp.) on wild geranium (*Geranium maculatum*); B) mason wasp (*Anacistricerus* sp.) on smartweed (*Persicaria* sp.); C) red flower longhorn beetle (*Brachyleptura rubrica*) on dogwood (*Cornus* sp.); D) margined calligrapher fly (*Toxomerus marginatus*) on hoary puccoon (*Lithospermum canescens*); E) eastern tailed blue (*Cupido comyntas*) on prairie ragwort (*Packera plattensis*); F) false milkweed bug *(Lygaeus turcicus*) on pale purple coneflower (*Echinacea pallida*).

and behavior. Guides consulted to assist with identification included Eaton and Kaufman (2006), Skevington et al. (2019), and Holm (2014, 2017, 2021).

A Nikon D500 camera with a Tameron 90mmVR macro lens was used to photograph as many pollinators as possible. Most of the photographs were uploaded to the following websites for additional documentation and identification help/confirmation: BugGuide (https://bugguide.net) and I-Naturalist (https://www.inaturalist.org). Specimens of a few dozen bees

were hand-collected in 2019 and 2020 and sent to Laura Rericha-Anchor (Cook County Forest Preserve District) for lab identification. These will be curated at the Field Museum. Attempts were made to photograph bees prior to collection to later match lab identifications with photographs.

Floral Associations

Meandering transects routes were mapped through different community types utilizing constructed lanes and trails, deer trails, creek beds and areas of less dense brush for ease of traversing the landscape. Botanical nomenclature follows Mohlenbrock (2014). Most plants were identified to species with the exception of a few genera: *Desmodium* (tick trefoils), *Erigeron* (fleabanes), and *Pycnanthemum* (mountain mints). Flowering plants with insect visitors observed during the survey were recorded for the site and assigned to each insect associated with the flowers.

Invasive Species

Information on invasive species, both flora and fauna, was collected along with the insect and plant data. Special attention was given to documenting the number of domesticated honeybees (*Apis mellifera*) on each site including observations of feral hives within the sites and any manufactured hives nearby.

Natural Community Types, Quality and Management

Survey routes were designed to include high-quality remnants, when present, as well as other community types with an emphasis on high-density patches of flora resources. Information on community types and grades (quality assessments) found on each site was obtained from the Illinois Natural Areas Inventory (INAI) database (IDNR 2021). The community type where each insect was found was also recorded.

To compare natural community types the 18 sites were divided into four groups: hill prairies, forests, grasslands or prairie, and wetlands. While these terms loosely describe the primary natural or remnant community, each site also included other buffer communities, generally forest or grassland patches. Thirteen of the sites surveyed are recognized on the INAI as Category I sites (high-quality remnant communities). The remaining five sites are Category II INAI sites (habitat for state endangered or threatened species).

Sites were divided into three groups based on the extent of management: 1) high intensity management - sites with at least two hot fires and brush clearing within the past five years; 2) moderate-to-low intensity management - sites which had moderate to cool burns and some brush control within the past 10 years; and 3) sites which have received no management in the past 20 years. Information on the frequency and effectiveness of management practices, primarily prescribed fire and brush clearing, was collected during routine surveillance by INPC staff and from IDNR District Heritage Biologists in charge of management on state-owned sites.

Table 2: Insect species richness and abundance for pollinator survey conducted from 2018 to 2020 (years 1-3) on nature preserves and land and water reserves in west-central Illinois.

Year	Total Taxa	New Taxa	Number of Individuals
2018	413	413	4,418
2019	401	137	3,986
2020	370	123	3,423
TOTAL		**673**	**11,827**

Results

Insect Diversity and Abundance

The total number of insect taxa documented for all three years combined is 673 (Table 2). Ideally, all observations would be made to species level; however, due to limitations with identification using photographs, only 393 have been identified to species, with the remainder assigned to subgenus, genus, tribe, subfamily, family or higher taxonomic ranks. As additional identifications are provided from photographs uploaded to BugGuide.net and I-Naturalist.com this information will be updated. Attempts were made to record descriptions for those taxa likely to have multiple species per subgenus, genus, tribe, etc., especially mining bees (*Andrena* spp.) which are single-brooded and often specialize in one plant genus or family. Only butterflies and skippers were all identified to species level.

Much effort was taken to be conservative in recording the total number of taxa, with the goal of attempting to represent total species. However, it is possible that some difficult to distinguish groups may be over or under-represented. For example, determinations of individual bee taxa could be slightly inflated by recognizing multiple taxa at the genus or higher taxonomic rank. However, it should be noted that bees within the genus *Lasioglossum* subgenus *Dialictus* (metallic sweat bees) are particularly diverse, comprising a dozen or more species. Some other difficult groups such as tachinid flies (Tachinidae) and muscid flies (Muscidae), by possibly not recognizing all individual taxa, may be under-counted.

Along with challenges related to taxonomic assignment is the determination as to whether the insect is

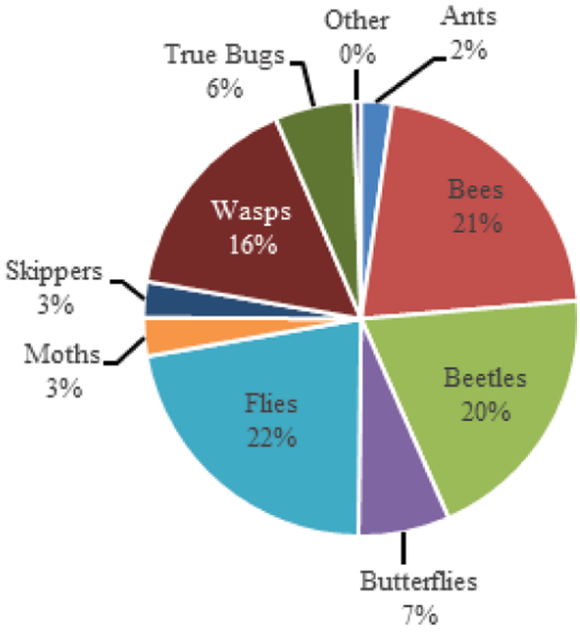

Figure 2. Taxonomic richness (rounded percentage of the number of taxa) of pollinators recorded at west-central Illinois nature preserves and land and water reserves for 2018-2020 combined (0% = < 0.5%).

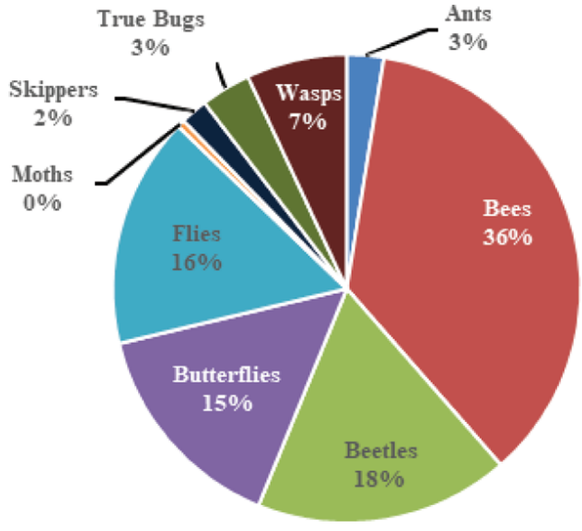

Figure 3. Taxonomic abundance (rounded percentage of the number of individuals) of pollinators recorded at west-central Illinois nature preserves and land and water reserves for 2018-2020 combined (0% = < 0.5%).

associated with pollination. Most observations were made of insects actually feeding on pollen or nectar of flowers; however, there are times when insects that feed on floral resources were involved in other activities, primarily resting or predatory/scavenger feeding behaviors for those with multiple dietary needs. Decisions on what taxa to count were also made based on previous observations of these insects feeding on flora resources or those coated with pollen.

Based on the number of different taxa for each taxonomic group for all three years combined (Figure 2), flies, bees, and beetles each made up about one-fifth of the total (20-22%) with wasp diversity also high (16%). Taxonomic richness ranged from a high of 175 taxa at both Mead Savanna and Short Fork Seep in 2018 to a low of 115 taxa at Ellison Creek Sand Prairie NP 2019. The total number of taxa recorded in 2018 and 2019 was similar; total taxa counts were lower in 2020 (Table 2).

Insect taxa numbers and total abundance recorded each year are shown in Table 2. In all three years, bees made up the majority of the total individuals observed throughout the year (Figure 3). Total abundance of butterflies, compared to other groups, was relatively high considering the low level of observed taxonomic richness, due to a few taxa found in large numbers. The opposite was true for wasps where, in most cases, only 1-3 individuals of each taxa were observed.

Floral Associations

Plant preference (foraging visitations) by insects was assessed for combined 2018-2020 surveys (Table 3). Potential pollinating insects were documented on over 209 plant species. The top 20 plants preferred by the largest number of pollinating insect species belong to nine different families highlighting the importance for plant species diversity. Three of the top-20 ranking plant species were goldenrods (*Solidago* spp.). Some of the plants visited by the most species of insects, including invasive species, were weedy and abundant at the sites visited.

Invasive Species

A quarter of the top 20 plants visited by the largest number of insect species were non-native plants: *Pastinaca sativa* (wild parsnip), *Alliaria petiolata* (garlic mustard), *Taraxacum officinale* (dandelion), *Daucus carota* (Queen Anne's lace), and *Barbarea vulgaris* (yellow rocket). All of these belong to families also represented by native species familiar to native insect pollinators. These non-native flowers all bloom during the spring and early summer. By mid-to-late summer ample natives such as *Solidago* (goldenrods) and

Table 3: Plants ranked by diversity of insect visitors to nature preserves and land and water reserves in west-central Illinois. * = non-native taxa.

Rank	Scientific Name	Common Name	# Insect Spp.
1	*Solidago canadensis*	Canada goldenrod	113
2	*Pastinaca sativa**	wild parsnip	96
3	*Erigeron annuus/strigosus*	daisy fleabane	84
4	*Ageratina altissima*	white snakeroot	81
5	*Cryptotaenia canadensis*	honewort	68
6	*Pycnanthemum* spp.	mountain mints	59
7	*Alliaria petiolata**	garlic mustard	49
8	*Monarda fistulosa*	wild bergamot	47
9	*Amorpha canescens*	leadplant	46
10	*Asclepias syriaca*	common milkweed	46
11	*Solidago ulmifolia*	elm-leaved goldenrod	45
12	*Claytonia virginica*	spring beauty	40
13	*Taraxacum officinale**	dandelion	40
14	*Cornus drummondii*	rough-leaved dogwood	38
15	*Daucus carota**	Queen Anne's lace	37
16	*Apocynum cannabinum*	Indian hemp	35
17	*Liatris aspera*	rough blazingstar	35
18	*Solidago nemoralis*	old field goldenrod	35
19	*Barbarea vulgaris**	yellow rocket	33
20	*Campanulastrum americanum*	American bellflower	33

Symphyotrichum (asters) reduce pollinators' reliance on non-native plants.

Natural Community Types and Quality

All survey sites included multiple vegetative communities in additon to the primary community (Table 4). While data were recorded on the community type where each insect was found, insects are mobile and most were not restricted to a particular community type. While wetlands constituted a small samples size (11% of all sites), they did have a greater taxonomic richness and abundance than other community types. There are no notable differences in taxonomic richness and abundance between high-quality remnants and more degraded sites (Table 5).

Management

Abundance may be greater, especially for bees, beetles, and butterflies, on the sites that were intensely managed (Table 6). The number of intensively managed sites surveyed is low and more data collection is needed to determine if the differences are significant. From data so far collected, little difference is evident between sites which had received moderate-to-low intensity management and sites that had not been managed.

Discussion

Insect Diversity and Abundance

The decision to use photography and personal observations rather than specimen collection as the chief means to document insect pollinators was made due to lack of resources (time and ability to process killed specimens) as well as a general need to demonstrate that non-lethal methods of pollinator data collection can be used to reduce the impact to native insects (some of which may be declining) on our protected natural areas. The use of photography as an effective means of data collection for pollinator-plant associations is supported by Ward *et al*. (2014) who found that two site visits per year at a minimum of 15 minutes each could provide a reliable estimate of bee diversity and abundance comparable to lethal methods (bowls and netting). Droege *et al*. (2016) and Connor *et al*. (2019) concur with the usefulness of photography and stress the importance of the taxonomic expertise of the observer/photographer in effectively using photography for data collection of bees and other flower-visiting insects.

Floral Associations and Invasive Species

Efforts to increase the availability of native floral resources for pollinators largely involves planting former

Table 4: Comparison of natural community types for nature preserves and land and water reserves in west-central Illinois.

Site name	Year	Primary natural community	Natural quality	Manage-ment	Time	Total taxa	taxa/hr	Total ind.	Ind/hr
Cecil White Prairie	2018	loess hill prairie	Cat. 1 Grade B	high	4.3	138	32.1	694	134
Josua Lindahl Hill Prairie	2018	loess hill prairie	Cat. 1 Grade B	mod/low	5.2	139	26.7	727	140
Grubb Hollow Hill Prairie	2020	loess hill prairie	Cat. 1 Grade B	mod/low	4.6	122	26.5	618	134
Singing Woods	2020	loess hill prairie	Cat. 1 Grade B	mod/low	4.6	117	25.4	437	95
Robinson Park Hill Prairies	2020	loess hill prairie	Cat. 1 Grade B	mod/low	4.8	124	25.8	617	121
Mississippi River Sand Hills	2018	sand hill prairie	Cat. 1 Grade B	mod/low	4.7	148	31.5	445	75
Harper-Rector Woods	2018	forest	Cat. 1 Grade B	none	4.6	135	29.3	643	140
Allendale Spring	2019	forest	Cat. 2 E/T spp.	none	4.8	163	34.0	733	153
Jubilee College Forest	2019	forest	Cat. 1 Grade B	none	4.6	158	34.3	665	145
Williams Creek Bluff	2019	forest	Cat. 1 Grade B	mod/low	6.0	141	23.5	615	103
Fall Creek Gorge	2020	forest	Cat. 2 E/T spp.	none	4.7	120	25.5	589	125
Burton Cave	2020	forest	Cat. 2 E/T spp.	none	4.3	131	30.5	440	102
Robert A. Evers	2020	woodland	Cat. 1 Grade B	high	5.0	159	31.8	722	144
Mead Savanna	2018	prairie	Cat. 1 Grade B	high	4.8	175	36.5	1077	224
Ellison Creek	2019	sand prairie	Cat. 2 E/T spp.	none	4,0	115	28.8	627	157
Stony Hills	2019	prairie restoration	Cat. 2 E/T spp.	mod/low	4.3	155	36.0	531	123
Short Fork Seep	2018	wetland	Cat. 1 Grade B	none	4.1	175	42.7	814	199
Haw Creek Sedge Meadow	2019	wetland	Cat. 1 Grade C	mod/low	4.6	141	30.7	800	174

crop fields and degraded areas with native vegetation (Vaughan *et al*. 2014). For remnant areas increasing pollen and nectar availability focuses on management: brush clearing and prescribed fire to reduce shade and promote more flowering, and control of invasive plants. Stubbs *et al*. (2007) and Kaiser-Bunbury *et al*. (2017) show that non-native plants are detrimental and efforts to control them and restore diverse native vegetation improves pollinator communities.

West-central Illinois is known for very high deer densities, compared to the rest of the state, and many of the early spring forest ephemerals have been lost due to extensive deer browse and other habitat degradation such that many insect pollinators are reliant upon

Table 5: Comparison of natural community quality for nature preserves and land and water reserves in west-central Illinois. * Denotes higher quality (Illinois Natural Areas Inventory, Category I) versus lower quality communities (Category II) supporting state endangered or threatened species.

Site name	Natural community	Natural quality*	Time (hrs.)	Total taxa	taxa/hr	Total ind.	Ind/hr
Cecil White Prairie	loess hill prairie	Cat. 1 Grade B	4.3	138	32.1	694	134
Josua Lindahl Hill Prairie	loess hill prairie	Cat. 1 Grade B	5.2	139	26.7	727	140
Grubb Hollow Hill Prairie	loess hill prairie	Cat. 1 Grade B	4.6	122	26.5	618	134
Singing Woods	loess hill prairie	Cat. 1 Grade B	4.6	117	25.4	437	95
Robinson Park Hill Prairies	loess hill prairie	Cat. 1 Grade B	4.8	124	25.8	617	121
Mississippi River Sand Hills	sand hill prairie	Cat. 1 Grade B	4.7	148	31.5	445	75
Mead Savanna	prairie	Cat. 1 Grade B	4.8	175	25.5	1077	224
Harper-Rector Woods	forest	Cat. 1 Grade B	4.6	135	29.3	643	140
Jubilee College Forest	forest	Cat. 1 Grade B	4.6	158	34.3	665	145
Williams Creek Bluff	forest	Cat. 1 Grade B	6.0	141	23.5	615	103
Robert A. Evers	woodland	Cat. 1 Grade B	5.0	159	31.8	722	144
Short Fork Seep	wetland	Cat. 1 Grade B	4.1	175	36.0	814	199
Haw Creek Sedge Meadow	wetland	Cat. 1 Grade C	4.6	141	30.7	800	174
Allendale Spring	forest	Cat. 2 E/T spp.	4.8	163	34.0	733	153
Fall Creek Gorge	forest	Cat. 2 E/T spp.	4.7	120	25.5	589	125
Burton Cave	forest	Cat. 2 E/T spp.	4.3	131	30.5	440	102
Ellison Creek	sand prairie	Cat. 2 E/T spp.	4.0	115	28.8	627	157
Stony Hills	prairie restoration	Cat. 2 E/T spp.	4.3	155	36.0	531	123

non-native plants during the spring and early summer. Native species that flower after many non-native species (e.g., *Solidago* and *Symphyotrichum*), may have not been as impacted by habitat degradation. Many of the plant associations documented were of the most abundant species found at the INPC survey sites in west-central Illinois and may not necessarily reflect preferences in other areas of the state. As pollinator-favored non-natives such as *Pastinaca sativa*, *Daucus carota*, *Alliaria petiolata*, *Melilotus* spp. (yellow and white sweet clovers), and *Elaeagnus umbellata* (autumn olive) are reduced and eliminated at managed sites, replacing them with native plants from the same family and/or with similar flowering times is critical to sustain pollinator communities.

Honeybees were seen on all but two of the survey sites. However, honeybee abundance does not currently appear to have an impact on the native bees and other

Table 6: Comparison of management intensity of nature preserves and land and water reserves in west-central Illinois. * high = high-intensity management: brush clearing; and at least 2 hot prescribed burns within past 5 years; mod/low = moderate to low intensity management: some brush clearing and/or 1 to 2 moderate-to-cool prescribed burns within past 5 years; none = no management conducted within past 10+ years.

Site name	Management*	Time (hrs.)	Total taxa	taxa/hr.	Total ind.	Ind/hr.
Cecil White Prairie	high	4.3	138	32.1	694	134
Robert A. Evers	high	5.0	159	31.8	722	144
Mead Savanna	high	4.8	175	36.8	1077	224
Josua Lindahl Hill Prairie	mod/low	5.2	139	26.7	727	140
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Burton Cave	none	4.3	131	30.5	440	102
Short Fork Seep	none	4.1	175	42.7	814	199

insect pollinators in most, if not all, of the INPC sites in west-central Illinois. While there is concern about the impacts of domesticated honeybees, the surveys thus far have revealed that this invasive species represents, on average, less than 5% of the total bee population overall. At a few sites, with known or likely feral hives within the site, honeybees represented up to 15-20% of bees. These included Stony Hills in 2019 and Burton Cave in 2020. Currently, the primary concern related to honeybees in this area is their preference for pollinating non-native invasive species which can contribute to the spread of these plants through increased seed production.

Natural Community Types and Quality

Much work has been done in Illinois to determine quality assessments of sites based on the conservatism of insects. This work was largely initiated by Panzer *et al*. (1995) and later followed by Wallner *et al*. (2012) and Heads *et al*. (2017). Work done by Ron Panzer and associates focused primarily on insects found in remnant prairies: Lepidoptera (butterflies and moths), Orthoptera (grasshoppers, walking sticks, katydids), Thysanoptera (thrips), Hemiptera (stinkbugs, leafhoppers, treehoppers, planthoppers), Coleoptera (carrion beetles), and *Bombus* (bumble bees). Adam Wallner and Chris Dietrich began the monumental task of assigning quality assessment values to Auchenorrhynca (leafhoppers, treehoppers, planthoppers, and cicadas). More recently Michael Jeffords and Susan Post created methods to assigned quality assessment values to butterflies in the state (Heads *et al*. 2017). This study seeks to contribute field observations toward these efforts.

There remains a critical need to collect more insect data since these insects play a critical role in the management of natural plant communities through pollination. While it is unclear how many flower-associated insects have been lost, finding 673 taxa over a period of three years indicates that a high taxonomic richness remains in west-central Illinois. It also appears evident that protected INPC sites are essential to insect diversity. More data are needed to determine whether there is a statistical difference in the taxonomic richness and abundance of high-quality remnants (INAI Category I) and more degraded (e.g., Category II and other) sites.

Management

To collect additional data to test the impacts of management, four more intensively managed sites will be added to the study over the next two years. Additionally, a few of the sites surveyed during the first round

are undergoing increased management and may rate as high intensity management during the next replication of surveys. Several of the sites within this project: Robert A. Evers, Meredosia Hill Prairie, Grubb Hollow Hill Prairie, and Robinson Park Hill Prairie are also being monitored by the Illinois Natural History Survey (INHS) as part of an Insect State Wildlife Grant (SWG, initiated in 2020) which is attempting to collect data on rare, state-listed, and SGNC leafhoppers, butterflies and skippers. Collection of pollinator data will complement the Insect SWG project.

The benefits of forest management for insect diversity are supported by Hanula *et al*. (2015) who show that tree thinning, and gap creation, prescribed fire, and invasive plant control are beneficial to pollinators within forest communities. Reduction in canopy cover allows for more sunlight penetration which improves conditions for more flowering plants and thus more pollen and nectar availability (Peterson and Reich 2008).

Prescribed fire strategies within burn units call for unburned refugia to be left. In all cases patches of unburned areas remain and fire is not forced into these patches. Also, managed sites undergoing aggressive forest/tree-thinning management all have ample refugia adjacent to these preserve/reserves which allows those species which may be lost to intense fire (e.g., those that overwinter above ground) to readily return to the landscape.

Conclusions

This pollinator study was designed to collect data on a wide variety of flower associated insects and the factors that may be influencing their populations. Initial consideration was given to factors such as flora composition, vegetative community types, and the impacts of invasive flora and fauna, and management intensity and frequency. There are other factors, some yet to be realized, that may provide for useful analysis when comparing pollinating insect communities.

This study is still in the first baseline collection phase with two more years to go before the surveys are replicated at these sites to note any changes after five years. Additional comparisons will be made for sites in close proximity, those within travel distance of insect pollinators. More data are needed to better determine taxonomic composition of remnants and various vegetative community types, and to assess the impacts of management more comprehensively. Land cover changes to the surrounding landscape will likely be minimal after five years, while some study sites are undergoing an increased frequency and intensity of management. There may be changes over time in the insect community for these sites versus those receiving little or no management. Questions remain regarding the optimal size and location of refugia in relation to the size and percentage of area burned, cleared, or sprayed. Answering these questions will be beneficial to the evaluation of management techniques.

Other factors to consider over time that may have impacts on the pollinator communities include temporal changes in plant communities, competition with domesticated honey bees, potential impacts of non-native insects introduced for biocontrol, increased external pressures such as agricultural pesticide usage, additional loss of habitat within the areas surrounding the protected study sites, and impacts of climate change on phenology and shifts in species range.

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