Assessing Plant-Pollinator Community Composition within Riley County, Kansas: A Cool Season Study

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Introduction

The mutualistic relationship between plants and pollinators is crucial for the health of our ecosystems. A study done on the effects of landscape composition and configuration on pollinator communities reported that variation in landscape composition, fragmentation, and surrounding environments significantly affected pollinator diversity (Senpathi et al. 2016). Gathering information on pollinator communities is vital to improving our understanding of ecological effects on pollinators, and for managing our lands to support the health of these populations and our environment.

Some of the most effective methods for measuring a community's health is through the metrics of diversity and abundance. Abundance is defined as, "a measure of the number or frequency of individuals" and diversity is defined as "the number of species present in an area or in a community" (Booth et al. 2003). These methods of measurement reflect the overall health of an ecosystem. As population abundance and diversity increase, it can be assumed that the ecosystem is healthier due to the stability added by the increasing number of population interactions.

Our study aimed to measure the ecological health of environments with varying land usage, by recording pollinator abundance and diversity at the start of the growing season. This study occurred over four different locations, each with a different land cover and land use. The first location, which was utilized as a control for the study, was the tallgrass prairie at Konza Prairie Biological Station. This location was considered the control due to its natural landscape and prescribed fire regime. The other locations were artificially developed, with land cover types categorized as Urban, Agricultural, and Agroforestry. We conducted this research with the goal to gain more knowledge on pollinators early in the growing season as most pollinator studies occur later in the summer, and for important discourse to occur regarding the state of our pollinator populations and management implications in the Flint Hills of Kansas.

Three main objectives of this study:

1. Effects of cool-season emergence of invertebrates,
2. Diversity and abundance of pollinators (i.e., bees, butterflies, and moths), and
3. Differences in biodiversity of invertebrates in the different land use areas.

Pollinators (primary and secondary) provide a huge economic service to the agriculture producers of Kansas and the United States. The United State Department of Agriculture Annual Strategic Pollinator Priorities Report from 2022 states that pollinators add tens of billions of dollars to the US agriculture products for our diverse diet. This region of Kansas is a producer of mainly wind-pollinated crops; however, there are those, like alfalfa and sunflowers that prosper with pollinator facilitation. Therefore, our brief study recorded a limited assessment of active invertebrate and pollinator abundance and diversity during the early growing season.

Background

We selected four sample locations to get a representation of the invertebrate count and diversity sample in the early growing season in and around Manhattan Kansas. Each treatment site represented land cover and use variance in the Flint Hills. The four locations were categorized as: agriculture, tallgrass prairie, urban, and agroforestry.

Study Area

I. Natural Prairie (Control)

Prairies are categorized by the range of grass and forbs species present, fertile soil, and their continental climate. (Haukos n.d.). Continental climate is identified as areas located away from large bodies of water, with cold winters, hot summers, and overall low precipitation. The soils of these prairies consist primarily of mollisols and are very fertile. As a result, much of native prairies have been converted for other land uses such as row-crop agriculture. The natural prairie location selected for this study was the tallgrass prairie at the Konza Prairie Biological Station. This location is a protected area, founded in 1971, which focuses on conservation, research, and public education regarding tallgrass prairies (The History of Konza Prairie, Kansas State University). The main vegetation consists of warm-season grasses such as bluestem (*Andropogon gerardii*, *Schizachyrium scoparium*) switchgrass (*Panicum virgatum*), and Indiangrass (*Sorghastrum nutans*). While managed by people through methods such as prescribed burns, it is the only natural study area utilized in our research. Due to the broad spaces, diverse flowering plant populations for nectar and pollen, and tallgrasses for shelter, prairies are one of the most important ecosystems for pollinators. The Konza Prairie has proven to be an especially useful resource for studying the relationships between pollinators and native Midwestern prairie ecosystems.

The location of the prairie study site was a couple hundred meters down the road from the headquarters of the Konza Prairie Biological Station. The surrounding environment consisted of prairie, agricultural land, and forested area. It was located away from heavy human action other than research and some roadways.

Figure 1: *Prairie Treatment Site*

II. Urban/Green Space

Urbanization is a major threat to invertebrates, and subsequently, pollinators. Habitat loss in addition to stresses from climate change negatively affect species abundance, diversity, ecological function, and biological cycles. Urban settings can still offer places of sanctuary for small communities or migration stopovers for invertebrates in a variety of ways (Weiner et al. 2014). The most common urban spaces are city parks, which can vary in plant diversity, with increases of rain and community gardens, green roofs, and even implementation of green art installations. Research on pollinator interactions in the Midwest is limited, but small studies have shown differences when compared to their native counterparts with reduction in abundance and species richness for urban habitats (Kearns et al. 2009). Flower density and diversity had the most effect on pollinator diversity, which will require active management (Daniels et al. 2020). These spaces can be beneficial in the colonization of endangered pollinator species as well as provide aesthetic value and preserve humanity's biocultural history.

The urban site selected was located on the campus of Kansas State University in Manhattan, Kansas (Figure 2). The plot was a native tallgrass green space in the courtyard of the Marianna Kistler Beach Museum (Figure 9). The surrounding area comprises office buildings that support traffic of students and professionals on a daily basis. The greenspace is actively protected and has low disturbance to facilitate safe nesting for species. The soil profile of the site is composed of 34% Smolan silt loam with 3-7% slopes, and 66% Reading silt loam that is moderately wet and very rarely flooded. Smolan soils are characterized by very deep, well and moderately well drained soils that formed from loess. Reading soils have similar depths and drainage but differ by being formed in silty alluvium.

Figure 2: *Urban Treatment Site*

II. Agriculture

In the area surrounding Manhattan, Kansas, agriculture areas are similar. Most farm fields are on level ground, include terracing and waterways, and may have border areas (field corners, edges) that include linear patches of trees that mark property lines. Further, agriculture areas are further fragmented by roads, creeks, rivers, power line right of ways, and homesteads. Use of no-till farming is present with residual stalks in the ground, yet there are tilled fields as well. Use of cover crop and fallow fields is not as common as other locations, but they are present. Soil type runs the gamut of sandy through silty loam to clay. All of these factors lead to the result of less biodiversity in plants, invertebrates, and vertebrates in agricultural areas. It is well documented that pollinators are negatively affected by the large, fragmented, and low in biodiversity fields used for agriculture (Middleton et al. 2021). This study, though short, would support that trend.

The agriculture area selected for this study was located near, if not inside, the city limits of Manhattan (Figure 3). The field is part of the Kansas State Agronomy test fields known as "North Farm". The field picked for the study has till and no-till portions and planted strictly to corn with no cover crop. There is a small stream that borders the northern edge, which has some intermittent shrubs and not mowed or sprayed with herbicide. The field has a gravel road that separates it from a soybean field to the south. The soil consists of Ivan and Kennebec silt loam, which is occasionally flooded. The test area was in post-harvest state for all three transects with no living crop. Transects one and two were on no-till while transect three was on a tilled plot. Herbicide was applied by the Agronomy department on the day of the initial transect layout and vegetation survey. All green plant life in the agriculture plots, only forbs, were thus not green in the following invertebrate sample days. However, data shown in the results section will represent the amount of living forbs found on the initial (pre-herbicide) survey.

Figure 3: *Agriculture Treatment Site*

III. Agroforesty

Agroforestry sites can be established by integrating natural border crops using native perennial flowers, as well as tree lines, natural grassland, hedgerows, forests, shrub, vegetation, and herb vegetation into agricultural land-use areas (Bentrup et al. 2019). Ecosystem stability and pollinator population stability could be achieved by integrating functional vegetation diversity among agricultural landscapes as a means to improve the ecosystem services (Butters et al. 2022). Agricultural areas that integrate agroforestry practices have shown greater pollinator conservation outcomes compared to homogeneous fields that did not adopt agroforestry practices (Staton et al. 2019). Integration of tree rows can provide provisions for habitat and nesting for pollinators, which predicts increased nesting bee abundance at a landscape scale in agroforestry systems. Integrating agroforestry practices into intensified settings can improve biodiversity and support pollinator abundance and diversity given the positive relationships between florally rich vegetation and diverse bee communities (Butters et al. 2022).

Figure 4: *Agroforestry Treatment Site*

The agroforestry site selected for observation was located in Manhattan, Kansas, USA (Figure 4). The sample plot is consistent with traditional agroforestry practices including the integration of tree and hedgerows in multi use fields. The surrounding land cover is composed of bordering crop fields, pastures, and tree lines.

Seasonal Parameters

The seasonal highs, lows, and rainfall for the Manhattan area in the month of April are not ideal growing weather for vegetation or for the activity of invertebrates. While the mean average temperature is above the freezing mark (66° F), there are periodic freezes in the month of April and the average low (44° F) is not ideal for pollinators. Below is a chart from the

National Oceanic and Atmospheric Administration of the monthly climate averages for temperature and precipitation for the Manhattan area from 1991-2020 (Figure 5).

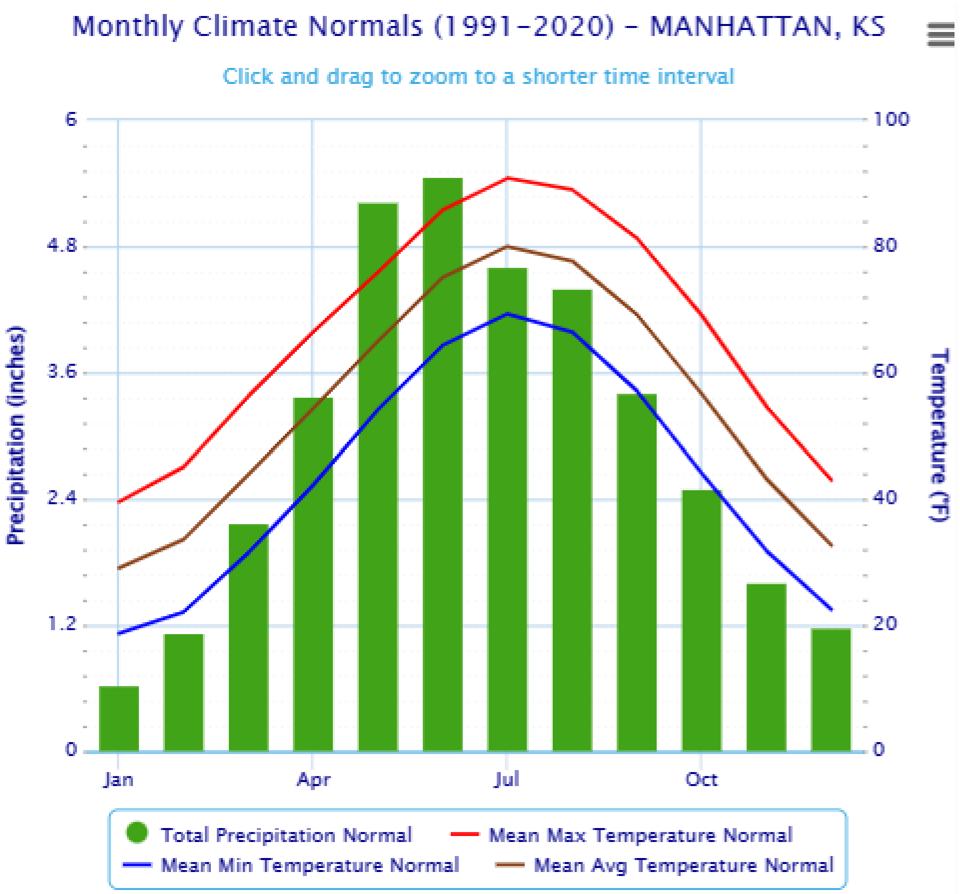


Figure 5

Methods

Community Sampling

The study was conducted over a two-week period with three simultaneous sampling rounds at each of the four sites. Each location was sampled three different times in the early spring (April 2023). Within each area, three transects measuring 100 m in length were identified and marked. Transects were used for collecting the visual density of the plant growth, composition of the plant/soil surface material, and swept for invertebrates.

Visual obstruction density (VOR) was recorded every 20 m along each leg of the transect using a Robel pole, using the four meters away/one-meter-high vantage point to view the first visible block (dm) along the pole. Plant material/soil surface cover was recorded at every approximate meter (every other step) as forb, grass, shrub, rock, bare ground, crop, or litter (all were included if represented). Invertebrates were collected using a bug net (four ft long) that had a 12 in. diameter opening. Each invertebrate collection was done after 10:00 am and before 3:00 pm. During the collection, the net was swung from side to side along the transect at every other step (approximately every meter). Contents of the nets were transferred to plastic bags and refrigerated until they were sorted and counted. Figures 5 thru 8 represent the sampling areas with the transects used (Figure 5 is tallgrass prairie, Figure 6 is agroforestry, Figure 7 is agriculture, Figure 8 is urban). Due to the time of year and weather conditions preceding the study the invertebrate counts were low across all the treatments. To make representative data comparisons, all transects per day were combined into a day's total collection and recorded as such.

Figure 6: Prairie Transect

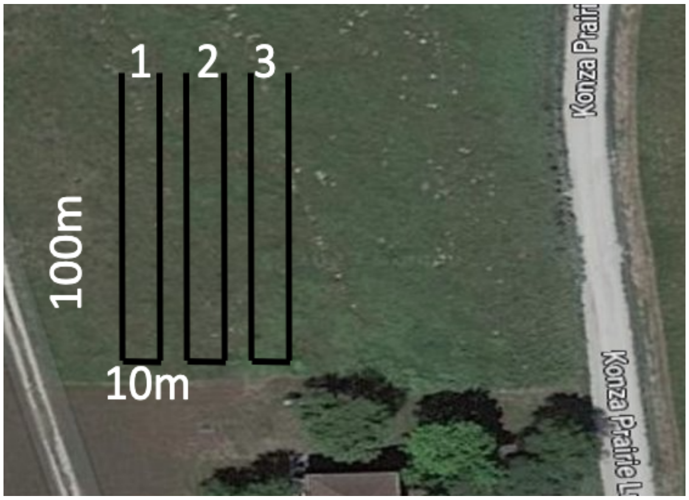


Figure 7: Agroforestry Transect

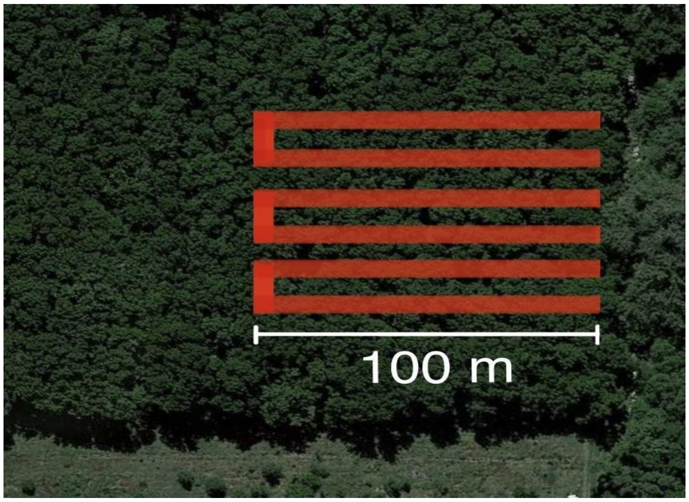


Fig. 8: *Agriculture Transect*

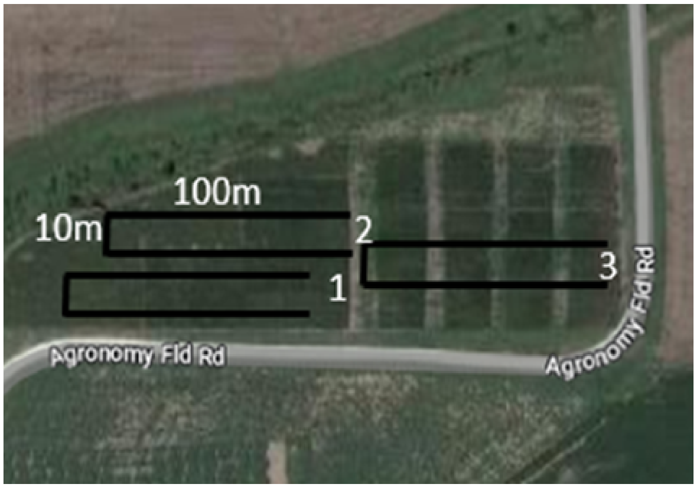
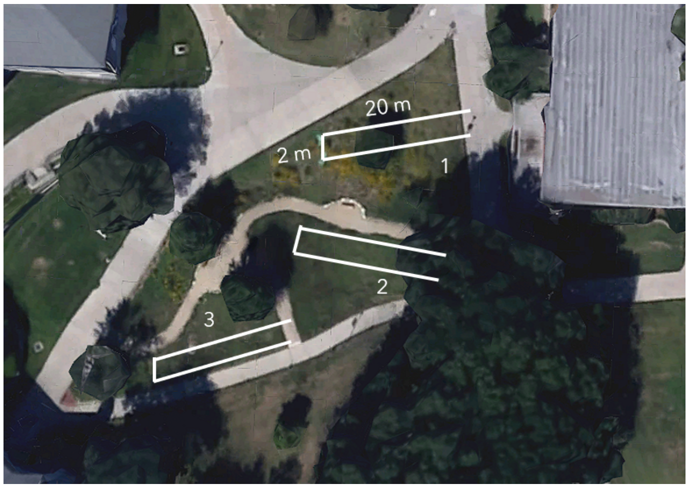


Fig. 9: *Urban Transect*



Analysis of Community Composition

For each study area, we compared invertebrate abundance (total number of invertebrates), invertebrate diversity (Shannon diversity index), invertebrate richness (number of groups observed), plant cover, and plant VOR (visual obstruction reading) among treatments.
We measured VOR using a Robel pole reading every 20 m of the transect, averaged VOR among transects then averaged for the entire site. We estimated percent composition of the plant community using step-points by recording every right step along the transects. We used continuous ground-level netting along the transects for invertebrate collection.

Results

The four treatment sites have a range of land cover, plant density, and invertebrate populations (Figure 10; Tables 1, 2). Similarities were apparent for the plant species and invertebrate groups present at the locations. Furthermore, low temperature ranges and other weather conditions had a common effect on findings across all study areas; therefore, differences in invertebrate communities were likely due to plant composition and structure.

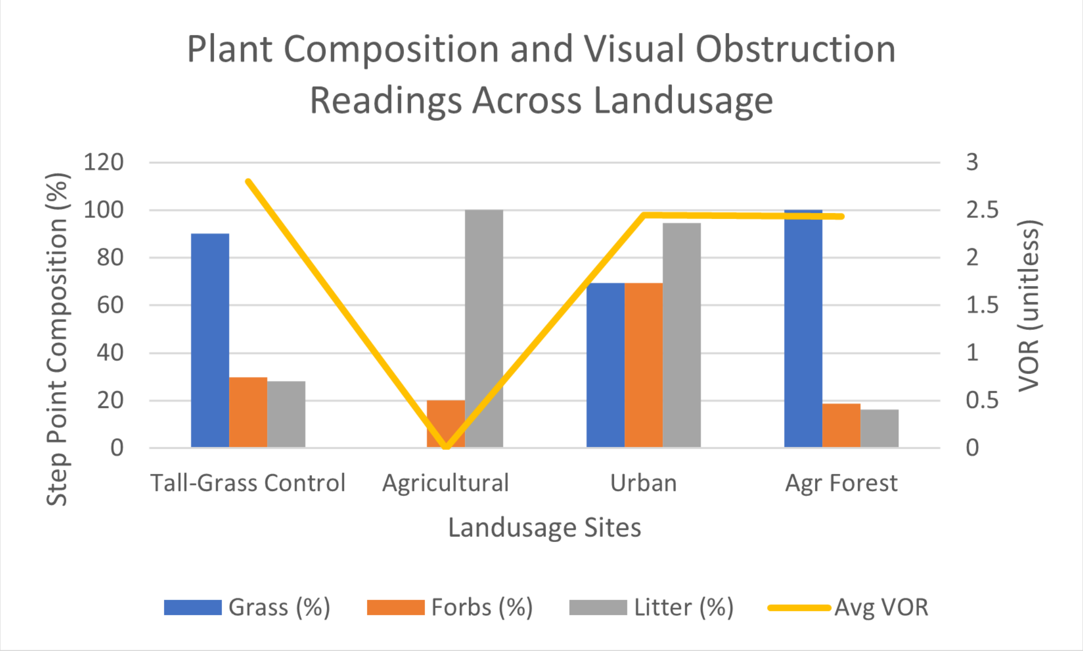


Figure 10: *Variations in the majorities of plant type were present across sites. Forbs were present among all land uses.*

Invertebrates of Different Landusage			
Treatment	**Abundance**	**Richness**	**Diversity Shannon Index**
Tall-Grass Control	48	4	1.20
Agricultural	0	0	0.00
Urban	30	6	1.74
Ag/Forest	294	7	1.38

Table 1: *Invertebrate abundance, richness, and diversity in each land cover treatment.*

	Invertebrate Group								
Treatment	**Grasshopper**	**Beetles**	**Bees**	**Winged Insects**	**Arachnids**	**Nymph Pollinator**	**Other**	**Total**	**Total Pollinators**
Prairie	0	6	0	4	21	17	0	48	17 / 48
Urban	5	0	5	5	5	0	10	30	5 / 30
Agroforestry	39	32	1	149	57	4	12	294	5 / 294
Agriculture	0	0	0	0	0	0	0	0	0

Table 2. *Invertebrate samples were organized into seven groups at the order level by common name; grasshopper, beetle, winged insect, arachnid, bee, caterpillar (nymph butterfly/moth), and "other". The two categories we are considering as direct pollinators for this study are bees and nymph pollinators.*

The three main findings from our data include: (1) agriculture treatment having zero invertebrates and zero living plant life; (2) the remaining treatments all had similar groups of invertebrates; and (3) the agroforestry had nearly three times the number of invertebrates (yet fewer pollinators). Lastly, the natural tallgrass prairie had the largest number of pollinators when splitting pollinators from total invertebrates.

Plant composition of the study areas varied. The prairie and agroforest treatments showed the most similarities of plant life with grasses being the majority of plant functional groups and litter being the lowest cover category. In the urban and agricultural treatments, plant litter was the greatest cover category. The urban location had the most balanced coverage of plant life with grasses, forbs, and litter functional groups comprising similar amounts of the site's composition. The agriculture treatment differed greatly from the rest in that it was essentially a fallow field with crop stubble (Figure 2). The herbicide treatment applied on the first day of sampling was

100% effective. The lack of biodiversity in plant life was directly reflected in the lack of invertebrates. This is the opposite of the other treatment areas, as they had more biodiversity in plant life, and support several groups of invertebrates. While there was lack of living vegetation on the transects in the crop field, it was surrounded by a buffer strip of tallgrass, shrub, and forbs. Yet, even with a perimeter of living vegetation, there were no transient invertebrates caught.

The three treatments (agroforestry, urban, tallgrass prairie) that had plant biodiversity also showed invertebrate abundance and diversity. All three showed nearly the same types of invertebrates yet differed in total numbers (Table 2). The agroforestry treatment had three times the number of invertebrates than other treatments with 294 total invertebrates collected (Table 2). The agroforestry also had a wider diversity of invertebrate types. Vegetation of the agroforestry was also more diverse with the presence of more trees/shrubs than the other treatments. The vegetation differences stand out as being a factor as invertebrate habitats differ and having more diversity in one leads to more diversity in the other. Additionally of note (and unexpected) was the number of spiders in each of three treatments. The number of predators was high in relation to the other individual invertebrate groups while the combined ratio of spiders to others was 25% (winged insects were highest at 47% of total invertebrates). This prevalence of predators was unexpected but added to the biodiversity of the three treatments that had invertebrate abundance and diversity.

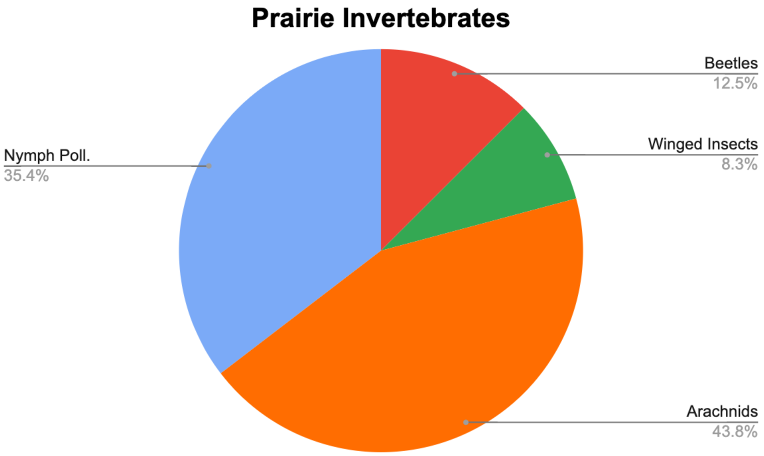


Fig. 11

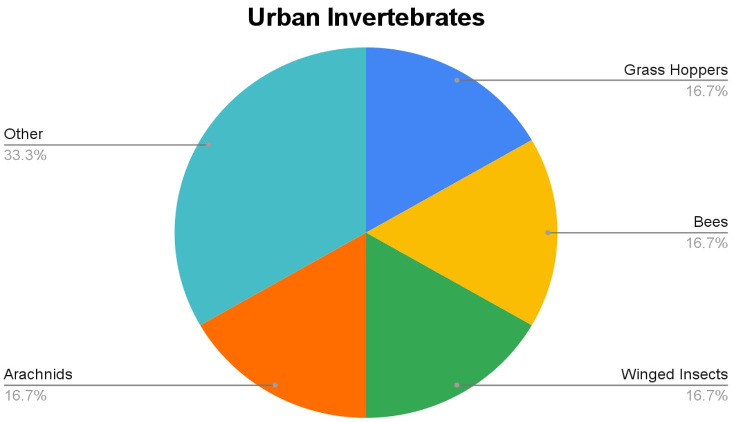


Fig. 12

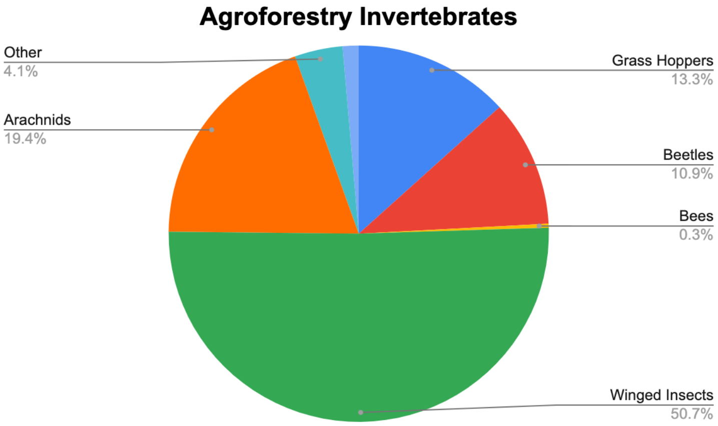


Fig. 13

Fig. 11-13: *Invertebrate composition among treatments (Prairie, Urban, and Agroforestry). Urban site data were factored by x5 to match transect length of other treatments.*

Findings related to pollinator species differed greatly from overall invertebrate findings. In this study, tallgrass prairie treatment had the greatest number of pollinators. Pollinators in both adult and nymph stages were found. The average VOR in the tallgrass prairie is also the highest, which may play a factor in pollinator abundance. After implementing a 5x multiplier on the urban location to compensate for transect length, the urban treatment and agroforestry location had the same number of pollinators (Table 2). However, pollinators account for a much greater percentage of total invertebrates in the urban location than in the agroforestry study area (Fig 12 & 13). It is of note that more nymph stage pollinators were found, which is in line with the lack of flowers in the growing vegetation.

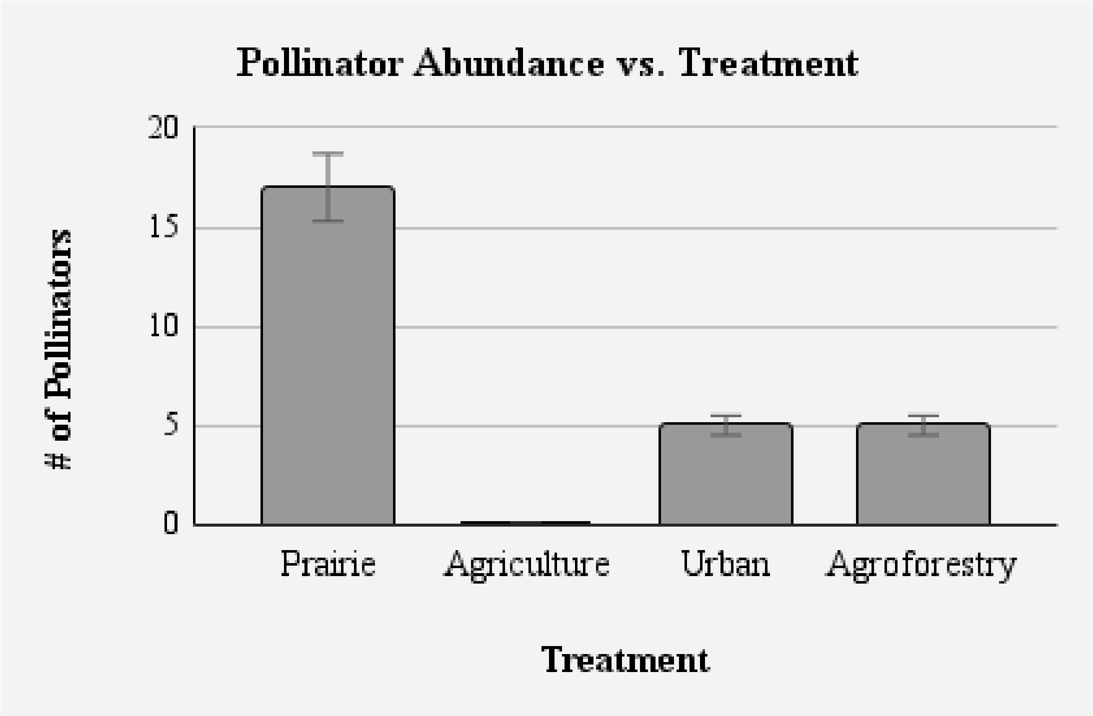


Figure 14: *Comparison of number of pollinators found in each treatment area*

In total, we collected a total of 346 individual invertebrates including a total of 23 individual pollinators consisting of 2 bees and 21 nymph lepidopterans. The treatment site with dominant pollinator abundance was the prairie control site, followed by the agroforestry plot (Figure 14). The agriculture plot collected zero invertebrates over the course of three sampling periods. The urban plot shown has been factored by x5 to match transect size standard. When calculating abundance, richness, and diversity (Shannon Index) of invertebrates, it was found that the agroforest treatment area had the largest abundance and richness, while the urban sector presented the highest amount of diversity. The urban location having the greatest invertebrate diversity may be related to the more balanced plant composition recorded at the urban location compared to the others (Fig. 10). This shows that even though the prairie location has the greatest amount of pollinators, it may not be the only indicator for ecological health.

Discussion

The effects of the cool season conditions in northeastern Kansas on invertebrate and pollinator emergence was noticeable from the abundance counts across treatment sites, even with similar weather conditions. Based off the assumption that forb density and diversity contribute most to pollinator abundance, we recorded low invertebrate activity across the native and urban sites relative to their plant compositions.

Many factors contributed to the quality of collection and sorting of samples, including the time of the season, individual approaches to collection, differentiating samples, and the short period research was conducted. The results were influenced in part due to the early season and temperature at the time (average high for April 2023 was 66° F and average low is 44° F); however, there were four days with low temperatures below or at 32F. These intermittent freezing temperatures may have influenced the type and number of invertebrates that we captured. Sorting and identifying of the collected invertebrates were done in a lab setting and combined to share the workload, at the expense of distinguishing transects and collection days from one another. The low abundance of primary pollinators can be attributed to individual proficiency with nets and what material each individual collected.

The agriculture crop field treatment yielded no invertebrates captured, this is likely not the true representation of the communities present in other cover types. This is supported by the low forb and grass compositions, plants favored by pollinators. Extensive disturbance from the tending of planted crops can negatively affect nesting viability for invertebrate communities and therefore, pollinators as well.

The agricultural forestry site had the greatest invertebrate abundance during the collection period. The findings showed greater than half of the collected invertebrates were winged, but none were identified as primary pollinators.

Lessons learned throughout the collection process such as expanding the time of collection, standardizing samples, include observations, and establish clearly the relationships being tested. The effort and results of our work may not be able to make strong inference across the Flint Hills, but we hope will add to the body of work for pollinators in Kansas and help guide future research.

Conclusion

To summarize, we evaluated the ecological health of varying cover types in the Flint Hills by recording pollinator abundance and diversity. The areas of study were established as a native tallgrass prairie plot for control, an urban plot, an agricultural crop field, and an agroforestry plot. Objectives were divided into three parts: determine cool-season emergence of invertebrates, quantify pollinator abundance and diversity, and compare these metrics among sites. Results from netting transects on each site showed that the agro-forest plot yielded the greatest abundance and diversity of invertebrates, followed by the prairie control field, then the urban greenspace, and lastly the crop field had no counts of invertebrates. The overall low invertebrate and pollinator abundance relates to our background information that pollinator communities are changing their biological season cycles and being eliminated from their habitats. Interpretations of data collected must include the consideration of the short collection period, individual proficiency during capture, and organization of sorting methods.

This report cannot adequately conclude the existence of a relationship between treatments based on the results. Differences in pollinator abundance and activity among sites can be answered by the management, frequency of disturbance of study sites, and present plant diversity. Conservation practices to assist pollinator communities are largely dependent on high flower density and diversity to provide proper habitat for nesting and foraging. The literature reviewed during this research project will hopefully serve as reference for future research within the topic of pollinators in the Midwest, as longer periods of collection and precise objectives will be needed.

References

Booth, B. D., Murphy, S. D., & Swanton, C. J. (2003). Weed ecology in natural and Agricultural Systems. SKUAST Jammu Digital Repository from, http://sherekashmir.informaticspublishing.com/437/

Daniels, B., Jedamski, J., Ottermanns, R., & Ross-Nickoll, M. (2020). A “plan bee” for cities: Pollinator diversity and plant-pollinator interactions in urban green spaces. *PLOS ONE*, *15*(7), e0235492. https://doi.org/10.1371/journal.pone.0235492

Harris, A. (2022). *Pollinating through art: Creating public art to restore pollinator habitats and revitalize urban communities* [Report]. https://krex.k-state.edu/handle/2097/42470

Haukos, J. (n.d.). *The Tallgrass Prairie*. Prairie Biology | Konza Environmental Education Program. Retrieved May 1, 2023, from https://keep.konza.k-state.edu/prairieecology/

Kearns, C. A., & Oliveras, D. M. (2009). Environmental factors affecting bee diversity in urban and remote grassland plots in Boulder, Colorado. *Journal of Insect Conservation*, *13*(6), 655–665. https://doi.org/10.1007/s10841-009-9215-4

Middleton, E.G., MacRae, I.V., & Phillips, C.R. (2021) Floral plantings in large-scale commercial agroecosystems support both pollinators and arthropod predators. Insects, 12 (2), 91. https://doi.org/10.3390/insects12020091

National Oceanic and Atmospheric Administration website. Climate (weather.gov)

Senapathi, D., Goddard, M. A., Kunin, W. E., & Baldock, K. C. (2016). Landscape impacts on pollinator communities in temperate systems: Evidence and knowledge gaps. *Functional Ecology*, *31*(1), 26–37. https://doi.org/10.1111/1365-2435.12809

Web Soil Survey. (n.d.). Retrieved April 15, 2023, from https://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx

Weiner, C. N., Werner, M., Linsenmair, K. E., & Blüthgen, N. (2014). Land-use impacts on plant–pollinator networks: Interaction strength and specialization predict pollinator declines. *Ecology*, *95*(2), 466–474. https://doi.org/10.1890/13-0436.1