The Effect of Fragmentation on Bee Species Richness in Hill Prairie Remnants

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Introduction

North American bee populations have been steadily declining over the course of the last century due to significant environmental changes (Cameron et. al 2011). Such changes are mainly due to human influence, including those in pesticide use, climate, disease, and land usage (Potts et. al 2010; Grixti et. al 2009; Sampson & Knopf 1994; Otto et. al 2016). Land usage covers many areas, but the expansion of agriculture is one of the largest changes to have occurred. Before European agriculture began in earnest, there were more than 162 million hectares of tallgrass prairie in the North American Midwest (Sampson & Knopf 1994). More than 99% of that initial land mass has been destroyed, leaving less than 1% of the once expansive environment in a patchy network of fragments and remnants (Sampson & Knopf 1994). Today, only a fraction of the original Great Plains biome remains, and within Illinois there has been a devastating decrease in its expanse. Approximately 22 million acres of the midwestern state were once covered in various prairie environments, but now only an approximate 2,500 acres still exist, a remnant of 0.01% (Illinois DNR 2018). Restoration efforts work to keep these remaining patches of tallgrass prairie intact, as well as to reclaim and restore some Midwestern land to its former composition.

Restoring these prairie environments and ensuring their survival is especially important for pollinators. Many bee species, endangered and otherwise, use these areas as a basis for habitat and foraging (Harmon-Threatt & Chin 2016). These endangered species include *Bombus affinis,*

Bombus terricola, and multiple species of yellow-faced bees. Eight total species either have been or are in the process of being classified as endangered throughout North America (FWS 2018). *Bombus affinis*, the "rusty patched bumble bee", is endangered throughout North America, including the state of Illinois. A further decline in its population size would be extremely detrimental to the conservation efforts (FWS 2018, Grixti et. al 2008), as well as for the pollination of crop and forb species (Harmon-Threatt & Chin 2016).

As stated earlier, Illinois prairies are made up of remnants and fragments located in various regions throughout the state. Sites such as these can be classified as tallgrass prairies, shortgrass prairies, glades, marshy prairies, or even hill prairies. Some of these regions are highly unique, such as hill prairies. These habitats are found on steep bluffs and are the main prairie type found in southern Illinois. Because of this, they are the main type of prairie fragment that was tested for this study. They typically have loess soil, which is sandy and wind-blown. Most hill prairies are less than 5 acres, with a total of 530 acres of hill prairies found across in Illinois (IL DNR 2018). They are often surrounded by farmland of various types. Despite these similar characteristics across hill prairies, they can vary overall in their size, quality, and isolation from one another.

Previous studies have concluded that the difference in plant richness between large and small remnants is statistically insignificant (Polley et. al 2005), although it has also been established that floral resource diversity is important for the success of multiple bee species (Hines & Hendrix 2005; Hendrix, Kwaiser & Heard 2010). This may indicate that the size of a prairie environment influences bees' decisions on habitat usage simply because a larger area will most likely contain a larger quantity of flowering plants. While a few studies have focused on how the size of an environment can affect the species richness of bee communities (Hendrix, Kwaiser &

Heard 2010), the evidence found thus far has been inconclusive. Previous studies in this area of research completed in Illinois are limited, especially regarding bee preference on habitat size.

In this study, twenty-one differently sized prairie remnants were sampled to assess bee species richness with the assumption that larger prairie environments would have a higher richness of bees than their smaller counterparts (Lennartsson 2002). Remnants ranged in size from 0.24 to 4.05 square acres. Remnants were classified as small if they were under 1.0 square acre and classified as large if they were above 1.0 square acre. All sampling was completed from May through August of 2018, with sampling occurring once a month.

Methods

This study was conducted between the months of May and August of 2018. Three small test sites (<1.0 $acres^2$) were contrasted with 3 large test sites (>1.0 $acres^2$) to determine whether the size of a prairie remnant affected the number of bee species present. These size categories were chosen because one was an evenly dividing factor that gave an equal number of sites for both small and large. Nineteen sites were sampled in total, but due to difficulties in identification, only data from six sites could be used. All sites were visited between 10 a.m. and 2 p.m. on clear, sunny days. Preferred temperatures were between 65-75° Fahrenheit, but over the course of the testing period temperatures ranged from 70-92° Fahrenheit.

Bees were collected via an aerial net at each site, with enough sampling done to cover the entire area of each site. All specimens collected were transferred into jars containing ethyl acetate, pinned on site, and brought back to the lab for further identification using a local dichotomous key (published by Mike Ardruser). Queens were collected separately and photographed for later identification. Any specimen unable to be classified by lab personnel was professionally classified by Mike Ardruser.

A linear regression analysis was utilized to examine differences in bee species richness between small and large prairie remnants (SPSS).

Results

A total of 40 different bee species from 17 genera were collected from all sites combined. Of these 17 genera, the most common were from *Megachile* (known as resin, mortar, and leafcutter bees), with 5 different species. *Bombus griseocolis* was the only species found at every one of the six sites, while *Xylocopa virginica* was the only species found at five out of the six sites, the exception being White Rock. Most of the species found at only one site were collected from either Salt Lick Point or Eagle Cliff Prairie, the two prairies of highest richness. Nine unique species were collected from each of these two sites.

A regression analysis was run using SPSS to determine if bee species richness depends on the size of a prairie remnant, using a p-value of 0.05. Using data from the six usable sites, a significance of 0.79 was obtained. The R^2 value of the data was 0.0268, and the multiple R value was 0.164. The hypothesis states that a p-value less than or equal to 0.05 indicated significant correlation between site size and site richness.

Table 1 Site size and site richness, with size indicated in acres and richness describing the number of distinct species found at each site.

Site	Size (acres)	Richness
Overlook	0.24	4
White Rock	0.58	3
Eagle Cliff	0.94	21
Blufftop	1.28	10
Salt Lick	2.07	25
Fults	4.05	12

Discussion

With prairie remnant sizes ranging from 0.24 – 4.05 acres, there was no significant indicator of correlation between size and bee richness. While there were far fewer species collected from two of the three small sites than any of the large sites, the data indicates that, overall, size is not indicative of richness. Thus, it was determined that the null hypothesis of the experiment must be accepted. The linear regression run on the data indicated a p-value of 0.79, far above the 0.05 limit set for significance. The multiple R value was found to be 0.164, far below the significance value of 1. Together, these two variables designate the experiment as non-correlational. The R^2 value given by the linear regression analysis was 0.0268, an indication that the data did not fall on the line average of the data; it did not fit expectations for correlation.

All testing days were completed from 10 a.m. to 2 p.m., the times at which bee activity is the highest, and only when the temperatures were not either too low or too high for bee flight. Of the six sampled sites, Eagle Cliff and Salt Lick Point had the two highest scores of richness with 21 and 25, respectively. Eagle Cliff was a small site at 0.94 acres, while Salt Lick Point was a large site at 2.07 acres. In the opposite of expectations, the largest site had a richness of 12 with an area of 4.05 acres. These observations, correlated with the statistical results, necessitate the acceptation of the null.

Many sources of error could have caused the results to be deemed insignificant, with one major source being data compilation. Due to difficulties in categorizing the data, it was necessary to organize it differently for testing than in the manner of collection. While the number of individual bees, as well as site size, was collected for each prairie fragment at a site, for proper testing it was necessary to compile the data into full sites rather than fragments, leaving only six

data points with which to run the linear regression. Despite these discrepancies, the data used for the test was an accurate as possible representation of the richness and size of the remnant sites.

Other possible sources of error stem from characteristics differing from one site to another that could have an effect on site richness. Such factors could be the nearness of the site to woodland or farmland plots, the type of prairie being tested, the presence of predatory species to pollinators, and the herbaceous composition of each site, among others. Thus, many variables besides size could have had a determining factor in the richness of each site (Illinois DNR 2018, Rösch et. al 2013).

Eagle Cliff prairie was an outlier, as it was a small site but had the second-highest richness. It was surrounded primarily by forest, with farmland located approximately 100 meters away. The site was located next to a cemetery, the presence of which could have influenced the richness at Eagle Cliff due to flowers and landscaping on-site. Surrounding woodland could have also provided habitat opportunities for the bees and could potentially have contained many nests or hives. Salt Lick Point LWR was the second-largest site at 2.07 acres, but it had the highest richness at 25, meaning there were 25 different species of bees collected from its three sub-sites. Sub-sites were located on bluffs and were primarily surrounded by upland forest habitat. The sub-site of Salt Lick Point nearest to farmland was approximately 210 meters away. Prairie of the Rock Overlook was the smallest site at 0.24 acres^2 with a richness of 4. Its sub-sites were surrounded by woodland but were still very near to suburban areas and roads. Neither of the sub-sites were highly in contact with farm land, with the nearest agricultural plot approximately 147 meters away.

By contrasting the two highly rich sites with the site of lowest richness and comparing their surroundings, evidence shows that a nearness to farmland does not correlate with a lower richness of bee species in a fragmented prairie environment. This is evident by comparing Prairie of the

Rock Overlook to Eagle Cliff, the first of which is further from agriculture and has a smaller richness. Conversely, Salt Lick Point is the furthest of the three from any agricultural site and has the largest richness. Thus, there is no set correlation between agricultural distance and bee species richness in the samples from this study.

Illinois hill prairies are a unique habitat that house many different species of bees. This is indicated by the collection of 40 species from only 6 sites, even though the richness of each site was relatively low. Thus, this is an example of how important hill prairie habitats are for bee conservation, as bees are specifically important for the pollination of forbs, grasses, and the many agricultural species grown throughout Illinois (Harmon-Threatt & Chin 2016).

Conclusion

As climate change develops and land use continues to decrease the size of remnant environments used to support many pollinator communities, it is imperative for studies to be taken underway to understand what is necessary to maintain bee richness. Bees are not the only pollinators in the natural world, but they are essential for the proper pollination of many grasses, forbs, and managed crops. This study determined that the size of a prairie remnant is not correlated to the richness of a bee community; however, other factors that this research project did not specifically focus on could very well affect richness, either positively or negatively. Focusing on those possible effectors could lead to promising conservation techniques as well as aiding in the spread of knowledge on bee importance to the general population.

Understanding the effects of habitat and climate variables as they relate to bee species richness could increase the yield in agricultural settings as well as the prosperity of restoration efforts for prairie communities. Future research could lead to the discovery of new conservation methods that would allow endangered pollinator species to recover from decline. Understanding

pollinator decline could help researchers fight a further decrease in those populations by targeting the reasons for that decline.

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