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Assessing the stability and distribution of a newly discovered endangered bumble bee population in Northeastern Illinois

Barbara Locascio
Olivet Nazarene University, bakrupa@olivet.edu

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Student: Barbara Krupa, Zoology Undergrad

Faculty: Derek W. Rosenberger, M.A., PhD

Abstract:

Many species of bumble bees *(Bombus spp.)* have been declining in abundance across North America. In the Midwest declines, including that of *B. affinis*, recently listed as a federally endangered species, are attributed to several factors including habitat loss. Native tallgrass prairies could be ideal areas for *Bombus spp*. communities to sustain populations, due to native floral resources. However, few studies have been done to determine this. Our objective was to determine the stability and consistency of *B. affinis* populations at Midewin National Tallgrass Prairie and to investigate whether Goose Lake Prairie, a nearby prairie remnant, provides a stable habitat that may be sources for *B. affinis* and other *Bombus* species of conservation concern in the region. We used nets to survey twelve 100m transects throughout both sites, representing three different habitat types; remnant prairie, restored prairie, and cattle pasture/other. *B. affinis* was not found at either habitat type, despite records of their presence from a previous year, however we did find several other species of conservation concern at very low numbers. We also found that the remnant prairie had greater species abundance and richness of *Bombus* species with two very common species, *B. griseocollis* and *B. impatiens*, being very common. With our findings we were able to determine that there are indeed habitat preferences among *Bombus* species, although we were unable to detect a habitat preference for species of conservation concern.

Introduction:

Pollinators are essential for the sustainability of ecosystems and the reproduction of many agricultural crops, supporting 75% of the 115 major crop species grown globally, and up to 35% of global annual agricultural production (Chaplin-Kramer, et al. 2014). *Bombus spp.* declines have been noted worldwide, including in North America, Britain, continental Europe and China (Cameron et al. 2011; Colla et al. 2012; Williams & Osborne 2009; Williams et al. 2009). In Illinois, several species of once-common *Bombus spp.* such as; *B. terricola, B. auricomus, B. fervidus, B. fraternus, B. pensylvanicus, B. vagans*, and *B. affinis* have declined in abundance and distribution in recent years (Colla et al. 2012, Grixti et al. 2009; Koch et al. 2015).

B. affinis (the rusty patched bumble bee), once widely distributed throughout the Midwest and Northeast regions, has declined nearly 90% within the last 20 years (USFWS. 2019). In 2017, *B. affinis* became the first bumble bee to be listed as a federally endangered species under the United States Endangered Species Act (USFWS. 2018.). Several factors have been implicated in its decline. These factors include exposure to parasites and pathogens, pesticide use, lack of genetic diversity, climate change, and habitat fragmentation and loss (Cameron et al. 2011; Goulson et al. 2015; Hines et al. 2005).

Tallgrass prairies can potentially be optimal habitats for *B. affinis*, by providing floral resources for pollen and nectar as well as structural diversity for nesting habitats while allowing for minimal energy expenditure (Hines et al. 2005). Prior to settlement, Illinois had nearly 9 million ha of tallgrass prairie, however, by 1978 less than 2,300 acres of prairie remained (Petersen, 1996). Most of the undisturbed prairie sites today are found along railroads, settler cemeteries, and in places that are not suitable for farming (IDNR. 2018. Illinois).

The Midewin National Tallgrass Prairie, located in Wilmington, IL, established in 1996, is the first national tallgrass prairie in the country, representing a major effort to restore 20,000 acres of farm and industrial land to the unique and complex ecology of a tallgrass prairie (The Nature Conservancy. 2019). The nearby Goose Lake Prairie, located in Morris, IL, is the largest prairie remnant left in Illinois (IDNR. 2018). In August 2018, researchers from Olivet Nazarene University recorded the first known sightings of the endangered *B. affinis* in Will County, Illinois at Midewin National Tallgrass Prairie (Hughes, 2018). This survey found just two male *B. affinis*, which indicates a successful colony as males are produced after a nest has fully matured, however, does not indicate whether the colony was nearby, as males can disperse far from their natal nest (Hughes, 2018; Robert et al. 2017). Goose Lake Prairie has yet to be surveyed for *B. affinis* but provides undisturbed prairie habitat that may hold remnant populations of the insect and other *Bombus spp.* of conservation concern.

Building upon the previous work of the Rosenberger Conservation Lab at Olivet Nazarene University in 2018, our objective is to determine the stability of *B. affinis* populations at Midewin National Tallgrass Prairie. We also wanted to investigate whether Goose Lake Prairie, a nearby prairie remnant, may provide a stable habitat that may be sources for *B. affinis* in the region. We hypothesized that *B. affinis* will be present but in low numbers at Midewin

National Tallgrass Prairie and that a larger *Bombus spp.* community, including *B. affinis* will be present at Goose Lake Prairie due to its unaltered state.

Methods:

In this study we wanted to compare *Bombus spp.* populations among three different habitat sites. The three sites were; prairie remnants, which are grasslands consisting of native grasses and forbes that have never been plowed for agriculture, restored tallgrass prairie, which are grasslands that have been converted from anthropogenic use to a native plant community, and finally cattle pasture and other old field or non-prairie roadside sites dominated by exotic grasses and forbes. A previous survey (Hughes, 2018) established twelve, 100m, transect lines at Midewin National Tallgrass Prairie to monitor *B. affinis* from May-Sept 2018. Here we utilized seven of these previous survey transects and created an eighth transect along a point where *B. affinis* was found. Of the eight transects at Midewin National Tallgrass Prairie, four transects were in restored prairie sites, while the other four consisted of two transects in cattle pasture and two in non-prairie sites. We combined the cattle pasture and other into one category due too small sample sizes of each. Four additional transects were established at the remnant Goose Lake Prairie, following the protocols, guidelines, and methods provided by the USFWS, including checking the areas for floral resources, and taking representative photographs of suitable habitat areas (USFWS. 2018. Survey). The surveys took place from May 29th -September 30th, 2019.

We surveyed each transect line for 30 minutes using sweep nets and collected all *Bombus spp.* within one meter of the transect line. When each *Bombus sp*. was captured, they were transferred from the net, one at a time into a marked clear vial, and put into a cooler with ice for later identification, for no longer than 30 minutes.(USFWS. 2018. Survey). Once all *Bombus sp*. were identified they were released back on or near the flowers from which they were found. All plants that *Bombus sp*. were captured on were identified and recorded.

Data were analyzed in R. Differences between sites in mean species richness and abundance were analyzed using mixed effects ANOVA models with sampling period designated as a random effect. Model assumptions of homoscedasticity and normality of errors were visually assessed using residual graphs and square root transformations applied as needed. Means were separated using Tukey HSD tests.

Results:

Over the four months of the study, 216 *Bombus spp*. were captured and identified at both Midewin National Tallgrass Prairie and Goose Lake Prairie. We identified eight different *Bombus spp.* species; *B. griseocollis, B. impatiens, B. auricomus, B. fervidus, B. bimaculatus, B. pensylvanicus, B. fraternus, and B. vagans* (Table 1). Of the eight species identified, *B. affinis* was not found at any habitat site. However, five species we did identify were of conservation concern; *B. auricomus, B. fervidus , B. fraternus, B. pensylvanicus,* and *B. vagans*. However, these five species were low in abundance (Figure 1).

We found that Goose Lake Prairie does consist of a larger *Bombus spp*. community overall, with significantly higher mean abundance when compared to both restored prairie and cattle/other sites located throughout Midewin National Tallgrass Prairie ($F_{2,137} = 10.18$, $p < 0.0001$)(Figure 2). However, the greater abundance of *Bombus spp.* at the remnant site was due to significantly more of the very common *B. griseocollis* ($F_{2,137} = 10.60$, $p < 0.0001$) and *B. impatiens* ($F_{2,137} = 10.29$, $p < 0.0001$) while other species such as *B. fervidus*, and *B. vagans* were found mainly in the restored prairie and cattle/other sites (Figure 3). There was also a difference in average species richness per site with more species found on average at the remnant site than the cattle/other site. ($F_{2,137} = 6.74$, $p < 0.0016$) (Figure 4).

Table 1: Species captured and identified at Midewin National Tallgrass Prairie, and Goose Lake Prairie, from May 29th-Sept. 30th, 2019, their common name, conservation rank, total number of species caught and overall relative abundance percentage.

Bombus species	**Common Name**	**Conservation Rank***	**No. Caught**
B. griseocollis	Brown belted bumble bee	LC	94
B. impatiens	Common Eastern bumble bee	LC	77
B. auricomus	Black and gold bumble bee	VU	26
B. fervidus	Yellow bumble bee	EN	7
B. bimaculatus	Two spotted bumble bee	LC	6
B. pensylvanicus	American bumble bee	VU	4
B. fraternus	Southern Plains bumble bee	EN	1
B. vagans	Half black bumble bee	LC	1

LC = Least Concern, VU = Vulnerable, EN = Endangered
*(From IUCN, The International Union for Conservation of Nature's Red List of Threatened Species. Colla, 2012)

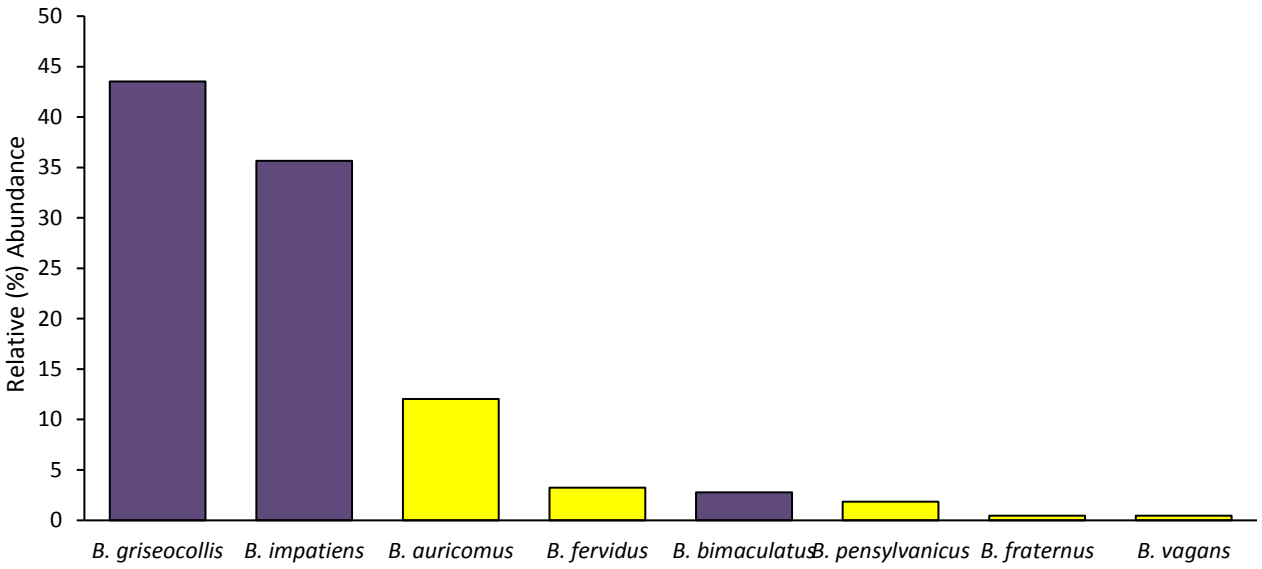

Figure 1: Relative abundance percentage of all species identified at Midewin National Tallgrass Prairie and Goose Lake Prairie from May 29th-Sept. 30th, 2019. Species of conservation concern are highlighted in yellow.

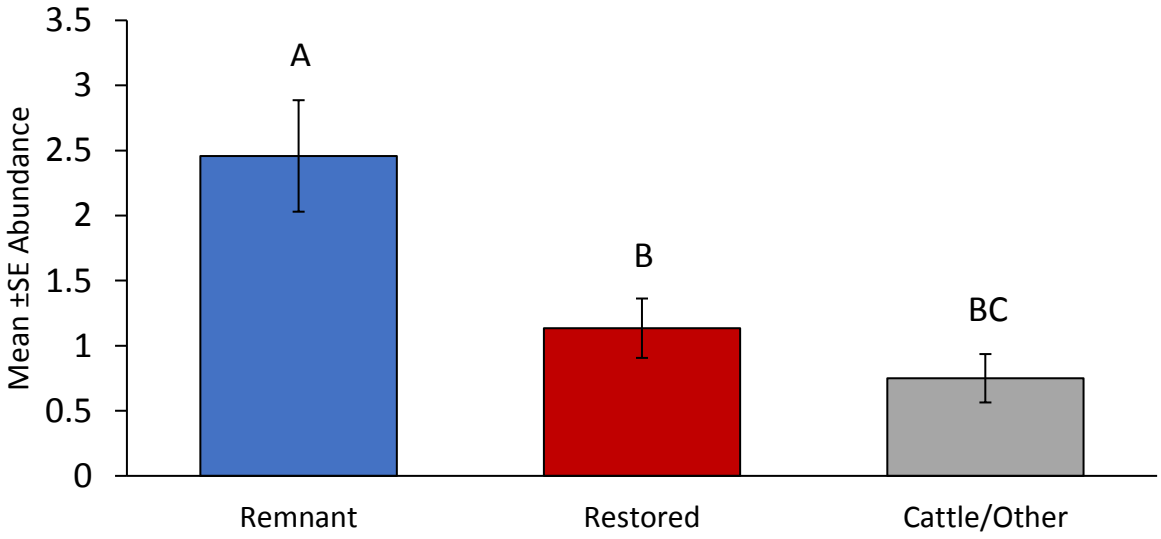

Figure 2: Mean species abundance of all *Bombus spp*. captured and identified from all three habitats, Remnant Prairie, Restored Prairie, and Cattle/Other from May 29th-Sept. 30th, 2019

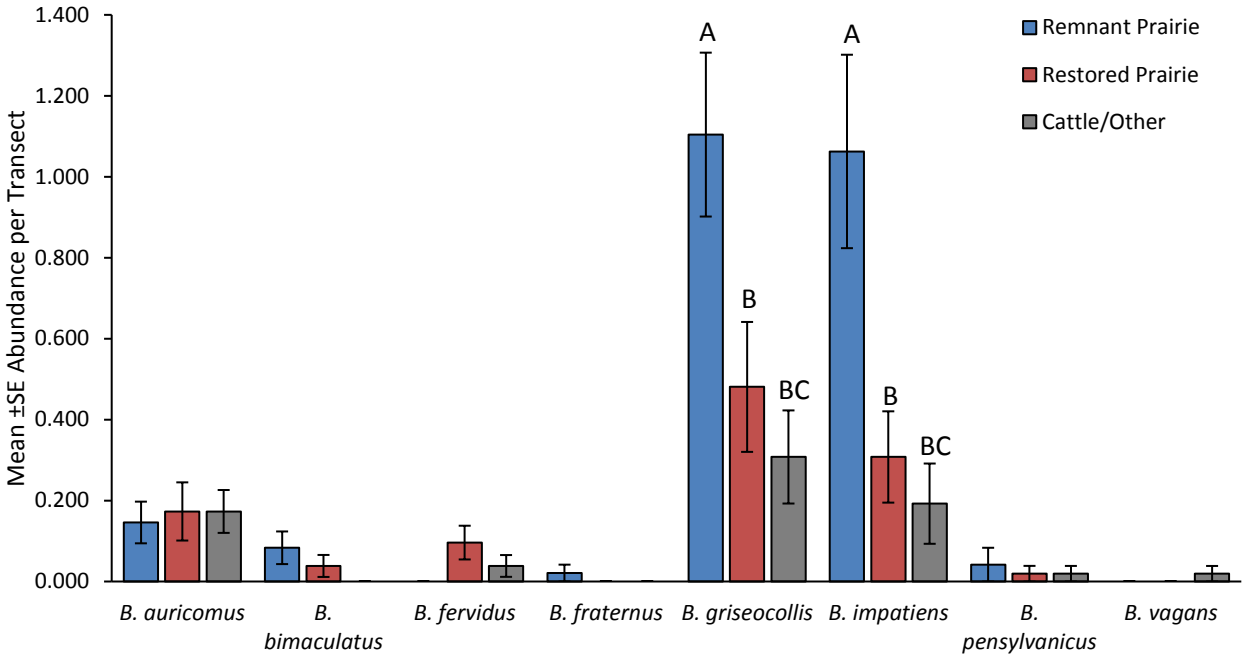

Figure 3: Mean abundance of species per transect and per habitat type at Midewin National Tallgrass Prairie and Goose Lake Prairie, from May 29th-Sept. 30th, 2019.

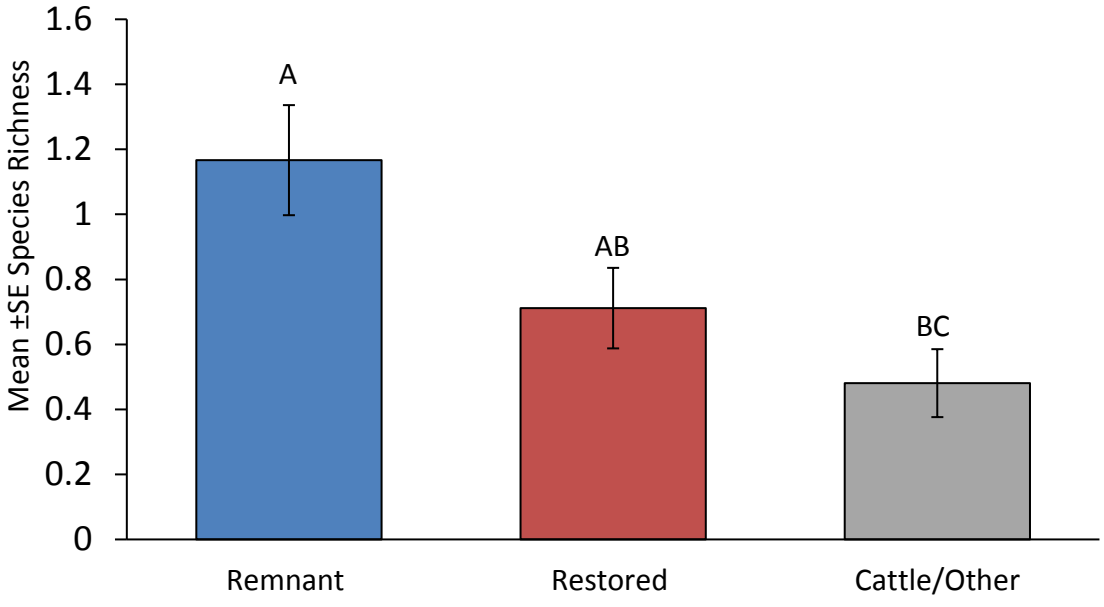

Figure 4: Mean species richness of all *Bombus spp*. captured and identified from all three habitats, Remnant Prairie, Restored Prairie, and Cattle/Other from May 29th-Sept. 30th, 2019.

Discussion:

Surveys across four months did not result in recapturing *B. affinis* at Midewin National Tallgrass Prairie or finding the species at Goose Lake Prairie. We believe this is because the population of *B. affinis* is indeed low. Hughes (2018) only found two male *B. affinis*, comprising just 0.13% of all the *Bombus spp.* found in 2018 (Hughes, A. 2018). Thus, it was unlikely that we would be able to find this species given the number of *Bombus spp*. captured this summer (216) compared to last year (798). Low numbers of *B. affinis* in 2018, and none found at either Midewin National Tallgrass Prairie or Goose Lake Prairie in 2019, demonstrates that populations of *B. affinis* are likely not stable in the area.

Our study does suggest that a remnant prairie, such as Goose Lake Prairie, can support a relatively high abundance of *Bombus spp.*, thus showing that it does provide an important habitat for *Bombus* communities (Figure 2). We also found that *B. griseocollis* and *B. impatiens* specifically, had a large population at the remnant prairie site compared to the restored prairie and cattle/other populations sites (Figure 3). However, there were some species such as *B. fervidus* and *B. vagans*, that were only found at restored prairie and/or cattle/other sites. Seeing that certain *Bombus spp*. were only found in specific habitats and not in others, suggests that there are foraging and habitat preferences within *Bombus spp*. Communities that should be investigated further.

We were able to capture and identify several other *Bombus spp*. that are of conservation concern. We identified *B. auricomus, B. fervidus, B. fraternus, B. pensylvanicus* and *B. vagans,* however, they were in very low numbers. In fact, the capture rate for the entire summer was low (n=216) relative to the previous year (n=798), despite greater sampling time. The difference between years is alarming. Several factors could have contributed to the lower capture rate, such as a later start to the summer that involved cooler temperatures and greater precipitation and in turn, a bloom season was relatively shorter compared to 2018. Annual fluctuations in abundance should be investigated further. We are currently working on direct comparisons between sites to more fully investigate these differences.

Further work is needed to assess the stability of *B. affinis* at Midewin National Tallgrass Prairie and in Will County, IL. While two males were found previously, we found no evidence of a sustained population at the sites where the two insects were found, or at other presumably

optimal sites around Midewin National Tallgrass Prairie and Goose Lake Prairie. With further research, it can be investigated whether there are other locations that could support *B. affinis*, and whether this season was just not supportive for the endangered bumble bee to thrive.

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