

**ASSEMBLY OF ARTHROPOD COMMUNITIES IN RESTORED
PRAIRIE, OLD FIELD AND MONOSPECIFIC STAND OF *PHALARIS*
ARUNDINACEA: A FUNCTIONAL PERSPECTIVE**

by

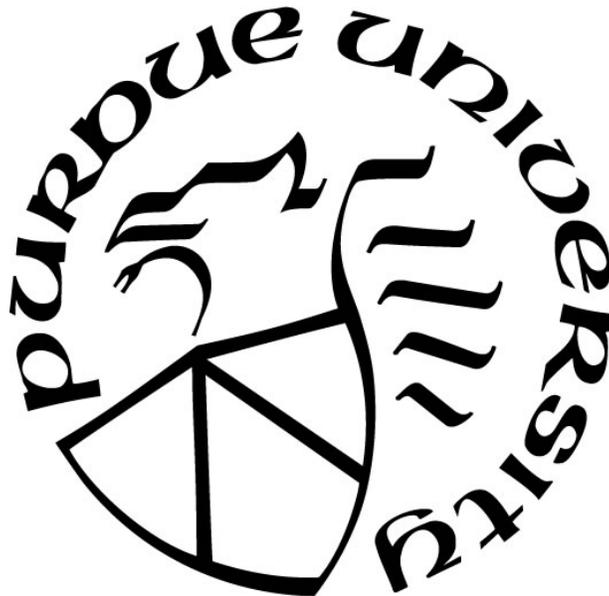
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A Thesis

Submitted to the Faculty of Purdue University

In Partial Fulfillment of the Requirements for the degree of

Master of Science



Department of Biological Sciences

Hammond, Indiana

May 2019

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I dedicate this to my wife. We talked about this since we met and we finally did it! And to my parents. My father for introducing us to the great outdoors during hikes, camp-outs, and backyard excursions. My mother for her inspiration in seeing things through and pursuing your dreams.

ACKNOWLEDGMENTS

I would like to thank my major professor, Dr. Young Choi, for finding a topic, helping me devise my thesis, and to carry it out. I take this time to thank Dr. John Shuey for his expertise in suggesting methods of arthropod capture and ideas on how to approach analyzing arthropod communities. Many thanks to Gabis Arboretum (formerly Taltree Arboretum) for opening up their fields for scientific investigations of their plant and arthropod communities over several memorable summers. I also thank Dr. Curtis Creighton for his help and suggestions in capturing beetles and more. I thank Dr. Vanessa Quinn for being a part of my committee and for her support and encouragement to present at the Indiana Academy of Science Annual Meeting in 2019. I thank Dr. Ting for her support and encouragement to keep going. I thank Erica Burnett for always signing me up for classes and greeting me with a welcoming and friendly smile. I would like to thank my wonderful, loving wife for all of her support as we both earned our Master's Degrees together. Our faithful cat, 'Skrewt', who always sat by us as we studied. And for putting up with all my 'bug' collections found throughout the house, including, but not limited to, the freezer. I thank my Uncle Clint for keeping me motivated to just get it done. And, I thank my parents, grandparents, and family and friends for their support and inquiries to my bug project.

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
C3 grass	Carbon-3 grass
C4 grass	Carbon-4 grass
CCA	Canonical Correspondence Analysis
OF	Old field
H'	Shannon-Weiner diversity index value
H ₀	Null hypothesis
NOAA	National Oceanic and Atmospheric Administration
<i>P. arundinacea</i>	<i>Phalaris arundinacea</i> (reed canary grass)
RCG	Reed canary grass (<i>Phalaris arundinacea</i>)
RP1	Restored prairie site 1
RP2	Restored prairie site 2
USDA	United States Department of Agriculture

GLOSSARY

Arthropod – invertebrate animals of the phylum *Arthropoda*, including spiders and insects such as bees, flies, beetles and centipedes

Canonical Correspondence Analysis – CCA is unique among the ordination methods in PC-ORD in that the ordination of the main matrix (by reciprocal averaging) is constrained by a multiple regression on variables included in the second matrix. In community ecology, this means that the ordination of samples and species is constrained by their relationships to environmental variables. CCA is most likely to be useful when: (1) species responses are unimodal (hump-shaped), and (2) the important underlying environmental variables have been measured. From <https://www.wildblueberrymedia.net/pc-ord-specifications>

C3 grasses – grasses identified as producing a 3-carbon molecule as the first product of photosynthesis. Associated with growth during cooler seasons and therefore needing low requirements of light and temperature. Feed quality is higher relative to carbon 4 grasses, though production is generally lower.

C4 grasses – grasses identified as producing a 4-carbon molecule as the first product of photosynthesis. Associated with growth during warm seasons and therefore adapted for higher light and temperature requirements. Production of biomass is typically higher than carbon 3 grasses, though feed quality is typically lower relative to carbon 3 grasses.

Detritivore – an organism whose primary source of nutrition comes from feeding on detritus, or dead organic material.

Grazer – specifically, an herbivore whose mode of feeding is chewing

Forb – herbaceous flowering plants that are not grasses

Functional diversity – the number of different functional groups in a given area or habitat

Functional group – a group organisms sharing similar characteristics, and fulfilling similar roles, in a community. The organisms perform a similar function in a given ecosystem, such as decomposition, primary production, herbivory, pollination or predation.

Herbivore – an organism whose primary source of nutrition derives from plants

Invasive species – an organism living in an ecosystem to which it is (a) not native and (b) detrimental to the functioning of the ecosystem in its absence

Pollinator – an arthropod, or any organism, who functions to spread pollen from the anther (male) and the stigma (female) between flowers or in the same flower. This may lead to fertilization and ultimately seed production

Predator – any organism, such as an arthropod, which engages in the active pursuit of another organism for the obligatory purpose of eating it for nutrition.

Relative species abundance – a component of biodiversity indicating the rareness of individual species relative to other species in a given area

Restoration (ecological) – restoring degraded, damaged, or destroyed habitats or ecosystems by human intervention

Sap sucker – an herbivore which derives its nutrition from plant fluids. They have a sucking mouth part they insert into plants, such as the xylem, phloem or leaves.

Scavenger – any organism deriving its nutrition primarily from dead plant (herbivorous scavenging) or animal (carnivorous scavenging) organisms

Species – a group of organisms that can mate and successfully produce fertile offspring

Species diversity – the number of distinct species in a given area; it is based on species richness, taxonomic or phylogenetic diversity and species evenness

Species evenness – describes how close the number of different species in a given area are to each other numerically

Species richness – the number of distinct species in a given area, such as a community or ecosystem

Structural diversity – the variation in the way parts are organized. In a prairie, the diversity of plants makes up the structural diversity by taking into account foliage, branches, and flowers

Taxonomic diversity – the diversity of species based on their taxonomic ranking; e.g. Order, Family, Genus, Species

Taxonomy – the science of classifying organisms on a set of shared characteristics

ABSTRACT

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Degree Received: May 2019

Title: Assembly of Arthropod Communities in Restored Prairie, Old Field and Monospecific Stand of *Phalaris arundinacea*: A Functional Perspective

Committee Chair: Young Choi

Effects of prairie restoration on arthropod diversity was investigated at Gabis Arboretum, Valparaiso, Indiana. A total of 35,408 arthropods belonging to 13 taxa in the restored prairie (RP1 and RP2), old field (OF), and monoculture stand of *Phalaris arundinacea* (reed canary grass – RCG) sites, were captured, counted, and compared. The enhanced plant species diversity in the restored prairies did not appear to promote the diversity of arthropod taxa. However, the restoration led to a more balanced composition of arthropod functional groups and thus elevated the diversity of functional groups. The arthropod assemblages in the three sites diverged clearly according to my canonical correspondence analysis (CCA) ordination. Pollinator abundance was greatest at RP and least at RCG site, positively correlating with greater forb diversity, and suggesting greater potential for nectar feeding and pollination potential at RP sites. Herbivore abundance was greatest at the RP sites, positively correlating with increasing plant species diversity. Predator abundance was significantly greater at the RCG site compared to the OF and RP sites; it was positively correlated with greater C₃ grass cover, a characteristic of the structurally homogenous RCG site, and negatively correlated with increasing plant diversity and forb cover, a characteristic of the diverse and more structurally complex RP sites. Given the apparent non-random distribution of arthropods among the field types, my results suggest plant species composition has a significant effect on arthropod assembly. The monoculture grass stand

was found to have a predator dominated arthropod community supported by a small, diverse herbivore community. It is concluded that the prairie restoration has resulted in alteration of arthropod communities supporting greater pollinator and herbivore abundance and a more balanced ratio of herbivores to predators due, in part, to increased plant structural diversity.

CHAPTER 1. INTRODUCTION

Grassland communities host hundreds of arthropod species (Reed, 1996; Haddad et al., 2001; Cook-Patton et al., 2011). Accounting for this are the multiple functional groups associated with arthropods: herbivores, omnivores, pollinators, detritivores, scavengers, parasites, and predators. This, coupled with the diverse and complex vegetative strata of the tallgrass prairie, allows for greater diversity and specialization in the ranks of arthropods. In the tallgrass prairie, arthropods are the primary herbivores and detritivores whose diversity is related to plant species diversity, structural diversity, patch size, and density. Being of such high diversity and abundance, arthropods are major contributors to prairie ecosystem structure, function, and processes (Whiles and Charlton, 2006; Joern and Laws, 2013).

Composition of arthropod communities is dependently linked to plant community composition (Haddad et al., 2001; Larsen et al., 2003; Whiles and Charlton, 2006; Gardner et al., 2009; Haddad et al., 2009; Joern and Laws, 2013). Natural areas with higher plant diversity are predicted to support a greater diversity of herbivores by providing greater variety of resources and refuge, therefore supporting greater predator abundance and diversity, acting to keep herbivore populations in check (Root, 1973). Haddad et al. (2009) found that the most plant-diverse plots had more diverse predator species than plant monocultures. Siemann et al. (1998) reported that the richness of herbivorous and predatory arthropods was positively correlated with number of plant species and functional groups. Cook-Patton et al. (2011) noted that richness and abundance of arthropods increase with plant genotypic richness in evening primrose (*Oenothera* sp.) populations. Meanwhile, a few authors (e.g., Koricheva et al., 2000; Schuldt et al., 2011) argued that lower plant diversity could simplify physical structure of habitat, increased predation

success, and thus large and diverse predator population, and thus led to larger and more diverse predator populations.

Changes in plant community composition may lead to alteration in habitat structure, and thus in arthropod community structure (Hunter and Price, 1992; Larsen et al., 2003; Atherton, 2013). For example, plant invasions alter the arthropod community assemblage positively and negatively in terms of richness, abundance and diversity (Marshall et al., 2008; Gardner et al., 2009; Spyreas et al., 2010; Litt et al., 2014). While Spyreas et al. (2010) found reduced arthropod diversity with invasion of exotic plants, Root (1973) argued that plant monocultures, according to resource concentration hypothesis, may create an abundant, homogenous stand exploited by only a few specialist herbivore species. Introduction of native plants, a typical procedure for prairie restoration in North America, is also a way to change plant community composition. Successful introduction of plants almost invariably enhances the richness and diversity of plant species, and such enhancements are reported to promote arthropod diversity in literature (e.g., Siemann et al., 1998; Haddad et al., 2001; Marshall et al., 2008; Kutschbach-Brohl et al., 2010; Litt et al., 2014).

The purpose of this study is to investigate the effects of prairie restoration on the assemblage of arthropod communities in Gabis Arboretum, Valparaiso, Indiana. Two hypotheses are tested. First, that enhanced plant diversity and richness would promote the arthropod diversity in the restored prairie. Second, the arthropod communities in the restored prairie would diverge from the unrestored abandoned farmland. This thesis characterizes arthropod assemblages and their relation to plant species composition and functional guilds and to determine the effect of prairie restoration on the arthropod communities.

CHAPTER 2. METHODS

2.1 Description of Study Area

Gabis Arboretum at Purdue University Northwest, formerly called Taltree Arboretum, is located on the Valparaiso Moraine (Figure 1A and B) of Lake Michigan. The moraine, created after the Wisconsin glaciation that occurred approximately 32,000 – 11,000 years ago, runs east-to-west with the landforms ranging knob-and-kettle topography to gently rolling till-plain (Homoya et al., 1985). The predominant soil types found at our study sites include Blount silt loam (Lake Michigan Lobe) and Ozaukee silt loam, typical of ground and end moraines consisting of loess over silty clayey parental material (Homoya et al., 1985; USDA soil survey). Climate for Valparaiso, IN (1981 – 2010) mean annual precipitation was 95 cm, mean January and July temperatures were -5° C and 23° C, respectively, according to climate data recorded by a local weather station at Valparaiso, Porter County Municipal Airport (National Oceanic and Atmospheric Administration, 2018).

The arboretum, covering 146 hectares, consists of an old field (abandoned farmland), woodlands, wetlands and a tallgrass prairie that was restored from 16 hectares of old field (Figure 1B and D). More than 50 species of plants, native to tallgrass prairies of the US Midwest, were introduced during the prairie restoration in 1998 (Restored Prairie #1 in Figure 1B) and 2000 (Restored Prairie #2 in Figure 1B). The prairie has been burned periodically by the arboretum management. No such restoration was given to the remaining old field that went through spontaneous secondary succession. In addition, reed canary grass (*Phalaris arundinacea*), an exotic invasive species from Europe, has invaded and established nearly monospecific stands in many areas of old field (Figure 1D and E). According to Choi (2010),

plant species diversity and richness and the dominance by native plants were approximately 1.5 time higher than the old field.

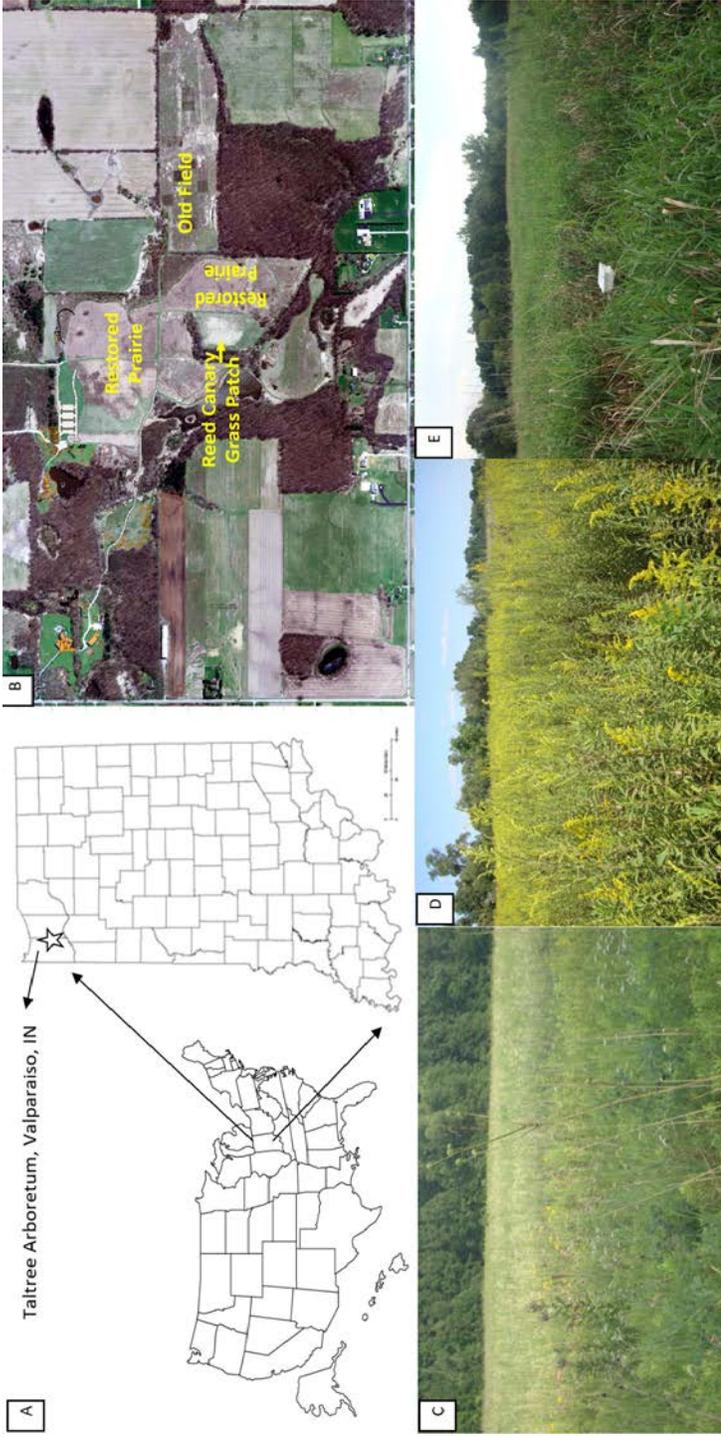


Figure 1: (A) Location of Gabris Arboretum in Valparaiso, Indiana and (B) aerial view of restored prairie, old field, and the reed canary grass (*Phalaris arundinacea*) stand in the arboretum. Ground views of (C) restored prairie displaying a mix of grasses and forbs, (D) old field dominated by Canadian goldenrod (*Solidago canadensis*), and (E) monospecific stand of reed canary grass.

2.2 Field Sampling

Choi (2010) established 98 permanent sample points on six transects in the restored prairies (hereafter termed RP1 and RP2), 15 points on three transects in the old field (hereafter termed OF), and 10 points on two transects in a monospecific stand of reed canary grass (hereafter termed RCG). All transects run from north to south with the lengths varying from 100 m to 200 m. The sample points in each transect were spaced with 20 m intervals. Vegetation inventory was conducted three times in the summer months of 2008, 2013 and 2018 by Choi (2010 and unpublished data). In each inventory, all herbaceous plants occurring in a square plot (2 m x 2 m) at each sample point were identified to species. Ground cover (%) of each species was estimated with a point-contact frame in each plot.

For arthropod sampling, I selected a total of 29 sample points – 10 in RP1, nine in RP2, and 5 in each of OF and RCG – from the ones established in 2008 (Choi, 2010) based on the vegetation data collected in 2013 (Choi, unpublished). The selected sample points were most representative to the vegetation characteristic for each of RP1, RP2, OF, and RCG in terms of plant species composition and cover; their species diversity and cover were closest to the mean values of all plots in each area.

Ground-dwelling arthropods were collected with two pitfall traps at each of 29 sites, totaling 58 traps, in 2014. At each site one trap was baited with chicken liver the other with locally procured cow manure. The traps were placed opposite each other 1 meter from a metal pipe marking plot location. The pit-fall trap assemblage consisted of the following: 2 nested 532-mL plastic cups with 9-cm diameter opening flush with the ground in a hole accommodating the cups. A 60-mL soufflé cup was suspended from a 20 x 20 cm chicken wire screen using scrap copper wire. This was placed over the nested cups and secured with 5-cm galvanized deck staples. This acted as bait holder and protective screen against small animal intruders. For

protection from rain and excessive sunlight, a 240-cm diameter foam plate acted as a canopy, held in place by four 15-cm deck nails. The traps were filled with 250-mL of propylene glycol-based antifreeze. Every two weeks from June to August, 2014 arthropods were collected (5 total collections) and traps were recharged with fresh propylene-glycol based antifreeze, bait, and any damages were repaired. To collect arthropods, the contents of the plastic cup were emptied into a 15-cm diameter fine mesh metal screen strainer. From the strainer they were transferred to a 125-mL Nalgene® plastic container and stored in 70% isopropyl alcohol.

Plant-dwellers were collected with a sweep net in June and July, 2015 at each of the 29 sites. Netting was performed by deeply sweeping into the vegetation of each plot 50 times, using a side to side motion in a full 180° arc, in a circle with a 3-meter radius around the metal pipe marking the location. Diameter of the sweep net collecting hoop was 38 cm. Arthropod captures were transferred to 1-L plastic Ziploc® bags, stored on ice in a cooler until they could be stored in a freezer. Pollinators were collected with pan traps. The traps were set up at 5 sample points in each of RP, OF, and RCG, for three times (June, July, and August) in 2016. Each trap consisted of a white plastic square container 30 cm x 20 cm x 10 cm, filled with approximately 500 mL of soapy water (tap water plus a few drops of dish soap), resting atop a tomato cage (1.1 m height). All captures were transferred to a 125 mL plastic Nalgene container and stored in 70% isopropyl alcohol.

2.3 Statistical Analysis

All captured arthropods were identified to family level and enumerated. Cover values of plant species occurring in each of the 29 sites were extracted from the data collected by Choi (unpublished) in 2013. Relative abundance (or importance) of each arthropod family (or plant species) was determined by multiplying 100 to the fraction of each family abundance (or species

cover) to total abundance (or cover) in each site. Diversity of arthropod families (or plant species) were determined by Shannon-Wiener Index (H' ; Shannon and Weaver, 1949).

Abundance (or cover), richness, diversity of arthropod families (or plant species) among the four sites (RP1, RP2, OF, and RCG) were compared with one-way analysis of variance (ANOVA) using STATISTIX Version 10 (Analytical Software, 2013).

The relative importance values of 42 arthropod families (families with >30 individuals collected) (Appendix III) and 29 plant species (ones with highest relative importance) (Appendix II) were inputted into two separate matrices; arthropod and plant as primary and secondary respectively and subjected to canonical correspondence analysis (CCA) ordination of PC-ORD Version 6 (McCune and Medford, 2006; MjM Software, 2011).

All arthropods were grouped into one of six functional groups – sap-sucking herbivores, grazing herbivores, predators, detritivores, scavengers, and pollinators – following the identification guide by Marshall (2006). A subset of herbivores was separated out based on relative size (< 1.0 cm) as small herbivores which are potential prey for predatory arthropods. All plants were sorted into three functional groups of forbs (herbaceous plant that is not a grass), cool-season C_3 , and warm-season C_4 grass. Abundance (or cover), relative abundance (or importance), richness, and diversity of the six arthropod and three plant functional groups among the four sites (RP1, RP2, OF, and RCG) were compared with one-way analysis of variance (ANOVA), followed by Tukey's pairwise mean comparison, using STATISTIX Version 10 (Analytical Software, 2013). In addition, H' of the six arthropod functional groups for RP1, RP2, OF, and RCG were calculated and compared with the ANOVA and Tukey procedure.

Correlations between the arthropods and plant variables were determined with linear regression of STATISTIX Version 10 (Analytical Software, 2013). Abundance, family richness,

diversity of taxonomic and functional group of arthropods were the dependent variables of the cover and diversity (H') of plant taxonomic, and functional groups. Correlations between ground-dwelling arthropods (dependent variable) and small herbivore abundance (independent variable) was also determined.

CHAPTER 3. RESULTS

3.1 Plant Diversity and Richness

The restored RP sites exhibited significantly higher richness and diversity of plant species than the unrestored OF and RCG sites ($p < 0.05$; Table 1; Figure 2). A majority of grasses in RP consisted of several warm-season C_4 species including big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*) and Indian grass (*Sorghastrum nutans*), whereas the OF and RP were dominated by two cool-season C_3 grasses – reed canary grass and Kentucky bluegrass (*Poa praetensis*). Canada goldenrod (*Solidago canadensis*) shares a substantial amount of dominance in the OF sites. RCG sites were nearly a monospecific stand of reed canary grass. Diversity and richness of forb species were also significantly higher in RP than OF and RCG sites ($p < 0.05$; Table 1), according to the data collected by Choi (unpublished) in 2013.

3.2 Arthropod Diversity and Richness

A total of 35,408 arthropods, belonging to 13 orders and 90 families (Appendix I), were captured (Table 2). Subphylum Hexapoda (insects), constituted over 80% of the arthropods captured. A majority (>50%) of the arthropods belonged to Order Coleoptera (beetles). Subphylum Chelicerata (spiders) accounted for 19% of the totals dominated by individuals in the Order Opiliones (daddy-long legs). Subphylum Myriapoda accounted for 1% of the total, primarily Order Julida (millipedes) (Table 2).

Herbivores and pollinators were more abundant in RP1 and RP2 than OF and RCG sites ($p < 0.05$; Table 3). Predators were more abundant in RCG than the others ($p < 0.05$; Table 3). Scavengers were most abundant in RP2 followed by OF, RCG, and RP1 ($p < 0.05$; Table 3).

There was no significant difference in detritivore abundance among the four sites ($p > 0.05$; Table 3). Sap sucker diversity was higher in OF and RCG than RP1 and RP2 ($p < 0.05$; Table 3). Predator diversity was highest in OF, followed by RP2, RCG and RP1 ($p < 0.05$; Table 3). Detritivore diversity was highest in RCG and lowest in RP1 ($p < 0.05$; Table 3). Pollinator and scavenger diversity were similar among the four sites ($p > 0.05$; Table 3). Taxa diversity and richness at family level were not different significantly among the four sites for all functional groups (Table 4).

3.3 Arthropod Community Assembly

The taxonomic diversity of both arthropod and plant taxonomic diversity had no significant correlation ($r = -0.18$; $p = 0.2$) (Figure 3A). However, the diversity of the arthropod functional groups was slightly higher in RP1 and RP2 than OF and RCG sites ($p > 0.05$; Table 3) significantly, positively correlating with plant functional group diversity ($r = 0.35$; $p < 0.05$) (Figure 3B). The higher diversity in RP1 and RP2 was mainly due to their higher evenness among the six functional groups. For example, RCG sites are highly biased to predators (Figure 4). Furthermore, the CCA ordination (Figure 5) reveals a clear divergence of arthropod assemblies in RP (signified by the letter “P” on the right side of the graph), RCG (the letter “G” on the upper-left side of the graph) and OF sites (letter O on the lower-left side of the graph).

Pollinators, such as sweat bees (Halictidae - HALT; Figure 5), micromoths (Microlepidoptera, UMOTH), and hoverflies (Family Syrphidae, SYRPH) corresponded to the gray golden rod (*Solidago nemoralis*, SONE), rattlesnake master (*Eryngium yuccifloium*, ERYU), little bluestem (*Schizachyrium scoparium*, SCSC), Indian grass (*Sorghastrum nutans*, SONU), and compass plant (*Silphium laciniatum*, SILA) of RP vegetation. Some herbivores – such as broad-headed bugs (Alydidae, ALYD) and treehoppers (Membracidae, MEMBR) – and

carnivorous harvestmen spiders (Phalangiidae, PHALA) also showed a preference to the RP sites.

The presence of Lampyridae (LAMP), predatory firefly larvae, was related to Canada goldenrod (SOCA) of OF sites. In RCG sites predators, such as wolf spiders (Lycosidae, LYCO), and ground beetles (Carabidae, CARA), were strongly associated with monospecific stands of reed canary grass (*Phalaris arundinacea*, PHAR). Small herbivores, such as horned powder-post beetles (Bostrichidae, BOST), silvan flat bark beetles (Silvanidae, SILV), true bugs (Blissidae, BLIS), and certain tiny-sized grasshoppers (Acridae, ACRID), corresponded to the vegetation of OF and RCG. Plant bugs (Miridae, MIRID) and herbivorous sap-suckers the leafhoppers (Cicadellidae, CICA), , were also a characteristic of the RCG and OF sites.

3.4 Pollinators and Herbivores

Pollinator abundance was positively correlated to the diversity of plant species ($r = 0.62$; $p < 0.05$) (Figure 6A) particularly for the forbs ($r = 0.55$; $p < 0.05$) (Figure 6B), while the opposite was true for C₃ grass cover ($r = -0.52$; $p < 0.05$) (Figure 6C). Pollinators were 1.5 – 2 times more abundant in the RP site ($p < 0.05$; Table 3; Figure 4), where flowering plant diversity and richness was greatest ($p < 0.05$; Table 1). HALT and SYRPH were 6 – 7 and 5 – 50 times, respectively, more abundant in the RP than the OF and RCG sites. No UMOTH were captured in the OF and RCG sites (Table 5).

Herbivore abundance also increased with the diversity of plant species ($r = 0.41$; $p < 0.05$) (Figure 7A). It also increased with the increasing cover of C₄ grasses ($r = 0.49$; $p = 0.01$) (Figure 7C), while the opposite was true for C₃ grasses ($r = -0.37$; $p = 0.05$) (Figure 7B). Meanwhile, the diversity of herbivore families was negatively correlated with the diversity of plant species ($r = -0.57$; $p < 0.01$) (Figure 8A). It was also negatively correlated to C₄ grasses (r

= -0.68; $p < 0.01$) (Figure 8C), while the opposite was true for C_3 grasses ($r = 0.60$; $p < 0.01$) (Figure 8B).

Abundance of two small-body-size herbivore sap-sucker families, MEMBR and CICA (Suborder Auchenorrhyncha), exhibited contrasted correlations to plant species richness and diversity. CICA abundance was negatively correlated to forb species diversity ($r = -0.50$; $p < 0.01$) (Figure 9A) and the cover of C_4 grasses ($r = -0.51$; $p < 0.01$) (Figure 9C), and positively correlated to the C_3 grasses ($r = 0.58$; $p < 0.01$) (Figure 9B), while Membracidae showed the opposite ($r = 0.44$; $p < 0.05$; $r = 0.38$; $p < 0.05$) (Figures 10A and B).

3.5 Predators

Predators were most abundant in the RCG sites ($p < 0.05$; Table 3), where the plant species richness and diversity were lowest ($p < 0.05$; Table 1). This has led to negative correlations between the predator abundance and plant species diversity ($r = -0.55$; $p < 0.01$) (Figure 11A). It was also negatively correlated to the covers of forbs ($r = -0.49$; $p < 0.01$) and C_4 grasses ($r = -0.55$; $p < 0.01$), and the opposite was true for C_3 grasses ($r = 0.34$; $p = 0.07$) (Figure 11B – D). Predators outnumbered herbivores in all four study sites. Their abundance was 4.4, 4.0, and 1.4 times greater than herbivore abundance in the RCG, OF, and RP sites respectively ($p < 0.05$; Table 3). The small herbivores, suggestive of prey for predators, were positively correlated with predators ($r = 0.55$; $p < 0.05$) (Figure 12A) of which ground-dwelling CARA and LYCO were the major taxa ($p < 0.05$; Table 5). These small herbivores also exhibited a strong positive correlation with the cover of C_3 grasses ($r = 0.49$; $p < 0.01$) (Figure 12B).

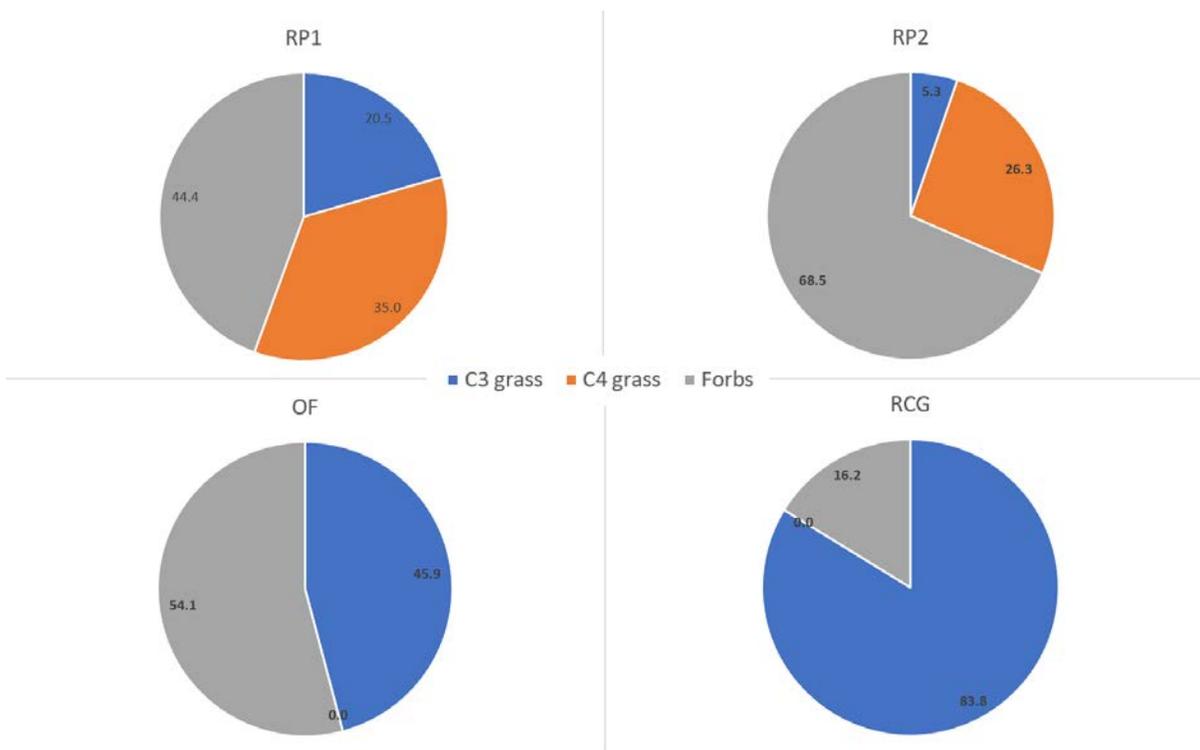


Figure 2: Composition (percent relative abundance) of the three plant functional groups (C₃ grasses, C₄ grasses, and Forbs) at the two restored sites (RP1, RP2), old field (OF), and reed canary grass stand (RCG).

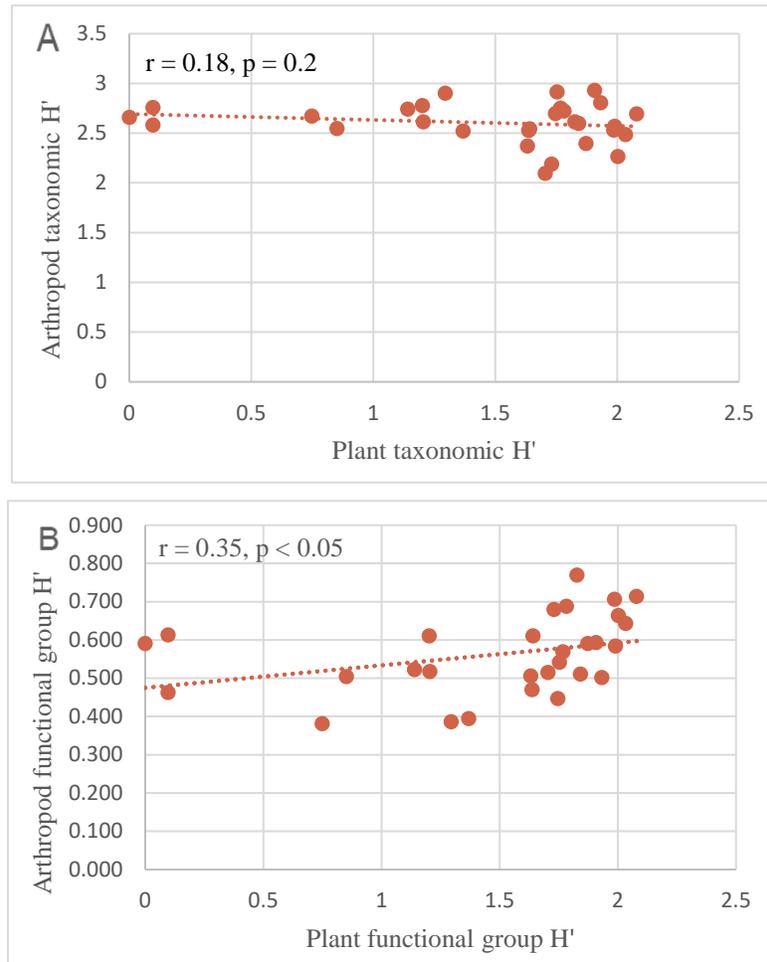


Figure 3: Scatter plots for (A) the linear regression analysis of arthropod taxonomic diversity (H') versus plant taxonomic diversity (H') at family level and (B) arthropod functional group diversity (H') versus plant functional group diversity (H'). Correlation coefficient (r) and probability of type I error (p) are given in each regression.

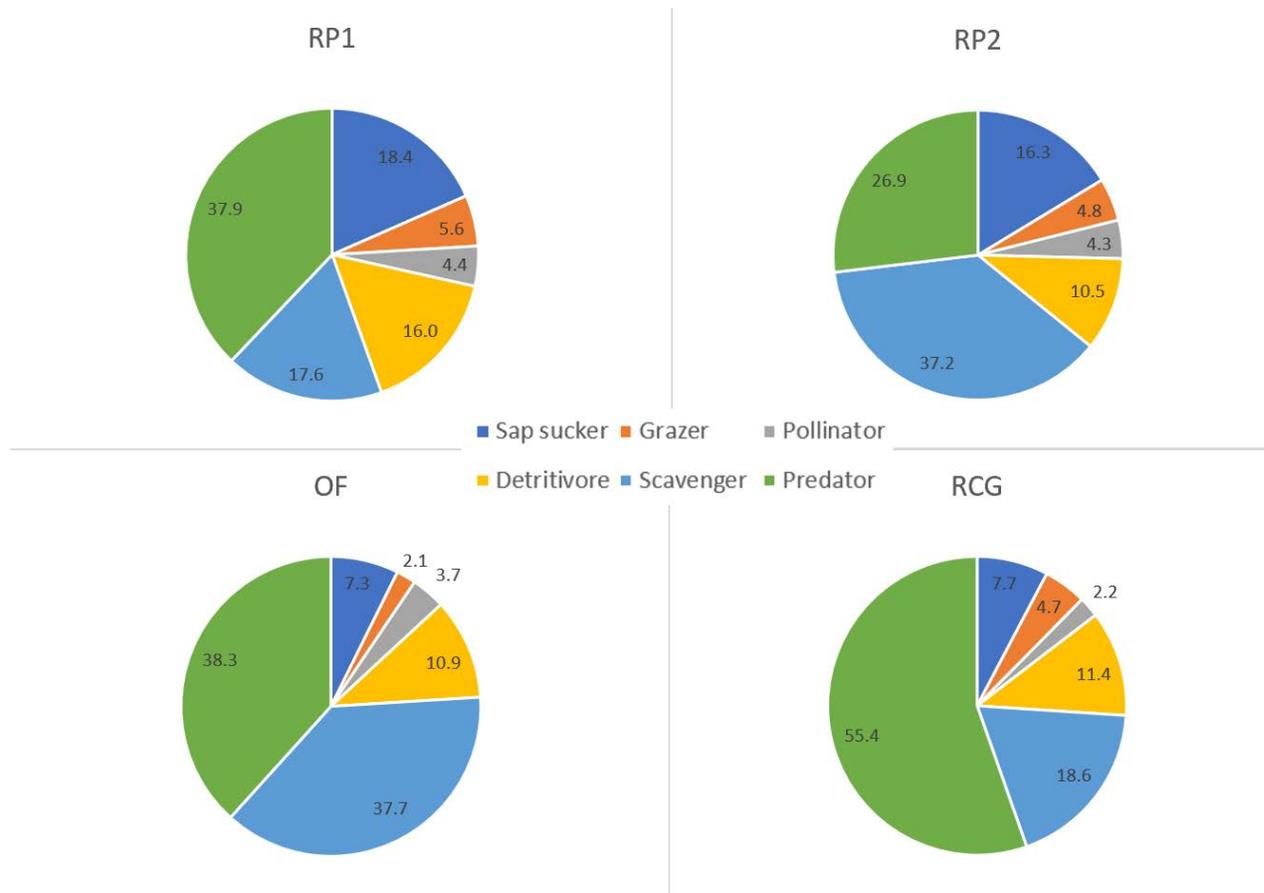


Figure 4: Composition (percent relative abundance) of the six arthropod functional groups at the two restored sites (RP1, RP2), old field (OF), and reed canary grass stand (RCG).

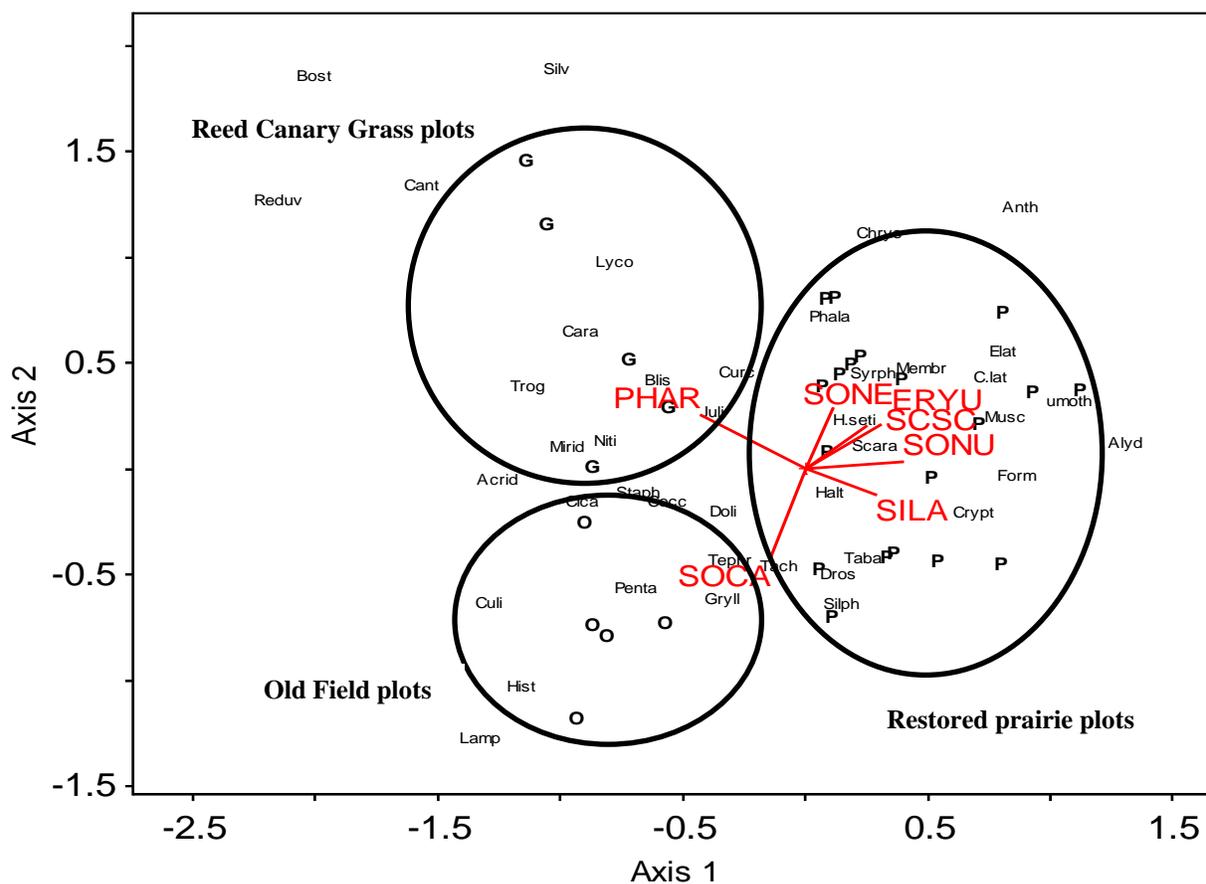


Figure 5: Canonical Correspondence Analysis ordination of 42 arthropod families overlaid with correspondence to the plant species from the 29 plots at Gabis Gardens in Valparaiso, IN. Restored prairie, old field, and reed canary grass plots are signified with the letter P, O and G, respectively. Each arthropod family is signified with an acronym that comes from the first 4-5 letters of family. See Appendix II and III for the full family names. Acronyms for plant species come from first two letters of genus and species names (PHAR *Phalaris arundinacea*, SOCA *Solidago canadensis*, SONE *Solidago nemoralis*, ERYU *Eryngium yuccifolium*, SCSC *Schizachyrium scoparia*, SONU *Sorghastrum nutans*, SILA *Silphium laciniatum*).

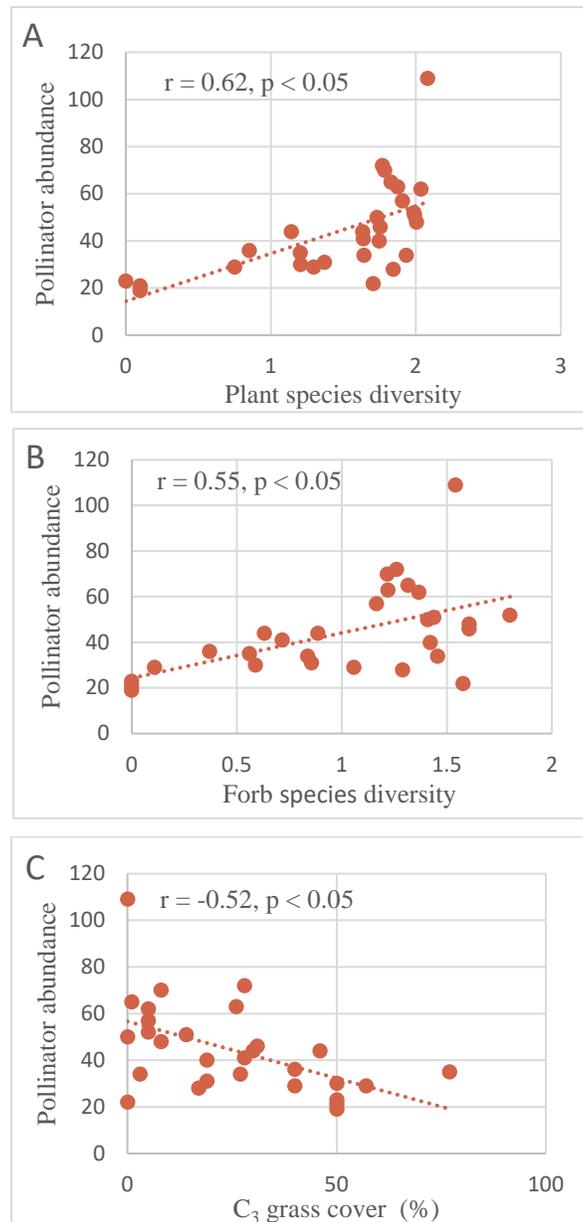


Figure 6: Scatter plots for the linear regression analysis of pollinator abundance on the following (top to bottom): (A) plant species diversity, (B) forb species diversity, (C) C₃ grass cover (%). Correlation coefficient (r) and probability of type I error (p) are given in each regression.

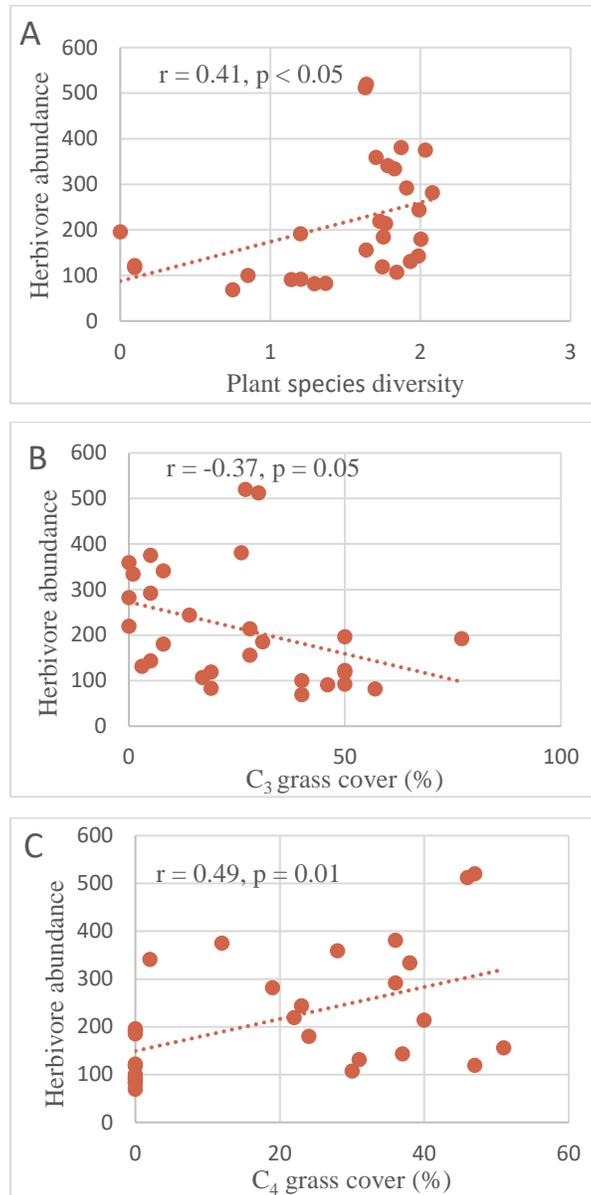


Figure 7: Scatter plots for the linear regression analysis of herbivore abundance on the following (top to bottom): (A) plant species diversity, (B) C₃ grass cover (%), (C) C₄ grass cover (%). Correlation coefficient (r) and probability of type I error (p) are given in each regression.

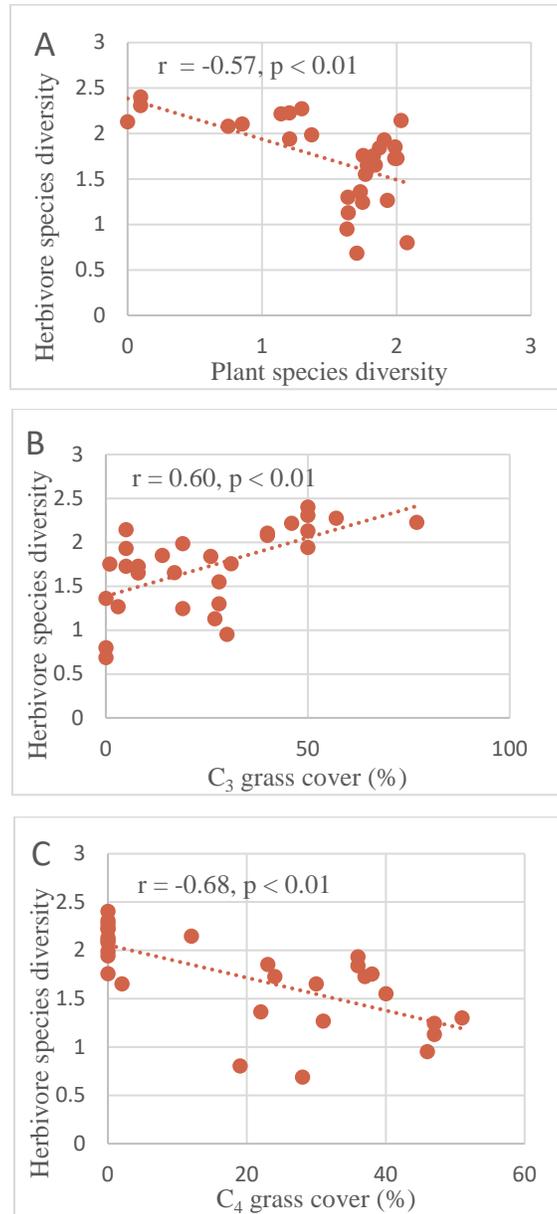


Figure 8: Scatter plots for the linear regression analysis of herbivore diversity on the following (top to bottom): (A) plant species diversity, (B) C₃ grass cover (%), (C) C₄ grass cover (%). Correlation coefficient (r) and probability of type I error (p) are given in each regression.

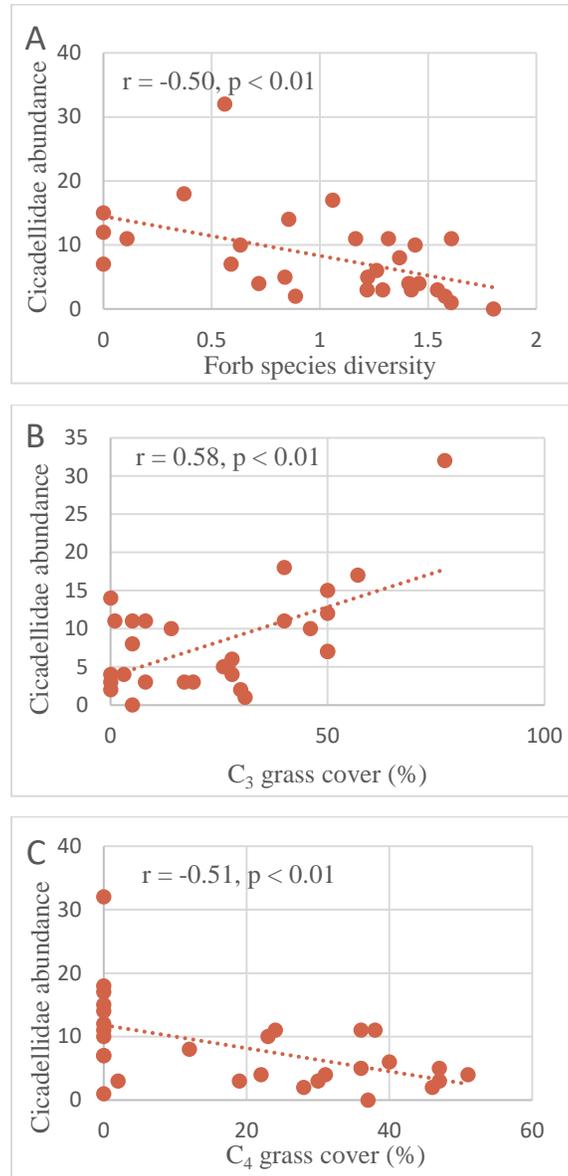


Figure 9: Scatter plots for the linear regression analysis of Cicadellidae abundance on the following (top to bottom): (A) forb species diversity, (B) C₃ grass cover (%), (C) C₄ grass cover (%). Correlation coefficient (r) and probability of type I error (p) are given in each regression.

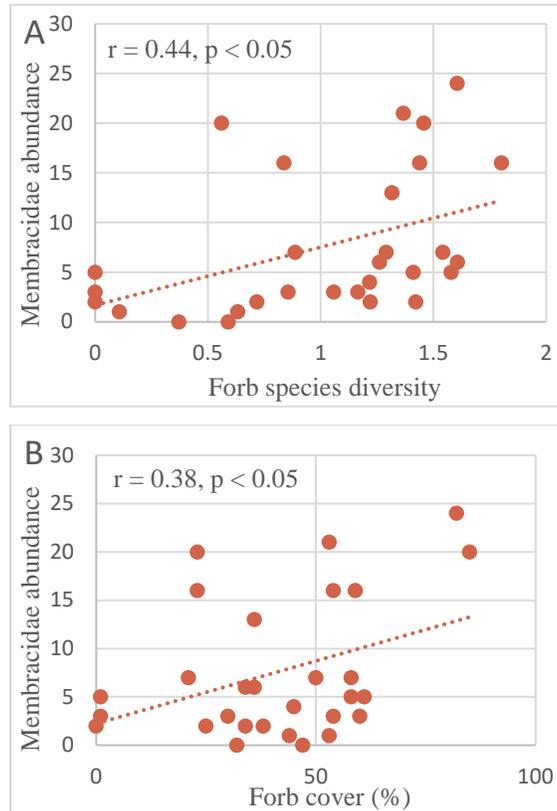


Figure 10: Scatter plots for the linear regression analysis of Membracidae abundance on the following (top to bottom): (A) forb species diversity and (B) forb cover (%). Correlation coefficient (r) and probability of type I error (p) are given in each regression.

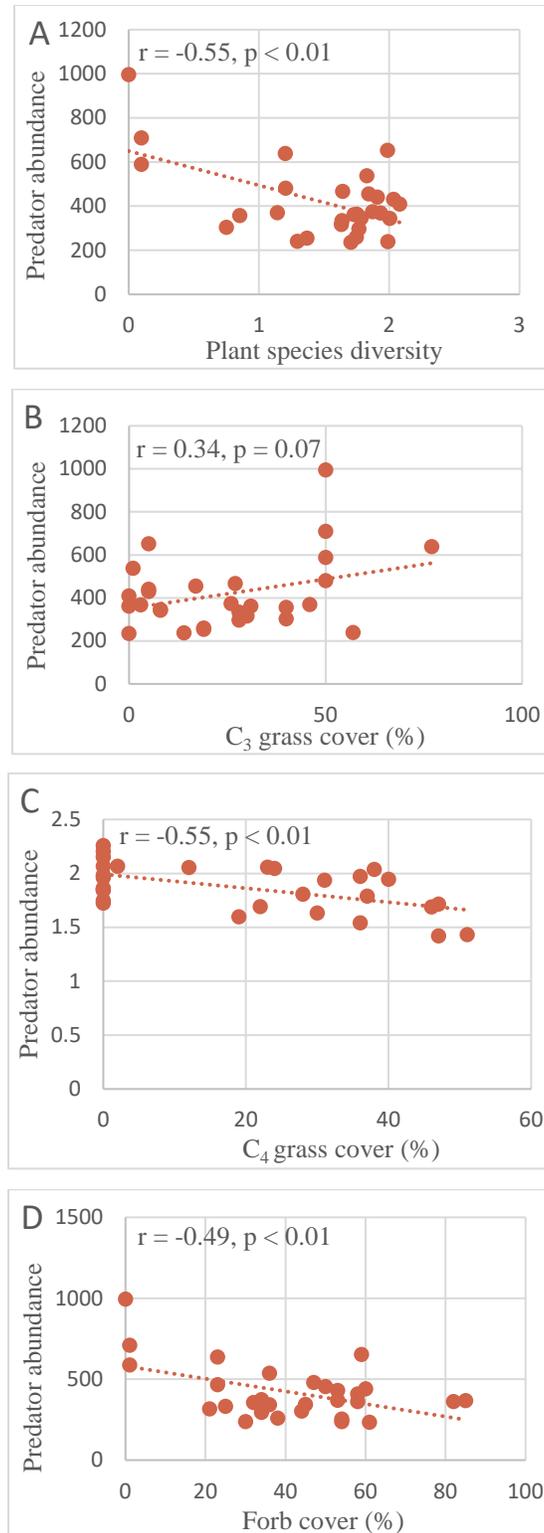


Figure 11: Scatter plots for the linear regression analysis of predator abundance on the following (top to bottom): (A) plant species diversity, (B) C_3 grass cover (%), (C) C_4 grass cover (%), (D) forb cover (%). Correlation coefficient (r) and probability of type I error (p) are given in each regression.

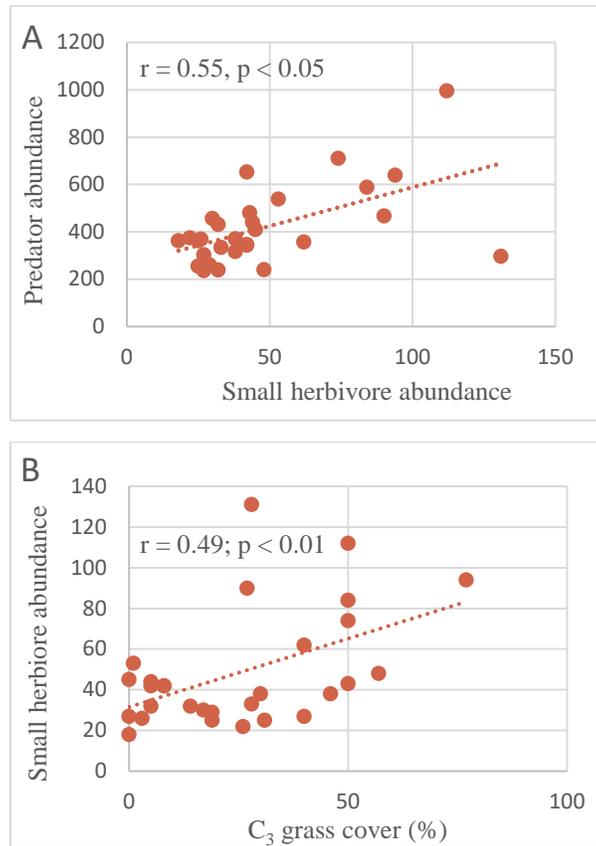


Table 1: Plant Cover, Richness, and Diversity. Mean (\pm standard error of mean) cover, diversity (Shannon-Weiner Index, H'), and richness (number of species, S) of three functional groups (forb, C₃, and C₄ grass) in the restored prairie (RP), old field (OF), and reed canary grass (RCG) sites. Values sharing the same alphabet letter are not statistically different at $\alpha = 0.05$ for each parameter in Tukey's pair wise mean comparison. Adopted from the data collected by Choi in 2013 (unpublished). Probability of type I error (p) is given to each one-way analysis of variance (ANOVA).

Parameter	Functional group	RP1 (n=10)	RP2 (n=9)	OF (n = 5)	RCG (n = 5)	P
Cover (%)	Forbs	44.4 \pm 7.4 ^A	68.5 \pm 3.3 ^A	54.1 \pm 4.0 ^B	16.2 \pm 6.4 ^A	p < 0.05
	C4 Grass	35.0 \pm 4.6 ^A	26.3 \pm 3.5 ^B	0.0 \pm 0.0 ^C	0.0 \pm 0.0 ^C	p < 0.05
	C3 Grass	20.5 \pm 3.2 ^A	5.3 \pm 1.5 ^B	45.9 \pm 5.3 ^C	83.8 \pm 5.2 ^D	p < 0.05
	All	40.2 \pm 0.1 ^A	30.2 \pm 0.2 ^{A,B}	16.4 \pm 0.2 ^{A,B}	13.1 \pm 0.1 ^B	p < 0.05
Diversity (H')	Forbs	1.335 \pm 0.1 ^A	1.580 \pm 0.0 ^A	0.711 \pm 0.3 ^B	0.324 \pm 0.2 ^B	p < 0.05
	C4 Grass	0.526 \pm 0.1 ^A	0.406 \pm 0.1 ^A	0.0 \pm 0.0 ^B	0.0 \pm 0.0 ^B	p < 0.05
	C3 Grass	0.0 \pm 0.0 ^A	0.0 \pm 0.0 ^A	0.261 \pm 0.1 ^{A,B}	0.226 \pm 0.1 ^B	p < 0.05
	All	1.896 \pm 0.0 ^A	1.781 \pm 0.0 ^A	1.063 \pm 0.1 ^B	0.538 \pm 0.3 ^C	p < 0.05
Richness (S)	Forbs	5.8 \pm 0.4 ^A	7.2 \pm 0.4 ^A	3.4 \pm 0.7 ^B	1.8 \pm 0.7 ^B	p < 0.05
	C4 Grass	1.9 \pm 0.2 ^A	2.0 \pm 0.2 ^A	0.0 \pm 0.0 ^B	0.0 \pm 0.0 ^B	p < 0.05
	C3 Grass	1.0 \pm 0.0 ^A	1.0 \pm 0.0 ^A	1.6 \pm 0.2 ^{A,B}	1.4 \pm 0.2 ^B	p < 0.05
	All	10.1 \pm 0.5 ^A	8.7 \pm 0.3 ^A	5.0 \pm 0.8 ^B	3.2 \pm 1.0 ^B	p < 0.05

Table 2: Arthropod Capture Totals. Number of arthropod captures during 2014 to 2016 sampling period. Grouped according to Subphylum and Order, total family count, total abundance (sum), and percent of the total captures (% share).

Subphylum	Orders	Number of Families	Sum	% Share
Hexapoda	Coleoptera	26	19293	54
	Hemiptera	17	4695	13
	Diptera	17	2418	7
	Hymenoptera	8	1350	4
	Lepidoptera	6	434	1
	Orthoptera	7	285	1
	Mecoptera	1	10	<0.1
	Phasmatodea	1	4	<0.1
	Mantodea	1	3	<0.1
	Opiliones	1	4500	13
Chelicerata	Araneae	1	2004	6
	Julida	3	381	1.1
Myriapoda	Lithobiomorpha	1	31	0.1
	All	90	35408	100

Table 3: Arthropod Functional Group Captures. Mean (\pm standard error of mean) abundance (number of individuals), richness (number of families, S) and diversity (Shannon-Weiner diversity, H') of arthropod functional groups captured at restored prairie (RP1, RP2), old field (OF) and reed canary grass (RCG) sites. Values sharing the same alphabet letter are not statistically different at $\alpha = 0.05$ for each parameter in Tukey's pair wise mean comparison. Probability of type I error (p) is given to each one-way analysis of variance (ANOVA).

Parameter	Arthropod Trophic Guild	RP1 (n=10)	RP2 (n=9)	OF (n = 5)	RCG (n = 5)	p-value
Arthropod Abundance	Predator	389.0 \pm 35.7 ^A	371.9 \pm 32.3 ^A	353.4 \pm 37.9 ^A	634.8 \pm 121.3 ^B	< 0.05
	Sap sucker	189.0 \pm 48.6 ^{A,B}	225.8 \pm 20.5 ^A	67.6 \pm 3.2 ^B	88.6 \pm 17.6 ^{A,B}	< 0.05
	Scavenger	180.2 \pm 26.1 ^{A,C}	515.0 \pm 61.5 ^B	347.6 \pm 41.7 ^{A,B,C}	213.0 \pm 59.7 ^{A,C}	< 0.05
	Detritivore	164.6 \pm 22.0 ^A	144.6 \pm 16.1 ^A	100.6 \pm 16.0 ^A	131.0 \pm 20.3 ^A	> 0.05
	Pollinator	59.3 \pm 4.3 ^{A,B}	45.4 \pm 7.7 ^A	34.0 \pm 2.8 ^B	25.4 \pm 2.9 ^B	< 0.05
	Grazer	57.8 \pm 9.8 ^{A,B}	66.0 \pm 8.8 ^A	19.4 \pm 3.4 ^B	53.4 \pm 9.8 ^{A,B}	< 0.05
	All	1069.9 \pm 88.8 ^A	1492.6 \pm 79.1 ^A	1001.6 \pm 82.3 ^A	1253.6 \pm 188.8 ^A	> 0.05
Arthropod Species Diversity (H')	Predator	1.696 \pm 0.1 ^A	1.926 \pm 0.1 ^{B,C}	2.13 \pm 0.05 ^C	1.83 \pm 0.05 ^{A,B}	< 0.05
	Grazer	1.235 \pm 0.1 ^A	1.352 \pm 0.1 ^A	1.501 \pm 0.2 ^A	1.695 \pm 0.1 ^A	> 0.05
	Pollinator	1.232 \pm 0.1 ^A	1.263 \pm 0.1 ^A	1.510 \pm 0.14 ^A	1.280 \pm 0.15 ^A	> 0.05
	Sap sucker	1.029 \pm 0.2 ^{A,C}	0.827 \pm 0.1 ^A	1.527 \pm 0.1 ^{B,C}	1.596 \pm 0.1 ^B	< 0.05
	Detritivore	0.647 \pm .01 ^A	0.867 \pm 0.1 ^{A,B}	0.980 \pm 0.08 ^B	0.960 \pm 0.03 ^B	< 0.05
	Scavenger	0.564 \pm 0.1 ^A	0.360 \pm 0.1 ^A	0.300 \pm 0.04 ^A	0.660 \pm 0.21 ^A	> 0.05
	All	1.580 \pm 0.04 ^A	1.530 \pm 0.04 ^A	1.380 \pm 0.05 ^A	1.320 \pm 0.04 ^A	> 0.05

Table 4: Regression Analyses of Arthropods. Regression analyses (r-values) between plant (independent variable) and arthropods (dependent variable) for richness (number of families, S) and diversity (Shannon-Weiner diversity, H') of arthropod functional groups captured at restored prairie (RP1, RP2), old field (OF) and reed canary grass (RCG) sites.

	Arthropod Functional Group		Plant Species H' (r)		Plant Species H' (p)		Plant Cover (%) (r)		Plant Cover (%) (p)	
Arthropod Species Richness (S)	Pollinator		0.18	> 0.05	-0.18	> 0.05				
	Predator		0.16	> 0.05	0.165	> 0.05				
	Sap Sucker		0.08	> 0.05	0.056	> 0.05				
	Grazer		0.04	> 0.05	0.203	> 0.05				
	Scavenger		-0.08	> 0.05	0.01	> 0.05				
	Detritivore		-0.12	> 0.05	-0.132	> 0.05				
Arthropod Species Diversity (H')	Predator		-0.11	> 0.05	-0.142	> 0.05				
	Scavenger		-0.12	> 0.05	-0.132	> 0.05				
	Pollinator		-0.18	> 0.05	-0.144	> 0.05				
	Detritivore		-0.29	> 0.05	-0.215	> 0.05				
	Grazer		-0.388	< 0.05	0.301	> 0.05				
	Sap Sucker		-0.57	< 0.05	-0.366	< 0.05				

Table 5: Major Arthropod Families. Mean (\pm standard error of mean) abundance (number of individuals) of major arthropod families and functional groups in the restored prairies (RP1 and RP2), old field (OF) and reed canary grass (RCG) stand. Values sharing the same alphabet letter are not statistically different at $\alpha = 0.05$ for each parameter in Tukey's pair wise mean comparison. Probability of type I error (p) is given to each one-way analysis of variance (ANOVA).

Family	Functional Group	RP1 (n=10)	RP2 (n=9)	OF (n=5)	RCG (n=5)	p-value
Curculionidae	Grazer	24.8 \pm 9.4 ^A	15.2 \pm 1.5 ^A	14.2 \pm 3.8 ^A	22.4 \pm 3.0 ^A	> 0.05
Chrysomelidae	Grazer	11.2 \pm 3.6 ^A	7.6 \pm 1.9 ^A	0.2 \pm 0.2 ^A	14.8 \pm 5.5 ^A	> 0.05
Blissidae	Grazer	4.6 \pm 0.9 ^A	6.9 \pm 1.8 ^{A,B}	5.4 \pm 1.4 ^A	13.6 \pm 2.8 ^B	< 0.05
Acridae	Grazer	1.0 \pm 0.3 ^A	0.3 \pm 0.2 ^A	4.4 \pm 1.9 ^A	4.0 \pm 2.3 ^A	> 0.05
Silvanidae	Grazer	0.9 \pm 0.9 ^A	0.0 \pm 0.0 ^A	1.2 \pm 1.2 ^A	2.2 \pm 1.7 ^A	> 0.05
Bostrichidae	Grazer	0.8 \pm 0.2 ^A	0.2 \pm 0.1 ^A	1.6 \pm 1.4 ^{A,B}	8.8 \pm 5.4 ^B	< 0.05
Coccinellidae	Grazer	0.0 \pm 0.0 ^A	2.6 \pm 0.9 ^C	0.0 \pm 0.0 ^{A,B}	2.6 \pm 0.4 ^{B,C}	< 0.05
Alydidae	Sap Sucker	141.9 \pm 51.1 ^{A,B}	181.2 \pm 20.7 ^A	19.8 \pm 3.9 ^B	27.6 \pm 9.6 ^{A,B}	< 0.05
Miridae	Sap Sucker	4.3 \pm 1.7 ^A	4.8 \pm 0.9 ^A	12.2 \pm 3.0 ^B	11.0 \pm 2.0 ^{A,B}	< 0.05
Cicadellidae	Sap Sucker	3.3 \pm 0.6 ^A	7.0 \pm 1.3 ^{A,B}	12.0 \pm 1.9 ^{B,C}	16.6 \pm 4.2 ^C	< 0.05
Membracidae	Sap Sucker	50.5 \pm 12.4 ^A	37.5 \pm 11.7 ^A	1.0 \pm 0.5 ^A	6.2 \pm 3.6 ^A	> 0.05
Halictidae	Pollinator	16.0 \pm 5.3 ^A	19.0 \pm 6.3 ^A	11.2 \pm 1.8 ^A	14.2 \pm 1.7 ^A	> 0.05
Micromoths	Pollinator	14.1 \pm 4.4 ^A	25.7 \pm 8.9 ^A	0.0 \pm 0.0 ^A	0.0 \pm 0.0 ^A	> 0.05
Syrphidae	Pollinator	5.6 \pm 1.8 ^A	2.4 \pm 0.8 ^A	4.0 \pm 0.0 ^A	0.4 \pm 0.2 ^A	> 0.05
Lycosidae	Predator	69.5 \pm 12.3 ^A	36.1 \pm 9.7 ^A	47.0 \pm 12.1 ^A	149.8 \pm 26.3 ^B	< 0.05
Carabidae	Predator	15.6 \pm 2.5 ^A	34.7 \pm 7.7 ^A	25.2 \pm 8.1 ^A	87.2 \pm 31.0 ^B	< 0.05
Phalangidae	Predator	184.6 \pm 21.9 ^A	139.3 \pm 15.3 ^{A,B}	61.6 \pm 12.2 ^B	218.4 \pm 43.9 ^A	< 0.05
Lampyridae	Predator	6.2 \pm 1.6 ^A	23.7 \pm 8.3 ^A	81.8 \pm 21.0 ^B	26.2 \pm 17.4 ^A	< 0.05

CHAPTER 4. DISCUSSION

4.1 Plant Diversity on Arthropod Assembly

No concrete evidence was found in support of the first hypothesis “enhanced richness and diversity of plant species promotes the diversity of arthropod taxa” in this study (Figure 3A; Table 3; Haddad et al., 2001; Haddad et al., 2009; Siemann et al., 1998). The arthropods captured by the three methods – pitfall trap, net-sweeping, and pan trap – in this study would probably not reflect its whole spectrum, particularly the microscopic ones. Also, each of the three samplings were conducted for only one growing season. Considering the dynamic nature of arthropod assembly, a multi-year sampling might bring a different result. Moreover, my arthropod identification was limited to family, except in a few cases. Thus, the taxonomic diversity of arthropod in this study did not reach to species. For this reason, I do not necessarily reject this hypothesis at this time.

No apparent source population of prairie specialists is located in close proximity to Gabris Arboretum. However, edge effects have likely played a role in our captures. The OF and RCG sites are located in a close proximity to wooded areas, therefore, there is a strong chance for the woodland species, such as certain species of family Silphidae, travel to these sites in search of food. A vast majority of the arthropods in the three sites were more likely a generalist population. However, a few taxa exhibited potential specificity to the habitats of restored prairies. Reflective of their preference for the nitrogen rich legumes (Silva et al., 2010; Ventura et al., 2000), Alydidae were also found in the greatest abundance at restored sites where legumes were located. Larvae of Chrysomelidae, which are herbivores, detritivores or both, are often found encased in plant debris or fecal matter (Marshall, 2008). In my study, they were captured almost exclusively in the restored prairie sites, suggesting their preference to the plants of

restored prairie. *Campylenchia latipes* (white-footed treehopper) of Membracidae is often found on goldenrods in disturbed areas (Marshall et al., 2008). This species was captured only in the restored sites where *Solidago nemoralis* (gray goldenrod) occurred. These observations may not necessarily support the host-specificity of such taxa as Alydidae, Chrysomelidae, and *Campylenchia latipes* to the plants of restored prairies at this time. However, it is clear that the presence of these taxa has contributed to the divergence of arthropod assembly in the restored prairie sites (Figure 5). Such plant-herbivore relations need to be investigated further.

The higher diversity of arthropod functional groups in the RP sites (Table 3) suggests that the restoration of prairie vegetation appears to promote the functional, rather than taxonomic, diversity of arthropods (Figure 3A – B). The CCA shown in Figure 5 supports the second hypothesis. The prairie restoration leads to a clear divergence in the arthropod assemblages from the unrestored old field and reed canary grass stand, which are characterized by lower richness and diversity of plant species and the dominance of C₃ grasses (Table 1, Figure 2). Comparable results were reported in literature (e.g., Nemeč et al., 2008, Gardner et al., 2009, Kutschbach-Brohl et al., 2010, Cook-Patton et al., 2011). A strong bias in the arthropod assemblages, as reflected by the lower evenness (Table 3, Figure 4) in OF and RCG, suggests that such divergence is driven by functional groups rather than taxa.

4.2 Pollinators and Herbivores

The higher abundance of pollinators in RP sites (Table 3) was mainly due to the presence of flowering forbs (Figure 6B). This result is consistent with Litt et al. (2014) who found reduced abundance of pollinators in the stands of invasive grasses. The forbs did not appear to promote the diversity of pollinator families in RP1 and RP2 (Table 4) for now. However, my

sampling period was limited to only one growing season. Further monitoring for an extended period is needed to conclude whether pollinator diversity is promoted by forb diversity.

Kutschbach-Brohl et al. (2010) argued that the plant communities with higher forb abundance, particularly with legumes that have high N tissue content (Haddad et al., 2009), may provide phenologically consistent available food resources and a more diverse habitat structure offering increased refuge opportunities. The positive correlation revealed in Figure 7A and C, driven by the major herbivorous taxa, the leguminous sap-sucker Alydidae (Ventura et al., 2000), agrees with Haddad et al. (2001; 2011) who reported a positive link between the plant species diversity and herbivore abundance. Although C₄ grasses are generally less palatable (Haddad et al., 2009) this positive correlation suggests abundant herbivore populations can be supported by a diverse habitat including a rich diversity of forbs and C₄ grasses such as present at RP1 and RP2, supplying resources for both nutritional (forb) and refuge (grass/forb mix) needs (Table 1; Figure 2).

The positive correlation between the C₃ grass cover and small herbivore abundance (Figure 12B) aligns with palatability. Due to its high protein content, C₃ grasses have been regarded more palatable to herbivores (Caswell et al., 1973; Tschardtke and Greiler, 1995; Haddad et al., 2001; Fetcher et al., 2015), and a reliable source of food for smaller herbivores in this monoculture (Root, 1973; Russell, 1989). As suggested by strong correlations with many parameters in this study (Figures 6C, 7B, 8B, 9B, 11B, 12B), the cover of C₃ grasses appeared to be a major driving force for divergence of arthropod assemblages in the RCG sites (Figure 5). Similar findings have been reported elsewhere in literature (e.g., Haddad et al., 2000; Emery et al., 2015; Kutschbach-Brohl et al., 2010).

Abundance of small-herbivore arthropods may depend on structural complexity of the plant community. Nemeč et al. (2008) reported that the abundance of small herbivores is tied to its host plants, while Wallner et al. (2012) found generalist herbivore Auchenorrhyncha can thrive among exotic plants (Wallner et al., 2012). The simplified vertical structure (Kutschbach-Brohl et al. 2010) of C₃ reed canary grass in the RCG sites could be a favored habitat for an insect (Lawton and Schroder, 1977; Joern, 1982; Nemeč et al., 2014) like Cicadellidae as shown in Figure 9B.

On the other side, the increasing abundance of Membracidae with forb diversity and cover (Figure 10) was likely favored by the complex structure of plant community. Structural complexity, resulting from the combination of diverse forb and grass species, may allow greater access to woody plant species for feeding, resting, over-wintering or oviposition (Dietrich et al., 1999; Nemeč et al., 2008). Therefore, the discrepancy between the abundance of Cicadellidae and Membracidae was likely due to their host and site specificity. The complex structure of diverse plant species in the restored prairie favors Membracidae, while Cicadellidae was fostered by the simpler structure of monospecific reed canary grass stand.

4.3 Predators

As shown in Table 3 and Figure 11, predators occurred most in the RCG sites where plant species richness and diversity were lowest and the C₃ grass cover was highest. Ground beetles and spiders in the RCG were significantly more abundant than at the RP and OF sites holding, >50% of all predator abundance (Table 5), positively correlating with lower diversity habitat and C₃ grass cover (Figure 11A and B) found at RCG sites. Grass stands may allow greater predatory success by offering a simpler vertical structure that may reduce hiding places for potential prey (Hunter and Price, 1992; Atherton, 2013).

According to resource concentration hypothesis, abundant herbivorous populations can be supported by a concentrated, homogeneous food supply, such as at sites overtaken by an invasive plant species (Root, 1973; Beaulieu and Wheeler, 2002; Tallamy, 2004; Spyreas et al., 2010; Wallner et al., 2012). Simplified vegetation structure, as found in the RCG site, can be advantageous for predators to capture prey (Hunter and Price, 1992; ; Schuldt et al., 2011; Atherton, 2013; Nemeč et al., 2014). My results (Figures 4, 12B and Tables 3, 5) in the RCG sites contradicts the notion where greater predator abundance and diversity correlates with increasing plant diversity (Root, 1973; Haddad et al., 2001; Haddad et al., 2009). The monospecific RCG stand was dominated by a robust predator population primarily constituted of CARA, LYCO, and PHAL (Table 5) with a more diverse herbivore community (Table 3; Figure 8A and B). These data lend support to the use of monocultures in applications where plant diversity is not desired, such as use in phytoremediation (Gersberg et al., 1986; Weis and Weis, 2004), though bioaccumulation in arthropod herbivores may be a concern depending on the application.

The low plant diversity and simple vertical structure of the monospecific RCG sites may account for the greater abundance of the active, predatory CARA beetles and ground-dwelling spiders. The structurally simple monoculture grass stand could allow for increased motility (Koricheva et al., 2000; Litt et al., 2014) and theoretically lead to increased success in preying on the diverse small herbivores like CICA (Nyffeler and Benz, 1988; Nyffeler, 1999; Kielty et al., 2002) leading to greater fitness. Together, these results help explain the divergence between the RCG, old field, and restored prairie sites.

CHAPTER 5. CONCLUSIONS

Diversity of plant species was greater in the restored prairie than the old field and reed canary grass sites; however, it did not correspond to a greater diversity of arthropod taxa at family level. Meanwhile, I found a higher diversity of functional groups of arthropods in the restored prairie. Also, a clear divergence of arthropod communities in restored prairie from the old field and reed canary grass sites corresponds to the plant communities they inhabit. I attribute the divergence to the enhanced plant species diversity established by prairie restoration.

Pollinators were more abundant in the restored prairie where forb diversity and abundance were greatest. Herbivore abundance was also greatest at the restored prairie sites where the plant community was more diverse in regards species and structure. This led to arthropod functional groups greater evenness and thus diversity at the restored prairie sites. Predator abundance was significantly higher and herbivore abundance lower in the monospecific reed canary grass sites where herbivore diversity was greatest.

Given the apparent non-random distribution of arthropods among the field types, my results suggest plant community composition has a significant effect on arthropod community composition. The monoculture grass stand was found to have a predator dominated arthropod community supported by a diverse small herbivore community. In conclusion, the restoration of native prairie appears to elevate compositional and structural diversity of plant communities, increase the abundance of pollinators and herbivores, and balance and diversify the functional groups of arthropods. Prairie restoration is strongly recommended for the old field and reed canary grass stands of Gabis Arboretum.

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APPENDIX I: LIST OF ARTHROPOD TAXA FOUND IN THE STUDY SITES

Order	Family	Genus species
Araneae	Lycosidae	
Coleoptera	Anthicidae	
Coleoptera	Blattodea	
Coleoptera	Bostrichidae	
Coleoptera	Cantharidae	
Coleoptera	Cantharidae	<i>Chauliognathus pensylvanicus</i>
Coleoptera	Carabidae	
Coleoptera	Chrysomelidae	<i>Cryptocephalinae</i> spp.
Coleoptera	Chrysomelidae	<i>Plagiodora versicolora</i>
Coleoptera	Chrysomelidae	<i>Anomoea laticlavata</i>
Coleoptera	Cleridae	
Coleoptera	Coccinellidae	
Coleoptera	Curculionidae	
Coleoptera	Dermestidae	
Coleoptera	Elateridae	
Coleoptera	Geotrupidae	
Coleoptera	Histeridae	
Coleoptera	Lampyridae	
Coleoptera	Mordellidae	
Coleoptera	Nitidulidae	
Coleoptera	Popillia japonica	
Coleoptera	Ptilodactylidae	
Coleoptera	Scarabaeidae	<i>Phanaeus vindex, Onthophagus hecate</i>
Coleoptera	Silphidae	<i>Nicrophorus</i> spp., <i>Necrophila americana, Oiceoptoma</i> spp.
Coleoptera	Silvanidae	
Coleoptera	Staphylinidae	
Coleoptera	Trogidae	
Diptera	Asilidae	
Diptera	Ceratopogoniidae	
Diptera	Chironimidae	
Diptera	Culicidae	
Diptera	Dolichopodidae	
Diptera	Drosophilidae	
Diptera	Muscidae	
Diptera	Rhagionidae	
Diptera	Stylogastridae	
Diptera	Syrphidae	

Diptera	Tabanidae	
Diptera	Tachinidae	<i>Hineomyia setigera</i>
Diptera	Tachinidae	
Diptera	Tephritidae	
Diptera	Tephritidae	<i>Eurosta solidaginis</i>
Diptera	Tipulidae	
Diptera	Ulidiidae	
Hemiptera	Alydidae	
Hemiptera	Blissidae	
Hemiptera	Cecropidae	
Hemiptera	Cicadellidae	
Hemiptera	Geocoridae	
Hemiptera	Membracidae	
Hemiptera	Membracidae	<i>Campylenchia latipes</i>
Hemiptera	Miridae	
Hemiptera	Nabidae	
Hemiptera	Pentatomidae	
Hemiptera	Phymatidae	
Hemiptera	Reduviidae	
Hemiptera	Rhopalidae	
Hemiptera	Rhyparochromidae	
Hemiptera	Scutelleridae	
Hemiptera	Thyreocoridae	
Hemiptera	Tingidae	
Hymenoptera	Apidae - Asinae	
Hymenoptera	Bombus	
Hymenoptera	Bracionidae	
Hymenoptera	Crabronidae	
Hymenoptera	Formicidae	
Hymenoptera	Halticidae	
Hymenoptera	Ichneumonidae	
Hymenoptera	Vespidae	
Julida	Julidae	
Julida	Polydesmidae	
Julida	Xystodesmidae	
Lepidoptera	Hesperiidae	
Lepidoptera	Lycaenidae	
Lepidoptera	Moth	
Lepidoptera	Nymphalidae	
Lepidoptera	Pieridae	
Lepidoptera	Microlepidoptera	
Lithobiomorpha	Lithobiidae	
Mantodea	Mantodea	

Mecoptera	Panorpidae	
Opiliones	Phalangidae	
Orthoptera	Acridae	
Orthoptera	Gryllidae	
Orthoptera	Myrmecophilinae	
Orthoptera	Odonatata	
Orthoptera	Tetrigidae	
Orthoptera	Tettigoniidae	<i>Scudderia curvicauda</i>
Orthoptera	Tettigoniidae	
Phasmatodea	Diaphomeridae	

APPENDIX II: LIST OF PLANT TAXA USED IN CCA ORDINATION

Code	Scientific name	Common name
ACMI	<i>Achiilia millefoium</i>	Field yarrow
ALST	<i>Allium stellatum</i>	Wild garlic
ANGE	<i>Andropogon geradii</i>	Big bluestem
CHLE	<i>Chryxanthemum leucanthemum</i>	Daisy oxeye
CIDI	<i>Cirsium discolor</i>	Field thistle
DACA	<i>Daucus carota</i>	Queen Anne's lace
DECA	<i>Desmodium canadense</i>	Prairie tick trefoil
ERYU	<i>Eryngium yuccifolium</i>	Rattlesnake master
FRVI	<i>Fragaria virginiana</i>	Wild strawberry
HIPR	<i>Hieraciu, pratense</i>	Hawkweed
MOFI	<i>Monarda fistulosa</i>	Bergamot
PEDI	<i>Penstemon digitalis</i>	Foxglove beard tongue
PHAR	<i>Phalaris arundinacea</i>	Reed canary grass
POPR	<i>Poa pratensis</i>	Kentucky bluegrass
RAAB	<i>Renunculus abortivus</i>	Crowfoot buttercup
RARA	<i>Raphanus raphanistrum</i>	Wild radish
SCSC	<i>Schizachyrium scoparium</i>	Little bluestem
SIIN	<i>Silphium integrifolium</i>	Rosinweed
SILA	<i>Silphium laciniatum</i>	Compass plant
SIPE	<i>Silphium perfoliatum</i>	Cup-plant
SITE	<i>Silphium terebinthinaceum</i>	Prairie dock
SOCA	<i>Solidago canadensis</i>	Canada goldenrod
SONE	<i>Solidago nemoralis</i>	Gray goldenrod
SONU	<i>Sorghastrum nutans</i>	Indian grass
SOOD	<i>Solidago odora</i>	Sweet goldenrod
TAOF	<i>Taraxacum officinale</i>	Dandelion
TRHY	<i>Trifolium hybridum</i>	Alsike clover
TROH	<i>Tradescantia ohiensis</i>	Spiderwort

APPENDIX III: LIST OF ARTHROPOD TAXA USED IN CCA ORDINATION

Code	Scientific name	Common name
ACRID	Acrididae	Spur-throated grasshoppers
ALYD	Alydidae	Broad-headed bugs
ANTH	Anthicidae	Ant-like flower beetles
BLIS	Blissidae	Hairy-Chinch bug
BOST	Bostrichidae	Branch and twig borers
C.LAT	<i>Campylenchia latipes</i>	Wide-footed treehopper
CANT	Cantharidae	Soldier beetles
CARA	Carabidae	Ground beetles
CHRY	Chrysomelidae	Leaf beetles
CICA	Cicadellidae	Plant hoppers
COCC	Coccinellidae	Lady beetles
CRYPT	Cryptocephalinae	Case-bearing leaf beetles
CULI	Culicidae	Mosquitoes
CURC	Curculionidae	Weevils
DOLI	Dolichopodidae	Long-legged flies
DROS	Drosophilidae	Fruit flies
ELAT	Elateridae	Click beetles
FORM	Formicidae	Ants
GRYLL	Gryllidae	True crickets
H.SETI	<i>H. setigera</i>	Tachinid fly
HALT	Halictidae	Sweat bees
HIST	Histeridae	Hister beetles
JULI	Julidae	Millipedes
LAMP	Lampyridae	Lightning bug larvae
LYCO	Lycosidae	Wolf spiders
MEMBR	Membracidae	Tree hoppers
MIRID	Miridae	Plant bugs
MUSC	Muscidae	Stable flies
NITI	Nitidulidae	Sap-feeding bugs
PENTA	Pentatomidae	Shield-shaped stink bugs
PHALA	Phalangidae	Harvestmen/Daddy-Long legs
REDUV	Reduviidae	Assassin bugs
SCARA	Scarabaeidae	Scarab beetles
SILPH	Silphidae	Carrion beetles
SILV	Silvanidae	Silvanid flat bark beetles

STAPH	Staphylinidae	Rove beetles
SYRPH	Syrphidae	Flower flies
TABA	Tabanidae	Horse flies
TACH	Tachinidae	Parasitic flies
TEPHR	Tephritidae	Fruit flies
TROG	Trogidae	Hide beetles
UMOTH	Microlepidoptera	Micromoths