

1 Use of botanical gardens as arks for conserving pollinators and plant-pollinator interactions: A  
2 case study from the US Northern Great Plains  
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19 **Abstract**

20 Botanical gardens have contributed to plant conservation through the maintenance of both living  
21 and preserved plant specimens for decades. However, there is still a large gap in the literature  
22 with regards to understanding the potential conservation value botanical gardens could provide  
23 for local pollinators. We investigated how plant-pollinator community structure and diversity  
24 may differ between botanical gardens and native habitats by sampling and comparing between  
25 two environments: a restored native grassland patch within a local botanical garden and fifteen  
26 native, remnant temperate grassland sites in the Northern Great Plains. We found pollinator  
27 diversity within the restored native grassland patch was greater than 55% of total remnant  
28 temperate grassland transects throughout the entire flowering season, while plant diversity and  
29 network community metrics between the two environments remained similar throughout, except  
30 that remnant prairies have more links (higher connectance) with pollinators than the garden  
31 patch. Overall, our findings demonstrate the promising role restored native grassland patches in  
32 botanical gardens could play as reservoirs for local pollinator communities by supporting plant-  
33 pollinator interactions comparable to those found in native habitat remnants in the same region.

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38 **KEYWORDS:** Plant-pollinator interactions, Botanical Gardens, Pollination, Pollinator  
39 Diversity, Network Analysis, Natural Areas, Conservation

## 40 **Introduction**

41 Biodiversity loss is a global crisis that many countries have attempted to address through  
42 numerous methods of preservation and conservation management strategies (Mutia 2009;  
43 Benedict and McMahon 2006; Hostetler et al. 2011; Bortree et al. 2013). The propagation and  
44 maintenance of botanical gardens is one strategy that has been implemented, particularly for  
45 plant conservation (Hurka 1994; Primack and Miller-Rushing 2008; Powledge 2011; Miller et al.  
46 2016; Chen and Sun 2018). Botanical gardens and urban green spaces may serve as potential  
47 reservoirs for pollinators (Pinheiro et al. 2006; Levé et al. 2019; Buchholz et al. 2020). However,  
48 there is still a gap in the literature with regards to understanding how botanical gardens support  
49 pollinators and preserve plant-pollinator interactions. For example, a literature search (Web of  
50 Science, November 11<sup>th</sup>, 2020) using the terms “botanical gardens and pollinator diversity” and  
51 “botanical gardens and plant diversity” resulted in 14 and 293 citations, respectively,  
52 demonstrated much greater focus on the contribution of botanical gardens to plant conservation  
53 and diversity than pollinators. Clearly, the potential conservation value botanical gardens hold  
54 could extend beyond plant conservation. These gardens could provide space for several resources  
55 that pollinators utilize (i.e., foraging and nesting resources), even in areas that would typically  
56 be considered resource-poor (e.g., cities) (Lewis et al. 2019).

57

58 With approximately 1,775 botanical gardens worldwide (Botanic Gardens Conservation  
59 International, 2020), these sites could provide increasingly important conservation resources that  
60 can be utilized to alleviate the accumulating threats towards pollinators (i.e., habitat loss  
61 and fragmentation, pesticide use, and invasive species introductions) (Kearns et al. 1998;  
62 Kremen et al. 2002; Steffan-Dewenter et al. 2005). Habitat loss and fragmentation are two

63 primary causes for pollinator decline (Potts et al. 2010; Vanbergen et al. 2013; Habel et al. 2019)  
64 and are expected to continue with increased urbanization and agricultural intensification (Foley  
65 et al. 2005; Lundgren and Fausti 2015; UN DESA, 2018). This is particularly concerning  
66 considering animal-driven pollination is essential to the reproduction of over 70% of flowering  
67 plant species (Potts et al. 2010) and 35% of crops globally (Klein et al. 2007; Vanbergen et al.  
68 2013).

69

70 With the space and habitat that is left, can we look to botanical gardens as a proxy for native  
71 habitat to provide refugia for pollinators? Urban green spaces and botanical gardens can  
72 positively influence pollinator abundance or diversity depending on total area, floral abundance,  
73 and degree of urbanization (Tommasi et al. 2004; Gotlieb et al. 2011; Fortel et al.  
74 2014; Micholap et al. 2017). In the United States, there are even cities which support a greater  
75 diversity of native bees than neighboring rural areas (Hall et al. 2017; US Fish and Wildlife  
76 Service, 2015). Furthermore, there is a rise in initiatives to promote expanding urban private and  
77 public garden space with the hopes of promoting and sustaining stable pollinator  
78 communities (e.g., The Million Pollinator Garden Challenge sponsored in part by  
79 the United States Botanic Garden Conservatory). With the increased interest in carving  
80 out urban spaces for pollinators, there is a need to assess the stability of plant-pollinator  
81 community structures in the context of botanical gardens (Spiesman and Inouye 2013). The  
82 stability of pollination services is dependent upon maintaining diverse and resilient plant-  
83 pollinator communities (Klein et al. 2007). Network theory has been utilized to examine how the  
84 mutualistic interactions within plant-pollinator communities influences their structure and in a  
85 broader sense, interpret the mechanisms behind biodiversity and community resilience

86 (Memmott et al. 2004; Bascompte et al. 2006; Blüthgen et al. 2008; Dupont et al. 2009; Hadley  
87 and Betts 2012; Spiesman and Inouye 2013; Soares et al. 2017; Redhead et al. 2018). Using a  
88 network-based approach, we can assess how plant-pollinator communities are structured in  
89 botanical gardens to determine if they may serve as supplementary resources for preserving  
90 plant-pollinator interactions. However, we lack information on how plant-pollinator interactions  
91 in botanical gardens compare to nearby natural habitat.

92

93 We focus our study in McCrory Gardens, a botanical garden located in Brookings, (eastern)  
94 South Dakota, a small city with a population of 24,000. Our goal is to assess the structure of  
95 plant-pollinator communities in botanical gardens and how they compare to nearby natural  
96 habitats. The garden is located within the Prairie Coteau, a region containing some of the largest  
97 remaining tracts of tall-grass habitat in the Northern Great Plains, with temperate grassland  
98 remnants nestled within an actively transforming and working landscape (Bauman et al.  
99 2016). In the center of McCrory Gardens, we focused our sampling within a 1,600 m<sup>2</sup> area  
100 designated as a restored native grassland patch that was established in 2018. This planted native  
101 grassland garden, embedded within a larger landscape of varying patches of natural and modified  
102 habitat, provides us a study system with which to compare how plant-pollinator communities  
103 within botanical gardens measure to those found in natural remnant habitats. Habitat loss and  
104 fragmentation is still a substantial threat to the temperate grasslands of the Northern Great Plains  
105 with documented rates of conversion from grassland to agricultural crops reaching ~1.0-5.4%  
106 annually from 2006 to 2011 (Wright and Wimberly 2013). A better understanding of plant-  
107 pollinator community structure in botanical gardens and their role in pollinator conservation will

108 become increasingly important for future management decisions seeking to bolster pollination  
109 services.  
110  
111 We measure the diversity of plant-pollinator communities within natural temperate grassland  
112 areas and a restored grassland patch in a botanical garden, then quantify plant-pollinator  
113 interactions using a network-based approach in order to answer the following questions: 1) How  
114 does the pollinator diversity found within a restored grassland patch located in a botanical garden  
115 compare to the diversity found within native temperate grassland sites? 2) Likewise, how does  
116 the diversity of the biotically-pollinated plant community within a restored grassland patch  
117 compare to that of native temperate grassland sites? And 3) What is the overall structure of plant-  
118 pollinator community interactions within a restored grassland patch located in a botanical garden  
119 and how do they compare on average to plant-pollinator networks in native temperate grassland  
120 sites? These questions become increasingly relevant with the progressive loss of biodiversity  
121 as urbanization and agricultural intensification continues to encroach upon natural  
122 landscapes (Ramankutty et al. 1999; Hoekstra et al. 2005).

123

## 124 **Materials and Methods**

### 125 *Study area*

126 McCrory Gardens (long: -96.791080, lat: 44.309100) is a botanical garden located in Brookings,  
127 South Dakota, that is operated and maintained by South Dakota State University (SDSU). The  
128 garden is located 300 m from an 18-hectare SDSU agricultural plot to the north and about 2 km  
129 from private farmland to the east. Otherwise, it is surrounded by the SDSU campus, residential  
130 housing and apartments, shopping malls, large box stores, and major thoroughfares. Founded in

131 the early 1960s, McCrory Gardens contains over 10 hectares of display gardens that showcases a  
132 variety of ornamental and native plant species. The garden's origin began with a mission to  
133 maintain a research garden that displays and educates the public on plant species that were or are  
134 a part of the South Dakota landscape. In continuation with this original mission statement, the  
135 Prairie Centennial Garden was established in 2018 in the center of McCrory Gardens. This 1,600  
136 m<sup>2</sup> plot is a restoration native grassland garden with 85% of the plants grown from seed by the  
137 McCrory gardens staff (seeds provided by Prairie Moon Nursery in Winona, MN & Jelitto  
138 Perennial Seeds) and the remaining 15% of plants were relocated or reused from other areas  
139 within McCrory Gardens. Seed from Jelitto was not locally sourced but came from locations as  
140 close as Minnesota and as far as Colorado.

141

142 To compare the diversity of insect pollinators and plants, and plant-pollinator community  
143 structure between the botanical garden and native temperate grassland remnants, we selected  
144 fifteen remnant temperate grassland sites within the Prairie Coteau region in eastern South  
145 Dakota. Within South Dakota, this region covers approximately 17 counties and contains some  
146 of the most land cover remaining of native tall-grass prairie in the Northern Great Plains  
147 (Bauman et al. 2016). In eastern South Dakota, approximately 17% of the undisturbed grasslands  
148 within the Prairie Coteau region remain intact making this a valuable resource for tall-grass  
149 habitat in the Northern Great Plains. Remnant temperate grassland sites ranged in size from 8 to  
150 > 400 hectares and were selected based on quality of the site as advised by local experts and  
151 managers (see *Acknowledgements*), as well as manifesting a range of site characteristics,  
152 including size, local landscape use, and proximity to other semi-disturbed grasslands. Full

153 description of site names, location coordinates, county, size and ownership are provided in  
154 Vilella-Arnizaut et al. (bioRxiv, doi.org/10.1101/2021.02.12.431025).

155

156 *Data collection*

157 *Pollinator observations*

158 We conducted pollinator observations in the restored native grassland patch in McCrory Gardens  
159 and fifteen remnant temperate grassland sites within eastern South Dakota between May and  
160 October 2019. We sampled a total of 10 transects within the restored native grassland patch in  
161 McCrory Gardens and 114 transects across all remnant temperate grassland sites throughout the  
162 entire growing season for one year, see Vilella-Arnizaut et al. (bioRxiv,  
163 doi.org/10.1101/2021.02.12.431025) for more details.

164 Pollinator observations were conducted for 30 minutes along 30 x 1 m transects on days warm  
165 enough to allow insect flight and in time periods when pollinators are expected to be active (15-  
166 35° C, between 08:00 - 17:00 hours). We divided the sampling into three seasons: early (May-  
167 June), mid (July-August) and late (September-October). Season intervals were selected based on  
168 consistent flowering phenology shifts found in the plant communities of the Prairie Coteau. For  
169 example, species belonging to the genera *Anemone* (*Ranunculaceae*), *Viola* (*Violaceae*), and  
170 *Sisyrinchium* (*Iridaceae*) predominately bloomed in the early season, while the mid and late  
171 seasons were dominated by species in the *Fabaceae* and *Asteraceae* (legume and sunflower  
172 families, respectively). Though these two families were predominately found in both seasons, the  
173 mid-season is distinct as this period marked a peak in the number of families in bloom with  
174 approximately six times more families present in our surveys in comparison to other seasons.  
175 Late season was characterized by a distinct shift in floral composition in which *Asteraceae*



176 became the most prominent family in all sites with nearly all other families no longer flowering  
177 for the year.

178

179 From our roster of sites, which included the restored native grassland patch in McCrory Gardens  
180 and the fifteen temperate grassland sites, we randomly sampled each site until flowering ceased  
181 at each location. Location and direction of transects were randomized at each visit using a list of  
182 randomly generated numbers to determine number of steps and cardinal directions before placing  
183 transects down. Transects were geospatial referenced using a Trimble Geo 7x GPS unit with 1-  
184 100 cm accuracy. We walked the entire length of the transect and recorded all plant-pollinator  
185 interactions from within one meter of the transect line on both sides. We defined pollinators as  
186 insect floral visitors that made contact with both the male and female reproductive parts of the  
187 flower, a commonly used criterion (Fenster et al. 2004). We documented each pollinator and the  
188 associated biotically-pollinated plant species when an interaction occurred. Additionally, we  
189 documented pollinator return visits to plants.

190

191 Pollinators were identified in situ to family and genus, then to morphospecies in order to  
192 quantify insect diversity. The pollinator observations in our study only focus on diurnal  
193 pollinators, however, this does not present a significant bias in our sampling. Our data set  
194 portrays a robust, representative sample of the plant-pollinator networks in this region  
195 considering only one species (*Silene vulgaris*) detected in our floral surveys (described in the  
196 next section) relies on nocturnal pollination, and this one species was only present in 1 transect  
197 of the 124 sampled. Insect voucher specimens were collected in the field with an aspirator and

198 net, later identified to lowest taxonomic level and then categorized into functional groups.  
199 Specimens were identified using resources available through [discoverlife.org](http://discoverlife.org), [bugguide.net](http://bugguide.net), and  
200 Key to the Genera of Nearctic Syrphidae (Miranda et al. 2013). Voucher insect specimens were  
201 verified for sampling completeness using the help of experts and the Severin-McDaniel Insect  
202 Research Collection available at South Dakota State University.

203

#### 204 *Floral surveys*

205 Floral surveys were conducted directly after insect pollinator observation surveys along the same  
206 transect with a 1 m<sup>2</sup> quadrat. The quadrat was placed at each meter mark from 0 to 30 m where  
207 we documented the presence of each biotically-pollinated plant species, number of individuals  
208 per species, number of flowering units defined as a unit of one (e.g., Ranunculaceae) or a  
209 blossom (e.g., Asteraceae) requiring a small pollinator to fly in order to access another flowering  
210 unit per species, and percent cover within quadrat per species. We also quantified the symmetry  
211 of flowers (radial vs. bilateral), since symmetry is often related to the degree of pollinator  
212 specialization (Fenster et al. 2004, Fenster and Marten-Rodriguez 2007). Hence, a greater  
213 proportion of either may affect the parameters of network analyses at the remnant temperate  
214 grassland communities and the restored native grassland patch in McCrory Gardens. Plant  
215 voucher specimens were not collected in McCrory Gardens, but photographs were taken and then  
216 verified by head gardener, Chris Schlenker. In the remnant temperate grassland sites, plant  
217 voucher specimens were collected and identified using Van Bruggen (1985) and verified with the  
218 help of experts (see *Acknowledgements*) and are curated at the C. A. Taylor Herbarium at South  
219 Dakota State University. Digitized plant collections for this study may be accessed on the  
220 Consortium of Northern Great Plains Herbaria (<https://ngpherbaria.org/portal/>).

221

222 *Pollinator and plant diversity*

223 Pollinator and plant Shannon diversity were calculated using the ‘vegan’ package, version 3.6.3,  
224 in R (R Core Team 2013; Oksanen et al. 2019). The Shannon index is calculated using the  
225 following formula:

226 
$$H' = - \sum p_i * \ln p_i$$

227 Where  $p_i$  is the proportions of each species found in a community and  $\ln$  is the natural log. All  
228 diversity indices were natural log transformed. Shannon is the only diversity index presented in  
229 this study as it accounts for abundance, richness, and evenness. Pollinator diversity was  
230 calculated at the functional, family, and genus level by transect and season. Values used in  
231 pollinator diversity did not include return visits recorded during observation surveys. Although  
232 we recorded morphospecies in the field, we found genus to be the lowest, most robust taxonomic  
233 level in the data set for insect pollinators that could be identified with accuracy. Approximately  
234 99.5% of total insect pollinator samples collected and observed within McCrory Gardens were  
235 identified to genus. Samples from McCrory Gardens that were not identified to genus were  
236 identified to next taxonomic level (family or functional group 0.5%) and given a catch-all  
237 classification which was used for pollinator genus analyses. Insect pollinators that could not be  
238 identified to genus were placed in a catch-all genus that consisted of the first five letters of their  
239 family name. For example, for a fly pollinator in the family Muscidae, we created a genus named  
240 Gen\_Musci in the dataset in order to include these visitors in the analyses. We found pollinator  
241 genus diversity to be correlated with functional group diversity (Fenster et al. 2004) and family  
242 diversity in both environments (Supplemental table 1). We focus our results and comparisons on  
243 pollinator genus diversity to reduce the number of analyses. However, we provide the

244 distribution data for all three categories of pollinator diversity for completeness. Statistical  
245 analyses for the remaining pollinator categories across seasons are provided in supplementary  
246 materials (Table 2).

247

248 Likewise, plant diversity was calculated at the family, genus, and species level by transect and  
249 season using number of individuals recorded during floral surveys. We generated correlation  
250 plots for all plant diversity levels as well and found that plant species diversity was correlated  
251 with family diversity and genus diversity (Supplemental tables 1). Thus, we focus on plant  
252 species diversity in our results and comparisons, but as above, we provide distribution data for  
253 the three categories of plant diversity for completeness. Statistical analyses for the remaining  
254 plant categories across seasons are provided in supplementary materials (Table 2). Details for  
255 correlation results and diversity metrics for both plant and pollinator communities in the natural  
256 temperate grassland sites are provided in Vilella-Arnizaut et al. (bioRxiv,  
257 [doi.org/10.1101/2021.02.12.431025](https://doi.org/10.1101/2021.02.12.431025)). However, we provide a synopsis of the diversity for the  
258 plant and pollinator communities in the natural temperate grassland sites in the results.

259

### 260 *Network analysis*

261 We built quantitative visitation networks for each site using transects as our replicates to quantify  
262 plant-pollinator community structure. We calculated network metrics for each transect in order to  
263 statistically compare between the restored native grassland patch in McCrory Gardens and all  
264 remnant temperate grassland communities. We used transects as our replicates to compare  
265 network metrics between the two environments. We construct our network analysis based on the

266 entire flowering season (May – October) because of limited sampling in the early and late  
267 seasons in both remnant temperate grassland sites and the garden. Networks were constructed  
268 using a matrix of interactions between plants and pollinators including unique and return visits  
269 recorded during pollinator observation surveys. Documenting return visits allows us to quantify  
270 plant-pollinator communities using weighted network values that also account for visitation  
271 frequency. For each network, we calculated network specialization (H2'), connectance and  
272 nestedness. We also provide the means of each network metric within a given season using  
273 transects as our replicates for the restored native grassland patch within McCrory Gardens and all  
274 remnant temperate grassland sites in supplementary materials (Table 3). All network metrics  
275 were calculated using the 'bipartite' package in R (Dormann et al. 2009).

276

### 277 *Statistical Analyses*

278 We implemented Mann-Whitney U tests to compare pollinator genus diversity, plant species  
279 diversity and network metrics between remnant temperate grassland sites and the restored native  
280 grassland patch in McCrory Gardens using transects as our replicates. We compared these  
281 metrics across all three seasons since early and late season sampling were limited due to  
282 inclement flooding conditions. We used the 'stats' package in R to execute the Mann-Whitney U  
283 tests (R Core Team 2020). Chi-square tests were implemented in Microsoft Excel to examine  
284 differences in floral morphology (radial vs. bilateral symmetry) between the restored native  
285 grassland patch in McCrory Gardens and remnant temperate grassland communities.

286

## 287 **Results**

### 288 *Pollinator community*

289 Within the restored native grassland patch in McCrory Gardens, we observed 10 functional  
290 groups, 25 families, and 48 genera of pollinating insects (see Appendix A for full list). Among  
291 all 15 remnant temperate grassland communities, we observed 10 functional groups, 45 families  
292 and 79 genera of pollinating insects (see Vilella-Arnizaut et al. bioRxiv,  
293 [doi.org/10.1101/2021.02.12.431025](https://doi.org/10.1101/2021.02.12.431025) for full list). Across all three seasons, we found a significant  
294 difference in pollinator genus diversity between environments with the restored native grassland  
295 patch in McCrory Gardens manifesting higher pollinator diversity (Genus:  $U = 993$ ,  $n_1 = 114$ ,  $n_2$   
296  $= 10$ ,  $p < 0.0002$ , Mean  $\pm$  SE: Grassland Remnants  $= 1.19 \pm 0.05$ , Garden  $= 1.85 \pm 0.10$ ). Shannon  
297 diversity of pollinator genera within the restored native grassland patch ranged from 1.28 - 2.28,  
298 while the Shannon diversity of pollinator genera within remnant temperate grassland sites ranged  
299 from 0 – 2.31 across all three seasons (Fig. 1). Early season pollinator genus diversity within the  
300 restored native grassland patch was 1.77 with Syrphidae (54%), Muscidae (15%) and Vespidae  
301 (12%) comprising the majority of observations (Fig. 2). Within remnant temperate grassland  
302 sites, early season pollinator genus diversity ranged from 0 – 2.03 with Syrphidae (36%),  
303 Muscidae (20%), Chloropidae (14.5%), and Halictidae (14%) dominating most interactions.  
304 Mid-season pollinator genus diversity within the restored native grassland patch ranged from  
305 1.28 - 2.28 with Syrphidae (31%), Cantharidae (20%) and Tachinidae (9%) comprising the most  
306 observed interactions (Fig. 2). Mid-season pollinator genus diversity within remnant temperate  
307 grassland sites ranged from 0 – 2.31 with Apidae (27%), Syrphidae (25.7%), Cantharidae  
308 (12.5%), and Halictidae (11%) as the most common pollinators. During the late season,  
309 pollinator genus diversity within the restored native grassland patch in McCrory Gardens was

310 2.10 with Apidae and Syrphidae constituting nearly all interactions during this season with 68  
311 and 25 percent, respectively (Fig. 2). Within remnant temperate grassland sites, late season  
312 pollinator genus diversity ranged from 0.3 – 1.9 with Syrphidae and Halictidae constituting 58  
313 and 28 percent of observations, respectively.

314

### 315 *Plant community*

316 We sampled a total of 7 families, 19 genera, and 23 species of biotically-pollinated plants within  
317 the restored native grassland patch in McCrory Gardens (see Appendix B for full list). Among all  
318 15 remnant temperate grassland communities, we sampled a total of 24 families, 61 genera, and  
319 87 plant species (see Vilella-Arnizaut et al., bioRxiv, doi.org/10.1101/2021.02.12.431025 for full  
320 list). Out of 23 biotically-pollinated plant species in the restored native grassland patch, we  
321 determined 4 species displayed bilateral symmetry while 19 species displayed radial symmetry.  
322 Likewise, across remnant temperate grassland communities, we determined 25 species exhibited  
323 bilateral symmetry while 62 species exhibited radial symmetry. After conducting a chi-square  
324 test, we found no difference between environments with regards to proportion of floral  
325 morphology,  $\chi^2$  (1 df, N = 110) = 1.17,  $p > 0.50$ . Across all three seasons, we found no statistical  
326 difference in plant species diversity between environments (Species: U = 739,  $n_1 = 114$ ,  $n_2 = 10$ ,  $p$   
327  $> 0.10$ , Mean  $\pm$  SE: Grassland Remnants =  $0.77 \pm 0.05$ , Garden =  $1.07 \pm 0.21$ ). Within the  
328 restored native grassland patch, Shannon diversity of biotically-pollinated plant species ranged  
329 from 0.25 – 1.96 throughout the entire sampling season (Fig. 3).

330

331 Likewise, Shannon diversity of biotically-pollinated plant species within remnant temperate  
332 grassland sites ranged from 0 -2 throughout the entire sampling season. Early season plant  
333 species diversity in the restored native grassland patch was 0.25 with *Achillea millefolium* as the  
334 most common species recorded on transects (Fig. 4). Within remnant temperate grassland sites,  
335 early season plant species diversity ranged from 0 – 1.33 with *Anemone canadensis*, *Gallium*  
336 *boreali* and *Fragaria virginiana* as the most common species found on the transects. Mid-season  
337 plant species diversity within the restored native grassland patch ranged from 0.27 - 1.96 with  
338 *Coreopsis tictoria* and *Achillea millefolium* as the most common species recorded on transects  
339 (Fig. 4). Mid-season plant species diversity within remnant temperate grassland sites ranged  
340 from 0 – 2 with *Melilotus sp.*, *Anemone canadensis*, and *Amorpha canescens* as the most  
341 common species found on the transects (Fig. 4). Late season plant species diversity within the  
342 restored native grassland patch was 1.2 with *Helianthus maximiliani* as the most common  
343 species recorded on transects, while late season plant species diversity within remnant temperate  
344 grassland sites ranged from 0.17 – 1.5 with *Symphyotrichum lanceolatum*, *Symphyotrichum*  
345 *ericoides* and *Heliopsis helianthoides* as the most common species found on the transects (Fig.  
346 4).

347

#### 348 *Plant-pollinator network analysis*

349 Within the restored native grassland patch in McCrory Gardens, we observed 165 unique plant-  
350 pollinator interactions and a total of 3,146 observations of pollinators visiting plants from May  
351 through October. The most common floral visitors throughout the entire sampling period in  
352 McCrory Gardens were Syrphidae (38%), Cantharidae (12%), and Apidae (11%). The plant  
353 species with the most interactions in McCrory Gardens throughout the sampling season include



354 *Achillea millefolium* (50%), *Helianthus maximilianii* (8%), and *Solidago rigida* (7.7%). Network  
355 specialization (H2') ranged from 0.26 - 0.64 throughout the entire sampling season for the  
356 restored native grassland patch, while network specialization ranged from 0.56 – 0.80 in the  
357 remnant temperate grassland communities (Supplemental table 3). Full details for network  
358 analyses in the remnant temperate grassland sites are provided in Vilella-Arnizaut et al.  
359 (bioRxiv, doi.org/10.1101/2021.02.12.431025), however we provide a synopsis of results below.

360

361 Within the restored native grassland patch, connectance ranged from 0.29 – 0.67 and nestedness  
362 ranged from 17 – 29 across all three seasons (Supplemental table 3). Likewise, within the  
363 remnant temperate grassland communities, connectance ranged from 0.40 – 0.50 and nestedness  
364 ranged from 25 – 34 across all three seasons (Supplemental table 3). We did not find a  
365 significant difference in H2' between environments when using transects as our replicates ( $U =$   
366 423,  $n_1 = 92$ ,  $n_2 = 10$ ,  $p > 0.60$ , Mean  $\pm$  SE: Grassland Remnants =  $0.60 \pm 0.03$ , Garden =  $0.57 \pm$   
367 0.06). Additionally, we found no significant difference in nestedness between environments ( $U =$   
368 495,  $n_1 = 92$ ,  $n_2 = 10$ ,  $p > 0.60$ , Mean  $\pm$  SE: Grassland Remnants =  $26.4 \pm 1.72$ , Garden =  $28 \pm$   
369 1.73), however, we did find the remnant temperate grassland sites to have significantly higher  
370 connectance than the restored native grassland patch ( $U = 250$ ,  $n_1 = 92$ ,  $n_2 = 10$ ,  $p < 0.03$ , Mean  
371  $\pm$  SE: Grassland Remnants =  $0.44 \pm 0.016$ , Garden =  $0.34 \pm 0.04$ ).

372

## 373 **Discussion**

374 Our study expands on the limited literature available exploring the extent to which botanical  
375 gardens can support pollinator communities and pollination services. Previous research has

376 examined how urbanization and impervious surfaces may impact pollinator movement (Fortel et  
377 al. 2014; Levé et al. 2019). Recent work has highlighted the potential conservation value of  
378 urban green spaces for pollinator communities, especially those found within cities (Micholap et  
379 al. 2017; Lewis et al. 2019). We further develop these approaches by quantifying and comparing  
380 the diversity and interactions of plant-pollinator communities within a restored native grassland  
381 patch centered in a botanical garden and remnant temperate grassland habitats in order  
382 to understand how these environments may differ with regards to plant-pollinator community  
383 structure. We found that the restored native grassland patch in McCrory Gardens fell within  
384 similar ranges of Shannon diversity for both plant and pollinator communities in comparison to  
385 those found within remnant temperate grasslands. Network metrics were similar across seasons  
386 between communities, except for connectance. Below, we discuss and compare the diversity and  
387 network community structure between remnant temperate grassland habitats and the restored  
388 native grassland patch in McCrory Gardens.

389

### 390 *Comparing and contrasting diversity of the plant-pollinator communities*

391 Across all three seasons, pollinator diversity in all taxonomic groups within the restored native  
392 grassland patch overlapped with the mid to upper range of diversity reflected in the remnant  
393 temperate grassland transect samples (Fig. 1). Pollinator diversity within the restored native  
394 grassland patch was greater than 55% of total remnant temperate grassland transects across the  
395 three sampling seasons. For both remnant temperate grassland communities and the restored  
396 native grassland patch, pollinator diversity was greatest in the mid and late seasons. These results  
397 for pollinator community diversity indicate the restored native grassland patch in the botanical  
398 garden can maintain a relatively diverse pollinator community comparable to the diversity found

399 within remnant temperate grassland habitats in the same region. Greater pollinator diversity from  
400 genus to functional group level could benefit botanical gardens and urban green spaces by  
401 promoting community resiliency through functional redundancy (Kühnel and Blüthgen 2015).

402

403 Likewise, floral community diversity within the restored native grassland patch overlapped  
404 with the mid to upper range of diversity reflected in the remnant temperate grassland transect  
405 samples across all three seasons. However, we noted the restored native grassland patch is less  
406 diverse than remnant temperate grasslands in the early season. Approximately 90% of the  
407 transects sampled in remnant temperate grassland sites had greater floral diversity in all  
408 taxonomic groups (e.g., family, genus, species) in the early season compared to the restored  
409 native grassland patch. However, when compared across all three seasons, we did not find a  
410 significant difference between environments. The increased floral genus and species diversity  
411 found within the restored native grassland patch in the mid and late season (Fig. 4) is likely due  
412 to the diversity within Asteraceae, as approximately 96% of the individuals we documented  
413 in the garden transects belong to this family. This may also explain why floral diversity in the  
414 restored native grassland patch is lower across all taxonomic groups in the early season,  
415 as the vast majority of asters we sampled bloomed in the mid and late seasons.

416

#### 417 *Comparing and contrasting network metrics*

418 The greatest overlap in network metrics (i.e., nestedness, connectance, and specialization)  
419 between the restored native grassland patch and remnant temperate grasslands occurred during  
420 the mid-season. Across seasons, indices for nestedness and network specialization demonstrated  
421 no significant difference. However, values for connectance were significantly higher in the

422 remnant temperate grassland sites than the restored native grassland patch. Connectance is often  
423 used in ecological networks to measure community complexity and is generally positively  
424 associated with conservation value (Dunne et al. 2002; Thébault and Fontaine 2010; Tylianakis  
425 et al. 2010; Hagen et al. 2012). Communities with increased interaction complexity are expected  
426 to be more stable and robust to species loss in theory (Dunne et al. 2002). However, Heleno (et  
427 al. 2012) notes that connectance alone should not be used to determine conservation value as it is  
428 context-specific depending on the different conservation values of species in a network. Overall,  
429 results indicate that plant-pollinator community interactions in the restored native grassland  
430 patch are less complex than remnant temperate grassland sites. The higher level of complexity in  
431 plant-pollinator communities within natural habitats may be attributed to the distinct  
432 phenological shifts in the flowering community across seasons, which have evolved with the  
433 local pollinator fauna over a longer evolutionary time scale (Gomez & Zamora 2006; Minckley  
434 & Roulston 2006; Craine et al. 2012). This temporal variability could explain how natural  
435 habitats maintain more complex interactions than their garden counterparts. Successful  
436 recruitment of native plants is an on-going challenge in temperate grasslands (Martin and Wilsey  
437 2006; Gibson-Roy et al. 2007; Johnson et al. 2018) and may be an obstacle botanical gardens  
438 will have to overcome when seeking to maintain complex and stable plant-pollinator  
439 communities in restoration plots. Botanical gardens that wish to establish native plant restoration  
440 plots will likely need to consider a balance between aesthetics and diversity in order to increase  
441 the complexity of plant-pollinator community interactions.

442

443 Moreover, the landscape surrounding natural habitats may provide other resources (e.g.,  
444 nesting resources) that some pollinators may require in order to thrive, particularly those whose  
445 foraging distance is shorter to other more generalized and mobile visitors (i.e., honey bees)  
446 (Beekman and Ratnieks 2000). The spatial variability of resources found within natural habitats  
447 is likely a factor attributing to the difference in connectance between environments, though  
448 landscape analysis for the garden community was beyond the scope of this paper. In general, the  
449 restored native grassland patch within McCrory Gardens demonstrates similar plant-pollinator  
450 community structure to the remnant temperate grassland sites. Nested networks displaying a  
451 higher degree of connectance are considered more resilient and stable, making them important  
452 considerations for conservation value (Memmott et al. 2004; Okuyama and Holland 2008;  
453 Thébault and Fontaine 2010). The nested pattern found in the networks indicates a degree of  
454 interaction redundancy that likely contributes to community stability (Bascompte et al. 2003;  
455 Nielsen and Bascompte 2007). However, it appears that the remnant temperate grassland  
456 habitats within the Northern Great Plains support a greater degree of interaction complexity in  
457 their plant-pollinator communities. This could be concerning for maintaining stable pollination  
458 services in botanical gardens, as community complexity is associated with stable and robust  
459 communities.

460

### 461 **Conservation Implications**

462 Our findings demonstrate the promising role botanical gardens could play as restoration  
463 reservoirs for local pollinator communities by supporting plant-pollinator interactions  
464 comparable to those found in natural habitat remnants in the same region. In the absence of large

465 swaths of preserved habitat, small reservoirs have been notably valuable for wildlife  
466 conservation, though the context of the landscape is important when seeking to maximize  
467 regional insect diversity (Shafer 1995; Tschardt et al. 2002). Though this study does not  
468 directly examine landscape effects which may explain some differences between environments,  
469 the restored native grassland patch located in McCrory Gardens demonstrated comparable  
470 measures of plant-pollinator community structure to natural habitats and greater pollinator  
471 diversity indicating the garden's potential in serving as a beneficial patch for pollinator  
472 communities. Future work studying the influence of increased green spaces in urban areas in  
473 conjunction with conserving remaining patches of natural habitat will be invaluable in our  
474 understanding of how best to conserve pollinator communities and stable pollination services.

475  
476 Temperate grasslands are among the least protected habitat types in the world, with conversion  
477 outpacing conservation by eight to one (Hoekstra et al. 2005). In the United States, the temperate  
478 grasslands of the Northern Great Plains are a valuable resource for approximately 40% of  
479 transported honey bee colonies from May through October by providing abundant floral  
480 resources through regional blooms (USDA, 2014). However, the Great Plains has experienced  
481 considerable habitat loss due to landscape conversion with more than 96% of the grassland  
482 habitat of the Great Plains already been converted to cropland or other less diverse vegetation  
483 (Bauman et al. 2016). Botanical gardens have the potential to provide abundant floral resources  
484 to pollinator communities within increasingly disturbed landscapes; however, the role of  
485 botanical gardens in pollinator conservation is critically understudied.

486

487 Our aim for this study was to provide further understanding on the extent to which botanical  
488 gardens can serve as supplementary resources for pollinator communities within critically  
489 fragmented landscapes. More research focused on plant-pollinator interactions in botanical  
490 gardens, particularly in regions that experience distinct flowering shifts within the growing  
491 season, paired with sampling of plant-pollinator interactions in natural habitats could help us  
492 understand how effective botanical gardens may be as additional sources of habitat. Increasing  
493 sampling within distinct flowering seasons and environments could provide important context  
494 for conservation of pollination services on a wider scale. For example, within the restored native  
495 grassland patch in McCrory gardens, we found that floral diversity is similar to floral diversity in  
496 the remnant temperate grasslands, however, we see that floral diversity within the restored native  
497 grassland patch is primarily from Asteraceae. Extending sampling to include early season species  
498 could elucidate how early season pollinators may be affected by this gap in resources before  
499 Asteraceae species are blooming. Consequently, gardens could adjust management once  
500 these nuances are better understood. Additionally, extending research across multiple years  
501 could provide valuable insight into how plant-pollinator communities may shift following the  
502 progression of native restoration gardens. Continued research tracking the influence and  
503 progression of green spaces on plant-pollinator interactions over time could expand as initiative  
504 for private and public green spaces grows. Increasing urban garden areas may very well act  
505 similarly to habitat corridors, which have been shown to be beneficial in improving wildlife  
506 conservation (Correa Ayram et al. 2016). By understanding the effectiveness of botanical  
507 gardens in supporting pollinator populations, we can view urban spaces as valuable conservation  
508 tools rather than barriers.

509

510

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519



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- 720



721 Figure Legends

722 Figure 1. Distribution of Shannon diversity of pollinators at the functional, familial, and genera  
723 level between remnant temperate grassland sites in the Prairie Coteau near Brookings, SD and  
724 McCrory Gardens across the three sampling seasons (May – October 2019). The black bars refer  
725 to transects conducted in McCrory Gardens while the white bars refer to transects conducted in  
726 the remnant temperate grassland sites. Distributions demonstrate diversity on the transect level  
727 and are overlaid (i.e., not stacked) for comparison between sites. Height of distribution bars  
728 refer to number of samples (transects) that fell within diversity range indicated on the x-axis.  
729 Diversity displayed for remnant temperate grassland sites are also provided in Vilella-Arnizaut et  
730 al. (bioRxiv, doi.org/10.1101/2021.02.12.431025).

731 Figure 2. Comparing distribution of Shannon diversity of pollinators at the functional, familial,  
732 and genera level between remnant temperate grassland sites in the Prairie Coteau near  
733 Brookings, SD and McCrory Gardens for each sampling season in 2019 (Early: May – June,  
734 Mid: July – August, Late: September – October). The black bars refer to transects conducted in  
735 McCrory Gardens while the white bars refer to transects conducted in the remnant temperate  
736 grassland sites. Distributions demonstrate diversity on the transect level and are overlaid (i.e.,  
737 not stacked) for comparison between sites. Height of distribution bars refer to number of samples  
738 (transects) that fell within diversity range indicated on the x-axis. Diversity displayed for  
739 remnant temperate grassland sites are also provided in Vilella-Arnizaut et al. (bioRxiv,  
740 doi.org/10.1101/2021.02.12.431025).

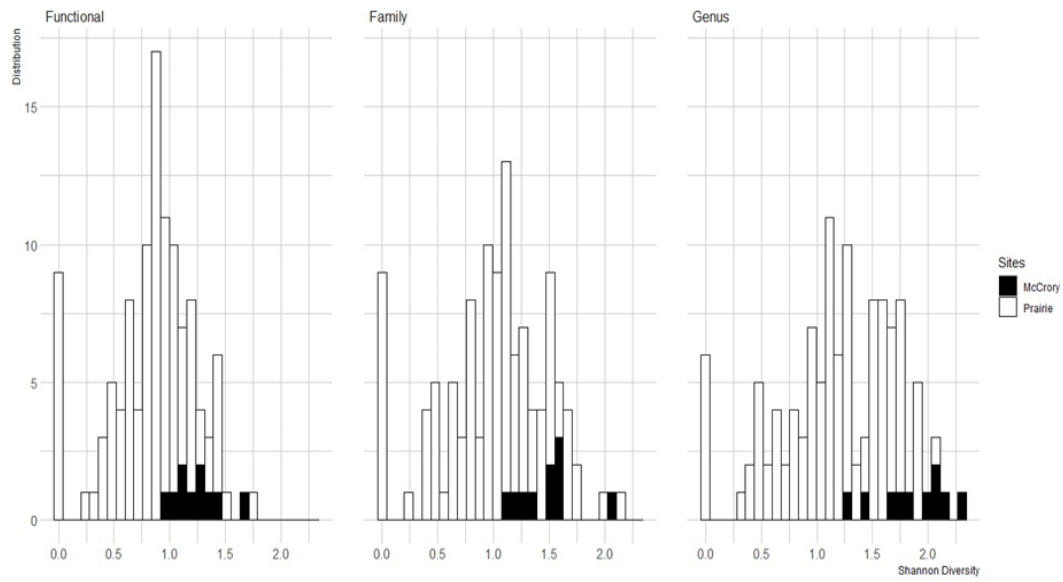
741 Figure 3. Distribution of Shannon diversity of biotically-pollinated plants at the familial, genera  
742 and species level between remnant temperate grassland sites in the Prairie Coteau near  
743 Brookings, SD and McCrory Gardens across the three sampling seasons (May – October 2019).

744 The black bars refer to transects conducted in McCrory Gardens while the white bars refer to  
745 transects conducted in the remnant temperate grassland sites. Distributions demonstrate diversity  
746 on the transect level and are overlaid (i.e., not stacked) for comparison between sites. Height of  
747 distribution bars refer to number of samples (transects) that fell within diversity range indicated  
748 on the x-axis. Diversity displayed for remnant temperate grassland sites are also provided in  
749 Vilella-Arnizaut et al. (bioRxiv, doi.org/10.1101/2021.02.12.431025).

750 Figure 4. Distribution of Shannon diversity of biotically-pollinated plants at the familial, genera,  
751 and species level between remnant temperate grassland sites in the Prairie Coteau near  
752 Brookings, SD and McCrory Gardens for each sampling season in 2019 (Early: May – June,  
753 Mid: July – August, Late: September – October). The black bars refer to transects conducted in  
754 McCrory Gardens while the white bars refer to transects conducted in the remnant temperate  
755 grassland sites. Distributions demonstrate diversity on the transect level and are overlaid (i.e.,  
756 not stacked) for comparison between sites. Height of distribution bars refer to number of samples  
757 (transects) that fell within diversity range indicated on the x-axis. Diversity displayed for  
758 remnant temperate grassland sites are also provided in Vilella-Arnizaut et al. (bioRxiv,  
759 doi.org/10.1101/2021.02.12.431025).

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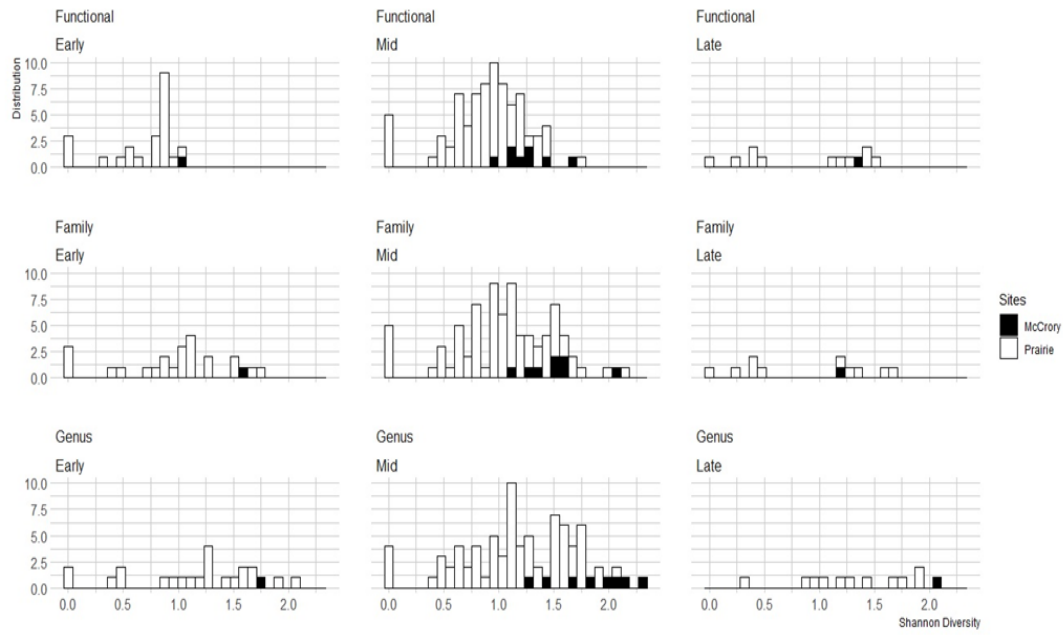
761 *Figure 1*



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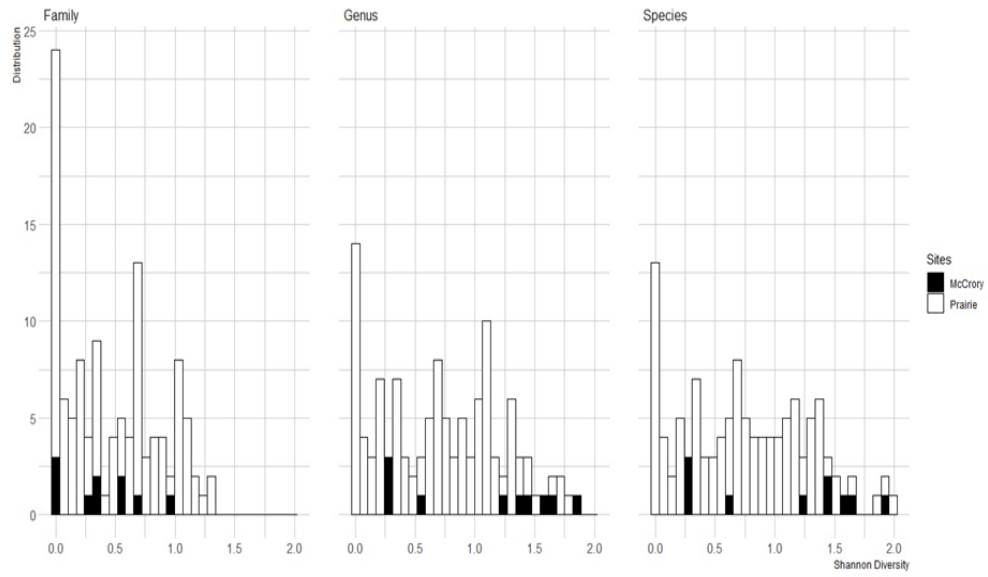
764 *Figure 2*



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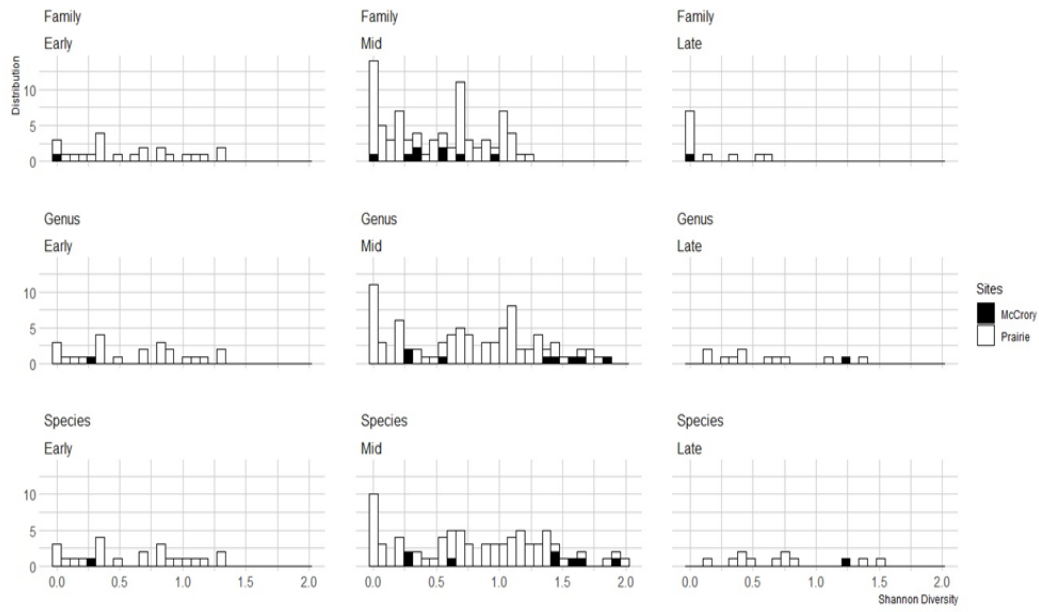
767 *Figure 3*



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770 *Figure 4*



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773 Appendices

774 *Appendix A*

775 The table below lists all of the pollinators observed and identified in the Prairie Centennial  
776 Garden within McCrory Gardens, Brookings, South Dakota in 2019 down to lowest taxonomic  
777 level. Insect pollinators that could not be identified to genus were placed in a catch-all genus that  
778 consisted of the first five letters of their family name. For example, for a fly pollinator in the  
779 family Muscidae, we created a genus named Gen\_Musci in the dataset in order to include these  
780 visitors in the analyses. All insect pollinators could be identified down to family except for two  
781 non-syrphid fly visitors we named Gen\_Myst which make up < 0.5 % of visitations. Table also  
782 includes number of total observed interactions of each pollinator from May through October  
783 2019.

Pollinators	Family	Functional Groups	Number of total interactions from May through October
<i>Agapostemon spp.</i>	Halictidae	Small bee	12
<i>Agapostemon sp. 1</i>	Halictidae	Small bee	1
<i>Agapostemon sp. 2</i>	Halictidae	Small bee	4
<i>Allographta obliqua</i>	Syrphidae	Syrphid	9
<i>Andrena sp. 1</i>	Andrenidae	Small bee	11
<i>Andrena sp. 2</i>	Andrenidae	Small bee	3
<i>Andrena sp. 3</i>	Andrenidae	Small bee	42
<i>Andrena sp. 4</i>	Andrenidae	Small bee	5
<i>Andrena sp. 5</i>	Andrenidae	Small bee	4
<i>Anthophora terminales</i>	Apidae	Small bee	9

<i>Apis mellifera</i>	Apidae	Honey bee	25
<i>Archytas sp. 1</i>	Tachinidae	Non-syrphid fly	162
<i>Bombus spp.</i>	Apidae	Large bee	80
<i>Bombus griseocollis</i>	Apidae	Large bee	20
<i>Bombus impatiens</i>	Apidae	Large bee	14
<i>Bombus bimaculatus</i>	Apidae	Large bee	24
<i>Bracon sp.</i>	Braconidae	Small wasp	1
<i>Ceratina sp. 1</i>	Apidae	Small bee	5
<i>Cerceris sp. 1</i>	Crabronidae	Small wasp	24
<i>Cerceris sp. 2</i>	Crabronidae	Small wasp	3
<i>Chauliognathus pensylvanicus</i>	Cantharidae	Beetle	372
<i>Cisseps fulvicollis</i>	Erebidae	Lepidopteran	5
<i>Crabronina sp. 1</i>	Crabronidae	Small wasp	11
<i>Danaus plexippus</i>	Nymphalidae	Lepidopteran	36
<i>Diabrotica barberi</i>	Chrysomelidae	Beetle	2
<i>Eristalis-BFBF</i>	Syrphidae	Syrphid	23
<i>Eristalis transversa</i>	Syrphidae	Syrphid	3
<i>Eristalis spp.</i>	Syrphidae	Syrphid	28
<i>Gen_Antho spp.</i>	Anthocoridae	Hemiptera	8
<i>Gen_Bomby spp.</i>	Bombyliidae	Non-syrphid fly	1
<i>Gen_Calli spp.</i>	Calliphoridae	Non-syrphid fly	153
<i>Gen_Chlor spp.</i>	Chloropidae	Non-syrphid fly	10
<i>Gen_Chrysid spp.</i>	Chrysididae	Small wasp	11
<i>Gen_Chrys sp. 1</i>	Chrysomelidae	Beetle	3



<i>Gen_Dolic spp.</i>	Dolichopodidae	Non-syrphid fly	6
<i>Gen_Halic sp. 1</i>	Halictidae	Small bee	5
<i>Gen_Halic spp.</i>	Halictidae	Small bee	2
<i>Gen_Ichne spp.</i>	Ichneumonidae	Small wasp	2
<i>Gen_Mirid spp.</i>	Miridae	Hemiptera	3
<i>Gen_Musci spp.</i>	Muscidae	Non-syrphid fly	225
<i>Gen_Myst sp. 1</i>	Gen_Myst	Non-syrphid fly	3
<i>Gen_Myst sp. 2</i>	Gen_Myst	Non-syrphid fly	13
<i>Gen_Noctu spp.</i>	Noctuidae	Lepidopteran	1
<i>Gen_Sarco spp.</i>	Sarcophagidae	Non-syrphid fly	27
<i>Gen_Strat spp.</i>	Stratiomyidae	Non-syrphid fly	2
<i>Gen_Syrph sp. 1</i>	Syrphidae	Syrphid	8
<i>Gen_Syrph spp.</i>	Syrphidae	Syrphid	8
<i>Gen_Syrph sp. 2</i>	Syrphidae	Syrphid	16
<i>Gen_Syrph sp. 3</i>	Syrphidae	Syrphid	1
<i>Gen_Syrph sp. 4</i>	Syrphidae	Syrphid	1
<i>Gen_Vespi spp.</i>	Vespidae	Large wasp	21
<i>Halictus spp.</i>	Halictidae	Small bee	52
<i>Helophilus sp. 1</i>	Syrphidae	Syrphid	133
<i>Hylaeus sp. 1</i>	Colletidae	Small bee	34
<i>Lasioglossum spp.</i>	Halictidae	Small bee	3
<i>Lejops spp.</i>	Syrphidae	Syrphid	7
<i>Megachile brevis</i>	Megachilidae	Small bee	107
<i>Melissodes spp.</i>	Apidae	Small bee	2

<i>Melissodes sp. 1</i>	Apidae	Small bee	23
<i>Melissodes sp. 2</i>	Apidae	Small bee	4
<i>Melissodes sp. 3</i>	Apidae	Small bee	3
<i>Melissodes sp. 4</i>	Apidae	Small bee	2
<i>Melissodes sp. 5</i>	Apidae	Small bee	137
<i>Merodon equestris</i>	Syrphidae	Syrphid	2
<i>Papilio glaucus</i>	Papilionidae	Lepidopteran	3
<i>Parancistrocerus sp. 1</i>	Vespidae	Small wasp	119
<i>Phyllotreta spp.</i>	Chrysomelidae	Beetle	1
<i>Phyllotreta sp. 1</i>	Chrysomelidae	Beetle	1
<i>Phyllotreta vitatta</i>	Chrysomelidae	Beetle	1
<i>Polistes spp.</i>	Vespidae	Large wasp	2
<i>Polistes fuscatus</i>	Vespidae	Large wasp	2
<i>Sphaerophoria sp. 1</i>	Syrphidae	Syrphid	2
<i>Sphecius speciosus</i>	Crabronidae	Large wasp	5
<i>Sphecius spp.</i>	Crabronidae	Large wasp	4
<i>Sphex pensylvanicus</i>	Sphecidae	Large wasp	4
<i>Stratiomys sp. 1</i>	Stratiomyidae	Non-syrphid fly	41
<i>Stratiomys sp. 2</i>	Stratiomyidae	Non-syrphid fly	23
<i>Syritta sp. 1</i>	Syrphidae	Syrphid	92
<i>Tetraopes tetrophthalmus</i>	Cerambycidae	Beetle	3
<i>Toxomerus spp.</i>	Syrphidae	Syrphid	854
<i>Vanessa atalanta</i>	Nymphalidae	Lepidopteran	12

784

785

786 *Appendix B*

787 The table below lists all of the biotically-pollinated flowering plants identified in the Prairie

788 Centennial Garden within McCrory Gardens, Brookings, South Dakota in 2019 down to lowest

789 taxonomic level. All species except *Epilobium* sp. were identified to species level.

<b>Species</b>	<b>Common Name</b>	<b>Family</b>	<b>Plant Code</b>
<i>Achillea millefolium</i>	common yarrow	Asteraceae	ACHMIL
<i>Allium stellatum</i>	prairie onion	Amaryllidaceae	ALLSTE
<i>Asclepias incarnata</i>	swamp milkweed	Apocynaceae	ASCINC
<i>Asclepias tuberosa</i>	butterflyweed	Apocynaceae	ASCTUB
<i>Coreopsis tictoria</i>	plains coreopsis	Asteraceae	CORTIC
<i>Dalea purpurea</i>	purple prairie clover	Fabaceae	DALPUR
<i>Echinacea angustifolia</i>	narrow-leaved coneflower	Asteraceae	ECHANG
<i>Epilobium</i> sp.	Willowherb	Onagraceae	EPILOBIUM
<i>Erigeron canadensis</i>	Horseweed	Asteraceae	ERICAN
<i>Erigeron philadelphicus</i>	Philadelphia fleabane	Asteraceae	ERIPHI
<i>Eupatorium perfoliatum</i>	common boneset	Asteraceae	EUPPER
<i>Gaillardia aristata</i>	common blanketflower	Asteraceae	GAIARI
<i>Gaillardia x grandiflora</i>	mesa yellow	Asteraceae	GAIGRA
<i>Heliopsis helianthoides</i>	smooth oxeye	Asteraceae	HELHEL
<i>Helianthus maximiliani</i>	maximilian sunflower	Asteraceae	HELMAX
<i>Liatris spicata</i>	floristan white blazing star	Asteraceae	LIASPI
<i>Liatris aspera</i>	button blazing star	Asteraceae	LIAASP

<i>Liatris ligulistylis</i>	meadow blazing star	Asteraceae	LIALIG
<i>Liatris punctata</i>	dotted blazing star	Asteraceae	LIAPUN
<i>Liatris pycnostachya</i>	prairie blazing star	Asteraceae	LIAPYC
<i>Linum flavum</i>	golden flax	Linaceae	LINFLA
<i>Lythrum salicaria</i>	purple loosestrife	Lythraceae	LYSTAL
<i>Monarda fistulosa</i>	wild bergamot	Lamiaceae	MONFIS
<i>Rudbeckia fulgida</i> <i>var. sullivantii</i>	Goldstrum	Asteraceae	RFUSU
<i>Solidago gigantea</i>	late goldenrod	Asteraceae	SOLGIG
<i>Solidago rigida</i>	stiff goldenrod	Asteraceae	SOLRIG
<i>Symphotrichum</i> <i>novae-angliae</i>	new england aster	Asteraceae	SYMNOE
<i>Teucrium canadense</i>	Canada germander	Lamiaceae	TEUCAN
<i>Veronicastrum</i> <i>virginicum</i>	culver's root	Plantaginaceae	VERVIR