Seasonal variation in bee abundances in rangeland ecosystems of the Front Range region is affected by land-use

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EXECUTIVE SUMMARY

Researchers from CSU sampled pollinators using specialized trapping devices at three sites on Boulder County Open Space and City of Boulder property in 2018. Results indicate significant biodiversity of native bee pollinators in Boulder County, with bee abundances maximized in June and July and in non-disturbed grassland habitats. Habitats exposed to cattle grazing supported the fewest bees, but sites invaded with cheatgrass (*Bromus tectorum* or *B. japonicus*) supported moderate bee abundances. Ongoing efforts on the project include bee identification and development of species-area relationships, and continued updates will be provided to land managers within the next calendar year.

ABSTRACT

Pollinator populations are experiencing widespread declines, and these losses are significant concern for agriculturalists, food economies, and ecosystem management practitioners. Here, we monitor native bee populations in Boulder County Open Space and City of Boulder sites in the summer of 2018 using blue vane traps. A total of 368 specimens were collected over four collection periods and represented by at least 17 taxa with ~38% of the overall bee abundance represented by bumblebees (*Bombus* spp.) and ~20% of the overall abundance comprised of longhorn bees (*Melissodes* spp.). Bee population abundance and species richness was compared across seasons, with peak abundance and diversity in June, though July also supported high bee abundances. Sites were in grassland habitats and consisted of a grazed site, a cheatgrass-invaded site, and a relatively non-disturbed 'natural' grassland site. Abundances were lowest overall in the grazed site, highest at the non-disturbed site, and intermediate at the cheatgrass-invaded site; these differences were particularly pronounced early in the growing season (May-Jul). However, late in the growing season (Aug), bee abundances at grazed sites resembled those at non-disturbed and cheatgrass-invaded sites. This monitoring effort is part of a larger sampling network of 30 total sites spanning the Front Range region; ongoing efforts are focusing on continuing to characterize taxonomic diversity in bee specimens across all sites and make comparisons of seasonal variation in bee abundance and diversity across grazed, invaded, and non-disturbed habitats. Submission of a larger and more detailed report as a peer-reviewed article is expected in 2019.

Keywords: Biodiversity, Grassland habitats, Land Use Classification, Pollinators, Rangeland

INTRODUCTION

Wild pollinators are key species for agriculture as well as natural vegetation playing vital role in maintaining ecosystem biodiversity and function (Garibaldi et al., 2013, Kremen et al., 2007). Approximately 75% of crop-plant species globally depend on pollinators (Kleijin et al., 2015, Ollerton et al., 2011), and despite their crucial role in ecosystem productivity, there remains little known about factors regulating abundance or diversity of insect pollinators in Colorado or on rangelands in general (Gilgert and Vaughan 2011), though pollinator fauna are described for some urban landscapes (Kearns and Oliveras 2009a, b; Scott et al. 2011).

Our study sites consist primarily of shortgrass prairie rangelands along the foothills of Front Range of Colorado. The shortgrass prairie is dominated by blue gramma (*Bouteloua gracilis*), buffalo grass (*Bouteloua dactyloides*) and others. Besides grasses, rangelands harbor many native forb species crucial to pollinators including *Liatris puntuata, Grindelia squarrosa,* prickly pear cacti (*Opuntia polyacantha*), and rabbitbrush (*Ericameria nauseosa*), among others. It is considered that vegetation in the rangelands are evolved with grazing and have developed tolerance to ungulate grazing (Klipple and Costello, 1960) and many rangelands are naturally grazed by bison, antelope, and other species. Now, most of Front Range rangelands area either privately and publicly ranches or open space natural areas developed for recreational activities. Most open space areas are enclosed or otherwise protected from commercial grazing by park or county resource managers. Though most of the open spaces are enclosed from grazing, many are invaded by cheatgrasses (invasive *Bromus* spp.) native to Europe and Asia. Evidence has shown that these grasses are expanding in rangelands of the western United States and altering both vegetation communities and natural disturbance regimes (Knapp1996). Accordingly, the

Colorado Front Range is an ideal landscape to study the effects of both grazing and invasive species (cheat-grass) on interactions between habitat factors and pollinator communities.

It is presently unknown whether invasion by cheatgrasses or grazing are associated with wild pollinator declines in the Front Range region. Exotic plant species have indirect effect on pollinators by changing the distribution, composition and abundance of native floral resources and/or nesting habitats (Goodell and Parker 2017). For instance, site invasion by *Bromus tectorum* is widespread in Front and may reduce local site occupancy by forbs (Parkinson et al 2013) or constrain local species richness (Melgoza et al, 1990, Knapp 1996); these effects may indirectly effect bee communities by altering access to foraging and nesting sites (McKinney and Lockwood, 1999). Here, our goal is to compare the relative effects of cheatgrass invasion and cattle grazing on bee species abundance and richness, as well as the abundance and richness of floral resources, using relatively nondisturbed grassland habitats as 'control' sites. Sites in Boulder County represent approximately 10% of our sampling effort across the Front Range, and our short-term results provide new insights into seasonal variation in pollinator abundance across three sites.

METHODS

Site selection and field measurements: We selected three habitats types for sampling; sites that were (1) grazed by cattle, (2) sites that were dominated by cheatgrass, and (3) relatively non-disturbed 'natural' grassland sites (Table 1). All sites are a minimum distance of 1 km to reduce potential for spatial autocorrelation, and one site of each 'type' is located in Boulder County. A geographic information system (ARCGIS, Esri, Inc.) was used to characterize landscape diversity based on remote sensing data (LANDFIRE datasets), and the relative proportion of each site that was 'urban' within a 500 m buffer zone around each site was

quantified. At each site, point-intercept transects were used to characterize site vegetation, with five 100-m transects placed equidistant around bee traps, and intercepts placed at 1 m distances along each transect. At each intercept, cover was determined to be 'native grass', '*Bromus* spp.', 'floral', 'woody debris', 'rock' or 'soil'. All floral intercepts were identified to the highest level of taxonomic resolution (species, in many cases), and floral traits were quantified for each identified species.

Bee collection and identification: Bee were collected using blue vane traps (Springstar, Inc., Woodinville, WA). Collections were made by placing one trap at a central location in study sites, with the trap base suspended ~1 from the ground surface. Traps were left for a period of 72 h and then contents were collected into large plastic bags, placed on ice immediately, and returned to the laboratory on the same day. One collection was made at each site in May, June, July, and August in 2018 (Table 2). Trap contents were sorted, and all bees were pinned, labeled, and mounted in collection boxes. Bees were sorted to morphospecies and identified to the highest level of taxonomic resolution by comparing to specimens curated in the C.P. Gillette Museum (CSU), as well as using pollinator identification resources (textbooks) and the expertise of professional insect taxonomists (Prof. Boris Kondratieff, CSU). Identification is ongoing and projected for completion in Spring of 2019.

RESULTS

A total of 368 specimens were collected over four collection periods and represented by at least 17 taxa with ~38% of the overall bee abundance represented by bumblebees (*Bombus* spp.), ~20% of the overall abundance comprised of longhorn bees (*Melissodes* spp.), and ~14% of bee abundance comprised of sweat bees (*Lasioglossum* spp.; Figure 1; more detailed species list provided in Table 3). Bee population abundances were highest in June and July, with abrupt

declines in August, likely due to initiation of overwintering behaviors. Through the early- (May) and middle-growing season (June, July), the site with cattle grazing exhibited the lowest overall bee abundance, but this difference was eroded by late in the growing season (August). Non-disturbed control grassland sites supported the greatest bee abundance, and sites invaded by cheatgrasses were intermediate (Figure 2)

DISCUSSION

In our preliminary monitoring of bee communities in Boulder County, we determined that significant bee diversity exists within the county, and that this diversity tends to vary seasonally and relative to the type of biotic disturbance that occurs at sample sites (cattle grazing vs. cheatgrass invasion vs. non-disturbed grassland). Altogether, a relatively small proportion (2%) of the bees collected in this study It remains undetermined whether these findings are broadly extendable to sites across the region, and a clearer understanding of these biotic effects on pollinator resources is pending final identification of specimens and a more thorough analysis of bee community data. More detailed findings are projected by Spring 2019, and final reporting will take the form of a peer-reviewed manuscript to be submitted for publication.

It is not entirely unexpected that grazing resulted in reduced bee abundances, as consumption of forb species by cattle may be a primary mechanism for loss of biodiversity in rangeland systems (). However, it was surprising that cheatgrass-invaded sites maintained a higher species abundance than grazed sites, as these sites are generally depauperate of floral resources early in the growing season. It is possible that cheatgrass-invaded sites are superior nesting sites, but not foraging sites. Another possibility is that landscape richness and urbanization, with are both processes occurring at larger spatial scales than at the sites of bee collection, are driving bee abundances and diversity more so than effects occurring at the site-

scale. Further analysis will reveal whether local or landscape factors are stronger drivers of local abundances and diversity in Front Range bee communities.

Understanding the factors that govern local bee abundances and diversity will be fundamental to designing conservation strategies for retention of ecosystem services in the Front Range, particularly with continued population growth and projections of ongoing urbanization. Our results, once finalized, can help managers to determine which habitat types may be more likely or less likely to support pollination services, and will provide specific locations (i.e., sample collection sites) where directed vegetation management actions may be useful for enhancing pollinator diversity. In addition, future work will characterize functional diversity of bee communities and floral resources at study sites and is expected to provide an additional dimension of analysis. For instance, functional diversity may be equivalent across habitat types, even if biological or taxonomic diversity is variable across habitat types.

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171 **Table1:** Study sites with their coordinates.

Sites	**Coordinates (°N, °W)**
Agriculture center	40.201236, 105.162970
Ron Steward Preserve at Rabbit Mountain (South)	40.250538, 105.214050
Ron Steward Preserve at Rabbit Mountain	40.241479, 105.225994

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173 **Table 2.** Installation and collection dates for blue vane traps in 2018.

BVT installation date	**BVT collection date**
May-16, 2018	May-19, 2018
June-18, 2018	June-22, 2018
July-18, 2018	July-21, 2018
August-10, 2018	August-13, 2018

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Table 3. Abundances of identified bee taxa from field collections in 2018. Current taxonomic resolution is coarse, and diversity is expected to increase substantially as sorted morphospecies are identified by expert entomologists.

Species	**No. individuals**
Agapostemon sp	35
Anthidium sp	4
Anthophora sp	17
Apies melifera	8
Bombus appositus	7
Bombus fervidus	28
Bombus griseocollis	5
Bombus huntii	2
Bombus nevadensis	21
Bombus pensylvanicus	87
Lasioglossum sp	56
Megachile sp	10
Melecta pacifica	2
Melissodes sp	79
Other species/not identifed	16
Svastra sp	18
Vespula penyslvanica	8
SUM	368

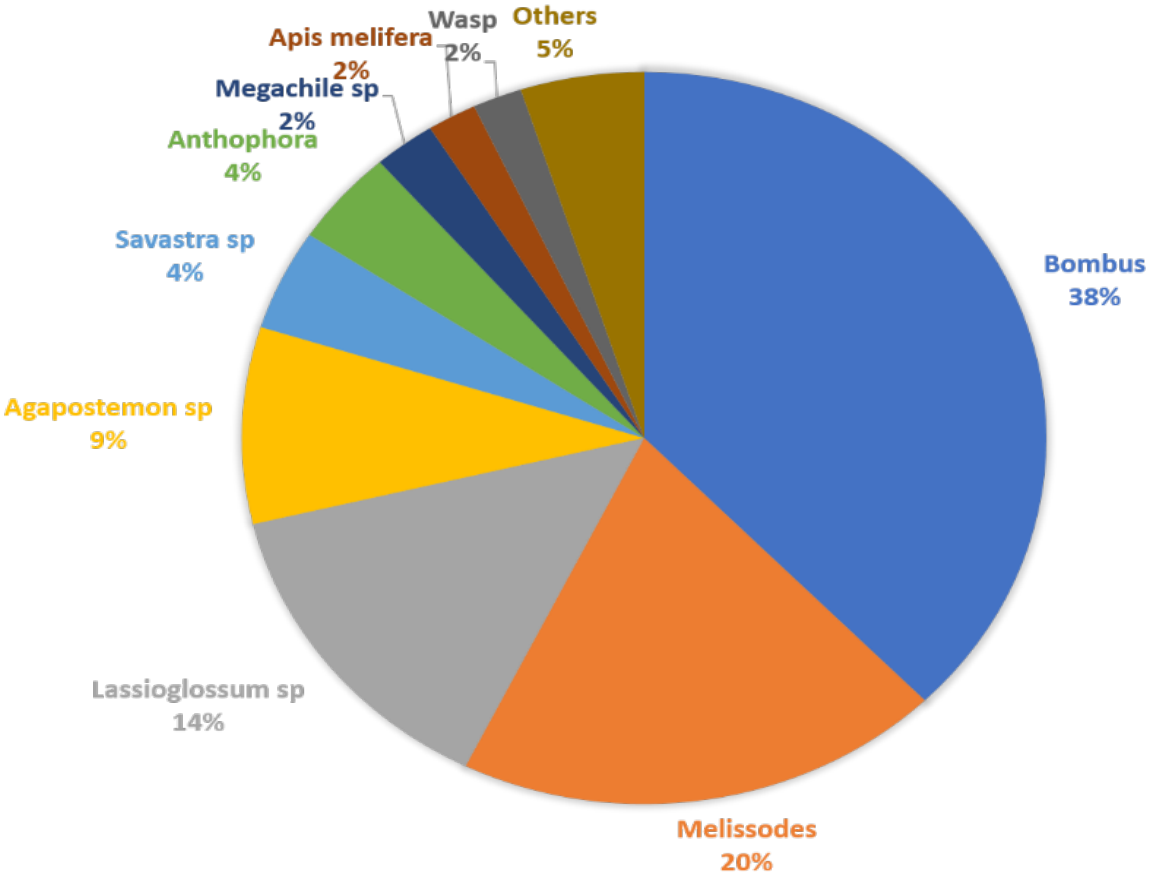
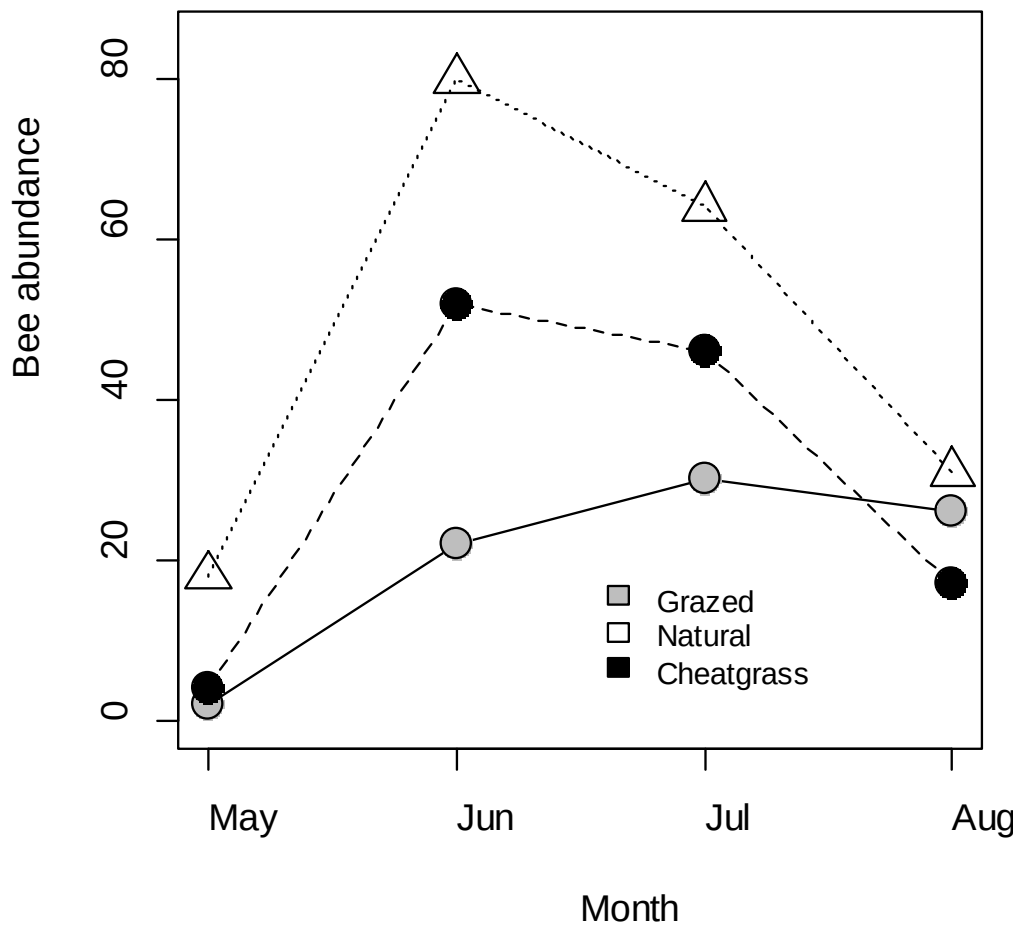


Fig. 1. Relative composition of bee genera trapped during the 2018 field season on Boulder County Open Space and City of Boulder study sites.



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184 **Fig. 2.** Seasonal variation in bee abundances at grazed, cheatgrass-invaded, or ‘natural’, sites.