

Effects of *Bombus* Pollinator Removal on Fly Foraging Behavior

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Abstract

Native *Bombus* species are in decline in the United States. Since pollinators are such integral species in a system, the extinction of a single *Bombus* species could potentially have far reaching consequences on crop production and plant reproduction necessary for species diversity and agriculture. However, there are studies to suggest that other pollinators would fill the niche of the most abundant *Bombus* in a system should that *Bombus* become extinct (Memmott et al. 2004). This study examines how Diptera fly pollinators in a system react to the removal of a single *Bombus* species. I hypothesized that Diptera pollinators will expand their foraging range in the absence of the most abundant *Bombus* species. By comparing fly behavior in controlled and manipulated (experimental species removal) states, I observed a change in fly foraging that was supported by the data analysis. This study confirmed my hypothesis showing a correlation between fly foraging and the removal of the most abundant *Bombus* species.

Keywords: *Bombus* extinction, Diptera, fly pollinators, Syrphidae, Bombyliidae

Introduction

Pollinators are essential to global biodiversity (Potts et al. 2010) as they affect the sexual reproduction of many wild plants and global food crops consumed directly by humans (Klien et al. 2007, Potts et al. 2010). Native plants, including approximately ninety percent of angiosperm species depend on insect pollination in order to reproduce (Burd 1994, Kearns et al. 1998, Ollerton et al. 2011). In addition, nearly eighty seven percent of global food crops of fruits, vegetables, and seeds are dependent on animal-mediated pollination (Klien et al. 2007). Recent studies suggest that declines in pollinators are ongoing (Potts et al. 2010) and could lead to a major decline in both wild plants and nutrients from crops consumed by humans (Klien et al. 2007, Potts et al. 2010, Eilers et al. 2011).

While there is evidence to support a general correlation between pollinator declines and negative effects on plant species (Kearns et al. 1998; Biesmeijer et al. 2006, Burkle et al. 2013), other studies suggest that plant species may be relatively resilient to pollinator losses. For example, (Memmott et al. 2004) proposed that since plants are visited by several species of pollinators, plants have backup in the event that one species of pollinator begins to decline in numbers.

A manipulative experiment conducted here at RMBL (Brosi & Briggs 2013), however showed an impact on foraging behavior of pollinators and plant reproduction when a single-species of bumble bee is removed from its normal foraging site. This confirms that a single pollinator species can have long-term and short-term impacts on species specialization and niche differentiation, which in turn can affect plant pollination. Still, there is a lack of data/research that explains how specific single-species removals will affect more distantly related pollinator taxa, such as flies (Diptera). Flies are key pollinators for many native plant taxa and some agricultural crops (Szymanski et al. 2008). I specifically focused on two fly families,

the Syrphidae (hoverflies) and Bombyliidae (bee flies), which are both integral pollinators of high-altitude systems, are easily identifiable, and are relatively straightforward study subjects.

In this study, I examined how fly foraging habits were influenced by the removal of a single bumble bee species. I built on ongoing bumble bee species removal experiments. I examined the Syrphids and Bombyliids of the Rocky Mountain Biological Lab in Colorado (altitude ~ 9,500ft) to determine if experimental bumblebee removals impact the floral fidelity of flies and change the community of plants that are visited by the flies. Due to the changes in resource availability caused by the bumblebee removals, I hypothesized that experimental bee removals will result in a greater niche breadth of fly pollination as floral resources/niches are opened up when bumble bees are removed.

Methods

I used 12 separate 20 x 20m plots surrounding the Rocky Mountain Biology Laboratory (Gunnison County, Colorado) that were each be separated by a minimum of 1 km (Figure 1). I selected plots that showed a high number of observed pollinators near blooming flowers. Each plot was studied in a control and a manipulated (species removal) state. No plots were used more than once. There was a one day interval between experimentation in the manipulated and controlled states, insuring the community of flowering plants will be essentially identical between the experimental states in each plot.

Fly Foraging Observations

I observed the foraging patterns of Syrphidae and Bombyliidae fly species by attempting to log the identity of specific plant species visited by the pollinators in a single sequence. I attempted to record a minimum of ten varying Diptera individuals and their foraging sequences in each plot. I stopped recording the sequence of plant visits when the fly was observed for more than ten minutes, visited over one hundred flowers, or when the fly moved five meters away from the plot. I discarded data from Dipteras that visited fewer than five individual flowers.

Control Days

To begin control days (no species removal), team members recorded all flowering plants along the 5m and 15m transects.

Network Observations

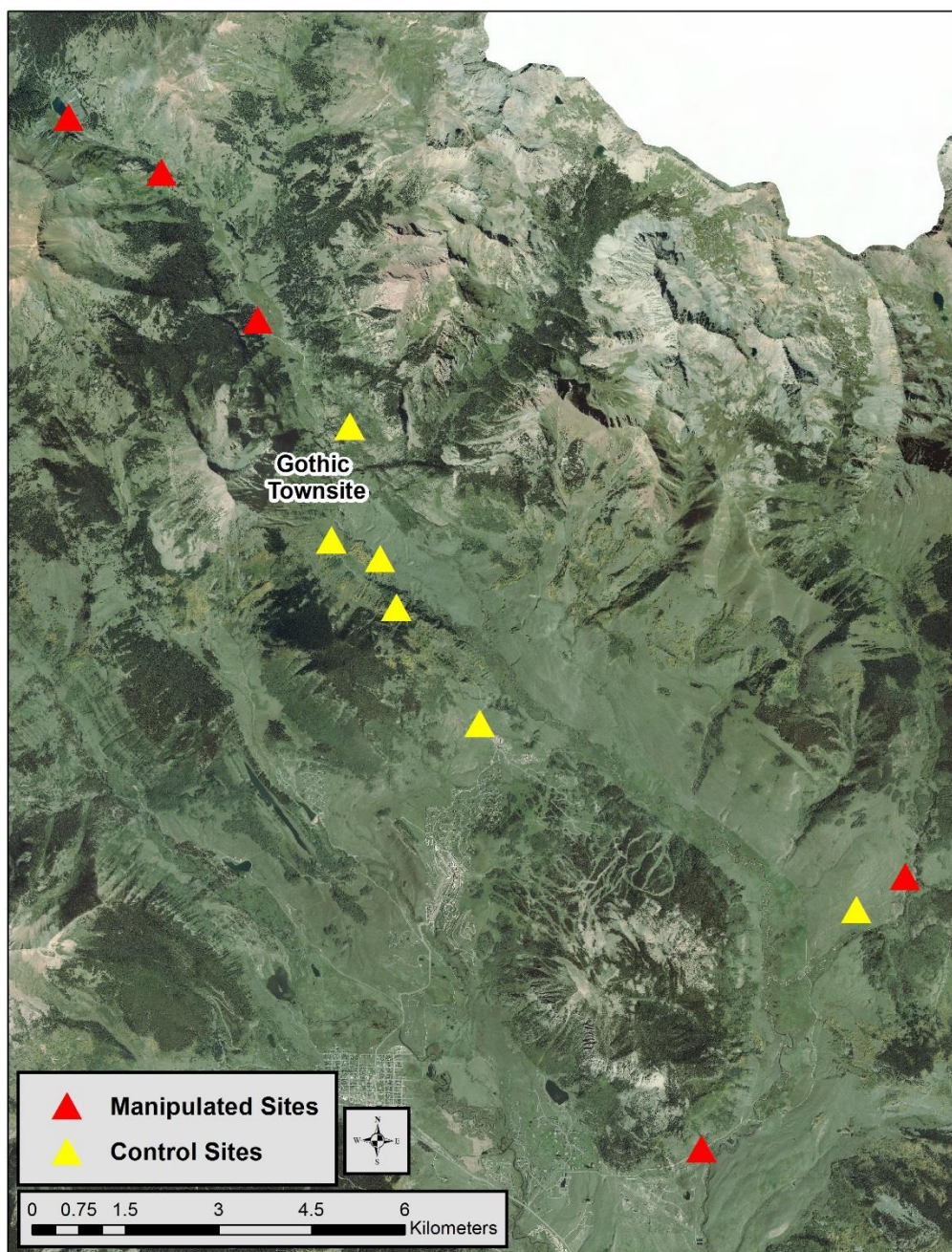
To conduct network observations, a different person stood on the first transect, 5m transect, 15m transect, and 20m transect and walked the length of the transect for 5 minutes recording all pollinator visits to flowering plants. After 5 minutes, each person shifted over one transect until each person had conducted observations at each transect.

Two people then net Bombus species for 20 minutes within the plot. We recorded the most abundant species in this plot (species we caught the most in 20 min). The bees are placed in a cooler with ice packs to put them to sleep. Once they are asleep, a tarsal is removed from each species to do gene sampling. After 20 minute netting and tarsal removal is complete, the bees are released. However, if more than 30 bees are netted, then we did not collect tarsals but would conduct a manipulation study.

Manipulation Days

All previous steps for control days with the exception of counting open flowers along the transect.

Instead, the team nets the most abundant species of Bombus while one team member records caught bees and places them on ice. Tarsals are removed from these bees and the bees are released at the end of netting. Netting should continue until there are no observed most abundant species for 15min.

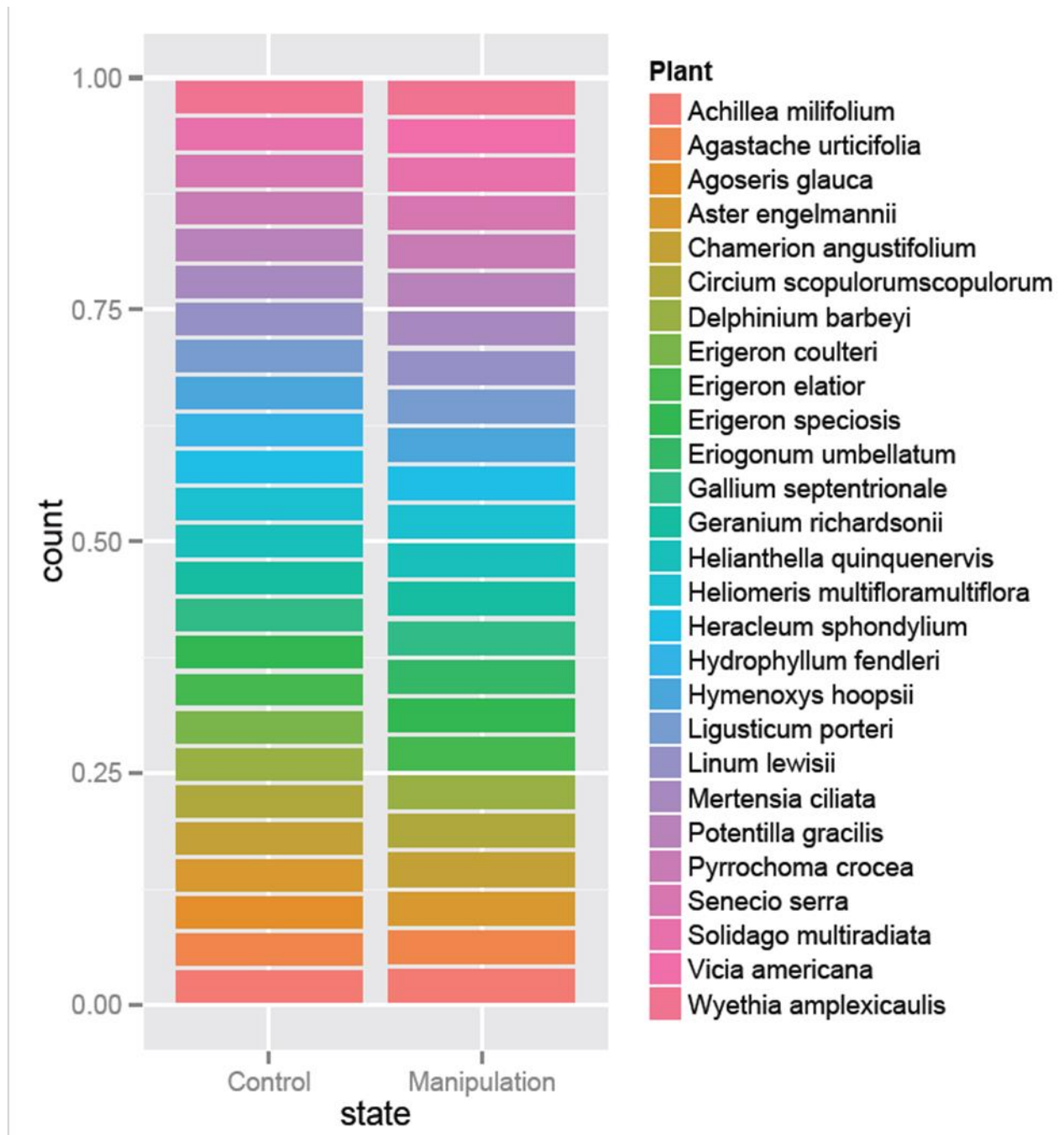


(Figure 1. GIS Map of sites used for 2015 study)

Results

On control days when there were no species removed, the flies were less likely to forage on flowers associated with high *Bombus* fidelity and mainly foraged on a single plant species. Flies were more likely to forage on a wider niche of plants after the removal of a single pollinator species during the manipulation days. We observed that fly foraging fidelity decreased during manipulation days as compared to control days during our network observations.

Using paired t-tests I saw that there was a significant difference between fly foraging habits in a controlled versus manipulated states ($p: .008$, $df: 11$, $t: -3.18$). My analysis confirmed that flies are more likely to increase their foraging range/niches in the absence of the most abundant *Bombus* species (Figure 2). I used a relativized niche breadth in order to even out data between days of very high numbers of observed flies with days of low observed flies. I divided the number of plant species visited by the number of total fly visits observed.



(Figure 2. Graph representing the count of pollinators that visited a single species of open flower. Fly counts were high and consistent during control days. During manipulation days counts of fly visitors per plant were lower demonstrating that flies tended to visit the same species of flower less frequently when a *Bombus* species was removed)

Discussion

The results of this study confirmed my hypothesis that flies will expand their niche breadth in the absence of the most abundant *Bombus* species. This shows that even among distant pollinator species, there is a correlation between the loss of the most abundant pollinator in a system and the foraging behavior of other pollinators. Due to the high abundance of a single species of *Bombus* in a plot, it limits the resource availability available for fly foraging. When that species is removed, a larger niche becomes available for other pollinators in a system.

Observed *Bombus* foraging behavior conducted by (Brosi and Briggs 2013) also showed high fidelity foraging by *Bombus* species, and a change in foraging patterns by other pollinators in a system. There were similar behaviors observed in this study as well. *Bombus* species tended to have high fidelity which limited the plants available for fly foraging. However, the behavior of the flies changed during the manipulation days. There are several impacts of this change in behavior on plant species pollination and reproduction.

Our results have implications for the impacts of declining *Bombus* species on plant pollination. Should a single species of pollinators become extinct, in their absence *Diptera* will expand their foraging niches and pollinate a greater variety of flowers. However, whether this would have a positive or negative impact on native plants is yet to be determined. It could be positive in the fact that pollination will still occur even in the event of an extinction; but, due to the high efficiency of *Bombus* pollinators compared to flies, there is potential for a decrease in plant reproduction and pollination. This would be detrimental especially for crop production and calorie consumption by humans.

However, there is still further experimentation to be conducted on *Diptera* foraging patterns and floral preferences. One limitation of this study is that it can only be conducted for as long as the plants are flowering which shortens our sampling time. We can only look at patterns across several summers, but cannot conduct a study to compare how fly foraging changes immediately and then for long-term afterwards.

Another limitation was the lack of bumble bees at the beginning of the summer. Due to the long winter, it took longer for queens to establish colonies and for the workers to emerge. As a result, we were not able to conduct manipulations at all twelve sites. It also reduced the period in which we could study fly and *Bombus* pollination patterns since there was a gap between flowers blooming and pollinator emergence.

In conclusion, this study provided better insight about the relationships between more distant pollinators in a system. When the most abundant *Bombus* species is removed from a system, it expands the niche available for *Diptera* flies to forage. The *Diptera* will take advantage of this niche opening and forage on a wider variety of plants. This change in pollinators could have lasting impacts on the reproduction and pollination of plants that may not be beneficial long-term. While *Diptera* are necessary pollinators in a system, it is also necessary to preserve the number of *Bombus* species to prevent extinctions.

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