

**The effects of elevation on flower abundance and pollinator visits on *Helianthella*
*quinquenervis***

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Abstract

Spatial-temporal variation in pollinator populations can have an impact in plant reproduction. This study assessed the effects of elevation on flower abundance, pollinator visitation, and types of pollinators visiting the *Helianthella quinquenervis*. This flower species was chosen due to its vast abundance at various elevations in Gothic, CO. I used data from 2021 and 2022 collected from the Avery Picnic (low elevation) and Virginia Basin (high elevation) field sites to address these questions. Flower counts and pollinator visits would be recorded on a weekly basis at both sites during the blooming season of the *H. quinquenervis*. There was a significant difference in flower abundance between sites in both years, however the results did not support the initial prediction that flower abundance would be greater at the high elevation site. There was no significant difference in the number of pollinator visits between the two field sites. And lastly, *Bombus* were the most abundant pollinators at both elevations, however more data is needed to more accurately describe the types of pollinators visiting at low elevation sites. Flower production and pollinator visitation in *H. quinquenervis* is not driven by elevation, which suggests that future research should focus on other factors, such as snowmelt, to explain the observed results.

Introduction

Plant-pollinator networks are dynamic and constantly vary in response to multiple factors in the environment. Temporal changes in pollinator structure, however, may result in shifts of species that occupy certain ecological roles (Alarcon et al., 2008), which could impact the success of plants that depend on them. For example, pollinator removals in the past have resulted in fewer plant species being visited (Brosi et al., 2017). In locations where plants have a short window to reproduce, such as deserts or sub-alpine habitats, plant-pollinator interactions could significantly impact plant population success.

Virginia Basin, near Gothic CO, is located at approximately 3,500 meters in elevation. It is one of the highest elevation sites in North America where plant-pollinator interactions are studied to document temporal changes in plant abundance and visitation (Gascon, 2023). It is with this interest in mind that I seek to contribute further research into the differences in flower abundance and visitation patterns of plant species that reside in high elevation sites compared to lower elevations.

Previous research on alpine plants suggests that they produce more flowers in higher elevations to attract the pollinators that reside there (Bonelli et al., 2022). For this project I will focus on *Helianthella quinquenervis* (Asteraceae), which is one of the more common plant species in the Virginia Basin. I hypothesize that there will be greater flower abundance of *Helianthella quinquenervis* at higher elevations when compared to lower elevation sites. And although the Asteraceae family comprises nearly 10% of all flowering plant species (Mandel et al., 2019) *Helianthella* has remained one of the most understudied groups in plant biology with the last notable contribution to this genus being its classification assembled in the 1950's (Riley,

2022). Thus, the effects of elevation on flower production combined with the lack of notable research contributions make *Helianthella quinquenervis* a species worth studying.

In addition to comparing flower abundance of *Helianthella quinquenervis* at Virginia Basin to a lower elevation field site, I also will compare the diversity of pollinators and the total number of visits per flower to better understand how elevation might influence plant success. Given what we know about flower abundance being greater in alpine environments (Bonelli et al., 2022), I predict that *Helianthella quinquenervis* will receive a lower diversity of pollinator visits in the Virginia Basin due to flies being the predominant pollinator at higher elevations given their favorable larval habitat and low energy requirements (Kearns, 1992). Additionally, this prediction of lower pollinator diversity leads me to predict that the number of visits will likely remain the same when compared to lower elevation.

Methods

The high elevation Virginia Basin field site is located at 3350m of elevation and 3 kilometers away from Gothic (Figure 1), while the lower elevation Avery Picnic field site (2900m) is located up the road from Gothic. At each site there were eight transacts that measure 20m by 1m. Each one of these transacts is divided into 10 equally sized 2m segments from which we collected our sample data from. To ensure we collected a representative sample, every week we used a randomizer to determine the order in which the segments were observed. Observations at each segment were made for one minute and thirty seconds from the front and back side resulting in 3 minutes total of observations. During these surveys, plant pollinators were caught with a net to identify into a major taxonomic group as well as the flowers they were caught on. Additionally, bugs caught that did not belong to the bumble bees were then brought back to the lab to freeze, pin, and identify for future records at RMBL. Given the later than normal bloom of

Helianthella quinquenervis, historical data from 2021 and 2022 at Virginia Basin and Avery Picnic were used for analysis.

Results

For 2021 I found a significant difference in flower abundance per segment between Virginia Basin and Avery Picnic (t-test assuming unequal variances: $t=-2.57$, $df=62$, $p = 0.013$) with transect segments at Avery Picnic having greater *Helianthella quinquenervis* densities. Virginia Basin had a mean flower abundance per segment of 5.58 (SE= 0.360), while Avery Picnic had a mean of 10.661 flowers per segment (SE= 1.943, Figure 2). In the 2022 flower abundance data I also found a significant difference (t-test assuming unequal variances: $t=4.977$, $df=104$, $p<0.001$), but this time more flowers were produced per segment at Virginia Basin compared to Avery Picnic. Virginia Basin had a greater mean number of flowers per segment average at 7.655 (SE=.578), while Avery picnic had a mean of 3.485 flowers per segment (SE = 0.606, Figure 3).

To compare pollinator visit, I first divided the number of visits recorded per segment, per sampling date, by the number of open *Helianthella quinquenervis* flowers in that segment, to correct for differences in flower abundance. For the 2021 data I did not detect a significant difference in the number of visits per flower between Virginia Basin and Avery Picnic (t-test assuming unequal variances: $t=-1.09$, $df= 18$, $p =0.29$) *Helianthella quinquenervis* flowers at Virginia Basin received a mean of 0.270 (SE = 0.019) pollinator visits, while at Avery Picnic they received a mean of 0.410 visits per flower (SE = 0.128, Figure 4). Again in 2022, there was no significant difference (t test assuming unequal variances: $t=-0.11$, $df=50$, $p=0.912$) in pollinator visits to *Helianthella quinquenervis*. Flowers at Virginia Basin received a mean of

0.246 (SE= 0.046) visits per flower, while those at Avery Picnic received a mean of 0.259 (SE= 0.070, Figure 5) visits per flower.

In terms of the composition of flower visitors to *Helianthella quinquenervis* at Virginia Basin and Avery Picnic, I found a significant difference in the types of visitors observed in 2021 (Chi-square test of independence $\chi^2 = 8.107$, $df=1$, $p<0.05$). At Virginia Basin 94.2% of the visitors were bumblebees, and the rest were a mix of other pollinators (solitary bees, flies, beetles and moths), while at Avery Picnic 79.5% of the visitors were bumblebees and the rest were other pollinators (Figure 6). In 2022, however, there was no significant difference in the composition of flower visitors (Chi-square test of independence $\chi^2 = 1.334$, $df=1$, $p>0.05$). At Virginia Basin 80.3% of the visitors were bumblebees, and the rest were a mix of other pollinators, while at Avery Picnic 62.5% of the visitors were bumblebees and the rest were other (Figure 7). The lack of significance in 2022 was likely due to the low number of flower visitors recorded at Avery Picnic ($n=8$).

Discussion

The purpose of this study was to document the impacts of elevation on *Helianthella quinquenervis* flower abundance and pollinator visitations. Previous research details the success that high alpine plants have in increased flower production to attract more pollinator visitations (Bonelli et al., 2022). My Hypotheses was that *Helianthella quinquenervis* would share a similar pattern in flower production and visitation to other high alpine flowers. This plant species was specifically chosen for this study given its vast abundance during previous years in the Gothic townsite. Flowers from the Asteraceae family have some of the most expansive and diverse species from any other family because they have each evolved to be highly specialized to their environment as seen through their phenological structures (Mandel et al., 2019).

However, during the 2024 field season, *H. quinquenervis* did not bloom until much later in than in previous years and is why data from 2021 and 2022 was used to examine any patterns. Based on the results, I conclude that flower production is not primarily driven by elevation. My initial predictions were based on a study of the flower production and pollinator visitations to *Androsace brevis* (Primulaceae) at high elevation, It is possible that the species in the Primulaceae respond differently to elevation than species in the Asteraceae, and requires further studies.

Pollinator visitation is one of the most important factors to the success of plant reproduction however, pollinators prefer large populations of plants as it brings more rewards to them (Gascon, 2021), so I expected to find a relationship between higher pollinator visitations and a high abundance of flowers. But the results of this experiment, demonstrate there was no significant difference in pollinator visitation between Virginia Basin and Avery Picnic despite both sites having shown a significant difference in flower counts both years. This could come because of the types of visitors these flowers were receiving, as previous research has found a direct correlation between wasp and fly visits and the success of high elevation alpine plants (Bonelli et al., 2022). Pollinator visitation data from 2021 and 2022 show how bumblebees made up most visits on both sites (Figures 6 & 7) which indicate a lower population of flies and wasps pollinating at both sites. The presence of flies at high elevations tends to be largely because of the absence of other insects (Kearns, 1992). Although the difference is not significant, Virginia Basin did see more flower abundance in 2022 when pollination from insects other than bees increased. There is not sufficient data to clarify whether this increase in flower abundance truly does relate to the types of visitors coming to the *Helianthella quinquenervis* so future research should focus on gathering a larger sample of pollinator visitations.

An additional variable that is notable to this research is the effects of late snowmelt in high elevations. Previous research details the sensitivity of the *H. quinquenervis* when it comes to frosting in the early season which is a major factor on why this flower only blooms in the mid to late season once most snow has melted (Inouye, 2008). The phenology of the *H. quinquenervis* at higher elevations was likely affected by the date of snowmelt during the years that data was collected. Even with the snowmelt, previous research still concludes that other variables such as microhabitat differences in snow accumulation, snowmelt patterns, and cold air drainage during frost events can be significant (Inouye, 2008). Future research on the *H. quinquenervis* could address its changes in phenology over the years in correlation to their date of blooming.

Acknowledgements

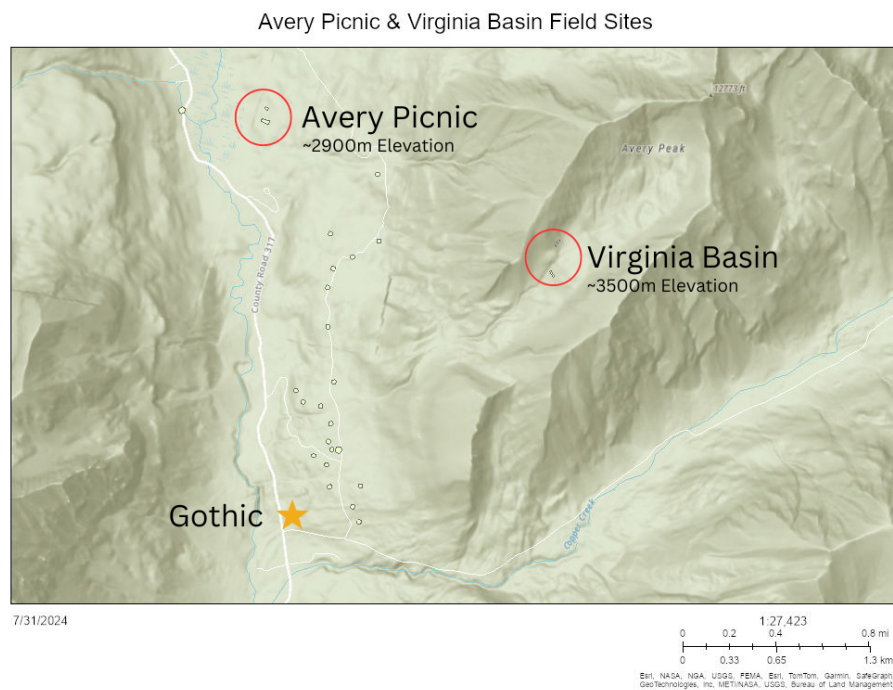
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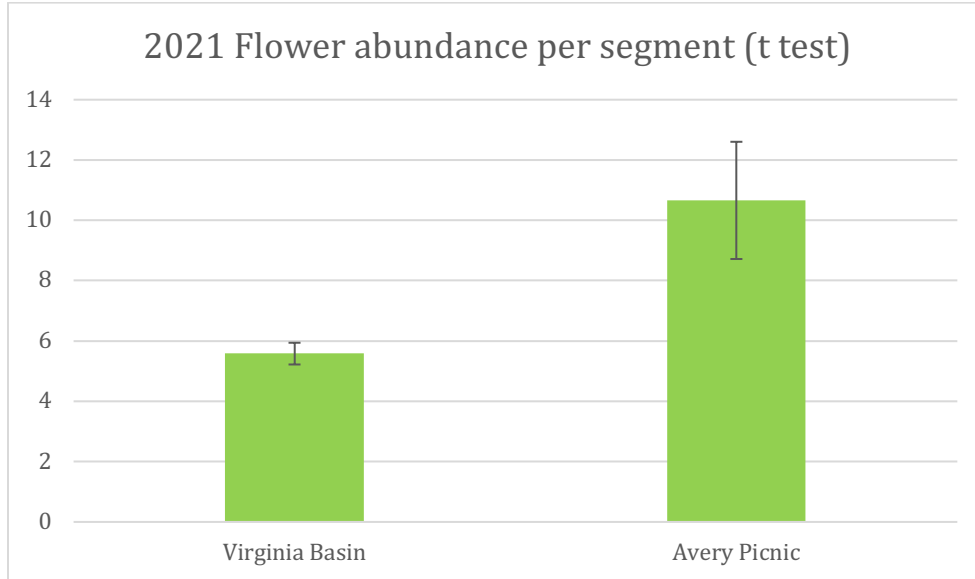
Figures

Figure 1



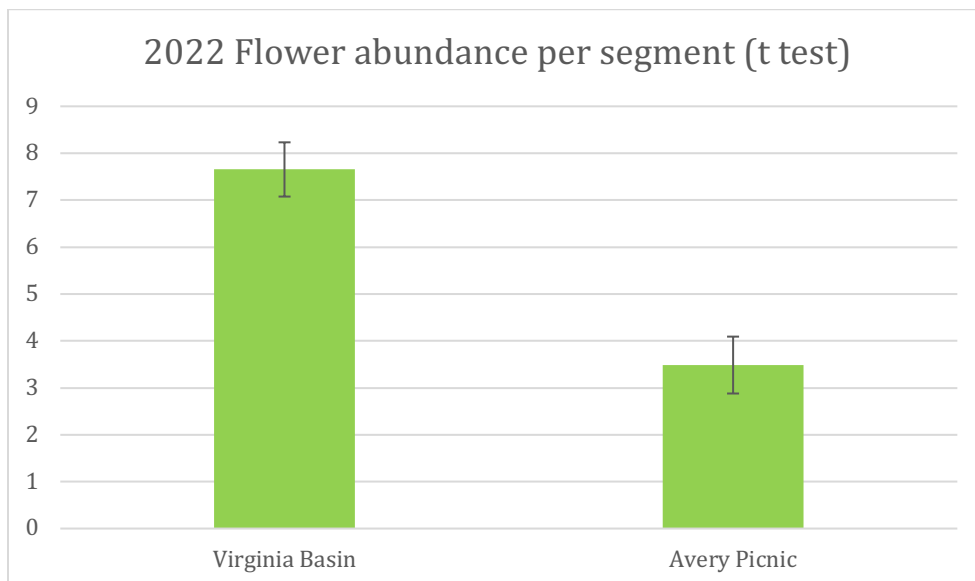
Avery Picnic located around 2900m o and Virginia Basin located around 3500m of elevation.

Figure 2



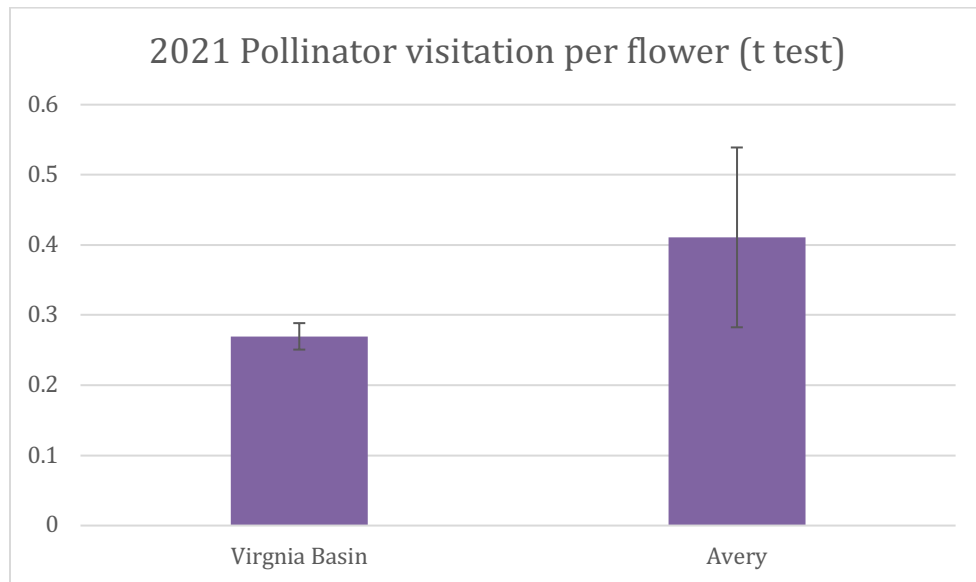
Mean (SE) flower abundance of *H. quinquenervis* at Virginia Basin and Avery Picnic in 2021. There was a significant difference in flower abundance (t-test assuming unequal variances: $t=-2.57$, $df=62$, $p = 0.013$). Virginia Basin had a mean flower abundance per segment of 5.58 (SE= 0.360) while Avery Picnic had a mean of 10.661 flowers per segment (SE= 1.943).

Figure 3



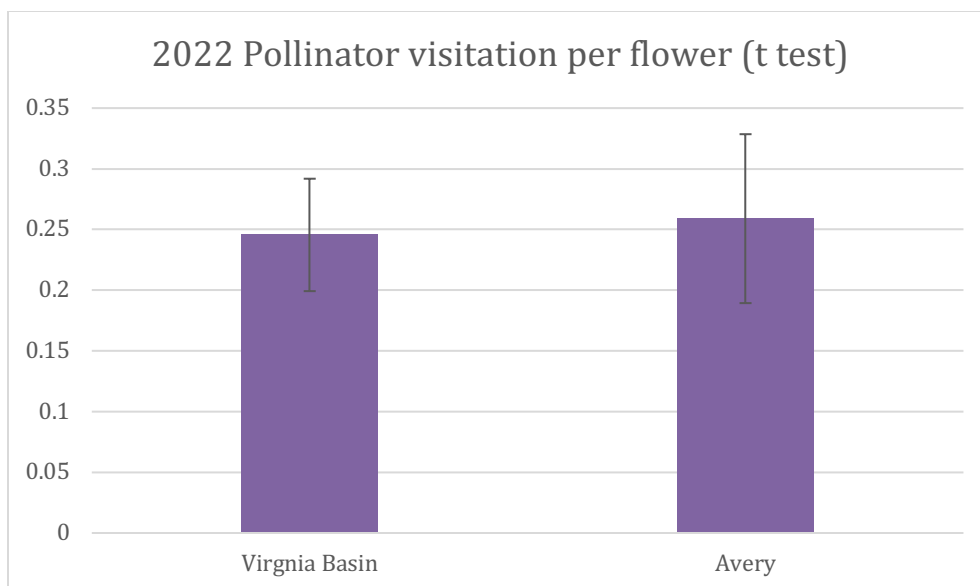
Mean (SE) flower abundance of *H. quinquenervis* at Virginia Basin and Avery Picnic in 2022. There was a significant difference (t-test assuming unequal variances: $t=4.977$, $df=104$, $p<0.001$). Virginia Basin had a mean number of flowers per segment average at 7.655 (SE=.578), while Avery Picnic had a mean of 3.485 flowers per segment (SE = 0.606).

Figure 4



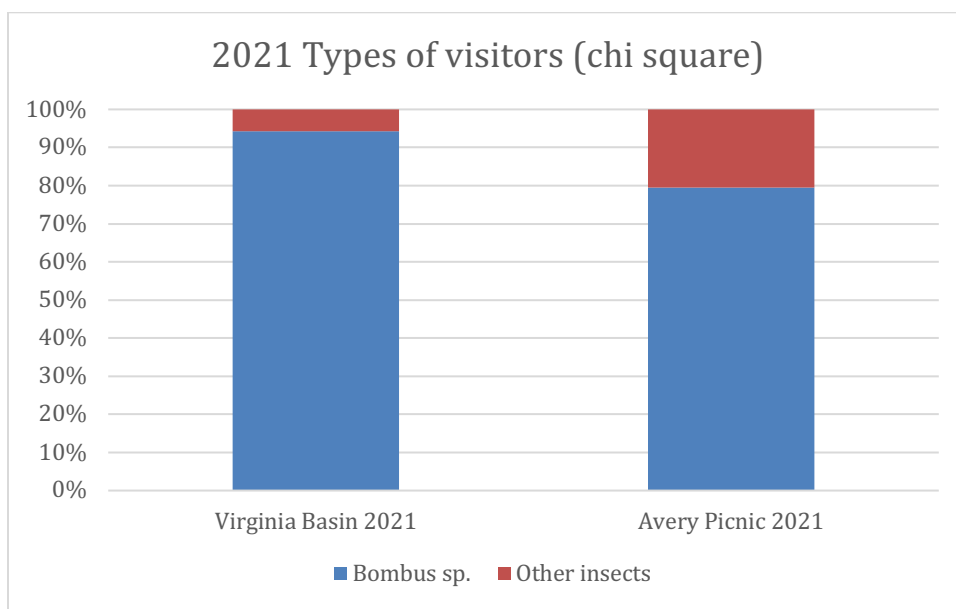
Mean (SE) number of visits per flower per segment in 2021. There was no significant difference in visits between sites (t-test assuming unequal variances: $t=-1.09$, $df=18$, $p=0.29$). Virginia Basin had a mean of 0.270 (SE = 0.019.) pollinator visits per flower per segment while, Avery Picnic had a mean of 0.410 visits per flower per segment (SE = 0.128).

Figure 5



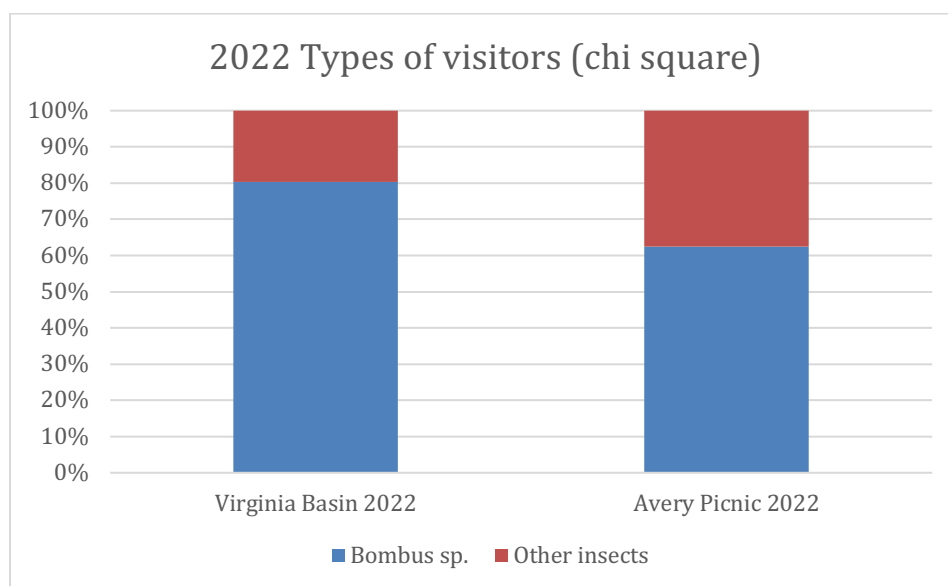
Mean (SE) number of visits per flower per segment in 2022. There was no significant difference (t test assuming unequal variances: $t=-0.11$, $df=50$, $p=0.912$) in the mean number of visits per flower per segment. Virginia Basin had a mean of 0.246 (SE= 0.046) visits per flower per segment while Avery Picnic had a mean of 0.259 (SE= 0.070) visits per flower per segment.

Figure 6



Relative composition of flower visitors in 2021. There was a significant difference (Chi-square test of independence $\chi^2 = 8.107$, $df=1$, $p<0.05$) in the composition of visitors between both sites. At Virginia Basin, 94.2% of the visitors were bumblebees with the rest being other pollinators, while at Avery Picnic 79.5% of the visitors were bumblebees with the rest being other pollinators.

Figure 7



Relative composition of flower visitors in 2022. There was no significant difference (Chi-square test of independence $\chi^2 = 1.334$, $df=1$, $p>0.05$) in the visitors to both sites. At Virginia Basin 80.3% of the visitors were bumblebees with the rest being other pollinators. At Avery Picnic 62.5% of the visitors were bumblebees with the rest being other pollinators.