

Temporal variation in high elevation plant-pollinator communities

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Abstract

Plant-pollinator communities contribute to global diversity and are a good indicator of the health of an ecosystem. Climate change is causing phenological changes of flowering plants and pollinators. Changes in plant phenology can lead to a pollinator not being able to find sufficient pollen and nectar resources, while plants may produce fewer seeds. The focus of this study is to compare species diversity of a plant-pollinator community across three years in Virginia Basin, CO. Species richness and species diversity were greater in 2021 and 2022 compared to 2000. These results support the idea that insects are moving to higher elevation due to climate change. Increasing our sampling effort could give us different results. Further study of plant-pollinator networks across a range of temporal scales is needed, as the ability for plants and pollinators to adapt to mismatch remains unclear.

Introduction

The interaction between plants and pollinators is an important contribution to global diversity (Burkle & Alarcón, 2011). It is estimated that 85.0% of flowering plants require pollination by animals (Ollerton et al. 2011). The amount of seed produced tends to be higher when the seed are fertilized from pollinator visitation (Rodger et al. 2021). Humans rely on animal pollination either directly or indirectly for an estimate of one third of the food they eat (Kearns et al., 1998).

Global climate change is causing a shift in phenology of both plant and pollinators. Insects and plants respond differently to climate change, this difference in change can cause temporal and spatial mismatch to occur (Rahimi et al. 2021). A flower reproducing before or after the

appropriate season can lead to failure of a flower to be pollinated (Inouye 2008). Pollinators are experiencing more phenological change than plants are, which is potentially leading to interaction mismatch (Burkle & Alarcón, 2011). Insect population and plant production can drastically vary among years and this variation potentially plays a role in the frequency (or lack) of interactions (Burkle & Alarcón, 2011). The ability for plants and their pollinators to adapt to spatial and/or temporal mismatches remains unclear (Gérard et al. 2020). Fewer pollinator interactions could lead to reduced seed production in an estimated 79% of plant species (Rodger et al. 2021). Plants are the base of food chains while providing habitats for animals, therefore declines on plant diversity can have further cascading effects on animals (Rodger et al. 2021). Pollinators play an important role in maintaining healthy plant populations, thus the focus in vulnerability of plants to pollinator decline is of importance (Rodger et al. 2021). This study aims to analyze how species diversity of plant-pollinators has changed at a high elevation site in Colorado throughout the years, while also contributing to the long-term study of plant-pollinator communities. I hypothesize that species diversity has decreased throughout the years due to phenological mismatch occurring.

Methods

Study site

Our study site was located near the Rocky Mountain Biological Laboratory (RMBL) in Gothic, Colorado USA (38° 57'5" N, 106° 59'3" W, 2900m a.s.l.). Data was collected in a sub-alpine meadow known as Virginia Basin located at 3500m elevation (Figure 1) at four kilometers northeast of Gothic, Colorado.

Experimental design

Eight transects were established, each measuring twenty meters long and one meter wide. There was a one-meter space between each transect to allow space for walking outside of the established plots. Each of the eight transects were divided into two-meter segments, producing a total of ten segments in each transect. Sampling took place one to two times a week from June 27th, 2022 to July 27th, 2022 during the hours of 10:00AM and 3:00PM.

Data collection

Each transect was observed and number of flowers in each segment was documented on a weekly basis. Plant-pollinator observations consisted of observing each segment for a total of three minutes; the three minutes were divided into 90 seconds per side of each segment. A pollinator-interaction was valid only when an insect landed on the reproductive organ of the plant. If an insect such as a: bee, fly, moth, wasp, or beetle was pollinating, it was netted and transferred into a plastic vial. Vial was labelled and interaction was recorded which included: date, time, plant species, and pollinator ID. Exceptions to insects caught included bumble bees and bees in the genus: *Osmia*; these species were not caught to reduce disruption of current studies being conducted on them. Vials containing insects were then humanely euthanized by placing them in a freezer for a minimum of 24 hours. After the 24 hours, insects were pinned and identified to category level established by the Brosi lab. Insects from the previous year of 2021 were also categorized using the same method. Insects from the year 2000 were previously categorized.

Analysis

Plants whose flowers received six or more visits during the 5 weeks of sampling were included in the analysis. The following variables were calculated for each plant species and then averaged within each year: number of pollinator visits, species richness of pollinator visitor categories, and species diversity of pollinators visitor categories based on the Shannon Diversity Index. One-way ANOVA was used to compare the averages of floral abundance, visits, species richness, and species diversity throughout the three years of data. Tukey's HSD post-hoc test was used to assess the significance of differences between the averages of the groups.

Results

In 2000, plants received an average of 38.727 visits (SE= 13.154), 2021 had an average of 31.182 visits (SE= 10.612), and 2022 contained an average of 26.100 visits (SE= 7.472) (Figure 2). There was no significant difference in the average number of pollinator visits throughout the three years ($F = 0.339$, $df = 2, 29$, $p = 0.715$). The average species richness of pollinator visitors in 2000 was 3.182 (SE= 0.400), 2021 contained an average of 6.545 (SE= 0.878), and 2022 contained an average of 6.000 (SE= 0.803) (Figure 3). There was a significant difference in species richness throughout the years ($F = 6.429$, $df = 2, 29$, $p = 0.0048854$). The results of a post-hoc test indicate that the year 2000 is statistically lower than the year 2021 and 2022, while the year 2021 and 2022 shared no statistical difference from each other (Tukey HSD: 2.612). The average species diversity of pollinator visitors to plants in 2000 was 0.580 (SE= 0.085), in 2021 the average was 1.455 (SE= 0.117), and in 2022 the average was 1.338 (SE= 0.183) (Figure 4). The results of statistical tests indicate a significant difference in species diversity throughout the years ($F = 13.454$, $df = 2, 29$, $p = 0.00007351$). Post-hoc test indicates that the year 2000 is

statistically lower than the year 2021 and 2022, while there was no statistical difference in the years 2021 and 2022 (Tukey HSD: 0.475). The average floral abundance in 2000 was 779.818 (SE= 153.389), 2021 had an average of 738.091 (SE= 121.244), and 2022 had an average of 878.800 (SE= 207.494) (Figure 5). Statistical tests indicate no significant difference in floral abundance ($F = 0.194$, $df = 2, 29$, $p = 0.824$).

Discussion

The results indicate that the number of pollinator visits and floral abundance has roughly remained the same throughout the three years, but species richness and species diversity of pollinator visitors to plants has increased when comparing 2000 to 2021 and 2022. Species richness and species diversity has remained relatively similar in the past two years (2021 and 2022). My prediction that species diversity would be decreasing due to phenological mismatch was not supported. One reason as to why we are seeing an increase in diversity could potentially be due to rewiring occurring in pollination systems. Previous studies have shown that if plants and pollinators are able to adapt to resource use in combination with rapid rewiring occurring then they can become resilient to phenological changes (CaraDonna et al. 2017). Another reason as to why species diversity is increasing could be due to the fact that insects are moving to higher elevation due to warming climates (McCain and Garfinkel 2021). Insects living in mountains are also able to find more diversity in their plant resources (Halsch et al. 2021). One important factor to consider in this study is the sampling effort taken. Sampling effort is an important factor that shapes network structure across different temporal scales due to it positively effecting species richness (Schwarz et al. 2020). If sampling effort is not greatly increased, temporal scale networks will be depicted as larger but not necessarily complete (Schwarz et al. 2020). There is evidence that shows that species interactions are established and terminated quickly across a

season (CaraDonna et al. 2017) which could indicate that the full network structure in our data is not visible due to low sampling effort. Studying plant-pollinator networks across a range of temporal scales may be important to get the big picture of the causes and consequences of their structures (Schwarz et al. 2020). Future studies should take sampling effort into consideration when gathering data. Another factor that can be included in studies is temperature. Mean annual temperature can indicate which species can potentially interact and the length and synchrony of the periods of those interactions (Schwarz et al. 2020). Ultimately, to increase our understanding of long-term temporal patterns it's beneficial to resurvey plant-pollinator interactions from former study sites and build upon existing data (Burkle & Alarcón, 2011).

Literature Cited

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Figures

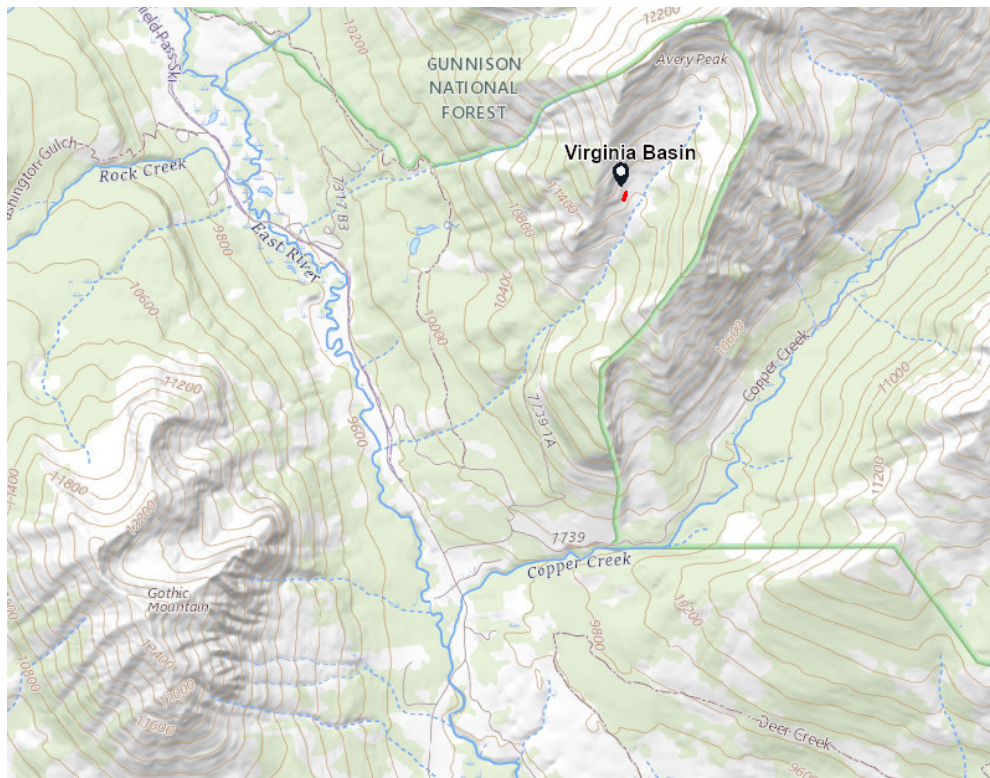


Figure 1. Location of field site in Virginia Basin, CO.

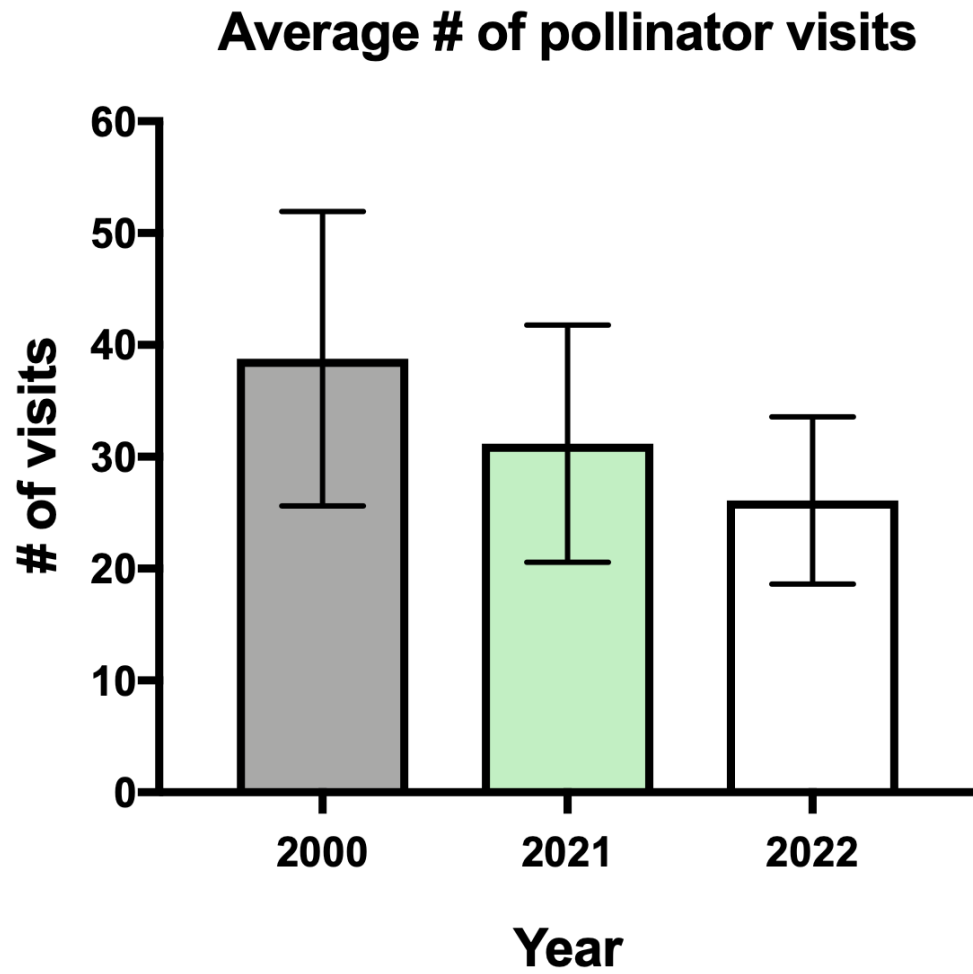


Figure 2. Average number of pollinator visits per plant for 2000, 2021, and 2022.

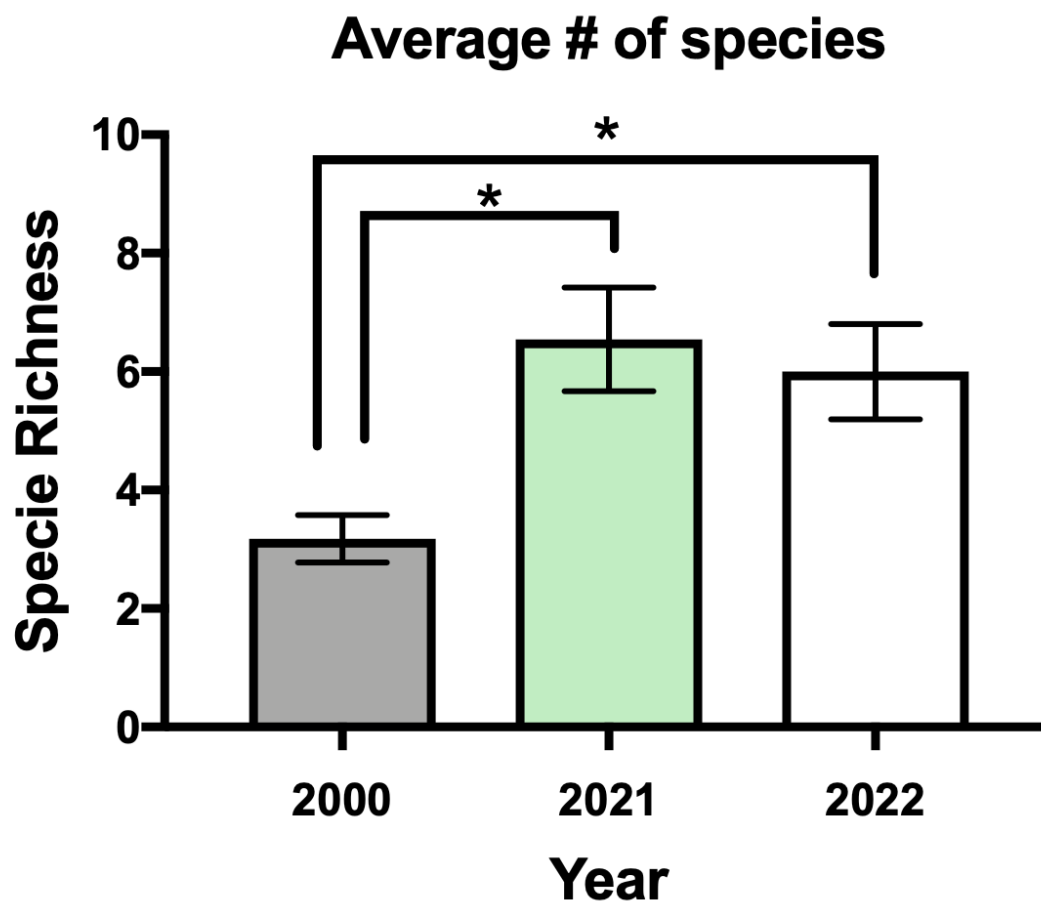


Figure 3. Average species richness of pollinator visitors for 2000, 2021, and 2022. Asterisk indicating significant difference.

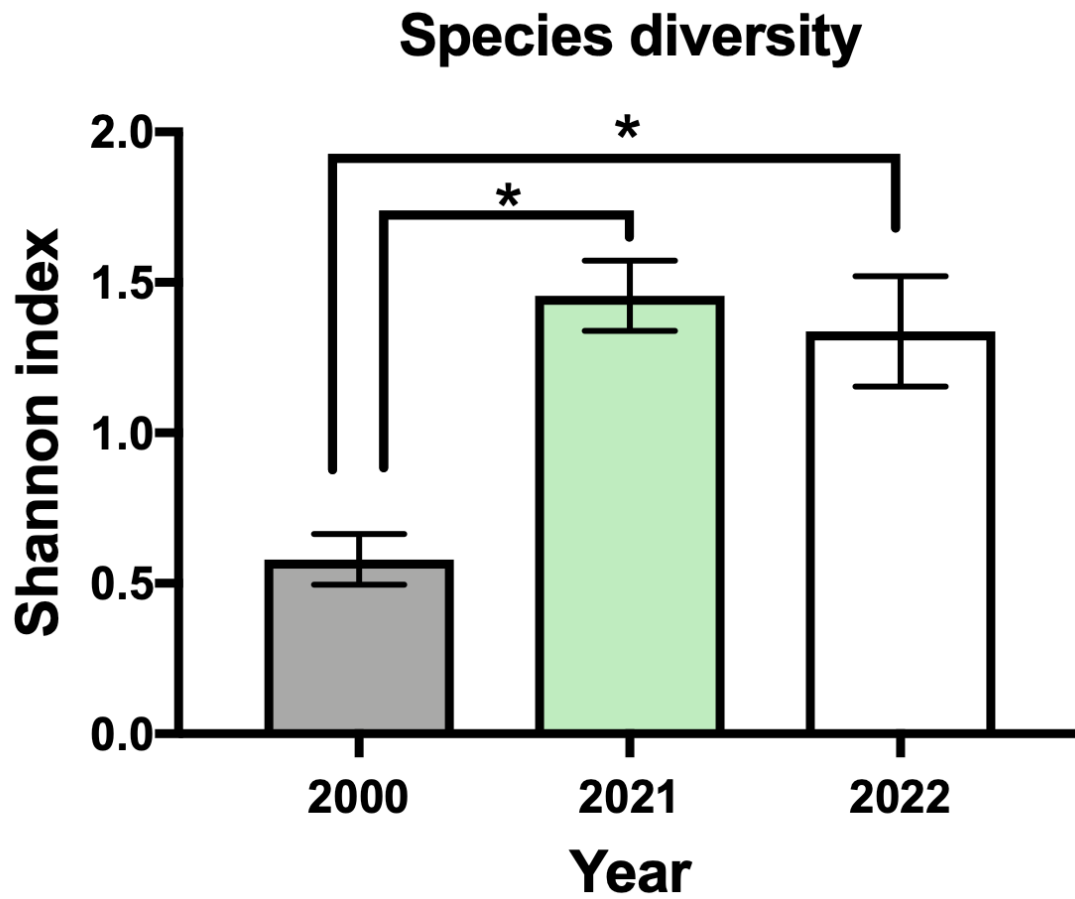


Figure 4. Average species diversity of pollinator visitors for 2000, 2021, and 2022. Asterisk indicating significant difference.

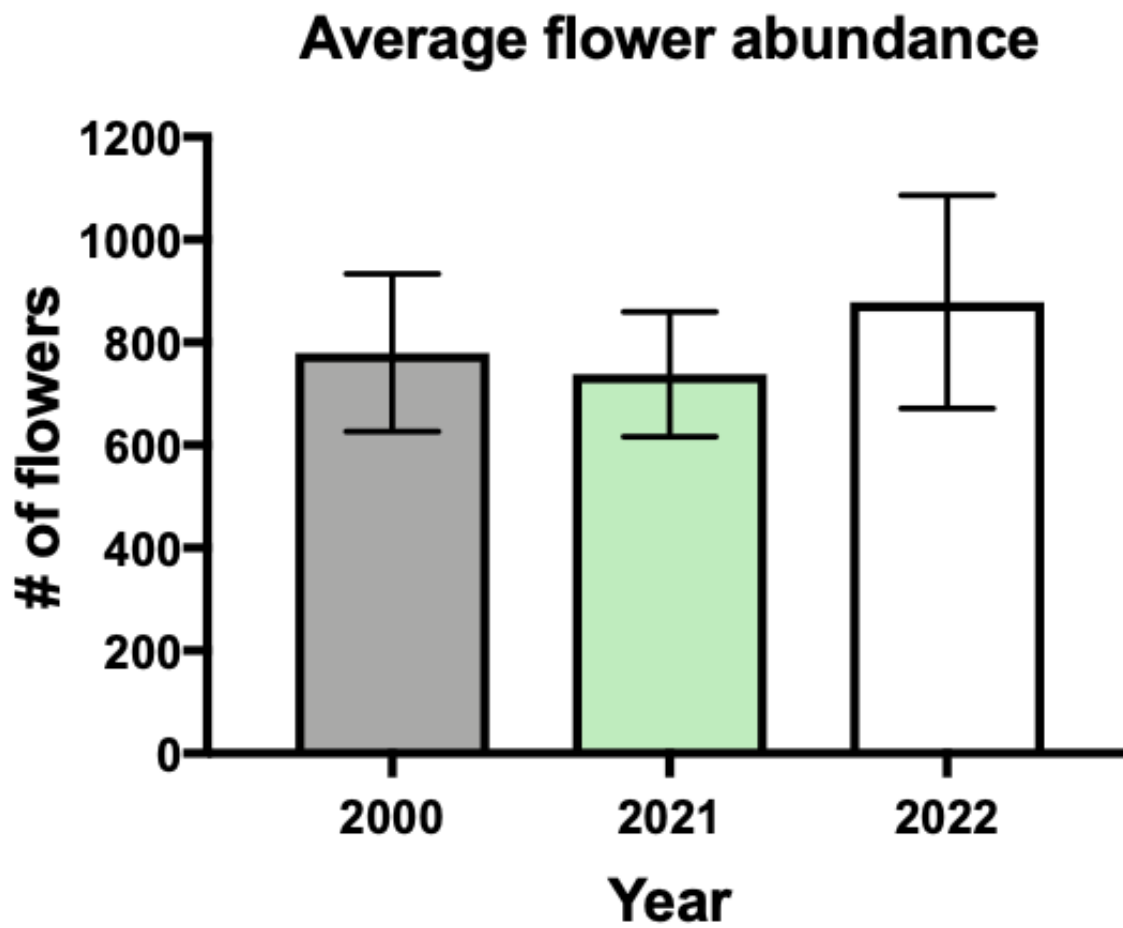


Figure 5. Average number of flowers for 2000, 2021, and 2022.