CLIMATE CHANGE ADAPTATION PROGRAM

Creating Climate-Resilient Agricultural Pollinator Communities in Bulkley-Nechako and Fraser-Fort George

Project Report

March 2023

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Project Summary

Fieldwork: Pollinator biodiversity and floral resources were surveyed between mid-May and early September 2022 on 25 agricultural sites and neighbouring forested areas across the Bulkley-Nechako and Fraser-Fort George Regional Districts.

Data Collection: A total of 73 species of pollinating bee and 70 species of hoverfly were identified from the 2863 specimens caught in 366 pan trap samples in 2022. There were 121 species of flowering plants identified growing in or near agricultural fields, 72 of these native, that were considered potential resources for pollinators.

Results: Pollinator biodiversity on farms in this region is generally highest on forest edges, for both forage and fruit/vegetable producing operations, and is positively influenced by floral diversity and the size of forest patches adjacent to croplands. Field size is negatively related to pollinator species richness, but this relationship is weakened if floral diversity is high.

Interannual Differences: Slightly more pollinating bee and hoverfly species were documented in 2022 than in 2021, but the average species richness on each site was lower in 2022 than 2021. In 2021, the combination of high temperatures and earlier hay dates was associated with seasonal declines in pollinator biodiversity, while in 2022, cooler temperatures and later haying dates were associated with more stable pollinator species richness across all sites.

Final Outputs: Producer-focused handouts on the following topics have been prepared for distribution: i) native plant species that support pollinators; ii) suppliers of native plant species for pollinator habitat enhancement; iii) the role of forests in supporting native pollinators; iv) recommendations for forage crop diversification for pollinator enhancement; v) a brief guide to the major groups of pollinating bees and hoverflies present on farms in the Bulkley-Nechako and Fraser-Fort George Regional Districts.

Knowledge Transfer: We are in the process of setting up long-term archiving for materials associated with this project with the University of Northern British Columbia's Dataverse, where they will be accessible to the public; there is a public talk on this information planned for Feb. 14, and articles intended for publication in peer-reviewed journals are in development.

2022 Fieldwork

In 2022, we sampled 25 sites between Dunster and Smithers, BC. These sites represented both forage producers (mostly alfalfa; 18 sites) and fruit/vegetable producers (7 sites). All sites were sampled for pollinator and floral diversity at least four times between May and September.

Pollinator sampling: this protocol consisted of three sets of 18 pan traps, with one set placed in the field interior, one set along the edge of the field next to the forest, and one set in the forest. The traps were painted with UV-reflectant paint in three colours (white, yellow, and blue; 6 of each colour in each transect), filled with soapy water, and collected approximately 24 hours after being deployed. Field edges were defined as areas where cultivated land and semi-natural habitat met, with trees and native vegetation present on one side, and domesticated crops on the other – in most cases, this meant a mix of domestic and native plant species, and partial canopy cover overhead. Traps considered 'forest' samples were generally placed in areas of greater canopy cover, typically at least five meters away from field edge traps, where there was no intentional cultivation of domesticated plants, and free-growing native vegetation in the understory.

In sorting the contents of pan traps, this year we focused only on pollinating bees (Hymenoptera from the families Andrenidae, Apidae, Colletidae, Halictidae, and Megachilidae) and hoverflies (Diptera from the family Syrphidae), since surveys in 2021 indicated these were the dominant groups of pollinators on agricultural sites, and were adequately inventoried by the pan trap method (i.e., inventory completeness was > 90% for these groups; beetles and butterflies/moths were not adequately inventoried by this method). Many specimens were identified using exemplars from the 2021 collections, but 285 specimens were also sent for identification via DNA barcoding. A complete list of the species barcoded in 2022 is available in Table A1 (2022_pollinator_appendix.xlsx).

Floral diversity surveys: When collecting pan traps on each site we also identified plants in bloom (including, but not limited to: wildflowers, trees, shrubs - anything with flowers and/or reproductive structures that pollinators may use as food, that were available when pollinators are being sampled). Unknown plants were collected and/or photographed for later identification, and both native and domesticated species were included in this inventory. We focused on inventorying common plants by only counting species that were seen in bloom at least three times while walking the pan trap transects. After identification, the known pollinator associations for each plant species were determined via a literature search, to determine the relative value of a given species for pollinator enhancement.

2022 Data Collection

Pollinator collections: We collected a total of 366 pan trap samples in 2022 (4 – 5 visits per site, resulting in 122 samples in each category: field interior, edge, and forest). After removing all items other than pollinating bees and hoverflies, there were 2863 specimens to identify, and among these we found 73 species of pollinating bee and 70 species of hoverfly (see Table A2 in the appendix for a complete list of species with details regarding occurrence, geographic distribution, and crop associations).

Floral diversity: A total of 121 plant species in bloom were identified across all sites (see Table A3 for a full list); of these, 72 species of native plants growing in or near agricultural areas were identified that should be considered likely candidates for pollinator enhancement projects.

2022 Results

Pollinator biodiversity: Site-level pollinator species richness showed a weak positive relationship to the area of forest patches adjacent to croplands ($r = 0.046$), and a much stronger negative relationship with field area ($r = -0.148$). However, declines in pollinator biodiversity associated with field size were mostly observed when the size of cropland area exceeded 100 acres; below this size, declines associated with field size were modest (see Figure 1).

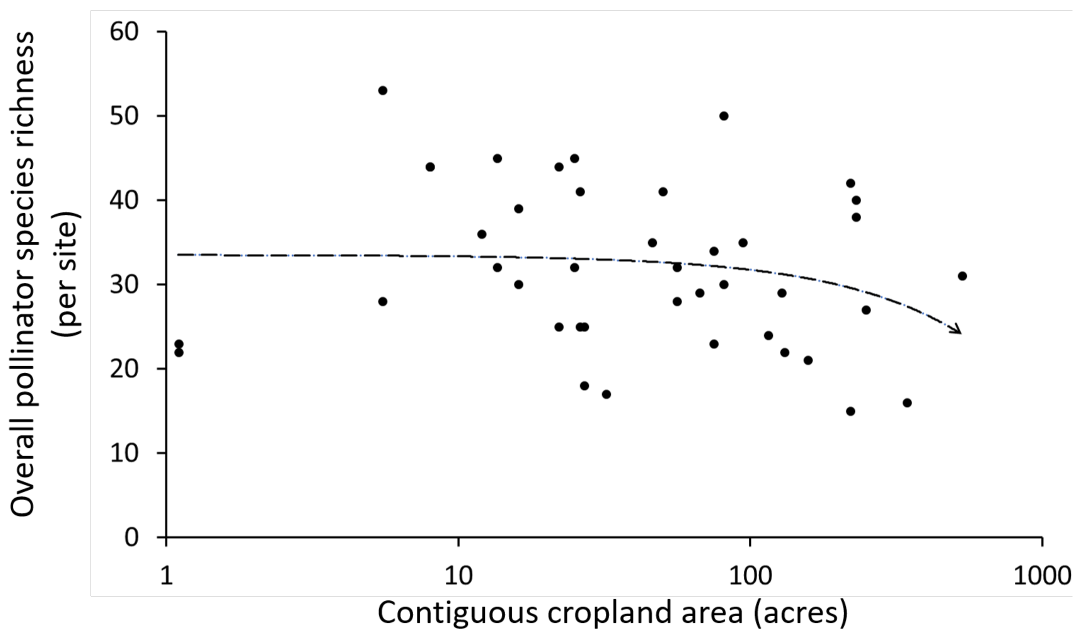

Figure 1. Total pollinator species richness (number of species found over the course of the growing season) all sites sampled, relative to the total contiguous area used as croplands, scaled logarithmically. The trendline illustrates the general decline in pollinator biodiversity with field size, which was observed largely among sites with 100 or more acres of contiguous cropland.

Pollinator biodiversity under the forest canopy was typically slightly lower than on field edges early in the season, but unlike in edges and field interiors, it tended to peak early in the spring and decline thereafter. Of the 143 pollinator species documented in 2022, 80 species occurred in forest samples, but only five of these were captured exclusively in forests (one bee species, *Osmia atriventris*, and four hoverfly species, *Baccha cognata, Pipiza quadrimaculata, Platycheirus flabella,* and *Temnostoma obscurum*). The vast majority of pollinating bee and hoverfly species found in forests in this region were also found on field edges adjacent to forests, where overall pollinator biodiversity and floral diversity were highest.

Floral diversity and pollinator species richness: Seasonal patterns of change in floral diversity differed depending on location within a site: the number of flowering plants in bloom was generally lowest on field edges and in field interiors early in the season, and increased thereafter. In contrast, floral diversity under the forest canopy peaked early in the growing season (May/June), and declined thereafter. On most sites floral diversity was consistently higher on field edges near forested areas than in field interiors or in the forest (Figure 2).

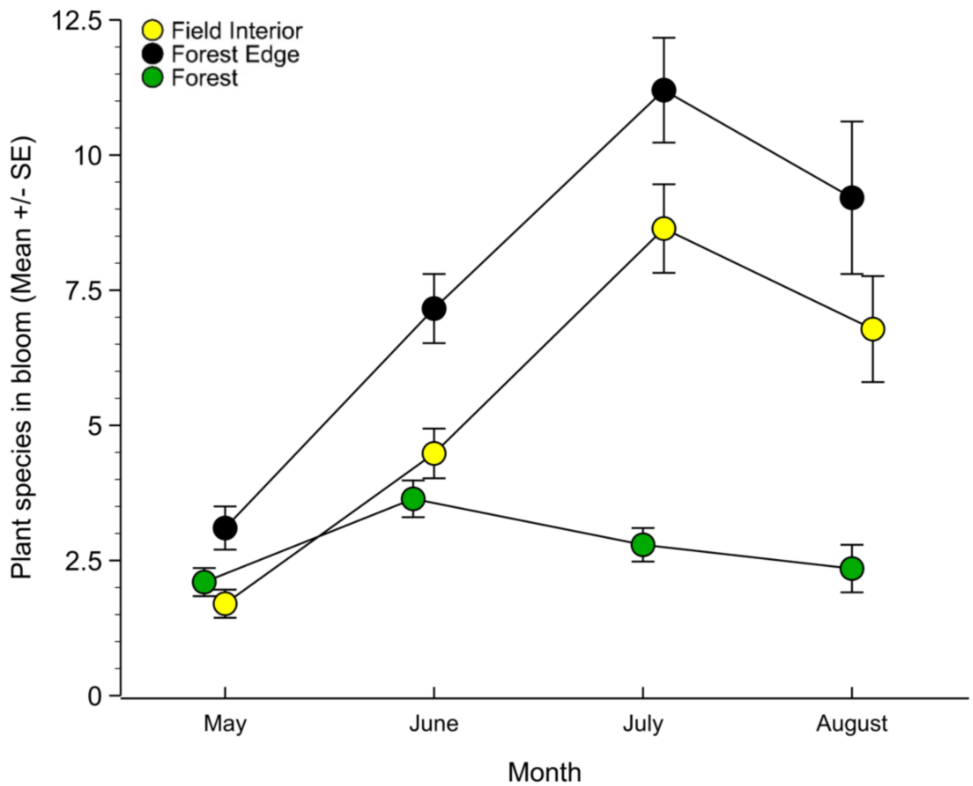

Figure 2. Seasonal (monthly) average floral diversity ± standard error (SE) in field interiors (yellow markers), forest edges (black), and under the forest canopy (green) across all sites.

There were consistent positive relationships between the number of flowering plant species in bloom and the species richness of pollinators captured in pan traps. Notably, this relationship was relatively weak when site-level summary data were evaluated (i.e., total pollinator species richness is weakly correlated to overall floral diversity, $r = 0.055$); the correlation was much stronger when field interior, edge, and forest samples were evaluated separately, with floral diversity data restricted to plants found in each of these areas respectively ($r > 0.17$). Interestingly, pollinator biodiversity was more strongly related to the number of native and domesticated (crop) plant species in bloom than overall floral diversity (which included both native and domesticated as well as exotic plants considered invasive or noxious weeds), an indication that many native pollinators may benefit from crop diversification in addition to the availability of native plants, but that invasive plant species are unlikely to benefit pollinator biodiversity.

Synthesis: Initial analyses indicate that pollinator species richness in agricultural areas increases with forest patch size and floral diversity, and declines as the area of land cleared for crop production increases. However, the negative effect of cropland area on pollinator biodiversity is largely observed when floral diversity is also low. Sites with large contiguous areas of croplands but high floral diversity had pollinator species richness comparable to smaller fields with low floral diversity (Table 1).

Table 1. Average total pollinator species richness ± standard error (SE) on sites, categorized according to area of contiguous cropland and floral diversity, with exotic plant species excluded; average total floral diversity of native and domesticated plants across all sites was 19.52 species.

Field area	Floral diversity	*n* (sites)	Pollinator species richness (mean ± SE)
Large (≥ 75 Acres)	Above average	8	31.3 ± 2.6
	Below average	4	23.0 ± 2.9
Small (< 75 acres)	Above average	4	38.5 ± 4.6
	Below average	9	29.7 ± 2.7

Collectively, these findings indicate that the effects of larger field size on pollinator biodiversity can be at least partially mitigated by increasing floral diversity. This suggests that pollinators are likely to benefit from both habitat enhancement using native plants as well as crop diversification with domesticated plant species, if the crops chosen are pollen and/or nectar-bearing (i.e., legumes, fruits, vegetables; grasses/cereals were not evaluated here due to the lack of evidence indicating their value to native pollinators, and difficulty in field identification).

Interannual Differences

The pan trap protocols in each year of the study differed slightly (3 x 18 traps per site in 2022, 2 x 24 traps per site in 2021) but given the similar overall sampling effort per site, the resulting data are broadly comparable. There were a few more pollinating bee and hoverfly species documented in 2022 than in 2021 (143 in 2022, relative to 131 in 2021), but the average species richness on each site was lower in 2022 than 2021 (30.24 in 2022, relative to 32.17 in 2021). There were substantial differences in community composition between years, with 23 bee and 22 hoverfly species unique to 2022 samples, and 15 bee and 12 hoverfly species unique to 2021 **(**see Table A4 for a list of pollinating bees and hoverfly species caught in 2021 and 2022). Most noteworthy were the capture in 2022 of long-horned bees (*Eucera* and *Melissodes* spp.) and cellophane bees (*Colletes* spp.), which were not found in 2021. Additionally, there was a greater abundance and diversity of leafcutter bees (particularly from the families *Osmia* and *Megachile*) in 2022 relative to 2021.

The other most noteworthy difference in pollinator biodiversity among years was in the change over time during the growing season in pollinator species richness. In 2021, the combination of high temperatures and earlier hay dates was associated with seasonal declines in pollinator biodiversity, while in 2022, cooler temperatures and later haying dates were associated with more stable pollinator species richness across all sites (Figure 3).

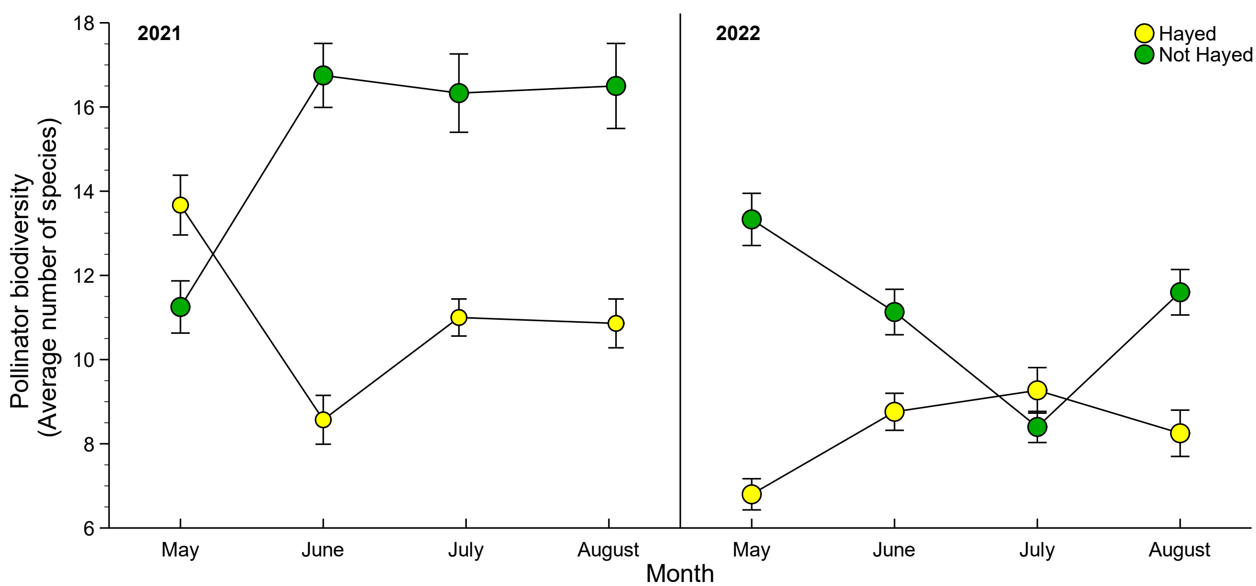

Figure 3. Seasonal (monthly) average pollinator species richness ± standard error (SE) of sites that were hayed at some point during the growing season (yellow markers) or grazed/left fallow during the season (green), in 2021 (left panel) and 2022 (right panel). The average hay date in 2021 was July 3, while in 2022, it was August 1.

Final Outputs

Five documents have been prepared for distribution to producers and the general public, based on the findings from this study; they are listed below.

1. Floral resources for native pollinators on farms in BC's Central Interior

There is a significant gap in our knowledge regarding which native plants grow successfully in agroecosystems in this region and are used as resources by pollinators. Producers interested in pollinator enhancement may be unsure what types of plants to use. This handout summarizes the results of floral diversity surveys that were carried out in 2022, and provides a list and pictures of the most common species found on farms that support pollinators, in addition to detailed information about the growing conditions, pollinator associations, and typical flowering period for all pollinator-friendly native species we documented. This information will allow producers to make better-informed decisions about habitat preservation or enhancement for pollinator conservation

2. Resources for pollinator enhancement in BC's Central Interior

Producers looking to carry out pollinator habitat enhancement are often unsure where to find native plants that will not become invasive and are well-adapted to local growing conditions. We identified suppliers either located in the interior, or willing to ship their products here, for the most common pollinator-supporting plants we identified in floral diversity surveys. We compiled contact information and product availability for all suppliers we identified, to produce an easy-to-read guide for producers looking for seeds and/or starts of native plants that will support native pollinator biodiversity.

3. Forests benefit pollinators on farms in BC's Central Interior

'Non-productive areas' in agroecosystems include forest patches and riparian zones; these may function as important habitat for some native pollinators. Producer decisions on land use (i.e., forest patch retention, riparian zone management) should benefit from having empirically supported information about how forests influence pollinator biodiversity. This handout explains how we found that the diversity of both insect pollinators and food resources for pollinators (number of plant species in bloom) were generally highest on field edges near forests; additionally, we show how forest-associated plants may be particularly important early in the spring. Collectively, these findings indicate that retaining forests and native vegetation on forest edges is likely to promote pollinator biodiversity.

4. Crop diversification in forage production: benefits to pollinator biodiversity

In agroecosystems, some pollinators may depend on domesticated crops for food. This handout details one of the findings of our work, that forage crops are likely an important resource for native pollinators in the Bulkley-Nechako and Fraser-Fort George Regional Districts, particularly in years with higher than expected temperatures. We provide recommendations for plants that have forage value as well as being useful to pollinators, that could be used to increase floral diversity in croplands and describe a simple method producers can use to assess and compare pollinator diversity between areas planted with different crops.

5. **Pollinating bees and hoverflies on farms in the Bulkley-Nechako and Fraser-Fort George Regional Districts: a brief introduction**

Prior to this study, the only comprehensive inventories of pollinators found in agroecosystems in British Columbia were from the Okanagan and the Lower Mainland. These have no use for producers in the Bulkley-Nechako and Fraser-Fort George Regional Districts, due to substantial differences in pollinator species and types of crops grown here. The handout we have prepared describes the general characteristics that can be used to identify five groups of pollinating bees (Hymenoptera, from the families Andrenidae, Apidae, Colletidae, Halictidae, and Megachilidae) as well as common hoverflies (Diptera from the family Syrphidae) found during pollinator surveys on farms in this region in 2021 and 2022.

Knowledge Transfer

Specimens: All of the specimens sent for DNA barcoding are on permanent loan to the Biodiversity Institute of Ontario; we also intend to donate specimens to the Royal BC Museum. We are also in the process of arranging to send *Hylaeus* specimens to an interested researcher at the Royal Saskatchewan Museum.

Data and Document Archiving: We are currently in the process of setting up long-term hosting for all project materials with UNBC's Dataverse, hosted by Borealis Data; these files will be publicly accessible and freely downloadable for the foreseeable future.

Presentations: Some of the data from this project were analyzed and presented at the joint meeting of the Entomological Societies of Canada, America, and British Columbia, on November 14, 2022. Additionally, there was a final webinar held on Feb. 14, 2023, to summarize all the outputs listed above, and to ensure interested parties are informed about the location of the archived materials. The David Douglas Botanical Society has expressed interest in hosting a talk about plants for pollinator enhancement at some point in the spring of 2023. We are also developing manuscripts for publication in peer-reviewed journals.