Angiosperm Diversity in Pollination Systems

It is recommended you do this after doing 'Exploring the iNaturalist Database and Understanding Species Information' and before 'Downloading and Visualizing Project Data from the iNaturalist Database'

Overview

This activity will explore how plant-pollinator interactions can provide an estimate of ecosystem health. We will use basic network analysis to evaluate plant-pollinator interactions through creating bipartite plots and calculating nestedness, which is a metric of ecosystem health.

The example in this exercise uses data from the Calgary Pollinators Project on iNaturalist. You will use observations of pollinators that visited flowering angiosperm species at two parks in Calgary – Nose Hill Park and Prince's Island Park. However, you may adapt this guide for any project on iNaturalist, or for different city parks within the Calgary Pollinators Project. Reference the Downloading and Visualizing Project Data from the iNaturalist Database activity for instructions on how to download data for different parks that is suitable to be converted into a usable matrix for analysis of plant-pollinator interactions.

This activity works best in groups of three/four

1. Learning about plant-pollinator networks — 25 - 30 minutes
2. Visualizing and analyzing a plant-pollinator network — 25 - 30 minutes

Objectives

- Explore plant-pollinator interactions
- Basic network analysis
- Creating bipartite plots
- Assess ecosystem health by measuring nestedness

Materials

- Internet browser

Vamosi, J., Albor, C., Doll, J., Baboi, M., Summers, M., Adams, S. (2024). Angiosperm Diversity in Pollination Systems. QUBES Educational Resources.

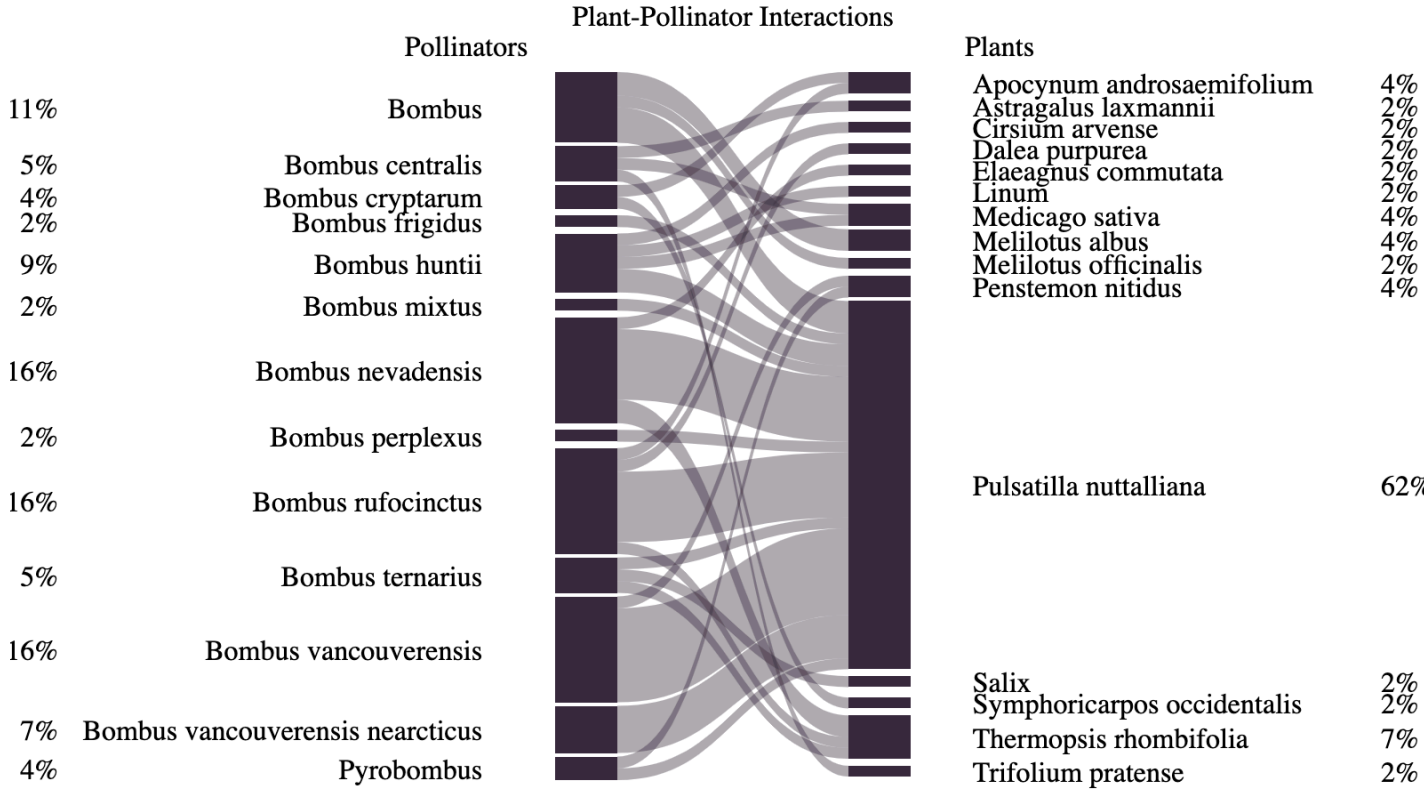
Total activity time	**50 – 60 minutes**

Vamosi, J., Albor, C., Doll, J., Baboi, M., Summers, M., Adams, S. (2024). Angiosperm Diversity in Pollination Systems. QUBES Educational Resources.

1. Learning about plant-pollinator networks

Part 1: Understanding the basics of a plant-pollinator network.

Example 1) Here is what the bipartite interaction matrix looks like for *Bombus* interactions at Nose Hill in 2023. A **node** represents the different species within a bipartite network. In this case the two sets of nodes are insect species and plant species. A **line** connecting an insect node to a plant node means that the insect interacts with that plant.



The **thickness of the line** relates to the number of times that insect species was observed interacting with that plant, i.e. the thicker the line, the more interactions have been observed. Additionally, the **percentages beside the nodes** can indicate the proportion of interactions that involve each node. For instance, an insect node percentage shows the proportion of plant interactions this insect is responsible for. Similarly, a plant node percentage represents the proportion of insect interactions this plant is involved in. These percentages can help identify key species within the network, such as the most interactive or dominant plant or insect species.

Vamosi, J., Albor, C., Doll, J., Baboi, M., Summers, M., Adams, S. (2024). Angiosperm Diversity in Pollination Systems. QUBES Educational Resources.

Begin with the data files from two parks in Calgary: Nose Hill Park and Prince's Island Park. The data in these files is pulled straight from INaturalist and is already arranged into a matrix. All the insects are in the first column and all the plants are in the first row. At the intersection of a certain plant and insect there will either be a 0 or 1 in that space. If there is a 0 it means that interaction was not observed. If there is a 1 it means that interaction has occurred.

	Medicago sativa	*Pulsatilla nuttalliana*
Bombus centralis (bee)	1	0
Bombus rufocinctus (bee)	0	1

In this table you can see that *Bombus centralis* interacts with *Medicago sativa and* not *Pulsatilla nuttalliana*. *Bombus rufocinctus* interacts with *Pulsatilla nuttalliana* and not *Medicago sativa*. You can confirm these interactions by tracing the lines in **Example 1** above.

Categorize your angiosperm species into flower type by their **zygomorphy/ actinomorphy**, and whether they are **monocots/eudicots**. There is a possibility of 4 flower types in total.

Actinomorphy Flowers that are radially symmetrical and have multiple lines of symmetry (like a starfish), are called actinomorphic.	**Zygomorphy** Flowers that are bilaterally symmetrical and have a single line of symmetry (like humans), are called zygomorphic.

You can use Google Images (https://images.google.ca/) to learn about flower morphology and differentiate between zygomorphy and actinomorphy.

Vamosi, J., Albor, C., Doll, J., Baboi, M., Summers, M., Adams, S. (2024). Angiosperm Diversity in Pollination Systems. QUBES Educational Resources.

Counting Floral Units

Individual flowers (e.g. hawthorn) – each flower counts as one unit flower. This drawing has 15 flower units!

Umbels (flowers that have small flowers grouped into 'umbels', like inside-out umbrellas, e.g. hogweed) – each umbel counts as one flower unit. This drawing is of 1 flower unit!

Flower heads (where there are lots of tiny flowers within a larger flower, e.g. dandelion) – each flower head counts as one unit flower. This drawing has 2 flower units!

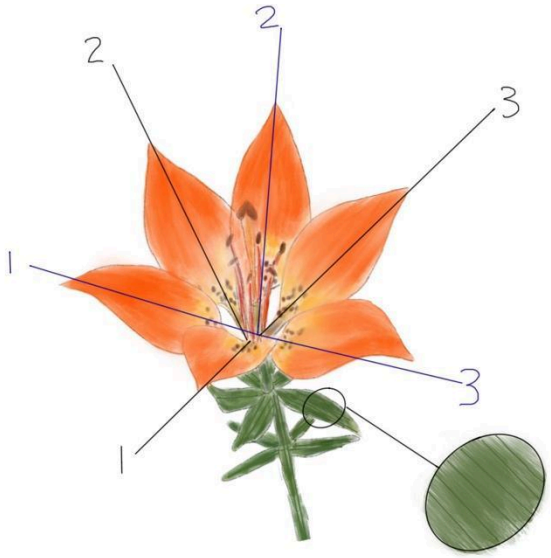
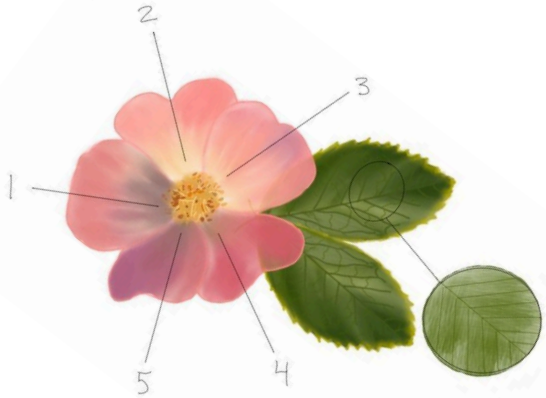
Flower spikes (where a number of small flowers are arranged along a stem, e.g. lavender) – each flower spike counts as one unit flower. This drawing has 4 flower units!

Taylor Ford-Sahibzada

Here are some examples of the different types of flowers you will come across when categorizing your angiosperms, refer to these images if you need to as some can be tricky, for example: Any members of Asteraceae in the dataset have flowers that are tightly arranged into inflorescences that are called heads. The flowers in these inflorescences are epigynous and you can categorize them as actinomorphic.

Vamosi, J., Albor, C., Doll, J., Baboi, M., Summers, M., Adams, S. (2024). Angiosperm Diversity in Pollination Systems. QUBES Educational Resources.

Differentiating between mono and eudicots can be more challenging and requires some basic taxonomic knowledge. In this exercise it will be most helpful to look at the flower parts and leaf veins.

	
Monocots Flower parts are usually in multiples of three Leaf veins are usually parallel Fibrous root system Vascular bundles usually scattered One cotyledon / seed leaf	**Eudicots** Flower parts are usually in multiples of four or five Leaf veins are usually net like or branching Usually have a taproot Vascular bundles usually arranged in a ring Two cotyledons / seed leaves

You can group the plant into four types:

1. Actino/monocot
2. Zygo/monocot
3. Actino/eudicot
4. Zygo/eudicot

Vamosi, J., Albor, C., Doll, J., Baboi, M., Summers, M., Adams, S. (2024). Angiosperm Diversity in Pollination Systems. QUBES Educational Resources.

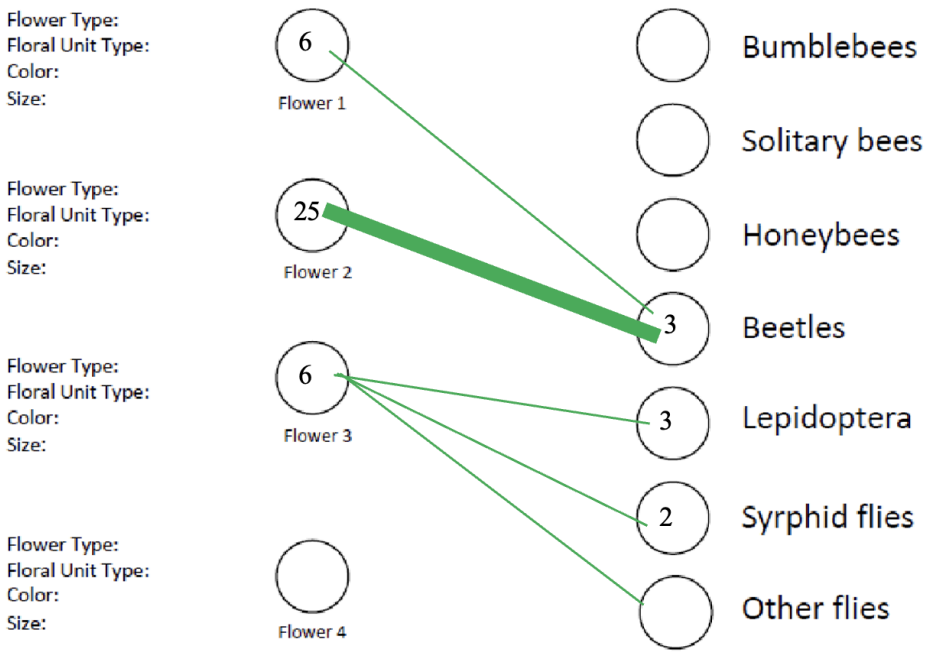
It may be easier to rearrange your data table to look like this in order to easily categorize and retrieve information you need from raw data:

A	B	C	D	E	F
	Mono/Eudi	Actin/Zygo	Acmaeops (beetle)		Batyle (beetle)
Achillea	Eudicot	Actino…	0		1
Rosa	Eudicot	Actino…	0		0
Trifolium	Eudicot	Zygom…	0		0
Cirsium	Monocot		0		0
Sinapis	Eudicot		0		0
Heliopsis			0		0
Sonchus			0		0
Bellis			0		0

There is a document that will be able to talk you through the process of rearranging your raw data

1. Plot by hand a plant-pollinator interaction network for Prince's Island Park, combining data from pollinators (in the first column) and plant genera in all the other columns as shown in **Example 2**. Creativity in visualizing these data is highly encouraged (you can experiment with line thickness, color, pictures, etc.) – just make sure all the relevant flower type and insect group information is included.

Example 2) Hand drawn plant-pollinator interaction network



Vamosi, J., Albor, C., Doll, J., Baboi, M., Summers, M., Adams, S. (2024). Angiosperm Diversity in Pollination Systems. QUBES Educational Resources.

In **Example 2**, there were only three different types of flowers: six flowers of type 1, 25 of type 2, and 6 of type three. Any flower that is a different color, form, or shape should be a distinct group.

2. Add your total number of visitors across your two sites. In the **Example 2**, there were three types of beetles observed, three lepidoptera, two syrphid flies, and one other fly.

   You will see that the pollinators in the Prince's Island Park and Nose Hill files have been divided into bees, wasps, flies, lepidopterans (butterflies/moths), etc.

3. Draw connections between the flower types and the pollinator types. In **Example 2**, the line between beetles and flower type 2 is thicker because there were many distinct interactions between these groups – again, be creative about how best to visualize your data completely and accurately.

Provide your simplified network below and answer the questions on the following page.

Vamosi, J., Albor, C., Doll, J., Baboi, M., Summers, M., Adams, S. (2024). Angiosperm Diversity in Pollination Systems. QUBES Educational Resources.

Questions:

1. What shape (zygomorphic or actinomorphic) was most attractive (i.e., received the highest number of visits)? Why do you think that is?

2. What clade (monocot or eudicot) was the most common in this park? *If monocots were previously measured to be 5% of the flowering species in the park*, which clade received the highest proportion of visits when accounting for their abundance?

3. Which flower type was associated with the most diverse set of floral visitors (highest number of pollinating groups as visitors)?

Vamosi, J., Albor, C., Doll, J., Baboi, M., Summers, M., Adams, S. (2024). Angiosperm Diversity in Pollination Systems. QUBES Educational Resources.

2. Visualizing and analyzing a plant-pollinator network

Part 2: Visualizing and analyzing a plant-pollinator network.

Having diverse flowering communities can attract a greater diversity of pollinators. These pollinators can pollinate crops such as canola in nearby fields, which can improve our food security. Therefore, there is a great deal of interest in Calgary and other cities to increase the ecosystem health in urban parks and natural areas.

Measurement of ecosystem health is difficult, but one simple way is to measure the degree of nestedness in plant-pollinator networks.

We will use the Shiny app at https://aaronecology.shinyapps.io/Network/ (Greenville, 2018) to visualize and conduct analyses of the network data at these two parks. This app can calculate a value for nestedness of the overall matrix in the park.

Nestedness is the tendency for ecological specialists to interact with a subset of species that also interacts with generalists. As nestedness increases, species rely less on a single species for an ecosystem service (such as food delivery or pollination) and the ecosystem is considered more resilient.

1. Go to the app and upload the .csv file for Prince's Island Park (prince_island.csv) and ensure that you have ticked the box that the data file has a Header, and that abundance is set to "no". Once the file is uploaded, go to the tabs at the top and choose "Network Graph". Download the graph that appears for your dataset.

2. Go again to the tabs at the top and choose "Nestedness". What is the value for NODF2 for this park?

3. Repeat these steps for Nose Hill Park and compare the nestedness values for the two parks.

Vamosi, J., Albor, C., Doll, J., Baboi, M., Summers, M., Adams, S. (2024). Angiosperm Diversity in Pollination Systems. QUBES Educational Resources.

Provide your networks and nestedness values for the two parks and answer the questions on the following page.

Vamosi, J., Albor, C., Doll, J., Baboi, M., Summers, M., Adams, S. (2024). Angiosperm Diversity in Pollination Systems. QUBES Educational Resources.

Questions:

1. Compare and contrast your two sites in terms of nestedness. Which park is more likely to maintain stable pollination rates if an invasive species were to be introduced, and why?

2. If *Bombus* disappeared from each park, list the plant species that would not have received any visits? Thinking back to natural selection, how would this affect the fitness of these plant species?

3. Over one thousand years of continued absence of *Bombus*, describe what would likely happen to these species? How would this alter the proportions of zygomorphic species in these parks?

Vamosi, J., Albor, C., Doll, J., Baboi, M., Summers, M., Adams, S. (2024). Angiosperm Diversity in Pollination Systems. QUBES Educational Resources.

References

Greenville, A.C. (2018). Bipartite Network Analysis vs1.0.2.

Vamosi, J., Albor, C., Doll, J., Baboi, M., Summers, M., Adams, S. (2024). Angiosperm Diversity in Pollination Systems. QUBES Educational Resources.