Seattle University

Urban Campus Native Bee Conservation Guide

Tools and resources for implementing habitat, monitoring bees, and educating the general public about native bees.

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CEJS Francis Student Research Fellowship

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TABLE OF CONTENTS

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INTRODUCTION

Around the world, there are nearly 20,000 species of bees, with nearly 3,600 of these species residing in North America (*Wild Bee Conservation*, 2015). However, more than 40 percent of the world's bee species are vulnerable to extinction with one in six now being regionally extinct (*Native Bees*, 2018). Agriculture, habitat loss, pesticide use, climate change, and competition and disease from non-native honeybees are just a few factors contributing to the loss of bees who are native to the Americas (Koh et al., 2015a). While urban developments contribute to habitat loss, cities can aid in counteracting the effects of urbanization by creating garden refuges for bees (Wilson & Jamieson, 2019). With the help of urban campuses, cities can produce a valuable habitat for supporting bee communities.

Aim of Project

This guide is intended to help improve urban campuses' native bee conservation efforts by providing resources and guidelines. It is important to note that this guide largely focuses on the Pacific Northwest region, however, there are resources provided throughout this document for other regions as a means to modify and apply the same guidelines. Thus, the overarching aim of this project is to create a single document with the information and tools required for implementing and maintaining sustainable habitats for native bee conservation on urban campuses, monitoring, and providing public educational opportunities. (See Appendix A for the CEJS fellowship project components).

Importance of Native Bees

Bees use the nectar of plants for energy and the pollen as a protein and vital nutrient resource. Pollen is used as larvae food and is transferred from plant to plant during collection. This transferring of pollen is known as pollination.

Insect-driven pollination is a critical part of both natural ecosystems and agriculture; without it, these systems would fail. Bees alone pollinate approximately 75% of all United States fruits, nuts, and vegetables. This means that one out of every four bites of food is made possible by bees (Communications & Publishing, 2015). Without pollination by bees, many crops would cease to exist, including almost all fruit and grain crops totaling around 150 different food crops, not including the other countless non-crop plants (*Why Is Pollination Important?*, 2022).

Pollinators not only produce ⅓ of our food supplies via pollination, but they also help to:

- produce half of the world's plants that provide oils, fibers, and other raw materials.
- pollinate plants that are used to create medicine.
- contribute to food and wildlife coverage production.
- promote plant growth (especially roots) which helps to keep waterways clean and prevents soil erosion.
- facilitate plant reproduction and thus abundance, which in return takes carbon dioxide out of the atmosphere and produces oxygen (Foundation, 2014).

By helping to conserve native bees, we are not only helping to save them from extinction but are also combating global warming. Bees are essential for the reproduction and health of many plants which contribute to keeping our waterways clean by preventing soil erosion, and by taking in greenhouse gasses that are causing our Earth to warm. Bees may be small but without pollinators "the human race and all of the Earth's terrestrial ecosystems [will] not survive" (*Why Is Pollination Important?*, 2022a). With bees being considered the most efficient pollinators, and native bees pollinating around 80 percent of the world's flowering plants, their importance to not just humanity, but the world is evident (Communications & Publishing, 2015).

Native bees are additionally two to three times better pollinators than the more commonly known, but non-native, western honeybees (*Apis mellifera*) (Gashler, 2022), and are the primary pollinators for almost all crops (Communications & Publishing, 2015)! Honeybees were first brought over to the Americas by European settlers in the 17th century and have since been industrialized in the United States creating inevitable stress on native bees. Honeybees have been shown to transmit diseases to native bees and destabilize natural ecosystems by competing for the same resources as native bees (Center for Biological Diversity, 2020). While it is true that honeybees are heavily utilized in modern agriculture for crop pollination, the larger environmental picture is much less rosy when considering their impact on native bees. Large-scale honeybee beekeeping has inevitably led to the misguided public understanding that honeybees are native and that beekeeping will help "save the bees" when in reality, beekeeping honeybees can cause more harm than good and should not be seen as a viable solution to "saving the bees". Honeybees are incapable of supporting a healthy ecosystem. Not only that but, "Beekeeping companies and various *non-science-based* initiatives have *financially benefited* from the *decline of native pollinators*," (McAfee, 2020). Misguided enthusiasm and support for the upbringing of non-native bee species will only continue to lead to the

detriment of native bees unless clear actions in support of native bees, backed by science, are taken.

Types of Native Bees

According to Hillary Sardiñas, a former Pacific Coast Pollinator Specialist for the Xerces Society for Invertebrate Conservation, some of the major groups of native bees in the Pacific Northwest (PNW) region include sweat bees *(Lasioglossum & Halictus)*, bumblebees *(Bombus)*, miner bees *(Andrena)*, mason bees *(Osmia)*, leafcutter bees *(Megachile)*, and cuckoo bees *(Sphecodes, Nomada, Triepeolus, & Coelioxys)*. Each of these native bee species differs in taxonomy and plays specific niches in the environment. For instance, bumblebees have the unique ability to "buzz pollinate, or vibrate a flower at a frequency that causes pollen otherwise locked within a flower" to become dislodged and attainable to bees. Other bees such as the sweat bee, are able to pollinate by climbing deep into flowers due to their tiny size, thereby accessing pollen that would otherwise be unattainable to other larger bee species (Sardiñas, 2016).

Approximately 90% of all North American native bees are solitary nesters. Of the solitary nesters, 30% take up residency in abandoned tunnels and burrows, and 70% nest in the ground, via digging their own tunnels (*Wild Bee Conservation*, 2015). As solitary bees lack colonies and social structure, they are characterized to be non-aggressive and rarely sting, with only 30% of female solitary bees even possessing a stinger (masonbeesforsale.com, 2022).

Not only are there a variety of native bee species, but there are also an array of observed behavioral and nesting traits. Bees can be grouped based on their social and nesting behaviors as solitary, communal, eusocial, semi-social, or parasitic. It is important to note that the behavioral and nesting habits of species exist on a spectrum with solitary and eusocial on opposite extreme ends. Behaviors may vary for a variety of reasons, including the time of year, geographical location, and many other unknown factors (Buckley et al., 2016).

Solitary bees are classified as females working independently and individually to build their own nest(s) and provide for offspring; some solitary bees also live in communal nests where they live independently of one another only sharing a nest entrance (Antoine & Forrest, 2020).

Eusocial species, on the other hand, are on the opposite end of the social spectrum for bees. Eusocial bee species are known as the "social" species of bee, demonstrating a hierarchical social construct. In eusocial species, a queen is assigned that gives birth to worker offspring that perform and divide duties around the nest (Antoine & Forrest, 2020).

Within this social spectrum, there are semi-social bees. Semi-social bees have a division of females that lay eggs, while the second division of females acts as worker bees. Semi-social bees can often be characterized by colonies without a defined queen (Lavoipierre, 2013).

While a minority, there are a few bee species such as the cuckoo bee that are classified as parasitic. These parasitic bees invade other bee nests often killing other bees or leaving their offspring behind to be raised by a host (Antoine & Forrest, 2020).

Despite these social differences, nearly all native bees have the same or similar annual lifecycle. With all bees undergoing an egg, larva, pupa, and adult stage, there are still some major differences between the lifecycle of solitary bees compared to that of bumblebees, or eusocial bees.

Solitary bees live for about a year and can be observed only in the adult stage of their lifecycle for about three to six weeks. For the rest of the year, most solitary bees go through an egg, larva, and pupal stage all within a hidden nest (*Wild Bee Conservation*, 2015)

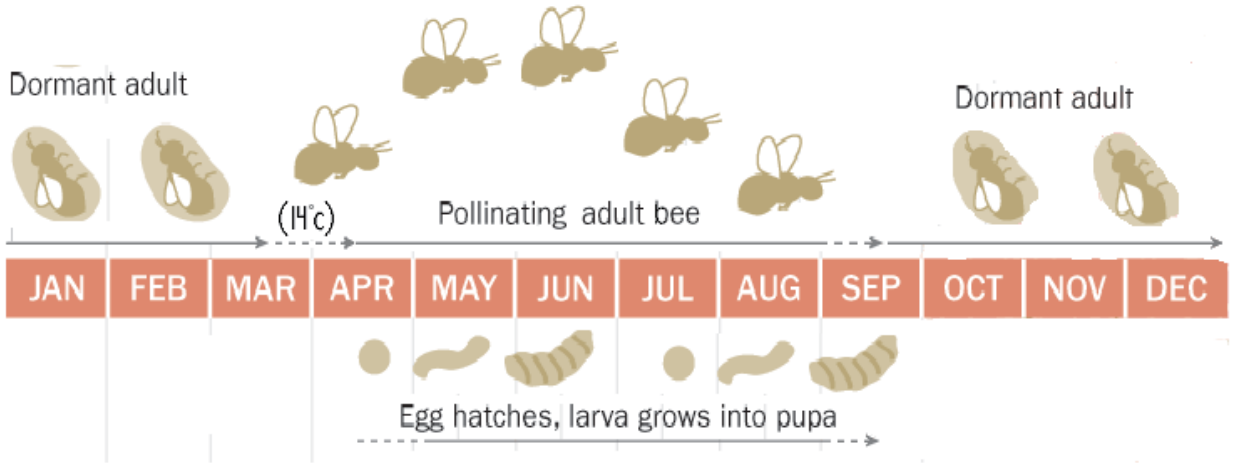


Fig. 1. Lifecycle of most solitary bees (Source: The Corner Pollinator Garden & Wildlife Habitat as adapted from Bee Friendly).

The only North American native bee that is social, or eusocial, is the bumblebee (Dickinson, 2018). The bumblebee life cycle begins with a queen bee emerging from hibernation in the spring and searching for a suitable nesting site. As bumblebees are said to be “opportunistic nesters,” they typically prefer existing cavities such as empty mouse burrows. The queen will then create pots or brood cells from wax to hold nectar and pollen in which she lays and incubates her eggs. The eggs will hatch after 4-6 weeks producing female worker bees that will take on various duties including foraging, and attending to the growing number of brood cells. These worker bees only live for approximately 1-2 months before they are replaced by more worker bees. The queen will continue laying eggs throughout the summer steadily increasing the colony's size. Nearing the end of summer new queens and male bees, called drones, will emerge from the nest to mate. The new queen bees will then find a new site to hibernate in over winter while the rest of the colony dies. Due to bumblebees having an annual life cycle, they do not generally occupy the same nesting site for more than one year (*About Bumble Bees*, 2014).

Diversity, Abundance, & Richness

The richness of a bee population refers to the number of individual bee species within a given area, whereas abundance is the number of individuals belonging to each species. The third factor, diversity is an assessment of both richness and abundance, which can be further characterized by phylogenetic diversity, which is the measure of evolutionary history represented within a community (Grab et al., 2019). Phylogenetic diversity can be thought of as the distance between species on a phylogenetic tree; the greater the distance, the greater the phylogenetic diversity.

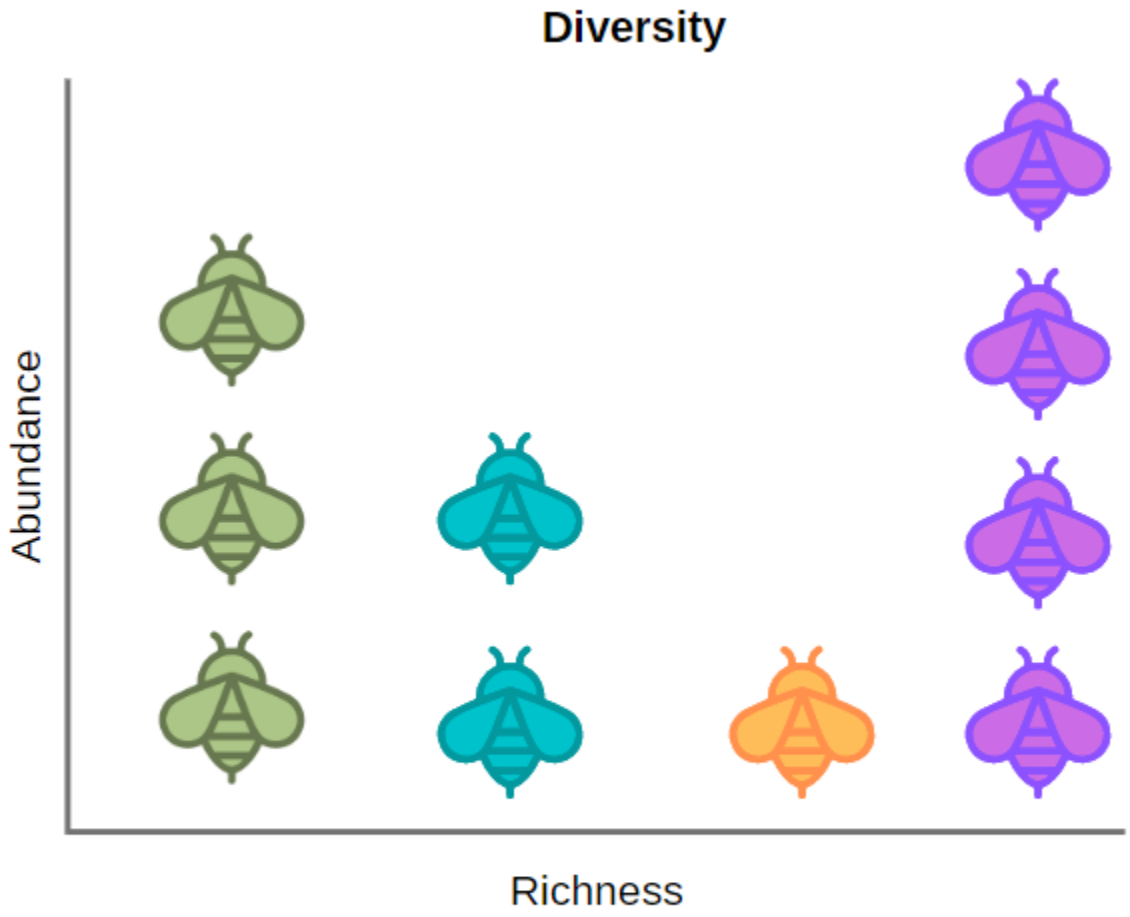


Fig. 2. Richness is the number of species in an area (x-axis) as shown by the various colors (richness = 4). Abundance is the number of individuals per species (y-axis), as shown by the number of bees that are the same color. Species diversity describes a communities structure based on both richness and abundance.

Species abundance distribution describes community structure and is a key component of biodiversity research (Antão, Magurran, & Dornelas, 2021). Thus, as pollinators support biodiversity, their abundance and diversity are used as an indicator of the overall health of ecosystems (*The Importance of Pollinators*, 2021).

There are several strong relationships between the diversity, stability, and resilience of an ecosystem as a result of bee diversity. When discussing resilience, it refers to the

ability of an ecosystem or species to recover after experiencing a stressor. Whereas stability is the ability to withstand those stressors. Consider a wind storm, a tree's ability to withstand the wind is its sustainability, and if the tree were to fall over during the wind storm, the tree's ability to recover and continue growing would be its resilience. In the case of bees, maintaining biodiversity is imperative for the stability, productivity, and resilience of ecosystems (Engströma et al., 2020), all factors used in assessing ecosystem health.

Furthermore, studies have shown numerous relationships between bee biodiversity and the effects on crop quality and productivity. One such study found that as the ratio of agricultural coverage increases, bee species richness ($\beta = -0.28$) and phylogenetic diversity ($\beta = -0.34$) decreases; furthermore, as phylogenetic diversity increases, the number of seeds per fruit increases ($\beta = 0.12$), fruit weight increases ($\beta = 0.63$), and fruit malformations decrease ($\beta = -0.7$); moreover, as bee species abundance increases, fruit malformations decrease ($\beta = -0.52$) (Grab et al., 2019). One study found that as the number of apple seeds per fruit increased, the percentage of misshapen apples decreased, weight increased, flesh firmness increased, calcium content increased, and in a few groups of apples the acidity increased (Buccheri & Di Vaio, 2005).

Overall, the diversity of bees plays one of the most influential roles in crop production and sustainability (Grab et al., 2019). Therefore, the monitoring of native bee species abundance and diversity is imperative for furthering our understanding of their vital role in ecosystems and what factors most affect them.

While there are many factors that influence bee diversity, abundance, and richness, recent studies suggest that the most crucial component is plant species richness and abundance(Gerner & Sargent, 2022). As gardens are able to support greater bee abundance and richness, and flower beds are able to support a greater diversity of bee species (Gunnarsson & Federsel, 2014), it is through the implementation of these resources, and the increase of plant species richness and abundance that we can support bee conservation efforts, regardless of the degree of urbanization (Gerner & Sargent, 2022).

Conservation Status

It is currently estimated that around the world 1 in 6 bee species have gone regionally extinct and that more than 40% of the world's bee species are vulnerable to extinction (*Native Bees*, 2018). That equates to 28% of all bumblebees across Canada, the United States, and Mexico being in the International Union for Conservation of Nature (IUCN) *Threatened Category*. As of January 2017, the rusty patch bumblebee was the first bumblebee to be designated as an endangered species under the US Endangered Species Act (ESA) (*Rusty Patched Bumble Bee*, 2013). 50% of leafcutter species and 27% of mason bee species are classified as “at-risk” (*Wild Bee Conservation*, 2015). Overall, native bee species are rapidly declining, and unless drastic efforts are made to stop this decline, there is no evidence of this deterioration stopping anytime soon.

Reasons to NOT Buy/Import Bees

While honeybees dominate the field when it comes to domesticated and commercially available bees, the Common Eastern bumblebee (*Bombus impatiens*) is also commercially available and is the only species of bumblebee reared for pollination services in North America, despite them being native to the eastern U.S. and Canada (Bombus Task Force, n.d.). Regardless of the Common Eastern bumblebee not being native to North America, there are several reasons why our project refrained from the importation of commercial bumblebees and why we would advise others to do the same.

Robin E. Owen, from Mount Royal University, Canada, found that domestic bumblebees can unwittingly exacerbate detrimental effects on wild bee populations by spreading parasites and diseases. Despite having regulations that “screen” for microparasites, the majority of colonies shipped are still infected with one study finding 37 of 48 colonies to be pathogen carrying. These microparasites are very infectious and liable to spread very rapidly to wild bee populations which can kill our wild pollinators or leave them permanently deformed and unable to fly (Owen, 2016). Either way, the consequences and risks associated with the importation of bees are simply too great when working with an already declining bee population. Thus, under the principles of nonmaleficence, which states that the primary concern is to do no harm, it is unethical for us to be engaging in the purchasing and importing of bumblebees.

The Unknowns

As bee populations decline rapidly all over the globe, it is a race against time to find what practices will best help to retain and conserve native bees. However, there is still much that is unknown about native bees, which makes this task challenging to tackle and quantify. While we know many native bee species are at risk of extinction, we still do not know the status of many species due to inadequate data collection and sharing (*Wild Bee Conservation*, 2015). Furthermore, adequate and standardized methods for bee monitoring have not yet been established, as there is still debate about best practices. This is especially evident when studying smaller species of bees that can get as small as a grain of rice (*How Many Species*, 2020). Moreover, it is estimated that nearly 10% of bee species in the United States have yet to be named or documented (*How Many Species*, 2020). There is also the question of what is causing the rapid decline of our native bees and to what extent are each of these factors affecting native bee species. Due to the difficulties in monitoring, the conservation status, distribution, nesting sites, and behavior of most solitary bees is unknown.

HABITAT

While creating foraging habitat is a vital component of conservation efforts, it does not always fully encapsulate the needs of bee species. Foraging habitat entails floral plants that provide food resources to bees while nesting habitat can imply a number of factors that provide homes to bees. For instance, many landscaping practices focus on floral abundance but may limit available nesting resources to bees. With nesting resources being a primary limiting factor for most bee population growth and diversity, it is important to modify landscaping practices that reflect these needs in order to create an effective and holistic conservation approach (Buckles & Harmon-Threatt, 2019).

Landscaping practices that can aid in bee conservation include

- Leave areas of bare soil undisturbed and untilled.
- Refrain from adding organic matter to potential nesting sites.
- Provide grassy thickets.
- When winter comes, leave the leaves.
- Minimize ground disturbances.
- Check for dwelling bees before pruning perennials or moving longs and rocks.
- Mow at low speed when flowers are not in bloom, such as in the fall or winter.
- Avoid the use of pesticides or use bee-friendly alternatives (see Ways Everyone Can Help).

For a full assessment of pollinator habitat in yards, gardens, and parks, see the Xerces Society Habitat Assessment Guide.

Bee Bucket Trial

With the majority of wild bees nesting in soil, we decided to create structures based on the needs of these ground-nesting bees. However, there remains a poor understanding of how individual soil characteristics such as hardness, bulk, density, temperature, bare ground availability, and pH affect bee community structures although these characteristics have been identified to be important to bee nesting (Buckles & Harmon-Threatt, 2019). With soil preferences varying between bee species, it proves difficult to generalize ground-nesting requirements. Despite this, the general observation is that ground-nesting bees have a preference for well-drained sites and direct soil surface access (USDA National Agroforestry Center, 2007). Thus, the design of the bee

Fig. 3. Beginning stages of the bee bucket structures.

buckets aimed to minimize soil moisture while optimizing soil drainage.

The construction of the bee buckets kept sustainability in mind and utilized all recycled and repurposed materials including:

- square 4-gallon buckets
- scrap wood
- chicken wire

In the event that the bee buckets become inhabited with beneficiary ground-nesting wasps and swarming occurs, the lids to the buckets were kept so the bee buckets could be temporarily closed with the swarm inside allowing for them to be moved to a more suitable location where the swarming won't pose a risk to people.

The square 4-gallon buckets had several traits that made it the most appealing material to use as the base of the structure. For starters, the material is already waterproof, helping to create that ideal dry environment we were going for. Secondly, it already had handles installed that could be used to lift the structure out of the ground should wasp swarming occur. This type of bucket is easily accessible thereby facilitating the outreach of this project should the structures be found to be beneficiary. And lastly, most ground-nesting bees create tunnels that are 6-16 inches below the ground and the average depth of the buckets is around 13 inches which can accommodate most ground-nesting bees in the PNW region (Xerces Society for Invertebrate Conservation, 2017).

Fig. 4. Dr. Heather Brown drilling holes in the base of the bee bucket structures.

Fig. 5. Breann Kniffen stapling chicken wire to the frame of the bee bucket structures.

We drilled holes in the bottom of the buckets to help create drainage and then added chicken wire to the parameters of the wood structure as a means of keeping unwanted guests out. Potential unwanted guests included rodents, rabbits, birds, and pets.

While there are methods for attracting bees to the structures, such as painting the roofs of the structure violet or spraying the area with particular pheromones or scents, we first want to observe if the structures can attract bees with no added artificial enticements.

For the installation of the buckets, six locations were selected on SU's campus in a variety of settings. Most were placed where there was overhead coverage, while two were placed in the open (buckets 1 & 3). Although it is noted that shrubbery surrounding buckets 3 and 5 has greatly increased since the installation of the structures. These sites were determined on digging accessibility, proximity to foraging resources, and previous observations of, or lack of, bee activity. When filling the buckets several rocks were added to the bottom of the bucket as a secondary form of drainage, and soil was sorted through to check for pests and take out unwanted debris. The filtering of the soil also provided us an opportunity to try and add as much surrounding silt to the soil as possible as it was very sparse in the areas we dug in, and silt aids in drainage and is often a preferred soil trait among ground-nesters. The soil was then lightly compressed before adding the structure's roof.

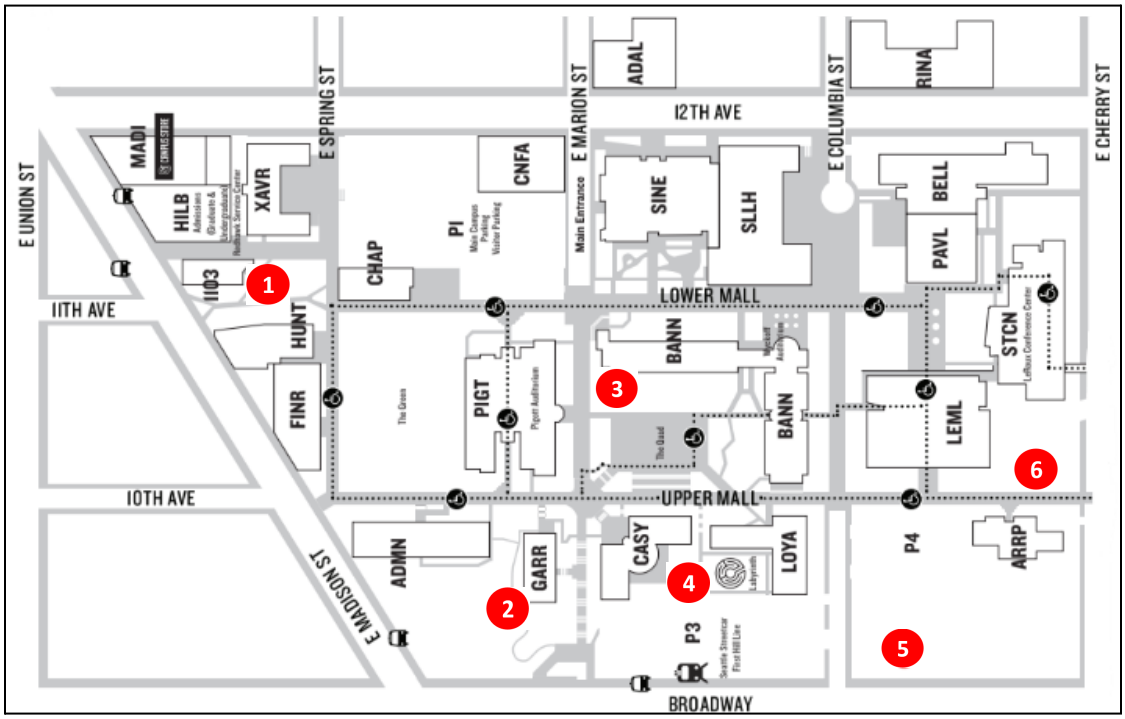


Fig. 6. Installation sites of the six bee buckets on Seattle University's campus. Numbers correspond to installation sites on the map.

Several bumblebee nesting sites have been observed on campus residing under leaf and mulch piles. Thus a few dehydrated leaves were added to the surface to more closely mimic the observed habitat of bumblebees. Early spring of 2022 has experienced cooler temperatures than anticipated, and thus monitoring of these structures is an ongoing project to determine if these structures are viable habitats. With observation, we can also come to find if these structures are suitable habitats for hibernating queen bumblebees.

Fig. 7. Installed and finished bee bucket products. Numbers correspond to installation locations in Fig. 6.

Maintenance

It is crucial that any man-made bee structures be regularly checked for pests and parasites to avoid the spread of diseases and pests to surrounding bee populations. Many pests, such as pollen mites, can easily disperse into multiple solitary bee nests when they are close together, as they are in many bee hotels. Similarly, many cheap kinds of wood used for creating bee hotels have cracks in them allowing for an increased chance of pollen mites or creating damp environments perfect for chalkbrood, a type of fungal disease (Brokaw et al., 2017).

For mason bee structures, the proper cleaning, harvesting, and storing techniques are essential for maintaining mason bee health and preventing harm if they are to be used as a conservation effort. Without proper maintenance, mason bee blocks can contribute to disease build-up and spreading (Crown Bees, 2022). However, there is still contradicting evidence surrounding the efficiency of bee hotels as there are still many nesting factors not well understood by scientists.

There is one program, however, that has taken these considerations into account and has been laying down new programs to help promote the use of native bees as pollinators in the agricultural industry as well as for personal use. Rent Mason Bees is an Orchard Bee Association certified organization based in Washington State and is the first and only program in the U.S. that helps to host mason bees in a sustainable manner. The program works by renting out mason bee blocks and mason bees in the spring to farmers and gardeners.

> “In the fall, once the developing bees have spun their protective cocoons, hosts mail back their nesting blocks back to RMB. The nesting blocks and bee cocoons are thoroughly cleaned and sorted to eliminate pests, including pollen mites, chalkbrood, and Houdini flies, which are a threat to native bee species. After all cocooned bees are cleaned, they are safely stored in hibernation over winter” (Rent Mason Bees, 2021).

Rent Mason Bees follows strict guidelines to ensure the safety of pollinators by separating bees by region and only sending mason bees back out to the region they originated from to prevent the introduction of any new diseases to the local bees. It is a great program to get the community involved in hosting, supporting, and educating the public about native bees without the worry of improper maintenance. (For more information on the Rent Mason Bees program, click here). Furthermore, this provides an alternative to the importation and buying model as this model emphasizes the *localization* of bees while simultaneously increasing winter moral rates through the incubation process.

When maintaining nearly any man-made bee structure there are a few key components that can aid in the prevention of spreading diseases and pests.

Man-Made Bee Structure Maintenance

- Rotate and clean tubing used for cavity-nesting bees every spring.
- Boil wooden block bee hotels yearly and adequately dry before hanging up.
- Place occupied or capped tubes in a mesh bag to prevent parasitic attacks.
- Check regularly for any signs of mildew or mold growing and replace the structure if this begins occurring.
- Monitor for spider webs, these may indicate the structure is in a location that is too dark.
- If you find mites consider buying ladybugs which are natural predators of mites.

The Maintenance of the Bee Buckets Requires

- Bi-weekly checking of any mold growth(s) during the rainy season. If there is any sign of mold remove it immediately and add a thin layer of sand or silt to prevent future moisture build-up.
- Till the soil between seasons if it appears the structure was inhabited the prior season, but be sure to check that the nest is empty before tilling. When tilling, add silt if the soil is damp.

These structures were designed with the intent to cater towards solitary ground-nesting bees, as they compose the majority of the native bee demographic, and for hibernating singular bumblebees, as several bumblebee nests have been observed on SU's campus. With the intent that these structures be inhabited by solitary or singular bumble bees, there is a much lower risk of these structures becoming breeding grounds for pests and disease as most parasitic problems involve cavity-nesting bees and colony bees. Furthermore, ground-nesting bees do not reuse their nests, and queen bees seek out new nesting locations once emerging from hibernation, both of which will reduce the chances of parasites and diseases.

BLOOM GAP

“Bloom gap” describes a two or more week period where there are no plants in bloom per campus block from March to November. Although the terminology and the parameters of a bloom gap vary from resource to resource, our definition was decided upon based on the ease of quantifying these parameters, location in the PNW region, and the average flight distance of bumblebees (which is about ⅓ - 1 mile (Schweitzer et al., n.d.)). However, it is important to note that flowering periods can vary from species, latitude, elevation, weather, and year-to-year variation, making the parameters of a bloom gap vary from location to location (Vaughan et al., 2006). In general, the aim is to provide abundant food resources to bees for the entire duration that they are active.

Studies have shown that food limitations related to bloom gaps have led to bumblebee nest failure, accentuating the need for supplying reliable nectar and pollen supplies when bees are active from spring to late summer, in the PNW region this is typically March to November (Schweitzer et al., n.d.). Similarly, botanical diversity contributes to the diversity of bee species which offers resilience to an ecosystem (Elsa E., 2011). Thus, by supplying plants with overlapping bloom periods for the whole season, we can aid in increasing bee abundance, diversity, and richness (Schweitzer et al., n.d.).

> “Gardeners may be unwittingly purchasing toxic seedlings and plants attractive to pollinators for bee-friendly gardens, only to poison them in the process.”
>
> (Brown et al. 2013)

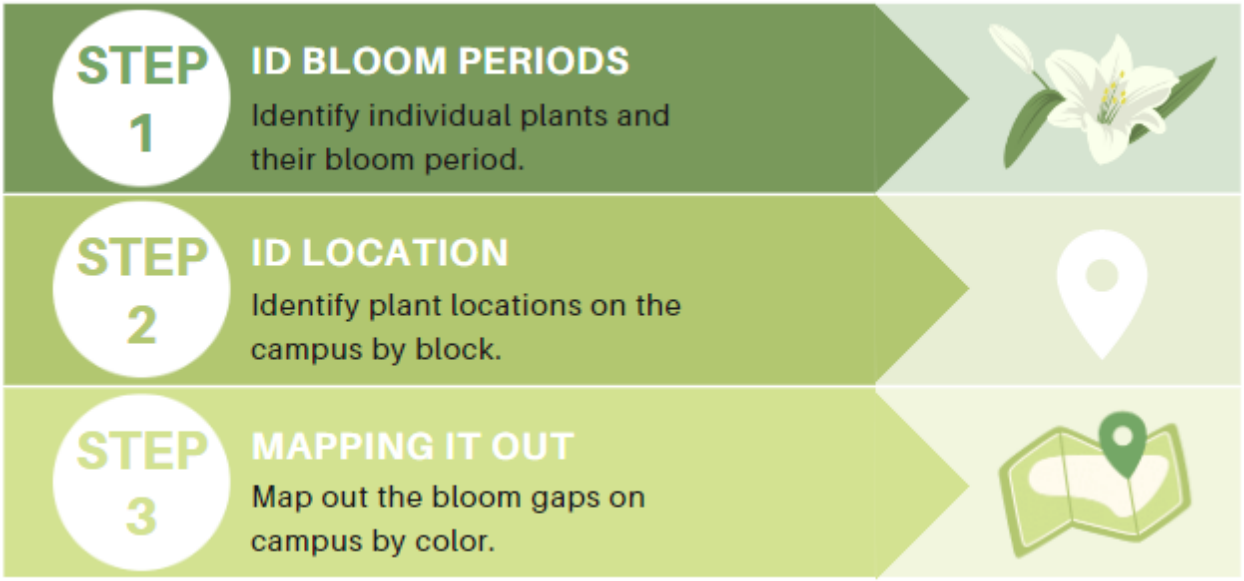
Gardeners beware! While it may be tempting to run down to the store and buy plants to help supply food for the bees, there is a dark side to many mainstream nursery plants that is harming our bees. As we all know, pesticides are harmful to the bees, however, neonicotinoid pesticides are the most popular insecticide used in the United States and it is wiping out our plants and animals (Ann Burd, 2021). Even low-level exposure to neonicotinoid pesticides can cause severe damage to bees including, “compromised immune system[s], altered learning, and impaired foraging, effectively exacerbating the lethality of infections and infestations” (Brown et al., 2013). And these pesticides are on nursery plants at stores like Home Depot, Lowe’s, and the Orchard Supply Hardware store. These garden plants expose bees to these deadly pesticides. Unfortunately, these pesticides can’t just be rinsed off with water as the toxins are taken up through the roots and leaves of plants and distributed throughout the plant, lasting in the plant for months to even years after the initial treatment (Brown et al., 2013).

To prevent risking neonicotinoid exposure:

- Ask your local plant nurseries about their pesticide practices before buying.
- Purchase organic plant starters and organic soil for your gardens.
- Buy untreated seeds.
- Use bee-friendly alternatives for unwanted pests, such as neem oil, Organocide® Bee Safe 3-in-1 Garden Spray, or the Mighty Mint®.
- Spread the word and notify other gardeners of the dangers of neonicotinoids.

Charting Campus Bloom Gaps

Charting bloom gaps on campus is necessary for determining where there are food limitations, what those limitations are, and how to fix them with plants that provide overlapping bloom periods. This process begins with three major steps:



STEP 1: ID BLOOM PERIODS

Charting bloom gaps on campus begins by first identifying what plants are on the campus and what time of year the plants are in bloom.

For help identifying plants, there are several smartphone apps that are excellent resources for this.

Plant Identification Apps:

PlantSnap
Where Nature and Technology Live in Harmony

PLANTA

LeafSnap

Identifying the bloom period of each plant can be done by manually observing and logging what plants are in bloom over the course of the year using the Bloom Chart (as shown below in Fig. 8), or by using the Lady Bird Johnson Wildflower Center plant database.

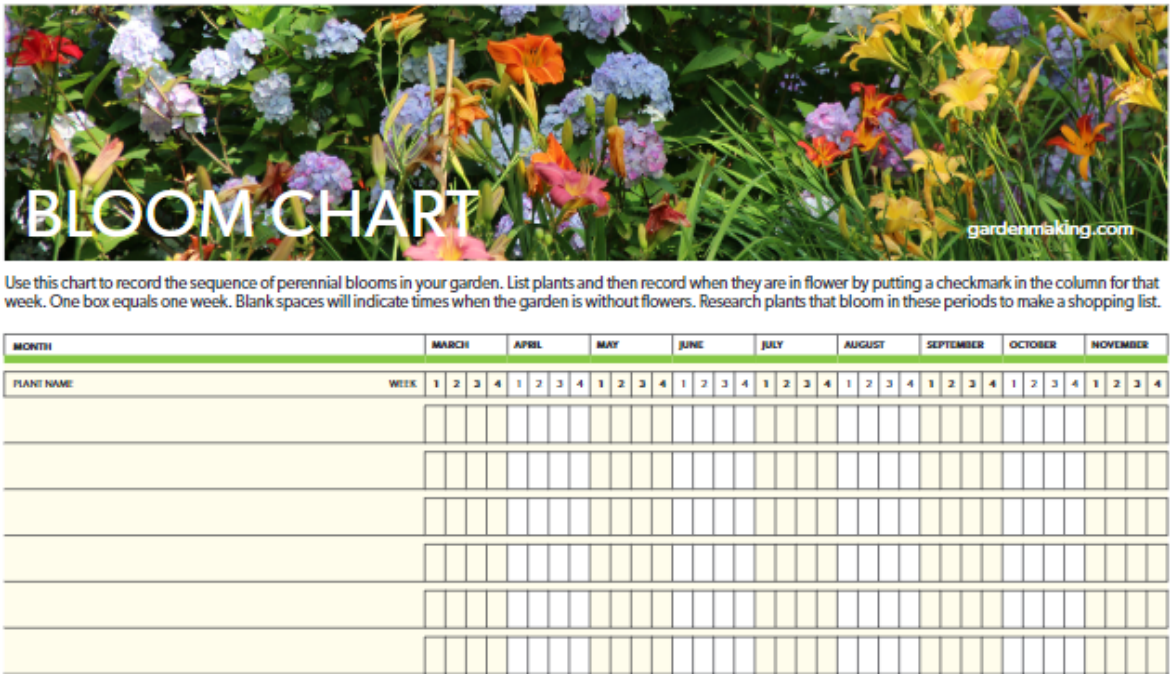


Fig. 8. Bloom Chart for step one of charting campus bloom gaps, identifying individual plants and their bloom periods. See Appendix B for access to Bloom Chart. (Source: GardenMaking)

STEP 2: ID LOCATION

The next step is to identify the location of these plants on the campus. For Seattle University's campus, I accomplished this by creating a grid using block identifications that correspond to the campus map (corresponding block IDs highlighted in yellow). This portion of charting can easily be customized to any campus map by placing letters on the y-axis, and numbers on the x-axis, allowing for specific blocks to be identified in a numerical fashion making it easier to identify plant locations based on the parameters set for a bloom gap. Using the bloom chart and the plant's location, the months can then be identified as having a bloom gap (as denoted with an X), or having no bloom gap (as denoted with a checkmark) in the Identifying Bloom Gaps Chart (as seen in Fig. 10). Remember, the goal is to have plants in bloom from March to November.

Fig. 9. SU campus map grid broken down by block. Y-axis labeled with letters, x-axis labeled with numbers.

Identifying Bloom Gaps on Seattle University Campus

	Bloom Period								
Block ID	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
F2	✓	✓	✓	✓	✓	✓	✓	✓	✓
F3	✓	✓	✓	✓	✓	✓	✓	✓	✓
E1	✓	✓	✓	✓	✓	✓	✓	✓	✓
E2	✓	✓	✓	✓	✓	✓	✓	✗	✗
E3	✗	✗	✓	✓	✓	✓	✗	✗	✗
D1	✓	✓	✓	✓	✓	✓	✓	✓	✓
D2	✗	✗	✓	✓	✓	✓	✓	✓	✓
D3	✓	✓	✓	✓	✓	✓	✓	✓	✓
D4	✓	✗	✗	✗	✓	✓	✓	✓	✓
D5	✓	✓	✓	✓	✓	✓	✓	✓	✗
C1	✗	✗	✗	✓	✓	✓	✓	✓	✓
C2	✓	✓	✓	✓	✓	✓	✓	✓	✗
C3	✓	✓	✓	✓	✓	✓	✓	✓	✗
C4	✗	✗	✓	✓	✓	✓	✓	✓	✓
C5	✓	✓	✓	✓	✓	✓	✓	✓	✓
B1	✓	✓	✓	✓	✓	✓	✓	✓	✓
B2	✓	✓	✓	✓	✓	✗	✗	✓	✓
B3	✓	✓	✓	✓	✓	✗	✗	✓	✓
B4	✓	✓	✓	✓	✓	✓	✓	✓	✓
B5	✓	✓	✓	✓	✓	✓	✓	✓	✓
B6	✓	✓	✓	✓	✓	✓	✓	✓	✓
B7	✓	✓	✓	✓	✓	✓	✓	✓	✓

✗ Denotes that there are no plants in this block that are in bloom during the indicated month

✓ Denotes that there are plants in this block that are in bloom during the indicated month

Fig. 10. SU step 2 chart for identifying plant locations on the campus by block, then identifying if the plants in each block remain in bloom from March to November. See Appendix C for a blank version of this document.

STEP 3: MAPPING IT OUT

The final step in charting campus bloom gaps is to cross-reference the Bloom Chart to the Identifying Bloom Gaps Chart which will indicate what block on campus has the most to least severe bloom gaps which can be expressed as colors as seen in the exemplary SU Campus Bloom Gaps Map (Fig. 11). Light green indicates blocks that demonstrate no bloom gaps, while blocks highlighted in red depict the most severe bloom gaps and where gardening efforts should be focused to aid in closing this gap.

Fig. 11. SU chart for step 3 of charting bloom gaps on campus, mapping out bloom gaps on campus by color. See Appendix D for a blank version of this document.

Finding Native Plants

Now that the campus bloom gaps are charted, the gardening to close these gaps can begin.

An excellent resource for finding native plants in the PNW region is the King County Native Plant List guide. However, the list provided is inconclusive as it does not state the bloom periods of these plants. Thus, I have created a complimentary King County Native Plant Bloom Period Chart (Fig. 12) for 150 plants that correspond to all the native plants listed under the King County Native Plant List. The goal of the Bloom Period Chart is to create a solid green line from March to November indicating the successful implementation of plants that will offer a full season of food to native bees.

King County Native Plant Bloom Guide

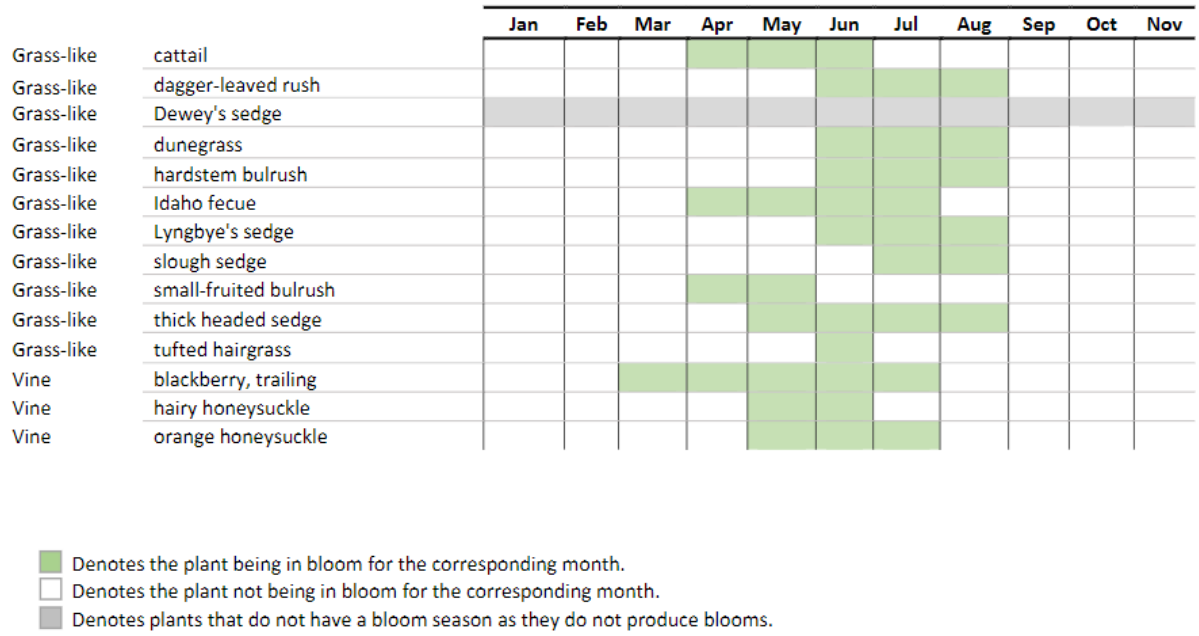
(https://green2.kingcounty.gov/gonative/Plant.aspx?Act=list)

		Bloom Month										
Type	**Common Name**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**
Tree	bigleaf maple				■	■						
Tree	bitter cherry				■	■						
Tree	black cottonwood				■							
Tree	black hawthorn					■	■					
Tree	cascara				■							
Tree	Douglas' Maple				■	■						
Tree	Douglas-fir				■							
Tree	gand fir				■	■						
Tree	Hookers willow			■	■							
Tree	madrone; madrona			■	■	■						
Tree	Oregon ash				■							
Tree	Oregon white oak; Garry oak			■	■	■						
Tree	Pacific crabapple				■	■						
Tree	Pacific dogwood				■	■	■	■				
Tree	Pacific willow			■	■	■	■					
Tree	paper birch				■							
Tree	quacking aspen				■	■						
Tree	red alder			■	■							
Tree	shore pine				■	■						
Tree	Sitka spruce				■	■						
Tree	Sitka willow			■	■							
Tree	slide alder					■	■					
Tree	vine maple			■	■	■						
Tree	Western hemlock				■							
Tree	Western redcedar				■							
Tree	Western white pine				■							
Tree	yew						■	■				
Shrub	blad hip rose				■	■						
Shrub	beaked hazelnut	■	■	■								
Shrub	black cap raspberry				■	■						
Shrub	black gooseberry					■	■					

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Shrub	blue elderberry			■	■	■	■	■	■	■		
Shrub	bog laurel				■	■						
Shrub	bog rosemary						■	■				
Shrub	devil's club							■				
Shrub	evergreen huckleberry			■	■	■						
Shrub	hairy manzanita			■	■	■						
Shrub	highbush cranberry; mooseberry					■	■					
Shrub	hybrid manzanita		■	■	■							
Shrub	indian plum; osoberry			■								
Shrub	low Oregon grape				■	■	■					
Shrub	mock orange			■	■	■	■	■				
Shrub	nootka rose					■	■	■				
Shrub	oceanspray					■	■	■	■			
Shrub	Oregon box				■	■	■					
Shrub	Pacific ninebark					■	■	■				
Shrub	Pacific rhododendron				■	■	■	■				
Shrub	Pacific wax myrtle				■	■	■	■				
Shrub	red elderberry					■	■					
Shrub	red huckleberry					■	■					
Shrub	red stem ceanothus					■	■	■				
Shrub	red-flowering currant			■	■							
Shrub	red-osier dogwood					■	■					
Shrub	salal				■	■	■	■				
Shrub	salmonberry			■	■	■	■					
Shrub	serviceberry; juneberry				■	■	■					
Shrub	snowberry						■	■				
Shrub	snowbrush; sticky laurel				■	■	■	■	■			
Shrub	spiraea; hardhack						■	■	■	■		
Shrub	stink currant					■	■					
Shrub	subalpine spirea						■	■	■			
Shrub	swamp rose; clustered wild rose					■	■	■				
Shrub	sweet gale							■	■	■		
Shrub	tall Oregon grape			■	■	■						
Shrub	thimbleberry					■	■	■	■			
Shrub	twinberry			■	■	■	■	■	■			

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Shrub	white spitea; shiny-leaved spirea											
Groundcover	beach strawberry											
Groundcover	bleeding heart											
Groundcover	blue-eyed grass											
Groundcover	bracken fern											
Groundcover	broad-leaved stonecrop											
Groundcover	bunchberry											
Groundcover	camas, common											
Groundcover	camas, great											
Groundcover	Cascade penstemon											
Groundcover	chocolate lily											
Groundcover	coastal gumweed											
Groundcover	columbia lewisia											
Groundcover	common harebell											
Groundcover	Cooley's hedge nettle											
Groundcover	cow-parsnip									-		
Groundcover	deer ferm											
Groundcover	Douglas aster											
Groundcover	edible thistle											
Groundcover	false lily-of-the-valley											
Groundcover	false Solomon's-seal											
Groundcover	farewell-to-spring											
Groundcover	fireweed											
Groundcover	foam flower											
Groundcover	fringecup											
Groundcover	goat's beard											
Groundcover	golden eyed grass											
Groundcover	goldenrod											
Groundcover	graceful cinquefoil											
Groundcover	Hendersons checker mallow											
Groundcover	inside-out flower											
Groundcover	kinnikinnik; bearberry											
Groundcover	kneeling angelica											
Groundcover	lady fern											
Groundcover	licorice fern											

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Groundcover	maidenhair fern											
Groundcover	nettle											
Groundcover	nodding onion											
Groundcover	oak fern											
Groundcover	Oregon iris											
Groundcover	oxalis; wood sorrel											
Groundcover	Pacific waterleaf											
Groundcover	palmate coltsfoot											
Groundcover	pearly everlasting											
Groundcover	piggyback plant; youth-on-age											
Groundcover	rattlesnake plantain											
Groundcover	Scouler's corydalis											
Groundcover	sea-watch											
Groundcover	showy fleabane											
Groundcover	silverweed											
Groundcover	small flowered alumroot											
Groundcover	spreading stonecrop											
Groundcover	star-flowered false Solomon's-seal											
Groundcover	stream violet											
Groundcover	swamp lantern; skunk cabbage											
Groundcover	sword fern											
Groundcover	taper-tip onion; Hooker's onion											
Groundcover	thrift; sea pink											
Groundcover	trailing snowberry											
Groundcover	trillium											
Groundcover	twinflower											
Groundcover	vanilla leaf											
Groundcover	wapato; arrowhead											
Groundcover	Western columbine											
Groundcover	Western starflower; Indian potato											
Groundcover	wild ginger											
Groundcover	wild strawberry											
Groundcover	woodland strawberry											
Groundcover	yarrow											
Groundcover	yellow monkey-flower											



		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Grass-like	cattail											
Grass-like	dagger-leaved rush											
Grass-like	Dewey's sedge											
Grass-like	dunegrass											
Grass-like	hardstem bulrush											
Grass-like	Idaho fecue											
Grass-like	Lyngbye's sedge											
Grass-like	slough sedge											
Grass-like	small-fruited bulrush											
Grass-like	thick headed sedge											
Grass-like	tufted hairgrass											
Vine	blackberry, trailing											
Vine	hairy honeysuckle											
Vine	orange honeysuckle											

Denotes the plant being in bloom for the corresponding month.
Denotes the plant not being in bloom for the corresponding month.
Denotes plants that do not have a bloom season as they do not produce blooms.

Fig. 12. Bloom period chart for King County Native Plant List. Bloom period information was derived from the Lady Bird Johnson Wildflower plant database. See Appendix E for access to a pdf version of this document.

To find additional plants and their bloom period, the Lady Bird Johnson Wildflower Center plant database can be used.

If you do not live in the Pacific Northwest region, the Xerces Society for Invertebrate Conservation has compiled lists of native plants with blooming durations specific to various regions of the United States (click here to access the Xerces Society Pollinator-Friendly Native Plant Lists).

Additional WA Plant Finding Resources

For Inland Pacific Northwest, the Pullman Plant Materials Center offers an additional plant list resource, complete with both native and non-native plants.

For a more comprehensive Pacific Northwest native plant list that discusses each plant in detail, the Real Gardens Grow Natives website offers an amazing catalog for gardening purposes.

For the Eastern Washington region, the USDA - Natural Resources Conservation Service provides a thorough plant list with indications as to which plants are native.

BEE MONITORING METHODOLOGY

The rapid decline of our key pollinators creates a drastic need for wild bees documentation and monitoring. By monitoring wild bees, we can begin taking steps towards answering questions such as: What types of habitats are critical for their survival? How does mowing, agro-forestry, pesticide application, habitat modification, fragmentation, and revegetation affect wild bees? How is climate change and introduced bee species changing the structure of bee communities? Are management interventions aimed at assisting bees, such as agri-environment programs, producing the desired benefits in terms of bee conservation and pollinator promotion? It's vital to utilize the correct sampling procedures to answer these queries. If you use the wrong methodologies, your results will be invalid, and your conclusions may be suspect, if not outright false and misleading (Agrilinks Team, 2020).

Monitoring Practices

When comparing the effectiveness of various bee sampling methods, including observational records, targeted netting, mobile gardens, pan traps (blue and yellow), vane traps (blue and yellow), and trap-nests, it was found that observational records were most effective in capturing the abundance of bees. However, many observational practices are unable to distinguish finer details of bees on the taxonomy level. When capturing individuals to obtain taxonomic identification, targeted sweep netting was shown to vastly outperform passive sampling methods (Prendergast et al., 2020).

However, due to the cost of professional sweeping nets, difficulties employing the technique, large-scale accessibility issues, and possible risks to the monitors and the bees, we determined that for the purpose of citizen-based monitoring, it is best to use the transect method of collecting data through observation. When comparing other organizations' citizen science methodology, the primary method utilized was strictly observational as seen in the Xerces Society monitoring protocols (Ward et al., 2014), the Washington State University’s (WSU) native bee field guide (Bloom, n.d.), and the WSU’s citizen science guide to wild bees (Bloom & Crowder, n.d.).

SU Methodology

In our monitoring practices, there is a crucial emphasis to *do no harm*. The aim of monitoring bees is to aid in our understanding of their overall health and to help us address areas in which we can assist conservation efforts. The safety of bees is our number one priority and should always be placed before any data collection, as the goal of bee monitoring is to help them, not to kill or cause harm.

Data collection sheets and methodology practices were adapted for SU's campus from The Bees of Cascadia College and UW Bothell citizen science protocol for studying bee species diversity on campus (Attebery, 2019). (A copy of the SU adapted data collection sheets can be found in Appendix F).

Monitoring Parameters

Weather

- Wind: less than or equal to 8 mph
- Forcast: part/full sun, cannot survey during rain/fog events
- Temperature: greater than or equal to 50°F (10℃)

Transect

- Transect Dimensions: 1.5 m² (4.9 ft²)
- Transect Requirements:
  - plant coverage is greater than or equal to 50% of transect coverage
  - plant patches are more than 50% in bloom
- Plant Requirements:
  - active pollen supplies (rub the stamen between your fingers, if pollen rubs off then this plant is eligible for surveying)
  - plants growing in clusters
- Choose a different plant for each of the three surveys

Surveying

- Number of Volunteers: 2 (one observing, one recording data)
- Monitoring Duration: three consecutive 10 min. surveys + 20 min. of photographing
- Frequency: weekly*

*Methodology frequency is based on the *ideal* availability of two people (at the same time) for approximately one hour a week. If the number of bee monitoring volunteers increases, additional surveys should be performed throughout the week.

2021 SU Data & Analysis

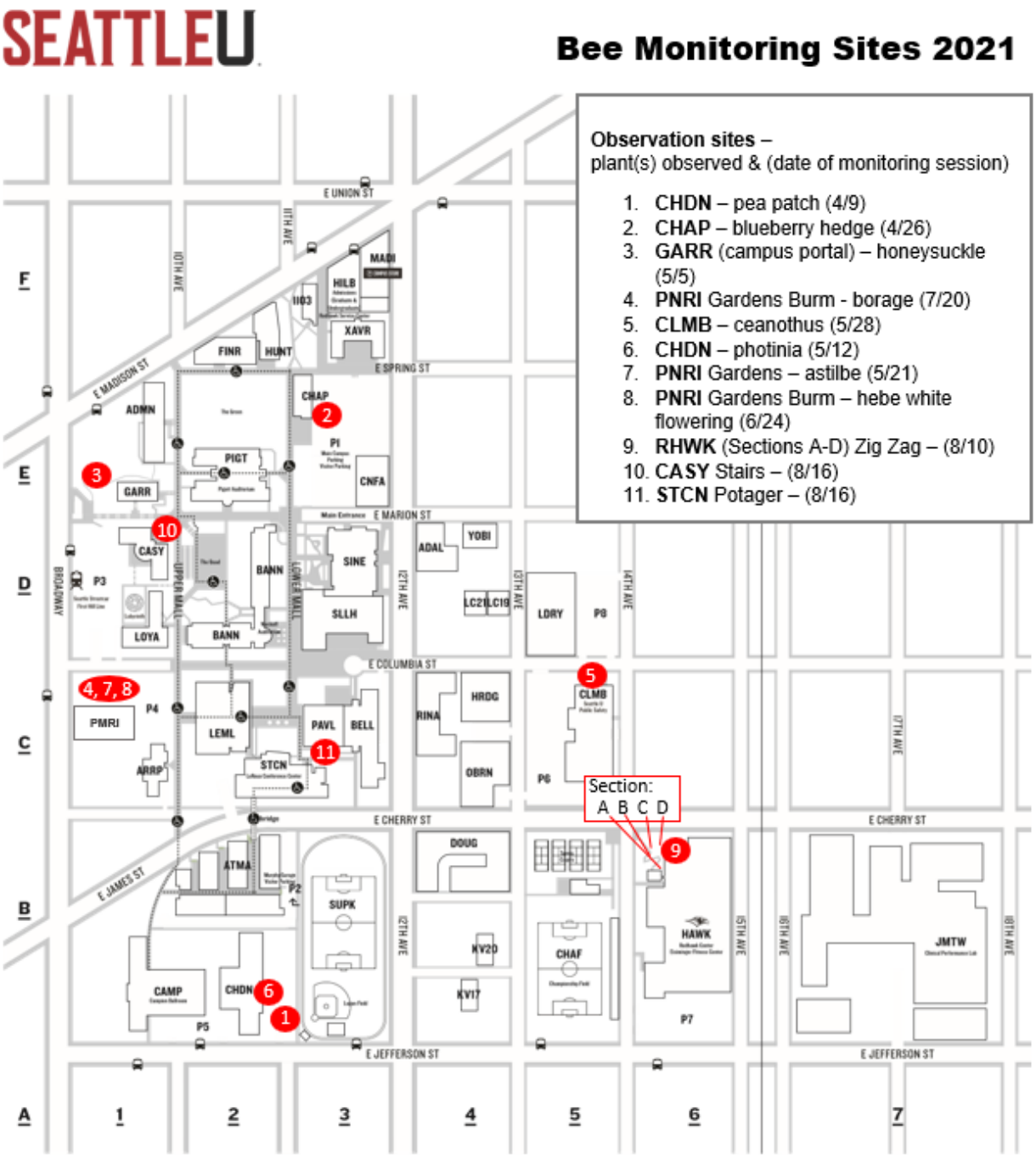


Fig. 13. Bee monitoring sites on Seattle University's campus used in 2021 over a five-month span (April - August) with nine monitoring sessions.

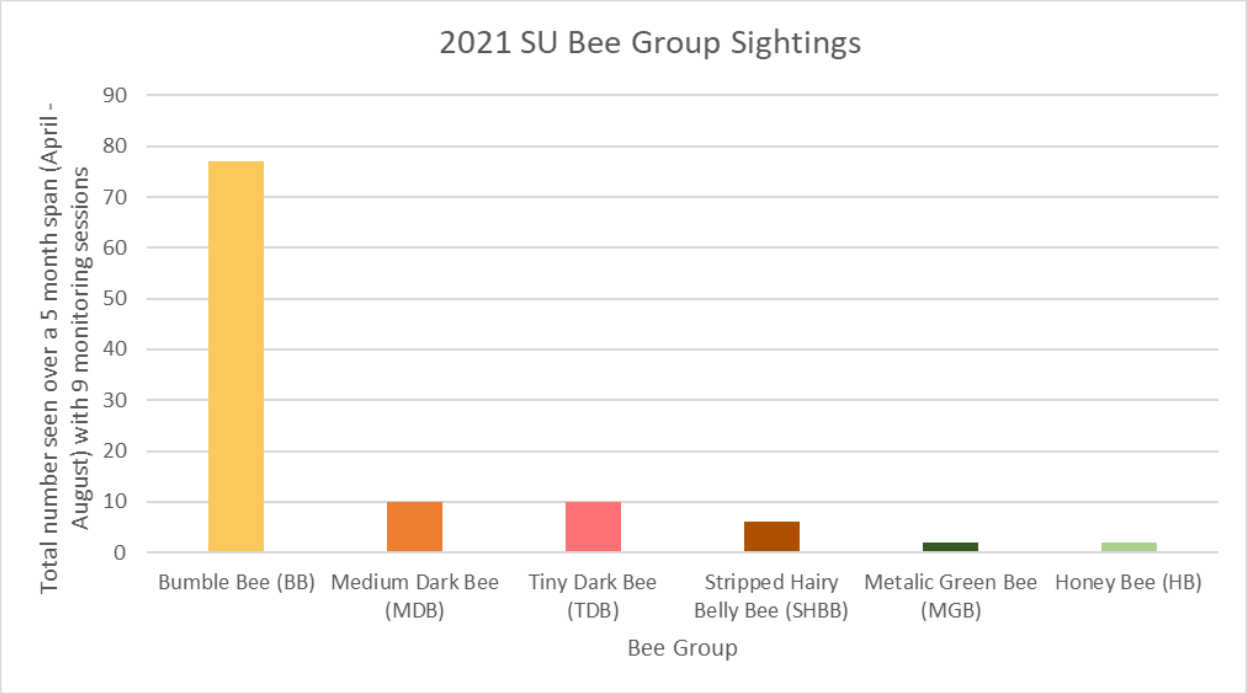


Fig. 14. Richness (y-axis) of bee groups sighted on SU's campus from 2021 bee monitoring.

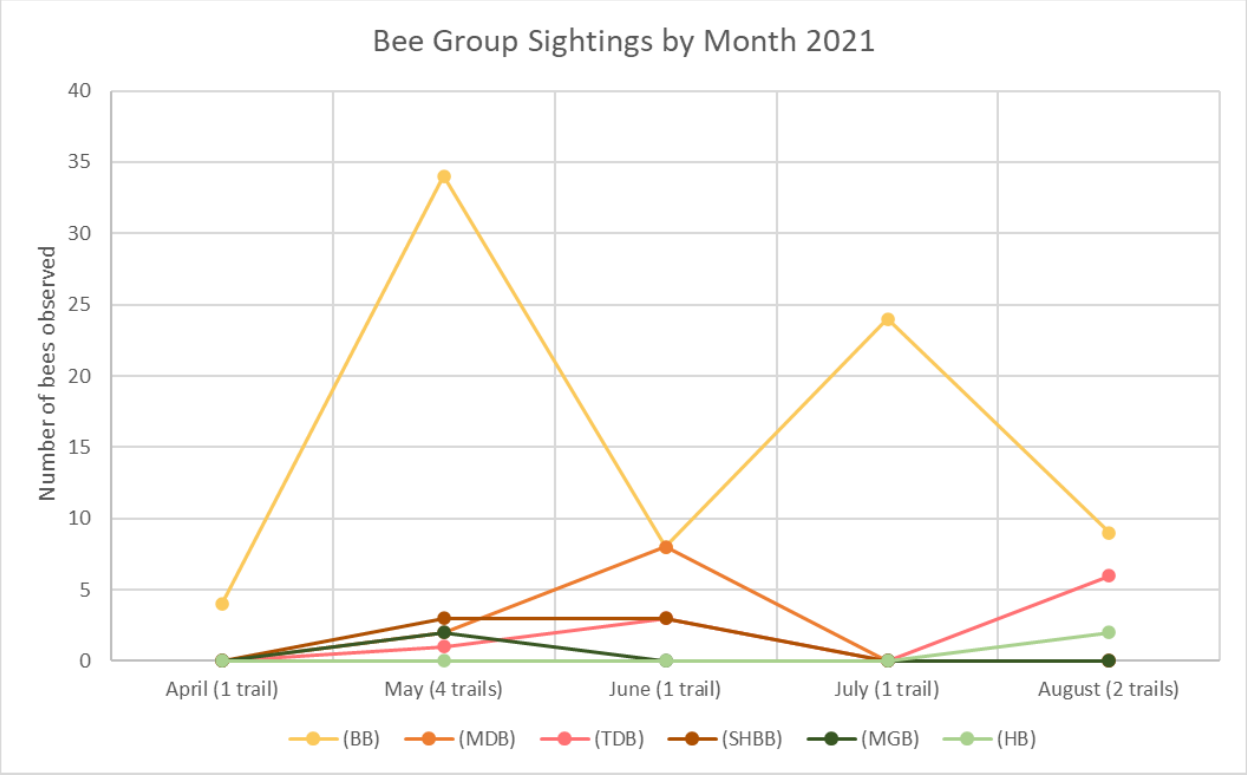


Fig. 15. Abundance and richness of bee groups observed on SU's campus in 2021 by month.

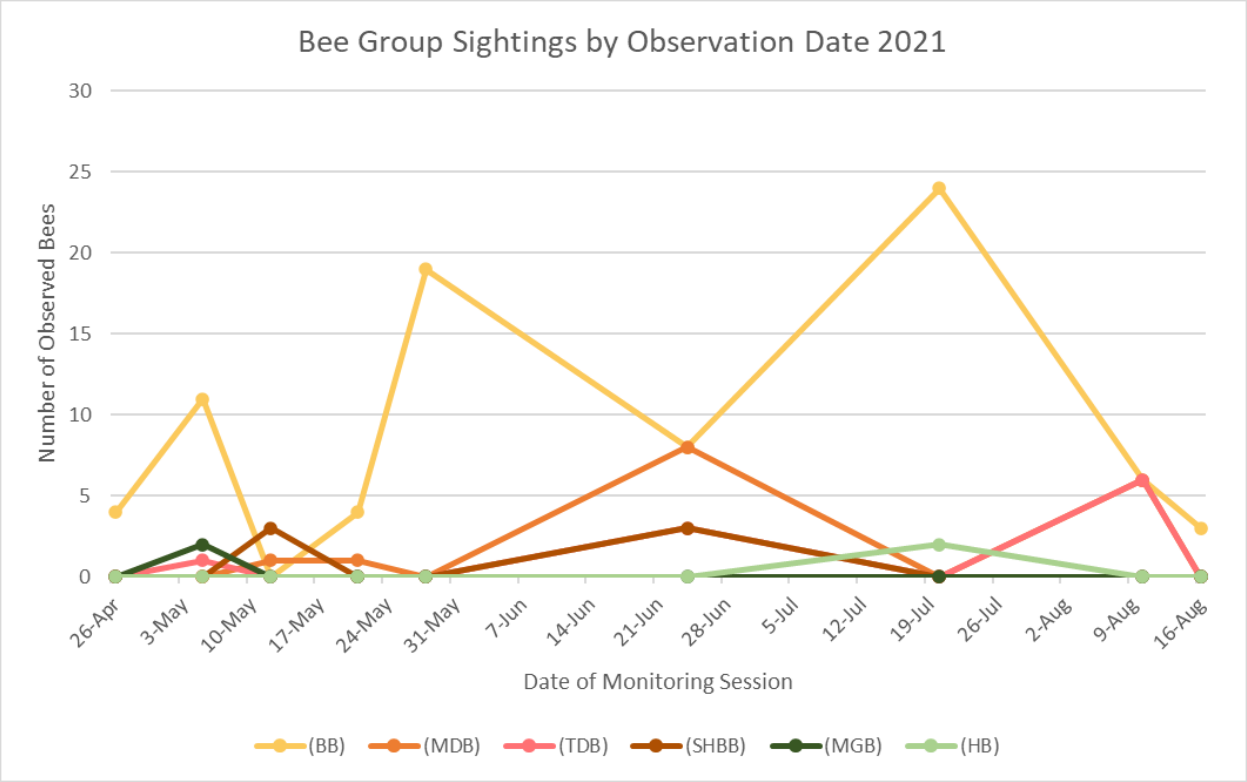


Fig. 16. Abundance and richness of bee groups observed on SU's campus in 2021 by bee monitoring date.

Regardless of species, there is a close correlation between the number of bumble bee foragers observed and the number of nesting sites (Geib et al., 2015). Data collected thus far suggests SU's campus hosts several bumblebee nests. Additionally, bumble bee "population size is likely to correlate positively with average individual health" (Parreño et al., 2021), and for many bees, nesting resources are a primary limiting factor in population growth and diversity (Buckles & Harmon-Threatt, 2019). Thus continuously observing bumble bee species may suggest that SU's campus provides a diverse and plentiful floral diet as well as the necessities for nesting sites.

While other bee groups were not as common as the bumble bee (BB) group, six out of eight bee groups were sighted on SU's campus (bee groups were established by the CCUWBee Monitoring project). It is also important to note that some native bee species can be as small as 2 mm, making it incredibly difficult to spot them all. Thus, further data is needed to accurately assess the diversity of bees on SU's campus.

Future monitoring sessions should range from March to November and be as frequent as possible. Once more data is made available, it would be extremely beneficial as a monitoring resource to display the data as a chart correlating the PNW bee sightings to month, similar to the Houston Native Bees chart.

Citizen Science Resources

For bee monitoring to be successful on any urban campus, there must be a public outreach effort. Bee monitoring relies on citizen science and volunteer interest for the longevity and success of the project. Fortunately, there has been a great success in citizen scientists efficiently collecting data on native bees in urban settings; data suggests that with prior training and continued engagement, citizen scientists were able to efficiently collect accurate data comparable to that of expert data collections (Mason & Arathi, 2019).

Recruiting Volunteers

When recruiting volunteers, the largest component to having a successful outreach is being able to target a wide audience. To do this, the opportunity and its details about what the volunteers will be doing need to be easily accessible and publicized.

Outreach Opportunities for Recruiting Volunteers

- Post volunteering opportunities on social media.
- Hang flyers or have the opportunity posted on a campus sign.
- Sending email invites.
- Have a link on the homepage of the campus's website.
- Host events in the community, such as
    - bee-friendly gardening demonstrations with native plant seed giveaways, or
    - advocating at a public market booth.

Campuses in academic settings have additional options for aiding in the recruitment of volunteers. In university settings, bee monitoring could be used as an undergraduate research elective. At SU, this would be considered a 3990 BIOL elective credit which could range from 1-3 credits depending on the students' time commitment offered Spring and Summer quarter. Secondary school campuses could make bee monitoring an activity for environmental clubs to engage in, or could consider making a designated bee club that focused on a variety of conservation practices.

Training Resources

For the success of volunteers being able to efficiently collect data, they must go through an intensive training program prior to the start of monitoring, which lasts approximately two hours (Mason & Arathi, 2019). Below is a list of exemplary training resources for training volunteers.

Videos

- Native Pollinators of Western Washington
- Xerces Classroom: North American Bee Diversity and Identification

Materials

The Great Sunflower Project provides identification bee-cards which are an excellent resource for all skill levels in identifying bees based on physical characteristics, pollen transportation method, foraging type, and active seasons. Each card also gives information about the species' food resources, nesting resources, and a fun fact.

Fig. 17. Preview of The Great Sunflower Project Bee-Cards (Source: The Great Sunflower Project, n.d.).

Xerces Society provides Maritime Northwest Citizen Science Monitoring Guide complete with Citizen Science Monitoring Datasheets, and a Bee Morphogroups Cheat Sheet (Minnerath et al., 2021).

Retaining Volunteers

Once volunteers join the project, it is vital to retain volunteers by engaging in the volunteer work and acknowledging their efforts.

Volunteer Retainment Suggestions

- Offer Support & Training
  Considering bringing in an expert for first on-site monitoring, and have training prior to starting the research.

- Highlight the Impact of Volunteers
  At the end of every season, show volunteers the data they collectively obtained and what this may indicate about the bees on campus.

- Feature Volunteers on Social Media
  Show appreciation for volunteers by displaying their work and giving thanks for their time commitments.

- Give Small Tokens of Gratitude
  At the end of the season, consider giving volunteers native plant seeds as a thanks, or a certificate of appreciation.

- Send Bi-weekly Newsletters
  These could include reminders about monitoring dates, tips for bee identification, or other interesting and relevant research.

PUBLIC AWARENESS

Survey Analysis

The aim of surveying SU members was to gain insight into what exactly classifies as being common knowledge when discussing bees. Exposing common misconceptions and identifying common knowledge helped informed what information was the most beneficial to display on bee signage. Furthermore, as the conservation of bees is a societal effort, the support and public understanding of the issues is fundamental to stopping the decline of native bees. Without understanding, the problem cannot be recognized nor addressed.

Participant Breakdown

166 surveys total
148 complete
18 partially complete

	Number of Surveys		
	Total	Complete	Partially
Albers School of Business & Economics	5	4	1
College of Education	7	7	0
College of Science & Engineering	49	43	6
College of Arts & Science	54	49	5
College of Nursing	9	9	0
School of Law	19	17	2
School of Theology & Ministry	2	2	0
Other	21	17	4

Table 1. Survey participant breakdown by SU schools accessing common knowledge about bees.

When comparing the participant breakdown of survey submissions by school to the number of individuals enrolled in each school (*Undergraduate*, n.d.), it was found that survey results accurately depicted SU's demographic with the exception of the Alberts School of Business & Economics, and the College of Nursing, whom were both underrepresented in these results.

The survey was sent out via email and advertised across campus using fliers with an attached QR code (see Appendix G for survey, survey results, and flier). Participants were asked to answer 10 questions before reading a short infographic regarding native bees and then answered three questions following the infographic. All participants who partially completed the survey did not read the infographic nor answer the last three questions, and thus their results were not recorded when comparing responses before and after the infographic but were included for factual question responses (questions 3-6, and 8). All questions were multiple choice with the exception of Q1 asking for participants' major or degree. To aid in participation the survey was kept short (due to Zoom fatigue caused by COVID-19 quarantine), visually appealing via the use of colors, and graphic sliders, and was made easily accessible through mobile compatibility and QR codes. The survey was available for one month in February 2022.

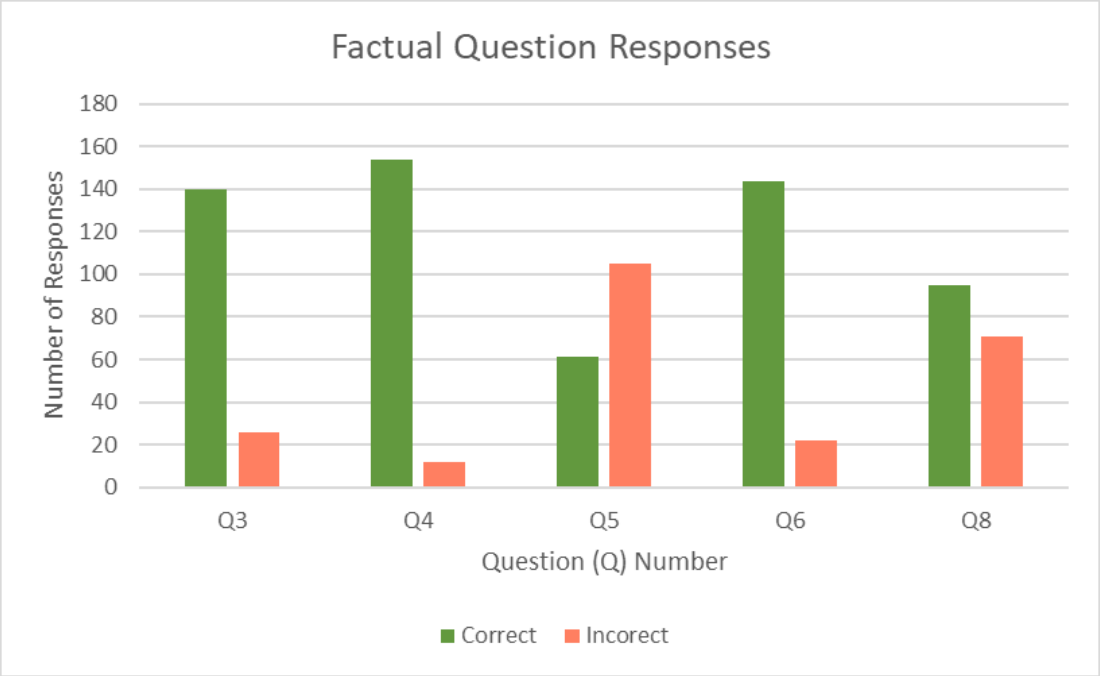


Fig. 18. A comparison of participant responses to true or false, and yes or no questions. Q3: All bees are black and yellow? (True or False). Q4: All bees sting. (True or False). Q5: Do all bees live in colonies? (Yes or No). Q6: Do all bees produce honey? (Yes or No). Q8: Is the honeybee native to North America? (Yes or No).

Figure 18 indicates that 85% of participants accurately identified that not all bees are black and yellow, 92% accurately identified that not all bees sting, and 86% accurately identified that not all bees produce honey. However, 65% of participants inaccurately indicated that all bees live in colonies, and 43% inaccurately selected the honeybee as being native to North America. Moreover, as 15% of participants inaccuretly identified all bees to be black and yellow, this indicates a lack of common awareness about the diversity of native bees as many are blue or green.

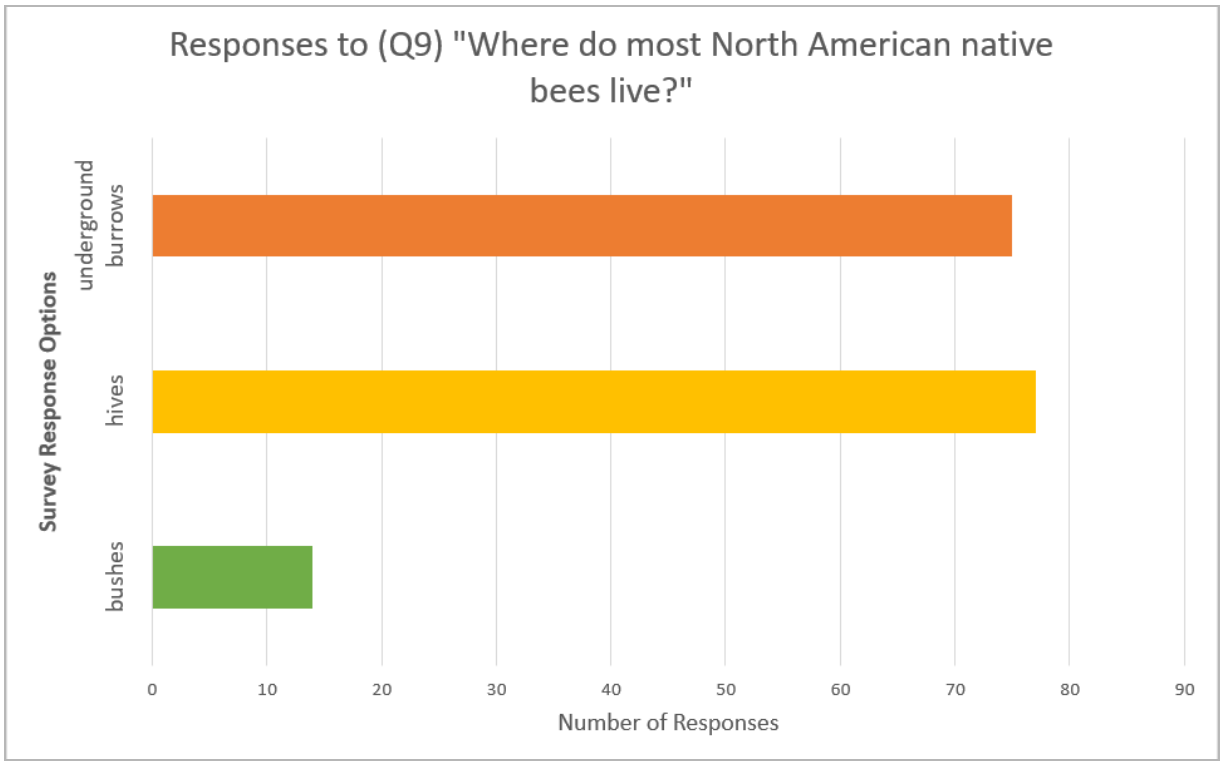


Fig. 19. Responses for Q9: "Where do most North American native bees live?". Underground burrows totaled 75 responses, hives totaled 77 responses, and bushes totaled 14 responses.

Figure 19 indicates that nearly 46% of participants inaccurately identified native bees as hive-dwelling insects.

With 46% of participants selecting that bees live in hives, and 65% selecting that bees live in colonies, these statistics indicate that there is either a lack of public awareness about the majority of native bees' social behaviors, or the common knowledge of the existence of solitary bees. Thus, it is advised that educational signage address the need to inform viewers about solitary bees, and the non-native standing of the honeybee as these were some of the broadest misconceptions found from the survey results.

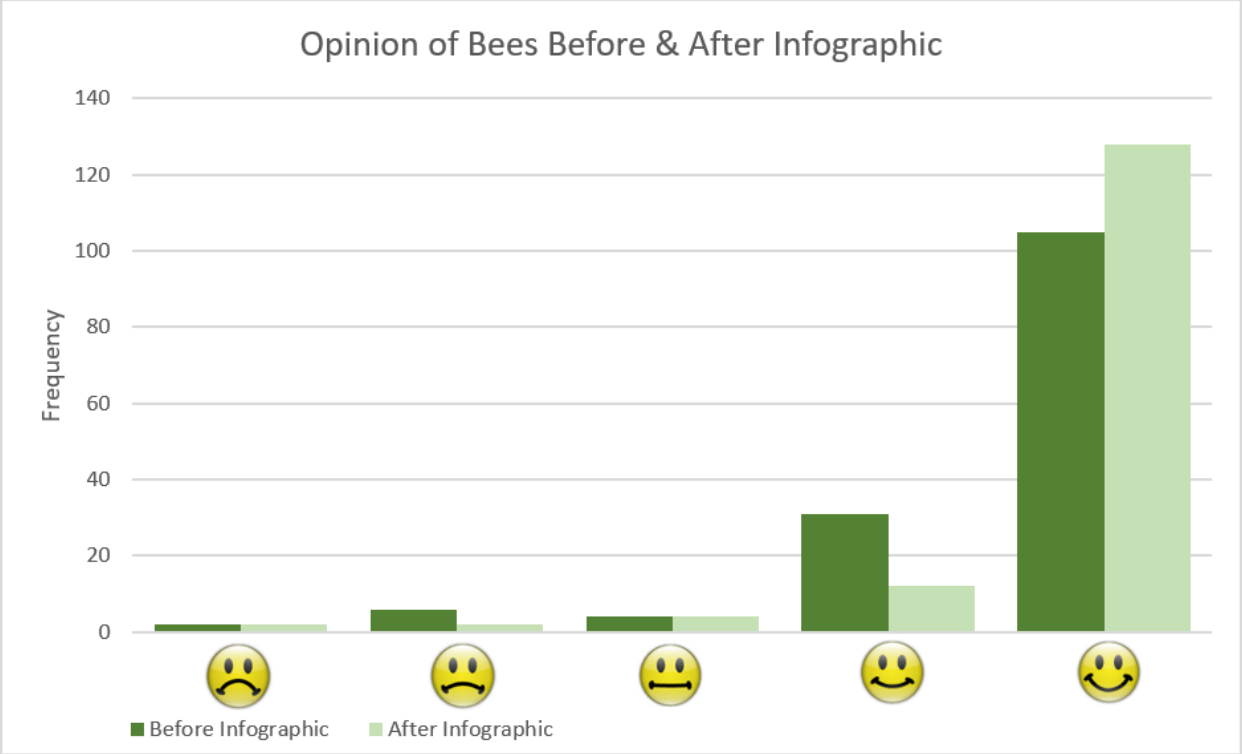


Fig. 20. compares how participants felt about bees before and after looking over the infographic using a graphic smiley-face slider. Before infographic (Q2): How do you feel about bees? After infographic (Q12): After learning about native bees, how do you feel about bees?

Figure 20 demonstrates that educational signage about bees slightly improves the general feelings regarding bees, although not supported by a strong correlation (r^2 = 0.253). Therefore, it would perhaps be most beneficial to focus on the educational aspect of the signage and not with the aim of changing the general public's feelings surrounding bees.

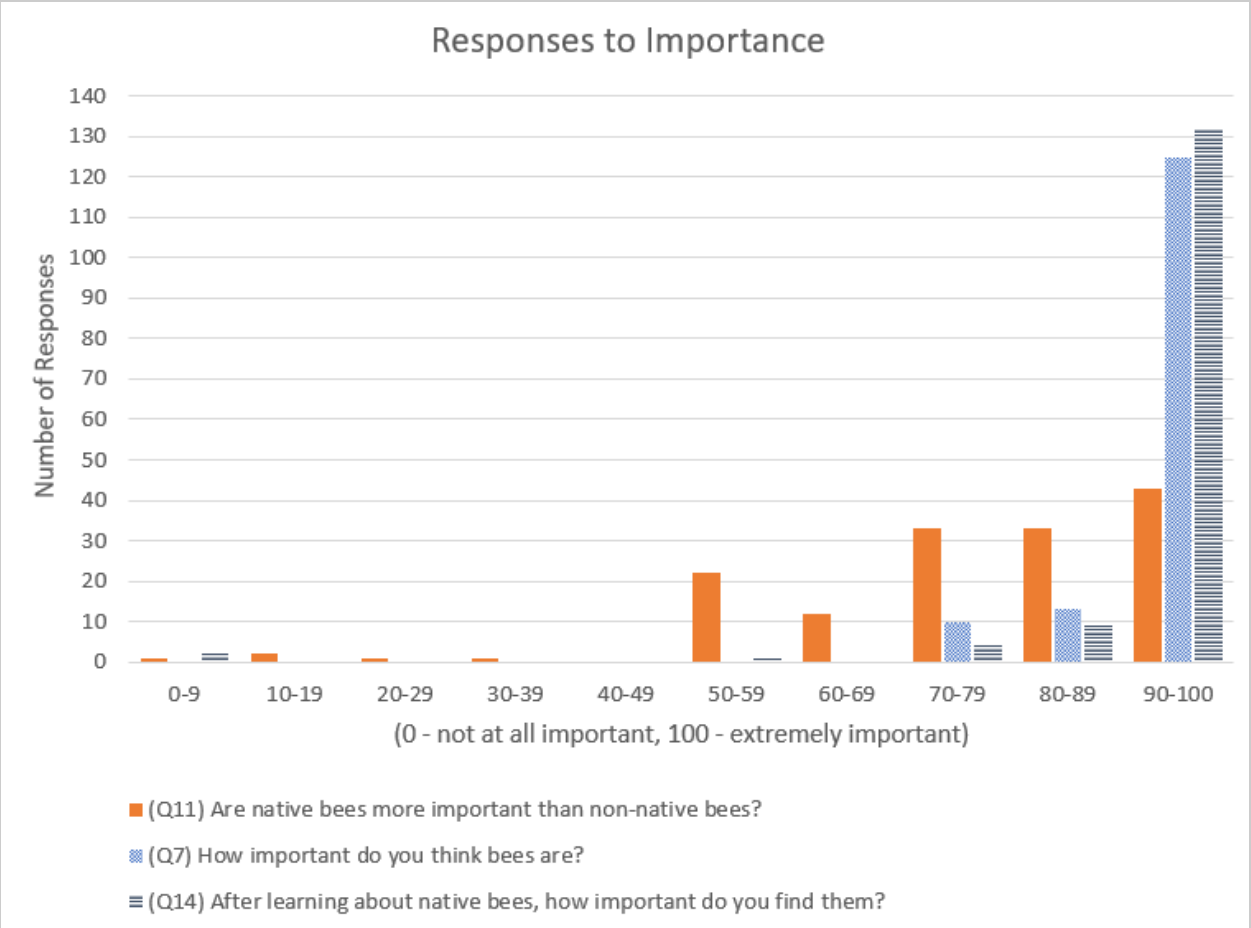


Fig. 21. Compares three questions all regarding the importance of bees. (Q7) "How important do you think bees are?" (shown in yellow) had a minimum importance rating of 70 (very important), a maximum importance rating of 100 (extremely important), a median of 100, and an average of 96. (Q11) "Are native bees more important than non-native bees?" (shown in red) had a minimum importance rating of 8, a maximum of 100, a median of 80, and an average of 77. (Q14) "After learning about native bees, how important do you find them?" (shown in blue) had a minimum importance rating of 5, a maximum of 100, a median of 100, and an average of 96.

Figure 21 indicates that informing the public about bees does not significantly change the opinions people have regarding the importance of bees ($r^2 = 0.2652$). However, when discussing the importance of bees, there is a drop in response ratings when comparing the importance of native to non-native bees with no correlation to the importance of bees before ($r^2 = 0.0688$) reading the infographic or after reading the infographic ($r^2 = 0.0599$). With nearly 43% of participants inaccurately labeling the honeybee as native to North America, it was surprising to find no correlation between those that identified the honeybee as native and those that responded with native bees not being more important than non-native bees (Q11) ($r^2 = 0.0009$). There was additionally no correlation between those that identified the honeybee as non-native and claimed native bees to be more important than non-native bees ($r^2 = 0.0023$). With no correlations to participants choosing native bees to be less or more important than non-native bees, further analysis is needed to accurately articulate the public's reasoning behind these results as they can not be determined from the given data.

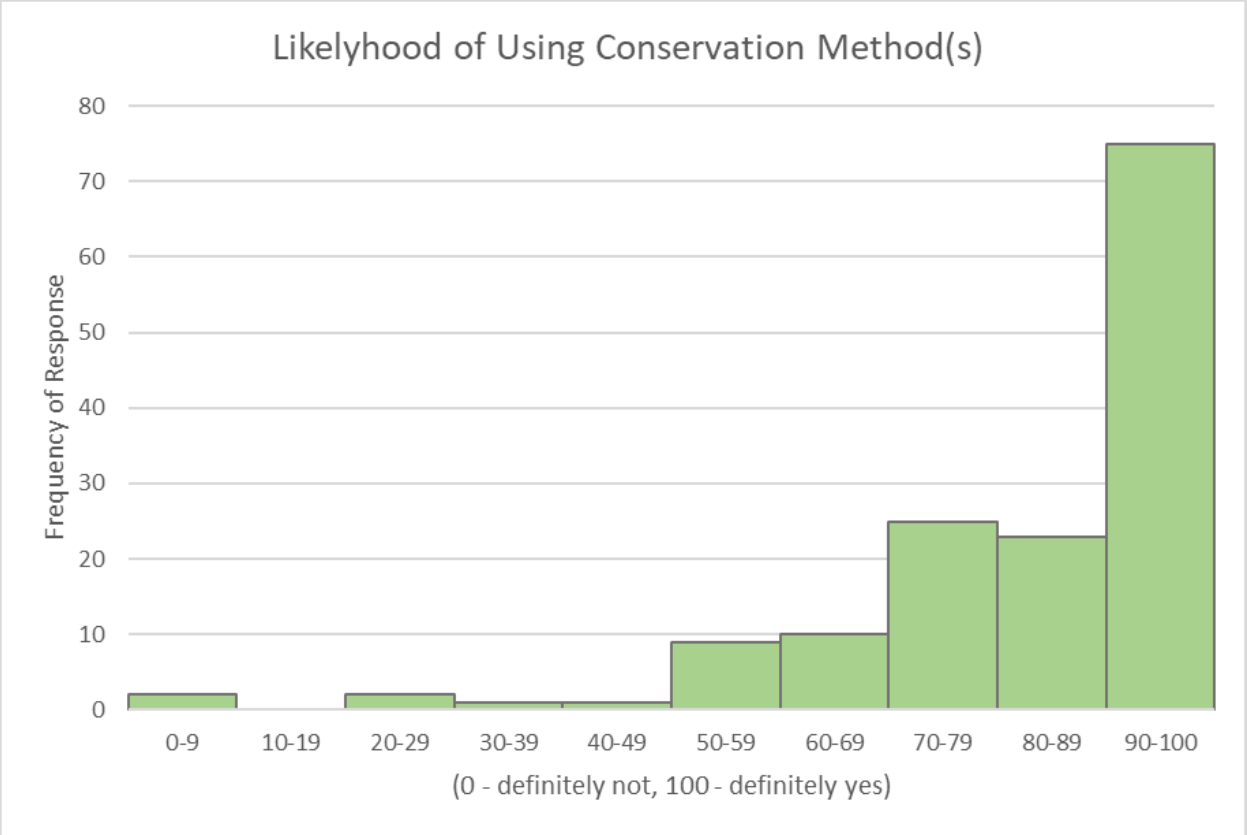


Fig. 22. demonstrates the distribution of responses to (Q13) "Will you use any of the strategies mentioned to help save the bees?". With 0 being "definitely not", 30 "probably not", 50 "might or might not", 70 "probably yes", and 100 "definitely yes". Only completed survey responses were included in the comparison of Q13 giving a minimum likelihood score of 3, a maximum score of 100, a median score of 90, and an average score of 83.

Figure 22 may suggest that educational signage displaying various strategies for helping or partaking in bee conservation may be beneficial for involving and educating the general public in bee conservation. Strategies mentioned in the infographic included alternatives for using pesticides, providing water sources, growing native plants, providing housing, and buying organic and/or Bee Better Certified™ foods. The survey also concluded that approximately 98% of participants knew that the current status of native bees is decreasing. Implying that perhaps the population status of bees is not an efficient usage of signage.

Suggested Signage

Signage can be used in numerous settings as an educational outreach tool capable of reaching a wide audience. When designing signage for campuses, my survey data indicates that there are three key points to emphasize:

1. Debunk common misconceptions
2. Have an interactive aspect
3. Provide methods for getting involved

Some common misconceptions to tackle, according to the survey results, include stating that the honeybee is not native to North America, asserting the existence of solitary bees, as well as stating that most solitary bees are primarily ground-nesting dwellers.

Having an interactive aspect to the signage will not only contribute to the public's knowledge but will create an opportunity for the public to engage with the material and encourage the exploration of the campus. An interactive piece could include displaying images of the local plants on the campus that provide foraging resources to the bees from March to November (as seen in Fig. 23). Not only does this demonstrate how the campus has worked to avoid bloom gaps, but it also gives people an idea of what they could plant in their yards to achieve the same goal, and will allow people to actively search for these plants on the campus. Another suggestion is to include images of several types of native bees or pollinators, showcasing some of the region's diversity and providing people an opportunity to actively search for them on the campus (as seen in Fig. 24).

Lastly, it is important both for the longevity and outreach of the project that methods for getting involved are provided. Individuals who actively engage with the signage are more likely to want to get involved with the campus's bee monitoring compared to individuals who don't. Thus, it is the perfect opportunity to advertise how people can get involved in campus bee monitoring projects. Additionally, the survey suggests providing information on how individuals can take action to help native bees is of beneficial use as the majority of participants claimed that they would most definitely use at least one of the methods provided in the infographic.

I made an exemplary sign for the use of urban campuses which can be customized to each campus's needs and wants (as seen in Fig. 23). Please see Appendix H to access the template of Fig. 23.

BEE-FRIENDLY CAMPUS

Our campus provides habitat, foraging, and nesting resources to native bees.

4,000

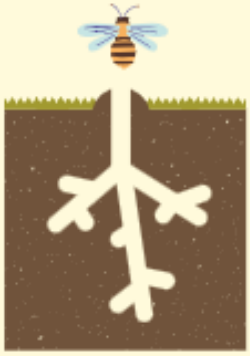
native bee species line in

North America

About

70%

nest in the ground
& most are solitary



Fun Fact

Did you know the honey bee is NOT native to the Americas? The honey was introduced to the Americas by European settlers and has since become problematic for native bees. Native bees are also 2-3X better pollinators compared to honey bees.

Our campus has planted an array of native plants ensuring that there is always something in bloom from March to November, ensuring that the bees always have a food source available to them.

Golden Tickseed
Feb. - Nov.

Blue Elderberry
Mar. - Sep.

Spotted Joe-pye Weed
Aug. - Oct.

Bee Balm
Apr. - Oct.

Slender Yellow Wood Sorrel
May. - Nov.

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We can make it all better again, together.
GET INVOLVED BY VISITING CAMPUSBEES.EDU

Fig. 23. General bee-friendly campus signage. (Editable version available in Appendix H).

The [United States Geological Survey (USGS) Bee Inventory and Monitoring Lab] has compiled an excellent photo catalog of bees that are under the Public Domain and is an exemplary resource for creating or editing educational signage and posters.

Customizing this plan to Seattle University's proposed Bannan roof garden, I have created suggested signage which can be seen below, or viewed by seeing Appendix I (view by clicking here).

Fig. 24. SU Bannan Green Roof Renovation suggested/exemplary signage for a pollinator-designated garden. (Accessible in Appendix I).

In this exemplary signage, additional resources were added with the intent of this being used as designated garden signage. Expanding off of the more general signage, there is a QR code that provides a resource for finding native plants in specified regions along with their bloom periods, as well as an additional resource mentioned in the text. Furthermore, the methods for helping native bees are provided in the right column, along with a small section about the garden, and a section emphasizing the importance of native bees.

Ways Everyone Can Help

When providing resources for how people can help partake in bee conservation, it is important to keep in mind varying financial statuses, accessibility to resources, and the practicality of the methods being provided. Here are just a few methods that provide people with tools to participate at a variety of levels:

- **Plant Native Plants**
  Native bees have evolved to feed on native plants. Plant a large variety of plants to support a large variety of pollinators.

- **Full Season of Bloom & Food**
  Select plants with overlapping blooming periods from March to November. This provides pollen and nectar throughout the entire season for bees to feed on.

- **Provide Water**
  Provide a shallow dish of water such as a frisbee with marbles in it.

- **Provide Nesting Resources**
  This can be as simple as leaving a dirt patch undisturbed in the yard or leaving plant stem clippings in the yard.

- **Avoid Pesticides**
  Instead, use organic alternatives for unwanted pests, such as neem oil, Organocide® Bee Safe 3-in-1 Garden Spray, or the Mighty Mint®.

- **Buy Bee-Friendly Foods**
  Buy organic foods when possible and look for foods, such as cherries, blueberries, and even Haagen-Dazs® ice cream, with the Bee Better Certified™ seal.

- **Bee Monitoring Volunteer**
  Share your findings with iNaturalist or download the Insight Citizen Science app to become a volunteer! This helps scientists monitor the abundance and distribution of bees. Or join the Friends of the Earth BeeAction campaign to petition retailers to stop selling neonicotinoid pesticides!

BANNAN GREEN ROOF RENOVATION

Within this guide, I have created a method applicable to all urban campuses for accessing and identifying bloom gaps, including the construction of a native bloom period chart for the public in the King County area to use as a tool, and a native plant list specific to SU Bannan Green Rood complete with each plants' growing requirements. I additionally conducted a survey assessing common knowledge and misconceptions about native bees and used my analysis of the data to create bee signage for public use and signage specific to SU. Moreover, I designed a ground-nesting bee structure in the hopes of creating more ideal habitat for native bees. Overall, a major goal of this project was to not only put together some of the broader outlines for urban campuses to use in conservation efforts, but to specify this plan to SU's campus and implement the guidelines to set an example for other urban campuses.

Native Plant Suggestions

Nearly 20% of native bees are considered to be specialist bees. These specialist bees only feed on one or a few related plant species, usually all within the same genus, with several strictly feeding on native plants (Dingwell, 2015). Thus, it is imperative that in order to conserve the native bees we must also conserve our native plants and vice versa. (For finding native plant suggestions and resources see Bloom Gap).

To cater conservation efforts on SU's campus, I customized a list of native plants for the use of the proposed SU's Bannan roof garden with several key projects in mind. First was the soil quality that the Bannan roof has to offer, which was previously researched in the Bannan Green Roof Renovation project, and for which former SU student Zachary Smith helped design concept maps for. When making the Bannan Garden Roof Renovation Native Plant Suggestions list I also considered the Edible Campus project, while simultaneously aiming at providing a full season of foraging and habitat resources to native bees.

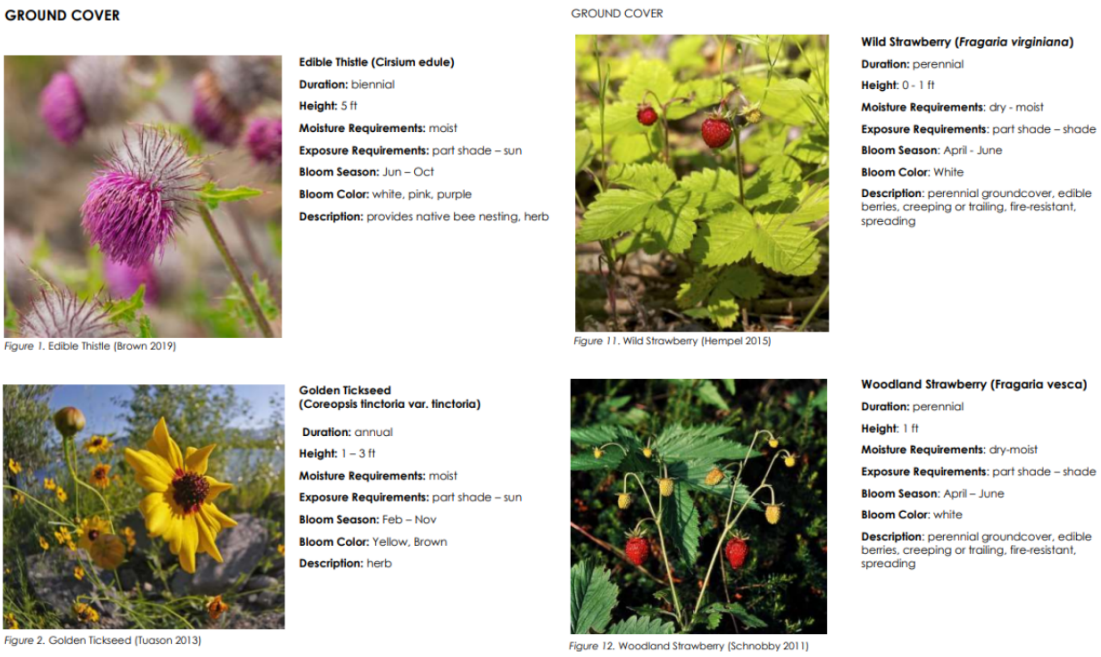

Fig. 25. Bannan Garden Roof Renovation Native Plant Suggestions preview, see Appendix J for access to the complete document.

Accessibility

An important aspect of creating educational gardens is to make them inclusive experiences. Inclusivity should incorporate providing accessible trails and providing educational materials obtainable to a variety of needs.

To create trails that are accessible to persons with disabilities, the trails should be firm and stable, as well as resilient to weather (USDA Forest Service, 2012). To achieve this, there are a few key specifications to follow.

Wheelchair Accessible Trail Requirements:

- Running slopes no steeper than 1:20.
    - Changes in level with a maximum of ¼ inch are permitted to be vertical.
    - Changes in level between ¼ - ½ inch need to have a slope not steeper than 1:20 (for every inch of height change there needs to be at least 20 inches of route run).
    - Changes in levels greater than ½ inch must be ramped.

- Trails should be 36 inches minimum in width.

- Trails must be firm and stable.
    - This can be achieved by using WoodCarpet® Bonded 1

One method the Catoctin Mountain Park used for creating wheelchair-accessible terrain was to use WoodCarpet® Bonded 1, a natural product that contains no chemicals or artificial ingredients (National Park Service, 2021). A perk of this terrain design is that it is designed with a WoodCarpet® top layer and a compact gravel underlay which provides water drainage to avoid the trails from getting soggy, an important component for areas with frequent rain (Zeager Bros. Inc., 2022).

To provide accessibility for educational opportunities, both language and seeing impairments should be considered. A solution to language inclusivity is to provide QR codes on the signage that link to the same informational signage in various languages, especially those most prevalent in the given region. In the King County district alone, 170 languages are spoken with Spanish, Chinese, and Vietnamese being the three most common following English (Felt, 2017). The same method of using a QR code can be used for those with visual impairments. Brail can be placed on the signage next to a QR code that informs readers of the location of the QR code which will read out loud the signage's informational content. Brail QR stickers can be easily purchased through the Braille House non-profit organization for just $3.30 a sticker (Braille House, 2021).

When accessibility is incorporated into garden layouts, it helps strengthen communities by aiding to bring disability justice and equitable opportunities.

Garden Certification

Another way to join the movement to promote and conserve our native bees is to join the Xerces Society's Bring Back the Pollinators campaign. Agreeing to the Xerces Society Pollinator Pledge additionally places your garden on their Pollinator Pledge map where people around the world can view those who participate in this pledge, and it's free to sign up!

Xerces Society Pollinator Pledge

1. Grow a variety of bee-friendly flowers that bloom from spring through fall.

2. Protect and provide bee nests and caterpillar host plants.

3. Avoid using pesticides, especially insecticides.

4. Talk to neighbors about the importance of pollinators and their habitat.

For more additional pollinator conservation resources, the Xerces Society is a phenomenal resource (Xerces Society, 2021a).

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APPENDIX

Appendix A

CEJS Fellowship Reasearch Project Components

This appendix consists of the CEJS Fellowship research project components as listed under the report guidelines that were not discussed in the guide.

Original Project & Intentions

The objective of this project is to gain insight about the diversity and abundance of native bee species in WA state, increase native bee awareness to the public, and increase native bee abundance on SU campus by testing if bee housing structures increase native bee survival rates. For the field research portion of this project, I will be cooperating with Seattle University's Ground and Landscaping department and the CCUWBee Monitoring Study. I will take part in the bee monitoring study and use the data collected in the study to construct two types of bee habitats on campus targeted towards wood and ground-nesting bees. Nesting materials will be specified to the type of native bee species found living in the area. To increase community awareness of the importance of native bees, these structures will have an interpretation sign indicating what native species it houses, identifiers and images of the native bees, and other additional information relative to the project with a QR code to the Grounds and Landscaping webpage. The species found in the shortest supplies will be purchased through a local beekeeper within WA state and introduced into the

area in the Spring of 2022. I will conduct a second bee monitoring study the following Spring to evaluate if these structures can be a sustainable native bee conservation solution to the global decline in pollinator populations.However, due to ethical ramifications, sustainability of the project, demographic of solitary bee nesting locations, and the associated potential risks to bee populations, above ground structures were not built. Several studies have suggested that importing bees can bring new diseases to the area negatively impacting established bee populations. Furthermore, while building above ground nesting structures for bees may be beneficial, several studies have shown they do not help native bees anymore than they do wasps or other insects. Moreover, the original design of the structure had the nesting sites clustered together (which is not common for most solitary bees in natural nesting sites) allowing for pests to infect a greater number of larvae over winter further hurting bee populations.

The original project aimed to gain a better understanding of native bee species abundance and diversity in WA state comparing urban and city environments (mores specifically comparing Wenatchee to Seattle), increase the overall health of the SU campus ecosystem and collect critical data for understanding how providing native bee housing helps recruit and retain native bee populations. The installation of these structures will also provide a sustainable and easily accessible way for more people to participate in native bee conservation efforts, provide further research opportunities, and create a unique interactive experience for bringing awareness to the issue. By bringing in more native bees into the area and building habitat structures we will increase diversity and abundance on, and around, Seattle University’s campus. Due to insufficient data, bee monitoring in Wenatchee was not utilized in this guide.

Methodology

See Bee Monitoring Methodology.

Implemented Timeline

	Date
Bee Monitoring Training	3/27/2021
Bee Monitoring	4/26/2021 - 8/16/2021
IRB Survey Exemption	1/25/2022
Survey	2/8/2022 - 2/30/2022
Construction of Bee Buckets	2/18/2022 - 3/10/2022
Installation of Bee Buckets	3/10/2022 - 3/11/2022
Presentation	5/24/2022
Guide Completion	6/13/2022

Project Findings

To accurately assess the abundance, diversity, and richness of bee morphogroups on SU's campus, approximately five years of data collection will be required. See Citizen Science Resources for project findings about the 2021 bee monitoring data, and the Survey Analysis for findings about common knowledge about native bees among SU affiliates.

Cost

There were no finacial costs associated with this project.

Lessons Learned

- Sweeping nets should only be used by trained individuals when monitoring bees, and does not appear to be a viable strategy for implementing in citizen science.
- Learning about the bloom gap(s) on campus will require a team and may take between 1-2 years to complete for SU's campus.
- There is a large student interest in becoming involved with bee projects on campus, however there is are currently no public opportunities offered on SU's campus.

Recommendations for Future Reaserch

For future reaserch projects on native bees, I would highly recommend:

- focusing on one morphogroup of bee.
- focusing on one aspect such as identifying nesting sites on campus, outreach/student involvement, closing the bloom gap, or implementing other parts of this guide.
- studying with a group and distributing the work load.

Supporting Materials

See Figures, Table 1, and Appendix.

Appendix B

Step 1: Bloom Chart

This appendix consists of the Bloom Chart (Adam, 2016) used in step one of charting bloom gaps on campus by identifying individual plants and their bloom periods.

The Bloom Chart document can be accessed by clicking here, or by going to:

https://1drv.ms/b/s!Ar3A7iDzUFmTngq1nkvsjdqCuvHl

Use this chart to record the sequence of perennial blooms in your garden. List plants and then record when they are in flower by putting a checkmark in the column for that week. One box equals one week. Blank spaces will indicate times when the garden is without flowers. Research plants that bloom in these periods to make a shopping list.

MONTH		MARCH				APRIL				MAY				JUNE				JULY				AUGUST				SEPTEMBER				OCTOBER				NOVEMBER			
PLANT NAME	WEEK	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4

For more more ideas to inspire your gardening, go to gardenmaking.com

GARDENMAKING
Inspiring & informing home gardeners

Appendix C

Step 2: Identifying Plant Location on SU Campus

This appendix consists of a blank chart used for identifying plant locations on the SU's campus by block, then identifying if the plants in each block remain in bloom from March to November.

The Plant Location Chart can be accessed by clicking here, or by going to:

https://1drv.ms/b/s!Ar3A7iDzUFmTnglur2w7OsBgO67l

Identifying Bloom Gaps on Seattle University Campus

	Bloom Period								
Block ID	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
F2									
F3									
E1									
E2									
E3									
D1									
D2									
D3									
D4									
D5									
C1									
C2									
C3									
C4									
C5									
B1									
B2									
B3									
B4									
B5									
B6									
B7									

✗ Denotes that there are no plants in this block that are in bloom during the indicated month

✓ Denotes that there are plants in this block that are in bloom during the indicated month

Appendix D

Step 3: Mapping Out Bloom Gaps on SU

This appendix consists of a blank map of SU with a coordinate system; used in step three of charting bloom gaps on campus via mapping out bloom gaps by color and block.

The SU Bloom Gap Map can be accessed by clicking here, or by going to: https://drive.google.com/file/d/1taIEF7N1MPoxLWsuvoOyd5uB5SjcdHv8/view?usp=sharing

SEATTLEU

Campus Bloom Gaps 2022

☐ No bloom gap ☐ 1 month bloom gap ☐ 2 month bloom gap

☐ 3 month bloom gap ☐ +4 month bloom gap

Campus Buildings and Areas

1103 East Madison Building	1103	F3
1313 East Columbia Building	CLMB	C5
Administration Building	ADMN	E1
Advancement & Alumni Building	ADAL	D4
Arrupe Jesuit Residence	ARRP	C1
Bannan Center Wyckoff Auditorium	BANN	D2
Bellarmine Hall	BELL	C3
Campion Hall Campion Ballroom	CAMP	B1
Casey Building Casey Commons	CASY	D1
Championship Field	CHAF	B5
Chapel of St. Ignatius	CHAP	E3
Chardin Hall	CHDN	B2
Douglas Apartments	DOUG	B4
Fine Arts Building	FINR	F2
Garrand Building	GARR	E1
Harding Building	HRDG	C4
Vi Hilbert Hall Admissions/Enrollment Services	HILB	F3
Hunthausen Hall	HUNT	F2
James Tower (at Swedish Cherry Hill)	JMTW	B7
Kolvenbach House 1217	KVI7	B4
Kolvenbach House 1220	KV20	B4
Laundry Building	LDRY	D5
Lee Center for the Arts	CNFA	E3
Lemieux Library & McGoldrick Learning Commons	LEML	C2
Logan Court 819 A,B,C	LI9	D4
Logan Court 821 B,C	L2I	D4
Loyola Hall	LOYA	D1
Madison Building Campus Store	MADI	F3
Murphy Apartments	ATMA	B2
O'Brien Center	OBRN	C4
Pigott Building Pigott Auditorium	PIGT	E2
Pigott Pavilion for Leadership	PAVL	C3
Redhawk Center	HAWK	B6
Rianna Building	RINA	C4
Seattle University Park Logan Field	SUPK	B3
Sinegal Center for Science & Innovation Oberto Commons	SINE	D3
Student Center LeRoux Conference Center	STCN	C2
Sullivan Hall	SLLH	D3
Xavier Hall	XAVR	F3
Yobi Apartments	YOBI	D4

Parking Areas & Garages

P1	Main Parking Lot / Visitor Parking	E3
P2	Murphy Garage (below apartments) / Visitor Parking	B2
P3	Broadway Garage	D1
P4	10th & East Columbia Lot	C1
P5	10th & East Jefferson Lot	B2
P6	13th & East Cherry Lot	C5
P7	14th & East Jefferson Lot	B6
P8	14th & East Columbia Lot	D5

Popular Destinations

Athletics & Recreation	Go to the...		
Athletics	Redhawk Center	HAWK	B6
Athletics Administration	O'Brien Center 1218 E Cherry St Entrance	OBRN	C4
Fitness / Recreation	Eisiminger Fitness Center	HAWK	B6

Collegiums	Go to the...		
The Commuter Link	1103 E Madison Building	1103	F3
McGoldrick Collegium	Hunthausen Hall	HUNT	F2
Reidy Collegium	Student Center	STCN	C2

Galleries	Go to the...		
Hedreen Gallery	Lee Center for the Arts	CNFA	E3
Kinsey Gallery	Advancement & Alumni Building	ADAL	D4
Vachon Gallery	Fine Arts Building	FINR	F2

Meeting & Event Locations	Go to the...		
Boeing Room	Lemieux Library & McGoldrick Learning Commons	LEML	C2
Campion Ballroom	Campion Hall	CAMP	B1
Casey Atrium	Casey Building	CASY	D1
Casey Commons	Casey Building	CASY	D1
LeRoux Conference Center	Student Center	STCN	C2
Oberto Commons	Sinegal Center	SINE	D3
PACCAR Atrium	Pigott Building	PIGT	E2
Pigott Auditorium	Pigott Building	PIGT	E2
Wyckoff Auditorium	Bannan Center, East Entrance	BANN	D2

Schools & Colleges	Go to the...		
Albers School of Business & Economics	Pigott Building	PIGT	E2
College of Arts & Sciences	Casey Building	CASY	D1
College of Education	Loyola Hall	LOYA	D1
College of Nursing	Garrand Building	GARR	E1
College of Science & Engineering	Bannan Center	BANN	D2
School of Law	Sullivan Hall	SLLH	D3
School of New & Continuing Studies	Harding Building	HRDG	C4
School of Theology & Ministry	Hunthausen Hall	HUNT	F2

Services & Programs	Go to the...		
Admissions Office Grad & Undergrad	Vi Hilbert Hall	HILB	F3
Alumni Engagement Office	Advancement & Alumni Building	ADAL	D4
Billodue Makerspace	Sinegal Center	SINE	D3
Campus Ministry	Student Center	STCN	C2
Campus Store	Madison Building	MADI	F3
Career Engagement Office	Pigott Pavilion for Leadership	PAVL	C3
Center for Student Involvement	Student Center	STCN	C2
Conference & Event Services	1313 East Columbia Building	CLMB	C5
Controller's Office	O'Brien Center 1218 E Cherry St Entrance	OBRN	C4
Development Office	Advancement & Alumni Building	ADAL	D4
Enrollment Services	Vi Hilbert Hall	HILB	F3
Education Abroad	Pigott Pavilion for Leadership	PAVL	C3
Facilities Services	1313 East Columbia Building	CLMB	C5
Human Resources	Rianna Building 718 12th Ave Entrance	RINA	C4
International Student Center	Pigott Pavilion for Leadership	PAVL	C3
Law Clinic, Ronald A. Peterson	Sullivan Hall	SLLH	D3
Marketing & Communications	O'Brien Center 715 13th Ave Entrance	OBRN	C4
Military Science, Department of	O'Brien Center 709 13th Ave Entrance	OBRN	C4
Office of Multicultural Affairs	Pigott Pavilion for Leadership	PAVL	C3
Public Safety, Seattle U	1313 East Columbia Building	CLMB	C5
Redhawk Service Center	Vi Hilbert Hall	HILB	F3
Registrar	Vi Hilbert Hall	HILB	F3
Sundborg Center for Community Engagement	Sinegal Center	SINE	D3
Student Financial Services	Vi Hilbert Hall	HILB	F3
University Administration	Administration Building	ADMN	E1

Spiritual Spaces	Go to the...		
Chapel of Saint Ignatius	Chapel of Saint Ignatius	CHAP	E3
Chardin Prayer Room	Chardin Hall	CHDN	B2
Ecumenical Chapel	Campion Hall	CAMP	B1
Immaculate Conception Chapel	Administration Building	ADMN	E1
Labyrinth	Loyola Hall Garden	LOYA	D1
Multifaith Prayer Room	Campion Hall	CAMP	B1

HC 2021-09

Appendix E

King County Native Plant Bloom Period Chart

This appendix consists of a complimentary King County Native Plant Bloom Period Chart I designed for 150 plants that correspond to all the native plants listed under the King County Native Plant List. Bloom Period chart for King County Native Plant List (“Plant List - Native Plant Guide,” 2013). Bloom period information was derived from the Lady Bird Johnson Wildflower plant database (“Lady Bird,” 2022).

The King County Native Plant List can be accessed by clicking here, or by going to: https://green2.kingcounty.gov/gonative/Plant.aspx?Act=list

The King County Native Plant List Bloom Period chart can be accessed by clicking here, or by going to: https://1drv.ms/b/s!AhJXdJ0MImngbi_6TvVxjxcApyw?e=MmxWxU

King County Native Plant Bloom Guide

(https://green2.kingcounty.gov/gonative/Plant.aspx?Act=list)

Type	Common Name	Bloom Month										
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Tree	bigleaf maple				■	■						
Tree	bitter cherry				■	■						
Tree	black cottonwood				■							
Tree	black hawthorn					■	■					
Tree	cascara				■							
Tree	Douglas' Maple				■	■						
Tree	Douglas-fir				■							
Tree	gand fir				■	■						
Tree	Hookers willow			■	■							
Tree	madrone; madrona			■	■	■						
Tree	Oregon ash				■							
Tree	Oregon white oak; Garry oak			■	■	■						
Tree	Pacific crabapple				■	■						
Tree	Pacific dogwood				■	■	■	■				
Tree	Pacific willow			■	■	■	■					
Tree	paper birch				■							
Tree	quacking aspen				■	■						
Tree	red alder			■	■							
Tree	shore pine				■	■						
Tree	Sitka spruce				■	■						
Tree	Sitka willow			■	■							
Tree	slide alder					■	■					
Tree	vine maple			■	■	■						
Tree	Western hemlock				■							
Tree	Western redcedar				■							
Tree	Western white pine				■							
Tree	yew						■	■				
Shrub	blad hip rose				■	■						
Shrub	beaked hazelnut	■	■	■								
Shrub	black cap raspberry				■	■						
Shrub	black gooseberry					■	■					

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Shrub	blue elderberry											
Shrub	bog laurel											
Shrub	bog rosemary											
Shrub	devil's club											
Shrub	evergreen huckleberry											
Shrub	hairy manzanita											
Shrub	highbush cranberry; mooseberry											
Shrub	hybrid manzanita											
Shrub	indian plum; osoberry											
Shrub	low Oregon grape											
Shrub	mock orange											
Shrub	nootka rose											
Shrub	oceanspray											
Shrub	Oregon box											
Shrub	Pacific ninebark											
Shrub	Pacific rhododendron											
Shrub	Pacific wax myrtle											
Shrub	red elderberry											
Shrub	red huckleberry											
Shrub	red stem ceanothus											
Shrub	red-flowering currant											
Shrub	red-osier dogwood											
Shrub	salal											
Shrub	salmonberry											
Shrub	serviceberry; juneberry											
Shrub	snowberry											
Shrub	snowbrush; sticky laurel											
Shrub	spiraea; hardhack											
Shrub	stink currant											
Shrub	subalpine spirea											
Shrub	swamp rose; clustered wild rose											
Shrub	sweet gale											
Shrub	tall Oregon grape											
Shrub	thimbleberry											
Shrub	twinberry											

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Shrub	white spitea; shiny-leaved spirea											
Groundcover	beach strawberry											
Groundcover	bleeding heart											
Groundcover	blue-eyed grass											
Groundcover	bracken fern											
Groundcover	broad-leaved stonecrop											
Groundcover	bunchberry											
Groundcover	camas, common											
Groundcover	camas, great											
Groundcover	Cascade penstemon											
Groundcover	chocolate lily											
Groundcover	coastal gumweed											
Groundcover	columbia lewisia											
Groundcover	common harebell											
Groundcover	Cooley's hedge nettle											
Groundcover	cow-parsnip									-		
Groundcover	deer ferm											
Groundcover	Douglas aster											
Groundcover	edible thistle											
Groundcover	false lily-of-the-valley											
Groundcover	false Solomon's-seal											
Groundcover	farewell-to-spring											
Groundcover	fireweed											
Groundcover	foam flower											
Groundcover	fringecup											
Groundcover	goat's beard											
Groundcover	golden eyed grass											
Groundcover	goldenrod											
Groundcover	graceful cinquefoil											
Groundcover	Hendersons checker mallow											
Groundcover	inside-out flower											
Groundcover	kinnikinnik; bearberry											
Groundcover	kneeling angelica											
Groundcover	lady fern											
Groundcover	licorice fern											

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Groundcover	maidenhair fern											
Groundcover	nettle											
Groundcover	nodding onion											
Groundcover	oak fern											
Groundcover	Oregon iris											
Groundcover	oxalis; wood sorrel											
Groundcover	Pacific waterleaf											
Groundcover	palmate coltsfoot											
Groundcover	pearly everlasting											
Groundcover	piggyback plant; youth-on-age											
Groundcover	rattlesnake plantain											
Groundcover	Scouler's corydalis											
Groundcover	sea-watch											
Groundcover	showy fleabane											
Groundcover	silverweed											
Groundcover	small flowered alumroot											
Groundcover	spreading stonecrop											
Groundcover	star-flowered false Solomon's-seal											
Groundcover	stream violet											
Groundcover	swamp lantern; skunk cabbage											
Groundcover	sword fern											
Groundcover	taper-tip onion; Hooker's onion											
Groundcover	thrift; sea pink											
Groundcover	trailing snowberry											
Groundcover	trillium											
Groundcover	twinflower											
Groundcover	vanilla leaf											
Groundcover	wapato; arrowhead											
Groundcover	Western columbine											
Groundcover	Western starflower; Indian potato											
Groundcover	wild ginger											
Groundcover	wild strawberry											
Groundcover	woodland strawberry											
Groundcover	yarrow											
Groundcover	yellow monkey-flower											

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Grass-like	cattail											
Grass-like	dagger-leaved rush											
Grass-like	Dewey's sedge											
Grass-like	dunegrass											
Grass-like	hardstem bulrush											
Grass-like	Idaho fecue											
Grass-like	Lyngbye's sedge											
Grass-like	slough sedge											
Grass-like	small-fruited bulrush											
Grass-like	thick headed sedge											
Grass-like	tufted hairgrass											
Vine	blackberry, trailing											
Vine	hairy honeysuckle											
Vine	orange honeysuckle											

Denotes the plant being in bloom for the corresponding month.
Denotes the plant not being in bloom for the corresponding month.
Denotes plants that do not have a bloom season as they do not produce blooms.

Bloom information was found using The University of Texas at Austin plant database the Lady Bird Johnson Wildflower Center (https://www.wildflower.org/plants/combo.php?fromsearch=true&distribution=WA&habit=&duration=&moist_moist=1)

Appendix F

SU Campus Bee Monitoring Data Sheets

This appendix consists of the SU Bee Monitoring Data Sheets used in 2021, which were derived from CCUWBee (Attebery, 2019).

Blank SU Campus Bee Monitoring Data Sheets can be accessed by clicking here, or by going to: https://1drv.ms/b/s!AhJXdJ0MImngds1gRQZLPkHxGnE?e=LbvbO4

Seattle University Campus Native Bee Study
Resource: CCUWBee Monitoring Datasheet for Campus Bees

Site Details

Date: _____ Plant species: _____

Surveyor names: _____

Site Conditions

Temperature: _____°F Wind (circle one): calm / gentle breeze / breezy Speed: _____ mph

Sky (circle one): clear / cloudy / overcast / sunny/ rainy Observation Start Time: _____

Monitoring

Pick a species of plant to survey, focus on a 1.5 meter square area for each survey. Set timer to 10 minutes and hit start when ready. Note any bees that you see and identify to your confidence level. Repeat the surveys 3 times within 40 minutes (abundance and diversity). Use the remaining 20 minutes (or more) take photos of pollinators using the plant species of focus.

FLORAL VISITOR GROUPS:

Honey bee (HB)	Bumble bee (BB)	Metallic green bee (MGB)
Tiny dark bee (TDB)	Chap leg bee (CLB)	Striped hairy belly bee (SHBB)
Medium dark bee (MDB)	Metallic hairy belly bee (MHBB)	

OBSERVATIONS:

Survey #1		
Location:		
Observations	Bee Group/Species	Abundance
1		
2		
3		
4		
5		

Adapted from: Minnerath, A., Vaughan, M., Lee-Mader, E. (2016). Maritime Northwest citizen science monitoring guide: Native bees and butterflies. The Xerces Society for Invertebrate Conservation, Portland, Oregon. Updated March 13, 2018

Seattle University Campus Native Bee Study
CCUWBee Monitoring Datasheet for Campus Bees

Survey #2		
Location:		
Observations	Bee Group/Species	Abundance
1		
2		
3		
4		
5		

Survey #3		
Location:		
Observations	Bee Group/Species	Abundance
1		
2		
3		
4		
5		

Special Notes:

Adapted from: Minnerath, A., Vaughan, M., Lee-Mader, E. (2016). Maritime Northwest citizen science monitoring guide: Native bees and butterflies. The Xerces Society for Invertebrate Conservation, Portland, Oregon. Updated March 13, 2018

Seattle University Campus Native Bee Study
Resource: CCUWBee Monitoring Datasheet for Campus Bees

Appendix G

SU Bee Survey

This appendix consists of raw data for the 2022 SU bee survey results, followed by the survey that was administered and the flier used to advertise the survey. 166 submissions were used for questions (Q's) 1-11, while 148 submissions were used for questions 12-14 as 18 participants stoped the survey once reaching the infographic.

Q1: What is your major/degree?

Q2: How do you feel about bees?
(1 - extremely bad, 5 - extremely good)

Min	1
Max	5
Median	5
Averge	5

Q3: All bees are black and yellow.

False	140
True	26

Q4: All bees sting.

False	154
True	12

Q5: Do all bees live in colonies?

No	61
Yes	105

Q6: Do all bees produce honey?

No	144
Yes	22

Q7: How important do you think bees are?
(0 - not at all important, 100 - extremely important)

Min	70
Max	100
Median	100
Average	96

Q8: Is the honey bee native to North America?

Yes	71
No	95

Q9: Where do most North American bees live?

Underground burrows	75
Hives	77
Bushes	14

Q10: Is the current native bee population in North America increasing, decreasing, or remaining the same?

Increasing	2
Decreasing	162
Remaining the same	2

Q11: Are native bees more important than non-native bees?
(0 - definitely not, 100 - definitely yes)

Min	8
Max	100
Median	80
Average	77

Infographic

Q12: After learning about native bees, how do you feel about them?
(1 - extremely bad, 5 - extremely good)

Min	1
Max	5
Median	5
Average	5

Q13: Will you use any of the strategies mentioned to help save native bees?
(0 - definitely not, 100 - definitely yes)

Min	3
Max	100
Median	90
Average	83

Q14: After learning about native bees, how important do you find them?
(0 - not at all important, 100 - extremely important)

Min	5
Max	100
Median	100
Average	96

Native Bee Survey

You are being invited to participate in a study about native bees! This study is being done as part of a CEJS Fellowship research project. The purpose of this research is to provide a baseline about SU students and faculty understanding of native bees, to spread public awareness about native bees, and to test how awareness might influence future behaviors. By partaking in the survey, you agree and understand that you will be a part of the native bee study, that you are an SU member, and that you will provide your major/degree. This survey is anonymous and completely voluntary, and no identifying information will be collected.

What is your major/degree?

How do you feel about bees?

All bees are black and yellow.

True

False

All bees sting.

True

False

Do all bees live in colonies?

Yes

No

Do all bees produce honey?

Yes

No

How important do you think bees are?

***for best viewing on a moblie device, turn to landscape orientation.**

Not at all important 0 10 | Slightly important 20 30 | Moderately important 40 50 60 | Very important 70 80 | Extremely important 90 100

Importance

Is the honeybee native to North America?

Yes

No

Where do most North American native bees live?

hives

underground burrows

bushes

Is the current native bee population in North America increasing, declining, or remaining the same?

increasing

remaining the same

decreasing

Are native bees more important than non-native bees?

*for best viewing on a moblie device, turn to landscape orientation.

Definitely not — Probably not — Might or might not — Probably yes — Definitely yes

0 10 20 30 40 50 60 70 80 90 100

Native bees are more important.

Native Bees

To North America

WHAT IS A NATIVE BEE?

A native bee is any bee that occurs naturally in the region and was not brought over from another area. **Native bees are two to three times better pollinators than honeybees.**

Fun Fact: Did you know that a honey bee is NOT native to North America? The honey bee is actually native to Europe and is one of the few bees that produces honey and lives in a colony.

WHERE DO THEY LIVE?

Around 70% of native bees live in underground burrows and nearly all of them are solitary bees, meaning they do not live in colonies and prefer to live alone. Others live in hollow trees and hollow plant stems.

WHY ARE THEY IMPORTANT?

HELP FIGHT CLIMATE CHANGE

Native bees are one of the most effective pollinators that helps keep plants alive and thriving. Plants in return:

- absorb CO2
- prevent soil erosion
- keep waterways clean

SUPPLY FOOD

About 1/3 of the food we eat is pollinator dependent.

- Without bees over 100 crops would disappear such as: apples, avocados, cherries, almonds, etc.

MAINTAINS DIVERSITY

Some native plants can only be pollinated by native bees. Without native bees we would lose diversity of our native plants which can effect entire ecosystems.

HOW ARE NATIVE BEES DOING?

- 9 species of bee are critically endangered
- 18 species are endangered
- 16 species are at risk of becoming endangered

More than **HALF** of native bees are declining, and nearly 1 in 4 native bee species is at increasing risk of extinction.

BEE BETTER CERTIFIED

XERCES SOCIETY

WHAT CAN WE DO?

Buy organic foods when possible and look for foods with the Bee Better Certified sticker on them. These stickers indicate that the food is being grown in a sustainable way that protects bees and other vital pollinators. This sticker can be found on blueberry and cherries from CalGiant, Rainier Fruit, and Homegrown Organic producers. It can even be found on Haagen-Dazs products (the ice cream company.)

OTHER WAYS TO HELP

- **Avoid using pesticides**
  Instead use organic alternatives for unwanted pests, such as neem oil, Organocide® Bee Safe 3-in-1 Garden Spray, or the Mighty Mint®.
- **Provide water.**
  Simply fill a shallow dish with water and some marbles or small pebbles, this will create a safe drinking location for the bees to rest.
- **Grow native plants**
  Anytime you are getting ready to garden or landscape check what plants are native to your area, these provide native bees with plentiful food supplies.
- **Provide housing.**
  This can be as simple as leaving a dirt patch undisturbed in the yard or leaving hollow plant stems outside.

After learning about native bees, how do you feel about them?

Will you use any of strategies mentioned to help save native bees?

***for best viewing on a moblie device, turn to landscape orientation.**

Definitely not		Probably not		Might or might not			Probably yes			Definitely yes
0	10	20	30	40	50	60	70	80	90	100

Using strategies

After learning about native bees, how important do you find them?

***for best viewing on a moblie device, turn to landscape orientation.**

Not at all important		Slightly important		Moderately important			Very important			Extremely important
0	10	20	30	40	50	60	70	80	90	100

Importance

NATIVE BEES

WHAT DO YOU KNOW?

TAKE THE SURVEY

Find out and become apart of a CEJS fellowship research project! Help provide a base line about SU student and faculty understanding of native bees, spread public awareness about native bees, and test how awareness might influence future behaviors.

Now-March 1st 2022

Questions? Contact kniffenbrean@seattleu.edu

Affiliation: Center for Enviromental Justice & Sustainability (CEJS)

Appendix H

General Examplory Bee-Friendly Educational Campus Signage

This appendix consists of an Exemplary Bee-Friendly Educational Campus Signage which can be customized to individual campus's needs. No permission is required for the usage or editing of the signage.

The template version of the Exemplary Bee-Friendly Educational Campus Signage can be accessed by clicking here (a Canva account is required for access, but is free to open), or go to: https://www.canva.com/design/DAE-L2FEBT4/gUUtEbjuXqLTeXSNq_42rQ/view?utm_content=DAE-L2FEBT4&utm_campaign=designshare&utm_medium=link&utm_source=publishsharelink&mode=preview

For a preview of the template click here, or go to: https://www.canva.com/design/DAE-L2FEBT4/gUUtEbjuXqLTeXSNq_42rQ/view?mode=prototype

BEE-FRIENDLY CAMPUS

Our campus provides habitat, foraging, and nesting resources to native bees.

4,000 native bee species line in **North America**

About **70%** nest in the ground & most are solitary

Fun Fact

Did you know the honey bee is NOT native to the Americas? The honey was introduced to the Americas by European settlers and has since become problematic for native bees. Native bees are also 2-3X better pollinators compared to honey bees.

Our campus has planted an array of native plants ensuring that there is always something in bloom from March to November, ensuring that the bees always have a food source available to them.

Golden Ticksood
Feb. – Nov.

Blue Elderberry
Mar. – Sep.

Spotted Joe-pye Weed
Aug. – Oct.

Bee Balm
Apr. – Oct.

Slender Yellow Wood Sorrel
May. – Nov.

TALK TO US
(04) 298 5985 2092
+76 209 1092 4095
campus.edu

We can make it all better again, together.
GET INVOLVED BY VISITING CAMPUSBEES.EDU

Appendix I

SU Bannan Garden Suggested Signage

This appendix consists of the SU Bannan Garden Suggested Signage I designed specifically for the University's Bannan roof.

A preview of the SU Bannan Garden Suggested Signage can be accessed by clicking here, or by going to: https://www.canva.com/design/DAE-GRiMycg/TfYgMTCnUGMNRMdIXnhbSw/view?mode=prototype

For editing access please contact SU's CEJS department.

BANNAN NATIVE BEES GARDEN

Providing Habitat, Foraging, and Nesting Resorces

ABOUT THE GARDEN

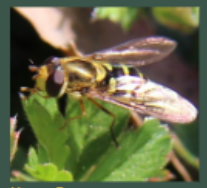
The Bannan Native Bees Garden is a pollinator sactuary providing a full season of blooms from March to November, ensuring there is always a food source for the entirety of active bee season. Seatttle University actively monitors the abundance and diversity of bees on campus and uses the garden as a means for native bee conservation and monitoring opportunities. Nesting resources are provided via undisturbed areas of soil, plants, and manmade built structures. The plants in the garden are all native to the PNW area and many of them have stems filled with pith - a soft sponge plant tissue, providing nesting resources to native bees.

IMPORTANCE OF NATIVE BEES

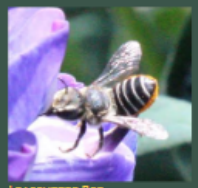
In almost all crops, native bees are the primary pollinator. Native bees are also 2-3X better pollinators than honey bees! When more pollen in spread, more crops grow and crops can increase in size and weight. Native bees alone, pollinate almost 80% of all flowing plants globally! That's more than 130 types of crops! This means that 1 out of every 4 bites of food people eat depends on bees! Bees also help fight climate change by supporting supporting plant health and helping to produce more plants. However, nearly 25% of bee species are at risk of extinction and many are already on the brink. (United States Geological Survey)

POLLINATORS AT WORK

Can you idenfity any of these pollinators in the garden?



HOVER FLY
Syrphus



LEAFCUTTER BEE
Megachile

BUMBLE BEE
Bombus

GREEN SWEAT BEE
Agapostemon

TINY DARK BEE
Panurginus

CARPENTER BEE
Xylocopa

HOW YOU CAN HELP

PLANT NATIVE PLANTS
Native bees have evolved to feed on native plants. Plant a large variety to support a large variety of pollinators.

FULL SEASON OF BLOOM
Select plants with overlapping blooming periods from March to November. This provides pollen and nectar throughout the growing season.

PROVIDE WATER
Provide a shallow dish of water such as a frisbee with marbles in it.

PROVIDE NESTING RESOURCES
This can be as simple as leaving a dirt patch undisturbed in the yard or leaving plant stem clippings in the yard.

AVOID PESTICIDES
Instead, use organic alternatives for unwanted pests, such as neem oil, Organocide® Bee Safe 3-in-1 Garden Spray, or the Mighty Mint®.

BEE BETTER CERTIFIED
XERCES SOCIETY

BUY BEE-FRIENDLY FOODS
Buy organic foods when possible and look for foods, such as cherries, blueberries, and even Haagen-Dazs® ice cream, with the Bee Better Certification.

FUN FACT

Did you know the honey bee is NOT native to the Americas? The honey was introduced to the Americas by European settlers and has since become problematic for native bees. Honey bees transmit diseases to native bees and competefor the same food sources.

WHERE DO THEY LIVE

North America is home to around 4,000 native bee species. Of those 4,000 species about 70% nest in the ground and are solitary, meaning they do not live in colonies. Many solitary bees also nest in the stems of branches which they hollow out.

NATIVE PLANT FINDER

For help finding native plants and their blooming periods in your area scan the barcode. Or visit green2.kingcounty.gov to find plants native to the King County area.

Appendix J

Native Plant Suggestions for the SU Bannan Green Roof Renovation

This appendix consists of the native plant suggestions I have compiled for SU to use as a reference in the Bannan Green Roof Renovation project which entails the future installment of a garden.

The SU Native Plant Suggestions list can be accessed by clicking here, or by going to: https://1drv.ms/b/s!AhJXdJ0MImngepe5fc0JeD_1MQA?e=yGnWqm

2021-2022 BANNAN GARDEN ROOF RENOVATION

Native Plant Suggestions

All native plant suggestions consider and focus on the Bannan Garden Roof Renovation Concept layouts, including the plant's growing capacity, the edible campus project, the plant's bloom season, and ability to provide native bee nesting and foraging resources.

Date: 2/18/2022

By: Breann Kniffen

Seattle University 901 12th Ave, Seattle, WA 98122

Table of Contents

GROUND COVER

Figure 1. Edible Thistle (Brown 2019)

Edible Thistle (Cirsium edule)

Duration: biennial

Height: 5 ft

Moisture Requirements: moist

Exposure Requirements: part shade – sun

Bloom Season: Jun – Oct

Bloom Color: white, pink, purple

Description: provides native bee nesting, herb

Figure 2. Golden Tickseed (Tuason 2013)

Golden Tickseed
(Coreopsis tinctoria var. tinctoria)

Duration: annual

Height: 1 – 3 ft

Moisture Requirements: moist

Exposure Requirements: part shade – sun

Bloom Season: Feb – Nov

Bloom Color: Yellow, Brown

Description: herb

GROUND COVER

Goldenrod (Solidago canadensis)

Duration: perennial

Height: 3 - 6 ft

Moisture Requirements: dry – moist

Exposure Requirements: part shade – sun

Bloom Season: Sep – Nov

Bloom Color: Yellow

Description: herb, provides nectar for bees and butterflies, edible

Figure 3. Goldenrod (Barnes and U.S. Fish and Wildlife Service 2013)

Pearly-everlasting (Anaphalis margaritacea)

Duration: perennial

Height: 1 - 3 ft

Moisture Requirements: dry

Exposure Requirements: part shade – sun

Bloom Season: Jun – Oct

Bloom Color: Yellow, White

Description: herb, attracts butterflies, used in medicinal medicine

Figure 4. Pearly-everlasting (Krzysztof Ziarnek 2016)

GROUND COVER

Figure 5. Shrubby Cinquefoil (Xaver 1997)

Shrubby Cinquefoil (Dasiphora fruticosa)

Duration: perennial

Height: 2 - 4 ft

Moisture Requirements: dry – moist

Exposure Requirements: part shade – sun

Bloom Season: Jun – Nov

Bloom Color: Yellow

Description: shrub, attracts butterflies, young shoots and leaves are edible

Figure 6. Sideoats Grama (Erutuon 2081)

Sideoats Grama (Bouteloua curtipendula)

Duration: perennial

Height: 1 – 3 ft

Moisture Requirements: dry – moist

Exposure Requirements: part shade – sun

Bloom Season: Jun – Nov

Bloom Color: Red, Orange, Yellow

Description: attracts birds and butterflies, deer resistant, cold tolerant, heat tolerant, drought tolerant

GROUND COVER

Figure 7. Silver Bur Ragweed (Eric 2009)

Silver Bur Ragweed
(Ambrosia chamissonis)

Duration: perennial

Height: 5 – 10 ft

Moisture Requirements: NA

Exposure Requirements: sun

Bloom Season: Apr – Nov

Bloom Color: White, Yellow, Green

Description: edible, produces cypsela fruit

Figure 8. Slender Yellow Wood Sorrel (R 2020)

Slender Yellow Wood Sorrel
(Oxalis dillenii)

Duration: perennial

Height: 0 – 1 ft

Moisture Requirements: dry – moist

Exposure Requirements: part shade – sun

Bloom Season: May – Nov

Bloom Color: Yellow

Description: typically found in fields, edible

GROUND COVER

Western Showy Aster (Eurybia conspicua)

Duration: perennial

Height: 1 – 3 ft

Moisture Requirements: moist

Exposure Requirements: part shade – sun

Bloom Season: Jun – Nov

Bloom Color: yellow, blue, violet

Description: edible

Figure 9. Western Showy Aster (Xaver 2008)

White Sand Verbena (Abronia mellifera)

Duration: perennial

Height: 0 – 3 ft

Moisture Requirements: dry – moist

Exposure Requirements: part shade – sun

Bloom Season: Mar – Nov

Bloom Color: white, pink, green

Description: edible fruit and roots

Figure 10. White Sand Verbena (Lavin 2010)

GROUND COVER

Figure 11. Wild Strawberry (Hempel 2015)

Wild Strawberry (*Fragaria virginiana*)

Duration: perennial

Height: 0 - 1 ft

Moisture Requirements: dry - moist

Exposure Requirements: part shade – shade

Bloom Season: April - June

Bloom Color: White

Description: perennial groundcover, edible berries, creeping or trailing, fire-resistant, spreading

Figure 12. Woodland Strawberry (Schnobby 2011)

Woodland Strawberry (Fragaria vesca)

Duration: perennial

Height: 1 ft

Moisture Requirements: dry-moist

Exposure Requirements: part shade – shade

Bloom Season: April – June

Bloom Color: white

Description: perennial groundcover, edible berries, creeping or trailing, fire-resistant, spreading

GROUND COVER

Figure 13. Kinnikinnik (Blanc 2013)

Kinnikinnik; Bearberry (Arctostaphylos uva-ursi)

Duration: perennial

Height: 1 ft

Moisture Requirements: dry

Exposure Requirements: sun - part shade

Bloom Season: April – May

Bloom Color: white, pink

Description: evergreen groundcover, drought tolerant, creeping or trailing, fire-resistant

Figure 14. Showy Fleabane (Korzun 2012)

Showy Fleabane (Erigeron speciosus)

Duration: perennial

Height: 2 ft

Moisture Requirements: dry - moist

Exposure Requirements: sun - part shade

Bloom Season: Jun – Oct

Bloom Color: white, yellow, blue, purple

Description: perennial groundcover

GROUND COVER

Figure 15. Yarrow (Bff 2012)

Yarrow (Achillea millefolium)

Duration: perennial

Height: 1 ft

Moisture Requirements: dry - moist

Exposure Requirements: sun - part shade

Bloom Season: Jul – Sep

Bloom Color: white, pink

Description: perennial groundcover, drought tolerant, spreading

Figure 16. Blackberry (Dominic 2015)

Blackberry, Trailing (Rubus ursinus)

Duration: perennial

Height: 3 – 6 ft

Moisture Requirements: dry - moist

Exposure Requirements: sun - shade

Bloom Season: Mar – Jul

Bloom Color: white, pink

Description: deciduous vine, edible berries, creeping or trailing, drought tolerant, spreading, vine-like ground cover

Figure 17. Taper-Tip Onion (Keck 2009)

Taper-Tip Onion; Hooker's Onion
(Allium acuminatum)

Duration: perennial

Height: 1 ft

Moisture Requirements: dry

Exposure Requirements: sun - part shade

Bloom Season: May – Jul

Bloom Color: pink, purple

Description: perennial groundcover, drought tolerant

SHRUBS

Figure 18. Blue Elderberry (Richardson 2013)

Blue Elderberry (Sambucus nigra ssp. Cerulea)

Duration: perennial

Height: 23 ft

Moisture Requirements: moist

Exposure Requirements: sun – part shade

Bloom Season: Mar – Sep

Bloom Color: white

Description: deciduous shrub, edible berries

Figure 19. Trailing Black Currant (Flogaus-Faust 2006b)

Trailing Black Currant (Ribes laxiflorum)

Duration: perennial

Height: 3 – 6 ft

Moisture Requirements: moist – wet

Exposure Requirements: sun – shade

Bloom Season: Apr – Jul

Bloom Color: white, red, pink, green, purple

Description: edible berries, attracts birds

SHRUBS

Figure 20. Bog Laurel (Odland 2018)

Bog Laurel (Kalmia microphylla)

Duration: perennial

Height: 3 ft

Moisture Requirements: wet

Exposure Requirements: sun - part shade

Bloom Season: April – May

Bloom Color: purple

Description: evergreen shrub

Figure 21. Evergreen Huckleberry (Kaldari 2018)

Evergreen Huckleberry (Vaccinium ovatum)

Duration: perennial

Height: 6 ft

Moisture Requirements: dry - moist

Exposure Requirements: part shade - shade

Bloom Season: Mar – May

Bloom Color: pink

Description: evergreen shrub, edible berries, fire-resistant, spreading

SHRUBS

Black Cap Raspberry (Rubus leucodermis)

Duration: perennial

Height: 7 ft

Moisture Requirements: dry - wet

Exposure Requirements: sun - shade

Bloom Season: Apr – May

Bloom Color: white, pink

Description: perennial shrub, edible berries, helps eliminate invasive blackberries, thorns

Figure 22. Black Cap Raspberry (Aleazrocha 2016)

Black Gooseberry (Ribes lacustre)

Duration: perennial

Height: 5 ft

Moisture Requirements: moist – wet

Exposure Requirements: sun – shade

Bloom Season: May – Jun

Bloom Color: pink, yellow, green, brown

Description: deciduous shrub, edible berries, thorns, fire-resistant

Figure 23. Black Gooseberry (Siegmund 2007)

SHRUBS

Highbush Cranberry; Mooseberry (Viburnum edule)

Duration: perennial

Height: 12 ft

Moisture Requirements: moist – wet

Exposure Requirements: sun - part shade

Bloom Season: May – Jun

Bloom Color: white

Description: deciduous shrub, edible berries, fire-resistant

Figure 24. Highbush Cranberry (Chapman 2009)

Indian Plum; Osoberry (Oemlaria cerasiformis)

Duration: perennial

Height: 15 ft

Moisture Requirements: dry – moist

Exposure Requirements: part shade – shade

Bloom Season: Mar

Bloom Color: white, green, brown

Description: deciduous shrub, edible berries, fire-resistant, spreading

Figure 25. Indian Plum (Rusk 2016)

SHRUBS

Figure 26. Low Oregon Grape (DHochmayr 2008)

Low Oregon Grape (Mahonia nervosa)

Duration: perennial

Height: 3 ft

Moisture Requirements: dry – moist

Exposure Requirements: part shade – shade

Bloom Season: Apr – Jun

Bloom Color: yellow

Description: evergreen shrub, edible berries, fire-resistant, spreading, thorns

Figure 27. Red Huckleberry (Schutzenhaus 2011)

Red Huckleberry (Vaccinium parvifolium)

Duration: perennial

Height: 10 ft

Moisture Requirements: dry – moist

Exposure Requirements: part shade – shade

Bloom Season: May – Jun

Bloom Color: white pink, green

Description: deciduous shrub, edible berries, spreading, fire-resistant

SHRUBS

Figure 28. Salal (Dwyer 2010)

Salal (Gaultheria shallon)

Duration: perennial

Height: 5 ft

Moisture Requirements: dry – moist

Exposure Requirements: part shade – shade

Bloom Season: Apr – Jul

Bloom Color: white, pink

Description: evergreen shrub, edible berries, drought tolerant, spreading

Figure 29. Salmonberry (Olympic National Park 2004)

Salmonberry (Rubus spectabilis)

Duration: perennial

Height: 10 ft

Moisture Requirements: moist – wet

Exposure Requirements: sun – shade

Bloom Season: Mar – Jun

Bloom Color: red, pink, purple

Description: deciduous shrub, edible berries, fire-resistant, spreading, thorns

SHRUBS

Figure 30. Snowberry (Zell 2009)

Snowberry (Symphoricarpos albus)

Duration: perennial

Height: 5 ft

Moisture Requirements: dry – moist

Exposure Requirements: sun – shade

Bloom Season: Jun – Jul

Bloom Color: white, pink

Description: deciduous shrub, edible berries, drought tolerant, fire-resistant, spreading

Figure 31. Tall Oregon Grape (Dguendel 2011)

Tall Oregon Grape (Mahonia aquifolium)

Duration: perennial

Height: 8 ft

Moisture Requirements: dry – wet

Exposure Requirements: sun – shade

Bloom Season: Mar – May

Bloom Color: yellow

Description: evergreen shrub, edible berries, fire-resistant, spreading, thorns, drought tolerant

SHRUBS

Thimbleberry (Rubus parviflorus)

Duration: perennial

Height: 8 ft

Moisture Requirements: dry – moist

Exposure Requirements: sun – shade

Bloom Season: May – Aug

Bloom Color: white

Description: deciduous shrub, edible berries, spreading, drought tolerant

Figure 32. Thimbleberry (Annie 2020)

Twinberry (Lonicera involucrate)

Duration: perennial

Height: 3 – 6 ft

Moisture Requirements: moist – wet

Exposure Requirements: sun – shade

Bloom Season: Mar – Aug

Bloom Color: red, orange, yellow

Description: deciduous shrub, edible berries, fire-resistant

Figure 33. Twinberry (Flogaus-Faust 2006

TREES

Figure 34. Pacific Dogwood (Shebs 2007)

Pacific Dogwood (Cornus nuttallii)

Duration: perennial

Height: 60 ft

Moisture Requirements: dry – moist

Exposure Requirements: part shade

Bloom Season: Apr – Jul

Bloom Color: white, pink

Description: deciduous tree, drought tolerant

Figure 35. Serviceberry (Tuason 2011)

Serviceberry; Juneberry (Amelanchier alnifolia)

Duration: perennial

Height: 20 ft

Moisture Requirements: dry – moist

Exposure Requirements: sun – shade

Bloom Season: Apr – Jun

Bloom Color: white

Description: deciduous shrub, edible berries, drought tolerant

Plant information was derived from Lady Bird Johnson Wildlife Center Plant Database.