Green Teacher

Friends of the Earth
Les Ami(e)s de la Terre

Bees and Pollinators Learning Package

By Green Teacher and Friends of the Earth Canada, Summer 2022





In Summer 2022, Green Teacher and Friends of the Earth Canada collaborated on a special themed issue (# 132) of Green Teacher magazine dedicated to wild native bees. This comprehensive learning package collects the six articles (all of which appeared in the magazine) and six educational activities from that project. We hope that these resources help you and your learners as you explore the lives of these important, beautiful, and fascinating pollinators. Enjoy!

Why Wild Native Bees Matter

An overview of bees' importance to biodiversity and food crops

Christine Hanrahan, Fletcher Wildlife Garden

Leafcutter bee – *Megachile*

By **Beatrice Olivastri**

FRIENDS OF THE EARTH IS grateful for the opportunity to work with Green Teacher to highlight the importance of wild native bees to biodiversity and to food security. Worldwide, bees include some 20,000 described species. Wild bees are key to the sexual reproduction of hundreds of thousands of wild plants and also to the yield of about 85% of food crops. Before the Honey bee was introduced from Europe in 1622, there were over 4,000 native bees in North America. While many of the "saving the bee" campaigns focus on the Honey bee, many wild native bees are more efficient crop pollinators than the non-native Honey bee.

In this article, we look at native bees and crops they pollinate in North America and the threats they face. But first, we consider the critical need to reposition insects from "pests" to be eradicated to essential members of a hugely intricate and intimate community that constitutes biodiversity. When the first wild animal a child encounters is likely to be an insect in their immediate surroundings, is s/he likely to learn about dangerous pests or vital members of a community essential to biodiversity?

Most conservation efforts have historically focused attention on protecting rare, charismatic, and endangered species, but the "insect apocalypse" repositions insects as integral to ecosystem functioning.

In 2017, Germany's Krefeld Entomological Society reported on steep unexplained reductions of flying insects at more than 60 sites at nature preserves followed by a peer-reviewed report that documented a drop in flying insect biomass by 76%. This work triggered the media to designate the declines as the "insect apocalypse".

Insects comprise much of the animal biomass linking primary producers (plants) and consumers (animals), as well as higher-level consumers in freshwater and terrestrial (land-based) food webs. Scientists describe insects as situated at the "nexus of the many trophic links" with the more

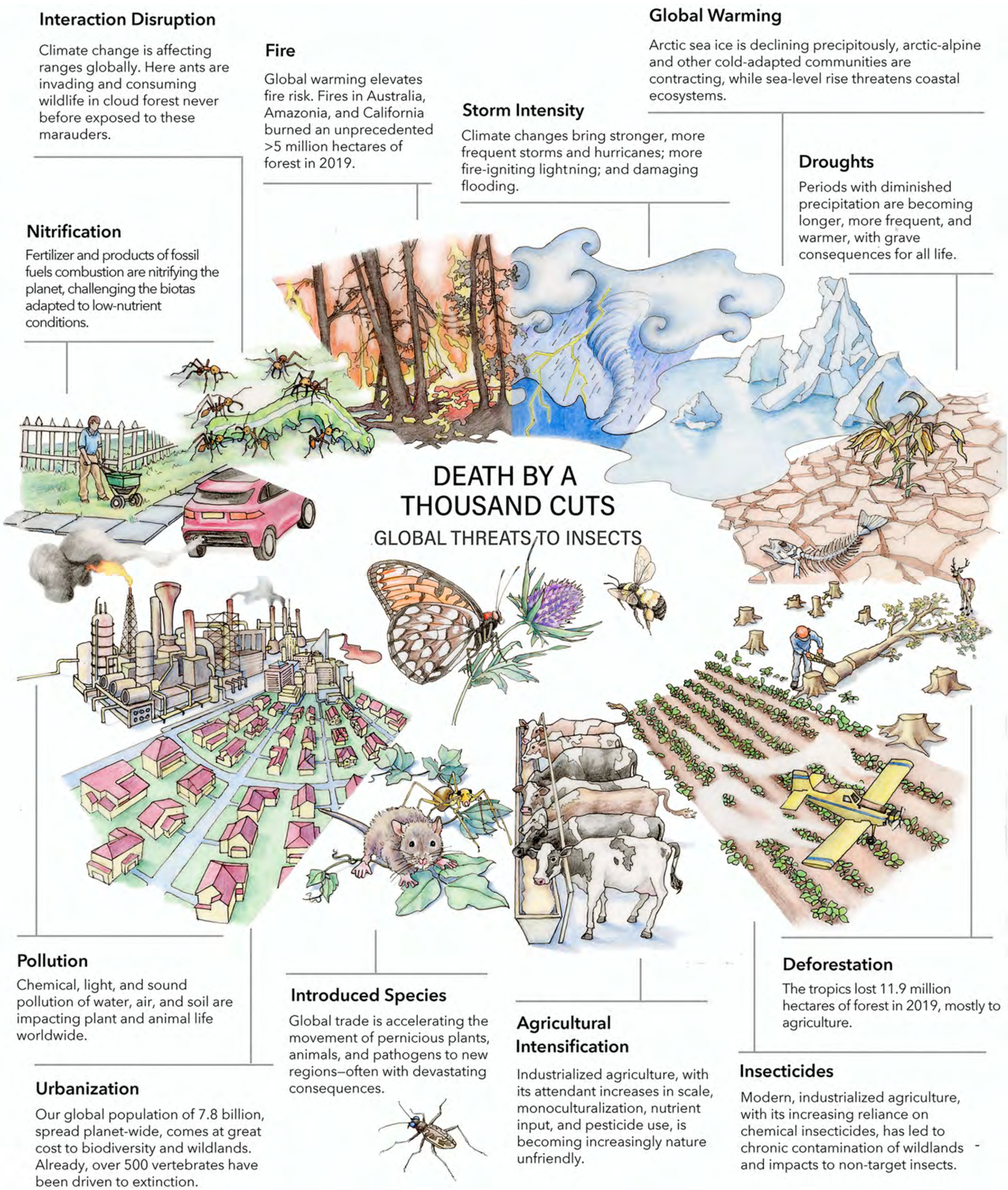


Fig. 1. Death by a thousand cuts: Global threats to insect diversity. Stressors from 10 o'clock to 3 o'clock anchor to climate change. Featured insects: Regal fritillary (*Speyeria idalia*) (*Center*), rusty patched bumble bee (*Bombus affinis*) (*Center Right*), and Puritan tiger beetle (*Cicindela puritana*) (*Bottom*). Each is an imperiled insect that represents a larger lineage that includes many International Union for Conservation of Nature "red list" species (i.e., globally extinct, endangered, and threatened species). Illustration: Virginia R. Wagner (artist).

abundant insects providing ecosystem services upon which humans depend. These include pollination of fruits, vegetables, and nuts; the biological control of weeds, agricultural pests, disease vectors, and other organisms that compete with humans or threaten our quality of life; and the macro-decomposition of leaves and wood and removal of dung and carrion, which contribute to nutrient cycling, soil formation, and water purification.

Unprecedented downward declines in flying insects can be linked to many factors. In a compelling introduction to a of special issue of 11 papers examining insect decline from many perspectives, David Wagner et al. declare that "Nature is under siege" characterized by "death by a thousand cuts" as illustrated in Figure 1 (republished with permission).

Habitat degradation & pesticide exposure as threats to wild bees and food security

Even though wild bees provide pollination services to agricultural land, large fields of conventionally grown monocultures are very damaging to wild bees. The widespread use of pesticides in conventional farming has devastating effects on wild bee communities. The widespread conversion of natural habitats into agricultural landscapes has decreased the availability of adequate nesting sites and floral diversity for foraging. In particular, systemic pesticides such as neonicotinoids (neonics) can be applied as soil drenches or seed coatings and then persist in the soil, some for up to 1000 days.

For crops like pumpkins, squash, and gourds (called *Cucurbita* crops), losses of pollination services can be especially detrimental because these crops are entirely dependent on pollination by bees to set their fruit. One of most important wild pollinators of Cucurbita crops is the hoary squash bee, *(Eucera (Peponapis) pruinosa)* which is a cavity-nesting solitary bee. Because they nest in the ground, these and other solitary bees can suffer from exposure to neonicotinoids in their nests and show problems with homing ability, reproductive output, developmental delays and reduced adult size and longevity.

While all bees that forage on neonic-treated crops may be at risk from residues in pollen and nectar, those that are ground nesting have this additional exposure to long-lived residues in the soil. As many as three quarter of all wild bee species nest in the ground and spend much of their life cycle underground.

The US Department of Agriculture (USDA) developed a chart showing which bees are attracted to food crops. Originally designed to help determine which bees might be exposed to pesticides that the USDA needed to evaluate for market registration, the same information shows bumble bees and solitary bees associated with certain food crops. We expect the solitary bees are at additional risk from pesticides because they are ground nesting. Much more work is needed to assess residues of pesticides in soil and their impact on wild bees.

Please see the food charts on pages 4 and 5.

Honey bees are not native to North America, and many farmers import Honey bee queens and workers by the hundreds of thousands to pollinate their farms or produce honey. Others spend thousands of dollars renting hives of honeybees to aid in pollination. Honey bees provide effective pollination in agriculture, where large masses of land are planted with monocultures.

Honey bees outcompete wild native bees for floral resources such as pollen and nectar, due to their large foraging distance capability and the sheer number of bees that can inhabit one hive (up to 100,000 bees). Wild native bees typically have much smaller foraging distances (up to 2 km for robust bumble bees, but much less for other species). Wild native bee foraging has been shown to decrease in close proximity to a Honey bee hive.

In the last two decades, a great deal of research has assessed whether restoring native habitat and wild pollinators to farmland could make North America's food supply more sustainable. The answer seems to be maybe but not where pesticides are still being used.

In an early study of watermelon pollination in California, scientists monitored how frequently 30 different bee species visited a flower and how much pollen each bee deposited. They already knew that 1,000 grains of pollen were required to grow a single juicy watermelon. They found that growers on organic farms surrounded by wild plants could rely on wild native pollinators for watermelon pollination — no hired hives of honey bees were needed. In contrast, they found on conventional monoculture farms (typically with one single crop) that wild bees were ineffective and Honey bee hives were needed. The scientists concluded that "Continued degradation of the agro-natural landscape will destroy this "free" service, but conservation and restoration of bee habitat are potentially viable economic alternatives for reducing dependence on managed honey bees."

Fast forward 20 years and this lead scientist joined others to consider whether pollinator-attractive field border plantings (hedgerows and forb (herbs others than grasses) strips) can increase bee diversity and abundance in agricultural areas. Their findings demonstrated that pesticides reside in these plantings and the soil and can be detrimental to the very wild bees they're supposed to support — even when the plantings did not receive direct application of pesticides. The research findings suggest that adding pollinator-attractive field border plantings may be harmful for wild bees when pesticides are still in use in the fields and crops.

Climate change as a threat to wild native bees

Climate change is contributing to the decline of wild native bees. Particularly vulnerable are bumble bees and other species of large-bodied bees, as bigger bees have less heat tolerance.

Increasing frequency of hotter temperatures predicts species' local extinction risk, chances of colonizing a new area, and changing species richness. These effects have been found to be independent of changing land uses or habitat loss, meaning climate change presents a serious risk to wild native bees. A team of researchers found that wild bees are more affected by climate change than by disturbances to their habitat, and that addressing land-use changes alone is not sufficient for protecting bees. They found that different bee species were most affected by different weather condi-

Excerpted from: ***Attractiveness of Agricultural Crops to Pollinating Bees for the Collection of Nectar and/or Pollen, USDA 2017***

x = attractive under certain conditions, xx = very attractive, - = not attractive

Crop	Honey bee pollen	Honey bee nectar	Bumble bees	Solitary bees	Requires bee pollination	Uses managed pollinators	Notes
Alfalfa	x	xx	x	xx Alfalfa leafcutting bee, Alkali bee	for seed production only	for seed production only	Only a small percentage of alfalfa is grown for seed; typically using managed alfalfa leafcutting bees, alkali bees or honey bees. Timing of hay or silage harvest, relative to bloom, varies by agronomic practice, with earlier cuts typically occurring prior to bloom and later cuts being harvested up to 25% bloom.112
Almond	xx	x	x	x Osmia	yes	yes	
Apple	xx	x	x	xx Andrena, Anthidium, Halictus, Osmia, Anthophora, Habropoda	yes	yes	
Apricots	xx	xx	xx	x Osmia	yes	yes	
Artichokes	x	x	x	x	yes	no	
Asparagus	x	x	data not available	data not available	for seed production only	for seed production only	Only a small % of asparagus acreage is grown for seed.
Blueberry	x	x	xx	xx Andrena, Colletes, Osmia, Anthophora, Xylocopa	yes	yes	Apis M. and Megachilidae used in commercial pollination.
Beans (dry, broad, horse)	xx	xx	xx	x Anthophora, Eucera, Megachile, Xylocopa	yes		
Blackberry	x	x	xx	xx	yes	yes	
Cabbage and other brassica	xx	xx	x	x	for seed production only	for seed production only	
Cauliflower and broccoli	xx	xx	x	x Andrenidae, Nomadidae, Megachilidae	for seed production only	for seed production only	
Cherries	xx	x	x	xx Osmia	yes	yes	
Cranberry	x	x	xx	xx Andrena, Agapostemon, Melitta, Megachile	yes	yes	

Cucumber and gherkins	x	x	x	x Melissodes, Andrena	yes	yes	
Currants	-	x	xx	x Anthophora	yes	no	
Gooseberry	-	x	xx	x	yes	no	Little production in the US
Grapefruit	xx	xx	x	data unavailable	yes	no	
Kiwi	x	x	x	x	yes	yes	
Legumes	xx	xx	xx	x Anthophora, Eucera, Megachile	yes	no	
Mustard seed	xx	xx	x	x	yes	no data available	*B. juncea* extensively grown on Great Plains and southern Canadian prairies; is 2/3 self fertile and 1/3 out crossing, so bees partially required
Peach, nectarine	x	x	x	x Osmia	yes	yes	
Pear	x	x	x	x Osmia, Andrena	yes	yes	
Plum, sloes	x	x	x	x Osmia, Anthophora	yes	yes	
Pumpkin, squash, gourd	x	x	xx	x Agapostemon, Melissodes, Peponapis	yes	yes	
Raspberry	x	x	xx	x Osmia, Anderna, Coletes, Halictus	yes	yes	
Strawberry	x	x	x	x Andrena, Halictids, Osmia	no	yes	Not essential, but some growers add supplemental hives to compliment wind pollination
Sunflower seed	xx	xx	xx	xx Halictus, Dieunomia, Megachile, Melissodes, Svastra, Xylocopa	yes	yes	
Tomato	-	-	x	x	yes	yes	May be grown in glasshouses where bumble bees are needed for pollination
Watermelon	x	x	x	x Agapostemon, Floridegus, Halictus, Hoplitus, Melissodes	yes	yes	

tions. For example, areas with more rain had fewer spring bees, showing that the rain limits the ability of spring bees to collect food for their offspring. Similarly, a very hot summer, which might reduce the number of flowering plants, was associated with fewer summer bees the next year. Warm winters led to reduced numbers of some bee species.

Climate change has had different effects on different bee species. Wild bee species that are adapted to hot southern climates may increase their native ranges, while larger species that are adapted to northern climates have declined as populations fail to move south. One study found that while some species have been able to shift in latitude or elevation in response to periods of rapid climate change, the majority of bumble bee species have failed to disperse beyond their northern range limits, while suffering losses at their southern range limits.

Climate change is responsible for changing timing of life cycles between bees and flowers. Elevation of the location seems to play a large role in when bees start foraging but also whether they're ground nesting or above ground can factor into when they emerge from overwintering. The most important factor was snowmelt timing. There could be a mismatch in timing between bees emerging and flowering plants reaching their flowering peak — resulting in limited pollination and fewer bees.

While we can hope that wild bees and plants may be able to adapt to each other's schedules, climate change requires individual and societal action to reduce greenhouse gas emissions in line with the Paris Accord. Time is running out for this turnaround.

The city as a refuge for wild native bees

There is less floral forage over shorter periods for pollinators with habitat loss from natural areas converting to farming, with the transition of traditional agriculture to monoculture commodity crops and with use of systemic pesticides and herbicides (neonicotinoids applied to seed, absorbed by plants, and circulated throughout). Urban land can offer safe habitat for wild native bees and other pollinators faced with the dangers of pesticides on monoculture fields. The city with yards, gardens, parks, and vacant lots can offer a wide range of locations for nesting and foraging for flowers. Scientists are excited about the potential for connecting bee gardens with species monitoring while learning more about the social and cultural drivers of wild bee diversity in green spaces in cities. For example, bee diversity in one city seems to be higher in low-income and low-population neighborhoods containing more vacant lots. Residential pesticide use is lower in low-income neighborhoods, raising the potential for pollinator conservation to improve local food security and community development.

Action to protect wild native bees starts with learning about them

To conclude, insects' decline in abundance and diversity is serious across the globe at the very time we, humans, are gaining a clearer understanding of how vital their role is. Insects, such as wild native bees, are one of the most easily accessible groups of wildlife, with so much to inspire life-long appreciation of nature — learning to identify the species, their life cycles, their behavior, as well as the negative impacts of modern agriculture, climate change, and habitat loss on their survival. Connecting the role of wild native bees to the food we grow in gardens as well as farmers' fields offers locally and globally relevant lessons for students, their families, and their communities.

Educators can play an important and unique role in moving students and parents away from "insect as enemy" toward insects as essential for pollination; for the food supply they constitute for countless other species such as bats, birds, and fish; and for the recycling of nutrients, to name just a few of insects' roles.

To embrace the mission of saving the wild native bees, there are a growing number of community-science initiatives to survey, raise awareness, and take action. Many scientists believe that, in the future, the richest sources of occurrence data for insects will come from community-science efforts reporting to iNaturalist but also specialized projects such as Bumble Bee Watch.

Should you join this mission to save wild native bees, we hope this special issue of Green Teacher gives you a great starting point.

The Lives of Wild Native Bees

What they do and where they do it

A primer on the pollination of flowering plants

Excerpted from *A Garden for the Rusty-Patched Bumblebee: Creating Habitat for Native Pollinators (Ontario and Great Lakes Edition)*,© Lorraine Johnson and Sheila Colla, illustrations © Ann Sanderson. Published 2022 by Douglas & McIntyre Ltd.

In order for many flowering plants to reproduce, pollen (the plant equivalent of sperm) must move from the male part to the female part of the flower. Some plants have the male and female parts within the same flower; some have separate male flowers and female flowers on the same plant; and some have male flowers and female flowers on separate plants entirely. Some can fertilize themselves, while others need another mate nearby for cross-pollination. Some plants that have both male and female flowers on the same plant have features that ensure cross-pollination (for example, the females are receptive to pollen only after the males have already released their pollen). In other words, there's lots of variation and specificity.

When fertilized, the female part produces fruits or nuts containing seeds, which, after dispersal, germinate to produce new plants.

Some plants (conifers and grasses, for example) are wind-pollinated — that is, the pollen moves from the male part to the female part by wind. The pollen-like structures in moss may be transferred in water. But most plants — approximately 75 per cent — have pollen that is transported by animal pollinators, including insects, hummingbirds, bats, and others.

Bees are the main pollinators of flowering plants in Canada and other temperate regions, though wasps, flies, beetles, hummingbirds, butterflies, and moths are also pollinators. The pollination "services" these insects provide is in fact a by-product of an entirely different intention. These insects are visiting flowers in order to feed on nectar and pollen (and/or to collect pollen) and, in the process of foraging, pollen sticks to their bodies and is transferred to other plants they visit. It is important to note that diverse wild bee communities are often more efficient and effective pollinators than non-native honeybees. As well, native bees exhibit a trait known as floral constancy, which means that they tend to repeatedly visit a particular species of plant on their individual foraging trips and hence, efficiently cross-pollinate that species.

Bees utilize a wider variety of plant species for nectar than they do for pollen. However, the physical traits of various bee species (the length of their mouthparts, for example) do affect their ability to extract nectar from certain flower shapes, such as deep flowers. Although some male bees feed on pollen, it is only the female bee that gathers pollen in order to take it back to provision her nest, where she lays her eggs and where the developing larvae will feed on the pollen. Many female bees have a "pollen basket" on their hind legs, abdomens, or stomachs in which they store pollen before transporting it back to the nest. If you watch bees closely, you'll be able to see, without need of a magnifying device, pollen grains on their bodies, giving them a colourful glow. Female bees mix pollen and nectar into a loaf called "bee bread," which the larval bees eat. While a particular bee species might depend on the pollen of a particular plant species, genus, or family, it doesn't necessarily mean that the plants themselves depend on that bee species for pollination. Other, generalist bee species (polylectic bees) — those that collect pollen from a broad range of species — can also pollinate the plant.

By **Beatrice Olivastri** and **Caitlin McCloskey**

IN SOME CASES, the use of pesticides has reduced or obliterated wild native bees and people must hand-pollinate plants. The classic example is in China. UK Professor Dave Goulson (https://profiles.sussex.ac.uk/p126217-dave-goulson) describes the situation:

Evidence from around the world points to falling and increasingly unpredictable yields of insect-pollinated crops, particularly in the areas with the most intensive farming. Where crops are grown in vast fields, there are not enough insects to go around. If insecticides are sprayed too frequently, then vital pollinators cannot survive.

The most dramatic example comes from the apple and pear orchards of southwest China, where wild bees have been eradicated by excessive pesticide use and a lack of natural habitat.

In recent years, farmers have been forced to hand-pollinate their trees, carrying pots of pollen and paintbrushes with which to individually pollinate every flower, and using their children to climb up to the highest blossoms. This is clearly just possible for this high-value crop, but there are not enough humans in the world to pollinate all of our crops by hand. (Reference: https://chinadialogue.net/en/food/5193-decline-of-bees-forces-china-s-apple-farmers-to-pollinate-by-hand/)

Bombus terricola

very short foraging ranges, so it is imperative to their survival that their nests are close to the plants they depend on.

Even plants that self-pollinate benefit from the presence of bees, as wild bee pollination has been shown to increase the yield of many fruit-bearing plants. (Reference: https://www.science.org/doi/abs/10.1126/science.1230200)

Where and how do wild bees live? (Bee nesting and sociality)

"Guilds" are a way of categorizing wild bee nesting behaviour. Approximately 70% of wild native bees are ground nesting, which means that they burrow tunnels in soil to create their nests. Different species have different preferences for soil type, ranging from loose and sandy soil to hard-packed earth. The size and shape of ground nests differ among bee species.

The remaining 30% of bees nest above ground, in pre-existing cavities in dead trees, pithy plants stems, or any other types of cavities (some species even use abandoned snail shells).

Some cavity-nesting bees excavate their own cavities in standing wood with their powerful mandibles. Others, such as bumble bees (*Bombus*) using pre-existing cavities such as rodent holes. Finally, some bees are cleptoparasitic, meaning they do not construct their own nests but instead lay eggs in active nests of other species

Scientists know very little about nesting sites and the way ground-nesting bees can be impacted from a wide range of activities, including the use of tillage in agricultural systems that can destroy shallow nests. The use of pesticides to combat insect pests can also affect wild bees by reducing the number of nests they build, the amount of pollen they harvest, and the number of offspring they produce. Other farming practices such as cover crops, plastic cover, or straw on the soil surface may have consequences for ground-nesting bees and need more research. Scientists are calling for more research to understand how to support ground-nesting bees and the vital services they provide. (Reference: **Nesting habitat of ground-nesting bees: a review** https://resjournals.onlinelibrary.wiley.com/doi/full/10.1111/een.12986)

Nesting guilds

Solitary ground nesters – These bees dig holes in the ground for nests and live on their own (examples include *Colletes, Andrena, Agapostemon*, *Lasioglossum* subgenus *Lasioglossum*, *Lasioglossum*, and *Eucera).* Males do not usually

Some terminology for bee behaviour

Bees feed on nectar and pollen or collect it and, while doing so, they also transfer pollen. **Pollination**, then, is usually the unintended byproduct of a bee's foraging activity. **Foraging** is the behaviour that bees engage in when they are collecting food. Bees feed on pollen from a flower for protein and fats, and nectar for carbohydrates and nutrients. Just like humans need a balanced diet, so do bees. As they fly from flower to flower collecting pollen and sipping on nectar, pollen grains stick to a bee's fuzzy legs or body. When a bee visits the next flower, some of that pollen gets shaken off and lands on that new flower. This is how cross pollination occurs.

Bees and flowers share a **symbiotic relationship**. The flowers feed the bees, and the bees pollinate the flowers. Both organisms rely on the other for their survival. While all bees feed on plants for pollen, nectar, or both, different bee species vary widely in their dietary habits. Some bees are **generalists**, meaning that they visit many different types of plants, and some are **specialists**, meaning that they might feed only on one specific plant, or a family of plants.

The types of plants that bees require for foraging are referred to as **floral resources**. It's very important for bees to have access to abundant floral resources within close proximity to their nesting site. While some larger bees (like honey bees or bumble bees) can travel many kilometres in search of food, other wild bees have much shorter **foraging ranges** (the distance from the nest that a bee is able to travel while foraging). The Squash bee, for example, is a dietary specialist of Cucurbita flowers (pumpkin, squash, zucchini, and Wild buffalo gourd). Squash bees are thought to have help with nest building or providing provisions for larvae.

Social ground nesters – These typically have one reproductive female per nest and many other females that help with nest building and foraging. They are generally active for only a few weeks. These bees prefer open habitat, especially dry, sandy soil (*Lasioglossum* subgenus *Evylaeus, Augochlorella, Halictus*).

Cavity-nesting (or above-ground nesting) – These bees are often solitary and nest in pithy plant stems, rock cavities, and abandoned beetle burrows in wood and usually find a pre-existing cavity (*Hylaeus, Augochlora, L. (D.) cressonii* Robertson, *L. (D.) semicaeruleum* Cockerell, *Hoplitis*, *Osmia*, *Ceratina*).

Carpenter bees – These bees can live communally with several reproductive females sharing a nest. They excavate tunnels in wood, often in wood structures but also in woody plants or raspberry canes.

Bombus spp. – Bumble bees have their own guild because they are social (not solitary) cavity nesters with colonies which can have many individuals per nest and activity over a long period, typically from spring through to the fall. They can nest below ground or above ground, depending on the species.

Cleptoparasitic – They do not construct their own nests but instead lay eggs in active nests of other species. These bees are known as Cuckoo bees and are part of the *Apidae* and *Halictidae* families.

Sociality

Bee species also differ from one another in terms of sociality. The vast majority of native bees in North America are **solitary**, meaning that once the female mates, she builds her nest and provides for her offspring alone.

Some solitary bees nest in **aggregations**, in which each bee builds and maintains their own nest, but in close proximity to other bee nests. Aggregations typically occur among ground-nesting bees and can contain hundreds or even thousands of nests.

Other species of solitary bees nest **communally**, in which several bees share the same entrance to a nest, but create separate nests once inside. This is like the bee equivalent of an apartment building, in which more than 40 bees might share an entrance but have their own nest and egg cells.

Some bees are **semi-social**, behaving very similarly to social bees like honey bees who live in a colony. The key difference is that semi-social nests are generally much smaller, less complex, and the semi-social nest lasts for just one generation.

Most people will be familiar with **eusocial** bees, like honey bees and bumble bees. Eusocial bees live in a colony where provisioning and caring for offspring duties are shared. A eusocial colony consists of a queen, her daughters, and drones (males). Honeybee colonies are made up of tens of thousands of bees, may last many generations, and are capable of complex communication. Bumble bee colonies are much smaller and only a new queen survives through the winter to re-establish the colony.

Learning about Wild Native Bees Using the Taxonomic Structure

Taxonomy is the science of classification of plants and animals.

All images from the United States Geological Survey

Andrena robertsonii

By **Caitlin McCloskey** and **Beatrice Olivastri**

Order: Hymenoptera is a large order of insects, comprising the sawflies, wasps, bees, and ants. Over 150,000 living species of Hymenoptera have been described, in addition to over 2,000 extinct ones.

Family: Seven families of bees: *Andrenidae, Apidae, Colletidae, Halictidae, Megachilidae, Melittidae (all in North America), Stenotritidae (only in Australia)*

Note: For more on bee families, see this article from the University of Minnesota's Bee Lab.

Genus: Each family is made up of many species, which are grouped together into a genus (plural: genera). For example, within the family *Apidae* are the genera *Bombus* (bumble bees), and *Apis* (honey bee). Honey bees and bumble bees are related, as they are in the same family, but are from different genera. The genus *Bombus* is comprised of about 200 species, one of which is the Rusty-patched bumble bee.

Species: Each genus is made up of several or many individual bee species. Worldwide, there are more than 20,000 species of bees documented, with some 4,000 native bees represented in North America. The 20,000 species of bees are classified into the seven families of bees.

The following genera are present in North America:

Andrenidae

Andrenidae is among the largest bee family, with more than 4,500 species categorized into more than 40 genera. North of Mexico, there are over 1,200 species in 13 genera. In Canada and the United States, the different genera of the Andrenidae family are as follows:

Andrena (mining bees): 1,400 species worldwide; 550 species in US; 100 species in Canada
Distribution: All regions of the US; all provinces in Canada (*Andrena* venture much farther North than other bee species and are present in Alaska and the Canadian territories.)
Sources of pollen and nectar: Generalists, some specialists (important pollinators of blueberry, cranberry, apple, wild and cultivated onion)

Ancylandrena:
Distribution: Southwest region

Megandrena:
Distribution: Parts of the Southwest (California, Nevada, Arizona)

Calliopsis (mining bees): 90 species in Western Hemisphere; 70 species north of Mexico; approximately 6 species in Canada
Distribution: Southwest, Southern plains regions
Sources of pollen and nectar: Specialists and picky generalists (spurges, legumes, potato family, sunflower family)

Perdita (fairy bees): over 650 species in North America, 12 species in Canada
Distribution: Only in North America, especially common in Southwest region.
Sources of pollen and nectar: Specialists (evening primrose, prickly pear cactus, globe mallow, sunflower, lotus, borages)

Macrotera: 30 species in United States: Midwest, and southwest regions

Subfamily *Panurginae*

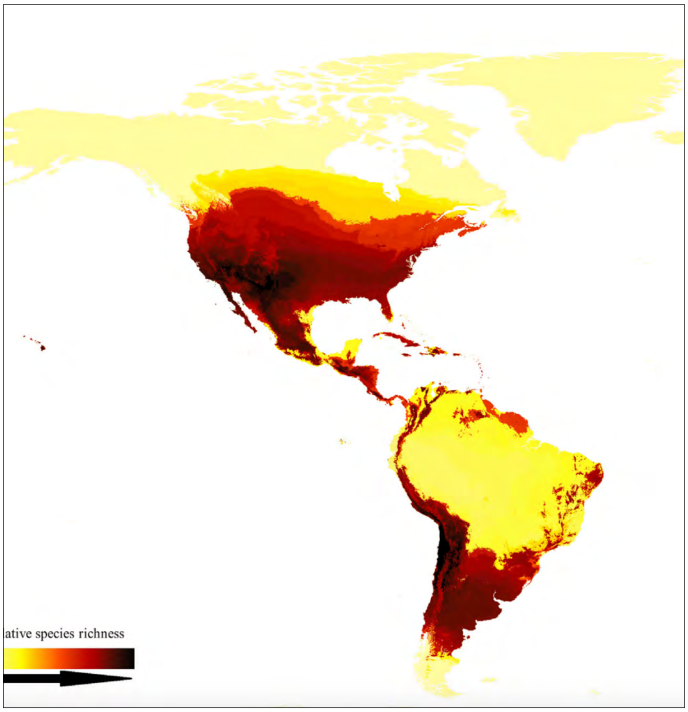
Pseudopanurgus: 12 species in North America; 6 species in Canada
Distribution: Relatively uncommon but range from Midwest to Southwest region of US; low likelihood of occurrence in BC, AB, SK, southern ON, and QC

Panurginus: 18 species in US; 3 species in Canada
Distribution: Present in all regions of the US; found in BC, AB, SK, ON, and QC
Sources of pollen and nectar: Floral generalists; some specialists (mustards, roses, buttercups)

Protandrena: 80 species in the United States and Canada
Distribution: All across the United States; southern part of all Canadian provinces (not present in Newfoundland or the territories)
Sources of pollen and nectar: Generalists and specialists (bee balm)

Anthemurgus: 1 species in the United States and Canada
Distribution: Occurs in Southeast and Northeast regions
Sources of pollen and nectar: Specialist (yellow passionflower)

Protoxaea: 3 species worldwide, 1 species in the US
Distribution: Southern Texas, southern Arizona, southern New Mexico
Sources of pollen and nectar: Generalists with preferences (pea family, potato family, creosote bush)



This map of relative species richness of bees is featured in the article *Global Patterns and Drivers of Bee Distribution* (November 19, 2020) by Michael C. Orr, Alice C. Hughes, Douglas Chesters, John Pickering, Chao-Dong Zhu, and John S. Ascher (https://doi.org/10.1016/J.CUB.2020.10.053).

Foraging definitions

Floral resources: The types of plants on which bees feed for pollen and nectar
Dietary Specialist: Bees that feed only on one specific plant, or a family of plants (e.g., the squash bee specializes on plants from the cucurbita family.)
Dietary Generalists visit and feed on a large variety of plants (e.g., bumble bees are generalists that pollinate many different food crops and flowering plants.).

Apidae

Apidae is a massive bee family, with more than 5,700 species worldwide in over 200 genera worldwide. The genera that are found in Canada and the United States are as follows:

Apis mellifera (European honeybee): As the name suggests, honeybees are not native to North America.
Distribution: All US states; all Canadian provinces and territories
Sources of pollen and nectar: Generalists

Bombus (bumble bees): About 250 species worldwide; less than 50 species in North America
Distribution: All US states; all Canadian provinces and territories
Sources of pollen and nectar: Generalists (buzz pollination of tomato, eggplant, peppers, potato, blueberries, and other crops)

Anthropora (digger bees): 410 species worldwide; 50 species in the US; 11 species in Canada

Distribution: Western US (north and south), less common occurrence throughout the rest of the country; BC, AB, southern ON, QC, NS, NB, PEI

Sources of pollen and nectar: Generalists and specialists (primrose and creosote family)

Xylocopa (large carpenter bees): Over 500 species known worldwide; around 10 species known in United States and Canada

Distribution: No species are present across the entire US, but various species are present in the Great Plains, Western regions, and Southwest; BC

Sources of pollen and nectar: Generalists (efficient pollinators of passionfruit, tomato, cotton)

Xenoglossa strenua

Ceratina (small carpenter bees): 350 species worldwide; 22 species in United States and Canada (North of Mexico)

Distribution: All US states, including introduced species in Hawaii; BC, AB, southern ON, and QC

Sources of pollen and nectar: Generalists

Anthophorula: 63 species in the Western Hemisphere; 40 species in the US

Distribution: Northwest, Southwest, Midwest

Sources of pollen and nectar: Generalists; some specialists (sunflower family, buckwheat family, Solanaceae family: potato, chilies, tomato, eggplant)

Exomalopsis: 88 species south of Mexican border, 10 species north of the Mexican border

Distribution: Southwestern US

Sources of pollen and nectar: Similar to *Anthophorula*

Melissodes (long-horned bees): 130 species worldwide; 100 species in US; 20 species in Canada

Distribution: All US states; all Canadian provinces except Manitoba and territories

Sources of pollen and nectar: Specialists (sunflower family, pea family, poppy mallows, farewell-to-spring flowers, prickly poppies, evening primrose)

Eucera: 300 species worldwide; 1 subgenus in North America: 55 species in US; 7 species in Canada

Distribution: Present in all regions of US, with particularly high occurrence rates toward either coast; BC, AB, southern ON, QC

Sources of pollen and nectar: Generalists and specialists (pea family, prairie clover, vetches)

Peponapis (squash bees): 15 species in the Americas; 6 species in US; 1 species in Canada

Distribution: Midwest, Northeast, Southeast, Southwest, Southern Plains; ON

Sources of pollen and nectar: Specialists (squash and cucurbit family)

Xenoglossa (squash bees): 7 species worldwide; 5 species in US

Distribution: All US regions except parts of the Pacific Northwest

Sources of pollen and nectar: Specialists (squash and cucurbit family)

Diadasia: 45 species in the Western Hemisphere; 25 species in US and Southern Canada

Distribution: Pacific Northwest, Midwest, Southwest regions; BC, AB

Sources of pollen and nectar: Specialists (cactus, sunflower, morning glory, farewell-to spring flowers)

Habropoda: 50 species worldwide; 21 species in the US; 3 species in Canada

Distribution: Across the US, concentrated in the west (California); southern Canada, BC

Sources of pollen and nectar: Generalists and specialists (efficient pollinator of blueberries)

Centris: 200 species in the Western Hemisphere; 23 species north of Mexico

Distribution: Southwest, Southeast, Southern Plains regions

Sources of pollen and nectar: Generalists and specialists (Brazil nut, cashew, west Indian cherry, eggplant)

Cuckoo bees:

Epeolus (parasite of Colletes): 57 species north of Mexico; 12 species in Canada

Distribution: All US states; Southern Canada, BC, AB

Cleptoparasite of *Colletes*

Nomada: 726 species worldwide, 300 species in US, 40 species in Canada

Distribution: All US states; all Canadian provinces

Cleptoparasite of Andrena; some species also parasites of *Colletes, Melitta, Agapostemon, Lasioglossum, Halictus, Exomalopsis*, and *Eucera*

Triepeolus: 148 species worldwide; 100 species in the US; 6 species in Canada

Agapostemon

Distribution: All US states; Southern Canada, BC, AB
Cleptoparasite of *Eucerini, Anthophora, Centris, Melitoma, Ptiloglossa, Xenoglossa, Protoxaea*, and *Dieunomia*

Colletidae

The *Colletidae* family includes 56 genera, with only 2 genera being widespread in Canada.

Colletes (cellophane, plasterer, or polyester bees): 495 species worldwide; 99 species in US; 25 species in Canada
Distribution: Every US state except Hawaii; all Canadian provinces except the far North Sources of pollen and nectar: Generalists; specialists (pea family, sunflower family)

Hylaeus (yellow-faced or masked bees): 760 species worldwide; 50 species in the United States and Canada
Distribution: Present in every US state, including Hawaii; southern Canada
Sources of pollen and nectar: Generalists; specialists (rose family)

Diphaglossinae: 5 species in the US
Distribution: Midwest, Southwest regions
Sources of pollen and nectar: Preference for pea and mint family

Halictidae

Halictidae has more than 3500 species in 76 genera worldwide; 16 genera are found in the United States; 9 genera are found in Canada.

Agapostemon (metallic green sweat bees): 42 species worldwide; 14 species in the United States and Canada
Distribution: All US states; along the Canada/US border
Sources of pollen and nectar: Generalists

Halictus (sweat bees): 206 species worldwide; 10 species in the United States and Canada
Distribution: All US states; BC, AB, SK, ON, QC, NS, NB
Sources of pollen and nectar: Generalists (key pollinators of carrot, onion, sunflowers)

Lasioglossum (small sweat bees): 1,813 species worldwide; 287 species in the United States and Canada.
Distribution: All US states; all Canadian provinces, with some occurrences in the territories
Sources of pollen and nectar: Generalists; specialists

5 subgenera found in North America:

Lasioglossum (Dialictus): 300 species north of Mexico
Sources of pollen and nectar: Generalists

Lasioglossum (Evylaeus): 70 species in US and Canada
Sources of pollen and nectar: Generalists

Lasioglossum (Lasioglossum): 30 species in US and Canada
Sources of pollen and nectar: Generalists

Lasioglossum (Sphecodogastra): 8 species in North America
Sources of pollen and nectar: Specialists (evening primrose)

Lasioglossum (Hemihalictus): 1 species in US
Sources of pollen and nectar: Specialists (chicory, false dandelions)

Augochlorini Tribe (green metallic sweat bees):

Augochloropsis: 144 species in the Western Hemisphere; 3 species in US and Canada
Distribution: Northern plains, Rocky mountains, rarely Southwest region

Augochlorella: 20 species worldwide; 7 species in US; 2 species in Canada
Distribution: Midwest, Southeast, Northeast, Southern Plains, Northern Plains; Nova Scotia

Augochlora: 117 species worldwide; 4 species in US; 1 species in Canada
Distribution: Southeast, Northeast regions; Québec

Dufourea (shortface bees): 140 species worldwide; 70 species in North America; 8 species in Canada
Distribution: Pacific Northwest, Midwest, Southwest, with lower likelihood of occurrence across the rest of the states; BC, AB, rarely occurring in Northwest Territories Sources of pollen and nectar: Specialists (primrose, mustard, cactus, pea, waterleaf, poppy, rose, figwort families)

Nomia (sweat bees/alkali bees): 9 species north of Mexico
Distribution: Southwest, Midwest, Pacific Northwest, southern Canada
Sources of pollen and nectar: Generalists (important pollinator of alfalfa)

Dieunomia: 9 species in US and Canada
Distribution: Southwest, Pacific Northwest; along the US/Canada border
Sources of pollen and nectar: Specialists (sunflower)

Sphecodes (cuckoo bees): 293 species worldwide; 75 species in the US; 41 species in Canada

Distribution: All US states; all Canadian provinces
Cleptoparasite of *Halictidae* family; also *Colletes, Andrena, Calliopsis, Perdita,* and *Dasypoda*

Megachilidae

Megachilidae are a diverse bee family, with 76 genera encompassing more than 4000 species worldwide.

Osmia (mason bees): 500 species worldwide; 130 species in the US; 60 species in Canada
Distribution: All US states; all Canadian provinces and territories
Sources of pollen and nectar: Specialists (rose family: orchard trees like apple, almond, plum, cherry; pea family; scientists are exploring osmia as pollinators of kiwi, raspberry, blackberry, blueberry)

Osmia lignaria

Hoplitis (mason bees): 300 species worldwide; 60 species in the United States and Canada
Distribution: All US states; all Canadian provinces, with low likelihood of occurrence in territories
Sources of pollen and nectar: Specialists (pea family, borage family)

Megachile (leafcutter bees): 1503 species worldwide; 140 species in the US; 25 species in Canada
Distribution: Very high occurrence across all US states; all Canadian provinces, with lower occurrence in the territories
Sources of pollen and nectar: Generalists; specialists (important pollinators like alfalfa leafcutting bee)

Heriades (small resin bees): 136 species worldwide; 12 species in the US; 4 species in Canada
Distribution: All US states; along the US/Canada border
Sources of pollen and nectar: Generalists

Anthidium (wool carder bees): 160 species worldwide; 36 species in the US; 5 species in Canada
Distribution: Southwest, Midwest (preference for desert habitats); BC, AB
Sources of pollen and nectar: Generalists, specialists (pea family, sunflower family)

Dianthidium: 21 species in the US; 3 species in Canada
Distribution: Southwest, Midwest, Pacific Northwest; BC
Sources of pollen and nectar: Generalists, preference for sunflower family

Lithurgopsis: 9 species worldwide; 7 species north of Mexican border (uncommonly occurring in Canada)
Distribution: Midwest, Southwest regions
Sources of pollen and nectar: Specialists (important pollinators of cactus)

Coelioxys (cuckoo bees): 474 species worldwide; 47 species in the United States and Canada
Distribution: All US states; all Canadian provinces
Cleptoparasite of genus *Megachile*

Melittidae

Melittidae is a small and relatively uncommon family of bees, with about 200 species worldwide.

Melitta: 50 species worldwide; 4 species in the United States and Canada
Distribution: Northeast region; southern ON and QC
Sources of pollen and nectar: Specialists (blueberry, cranberry, mallow plant family)

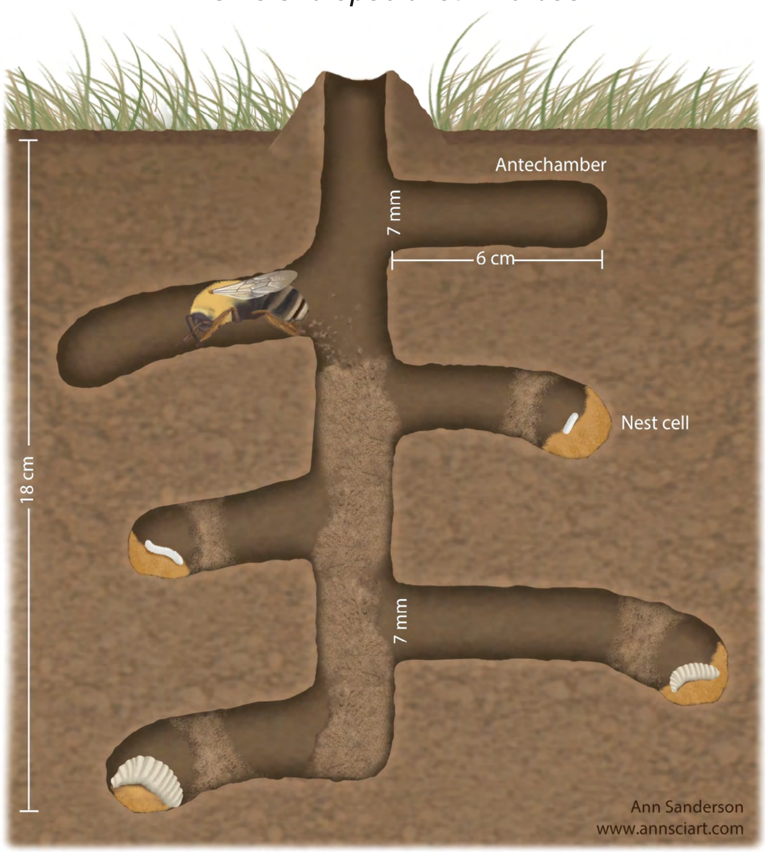
Hesperapis: 40 species worldwide; 25 species in the United States
Distribution: Southwest, Midwest

Macropis (cuckoo bees): 16 species in the Northern Hemisphere; 4 species in the US and Southern Canada
Distribution: Northeast, parts of the Midwest region; Southeast Canada Sources of pollen and nectar: Specialists (loosestrife)

Osmia lignaria

Hoary Squash Bee (*Eucera pruinosa*)

Profile of a specialist wild bee



Permission granted from Ann Sanderson and Susan Chan to use graphic

Hoary squash bee nesting diagram from
https://www.nature.com/articles/s41598-019-47805-1/figures/1

By **Susan Chan**

THIS WILD BEE SHOWS an unusually high degree of specialization by depending entirely on *Cucurbita* crops for pollen. Each hoary squash bee female builds her own nest in the ground, typically within the field areas growing pumpkins, squash, and gourds (*Cucurbita* crops). These would be the same areas where systemic pesticides called neonicotinoids are often applied as soil drenches or seed treatments. This means that the squash bee could be exposed to pesticide poisoning from the soil itself and from the pollen and nectar it harvests from the crops. Research conducted by me and Nigel E. Raine at the University of Guelph found that when the bees were exposed to a crop treated at planting time with soil-applied imidicloprid (a neonicotinoid), the squash bees built 85% fewer nests, left 5.3 times more pollen unharvested and produced 89% fewer offspring when compared to exposure to crops planted with untreated seeds.

The farmers growing these crops might not see these pesticide impacts on the wild bees until the next growing season.

Since 70% of solitary bees nest in the ground and spend most of their lives there, pesticide exposure to ground-nesting bees is of growing concern. (Reference: https://www.nature.com/articles/s41598-021-83341-7)

How Are Wild Native Bees Protected?

Programs and resources

Species Profile

Ann Sanderson

Rusty-patched bumble bee (*Bombus affinis*)

Rusty-patched bumble bee *(Bombus affinis)* – listed as endangered in both Canada and the US

Historically, the Rusty-patched bumble bee was broadly distributed across the eastern United States, Upper Midwest, and southern Québec and Ontario in Canada. Since 2000, this bumble bee has been reported from only 13 states (Illinois, Indiana, Iowa, Maine, Maryland, Massachusetts, Minnesota, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, and Wisconsin) and one Canadian province (Ontario). This bee is threatened by disease, pesticides, and habitat fragmentation, each of which could cause extirpation (lost from the wild) in the near future.

Read about listing of the Rusty-patched bumble bee in the US: https://ecos.fws.gov/ecp/species/9383

Read about the listing of the Rusty-patched bumble bee in Canada: https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry/recovery-strategies/rusty-patched-bumble-bee-2020.html

Watch *A Ghost in the Making: Searching for the Rusty-patched bumble bee*: http://www.rustypatched.com/the-film

This is natural history photographer Clay Bolt's multi-year quest to tell the stories of our native bees, and one elusive species: the Rusty-patched Bumble Bee. Clay's journey finally brings him to Wisconsin, where he comes face to face with his quarry and discovers an answer to the question that has been nagging him: why save a species?

By **Beatrice Olivastri** and **Caitlin McCloskey**

CANADA HAS ITS Species at Risk Act as a key tool for protecting hundreds of wild plants and animal species from becoming extinct: https://www.canada.ca/en/environment-climate-change/services/species-risk-education-centre/your-responsibility/your-responsability-guide.html#toc0

Both federal and provincial/territorial jurisdictions are involved in protecting wildlife. The SARA Public Registry provides a list of species provided a level of protection under the Act.

The US has its Endangered Species Act (ESA): https://www.epa.gov/laws-regulations/summary-endangered-species-act

One of the lead federal agencies for implementing the US ESA is the U.S. Fish and Wildlife Service (FWS), which maintains a worldwide list of endangered species. Species include birds, insects, fishes, reptiles, mammals, crustaceans, flowers, grasses, and trees.

A global watch on threatened species is provided by The IUCN Red List of Threatened Species. Established in 1964, the International Union for Conservation of Nature's Red List of Threatened Species has evolved to become the world's most comprehensive information source on the global extinction risk status of animal, fungus, and plant species as well as the measures needed to safeguard them. You can search the name of a wild native bee to see if it is considered threatened and, if so, access a great deal of information on its habitat, ecology, threats, and more.

Resources List

Identifying and learning about wild native bees

By **Caitlin McCloskey** and **Beatrice Olivastri**

Print resources

Bees: An Identification and Native Plant Forage Guide by Heather Holm (Pollination Press, 2017)

Bee and Pollinator Books, plants list and posters by Heather Holm: https://www.pollinatorsnativeplants.com/

The Bees in Your Backyard: A Guide to North America's Bees by Joseph S. Wilson and Olivia Messinger Carril (Princeton University Press, 2015)

Poster and fold out guides for *Common Bees of Western North America* and *Common Bees for Eastern North America* https://www.beesinyourbackyard.com/shop

An Identification Guide: Bumble Bees of North America by Paul Williams, Robbin Thorp, Leif Richardson, & Sheila Colla (Princeton University Press, 2014)

Websites: Global

The Packer lab (PCYU): https://www.yorku.ca/bugsrus/PCYU/PackerCollection

PCYU has been one of the fastest growing bee collections in the world, is the largest bee collection in Canada, and has specimens from over 100 countries with perhaps ¼ of all bee species represented (although comparatively few are identified to the species level as of yet) and >90% of the world's bee genera.

iNaturalist: https://www.inaturalist.org/

In the US, iNaturalist is a joint initiative of the California Academy of Sciences and the National Geographic Society. Every observation can contribute to biodiversity science, from the rarest butterfly to the most common backyard weed. iNaturalist shares your findings with scientific data repositories like the Global Biodiversity Information Facility to help scientists find and use your data. All you have to do is observe.

In Canada, iNaturalist, https://inaturalist.ca/ is a joint initiative with the Canadian Wildlife Federation, Royal Ontario Museum, and Parks Canada. Your findings are shared with scientific data repositories like the NatureServe Canada, Canadensys, and the Global Biodiversity Information Facility.

Susan Willis Chan, PhD, provided inspiration and technical advice for this special wild native bee issue. She is a Postdoctoral Researcher at the School of Environmental Sciences at the University of Guelph. She began her career as a high school environmental science and biology teacher. Susan's research focuses on crop pollination, the effects of pesticides on pollinators, and the use of biological control methods to replace pesticide use on farms. Her recent research considered the effects of realistic exposure via squash crops treated with systemic insecticides for a ground-nesting bee species (Hoary squash bee, *Eucera pruinosa*). Aligning with her research, Susan is passionate about teaching courses in sustainable agriculture and environmental topics related to agriculture.

Beatrice Olivastri has spent more than 40 years as an environmentalist, is co-founder of Friends of the Earth (1978), and has led the organization as the Chief Executive Officer for 25 years. It now works with 72 other national Friends of the Earth groups around the world. Bea oversees development and delivery of campaigns and legal action currently addressing Climate Change, Environmental Justice, and Biodiversity. She has found Friends of the Earth's Bee Cause campaign to be the most compelling cause since acid rain for mobilizing action by concerned citizens of all ages.

Caitlin McCloskey is a Carleton University graduate in environmental studies. She first came to Friends of the Earth to work on a research project on glyphosate — the most widely used pesticide in the world. This project was the beginning of a long-standing interest in pesticides. After finishing her studies and travelling, Caitlin returned to Friends of the Earth, this time as a full-time researcher and communications specialist. She contributes to content writing and creation for Friends of the Earth's campaigns.

For an expanded list, including regional resources for Canada and the United States, click here.

Activity 1: A Menu Brought to You by Wild Native Bees

An activity for middle school students

By **Green Teacher staff**

Overarching inquiry question: *Which species/genera of bees contribute to a healthy diet?*

Core activity:

*Split the class into groups of three or four students. Each group will be responsible for creating a one-day menu. Each meal or snack must include at least one (ideally two or more) of the following foods:

- Almonds
- Apples
- Apricots
- Artichokes
- Blueberries
- Beans (dry, broad, horse)
- Cauliflower
- Broccoli
- Cherries
- Cranberries
- Cucumbers/pickles
- Currants
- Legumes
- Peaches
- Nectarines
- Pears
- Plums
- Pumpkins
- Squash
- Gourds
- Raspberries
- Strawberries
- Sunflower Seeds
- Watermelons

Example menu:

Breakfast: Oatmeal with blueberries; apple juice; peach; sliced strawberries

Morning snack: Almonds

Lunch: Sandwich with lettuce, cucumbers, and a sauce of your choice; plum; mixed squash

Afternoon snack: Watermelon slices

Dinner: Bean salad, including broccoli and cauliflower; rice; raspberry pie

Snack throughout the day (optional): Sunflower seeds

*Each group then consults the agricultural crops chart on pages 4 and 5 to determine which bee genera have possi-bly pollinated food included on their group's menu. These genera are documented alongside the menu. Students then consult the taxonomic information on pages 10 to 14 to determine which documented bee genera can be found in your region. These genera are noted.

*The groups share their menus with each other as well as their documented bee genera. A class log of total local bee genera documented among all groups is kept.

Additional research:

*Each group researches the native forage plants of their documented bee genera. Once these forage plants have been identified, groups check to see which plants are native to your region. These plants are documented.

Culminating event:

*Have a class potluck where each meal includes foods whose flowers have been pollinated by local bee genera. Identify the bees and forage plants you can "thank" for the meal.

Optional extensions:

*Research threats to the various bee species/genera documented in this activity and devise an action plan for supporting these species.

*Find photographs of the documented bee genera and forage plants; print them and post them throughout your learning space.

*Visit a local green space where some of the documented forage plants can be found and search for their pollinators. Specifically try to find bees that were documented in the core activity. Make field sketches and notes on the forage plants and their pollinators.

Activity 2: Squash Bee Pollination Simulation

An activity for elementary school students

By **Green Teacher staff**

Overarching inquiry question: *How do humans and squash bees affect and depend on each other?*

Materials:

- Nectar cards or chips (10 per student)
- Pollen cards of chips (10 per student)
- "Male flower" labels (one per five students)
- "Female flower" labels (one per five students)
- "New pollen" labels (one per "female flower")
- "Nest" labels (one per female student)

Set-up:

*In a confined area, ideally outside, establish the foraging and nesting site. It consists of "male flowers," "female flowers," and "nests." To mimic conditions in nature, the "flowers" should be grouped together and the "nests" should be grouped together, albeit close to the "flowers." Each "male flower" station should have an equal number of nectar cards/chips and pollen cards/chips; each "female flower" station should have an equal number of nectar cards/chips only (because female flowers don't produce pollen). Each "female flower" station also includes a sub-section called "new pollen" to represent pollen that has been transferred from a male flower as part of cross-pollination.

Note: Place the nest and flower stations far enough apart so that students have room to move around and get some exercise.

Background:

*Introduce the class to the Hoary (AKA Pruinose) squash bee (*Eucera pruinosa*) with images from iNaturalist and with the nest image from this article (Page 15)

*Review the species' foraging and nesting habits according to content from the aforementioned article.

Core activity:

*Conduct a pollination simulation in two rounds. In Round 1, boys (representing male bees) and girls (representing female bees) go from "flower" to "flower" collecting nectar and pollen cards/chips. Boys keep their nectar cards/chips and transfer their pollen cards/chips from "male flowers" to the "new pollen" section of "female flowers". Girls keep some of their nectar cards/chips and take some to their respective "nests"; girls take some of their nectar cards to their respective "nests" and take some from "male flowers" to the "new pollen" section of "female flowers."

*After Round 1, do a debrief to look at how much pollen has been transferred from "male flowers" to "female flowers" (cross-pollination) and how much pollen and nectar has been delivered to females' "nests." Note that in nature, nectar and pollen are combined to form "bee bread," which is fed to developing bee larvae.

Note: Remind students that in nature, squash bees don't deliberately cross-pollinate. This happens as a result of their moving from flower to flower during foraging.

*For Round 2, select a small group of students (one per "male flower") to guard the "male flowers." Their goal is to prevent pollen from being taken. Run the simulation again. This time, it's likely that less pollen per student has been transferred to "female flowers" and to "nests."

*After Round 2, do another debrief, this time mentioning that the guards represented a soil-applied pesticide (imidacloprid, a neonicotinoid) and that in nature, use of this type of pesticide results in less pollen being harvested, fewer nests built by females, and fewer offspring.

Follow-up:

*Reveal to students that the flowers from the activity were from plants that humans eat: pumpkins, squash, and gourds (Cucurbita crops). Specify that these plants cannot produce their fruits (that we eat) without pollination from Hoary squash bees unlike some crops (e.g., corn) that are pollinated by the wind.

*Assign each student to write a short story about a Hoary squash bee in a pumpkin/squash/gourd patch. Encourage students to incorporate what they have learned about squash bees and pollination into their stories.

Optional extensions:

*Host a class meal that includes pumpkins/squash/gourds and begin the meal by thanking Hoary squash bees for making the meal possible.

*Take students to a site where pumpkins/squash/gourds are in bloom (typically in August) and observe real Hoary squash bees at work. Try to identify males and females (long orange hairs on their hind legs) and see if you can see females travelling to and from their ground nests.

Resources:

Bees: An Identification and Native Plant Forage Guide by Heather Holm (2017) *(Note: Page 89 is about squash bees.)*

Activity 3: Bumble Bee Polination Observations

An activity for secondary school students

By **Green Teacher staff**

Overarching inquiry question: *What makes a particular site attractive to bumble bees?*

Materials:

- Nature journaling sheets (one per student)
- Writing utensils (one per student)
- Hands lenses (optional)

Preliminary work:

*Visit the North-America-specific Bumble Bee Watch website: https://www.bumblebeewatch.org/.
*Click on the tab "Bumble Bee Species": https://www.bumblebeewatch.org/app/#/species/profile
*Sift through the listed species and by checking the range maps, determine which bumble bee species occur in your area.
*Read through the *Bumble Bees FAQs* (Appendix A below) to establish a solid baseline of knowledge about bumble bee ecology.

Note: If you are not based in North America, seek a bumble bee list for your area.

Core activity:

*Conduct a field study of a site where numerous flowering plants are in bloom. Ideally, this would be on the grounds of your education facility, but if this is not possible, try to find somewhere nearby.

Note: Because bumble bees are generalist foragers, they visit a wide variety of plants. Even flowering plants (e.g., White Clover) on semi-manicured lawns can abound with bumble bees.

*Each student (or groups of students — educator's choice) completes the included worksheet (Page 23 below).

Tips:
**The site data, including weather, can be taken as a class.*
**If multiple bumble bee species are present, have each student/group focus on one species.*
**Sketches of bumble bees and flowers are encouraged on the worksheet.*

Follow-up:

*Based on the descriptions of the bumble bees observed during the site visit, determine which species was/were observed. Remember to references the Bumble Bee Watch website to help with identification.
*Have each student/group share their results with the entire class/group. Based on the observations, discuss and answer the following discussion questions?

- *What about this site makes it attractive to bumble bees? (Give specific evidence.)*
- *What about this site is potentially unattractive to bumble bees? (Give specific evidence.)*
- *How could this site be made more attractive to bumble bees?*
- *What specific steps could be taken to make this site more attractive to bumble bees? What would the time and financial costs be?*

Optional extension:

*Write a report to a person or group in charge of the study site and propose how it could be altered to be more attractive to bumble bees. Include in this report an action plan that includes the following:
-required tasks
-human and time resources
-materials needed
-project budget (start-up and annual)

Additional Resources:

Bees: An Identification and Native Plant Forage Guide by Heather Holm (2017)
Bumblebee Economics by Bernd Heinrich (2004)
Bumble Bees of North America: An Identification Guide by Paul Williams, Robbin Thorp, Leif Richardson, & Sheila Colla (2014)
A Sting in the Tale: My Adventures with Bumblebees by Dave Goulson (2014)

Possible adaptation

*If this activity is conducted in early spring (in temperate locations), the only active bumble bees would be queens searching for suitable nesting sites. This activity could be adapted, then, to involve learners following queen bumble bees to see which locations they select for nesting.

Appendix A: Bumble Bee FAQs

***Note: Content has been derived from the book** Bumble Bees of North America: An Identification Guide **by Williams, Thorp, Richardson, & Colla (2014)**

Q: How are bumble bees different from honey bees?
A: Though both types of bees are social, honey bee queens and colonies can persist for several years, while bumble bees start new colonies (with new queens) every year.

Q: In the temperate zone, what happens to bumble bees in the winter?
A: Workers, males, and old queens die; new queens (emerged late in the growing season) hibernate and emerge the following spring.

Q: Where do queens hibernate?
A: Queens usually hibernate in old rodent holes or under loose plant debris.

Q: What gives bumble bees their distinctive colors?
A: Their body hairs (also known as pile or pubescence)

Q: What are the most favorable conditions for bumble bees?
A: Bumble bees need access to flowering plants consistently throughout the growing season. Open areas with nearby trees and plenty of attendant flowers are preferred. Warm temperatures (not too hot or cold) are also ideal. On hot days, most foraging is done in the morning and evening.

Q: How come I sometimes see bumble bees in cold weather?
A: Bumble bees are often active on cool days in the spring and fall. They stay warm by shivering the flight muscles on their thorax.

Q: Where do bumble bees nest?
A: Though each species is unique, you can generally find bumble bee nests in old rodent holes, hollow logs, or human structures.

Q: Is it possible to see queen bumble bees?
A: Yes. In early spring, you only see queens, which are foraging and searching for nesting sites. Queens are seen much less often in the summer before becoming relatively common again in the fall when new queens are searching for a hibernating site and seeking pollen and nectar to provision themselves through hibernation.

Q: How do I know if a bumble bee is male or female?
A: Females (queens and workers) have six segments on their abdomen, while males have seven. Males also emerge later in the growing season after female workers have been foraging for a while.

Q: How do I know if a female is a queen or a worker?
A: Queens are bigger than workers. Queens also tend to be much less active when workers are actively foraging mid-way through the growing season.

Q: How are a queen's eggs fertilized?
A: Late in the growing season, a queen mates with a single male. Her fertilized eggs are laid the following spring (after the queen hibernates). Workers (all females) emerge from these eggs. Males emerge from unfertilized eggs later in the growing season.

Q: What roles to male bumble bees play?
A: Males tend not to collect food for the colony; rather, they seek food for themselves and try to find a queen with which to mate.

Q: How do bumble bees collect pollen?
A: For most bumble bees (cuckoo bumble bees in the subgenus **Psithyrus** excepted), pollen is stored in structures on the hind legs called corbicula (singular: corbiculum). Pollen-filled corbicula (also called pollen baskets) look like bulging yellowish saddle bags.

Q: Do bumble bees deliberately collect pollen?
A: Yes. While some non-bee pollinators (e.g., hummingbirds) only deliberately collect nectar, bees collect both pollen and nectar to eat and/or to feed their developing larvae.

Q: On which flowers can I find bumble bees?
A: Each species has preferred species, but in general, bumble bees as a group are generalist foragers and can feed on a broad range of flowering plants. This includes species like clovers covering urban lawns. Once a bumble bee finds a flower at which to forage, it usually feeds only on one species at a time.

Q: What is "buzz" pollination?
A: "Buzz" pollination is a special means of pollinating by which bumble bees vibrate their flight muscles. Crop plants like blueberries, cranberries, and tomatoes benefit from "buzz" pollination from bumble bees. This, in turn, benefits humans.

Activity 3:
Bumble Bee Observations

Observer: ______________________________ **Site:** ______________________________
Date: ______________________________ **Time (start and end):** ______________________________

Weather (temperature, cloud cover %, wind speed and direction, precipitation): ______________________________
____
____
____

Description of site (terrain/slope, primary plants present, degree of plant cover, sun/shade):
____
____
____

Description of observed species (Focus on the arrangement of colors on the thorax and abdomen.):
____
____
____

Behavior of observed species
**flower(s) on which it forages*
____
____

**how long it spends on individual flowers*
____
____

**how long it spends foraging before leaving the site*
____
____

**how it accesses pollen and nectar (e.g., crawling inside flower, "buzz" pollinating, piercing a hole in flower, etc.)* _______
____
____

**interactions with other bumble bees (same species or different species)*
____
____

**interactions with other insects*
____
____

Additional observations
____
____
____
____

Activity 4: Storytelling with Wild Native Bees

An activity for elementary school students

By **Green Teacher staff**

Overarching inquiry question: *How do wild native bees impact what food we eat?*

Materials:

- Paper
- Colored drawing utensils

Background:

*Refer to the chart in this article on Pages 4 and 5, which shows which social bees (honey bees and bumble bees) and solitary bees pollinate different crop plants as well as which crops require bee pollination. The genera of solitary bees (Latin names) are listed in the chart; here is a key to the English names of each genus referenced in this activity:

Agapostemon (Metallic green sweat bees)
Andrena (Mining bees)
Anthidium (Wool carder bees)
Anthrophora (Digger bees)
Bombus (Bumble bees)
Colletes (Cellophane bees)
Dieunomia (Sweat bees)
Florilegus (Long-horned bees)
Halictus (Sweat bees)
Hoplitus (Small mason bees)
Megachile (Leafcutter bees)
Melissodes (Long-horned bees)
Melitta (Blunt-horn bees)
Osmia (Mason bees)
Peponapis (Squash bees)
Svastra (Long-horned bees)
Xylocopa (Large carpenter bees)

Note: Some groups (e.g., Long-horned bees) belong to multiple genera.

Note: Refer to Pages 10 to 14 for more information on bee genera.

Core activity:

*Read aloud the short story *Lilly's Big Blue Bag* (Appendix A) and ask students to listen for the different foods you mention (sauces and condiments included). Once finished reading the story, ask the class how many foods were mentioned. (Answer: 18)

Note: You may need to read the story more than once.

*List all 18 foods so that everyone can see the list. Give each student a piece of paper and some colored writing utensils. Their task is to draw a picture of their favourite food from the list.

*Referencing the chart from Pages 4 and 5, reveal to each student which bee genera may have helped pollinate their favourite food from the story.

Note: It is recommended to use the English names of the bee genera.

*Each student then adds to their drawing the following sentence: *My (food) was likely pollinated by (names of applicable bee genera).*

*Using a digital resource like iNaturalist, show the class example pictures of each genus referenced in the drawings.

Follow-up:

*On the back of the same piece of paper with the drawings, each student must write their own version of the rest of the short story *Lilly's Big Blue Bag*. Some prompt questions:

- Does Lilly choose the squash or the watermelon? Maybe both?
- How does Lilly prepare her food (cooked, sliced, etc.)
- What happens on Lilly's way to school?
- What happens during the picnic?
- What other foods are at the picnic?
- Who else is at the picnic?
- What is the weather like during the picnic?
- Do Lilly's teacher and classmates like the food she has brought?

Optional extensions:

*Have students write the prequel to the story, specifically the part where the bees pollinate the flowers of the different foods mentioned in the short story *Lilly's Big Blue Bag*.

*Host your own class picnic featuring foods from the story. Make a point of mentioning all of the bee genera that helped make the meal possible through their pollination.

Resources:

Bees: An Identification and Native Plant Forage Guide by Heather Holm (2017)

Appendix A: Story (Lilly's Big Blue Bag)

Lilly wakes up early on this Saturday morning full of excitement. Why is she so excited? It's picnic day with her third-grade class! Lilly is also a bit nervous, though, because she hasn't prepared her meal yet.

Last week, when Ms. Jimenez announced the plans for the picnic, everyone volunteered to bring different foods. One student would bring fresh **apples**; another, **peaches**; another, **nectarines**. A small group said they would take care of berries, specifically **blackberries**, and **raspberries**. Someone even offered to bring **sunflower** seeds. Lilly had wanted to bring fresh **plums** from the tree in her backyard, but there is just one problem: all the plums have fallen to the ground and are being eaten by wasps!

Lilly needs a new plan, and she needs it quick. She rushes down to the kitchen to see what she can find. Opening the cupboard, Lilly sees some cans of **beans** and a bag of **almonds**. No, those won't do. She opens the refrigerator. There's a jar of **cranberry** sauce, a can of **pumpkin** paste, two types of jams — **blueberry** and **apricot** — and some **mustard**. Those won't do either. Maybe there's something in the crisper. Lilly looks inside and finds one **tomato** and half a **cucumber** — not enough to feed even one person. Uh-oh!

Feeling panicked, Lilly closes the refrigerator and circles around for some more ideas. The countertop is empty except for a few cups and plates. What is she going to tell Ms. Jimenez?

Then, Lilly remembers something from last night. Her mother had asked her to put away the food in the big blue bag by the front door. Is the big blue bag still there? With a mix of nervousness and anticipation, Lilly bolts to the front door to find the big blue bag nestled against her boots. But what's inside? Still nervous, Lilly slowly opens the bag. She breathes a deep sigh of relief upon seeing what's there: one big **squash** and an enormous **watermelon**. Phew!

To be continued...

Activity 5: Local Bee Diversity

An activity for middle school students

By **Green Teacher staff**

Overarching inquiry question: *How can local bee genera be supported?*

Preparation:

*Refer to the article *Learning about Wild Native Bees Using the Taxonomic Structure*, Pages 10–14. For each listed genus, there is information on (geographic) distribution and sources of pollen and nectar. Split the class into six groups, each responsible for a family of bees:

Andrenidae
Apidae
Colletidae
Halictidae
Megachilidae
Melittidae

*Each group must first identify based on distribution which genera within their assigned family are likely to be found in your region. These genera can be noted on the included table (Page 27 below).

*Next, for each genus likely found in your region, each group must identify and document their sources of pollen and nectar. This should also be noted on the following table.

*Each group must then find a listing of local native pollinator plants. Such lists could be available at a local farm, plant nursery, or garden center. There are also lots of resources online, such of Heather Holm's plant list posters on her website at https://www.pollinatorsnativeplants.com/plant-lists--posters.html. The listing of local native plants must then be cross-referenced with the table to which each group has contributed. The purpose is to find which plants (families, genera, and species) from the table listing of sources of pollen and nectar are also listed as local native pollinator plants.

*Each group shares their results with the rest of the class.

Application:

*Each group is responsible for designing a small pollinator garden plot that would be attractive to a wide diversity of local native bee genera. The garden plot must be plausible on the campus. Items to consider include the following:

-soil type (sand, silt, clay, loam)
-moisture levels (dry, mesic, moist/wet)
-daily shade (none, partial, full) *(Note that this can change throughout the year.)*

*Here are some tips for garden design:

*Use multiple layers (based on average plant height), with taller pants farther back in the garden. *(Note that plant height is often affected by growing conditions.)*

*Try to ensure that there are blooms at all times throughout the growing season; thus, be sure to plant spring-blooming, summer-blooming, and fall-blooming flowers.

*Diversify the colors of your garden. Even better, ensure that there is a diversity of colours at all times throughout the growing season.

*If planting in the ground is not an option on your campus, consider planting in containers.

Culminating event:

*Each group presents their garden plot design, detailing the plant species included as well as the bee genera that could be attracted to them.

Optional extensions:

*Choose one group's garden design and plant the garden! If financial and/or human resources are limited, start small.
*Tour your campus with an expert in local native plants to see what is already on site. Perhaps multiple bee genera already have numerous floral resources available to them.
*Visit an outlet in your community where local native pollinator plants are available. The staff at these places can be rich sources of information.
*Conduct regular biodiversity monitoring of your garden plot to document which bee genera visit it. A website like iNaturalist (and its increasingly accurate auto-ID function) could be a tremendous resource.

Resources:
Bees: An Identification and Native Plant Forage Guide by Heather Holm (2017)

Activity 5: Local Bees and Plants

Region: ______________________________

Bee Family: ___________________________

Bee Genus (Plural: Genera)	Sources of pollen and nectar (plants)

Activity 6: Rusty-patched Bumble Bee Conservation Status Simulation

An activity for secondary school students

By **Caitlin McCloskey** and **Beatrice Olivastri**

Overarching inquiry question: *Which factors are considered when determining the conservation status and conservation plan for a species at risk?*

Summary:

Nine stakeholder groups participate in a town hall meeting that consists of debates between four pairs of stakeholder groups. The central topic is the conservation of the Rusty-patched Bumble Bee (RPBB).

Roles:

Farmers The farmer group argues for the use of managed bees (causing pathogen spillover) and pesticide use (preventing them from becoming a certified organic farm). • The farmers group needs to produce food to feed their communities and pay their bills. • Monocultures and pesticides have degraded this bees' habitat and floral resources. • Farmers are tasked with evaluating farm practices and presenting a plan that can be adopted by farmers in the area to protect the RPBB.	**Miners or forestry company** (pollution and habitat degradation) • They contribute to the pollution (and climate change) of the area. The town's economy relies heavily on the profits from the mine. • How does clearcutting forests for timber impact the flora and fauna? What can be done to protect at-risk species?	**Land developers** (habitat loss and degradation) • Land developers need to build homes and buildings. • What they can do: Ensure that when choosing a site for new builds, habitat is left intact and not fragmented. • The town has an intensive downtown core with little vegetation. What can be done to improve bee habitats among urbanized areas? (e.g., bee corridors, avoiding fragmented landscapes)
Mayor of the town • S/he has conflicting objectives: need to develop the city and allow for growth while protecting the wildlife. • Farmers from the nearby orchard have come to the mayor to complain that decreasing bee populations are affecting their yield. • The mayor implements a new program, hiring students over the summer to hand-pollinate the orchards (emulating efforts seen in China and Ghana).	Student climate activists • They are outraged at the mayor's suggestion that hiring students to hand-pollinate the fruit trees is adequate action — students engage in debate with the mayor over the lack of action and the ridiculous suggestion of having kids hand-pollinate trees! • They are concerned about the impacts climate change is having on wildlife and thus advocate for the importance of addressing climate change.	COSEWIC scientists • The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (or equivalent if you are not based in Canada) student group presents the designation of the bee and an explanation of its importance to the ecosystem as well as to crops. • This group makes recommendations to protect the endangered species. • What kind of protections need to be put in place? How would those protections affect different members of the community?

Wildlife and environmental groups (naturalists)	Representatives for Traditional Ecological Knowledge (TEK) (AKA Aboriginal Traditional Knowledge)	**Federal or state/provincial government** *(Note: Maybe facilitated by teacher)*
• This group has noticed a decrease in numbers of their favorite bee species. This in turn has resulted in fewer birds and flowers in the area. • Environmentalists are deeply concerned about what they are observing in their community. • Environmentalists will think about how the decline of one species impacts the rest of an ecosystem and thus advocate for the protection of the bees.	• In accordance with the Species at Risk Act (2002), c. 2 (or equivalent if you are not based in Canada), in evaluating a species, COSEWIC must incorporate Aboriginal traditional knowledge into its assessment. • This includes convening a subcommittee that specializes in TEK. • COSEWIC must carry out its functions on the basis of the best available information on the biological status of a species, including scientific knowledge, community knowledge, and TEK. • Students in this group would represent the environment and the Rusty-patched Bumble Bee against interests such as logging, agriculture, and pesticide use.	• S/he acts as a mediator for all other groups and interests. • S/he must consider all interests and present a final solution that is put to a vote.

Core activity:

Preface

COSEWIC students are responsible for introducing the Rusty-patched Bumble Bee to the rest of the class — the threats and limitations the species is facing, their contributions to biodiversity and crop pollination. They will also explain what the purpose of the Species at Risk Act is and the role of COSEWIC.

Learning objectives

1. Understanding the importance of pollinators in the environment, and their contributions to the food we eat every day
2. Understanding the role of government in the protection and conservation of endangered species

Session 1

Students are grouped into their roles and give a short presentation introducing their interests and perspectives of their group to the class.
Students will be asked to consider their roles in the context of environmental, social, and economic contexts, as these competing interests all shape the ability or will to conserve and protect endangered species.

Learning objective

1. Understanding that issues surrounding conservation and the environment are multifaceted (This part of the simulation will expand students' ability to look at an issue from multiple perspectives. There are no right or wrong answers; each group has a valid set of interests and goals.)
2. Learning about how human society impacts the wildlife around us and environmental stewardship

Session 2

After each group has presented their roles to the class, the mayor's office will hold a town hall meeting. This is the time for students to engage in debates. Debates will be held between the following:

*The students and the mayor's office
Topics: Hand pollination, climate change

*The miners and forestry company and the representatives of Aboriginal Traditional Knowledge
Topics: Forestry and the impacts of logging and habitat degradation

*The farmers and the wildlife and environmental groups
Topics: Pesticide use and monocultures — impacts on wildlife

*The COSEWIC scientists and the land developers
Topics: Habitat loss and conservation

Learning objective

1. Understanding the various topics related to pollinators that will be presented and debated (hand pollination, climate change, habitat loss, pollution)

Optional extensions:

*Keeping in mind that there is no one-size-fits-all solution (i.e., no stakeholder group is likely to be completely satisfied), determine some policies for the conservation of the Rusty-patched Bumble Bee. These can be drafted collaboratively and voted on democratically.

*Write a report summarizing the proceedings at the town hall meeting.

*Discuss how this situation applies to your local community. Are there any unique factors that would need to be taken into account?

Possible adaptation

*If you live in a region where the Rusty-patched Bumble

Bee does not occur or did not historically occur, consider conducting a similar activity for a different bumble bee species in decline (e.g., Franklin Bumble Bee) or a different insect species in decline (e.g., Monarch butterfly).

Additional Resources:

Canada
Species at Risk Act: https://laws-lois.justice.gc.ca/eng/acts/s-15.3/page-1.html

Canada's three-year recovery plan for Rusty-patched Bumble Bee (2020):
https://wildlife-species.canada.ca/species-risk-registry/virtual_sara/files/plans/rs_rusty_patched_bumble_bee_e_final.pdf

Recovery strategy:
- Studies to identify critical habitat
- Identify activities likely to result in the destruction of critical habitat
- Decrease in pesticide use

A guide to your responsibilities under the Species at Risk Act:
https://www.canada.ca/en/environment-climate-change/services/species-risk-education-centre/your-responsibility/your-responsability-guide.html#toc7

Learning about the bill: Parliament simulation guide to learning about federal Acts: https://lop.parl.ca/About/Parliament/Education/CommitteeSimulation/sm-learning_about_bill-e.html

Film
A Ghost in the Making: Searching for the Rusty-patched Bumble Bee: http://www.rustypatched.com/the-film

United States
Endangered Species Act: https://www.fws.gov/sites/default/files/documents/endangered-species-act-accessible.pdf

Recovery plan for the Rusty-patched Bumble Bee: https://ecos.fws.gov/docs/recovery_plan/Final%20Recovery%20Plan%20_Rusty%20Patched%20Bumble%20Bee_2021.pdf

Recovery strategy:
1. Preventing further loss of populations by:
   - identifying and ameliorating the threats driving the declines
   - increasing the health of individuals and the number of colonies comprising populations
   - ensuring appropriate connectivity between populations
2. Ameliorating pervasive threats, including those from pathogens, pesticides, habitat loss, managed bees, and effects of climate change.
3. Buffering against catastrophes and environmental stochasticity (may require reintroduction into unoccupied areas within the historical range) by increasing the number of genetically and demographically healthy populations and the spatial distribution of those populations.
4. Buffering against novel changes in its physical and biological environment by restoring populations across the breadth of its natural adaptive diversity.
5. Protecting populations and their habitats and abating threats into the foreseeable future.

Books
Bees: An Identification and Native Plant Forage Guide by Heather Holm (2017)
Bumblebee Economics by Bernd Heinrich (2004)
Bumble Bees of North America: An Identification Guide by Paul Williams, Robbin Thorp, Leif Richardson, & Sheila Colla (2014)
A Sting in the Tale: My Adventures with Bumblebees by Dave Goulson (2014)

Appendix A: Background Information

Rusty-patched Bumble Bee

Canadian designation: endangered
https://wildlife-species.canada.ca/species-risk-registry/virtual_sara/files/cosewic/sr_Rusty%20patched%20Bumble%20Bee_0810_e1.pdf
American designation: endangered
https://ecos.fws.gov/ServCat/DownloadFile/120109
International Union for the Conservation of Nature (IUCN) designation: critically endangered
https://www.iucnredlist.org/species/44937399/46440196

Summary
The Rusty-patched Bumble Bee (Bombus affinis) is a generalist species that uses open habitats; it has been found in a variety of habitats, such as mixed farmland (cropping and livestock use), savannah, sand dunes, marshes, and urban and wooded areas. Rusty-patched Bumble Bees are generalist foragers, collecting nectar and pollen from a wide variety of wildflowers.

The Rusty-patched Bumble Bee was designated as endangered in Canada in 2010, endangered in the United States in 2017, and placed on IUCN's red list in 2014 with the status critically endangered.

Historically, the Rusty-patched Bumble Bee was broadly distributed across the eastern United States and Upper Midwest as well as southern Québec and Ontario in Canada. Since 2000, this bumble bee has been reported from only 13 states and one Canadian province: Illinois, Indiana, Iowa, Maine, Maryland, Massachusetts, Minnesota, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, Wisconsin (USA), and Ontario (Canada).

In the 1970s, the Rusty-patched Bumble Bee was relatively common compared to other bumble bee species. Dramatic declines were noticed by the mid-1990s in Canada and in the USA. In Canada, only three specimens were observed (one in 2005 and two in 2009) despite extensive targeted searches from 2005 to 2009.

Backgrounder on limiting factors and threats to the Rusty-patched Bumble Bee
The Rusty-patched Bumble Bee is at the northern limit of its range in Canada. Climatic variables such as snow cover, precipitation, and growing season length are likely important

determinants of suitable habitat for the species. Given that the Rusty-patched Bumble Bee is found only at high elevations in the southern part of its range, it is likely that the species is restricted to a narrow climatic niche. Williams et al. (2009) found that bumble bees with narrow climatic niches are more vulnerable to extinction.

The reason for the sudden decline of this previously common species throughout its large range is unknown. It has been hypothesized that the species suffered from introduced diseases from managed bumble bees used for greenhouse pollination.

The primary threats to the Rusty-patched Bumble Bee are the use of pesticides, particularly neonicotinoids, pathogen transmission and spillover, climate change and severe weather events as well as intensive agriculture, urban and suburban development, and road network development.

Agriculture and forestry effluents — pesticide use
Bumble bees are non-target species that can be adversely affected by pest and weed control programs implemented in the agriculture and forestry sectors. They can be poisoned by pesticides when they absorb toxins directly through their exoskeleton, drink contaminated nectar or gather contaminated pollen, or when the larvae consume contaminated pollen. Various life-history traits of the Rusty-patched Bumble Bee (such as large body size, early emergence, and long colony cycle) may make it especially vulnerable to accumulation of pesticides in the colony.

Pesticide of concern: systemic insecticides (such as neonicotinoids), non-systemic or contact insecticides, herbicides (such as glyphosate), and fungicides

Invasive/non-native species — pathogen transmission and spillover
Commercial bumble bee species and other bee species that are used in Canada for honey production and for pollination of fruit and vegetable crops can act as vectors of pathogens that are harmful to the Rusty-patched Bumble Bee. The increased use of imported bumble bees for pollination in greenhouses has been linked to the decline of bumble bee (Bombus) species, including the Rusty-patched Bumble Bee.

Climate change and severe weather
Climatic parameters, such as temperature and precipitation, have strong effects on the distribution and composition of bumble bee fauna. Many studies worldwide have indicated that climate change is contributing to the current declines in bumble bee species. The Rusty-patched Bumble Bee, which is believed to have a restricted climatic niche, may be especially sensitive to the effects of climate change in Canada, since bumble bee species tend to be more vulnerable to extinction if they have narrow climatic tolerances and are close to the limit of their range.

Intensive agriculture
The increased reliance on intensive agriculture has resulted in decreased quality foraging habitat for bumble bees in many countries. Intensive farming monopolizes large areas of land to grow plant species which, for the most part, have a very brief flowering period that does not meet the needs of bumble bees, which require a continuous succession of flowers throughout the colony cycle. Intensive agriculture has significant indirect effects, considering the widespread use of pesticides in intensive cropping systems.

Urban and suburban development
The Rusty-patched Bumble Bee's Canadian range is located in the most highly populated and urbanized regions of the country. Because of habitat loss and fragmentation resulting from urban development, the species may have greater difficulty finding the various types of habitats (nesting, overwintering, and foraging) it needs during its life cycle. Conversion of land for urban and suburban development continues to transform and fragment habitat, a situation that has likely had an adverse effect on populations of bumble bee species, including the Rusty-patched Bumble Bee. However, it is important to add that a variety of studies mention the existence of large populations of bumble bees in components of the urban landscape where there is an abundance of flowering plants (e.g., community and botanical gardens, urban wild areas, flower beds containing native or non-native flower species, managed or natural urban parks, green roofs). Urban habitats could support large populations of bumble bees and could play a valuable role in bumble bee conservation.

Special significance of the species
The Rusty-patched Bumble Bee is in flight for a longer period than are most other bumble bees, and it visits numerous plant genera in many habitat types. Thus, it is likely an important pollinator of both agricultural crops and native flowering plants. The loss of this species may result in increased vulnerability of native mammals, birds, and other organisms which rely on pollinated plants for food and shelter. This species has also been used in the past for scientific study, as it is easily reared in captivity and has become an important reference species for research in physiology and sociobiology.

Factors contributing to decline and risk
Pathogens, pesticides, habitat loss and degradation, climate change, small population dynamics