

Native pollinator observation and monitoring

A pilot project

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1 — Introduction

1.1 Background on native pollinators

Our initiative aims to develop and promote quantitative monitoring of native pollinators in collaboration with ecological farmers and engaged citizens. Our objective is to initiate a citizen science network in Ontario that tracks the diversity and abundance of native pollinators, promotes knowledge and awareness of native pollinators, and ultimately supports the protection of these and other insects in a diverse landscape.

Native pollinators and their role in pollination

Wild pollinators deliver a significant but unknown share of pollination services to agriculture [1, 2, 3]. A recent article published in *Science* points out that flower visitation by wild insects showed a universally positive impact on all 41 fruit crop systems that were examined worldwide [7]. In contrast, only six of these fruit crops responded positively to flower visitation by honey bees [7]. For horticulture crops such as watermelons and tomatoes, studies indicate that honey bees are less effective than native bees [4]. Farmers perceive the same for blueberries [9]. Thus, while honeybees are important, it is clear that native pollinator species are critical for plant productivity. In Ontario, almost all ecological farms and many larger organic vegetable farms almost exclusively rely on native pollinators to provide pollination services for their crops (e.g. Pfennings, Zephyr Organics) [8]. With much uncertainty remaining, it is apparent that native biodiversity increases the resiliency of our food system; rich pollinator biodiversity helps compensate for environmental stresses and also landscape degradation across scales. Diverse native pollinators thus increase the resilience of pollination services for agriculture and nature [6].

Decline of honeybees and wild pollinators

There is clear evidence of recent declines in both wild and domesticated pollinators, and parallel declines in the plants that rely upon them [10, 11, 12].

Neonicotinoid pesticides are most widely cited as causes for this decline. The direct toxicity of concentrated dusts and spray from such pesticides has long been acknowledged, and farmers aim to minimize the exposure with their application practices. Recently, evidence is growing that there are sub-lethal dosage impacts on the long-term survival of honeybees. For example, Chensheng and his colleagues from Harvard University [13] recently showed how very low dosages of neonicotinoid pesticides hardly impact the survival of honeybees during summer, but cause high death rates during winter. Other research indicates that native pollinators are even more susceptible to neonicotinoids. For example, while colony-building honey bees may be able to deal with a loss of 20

Ontario's honey bee industry is being hit hard by mass dying of honey bees. The Ontario Beekeepers' Association names neonicotinoid pesticides as a significant contributing factor. The Ontario Ministry of

Agriculture and Food (OMAF) formed a working group that includes equipment manufacturers, seed companies, grain farmers, the University of Guelph, Bayer Crop Science, CropLife Canada, Syngenta, several government agencies, and beekeeper representatives in an attempt to arrive at a consensus on actions to take regarding neonicotinoids. This stakeholder group could only come to a consensus on a few immediate actions, but large gaps in opinion remain between beekeepers, chemical input suppliers, and farmers on the action to be taken [15]: “The thirteen options for action include improvements to growing practices and communications, environmental enhancements, technology advancements and training as well as regulatory approaches. Where consensus was reached, government and industry have collaborated extensively and taken action to implement those options.” (Executive Summary). OMAF is performing additional research to map risks for crop exposure to pests and economic costs of abstaining from the use of neonicotinoids [16]. This research may lead to actions in line with the minimum-action demand of the Xerces Society for Invertebrate Conservation [14], who recommends returning to integrated pest management practices where pesticides are only applied if high pest pressure is present, instead of generally coating all seeds pre-emptively across our landscapes [17]. In 2013, Europe decided to implement a two-year total moratorium on the most common neonicotinoid pesticides, but it remains open which other alternatives European farmers will find to curtail damage from pests.

Pesticides are not the only causes of pollinator decline. Habitat destruction, for example the removal of hedge rows and the loss of native plants and plant diversity, are additional drivers for their decline. Introduced pests such as the varroa mite (*Varroa destructor*) and the diseases they vector are spreading and causing major problems for honey bees. Adverse effects from pesticides are thus only one aspect of concern that reflects the realities of our complex food system.

The situation in Grey Bruce

Grey and Bruce Counties are the home to many beekeepers and harbour many large natural areas, pastures, hedge rows, wetlands, and forests within their boundaries. The most recent data from Statistics Canada from 2011 indicate that a beekeeper in Ontario owns an average of 32 hives [18], whereas our area is home to a number of larger commercial beekeeping operations, whose hives number in the hundreds. The overall good performance of beekeepers in the watersheds of Bighead River, Grey Highlands, and the Bruce Peninsula can partly be attributed to their remoteness, but also to the skill, care, and caution that characterizes our local bee keepers.

Little is known about the state of native pollinators in this area, but it is likely that there is a steep gradient depending on the diversity of landscape and the existence of foraging and nesting habitat. Also, with the conversion of pasture-based landscapes into grain and oil seed crops, changes in honey bee, native pollinator, and other animal populations can be expected. However, at this point no one is even looking at these changes.

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1.2 The Project "Native pollinator observation and monitoring"

Project goal

This project proposes to win citizens who already have experience in nature observation to become stewards for native pollinators. We seek to identify and develop a strategy that successfully monitors the state of our native pollinator populations as a citizen science project, not unlike the annual Christmas bird counts that birders engage in, or the amphibian and reptile counts of road kill.

Our target group includes ecological farmers and community groups. Ecologically-minded farmers not only spend considerable time already conducting field observations of their plants, but also have a strong interest in maintaining and improving pollinator health. From a scientific monitoring perspective, these farmers remain at the same location for a long time, which promises continuity and good return on

investment for their education about pollinators. At the same time, community groups such as schools, conservation groups, community gardens, and garden clubs have large networks and may have more time at hand for observation and monitoring tasks, and even for the development of a robust but easy monitoring method that is the objective of this pilot project. Ultimately, we see education for ecologically interested farmers and community groups as strategy to win a strong partner and advocate for native pollinators.

For the 2015 season, Ontario Nature has expressed great interest in supporting a farmer-led initiative on pollinator observation with their expertise in citizen science, data analysis, and funding. To build a meaningful partnership between farmers and conservationists, the 2014 pilot season aims to build capacity and experience within the farming community in what works for them, as well as collecting initial data to help refine the project in its next stages.

Pilot project actions

With the interest and financial support of ten ecological farmers, this project was initiated and a set of pollinator monitoring options were gathered from other citizen science projects. For 2014, the main goals are capacity building, habitat assessment, and testing of selected monitoring approaches by collaborating with two groups, in order to develop a protocol to observe and monitor the state of our native pollinators:

1. Ecological farmers with a focus around Southwestern Ontario, and
2. Community groups (garden clubs, schools)

The first activity was a workshop on April 14th, 2014, where ideas were discussed with leaders of the ecological farming community, and the project received further direction. This strain of action will continue within the internship program of the CRAFT network, as well as with the Ecological Farmers of Ontario, with whom we submitted a grant proposal.

We hope to find resources that will help our expert travel to all participating farms and perform habitat assessments, as well as data analysis of all monitoring data that we generate with our participants.

In Grey Bruce, we recently received grant funding from the TD Friends of the Environment to help embark on the 2014 pilot project. Proposed activities are to replicate the monitoring activities that are being conducted by ecological farmers, but working specifically in Grey Bruce with community, youth groups, and the interested public. The purpose of this work is to raise awareness of native pollinators and the threats they face, and also to test the monitoring strategies that are being developed with the ecological farmers.

Partners

The project is executed in collaboration with the Ecological Farmers of Ontario Visit EFAO, the Collaborative Regional Alliance for Farmer Training in Ontario Visit CRAFT, and the Grey Sauble Conservation Authority Visit GSCA.

Acknowledgement

Seed funding was provided by 10 farmers See Participating Farmers. Without their encouragement and financial donations, this project would not have happened. Also, we are grateful for funding provided by the TD Friends of the Environment Foundation, who enable us to purchase many of the workshop materials, plants, and print materials. Thank you!

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1.3 Monitoring options: Summary

This page lists options for observing and monitoring native pollinators. The methods vary in objective and level of involvement. We differentiate three main objectives:

1. Measuring pollination success.
2. Observation and counting of pollinator diversity and abundance.
3. Colonization of nesting habitat.

Please find examples for each of these below!

Measuring pollination

This section focuses on determining pollination success by measuring the percentage of flowers that are successfully pollinated relative to the total number available. The approach focuses on the outcome (pollination) rather than the details involved in the process, such as the identity and diversity of the pollinator community responsible for pollination. It is somewhat similar to monitoring birds by measuring how long it takes until a bird feeder is empty. It gives neither information about the diversity, nor the types of pollinators, but indicates areas where plant productivity has become limited due to a lack of pollination success.

The purplestem aster

The purplestem or swamp aster (*Symphotrichum puniceum*) flowers in its second year in late summer and produces seed heads containing about a hundred seeds each. In comparative experiments, it was determined that: (a) it is relatively easy to distinguish pollinated from unpollinated seeds, and (b) partial pollination of this species indicates lack of pollinators. Pollination is quantified during the seed stage, so this experiment will take time before results can be evaluated.

Clover flowering duration

Red clover (*Trifolium pratense*) and white clover (*T. repens*) are common and easily established cover crops where pollination success can be observed even during the flowering stage. Each clover flower consists of multiple florets that are pollinated independently. With little practice, it is easy to distinguish: (a) florets that have not yet opened, (b) open florets, and (c) finished florets that turn brown immediately after pollination. This experiment covers a number of flowers with cages to prevent pollination, then removes the cage for a determined length of time and replaces the cage. Participants then count the percentage of florets that are pollinated, which are identified by their brown colouration. Results are available after few days.

Field transects and pollination intensity

In a large field, pollination can diminish from the edges toward the center if there are not sufficient pollinators. Pollination is crucial for successful plant productivity. As a result, complete pollination across fields is of great interest to farmers. One useful way to compare pollinator density and determine pollination success for a crop of interest is to observe pollinators as you move from field to adjacent natural areas. Using a transect method, participants may perform stationary pollinator monitoring at a series of locations of uniform distance from one another, moving from natural area to crop.

Observation and counting of pollinator diversity and abundance

Specific observation and counting strategies generate data that can be compared across habitats, geographic regions, and correlated with other factors such as land use type and insecticide use. Observations can be taken at different levels of comfort of the observer. This ranges from major classification (bee, wasp, fly, beetle, butterfly, moth) to more specific identification (species or pollinator type - e.g., sphinx moth, sweat bee, etc). Observation is also a good starting point to understand and recognize the diversity of pollinator insects, and to those who embrace it provides a moment of peace after a busy day.

The Great Sunflower Project

During the flowering time of a sunflower (Lemon Queen), participants conduct a 15-minute observation period on a weekly basis to identify and record the pollinators visiting the sunflowers. This strategy replicates a successful citizen science project that was first established in 2007 by Stanford University Professor Gretchen LeBuhn as a way to involve citizens in the monitoring of pollinators in their backyards. The project has grown to more than 100,000 volunteers across North America and has generated invaluable data about the distribution of bees and other pollinators across the continent, and the effects of pesticides on pollinators.

Squash bee counts

Squash bees are a native bee that is the best pollinator for pumpkins, squash, zucchini, and other members of the cucurbit vegetable family. These solitary bees are ground nesters and generally represent a fairly healthy ecosystem. To quantify the abundance of squash bees, we will examine 100 flowers and count all squash bees that are present, with five repetitions per field. To be comparable, this experiment will take place in the second week of August across the province, between 8:00 – 9:00 AM.

Walking transects

In contrast to stationary observation, it is also possible to survey a greater area if a travelling observation approach is utilized. With this approach one can walk through an environment of interest, stopping at predetermined time intervals, target a particular flowering plant across space, or one can scan the flowers while walking and stop for observation when a pollinator is detected.

Photography

Pollinators are beautiful and extraordinary creatures! As such, they make wonderful subjects for avid photographers. Though it can be challenging to capture the perfect image of small insects on the move, photographs can be invaluable resources for identifying pollinators. Participants can target a focal group of pollinators or plant species, or can combine photography with a standard observation monitoring protocol, but photographs will be aggregated and an expert entomologist will assist when needed to identify the species captured in the images.

Microscopy and pollen

By enhancing a smartphone with readily available lenses, participants will construct their own microscope for approximately \$10 and half an hour of shop time. Participants can either then set up a small insect trap and take magnified photographs of the specimens in the trap. Such "kill-based monitoring" is the only method that can also quantify nocturnal and very small pollinator species which are not observable visually. Based on your photograph, internet websites exist that help you identify your pollinator species.

Alternatively, the magnification is good enough to observe pollen and pollen variety. Pollen from different plants can be distinguished with some practice, and allow estimating foraging range of bees.

This monitoring option is most suitable for ambitious science classes.

Group specific monitoring

Plants are pollinated by an incredibly diverse and beautiful suite of insects: ants, bees, beetles, butterflies, moths, and wasps all contribute pollinator services to a variety of flowering plants, shrubs, and trees. However, not all species provide the same degree of pollinator services to plants, and different pollinators exhibit preferences for pollinating particular types of plants. Furthermore, pollinators may also vary in the time of day and temperature range within which they will fly, as well as the distances they will fly, and the resources they are gathering from plants. Participants with an interest in a particular group of pollinators may choose to monitor and observe that group in particular. Depending upon the group of interest, participants will need to target the plant species observed as well as the time of day of the observations, depending upon the focal pollinator group being monitored. This allows an individual to gain a deeper knowledge about one particular component of the pollinator community, and may also allow for more specific levels of identification than possible when observing all pollinators.

Colonization of nesting habitat

If nesting habitat is available, it may attract pollinators from the surroundings who are looking for nesting space and find that material adequate. The colonization of empty habitat indicates that there is a population seeking it, either because they expanded, or because they were displaced from other habitat. By providing a number of nesting spaces and monitoring the colonizing species, we can learn about the diversity and abundance of pollinators.

Bumble Bee boxes

Bumble bees have been shown to dramatically improve pollination for a number of vegetable crops grown in greenhouses—particularly tomatoes—but these commercial pollinators harbour diseases that native bumblebees are susceptible to. Bumblebees are fairly flexible in their choice of nesting locations; they seek a roughly shoebox sized cavity, and will often establish nests in old rodent burrows, or in clumps of tall grass that have dried and toppled in the fall. However, bumblebees can also be coaxed into using a variety of human created nest boxes that can also allow for nest observation and monitoring. By constructing and monitoring artificial bumblebee nest boxes, it allows an unprecedented opportunity to observe bumblebee nest development throughout the season of the colony. It also allows for the possibility of identifying the bumblebee species present and nesting in the area, and allows for monitoring for the endangered rusty-patched bumblebee.



2 — Monitoring abundance and diversity

2.1 Introduction

Specific observation and counting strategies generate data that can be compared across habitats, geographic regions, and correlated with other factors such as land use type and insecticide use. Observations can be taken at different levels of comfort of the observer. This ranges from major classification (bee, wasp, fly, beetle, butterfly, moth) to more specific identification (species or pollinator type - e.g., sphinx moth, sweat bee, etc). Observation is also a good starting point to understand and recognize the diversity of pollinator insects, and to those who embrace it provides a moment of peace after a busy day.

2.2 The Great Sunflower Project

Background

The great sunflower project was first established in 2007 by Stanford University Professor Gretchen LeBuhn as a way to involve citizens in the monitoring of pollinators in their backyards. Since that time, that project has grown to more than 100,000 volunteers across North America and has generated invaluable data about the distribution of bees and other pollinators across the continent, and the effects of pesticides on pollinators.

The basic premise of the initial project was to provide seeds to all volunteers of a single sunflower variety, Lemon Queen, to be planted in the gardens of participants. Once the sunflowers begin to flower, participants conduct a 15-minute observation period on a weekly basis to identify and record the pollinators visiting the sunflowers. Because the variety and species of plant used is held constant, the data generated can then be compared across habitats, geographic regions, and correlated with other factors such as land use type and insecticide use.



Figure 2.1 — *The lemon queen sunflower*

Protocol/Monitoring

Participating in the great sunflower challenge allows us to compare the species diversity and density of plant pollinators to that of other geographic regions, as well as to be able to compare across our locations within southern Ontario. This will provide invaluable data with regard to areas of particular conservation interest, as well as identifying whether particular locations may benefit by employing strategies to boost pollinator nesting and foraging habitat.

Sunflower project protocol

- Lemon queen sunflower seedlings will be provided to project participants.
- Plants will be planted and then tended as necessary.
 - Plants require full sun
 - Plant spacing: 15 inches apart
 - Plant height: 5-8 feet
 - Bloom duration: 6 weeks

Sunflower observation

1. Once flowers begin to bloom, plants are monitored once weekly for 15 minutes.
2. Environmental data to record:
 - (a) Date
 - (b) Time of day monitored
 - (c) Temperature
 - (d) Weather (Sunny, cloudy, precipitation, wind)
 - (e) Number of flowers observed
3. Pollinator observation
 - (a) Pollinator identification to the level of comfort of the observer. This ranges from major classification (Bee, wasp, fly, beetle, butterfly, moth) to more specific identification (species or pollinator type? e.g., sphinx moth, sweat bee, etc).
 - (b) Quantification- the number of individuals of each pollinator observed should be documented.

2.3 Pollinator Observation and walking transects

Background

Plants are pollinated by an incredibly diverse and beautiful suite of insects: Species of ants, bees, beetles, butterflies, moths and wasps all contribute pollinator services to a variety of flowering plants, shrubs and trees. However, not all species provide the same degree of pollinator services to plants, and different pollinators exhibit preferences for pollinating particular types of plants. Furthermore, pollinators may also vary in the time of day and temperature range within which they will fly, as well as the distances they will fly, and the resources they are gathering from plants. Therefore a large degree of variation in the pollinator community may be observed depending on where and when one observes pollinators.

Observing pollinators is the only way to identify the major pollinators present and active in a given location without the use of traps. This allows the pollinators to remain in the wing while still gathering information about how many species of pollinators are present, their identity, abundance, and the plants being visited. These observations will allow us to compare pollinator diversity and abundance across different habitat types, microclimates, and geographic areas.



Protocol/Monitoring

There are a number of approaches that can be taken to conducting pollinator observations, which fall into two broad categories: Stationary observation is conducted by observing and documenting all of the pollinators visiting a particular plant or area for a standardized unit of time, often a 15 minute observation period is chosen. Traveling observation is accomplished by observing pollinators while moving (this can be hiking in a new location or by repeated surveying pollinators during a walk around one's farm or property).

Observational strategies can also focus on examining how pollinator communities vary as temporal or seasonal factors also change in a single location, for

- Temporal Observation
- Seasonal Observation

Pollinator observation protocol (weekly)

1. Choose observation type that you are interested in completing: (Stationary observation, traveling observation).
2. Choose observation study type:
 - (a) *Taxon specific*: Focusing on a particular group of pollinators (ants, bees, beetles, butterflies, moths, wasps).
 - (b) *Temporal observation*: observing pollinators at multiple 15-minute intervals throughout the day. This includes evening observations if interested! This is the time to observe our moth pollinators!
 - (c) *Plant specific monitoring*: this includes the sunflower project, but in addition to sunflowers, a particular native flowering plant or crop plant species of interest can be chosen for observing pollinators for this species.

- (d) Transect monitoring: Observing pollinators as you move from one environment to another by making 15 minute observations at measured distances as you transition from one habitat to another (e.g., meadow to cultivated field).
3. Environmental data to record:
- (a) Date
 - (b) Time of day monitored
 - (c) Temperature
 - (d) Weather (Sunny, cloudy, precipitation, wind)
 - (e) Identity and number of flowers observed
4. Pollinator observation
- (a) Pollinator identification ?to the level of comfort of the observer. This ranges from major classification (Bee, wasp, fly, beetle, butterfly, moth) to more specific identification (species or pollinator ?ype? e.g., sphinx moth, sweat bee, etc..).
 - (b) Quantification- the number of individuals of each pollinator observed should be documented.

POLLINATOR MONITORING DATASHEET (Sunflower, open observation)

Instructions: 1. Fill out top of data sheet; 2. Set timer for 15 minutes, and when ready hit start; 3. Note any floral visitors you see and identify to your confidence level; 4. Fill out remainder of top of datasheet; and 5. Make additional notes about the site.

Site Name: _____ **Date:** _____ **Observer:** _____

Observation start time: _____ **Observation end time** _____

Weather at start: Shade temp C) _____ **Wind (m/s):** _____ **Sky: clear/partly cloudy/bright overcast**

Weather at end: Shade temp C) _____ **Wind (m/s):** _____ **Sky: clear/partly cloudy/bright overcast**

Visitor Categories:

Type = Honey bee, Other Bee, Fly, Wasp, Moth, Butterfly (add type if you know!), Spider, Beetle, Bug, Bird,

Ant, UFI (Unidentified flying insect)

Bee Groups (in brackets: common descriptions) _____

Honey Bee = HB

Carpenter = Carpenter

Hairy Leg Bee = HLB

Green Sweat Bee = Green Sweat Bee

Cuckoo Bee = Cuckoo (red abdomen/small/large)

Bumble bee = Bumble (black face/yellow face/orange tip/four stripe/yellow body)

Striped Sweat Bee = SSB (small/medium)

Tiny Dark Bee = TDB (dull round tip/shield tip/yellow face and wasp-like

Striped Hairy Belly Bee = SHBB (tiny/small/medium)

Metallic Hairy Belly Bee = MHBB (blue/black/green)

OBSERVATION

Important: Remember to look out for flowers, stand so that you do not cast a shadow, and only ID floral visitors to the level at which you are confident in your identification

Pollinator Type	# of times pollinator seen on bloom	Description	Plant Identification
TDB	3		Swamp aster
Butterfly	1	Orange with black patterns, white checkerboards on tip of wings	
UFI	1	Black, hairy, 2m high, growls at me	Raspberry

2.4 Squash bee monitoring

Background on squash bees

Squash bees (*Peponapis pruinosa*) are solitary, ground nesting bees that forage for pollen and nectar from flowering plants in the genus Cucurbita (summer and winter squash, pumpkins). Often nesting in untilled field margins or nearby unvegetated fields adjacent to squash crops, these bees provide critical pollination services to farmers growing cucurbit crops (see photograph 2.2).

Squash plants produce separate male and female flowers that require insect pollination for successful fruit development. Although honeybees and bumblebees will also visit squash flowers to some degree, it is not their preferred forage, leaving most of the squash pollination provided by squash bees. Squash bees collect both the nectar and the protein-rich pollen that is fed to their developing larvae. Squash bees also court and mate within squash flowers. Male bees can be found sleeping in the flowers that have finished blooming.

Squash flowers open in the early morning, and last only 5 - 6 hours, after which they will close and wilt, with the plant's next offering of open blooms provided the following morning. As a result, squash bee activity on the flowers is often at its peak shortly after the blooms have opened for the morning. Therefore it is important to conduct any observational or monitoring activities of these pollinators in the morning hours.

Farmers should keep in mind that squash bees are ground nesters who lay their eggs into caves built into open soil/sand, with a depth of approx 6 inches. Deep tilling and plowing will destroy these nests and interrupt the annual regeneration. Nests look similar to ant nests, but are generally more compact and lack ant traffic. If you find squash bee nests on your farm and want to preserve population, make leave soil horizons at depth of 5 inches and more undisturbed. Furthermore, squash bees tend to return to successful nesting sides in the next years.

Squash bee identification

Squash bees can be confused with honey bees - they have similar size, similar form, similar coloration. Two features distinguish them:

1. Their abdominal colouring is a little stronger black and white, especially the males are fairly whitish. But with pollen sticking all over them, and shading, that can be tricky to see.
2. The hind legs of honey bees are flat, and honey is collected only in one little area where it clings. Squash bees have round hind legs that are much more hairy, and pollen sticks to the whole leg. Male squash bees don't need to collect pollen and have no hair on their hind leg.

What is much easier to spot are behavioral differences. Squash bees are ground-nesting and solitary bees. They hang out in pollinated squash flowers at night, and male squash bees linger in opening flowers during the early morning - and that is how you can catch them!

Here is a video that helps you distinguish squash and honey bees: <https://www.youtube.com/watch?v=a2UcgRx9ugE>

This video is for distinguishing male and female squash bees (for the advanced): <https://www.youtube.com/watch?v=7hk3E2NeABY>

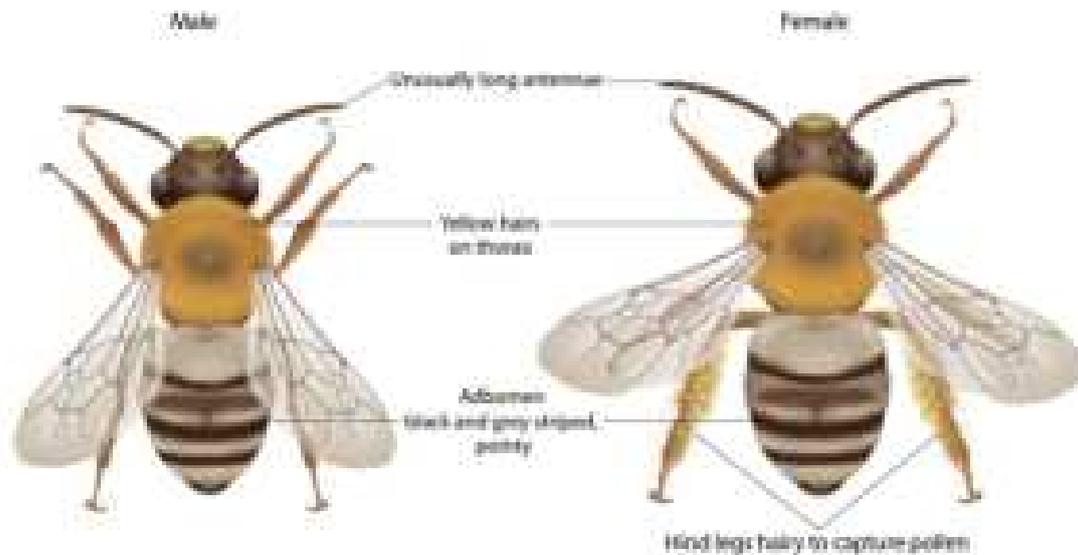


USDA, from commons.wikimedia.org

Figure 2.2 — Squash bee *Peponapis pruinosa*

Squash Bee Monitoring Protocol

To determine the presence and abundance of squash bees in Cucurbit fields will be accomplished using a replicated transect method. Because mating time for squash bees in this area is at its peak in early August, we will conduct our survey in the 2nd week of August, 2014. Also, because of the morning blooming of the flowers, observations will be conducted between 8:00-9:00 am when squash bee flower visitation is at its greatest.



SOURCE: *The Pollination System of Pumpkin, Squash, Summer Squash, and Zucchini.*
 By Susan Chan, M.Sc. Copyright Farms At Work (available at <http://farmsatwork.ca/>)

Figure 2.3 — Male and female squash bees

1. Five transects (straight lines in the field from the edge into its centre) are identified and marked within a squash/pumpkin/zucchini field. Length and distance between transects will be determined by field size, but should be laid out so that observation has been distributed throughout the field area.
2. Environmental data to record:
 - (a) Date and location
 - (b) Observation start and end times.
 - (c) Temperature and weather (sunny, cloudy, precipitation, wind)
3. For each transect, 100 squash flowers will be observed. For each flower observation, we will determine:
 - (a) Squash bee presence/absence and the total number of squash bees per flower;
 - (b) Number of male and female squash bees. Females are larger and have hairy legs for pollen collection (see Figure 2.3 for male and female squash bee comparison).

!!! Beginners may not be able to distinguish male and female squash bees, it takes a bit of practice. In this case, you can still count the total number. For sexes, try your best and note down whether you feel comfortable with the distinction or not.

IMPORTANT!

This experiment is best conducted during early hours (morning before 9:00 AM) and with warm and sunny weather. Also, if you don't see anything, that is also a good result - please send us your sheet anyway!

Please send this page (even if you did not see any!) and, if you filled it out, the pollinator habitat assessment, to this address:

Thorsten Arnold, Grey Bruce Centre for Agroecology,
#241063 Concession Rd 3, RR3 Allenford, ON, N0H 1A0

SQUASH BEE MONITORING - DATA SHEET

Name of Farm: _____

Monitoring date: _____

Observer: _____

Observation site Name (Field ID): _____

Record before start:

Observation time Time start observation: _____
Weather at start: Shade Temp (°C) : _____
 Wind (Beauford Force) : _____
 Sky (underline) : Clear / partly cloudy / bright overcast

Transect ID	Observation duration	Number of flowers visited	Squash bee count		
			Males	Females	Total

Record after end of observation:

 Time end observation: _____
Weather at end: Shade Temp (°C) : _____
 Wind (Beauford Force) : _____
 Sky (underline) : Clear / partly cloudy / bright overcast

2.5 Pollinator Photography

Pollinators are not only important to us for the food they help us produce, but their diverse colors, textures and those of the flowers they visit make them wonderful subjects to photograph. While capturing the perfect image of small insects on the wing may be challenging, these photographs can serve as invaluable resources for identifying pollinators and their plant hosts without having to kill and collect specimens. For this project, we are seeking participants to combine either stationary or traveling pollinator observations with a catalog of photographic images of the pollinators they encounter. If interested in a particular group of insects, participants can choose to photograph a focal group of pollinators or those that visit a particular plant species. Images will then be submitted along with the related environmental data to be aggregated into a gallery of native pollinators of Southern Ontario. Bees, butterflies and other pollinators are small and busy moving from flower to flower in search of the nectar and pollen that they seek. As such, it can be difficult to capture clear photos. However, there are several components that make pollinator photographs useful and beautiful:



Figure 2.4 — *A good photograph of a bumblebee that gives good vision to all body parts*

- *Focus:* Make sure that the subject is in focus.
- *Size:* Compose the photo so that the pollinator is large enough so that the key characteristics can be viewed.
- *Lighting:* Choose overcast, cloudy, or filtered light for best images. This is not mandatory, and there may be instances where sunny days provide the best chance to capture pollinator images.
- *Flash:* Using flash can help with both insect behavior and color enhancement.
- *Staging:* It may be easier to first scan the area to determine what flowers are being visited, and then choose a flower ahead of time, adjust camera settings, and then wait for visitors to come to you.
- *Angle:* In order to successfully identify the species, it is ideal to take multiple photographs of the subject from different angles. Taking an image of the dorsal view (from above) is of greatest utility, particularly with wings open. If additional angles can be taken, capture images of the profile as well.
- *Shoot first and edit later:* In the era of digital photography, we are lucky that we can view the images without having to print them first. As such it is recommended that you take as many photos of the target images as you can in attempts to capture the focus and angle you desire. If your camera has a burst setting function, it may be useful to experiment with this feature.
- *Plant species:* Identification of plant species can be helpful in some cases to identify the pollinator, and are often beautiful components of the image. If possible, include detail of the flower to enable plant species identification. It is also desirable to take additional photos of the plant species to capture additional detail that it may not be possible to obtain in the pollinator – focused photo.

Photography Protocol Details

1. Fill out Monitoring Datasheet before beginning observation session. Fill in all relevant location and record requested environmental data at beginning and end of session.
2. Conduct either stationary or traveling monitoring protocol based on participant choice and follow relevant protocol for data collection (see protocol sheets for pollinator observation and monitoring)
3. Try to capture pollinator in image from dorsal and side views.
4. Take additional photographs of plant species as well so that both pollinator and plant species can be identified.

We recommend two excellent website for more tips and tricks for taking photographs of pollinators:

- <http://beespotter.mste.illinois.edu/topics/photos/>
- <http://bumblebeewatch.org/contents/photo-tips/>

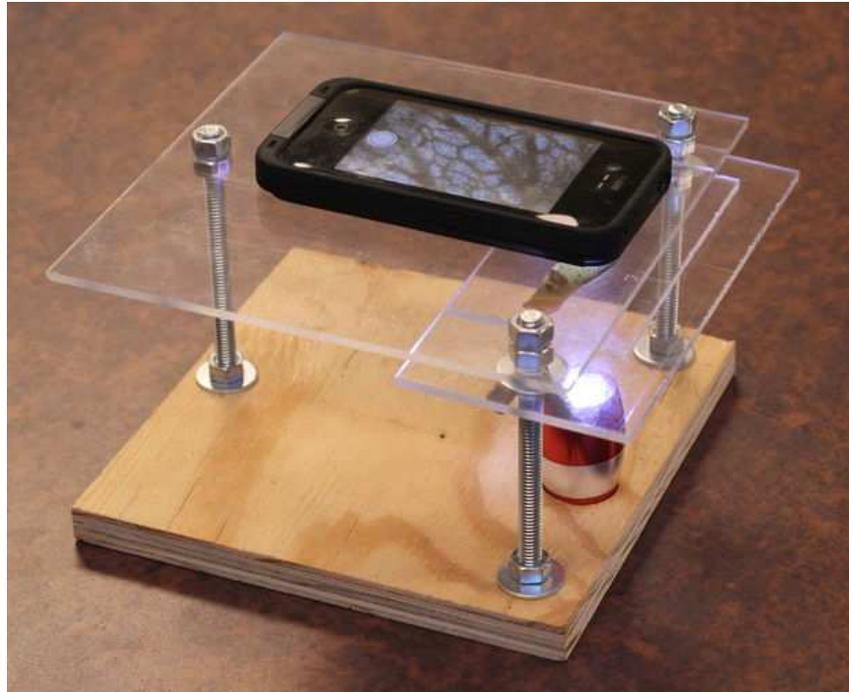
If you have made a good photograph in the region of Southern Ontario and/or Grey Bruce, please sent this photo to thorsten.arnold@gbcae.com. We are starting to build up a collection of photographs that are specific for this area, and your photo will support this effort.

If your photo is a bumblebee, you may also submit your picture to <http://bumblebeewatch.org>, who specifically monitor bumble bees in Canada and offer great resources about bumblebees.

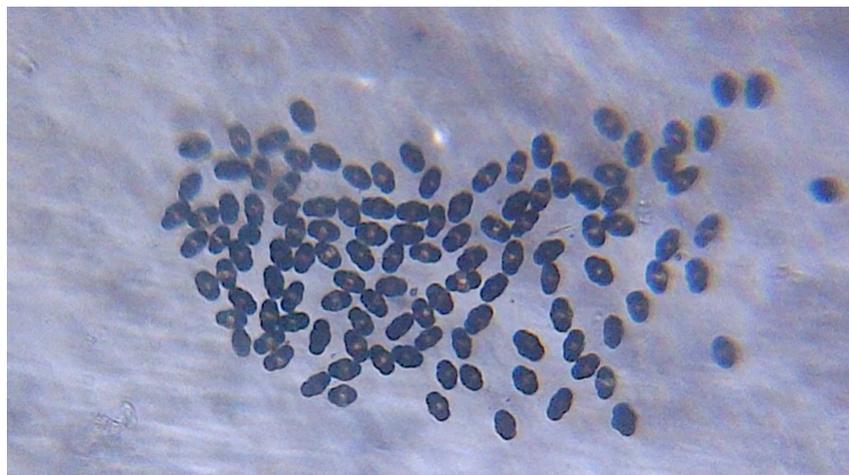
2.6 Microscopy of pollen

One interesting idea for citizen science was to build a cheap, smartphone-based microscope with participants, and use it to photograph pollen in honey. This idea is more realistic than it sounds: we followed instructions from the website Instructables (<http://www.instructables.com/>) and built what is called the \$10 microscope (Figure 2.5, <http://www.instructables.com/id/10-Smartphone-to-digital-microscope-0>). Indeed, the design allowed us photographing pine pollen at fairly good resolution using the two lenses aligned (Figure ??). The price, unfortunately, only is valid if building several microscopes because plexi does not come in the required size.

Due to time constraints, we have decided not to pursue this further within the pilot year. If individuals are interested in looking at pollen, e.g. in their honey samples, we'd be delighted to share our experience.



SOURCE: *\$10 Smartphone to digital microscope conversion!* (instructions available at <http://www.instructables.com/id/10-Smartphone-to-digital-microscope-conversion/>)



Pine pollen at 400 times magnification (Photo: Thorsten Arnold)

Figure 2.5 —



3 — Monitoring Pollination Deficit

3.1 Introduction

Monitoring pollination of floral plants is like measuring bird abundance by observing how long it takes until the feeder is empty – it gives little information on what type of pollinators are active, their diversity, or their total abundance. With decreases in diversity and abundance, pollination will continue to stay reasonable for a good time even though the ecological system may already have become vulnerable and little resilient. At the same time, farmers are ultimately concerned with crop pollination because it determines their yields. Pollination will decrease in areas where pollinator declines are already far advanced, in large fields where field size exceeds foraging distances of pollinators, or in areas with unbalanced bloom where a single blooming crop requires large populations of pollinators that are otherwise not sustained by surrounding habitat.

Two aspects are important when choosing a plant to measure pollination: (1) self-compatibility and (2) pollinator specificity, and (3) reproducibility:

1. Pollination only gives insights into insect populations if plants actually require insects to move pollen from one flower to the other, and not on wind pollination. Some plants that are self-incompatible and rely on cross pollination by insects. Examples are the cucurbit family (squash, melons, cucumbers), some cover crops (vetch, clover), berries and fruits, and many flowers (sunflowers, asters, etc). Other plants that require insect pollination are radishes, carrots, parsnips, dill or fennel. This group of crops however only blooms in their second year, so pollination is only critical for seed producers. For many other crops, cross pollination improves yields and crop quality in a way that is hard to pin down on insect pollination alone.
2. Pollinator specificity is a second concern when measuring pollination. Even for obligate cross pollinators, pollination only indicates those insect populations that are relevant for pollination. For example, squashes can only be pollinated by long-tongued bee species. For these, squash bees, bumble and sweat bees are far more successful pollinators than honey bees, and farmers are well advised to promote habitat for such species. The small flowers from carrots and dill are preferably by-passed by long-tongued insects but are preferred by flies, wasps, and small sweat bees. Many other plants are generalists and pollination is less dependent on insect shape.
3. A third aspect is practicality and the reproducibility of results and simplicity. For different aster species, the CANPOLIN project has evaluated how pollination can be measured. This project recommends the Purplestem Aster (*Symphotrichum puniceum*) because of its habitat range, robustness, response to pollinators, and the simplicity of counting pollinated seeds.

3.2 The purplestem aster (*Symphyotrichum puniceum*¹)

This project is inspired by the Purplestem Aster Pollination Adventure (PAPA) by Pollination Canada (www.pollinationcanada.ca), which proved successful during a pilot project in Kitchener/Waterloo, but unfortunately has not received further funding to the point in time when this report was written. However, the method builds on solid scientific preparation that was provided through the CANPOLIN project hosted at UGuelph², which has shown that the purplestem aster is exceptionally well suited for simple quantification of pollination success.

Participants grow three (3) purplestem asters, a native plant that does well in sun or partial sun, OR observe some purplestem asters already thriving in a garden or along a hiking path. These asters generally bloom in late summer or autumn (August until September), and participants will count the total number of blooms on each of the three (3) plants. A couple weeks later, they snip off ten (10) seed-heads from each of their three (3) plants and mail those seed-heads to us. We will then count the number of fertilized and unfertilized seeds, which is a reflection of the pollination it received.

Purplestem asters only flower in their second year of establishment. Thus, this option is only viable for the pilot year if you already can find established plants or acquire established plants. For planting purplestem asters from seed, St. Williams Nursery and Ecology Centre in St. Williams, ON, has recommended the following guidelines: Seeds can be stored dry in natural conditions until a month before seeding. The seeds then should be stored in cold, moist peat or vermiculite, in a plastic bag (ziploc) in the fridge (around 2C) for a month before seeding. The latest seeds can be started is September 1st if in warm bright circumstances (therefore, the latest date to store the seeds in the fridge is August 1st). It will flower around the autumn of its second year, and thus in your first year, we don't expect results. Just tender loving care to get it established!

The photographs on the next page include two photographs of ripe seed heads. In the left one, the seed head has been deliberately opened a bit so that you can see the mature seeds (the actual seeds are located at the bottom of the white "bristles" each seed is attached to what looks like a mini broom)! The picture on the right consists of three unbroken seed heads. To be sure that you are snipping mature seed-heads, wait until a few seed-heads start to open (becoming all fuzzy), then harvest from the remaining unopen seed-heads that resemble the picture on the right.

More on the purplestem aster at <http://ontariowildflowers.com/main/species.php?id=15>.

¹Formerly *Aster puniceus*

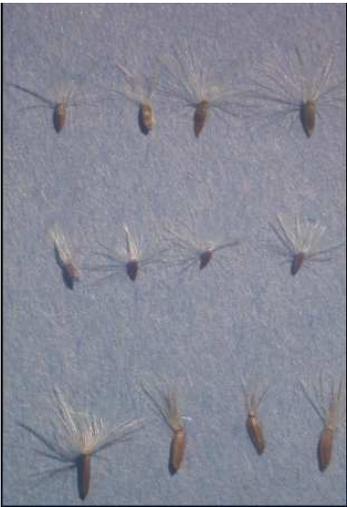
²Compare CANPOLIN report: Expansion of the Pollination Service Measurement (PSM) concept in Southern Ontario. Thomas Woodcock, Laura Pekkola, Robert Wildfong, Kim Fellows, Peter Kevan. March 18, 2013. Report prepared for Environment Canada - CESI Program



Aster Flowers



Seed head



Fertilized seeds



Unfertilized seeds

Photographs of seed heads and seeds taken from Seeds of Diversity Canada, Presentation by Kim Fellows

Figure 3.1 — *Purplestem aster (Aster Punicum)*

3.3 Clover flowering duration

Clovers are important as livestock forage, green manure and cover crops, and also as honey plants. Red clover (*Trifolium pratense*), white clover (*T. repens*), and alsike clover (*T. hybridum*) are the major species grown in Ontario. The flowers of clover share a typical legume structure: Many small and narrow tubular florets are grouped together in inflorescences. The anthers release the pollen inside the bud prior to opening. When a visitor lands on the flower, its weight causes the anthers and stigma to extend forward and press against the head of the visitor. Afterwards, the sexual structures return to their original position, allowing the same flower to deliver pollen repeatedly. In general, all three species of clover are self-sterile and insect pollinators are required for successful seed set, although some self-fertile varieties exist, especially in white clover.

Clover species offer desirable resources to honeybees, but they must exert a considerable effort to access them due to the shape of the flower. Clovers require long-tongued bees (mostly honey bees and bumble bees) for pollination, as these are the only insects that can reach the nectar. Smaller insects may be able to access the pollen. Pollinated florets soon wilt and lose their colour, so a field full of colourful, blooming flower heads is an indication of poor pollination. In the field, flowering time of clover florets is thus a good indication of pollination services provided by long-tongued insects. When good pollination is present, the florets should trip over as rapidly as they appear. An inflorescence is then dominated by florets yet to open and finished florets, with a thin band of open florets (see image).

Method:

Start with filling out a description of the landscape around your field (Attachment 1). Then, select a patch with red clover (e.g. in a mixed cover crop field) that is ready to start flowering but where flowers have not opened yet. Mark 20 separate flower buds in two manners:

1. With a metal stake, mark each location so that it is visible. Each metal stake carries a number, e.g. on duck tape. This number identifies one flower bud.
2. With a marker (tape, wire strap), carefully mark fifteen (15) buds across the field at similar development stage, such that the inflorescence is still fully closed. In addition, mark each with metal stake and a colorful flag such that the markings can be found in the field.
3. Bag ten (10) inflorescence with a small paper bag (e.g. as used for making tea). This protection prevents any pollinators to access open florets. Be careful not to injure the plant.
4. Once the florets have mostly opened and surrounding (unmarked) inflorescences are partly pollinated, remove the bags on five (5) inflorescences in the morning (8:00 AM). Mark the bags that were removed clearly. Leave the flowers open all day, and re-position the marked bags in the evening (8:00 PM)³. Choose a sunny day when pollinators are generally active. You have now three groups of five flowers: five naturally pollinated (not bagged), five where pollination is totally blocked (no mark), and five that were pollinated for a specific time interval of one 12-hour-day (marked). The first two are your control groups, the last measures the pollination effectiveness on a specific day.



Figure 1 A clover flower with closed, open and finished florets

Figure 3.2 — White clover (*Trifolium repens*) with pollinated florets. Image taken from Foundation for Arable Research (FAR), *Arable Update* No. 57, October 2007

³If you also do the Night Pollination variation (6), it is OK to move the day to 7:00 AM – 7:00 PM

5. On the evening of the next day, cut all marked inflorescences and bring them into the house. Be sure to remember to which group each flower belongs. On each inflorescence, count the number of florets (a) yet to open, (b) open, and (c) pollinated.

Variations:

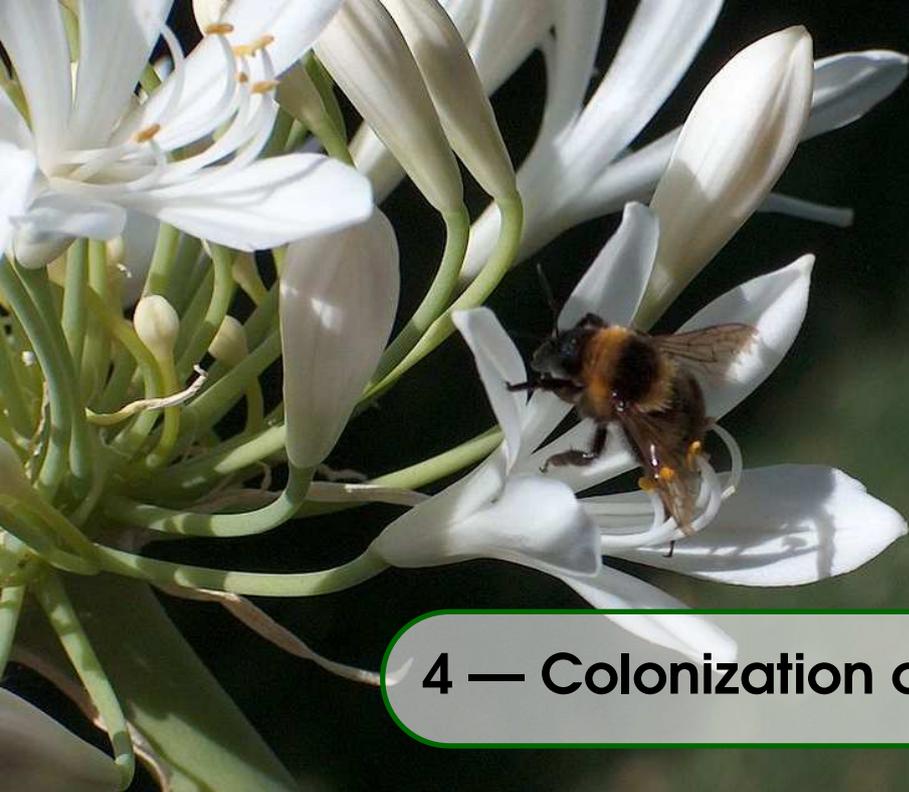
In addition to the 12-hour-day group, you can add additional groups of five (5), without replicating the control groups (natural / totally blocked):

6. *Night pollination by moths and other night pollinators:* Cover additional five (5) flowers. Leave this group uncovered between 7:00 PM and 7:00 AM.
7. *Morning pollination:* Cover additional five (5) flowers. Leave that uncovered for 6-hours (6:00 AM – 12:00 AM)
8. *Pollinator temporal activity:* Cover additional twenty (20) flowers or 4 groups. Uncover each group at a separate time for three hours (6:00 AM – 9:00 AM), (9:00 AM – 12:00 AM), (12:00 AM – 3:00 PM), (3:00 PM – 6:00 PM). Make sure to mark each group clearly to avoid confusion!

If you have low pollinator activity, especially this variation may not give good results after only one day. In this case, you may repeat the experiment for three consecutive days where there is sufficient sun for pollinators to fly.
9. *Weather-dependency of pollination:* For testing n weather conditions, mark and bag n*5 inflorescences. To test one condition, uncover one group of five inflorescences for one day. Mark the day and record weather conditions at your farm (temperature, wind, humidity, cloud cover, whatever you have) in great detail.

Results:

The average flowering time is used to compare pollination services by long-tongued insects across a larger spatial area. Shorter flowering times indicate better pollination. Given that the experiment is coordinated and reflects comparable weather conditions, a spatial map on multiple farms allows comparing pollinator effectiveness across the province. It is thus important to perform this activity when the weather is similar over the full study area.



4 — Colonization of nesting habitat

4.1 Introduction

If nesting habitat is available, it may attract pollinators from the surroundings who are looking for nesting space and find that material adequate. The colonization of empty habitat indicates that there is a population seeking it, either because they expanded, or because they were displaced from other habitat. By providing a number of nesting spaces and monitoring the colonizing species, we can learn about the diversity and abundance of pollinators.

4.2 Bumblebee Nestbox Observation

Background

There are approximately two hundred species of bumblebees found in temperate regions of world, and approximately twenty seven species that we find in Ontario. Like many other bees, a number of bumblebee species are declining in population sizes. This is due to a number of factors including: (1) reduced available forage and/or nesting sites; (2) widespread use of insecticides in agricultural and home settings; and (3) spread of disease through escape of commercial bumblebees now used in greenhouse vegetable production. Bumblebees have been shown to dramatically improve pollination for a number of vegetable crops grown in greenhouses—particularly tomatoes—but these commercial pollinators harbor diseases that native bumblebees are susceptible to. One bumblebee species in particular, the rusty-patched bumblebee, has suffered dramatic declines, and is currently protected under Ontario’s Endangered Species Act.

Natural History/Life Cycle

Bumblebees are generalist species, feeding on a wide range of flowers for pollen and nectar. Queen bees emerge in spring from overwintering, and will begin to establish a new colony, which she will provision with nectar and pollen. The colony will grow in size throughout the summer, and the newly hatched female worker bees will take over care of developing larvae within the colony. Male and queen bees will be produced and mate in the later summer season. Mated queens will then overwinter to emerge the following early spring and establish a new colony of her own.

Bumblebees are fairly flexible in their choice of nesting locations; they are seeking roughly shoebox sized cavity, and will often establish nests in old rodent burrows, or in clumps of tall grass that has dried and toppled in the fall. However, bumblebees can also be coaxed into using a variety of human created nest boxes that can also allow of nest observation and monitoring.

Protocol/Monitoring

By constructing and monitoring artificial bumblebee nest boxes, it allows an unprecedented opportunity to observe bumblebee nest development throughout the season of the colony. It also allows for the possibility of identifying the bumblebee species present and nesting in the area, and allow for monitoring for the endangered rusty-patched bumblebee. Nest preparation/installation

1. Construct bumblebee nest boxes following the attached protocol.
2. Nests can be located in a variety of locations, however it is preferable to select a place where it is out of the way of humans. Nests can be placed at ground level or buried. See attached protocol for details regarding nest box entrances.
3. Nests should be installed as early as possible in the spring season. If the nest remains unoccupied at the end of July then it can be removed and stored away for reinstallation next spring.

Nest observation

1. Nests can be monitored once weekly to determine whether occupancy has been achieved.
2. Once evidence of bumblebees has been detected, nests can be observed every two weeks.
3. When monitoring the nest, choose a day that is warm and sunny if possible. Make sure that observation nests have been fitted with a plastic inner cover to allow observation but minimize disturbance.
4. Document the following:
 - (a) Date, time, temperature, weather conditions (sunny, breezy, cloudy, precipitation).
 - (b) Observe the nest before opening from a distance, determine whether you can identify the adult bees entering and exiting the nest.
 - (c) Always approach the nest from the opposite direction from the nest entrance. Open nest box and determine size of colony, bees observed and approximate number, developing

Building the nest box

All material was taken from The Xerces Society Factsheet: *Nests for Native Bees*. The full publication can be accessed on their website.

TO CONSTRUCT a wooden bumble bee box, use preservative-free lumber. An appropriate size will have internal dimensions of about 7 x 7 x 7 inches (18 x 18 x 18 cm).

What to do

Drill a few ventilation holes on the upper sides of the box (near the roof) and cover with window screen to deter ants. Make an entrance tunnel from 3/4-inch (19mm) diameter plastic pipe or tubing, and fill the box with soft bedding material, such as 2- to 3-inch (5-7 cm) lengths of soft unraveled string or yarn, dry straw, bedding from a hamster cage, or upholsterer's cotton. (Do not use cotton balls, as the fiber become tangled in the bee's legs). The box must be weathertight; if the nest gets damp, the larvae may become too cold, and mold and fungus will grow. The bedding may be placed on top of a folded sheet of chicken wire to help keep it off the bottom of the nest box, improving ventilation through the nest and keeping it drier.

Setting up the nest

Place the nest in a dry, undisturbed area that has some obvious landmarks (a forest or hedgerow edge, fence post, rock, or building) to aid the bees' navigation as they return from foraging. Nesting boxes at ground level or slightly buried (either with soil or straw) are the most attractive to queens of many bumble bee species. Boxes placed on the surface should be level and stable.

An inviting entrance

If you bury your box, add an entrance pipe extension that gently slopes up to the surface. Ideally, even a box sitting on the surface will have a tube – at least 3/4 inch (19mm) in diameter – that runs from the entrance, looping underground, coming up a foot or two from the nest. Protect the tube entrances with a large flat rock or something similar to prevent water from infiltrating the nest and excavate a shallow hole around the entrance to make it easier for bumble bee queens to find it. Make it look like an obvious little cve to inspire queen bumble bees to investigate.



(Source: copied from Xerces Society)



5 — Pollinator Resources

Vegetables & Pollination

Booklet:

Pollinator Management For Organic Seed Producers. *Eric Mader and Jennifer Hopwood, Xerces Society*

On 22 pages, this excellent booklet summarizes what vegetable growers should know about pollinators on their field. Targeted to seed producers, it provides colorfully illustrated descriptions of pollinators and crop-specific considerations, such as separation distances for breeding.

Providing habitat on your farm

Booklet:

A Landowner's Guide to Conserving Native Pollinators. *Susan Chan, Farms At Work*

As one of Ontario's leading pollinator experts, Susan Chan summarizes bee biology and measures to protect native pollinators in our Province. This booklet contains rich tables on local plant species and their foraging season, as well as local sources for native plants. The booklet can be obtained through the Canadian Organic Grower for \$10.

General

Book:

Attracting Native Pollinators: Protecting North America's Bees and Butterflies. *The Xerces Society*

On 380 pages, *Attracting Native Pollinators* provides everything that you may need to know about creating and managing pollinator habitat. The book also contains illustrated descriptions of pollinator families and native plants. In Canada, it is distributed through Lee Valley for only \$23. We highly recommend this book as the most thorough but accessible information source.

Neonicotinoids

The impact of neonicotinoid pesticides on pollinator population health is widely discussed. While not the focus of this project, we recommend two balanced reads:

Booklet with review:

Are Neonicotinoids Killing Bees? *The Xerces Society*,

This booklet summarizes scientific facts about neonics and pollinators, and recommends actions to minimize their exposure. We find this booklet one of the most balanced and scientifically robust sources in this

highly emotional debate.

Scientific Article:

Sub-lethal exposure to neonicotinoids impaired honey bees winterization before proceeding to colony collapse disorder, by Chensheng Lu, Kenneth M. Warchol, Richard A. Callahan. *Bulletin of Insectology* 67(1): 125-130, 2014

This academic paper is the first peer reviewed study that clearly links the colony collapse disorder with minute doses of these pesticide.

Report:

Evaluation of Canadian bee mortalities in 2013 related to neonicotinoid pesticides Health Canada Interim Report. Visit Website at http://www.hc-sc.gc.ca/cps-spc/pubs/pest/_fact-fiche/bee_mortality-mortalite_abeille-eng.php

Guide books and eGuides

Several insect guides are available in print and online. For us, the following stick out:

Bug Guide.

This geeky but excellent website is dedicated to insects and other arthropods and provides a free identification service. The website describes itself as an "online community of naturalists who enjoy learning about and sharing our observations of insects, spiders, and other related creatures". Visit Website <http://bugguide.net/>

e-Butterfly.

This website provides information and resources for North Americans who want to discover and share images, distribution maps, and other information regarding butterflies in North America. Visit Website <http://www.e-butterfly.org/contents/?portal=e-butterfly>

The Bee Genera of Eastern Canada.

This article provides descriptions and keys to the bees of Eastern Canada. Authors: Packer, L., Gernaro, J.A., and Sheffield, C.S. *Canadian Journal of Arthropod Identification* No.3. 2007. doi: 10.3752/cjai.2007.03. Visit Website http://www.biology.ualberta.ca/bsc/ejournal/pgs03/pgs_03.html

The Bees of the Eastern United States.

This book by Theodore Mitchell provides detailed information regarding all North American bee species. It has been made available online as a series of pdfs free for download from North Carolina State University's Insect Museum website. Visit Website <http://insectmuseum.org/easternBees.php>

Bee Photography Guide.

This site provides tips and tricks for taking photographs of pollinators. Visit Website <http://beespotter.mste.illinois.edu/topics/photos/>

Hi Resolution Bee photos.

U.S. Geological Survey. Visit Website <http://www.e-butterfly.org/contents/?portal=e-butterfly>

More resources

Pollinator Guelph.

Pollinator Guelph maintains a well-organized and up-to-date list of pollinator resources, which include resources for teachers, videos, and countless good links. Visit Website <http://www.pollinator.ca/>

[guelph/](#)

Xerces Society.

International, nonprofit organization that protects wildlife through the conservation of invertebrates and their habitat. Visit Website <http://www.xerces.org/>

Bumblebee Watch Bumble Bee Watch is a citizen science project through the partnership of The Xerces Society, the University of Ottawa, Wildlife Preservation Canada, BeeSpotter, The Natural History Museum, London, and the Montreal Insectarium. Learn more about this project here. Visit Website <http://bumblebeewatch.org>

Resources for educators:

Various curricula. Visit Website <http://www.xerces.org/educational-resources/#online>

5.1 Wind speed - Beauford Scale on land

Beauford Force	Wind Speed		Descriptive Term	Effects observed on land
	Km/h	m/s		
0	Less than 1	< 0.3 m/s	Calm	Smoke rises vertically.
1	1.1–5.5 km/h	0.3–1.5 m/s	Light air	Direction of wind shown by smoke drift, but not wind vanes.
2	5.6–11 km/h	1.6–3.4 m/s	Light breeze	Wind felt on face. Leaves rustle. Ordinary vane moved by wind.
3	12–19 km/h	3.5–5.4 m/s	Gentle breeze	Leaves and small twigs in constant motion. Wind extends light flag.
4	20–28 km/h	5.5–7.9 m/s	Moderate breeze	Raises dust and loose paper. Small branches are moved.
5	29–38 km/h	8.0–10.7 m/s	Fresh breeze	Small trees with leaves begin to sway. Crested wavelets form on inland waters.
6	39–49 km/h	10.8–13.8 m/s	Strong breeze	Large branches in motion. Whistling heard in telephone wires. Umbrellas used with difficulty.
7	50 - 61 km/h	13.9–17.1 m/s	Near gale	Whole trees in motion. Inconvenience felt in walking against wind.
8	62 - 74 km/h	17.2–20.7 m/s	Gale	Breaks twigs off trees. Generally impedes progress. Walking into wind almost impossible.
9	75 - 88 km/h	20.8–24.4 m/s	Strong gale	Slight structural damage occurs, e.g. roofing shingles may become loose or blow off.
10	89 - 102 km/h	24.5–28.4 m/s	Storm	Trees uprooted. Considerable structural damage occurs.
11	103 - 117 km/h	28.5–32.6 m/s	Violent storm	Widespread damage.
12	118 - 133 km/h	≥ 32.7 m/s	Hurricane	Rare. Severe widespread damage to vegetation and significant structural damage possible.

Source: *Estimating windspeed using Beauford Scale (Environment Canada)*

5.2 Distinguishing pollinators: Basics

The following images are taken from the POCKET IDENTIFICATION GUIDE by *The Pennsylvania Native Bee Survey – Citizen Scientist Pollinator Monitoring Guide*. This guide was created by Xerces Society, PennState University, Pennsylvania Department of Agriculture, and HD HB. All credit goes to these authors. The guide was included for completeness, and we recommend developing an Ontario-specific guide with location-specific photographs, which is not available.

Bees vs. Wasps vs. Flies

- Bees**
- Usually Very Hairy
 - Four Wings
 - Long, Elbowed Antennae
 - Legs Broad and Hairy
 - Often Loaded w/ Pollen (On Scopa)
- Wasps**
- Usually Less Hairy or Not At All
 - Four Wings
 - Long Antennae, Not Elbowed
 - Legs Narrow and Not Hairy
 - No or Little Pollen (No Scopa)
- Flies**
- Usually Less Hairy or Not At All
 - Two Wings
 - Short, Thick Antennae
 - Legs Narrow and Not Hairy
 - No or Little Pollen (No Scopa)



Honey Bees



Size and Shape: Medium to large, moderately robust.

Color: Orange-brown to nearly black.

Hair: Fuzzy thorax and head, legs and abdomen less hairy.

Stripes: Abdomen tri-toned, with black, pale and orange-brown stripes of hair and body coloration.

Scopa: Enlarged, flattened hind legs; hairless in the center.

Antennal Length: Short.

Notes: Makes a buzzing sound when flying; the only bee with “hairy eyes”.

Bumble Bees

Size and Shape: Medium to very large, robust.

Color, Hair and Stripes: Body black, with yellow, black, and, sometimes, orange hair stripes on thorax and abdomen.

Scopa: Hind legs enlarged and flattened; hairless in center.

Antennal Length: Short for females (for most bumble bees encountered), long for males.

Notes: Make a low buzzing sound when flying; painful sting that does not linger.



Large Dark Bees



Size and Shape: Small to Medium/large, relatively narrow to moderately robust.

Color and Hair: Body dark, thorax covered in short, white to yellowish hairs; females with facial foveae; males with beard or mustache or yellow facial markings.

Stripes: If present, made up of pale hairs.

Scopa: On hind legs, often pale and short.

Antennal Length: Short in females, longer in males.

Notes: Can be numerous in Spring and Fall; one rare species, *Nomia nortoni*, with iridescent abdominal stripes.

Metallic Hairy Belly Bees

Size and Shape: Small to medium/large and robust.

Color, Hair and Stripes: Dull to bright metallic green or blue; dark, white or pale yellow to orange; stripes absent or faint on abdomen; some very hairy and dark with coppery reflections.

Scopa: On underside of abdomen (look for pollen load).

Antennal Length: Short.

Notes: Most numerous in spring; active for only a short period of time; a couple of species with short facial “horns”.



Hairy Leg Bees

Size and Shape: Small/medium to medium/large and robust.



Color and Hair: Dark, with white to yellowish/orange hairs.

Stripes: Abdomen often with pale stripes.

Scopa: On hind legs; appear as dense stands of long hair (like pipe-cleaners).

Antennal Length: Generally longer than most bees, especially males, who have very long antennae.

Notes: Very quick; difficult to collect.



Large Carpenter Bees

Size and Shape: Very large and robust.



Color and Hair: Shiny, nearly hairless black abdomen; thorax covered in yellow/light hair; males with a yellow spot on face.

Stripes: None.

Scopa: Hind leg enlarged, completely covered in scopal hairs.

Antennal Length: Short.

Notes: Will only see one or a few at a time; only species in PA: *Xylocopa virginica*.



Small Dark Bees

Size and Shape: Tiny to small/medium, moderately narrow.



Color, Hair and Stripes: Dark, often metallic; sometimes with yellow marks on face, thorax and/or legs; abdomen can be yellowish or reddish; body often dulled by short pale hairs, that can be in stripes or patches on abdomen.

Scopa: On hind legs, but can be difficult to see without pollen load.

Antennal Length: Short in females, longer in males.

Notes: Often most abundant group in the garden throughout the season.



Green Sweat Bees

Size and Shape: Small to Medium, relatively narrow.



Color, Hair and Stripes: Metallic green; abdomen can be dark and striped with yellow body markings or pale hairs.

Scopa: On hind legs; less noticeable than other bees, unless covered in pollen.

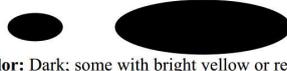
Antennal Length: Short in females, longer in males.

Notes: Relatively fast flying and numerous; most are ground nesters, but one especially numerous species nests in rotting wood, and, so, may be found in areas with a lot of woody debris.



Dark Hairy Belly Bees

Size and Shape: Small to very large, usually robust, can be relatively narrow.



Color: Dark; some with bright yellow or red markings on thorax and abdomen.

Hair and Stripes: Thorax and head thickly covered in white/pale to orange-colored hairs; abdomen with pale to white stripes or not striped.

Scopa: On underside of abdomen, can be dark or pale to orange (look for pollen).

Antennal Length: Short.

Notes: Abdomen often flexed upward (or "elevated") when feeding.



Cuckoo Bees

Size and shape: Tiny to medium and often narrow-bodied.



Color: Body black, red, or yellowish; often wasp-like, with elaborate body markings or light-colored hair patterns.

Hair and Stripes: Usually not very hairy; some with short, densely-arranged hair covering entire body.

Scopa: Lack pollen carrying structures.

Antennal Length: Sometimes short, often long (especially males).

Notes: Look very wasp-like; only minor pollinators - most are nest parasites.

