A Landowner's Guide to

Conserving Native Pollinators in Ontario

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Susan Chan

Cover photo: Johanna James Heinz

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Photo by Susan Chan

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Halictid Bee (*Agapostemon virescens*)
© Copyright John Ascher/
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Introduction:

Native pollinators are keystone species whose contribution to the stability of the systems that feed and sustain all living things on Earth is invaluable. As they are gathering nectar and pollen for themselves, pollinators transfer pollen from male to female parts of the flower, allowing plants to reproduce and set seeds. Besides being critical for growing the next generation of plants, these seeds and the fruit which accompanies them, are often an important food source for animals and humans. Although most of the staple grains (wheat, rice, oats, rye, triticale, sorghum, and corn) in human and animal food systems are wind pollinated, the fruits, nuts, oilseeds, and many vegetables, require a pollinator other than wind to maximize production and quality. In the past, agriculture has largely ignored wild pollinators and has depended almost entirely upon domesticated, non-native honey bees to provide pollination services for the crops grown on farms. However, honey bee populations have been declining sharply because of disease, parasites, and poor overwintering, and it is now critical to look to a more diverse population of pollinators to meet the pollination requirements of agricultural crops. These pollinators can be birds, moths, flies or beetles, but overwhelmingly they are native wild bees of all shapes, sizes, and description.

It is clear that animals need plants and that many plants need native pollinators to reproduce, but what is it that pollinators, especially bees, need in order to continue to provide pollinating services? Firstly, pollinators need to be recognized as vitally important throughout rural and urban landscapes, both for their role in human food production and in maintaining healthy natural ecosystems. Secondly, pollinators need food in the form of a variety of nectar - and pollen-rich flowers available throughout their foraging period. Thirdly pollinators need suitable undisturbed nesting sites close to their forage, and lastly all pollinators need to be protected by reducing the use of pesticides in all contexts. These needs can all be addressed with minimal effort by landowners on their land, whatever the size or location of that land.

This guide is intended to inform landowners about the process of pollination, to introduce them to native bees, and to provide strategies and tips to help landowners to take action to protect and encourage pollinator populations on their land. Each of these topics is covered separately in a different section of the handbook.

Section 1 (Green page edges): Covers information about pollination.

Section 2 (Yellow page edges): Includes information about common pollinating bees in Ontario.

Section 3 (Red page edges): Explains why pollinators are vulnerable to extinction.

Section 4 (Blue page edges): Provides concrete action plans to conserve pollinators in a variety of land ownership contexts and possible sources of cost-share funding for pollinator plantings. Case studies are presented.

Appendices (Purple page edges)

Notes:

Section 1. Pollination

Pollination is the first step in plant sexual reproduction. Because plants are not able to transfer pollen themselves, they have evolved a wide variety of mechanisms to use natural elements such as wind and water, or other organisms to do it for them. Of course, pollination services rendered by other organisms come with a cost - the cost of floral resources such as nectar and pollen, both of which are produced by plants and may be eaten by pollinators.

To understand pollination, it is helpful to understand the two parts that contribute to the system - the plants and the pollinators. This section will present the basic knowledge needed to understand the process of pollination.

Plant Reproduction:

Most plants, like animals, need to reproduce sexually to produce the next generation. This sexual reproduction happens in a plant's flowers. A flower is composed of sexual organs surrounded by petals which can be various shapes, sizes and colours. For photographs of the various flower types see the Pollination Canada listing in Appendix 1.

The male sexual organ produces pollen on its anthers (Figure 1). The anthers split open to release pollen, usually at the time that the flower opens. Pollen from wind-pollinated flowers such as ragweed is usually light and dry so that it can be easily dispersed by the wind, but pollen from insect-pollinated flowers such as goldenrod is characteristically oily and heavy so that it will stick to insects, rather than be blown around.

The female sexual organ consists of the ovary containing ovules at the bottom, connected by the style to the sticky stigma at the top of the organ. At the base of most flowers, a nectar-producing organ (nectary) is located (Figure1).

Nectar production usually begins when a flower opens and stops when fertilization is complete. The type and concentration of sugars in the nectary vary widely from plant to plant. An acre of alfalfa can produce hundreds of pounds of nectar, whereas an acre of cantaloupe produces only about two pounds. [1]

The Purpose of Pollination:

The purpose of pollination is to set seed in the ovaries of a plant. Furthermore, in many fruit crops, fruit don't grow or are misshapen if there are not enough seeds set. Misshapen strawberries or small lopsided apples are often caused by poor pollination.

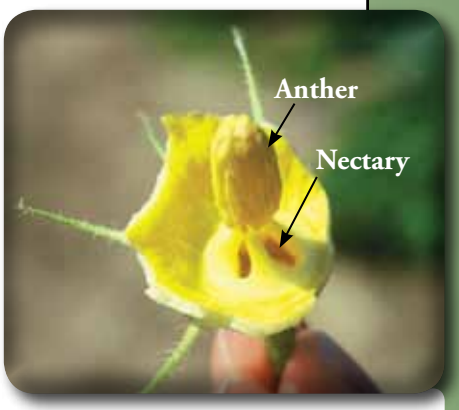

Figure 1. Male pumpkin flower with petals removed to show anther stripped of pollen and the nectary at the base.

The Processes of Pollination and Fertilization:

In its simplest form, pollination is the transfer of pollen from the male anther to the receptive sticky female stigma of a flower. Once on the stigma, the pollen grows a tube down through the style to the ovary, where it fertilizes an ovule. Each fertilized ovule develops into a single seed. But as with many things in natural ecosystems, there are all sorts of variations on the theme. For example apple flowers have both their anthers and stigmas on one flower, pumpkins have anthers on one kind of flower and stigmas on

[1] McGregor, S.E. 1976.

another kind of flower on the same plant, and hazelnuts have only one kind of flower on a single plant.

To further complicate things, some plants are self-fertile, meaning that they are able to set seed from pollen coming from the same flower, while others require cross-fertilization and need pollen from another flower, another plant, or even another variety to set seed. However, most plants benefit from cross pollination, even the ones that are self-fertile. Some plants have stigmas that are only receptive to pollen at certain times of day, while others may only release their pollen at certain times of day. These factors affect how successful pollination is at actually setting seed in the ovary and may determine which pollinators are the best for a certain plant.

Methods of Pollination:

Generally there are several ways that pollen is transferred from the anther to the stigma: Wind, insects, animals, and water can each act as pollination agents. Wind pollinated plants include all grains (wheat, barley, oats, rye, corn, sorghum, triticale, rice, and millet), all other grasses, and many trees as well as other plants such as ragweed. As a general rule, if a plant's flowers are not showy, that plant is probably wind pollinated. The majority of the remaining plants, including fruits, vegetables, oilseeds, herbs, wild meadow plants, shrubs, and understory plants in the forest are pollinated by insects. Close to 80 percent of flowering plants are dependent for pollination on insects or other animals.

Notes:

Section 2. Pollinators

Insect pollinators can include a variety of organisms such as bees, flies, butterflies and moths, wasps, and beetles. However, the most important insect pollinators are the bees. Bees are such good pollinators because they

- need pollen and nectar for food,
- often have hairy bodies which pick up and hold on to pollen (Figure2),
- usually forage on one particular nectar/ pollen plant crop at a time,
- visit many flowers on a single foraging trip so pollen gets transferred from flower to flower.

Bees and flowering plants need each other. Bees provide crucial pollination services by transporting pollen trapped on their hairy bodies between flowers of the same species. In return plants provide nectar and pollen to bees for food.

The most important insect pollinators are bees

All About Bees

Although most people are only familiar with the European honeybee, in Eastern Canada there are about 400 wild bee species, grouped into five families. These families are listed in Table 1. Of these, about 300 species are important as pollinators [1]. Most of these wild bees do not have common names and most live and forage un-noticed in fields and gardens in this area. In fact, much of the pollination value that is normally attributed to honey bees may be due to the pollination activities of un-noticed wild bees. In this handbook, some of the wild bees that have no common name will be given common names, based on suggestions by Laurence Packer, in his book, *Keeping the Bees.*

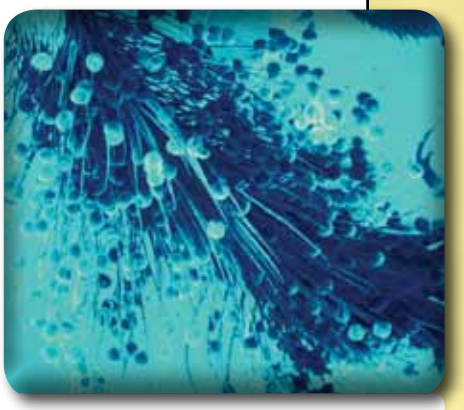

Figure 2: Scanning electron micrograph of pollen trapped on the body hair of a solitary bee (Peponapis pruinosa).

Bees are often associated in peoples' minds with making honey, living in hives, stinging and swarming. Although honey bees do all of these things, most of the hundreds of wild bees that are native to Eastern Canada do not. Most wild bees live a solitary lifestyle for one season and then die, so they have no need to accumulate honey stores to survive the winter. Instead they store up pollen for their offspring which usually overwinter as larva or pupa. Because they live alone, these solitary bees do not swarm and they tend not to sting.

Table 1. The bee families of Ontario [2]

Bee Family Name	Types of bees in this family in Ontario
Andrenidae	Miner bees
Apidae	Squash, carpenter, bumble, and honey bees
Colletidae	Cellophane and masked bees
Halictidae	Sweat and pearly-banded bees,
Megachilidae	Leafcutter, orchard, and mason bees

[1] Packer, Laurence, Genaro, Julio A., Sheffield, Cory S. 2007.

[2] Packer, Laurence. 2010.

- **Generalists forage for nectar and pollen on a wide variety of plant species**
- **Specialists forage for pollen on specific plant species, but are less particular about nectar**

Even if they do sting, the sting has none of the punch that a honey bee sting does. The notable exceptions are the 27 species of bumble bees. Bumble bees are not solitary and so their behaviour somewhat resembles that of the honey bee. They do make small quantities of honey for their own consumption, and they have a painful sting (though they rarely use it except near their nests). Although they live in small colonies, they do not swarm, nor do they live normally in hives, although managed bumble bee colonies are kept in boxes in greenhouses. Bumble bee colonies do not survive the winter; instead the colony produces a crop of new queens in the fall. These queens mate, disperse and overwinter individually, each starting a new colony the next spring.

Figure 3. Resin casts of ground nests of the solitary bee (Peponapis pruinosa).

Figure 4. Spring orchard bee (Osmia sp.) pupae in nest lined with mud constructed in channels of greenhouse glazing material.

Foraging Behaviour: Specialist vs. Generalist Bees

In some cases, certain wild bees will only forage for pollen on specific species of plants. These are known as specialist bees. For example, a species of sweat bee (*Lasioglossum oenotherae)* collects only evening primrose pollen, and the hoary squash bee (*Peponapis pruinosa*) collects only pumpkin or squash pollen. However it is more common for native wild bees to be generalists. Generalists forage for nectar and pollen on a variety of plant species, in much the same way that honeybees do.

Figure 5. Brood cell constructed from alfalfa leaves.

Figure 6. Bumble bee nest exposed to show brood cells.

Lifecycle of Bees:

Most bees share a similar lifecycle. An adult mated female lays an egg in a cell which hatches into small grub-like larva, known as brood. Over a period of time, the brood has access to food and grows in size. It then stops growing, pupates, and becomes an adult bee which emerges from the cell and begins to forage for food, search for a mate, and reproduce. How long this process takes and whether or not there is contact between generations depends upon the type of bee.

Bee Nests:

All bees raise their brood in nests of some description. Some construct simple tunnels in the earth (Figure 3), some occupy existing holes in wood or pithy stems. Of these, some use mud, some use leaves, and others use cellophane-like secretions to line their cells (Figure 4&5).

Other bees, such as honey bees or bumble bees, create complicated nests out of beeswax or other substances within cavities or in man-made hive boxes (Figure 6).

Figure 7. A larva of a solitary bee on a pollen plug.

Solitary Bees:

Most wild bees are solitary, meaning that individual mated female solitary bees construct a nest and collect all of the pollen and nectar required for each offspring into a single pollen plug. The offspring eats the pollen plug and develops without any further contact with the mother (Figure7).

Although each female independently builds her own nest, a number of these nests may be found in an aggregation in the same area (Figure 8).

Communal Bees:

Some species of wild bees such as the metallic-green headed *Agapostemon virescens* are considered communal because individual females share a nest entrance in the ground but each reproduces in a solitary way within the nest. [3]

Figure 8. Nesting aggregation of mining bees (Colletes sp.) in a sandbank.

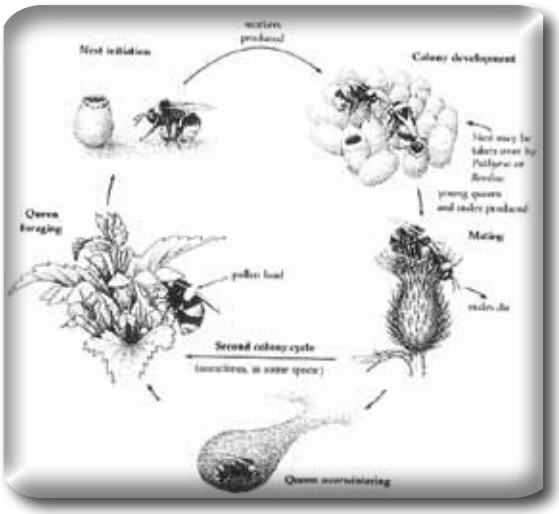

Figure 9. A life cycle of a bumble bee colony.

[3] Packer, Laurence, Genaro, Julio A., Sheffield, Cory S. 2007.

At the end of their foraging season, the adults of both solitary and communal bee species usually die, leaving the brood to overwinter and emerge the next season.

Social Bees:

Other bees, such as honey bees, bumble bees, and some sweat bees are more social. They create colonies in which only one reproductive female (the queen) lays eggs, but many non-reproductive females work together to provision and care for the brood throughout its development. Honey bee colonies survive the winter, however colonies of bumble bees and sweat bees are started anew each spring by a single overwintered mated queen who then lays eggs to establish a new female workforce (Figure 9).

Honey Bees for Pollination:

As agriculture has become more industrialized, farmers needing the services of pollinators have depended more and more heavily on a single managed pollinator - the European honey bee. Honey bees make good pollinators mostly because

- they are available in large numbers,
- they forage throughout the growing season,
- they are generalist foragers,
- they can be managed by humans, and
- they can be moved into and out of crop areas as needed.

Figure 10. Blue Orchard Bee (Osmia lignaria) on pussy willow.

For example, honey bees may be moved into orchards in Niagara or Collingwood to pollinate apple trees, shipped to Nova Scotia to pollinate the blueberry crop, or moved onto canola fields in New Liskeard to improve seed set.

Figure 11. Halictid, Leafcutter, and Miner bees.

However, since the late 1980's, the health of the managed honey bee population in Ontario has been under repeated attack by a series of new disease or parasite threats (tracheal mites, varroa mites, and new virulent strains of nosema), or increased threat from existing diseases, notably American foulbrood, which is kept at bay by prophylactic antibiotic treatment of all conventionally-managed hives. Because of these

diseases, overwintering losses have increased considerably in the province. Parasitic mites are becoming increasingly resistant to the chemicals used to control them, and the threat of invasion by the small hive beetle is imminent, with a pocket of infected hives already existing in Southwestern Ontario. In the United States, a phenomenon known as Colony Collapse Disorder has decimated the honey bee population across the country and the demand for pollination services has outstripped the availability of managed colonies to service that demand. In the California almond industry, honey bee colonies from Australia are increasingly being imported to meet the demand for pollinators for that crop. It is becoming apparent that dependence on a single species of bee for pollination of agricultural crops is risky.

The more sustainable alternative is to have access to a wide variety of pollinators who collectively pollinate agricultural crops, as well as native plants, shrubs, and understory forest plants

Wild bees are important for the pollination of many food crops and most non-crop flowering plants, and they play a crucial role in most terrestrial ecosystems. Wild blue orchard bees (*Osmia spp*.) (Figure 10) are recognized as the best pollinators for orchards because they forage in the poor weather conditions that often accompany flowering in the spring and are not easily distracted by other floral sources.

In Nova Scotia, wild bees are important to blueberry production. Blueberry flowers have anthers that hide their pollen on the inside instead of making it readily available to foragers, as is usually the case. To release the pollen, a pollinator must vibrate the flower by buzzing. Honey bees don't do this effectively, but wild bumble bees and several species of solitary bees, such as halictid, leafcutter and miner bees can (Figure 11).

Likewise, the wild hoary squash bee is the best pollinator of squashes and pumpkins because its life cycle on a daily and seasonal basis matches the flowering period of these plants closely (Figure 12).

Several wild bee species are now being managed as pollinators. Alfalfa leafcutter bees are directly responsible for most of the alfalfa seed grown in

Important Wild Pollinators for Crops

- Orchard bees are good pollinators of orchard crops like apples
- Miner, sweat, bumble and leafcutter bees pollinate blueberries well
- Alfalfa leafcutter bees are the best pollinators of alfalfa
- Bumblebees are good at pollinating greenhouse crops
- Hoary squash bees are the best pollinator of pumpkins and squashes

Figure 12. Hoary squash bee (Peponapis pruinosa) on a squash flower.

Canada. This seed is then planted by farmers to grow high quality hay for cattle, which in turn produces much of the beef and dairy products eaten in Ontario.

Managed bumble bee colonies are regularly used for pollination of greenhouse tomatoes and cucumbers because they do not become disoriented inside greenhouses like honeybees do. Tomato flowers, like blueberry flowers, require buzz pollination - a task bumble bees do with ease.

Notes:

Section 3: Vulnerability of Wild Bee Pollinators

Despite the many species of native wild bees in Eastern Canada, there have been noticeable declines in native bee populations. Two species of bumble bee, the rusty-patched and the yellow-banded bumble bee are now almost impossible to find in Ontario, though they were very common only 30 years ago. As of 2010, the Rusty-patched Bumble Bee was the first bee to be placed on the Ontario Species at Risk list with a designation of Endangered. Several other western bumble bee species are close to extinction.

Unfortunately wild bees are more vulnerable to extinction than are most other groups of insects. Because of their small size, many of these bees are not able to fly very far to find food. Furthermore, many do not develop large populations because of their solitary lifestyle. Those wild bees that are semi-social (sweat bees and bumble bees) require a large amount of food resources to maintain their colonies during the foraging season, but only the queens of the colonies live through the winter to start the cycle again in the spring. These overwintered queens are the fragile link between success or failure of a population from year to year. As populations dwindle, the genetic diversity within species also dwindles, with devastating results.

The activities of humans may further reduce these bees' ability to survive. Through human activities, their natural food sources are being reduced, their nesting sites are being destroyed, diseases are being spread rapidly, and they are being poisoned by insecticides. Most often these devastating effects are not intentional but come as a side effect of modern management practices on farms, in forests, in gardens, and on road allowances across the country.

Wild bees are vulnerable to extinction because

- they don't forage over long distances and they do not reproduce in large numbers
- their food sources and nesting sites are being eliminated
- diseases may be rapidly spread over large areas by movement of managed bees
- they are highly sensitive to insecticides sprayed to control other insects
- their genetic diversity is reduced because of dwindling populations

Causes of Reduction in Food Sources

Natural food sources for wild pollinators have become more scarce on many farms, gardens, and road allowances because of management practices that ignore the needs of pollinators in favour of competing interests.

Burning Blueberry Fields

On managed blueberry fields, plants are burned off every other year to increase subsequent berry production. This means that every second year, wild pollinators that overwinter and emerge have no access to the food that their parents foraged on the previous year. They are forced to seek food elsewhere, often having to fly long distances. This keeps their populations low and unstable.

Cutting of Hay Fields at First Bloom
In legume-rich hay fields that have the potential to provide large amounts of nectar to all types of pollinating insects, the hay is cut just as it begins to bloom to achieve maximum nutritional quality in the hay. This may make sense from the cows' perspective, but pollinators lose a veritable feast which may be critical to their survival.

Removal of Hedgerows
A management practice that makes it easier to use large machinery on the farm, the removal of hedgerows, contributes to the loss of food resources for pollinators. Wild apples, choke cherries and hawthorns, so common in hedgerows, provide reliable and plentiful nectar and pollen resources to pollinators in May and June.

Figure 13. Dandelion, a plentiful source of pollen and nectar in early spring.

Elimination of Weeds
Regardless of method, elimination of flowering weeds from field margins, gardens, natural spaces, and along hydro lines and road allowances further reduces sources of nectar and pollen vital to the stability of wild pollinator populations. In fact, many of the weeds that farmers, government agencies, and gardeners seek to control are vital sources of nectar and pollen to pollinating insects. For example, weeds such as dandelion and coltsfoot (Figure 13) provide copious amounts of nectar and pollen to many species of wild bees in the early spring when other plants are scarce.

Sweet clover, one of the best nectar producers in Ontario in the summer, is often routinely cut from road margins by maintenance crews before it blooms.

Managed Burning of Tall Grass Prairie
Best practices for tall grass prairie call for burning. However, burning is detrimental to native bee populations unless it is done in narrow strips which allow the bees to move onto unburned areas with ease.

New Flower Varieties
Wild pollinators are having to contend with new garden flower varieties that look like the real thing, but don't produce pollen and/or nectar. For example, sunflowers have reliably been producers of copious amounts of pollen in July and August. With their increasing popularity as cut flowers, newer varieties have been bred to be more visually attractive. However they have also been bred not to produce pollen, making them useless to foraging pollinators. This problem of reduced floral resources as a result of breeding is also a problem in certain varieties of canola and buckwheat used on farms.

Case Study: The Rusty-Patched Bumble Bee *(Bombus affinis)*

The rusty-patched bumble bee (*Bombus affinis*) used to be found commonly in large areas of southern Ontario and Quebec in diverse habitats including mixed farmland, sand dunes, marshes, urban and wooded areas. It forages on a wide range of flowering plants and nests in abandoned rodent burrows. Recently, despite extensive searches for it by scientists, only three specimens have been observed in Canada between 2005-2012. The decline in its population has been so drastic that in April 2010, it was added to the Canadian Species At Risk registry as an endangered species. For more information see http://www.mnr.gov.on.ca/stdprodconsume/groups/lr/@mnr/@species/documents/document/stdprod_086037.pdf

The cause of the population decline of the Rusty-Patched Bumble Bee is not known precisely but it is thought to be related to habitat destruction, use of pesticides, and the inadvertent introduction of disease into wild populations by commercially-raised bumblebees used for greenhouse pollination.

The Rusty–Patched Bumble Bee is thought to be an important pollinator of both agricultural and native flowering plants because it forages for a longer period than most other bumble bees and is found in such varied habitats. The loss of this bee may affect native animals that rely on the plants that it pollinates.

Identifying the Rusty-Patched Bumble Bee is fairly easy because of the distinctive rusty patch on its abdomen clearly shown in these photographs. Note that the rusty patch is only in the middle of the 2nd abdominal segment, not all the way across. As its name indicates, it is just a patch of rusty coloured hairs, surrounded by yellow hairs.

If you are in your garden, at the beach, or on the farm, pay attention to the flowering plants you may see. If you think that you see a bumble bee, take a photograph and take note of the date, time and place that you observed the bee. Photos taken by citizen-scientists can contribute a great deal to increasing our knowledge of this endangered species. Send photographs with information about where and when the photo was taken to info@beefriend.org or post the photos and information to the Rusty-patch Bumble Bee Project facebook page.

Causes of Nesting Site Destruction:

Like the causes of declining resources, destruction of wild bee pollinator nesting sites is usually unintentional.

Roadside Plantings:
South-facing sparsely-vegetated cuts along roadsides, so attractive as nesting sites to ground nesting solitary bees, are being seeded with crown vetch in an effort to reduce erosion and make the cuts more visually appealing. The growth of this dense vegetation does hold the soil well, but it also shades the soil surface and makes it almost impossible for ground-nesting bees to excavate nests.

Cane Removal in Raspberry Fields:
In raspberry fields, best practices include cutting back bearing canes and removing them from the fields, often to be burned. This encourages fruit bearing the following year and eliminates a possible reservoir of disease. However, it also eliminates pollinating bees that make their nests in those raspberry canes.

Field or Garden Cultivation:
Cultivation in farmers' fields, especially around the edges, can destroy the nesting sites and disturb the overwintering brood of ground-nesting bees. The same is true of cultivation in home gardens.

Use of Mulch:
The use of mulch in the garden, a good gardening practice from the perspective of water conservation, can be devastating to ground nesting bees. If the bees already use the area that is mulched for nesting, they will be unable to find their nests because they have been covered up; if they wish to colonize the area, they will be unable to because they cannot reach the bare soil to dig their nests.

Removal of Dead Wood:
Cutting down standing dead trees or shrubs can also deplete nesting sites for the solitary bees that nest in wood, not to mention myriad other creatures that make their homes there.

Paving Walkways:
Paving over walkways and paths also removes prime real estate for the wild bees that make their nests in the ground. However using flagstones with spaces between them creates permanent places for ground nesting bees to nest.

Removal of Hedgerows:
Lastly, the removal of hedgerows, besides eliminating nectar resources, can remove long-standing nesting areas, such as rodent burrows, which may harbour large populations of wild pollinators, especially bumble bees.

Spread of Disease:

At present there are few wild pollinators that have been systematically managed by humans to provide pollination services. However, it is thought that those that have been domesticated and managed for pollination on a large scale (like bumble bees used for pollination in greenhouses) may have contributed to an epidemic of disease among wild populations, causing their noticeable decline. Disease-carrying individuals from managed colonies can escape from greenhouses into the wild and so spread new disease to wild populations, with devastating effects.

Causes of Poisoning:

A more direct cause of population decline among wild bees has been the use of insecticides on the farm and in the forestry industry. This pesticide use has been directed at pest insects but has affected a broad range of insects, including wild pollinators.

Insecticides may directly kill the adult pollinator, may affect the development of brood that is feeding on insecticide-tainted pollen, or may affect foraging behaviour, reducing the efficiency of foragers. Regardless, populations of wild bees and other insect pollinators may be severely undermined by the use of insecticides. Furthermore, it is becoming increasingly apparent that weakening caused by exposure to pesticides leaves bees more vulnerable to disease. A class of insecticides known as neonicotinoids are increasingly being singled out as the culprits in causing sub-lethal negative effects in bees (increased disease susceptibility and disorientation during foraging) without killing them directly.

Pollinators may come in contact with the insecticides if

- the insecticides are sprayed directly on them as they forage,
- their nest entrances are soaked with pesticide, or
- they collect pollen that has been exposed to pesticide.

Bee Name		# of Species	Nesting Habit	Social Behaviour	Preferred Plant	Active Season
Genus	**Common**					
Anthidium	Wool Carder Bee	1	Cavity	Solitary	Stachys	Summer
Chelostoma		3	Stem Cavity	Solitary		Summer
Hoplitis		8	Stem Mason Cavity	Solitary		Summer
Megachile	Leafcutter Bees	18	Stem Ground Wood Cavity	Solitary		Spring/ Summer
Osmia	Orchard Bees	23	Cavity	Solitary		Spring/ Summer
Anthophora		1	Stem Ground	Solitary		Spring/ Summer
Bombus	Bumble Bees	27	Cavity	Social		All Season
Ceratina		3	Stem	Solitary		All Season
Melissodes		10	Ground	Solitary	Thistles	Summer/ Fall

Bee Name		# of Species	Nesting Habit	Social Behaviour	Preferred Plant	Active Season
Genus	**Common**					
Xylocopa	Large Carpenter Bee	1	Wood	Communal		All Season
Andrena	Andrenid Bees	75	Ground	Solitary		All Season
Calliopsis		1	Ground	Solitary		Summer
Perdita		5	Ground	Solitary		Summer
Protandrena		6	Ground	Solitary		Summer
Apapostemon		4	Ground	Solitary		All Season
Augochlora		1	Wood	Solitary		Summer
Augochlorella		1	Ground	Social		All Season
Augochloropsis		1	Ground	Communal?		Summer
Dufourea		3	Ground	Solitary		Summer
Halictus	Gregarious Bees	4	Ground	Solitary Social		All Season
Lasioglossum	Sweat Bees	71	Ground Wood	Solitary	Staghorn Sumac	All Season
Colletes		16	Ground	Solitary		All Season
Hylaeus	Masked Bees	12	Ground	Solitary		Summer

Section 4: Conservation of Pollinators

As a landowner, you can do a lot to protect and encourage wild pollinators, especially bees, on your land. This will benefit you if you are

- a farmer who needs pollination services for seed or fruit crops on your farm,
- a gardener who wants to observe a variety of living things in your garden,
- a forest owner who wishes to continue to enjoy the early spring flowers in the forest understory, or
- a concerned person who understands that it is vitally important to the survival of our food production systems and natural ecosystems that we maintain as large a pool of wild pollinators as possible.

There are some basic, easy, and inexpensive steps that can be taken on a piece of land to increase the likelihood of pollinator survival and proliferation. It should be noted that the size of the piece of land matters very little. Many wild bees will thrive in the small spaces of an urban environment if they are encouraged to do so.

Step 1: STOP using insecticides to kill pests.

Insecticides often kill more beneficial insects than they do pests. These beneficial insects include pollinators of all kinds. Bees are especially susceptible to poisoning by insecticides, including natural insecticides and home remedies. If you must continue to use insecticides on parts of your property, consider creating resource-rich, insecticide-free zones that can act as pollinator preserves. Plant barrier hedges around those preserves to reduce insecticide drift and apply your insecticides in the evening after pollinators have stopped foraging. This will reduce the harm done by insecticides but will not eliminate it, especially for pollinators that live on the crop that they pollinate. It should be noted that it is illegal under the *Bees Act* to spray fruit trees when they are in bloom because of the harm done to pollinators. The insecticide Furadan is extremely toxic to bees and should be avoided. Certain classes of insecticides such as neonicotinoids have been banned in Europe because of their suspected harmful effects on pollinators—these should also be avoided. For information about the relative toxicity of various other pesticides please see the following OMAFRA website: http://www.omafra.gov.on.ca/english/food/inspection/bees/pollination.htm#table1. Of the 102 pesticides registered for use on fruit crops in Ontario, 50 are highly toxic or moderately toxic to bees. OMAFRA issues instructions to remove honey bee colonies from areas being sprayed, but wild bee populations cannot be protected in the same way, leaving them fully exposed to pesticides.

Step 2: LEARN to become aware of the pollinators that may forage or nest on your property.

Look for insects on flowers in all seasons and at various times of day; if they are covered in pollen or if they have pollen balls on their hind legs, they are pollinating bees. Scan the ground for small, neat, pencil-sized holes that might be the entrances to bee nests in the ground (see Figure 12).

Take a moment to inspect dead tree trunks, or hollow stems for evidence of bee nesting activity. Bees will colonize old beetle bore holes. Tear

open a wilted pumpkin flower or two to search for sleeping male hoary squash bees, and look for neat, semi-circular cutouts on the leaves of your rosebushes, evidence that you have leaf cutter bees working in your garden (Figure14).

The more time you take to observe, the more bees or evidence of bees you will likely see.

Figure 14. Evidence of leafcutter bees in the garden

As you look, you will notice that bees can come in all sizes, colours, and shapes. Some wild bees are tiny (the sweat bees, for example) while others are large (the bumble bees), with a range of sizes in between. Some are dull black (carpenter bees), grey (hoary squash bees) or brown (band-footed sweat bees). Others are a beautiful metallic green or blue (halictid bees), while still others have clear yellow or white markings on them. Some bees seem almost furry (bumble bees), while others like the yellow-faced bees seem almost bald. Some bees are delicate and slim (*Calliopsis spp.*), making bumble bees look portly in comparison.

Identifying the wild bees you see may be difficult because there are so many different species in Ontario, but for the purposes of most landowners, awareness is more important than identification. Once you've started paying attention to the fascinating world of wild bees, you may become interested in meeting the bees one by one and learning their names. To help you do this, a pictorial key to the bees of Eastern Canada is available on line at http://www.biology.ualberta.ca/bsc/ejournal/pgs_03/pgs_03.pdf, especially pages 6-15. An excellent pictorial guide to the bumble bees of Eastern North America is available on line at http://www.fs.fed.us/wildflowers/pollinators/documents/BumbleBeeGuide2011.pdf.

Discover Life http://www.discoverlife.org/ offers a very helpful interactive identification tool for bees. Just browsing any of these online resources is an excellent way to acquaint yourself with the many bees that may be found on your property and elsewhere. Pollination Canada provides an observer's kit that can be downloaded from their website to aid you as you observe the pollinators on your property (http://www.seeds.ca/proj/poll/index.php?n=pc_observers_kit). Free information sessions about the Rusty-patched Bumble Bee and other pollinators can be booked through the Rusty-patched Bumble Bee Project facebook page.

Step 3: LEAVE the hedgerows and natural areas on your property undisturbed.

Hedgerows are commonly made up of trees and shrubs that are excellent sources of food for pollinators. These include hawthorn, choke cherry, lilac, staghorn sumac, wild roses, and wild apples. Furthermore hedgerows can harbour colonies of bumble bees that take up residence in abandoned rodent burrows or other cavities created by piles of rocks. Leave the wild edges and corners of fields alone - let them be wild, even if they are overgrown with weeds. Many of those weeds are reliable and abundant sources of food for pollinators and other insects. Even if you do nothing else on your property, preserving the hedgerows and wild spots is an important contribution to pollinator conservation because it preserves foraging and nesting habitat.

Figure 15. Blueweed/Vipers bugloss in flower

Figure 16. Common Milkweed in flowers

Figure 17. Swamp Milkweed in flower

Step 4: PLANT native or heirloom variety plants on your property

Native Herbaceous Plants: Native herbaceous flowering plants such as those listed in Appendix 2 are all good resource plants for pollinators. Many of these are perceived as weeds or plants of no value, but this is a short-sighted evaluation of their contribution to the ecosystems in which they are found.

Appendix 3 provides a list of suppliers of native plants in Ontario.

Trees for Pollen, Nectar, and Resin: Trees such as alders, willows, and red maples produce some of the earliest supplies of pollen to be found in the spring (Figures 18 & 19). Basswoods and locust trees provide copious nectar in the summer. Fruit trees such as apple, plum, pear, and sour cherry are also excellent resource plants, as well as providing fruit for the grower (or the birds as the case may be!). Balsam poplar (Figure 20) produces resins which some bees, for example the yellow and black striped *Paranthidium jugatorium,* may use to build its nest.

Aromatic Herbs: Aromatic herbs such as thyme, chives,

Figure 18. Willow flower, April 29

Figure 19. Red maple flower, April 29

Figure 20. Balsam Poplar flower, April 29

Figure 21. Chive flowers

Figure 22. Borage flowers

Figure 23. White sweet clover

sage, comfrey, oregano, and borage produce abundant nectar and are attractive to a wide variety of pollinators. Some of these herbs are perennial, while others self-seed year after year. Borage blooms well into the fall, long after many of the other herbs have become dormant for the season and is a favorite with bees (Figures 21 and 22).

Weeds and Heirloom Varieties: Various weeds such as sweet clover (Figure 23), goldenrod (Figure 24), and cow vetch (Figure 25) are outstanding nectar and/or pollen producers. If you want to grow other more traditional garden flowers to attract pollinators, choose heirloom varieties that have retained their ability to produce nectar and pollen. Heirloom varieties of any of the flowers listed in Appendix 2 are all good choices that benefit a wide range of pollinators, not just bees.

Shrubs: Shrubs are also an important source of resources for bees. Consider planting shrubs that flower at different times during the season such as elderberry, false spirea, beauty bush, or staghorn sumac (Figure 26). A more complete list including native species is provided in Appendix 2.

Figure 24. Canada goldenrod

Figure 25. Cow vetch

Figure 26. Staghorn sumac in flower

Case Study: Conserving Pollinator Habitat on the Farm

Laura and Bill run a certified organic farm which produces vegetables, small amounts of honey, pastured poultry, and grains. Because the property is certified organic, no herbicides or pesticides are used. As such the property is a safe haven for all insects, including wild bees.

Although most of the farm acreage is devoted to growing grains and soybeans that do not require insect pollination, Laura and Bill understand the importance of providing floral resources to pollinators and beneficial insects as many of the vegetables and fruit grown on their farm do require pollination. They make use of permanent plantations around field margins and in hedgerows, as well as a bee-friendly crop rotation system to provide resources to pollinators on their farm.

Much of the acreage on the farm is covered in undisturbed wetlands, home to important early spring pollen-producing plants such as alders, willows, and red maples. The arable part of the farm is divided into fields by undisturbed hedgerows. A variety of resource-rich plants have established themselves in these hedgerows including hawthorn, wild plum, chokecherry, apple, and lilac. A stand of balsam poplar is well established along the eastern property line, contributing resin to those bees that use it. A row of black locust trees lines one of the on-farm laneways. During their blossoming period, these trees hum with the foraging activities of thousands of bees. A number of large ornamental mock orange bushes near the house are covered in foraging bees during bloom, squashes grown for food in the vegetable garden provide nectar and pollen, and a row of raspberries provides nectar and a potential home for stem-dwelling bees. Lastly, the nooks and crannies on the farm all harbor weed plants of value as pollen and nectar producers. These include the foraging staples of dandelion in the spring, wild mustard in the summer, and asters and goldenrod in the fall.

Besides leaving the hedgerows, trees, bushes, and weeds that were established on the farm when they purchased it, Laura and Bill have also intentionally planted a self-seeding band of yellow sweet clover around the margins of several fields as a nectar source for the honey bees on their farm. Interestingly, aside from providing enormous benefit to many types of bees, sweet clover is an effective soil-building plant. It is a deep-rooted biennial that mines the subsurface layers of the soil and brings those nutrients to the soil surface, thus enriching the top soil. Furthermore, because it is a legume, it can form a symbiotic relationship with soil bacteria to capture nitrogen from the air and fix it in the soil, thus increasing soil fertility.

To build soil fertility and suppress weeds on their farm, Laura and Bill use a crop rotation system which includes cash crops such as spelt and soybeans, and cover crops such as red clover and buckwheat. The red clover is an excellent long-lasting summer nectar source for bees because it is not cut for hay. Buckwheat is grown as an allopathic weed suppressant and green manure. Because the Koto variety drops less seed than other varieties, Bill allows it to fully go to flower before it is incorporated into the soil. However Koto is also a poor nectar producing variety and so does not contribute to the establishment and maintenance of strong wild pollinator populations.

Figure 27. Yellow sweet clover planted on field margins

Forage or Cover Crops:
Landowners can plant soil improving crops such as clovers, alfalfa, field peas, or buckwheat as a cover crop or green manure in a crop rotation. If allowed to flower, these crops will provide a veritable feast of nectar for all insects. Buckwheat used as a green manure or cover crop has traditionally been cut at first flower because the seed sets quickly, matures, and drops before flowering is complete. However, during bloom buckwheat can provide large nectar and pollen resources to pollinators (Figure 28). Care should be taken to choose a nectar-rich variety for this purpose, as some varieties have been intensely bred to reduce seed shattering (Koto variety, for example) and as a result have lost their ability to produce nectar.

Figure 28. Buckwheat in bloom

Establishing Stands of Resource-Rich Plants:
To establish stands of resource-rich plants, sow seed from a variety of nectar rich and/or pollen rich plants in well-prepared ground in the unused or waste spaces on your property. Using hydro-seeding is an effective method on a large scale. Just throwing seeds into thickly vegetated areas without cultivating the soil will not work well as the competition for light, water, and nutrients after the seeds have germinated will be too intense. Another option is to grow or purchase nectar/pollen plants and plant them into these areas in groups. This is the establishment method of choice for planting in hedgerows, though it is more costly.

Choose a Variety of Plants:
Regardless of the establishment method, make sure that the plants you choose bloom at different times over the season so that bees have something to forage on throughout the season. To accommodate the variety of mouthparts, foraging behaviours, and sizes among bees and other beneficial insects, try to include plants with different flower shapes and sizes. Pollination Canada (http://www.seeds.ca/proj/poll/index.php?k=21) has excellent photographs of the six flower types on its website.

Figure 29. Evening primrose in flower

Figure 30. Stachys plant. Notice the wool on the leaves which wool carder bees collect

Choose Plants for Specialist Foragers:
Some bees are specialist foragers who collect pollen from only certain plant species. Be sure to include islands of these plants if you wish to attract these interesting specialists. For example, planting evening primroses (Figure 29) will attract the bee *Lassioglossum oenethera*, planting lambs' ears (*Stachys*, Figure 30) will attract wool carder bees

(*Anthidium spp*), planting thistles will attract the specialist bee *Melissoides desponsa*, and planting staghorn sumac will attract the band-footed sweat bee. An annual planting of squashes or pumpkins will attract the hoary squash bee, an interesting specialist bee whose males sleep in a coma-like state inside the squash or pumpkin flowers once they wilt and close.

Appendix 2 provides a list of good nectar/pollen sources, with information about time of flowering, whether or not the plants are native, and information about growing requirements. You can use this table to create a plant mix to be used in waste areas, on marginal land, along the edges of fields, in hedgerows or in gardens.

Intercropping:
In high value perennial crops needing pollination, narrow bands of inter-cropped resource-rich plants can be planted within fields to create permanent pollinator reservoirs. This will not only increase the stability of pollinator populations in the field, it will provide resources for a large number of other beneficial insects.

Step 4: ESTABLISH and protect suitable nesting sites for pollinating insects.

Characteristics of a Good Nesting Site

A large number of native bees that are important for pollination make their nests in the ground. Most of these ground-nesting bees prefer nesting sites that

- are close to the plants they forage on,
- have heavier soils that keep their shape,
- have a southern exposure,
- are well drained,
- have a minimum of plant cover

Artificial Mounds or Natural Slopes:
Creating piles of heavy soils in a sunny place can be one way to create nesting sites. However, these will require maintenance as weed seeds germinate and cover what was once bare ground. Furthermore, the piles will erode in time. A less labour intensive solution is to find south facing slopes that already exist on your land and reserve them as nesting sites. If these slopes are naturally sparsely vegetated, so much the better. If they are grassy, the grasses can be cut short and maintained to allow bees access to the soil.

Uncultivated Field Margins:
Field margins can also be reserved for ground nesting bees. Deep cultivation or plowing in these margins will destroy the nests of ground-nesting bees, but scuffling the soil surface to control weeds in these margins will do no lasting harm as the nests are fairly deep. Creating a nesting reserve as described above around the margins of fields planted to pumpkin or squash is a very effective way to build up a strong population of hoary squash bees, the most efficient pollinator of these crops. Because this bee is a specialist on pumpkins and squashes, once a strong population of the hoary squash bee is established, the crop's daily batch of flowers will be completely pollinated long before the first honey bees ever show up in the field to forage.

Sandy Nesting Sites:
Unlike most ground nesting bees, the wild bee *Calliopsis andreniformis* prefers sandy soils for nesting. These bees can be well served by nesting in a sandy horseshoe toss, or an abandoned sandbox. Of course naturally sandy areas on your land can also be reserved for *Calliopsis* nesting sites.

Stems:
Another common nesting material used by native bees is the pithy stems of plants like blackberries and raspberries. Bees that nest in these pithy stems include most of the yellow-faced bees *Hylaeus*, all species of small carpenter bee *Ceratina*, and many species of leafcutter bees. When you remove all the old stems from raspberries to encourage fruiting, you are likely removing many of the nests containing bees that would be helping to pollinate the crop the next year. Removing the canes from the plants is necessary for fruit production, but instead of destroying them, keep them in vertical bundles within the field for at least one year. This maintains the nesting sites close to the plants and allows for the development of a stable population of pollinators. Burning the canes, shredding them, or sending them to the landfill site is disastrous for the pollinators who nest in them.

Making and setting out artificial nests for stem-swelling bees is a fairly simple procedure which may help to stabilize pollinator populations from year to year. The success of artificial nests depends somewhat on their placement. Place them against an obvious landmark like a barn or shed wall so that the bees are able to locate them easily. They are best placed out of direct sun where they may overheat, and they should be protected from rain, flooding, or being knocked over. The closer the nest can be placed to foraging resources, the easier it will be for pollinating bees to establish themselves and thrive in a nest. Once the nest is active with adult bees flying in an out, be sure not to move it or many of the adults will not be able to locate the nest again.

Instructions for Constructing a Simple Artificial Nest for Stem-Dwelling Pollinators

Materials:

- Hollow-stems grasses or bamboo of various diameters
- Hand-held pruning clippers
- String
- Plastic pail or wooden box

Cut the stems of the hollow grass or bamboo to various lengths approximately 6 inches long. Avoid having all the stems cut to the exact same length so that different stems are distinguishable from one another to the bees that may take up residence there. Another way to make the individual stems distinguishable to bees is to cut them all the same length, bundle them together and then paint geometric designs on the cut surface in blue or black.

Once the stems are all cut, tie them together into a bundle and place them lying horizontally inside a wooden box or a plastic pail lying on its side. The box or pail provides some protection from sun and rain. An alternative to tying the stems together is to fill a small plastic pail with the straws and then lay the pail on its side.

See Figure 31.

It is not uncommon for artificial nests to harbour more than one species of bee if the stem diameters within a bundle vary. Furthermore *kleptoparasitic* bees (bees that invade the nests of other bees, destroy some of the eggs, and lay their own eggs there) may also show up at the trap nests. To reduce parasitism and to avoid overpopulating a particular area, scatter trap nests in different suitable locations on your property.

Artificial nests should be changed once the next generation of pollinators emerges from them to avoid creating a reservoir of a fungal disease called chalkbrood that kills bee larva. Burn the discarded trap nests, if possible. Commercially artificial nests used in alfalfa fields are cleaned and sterilized with a bleach solution to solve this problem.

DiscoverLife, a project whose mission is to assemble and share knowledge in order to improve education, health, agriculture, economic development, and conservation throughout the world, is hosting a citizen-scientist research project to understand the impact of climate change and other factors on nest timing and geographic distribution in the group of native bees known as mason bees or *Osmia* (pronounced OZ-mee-uh). Instructions for how to construct a nest for these bees and how to participate in the research can be found at http://www.discoverlife.org/bee/opp/design.html.

Wood:
Native Virginia carpenter bees, (*Xylocopa virginica*) bore holes in wood to make their nests. Drilling an assortment of holes of different sizes in dead standing trees, or in blocks of wood can encourage these bees to nest on your property (see Figures 16 & 17). Some leaf cutter bee species like to nest in rotting wood so leaving rotting logs can also create wild bee nesting sites. The website http://www.studiogblog.com/shed-other-garden-buildings/encouraging-native-bees-with-insect-walls/ provides many inspirational photographs of bee houses made of a wide variety of materials. It should be noted however, that although the idea of creating a visually beautiful nesting "condo" for bees is very appealing to humans, concentrating bee nests in one location over many seasons, especially in a structure that cannot be cleaned or disinfected, will lead to an increase in the pests and diseases that affect those nests. It may be better to be less artistic and scatter bee nests around your property in simple, cleanable or disposable nests.

Figure 31. A bundle of large gass stems tied together can provide nesting sites.

Figure 32. An assortment of holes drilled into deadwood can provide nesting sites.

Cavities:
Bumble bees are cavity nesters. In the spring, the mated bumble bee queen, who is the sole survivor from the previous year's colony, searches out a suitable nesting cavity and begins to raise a new batch of female bees. This next generation of bees then takes over the job of building the colony, foraging for food, taking care of

brood, and defending the nest, while the queen devotes herself to laying eggs (see Figure 13). Because queens begin their search for nesting cavities early in the spring, if you want to attract bumble bee queens to nest in artificial cavities like overturned clay pots or empty wooden nest boxes, these need to be put in place the previous fall. Avoid the use of metal containers for this purpose because they get too hot for bees on the hot sunny days of summer. If a bumble bee colony does become established in an artificial cavity that you provide, do not move it or you will substantially weaken the colony. Choose a location that is not too close to areas where you work, play, or sit. Bumble bees can become very protective of their nests, and will defend them by attacking you. Instructions for making a bumble bee nest box are located at http://www.bumblebee.org/nestbox_plans.htm.

Figure 33. A shallow water container that allows bees to land and collect water without drowning.

Mud Puddles:
Some wild bees use mud to construct their nests. Creating small areas in which water can collect and form mud gives these bees access to the material they need for their nests. This is especially important during droughts when mud is not naturally available. A pail of soil saturated with water also makes an excellent "mud puddle", especially if you create landing areas for bees with twigs.

Step 5: PROVIDE water.

Water is used by bees for cooling, for creating their pollen balls, and sometimes for making mud for nest construction. Keeping a source of water available is a good idea but it must be in a form that is useful to insects. A shallow container filled with small pebbles or coarse sand that rises above the level of the water is ideal, as is a container that has wood chips floating on the water's surface (Figure 33). Both of these arrangements allow bees to land and drink without falling into the water and drowning. A pond with a gradual gently-sloped bank can also work.

Step 6: PARTICIPATE in citizen-scientist research projects.

Take photographs of the bees you see, recording the place, time, host plant or nesting site, and date of the photo. Submit these photos to on-line identification services such as the one offered at http://bugguide.net/. As a result you will learn and your identified photos will be added to a growing collection of data about wild bees in North America. If you are excited by the idea of playing a more active role in research on your property, DiscoverLife has a variety of citizen-scientist projects about bees that anyone can participate in. All the instructions you need are on their website (http://www.discoverlife.org/), including instructions for participating in a study of the

Figure 34. Coltsfoot in flower

nesting habits of mason bees. The Xerces Society hosts a citizen-scientist survey for the Rusty-patched Bumble Bee. Photos can be sent to bumblebees@xerces.org. If you want to expand your horizons to include other insects, Monarch Watch, an organization dedicated to monarch butterfly conservation also offers opportunities to be involved in research on the migratory behaviour of that insect.

Four Things to Remember As You Create Habitat for Pollinator Bees

1. Nesting sites for wild pollinating bees need to be located close to the resources they use for food.

Nesting sites and floral resources go together. Any effort to encourage pollinator populations on your land needs to take this into consideration. Some of the smaller wild bees cannot afford to travel farther than about a hundred meters between their nest and the plants they forage on. For many wild bees, creating perfect nesting sites hundreds of meters away from flower resources is futile. If you do find a superior place to establish a nesting site, especially a ground nesting site, make the extra effort to provide resources for foraging alongside the nesting site. This will improve the likelihood of success. In an agricultural context, this is why using field margins as nesting preserves is so effective. The bees live and work in the same neighbourhood and commuting is kept to a minimum.

2. Establishing strong, stable populations of wild bees takes time.

Most wild bees are solitary. This means that even relatively strong populations may go un-noticed by the casual observer because the bees nest in scattered nesting sites. Because each female solitary bee only raises a handful of offspring, and some of these may die of natural causes, there is not likely to be a noticeable population explosion of wild bees on your property in the short term. Be patient, and take the long view when you are striving to conserve wild bee populations. Remember also that if you have few bees on your property at present, they will have to migrate in slowly and then establish themselves. You may never have the privilege of hosting many of the wild bee species found in Ontario because your land may not be suited to their needs. This is to be expected.

3. Some species of wild bees may only be around at certain times.

Specialist wild bee species forage for only the period of time when their host plants are blooming. On a seasonal basis, for example, you may notice a variety of wild bees on early spring forest plants. However once those plants stop blooming, the bees that visit them seem to disappear. In fact, they have completed their lifecycle. The adult females that you noticed have collected pollen from the spring flowers, provisioned their nests, laid eggs and died, all in the short period of time in which these flowers bloom. The same holds true for any specialist pollinator. You may also notice a similar pattern on a daily basis. For example, if you were to wake up at dawn and wander down to your pumpkin patch, you might see large numbers of hoary squash bees flying from flower to flower. However, if you were to wander in the same patch in the afternoon, you wouldn't find a single squash bee. If you were observant,

you would notice that all the pumpkin flowers were also closed and wilted at that time. These squash bees are specialist foragers and when the pumpkin flowers wilt, they simply stop foraging for the day. So do not panic if the wild bees that you are seeking to protect disappear after a certain time of season or day; this may be a reflection of their normal lifecycle or foraging cycle. Learning to recognize the bees you see will allow you to know which are specialists and can be expected to behave in this way.

4. Honey bees can compete heavily with wild bees for resources.

Honey bees are wonderful pollinators and produce the nectar of the gods - honey! Maintaining a few hives of bees or hosting the bees of a beekeeper on your land is an excellent idea, but keep in mind that they can also compete with wild bees for pollen and nectar resources. Limiting the number of managed hives on your property and keeping those hives in a single location may be the best way of maintaining healthy populations of both wild and managed bees.

Notes:

Resources to Help You in Your Conservation Efforts

Web resources:

BeeSpotter http://beespotter.mste.illinois.edu/

[This website is dedicated to the bees of Illinois only. However, it remains a useful resource for photographs of pollinating bees, contributed by people all over the state of Illinois. An excellent photograph on this website of the rusty-patched bumble bee, an endangered bumble bee species, has been used in this handbook.]

Bug Guide http://bugguide.net/

[This excellent website is exclusively about 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" Some photos from this website have been used in this handbook.]

Bumblebee.org http://www.bumblebee.org/

[This website is from the UK and is devoted to information about bumble bees. It includes information of interest to bumble bee enthusiasts in North America as well as good drawings and photos of an assortment of other wild bee. Several of the drawings in this handbook were taken from this site.]

Bumblebees of the Eastern United States. 2011. Sheila Colla, Leif Richardson, and Paul Williams. USDA. http://www.fs.fed.us/wildflowers/pollinators/documents/BumbleBeeGuide2011.pdf

[This is an excellent guide to identifying the bumble bees of the Eastern United States and is applicable to the bumble bees of Ontario]

DiscoverLife http://www.discoverlife.org/

[This is an excellent, extensive collection of photos, identification keys, descriptions, and maps for identifying all kinds of living things. Look under the Apoidea to find bees. DiscoverLife also has many citizen-scientist research projects that anyone can participate in. Photos on this site are available for public use under conditions specified in their fair use policy. Many have been used in this handbook.]

Insects and Other Arthropods http://www.kendalluk.com/bumble.htm

[This website is authored by David A Kendall and includes a wide variety of topics having to do with arthropods of all types. The excellent photo of the bumble bee nest used in this handbook came from this site.]

Pollination Canada http://www.seeds.ca/proj/poll

[This website has some interesting tips for helping pollinators and for watching and recording their activities. They provide an observers kit that can be downloaded to help you with your observations.]

The Rusty-patched Bumble Bee Project facebook page http://www.facebook.com/RustyPatchedBumbleBee

[This facebook page gives up-to-date information about the Rusty-patched Bumble Bee Project, funded through Ontario's SARSF to raise awareness about and to survey for the endangered Rusty-patched Bumble Bee.

Xerces Website

http://www.xerces.org/pollinator-conservation/

[The Xerces society is a nonprofit organization that protects wildlife through the conservation of invertebrates and their habitat. Established in 1971, the Society is at the forefront of invertebrate protection worldwide, harnessing the knowledge of scientists and the enthusiasm of citizens to implement conservation programs. They are an excellent resource for pollinator conservation knowledge and ideas and have a number of very well respected publications.]

Books:

Packer, Laurence. 2010. *Keeping the Bees.* HarperCollins Publishers Ltd. Toronto.

[This is an easy, informative read with lots of anecdotes, and invaluable information about bees all over the world.]

Journal/Magazine Articles:

Kevan, P.G., Savage, C. 2008. Plight of the bumblebee. *Canadian Geographic*. Dec. 2008. pp. 54-60.

[An interesting article about the decline of bumblebees from the foremost authority on pollination in Canada.]

McGregor, S.E. 1976. *Insect Pollination of Cultivated Crops.* USDA. Retrieved from http://afrsweb.usda.gov/SP2UserFiles/Place/53420300/OnlinePollinationHandbook.pdf.

[This scholarly article is the "bible" of the pollination requirements of cultivated crops, especially with respect to honeybees.]

Packer, Laurence, Genaro, Julio A., Sheffield, Cory S. The Bee Genera of Eastern Canada. 2007. *Canadian Journal of Arthropod Identification.* Retrieved from: http://www.biology.ualberta.ca/bsc/ejournal/pgs_03/pgs_03_main.html#intro.

[This scholarly article provided the information about the wild bees of eastern Canada]

Possible Sources of Funding for Pollinator Habitat Conservation:

Environmental Farm Plan has cost-sharing funds for wildlife habitat conservation that can be accessed for creating pollinator habitat on agricultural land. See http://www.omafra.gov.on.ca/english/environment/efp/efp.htm

Appendix 2. Resource-rich Plants for Pollinators

Plant Type	Plant Name	Flowering Period	Resource Provided			Type	Growing Tips
			Pollen	Nectar	Resin		
Trees	Maples (*Acer spp.*)	May	■			N	Variable
	Balsam Poplar (*Populus balsamifera*)	April			■	N	W-M/S
	Black Locust (*Robinia pseudoacacia*)	June		■		I	M-D/S
	Honey Locust (*Gleditisia triacanthos*)	Late June		■			M-D/S-PS
	Clammy Locust (*Robinia viscosa*)	Late June		■		N	M-D/S-PS
	Canada Plum (*Prunus nigra*)	May	■	■		N	M/S-PS
	Wild Apple (*Malus pumila*)	Late May	■	■			M/S
	Siberian Crab (*Malus baccata*)	Late May	■	■			M/S
	Hawthorns (*Crataegus spp*)	June	■	■		N	M-D/S-PS
	Mazzard Cherry (*Prunus avium*)	Mid-May	■	■			M-D/S
	Willows (*Salix spp.*)	April	■	■		N	W-M/S-PS
	Horse Chestnut (*Aesculus hippocastanum*)	May-June	■	■			
	Ohio Buckeye (*Aesculus glabra*)	Late May	■	■		N	M/S
	American Basswood (*Tilia americana*)	June-July		■		N	M-D/S-PS
	Large Leaf Linden (*Tilia platyphyllos*)	June-July		■			M/S-PS
	Chokecherry (*Prunus virginiana*)	May-June	■	■		N	M/S
	Russian Olive (*Elaeagnus angustifolia*)	June		■		I	M-D/S
Shrubs	Beauty Bush (*Kolkwitzia amabilis*)	June		■		O	M/S-PS
	Elderberry (*Sambucus nigra*)	June-July	■	■		N	M-W/S
	Indian Currant (*Symphoricarpus orbiculatus*)	July-Aug		■		N	M-D/S-PS
	Snowberry (*Symphoricarpus alba*)	June-July	■	■		N	D/S-Sh

N-Native plant; I-Invasive habit; O-Ornamental; A-Agricultural crop
W-Wet soil; M-Moist soil; D-Dry soil; S-Full sun; PS-Part sun; Sh-Shade

Plant Type	Plant Name	Flowering Period	Resource Provided			Type	Growing Tips
			Pollen	Nectar	Resin		
	Mock Orange (*Philadelphus coronarius*)	Early June		■		O	M/S
	Deutzia (*Deutzia gracilis*)	Late May		■		O	M/S
	Staghorn Sumac (*Rhus typhina*)	Early July	■	■		N	D/S
	Caragana (*Caragana arborescens*)	June		■		I	D/S
	False Spirea (*Sorbaria sorbifolia*)	July-Aug	■	■		I	M/S
	Red Raspberry (*Rubus idaeus*)	June	■	■		N	D/S
	Black Raspberry (*Rubus occidentalis*)	June	■	■		N	M/PS
	Lilacs (*Syringa spp.*)	Late June		■		I	M-D/S-PS
	Amur Privet (*Ligustrum amurense*)	Late June		■		I	M/S-PS
	Blueberry (*Vaccinium angustifolium*)	May-June		■		N	M-D/S-PS
Herbaceous Plants	Meadowsweet(*Spirea spp.*)	August	■	■		N	W-D/S
	False Indigo (*Amorpha fructosa*)	May-June	■	■			M-D/S
	Buckwheat (*Fagopyrum esculentum*)	Varies		■		A	M/S
	Wild Mustard (*Brassica spp.*)	June-Oct.		■			M/S
	Canola (Brassica napus)	Varies		■		A	M/S
	Alsike Clover (*Trifolium hybridum*)	June		■		A	M/S
	White Dutch Clover (*Trifolium repens*)	July		■		A	M/S
	Red Clover (*Trifolium pratense*)	June-July		■		A	M/S
	Sweet Clovers (*Melilotus spp.*)	June-Sept		■		A,I	M-D/S
	Alfalfa (*Medicago sativa*)	May-Oct.		■		A	M/S

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Plant Type	Plant Name	Flowering Period	Resource Provided			Type	Growing Tips
			Pollen	Nectar	Resin		
	Common Vetch (*Vicia cracca*)	July-Aug.		■		I	M-D/S-PS
	Jewelweed (*Impatiens pallida*)	July-Oct.		■		N	W-M/PS-Sh
	Fireweed (*Epilobium angustifolium*)	July-Sept.		■		N	D/S
	Common Milkweed (*Asclepias syriaca*)	July-Aug.		■		N	M-D/S-PS
	Swamp Milkweed (*Asclepias incarnata*)	July-Aug.		■		N	W-M/S
	Butterflyweed (*Asclepias tuberosa*)	June-Sept		■		N	M-D/S
	Blueweed (*Echium vulgare*)	June-Aug.		■		I	M-D/S
	Blue Vervain (*Verbena hastata*)	July-Aug.	■	■		N	M/S-PS
	Joe-Pye Weed (*Eupatorium maculatum*)	Aug.-Sept		■		N	W-M/S-PS
	Goldenrods (*Solidago spp.*)	Aug.-Oct.	■	■		N	M-D/S-PS
	New England Aster (*Aster novae-andiae*)	Aug.-Oct.	■	■		N	M/S-PS
	White Upland Aster (*Aster ptarmicoides*)	Aug.-Oct.	■	■		N	M/S-PS
	Common Sunflower (*Helianthus annus*)	July-Aug.	■	■		N	M/S
	Bull Thistle (*Cirsium vulgare*)	June-Sept	■	■		I	M/S-PS
	Knapweeds (*Centaurea spp.*)	July-Sept.		■		I	M/S
	Dandelion (*Taraxicum officinale*)	May-June	■	■			M-D/S-PS
	Coltsfoot (*Tussilago farfara*)	April-May	■	■			M/S-PS
	Perennial Sow Thistle (*Sonchus arvensis*)	July-Aug.		■		N	M/S
	Annual Sow Thistle (*Sonchus oleraceus*)	July-Aug.		■		N	M/S
	Hawkweeds (*Hieracium spp.*)	May-June		■		N	D/S

N-Native plant; I-Invasive habit; O-Ornamental; A-Agricultural crop
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Plant Type	Plant Name	Flowering Period	Resource Provided			Type	Growing Tips
			Pollen	Nectar	Resin		
	Purple Coneflower (*Echinacea purpurea*)	June-Aug.	■	■		N	M/S
	Pumpkin/Squash (*Cucurbita pepo*)	July-Aug.	■	■		A	M/S
	Lavender Hyssop (*Agastache foeniculum*)	July-Aug.		■		N	M/S
	Jerusalem Artichoke (*Helianthus tuberosus*)	Sept-Frost	■	■		I	M/S
	Evening Primroses (*Oenothera spp.*)	June-Sept.	■	■		N	M-D/S
	Tall Gazing Star (*Liatris aspera*)	Aug-Oct.		■		N	M-D/S
	Lamb's Ears (*Stachys sp.*)	June-Sept.		■		O	M-D/S
Aromatic Herbs	Thyme (*Thymus vulgaris*)	May-Oct.		■			M-S/S
	Mint (*Mentha spp.*)	June-Aug.		■		I	M-D/S
	Chives (*Allium schoenoprasum*)	June-July		■			M-D/S
	Lavender (*Lavendula angustifolia*)	June-Aug.		■			M-D/S
	Sage (*Salvia officinalis*)	June-Aug.		■			M-D/S
	Comfrey (*Symphytum officinale*)	May-Oct.	■	■			M/S
	Catnip (*Nepeta cataria*)	July-Sept.		■			M-D/S
	Coriander (*Coriandrum sativum*)	June-July		■			M/S
	Oregano (*Origanum vulgare*)	July-Aug.		■			M/S
	Borage (*Borago officinalis*)	July-Frost	■	■			M/S
	Bee Balms (*Monarda spp.*)	June-Aug.		■		N	M-D/S

N-Native plant; I-Invasive habit; O-Ornamental; A-Agricultural crop
W-Wet soil; M-Moist soil; D-Dry soil; S-Full sun; PS-Part sun; Sh-Shade

Appendix 3. Suppliers of Native Plants

Acorus Restoration
RR 1, Walsingham, ON.
N0E 1X0
P: (519) 586-2603
www.ecologyart.com

Baker Nursery Ltd
RR 2, Bayfield, ON
N0M 1G0
P: (519) 482-9995
todd.baker@hurontel.on.ca

The Cottage Gardener
4199 Gilmore Rd., RR 1
Newtonville, ON L0A 1J0
Tel: 905-786-2388
http://cottagegardener.com/
heirlooms@cottagegardener.com

Eco Logic Nursery
c/o Rick Cornelissen
21 Park Street,
Aylmer, ON N5H 2R4
P: (519) 765-3467
cornel@amtelecom.net

ForestCare
Box 150
St. Williams, ON. N0E 1P0
Toll Free: 866-640-8733
P: (519) 586-9916
www.forestcare.com

Fuller Native & Rare Plants
175 Airport Pkwy E.
Belleville ON K8N 4Z6
613-968-4643
http://fullerplants.com/

Greenfield Nursery Ltd.
RR 1, Ayr, Ont.
P: (519) 632-7592
green@golden.net

Groen's Nursery Ltd.
1512 Brock Rd,
RR 4, Dundas, Ont. L9H 5E4
P: (905) 659-7072

Kastrau Landscaping & Nurseries Ltd.
1210 Wilson St. E,
Hamilton, Ont. L8S 4K5
P: (905) 529-9323
pkastrau@cogeco.ca

Kraus V Nurseries Ltd
1380 Centre Rd,
Carlisle, Ont. L0R 1H0
P: (905) 689-4022
www.krausnurseries.com

Limestone Creek Restoration Nursery
RR 1, Campbellville, Ont. L0P 1B0
P: (905) 854-2914

Native Plant Source
318 Misty Cr,
Kitchener, Ont. N2B 3V5
P: (519) 748-4021
www.nativeplantsource.com

New Meadows Wildflower Seeds
38 Katherine St,
Kitchener, ON N2M 2K1
P: (519) 576-5956

North American Native Plant Society
PO Box 84, Station D
Etobicoke, Ont. M9A 4X1
www.nanps.org

Old Field Garden
2935 Porter Road,
Oxford Station, ON K0G 1T0
613-258-7945
http://www.oldfieldgarden.on.ca/

Ontario NativeScape (ONS)
PO Box 1168
Chatham, Ont. N7M 5L8
P: (519) 809-5764
rlsn@bellnet.ca

Ontario Native Plant Company
Unit 3, Bdlg 39, 60 Carl Hall Road
Downsview ON. M3K 2C1
P: (416) 633-1797
onp@nativeplants.on.ca

Otter Valley Native Plants
Box 31, RR 1
Eden, Ont. N0J 1H0
P/F: (519) 866-5639

PAO Associates
5312 Trafalgar Rd,
Hornby, Ont. L0P 1E0
P: (905) 875-0055

Pterophylla
RR#1
Walsingham, Ont. N0E 1X0
P: (519) 586-3985
gartcar@kwic.com

Sweet Grass Gardens
RR 6, 470 Second Line Rd,
6 Nations of the Grand River,
Hagersville, Ont. N0A 1H0
P: (519) 445-4828
info@sweetgrassgardens.com
www.sweetgrassgardens.com

V. Kraus Nurseries
PO Box 180, 1380 Centre St.
Carlisle, Ont. L0R 1H0
P: (905) 689-4022
F: (905) 689-8080

Van Den Nest Nursery
(Formerly Garden of Eden Tree Farm)
Box 20, Eden, Ont. N0J 1H0
P: (519) 866-5269
F: (519) 866-5507
edentree@amtelecom.net
www.amtelecom.net/~edentree/

Wildflower Farm Inc.
10195 Hwy 12 West, R.R.#2 Coldwater, ON
L0K 1E0
http://www.wildflowerfarm.com/
info@wildflowerfarm.com

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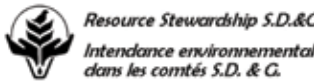

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