Protecting pollinators from pesticides in

APPLES

POLLINATOR PARTNERSHIP CANADA

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FOREWORD

Insect pollinators, especially bees, play a crucial role in the pollination of apple tree blossoms. Pollinator health is important to the long-term sustainability of apple production as well as to the broader environment, especially as pollinators are known to be in decline globally. Keeping managed bees and other pollinators, such as wild bees, healthy requires involvement from all those participating in apple production, from beekeepers to growers, agronomists, crop consultants, and pesticide applicators.

The focus of this guide is on promoting and protecting pollinator health in apple orchards, and is meant for all those involved in apple production. There are many factors that impact pollinator health in addition to pesticide exposure, including habitat loss, pests and diseases, and climate change. By reducing pollinators' exposure to pesticides, stakeholders can help pollinator populations be more robust and healthier in the face of multiple stressors.

This guide can be used as a quick reference on individual topics or can be read in its entirety for a deeper dive into the subject. It provides guidance on how to minimize the impacts of pesticides on pollinators (primarily bees) through informed decision-making, best management practices, and by maintaining good communication between all parties. The **first section** of this guide covers the relationship between managed and wild pollinators, and apple. The **second section** covers four important practices that help minimize the impacts of pesticides on pollinators: integrated pest management, communication, habitat, and pesticide product selection and use. The **third section** distills the information contained in sections 1 and 2 into action-oriented recommendations for growers, applicators, and beekeepers. The **resource section** includes more detailed information on the impacts of pesticides on bees, and how to identify and report suspected bee poisoning.

In addition to this guide, readers can consult the supplemental document for pollinator precaution levels for products registered for use in apple and for additional information on the pesticide risk characterization framework used by the Pest Management Regulatory Agency to designate precaution levels.

We hope this guide will help everyone involved in apple production learn more about the bees that pollinate this important crop and how we can maintain productive and healthy apple systems while protecting pollinators within those systems.

1 APPLE POLLINATION

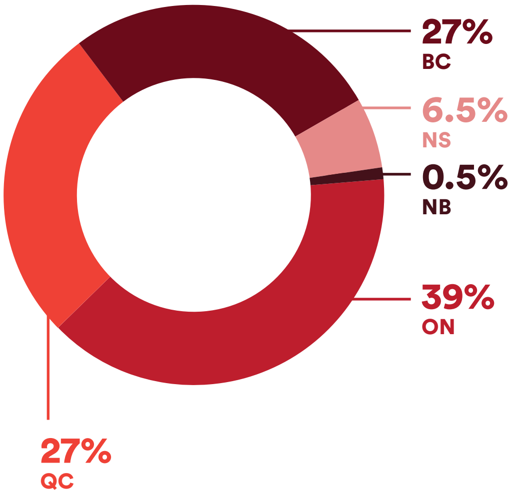
APPLE PRODUCTION IN CANADA

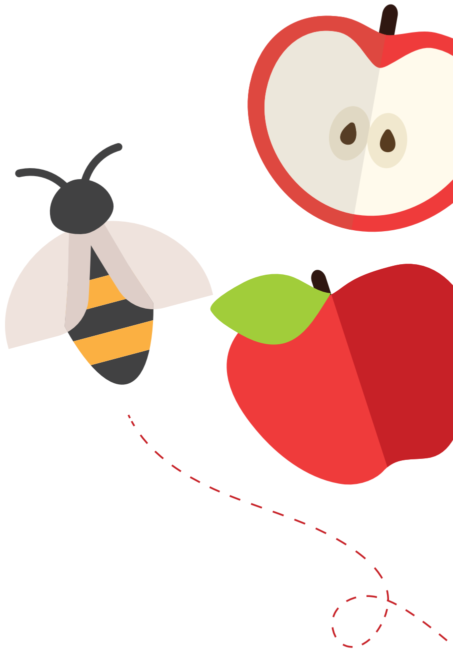
Apple (*Malus domestica*) is the most widely cultivated fruit in the world and has perhaps the longest history of cultivation of any crop. *Malus sieversii*, the domestic apple's ancestor, still grows wild in central Asia. Currently, a wide variety of apples are grown in Canada, with ongoing innovations continuously bringing new varieties and flavours to market. Researchers also are searching for wild relics in order to revive classic varieties. In Canada, there are about 20 commonly marketed varieties, including McIntosh, Honeycrisp, Empire, Ambrosia, and Gala, which make up the most production hectares.

Apple ranks second in Canada in total cultivated fruit area, with almost 1 million metric tonnes produced in 2019[1], representing a farm gate value of approximately $240 million CAD and an export value of over $41 million[2]. The pollination services of bees, wild and managed, contribute to this value significantly.

In Canada, three provinces share most of the apple production and hence pollination requirements for this crop. Ontario ranks first (39%), followed by British Columbia (27%), and Quebec (27%). Nova Scotia (6.5%) and New Brunswick (0.5%) represent a minor share of production and pollination needs[1,2]. The majority of apples grown in Canada are consumed domestically, with minor specialty exports. Producing a marketable product for both domestic and export markets requires consideration of many factors, including pest control and pollination requirements.

APPLE POLLINATION BY PROVINCE





APPLE FLOWERS NEED POLLINATION

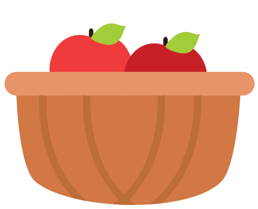
Apple pollen is heavy and sticky; it generally cannot be transferred by wind. For apples to set seed and develop fruit they require an insect pollinator. Bees are the primary pollinators, but apple flowers are also visited and likely pollinated by flies. Additionally, most varieties are self-incompatible, meaning there must be a source of compatible pollen from a different type of apple tree blooming at the time of receptivity. Apple trees that are planted for the purpose of providing pollen to the main crop trees are called pollinizers. Apple orchards are designed with pollinizer compatibility in mind, including varieties of apples that bloom on a synchronized schedule.

While many factors influence apple quality and yield, a lack of pollination, on its own or in combination with other factors, can lead to substandard production[3,4]. The amount of pollen transferred has an impact on apple quality and size[5]. Even and ample pollen transfer impacts fruit quality, size, and overall yield. However, pollen transfer is only beneficial up to a certain point as excessive pollination can set too many fruit that then need to be thinned. As with many crops, the combined visits by both managed honey bees and wild bee species during bloom lead to better seed set, larger fruit, and higher yields than pollination by managed or wild bees[6,7] alone. Wild bees have been shown to be better pollinators of apples than honey bees[8,9]. Research has shown that apple seed set and yield is boosted by an increase in the abundance of wild bees; but similar trends are not seen with increases in honey bee abundance[10].

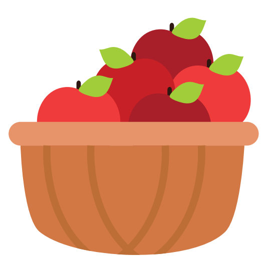
The majority of growers seek to ensure pollination by placing honey bees at specific stocking rates at the time of king bloom. Augmenting pollination with managed bumble bee colonies is also currently being assessed in Canada, with mixed results (Grigg-McGuffin, personal communication). Commercially managed mason bees, in particular *Osmia lignaria*, are used by some apple growers in the western United States, but the practice is not widespread.

Most apple growers seeking to increase pollination by wild bees focus on habitat support and integrated pest management (IPM) approaches. Natural pollination by wild bees can provide sufficient pollination, and is a reliable source of pollination when local habitat supports robust and diverse populations[11]. Many apple growers in Canada successfully produce marketable crops without using managed honey bees, instead relying on wild pollination services supported by habitat and IPM practices. However, because a lot of pollination is needed in a short time, and honey bees are often used for risk management in case weather is poor during bloom.

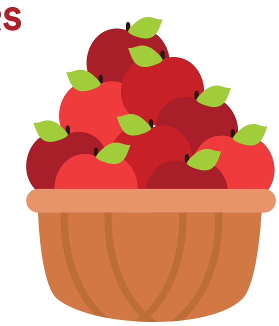
PRODUCTION BENEFITS FROM WILD AND MANAGED POLLINATORS



Little/no pollination
Heavy pollen and the need for a compatible partner tree. No pollinators (pollinator exclusion), results in little to no yield.



Limited pollination
When pollen is not sufficiently transferred to all five carpels, fruit will be small, malformed, and less marketable.



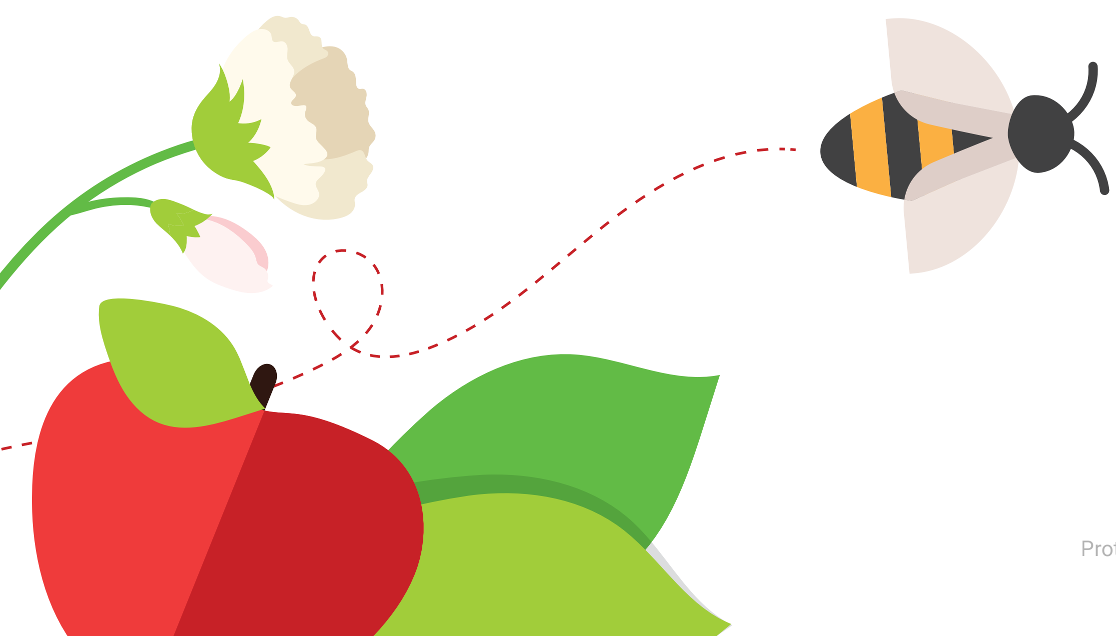
Robust pollination:
Full pollination resulting from diverse wild bee visits and correctly timed honey bee stocking results in larger, more even fruit, as well as more fruits per tree.

THE POLLINATORS OF APPLE

Apple blossoms are visited and pollinated by many types of insects, including flies such as flower flies (Syrphidae), and a diversity of bees. Bees are the most effective pollinators because of their active pollen collecting behaviour. While most people are familiar with managed honey bees, less well-known are native bees that provide valuable pollination services to many crops, including apple[11,12]. Native bees are those that have co-evolved with the plants of a given location over thousands of years. This guide uses the term 'wild' bees to distinguish between wild and native species that live without human intervention, and managed bees, which include not only honey bees but also some species of bumble bees and other bees. Read below to find out more about managed honey bees and the fascinating wild bees that make apple production possible.

Apple flowers grow in clusters of five to six flowers, with the king blooms being the primary or largest blossom that will produce the most desirable fruit. Apples will produce blooms over multiple weeks, but king blossoms begin blooming first and finish first. It is important that pollination occurs during king blossom bloom to ensure the best yields. Different apple cultivars have varying flower size and bloom during different periods. In addition, weather conditions can vary substantially during bloom and between years, and these factors of flower size, bloom time, and weather during bloom affect which pollinators will be active. This means that the dominant pollinators will vary by year and location, underscoring why pollinator diversity is important.

Apple bloom spans a number of weeks depending on variety, and the geographic range in which apples grow is wide. This means that the communities of bees and other pollinators that visit apple vary greatly by location and year.



HONEY BEES

Honey bees are commonly rented from beekeepers for apple pollination. They are a managed species first brought to North America by early European settlers. Honey bees are social insects that live in large colonies with tens of thousands of individual bees. Although honey bees are less efficient apple pollinators per visit than some wild bee species, they are easy to manage and transport, and can provide a large pollinating force that can adequately pollinate crops, especially when field sizes are large. Hives are typically placed at a rate of 2.5-6 hives/ha (1-2.5 hives/acre), or at a rate of 12 hives/hectare (5 hives/acre) when the landscape suggests that there would be low support from wild pollinators[13,14]. Sufficient yields are seen when hives are placed in orchards that have reached 5% bloom.

Unlike some flowers, apple blossoms are open and easily accessible to honey bees. The pollen and nectar provided by apple flowers is considered reasonably attractive to honey bees, with nectar sugar content ranging between 25-58%[14]. Apple varieties that produce larger volumes of nectar and pollen are more attractive and visited more frequently by honey bees than varieties with lower nectar and pollen production.

WILD BEES

There are over 800 species of wild bees in Canada, ranging in size from a few millimeters up to 25 mm in length. Wild bees are on-site natural allies that are known to increase apple production; even in the presence of high densities of honey bees, having more wild bees will increase apple yield[9,15,16]. Wild bees are present in and around fields all year, either as adults that can be seen flying and foraging, or as eggs, larvae, and pupae that are less visible but nonetheless present in nests in the ground, in twigs, and in cavities. In fact, many ground-nesting bees such as long-horned bees, mining bees, and sweat bees construct their nests in and around orchards.

Ensuring that wild pollination services are sufficient means supporting the needs of wild pollinators, mainly by providing food, shelter, and areas without harmful pesticides. For bees, food is the pollen and nectar found in flowers. Shelter is where they build their nests, including dried plant stalks and other insect burrows in wood, as well as bare or scrubby ground, which is the most common place for nesting wild bees.

The communities of wild bees that visit apple trees will vary across Canada and between varieties that produce early, mid, or late-season fruit. Because apples can bloom early in the spring, they can be visited by early season bees, such as mining bees (*Andrena* spp.) and cellophane bees (*Colletes* spp.), as well as various sweat bees (Halictidae), leafcutter bees (*Megachile* spp.), bumble bees (*Bombus* spp.), and mason bees (*Osmia* spp.) that are common later in the spring and throughout the summer[16].

There is an increasing amount of research on the importance of wild, native bees to agricultural production and the risks pesticides pose to them. While there are documented declines of wild bees in North America[17], additional research is needed to fully understand the impacts of factors such as habitat loss, diseases, parasites, climate change, competition with managed bees, transmission of pests or pathogens between managed and wild bees, and pesticide exposure[18-25] (See 'Wild pollinators of apple' on page 10 for more information and photos of common wild apple pollinators).

Pollination in apple orchards by wild bee pollinators can be encouraged in a number of ways, including:

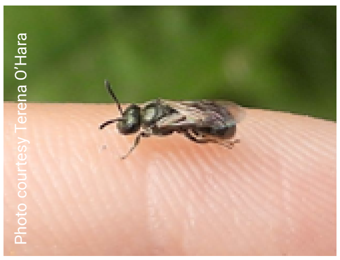
- Creating or leaving adjacent habitat which can provide nesting and floral resources for wild bees and can also support honey bee health (pg 16).
- Identifying and protecting wild bee nesting aggregations within or near orchards
- Allowing habitat between orchard rows to grow, especially early season flowers that can support early season wild bees.
- Reducing exposure to pesticides by following label recommendations and practicing integrated pest management (pg 20).

WILD POLLINATORS OF APPLE

These are come wild native bees that you may see in or around apple orchards. They are docile and rarely sting people. All those shown here are known to pollinate apple. Use the iNaturalist App to help identify bees.

MASON BEES

(genus *Osmia*) Mason bees are tunnel nesters and some people put out bee boxes to give them places to nest. In nature, they nest in hollow stems or existing tunnels in trees or fallen logs. They fly early in the season and have been found to be one of the most effective and efficient apple pollinators in areas where they coincide with apple bloom. They are small to medium sized and are sometimes mistaken for flies.

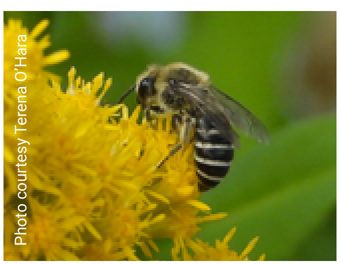


SWEAT BEES

(family Halictidae) Sweat bees can be as tiny as 4 mm, like the one on the left, or up to about 11 mm. Some are metallic, others bright green, and some have stripes. They are good pollinators of apple. In open, cup-shaped flowering with upright anthers, sweat bees can be seen collecting pollen in a 'swimming' motion. Most are solitary and nest in the ground. The little ones might land on you and lick your sweat in the summer!

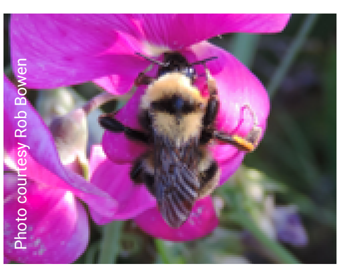
MINER BEES

(family Andrenidae) Like the sweat bees, mining or miner bees nest in the soil. They all are solitary but sometimes will nest in large numbers in one area. They range in size from 7 mm to 18 mm. Mining bees are common early season bees and their lifecycle coincides with apple bloom. They can be found nesting within fields or in the soil, on banks, or flat areas beside fields. Like all native bees, they are very docile and rarely sting people.



CELLOPHANE BEES

(family Colletidae) Cellophane bees are named after the cellophane-type material they use to line their nests. Most are solitary and nest in the ground, but some nest in above ground tunnels in places like grass and flower stems. Cellophane bees are early season species that commonly visit apple blossoms. Cellophane bees can travel over a kilometer from their nests so the ones you see visiting your apple blossoms may be nesting in your orchard or in neighbouring habitat.



BUMBLE BEES

(genus *Bombus)* Bumble bees are generalist feeders meaning they visit many types of flowers. They live in small colonies (~40-400 individuals) in the ground or above ground in cavities and can fly in cool and inclement weather. Bumble bee colonies start to grow in the spring, and therefore they look for pollen in large quantities. There are about 40 different types of bumble bees across Canada, and while it's relatively easy to tell a bumble bee from most other bees, it can be challenging to tell one species of bumble bee from another.

2 PRACTICES TO PROTECT POLLINATORS

Growing crops in a productive and cost-effective manner is crucial, as is keeping pollinators healthy. Pollinators and agriculture are intimately tied together because ~75% of crops require or benefit from insect pollination[26]. Balancing the need for crop protection with pollinator health calls for employing several practices that together result in resilient and productive agricultural systems.

This guide covers four important practices that can help all stakeholders protect pollinators while maintaining production:

- Integrated pest management
- Communication between beekeepers and farmers
- Supporting pollinators through habitat
- Selecting and using pesticide products

INTEGRATED PEST MANAGEMENT (IPM)

Using integrated pest management (IPM) yourself or hiring an IPM consultant can help you save money and time, reduce pesticide use, reduce impacts to wild pollinators, and enhance crop pollination. IPM is a pest management strategy based on ecosystem function and long-term prevention of pest damage. It combines techniques such as habitat manipulation, pest forecast models, cultural practices, pest-resistant varieties[27], and chemical and biological control.

Pest management materials should be selected and applied in a manner that minimizes risks to human health, beneficial and nontarget organisms, and the environment[27]. For example, pesticides are used only when field monitoring indicates that pest populations are exceeding pre-established economic thresholds. IPM plans help farmers meet their production and crop protection goals, while protecting pollinators and minimizing impacts to the environment.

IPM strategies sometimes require more initial thought and investment, but they have large and long-term payoffs that include cost savings from using fewer crop protection inputs, and better yields from stronger pollinator and beneficial insect populations. You can learn about IPM and implement IPM strategies yourself, or contract local IPM specialists.

Common pest management challenges in apple, that occur throughout the year include protection of leaves, buds, flowers, and new shoots from fungal or bacterial attack, protecting developing fruit from insects and diseases, and promoting tree vigour and root health. There is the potential for negative impacts on pollinators with some pest management strategies used to address these and other issues. Use of IPM strategies in apple can significantly reduce the need for chemical insecticide applications.

Learn more about IPM and specific pest control strategies in apple from the resources listed on page 31.

IPM PRINCIPLES:

- A multi-faceted approach that combines chemical, physical, biological, and cultural pest control methods.
- Prevention of infestations.
- Monitoring and identifying pests at frequent intervals throughout the growing season.
- Decision-making based on monitoring and thresholds.
- Selection of pest control products that are the least toxic to non-target, beneficial insects.
- On-going evaluation and improvement of management strategies.

Careful consideration of pollinator health should be taken in each of these steps to support pollinators without limiting the effectiveness of pest management.

IMPLEMENTING AN IPM PROGRAM CAN HELP YOU SAVE MONEY AND TIME, REDUCE PESTICIDE USE, REDUCE IMPACTS TO WILD POLLINATORS, AND ENHANCE CROP POLLINATION.

CASE STUDY

COMBINING HABITAT AND IPM TO SUPPORT POLLINATORS

At The Fruit Wagon, Doug and Leslie Balsillie have been farming 45 acres in Harrow Ontario since 1984. Their main crop is apple, grown on 25 acres. They also grow some peaches and pears, raspberries that bloom in the late summer, and market vegetables for their namesake Fruit Wagon. Over the last few years, they have been replacing their apple orchards with high density apple plantings, which provide higher quality fruits with fewer inputs, including less pesticide use.

The Balsillies have been renting commercial honey bee hives to pollinate their apples from a local beekeeper in Essex County. Nevertheless, they know that a diversity of wild, native bees visit their crops, so they support them with hedgerow plantings and by leaving flowering vegetation on marginal lands and orchard edges. Nearby, Leslie's old family farm, which she remembers as poor farmland but great habitat, was recently purchased by the Nature Conservancy. As protected habitat, it will provide benefits to local wildlife, including pollinators, and therefore to farm production.

In addition to protecting habitat, Leslie and Doug employ many integrated pest management (IPM) principles. Due to increased insecticide resistance and new regulatory restrictions in the nineties, the Balsillies began using multiple approaches to deal with pests. In 1994, codling moth and its resistance to available insecticides lead the Balsillies to use mating disruption – the use of synthetic pest insect sex pheromones to confuse mating males – as part of their IMP approach. The decrease in pesticides led to an increased abundance of beneficial insects and cost-savings and production benefits. Over two decades later, Leslie continues to scout the orchards twice a week and uses traps to determine if and when to apply pesticides, as well as degree-day models to optimize the use of other products and help reduce insecticides applications.

RESEARCH HIGHLIGHT

ADVANCES IN STERILE INSECT RELEASE (SIR) TO CONTROL CODLING MOTH

Sterile Insect Release (SIR) is a pest management tool that can significantly reduce the use of synthetic pesticides, which has environmental benefits and reduces the development of insecticide resistance. The technique involves introducing sterile male pests to increase the odds of females mating with them. This results in fewer offspring and less pest pressure. Though effective, there are some limitations to this tool including the size of the area that can be effectively and economically treated.

A research collaboration between Michigan State University and Washington State University on codling moth has been looking to improve guidelines on the type of release and the location of release, as well developing release plans for longer control results. A comparison of single point release to multiple points of release has shown males released at a single point can effectively cover a 4 hectare (10 acre) block. The release rate was also shown to have a minimal impact on success, with low numbers of males showing the same effectiveness as higher numbers.*

Various drone release methods have the potential to automate the release of the sterile male codling moths. A research team at the Okanagan-Kootenay Sterile Insect Release Board has been building on work from New Zealand and the United States and is fine-tuning the release height using uncrewed aircraft systems. Release from 35 m above ground resulted in better recapture rates within 50 m blocks when compared to hand release. Drone release techniques hold promise as an alternative to cost-prohibitive aircraft release and fit within the innovation and mechanization models being adopted by many orchards.

SIR is a great compliment to other forms of pest control. It has the potential to reduce the development of pest resistance and lower the use of synthetic chemicals that may have adverse impact on non-target, beneficial species.**

* Milkovich, M. 2021. Releasing research on sterile insect release: Michigan team studying sterile insect release in two states: https://www.goodfruit.com/releasing-research-on-sterile-insect-release/

** Esch, E.D.; Horner, R.M.; Krompetz, D.C.; Moses-Gonzales, N.; Tesche, M.R.; Suckling, D.M. Operational Parameters for the Aerial Release of Sterile Codling Moths Using an Uncrewed Aircraft System. Insects 2021, 12, 159. https://doi.org/10.3390/insects12020159https://www.mdpi.com/2075-4450/12/2/159

MAINTAINING CLEAR COMMUNICATIONS

Communication and cooperation between beekeepers and growers are the most effective ways to reduce honey bee poisoning from exposure to pesticides and cannot be overstated. Both beekeepers and growers benefit from developing positive working relationships and familiarizing themselves with each other's management practices.

DISCUSSIONS AND CONTRACTS BETWEEN GROWERS AND BEEKEEPERS SHOULD INCLUDE:

- Coordination of crop timing with dates of apiary arrival and departure.
- Details of the beekeeper's responsibility to provide strong and effective colonies for crop pollination.
- Details of the grower's responsibility to safeguard bees from poisoning.
- A clear designation of responsibility for providing supplemental water and feed.
- A description of pest management practices in the cropping system before colonies are delivered.
- A description of pesticides to be used on a crop while bee colonies are present.
- A description of buffers to be placed between treated areas and apiaries.
- A communication plan for informing neighbouring growers and applicators of apiary locations.
- A description of possible pesticide use in adjacent crops.
- A diagram showing the location of honey bee colonies.
- Reference to provincial and regional information on crop pests and spraying schedule where available.

The BeeConnected app is an open platform between growers, beekeepers, and applicators for discussion and planning for bee protection in farmlands.

http://www.beeconnected.ca/

SUPPORTING POLLINATORS THROUGH HABITAT

Maintaining or creating habitat around your farm can go a long way toward supporting healthy honey bees, increasing the abundance of wild bees, and improving their resilience to other stressors[28-31]. There is now an abundance of evidence showing that leaving non-invasive weeds, wildflowers, and other habitat patches around pollinator dependent crops such as apple increases pollination and crop production[29-33].

Having habitat to support honey bees and wild bees can be as simple as reducing unnecessary vegetation control. As such, it can involve no extra work and even some labour savings:

- Identify areas that are less productive, scrubby, or marginal. Keep these habitats for beneficial insects rather than cultivating these sections. This can save money and make the farm more efficient by intensifying production.

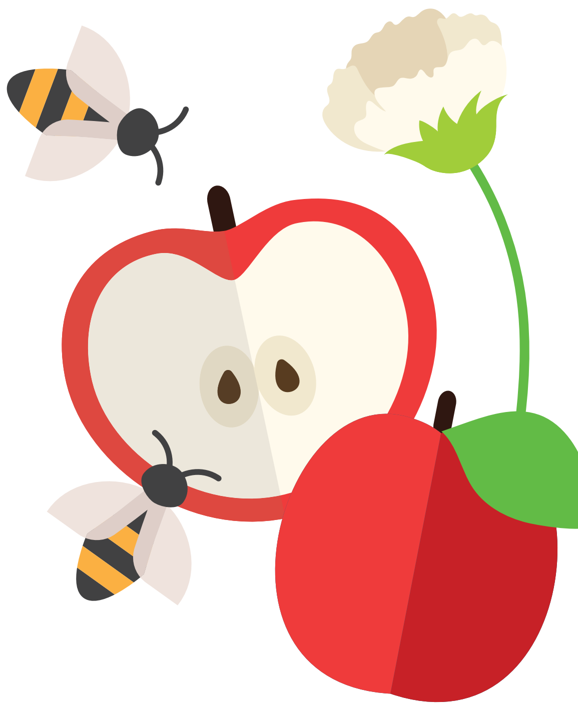
Proactively enhancing and creating pollinator habitat can also help attract and enhance pollinator populations on your farm and improve your potential crop yield through improved pollination:

- In buffer plantings around waterways, use plants that also provide forage and/or nesting habitat for bees.
- Create floral strips or hedgerows, which can take little or no land out of production, on field edges and other areas of your farm.

Ideal habitat for bees includes the following elements. Keep in mind that creating habitat with just some of these elements can significantly improve bee health and abundance:

- Flowering plants (native plants, cover crops, non-invasive weeds, or ornamental plants) that, in combination, bloom from early spring to fall support apple pollinators. This includes other species of trees.
- Undisturbed soil, including areas between apple trees, piles of debris such as sticks, dead leaves or compost, standing plant material, old logs, etc., which provide nesting sites for ground nesting, twig (tunnel) nesting, and cavity nesting bees.
- Protection of wild flowering plants from pesticide application and drift through pesticide-free buffers and thoughtful management.

There can be concern that non-crop floral resources will ‘pull’ honey bees or other bees away from the crop. However, research shows that non-crop floral resources can help honey bees by providing a diversity of pollen sources that they need to maintain health. Additionally, these areas enhance and attract wild bee populations rather than taking them away from the crops[30,32,33].



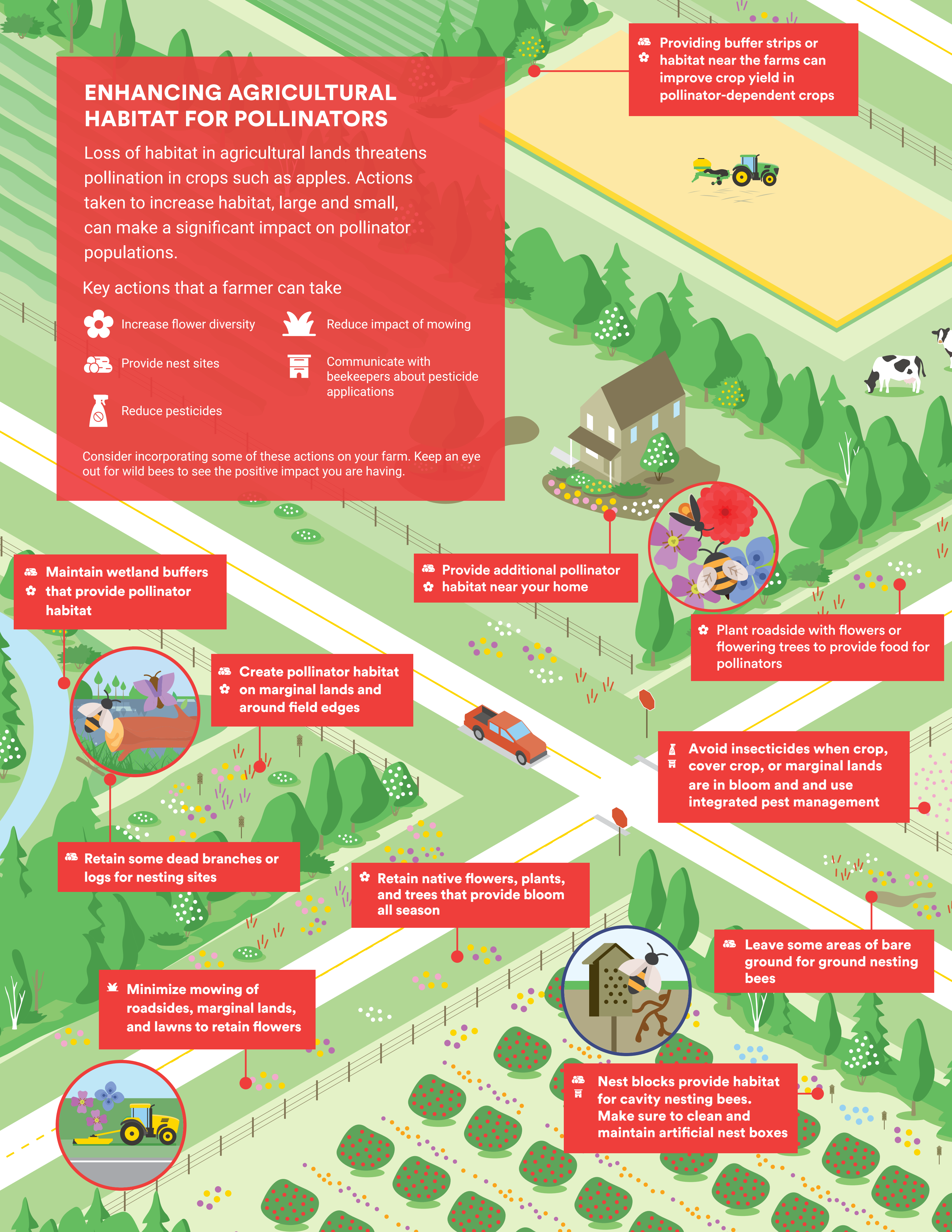
ENHANCING AGRICULTURAL HABITAT FOR POLLINATORS

Loss of habitat in agricultural lands threatens pollination in crops such as apples. Actions taken to increase habitat, large and small, can make a significant impact on pollinator populations.

Key actions that a farmer can take

- Increase flower diversity
- Reduce impact of mowing
- Provide nest sites
- Communicate with beekeepers about pesticide applications
- Reduce pesticides

Consider incorporating some of these actions on your farm. Keep an eye out for wild bees to see the positive impact you are having.



Providing buffer strips or habitat near the farms can improve crop yield in pollinator-dependent crops

Maintain wetland buffers that provide pollinator habitat

Provide additional pollinator habitat near your home

Plant roadside with flowers or flowering trees to provide food for pollinators

Create pollinator habitat on marginal lands and around field edges

Avoid insecticides when crop, cover crop, or marginal lands are in bloom and and use integrated pest management

Retain some dead branches or logs for nesting sites

Retain native flowers, plants, and trees that provide bloom all season

Leave some areas of bare ground for ground nesting bees

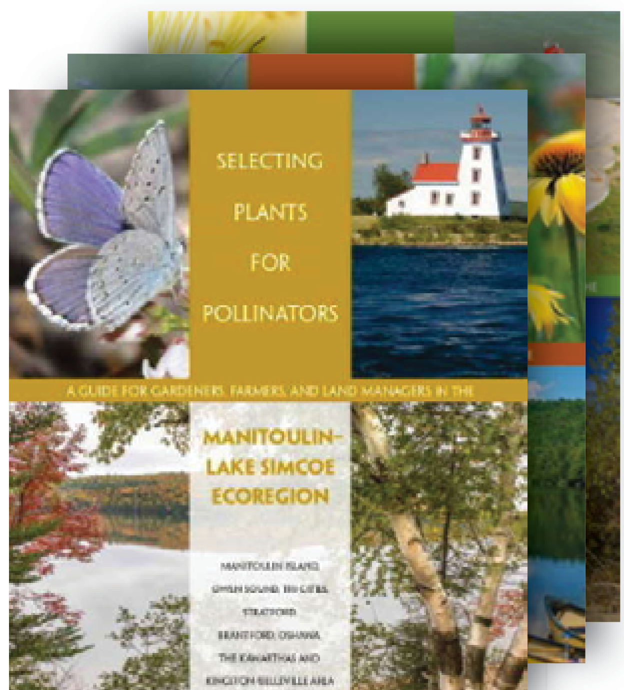
Minimize mowing of roadsides, marginal lands, and lawns to retain flowers

Nest blocks provide habitat for cavity nesting bees. Make sure to clean and maintain artificial nest boxes

Preserving and creating habitat for bees is an achievable goal for large- and small-scale apple growers. Small actions taken by many growers and landowners can add up to large benefits for the agricultural community. Preserving habitat for ground nesting wild bees includes protecting nesting areas from exposure to pesticides, tillage, and heavy machinery.

There are many other beneficial insects, including predators and parasitoids, in and around apple orchards. Minimizing use of pesticides and providing habitat will also help protect these biocontrol insects, possibly reducing future pest outbreaks.

For more information on ways to support pollinators with habitat and for specific recommendations of plants to support pollinators in your region see our Ecoregional Planting Guides and out Find Your Roots plant selector tool



CASE STUDY

CROPS AND PLANTINGS PROVIDE HABITAT FOR POLLINATORS

Apple Lane Farm Inc. is a 100-acre apple farm in Morristown, Nova Scotia, where Doug and Marlene Nichols along with daughter and son in-law, Elaine and Willem Schep, farm multiple crops. With pears, peaches, cherries, raspberries, and strawberries, as well as flowers for fresh sale and dried wreaths, there is something in bloom on the farm for a majority of the growing season. This means there is pollen and nectar for pollinators to forage on for most of the growing season.

Flower plantings at Apple Lane Farm serve the dual purpose of supporting pollinators and providing a farm product for the business. Managing a diverse farm that needs pollinators and making sure that pollinators are safe is a fundamental value that drives advancements in their thoughts and technologies. The farm has been seeking to use innovative technologies that promote habitat and minimize negative inputs into the watershed while remaining an efficient farming operation.

With the help of a provincial agricultural grant, Willem was able to obtain a new mechanical weed control attachment that utilizes a hydraulic swing arm that allows for controlled weeding between and around the trees. This offers maximum floral habitat throughout the season, and easy, fast mechanical control when a clear zone is needed. A drawback of traditional mechanical control is the time required; mechanizing this process makes it more viable for larger scale operations to move away from herbicide use.

Apple Lane Farm is also experimenting with native cover crop mixes, seeking to enhance local native plants and pollinators. In partnership with The Clean Annapolis River project, they are looking to plant native mixes along the ditches and borders around the orchard. In the coming season, they will try new mixes within the rows and between the trees as well. The farm also offers a large stonewall, which provides nesting habitat for pollinators, and several acres of woodland that boast an abundance of biodiversity.

"I think our industry knows the importance and sees the need for encouraging pollinator diversity as our crops are very much dependent on pollinators." Says Willem, "The challenge is to stay productive, efficient, and remain economically balanced while practicing methods that enhance biodiversity. With new technology and methods becoming available to us I think we will be able to tackle these challenges as we move forward."

SELECTING AND USING PESTICIDE PRODUCTS

Pesticides have become an integral part of many farm management systems. However, there are risks to pollinators associated with their use. Exposure to pesticides can kill bees or it can cause effects that do not kill them but can negatively impact foraging, learning, reproduction, or the long-term health of populations[34]. The following section outlines ways to minimize these risks while maintaining crop production and quality.

Health Canada's Pest Management Regulatory Agency (PMRA) uses a risk assessment framework to help eliminate unacceptable risks from pesticides. To learn more about this framework, see the supplemental document.

By using pesticides within an integrated pest management (IPM) framework, following label directions, considering mode of action, and selecting products that have low toxicity to bees, healthy bee populations can be maintained that will contribute to apple pollination, pollination of other crops, and natural ecosystems.

POTENTIAL PESTICIDE IMPACTS ON BEES

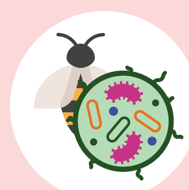
Bees can be impacted lethally or sublethally by pesticides. **For more information, see Recognizing and Reporting a Bee Poisoning in the Resources section on p.36.**

Lethal

increased bee death

Sublethal

increased susceptibility to pests and diseases



alteration of gut microbiome

decreased reproduction

learning and memory impairment

impaired orientation

reduced foraging

SELECTING LEAST TOXIC PESTICIDE PRODUCTS: UNDERSTANDING PESTICIDE RISKS

Bee poisonings are related to exposure amount, exposure time, and the toxicity of a pesticide. The term, 'pesticide' refers to all substances that are meant to control pests, including insecticides, fungicides, and herbicides. The highest risk to bees is from pesticide products that are highly toxic, have residual toxicity longer than 8 hours, can be found as residues in pollen, nectar, soil or where bees can be exposed to them, or are sprayed on the crop during bloom when the bees are present.

Risks are reduced by following pesticide labels closely and paying attention to changes in use restrictions.

Insecticides are generally more toxic to non-target insects than other types of pesticides because they are formulated to kill insects. Though herbicides and fungicides are generally less toxic than insecticides, they too can present risks. However, herbicides can also be useful and necessary for the creation and management of pollinator habitat, and fungicides often are a necessary component of commercial apple production.

Growers can compare the toxicity of pesticides by using the tables in the supplemental document and choose those that are least toxic to bees while still being effective against target pests. Use 'Table 2: Pesticide toxicity' to help the grower choose the lowest risk products. However, it is also important to use pesticides with different modes of action to avoid developing pest resistance, which means that only using the lowest toxicity product may not always be recommended. See pg 35 for resources on mode of action.

INSECTICIDES

nsecticides are designed to kill insects and therefore present a higher risk to managed and wild bees than other pesticides. Insecticides are considered a major factor contributing to agricultural productivity, yet without best practices they can be toxic to humans and/or animals, and can accumulate in the environment. Use of insecticides within an Integrated Pest Management framework (see pg 12) and following label directions for application to apple will help minimize risk to bees and other beneficial insects.

HERBICIDES

Herbicides target unwanted plants by interrupting or modifying a biological process specific to plants. For that reason, they are generally considered to have negligible direct effects on bees. Wide use of broad-spectrum herbicides can remove undesired weeds and flowers from landscapes; however, reduction of non-crop floral resources also reduces potentially important nectar and pollen sources for bees. When used to control invasive weedy plants in order to establish pollinator-supporting plants, use of herbicides can be beneficial to pollinators.

FUNGICIDES

During bloom and bee foraging, fungicides are often necessary for apple production to protect developing flowers, shoot and fruit, especially when wet weather coincides with bloom. However, there is evidence that some fungicides can negatively impact bees on their own[34] and in synergy with insecticides[35-38]. Following label directions, avoiding applying fungicides directly

RESEARCH HIGHLIGHT
ANTIBIOTICS USED TO CONTROL DISEASE MAY HARM BEES AND CROP POLLINATION

Recent research from the University of Washington and Emory University show that an antibiotic sprayed on orchard crops to combat bacterial diseases, such as fire blight in apple, slows the cognition of bumblebees and reduces their foraging efficiency*.

The antibiotic studied, streptomycin, is increasingly being used in North American agriculture, yet there is little information on potential impacts to managed and wild bees. The team fed bumble bees food with a high, but field-realistic, dose of streptomycin.

When they tested how the streptomycin-fed bees measured up to other bees that did not receive the antibiotic, they found that the treated bees were slower to learn where to find sugar water versus plain water in a laboratory experiment. Other experiments showed that the antibiotic-treated bees had shorter memories and visited fewer flowers than their control counterparts.

While the reason for the negative impacts of streptomycin on bumble bee foraging are not clear, the researchers speculate that the antibiotic is disrupting the bees' gut microbiome, possibly reducing beneficial microbes and decreasing the bee's immunity to diseases. The team plans to start experiments with streptomycin in experimental orchards which will help inform future recommendations for methods to protect bumble bees and other pollinators, and help farmers maintain pollination. There are a range of options for control of fire blight and other diseases in addition to antibiotic and other chemical use.

* Avila, L., E. Dunne, D. Hofmann, and B.J. Brosi. 2022. Upper-limit agricultural dietary exposure to streptomycin in the laboratory reduces learning and foraging in bumblebees. Proceedings of the Royal Society B: Biological Sciences, 1968, https://doi.org/10.1098/rspb.2021.2514

FOLLOW LABEL DIRECTIONS

Pesticide labels are legal documents. Product registration, toxicity testing, and product regulation are in place to protect honey bees and other pollinators from the negative effects of pesticides. **It is illegal to use a pesticide in any way other than for the purpose and in the manner stated on the label**. In addition, properly following pesticide labels is important from an economic perspective for the apple grower, as well from a human health perspective for the user, bystanders, and consumer as well as from an environmental perspective for bees and other beneficial insects. Applying too much of one pesticide, applying it repeatedly in the same place, or applying it outside of label use because of inattention to label details could cost the grower more money and could increase risk of the product to visiting bees.

For the most current information on label restrictions, use the PMRA online label search or download the PMRA pesticide label app.

- Review the entire label for precautionary and advisory statements. Look for “toxic to bees”.
- Crop-specific precautions may also be listed on the label.
- Although the bee precautions are mainly based on toxicity to honey bees, they are also relevant to other species of bees. Where differences in toxicity to other bee species are known, they are noted in Table 2 in the supplemental document.
- Residual toxicity to bees varies greatly between insecticides. When using insecticides with extended residual toxicity it is imperative that applicators carefully consider potential exposures to wild and managed bees and avoid applying insecticides to blooming plants (crops or weeds).
- Growers and other pesticide applicators are required to follow label restrictions.

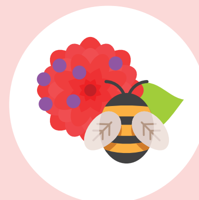
More PMRA information on pollinator protection can be found at: www.canada.ca/pollinators

Bee poisonings from exposure to pesticides can occur when:

- Beekeepers and growers do not adequately communicate.
- Pesticides are applied when bees are actively foraging.
- Pesticides are applied in apple orchards or weeds in the field or field margins during bloom.
- Pesticides are applied to other blooming plants in fields, field margins, or neighbouring fields.
- Pesticides drift onto blooming plants adjacent to the apple orchards.
- Systemic insecticides are translocated into the nectar and pollen of non- crop flowering plants because of their movement through soil and water.
- Bees collect insecticide-contaminated nesting materials, such as leaf pieces collected by alfalfa leafcutter bees. They can also be exposed to soil contaminated with pesticide residues as they build their ground nests.
- Honey bees collect insecticide-contaminated water (from drip tape or chemigation or in standing water near treated fields).

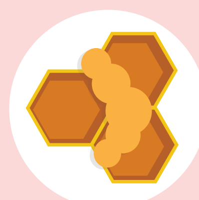
ROUTES OF PESTICIDE EXPOSURE TO BEES

Directly sprayed on or through contact with recently sprayed leaves and flowers



Consumption of contaminated pollen and nectar

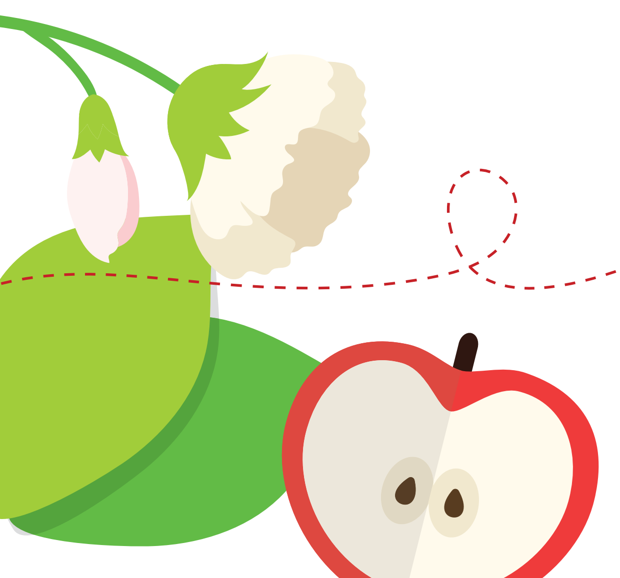
Contact with contaminated nesting materials



Effects on larvae through contaminated nectar, pollen, and cell materials

Contact with contaminated soil

Ways bees can be exposed to pesticide contaminants. Diagram adapted from Iris Kormann, Oregon State University.

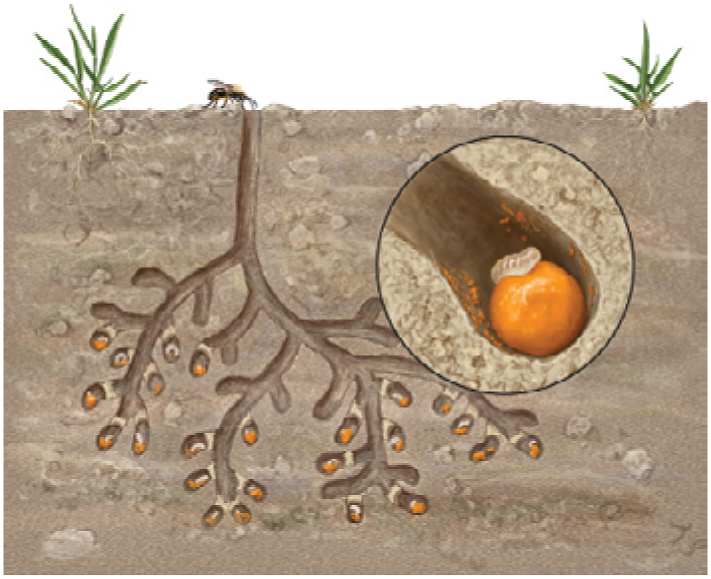


REDUCING BEE EXPOSURE TO PESTICIDES

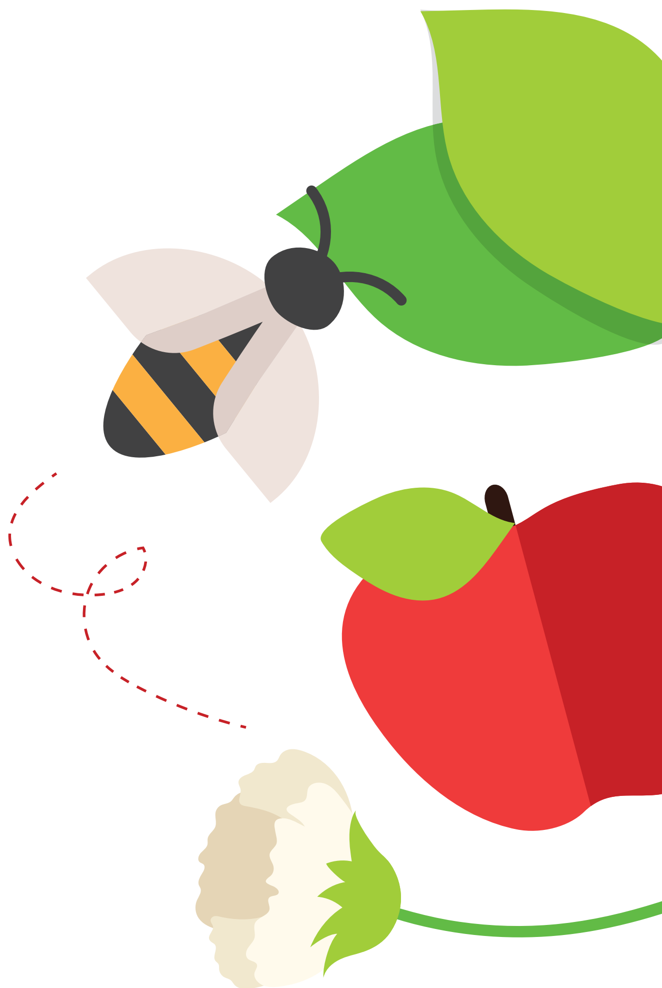
Be aware of pesticide restrictions in your region. When using pesticides, in addition to following label directions and maintaining clear communications with beekeepers and other stakeholders (see pg 20), other ways of minimizing managed and wild bee exposure include:

- Ensuring that pesticide drift is minimized to reduce contact with adjacent habitat. Install wind gauges for accurate decision-making.
- Applying fungicide, antibiotic, and growth regulator sprays early morning or late evening when bees are not actively foraging.
- Being aware that dandelion blooms in orchard laneways are open until about dusk.
- Not applying insecticides when open blossoms are present (target the prior stage at pink or post-bloom timings).
- Avoiding applying pesticides during warm evenings when honey bees are clustered on the outside of their hives.
- Avoiding applying pesticides (especially insecticides that have toxicity to bees) to any blooming flowers, even weeds; bees may be using these resources.
- Maintaining weed-free herbicide strips within tree rows to minimize bee foraging during the pesticide season.
- Being aware that any pesticides applied to crops at any time of the year can be absorbed in soil, potentially impacting ground nesting bees or taken up by non-crop plants that bees forage on.
- Looking for bees on crops, and for ground nests of solitary bees (e.g. long-horned bees, sweat bees, and mining bees) and bumble bees. Protect nest areas from insecticide spray.

Notes may be found in Table 2 of the supplemental document if it is currently known that greater precautions are needed for bumble bees or solitary bees than for honey bees.



Ground nesting bee tunnels



3 ACTION GUIDE

GROWERS AND PESTICIDE APPLICATORS

COMMUNICATION

- Write and agree to a contract that defines expectations and responsibilities between beekeeper and grower/applicator, including protocol for suspected pesticide incidents involving pollinators.
- Establish a chain of communication between all parties, including crop consultants and applicators.
- Outline a pest management plan that specifies which systemic products have been applied, which contact pesticides may be used during bloom, and methods to protect bees during application.
- Give 48 hours' notice to beekeepers when applications are necessary so that safety measures to protect the hives can be taken.

HIVE LOCATION

- When hosting hives on your property, provide a safe location that is out of the range of pesticide applications, including no-spray buffers.
- Be aware that there likely are more honey bee colonies than you are currently aware of in any area because honey bees have a foraging range of a few kilometers. Check with your Provincial Ministry/Department of Agriculture for hives that might be located in your area and use the BeeConnected app.

PRODUCT SELECTION AND USE

- Always read and follow pesticide label directions. Check for new restrictions on the label.
- Select pesticides that have the lowest pollinator precaution levels using the tables in the supplemental document.
- Be careful to only apply pesticides to target crops and avoid spray drift onto hives, other blooming crops, or flowering weeds nearby, whether or not the pesticide has a bee caution on the label. Since fine droplets tend to drift farther, apply spray at lower pressures or choose low-drift nozzles that produce medium to coarse droplet size. Turn off sprayers near water sources (ponds, irrigation ditches, or leaking irrigation pipes), when making turns, and at the ends of fields.
- Do not spray in windy conditions or conditions conducive to inversions in order to minimize drift.
- Never spray crop protection products onto hives, including low toxicity products such as herbicides and fungicides.
- Apply pesticides with residual toxicity when bees are inactive or not present. Bees generally forage during daylight hours and when temperatures exceed 13°C for some wild bees and 17°C for honey bees. When abnormally high temperatures result in foraging activity earlier or later in the day than normal, adjust application times accordingly to avoid bee exposure.
- Inspect chemigation systems to verify that bees cannot access chemigation water.

PLANNING AND SCHEDULING

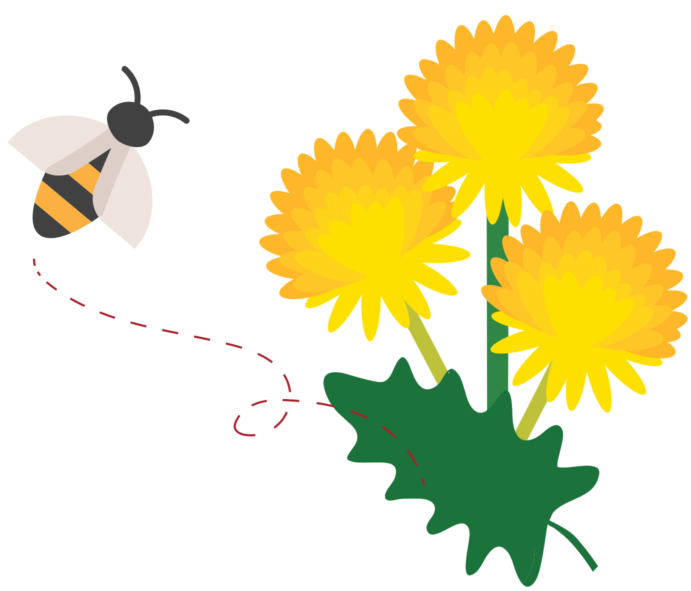
- Learn the pollination requirements of your apple varieties and when they are attractive to bees. If possible, plan your pesticide applications to occur well before and after bloom, when hives are not on location, and managed and wild bees are not active on the crop.
- Avoid spraying crops when bees are foraging during daylight hours, or when crops are flowering, if possible.
- Keep track of weather patterns, including wind, precipitation, humidity, and daily temperatures to avoid any unintentional pesticide drift to nearby bee foraging areas.

PEST AND WEED CONTROL

- Scout for pests and use economic thresholds for treatment decisions; you can learn the pests and beneficial insects and treatment thresholds yourself or hire an integrated pest management (IPM) scout or consultant that can help save you time and money by reducing unnecessary pesticide application. Use insect growing degree day models when possible.
- If necessary, control blooming weeds within fields such as dandelions before applying insecticides that have a long residual toxicity to bees. This is especially important in early spring, when bees will fly several kilometers to obtain pollen and nectar from even a few blooms of dandelions or wild mustard.

CONSIDERATIONS

- Consider non-chemical pest control, such as mating disruption, beneficial insects, pest resistant varieties and other cultural practices, for long-term control of insect pests. Sites with details of integrated pest management (IPM) practices can be in the resources section of this guide (pg 35).
- Look into programs that support planting habitat areas on your farm for honey bees, other pollinators, and other beneficial insects such as ALUS and Operation Pollinator, Bees Matter, or build your own bee habitat using Pollinator Partnership's Ecoregional Planting Guides or the Canadian Honey Bee Forage Guide



BEEKEEPERS

COMMUNICATION AND REGISTRATION

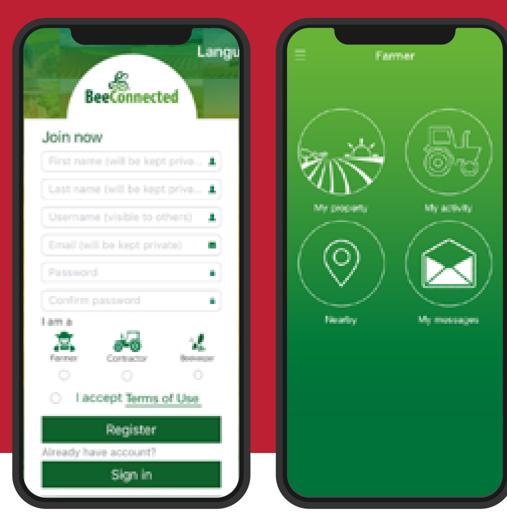
- Write and agree to a contract that defines expectations and responsibilities between beekeeper and grower, including protocol for suspected pesticide incidents involving pollinators.
- Do not leave unmarked colonies near fields. Post the beekeeper's name, address, and phone number on apiaries, large enough to be read at a distance.
- Register your colonies with your Provincial Ministry/Department of Agriculture. You can notify pesticide applicators of the location of your apiaries using the BeeConnected app.
- Communicate clearly to the grower and/or applicator where your colonies are located, when they will arrive, and when you will remove them.
- Ask the grower what pesticides, if any, will be applied while bees are in the field, when they will be applied, and whether the label includes precautionary statements for bees. Ask them to contact you if they decide on any new applications.
- Request 48 hours' notice from growers when applications are necessary so that safety measures to protect the hives can be taken.

PEST MANAGEMENT

- Learn about pest problems and management programs to develop mutually beneficial agreements with growers concerning pollination services and prudent use of insecticides. Seek information on major crop pests and treatment options for your region (see resource section for provincial links).
- Miticides, such as those used in hives for varroa control, are pesticides too. Use care when managing pests in and around bee hives, apiaries, and beekeeping storage facilities. Use pesticides for their intended use and follow all label directions carefully. Regularly replace brood comb to reduce exposure to residual miticides.

The BeeConnected app is an open platform between growers, beekeepers, and applicators for discussion and planning for bee protection in farmlands.

http://www.beeconnected.ca/



PROTECTING HONEY BEES FROM EXPOSURE

Place hives at least 6 m away from the crop with a no spray buffer, rather than directly adjacent to the crop, if possible.

- Work with growers to find a location for beehives that is at least 6 m away from the crop, including no-spray buffers.
- Do not return colonies to fields treated with insecticides that are highly toxic to bees until at least 48 to 72 hours after application. Bee deaths are most likely to occur during the first 24 hours following application.
- If practical, isolate apiaries from intensive insecticide applications and protect them from chemical drift. Establish holding yards for honey bee colonies at least 4 km from crops being treated with insecticides that are highly toxic to bees.
- Place colonies on ridge tops rather than in depressions. Insecticides drift down into low-lying areas and flow with morning wind currents. Inversion conditions are particularly hazardous.
- Verify that a clean source of water is available for bees, and if there is not one available, provide one.
- Feed bees when nectar is scarce to prevent long-distance foraging to treated crops.
- In areas where there is a risk of pesticide exposure, inspect bees often to recognize problems early.

RESOURCES

RECOGNIZING AND REPORTING BEE POISONING

Because of guidelines and regulation on product use, large-scale honey bee deaths are uncommon in developed countries, especially in recent years.

Nevertheless, incidents where large quantities of bees are killed by pesticides do occur and suggest a misuse of a product, system, or management protocol, or a possible result of a lack of communication.

Bee poisonings can be either lethal or sublethal. An example of lethal poisoning is when pesticide drift comes into direct contact with foraging honey bees, leading to large numbers of dead worker bees within or around the crop, or outside the hive entrance. In contrast, sublethal exposure does not kill bees outright but rather can lead to poor bee and hive health; reduced capacity to forage, orient, and learn; and many other symptoms[34].

Lethal and sublethal poisonings are harder to casually observe in wild bees than in managed honey bees but are nevertheless a risk. Without a marked hive or nesting site, they can easily go unobserved.

Known sublethal impacts on wild bees include reduced longevity, development, body mass, learning,

colony size, reproduction, navigation, and increased susceptibility to pest and pathogens[34-41]. If you see more than one dead bumble bee in a location, this may be an indication that there has been lethal exposure to a toxic substance.

The signs and symptoms listed below can be the result of pesticide exposure, but some can also be a result of viruses or other diseases. Careful observation of individual honey bee and colony behaviour, as well as preserving samples for testing (see instructions on pg 31), can help determine the underlying causes. In some cases, pesticide poisoning can be exacerbated when hive health is initially poor, emphasizing the importance of nutrition, water supply, and proper management practices by beekeepers to maintain the health of their colonies.

HONEY BEE POISONING

- Excessive numbers of dead and dying honey bees in front of hives.
- Severe colony imbalance, large brood size with few bees.
- Lack of foraging bees on normally attractive blooming crops.
- Stupefaction, paralysis, and abnormal jerky, wobbly, or rapid movements; spinning on the back.
- Forager disorientation and reduced foraging efficiency.
- Immobile, lethargic bees unable to leave flowers.
- Regurgitation of honey stomach contents and tongue extension.
- The appearance of "crawlers" (bees unable to fly). Bees move slowly as though they have been chilled.
- Dead brood, dead newly emerged workers, or abnormal queen behaviour, such as egg laying in a poor pattern.
- Queenless hives.
- Poor queen development in colonies used to produce queens, with adult worker bees unaffected.

PESTICIDE POISONING IS NOT ALWAYS OBVIOUS AND MAY BE CONFUSED WITH OTHER FACTORS:

- Delayed and chronic effects, such as poor brood development, are difficult to link to specific agrochemicals, but are possible when stored pollen, nectar, or wax comb become contaminated with pesticides. Severely weakened or queenless colonies may not survive the winter.
- Poisonous plants, such as death camas (*Zigadenus venenosus*), cornlily (*Veratrum viride*), and spotted locoweed (*Astragalus lentiginosus*), can injure and occasionally kill bee colonies.
- Viral paralysis disease, starvation, winter kill, and chilled brood can cause symptoms that may be confused with bee poisoning. Beekeepers may request a laboratory analysis of dead bees to determine the cause of an incident. Health Canada and provincial Departments of Agriculture or of the Environment (depending on the province) investigate suspected bee poisoning incidents (see pg 35 for contact information).

HONEY BEE RECOVERY FROM PESTICIDE POISONING

If a honey bee colony has lost many of its foragers but has sufficient brood and adequate stores of uncontaminated pollen and honey, it may recover without any intervention. Best practices include moving bees to a pesticide-free foraging area, if possible. If sufficient forage is unavailable, feed them with sugar syrup and pollen substitute, and provide clean water to aid their recovery. Protect them from extremes of heat and cold, and if needed combine weak colonies.

If pollen or nectar stores are contaminated, brood and workers may continue to die until the colony is lost. Additionally, pesticides applied by beekeepers can accumulate in colonies. If there is a possibility that pesticides have transferred into the hive beeswax, consider replacing the comb with a new foundation, using comb from unaffected colonies, or shaking the bees into a new hive and destroying the old comb and woodenware. Replacing brood comb on a regular schedule (typically 2 to 5 years) may prevent pesticide accumulation in brood comb wax and is also good practice for managing disease accumulation in comb.

HOW TO REPORT A SUSPECTED BEE POISONING

If you suspect a bee poisoning incident, or have a question or concern regarding an incident, contact the appropriate federal or provincial authority (see contact information on page 35). Describe why you suspect the bees may have been exposed. Provide photos or videos of the incident, list pesticide treatments you have applied to the hives and notes describing the previous health of the colony, prevailing winds, registrant name on the product label, product name, or active ingredients (from the pesticide label or PMRA's pesticide label search app), and any other pertinent details. Growers and beekeepers should work together to compile this information.

Preserve at least 56 grams (1/4 cup) of adult bees, brood, pollen, honey/nectar, or wax by immediately freezing in clearly labelled, clean containers, and ensure the samples stay dry and protected from light which can lead to the degradation of pesticides. This may be helpful if the incident is later determined to warrant laboratory analysis. It is also a good idea to have a sample of the affected bees as well as a sample from an unaffected apiary. In the event of enforcement action, some provinces will need to collect their own samples. Do not disturb the hives or site until the representative from your province's lead office has finished collecting information.

It also is important that, if you suspect a bee poisoning incident, you communicate with nearby growers and/or beekeepers, and act quickly so that the cause can be determined and prevented in the future.

PROVINCIAL RULES AND RESOURCES TO PROTECT POLLINATORS

The federal government is responsible for the registration of pest control products, and all three levels of government (federal, provincial/territorial, and municipal) play a role in regulating their sale and use. Ministries of certain provinces provide rules intended to reduce the hazard of pesticide application to bees, as well as guidance on bee management.

ALBERTA (MINISTRY OF AGRICULTURE AND RURAL DEVELOPMENT)

https://open.alberta.ca/dataset/b8f74b45-3867-456d-8c85-db6413eeb801/resource/d911d5f2-6fbb-48b1-a304-3ab3fdabaeaf/download/how-to-reduce-bee-poisonings-pesticides.pdf

780-415-2314

MINISTRY OF AGRICULTURE, FOOD AND FISHERIES

https://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/animals-and-crops/animal-production/bees/beekeeping-bulletins

604-556-3129

MANITOBA (MINISTRY OF AGRICULTURE)

http://web2.gov.mb.ca/laws/statutes/ccsm/b015e.php

604-556-3129

NEW BRUNSWICK (DEPARTMENT OF AGRICULTURE, AQUACULTURE AND FISHERIES)

https://www2.gnb.ca/content/gnb/en/departments/10/agriculture/content/bees.html

506-453-2108

NEWFOUNDLAND AND LABRADOR (DEPARTMENT OF NATURAL RESOURCES)

http://www.nlbeekeeping.ca/beekeepers-corner/research/

709-637-2662

NOVA SCOTIA (DEPARTMENT OF AGRICULTURE)

https://novascotia.ca/agri/programs-and-services/industry-protection/#bees

902-679-8998

ONTARIO (ONTARIO MINISTRY OF FOOD AND RURAL AFFAIRS)

http://www.omafra.gov.on.ca/english/food/inspection/bees/apicultu.html

1-877-424-1300

SASKATCHEWAN (MINISTRY OF AGRICULTURE)

http://www.agriculture.gov.sk.ca/

306-953-2304

PRINCE EDWARD ISLAND (DEPARTMENT OF AGRICULTURE AND FORESTRY)

https://www.princeedwardisland.ca/sites/default/files/legislation/A%2611-1-2-Animal%20Health%20and%20Protection%20Act%20Bee%20Health%20Regulations.pdf

902-314-0816

QUÉBEC (MINISTÈRE DE L'AGRICULTURE, DES PÊCHERIES ET DE L'ALIMENTATION)

http://legisquebec.gouv.qc.ca/en/ShowDoc/cs/A-1

(1-844-264-6289) 1-844-ANIMAUX

REPORT A BEE INCIDENT TO HEALTH CANADA

Bee incidents can also be reported by contacting Health Canada's PMRA at 1-800-267-6315. If you know which product may have caused the bee poisoning, you can also notify the pesticide company, which is required by law to report adverse effects to Health Canada. See the Useful Links section below (pg. 36) for a link to report a bee incident to Health Canada.

USEFUL LINKS

BEECONNECTED APP
http://www.beeconnected.ca/

RESOURCES FOR POLLINATOR FRIENDLY FARMERS AND GARDENERS
https://seeds.ca/pollination/resources/

INATURALIST APP
https://www.inaturalist.org/

GOVERNMENT OF ONTARIO CROP IPM
http://www.omafra.gov.on.ca/IPM/english/cucurbits/index.html

POLLINATOR PARTNERSHIP CANADA: POLLINATOR GUIDES
https://pollinatorpartnership.ca/en/ecoregional-planting-guides

HEALTH CANADA'S PEST MANAGEMENT REGULATORY AGENCY (PMRA) PESTICIDE LABEL SEARCH
https://pr-rp.hc-sc.gc.ca/ls-re/index-eng.php

INSECTICIDE RESISTANCE ACTION COMMITTEE: THE IRAC MODE OF ACTION CLASSIFICATION
https://irac-online.org/mode-of-action/

POLLINATOR PARTNERSHIP: TECHNICAL GUIDE FOR PRESERVING AND CREATING HABITAT FOR POLLINATORS ON ONTARIO'S FARMS
https://pollinatorpartnership.ca/en/ag-guides

REPORT A BEE INCIDENT TO HEALTH CANADA
https://www.canada.ca/en/health-canada/services/consumer-product-safety/pesticides-pest-management/public/protecting-your-health-environment/report-pesticide-incident.html

UNIVERSITY OF CALIFORNIA, INTEGRATED PEST MANAGEMENT
http://ipm.ucanr.edu/

PEST MANAGEMENT REGULATORY AGENCY, HEALTH CANADA: POLLINATOR PROTECTION
https://www.canada.ca/en/health-canada/services/consumer-product-safety pesticides-pest-management/growers-commercial-users/pollinator-protection.html

ONTARIO MINISTRY OF AGRICULTURE, FOOD AND RURAL AFFAIRS: INFORMATION FOR COMMERCIAL APPLE GROWERS IN ONTARIO
http://www.omafra.gov.on.ca/english/crops/hort/apples.html

PERENNIA: TREE FRUITS
https://www.perennia.ca/portfolio-items/tree-fruits/

BC MINISTRY OF AGRICULTURE: TREE FRUITS
https://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/animals-and-crops/crop-production/tree-fruits

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