Protecting pollinators from pesticides

HIGHBUSH BLUEBERRY

POLLINATOR PARTNERSHIP CANADA

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POLLINATOR PARTNERSHIP CANADA

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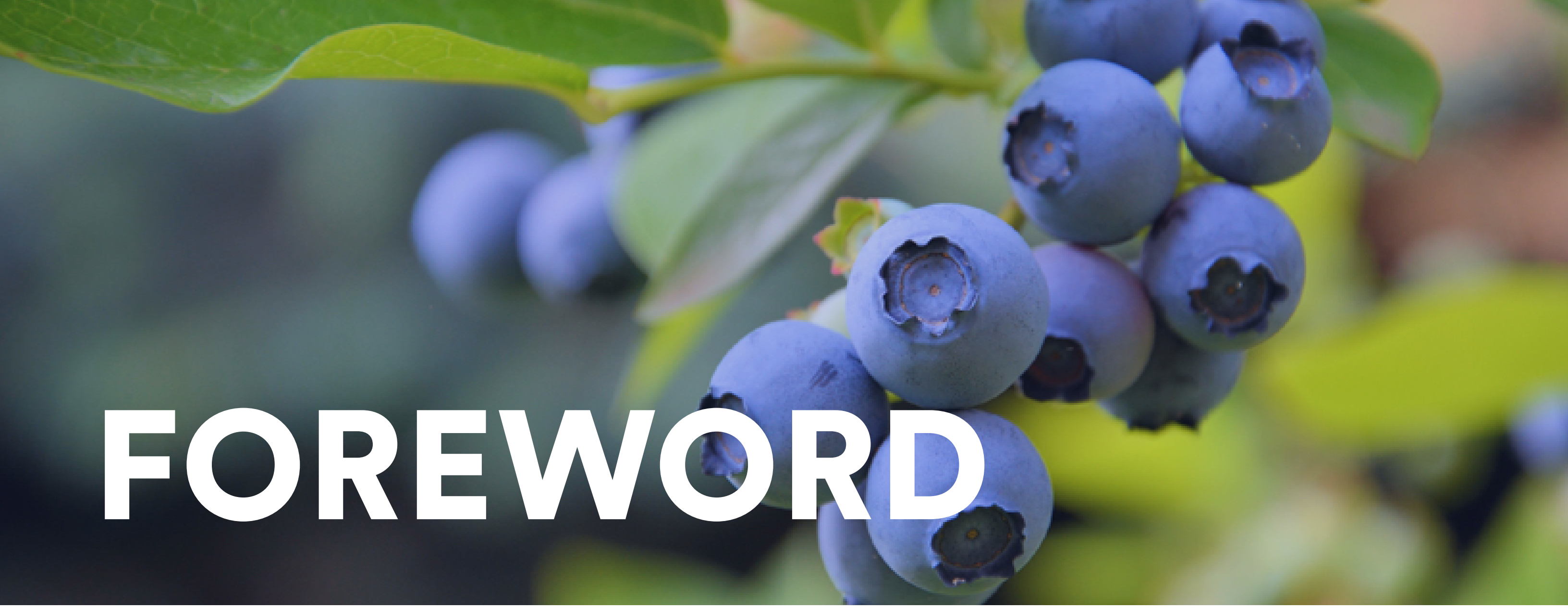


FOREWORD

Bees play a crucial role in the pollination of highbush blueberry and their health is important to the long-term sustainability of production as well as to the environment. Keeping managed and wild bees healthy requires involvement from all those participating in highbush blueberry production, from beekeepers to growers, agronomists, crop consultants, and pesticide applicators.

The focus of this guide is on minimizing the impacts of pesticides on pollinators and is meant for all those involved in highbush blueberry production. There are many factors that impact bee health in addition to pesticide exposure, including habitat loss, pests and diseases, and climate change. By reducing bees' exposure to pesticides, stakeholders can help bee populations be more robust and healthy 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 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 highbush blueberry. The second section covers four important practices that help minimize the impacts of pesticides on pollinators: integrated pest management, communication, habitat, and pesticide product use and selection. 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 highbush blueberry 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 highbush blueberry production learn more about the bees that pollinate this important crop and how we can maintain productive and healthy highbush blueberry systems while protecting their pollinators.

1 HIGHBUSH BLUEBERRY POLLINATION

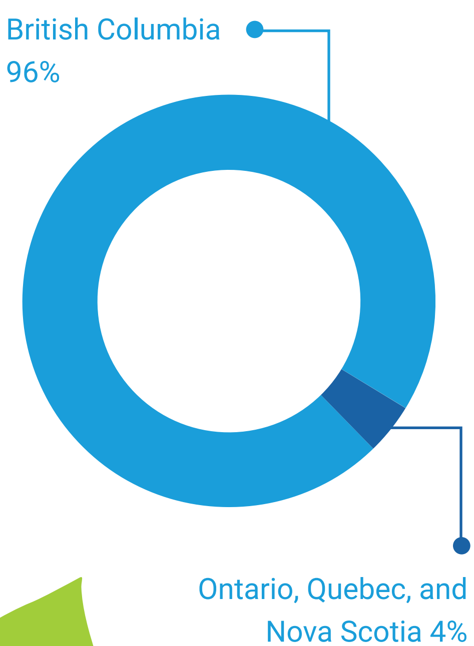
BLUEBERRY PRODUCTION IN CANADA

Blueberry is native to Eastern North America[1]. In Canada, two main types of blueberry are grown, the cultivated highbush blueberry (*Vaccinium corymbosum*) and the wild lowbush blueberry (*Vaccinium angustifolium*). Production systems are substantially different between these two types of blueberries and this document focuses on practices to protect pollinators in highbush blueberry.

Highbush blueberry is the most important fruit crop in Canada, with a farm gate value of approximately $177 million CAD in 2018 and an export value of over $200 million[2]. The pollination services of bees, wild and managed, contribute to this value significantly.

In Canada, the majority of highbush blueberry production occurs in British Columbia (96%) although production also occurs in Ontario, Quebec, and Nova Scotia. It is important that growers are able to produce a marketable product for both domestic and export markets, which requires consideration of many factors, including pest control and pollination requirements.

HIGHBUSH BLUEBERRY PRODUCTION



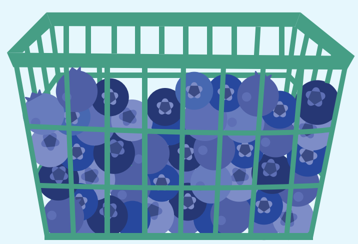
HIGHBUSH BLUEBERRIES NEED POLLINATION

Highbush blueberry varieties require insect pollination to produce optimal yields[3,4]. The combined visits by both honey bees and wild bee species during blueberry bloom lead to better seed set, larger fruit, and higher yields[5,6]. While many factors influence blueberry fruit set and crop yield, a lack of pollination, on its own or in combination with other factors, can lead to substandard production[7].

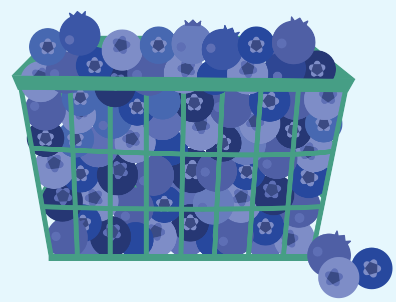
Highbush blueberry production has been found to be limited by insufficient pollination in British Columbia if supplemental pollinators are not used[6,8]. But, where there are greater numbers of bumble bees, other native bees, or higher honey bee stocking rates, there is less pollen limitation and therefore greater fruit size and/or greater fruit set[6,8,9]. Research show that with no pollination, highbush blueberry production decreases by 50-80% from typical levels[1,8]. With full pollination, production can be increased above typical levels by up to 38%, with an estimated added value of $15,000-18,000/ha[1,8]. One study found that managed honey bees alone could not reduce deficits, and that wild pollinators were needed to reach full pollination[8].

WILD AND MANAGED POLLINATORS' IMPACT ON PRODUCTION

Low production:
No pollinators



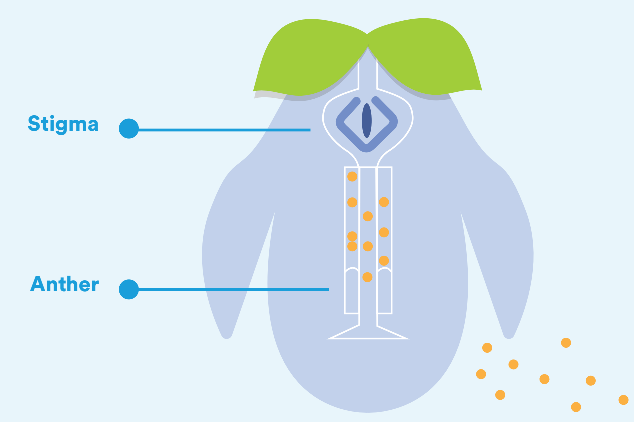
Typical production:
Managed honey bees and typical ambient wild pollinators in BC



Potential production:
Full pollination with managed honey bees and increased wild bee presence from habitat management. This can potentially increase revenue by $15,000-$18,000/ha[1,8]

THE POLLINATORS OF HIGHBUSH BLUEBERRY

Highbush blueberry is pollinated by many types of pollinators but the most important are bees. While most people are familiar with managed honey bees, less well-known are native bees that provide valuable pollination services to many crops, including highbush blueberry. 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, and managed bees, which include not only honey bees but also some species of bumble bees and other bees. Honey bees are not native to North America but are very important to agriculture. In contrast to most wild bees, honey bees are highly social species that live in colonies numbering in the tens of thousands. There are over 800 species of wild, native bees in Canada, ranging in size from a few millimeters up to 25 mm in length. Most wild bees are solitary, meaning that they build individual nests as opposed to colonies; they build these nests in the ground or in tunnels in old wood or vegetation. Bumble bees, however, are social and live in colonies. Read below to find out more about managed honey bees and the fascinating wild bees that make blueberry production possible



Poricidal anthers on a blueberry flower (figure adapted from University of Maine Fact Sheet No. 630, UMaine Exentsion No.2111)

Blueberry flowers have evolved for buzz pollination, which is achieved when certain bee species move their flight muscles rapidly, causing the anthers to vibrate and release their pollen[10]. Bumble bees, some miner and sweat bees, and large carpenter bees are able to buzz pollinate[11]. Honey bees are not able to buzz pollinate and are not very effective pollinators of blueberry[12]. However, because they can be brought to fields in large numbers (generally about 5 colonies/ ha are recommended in BC) and are able to drum on the anthers with their legs (among other pollination-aiding behaviours), they can successfully aid in crop pollination[1,13].

In bagging and cage studies, where insects are kept from accessing flowers, little or no blueberry fruit is produced[7,14]. Research also shows that higher bee abundance and a diversity of wild bees, in addition to managed honey bees, can lead to more flowers setting fruit and/or larger berries[1,8]. Therefore both honey bees and wild pollinators, like bumble bees, are important, since the best pollination occurs when there is a diversity of species visiting the blueberry crop.

HONEY BEES

Honey bees are commonly rented from beekeepers for highbush blueberry 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. While honey bees are less efficient blueberry 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 hives/acre (5-12 hives/ha) when the crop reaches 5-10% bloom and are usually removed from fields at petal fall. Different highbush blueberry cultivars have varying flower size, and honey bees prefer cultivars with a wider floral opening. While not all cultivars have been evaluated for ease of honey bee access, and many as yet unknown factors may influence honey bee preference for different cultivars, it is worth considering floral shape when evaluating pollination needs for this crop.

Foraging exclusively on pollen from blueberries may cause health problems in honey bees, possibly because of low protein content and/or high pH. Research from British Columbia found that most honey bees foraging in blueberry fields were foraging for nectar, not pollen, and only 7% of the pollen that was brought into the hives was blueberry pollen [8,15,16]. Research shows that honey bees in blueberry fields are healthier if they have access to a diversity of non-crop pollen sources[17]. Whether poor honey bee health after blueberry pollination is a result of low nutrition due to blueberry pollen and a lack of floral diversity, exposure to pesticides in blueberry crops, negative impacts from pests and diseases, or a combination of these, is unclear at this time and the focus of ongoing research (see research focus p.12).

WILD BEES

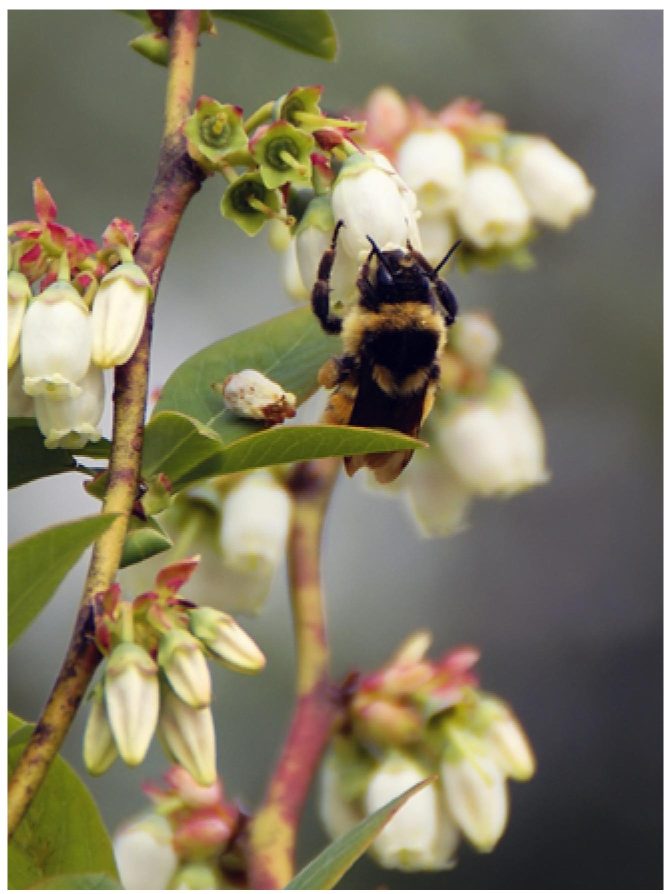
Wild pollinators are on-site 'natural resources' that are known to increase blueberry production; even in the presence of high densities of honey bees, having more wild bees will increase blueberry yield. Wild bees are present in and around fields all year, either as adults that can be seen flying and 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 on crop edges or in fields.

The communities of wild bees that visit highbush blueberry crops vary among regions. In the native range of wild (lowbush) blueberry (in Canada, from Manitoba east to Newfoundland), the diversity of wild bee species includes specialists on Vaccinium species (blueberry and related berries) such as mining bees, orchard bees, and bumble bees[1]. In the Fraser Valley of British Columbia, there are fewer *Vaccinium*-specialist bees, and the crop depends more heavily on wild bumble bees[8], though several other types of wild bees also are found on highbush blueberry in British Columbia. Research is ongoing as to the relative contributions of these different groups to blueberry pollination. Besides geographic location, field size may also affect which pollinators are present. A study in Michigan found that most of the pollination services in smaller (0.05-0.40 ha) highbush blueberry fields were provided by wild bees[9].

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[18,19], 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[20–24].

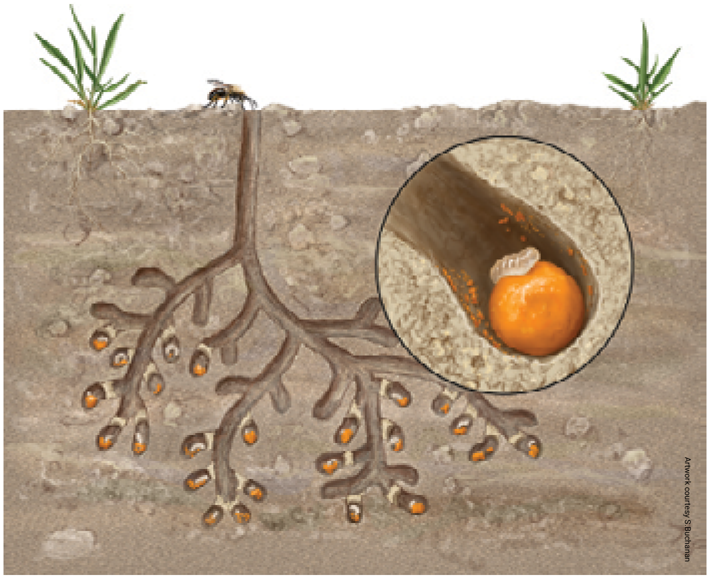
BUMBLE BEES

Bumble bees (*Bombus* spp.), like honey bees, are social insects, but they live in smaller colonies that number anywhere from 40 to 400 bees. They are more abundant on farms that have natural areas nearby[8,16]. Farms with large numbers of bumble bees visiting their blueberry crop tend to have better fruit set[25]. Bumble bees are able to forage in cooler weather than honey bees and most other wild bees, making them excellent pollinators of blueberries that bloom in the early spring when temperatures may be cool. Bumble bees have the ability to "buzz" blueberry flowers to release pollen, making them more efficient per visit than honey bees (e.g., bumble bees can deposit about twice the amount of blueberry pollen and handle flowers 50% faster than honey bees[15]). Bumble bees are the most common wild pollinators of blueberries in British Columbia and they contribute significantly to blueberry production in other regions as well.



OTHER WILD BEES

There are several other kinds of wild bees that pollinate blueberry flowers, including sweat bees, mason bees, mining bees, and cellophane bees, but these are present in small numbers in most Canadian highbush blueberry growing regions relative to honey bees and bumble bees[8,9,16]. In contrast to the latter, most wild bees are solitary and only produce one or two generations per year. Some of these wild bees live in the soil, while others live in aboveground cavities and tunnels in plant stems (including old blueberry canes) and wood. See 'Wild pollinators of blueberry' on page 11 for more information and photos of common wild blueberry pollinators.



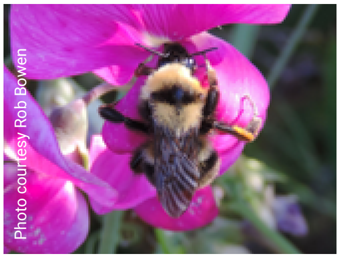
Ground nesting bee tunnels

Pollination of blueberry crops 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 (p. 19).
- Having smaller field sizes or fields that incorporate habitat as strips or patches. Field edges and marginal lands can be used for habitat.
- Reducing exposure to pesticides by following label recommendations and practicing Integrated Pest Management (p.15).

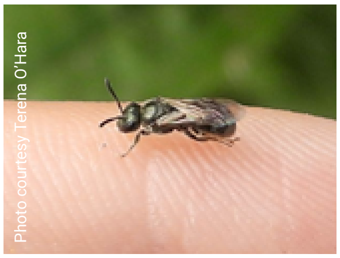
WILD POLLINATORS OF BLUEBERRY

These are some native bees that you may see in or around blueberry fields. They are docile and rarely sting people, and all of the ones shown here are known to pollinate highbush blueberry. Use the iNaturalist App to help identify bees.



BUMBLE BEES

(genus *Bombus)* Bumble bees are great pollinators of blueberries and other 'buzz' pollinated 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. There are about 40 different types of bumble bees across Canada and while it's pretty easy to tell a bumble bee from most other bees, it can be pretty tricky to know what type of bumble bee you are looking at.



SWEAT BEES

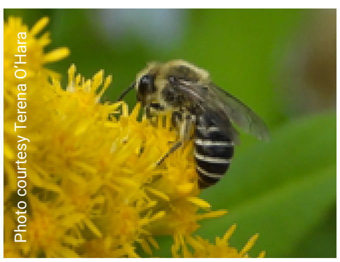
(family Halictidae) Sweat bees can be as tiny as 4 mm, like the one on the left, or up to about 11 mm. Some are metallic, others bright green, and some have stripes. They are good pollinators of blueberries and some can 'buzz' pollinate. They are solitary and nest in the ground. The little ones might land on you and lick your sweat in the summer!

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 efficient blueberry pollinators in areas where they coincide with blueberry bloom. They are small to medium sized and sometimes mistaken for flies.

MINER BEES

(family Andrenidae) Like the sweat bees, mining or miner bees nest in the soil. They all are solitary bees but sometimes will nest in large numbers in one area. They range in size from 7 mm to 18 mm. They can buzz pollinate and have been found to be good pollinators of highbush blueberry. Look for them 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. Some can buzz pollinate and they are known to pollinate blueberry.

RESEARCH HIGHLIGHT

EXPLORING THE CONNECTION BETWEEN BLUEBERRIES AND HONEY BEE HEALTH

Photo courtesy Heather Higo

Each spring, approximately 40,000 honey bee colonies are brought to highbush blueberry fields to pollinate the extensive acreage in British Columbia. However, poor honey bee health after highbush blueberry pollination has been an issue for many years. Some beekeepers are concerned that pollinating blueberries may affect bee health and increase the incidence of European Foulbrood (EFB). This is threatening the availability of colonies for pollination. If pollination of blueberry crops is causing problems for some beekeepers, a number of factors including poor nutrition during pollination, increasing virulence of pathogens, and exposure to insecticides or fungicides, could be acting alone or in combination.

Researchers from Agriculture and Agri-Food Canada (AAFC) have partnered with the University of British Columbia (UBC), the National Bee Diagnostic Centre, the British Columbia Honey Producers' Association, the British Columbia Blueberry Council, and the University of Saskatchewan to study why honey bees might be getting sick after pollinating blueberry crops. A goal of the study is to find strategies that both beekeepers and growers can implement to help keep pollinators in good health. Led by Marta Guarna (AAFC) and Heather Higo (UBC) they are assessing the health of colonies that are brought into blueberry fields and comparing them to colonies that are not in blueberry fields. They are also assessing if protein supplementation can improve the health of bees pollinating blueberry.


Photo courtesy Marta Guarna

During the spring and summer of 2018 and 2019, the team worked with five beekeepers to evaluate 250 colonies. EFB increased in all colony groups (in blueberry fields and controls), but colonies that pollinated blueberries had a higher incidence of EFB after pollination when compared to the non-pollinating colonies from the same beekeeper. Protein patty supplementation did not appear to improve the situation for bees in this study or in other studies[26–28].

Researchers are continuing to analyze the data and investigate whether a more pathogenic EFB-causing bacteria is part of the problem. In addition, their collaborators at the Western College of Veterinary Medicine in Saskatoon, SK are assessing the effects of some blueberry fungicides in combination and on their own, on the susceptibility of larvae to EFB-associated mortality in the laboratory[29]. Stay tuned as more information emerges from these studies.

In addition, the Economic Blueberry Pollination project (EcoBBP) in British Columbia is conducting an economic assessment of the net costs and benefits incurred by beekeepers who rent out their colonies for blueberry pollination in BC. The research investigates what is involved in preparing and managing colonies before, during, and after pollination; how the colonies are affected by disease or other health issues; and what additional operational changes are necessary and/or have been used as a result of blueberry pollination. This research will highlight the economic incentives for beekeepers and blueberry growers in an effort to reach a sustainable pollination outcome with productive blueberry pollination and healthy honey bee colonies.

2 PRACTICES TO PROTECT POLLINATORS

75% OF CROPS REQUIRE OR BENEFIT FROM INSECT POLLINATION

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[30]. 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
- Using pesticide products

INTEGRATED PEST MANAGEMENT (IPM)

Using integrated pest management (IPM) and 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 biological control, habitat manipulation, cultural practices, and the use of pesticides and pest-resistant plant varieties. Pest management materials are selected and applied in a manner that minimizes risks to human health, beneficial and nontarget organisms, and the environment[31]. For example, pesticides are used only when monitoring indicates they are needed according to established guidelines, and treatments are made with the goal of removing only the target organism. IPM plans help farmers meet their production and crop protection goals and protect pollinators, while 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 inputs, less crop damage from a reduced need for equipment in fields, and better yields from healthier and larger pollinator and beneficial insect populations. Growers can learn about IPM and implement IPM strategies themselves, or contract with local IPM specialists.

Learn more about IPM from the resources listed on page 39.

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.

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

CASE STUDY

ARROWWOOD FARM, ONTARIO

“Our focus is on growing the healthiest plants possible that can ultimately withstand diseases and pests. We do this by a nuanced fertilizer program including drip and foliar applications throughout the season. We also use soil amendments such as mulch, calcium silicate, and gypsum, to enhance soil quality and encourage strong biological activity in the root zone that builds up plant defences. In 2019, we started planting pollinator plants along the forest edge and near our blueberry fields to encourage pollinators. We are doing this to try to balance the need to remove alternate hosts for spotted wing drosophila, while maintaining resources for pollinators and other beneficial insects.

Other cultural methods we use include a strong pruning program to improve bush airflow, season-long inspection to remove any diseased branches or bushes, and manual control of weeds (including weed-trimmers). We’re still at the ‘experimental’ stage and we’re too small an operation to calculate the costs and benefits of our approach, but it just seems like the right thing to do.”

PHIL MODDLE, ARROWWOOD FARM

MAINTAINING CLEAR COMMUNICATIONS

Communication and cooperation between beekeepers and growers is the most effective way 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. Although the reasons for poor health in colonies after blueberry pollination are complex, open communication and coordination between beekeepers and blueberry growers can greatly reduce the risks to honey bees from pesticides.

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.

CASE STUDY
BARRIE HILL FARMS, ONTARIO

Along with several other fruit and vegetable crops, Morris Gervais of Barrie Hill Farms grows 40 acres of highbush blueberry on his farm in Ontario near Georgian Bay. Morris attributes part of his blueberry crop's success to the positive and long-standing relationship he has with the commercial beekeeper who supplies up to 90 hives annually to his farm. Morris needs to control cranberry fruit worm most years, and so as soon as blueberry pollination is finished, he provides the beekeeper with 48 hours notice so that they can move the hives before the insecticide is applied. In addition to honey bees, Morris is also familiar with the value of wild bees to blueberry pollination. He and his father have monitored bee visits to their crops and have noted the several different species of bumble bees and other native bees that visit their crop. For Morris, the steady buzz of pollinators, both wild and managed, is a sign of a successful harvest to come.

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

Photo courtesy Rufus Isaacs

Maintaining or creating habitat around your farm can go a long way toward supporting healthy honey bees, increasing the abundance of wild bees, and their resilience to other stressors[32]. In the past, non-crop areas were not believed to contribute to farm production. However, there is now an abundance of evidence that leaving non-invasive weeds, wildflowers, and other habitat patches around pollinator-dependent crops such as highbush blueberry increases pollination and crop production[25, 33-35].

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 support and attract wild bee populations rather than taking them away from the crops[17, 25, 36].

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:

- Selective weed control to increase pollinator friendly species.
- Keeping 'scrubby' areas rather than farming every piece of land: this can lead to more 'intensive' production; that is more yield on less land due to the enhanced pollination from wild bees and healthier honey bees.
- Identify areas that are lower production and 'marginal'. Keep these as habitat for beneficial insects rather than cultivating these sections. This can save money and enhance production.

Photo courtesy Rufus Isaacs

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

- Create floral strips or hedgerows, which can take little or no land out of production, on field edges and other areas of your farm[37].

Ideal habitat for bees includes the following elements, but 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 bloom early in the season to support blueberry pollinators.
- Flowering plants that, in combination, bloom from early spring to fall to support honey bees and wild bees such as bumble bees that need forage from spring to fall.
- Undisturbed soil, 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 from pesticide application and drift through pesticide-free buffers and thoughtful management.

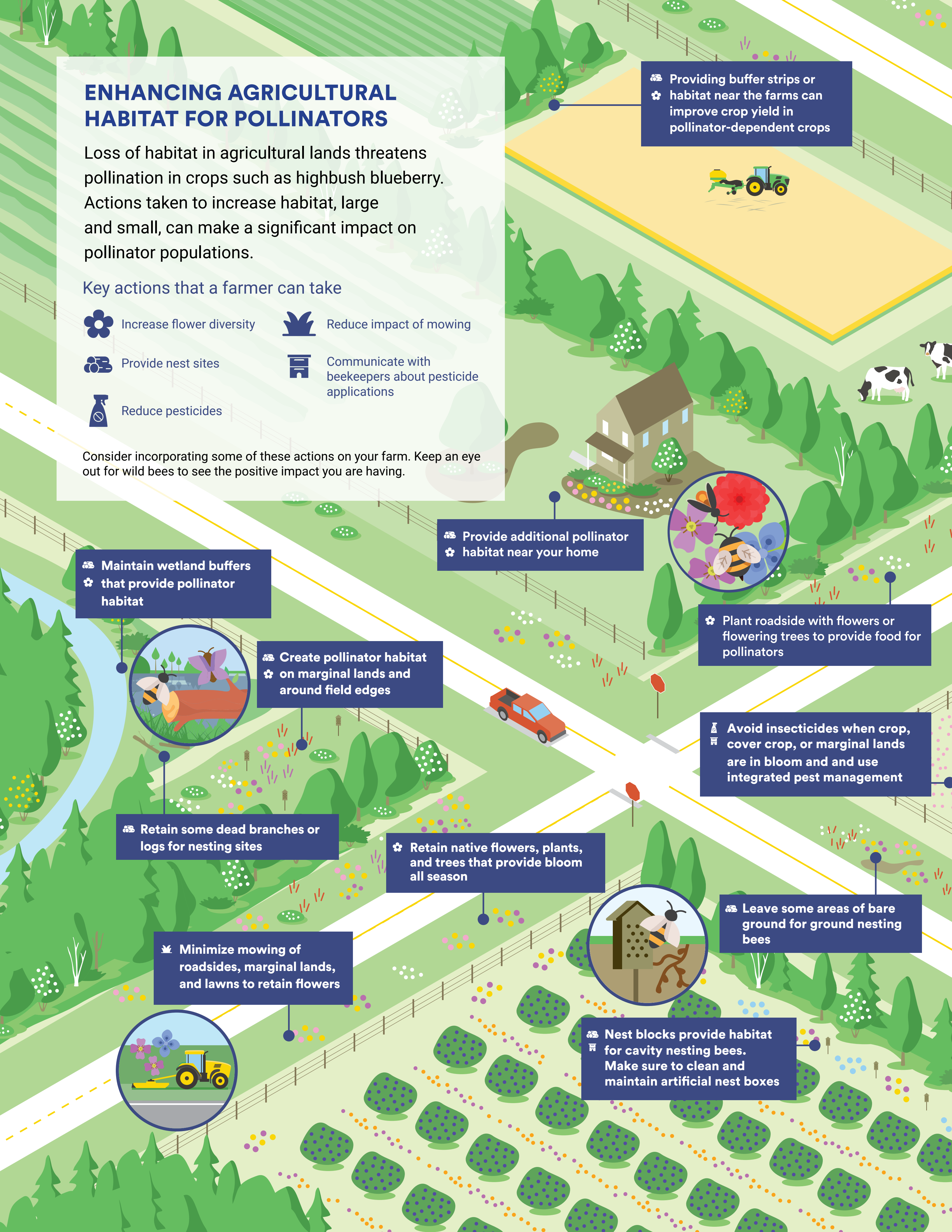
ENHANCING AGRICULTURAL HABITAT FOR POLLINATORS

Loss of habitat in agricultural lands threatens pollination in crops such as highbush blueberry. 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.

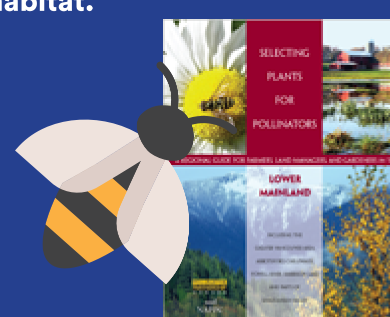


The unmowed hillside provides habitat for managed and wild bees. Placing hives slightly away from the crop helps protect them from pesticides. See page 23 Using Pesticide Products for more information.

Preserving and creating habitat for bees is an achievable goal for large- and small-scale blueberry growers. Small actions taken by many growers and landowners can add up to large benefits for the agricultural community.

There are many other beneficial insects in and around blueberry fields. Minimizing use of pesticides and providing habitat will also help protect these biocontrol insects, possibly reducing future pest outbreaks. See https://fieldguide.bcblueberry.com/beneficial-insects/

Visit www.pollinatorpartnership.ca for the EcoregionalPollinator Planting guide for your region for more information on conserving pollinators by maintaining and enhancing habitat.



USING PESTICIDE PRODUCTS

Pesticides are an integral part of agriculture. However, there are risks to pollinators associated with their use. The following practices outline ways to minimize these risks while maintaining crop production and quality. Bees can be impacted lethally or sublethally by exposure to pesticides. 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, and selecting products that have low toxicity to bees, healthy bee populations can be maintained that will contribute to blueberry pollination, pollination of other crops, and natural ecosystems.

POTENTIAL PESTICIDE IMPACTS ON BEES

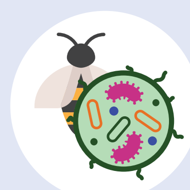
Bees can be impacted lethally or sublethally by pesticides. For more information, see Recognizing and Reporting a Bee Poisoning in the Resources section on p.36.

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

Bee poisonings are related to both exposure and to 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 or nectar of the crop where bees can be exposed to them, or are sprayed on the crop during bloom when the bees are present. 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. At the same time, herbicides can also be useful and necessary for the creation and management of pollinator habitat and fungicides often are a necessary component of highbush blueberry production (see below).

Some of the active ingredients in the following chemical families used in highbush blueberry crops have residual toxicity longer than 8 hours:

- Organophosphates such as malathion.
- N-methyl carbamates such as carbaryl.
- Neonicotinoids such as imidacloprid and thiamethoxam.

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 you 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 p.39 for resources on mode of action.

INSECTICIDES

Insecticides 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 they can be toxic to humans and/or animals, and accumulate in the environment. Use of insecticides within an Integrated Pest Management framework (see p. 15) and following label directions for application to highbush blueberry 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.

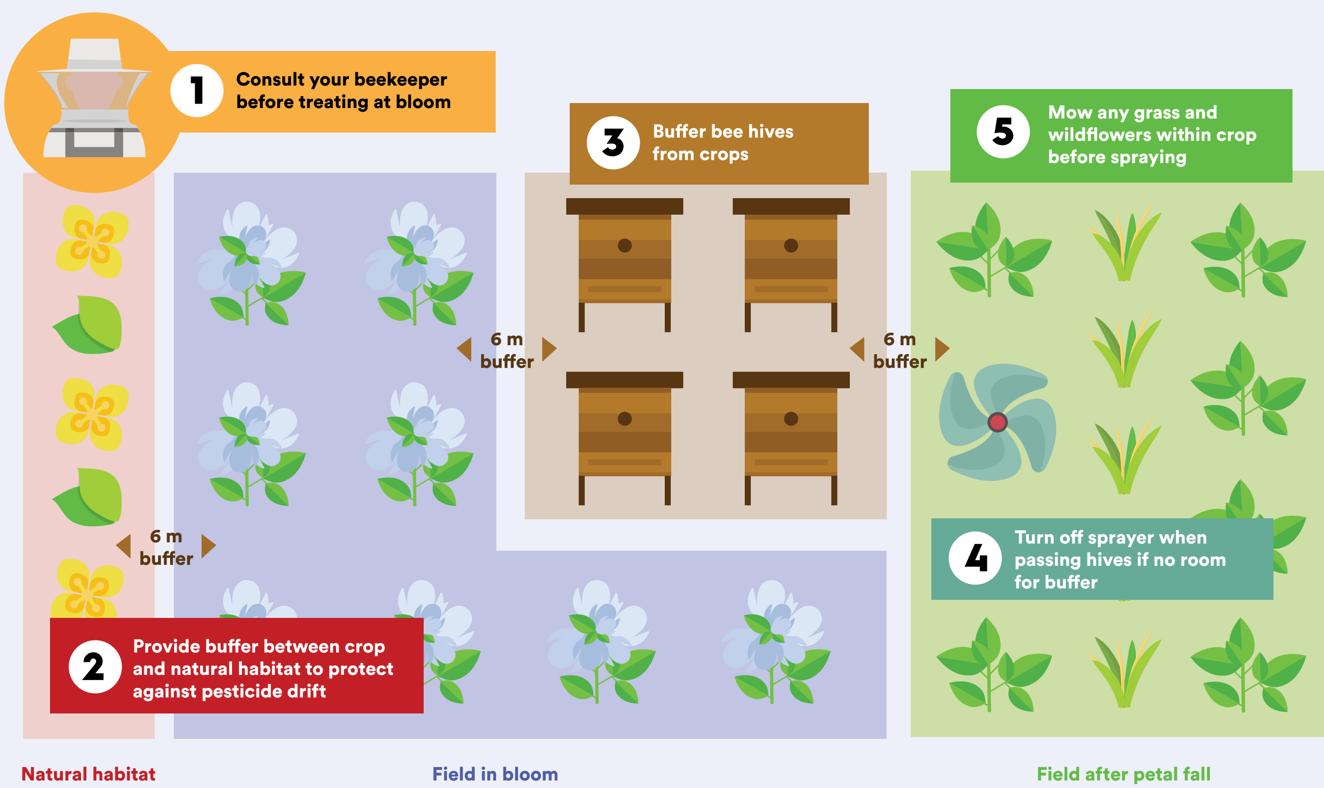
FUNGICIDES

Fungicides are often necessary for blueberry production to prevent the development of fruit rot diseases, especially when wet weather coincides with bloom. However, there is evidence that some fungicides can negatively impact bees on their own[38] and in synergy with insecticides[39, 40]. Following label directions, avoiding applying fungicides directly on or near honey bee colonies, and applying them when bees are not active, can help safeguard bee health.

SYNERGIES

Some products can have synergistic effects in the field, that is, they are more toxic in combination than individually. For example, the fungicides myclobutanil and propiconazole have each been found to synergize with some pyrethroids and neonicotinoids[41–43].

WAYS TO PROTECT BEES FROM PESTICIDE APPLICATION



Best management practices beekeepers and growers can use to reduce bee exposure to pesticides by creating buffers between treated fields, colonies, and bee forage areas. Diagram adapted from Iris Kormann, Oregon State University.

FOLLOW LABEL DIRECTIONS

Product registration, toxicity testing, and product regulation are in place to protect honey bees and other pollinators from the negative effects of pesticides. Pesticide labels are legal documents, and 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 point of view for the blueberry grower, as well as an ecological point of view for bees and other beneficial insects. Applying too much of one pesticide 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

- The Environmental Precautions/Hazards section of the pesticide label contains information designed to protect bees.
- 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

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.

Mow areas between blueberry rows to remove blooming flowers before applying pesticides that are toxic to bees.

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 to the blueberry crops 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 blueberry crop.
- Systemic insecticides (like neonicotinoids) can be 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.
- Honey bees collect insecticide-contaminated water (from drip tape or chemigation or in standing water near treated fields).
- Ground nesting or overwintering bees can be exposed through soil contaminated with pesticide[44].

REDUCING BEE EXPOSURE TO PESTICIDES

When using pesticides, in addition to following label directions and maintaining clear communications with beekeepers and other stakeholders (see p.16), other ways of minimizing managed and wild bee exposure include:

- Ensure that pesticide drift is minimized to reduce contact with adjacent habitat.
- Avoid applying pesticides during warm evenings when honey bees are clustered on the outside of their hives.
- Avoid applying pesticides (especially insecticides) to any blooming flowers, even weeds; bees may be using these resources.
- Be 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.
- Look 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.

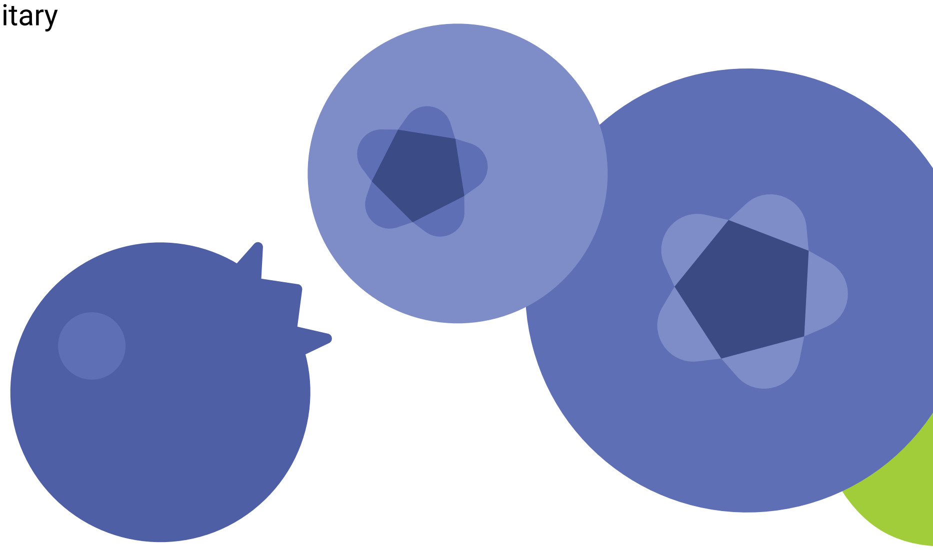
Notes may be found in Table 2 of the supplemental document if it is currently known that greater precautions are needed for bumble bees or solitary bees than for honey bees.

OTHER CONSIDERATIONS

Canada has a robust and comprehensive pesticide risk characterization protocol which informs pollinator precautions and use restrictions. These risk characterizations and label restrictions help prevent harm to bees. Tests are mainly conducted on honey bees which are generally a good proxy for testing oral and contact toxicity for all bees.

It is however recognized that other bees may be exposed in different ways than honey bees and toxicity may be different among types of bees; testing on other types of bees is being increasingly conducted and recommended[45, 46].

- Some products can interact in the field and increase toxicity synergistically[39-43]. These interactions are sometimes captured in label guidelines.
- Colonies may be exposed to one pesticide, moved to a new cropping system, and then exposed to a second pesticide. More research is needed to understand potential additive, synergistic, chronic, or delayed effects from repeated exposure. Reducing overall pesticide use through IPM can reduce chronic exposure.



3 ACTION GUIDE

GROWERS AND PESTICIDE APPLICATORS

COMMUNICATION

- Write and agree to a contract that defines expectations and responsibilities between beekeeper and grower, 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 products 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 those you are currently aware of in any area because they 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 http://www.beeconnected.ca/

PRODUCT SELECTION AND USE

- Always read and follow pesticide label directions.
- Select pesticides that have the lowest pollinator precaution levels using Table 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 in order to minimize drift.
- Less drift occurs during ground application than aerial application. During aerial application, do not turn the aircraft or transport materials back and forth across hives, blooming fields, or water sources.
- Never spray crop 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 blueberry crops and when they are attractive to bees. 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.
- 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 pest insects 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) consultant that can help save you time and money by reducing unnecessary pesticide application.
- 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 beneficial insects and other cultural practices, for long-term control of insect pests. Details of integrated pest management (IPM) practices can be found at https://ipmcouncilcanada.org/ and http://www.agr.gc.ca/eng/?id=1288805416537
- Look into programs that support planting habitat areas on your farm for honey bees, other pollinators, and other beneficial insects such as Operation Pollinator (https://www.syngenta.ca/commitments/operation-pollinator/), Bees Matter (http://www.beesmatter.ca/), or build your own bee habitat using Pollinator Partnership's Ecoregional Planting Guides or the Canadian Honey Bee Forage Guide (https://www.pollinatorpartnership.ca/)

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 http://www.beeconnected.ca/.
- 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 (also 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.

Place hives 6 m away from the crop with a no spray buffer (top photo), rather than directly adjacent to the crop (bottom photo), if possible.

PROTECTING HONEY BEES FROM EXPOSURE

- Work with growers to find a location for beehives that is at least 6 m away from the crop, including no-spray buffers.
- If it is not feasible to move your colonies prior to a pesticide application, protect honey bee colonies by covering them with wet burlap the night before a crop is treated with an insecticide. Keep these covers wet and in place as long as feasible (depending on residual toxicity of pesticide) to protect bees.
- 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 pesticide risk-prone areas, 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 workers 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[47,48].

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 [47,49–55]. 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 p.37), 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.

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.

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 p. 38 for contact information).

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 38). Provide photos or videos of the incident, 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 search in app at https://www.canada.ca/en/health-canada/services/consumer-product-safety/pesticides-pest-management/registrants-applicants/tools/pesticide-label-search.html), why you suspect the bees may have been exposed, pesticide treatments you have applied to the hives, 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 provinces 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 in order 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 applications to bees, as well as guidance on bee management.

ALBERTA (MINISTRY OF AGRICULTURE AND RURAL DEVELOPMENT)

https://www.alberta.ca/how-to-reduce-bee-poisonings-from-pesticides.aspx

780-415-2314

NOVA SCOTIA (DEPARTMENT OF AGRICULTURE)

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

902-679-8998

BRITISH COLUMBIA (MINISTRY OF AGRICULTURE)

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

604-556-3129

ONTARIO (ONTARIO MINISTRY OF FOOD AND RURAL AFFAIRS)

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

1-877-424-1300

MANITOBA (MINISTRY OF AGRICULTURE)

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

604-556-3129

SASKATCHEWAN (MINISTRY OF AGRICULTURE)

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

306-953-2304

NEW BRUNSWICK (DEPARTMENT OF AGRICULTURE, AQUACULTURE AND FISHERIES)

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

506-453-2108

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

NEWFOUNDLAND AND LABRADOR (DEPARTMENT OF NATURAL RESOURCES)

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

709-637-2662

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. 39) for a link to report a bee incident to Health Canada.

USEFUL LINKS

BEECONNECTED APP

http://www.beeconnected.ca/

BERRY GROWERS OF ONTARIO

https://ontarioberries.com/

BRITISH COLUMBIA BLUEBERRY COUNCIL

https://www.bcblueberry.com/

BRITISH COLUMBIA BERRY PRODUCTION GUIDE

https://www2.gov.bc.ca/gov/content/industry/agriservice-bc/production-guides

E.S. CROPCONSULT: IPM FACT SHEETS

http://escrop.com/factsheets/

GOVERNMENT OF BRITISH COLUMBIA: BLUEBERRY IPM POSTER

https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/animal-and-crops/plant-health/blueberry_ipm_poster.pdf

GOVERNMENT OF BRITISH COLUMBIA: PESTICIDES & PEST MANAGEMENT

https://www2.gov.bc.ca/gov/content/environment/pesticides-pest-management

HEALTH CANADA'S PEST MANAGEMENT REGULATORY AGENCY (PMRA) PESTICIDE LABEL SEARCH

http://escrop.com/factsheets/

iNATURALIST APP

https://www.inaturalist.org/

INSECTICIDE RESISTANCE ACTION COMMITTEE: THE IRAC MODE OF ACTION CLASSIFICATION

https://irac-online.org/mode-of-action/

POLLINATOR PARTNERSHIP CANADA: POLLINATOR GUIDES

https://pollinatorpartnership.ca/en/ecoregional-planting-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

FIELD GUIDE TO IDENTIFICATION OF INSECT PESTS, DISEASES AND OTHER DISORDERS IN BLUEBERRIES IN BC

https://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/animals-and-crops/plant-health/integrated-pest-management

POLLINATOR PARTNERSHIP: TECHNICAL GUIDE FOR PRESERVING AND CREATING HABITAT FOR POLLINATORS ON ONTARIO'S FARMS

https://pollinatorpartnership.ca/en/ecoregional-planting-guides

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