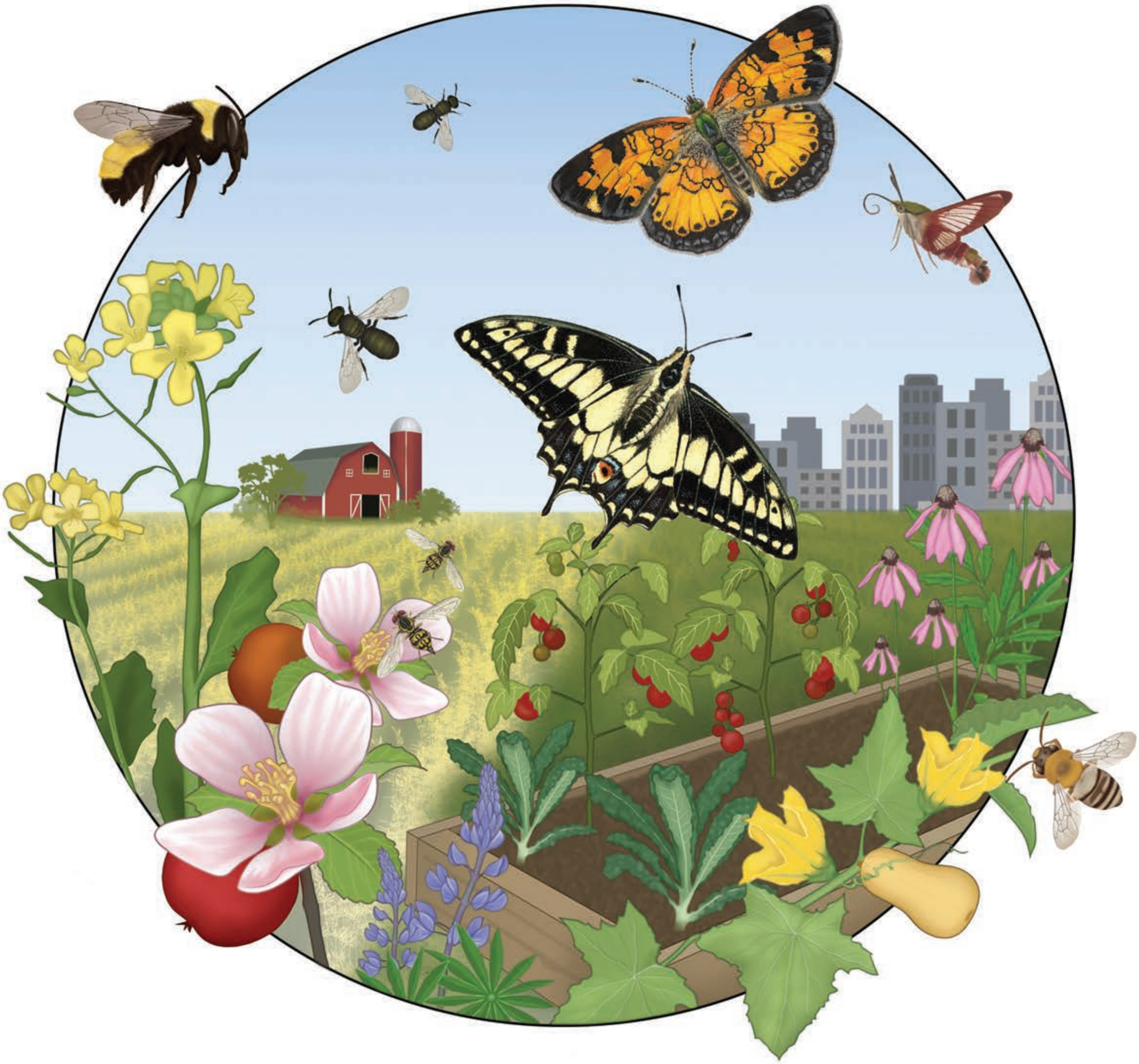
Conserving Canada's Wild Pollinators

NATIONAL STRATEGY RECOMMENDATIONS



Sheila R. Colla, Native Pollinator Research Lab
Rachel Nalepa PhD, Project Lead

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Weston Family Foundation

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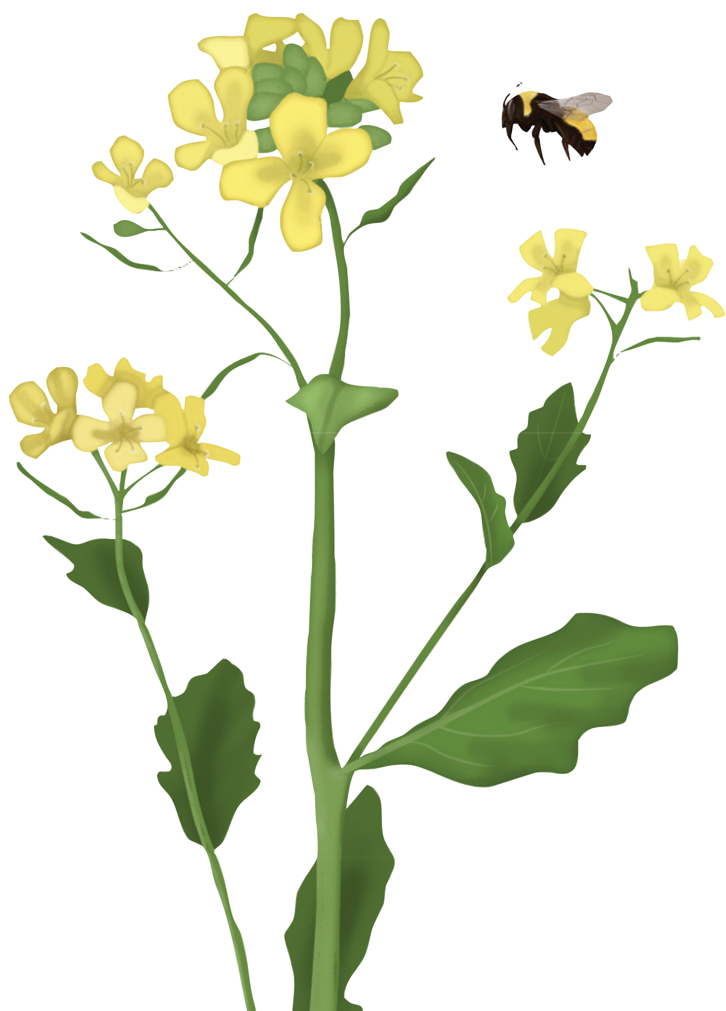

CONSERVATION SCIENCE
Colla Lab

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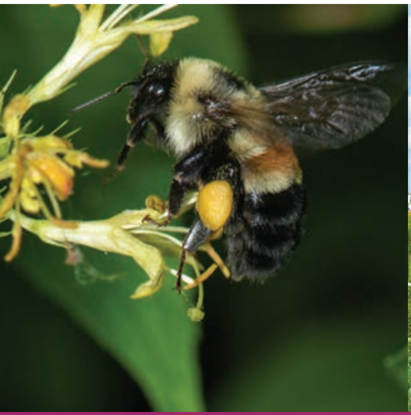
Due to human activity, Canadians are losing native plants and animals at an alarming rate. Species under threat include many of the wild pollinators that are integral to Canada's natural ecosystems and national food security. The science is clear: there is no single factor causing the decline of Canada's pollinators. Rather, it is the interaction of many factors that are contributing to pollinators' current state of stress, and these factors have different impacts in different regions and for different species. Researchers are working to further characterize these relationships, but in the meantime, there are many actions that we can take to maintain and create pollinator-friendly spaces in our communities that span cities, agricultural lands, protected areas and degraded lands. Pollinator decline is urgent and requires swift and sustained action in order to protect Canada's agricultural sector and the health of the natural environment.



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About this proposed strategy

This proposed strategy's **vision** is a pollinator-friendly Canada. More specifically, this strategy provides a blueprint that will help wild pollinators to not only survive, but to thrive. The vision is supported by **goals** that will address the top threats to Canada's wild pollinators including habitat loss, pesticides and disease, all in the context of ongoing climate change (see page 11). Each goal is linked to **objectives**, clear **action steps** and research that fills **knowledge gaps** in support of the objectives.

This proposed strategy's **development** was initiated by the Sheila R. Colla Native Pollinator Research Lab at York University in Toronto. Objectives, action steps and knowledge gaps were generated through consulting existing national plans and evidence-based initiatives, as well as iterative survey research involving scientific advisors and other participants representing Canadian and U.S.-based academics, NGO scientists, civil servants and agricultural industry members with expertise in pollinators and/or wildlife conservation. Through this survey work, we identified and included solutions that we determined to be both science-based and feasible to implement. The strategy does not necessarily reflect the views of survey participants.

The **scope** of this proposed strategy is geared toward developing forward-thinking federal leadership. The federal government is the outward face of Canadians striving to meet the commitments made to achieve the (yet unfulfilled) Aichi Biodiversity Targets set out by the Convention on Biological Diversity for 2020 and proposed targets for the post-2020 framework, many of which can be at least partially fulfilled through pollinator conservation actions (e.g., ensuring connectivity between terrestrial ecosystems, preventing/managing invasive species). The Canadian federal government is also the guarantor of monitoring efforts to measure progress toward those targets. The Canadian public has shown intense interest in protecting pollinators and research has demonstrated that the majority of people think government agencies should take the lead.[1]

Photo: Victoria MacPhail

This proposed strategy envisions a pollinator-friendly Canada and provides a blueprint that will help wild pollinators to not only survive, but to thrive.

Vision

A WILD POLLINATOR-FRIENDLY CANADA

Goal 1
Protect wild pollinators from pesticides

Objective 1A
Improve risk assessments for pesticides on wild pollinators

Objective 1B
Reduce reliance of agricultural systems on pesticides

Goal 2
Protect wild pollinators from disease

Objective 2A
Reduce pathogens in managed pollinators

Objective 2B
Limit pathogen spillover between managed and wild pollinators

Goal 3
Provide the resources that pollinators need to thrive

Objective 3A
Create and protect high quality habitat

Objective 3B
Support the ecological integrity of pollinator habitat

Goal 4
Build, share and apply our knowledge

Objective 4A
Improve monitoring efforts

Objective 4B
Invest in knowledge mobilization

Figure 1. Path to a wild pollinator-friendly Canada

Why do we need a national strategy?

Wild pollinators are important.

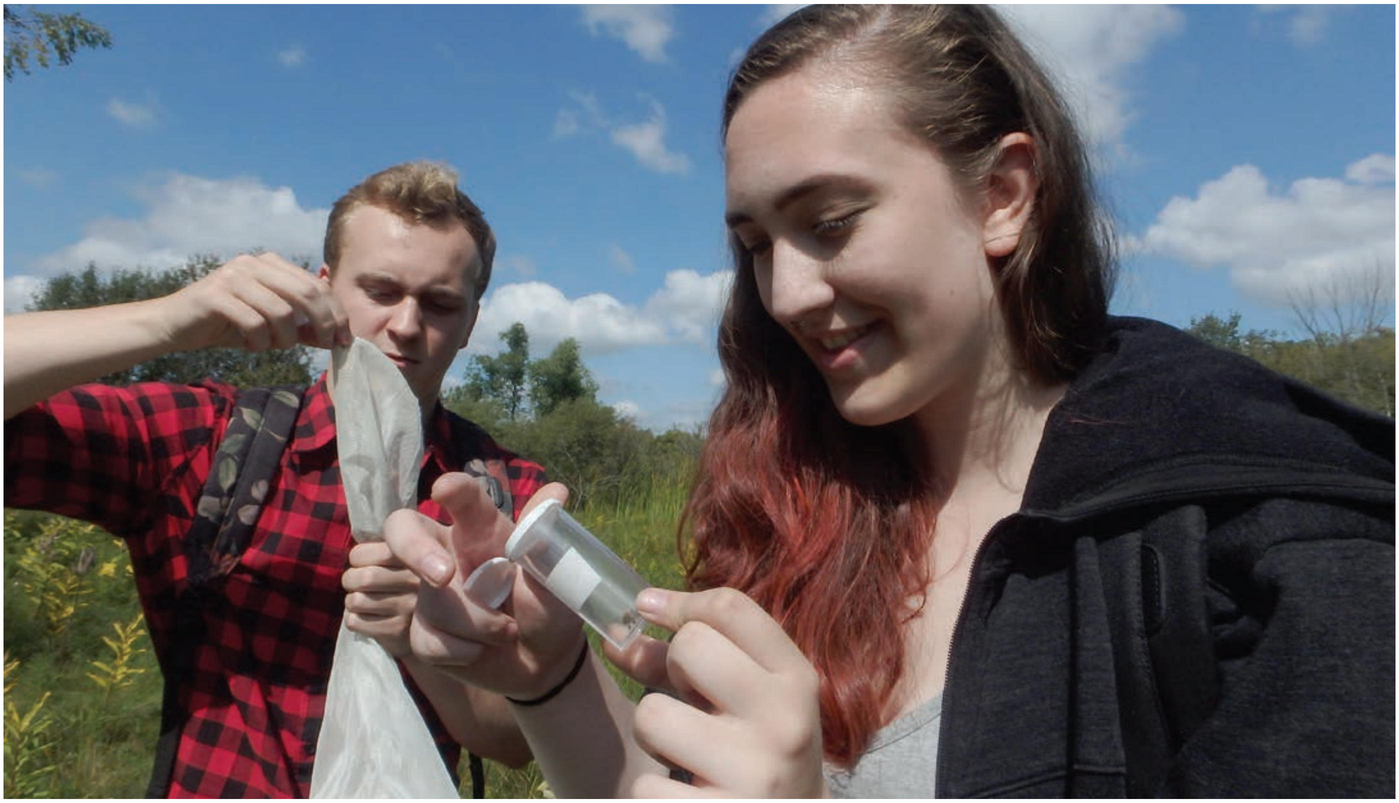
The value of Canada's wild pollinators cannot be overstated. They are essential to Canada's **economy** and **food security**, particularly in supporting the production of fruit, vegetable and seed crops. While studies on the value of wild pollinators are lacking in Canada, crop pollination services provided by native insects in the U.S. was estimated to be (USD)$9 billion.[2] Wild pollinators are also critical in maintaining the integrity of **ecosystems**. Flowering plants–including many rare species–have co-evolved with native pollinators and pollination is essential for their survival. Plant communities which are limited by pollination due to pollinator declines could cause cascading impacts on other wildlife which rely on these plants for food or shelter. These changes impact humans as ecosystems lose their resilience and ability to provide for our demands for food, fresh water, timber, fibre and fuel. The importance of wild pollinators goes beyond the pollination services that they provide: pollinators and the plants they pollinate possess recreational and spiritual value, foster a connection to our natural environment and are culturally significant, featuring in the folklore and art of many cultures.

Wild pollinators are in jeopardy.

While it is difficult to make a generalized statement about the status of all of Canada's wild pollinators, we know some species are declining and some are on the brink of extinction. There are approximately 30 pollinators currently listed under *Canada's Species at Risk Act* (SARA) including species of bees, butterflies and moths. Of bees, eight bee species are listed under SARA and several of them are estimated to have lost at least 50 per cent of their total population. Most of these listed species are on a trajectory toward extinction if we do not act urgently to reverse the trend. In the alarming span of roughly 25–30 years, the rusty-patched bumble bee is now on the brink of extinction after being one of the most common bumble bees in southern Ontario. If a species is not listed, it does not necessarily mean that they are not in trouble. Species may be considered at risk according to the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) but have not yet been listed under SARA which triggers protective measures on behalf of the government. Many other species may be threatened or endangered but we simply do not have enough information to assess their status. Funding for research and monitoring is urgently needed. In the meantime, we need to act with the precautionary principle in mind: wild pollinators are irreplaceable and once they are lost, they are lost forever.

Wild pollinators are essential to Canada's economy and food security, particularly in supporting the production of fruit, vegetable and seed crops.

Photo: Victoria MacPhail



Wild pollinator protection requires a vision.

Since the threats facing native pollinators are multiple and widespread, the effort to protect them needs to be coordinated across many sectors of society. Various pollinator plans have been adopted by Canadian municipalities and can provide examples of pollinator-friendly actions and ideas on how local governments, industries, and civil society collaborations can implement them. What is lacking is strong top-down leadership driving an agenda that includes pollinator-focused programmatic requirements for joint federal-provincial initiatives, increased and sustained resources dedicated to research and knowledge mobilization and regulation where appropriate.

A broad-scale reframing of pollinator conservation is needed to correct widespread misconceptions about wild pollinators and how to best support their populations. Public campaigns, media attention, resources and policies are almost exclusively geared toward issues facing managed, non-native honey bees, such as *Varroa* mites. This focus on the honey bee gives rise to misunderstandings. For example, research has shown that the majority of Canadians think that the honey bee is a species native to Canada.[1] While the honey bee is, much like other livestock, economically important in the agricultural sector, actions taken to 'save' them cannot be couched as biodiversity conservation. Broad-scale policies and resources directed towards honey bee management are not necessarily protective of wild pollinators and can, without discernment, actually harm them.[3] Conservation efforts must be crafted to support native biodiversity or specifically target the recovery of pollinator species at risk. The best of conservation initiatives can do both.

Photo: Victoria MacPhail

The roadmap to success

Adopt a national strategy.

The adoption of a national pollinator strategy is essential to orient stakeholders around a unified vision and a series of shared goals. A strategy should operationalize success by **setting targets** and **progress measures** for each objective that will support the fulfilment of goals related to minimizing the threat to wild pollinators as a result of pesticides, habitat loss and pathogens while increasing our knowledge and awareness. Many of the recommended objectives can be partially accomplished within existing frameworks and programming while others may require new approaches.

Guiding principles to underpin the development, adoption and implementation of a national strategy should include a commitment to the full **inclusion** of First Nations, Inuit and Métis peoples. This means developing respectful partnerships that centre their perspectives, unique knowledge, traditions and governance. Second, **sustainability** is paramount. Successful conservation outcomes depend on a strong commitment to the continuation of research funding and consistent programming in order to establish momentum and build on prior knowledge.

Solicit and co-develop regional pollinator plans.

Regional pollinator plans lay out how provinces and territories would work to support national goals. Indigneous people may choose to work in alliance to support national goals or create their own. In acknowledgement of Canada's diverse land use types, regional economies and norms for decentralized and self-governance, **standardized** yet **flexible** regional plans under the umbrella of a national strategy creates a system of **accountability** and should contain expectations on how progress should be reported up. No provincial pollinator plans currently exist; the 2016 Ontario Pollinator Health Strategy largely centred on honey bees and was cancelled without the public consultation required under Ontario law approximately two years after it was adopted.

Approve regional plans.

The federal government's role is to work closely with provincial bodies and others to shepherd the development, refinement and approval of pollinator plans. The federal strategy should adhere to an **evidence-based framework** that would also be adopted by regional plans. An approval process ensures that plans contain critical components and content. More specific conditions for approval can be stipulated within these categories. For example, meaningful consultation with Indigenous communities may be required within a framework component entitled "rightsholder inclusion." "Inventory of current initiatives" may specify that plan developers identify opportunities to integrate pollinator conservation into existing sector specific or other plans (e.g., agriculture, climate, sustainable development) to maximize the reach of conservation efforts and prevent the creation of parallel processes that waste resources. Federal funding to apply toward meeting regional plan commitments could be provided upon meeting predetermined plan conditions.

Adoption of a national pollinator strategy is essential to orient stakeholders around a unified vision and a series of shared goals.

Goals

1. Protect wild pollinators from pesticides

Pesticide use poses a widespread threat to pollinator health. More needs to be done to reduce the need for agrochemicals and to support growers while transitioning to more sustainable business models. Better systems are also needed to assess the safety of Canada-approved agrochemicals for wild pollinators and other wildlife.

2. Protect wild pollinators from disease

Pathogens such as viruses, fungi, bacteria and parasites can transfer from managed pollinators to wild populations. Canada must improve its efforts to monitor wild and managed pollinators for pathogens, reduce disease levels among managed stock and limit the exposure of wild pollinator communities to managed ones. Research on pathogens that affect wild pollinators needs to be prioritized to further understand how they impact individuals and populations, as well as how they are moving through the landscape.

3. Provide the resources that pollinators need to thrive

Wild pollinators have lost and continue to lose the quality habitat that they require to nest, overwinter and forage. We must adopt policies that stop habitat loss and create new habitat that considers the needs of wild pollinators in particular. We must also prevent habitat degradation in the form of habitat fragmentation and the spread of non-native species that may threaten the floral resources that pollinators depend on. Further research on the nesting and overwintering habitat for native bees needs to be prioritized so that more evidence-based recommendations can be implemented that are protective of the entire lifecycle of wild bees.

4. Build, share and apply our knowledge

We need a much clearer idea of how pollinators are doing and how their health and habitat are changing over time. We must collect evidence, establish baselines, measure progress and respond to new information. We recommend that Canada follow the example of many countries that have adopted an umbrella monitoring program that coordinates, funds and helps to develop monitoring initiatives within its borders. We also recommend that the government adopts a knowledge mobilization approach that prioritizes the establishment of consistent data standards, easy sharing of data, communicating best practices and knowledge co-creation with stakeholders, Indigenous rightsholders, scientists and others.

With immediate and sustained action, we can ensure that wild pollinators can continue to deliver the pollination services and other benefits that we rely upon for our health and well-being.

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Protecting pollinators in light of the climate crisis

Climate change is impacting pollinators in complex ways that scientists are just beginning to understand. Climate-induced threats include changes in precipitation patterns, like more frequent and intense rainfall events, that can interrupt foraging and mating and even kill pollinating beetles and ground nesting bees.[4] At the other extreme, drought can reduce the number of flowers available to foraging pollinators and result in less nutritious nectar and pollen.[5,6] Alternating wet and dry years linked to regional climate change has led to the extinction of two populations of Edith's checkerspot butterfly in California, a subspecies of which is listed as endangered in Canada.[7] Climate change is also altering the life cycles of pollinators and plants that have co-evolved and synchronized over thousands of years. Temporal mismatches between when plants are flowering and when pollinators are emerging, foraging or feeding can result in plants blooming and not receiving pollination or pollinators emerging and not having the proper pollen or nectar sources available to thrive.[8]

As the climate changes, pollinators (and plants) are disrupted in ways that are unique across taxa including poleward expansions, shrinking ranges as well as evidence of population declines and local extinctions.[9,10]

Climate change can amplify the effects of other stressors, such as pesticides and habitat loss, to pose unique threats to species or regional populations. For example, pollinators may have limited opportunities for range-shifts if they also encounter fragmented or homogenous landscapes that do not provide good habitat.[11,12] Pollinators expanding their ranges can introduce novel pathogens to native pollinator communities and the ways in which plant communities are shifting may create hubs where pathogens may spread more readily through the available floral resources.[13]

Pollinating species' persistence under a new climate regime is uncertain and will depend very much on their capacity for adaptation to changing environments.[14] Generally, evidence suggests that mobile species and those that are more flexible in what they eat and where they live will fare better in a warming world than sedentary and specialist species, ultimately leaving biological communities dominated by habitat generalists with reduced numbers of species overall.[15,16,17]

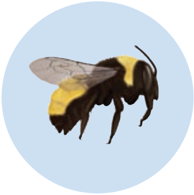
We strongly support immediate and radical action on reducing fossil fuel emissions and promoting climate change adaptation as a required step in protecting Canada's wild pollinators. Any national pollinator strategy must consider how the direct and indirect effects of a changing climate will be factored into decisions regarding monitoring, planning and conservation action. In turn, pollinator conservation can be tied to climate change mitigation and/or adaptation measures in Canada by providing carbon sequestration and green infrastructure through habitat expansion, for example.

We recommend sustained funding and other support for research that will deepen our understanding of how climate change will impact pollinators and answer the following questions:

- How can we manage and restore habitat (including habitat corridors) to build climate resilience in pollinator populations?
- How does climate change affect overwintering pollinator habitat?
- How does climate resilience (i.e., capacity to cope with a changing climate or other disturbances caused by climate change) vary between pollinator populations?
- What are pollinator species' limits to adaptation?
- How are the regular life cycle phases of interacting species changing relative to one another? (i.e., phenological mismatches)

Meet the native pollinators of Canada

There are thousands of species that are essential for the pollination of crops and other plants are found in Canada. The majority are insects such as bees, butterflies, moths, wasps, flies and beetles.



Of Canada's wild pollinators, bees are the most significant pollinators for the majority of plant species since bees spend most of their lives collecting nectar and protein-rich pollen to provide for their offspring (as compared to others who just eat these resources themselves on the flower). Of all the insects, bees are the most highly adapted for flower visitation and pollination.[18] Profound diversity can be found in the ecology of Canada's roughly 860 known native bee species, but some basic characteristics are shared among species. For example, all bees rear their young in nests. Females may create nests by burrowing a simple tunnel in the ground or into wood or by using pre-existing holes in wood or hollow plant stems. Bumble bees construct more elaborate nests out of beeswax within existing cavities in the ground, at the base of tall grasses or under thatched grass.

Almost all wild bee species are solitary. This means that mated female bees leave nectar and pollen in the nest to feed larvae but once they emerge, there is no intergenerational contact and little contact with other bees. Only bumble bees, large carpenter bees and some types of sweat bees are more social; they create colonies in which the queen (or dominant female) lays eggs and two or more females work together to provide for the brood. Male bees do not have any role in the life cycle aside from mating with females. Many wild bees overwinter in the ground, leaf litter, rotting wood or plant stems. Our native bees do not swarm like honey bees and rarely sting.

Flies often go unacknowledged for the role they play as pollinators and much more research is needed on them and their status. Examples of flies important for cash crops are hoverflies (i.e., flower flies, syrphid flies) and bee flies. Although they often sport colourings that mimic bees and wasps, they do not sting and can be distinguished by their one pair of wings (instead of two pairs like bees). Their flight style also differs as they are fast moving and can appear to be hovering in mid-air. As adults, they visit flowers to consume nectar and inadvertently collect and transfer pollen to other flowers. Flies can even provide services that bees do not. For example, hoverflies can provide long-distance pollen transfer and crop protection from pests such as aphids.[19]

Most Lepidoptera (i.e., butterflies and moths) feed on flower nectar as adults. Larvae do not rely on pollen but rather leaf tissue to survive. In general, butterflies are active during the day and moths are nocturnal. Lepidoptera do not have specialized parts on their body for carrying pollen as bees do, and although less efficient than bees, they do act as pollinators by incidentally moving pollen that brushes onto or sticks to their bodies as they forage.

SPOTLIGHT

Can honey bees replace wild pollinators in agriculture?

Honey bees are one of the most recognized and widely used pollinators worldwide but they are not native to Canada. They were brought from Europe to the Americas to pollinate crops and produce honey. Today, Canadian beekeepers and suppliers import honey bees from a short list of countries and regions including Chile, Australia and New Zealand. Although honey bees play an important role in Canada's agricultural sector, they cannot make up for a loss of wild pollinators. An overreliance on honey bees for pollination would not be desirable from an ecological standpoint nor an economic standpoint given that, in Canada, honey bees must be purchased or rented for a service that wild pollinators provide for free. It is also not wise to rely on a single species for all our crop pollination needs, as pest and disease outbreaks have been shown to drastically reduce populations of many species, including honey bees. Honey bees are often not as effective on a per bee basis, nor are honey bees the most efficient pollinators of many crops.[20] [21] For example, bumble bees perform buzz pollination in which the bee causes vibrations that dislodge pollen that would have otherwise remained trapped in the flower. Wild pollinators including bumble bees pollinate many of Canada's crops but this special function unique to bumble bees (and some solitary bee species) makes them indispensable pollinators for important crops such as tomatoes, peppers and cranberries that either require, or benefit from, buzz pollination to set fruit.

Originally brought from Europe to the Americas, honey bees cannot make up for a loss of wild pollinators.

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Goal 1: Protect wild pollinators from pesticides

Pesticides is an umbrella term used for herbicides, miticides, insecticides, and fungicides. These products contain active ingredients intended to target the pest and formulants (i.e., chemical additives to enhance or stabilize active ingredients). Pesticides are commonly used in Canadian agriculture and forestry sectors to protect crops from unwanted plants, invertebrates and fungi. Pesticides (in the form of herbicides) are also applied on public and private lands to control invasive or unwanted plant species and to maintain appearances of turfgrass for lawns, cemeteries and sports fields. Pesticides can be applied through a variety of methods including being sprayed directly onto plants, applied as a seed coating or injected directly into trees or soil. Unfortunately, pesticides can also harm or kill insects that benefit crops and ecosystems, including pollinators. Pesticides may also persist in soil and be transported by air or water to impact areas adjacent to where they are applied. These contaminated spaces may include waterways and areas where pollinators nest and forage.[22]

Given the growing body of scientific literature documenting negative impacts of insecticides on pollinators, we propose two **objectives** to mitigate impacts:

1. **improve risk assessments for pesticides on wild pollinator health; and**
2. **reduce the reliance of agricultural systems on pesticides.**

Improve risk assessments for pesticides on wild pollinator health

Improving the relative safety of pesticides requires reframing how we evaluate the risks that come with their use. Health Canada's Pest Management Regulatory Agency (PMRA) is responsible for performing risk assessments on pesticides prior to their authorization as well as periodically evaluating the impacts of approved pesticides to see if the risk of their continued use is acceptable. Evaluation of risk should consider the relationship between the toxicity (acute, chronic and sublethal) of the pesticide and the exposure.[23] For example, what are the pathways of exposure? What is the length and frequency of exposure? Interpreting risk also requires considering the broader context of uncertainty and the quality of available data. We suggest two main ways to better assess pesticide risk to reduce harm to insect pollinators: evaluate impacts on non-honey bee species and evaluate actual cumulative environmental exposures of pesticides.

First, we must routinely include insect species other than honey bees in risk assessments. For many reasons, honey bees have been the main insect species evaluated for pesticide risk. They are purchased and distributed across Canada for large-scale agricultural pollination. They have lent themselves easily to answering risk-related questions since they are convenient to use in the laboratory and in the field, easy to transport and are reared en masse in colonies. They have also been assumed to be adequate surrogates for other insect pollinators given their general sensitivity to acute toxicity from pesticides.[24 25] However, the life cycle and ecology of honey bees are vastly different from most of our native bee species, as are the pathways of exposure, since honey bees nest in managed nest boxes and not in the ground or in plant material.

Photo: iStock.com/Onfokus

Additionally, pesticide impacts and exposure vary among non-honey bee species. They depend on factors such as foraging time and behaviour, nesting biology, diet throughout the bee's life cycle and degree of sociality, among others.[24] Sometimes a lack of knowledge about a wild pollinator's biology and behaviour makes it difficult to truly understand the risk for how that species might be impacted. It also limits the ability to know whether extrapolating risk from honey bees is appropriate. For example, the majority of bee species nest in soil or use plant material for their nests. Both of these exposure routes are not well understood and are not yet routinely included in risk assessments. There has been recent progress in estimating pesticide toxicity and exposures on several types of non-honey bees that may serve as representatives for those that are more difficult to study, but more work is needed and evidence from field studies must inform assessments whenever possible.[26 27]

Second, we must ensure that our risk assessments reflect the combinations and amounts of pesticides that wild pollinators are realistically likely to encounter over time. Assessments should routinely consider pesticide cocktails as well as interactions between pesticides and other chemical formulations approved to be mixed with them in order to improve the usability of the pesticide product (i.e., adjuvants). To the extent possible, risk assessments and decision makers must also consider the growing literature on the additive and cumulative effects of agrochemicals and other stressors. For example, recent connections have been made between fungicide exposure, disease prevalence and bumble bee declines.[28]

The PMRA is working with scientists and international partners to increase our understanding of pesticide exposure to non-honey bees, but more transparency is required on how the PMRA gathers and incorporates current research into protocols and decisions. To promote transparency and evidence-based policy, an interactive platform for scientists performing independent research to share and discuss the results of their work directly with the PMRA is needed. A PMRA communication strategy that periodically and clearly details how PMRA is considering new evidence to improve assessments on pesticides being reviewed or pending approval would also be useful.

A comprehensive approach to better and more accurate risk assessments is two-pronged: improving protocols to include more non-honey bee species and prioritizing the incorporation of research that supports those protocols. When there are uncertainties about the impact of pesticides and other agrochemicals, the precautionary principle must be applied since the stakes can be high. For example, while colony-forming bees like honey bees may be able to compensate for the loss of worker bees to some degree, the death of a queen or nesting female solitary bee results in nest, and therefore reproductive, failure.[24]

Photo: Victoria MacPhail

Recent connections have been made between fungicide exposure, disease prevalence and bumble bee declines.

Reduce the reliance of agricultural systems on pesticides

Diverse approaches to growing crops can reduce the need for pesticides to control unwanted weeds, insects, fungi or other pests, such as through a combination of biological, physical, cultural, mechanical and/or behavioural pest control methods. The most mainstream approaches are Integrated Pest Management (IPM) and organic farming. Ideally, both of these land management approaches consider pesticides as a last resort, with clearly established economic thresholds for application, although IPM has faced considerable criticism that it has strayed in concept and practice from the ecological roots upon which it was founded decades ago.[29] For the agricultural industry, the biggest user of pesticides in Canada, benefits to adhering to IPM principles and organic farming can include reduced costs for chemical inputs and a healthier environment, without a reduction in profit or yield.[30]

Both the federal and provincial governments have roles to play in investing in and promoting diverse farming practices like organic farming or IPM. Past decisions have steered us to a place where pesticide use is the status quo, even for prophylactic uses. Canadians need stronger leadership, better coordination between federal and provincial bodies and sustained, targeted financial support in order to move towards more environmentally-friendly ag-systems.

Firstly, a National Agro-Environment Program that is firmly rooted in ecological principles should be established. Using the European Union Sustainable Use Directive and the mandated member state National Action Plans as a model framework, provinces and territories should design plans that include the means to reach quantifiable pesticide reduction targets that are determined at the federal level. Existing policy and programmatic federal-provincial scaffolding can be leveraged (e.g., Canadian Agricultural Partnership, Pesticide Management Centre) but they must be better coordinated and aligned in a joint and earnest commitment to biodiversity and soil health as basic tenets. Other than setting targets, the federal government would ensure standardization between plans, support the monitoring of pesticide use and coordination of information exchange between provinces.

Secondly, federal initiatives are needed to facilitate access to markets (e.g., untreated seeds for growers) or develop new ones. For example, larger companies do not reliably make untreated corn seed available to downstream distributors, may have a limited supply of untreated seed or may require that growers order seeds months in advance. Lastly, adequate and sustained financial resources to help achieve pesticide reductions is fundamental. A successful and cost-effective combination of agroecological practices can vary region to region, even farm to farm, so tailored extension services (i.e., government-to-grower education on how to apply new scientific research and knowledge to agricultural practices) must be supported. Financial support is also needed for growers wishing to reduce or eliminate pesticide use. A learning curve is inherent to any business model transition and the first few years are particularly risky, especially for aspiring organic growers. Government assistance in managing risk can go a long way in eliminating one of the largest barriers for growers wanting to enter into the organic industry or other sustainable growing approaches. Canada must find the political will to definitively redress market failures due to negative environmental externalities and signal support for more sustainable agricultural models.

SPOTLIGHT

The cautionary tale of neonicotinoid pesticides ("neonics")

The use of neonics (e.g., imidacloprid, thiamethoxam, clothianidin) on Canadian crops, especially corn, soybeans and canola has become widespread over the last decades. Their popularity continues to grow due to their ease of use, persistence in the target system and lower human toxicity than other insecticides. Neonics are water soluble, highly mobile and persist (often for multiple years) in the soil. Since they are systemic, the pesticides move throughout the tissues of plants and can be found in flower nectar and pollen of crops, in addition to those of adjacent plants that may be foraged on by pollinators. However, neonics have been extensively researched over the last two decades and now both acute and sublethal negative impacts on many pollinators and other non-target organisms are well documented. In 2019 and 2021, Health Canada halted or modified some uses of neonics. But some applications, including seed treatments, continue despite their known negative impacts. The quick adoption and proliferation of neonics in conventional farming can teach us some valuable lessons. Going forward, it is essential that PMRA's evaluative process is conducted with the highest degree of scientific integrity. This requires the seeking out and consideration of independently-produced research when making decisions. The same level of research intensity that has been directed to neonics also must be applied to other systemic compounds that are replacing neonics to ensure these chemicals pose less of a risk to pollinators.

The use of neonics on Canadian crops, especially corn, soybeans and canola is widespread. In 2021, Health Canada halted some uses of neonics, but some applications continue despite their known negative impacts on many pollinators.

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Goal 1. Protect wild pollinators from pesticides

Objective	Action	Knowledge gaps & supporting research
1A. Improve risk assessments for pesticides on wild pollinator health	• Further develop and routinely incorporate risk assessments for multiple insect species within a regulatory framework • Create a system for research dissemination from researchers to the PMRA • PMRA to provide an updated synthesis on PMRA's work to finalize methods for non-honey bee exposure estimates • PMRA to update the Pollinator Risk Assessment Guidance in concordance with current and evolving research • Clearly communicate changes to the Pollinator Risk Assessment Guidance and the reasons for these changes to the public • Change submission, review and assessment procedures under the *Pest Control Products Act* (PCPA) to improve the quality of industry submissions regarding impacts on pollinator health	Determine: • oral & contact pesticide exposure (e.g., soil, leaf matter, nest site selection and materials, flowers) from larval to adult stages • LD50 & toxicity values for ground & stem nesting dwelling pollinators • how to translate sublethal effects of pesticides seen in laboratory experiments into landscape-level effects on bee populations and communities • exposure and associated impacts of interactions between pesticides, adjuvants and tank mixes • relationship between pesticide exposure and susceptibility of pollinators to pathogens
1B. Reduce the reliance of agricultural systems on pesticides	• Invest in extension programs (including personnel) that provide growers and land managers support on technology transfer, best management practices and available environmental stewardship programs • Increase cost-share opportunities for agri-environment schemes that focus on pesticide reduction • Develop a National Agro-Environment Program with a clearly defined approach and concrete targets to reduce pesticide use • Provide transition advisory services (i.e., insurance, financial support and training to reduce risk in business model transitions to more sustainable practices) • Increase market access to untreated seeds (e.g., require a certain percentage of untreated seeds be made available under the *Seeds Act*)	• Determine agroecological farming practices to maintain production while reducing pesticide usage • Improve economic threshold models as a basis for accessing certain pesticides • Invest in research to find alternatives to pesticides for pest control

Goal 2: Protect wild pollinators from parasites and disease

Pathogens such as bacteria, protozoa, mites, viruses and fungi can cause pollinators to get sick and in some cases can be lethal. Human management can increase the amount of background and novel pathogens found in bees captively bred for agricultural pollination services. These pathogens can then spillover from infected managed pollinators to wild ones. There is evidence that pathogens can spread from managed bumble bees or honey bees to wild bumble bees.[31 32] Honey bees have also been shown to pass pathogens to solitary bees and hoverflies.[33 34] There is no documentation of captive monarchs passing pathogens to wild monarchs but the transmission potential is possible.[35] Pathogen amplification and spread can have severe consequences for wild populations, especially those encountering novel pathogens non-native to the region or those that may already have compromised immunity due to other stressors, such as a lack of nutrition. For example, it is hypothesized that captive-reared bumble bees spread a fungus to wild North American bumble bees that is linked to catastrophic declines in four native bumble bee species in the wild.[36] Pathogens can also spillback from wild populations into managed populations, making them reservoirs and vectors for further transmission to wild bees.[37]

We still have much to learn about how pathogens and diseases move between populations and across species and what sublethal and lethal impacts they may have. However, we do know that regulatory and other policies related to the management of commercial pollinators are not keeping up with the current scientific evidence regarding the level of threat that pathogen spillover may pose to pollinator biodiversity. We also know that there are simple steps that can be taken to curb this threat.

To help protect Canada's pollinators from pathogens, we must aim to meet two **objectives**:

1. **reduce pathogens in managed pollinator populations; and**
2. **limit the spillover and spillback of pathogens transmitted between managed and wild pollinators.**

This section focuses mostly on bees given the ubiquitousness and sheer volume of managed bees moved across Canadian provinces for pollination services and honey production.

We must reduce pathogens in managed populations and limit the spillover and spillback between managed and wild pollinators like those above.

Photo: Victoria MacPhail

Reduce pathogens in managed pollinator populations

The Canadian Food Inspection Agency (CFIA) is responsible for reducing the likelihood that honey bee diseases are brought into Canada. The CFIA issues permits to groups or companies that wish to obtain honey bees from approved international sources. During importation, pathogens, especially viruses, can be missed either because of inadequate screening techniques or because they are not screened for at all if they are not listed as viruses that strongly compromise honey bee health and commercial beekeeping. Sometimes, pathogens can be missed on visual inspection because they have not yet caused apparent disease. Pathogens can then be amplified as bees travel long distances under stressful conditions and are moved from field to field, province to province, to provide pollination services.

Monarchs and commercial bees other than honey bees (i.e., bumble bees and solitary bees) are either reared within Canada or imported (sometimes directly to an end-user through the mail) without any required screening. Voluntary biosecurity standards exist for the most commonly used managed bees and serve as guidance for producers and end users, but it is ultimately up to the issuing company to ensure that their pollinators are not diseased. Likewise, it is up to the consumer to: make sure that bees are managed well; seek advice about and/or report sick bees; obtain permits from the relevant provincial bodies if bees are to travel (if applicable); and ensure they are disposed of properly. In the case of the commercial bumble bee industry, there is low level of transparency regarding where bees are being shipped and what kind of screening they underwent prior to leaving the facilities.

Canada can reduce the risk of introducing novel pathogens and pests to wild bees by more rigorously testing and screening all managed bees. Testing should be done before importing or before leaving the facilities if they are produced in Canada. The *Bombus* task force for the North American Pollinator Partnership Campaign has laid a clear foundation for the development of a clean stock certification program for commercial bumble bees which recommends protocols for screening and testing.[38] The Sheila R. Colla Native Pollinator Research Lab has submitted commissioned work to Environment and Climate Change Canada that situates a clean stock program for bumble bees within the Canadian policy landscape.[39] Similar programs can be adopted for other managed bees including leafcutter bees and mason bees.

Until policies are in place to drastically reduce or eliminate the risk of introducing disease-causing microorganisms, importations and the domestic commercial rearing of bees should be undertaken with an abundance of caution.

Limit the pathogen spillover and spillback between managed and wild pollinators

Improving screening techniques and setting stringent requirements for testing stock at production facilities is essential. However, some pathogens are difficult to test for or the necessary routine molecular screening may be cost-prohibitive in certain cases. It is also difficult to completely avoid disease in situations where animals are reared in very large numbers, such as is the case with managed bees. Since bees spread diseases and parasites via direct contact with other insects or by depositing them on shared flowers, a second line of defence against spreading illnesses includes measures that minimize the contact that managed pollinators have with wild pollinators and the foraging resources that they use.

Preventing contact is especially important in areas where a managed pollinator is not native to the region in which they are being used. Introduced pollinators can compete with and cause stress to native species, making them more susceptible to diseases already circulating in the population or those passed through the managed pollinator.[40] For example, the common Eastern bumble bee is found frequently in the wild throughout Eastern Canada, but is also used to pollinate greenhouse and field crops in the Prairies and in British Columbia where it is not native. Escaped or improperly disposed of common Eastern bumble bees have now established non-native populations in the wild in these regions, which poses a great risk to surrounding native bee and plant communities.[41]

There are technological solutions to prevent bumble bee escapes from greenhouses and during transport, as well as to keep reproductive bees from escaping in field settings, but they are not commonly used. Recommendations on the proper use and disposal of colonies have been published yet these steps are considered to be best practices and are not required or enforced.

Situating managed bees away (i.e., outside their average flight distance) from important areas where wild bees forage and nest is an important step in reducing potential contact and the risk of disease spread. Areas that should be physically buffered from managed bees include protected areas, high-quality remnant habitats and areas where at-risk insect species occur. Ensuring a buffer also lends the added benefit of protecting native ecosystems since managed bees, most notably honey bees, can compete with wild bees and change the entire composition of vegetation to favour non-native plant species.[42 43] The ability to more cautiously site managed bees goes hand in hand with acquiring better knowledge about where managed bees are currently being used. As of now, there is limited or no tracking on managed bees so there is often no chain of accountability or way to trace their physical path to study the impact of any outbreaks.

There are multiple mechanisms that can be used to minimize pathogen spillover and spillback. Provinces regulate bee keeping (almost exclusively honey bees) under bee-specific or general animal health legislation. These could be amended or expanded to routinely include regulations on greenhouse practices as well as introducing or strengthening siting restrictions, disease reporting, transporting and record-keeping for all managed bees. Outside of regulation, cost-shares could be provided under the federal-provincial Canadian Agricultural Partnership for implementing measures in greenhouses to reduce bumble bee escapes or support the creation of natural pollinator reservoirs (i.e., forage habitat), an approach that has been shown to provide sufficient pollination and supplant the need for purchased bumble bees in some agrosystems.[44 45] Clean stock programs that track production and sales would allow for contact tracing and containment in the event of a disease outbreak.[38]

Photo: iStock.com/Daniel Prudek

Managed pollinators in Canada

Common and latin name	Native to Canada	Commercial use
 **European or western honey bee** *Apis mellifera*	No	Field-crop pollination; wax, pollen, and honey production Canada-wide
 **Alfalfa leafcutting bee** *Megachile rotundata*	No	Alfalfa and canola crop pollination in Canada's prairie provinces and lowbush blueberry in the Maritimes
 **Common eastern bumble bee** *Bombus impatiens*	Yes: Canada east of Manitoba	Pollination of greenhouse crops and, to a lesser extent, field crops
 **Blue orchard mason bee** *Osmia lignaria*	Yes: Genetically distinct populations in Canada's far eastern and western regions	Orchard crop pollination
 **Monarch butterfly** *Danaus plexippus*	Yes: Southern Canada (summer breeding habitat predominantly in Ontario and Quebec)	Reared and sold for release at events, weddings, etc.

First photo: iStock.com/Marco Photos. Second photo: Wikipedia/Pollinator. Third and fifth photos: Victoria MacPhail. Fourth photo: Wikipedia/Jim Rivers, OSU College of Forestry.

Goal 2. Protect wild pollinators from parasites and disease

Objective	Action	Knowledge gaps & supporting research
2A. Reduce pathogens in managed pollinator populations	• Establish clean stock program that tracks Third party-certified pathogen-free bumble bees • Require independent lab pathogen testing at commercially managed bee production centres • Ensure commercial breeders of monarchs follow protocols aimed at disease prevention	• Improve or develop pathogen screening techniques for all managed bees • Determine the role of nutrition and gut microbiota in immunity • Develop methods for treating disease in managed pollinators other than honey bees
2B. Limit the spillover and spillback of pathogens between managed and wild pollinators	• Regulate the proximity of managed bees to protected lands and species at risk* • Track managed bee movements • Require queen excluders on managed bumble bee colonies • Regulate the disposal of all commercial bee colonies	Determine: • natural levels of pathogen transmission and background disease in wild pollinators • virulence of disease-causing microorganisms and viruses and impacts on wild pollinator populations • role of floral resources in mitigating or contributing to pathogen spread

*See also Goal 3, Objective 3B

Goal 3: Provide resources that wild pollinators need to thrive

Pollinators need access to floral resources and undisturbed places to gather materials, build nests and overwinter. Unfortunately, pollinators are losing habitat at an alarming rate as we transform and fragment our natural spaces in order to create farms, cities, subdivisions, strip malls and supporting infrastructure such as parking lots and highways. For many populations of pollinators, especially specialists that rely on a particular type of habitat or plant, habitat loss is a major threat. For example, the endangered monarch butterfly and the extirpated Karner blue butterfly have specific habitat requirements (milkweed and lupine in oak savannah, respectively) at certain stages of their life cycle. Specialist bees are also considered to be at relatively high risk of endangerment due in part to habitat degradation or loss.[46] Humans and thriving pollinator communities can co-exist, but we must thoughtfully protect, develop and rehabilitate our landscapes in ways that integrate the needs of wild pollinators as well as our own.

We need urgent research on the ecology and biology of wild pollinators that will inform the creation and management of habitats where all pollinators can thrive. We must also support studies that evaluate created or restored habitat to learn how landscape interventions affect pollinator populations, with a focus on those with any degree of habitat specialization. We don't want to run the risk of losing our specialist bees and butterflies while just making generalist animals more common. This research will help refine our efforts by answering crucial questions related to how much habitat is needed, the best type of habitat for a given situation and where we should focus our efforts for conservation and restoration.

Supporting wild pollinators will depend largely on leveraging partnerships that already exist among governments, land trusts, conservation organizations, Indigenous groups, industry, community and landowner groups, as well as forging new relationships. The federal government's task is to facilitate these connections, provide grants to support their work, mobilize and amplify the knowledge that is generated and develop a system that counts achievements in habitat generation or protection toward the fulfilment of measurable targets.

Photo: iStock.com/Gary Kavanagh

Habitat loss is a major threat for pollinators that rely on a particular type of habitat or plant.

We propose two main **objectives** to ensure that we are providing the resources that allow pollinator communities in Canada to thrive:

1. **create and protect high quality wild pollinator habitat; and**
2. **support the ecological integrity of pollinator habitat.**

The first objective includes suggested mechanisms that encourage habitat creation and/or protection. The second objective supports these efforts by increasing the availability and access to native plants and seeds upstream and reducing the presence of invasive and/or non-native species.

Create and protect high quality wild pollinator habitat

To combat habitat loss, we must simultaneously take action to preserve what we have while creating more high quality habitat for wild pollinators. We can create habitat through increasing the number and size of Canada's national and provincial parks and wildlife areas, migratory bird sanctuaries, marine protected areas, Indigenous Protected and Conserved Areas (IPCAs) and Other Effective Area-based Conservation Measures (OECMs) to ensure that large swaths of habitat are safeguarded from human encroachment or carefully managed in tandem with community use.

In regard to human-altered landscapes (e.g., semi-natural, urban, agricultural, forestry sites), linking habitat fragments through corridors can connect habitats and create larger networks that are fundamental to supporting diverse and abundant pollinator communities.[47 48 49] Networks can reduce the distance that pollinators must travel to access resources and mates compared with disjunct habitat patches. They are also more likely to support specialist species that are less able than generalists to thrive in areas where the native plant-pollinator relationships are disturbed by fragmentation.[50] Networks also support the mobility of pollinators and other species in the face of future threats, such as climate change. Rights of way (i.e., linear tracts for infrastructure like utilities and transport) are examples of spaces that have been successfully managed to link habitats and serve as corridors for pollinators.

Expanding pollinator habitat in natural and semi-natural environments is crucial, however many wild pollinators can also do well in cities.[51 52] The effects of urbanization on pollinators are complex but research has shown that urban landscapes are compatible with multiple taxa including solitary bees and bumble bees.[53 54] Efforts to provide (and attend to ongoing management of) more floral resources, nesting and overwintering habitat in urban spaces such as community and residential gardens, urban forests, parks and cemeteries can all support pollinator diversity or serve as pollinator hotspots.[55] Targeting federal grants (e.g., Environment and Climate Change Canada's EcoAction Community Funding Program) to less affluent areas can help build capacity and lessen inequalities regarding the distribution of pollinators and the free ecosystem services they provide throughout the urban landscape.[52]

Expanding pollinator habitat in natural and semi-natural environments is crucial, however many wild pollinators can also do well in cities.

Photo: iStock.com/Debra Lee Wiseberg

Support the ecological integrity of pollinator habitat

All habitat creation and restoration efforts are welcome if carefully planned with native pollinators in mind. If project resources are limited or if an area is particularly large or depleted, an appropriate native plant seed mix applied to a prepared site can provide much needed forage. On smaller sites, or where resources allow, the use of plugs (i.e., seedlings rooted in soil) or older plants can quickly create habitat or fill in gaps. More focused efforts consider as many aspects of an intervention as possible to make sure they will best contribute to project goals. For example, pollen and nectar sources for pollinators are important but so are access to nesting materials, nesting and overwintering sites, larval host plants or other food sources and other resources. The right plant species must be selected that will suit the site conditions and desired habitat. The deliberate placement of future habitat can offer economic benefits; for example, natural or semi-natural habitat in proximity to agricultural lands can increase the yield for many crops in addition to increasing functional diversity.[56 57]

Invasive species (i.e., non-native species that have the ability to rapidly spread and dominate landscapes) can also drastically alter the composition of an ecosystem and the plant-pollinator relationships therein. Restoring habitat using a revegetation plan focused on native plant species can have swift and profound positive impacts on native pollinator populations including specialist communities.[58 59 60] More resources need to be directed toward research into the best species for habitat creation or restoration projects in different ecosystems, related propagation techniques, and the marketing and distribution of native plants to ensure that appropriate seeds, plugs, or older plants are readily available for generating or restoring habitat.

In certain cases, the presence or proximity of any managed pollinators that are not native to the area should also be reconsidered. Not only can they introduce pathogens to neighbouring wild populations (see **Goal 2**), they can favour exotic plants for forage, which in turn further spreads those species at the expense of native plants. Managed bees can also outcompete wild bees for floral resources and nesting sites.[61 62 63] Honey bees in particular can dominate a landscape; it has been estimated that a 40-hive apiary placed on natural habitats for three months can collect the equivalent amount of pollen to provision four million wild solitary bees.[64] Honey bee dominance has been shown to negatively impact wild bees in both urban settings and agricultural ones.[65 66]

Restoring habitat using a revegetation plan focused on native plant species can have swift and profound positive impacts on native pollinator populations.

Photo: iStock.com/Debra Lee Wiseberg

Goal 3. Provide the resources that wild pollinators need to thrive

Objective	Action	Knowledge gaps & supporting research
3A. Create and protect high quality wild pollinator habitat	• Create habitat with native plants along corridors (roads, train tracks, hydro lines) • Support initiatives that focus on connecting habitat and/or pollinator hotspots • Financial support for habitat creation/ restoration projects in less affluent areas to help build capacity • Incentivize set asides with the goal of maintaining non-cropped areas on farmland • Create or improve habitat at large industrial sites, such as landfills, aggregate operations and brownfield areas	Determine: • which pollinators should be prioritized and provided for • what type of habitat is needed (e.g., overwintering requirements, specific floral resources) for the prioritized pollinators • how much habitat is needed to support desired population levels • how to galvanize and coordinate people to create pollinator habitat through branding, campaigns, promoting partnerships, outreach, etc. • how landscape interventions, land uses and land alterations affect pollinator communities from local to landscape scales • the relationship between the presence of semi-natural habitat and crop yield in agricultural settings
3B. Support the ecological integrity of pollinator habitat	• Subsidize development of native seed stock • Support native plant producers and nurseries (e.g., U.S. National Strategy for Rehabilitation and Restoration by the Plant Conservation Alliance) • Eliminate invasive plants in seed mixes marketed as pollinator mixes • Regulate the proximity of managed bees to protected lands and species at risk	Determine: • how to design seed mixes that best suit a variety of habitat creation requirements • the competitive impact of non-native or managed pollinators on native pollinators (e.g., population biology, health) and scale at which these impacts occur • the benefits of native plants as well as any value of non-native/invasive plants to wild bee populations • the impacts of non-native pollinators on plant-pollinator visitation and pollination networks

Goal 4: Build, share and apply our knowledge about wild pollinators

In order to make the best decisions for wild pollinator biodiversity, we need to understand their needs. As a basic precursor to this, we need to know where wild pollinators and their required habitats are currently found. This is straightforward information but as native bee experts have observed, we lack this critical data for the majority of bees and pollinator conservation is struggling to advance without it.[67] This lack of basic knowledge applies to most of Canada's wild pollinators.

Evidence-based conservation is supported by developing straightforward, inclusive and accessible ways in which stakeholders and rightsholders can continually fill knowledge gaps together. The translation of scientific knowledge into conservation actions requires multiple approaches that the government can help facilitate. One approach involves filling a gap by creating materials that provide people with a basic education on wild pollinators and ways they can contribute to pollinator protection and habitat expansion. Another approach is to foster an organic sense of agency and ownership in pollinator conservation initiatives through supporting the co-creation of knowledge from different cultural perspectives on what it means to support pollinator health in peoples' own communities.

To deepen our understanding about pollinators and transfer this knowledge into sustained conservation actions on the ground we propose two **objectives**:

1. **improve monitoring efforts; and**
2. **invest in knowledge mobilization.**

Improve monitoring efforts

Monitoring is a basic tool for species conservation.[68] Through monitoring we establish baselines that enable us to track changes to pollinator populations, their disease levels and their habitat over time. It helps to set thresholds for concern that can signal that species are under duress and require protection. Monitoring efforts can inform policy creation (e.g., protecting identified biodiversity hotspots), evaluate the impacts of changes in the environment (e.g. a new road created), detect new zoonotic outbreaks (e.g. pathogen spillover from managed bees) or measure the effectiveness of a new policy or action (e.g., building a pollinator-friendly right-of-way) so we can engage in adaptive management. Monitoring is the bedrock upon which decisions about conservation must be built. It is how we determine the ecological requirements for specific or diverse pollinator groups and how we can provide resources across Canada's diverse ecozones or socio-ecological systems. Predictive models using monitoring data can provide a window into the future, and a chance to respond to estimated trends in population and habitat distribution.[67]

Despite the importance of monitoring, there is no government program in Canada charged with the routine, widespread monitoring of wild pollinator populations and few studies exist that repeat sampling at the same locations using the same method.[69] Monitoring is predominantly undertaken by non-governmental organizations, research institutions or large researcher networks that frequently have species or location specific project goals and do not necessarily create or share standardized data in any one place. These efforts may use different sampling methods from one another and do not systematically repeat their efforts, making compiling or comparing data very difficult if not impossible.

We recommend the development of a national-scale monitoring program that is targeted, well-coordinated and sustained. The objective would be to detect trends at different geographic scales with coordinated, comprehensive data sets conducive to rigorous statistical analyses.[70] An ideal nationally-spearheaded program would be collaborative and designed to move between a more centralized approach to a dispersed one made up of decentralized stakeholder networks to leverage the distinct advantages of both approaches.[70 71]

The government could collect or support the collection of the same information from the same sites annually (e.g., pollinator-dependent crop systems important to the national economy, national parks, habitat of protected species, natural disease levels). These data should be placed in an open repository and also be integrated with data routinely being collected through other government monitoring initiatives (e.g. land use change, pollution, climate, forest fires).[72] In general, we have sufficient knowledge about the drivers of pollinator decline to formulate hypotheses and test solutions. Judiciously chosen, representative sites will be the key for making quick progress on conservation goals while keeping costs in check for federally-managed programs.[73]

Dispersed monitoring activities and the many other native pollinator monitoring efforts already underway have great potential to bolster and complement centrally-managed efforts. For example, community science monitoring initiatives can be a powerful, cost-effective tool for advancing scientific knowledge while raising volunteers' appreciation of the environment (see spotlight). A major challenge is to harness the power of the large amount of data that is being generated from independent monitoring activities. While it's not possible, or even desirable, to integrate all data from all researchers, naturalists, farmers or NGOs, the government can provide easily transferable, open-access protocols to support the collecting of data that is standardized, scalable and conducive to meeting shared goals, as well as create and manage a centralized database for the collected data.[70 71]

Since a patchwork pattern of data sharing norms and collaboration already exists between stakeholders, the government can also help to connect these clusters of actors to others and adopt norms that make data integration easier, and in turn, more useful. These norms would dictate file formatting, persistent identifiers to make data more widely discoverable and the adoption of an Application Programming Interface (API) to make sure databases are compatible with common statistical programs.[71]

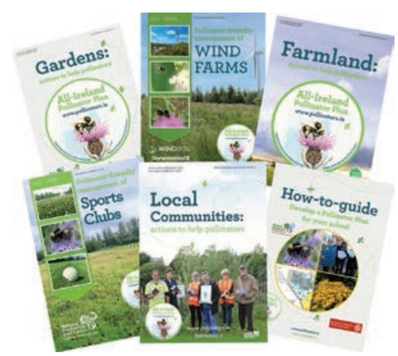
The government can also play a role in coordinating efforts between groups that are doing different tasks or collecting different data from the same areas. This might include combined surveys of birds and pollinators or biodiversity surveys combined with water sample collection on site (i.e., to detect local pesticide levels). We recommend a task force be established to perform a needs assessment and outline priorities for a comprehensive national pollinator monitoring program in close consultation with stakeholders.

Invest in knowledge mobilization

Government consideration of how knowledge from monitoring initiatives and other research is generated and communicated will help reach the broadest audience possible and ensure that information that supports pollinator conservation is useful to key groups.

Any government grants allocated to pollinator projects in high priority areas from a conservation perspective should be oriented around knowledge co-production as a prerequisite for funding. Co-production brings together stakeholders with diverse expertise, or from different sectors of society, into respectful partnerships with scientists to develop knowledge and engage with its application to real world challenges. [74] Valuing reciprocal and complementary learning between knowledge producers and users can enrich the base of knowledge that informs conservation actions. The sense of stewardship that can result from this process and the care devoted to building legitimacy for action may help bridge the frequently observed knowledge-action gap and lead to better conservation outcomes.[74 75 76] Part of this work entails reimagining and expanding the stakeholder circle to bridge silos between academic disciplines, work across sectors and to find community groups and organizations where pollinator conservation complements existing work. Those working on issues related to farming, forestry, food sovereignty and food security can enrich the conversation on pollinator decline and have the potential to reframe the problem and offer novel solutions.

The government needs to provide clear, simple guidelines about how actors in both public and private sectors can be part of the solution when it comes to supporting wild pollinators. Tailored, branded guidelines based in evidence-based practices would present a suite of options to schools, municipalities, healthcare facilities, farmers, land managers, gardeners and any business, whether it has access to outdoor space or not. Research has shown that for land managers, the mere service of distilling the latest relevant science can help reduce barriers they face incorporating evidence-based decision-making into their planning.[77] Clearly communicating the value of becoming involved in a national pollinator plan is key. Motivators to act can include increased market share, public or peer recognition or a tangible display of contribution to a cause. For example, in Ireland, a business can become an All-Ireland Pollinator Plan (AIPP) supporting partner by taking on actions provided in government-issued guidelines. The business may log its actions on a publicly available interactive map, have its logo displayed as a supporter on AIPP materials, and in turn display the AIPP logo as a way to communicate organizational values to their customer base. The Irish government maintains a website to educate partners with up-to-date resources such as flyers, webinars, case studies and animations as well as an acknowledgement of towns that have gone pesticide free.



Community guides distributed by the National Biodiversity Data Centre in Ireland

The government needs to provide clear, simple guidelines about how both the public and private sectors can help support wild pollinators.

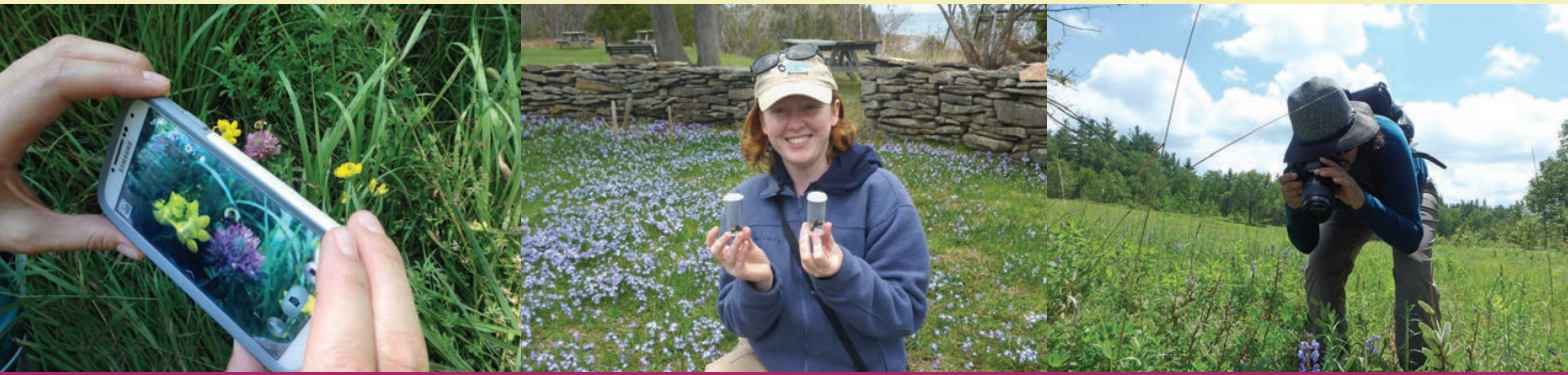
SPOTLIGHT

Community Science: Harnessing the power of the masses

Community science (also known as citizen science), put simply, engages the public in the process of scientific discovery. Overseen by professional scientists, community science initiatives enlist volunteers to gather data about biodiversity (or other topics) across broad areas or specific communities. Many national pollinator plans or regional monitoring programs include community science initiatives as a core component. For example, the U.K.'s monitoring approach solicits volunteers to count insects that visit certain flowers within a land patch of the volunteer's choosing. To help maximize the efficiency of community science projects and ensure high quality data, challenges in data processing need to be resolved. For instance, bottlenecks can result when there are too few taxonomic experts available to identify participant submitted photos or insect specimens.[78] Canada should follow England's lead and fund new positions in taxonomy and areas of taxonomic research such as new methods of rapid species identification (e.g., eDNA, DNA barcoding, machine learning for photographic identification). Current taxonomic expertise can be stretched by supporting monitoring efforts that are purposeful, targeted and that budget for identification. In the case of bees, studies involving diversity and abundance surveys have exploded in popularity and a lack of planning has resulted in the collection of vast numbers of bees and other insects ("bycatch"), some of which are never processed and may even be disposed of without any data being recorded.[70]

Many national pollinator plans or regional monitoring programs include community science (aka as citizen science) initiatives as a core component.

Photo: Victoria MacPhail



Goal 4. Build, share and apply our knowledge about wild pollinators

Objective	Action	Knowledge gaps & supporting research
4A. Improve monitoring efforts	• Determine priority areas, taxa and optimal methods for monitoring them • Create open access repository for cataloguing past, current and future data • Define the scope, objectives and cost of national-scale monitoring program • Increase species identification capacity by funding and training taxonomists	• Further develop rapid identification methods and how to best implement them in monitoring efforts • Digitize historical records • Perform needs assessment for process of standardizing current monitoring protocols
4B. Invest in knowledge mobilization	• Create tailored, branded guidelines for pollinator conservation for public and private sector actors • Cultivate possibilities for Indigenous research to thrive within existing knowledge production infrastructure • Support conferences and workshops for knowledge exchange among academics, stakeholders, rightsholders and other community groups • Require inclusion of knowledge co-creation and mobilization for project funding or government initiatives	• Prioritize research that can demonstrate the value of wild pollinators in monetary and sociocultural terms • Perform needs assessment for connecting data sharing structures and peer-to-peer networks

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