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THE WISCONSIN POLLINATOR PROTECTION PLAN

In Wisconsin, pollinator-dependent crops account for over $55 million in annual production.

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EXECUTIVE SUMMARY

In 2014, amid concerns about pollinator declines, honey bee health issues and the future of honey and crop production, the State of Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP) initiated a project to develop a statewide pollinator protection plan. DATCP partnered with researchers at the University of Wisconsin, Madison to gather scientific research and information from a diverse array of stakeholders to guide plan development. Goals of the plan include:

1. Improving public understanding of pollinator health issues and actions that affect pollinators.
2. Minimizing risks to pollinators through voluntary actions that Wisconsin residents, businesses and agencies can take.

Because many pollinator issues affect a diversity of species, the plan focuses on both managed bees and wild pollinators found in Wisconsin. The plan has a statewide scope and applies to many contexts, rural and urban, agricultural and non-agricultural.

This plan is separated into two sections. Section I serves as a broad introduction to pollinator issues and summarizes scientific research on these issues. Section II lays out management practices that address four goals for minimizing risks to pollinators:

- Expand the quality and quantity of habitat for managed and wild pollinators
- Minimize stressors on managed and wild pollinators
- Increase managed bee hive health and survival
- Outreach (Spread the word on pollinator friendly practices)

Section II is divided into four brief documents that can each stand on its own as best management practices for different groups: gardeners/homeowners, beekeepers, and agricultural and non-agricultural land managers, including conservation and restoration practitioners.

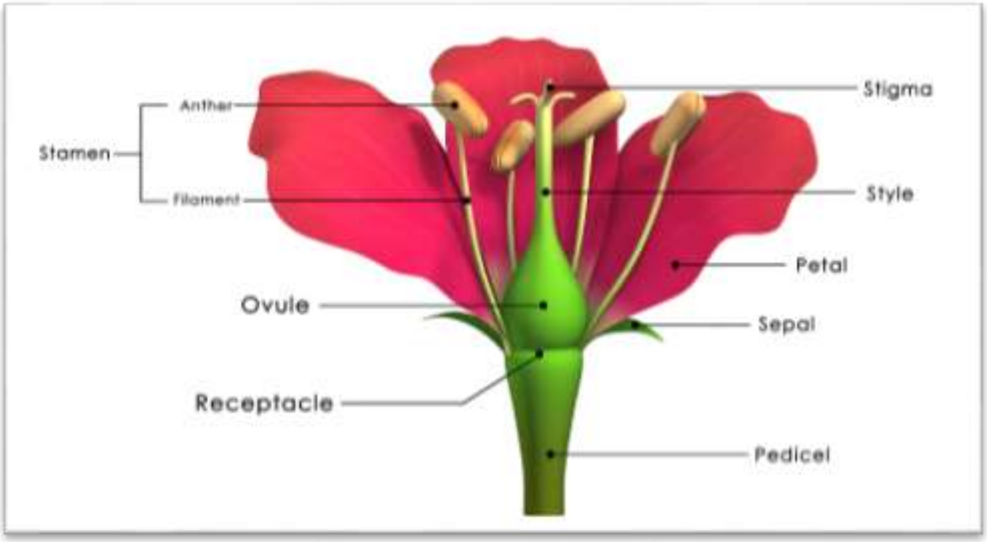
This document was developed in partnership with a diverse stakeholder group including growers, beekeepers, scientists, and representatives from industry, governmental agencies and non-governmental organizations. Three meetings were held to gather feedback from stakeholders throughout the planning process and to foster communication among stakeholders. An official public review period was held in January 2016. Key concepts from stakeholder and public input were compiled, summarized and made publicly available. This is a working document, so new ideas may be discussed for possible inclusion in future iterations of the plan. The plan creation process and a discussion of future initiatives are detailed in Appendix A.

SECTION I. POLLINATOR ROLES AND CONCERNS

As we learn more about the key roles pollinators play in natural and agricultural systems, it is becoming increasingly clear how much we rely on pollinators and how much our actions affect their health, persistence and ability to carry out pollination. Globally, an estimated 87% of flowering plants rely on animals—mostly insects—for pollination[1]. Animal pollinators are responsible for an estimated 35% of global crop production, and increase fruit or seed set for 75% of the world's leading food crops[2].

A pollinator is any animal that visits flowering plants and transfers pollen from flower to flower, thus aiding plant reproduction. North American pollinators include bees, butterflies, flower flies, beetles, wasps, hummingbirds, and in some parts of the southwestern U.S. and Mexico, nectar-feeding bats. Whereas nectar foraging animals like butterflies transport pollen only incidentally, bees purposefully collect pollen as a protein source for their offspring, making them the most efficient pollinators. There are approximately 20,000 bee species in the world, 3,600 in the United States[3] and 400 in Wisconsin. Forty-six species of North American bumble bee nest in colonies, as do some smaller bees, but over 90% of bee species are solitary (do not live in colonies) and wild (not managed by humans). Only a few bee species have been domesticated for agricultural use. These managed bee species include the most familiar crop pollinator in North America, the European honey bee (*Apis mellifera*), several bumble bee species often used in greenhouse pollination, and orchard and leafcutter bees used in fruit crops[4]. The European honey bee was introduced to North America in 1622.

The value of pollinators in natural ecosystems is difficult to quantify, but the economic value of pollinators to agriculture is clear. Global estimates show honey bees and wild bees each contribute approximately $1200 per acre in pollination services to pollinator-dependent crops, on average[5]. Crop visitation rate increases when more pollinator species are present[6], which can translate into higher fruit set and crop yield[7].



Current Status of Wisconsin Pollinators

In Wisconsin, pollinator-dependent crops account for over $55 million in annual production[8]. These crops include apple, cranberry, cherry, green beans, pickling cucumber and fresh market fruits and vegetables. Honey and beeswax are also important commodities in Wisconsin, accounting for $3.5 million in annual production[8].

While honey bee hive counts are not declining globally, high rates of annual colony loss are of concern in the United States and Europe[9]. During the 2014-15 winter season, Wisconsin was among the U.S. states suffering an annual honey bee colony loss greater than 60% [10]. Following several harsh winters, Wisconsin's honey production decreased 19% between 2013 to 2014 [11], and Wisconsin fell from 10th to 15th in honey production among states.

Wisconsin is home to several bumble bee species thought to be in decline[12], including the rusty-patched bumble bee (*Bombus affinis*), the yellow-banded bumble bee (*B. terricola*), and the American bumble bee (*B. pensylvanicus*). Wisconsin is also home to the federally endangered Karner blue butterfly (*Lycaeides melissa samuelis*)[13] and lies along the central migratory route of the monarch butterfly (*Danaus plexippus*), whose migration was named a "threatened phenomenon" by the International Union for Conservation of Nature (IUCN)[14]. For most other wild pollinator species, there is a lack of data on population status or trends.

Pollinator Health Issues

Pollinator health and population declines may arise when pollinator needs are not met. A wide range of factors have been associated with pollinator declines: habitat loss, nutritional deficiency, parasites, pathogens, chemical exposure, beekeeping practices, and extreme weather events (e.g., drought or winter cold).

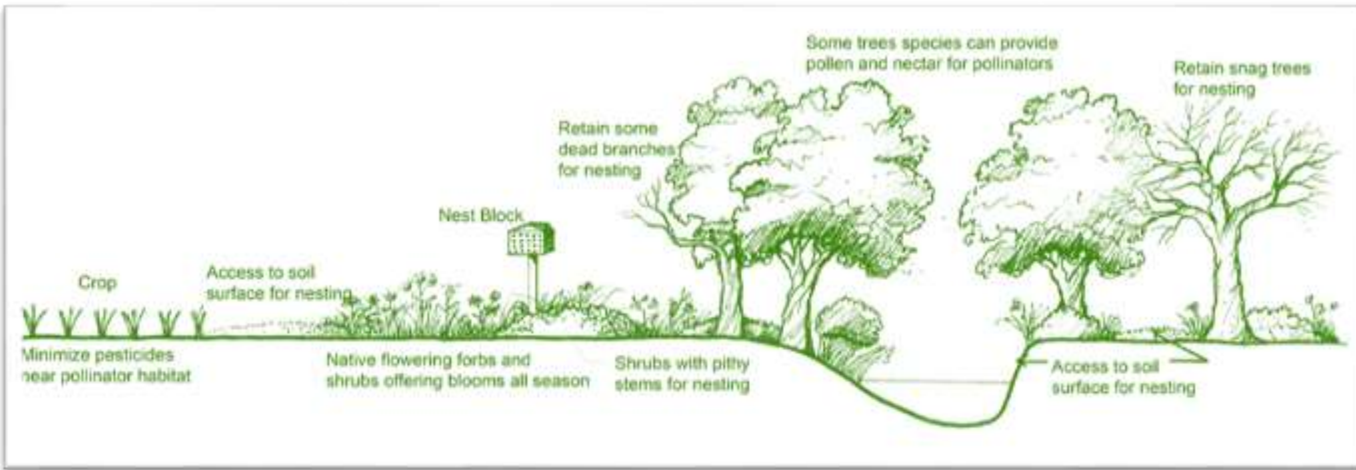
Habitat Loss & Nutritional Deficiency

Pollinator habitat needs differ by species, but one thing all pollinators require is blooming, pollen- and nectar-bearing flowers throughout their adult lifetimes. Pollinators also need places to nest or lay eggs and overwinter. Whereas honey bee nests are provided by beekeepers, wild bees build nests underground, at the bases of bunch grasses, in old rodent burrows or birds' nests, in hollow stems or in galleries carved into dead wood. Bees are central place foragers, meaning they travel limited distances before returning to their nests, and therefore need food sources close by[15]. In comparison, the two migratory flower visiting species found in Wisconsin, the monarch butterfly and the ruby-throated hummingbird, travel long distances and require wildflower nectar sources along their entire migratory routes, spanning from Canada to Mexico.

Diverse plant communities can support diverse pollinator communities in gardens, roadsides, farm fields and prairies[16,17,18,19]. In landscapes with fewer plant species, opportunities for pollinator nesting and foraging are more limited. A small fraction of native bee species have adapted well to the expansion of flowering crops like canola, sunflower, and blueberry, but most native pollinator species are not commonly found in areas where agricultural management is most intense[20], i.e., where crop fields are large and contain only one crop, and pesticide use is intensive. Land use is key in urban areas too – urban flower gardens often harbor diverse pollinator communities, but in areas dominated by skyscrapers or grass lawns pollinator diversity tends to be low[16].

In Wisconsin, we have many opportunities to integrate pollinator habitat into agricultural and urban areas. Wisconsin has many patchy landscapes mixed with forest, meadow, cropland, and residential and commercial developments, all of which can incorporate nesting habitat and a diverse array of wildflowers blooming throughout the season to accommodate pollinators' nesting and nutritional needs. Land managers, growers, lawn care professionals and gardeners can aid pollinators by modifying current management practices to improve existing habitat, or by creating new habitats. With the right design, these actions can also provide other mutually beneficial ecosystem services like erosion control, nutrient recycling, water purification and recharge, and pest control (by harboring insects that feed on pests).

Native and wild bees nest in a variety of places including bare soil, hollow plant stems, and dead wood. Graphic from Natural Resources Conservation Service (NRCS) Wisconsin Biology Technical Note 8: "Pollinator Biology and Habitat" and NRCS Agroforestry Note 34: "Enhancing Nest Sites for Native Bee Crop Pollinators."



Parasites & Pathogens

The invasive *Varroa* mite (*Varroa destructor*) appears to be the main culprit in pathogen-related honey bee colony loss[21]. Not only does the mite weaken honey bees by feeding on their hemolymph, it also transfers a number of debilitating pathogens like deformed wing virus (DWV) and Israeli acute paralysis virus (IAPV). The mite's original host is the eastern honey bee (*Apis cerana*) but it now proliferates in European honey bee colonies and since the 1950s has been transported globally. The eastern honey bee displays grooming behavior that effectively combs off and kills the mites[22], but this grooming behavior is not common in the more vulnerable European honey bee.

Although the *Varroa* mite parasitizes only honey bees, honey bee viruses have been found in bumble bee, solitary bee, wasp, ant and flower fly species[23]. Transmission of pathogens among individuals of different species can be direct or indirect. Direct transmission occurs when a pathogen spreads directly from one individual to another, for example when bumble bees or wasps enter an infected honey bee colony and become infected themselves. Indirect transmission occurs when shared flowers serve as an intermediary reservoir for the pathogen. In experiments, flower sharing has been shown to be a route for cross-species transmission: the gut parasite *Crithidia bombi* spread between bumble bee species[24], while IAPV and the fungal parasite *Nosema* passed from bumble bees to honey bees and vice versa[25,26].

Pesticide Exposure

Pesticides are substances meant to deter or kill organisms considered pests, including insects (insecticides), weedy plants (herbicides), fungi (fungicides), mites (miticides), and many others. The misuse of pesticides can affect pollinator health. Pesticide label directions are regulated by the Environmental Protection Agency (EPA). These label restrictions are intended to reduce risk to humans, other organisms and the environment. Pesticide regulations require that all pesticide label directions be followed.

Pesticides can be applied as sprays, dusts, granules, drenches, tree injections or seed coatings. Pesticides are generally more toxic to insects when direct contact is made, and may negatively affect beneficial insects like pollinators when broadcast over an area[27]. Seed and soil treatments are also of concern with systemic insecticides that spread throughout plant tissues after treatment. If insecticides migrate to plant pollen and nectar, sublethal effects on pollinators are a concern due to the potential for repeated insecticide exposure over time. Sublethal effects include changes in behavior, navigation, colony weight, or reproduction, some of which have been documented in bumble bees and other native bee species exposed to flowering crop fields[28] and lawn weeds[29] treated with typical doses of systemic insecticides. Some classes of systemic insecticides, such as neonicotinoids, are persistent and can remain in soil for weeks to months after treated seed is planted[30].

Pesticides other than insecticides also raise concerns for pollinators. For example, fungicide use is correlated with increased susceptibility to a fungal infection in honey bees[31] and some fungicide-insecticide mixtures appear to be more detrimental to honey bees than either pesticide alone[32]. Miticides and fungicides used in honey bee hive management can build up in pollen, honey and wax[33]. Herbicide use can indirectly affect beneficial insects by altering habitat. For example, the decline of monarch butterflies since the 1990s is correlated with a decrease in milkweed species due to herbicide use in agricultural fields[34].

Integrated pest management (IPM) aims to refocus pest management away from a sole reliance on pesticides. IPM strategies prioritize preventative solutions to pest problems like crop rotation and providing habitat for natural predators of crop pests (biological control agents)[35]. This decreases the probability of pesticide resistance (when a pesticide is no longer effective at controlling the target pest) and reduces pesticide exposure to non-target organisms including pollinators. When preventative measures are not enough to contain a pest outbreak, use of pesticides is warranted. While each pest situation is different, these components for diagnosing and managing pest issues are common across IPM programs[36]:

- Preventing pest problems
- Pest identification
- Monitoring and assessing pest numbers and damage
- Guidelines for when management action is needed
- Evaluating risk to the environment and non-target organisms, and choosing options that reduce risk
- Using a combination of biological, cultural, physical/mechanical and chemical management tools

Beekeeping Practices

Good beekeeping practices can ensure managed bees have adequate sources of food and water while minimizing the spread of disease among nearby hives and wild pollinator populations. Beekeepers decide where to place hives based on a number of factors: nutritional quality of flowering plants in the area, presence of flowers that will produce desirable honey flavors, and leasing opportunities with growers of pollinator-dependent crops.

Pest and pathogen concerns in beekeeping heightened in the 1980s when *Varroa* mites were introduced to the United States. Detecting and effectively managing *Varroa* mites in honey bee colonies is the key to controlling disease spread among hives and from hives to wild pollinator populations. As with other pesticide use, miticide treatments must be chosen carefully to ensure the treatment is not harmful to bees. Bees harbor a complex community of beneficial microbes to aid in digestion, immune function, and larval development. Prophylactic and repeated miticide treatments may interfere with these beneficial microbes and the possibility of mite resistance to the treatment[37]. Similarly, antibiotic resistance is a problem in hives treated prophylactically for American foulbrood, a disease caused by the bacterium *Paenibacillus larvae*. American foulbrood is a particularly nasty ailment - spores can remain viable for 40 years or more, and burning the infected hive is the surest way to prevent its spread.

Extreme Weather

From annual surveys of honey bees and monarch butterflies it is apparent that some of the most devastating population losses follow exceptionally harsh seasons or weather events. We see high losses of European honey bee colonies during hot, dry summers when drought limits floral resources. Honey bee workers stay alive all winter, and each colony needs at least 60 to 90 pounds of honey to survive through winter[38], or even more in cold Wisconsin winters. Exceptionally cold winters can wreak havoc on colonies that fail to maintain warmth until spring due to an inadequate supply of honey. Most migratory monarch butterflies overwinter as adults in a small area in central Mexico where they roost in large groups in trees. An extreme winter storm in this area could decimate the monarch population, necessitating many generations to recover from such a setback. Monarch butterflies cannot survive consistent temperatures below freezing, and the butterflies at overwintering sites may use up their fat stores before spring migration if the temperature is too warm[39].

Migration route that butterflies travel each year.

Harry O. Yates III, USDA Forest Service, Bugwood.org

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SECTION II. ACTIONS TO BENEFIT POLLINATORS

Goals for Pollinator Health

There are many actions land managers, gardeners, growers, pesticide applicators, and beekeepers can take that make a positive difference locally and collectively. Section II of this plan outlines best management practices (BMPs) that can benefit both people and pollinators. For example, practices that increase pollinator diversity can result in better pollination of garden plants and farm crops[1]. Providing habitat and mitigating pesticide effects can bolster bees' immune systems so that they are better able to handle other causes of compromised health, like disease.

The BMPs in Section II address the following goals:

1. Expand the quality and quantity of habitat for managed and wild pollinators
2. Minimize stressors on managed and wild pollinators
3. Increase managed bee hive health and survival
4. Outreach (Spread the word on pollinator friendly practices)

Because this plan is voluntary and directed at a broad array of audiences, the impacts of its recommendations are not easily tracked. Implementing the plan is not something any one person, organization or industry can do alone. Our collective actions will determine how successful this plan concepts are realized, and ultimately contribute to the future health of managed and wild pollinators. Potential avenues for evaluating progress towards the above goals are discussed in Appendix A.

Section II is divided into four brief documents that can each stand on its own as management guidelines in different contexts:

- BMPs for Improving Pollinator Habitat in Gardens & Lawns
- BMPs for Beekeeping to Maximize Pollinator Health
- BMPs for Maximizing Pollinator Health and Pollination Services on Farms
- BMPs for Improving Pollinator Habitat in Prairies, Roadsides and Open Spaces

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THE WISCONSIN POLLINATOR PROTECTION PLAN

BEST MANAGEMENT PRACTICES FOR

Improving Pollinator Habitat in Gardens & Lawns

Flowering plants need pollinators and pollinators need flowers. Globally, an estimated 87% of flowering plants rely on animals—mostly insects—for pollination[1]. Many of our favorite foods are partially or fully reliant on insect pollinators to produce fruit[2], including apples, almonds, strawberries, watermelon, tomatoes, sunflower seeds, coffee beans, and many others. In Wisconsin, high honey bee colony losses and concerns about declining wild pollinators highlight the importance of protecting pollinators from habitat loss, disease, pests and pesticides.

By planting a diverse array of flowers and undertaking other simple practices, your yard or garden can attract flower visitors including bees, butterflies, flower flies and hummingbirds. Bees in particular are superstar pollinators because they have special pollen carrying structures on their bodies. There are about 400 species of bee in Wisconsin, and home and community gardens can be great places for them to find food and nesting sites.

Flower visitors vary in their effectiveness at pollinating. Bees are the most efficient.

Wild bees

Flower fly (Syrphidae)

David Cappaert, Bugwood.org

Honey bee

Butterfly

Ruby-throated hummingbird

Pollinator plantings

Regional pollinator plant lists and planting guidelines are available from The Xerces Society[3], Pollinator Partnership[4], and Michigan State University Extension[5]. To find a nursery or seed source, see lists provided by the Wisconsin Department of Natural Resources (DNR)[6], Plant Native[7] and The Xerces Society[8].

The following are guidelines for choosing plants that will benefit pollinators:

- Choose plants that suit your yard, considering soil type, drainage, slope, and amount of available sunlight.
- Aim for at least three species of flowering plant in bloom at all times from early spring to late fall. Flowering plants include wildflowers, garden herbs and fruits/vegetables, and flowering shrubs and trees like redbud, American basswood, willows, and fruit trees.
- Avoid invasive plants and noxious weeds[9], which can crowd out other plants and reduce plant diversity, in turn reducing pollinator diversity.
- Incorporate native plant species into your garden. Gardens with native plants tend to attract more bee species[10,11] and support more butterfly and bird species[12,13] than those dominated by introduced ornamentals. Many native plants are drought tolerant and do not require fertilizer.
- Provide flowering plants other than highly modified cultivars. Whether native or non-native, flowering plants that have been highly modified through breeding have often lost pollen and nectar, or are too complex for bees to navigate. Some common garden plants like tulips, daffodils, petunias and ornamental roses are not typically visited by pollinators. Common garden herbs and wildflowers that do attract pollinators include mints, oregano, garlic, chives, parsley, lavender, zinnias, cosmos, and wild type sunflowers.
- Choose a variety of flower colors. Bees are most attracted to blue, white, yellow and purple flowers – they do not see red. Butterflies are drawn to orange, red, yellow and purple, while flower flies mainly visit white and yellow flowers. Hummingbirds are particularly attracted to red flowers.

Why plant milkweeds?

Monarch butterflies rely on milkweeds (genus *Asclepias*) to complete their life cycles, and monarch butterfly decline since the 1990s is closely correlated with a loss of milkweed plants. There are five species of milkweed native to Wisconsin[1]. Common milkweed (*Asclepias syriaca*) is known for its aggressive habit, but most milkweed species are not weedy and make beautiful and beneficial additions to gardens. Milkweeds don't just serve monarchs; they are attractive nectar sources for a wide range of pollinators. A directory of milkweed seed vendors is available through The Xerces Society[8].

Whorled milkweed *(Asclepias verticillata)*

Swamp milkweed *(Asclepias incarnata)*

Butterfly milkweed *(Asclepias tuberosa)*

Photos: Frank Mayfield

Garden cultivars that are "double flowered" with many petals frequently lack pollen or are too complex for bees to navigate. A good rule of thumb is to look at the flower parts. If it is difficult to see anthers (pollen-carrying structures) in the center of each flower, it is probably not a good plant for bees.

X Poor choices for bees: X

✓ Examples of bee-attractive flowers: ✓

Silphium sp.

Monarda sp.

Gentiana sp.

Native plant photos: Frank Mayfield

Nesting habitat for bees

Beekeepers provide honey bee colonies a home in hive boxes, but all the other species of bee found in Wisconsin nest in the wild. Bumble bees are social and nest in small colonies, but most other species of bee are solitary and do not form colonies. Small-bodied bees may only travel 200 yards or less from their nests, so it is important that nesting habitat be located near pollinator-attractive flowers. Some tips for providing nesting habitat:

- Leave some areas undisturbed. Most solitary bee species nest in the ground, in bare patches of semi-loose soil. Deep or frequent tilling can disturb nests.
- Plant native bunch grasses such as little bluestem. Bumble bees and solitary bee species will nest at the bases of bunch grasses.
- When possible, leave things a little messy. Bumble bees tend to nest in old rodent burrows, cavities, abandoned bird nests, and brush piles. Solitary bee species nest in hollow or pithy plan stems, downed logs, leaf litter, or old beetle holes.
- Avoid disturbing existing bee nests. Ground nests can resemble ant hills. Take time to observe and identify their inhabitants before assuming nests are homes for nuisance species. Solitary bees are docile and rarely sting unless handled.
- **Use homemade "bee hotels" with caution.** Homemade bee nests are often colonized by wasps, and can harbor predators and pathogens if not properly cleaned and maintained[14]. Wooden bumble bee boxes tend to have very low success rates[15]. For more information see "Providing Nest Sites for Pollinators"[16] from The Xerces Society.

Blooming "bee lawns"

- Lawns can be pollinator friendly if dandelions, clover and other flowering lawn plants are allowed to bloom. These can provide important early season pollen and nectar sources when other floral resources are sparse.
- Before applying an insecticide to treat lawn pests, first mow to remove any clover or dandelion blooms that might attract pollinators. By the time flowering lawn plants regrow, insecticides will be less present in nectar and pollen[17].

Pesticide use

Pesticides are one of many tools available to manage lawn and garden pests. When using pesticides follow the label directions exactly -- the label is the law. Before using any pesticide on lawns or gardens:

- Identify the pest and assess the damage. Many plants can tolerate insect damage and no action may be necessary. The UW-Extension Horticulture diagnostics lab[18] can help identify insect damage or disease.
- If pest damage is extensive, explore and understand options for management. Choose methods that minimize harmful effects on pollinators and beneficial insects that prey on pests[19,20]. A helpful online tool[21] ranking pesticides by bee toxicity is available from the University of California Statewide Agricultural & Natural Resources Integrated Pest Management Program (UC IPM).
- Understand the difference between systemic and non-systemic insecticides. Systemic insecticides migrate throughout the whole plant, including pollen and nectar[22], and may persist in soil for weeks to months[23]. When purchasing plants, ask nurseries if flowering plants have been treated with systemic insecticides.
- Avoid applying insecticides to flowering plants or to areas pollinators may be nesting.
- Do not repeatedly use the same pesticide or the pest may develop resistance to that pesticide over time. Pesticide resistance is the ability of an organism to tolerate the toxic effect of a pesticide, thus lowering the effectiveness of the pesticide in controlling the pest. Rotate pesticide types and modes of action to avoid resistance.

Honey bee swarm

Swarm and nest management

Honey bees swarm when a colony becomes too large and a queen leaves the hive with a group of worker bees to find a new nest site. Wasps do not swarm like honey bees, though they sometimes feed in groups and congregate if they are blocked from entering their nests. If you see what looks like a swarm:

1. Determine if the insects are honey bees or wasps[24].
2. If what you have is a honey bee swarm, a local beekeeper will often be willing to help remove it. Beekeepers can be found through Bee Removal Source[25] or Wisconsin Honey Producers[26].
3. If swarm removal is not possible or if you have wasps, structural pest control businesses can help. The Wisconsin Pest Control Association website[27] has a list of businesses that may offer assistance. Never block the entrance to a wasp nest, and never set a nest on fire.
4. If the swarm or nest was found in a building, make repairs after the insects are removed to prevent pests from reentering the structure.

Yellow jackets and other wasps typically have less hair and skinnier legs than bees.

Wasp

Photo: Richard Bartz

Honey bee

Photo: Andy Murray

Get Involved and Spread the Word

The more neighbors using best practices for pollinators, the greater the potential impact on pollinator health. Here are a few ways you can help spread the word on pollinator protection:

- Participate in the Million Pollinator Garden Challenge: http://millionpollinatorgardens.org/
- Advertise your pollinator friendly lawn: http://www.xerces.org/nrcs-pollinator-habitat-sign/
- Get involved in prairie restoration projects through Friend groups or other local organizations
- Become adept at distinguishing honey bees, solitary bees, wasps and flies[28]
- Get involved in citizen science:
    - Bumble Bee Watch: www.bumblebeewatch.org
    - The Great Sunflower Project: http://www.greatsunflower.org/
    - Monarch Watch: http://www.monarchwatch.org/tagmig/tag.htm

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[7] Native plant nursery finder: http://www.plantnative.org/

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[19] EPA data on residual time to 25% bee mortality (RT25): http://www2.epa.gov/pollinator-protection/residual-time-25-bee-mortality-rt25-data

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[24] See the University of Minnesota Bee Lab's document "Bothered by Bees or Wasps?": http://www.beelab.umn.edu/sites/beelab.umn.edu/files/bothered_by_bees_wasps.pdf

[25] List of bee removal experts in Wisconsin: http://www.beeremovalsource.com/bee-removal-list/wisconsin/

[26] Wisconsin Honey Producers list of beekeepers: http://www.wihoney.org/member-services

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[28] To distinguish among various kinds of bee, wasp, and fly, refer to the "Streamlined Bee Monitoring Protocol" from The Xerces Society: www.xerces.org/streamlined-bee-monitoring-protocol

Lesley Ingram, Bugwood.org

THE WISCONSIN POLLINATOR PROTECTION PLAN

BEST MANAGEMENT PRACTICES FOR

Beekeeping to Maximize Pollinator Health

Beekeeping is a rewarding venture, but new beekeepers may easily become overwhelmed by all the considerations that go into keeping bees. Habitat loss, nutritional deficiencies, pesticide exposure, parasites, pathogens, and harsh weather are some of the main causes of concern for bee health. Parasites, improper nutrition and pesticide exposure are compounding issues that can make colonies more susceptible to disease. The following practices are recommended to improve overall pollinator health and minimize hive loss in managed bees. Some practices apply only to the most common managed bee, the European honey bee (*Apis mellifera*), but many also apply to bumble bees kept for greenhouse pollination (typically *Bombus impatiens*).

Utilize good beekeeping practices to provide managed bees with adequate sources of food and water while minimizing the spread of disease among nearby hives and wild pollinator populations. Commercial honey bee hives are often transported from crop to crop throughout the growing season. Care must be taken to avoid dehydration and food stress during travel, and maximize hive exposure to floral diversity whenever possible. It is also important to consider pesticide use in the vicinity of hives to minimize harmful chemical exposure. As urban beekeeping gains popularity, new hobbyists should realize that all of these concerns—adequate pollen diversity, water availability, chemical exposure and disease control—apply in urban settings as well.

Habitat and nutrition

- Bees need a diverse mix of natural pollen and nectar. The best way to ensure adequate nutrition is to place bee hives in areas where at least three species of flowering plant are in bloom at all times from early spring through late fall.
- Honey bees, like most bees, are generalist foragers that will visit many different plant types. If you are interested in establishing habitat for your bees, Pollinator Partnership[1] and The Xerces Society[2] provide regional plant guides. Avoid foraging habitat that is full of plants considered weedy or invasive[3] in Wisconsin, as bee pollination may aid their spread. See the BMPs for improving pollinator habitat in gardens and open spaces in the Wisconsin Pollinator Protection Plan.
- Avoid garden cultivars and hybrids that have been bred for size, color or extra petals and provide little or no nectar and pollen for bees.
- Bees need water. Make sure uncontaminated water sources are readily available.
- Protein patties and sugar (dry or syrup) can be provided when floral resources are inadequate.
- Density matters. Too many hives placed in one location can lead to inadequate forage as well as increasing the likelihood of disease and parasite spread.

Winter preparation

Honey bee colonies are perennial; the queen and many workers live through the winter by feeding on honey stores and "shivering" to keep warm. This differentiates honey bees from bumble bee colonies that instead produce new queens in the fall that hibernate while the rest of the colony dies. Beekeepers managing honey bees can minimize the likelihood of overwintering colony loss by preparing hives each fall:

- Assess honey bee hive strength before winter. Assess honey quantity, brood production, and worker mortality. Check for disease and mites. Queens with low fertility can be killed, and small, healthy colonies combined, to increase probability of winter survival.
- Take steps to avoid starvation. Colonies in areas with cold winters need about 100 lbs. of honey stored to last the winter. If less than this is present in late fall, supplemental carbohydrates (sugar or candy board) can be added to the hive. Supplemental feeding with honey from an external source has been linked to disease spread. High fructose corn syrup that is old, has been heated, or is no longer clear may contain levels of hydroxymethylfurfural (HMF) that are unsafe for bees. Do not feed bees starches which can cause dysentery over winter.
- Keep the hive dry. Insulate the top of the hive to reduce condensation above the bee cluster. Wrap the hive with black tar paper and add ventilation near the top of the hive so humid air can escape.
- Hives should be kept behind a windbreak, moved to a southerly location, or moved indoors for the winter.
- Consider adding an entrance reducer or mouse guard at hive entrances in the fall to prevent rodent damage.

Disease and pest management

- Many pathogens are spread among managed colonies and from managed colonies to wild bees[4,5]. It is crucial to catch problems early, assess treatment effectiveness, and avoid unnecessary treatment. The following practices are recommended to track and prevent the spread of bee pathogens:
- Use a hive inspection sheet to keep track of regular hive health assessments[6]. The Wisconsin DATCP apiary program[7] offers free hive inspections May through October. Inspections include the identification of common pests and diseases as well as a visual check for exotic pests or diseases.
- Diagnose hive ailments and choose carefully among treatment options. A diagnostic field guide is available through Penn State University[8]. Disease diagnostic services are also available free of charge through the USDA Beltsville Bee Lab[9]. Read and follow all product label directions carefully when applying any disease or mite control products in beehives.
- Monitoring for *Varroa* mite. *Varroa* mites weaken honey bees by feeding on their hemolymph, and can transfer pathogens like deformed wing virus (DWV) and Israeli acute paralysis virus (IAPV) among colonies. Check for *Varroa* mites every 2-3 months using sticky boards, ether or powdered sugar rolls. As a suggested guideline, treat for Varroa when mite counts exceed 5 mites per 100 bees sampled. Visit the WDATCP Apiary webpage[10] for a list of current treatment options.
- Monitoring for *Nosema* fungal parasites. To check for *Nosema*, gut spores should be counted under a microscope; gut spore count > 1 million per bee warrants treatment.
- Monitoring for foulbrood bacterial diseases. The mottled appearance of live intermixed with dead brood cells can indicate a number of ailments including European foulbrood and American foulbrood[11].
- Foulbrood spores can remain viable for 40 years or more, and burning the infected hive is the surest way to prevent its spread.
- Resistance to the antibiotic Terramycin is a problem in some hives afflicted with American foulbrood. The USDA Beltsville Bee Lab[9] provides bee and comb testing for antibiotic resistance.
- If foulbrood is suspected, contact the State Apiarist[7].
- Pesticides and other substances added to the hive can accumulate in royal jelly, wax and honey[12], and persistent use of miticides and other pesticides increases the likelihood of pesticide resistance, eventually rendering treatment ineffectual.
- Rotate out a portion of old brood comb every year to reduce the buildup of pathogens and other substances.

Communication with growers and neighbors

- Maintain positive and open relationships with growers who lease your hives for pollination.
- Negotiate a rental fee, number of colonies per acre, and payment schedule.
- Agree upon timing of hive placement prior to crop bloom and colony removal after bloom.
- Discuss and determine the pesticide spray schedule and types of pesticides used (including insecticides, fungicides, and insect growth regulators (IGRs)). A helpful online tool[13] ranking pesticides and tank mixes by honey bee toxicity is available from University of California Statewide Agricultural & Natural Resources Integrated Pest Management Program (UC IPM).
- A signed contract can protect both the grower and beekeeper. A template contract based on USDA guidelines is provided by University of Florida Extension[14].
- Be aware of property boundaries. Public land agencies differ in their policies regarding managed species – some allow hives with a conditional use permit, and some do not allow them in any case. Public lands are often attractive areas for honey bee foraging, and beekeepers sometimes place hives on private land adjacent to natural areas.
- Be neighborly. If you are considering keeping hives near property lines, communicate your intentions with neighbors and be sensitive to their concerns about stings.
- Check with your local municipality for any beekeeping ordinances.

What is DriftWatch?

DriftWatch[1] is a non-profit organization that provides voluntary online mapping tools for crop producers, beekeepers, and pesticide applicators. Beekeepers can use the BeeCheck mapping tool to alert nearby pesticide applicators of their hives.

Additional concerns for commercial beekeepers

In addition to the management practices above, commercial and migratory beekeepers must also consider beehive stressors including long distance transportation, poor diets and overworking the bees.

- When transporting bees, maintenance of consistent temperature, ventilation and hydration are critical issues.
- Supplemental feeding of carbohydrates and/or protein may be necessary before and after crop bloom.
- Immediately report any suspected pesticide-related bee incidents to DATCP.
- No person may ship live honeybees or used beekeeping equipment into Wisconsin without first reporting the import shipment to DATCP in writing. The Honey Bee Import Report is available online[15]. Migratory beekeepers or bee haulers must be aware of Wisconsin and other state laws and regulations[16].

Other managed bee species

Several non-honey bee species are now commercially available for use in crop pollination. The bumble bee species *Bombus impatiens* is used in greenhouse tomato pollination and solitary mason bee species (*Osmia spp.*) are used in orchard crops. See "Managing Alternative Pollinators"[17] for management considerations, and costs and benefits of managing alternative bee species.

Beekeeper survey data – Get involved!

In 2011, USDA's Bee Informed Partnership began surveying beekeepers across the U.S. to shed light on factors that may be associated with honey bee colony loss. See the table below for results compiled from five years of overwintering colony loss and beekeeping practices[18]. Note that these results describe correlations, and *cannot be used to show that certain practices cause or prevent loss.* Furthermore, results describe one-to-one correlations rather than the effect of multiple treatments together on colony loss. This is an ongoing annual survey in which every beekeeper should participate (available each April at BeeInformed.org).

This table is based on **Bee Informed Partnership surveys** for winter colony loss for years 2010/11 through 2014/15.

Below are practices that correlated, in at least three out of five years, with:

More colonies lost:	Fewer colonies lost:	No difference in number of colonies lost:
Supplemental feeding with honey frames Reusing old or diseased brood comb	*Varroa* mite treatment with thymol-based products (ApiGuard, ApiLife Var), oxalic acid, formic acid, or the miticide Amitraz *Varroa* mite treatment by removing drone brood or screen bottom board* Supplemental feeding with commercial protein patties Supplemental feeding with candy boards or dry sugar Small hive beetle traps Prepping hives for winter	*Varroa* mite treatment with coumaphos (CheckMite), fluvalinate (Apistan), Sucrocide, powdered sugar, or mineral oil *Varroa* mite treatment using comb with small cell size Foulbrood treatment using antibiotics Terramycin or Tylan Nosema treatment using Fumagillin or Nosevet Tracheal mite treatment with MiteAThol or grease patties

*Keeping the screen bottom board in for the whole year was not correlated with higher losses than when removed for the winter.

Leasing colonies was not correlated to increased or decreased colony loss.

Additional support

Organizations:

Wisconsin DATCP webpage with links to beekeepers' organizations:
http://datcp.wi.gov/Farms/Bees_and_Honey/

Local chapters of Wisconsin Honey Producers: http://wihoney.org/local-chapters

Get to know your local bee club. Some clubs hold workshops for new beekeepers, have equipment for rent, can assist in swarm removal, and are invaluable sources of information.

The University of Minnesota Bee Lab provides beekeeping courses, a how-to video series, research database, and more: http://www.beelab.umn.edu/

The California-based *Project Apis m.* provides a newsletter with updates on newest developments in beekeeping, as well as BMPs and a research database:
http://projectapism.org/

Books and How-to's:

General handbook for new and experienced beekeepers:

- Sammataro, Diana, and Alphonse Avitabile. 2011. *The beekeeper's handbook, 4th ed.* Cornell University Press.

For beekeepers using bees for crop pollination:

- Delaplane, Keith S., Daniel R. Mayer, and Daniel F. Mayer. 2000. *Crop pollination by bees*. CABI.
- Almond Board of California. *Honey Bee Best Management Practices for California Almonds.* http://www.almonds.com/sites/default/files/content/attachments/honey_bee_best_management_practices_for_ca_almonds.pdf

USDA Pollination Handbook

- http://www.ars.usda.gov/SP2UserFiles/Place/20220500/OnlinePollinationHandbook.pdf

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[7] To schedule an inspection for the upcoming season, contact Elizabeth Meils, State Apiarist, Wisconsin Department of Agriculture, Trade and Consumer Protection, PO Box 8911, Madison WI 53708-8911, (608) 224-4572, elizabeth.meils@wisconsin.gov

[8] Pennsylvania State University field guide for diagnosing hive ailments: http://extension.psu.edu/publications/agrs-116/view

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[14] Template pollination agreement from University of Florida Extension, adapted from that found in the USDA Agriculture Handbook 496 and from *Crop Pollination by Bees*, by Delaplane and Mayer, 2000. https://edis.ifas.ufl.edu/aa169

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THE WISCONSIN POLLINATOR PROTECTION PLAN

BEST MANAGEMENT PRACTICES FOR

Maximizing Pollinator Health & Pollination Services on Farms

Thelma Heidel-Baker, The Xerces Society

Over one-fifth of the land area of Wisconsin is farmland, and opportunities abound to benefit pollinators through agricultural management practices. For growers raising pollinator-dependent crops, the benefit to fostering pollinators is clear: good crop yield depends on healthy pollinator communities. But all growers and farmers can benefit from pollinator-friendly practices. Hedgerows can harbor beneficial insects that control crop pests[1], and prairie plants grown on contour can limit soil erosion and nutrient loss[2]. Habitat benefitting pollinators can also double as forage for grazers or habitat for game species and other wildlife.

Contribution of insect pollinators to crop yields

The degree to which crops depend on insect-mediated pollination varies.

- Soybeans show an 18% higher yield and heavier seeds when honey bees and wild bees are present[3].
- Apple flowers are self-sterile and depend heavily on cross-pollination by bees to bear marketable fruit.
- Cranberry can bear fruit from wind-pollinated flowers, but more and heavier fruit is produced when bees are present[4].
- Tart cherry flowers can self-pollinate, but yields are boosted 2-4 fold when bees are present[5].
- Green bean seed yields are 9 - 35% higher with bumble bees present[6].
- Strawberry requires at least 20 bee visits per receptacle, and receives complementary pollination benefits from honey bees and wild bees[7].
- Raspberry sets more and heavier fruit when pollinated by bees.
- Pickling cucumbers tend to be misshapen when not fully pollinated by bees.
- Corn does not rely on insect pollination, but bees are known to feed on corn pollen when other floral resources are scarce.

Honey bee or Bumble bee

- A honey bee colony contains 100 to 1000 times more worker bees than a bumble bee colony, but on a per-bee basis, bumble bees are often more efficient pollinators because of their:
- Longer foraging hours and tendency to forage earlier in the day when day-opening flowers are at their most fertile.
- Higher flower visitation rates.
- Larger and hairier bodies.
- Tendency to switch among crop rows (good for crop varieties that require cross-pollination).
- Ability to "buzz pollinate" flowers with tubular anthers like tomato and cranberry. Honey bees do not have this ability. Plants with tubular anthers produce little nectar and provide low rewards for honey bees.

Honey bee

Bumble bee

Pollinator dependent crops have higher visitation rates when more pollinator species are present, however simply adding more honey bees to a field will not fully compensate for a lack of wild pollinators[8]. There are about 400 wild bee species in Wisconsin, so there is great potential for fostering bee diversity and boosting pollination services in and around crop fields.

Improving and Creating Habitat for pollinators

Farm fields located near natural areas like woodlands and prairies tend to have more bee species and higher crop fruit set than those surrounded by only farmland[9]. Habitat diversity is one reason many apple growers in Wisconsin get their pollination services from wild bees without having to rent honey bees[10].

For farms that are not near natural areas, attracting pollinators depends heavily on on-farm management practices[11]. A global study of 39 crops found that bee abundance was on average 76% higher in "diversified" fields – those with mixed crop types, or that had hedgerows or flower strips at the margin – than in monoculture fields[12]. In a Michigan study, wildflower strips planted adjacent to blueberry fields paid for themselves after four years due to a boost in crop yield[13]. Costs and benefits will depend on the type of crop grown (pollinator-dependent or not) and the goals of the grower. Pollinator benefits of on- and off-field management practices are summarized in the table below. For more information on installing pollinator habitat see the BMPs for Improving Pollinator Habitat in the Wisconsin Pollinator Plan.

Beneficial practices for pollinators

Location of Practice	Management Practice[14]	Potential Benefits
Outside crop fields	Leaving existing nesting habitat (dead wood, bare patches of soil, hollow stems, bunch grasses)	Diverse pollinator communities can be maintained long-term if adequate nesting habitat is located near foraging habitat.
	Adding wildflower strips or flowering hedgerows on slopes, field margins or roadside ditches	Increased pollinator diversity; higher yields of adjacent pollinator-dependent crops. Prairie strips can be configured to prevent loss of water, soil and nutrients from crop fields[15].
Within crop fields	Intercropping, cover cropping or agroforestry using pollinator attractive plants	Diverse pollinator communities can be maintained long-term if flowering plants are available spring through fall. Blooming cover crops like clovers and alfalfa can serve both grazers and pollinators[16].
	Growing multiple types of blooming crops	Increased pollinator health and diversity; higher yields of pollinator-dependent crops; diversified income streams.
	Reducing tillage intensity	Though they more commonly nest in field margins, wild bees have been found nesting within tilled fields[17]. Tilling can make soil more accessible to wild bees, but can also disturb established nests. Shallower tilling or leaving margins untilled may be beneficial for bees.
Within and outside crop fields	Strive to minimizing pesticide use	Minimizing the use of pesticides can reduce negative effects on beneficial species including pollinators. Do not drift off target, it is a violation of state law.
	Changing mowing, haying and herbicide practices	Pollinators benefit when (non-invasive) flowering plants are allowed to bloom in field margins or between crop rows (particularly when crop is not blooming). Letting alfalfa go to bloom before haying provides a rich resource for pollinators.
	Reducing the distance between beneficial crops and non-crop plants	Increased crop pollination; wildflower strips and flowering hedgerows are more effective when they border smaller fields by minimizing distances between crop flowers, bee nests, and non-crop foraging habitat.

Cost-share and technical assistance

Installing pollinator habitat requires up-front costs and establishment takes several years before all benefits are realized. A helpful summary of costs for prairie plantings in row crop systems is available from the Leopold Center for Sustainable Agriculture[18]. Funding and information may also be available through the programs listed below. Your local county land conservation department[19] can help determine your eligibility for certain cost-share programs.

Landowner Programs:

- Wisconsin Department of Natural Resources (DNR) Landowner Incentive Program (LIP)[22]
- United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Environmental Quality Incentives Program (EQIP)[23]
- USDA NRCS Conservation Reserve Program (CRP)[24] and Conservation Reserve Enhancement Program (CREP)[25]
- USDA NRCS Conservation Stewardship Program (CSP)[26]
- US Fish and Wildlife Service Partners programs[27]

Other organizations involved in habitat restoration:

- Healthy Grown Potatoes[28]
- Pheasants Forever[29]

Compensating for milkweed loss

Monarch butterfly population estimates for 2015 are 80% below their 20-year average[20]. Monarch butterflies need milkweed plants (genus *Asclepias*) to complete their life cycles, and their decline is closely correlated with the loss of milkweed plants in and near agricultural fields. There are five species of milkweed native to Wisconsin[21]. Common milkweed (*Asclepias syriaca*) is known for its aggressive habit, but most milkweed species are not weedy and make beautiful and beneficial additions to wildflower strips. Milkweeds don't just serve monarchs; they are attractive nectar sources for a wide range of pollinators. Note: Milkweed can be toxic to livestock. Although actively grazing animals will typically avoid it unless good forage is scarce, milkweed should be discouraged in fields that will be hayed.

Whorled milkweed (Asclepias verticillata)

Swamp milkweed (Asclepias incarnata)

Butterfly milkweed (Asclepias tuberosa)

Photos: Frank Mayfield

Pesticide use and avoiding drift

Growers face a difficult challenge of protecting crops from pests and disease while protecting pollinators and beneficial insects that eat crop pests. Cautious pesticide use is advised to avoid pest resistance and protect the health of beneficial insects and other non-target organisms. The following are guidelines for minimizing pesticide harm to pollinators.

- Always follow the pesticide label exactly regarding application timing and dose. The label is the law!
- Use Integrated Pest Management (IPM) guidelines for your crop pest problems. Identify the pest and degree of infestation before treating with pesticides. Use established economic thresholds when available to determine when control measures are warranted. Incorporate preventative management options such as resistant crop varieties and cultural control practices.
- Be aware of pesticide labels that contain "highly toxic to bees," "toxic to bees" and "extended residual toxicity" language. See also "EPA Information on Residue Toxicity Times."[30] Take equal caution using pesticides approved for use in organic agriculture; these are not necessarily safe for bees.

- To help choose products that are less toxic to pollinators, refer to the "Bee precaution pesticide rating" online tool[31] from University of California Statewide Agricultural & Natural Resources Integrated Pest Management Program (UC IPM), which ranks pesticides and tank mixes based on toxicity to bees.
- Avoid spraying pesticides on blooming plants being visited by pollinators. This includes crops, weeds in cropland, and wildflowers or weeds in field margins/ditches. If sprays must be used, avoid spraying during the day when pollinators may be foraging.
- Keep in mind that systemic insecticides applied as soil or seed treatment can remain plants for extended periods of time, and may be present in the pollen or nectar even if the insecticide is applied prior to bloom.
- Seed treated with pesticides is an option where pest problems have been diagnosed, yet prophylactic use should be avoided. If use of treated seed is warranted,
    - Remove blooming crop weeds before planting treated seed.
    - Reduce dust release when planting treated seed. Dust contaminated with pesticide sticks easily to bee hairs and can be transferred to nests and fed to larvae. Use seed treatments designed to reduce dust. If a dust formulation must be used, use deflectors that direct dust down.
    - Collect and properly dispose of any spilled treated seed. Treated seed can be toxic to birds and other wildlife if ingested.

- Refer to the ASTA and CropLife guide to seed treatments[32] and University of Wisconsin-Extension handout, "What's on your Seed?"[33]

- Educate yourself about safe pesticide use. The pesticide applicator certification training manual[34] is a useful resource for everyone, and is required training for some types of pesticide applicators.
- Pesticides should not drift off the target site. If it does, it is a violation of pesticide regulations.
- Consider using buffer strips between pollinator habitat and land that gets sprayed regularly with pesticides. Some landowner programs require this, e.g., the Natural Resources Conservation Service (NRCS) Conservation Reserve Program (CRP) requires a 150 ft. buffer between CRP land and sprayed areas.

What is DriftWatch?

FieldWatch[35] is a non-profit organization that provides voluntary online mapping tools for crop producers, beekeepers, and pesticide applicators. Crop producers can use the DriftWatch mapping tool to alert nearby pesticide applicators of their specialty crops.

Getting involved and spreading the word

The more neighboring land managers use best practices for pollinators, the greater the potential impact on pollinator health. Growers are encouraged to share their practices with agronomy businesses, grower groups, and land managers and participate in scientific research to help answer questions surrounding pollinator health in agricultural settings. Monitoring pollinator population trends to document what management practices do and do not work is important not only for pollinator health but crop production as well.

How can you tell if bees like your farm? Use the simple protocol[36] provided by The Xerces Society and a bee guide[37] from Michigan State University to identify bees and monitor their presence on your farm. The Xerces Society provides an assessment form[38] to score pollinator habitat on your farm and aid in management planning.

Books, Manuals and How-To's:

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  http://www.ars.usda.gov/SP2UserFiles/Place/20220500/OnlinePollinationHandbook.pdf
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THE WISCONSIN POLLINATOR PROTECTION PLAN

BEST MANAGEMENT PRACTICES FOR

Improving Pollinator Habitat in Prairies, Roadsides & Open Spaces

Providing a high diversity of species that offer flowers throughout the growing season is the most important action that can be taken to promote healthy pollinator communities. Pollinator habitat can be provided in small patches of land, large continuous fields, or linear strips, as in the case of roadsides and other right-of-ways. Collectively, these efforts can improve pollinator health, diversity and abundance. Open prairies and savannas provide plentiful nesting and forage opportunities for pollinators throughout the year. Because a tiny fraction of these habitats remain in the Midwest as small fragments of disjointed land, each opportunity for restoring or improving pollinator habitat is crucial.

Providing pollinator habitat is a goal that complements other management goals including erosion control, native plant propagation, and wildlife habitat. Included is a section devoted to the special considerations for roadsides, but most of the BMPs outlined below apply to a wide array of habitat improvement projects on public, private and tribal land.

Establishment timeline: What to expect for prairie plantings

Year One:

Few flowers. Native perennial prairie plants put energy into below-ground root building, not

Weeds. Mowing in the first year is necessary to prevent weed establishment.

Year Two:

Few flowers. Some early species will bloom.

Mowing or spot herbicide treatment may be used to control weeds.

Year Three and Beyond:

Many flowers. Plantings will begin to resemble a diverse tallgrass prairie.

Ongoing maintenance may consist of spot herbicide treatment to control weeds, and mowing, grazing, baling, or prescribed fire if desired.

Before starting a pollinator habitat project

It is important to start a habitat project with a plan that outlines short- and long-term goals, so that a management strategy can be designed to meet these goals. Natural Resources Conservation Service (NRCS), UW-Extension, or county conservation office staff may be able to provide guidance during this process[1]. Pertinent questions to answer during the planning stage include:

- How much of the area is currently covered by flowering plants? Are any of these flowering plant species key pollinator plants (like lupine)? Are any of them noxious or invasive weeds[2,3] that need to be controlled?
- If there are already non-weedy flowering forbs, shrubs or trees at the site, is it possible to enhance rather than replace the habitat?
- Are there nearby areas that might be used as nesting habitat for bees? This may include downed wood or snags, bunchgrasses, brush piles, old rodent burrows, or hollow stems.
- What is the land use on adjacent sites? What weeds are present and what pesticides are used there that might affect the project site?
- Are there high slope areas where erosion may result from disturbing soils?

How to pick a seed mix

Healthy pollinator communities depend on a variety of flowering plants with adequate nectar and pollen resources.

- A minimum goal is at least three plant species flowering at all times from early spring through late fall, but the more diverse the wildflower mix the better. The total seed count should be comprised mostly of forb seeds so that grasses do not crowd out forbs.
- Example regional seed mixes, vendor information, planting instructions, and a seed mix calculator are provided by The Xerces Society[4,5,6]. Regional plant lists and planting guides are available from the Wisconsin Department of Natural Resources (DNR)[7] and Pollinator Partnership[8].

Why choose native plants?

Some weedy and invasive[2] plants do provide nectar and pollen for pollinators, but the spread of these plants can crowd out other vegetation and reduce overall wildflower diversity over time. Other benefits:

- Native plants are adapted to local conditions, typically do not require fertilizer, and can tolerate drought and heat.
- Native prairie plants have deep roots, low water requirements and the ability to prevent runoff, nutrient loss and erosion.
- Native flowering plants co-evolved with native pollinators and many provide excellent pollen and nectar resources for both wild pollinators and honey bees.
- Native prairies are aesthetically pleasing and provide habitat for many wildlife and game species

- A good seed mix will contain plants that host butterfly larvae (e.g., milkweeds for monarch butterflies) and bunch grasses (e.g., little bluestem) that provide nesting habitat for bees and birds.
- If shrubs or trees are desired at your site, these can be chosen to benefit pollinators as well: American basswood, willows, and many fruit trees have flowers attractive to pollinators.
- A number of native seed nurseries that provide regionally-appropriate seed and stock are available in Wisconsin and neighboring states. Seed vendors and nurseries can be found through Wisconsin DNR[9], Plant Native[10] and The Xerces Society's milkweed seed finder[11].
- Annuals can be planted in the first year for rapid establishment of floral resources and weed blocking while perennial plants get established.

Costs and benefits

In general, the more wildflower species in a seed mix, the more expensive it is. Early spring blooming species tend to be especially costly because they are rarely harvested by combines. Native seed costs can be defrayed by hand harvesting from established local prairies with the help of volunteers. Despite the upfront costs and effort, benefits of native prairie plantings can pay off in the long run with lower inputs and maintenance requirements, reduced need for mowing and herbicide use, and less erosion and stormwater runoff.

Site preparation

Methods used to prepare the site will depend on site conditions. For sites that were historically native prairie, tree and brush removal may be enough to promote flowering plants that had been suppressed by shade. Many grassland sites, including older Conservation Reserve Program (CRP) lands and right-of-ways, require more work if they were planted with low diversity grass mixes or weedy brome grass where most forbs, except the most aggressive weedy species, have a difficult time establishing.

Removing vegetation can be done through sod removal, herbicide application, or solarization. For the pros and cons of each method, see "Establishing Pollinator Meadows from Seed" from The Xerces Society[12].

Maximizing native forb establishment

Sometimes prairie restoration projects fail pollinators because grasses establish more easily and crowd out flowering forbs. There are several steps you can take to aid forb establishment:

- Forbs should be well represented in seed mixes. Ideally, choose a mix that has a 3:1 ratio of wildflower to grass, by seed count.
- Seed in the fall (October – December). Many native forbs require a period of winter dormancy before germination. Grasses do not, and will get a head start on forbs if seeded in the spring.
- Be sure to include early season forbs. Some prepackaged seed mixes are biased towards late season wildflowers.
- Diversify grasses. Include short grasses that will not shade out forbs e.g., little bluestem, side-oats grama.
- Grasses and wildflowers can be planted in separate rows. Species will intermix naturally over time.
- Do not add fertilizer to native prairie plantings. Native prairie plants don't need it, and adding fertilizer will only help weeds[13].

Ongoing maintenance and monitoring

- While seedlings are getting established weed control is necessary and irrigation may be warranted in dry years. If herbicides are used for weed control, always follow the product label exactly for application timing and dose.
- Mature prairie plantings are drought resistant, and typically require no fertilizer or pesticides[14].
- Ongoing activities like mowing, burning or grazing are necessary to prevent woody encroachment into prairies and keep habitat open[15,16].
- Preventing weed outbreaks and protecting sensitive species are proactive endeavors, and require on-the-ground knowledge. Scout the land and adjacent roadsides early in the season (May-June) for noxious weeds and, if possible, remove by hand before they spread.
- Scout for particularly sensitive or beneficial plants like wild lupine. These species can be flagged and protected from ongoing management practices.
- Whenever possible, leave fallen trees and leaf litter on site; these provide nesting habitat for bees and other wildlife, and overwintering sites for butterflies.
- How can you tell if bees like your site? Use the simple protocol[17] provided by The Xerces Society and a bee guide[18] from Michigan State University to identify bees and monitor their presence on your site.

Ongoing management: Mowing and fire

Ongoing habitat management will be most beneficial to pollinators if it maximizes bloom time of a diverse array of flowering plants throughout the growing season. The management plan for a particular site will depend on site characteristics and management goals. General recommendations include the following:

- A combination of prescribed fire and end-of-season haying are critical to stimulate flowering in many plant species. Mowing can be done in lieu of burning, but fire is a better than mowing at stimulating flowering over time.
- Avoid burning and mowing between May 15 and August 1 during key growth times for wildflowers and when grassland birds nest and fledge.

Extra precautions should be taken if:

- The site is not within 100 ft. of un-burned/un-mowed land with non-crop vegetation. Roadsides, wide fence rows, old fields, brush patches, and other vegetated areas can serve as refugia for pollinators while vegetation is temporarily disturbed in a mowed or burned site. At sites without nearby refugia, no more than 2/3 to 3/4 of the flower patch habitat should be burned, hayed, or mowed at the end of the season.
- The site contains remnant original prairie. At remnant prairie sites, no more than 1/3 of the area should be burned, hayed, or mowed at the end of the season. If endangered or threatened species are present, Wisconsin DNR incidental take protocols must be followed for the given species.

Refer to Wisconsin Natural Resources Conservation Service (NRCS) Job Sheets 388 and 389[15] and Wisconsin DNR Technical Bulletin 187[16] for more guidance on prescribed burning.

Special considerations for roadsides and other right-of-ways

Roadsides cover over 10 million acres of land in the U.S. and 150,000 acres in Wisconsin, and are sometimes the only open, sunny areas in an area providing flowers for pollinators. Roadsides supporting native plants have been found to attract butterflies and harbor more bees and more bee species than those with nonnative flowers and grasses[19,20]. Roadside ditches and bunchgrasses growing in roadsides also provide nesting and egg-laying habitat for bees and butterflies. Long, linear right-of-ways also have the potential to act as corridors for pollinator movement[20].

"Well planned, sustainable native vegetation supports transportation goals for safety and efficiency by stabilizing slopes, reinforcing infrastructure, and improving the road user's experience by creating natural beauty and diversity along the roadside."

Federal Highway Administration handbook for practitioners[30]

Roadside maintenance requires a balancing act to control erosion (see Wisconsin NR 151[21]), stop the spread of invasive weeds (see Wisconsin NR 40[22]), protect driver safety, and provide attractive vistas for drivers. Once established, native prairie plants along roadsides can fulfill all of these goals. Establishing prairie plants along roadsides raises unique challenges, but ongoing projects and research give examples for how to address them:

Issues and guidance for roadside maintenance to benefit pollinators

Issue	Potential Solution	Guidance/Reference
Plants near the road edge must tolerate road salting.	Choose salt tolerant native forb species within the salt zone of roads.	The "Native Seed Mix Design for Roadsides"[23] manual from the Minnesota DOT provides guidance for balancing pollinator benefit, salt tolerance, region, cost and other factors in choosing roadside seed mixes..
A fast green-up time is required for erosion control.	An annual cover crop (oats or winter wheat) can be seeded in the first year after planting.	
Mowing is timed to cut off seed heads of invasive species, which often coincides with bloom time for wildflowers.	Between May and August, invasive species can be spot mown and/or spot treated with herbicide, while other areas mowed in a staggered fashion after August 1.	Minnesota's Roadside Mowing Law[24] restricts roadside mowing before August 1 to the first 8 ft. adjacent to the road shoulder. Guidelines are also available for roadside wildflower programs in Ohio[25] and North Carolina[26].
Driver safety (wildlife-car collisions)	For visibility, the road shoulder (~8 ft. from road edge) can be mowed regularly, and other areas of the right-of-way mowed less frequently.	Infrequently mowed perennial vegetation may be less preferred by deer than new vegetative growth[27]. Roadside shrub plantings in Indiana harbored more birds but did not result in more roadkill than roadsides without shrubs[28].
Pollinator safety (pollinator-car collisions)	Provide plantings that offer nesting and forage opportunities along each side of the road so that bees and butterflies have less reason to cross traffic.	Prairie roadsides harbor more butterflies than weedy or grassy roadsides, yet present lower mortality risk[20]. Even on narrow edges of high-traffic roads, prairie plantings harbor more bee species than weedy roadsides[29].
Disconnect between planting implementation and long-term management.	Successful right-of-way pollinator plantings require collaboration among landowners, natural resource experts, engineers and maintenance staff/volunteers.	Communication, maintenance, budgets, schedules, and many other issues are covered in "A Manager's Guide to Roadside Vegetation Using Native Plants" from the Federal Highway Administration[30].

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APPENDIX A. PLAN CREATION, IMPLEMENTATION & EVALUATION

A diverse array of organizations and individuals are concerned about declining pollinator populations, honey bee health issues and the future of honey and crop production in Wisconsin. In late 2014, the Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP) initiated the development of the Wisconsin Pollinator Protection Plan ("plan"). Several other states have developed or are in the process of developing pollinator protection plans. At the national level, the White House Pollinator Health Task Force was created in 2014, and released a national strategy[1] for pollinator protection in May 2015.

The Wisconsin plan was developed in collaboration with the University of Wisconsin-Madison (UW) Department of Entomology, bringing together DATCP's expertise in their apiary and pesticide programs with access to the latest research in pollinator health through UW. The plan is an opportunity to support Wisconsin's agriculture, beekeeping and other industries by developing voluntary actions residents can take to protect managed and native pollinators. The plan is not a regulatory tool.

A diverse stakeholder group was assembled to provide content and guide plan development at three facilitated stakeholder meetings held August-November, 2015. Stakeholders representing a range of agricultural, governmental, tribal and non-profit organizations participated and are listed in Table A1. These meetings were open to the public, and are summarized on the DATCP Pollinator Protection webpage[2]. Goals for the stakeholder meetings included:

1. Understanding stakeholder concerns and viewpoints on pollinator health issues.
2. Identifying a voluntary set of actions that Wisconsin residents, businesses, non-governmental organizations and agencies can take to protect pollinators.
3. Increasing communication among stakeholder groups.

The role of each stakeholder was to be a liaison between the entire stakeholder meeting group and their constituents. Stakeholders demonstrated a strong commitment to communicate the evolving plan content with the individuals or organizations he/she represented. This included soliciting feedback from those individuals and organizations to complete a two-way flow of information. Edits and comments on the draft plan were incorporated into subsequent revisions.

An official public review period was held in January 2016. [Enter summary of comments received here]

Table A1. Pollinator Protection Plan Stakeholder Group (Names in parentheses indicate invited stakeholders who were unable to attend meetings)

Organization	Representative
American Transmission Company	Johanna Sievewright
Butterfly Gardens of Wisconsin	Jack Voight, Larry Cain
Commercial Beekeeper	Doug Hauke
Cooperative Network	John Manske
CropLife America	Amy Winters
US Environmental Protection Agency	Dan Hopkins
Gathering Waters: Wisconsin's Alliance for Land Trusts	Meg Domroese (Mike Carlson)
The IPM Institute of North America	Thomas Green
Menominee Tribal Enterprises	(David L. Mausel)
Midwest Organic and Sustainable Education Service	(Harriet Behar)
Pheasants Forever - Dane County Chapter	Erin Holmes (Adam Hanson)
St. Croix Tribal Environmental Services	(Jon Knight)
Stockbridge-Munsee Community	Randall Wollenhaup (Jo Ann Schedler)
Syngenta Crop Protection LLC	David Flakne
US Fish and Wildlife Service	Kurt Waterstradt
USDA-Natural Resources Conservation Service	Steve Bertjens
University of Wisconsin Extension Specialist	Russell Groves (Christelle Guédot)
University of Wisconsin Extension (Facilitator)	John Exo
University of Wisconsin, Madison	Christina Locke
Wisconsin Agribusiness Association	Mike Dummer
Wisconsin Apple Growers Association	Sara Ecker
Wisconsin Farm Bureau	Karen Gefvert
Wisconsin Green Industry Federation	Brian Swingle, Brad DeBels, Ed Knapton
Wisconsin Honey Producers Association	Gordon Waller
Wisconsin Pest Control Association	Mike Werner
Wisconsin Potato and Vegetable Growers Association	Andy Wallendal
Wisconsin State Cranberry Growers Association	Tom Lochner
Wisconsin Dept. of Agriculture	Liz Meils, Mike Murray
Wisconsin Dept. of Natural Resources	Jay Watson, Rich Henderson
Wisconsin Dept. of Transportation	Christa Wollenzien
The Xerces Society for Invertebrate Conservation	Thelma Heidel-Baker (Sarah Foltz Jordan)

Evaluating the impact of the plan

This plan is meant to be an educational tool. The most fundamental way to measure its impact is to track its reach. How many residents and organizations have read it? How is it being used? Implementing the plan is not something any one person, organization or industry can do alone. DATCP will house the plan, but advertising the plan and putting it to use will take broad motivation and participation across and within organizations. The plan is meant as a starting point for action; the information it contains can be summarized and tailored for specific projects. Stakeholders provided the following ideas for metrics to track plan dissemination and use:

- Behavioral surveys – measure plan use and behavioral change pre / post plan release
- Track website hits and calls to DATCP regarding plan.
- Track the number of organizations, agencies, residents and others plus what programs (e.g. Conservation Reserve Program (CRP)) are using plan recommendations.
- Survey readers on how the plan content improves their knowledge of pollinator health issues.
- Develop and record an annual that organizations can use annually at growers' conferences.

Evaluating progress toward pollinator health goals

The plan outlines these goals for pollinator protection:

1. Expand the quality and quantity of habitat for managed and wild pollinators
2. Minimize stressors on managed and wild pollinators
3. Increase managed bee hive health and survival
4. Outreach (Spread the word on pollinator friendly practices)

Because this plan is voluntary and directed at a broad array of audiences, the outcomes of its recommendations are not easily tracked. Our collective actions will determine how successful these plan concepts are realized, and ultimately contribute to the future health of managed and wild pollinators. Table A2 lists ideas for measuring progress toward pollinator health goals, provided by the stakeholder group.

Table A2. Suggested metrics and strategies for measuring pollinator health outcomes

Type of outcome measured	Suggested metric/strategy
Direct measure of pollinator health	Track honey bee health and colony loss: • Hive health checklist via statewide inspection • Bee Informed surveys for colony loss • Expand the NASS survey on managed bees/honey production • Start a Bee Informed Tech Team in Wisconsin – like those started by Project Apis m. (grant funded)
Direct measure of pollinator health	Long-term monitoring research to track wild pollinator populations (collaborative effort).
Habitat	Identify where pollinator habitat is currently and monitor over time.
Habitat	Track acres of pollinator-friendly plantings along highway rights-of-way. DOT could monitor.
Habitat	Track acres of pollinator friendly plants in Conservation Reserve Program and other private land programs.
Habitat/Outreach	Work with specific landowners or land mangers as a pilot program.
Habitat/Outreach	Identify and offer incentives for "whole-farm" conservation planning.
Habitat/Outreach	Work with homeowners planting pollinator friendly plants.
Habitat/Outreach	Work with organizations advocating/planting pollinator friendly plants, e.g., Master Gardeners.
Outreach	Develop a baseline evaluation tool that could be used on a county or regional basis to evaluate education/awareness every 3-10 years. Gather current and new partners to apply for grant funding.
Outreach	Increase participation of large operators in Bee Informed surveys (large operators underrepresented in current surveys).
Capacity	Increase the Wisconsin apiary program's capacity to monitor and inspect more hives statewide. Promote hive registration to better track hive movement in and out of state.

Stakeholders recognized that some metrics will be easier to measure than others, while some may fall outside the normal job duties of any one organization. Further considerations and questions brought up by stakeholders include:

- We need research to determine if BMPs work (cause and effect).
- Any measurement should consider regional variation, e.g., northern vs. southern Wisconsin.
- Centralize information collected by individual groups in one place
- How do we know we have a problem and what the causes are?
- Will increasing habitat solve the problem(s)?
- What is the most valuable success outcome of the plan? (e.g. The number of bees? The number of people reached?)
- Highlight success stories in future plan iterations
- Staff time and resources needed

These are important points to consider as opportunities arise to define and address pollinator issues, and to evaluate strategies to improve pollinator health. Meaningful ways to measure pollinator health and define success are avenues of thought that will continue to be processed among DATCP and stakeholder groups.

Plan revisions

The stakeholder group identified the need to keep the plan current. As new research becomes available to address the present-day gaps in knowledge, the intent is to update plan content as necessary. While DATCP will host the plan and assist the stakeholders with outreach, DATCP does not intend on maintaining the plan alone. We envision DATCP acting as a link between the stakeholders going forward. When the time comes for revising the plan, DATCP will work with the stakeholders to determine the course of action. Recommendations for ongoing activities included:

- For the first year, tally public comments and feedback, keep it a working document
- Annually, ask stakeholder group for updates/comments/discussion – online or in person
- In addition to annual meetings, check in as needed for one-time issues (e.g., if the monarch butterfly or rusty-patched bumble bee is listed as an endangered species)
- Make updates as new science emerges
- Add success stories of pollinator protection in Wisconsin
- Collect feedback from other states with plans
- Potential to develop group-specific BMPs and share with stakeholders

Document Revision History		
Revision Date	**Author/Affiliation**	**Description of Changes**
11/12/2015	DATCP, UW Madison & Stakeholders	First draft sent to stakeholders
12/14/2015	DATCP, UW Madison & Stakeholders	Stakeholder input incorporated
		Draft made available for public comment

References

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[1] White House Pollinator Health Task Force. May 2015. "National strategy to promote the health of honey bees and other pollinators." www.whitehouse.gov/sites/default/files/microsites/ostp/Pollinator%20Health%20Strategy%202015.pdf

[2] Wisconsin DATCP. Pollinator Protection in Wisconsin. http://datcp.wi.gov/Farms/Bees_and_Honey/?Id=225