Lesley Ingram, Bugwood.org

THE WISCONSIN POLLINATOR PROTECTION PLAN

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

Give us your feedback on the plan with this 5 minute survey:
https://www.surveymonkey.com/r/MLGFGVV

DEPARTMENT OF AGRICULTURE, TRADE AND CONSUMER PROTECTION
FORWARD
WISCONSIN

April 2016

Acknowledgements

We thank all the stakeholders listed in Appendix A for their helpful input, and John Exo, UW-Extension, for facilitating stakeholder meetings. Additional thanks for support from the Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP): Robby Personette, Pesticide, Feed and Fertilizer Section Chief for the Bureau of Agrichemical Management; Shahla Werner, Plant Protection Section Chief for the Plant Industry Bureau; and Christopher Deegan, former Plant Protection Section Chief for the Plant Industry Bureau. Design by Laurie Lawrence, DATCP Art Director. The development of this plan was made possible by a USDA Specialty Crop Block Grant SCBG 14-005.

Authors

Christina Locke – Research Associate,
University of Wisconsin – Madison, Department of Entomology

Elizabeth Meils – State Apiarist,
Wisconsin Department of Agriculture, Trade and Consumer Protection

Michael Murray – Pesticide Program Manager,
Wisconsin Department of Agriculture, Trade and Consumer Protection

Steering Committee

Lori Bowman – Director, Bureau of Agrichemical Management,
Wisconsin Department of Agriculture, Trade and Consumer Protection

Claudio Gratton – Professor,
University of Wisconsin – Madison, Department of Entomology

Brian Kuhn – Director, Plant Industry Bureau,
Wisconsin Department of Agriculture, Trade and Consumer Protection

Photo and figure credits

Table of Contents

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. The department encourages the sharing of new ideas 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, moths, 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 and 400 in Wisconsin[3]. 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]. State endangered butterflies and moths include the northern blue butterfly (*Lycaeides idas*), the regal fritillary (*Speyeria idalia*), the Phlox moth (*Schinia indiana*), and several others[15]. For the vast majority of 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

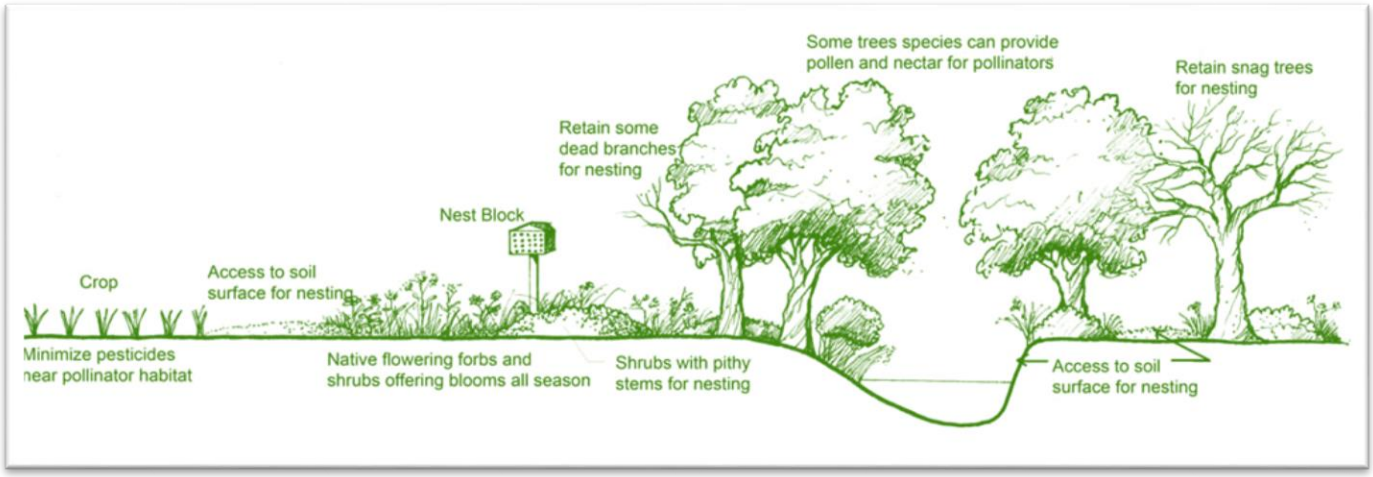
Pollinator habitat needs differ by species, but one thing all pollinators require is blooming, pollen- and nectar-bearing flowers throughout their lifetimes. Pollinators also need places to nest or lay eggs, feed as larvae, and overwinter. Whereas honey bee nests are provided by beekeepers, wild bees 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[16]. 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[17,18,19,20]. 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[21], e.g., 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[17].

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 these landscapes 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."



Bees and other pollinators require habitat for both nesting and feeding.

Parasites & Pathogens

The invasive *Varroa* mite (*Varroa destructor*) appears to be the main culprit in pathogen-related honey bee colony loss[22]. Not only does the mite weaken honey bees by feeding on their blood (hemolymph), mites can transfer a number of debilitating pathogens like deformed wing virus (DWV) and Israeli acute paralysis virus (IAPV). The mite's original host is the Asiatic honey bee (*Apis cerana*) but it now proliferates in European honey bee colonies and since the 1950s has been transported globally. The Asiatic honey bee displays grooming behavior that effectively combs off and kills the mites[23], 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[24]. 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[25], while IAPV and the fungal parasite *Nosema* passed from bumble bees to honey bees and vice versa[26,27].

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 use of pesticides can affect pollinator health. Pesticide label directions are regulated by the Environmental Protection Agency (EPA)[28]. These label restrictions are intended to reduce risk to humans, other organisms and the environment. Many pesticide labels include specific language related to honey bees and pollinators. 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[29]. 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[30] and lawn weeds[31] treated with typical doses of systemic insecticides. Some classes of systemic insecticides, such as neonicotinoids, are **persistent** and can remain in soil (and taken up by vegetation) for weeks to months after treated seed is planted[32].

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[33] and some fungicide-insecticide mixtures appear to be more detrimental to honey bees than either pesticide alone[34]. Miticides and fungicides used in honey bee hive management can build up in pollen, honey and wax[35]. 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[36].

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**)[37]. 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 IPM 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[38]:

- 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

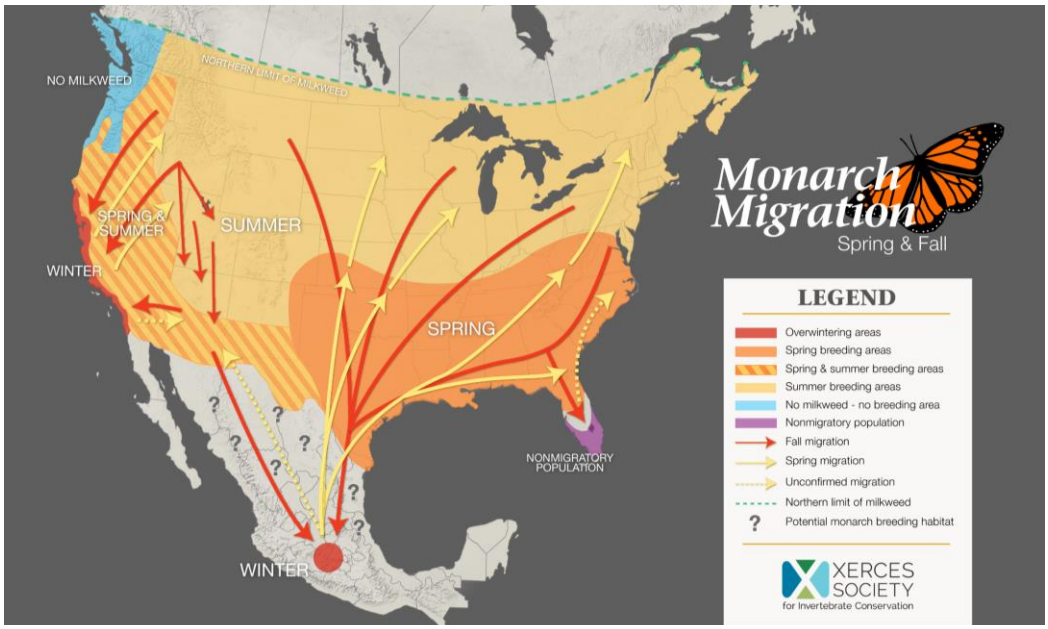
Good beekeeping practices can ensure managed bees have adequate sources of food and water while minimizing the spread of disease among nearby hives and wild pollinator populations. Beekeepers decide where to place hives based on a number of factors: nutritional quality of flowering plants in the area,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

Pest and pathogen concerns in beekeeping heightened in the 1980s when the *Varroa* mite was introduced to the United States. Effectively managing mites and pathogens in honey bee colonies is crucial for controlling disease spread among hives and from hives to wild pollinator populations, but treatments must be chosen carefully to minimize harm to colonies. Treating hives with pesticides or antibiotics can disturb the complex community of beneficial microbes that aid bee digestion, immune function, and larval development. It is therefore important to treat only after hive ailments are accurately diagnosed.

Extreme Weather

Annual surveys of honey bees and monarch butterflies show that some of the most significant population losses follow harsh seasons or extreme weather events. Unlike other bee species, honey bees overwinter as adults. Each honey bee colony needs at least 60 to 90 pounds of honey to survive a moderate winter[39], and starvation may result from inadequate honey stores if colonies are not provided supplemental feed. Migratory monarch butterflies also overwinter as adults, most congregating in a small area in central Mexico where they roost in trees. Extreme winter storms in this area can decimate the

monarch population, necessitating many generations to recover from such a setback. Monarchs are sensitive to large temperature fluctuations; they cannot survive consistent temperatures below freezing, but may use up their fat stores before spring migration if winter temperatures are too warm[40]. In the summer, droughts can adversely affect all pollinators by limiting the availability of nectar-producing flowers.



Wisconsin is home to migratory monarch butterflies in summer and fall.

References

---

[1] Ollerton, J., et al. 2011. "How many flowering plants are pollinated by animals?." *Oikos* 120.3: 321-326.

[2] Klein, A., et al. 2007. "Importance of pollinators in changing landscapes for world crops." *Proceedings of the Royal Society of London B: Biological Sciences* 274.1608: 303-313.

[3] Ascher, J. S. and J. Pickering. 2015. Discover Life bee species guide and world checklist (Hymenoptera: Apoidea: Anthophila). www.discoverlife.org

[4] Mader, Eric, Marla Spivak, and Elaine Evans. 2010. "Managing Alternative Pollinators : A Handbook for Beekeepers, Growers and Conservationists." http://www.sare.org/Learning-Center/Books/Managing-Alternative-Pollinators

[5] Kleijn, D., et al. 2015. “Delivery of crop pollination services is an insufficient argument for wild pollinator conservation.” *Nature Communications*, *6*.

[6] Garibaldi, L.A., et al. 2013. "Wild pollinators enhance fruit set of crops regardless of honey bee abundance." *Science* 339.6127: 1608-1611.

[7] Mallinger, R.E., and C. Gratton. 2015. "Species richness of wild bees, but not the use of managed honeybees, increases fruit set of a pollinator- dependent crop." *Journal of Applied Ecology* 52.2: 323-330.

[8] U.S. Department of Agriculture, Economic Research Service. 2014. “Annual Cash Receipts by Commodity, U.S. and States.” http://www.ers.usda.gov/data-products/farm-income-and-wealth-statistics/

[9] Potts, S.G., et al. 2010. "Global pollinator declines: trends, impacts and drivers." *Trends in Ecology & Evolution* 25.6: 345-353.

[10] Steinhauer, N., et al.; for the Bee Informed Partnership. 2015. “Colony Loss 2014 – 2015: Preliminary Results.” https://beeinformed.org/

[11] USDA National Agriculture Statistics Service. March 2015. “Wisconsin Ag News – Honey.” http://www.nass.usda.gov/Statistics_by_State/Wisconsin/Publications/Livestock/2015/WI_Honey_03_15.pdf

[12] Cameron, S. A., et al. 2011. Patterns of widespread decline in North American bumble bees. *Proceedings of the National Academy of Sciences*, *108*(2), 662–667.

[13] U.S. Fish & Wildlife Service. Endangered Species. http://www.fws.gov/midwest/endangered/insects/kbb/index.html

[14] Wells, S., et al. 1983. “The IUCN invertebrate red data book.” Gland, Switzerland: International Union for Conservation of Nature and Natural Resources.

[15] Wisconsin Dept. of Natural Resources list of endangered and threatened species: http://dnr.wi.gov/topic/EndangeredResources/ETList.html

[16] Zurbuchen, A., et al. 2010. Maximum foraging ranges in solitary bees: only few individuals have the capability to cover long foraging distances. *Biological Conservation*, *143*(3), 669–676.

[17] Lowenstein, D., et al. 2014. "Humans, bees, and pollination services in the city: the case of Chicago, IL (USA)." *Biodiversity and conservation* 23.11: 2857-2874.

[18] Hopwood, J. 2008. "The contribution of roadside grassland restorations to native bee conservation." *Biological Conservation* 141.10: 2632-2640.

[19] Garibaldi, L.A., et al. 2014. From research to action: enhancing crop yield through wild pollinators. Frontiers in Ecology and the Environment, 12(8), 439–447.

[20] Ebeling, A., et al. 2008. "How does plant richness affect pollinator richness and temporal stability of flower visits?." *Oikos* 117.12: 1808-1815.

[21] Klein, Alexandra-Maria, et al. 2007. "Importance of pollinators in changing landscapes for world crops." *Proceedings of the Royal Society of London B: Biological Sciences* 274.1608: 303-313.

[22] Manley, R., et al. 2015. "Emerging viral disease risk to pollinating insects: ecological, evolutionary and anthropogenic factors." *Journal of Applied Ecology* 52.2: 331-340.

[23] Peng, Y., et al. 1987. "The resistance mechanism of the Asian honey bee, Apis cerana Fabr., to an ectoparasitic mite, Varroa jacobsoni Oudemans."*Journal of Invertebrate Pathology* 49.1: 54-60.

[24] Manley, R., et al. 2015. "Emerging viral disease risk to pollinating insects: ecological, evolutionary and anthropogenic factors." *Journal of Applied Ecology* 52.2: 331-340.

[25] Durrer, S., and P. Schmid-Hempel. 1994. "Shared use of flowers leads to horizontal pathogen transmission." *Proceedings of the Royal Society of London B: Biological Sciences* 258.1353: 299-302.

[26] Graystock, P., et al. 2015. "Parasites in bloom: flowers aid dispersal and transmission of pollinator parasites within and between bee species." *Proc. R. Soc. B*. Vol. 282. No. 1813. The Royal Society.

[27] Singh, R. et al. 2010. RNA viruses in hymenopteran pollinators: evidence of inter-taxa virus transmission via pollen and potential impact on non-Apis hymenopteran species. PLoS ONE 5, e14357.

[28] EPA Pollinator Protection website: https://www.epa.gov/pollinator-protection

[29] Zhu, Y.C., et al. 2015. "Spray toxicity and risk potential of 42 commonly used formulations of row crop pesticides to adult honey bees (Hymenoptera: Apidae)." *Journal of economic entomology*: tov269.

[30] Rundlöf, M., et al. 2015. "Seed coating with a neonicotinoid insecticide negatively affects wild bees." *Nature* 521.7550: 77-80.

[31] Larson, J., et al. 2013. “Assessing insecticide hazard to bumble bees foraging on flowering weeds in treated lawns.” PloS One. DOI: 10.1371/journal.pone.0066375

[32] Goulson, D. 2013. "Review: An overview of the environmental risks posed by neonicotinoid insecticides." *Journal of Applied Ecology* 50.4: 977-987.

[33] Pettis, J. S., et al. 2013. Crop pollination exposes honey bees to pesticides which alters their susceptibility to the gut pathogen Nosema ceranae. *PLoS One*, *8*(7), e70182.

[34] Iwasa, T., et al. 2004. "Mechanism for the differential toxicity of neonicotinoid insecticides in the honey bee, Apis mellifera." *Crop Protection* 23.5: 371-378.

[35] Mullin, C., et al. 2010. "High levels of miticides and agrochemicals in North American apiaries: implications for honey bee health." *PLoS one* 5.3: e9754.

[36] Pleasants, J., and K. Oberhauser. 2013. "Milkweed loss in agricultural fields because of herbicide use: effect on the monarch butterfly population." *Insect Conservation and Diversity* 6.2: 135-144.

[37] Zehnder, G., et al. 2007. Arthropod pest management in organic crops. Annual Review of Entomology 52:57–80.

[38] University of California, Davis. “What is Integrated Pest Management (IPM)? http://www.ipm.ucdavis.edu/GENERAL/whatisipm.html

[39] Standifer, L.N. 1978. "Supplemental feeding of honey bee colonies." Agricultural Information Bulletin no. 413. http://naldc.nal.usda.gov/download/CAT87209984/PDF

[40] Masters, A., et al. 1988. "Monarch butterfly (Danaus plexippus) thermoregulatory behavior and adaptations for overwintering in Mexico." *Ecology*: 458-467.

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 these 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

Reference

---

[1] Garibaldi, L.A., et al. 2013. "Wild pollinators enhance fruit set of crops regardless of honey bee abundance." *Science* 339.6127: 1608-1611.

Joseph LaForest, UGA, Bugwood.org

THE WISCONSIN POLLINATOR PROTECTION PLAN

BEST MANAGEMENT PRACTICES FOR

Improving Pollinator Habitat in Gardens & Lawns

Give us your feedback on the plan with this 5 minute survey:
https://www.surveymonkey.com/r/MLGFGVV

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[3], 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[4], Pollinator Partnership[5], and Michigan State University Extension[6]. To find a nursery or seed source, see lists provided by the Wisconsin Department of Natural Resources (DNR)[7], Plant Native[8] and The Xerces Society[9].

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**[11], 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[12,13] and support more butterfly and bird species[14,15] 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 13 species of milkweed native to Wisconsin[10]. 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[9].

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. If it is difficult to see pollen-carrying anthers in the center of a flower, it may be a poor choice 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.
- **If local ordinances allow it, 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 plant 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[16]. Wooden bumble bee boxes tend to have very low success rates[17]. For more information see “Providing Nest Sites for Pollinators”[18] from The Xerces Society.

Blooming “bee lawns”

- If local ordinances allow it, let dandelions, clover and other flowering lawn plants 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, 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[19].

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[20] 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[21,22]. A helpful online tool[23] 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[24], and may persist in soil for weeks to months[25]. 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.
- Rotate pesticide types and modes of action to avoid pesticide resistance. Repeated use of the same pesticide increases the likelihood of pesticide resistance, eventually rendering treatment ineffectual.

Swarm and nest management

Honey bees swarm when a queen leaves the hive and moves to a new location with a group of worker bees. Do not confuse a honey bee swarm with a wasp nest; wasps do not swarm, though they may feed in groups or congregate if they are blocked from entering their nests. If you see what looks like a swarm:

Honey bee swarm

1. Verify the insects are honey bees and not wasps[26].
2. If what you have is a honey bee swarm, a local beekeeper will often be willing to remove it. Beekeepers can be found through Bee Removal Source[27] or Wisconsin Honey Producers[28].
3. If swarm removal is not possible or if you have wasps, the Wisconsin Pest Control Association website[29] has a list of businesses that may offer assistance.
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 Friends groups or other local organizations
- Become adept at distinguishing honey bees, solitary bees, wasps and flies[30]
- 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

References

[1] Ollerton, J., et al. 2011. "How many flowering plants are pollinated by animals?." *Oikos* 120.3: 321-326.

[2] Klein, Alexandra-Maria, et al. 2007. "Importance of pollinators in changing landscapes for world crops." *Proceedings of the Royal Society of London B: Biological Sciences* 274.1608: 303-313.

[3] Ascher, J. S. and J. Pickering. 2015. Discover Life bee species guide and world checklist (Hymenoptera: Apoidea: Anthophila). www.discoverlife.org

[4] The Xerces Society pollinator plant lists: http://www.xerces.org/providing-wildflowers-for-pollinators/

[5] Pollinator Partnership regional planting guides – use the "Eastern Broadleaf Forest Continental" guide for southern Wisc. and the "Laurentian Mixed Forest" guide for northern Wisc. http://pollinator.org/guides.htm

[6] Michigan State University Extension. October 2015. "Bees of the Great Lakes Region and Wildflowers to Support Them." Guide for identifying bees and wildflower planting guidelines. http://shop.msu.edu/product_p/bulletin-e3282.htm

[7] Wisconsin DNR list of native plant nurseries: http://dnr.wi.gov/files/pdf/pubs/er/er0698.pdf

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

[9] The Xerces Society list of vendors providing milkweed seed: http://www.xerces.org/milkweed-seed-finder/

[10] Wisflora: Wisconsin Vascular Plant Species: http://www.botany.wisc.edu/herb/

[11] The Wisconsin Dept. of Natural Resources list of invasive plant species: http://dnr.wi.gov/topic/Invasives/species.asp?filterBy=Terrestrial&filterVal=Y

[12] Tonietto, R., et al. 2011. "A comparison of bee communities of Chicago green roofs, parks and prairies." *Landscape and Urban Planning* 103.1: 102-108.

[13] Frankie, G., et al. 2005. "Ecological patterns of bees and their host ornamental flowers in two northern California cities." *Journal of the Kansas Entomological Society* 78.3: 227-246.

[14] Tallamy, D., and K. Shropshire. 2009. "Ranking lepidopteran use of native versus introduced plants." *Conservation Biology* 23.4: 941-947.

[15] Burghardt, K.T., et al. 2009. "Impact of native plants on bird and butterfly biodiversity in suburban landscapes." *Conservation Biology* 23.1: 219-224.

[16] MacIvor, J. Scott, and Laurence Packer. 2015. "'Bee hotels' as tools for native pollinator conservation: a premature verdict?." *PloS one* 10.3: e0122126.

[17] Lye, G.C., et al. 2011. Assessing the efficacy of artificial domiciles for bumble bees. Journal for Nature Conservation 19: 154-160.

[18] The Xerces Society guide for providing nesting habitat: http://www.xerces.org/providing-nest-sites-for-pollinators/

[19] Larson, J., et al. 2013. "Assessing insecticide hazard to bumble bees foraging on flowering weeds in treated lawns." PloS One. DOI: 10.1371/journal.pone.0066375

[20] University of Wisconsin – Extension Horticulture. Diagnostic lab and identification tools: http://hort.uwex.edu/diagnostic-labs-and-identification-tools/

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

[22] The Xerces Society list of garden products containing neonicotinoid insecticides: http://www.xerces.org/wings-magazine/neonicotinoids-in-your-garden/

[23] University of California Statewide Integrated Pest Management Program. "Bee precaution pesticide rating" online tool: http://www2.ipm.ucanr.edu/beeprecaution/

[24] Krischik, Vera A., et al. 2007. "Soil-applied imidacloprid is translocated to nectar and kills nectar-feeding Anagyrus pseudococci (Girault)(Hymenoptera: Encyrtidae)." *Environmental Entomology*36.5: 1238-1245.

[25] Goulson, Dave. 2013. "Review: An overview of the environmental risks posed by neonicotinoid insecticides." *Journal of Applied Ecology* 50.4: 977-987.

[26] 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

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

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

[29] Wisconsin Pest Control Association: http://wisconsinpest.com/

[30] 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

Give us your feedback on the plan with this 5 minute survey:
https://www.surveymonkey.com/r/MLGFGVV

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 across state lines 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. 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 area 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. Small, healthy colonies can be combined, and queens with low fertility can be replaced with young queens, 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 fed to bees before winter. Sucrose supplement (syrup or candy) can be applied in late winter or spring if honey stores are light. 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. Supplemental feeding with honey from an external source has been linked to disease spread.
- Keep the hive dry. Add ventilation near the top of the hive so humid air can escape.
- Keep the hive insulated and sheltered. Add insulation to the top of the hive, and keep the hive behind a windbreak and/or in a south facing location for the winter.
- Add 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[3,4]. 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[5]. The Wisconsin DATCP apiary program[6] 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[7]. Disease diagnostic services are also available free of charge through the USDA Beltsville Bee Lab[8]. Read and follow all product label directions carefully when applying any disease or mite control products in beehives.
- Monitor for *Varroa* mite. *Varroa* mites weaken honey bees by feeding on their blood (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 3-5 mites per 100 bees sampled. Visit the WDATCP Apiary webpage[9] for a list of current treatment options.
- Monitor for *Nosema* fungal pathogens. To check for *Nosema*, gut spores should be counted under a microscope; gut spore count > 1 million per bee warrants treatment.
- Monitor 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[10].
    - If foulbrood is suspected, contact the State Apiarist[6].
    - Foulbrood spores can remain viable for 40 years or more; burning the infected combs 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[8] provides bee and comb testing for antibiotic resistance.
- Minimize pesticide use in hives. Pesticides added to the hive can accumulate in pollen, wax and honey[11]. 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 pathogen buildup.

Communication with growers and neighbors

- Maintain positive and open relationships with growers who lease your hives for pollination.
- Negotiate a pollination 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[12] 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).
- Use a contract that protects both the grower and beekeeper. A template contract based on USDA guidelines is provided by University of Florida Extension[13].
- 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 FieldWatch?

FieldWatch[14] 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 crop pollination and solitary mason bee species (*Osmia spp.*) are used in orchard crops. Bumble bees are not affected by *Varroa* mite, but disease spread from managed bumble bees to wild bee populations is an issue[17,18]. See “Managing Alternative Pollinators” [19] 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[20]. 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.

Note that these results describe correlations, and *cannot be used to show that certain practices cause or prevent loss.*

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 Leasing colonies

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

Additional support

Organizations:

Wisconsin DATCP webpage with links to beekeepers' organizations: https://datcp.wi.gov/Pages/Programs_Services/ApiaryLinks.aspx

Local chapters of Wisconsin Honey Producers Association: 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

References

[1] Pollinator Partnership regional planting guides – use the “Eastern Broadleaf Forest Continental” guide for southern Wisc. and the “Laurentian Mixed Forest” guide for northern Wisc. http://pollinator.org/guides.htm

[2] The Xerces Society plant lists. http://www.xerces.org/pollinator-conservation/plant-lists/

[3] Colla, S. R., et al. 2006. Plight of the bumble bee: pathogen spillover from commercial to wild populations. *Biological Conservation*, *129*(4), 461–467.

[4] Graystock, Peter, et al. 2015. "Parasites in bloom: flowers aid dispersal and transmission of pollinator parasites within and between bee species." *Proc. R. Soc. B*. Vol. 282. No. 1813. The Royal Society.

[5] Example hive inspection sheet from Dadant & Sons, Inc.: http://pemibakerba.org/wp-content/uploads/2012/08/Hive-Inspection-Sheet.pdf

[6] 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

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

[8] The USDA Beltsville Bee lab can test bees and comb for diseases and antibiotic resistance: http://www.ars.usda.gov/Services/docs.htm?docid=7473

[9] Wisconsin DATCP Apiary Program. “Pest & Disease Management of Honey Bees” https://datcp.wi.gov/Pages/Programs_Services/PestsDiseaseMgmtHoneyBees.aspx

[10] De Graaf, D.C., et al. 2006. “Diagnosis of American foulbrood in honey bees: a synthesis and proposed analytical protocols.” Letters in Applied Microbiology. http://naldc.nal.usda.gov/download/28123/PDF

[11] Mullin, Christopher, et al. 2010. "High levels of miticides and agrochemicals in North American apiaries: implications for honey bee health." *PLoS one* 5.3: e9754.

[12] University of California Statewide Integrated Pest Management Program. “Bee precaution pesticide rating” online tool: http://www2.ipm.ucanr.edu/beeprecaution/

[13] 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

[14] FieldWatch, DriftWatch and BeeCheck voluntary mapping tools: http://www.driftwatch.org/

[15] Wisconsin DATCP Apiary Program. “Wisconsin Honey Bee Import Report.” https://datcp.wi.gov/Pages/Programs_Services/MovingBeesintoWI.aspx

[16] Apiary Inspectors of America. “Laws and Regulations.” http://www.apiaryinspectors.org/laws/index.html

[17] Morkeski, A. and A.L. Averill. 2010. “Managed pollinator CAP-coordinated agricultural project: Wild bee status and evidence for pathogen ’spillover’ with honey bees”. American Bee Journal. http://www.beeccdcap.uga.edu/documents/CAPArticle11.html

[18] Otterstatter, M.C., and J.D. Thomson. 2008. "Does pathogen spillover from commercially reared bumble bees threaten wild pollinators?." *PLoS One*3.7: e2771.

[19] Mader, Eric, Marla Spivak, and Elaine Evans. 2010. "Managing Alternative Pollinators : A Handbook for Beekeepers, Growers and Conservationists." http://www.sare.org/Learning-Center/Books/Managing-Alternative-Pollinators

[20] Bee Informed Partnership annual beekeeper survey results. https://beeinformed.org/results/

Thelma Heidel-Baker, The Xerces Society

THE WISCONSIN POLLINATOR PROTECTION PLAN

BEST MANAGEMENT PRACTICES FOR

Maximizing Pollinator Health & Pollination Services on Farms

Give us your feedback on the plan with this 5 minute survey:
https://www.surveymonkey.com/r/MLGFGVV

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 <u>all</u> 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 and/or habitat for game species and other wildlife.

Contribution of pollinators to crop yields

- Many crops have significantly higher yields when bees are present. These include apple, strawberry[3], soybean[4], cranberry[5], tart cherry[6], green bean[7], raspberry, cucumber and tomato.
- Pasture plants like clover and alfalfa require insect pollinators for successful seed set.
- 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:

- Higher flower visitation rates.
- Larger and hairier bodies.
- Longer foraging hours and tendency to forage earlier in the day when day-opening flowers are most fertile.
- Tendency to switch among crop rows (good for crops like apple that require cross-pollination).
- Ability to release pollen from tubelike flowers-- like tomato and cranberry--by vibrating at a certain frequency ("buzz pollination"). Honey bees cannot do this.

Honey bee

Bumble bee

Pollinator dependent crops have higher visitation rates when more pollinator **<u>species</u>** are present; 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[9], so there is great potential for boosting bee diversity and 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[10]. Habitat diversity is one reason many apple growers in Wisconsin get their pollination services from wild bees without having to rent honey bees[11].

For farms that are not near natural areas, attracting pollinators depends heavily on on-farm management practices[16]. A global study of 39 crops found that bee abundance was 76% higher in "diversified" fields – those with mixed crop types, or that had hedgerows or flower strips at the margin – than in monoculture fields[17]. In a Michigan study, wildflower strips planted adjacent to blueberry fields paid for themselves after four years due to a boost in crop yield[18]. Pollinator benefits of on- and off- field management practices are summarized below. Costs and benefits of these practices to the grower will depend on the type of crop grown (pollinator-dependent or not) and grower goals and values.

Beneficial Practices for Pollinators

Location of Practice	Management Practice[12]	Potential Benefits
Outside crop fields	Leave existing nesting habitat (dead wood, bare patches of soil, hollow stems, bunch grasses)	Pollinator communities can be maintained long-term if nesting habitat is located near flowering crops.
	Add wildflower strips or flowering hedgerows on slopes, field margins or roadside ditches	Higher yields of adjacent pollinator-dependent crops. Prairie strips can be configured to prevent loss of water, soil and nutrients from crop fields[13].
Within crop fields	Use pollinator attractive plants for intercropping or cover cropping	Higher yields of adjacent pollinator-dependent crops.
	Grow multiple types of blooming crops	Increased pollinator health and diversity; higher yields of pollinator-dependent crops; diversified income streams.
	Reduce tillage intensity	Shallower tilling and leaving margins untilled may be beneficial for bees nesting in crop fields and margins[14].
Within and outside crop fields	Minimize pesticide use	Minimizing the use of pesticides can reduce negative effects on beneficial species including pollinators.
	Change mowing or haying practices	Pollinators benefit when flowering plants are allowed to bloom in field margins or between crop rows (particularly when crop is not blooming).
	Reduce field size	Increased crop pollination when flowering crop plants are nearer to bees nesting in field margins.
Pastures	Incorporate legumes into pastures. Rotate grazing so that some paddocks allowed to fully bloom.	Blooming forage crops like clovers can increase pasture production while benefitting both grazers and pollinators[15].

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[19]. Funding and information may also be available through the programs listed below. Your local Farm Bill biologist[20] and land conservation staff[21] can help determine your eligibility for these and other programs.

Landowner Programs:

- Wisconsin Department of Natural Resources (DNR) Landowner Incentive Program (LIP)[24]
- United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Environmental Quality Incentives Program (EQIP)[25]
- USDA NRCS Conservation Reserve Program (CRP)[26] and Conservation Reserve Enhancement Program (CREP)[27]
- USDA NRCS Conservation Stewardship Program (CSP)[28]
- US Fish and Wildlife Service Partners programs[29]

Other organizations involved in habitat restoration:

- Healthy Grown Potatoes[30]
- Pheasants Forever[31]

Compensating for milkweed loss

Monarch butterfly population estimates for 2015 are 80% below their 20-year average[22]. 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 13 species of milkweed native to Wisconsin[23]. 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 the difficult challenge of minimizing crop pests while attracting beneficial insects like pollinators and pest predators. Cautious pesticide use is advised to avoid pest resistance and protect the health of beneficial insects and other non-target organisms:

- 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 needed. Incorporate preventative management options such as resistant crop varieties and cultural control practices.
- Heed pesticide labels that say "highly toxic to bees," "toxic to bees" or "extended residual toxicity".

- To help choose products that are less toxic to pollinators, refer to the "Bee precaution pesticide rating" online tool[32] from University of California Integrated Pest Management Program (UC IPM). Also see EPA's "Information on Residue Toxicity Times."[33] Take equal caution using pesticides approved for use in organic agriculture; these are not necessarily safe for 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. Spraying at night may avoid some harm to pollinators, but can still affect beneficial organisms; some predators of crop pests are most active at night.
- Keep in mind that systemic insecticides applied as soil or seed treatment can remain in plants for extended periods of time, and may be present in the pollen or nectar even if the insecticide is applied prior to bloom.
- Avoid using seed treated with pesticides unless a pest problem has been diagnosed. If treated seed is used:
  - 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[34] and University of Wisconsin-Extension handout, "What's on your Seed?"[35]

- Educate yourself about safe pesticide use. The pesticide applicator certification training manual[36] is a useful resource for everyone, and is required training for some types of pesticide applicators.
- Do not allow pesticides to drift off site, as this 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 FieldWatch?

FieldWatch[37] 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. Pesticide applicators should check the FieldWatch website for neighboring bee hives and specialty crops before appying pesticides.

FieldWatch
Communication. Cooperation. Collaboration.

driftwatch
Specialty Crop Site Registry
by FieldWatch

Getting involved and spreading the word

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. Growers are encouraged to share their practices with neighbors, grower groups, and agronomy businesses, and participate in scientific research to help answer questions about pollinator health in agricultural settings.

Thelma Heidel-Baker, The Xerces Society

How can you tell if bees like your farm?

Use the simple protocol[38] provided by The Xerces Society and a bee guide[39] from Michigan State University to identify bees and monitor their presence on your farm. The Xerces Society provides an assessment form[40] to score pollinator habitat on your farm and aid in management planning.

Books, Manuals and How-To's:

- For growers contracting managed bees:
  Delaplane, Keith S., Daniel R. Mayer, and Daniel F. Mayer. 2000. "Crop Pollination by Bees." CABI.
- USDA Pollination Handbook
  http://www.ars.usda.gov/SP2UserFiles/Place/20220500/OnlinePollinationHandbook.pdf
- USDA. 2015. "Attractiveness of Agricultural Crops to Pollinating Bees for the Collection of Nectar and/or Pollen."
  http://www.ree.usda.gov/ree/news/Attractiveness_of_Agriculture_crops_to_pollinating_bees_Report-FINAL.pdf
- Sustainable Agriculture Research and Education (SARE). "Cover Cropping for Pollinators and Beneficial Insects." Informational handout.
  http://www.sare.org/Learning-Center/Bulletins/Cover-Cropping-for-Pollinators-and-Beneficial-Insects
- Michigan State University. May 2007. "Conserving Native Bees on Farmland". Extension Bulletin E-2985.
  http://nativeplants.msu.edu/uploads/files/E2985ConservingNativeBees.pdf
- Pacific Northwest Extension. "How to Reduce Bee Poisonings from Pesticides." PNW 591
  http://extension.oregonstate.edu/crook/sites/default/files/bee2.pdf
- USDA NRCS Agronomy Tech Note #9. "Preventing or Mitigating Potential Negative Impacts of Pesticides on Pollinators Using Integrated Pest Management and Other Conservation Practices." http://www.xerces.org/guidelines/pollinator-pesticide-risk-reduction/
- NRCS. 2008. Wisconsin Biology Technical Note 8. "Pollinator Biology and Habitat."
  http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_020421.pdf
- The Xerces Society for Invertebrate Conservation. "Farming for Bees."
  http://www.xerces.org/guidelines-farming-for-bees/

References

[1] Thies, C., and T. Tscharntke. 1999. "Landscape structure and biological control in agroecosystems." Science 285.5429: 893-895.

[2] Iowa State University prairie STRIPS project. See “Publications” and “Practice Establishment and Management” tabs at: http://www.nrem.iastate.edu/research/STRIPs/

[3] Chagnon, M., et al. 1993. "Complementary aspects of strawberry pollination by honey and indigenous bees (Hymenoptera)." *Journal of Economic Entomology* 86.2: 416-420.

[4] Milfont, Marcelo de O., et al. 2013. "Higher soybean production using honeybee and wild pollinators, a sustainable alternative to pesticides and autopollination." Environmental Chemistry Letters 11.4: 335-341.

[5] Gaines-Day, H.R., and C. Gratton. 2015. "Biotic and abiotic factors contribute to cranberry pollination." *Journal of Pollination Ecology* 15.

[6] Kevan, P.G., et al. May 2013. “Cultivars that can self-pollinate are no guarantee of full yield.” The Grower 63:5. http://issuu.com/thegrower/docs/thegrower_may2013/18

[7] Ibarra-Perez, F. J., et al. "Effects of insect tripping on seed yield of common bean." 1999. *Crop science* 39.2: 428-433.

[8] Garibaldi, L., et al. 2013. "Wild pollinators enhance fruit set of crops regardless of honey bee abundance." *Science* 339.6127: 1608-1611.

[9] Ascher, J. S. and J. Pickering. 2015. Discover Life bee species guide and world checklist (Hymenoptera: Apoidea: Anthophila). www.discoverlife.org

[10] Garibaldi L., et al. 2011. Stability of pollination services decreases with isolation from natural areas despite honey bee visits. *Ecol Lett* 14: 1062–72.

[11] Mallinger, Rachel E., and Claudio Gratton. 2015. "Species richness of wild bees, but not the use of managed honeybees, increases fruit set of a pollinator- dependent crop." *Journal of Applied Ecology* 52.2: 323-330.

[12] List of management practices adapted from: Garibaldi, L., et al. 2014. From research to action: enhancing crop yield through wild pollinators. Frontiers in Ecology and the Environment, 12(8), 439–447.

[13] Iowa STRIPS project. https://www.nrem.iastate.edu/research/STRIPs/content/management-overview

[14] Sardiñas, H.S., et al. 2015. "Sunflower (Helianthus annuus) pollination in California's Central Valley is limited by native bee nest site location."*Ecological Applications*.

[15] Sustainable Agriculture Research and Education (SARE). “Cover cropping for pollinators and beneficial insects.” 2015. http://www.sare.org/Learning-Center/Bulletins/Cover-Cropping-for-Pollinators-and-Beneficial-Insects

[16] Garibaldi, L., et al. 2014. From research to action: enhancing crop yield through wild pollinators. Frontiers in Ecology and the Environment, 12(8), 439–447.

[17] Kennedy, Christina M., et al. "A global quantitative synthesis of local and landscape effects on wild bee pollinators in agroecosystems." *Ecology letters*16.5 (2013): 584-599.

[18] Blaauw, B. R., & Isaacs, R. 2014. Flower plantings increase wild bee abundance and the pollination services provided to a pollination- dependent crop. Journal of Applied Ecology, 51(4), 890–898.

[19] Leopold Center for Sustainable Agriculture. August 2015. “The Cost of Prairie Conservation Strips.” Available at www.leopold.iastate.edu/pubs/alpha/t

[20] Pheasants Forever. Find a biologist: https://www.pheasantsforever.org/Habitat/findBiologist.aspx

[21] Directory for Farm Service Agency and county conservation contacts: http://wisconsinlandwater.org/files/pdf/WILandWaterDirectory.pdf

[22] Monarch butterfly population data collected by personnel of the Monarch Butterfly Biosphere Reserve and WWF-Telcel Alliance, and summarized by The Xerces Society here: http://www.xerces.org/monarchs/

[23] Wisflora: Wisconsin Vascular Plant Species: http://www.botany.wisc.edu/herb/

[24] Wisconsin DNR Landowner Incentive Program: http://dnr.wi.gov/topic/endangeredresources/lip.html

[25] USDA NRCS Environmental Quality Incentives Program (EQIP): http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/

[26] USDA NRCS Conservation Reserve Program (CRP): http://www.nrcs.usda.gov/wps/portal/nrcs/main/wi/programs/

[27] USDA NRCS Conservation Reserve Enhancement Program (CREP): http://datcp.wi.gov/Environment/Land_and_Water_Conservation/CREP/index.aspx

[28] USDA NRCS Conservation Stewardship Program (CSP): http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/csp/

[29] US Fish and Wildlife Service Partners for Fish and Wildlife: http://www.fws.gov/midwest/partners/

[30] Healthy Grown Potatoes: http://eatwisconsinpotatoes.com/wisconsin-potatoes/healthy-grown/

[31] Pheasants Forever: https://www.pheasantsforever.org/Habitat/Why-Habitat.aspx

[32] University of California Statewide Integrated Pest Management Program. “Bee precaution pesticide rating” online tool: http://www2.ipm.ucanr.edu/beeprecaution/

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

[34] American Seed Trade Association / CropLife America seed treatment management practices: http://seed-treatment-guide.com/guide/

[35] University of Wisconsin Extension and UW Nutrient and Pest Management Program. “What’you’re your Seed?” http://ipcm.wisc.edu/download/pubsPM/Whats_on_your_seed_FINAL_4.pdf

[36] Wisconsin pesticide applicator training: http://ipcm.wisc.edu/pat/certification/requirements/

[37] FieldWatch, DriftWatch and BeeCheck voluntary mapping tools: http://www.driftwatch.org/

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

[39] Michigan State University Extension. October 2015. “Bees of the Great Lakes Region and Wildflowers to Support Them.” 110-page pocket guide for identifying bees, plus wildflower planting guidelines. http://shop.msu.edu/product_p/bulletin-e3282.htm

[40] The Xerces Society. "Pollinator Habitat Assessment Form and Guide for Farms and Agricultural Landscapes." http://www.xerces.org/wp-content/uploads/2009/11/PollinatorHabitatAssessment.pdf

THE WISCONSIN POLLINATOR PROTECTION PLAN

BEST MANAGEMENT PRACTICES FOR

Improving Pollinator Habitat in Prairies, Roadsides & Open Spaces

Give us your feedback on the plan with this 5 minute survey:
https://www.surveymonkey.com/r/MLGFGVV

Providing a high diversity of flowering plants 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, savannas and forest edge habitats provide plentiful nesting and forage opportunities for pollinators throughout the year. Because a small fraction of Midwestern land contains these habitat types, 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 roots, not blooms, during the first year.
- Weeds. Mowing in the first year before seed development is necessary to prevent weed establishment.

Year Two:

- Few flowers. Some early species will bloom.
- Mowing, hand pulling, or spot herbicide treatment of weeds before they go to seed.

Year Three and Beyond:

- Many flowers. Plantings will begin to resemble a diverse tallgrass prairie.
- Ongoing maintenance may consist of hand pulling and spot herbicide treatment to control weeds, and mowing, grazing, haying, 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. Your local county conservation office staff[1] may be able to provide guidance during this process. Pertinent questions to answer during the planning stage include:

- How much of the area is currently covered by herbaceous flowering plants (**forbs**) or flowering shrubs/trees? Are any of these species key pollinator plants (like lupine or milkweed)?
- Are there noxious or invasive weeds[2] that need to be controlled?
- 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.
- Match the seed mix to local site conditions (soil type, moisture, sun exposure, etc.) Example regional seed mixes, vendor information, planting instructions, and a seed mix calculator are provided by The Xerces Society[3,4,5]. Regional plant lists and planting guides are available from the Wisconsin Department of Natural Resources (DNR)[6] and Pollinator Partnership[7].

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.

Native plant benefits include:

- 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 the Wisconsin DNR[8], Plant Native[9] and The Xerces Society's milkweed seed finder[10]. The Wisconsin DNR also hosts a list of restoration consultants[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 (and with permission from the property manager or landowner). Limit your harvesting to <10% of available seed for any one species.

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]. Midwest-focused resources are available from the Minnesota DNR[13], the Midwest Invasive Plant Network[14], and The Prairie Enthusiasts[15].

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. Note also that some forbs require scarification before they will germinate.
- Be sure to include early season forbs. Some prepackaged seed mixes are biased towards late season wildflowers. Some early season forb seed must be collected and planted as soon as it is ripe.
- Diversify grasses. Include short grasses that will not shade out forbs e.g., little bluestem, side-oats grama.
- Do not add fertilizer to native prairie plantings. Native prairie plants don't need it, and adding fertilizer will only help weeds[16].

Ongoing maintenance and monitoring

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:

- Weeds will dominate a site quickly if not controlled from the start. Scout the land and adjacent roadsides early in the season (May-June) for noxious weeds and, if possible, remove by hand before they spread. Targeted herbicides can be used on weed species that spread vegetatively or are particularly difficult to control. If herbicides are used, always follow the product label exactly for application timing and dose.
- Mature prairie plantings are drought resistant, and typically require no fertilizer or pesticides[13]. Before prairie plantings are established, however, irrigation may be warranted in dry years.
- 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 better than mowing at stimulating flowering over time. For training opportunities and guidance, refer to the Wisconsin Prescribed Fire Council website[17], Wisconsin DNR Forest Management Guidelines[18], and Wisconsin DNR Technical Bulletin 187[19].

- It is important that pollinators have access to undisturbed areas (**refugia**) while vegetation is temporarily disturbed in a mowed, grazed, or burned site. Areas like roadsides, wide fence rows, old fields, and brush patches can serve as refugia if they are within 100 ft. of the site. At sites without nearby refugia, no more than 2/3 to 3/4 of the flower patch habitat should be mowed, grazed, or burned at one time. At sites with remnant original prairie, no more than 1/3 of the area should be mowed, grazed or burned at one time.
- Whenever possible, leave dead logs and leaf litter on site; these provide nesting habitat for bees and other wildlife, and overwintering sites for butterflies.
- Protecting sensitive species is a proactive endeavor that requires on-the-ground knowledge and regular scouting. Particularly sensitive or beneficial plants like wild lupine can be flagged and protected from ongoing management practices.
- If endangered or threatened species are present on your site, Wisconsin DNR management activities must follow incidental take protocols for the given species.

How can you tell if bees like your site?
Use the simple protocol[20] provided by The Xerces Society and a bee guide[21] from Michigan State University to identify bees and monitor their presence on your site.

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. Right-of-ways provide nesting and egg-laying habitat for bees and butterflies, and have the potential to act as corridors for pollinator movement[22,23]. Right-of-ways with flowering plants offer nectar and pollen for pollinators, and those with native plants have been shown to be especially beneficial to bees and butterflies[23,24].

"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[33]

Roadside maintenance requires a balancing act to control erosion (see Wisconsin NR 151[25]), stop the spread of invasive weeds (see Wisconsin NR 40[26]), 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"[27] 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.	Mowing in a staggered fashion, or restricting regular mowing to the first 8 ft. of roadside, allows wildflowers in other roadside areas to bloom.	Wisconsin DOT has mow timing guidelines for public safety and weed control[28]. Guidelines for roadside wildflower planting are available through programs in Ohio[29] and North Carolina[30].
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[31]. Roadside shrub plantings in Indiana harbored more birds but did not result in more roadkill than roadsides without shrubs[32].
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 butterfly mortality risk[24]. Even on narrow edges of high-traffic roads, prairie plantings harbor more bee species than weedy roadsides[23]. An overview of studies related to traffic impacts on pollinators is available in a Federal Highways Administration report[22].
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[33].

References

---

[1] Directory for county conservation contacts: http://wisconsinlandwater.org/files/pdf/WILandWaterDirectory.pdf

[2] The Wisconsin Dept. of Natural Resources list of invasive plant species: http://dnr.wi.gov/topic/Invasives/species.asp?filterBy=Terrestrial&filterVal=Y

[3] The Xerces Society seed mix and planting guidelines: http://www.xerces.org/pollinator-seed/

[4] The Xerces Society plant lists. http://www.xerces.org/pollinator-conservation/plant-lists/

[5] The Xerces Society seed mix calculator. http://www.xerces.org/xerces-seed-mix-calculator/

[6] Wisconsin DNR Technical Bulletin 188. 1995. "Plant Species Composition of Wisconsin Prairies: An aid to selecting species for planting and restorations based upon University of Wisconsin-Madison Plant Ecology Lab data." http://dnr.wi.gov/topic/research/publications/bulletins/

[7] Pollinator Partnership regional planting guides – use the "Eastern Broadleaf Forest Continental" guide for southern Wisc. and the "Laurentian Mixed Forest" guide for northern Wisc. http://pollinator.org/guides.htm

[8] Wisconsin DNR list of native plant nurseries: http://dnr.wi.gov/files/pdf/pubs/er/er0698.pdf

[9] Plant Native nursery finder: http://plantnative.org/

[10] The Xerces Society listing of milkweed seed providers: http://www.xerces.org/milkweed-seed-finder/

[11] Wisconsin DNR list of restoration consultants: http://dnr.wi.gov/files/pdf/pubs/er/er0699.pdf

[12] The Xerces Society. "Establishing Pollinator Meadows from Seed." http://www.xerces.org/wp-content/uploads/2013/12/EstablishingPollinatorMeadows.pdf

[13] Minnesota DNR. "Going Native: A Prairie Restoration Handbook for Minnesota Landowners." http://files.dnr.state.mn.us/assistance/backyard/prairierestoration/goingnative.pdf

[14] Midwest Invasive Plant Network guidance for weed management: http://www.mipn.org/control/

[15] The Prairie Enthusiasts protection and management of Midwestern prairies and savannas: http://www.theprairieenthusiasts.org/

[16] Blumenthal, Dana M., et al. 2005. "Effects of prairie restoration on weed invasions." *Agriculture, ecosystems & environment* 107.2: 221-230.

[17] Wisconsin Prescribed Fire Council education and training: http://prescribedfire.org/

[18] Wisconsin DNR Forest Management Guidelines, Chapter 17: Fire Management: http://dnr.wi.gov/topic/ForestManagement/documents/guidelines/chapter17.pdf

[19] Wisconsin DNR Technical Bulletin 187. 1994. "Bibliography of fire effects and related literature applicable to the ecosystems and species of Wisconsin." http://dnr.wi.gov/topic/research/publications/bulletins/

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

[21] Michigan State University Extension. October 2015. "Bees of the Great Lakes Region and Wildflowers to Support Them." 110-page pocket guide for identifying bees, plus wildflower planting guidelines. http://shop.msu.edu/product_p/bulletin-e3282.htm

[22] The Xerces Society for Invertebrate Conservation in collaboration with ICF International. 2015. "Literature Review: Pollinator Habitat Enhancement and Best Management Practices in Highway Rights-of-Way." Prepared for The Federal Highway Administration. https://www.environment.fhwa.dot.gov/ecosystems/documents/pollinators_BMPs_in_highway_ROW.asp

[23] Hopwood, J. 2008. "The contribution of roadside grassland restorations to native bee conservation." *Biological Conservation* 141.10: 2632-2640.

[24] Ries, Leslie, et al. 2001. "Conservation value of roadside prairie restoration to butterfly communities." *Conservation Biology*15.2: 401-411.

[25] Wisconsin DNR, Chapter NR 151. “Runoff management.” http://docs.legis.wisconsin.gov/code/admin_code/nr/100/151.pdf

[26] Wisconsin DNR, Chapter NR 40. “Invasive species identification classification and control.” http://docs.legis.wisconsin.gov/code/admin_code/nr/001/40.pdf

[27] Minnesota DOT. “Native Seed Mix Design for Roadsides.” http://www.dot.state.mn.us/environment/erosion/pdf/native-seed-mix-dm.pdf

[28] Wisconsin DOT roadside mowing policies: http://wisconsindot.gov/Pages/doing-bus/real-estate/roadsides/mowing/default.aspx

[29] Ohio DOT roadside pollinator habitat guidelines: http://www.dot.state.oh.us/districts/D09/Documents/Planting%20Guidelines.pdf

[30] North Carolina DOT roadside wildflower program: http://www.ncdot.gov/doh/operations/dp_chief_eng/roadside/wildflowerbook/

[31] The Xerces Society. “Pollinators and Roadsides: Managing Roadsides for Bees and Butterflies.” http://www.xerces.org/wp-content/uploads/2010/05/roadside-guidelines_xerces-society1.pdf

[32] Roach, Gerald L., and Ralph D. Kirkpatrick. 1985. "Wildlife use of roadside woody plantings in Indiana." *Transportation Research Record* 1016.

[33] Federal Highway Administration, US DOT. October 2007. “A Manager's Guide to Roadside Vegetation Using Native Plants.” http://flh.fhwa.dot.gov/about/css/documents/rr-managers-guide.pdf

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 January 19 – February 19, 2016. A summary of comments and how they were addressed is available at datcp.wi.gov, keyword "pollinator protection."

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 - Wisconsin	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, Dan Ziehli
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 survey that organizations can distribute 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, it is not easy to track the adoption of its recommendations and ultimate impacts on pollinator health. Measuring progress toward pollinator health goals will depend on participation by individuals and organizations, and we turned to our stakeholders to brainstorm ideas on specific ways to do this (Table A2).

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
1/19/2016	DATCP	Draft made available for public comment
4/5/2016	DATCP	Public comments incorporated into final version
7/14/16	DATCP	DATCP website links updated

References

[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. https://datcp.wi.gov/Pages/Programs_Services/PollinatorProtection.aspx