Protecting and enhancing pollinators in urban landscapes

for the US North Central Region

Rebecca Finneran, MSU Extension

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Introduction

Most of the fruit and vegetables we eat would not exist if we did not have honey bees and native bees to pollinate the flowers they developed from. Wildflowers, and most flowering trees and shrubs must also be pollinated by bees to produce fruit and seed. In addition to providing critical pollination services, some of our pollinators like monarch butterflies, swallowtail butterflies and hummingbirds are valued as wildlife that we enjoy in the yard and garden.

In the last 20 years, scientists have documented decreased survival rates of honey bees, a decrease in native bee diversity and a rapid decline in some species of butterflies and bumble bees. Researchers have identified the biggest threats to be a decrease in flowers due to habitat change, increasingly clean (weed-free) agricultural fields and widespread use of pesticides such as systemic insecticides in most corn and soybean fields and area-wide mosquito spray programs. The other significant threat is intercontinental spread of bee parasites or pathogens, like the Varroa mite, a major threat to honey bees.

Although some of the most important steps to protect pollinators must be made in agriculture or by managing public lands, we also need to protect pollinators in our yards and gardens. This bulletin explains how to select flowers, herbs, shrubs and trees that support a diversity of pollinators throughout the year, how to manage your yard and garden to protect pollinators, and how to provide food and nesting sites for them.

Pollinators in urban landscapes

Most plants need pollination to reproduce and grow fruit. While some plants are wind-pollinated, many require assistance from insects, bats, hummingbirds or other animals. Without pollinators, we would have little to no fruit, fewer vegetables and many plant species would not survive. Gardeners and farmers depend on pollinators to produce fruit and vegetable crops. In natural ecosystems, pollination is required for many types of native trees and shrubs to provide forage for birds and mammals.

For fruit and vegetable crops, honey bees, which are from Europe, are the most important pollinators because they can be brought in and out of orchards and fields easily. Honey bees have been estimated to pollinate 30 to 90% of many fruit crops, with native bee species accounting for most of the remaining

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pollination. The proportion of fruit pollinated by honey bees varies considerably among fruits and vegetables, and depends on whether or not hives are brought into the orchard for the pollination period, and the local population of feral honey bees.

Most honey bee colonies are kept outside city limits and are managed by commercial beekeepers, however, a growing number of small-scale beekeepers and hobbyists maintain colonies in urban landscapes. Bees can fly well over a mile to search for pollen and nectar, so colonies located within 3 miles of managed landscapes can be affected by the pesticides used.


Jason Gibbs, MSU Entomology

This cellophane bee is a native pollinator.

In addition to honey bees, we have over 3,600 species of native bees in the United States, along with flies, beetles, butterflies, wasps and other insects that provide pollination services. Some of these native pollinators play important roles in crop pollination and are critical for pollinating native plants. Native bees have evolved in the region where they are found, so they tend to be well adapted to the local climate, local flowering plants and may also have developed resistance to local diseases and parasites of bees. They are sometimes called “wild” bees along with the non-native species that are not managed by beekeepers.

Native bees, butterflies and other pollinators are wildlife, deserving protection in the same way birds such as raptors and songbirds are protected. Unfortunately, honey bee health is in decline, and some native bees and butterflies are threatened. Honey bees are well studied because of their economic importance. From April 1, 2014 to April 1, 2015, the U.S. lost 42% of its honey bee colonies, and winter losses since 2006 are generally around 30% every year. Beekeepers consider annual losses of 15-20% to be acceptable, and losses greater than this make it difficult or impossible to remain profitable. The Xerces Society reports in recent years monarch populations have declined by more than 80% from the 21-year average across North America. Declines have been reported for native bee populations as well, however, for most native species we do not have adequate information on how many were here in the first place.

Factors that threaten pollinator health

Most researchers agree that a combination of factors is causing declines in bee and pollinator populations, including loss of habitat or flowers that provide pollen and nectar, pesticide exposure, parasites and pathogens. Each of these has been found to negatively affect bees, but there is also evidence the combination of stresses is especially harmful. Bees and other pollinators depend on flowers for food – nectar provides carbohydrates, while pollen is their source of protein and is necessary for them to rear their young. Flowerless landscapes like mowed lawns with strict weed control or heavily paved areas of cities and fields with no plant diversity contain little food for bees, which leads to poor nutrition and compromised immune systems. Nutritionally weakened bees are more susceptible to disease and pesticides.

Many pests and pathogens also affect bees. The Varroa mite, a parasite of honey bees, is one of the most destructive factors causing honey bee decline. Other parasites and pathogens may become a more serious problem in hives weakened by Varroa mite.

In some cases, the flowers that bees forage on have pesticide (not just insecticide) residue on the petals or in the nectar and pollen. These chemicals can kill bees directly or cause a variety of sublethal effects such as impairing their ability to find their hive or provide food for their larvae. The toxicity of pesticides for bees ranges from highly toxic to relatively safe, depending on the specific chemical and the exposure. In some cases the impacts are worse when pollinators are exposed to combinations of pesticides. Since bees forage through a wide range of landscapes, they may be exposed to a complex mixture of many different chemicals.

One group of pesticides, the neonicotinoids, has recently been studied intensively by scientists to determine their impact on bees, primarily because of their widespread agricultural use on field crops. “Widespread” means that over 50% of the 89 million acres of soybeans and over 90% of the 88 million acres of corn planted in the USA in 2018 were planted using seed coated with a systemic neonicotinoid insecticide. However, in urban areas neonicotinoids used by homeowners in yards and gardens may be just as important.

Neonicotinoids are a class of insecticide that acts on the insect’s nervous system. They are more selective, having greater toxicity for insects than mammals, and safer for humans to use than most old classes of insecticides. They are toxic to insects when ingested or through direct contact. The most widely used neonicotinoids – imidacloprid, thiamethoxam, clothianidin and dinotefuran – are all highly toxic to bees. Products containing these active ingredients have bee-warning boxes on the label with important

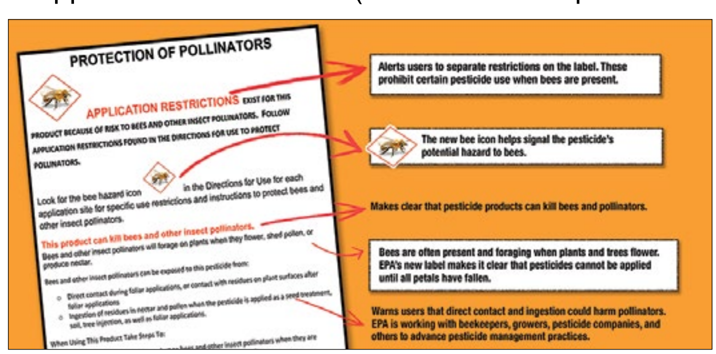
Rebecca Finneran, MSU Extension

Help pollinators by planting more flowers.

instructions for limiting bee exposure that must be followed. However, corn and soybean seed coated with a neonicotinoid do not have bee-warning labels. Neonicotinoids move upwards in xylem sap internally within plants when applied to the plant’s base (to roots via a soil application, or to the stem via injection or a basal spray), where they can later reach nectar and pollen. Pesticides remain primarily in leaf tissue following a foliar spray.

Neonicotinoids, like most insecticides, will cause significant harm if pollinators come directly into contact with them. This exposure generally occurs when a neonicotinoid is misused and sprayed on a blooming plant or one that will bloom soon, or when bees are exposed to dust of seed-coatings at planting time. However, researchers have found seed-coat treatments to canola seed can be harmful to native bees feeding on canola flowers in fields planted with treated seed.

Bees and other pollinators can also collect contaminated pollen or nectar from treated plants and bring it back to their colony, creating high risk of harm to the colony. Research studies have demonstrated native and honey bees can be harmed by small amounts of pesticides in nectar and pollen. When a neonicotinoid is applied as a soil drench (a dilute solution poured



The pollinator protection section of a pesticide label with active ingredients requiring a bee-warning.

around the plant base), it may persist for a year or more, especially in woody plants, and can also move into weeds or flowers growing over the drenched soil. If some of the insecticide moves into pollen or nectar it may kill bees directly, or act as a stressor to affect larval growth, susceptibility to diseases, navigation or winter survival.

How we manage ornamental landscapes has an impact on two of the most important factors affecting pollinators: habitat quality and pesticide exposure. The following two sections explain the best ways to **create and maintain good habitat for pollinators**, and how to **minimize pollinator exposure to pesticides**.

David Cappaert, Bugwood.org

Do you call it butterfly milkweed or butterfly weed? Both are common names. The scientific or Latin name is always *Asclepias tuberosa.*

Creating and maintaining pollinator-friendly habitat

Many types of insects feed on pollen and nectar, although two types of pollinators receive the most attention: bees and butterflies. The best way to encourage bees and butterflies is to grow many different types of flowering plants that produce nectar and pollen. Consider how much lawn you maintain and whether any of it could become habitat for pollinators by adding a diverse collection of plants. Consider allowing clover, ground ivy, black medic, vetch, dandelions and other flowering weeds to grow in your lawn, educating others about the benefit of flowering weeds, and helping change local ordinances that prohibit these "weeds" from growing in your area. Incorporate more flowering annuals, perennials including bulbs and herbs, shrubs and trees into your yard and garden so there is always something blooming throughout the season from early spring through autumn.

For natural areas of the yard and garden, or border areas, see the list of native plants below or find a region-specific list of pollinator-friendly plants, like one available at the Michigan State University Native Plants and Beneficial Insects website: www.nativeplants.msu.edu. Native plants are strongly recommended, but there are also many non-native ornamental plants that are excellent food plants for bees and butterflies. See our lists of plants that provide pollen and nectar for bees and butterflies.

There are several reasons why it is important to use the genus/species name (scientific name) when you investigate and buy your plants, trees and shrubs. Common names may be regional and could refer to a different type of flower depending upon local tradition. Also, be sure to find the exact species listed below because other species in the same genus may not be attractive to bees. *Salvia*, for example, is a popular annual bedding plant, but red salvia, which is a popular annual in the north central region, is not highly attractive to bees while blue salvia, *Salvia farinacea*, and several types of perennial salvia (*Salvia nemorosa*) are. Also, some cultivars of flowers may be more attractive than others.

The way you care for your plants also impacts whether blooms are available. Think about pruning plants such as Nepeta to encourage repeat bloom and slow to deadhead those such as Hosta that won't bloom again so bees have a change to forage on their blossoms.

Better habitat for bees

Annuals attractive to bees

In general, herbs and garden perennials are good for bees, while most annual bedding plants are less attractive to them. Annual flowers like impatiens are readily available at the garden center, but most have been bred for showy flowers or vigorous growth and do not produce enough pollen and nectar to be good food plants for bees or butterflies. Some annuals such as marigold and moss rose are valuable for pollinators and these provide summer-long pollen and nectar.

Below are some annuals that are good food plants for pollinators. Please note that some of these, like garden heliotrope, lantana and pentas, are considered annuals in northern states but are perennials in more southern states. Because some cultivars may be more attractive to pollinators than other cultivars in the same species, you may want to try several cultivars and observe which ones attract the most bees.

Annuals attractive to bees table	
Common name	**Genus species (scientific name)**
Ageratum (floss flower)	*Ageratum houstonianum*
Anise-scented sage	*Salvia guaranitica*
Aster	*Callistephus chinensis*
Baby's breath	*Gypsophila paniculata*
Beeblossom	*Gaura lindheimeri, Gaura spp.*
Bidens	*Bidens laevis*
Black-eyed Susan or gloriosa daisy	*Rudbeckia hirta*
Bluestar	*Amsonia illustris,* other native *Amsonia* spp.
Blue-eyed grass	*Sisyrinchium lucerne*
Blue salvia (mealycup sage)	*Salvia farinacea*
Borage or starflower	*Borago officinalis*
Calendula	*Calendula officinalis*
Calibrachoa	*Calibrachoa spp.*
Campion	*Lychnis chalcedonica, L. flos-cuculi*
Catnip or catmint	*Nepeta sp. (annuals and perennials)*
Chives	*Allium altaicum, A. ampeloprasum, A. cernum*, etc.
Clary sage	*Salvia sclarea (biennial)*
Cockscomb or woolflower	*Celosia plumose, argentia, pristada*
Common lantana	*Lantana camara*
Common sunflower	*Helianthus annuus*
Cornflower	*Centaurea cyanus*
Cosmos	*Cosmos bipinnatus*
Crane's bill	*Geranium bicknellii, G. x cantabrigiense, G. himalayense, G. maculatum, G. phaeum, G. pretense, G. sanguinea, G. viscosissimum*
Dahlia (open types)	*Dahlia* cv.

Annuals attractive to bees table (continued)	
Dead-nettle	*Lamium album, L. amplexicaule, L. galeobdolon, L. purpureum*
Dianthus	*Dianthus barbatus, D. giganteus*
Garden heliotrope	*Heliotrope arborescens*
Gentians	*Gentiana andrewsii, G. clausa, G. dahurica*
Lantana	*Lantana camara*
Lobelia	*Lobelia cardinalis, L. siphilitica*
Marigold	*Tagetes spp.*
Mignonette	*Reseda odorata*
Moss rose	*Portulaca grandiflora*
Nasturtium	*Tropaeolum*
Oxeye	*Heliopsis helianthus*
Pentas	*Pentas spp.*
Pineapple sage	*Salvia elegans*
Rattlesnake master, Sea holly or Eryngo	*Eryngium bourgatii, E. gigantium, E. maritimum, E. yuccifolium.*
Red-hot poker	*Kniphofia typhoides*
Salvia	*Salvia* spp. (annuals and perennials)
Snapdragon	*Antirrhinum majus*
Sneezeweed	*Helenium autumnale*
Spider flower or bee plant	*Cleome hassleriana, C. lutea, C. serrulata*
Sunflowers	*Helianthus annuus, H. divaricatus, H. maximiliani, H. mollis, H. petiolaris, H. strumosus*
Sweet William (biennial in southern parts of north central region)	*Dianthus barbatus*
Sweet alyssum	*Lobularia maritima*
Verbena	*Verbena bonariensis, V. hybrida, V. hastata, V. stricta, V. urticifolia*
Vervain	*Verbena bonariensis*
Yellowcress	*Rorippa palustris, R. sylvestris*
Zinnia	*Zinnia elegans*


Thomas Dudek, MSU Extension
Calibrachoa


Pixabay.com
Snapdragon


Erwin Elsner, MSU Extension
Butterfly weed


Erwin Elsner, MSU Extension
Bee balm

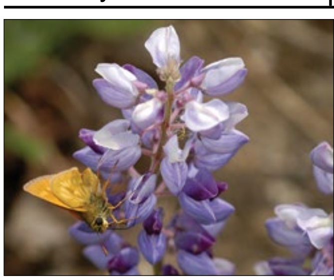
Herbaceous perennials attractive to bees

Researchers have identified that perennial flowers tend to be far more attractive to bees than annuals. Many different types of perennials are good for bees, from showy flowers to herbs. Herb gardens are an excellent resource for bees because they flower over a long period of time, and herbs grow fairly large and produce lots of flowers. The perennials and herbs listed below can be purchased from nurseries and garden centers in the North Central United States. Because species and cultivars vary in cold-hardiness, be sure to check the acceptable hardiness zones listed on the plant label and match it to the USDA Plant Hardiness Zone where you live (http://planthardiness.ars.usda.gov/PHZMWeb/).

Some of the plants listed below are also available as seeds in commercial "wildflower" mixes. If you are looking for native wildflower seed, a good source of information is the Xerces Society, which gives a list of plants and a supplier for each region (http://www.xerces.org/pollinator-seed/).

Herbaceous perennials attractive to bees

Common name	Genus species (scientific name)
Allium (many varieties)	*Allium*
Anise hyssop	*Agastache foeniculum*
Aromatic aster	*Symphyotrichum oblongifolium*
Aster	*Symphyotrichum novae-angliae* – 'Purple Done'
Astilbe, false spirea	*Astilbe* spp.
Basil, sweet basil (annual)	*Ocimum basilicum*
Bee balm	*Monarda* spp.
Bellflower	*Campanula* spp.
Betony	*Stachys monieri*
Bigleaf ligularia	*Ligularia dentate*
Black-eyed Susan, coneflower	*Rudbeckia* spp.
Blanket flower	*Gaillardia*
Blazing star	*Liatris spicata*
Butterfly bush	*Buddleja* or *Buddleia* spp.


Erwin Elsner, MSU Extension
Lupine


Diane Brown, MSU Extension
Sunflower

Herbaceous perennials attractive to bees (continued)

Common name	Genus species (scientific name)
Butterfly weed	*Asclepias tuberosa*
Calamint	*Calamintha nepeta*
Cardoon	*Cynara cardunculus*
Carolina lupine	*Thermopsis villosa*
Catmint	*Nepeta* spp.
Chrysanthemum (open types)	*Chrysanthemum*
Chocolate flower	*Berlandiera lyrata*
Clematis	*Clematis* spp.
Common poppy, red poppy	*Papaver rhoeas*
Common yarrow	*Achillea millefolium*
Coral bells	*Heuchera* spp.
Cornflower	*Centaurea* spp.
Crown vetch (ground cover)	*Securigera (= Coronilla) varia*
Cut-leaf mallow	*Malva alcea*
Eryngo, rattlesnack master (various names)	*Eryngium* spp.
English ivy	*Hedera sp.*
Fennel	*Foeniculum vulgare*
Foxglove or beardtongues	*Penstemon* spp.
Garden speedwell	*Veronica longifolia*
Globe thistle	*Echinops ritro*
Glory-of-the-snow	*Chinodoxa*
Hardy geranium, blue cranesbill	*Geranium ibericum* x (*Geranium himalayense*)
Hosta	*Hosta* spp.
Hyssop (naturalized in North America)	*Hyssopus officinalis*
Inula, Himalayan elecampane	*Inula royleana*
Japanese anemone	*Anemone hupehensis 'Robutissima'*
Large-leaved aster	*Eurybia macrophylla*
Lavender	*Lavandula*
Lemon balm	*Melissa officinalis*
Leucanthemella	*Leucanthemella serotine*
Lupine	*Lupinus* spp.
Mints	*Mentha* spp.
Mullein or velvet plant	*Verbascum*
Narrow-leaved foxtail lily	*Eremurus stenophyllus*
New England aster	*Symphyotrichum novae-angliae*
Ornamental onion, garlic, chives, leek, scallion	*Allium* spp., including *Allium* 'mellenium' and 'christophii'

Herbaceous perennials attractive to bees (continued)

Common name	Genus species (scientific name)
Oregano	*Origanum vulgare*
Pachysandra	*Pachysandra terminalis*
Parasol whitetop	*Doellingeria umbellate*
Pentas	*Pentas* spp.
Peony	*Paeonia* spp.
Pincushion flower	*Scabiosa caucasica*
Purple burkheya	*Berkheya purpurea*
Purple coneflower	*Echinacea purpurea*
Rosemary	*Rosmarinus officinalis*
Russian sage	*Perovskia atriplicifolia*
Salvia	*Salvia* 'Victoria blue', *Salvia nemorosa* 'Black and Blue', others
Sea holly	*Eryngium maritimum*
Sedum	*Sedum* spp.
Sedum, stonecrop	*Hylotelephium spectabile* and *telephium* and cvs.
Snakeroot	*Cimicifuga famose*
Sneezeweed	*Helenium*
Squill	*Drimia maritima*
Stiff-leaved aster	*Ionactus linariifolius*
Striped squill	*Punchkinia*
Stokes aster	*Stokesia laevis*
Sunflower	*Helianthus*
Swamp milkweed	*Asclepias incarnata*
Sweet alyssum	*Lobularia maritima*
Sweet clover	*Melilotus spp.*
Thyme	*Thymus* spp.
Tickseed	*Coreopsis*
Trout lily	*Erythronium americanum*
White wood aster	*Eurybia divarcata*

Shrubs attractive to bees

Flowering shrubs can be an excellent food source for bees because they tend to grow larger than herbaceous perennials, and therefore produce a larger number of flowers. Some species, like *Rosa rugosa*, bloom all summer.

Shrubs attractive to bees

Common name	Genus species (scientific name)
Black chokeberry	*Aronia melanocarpa*
Bottlebrush buckeye	*Aesculus parviflora*
Buttonbush	*Cephalanthus occidentalis*
Common witch-hazel	*Hamamelis virginiana*


John D. Byrd, Mississippi State Univ., Bugwood.org

Buttonbush


Diane Brown, MSU Extension

Elderberry


Jerry A. Payne, USDA Agric. Research Service, Bugwood.org

A bee visits fragrant sumac.


John Ruter, University of Georgia, Bugwood.org

Potentilla

Shrubs attractive to bees (continued)

Common name	Genus species (scientific name)
Cotoneaster	*Cotoneaster*
Dwarf fothergilla	*Fothergilla gardenia*
Eastern ninebark	*Physocarpos opulifolius*
Elderberry	*Sambucus* spp.
False indigo	*Amorpha fruticosa*
Flowering quince	*Chaenomeles spp.*
Fuzzy deutzia	*Deutzia scabra*
Highbush blueberry	*Vaccinium corymbosum*
Holly: American, box-leaved, Merserve hybrid, winterberry	*Ilex* spp.
Japanese tree lilac	*Syringa reticulata*
Lacecap hydrangea	*Hydrangea macrophylla*
Mockorange	*Philadelphus coronarius*
Ninebark	*Physocarpus opulifolius*
Panicle hydrangea	*Hydrangea paniculate* (many cultivars)
Potentilla (bush cinquefoil)	*Potentilla fruiticosa*
Privet	*Ligustrum vulgare*
Pussy willow	*Salix discolor*
Raspberry, blackberries	*Rubus* spp.
St. Johns-wort	*Hypericum spp.*
Silky dogwood, gray dogwood, redosier dogwood	*Cornus* spp.
Spicebush	*Lindera benzoin*
Spirea	*Spiraea* spp.

Shrubs attractive to bees (continued)

Common name	Genus species (scientific name)
Staghorn sumac	*Rhus typhina*
Sumacs	*Rhus* spp.
Summersweet, sweet pepperbush	*Clethra alnifolia*
Viburnums	*Viburnum* spp.
White fringe-tree or American yellowwood	*Cladrastis kentukea*
Wild prairie rose	*Rosa arkansana*
Winter honeysuckle	*Lonicera fragrantissima*

Trees attractive to bees

Flowering trees are critical to providing an ample food source for bees because of their large size and thousands of flowers. A blooming linden or black locust produces so much pollen and nectar that it dwarfs the amount provided by most garden flowers in comparison.

However, most trees only bloom for two to three weeks, so a succession of trees that bloom from early spring through summer is very helpful to bees. Trees in the North Central United States that are frequently mentioned as good food plants for bees are listed in the table below.

Trees attractive to bees
Source: Lovell 1926, Pellet 1947, Oertel 1980, Tew 2006, Mader et al. 2011, Mach and Potter 2016

Common name	Genus species (scientific name)	Bloom
Eastern redbud	*Cercis canadensis*	April
Red maple	*Acer rubrum*	April
Alternate-leaved, pagoda or green osier dogwood	*Cornus alternifolia*	May
Black tupelo, blackgum	*Nyssa sylvatica*	May
Cherry, peach, plum, almond	*Prunus* spp. (many)	May
Crabapple, apple	*Malus* spp. (many)	May
Hawthorn	*Crataegus* spp. (many)	May
Winter king hawthorn	*Crataegus viridis*	May
Red horse chestnut	Aesculus X carnea	May
Serviceberry	*Amelanchier* spp.	May
Willow	*Salix* spp.	May
Honey locust	*Gleditsia triacanthos*	May to early June
Black locust	*Robinia pseudoacacia*	Late May-early June
Catalpa	*Catalpa speciosa*	June
Linden, basswood	*Tilia* spp.	June
Tulip-tree	*Liriodendron tulipifera*	June
Amur maackia	*Maackia amurensis*	July-August
Bee-bee tree	*Tetradium (Evodia) daniellii*	July-August
Japanese sophora, Japanese pagoda	*Sophora japonica*	July-September
Seven sons tree	*Heptacodium miconioides*	August-September


Diane Brown, MSU Extension

Serviceberry


Diane Brown, MSU Extension

Linden or basswood

Wind-pollinated trees attractive to bees

Wind-pollinated trees do not produce nectar, but bees may take advantage of them as an abundant source of pollen. Pines, spruces and nearly all gymnosperms are not usually visited by bees unless it is to gather sap used for propolis, a sticky substance used to fill crevices and seal hives. However, several genera of wind-pollinated angiosperms are routinely visited by bees to collect pollen.

The most frequently visited wind-pollinated trees are listed in the following table. Red maple and willow are listed in both tables because they are wind-pollinated trees that are also considered important pollen or nectar sources for bees. Pollen from the wind-pollinated trees may be collected by bees because of a favorable nutritional value, the large amount of pollen produced, or because it is available at times when other food sources are scarce.

Wind-pollinated trees attractive to bees
Source: Kraemer and Favi. 2005, MacIvor et al. 2014, Oertel 1980

Common name	Genus species (scientific name)	Attractiveness to bees[1]
Ash	*Fraxinus* spp.	Somewhat attractive
Birch	*Betula* spp.	Somewhat attractive
Elm	*Ulmus* spp.	Very attractive
Hickory	*Carya* spp.	Somewhat attractive
Oak	*Quercus* spp.	Very attractive
Poplar	*Populus* spp.	Very attractive
Maple	*Acer* spp.	Highly attractive
Willow	*Salix* spp.	Highly attractive

[1]Level of attractiveness in this table is rated by number of reports of bees using pollen, level of bee activity, diversity of bee species observed and amount of pollen found in hives or nests.

Wildflowers attractive to bees

Wildflower mixes often contain seed of several of the attractive perennials listed in this table. A good source for native wildflower seed is the Xerces Society, which gives a list of plants and a supplier for each region (http://www.xerces.org/pollinator-seed/). Another list of native plants and wildflowers available from nurseries and seed companies maintained by the American Horticultural Society is organized by state (https://www.ahsgardening.org/gardening-resources/societies-clubs-organizations/native-plant-societies). MSU Extension publication E2973, "Attracting Beneficial Insects with Native Flowering Plants," provides photos and bloom time for many of the native flowers listed below. This publication is available for purchase at shop.msu.edu. Wildflowers described in E2973 are marked with an asterisk (*) in the following table.

Wildflowers attractive to bees

Common name	Genus species (scientific name)
American vervain, blue vervain	*Verbena hastata**
Aromatic aster	*Symphyotrichum oblongifolium**
Canadian milkvetch	*Astragalus canadensis**
Clover	*Melilotus* spp.
Clover	*Trifolium* spp.

*Wildflowers known to attract beneficial insects and described in MSUE publication E2973.

Wildflowers attractive to bees (continued)

Common name	Genus species (scientific name)
Coneflower	*Ratibida columnifera**
Coral Bells	Heuchera
Culver's root	*Veronicastrum virginicum**
Cup plant	*Silphium perfoliatum**
Foamflower	*Tiarella cordifolia*
Golden alexanders	*Zizia aurea**
Goldenrod	*Oligoneuron* spp.
Goldenrod	*Solidago speciosa*
Great blue lobelia	*Lobelia siphilitica*
Horsemint, spotted beebalm	*Monarda punctata**
Joe-Pye weed	*Eupatorium fistulosum**
Late figwort	*Scrophularia marilandica**
Meadowsweet (shrub)	*Spirea alba**
Missouri ironweed	*Vernonia missurica**
Mountain mints	*Pycanthemum* spp.*
Native milkweeds	*Asclepias* spp.*
Naturalized asters	*Aster* spp.
Nodding wild onion	*Allium cernuum**
Obedient plant, false dragonhead	*Physostegia virginiana**
Pale Indian plantain	*Cacalia atriplicifolia**
Penstemon, hairy beardtongue	*Penstemon hirsutus**
Prairie blazing star	*Liatris pycnostachya*
Purple prairie clover	*Dalea purpurea*
Rattlesnake master, eryngo	*Eryngium* spp.
Riddell's goldenrod	*Solidago riddellii**
Rough blazing star	*Liatris aspera*
Rough oxeye, false sunflower	*Heliopsis helianthoides*
Showy milkweed	*Asclepias speciosa*
Smooth aster	*Aster laevis**


Diane Brown, MSU Extension

Goldenrod


Diane Brown, MSU Extension

Joe-Pye weed

Wildflowers attractive to bees (continued)

Common name	Genus species (scientific name)
Thimbleweed herbaceous perennial	*Anemone cylindrica**
White wild indigo, false indigo	*Baptisia alba*
Wild quinine, American feverfew	*Parthenium integrifolium*
Woodland phlox	*Phlox divaricate*
Yellow coneflower	*Ratibida pinnata**
Yellow giant hyssop	*Agastache nepetoides**
Weeds	
Chickweed	*Stellaria media*
Clover	*Trifolium* spp.
Dandelion	*Taraxacum officiniale*
Knapweed (feral)	*Centaurea montana*
Smartweed	*Polygonum* sp.

Landscape plants and wildflowers attractive to butterflies for nectar feeding

Many of the flowering plants attractive to bees will also be visited by butterflies. However, butterflies are attracted to flowers almost entirely for feeding on nectar. They do not intentionally seek or collect pollen for food for their young as do bees. Some pollen may become attached to their mouthparts, legs or bodies as they draw nectar from flowers, but not nearly as much as is found on bees. Because of this, as a group butterflies are not as important as bees for pollinating plants, and flowers that are poor pollen sources can still be very attractive to butterflies for food, if they are a good nectar source.

The immature (caterpillar) stages of almost all butterfly species feed on plant leaves. An adult butterfly might readily take nectar from numerous plant species, but their host plant range as a caterpillar is often restricted to one or a few closely related plant species. It is very important to carefully select plant species if supporting butterflies is a goal of your gardening or landscaping. The plant lists below are based on published nectar records for over 80 species of common or widespread butterflies found in the North Central U.S. Plants that are also hosts for butterfly caterpillars are noted. One of the goals of the national plan to protect pollinators is to increase milkweed habitat for monarch butterfly larvae. Planting milkweed will also help monarchs. The best way to do this is to purchase milkweed seed from a commercial supplier. For more information on gardening for monarchs, see Elsner (2015) in this document's references.


Diane Brown, MSU Extension

Lantana


Ashley Bennett, MSU Entomology

Prairie phlox


Diane Brown, MSU Extension

Black-eyed Susan


Erwin Elsner, MSU Extension

Ironweed

Herbaceous plants attractive to butterflies

Like bees, butterflies seem to find perennial plant flowers more attractive than those of annual plants. It is also important to use mixtures of plants to provide for different flower types, plant height and blooming season. Certain annuals are helpful with this goal in that some bloom season-long.

Herbaceous plants attractive to butterflies

Common name	Genus species (scientific name)	Caterpillar host
Alfalfa	*Medicago sativa*	Yes
Asters and daisies	*Aster* spp. and related genera	Yes
Bee balm, bergamot	*Monarda* spp.	No
Black-eyed Susan	*Rudbeckia hirta*	Yes
Blazing star	*Liatris* spp.	No
Butterfly bush	*Buddleia davidii*	No
Clovers (especially red clover, *T. pretense*)	*Trifolium* spp.	Yes
Coreopsis	*Coreopsis* spp.	No
Dandelion	*Taraxacum officinale*	No
Dogbanes	*Apocynum* spp.	No
Goldenrods	*Solidago* spp.	No
Ironweeds	*Vernonia* spp.	No
Joe-Pye weed	*Eupatorium* spp.	No
Lantana	*Lantana* spp.	No
Milkweeds	*Asclepias* spp.	Yes
Mints	*Mentha* spp.	No
Orange hawkweed	*Hieracium aurantiacum*	No
Phlox	*Phlox* spp.	No
Purple coneflower	*Echinacea purpurea*	No

Herbaceous plants attractive to butterflies (continued)

Common name	**Genus species (scientific name)**	**Caterpillar host**
Speedwell	*Veronica* x 'Sunny Border Blue'	No
Spotted Joe-Pye weed	*Eupatorium maculatum*	No
Thistles (but not "star" thistles)	*Cirsium* spp.	Yes
Vetches (but not crown vetch)	*Vicia* spp.	Yes

Trees and shrubs attractive to butterflies

In addition to feeding on nectar from tree and shrub flowers, many butterfly species will suck juices from over-ripe fruits once they have fallen to the ground.

Trees and shrubs attractive to butterflies

Common name	**Genus species (scientific name)**	**Caterpillar host**
Blackberry	*Rubus* spp.	No
Blueberries	*Vaccinium* spp.	Yes
Butterfly bush	*Buddleja davidii*	No
Buttonbush	*Cephalanthus occidentalis*	No
Labrador tea	*Ledum groenlandicum*	Yes
Lilac	*Syringa* spp.	Yes
New Jersey tea	*Ceanothus americanus*	Yes
Redbud	*Cercis canadensis*	Yes
Shrubby cinquefoil	*Potentilla fruticosa*	Yes
Staghorn sumac	*Rhus typhina*	Yes
Wild cherries	*Prunus* spp.	Yes

Flowers throughout the year

The best habitats for bees have flowering plants rich in nectar and pollen throughout the growing season. Survey your yard and garden to see when flowers are abundant and when they are scarce. You can then add pollinator-attractive perennials, shrubs and trees to your garden that bloom at times to fill in the gaps and create a continuous flow of nectar and pollen from early spring through late fall.

In the chart on the next page, bloom time is shown in gray for flowers that are attractive to bees. The type of plant (annual, perennial, bulb or shrub) is indicated following the scientific name. Plant names appearing in bold print are super-attractive to bees.

Margaret Pooler, Bugwood.org

Lilac bush

Biological control and Integrated Pest Management (IPM) for protecting pollinators

For the past 30 years or more, most tree care professionals and many informed property owners have been managing destructive insects by minimizing pesticide use and encouraging predators and parasitoids that naturally keep pests under control. This approach is referred to as Integrated Pest Management (IPM), and it includes using Best Management Practices (BMPs) for preserving beneficial insects. In most states, landscape professionals must attend educational classes on pesticide safety and best management practices to receive their pesticide applicator license, a requirement for purchasing restricted use pesticides. Minimizing pesticide use along with implementing other IPM practices protects water resources from pesticide runoff, minimizes exposure of people, pets and wildlife to pesticides, and provides stable long-term pest control instead of the frequent boom and bust pest cycles associated with preventive use of broad-spectrum pesticides.

Erwin Elsner, MSU Extension

Bee on a cherry blossom.

Planting for a succession of flowers. Bloom time indicated in pink.

Plant	Plant type	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Eranthus cilicica	Bulb									
Helleborus spp.	Perennial									
Centaurea cyanus	Perennial									
Calendula spp.	Annual									
Coreopsis spp.	Perennial									
Rosa rugosa	Shrubs									
***Lavandula* spp.**	Perennial									
Campanula carpatica	Perennial									
Centaurea montana	Perennial									
Achillea spp.	Perennial									
Echinacea spp.	Perennial									
Eryngium spp.	Perennial									
Oreganum vulgare	Perennial									
Salvia spp.	Perennial									
Borago officinalus	Annual									
Thymus spp.	Perennial									
***Agastache* "Black Adder"**	Perennial									
Astilbe spp.	Perennial									
Echinops ritro	Perennial									
Melissa officinalis	Perennial									
Penstemon spp.	Perennial									
Solidago spp.	Perennial									
***Helenium* spp.**	Perennial									
Perovskia atriplicifolia	Perennial									
Dahlia spp. cv.	Perennial									
Sedum spectabile	Perennial									
Cosmos spp.	Annual									
Asters spp.	Perennial									
Chrysanthemum sp.	Annual/ Perennial									

The primary reason tree care professionals and property owners use pesticides is because of the devastating impact of invasive pests from Europe and Asia. Invasive pests multiply and sometimes completely destroy North American plants species for two reasons: (1) our North American plants may lack natural defenses (resistance) to invasive pests from Europe or Asia, and (2) invasive pest populations may build rapidly because we do not have the right predators and parasitoids to control them as in their native habitat.

Emerald ash borer, Japanese beetle and hemlock wooly adelgid are currently some of our most destructive invasive insects. Homeowners, business property owners and cities sometimes choose to use a pesticide to protect ash, hemlock and other trees and shrubs susceptible to invasive insects. However, when insecticides are used for invasive pests, they may impact pollinators and other beneficial insects and mites, including predators and parasitoids that keep plant pests under control. This publication is designed to provide best management practices for protecting a few valuable plants from invasive pests while minimizing the impact on pollinators and beneficial insects.

Note: When using any pesticide mentioned in this bulletin, read the label instructions and be sure the product is registered for use in the state where it is being used.

Problem-prone plants likely to need insecticide or fungicide treatment to remain healthy

Tree common name	Scientific name	Potential problems of concern
Ash	*Fraxinus* spp.	All North American *Fraxinus* spp. (ash) are susceptible to emerald ash borer, and once the borer is present they will not survive without insecticide treatments.
Austrian pine	*Pinus nigra*	Susceptible to Diplodia tip blight and Zimmerman pine moth.
Boxelder	*Acer negundo*	A weak-structure tree that hosts boxelder bugs, a nuisance in houses. Seeds and seedlings may be a problem.
Colorado spruce	*Picea pungens*	Prone to fungal cankers that kill the lower branches, particularly when drought-stressed.
Common lilac	*Syringa vulgaris*	Prone to powdery mildew, scale insects and bacterial blight. Look for blight-resistant cultivars.
Crabapple	*Malus* spp.	Many cultivars susceptible to leaf drop due to apple scab. Plant scab-resistant cultivars.
European mountain ash	*Sorbus aucuparia*	Susceptible to scab, fungal cankers, scale insects and borers.
European white birch	*Betula pendula*	All European and Asian cultivars are highly susceptible to bronze birch borer. Use native birch species when possible.
Poplars	*Populus* spp.	Fast growing, but susceptible to cankers, galls and borers.
Purpleleaf plum	*Prunus cerasifera* *Prunus* x *cistena*	Susceptible to borers, cankers and blacknot.
Russian olive	*Eleagnus angustifolia*	Branch dieback from cankers and verticillium wilt. Somewhat invasive.
Siberian elm	*Ulmus pumila*	Fast growing, but short-lived and brittle. Not tolerant of shade. Variable level of resistance to Dutch elm disease.
Willow	*Salix* spp.	Brittle and susceptible to crown gall, cankers and borers.
Wintercreeper euonymus	*Euonymus fortunei*	Highly susceptible to euonymus scale. Unlikely to survive without treatment for scales.

Selection, planting and care of trees and shrubs to avoid the need for pesticides

The best way to minimize pollinator exposure to pesticides is to create and maintain healthy landscapes with plants that rarely require a pesticide application. Choose perennials, shrubs and trees that are adapted to your climate and soil type. Make sure they are winter hardy in your area and will get the amount of sunlight they require. The most important considerations needed to establish healthy plants are covered in the seven categories that follow.

1. Do not choose plants known to have major pest or disease problems. The best way to avoid the need for pesticides is to choose pest-resistant plants. Review the problem-prone plants in the table on this page before buying plants. In many cases, resistant cultivars or alternative plant types with the same characteristics are given. There are many guides available for choosing other trees and shrubs as alternatives to the problem-prone trees listed below (See Cregg and Schutzki 2006).

Diane Brown, MSU Extension

Blooming sedum

2. Make sure the plant you are considering is winter-hardy in the climate zone where you live. This is easy to do using the USDA Plant Hardiness Zone Map: http://planthardiness.ars.usda.gov/PHZMWeb/

This website has an interactive map of plant hardiness zones for all of the U.S. Perennials, trees and shrubs at the garden center should have the cold-hardiness zone listed on the tag of each plant. If your area is listed as zone 5b, for example, make sure the plants you buy have zone 5b or a smaller number listed (smaller numbers are more cold-hardy).

3. Check your soil pH. Appropriate soil pH levels are often listed on plant labels. Make sure your soil pH falls within the range considered adequate for the tree type you are considering. Some classic examples of trees sensitive to high pH soils are red maple, pin oak and white pine. The foliage may begin to turn yellow (chlorosis) when trees grow in soil with a pH above 7.5 due to a lack of iron or manganese. These deficiencies are caused by tree roots failing to absorb these metals from high pH soils. To learn your soil's pH, you will need to send a sample to a soil lab. The MSU soil lab (http://www.spnl.msu.edu/) offers a kit for collecting and mailing soil samples and will return customized results on a variety of soil characteristics. Order E3154 at shop.msu.edu

4. Check light and moisture requirements. Some trees and shrubs do not grow well in shady sites, and some actually prefer some shade. Find light and moisture requirements on the plant's label and make sure it will receive enough hours per day of sunlight to thrive.

Rebecca Finneran, MSU Extension

Check for variability in soil moisture and light and select plants accordingly.

5. Allow enough space for the root system and branches to grow to full size. Note the maximum height listed on the plant label and make sure this is appropriate for the site. Trees and shrubs need room for roots to grow down and outward from the trunk. In general, small trees should not be planted any closer than 8 feet from a building, and large trees no closer than 15 feet away, although 20 feet or more is better.

6. Prepare planting sites properly. Dig a hole at least twice as large as the root ball and fill with the soil that was removed amended with no more than 5% organic matter. Heavy clay soils can be amended by adding some sand or silt. Make sure water drains well from the planting site. Unravel roots before planting and place the root ball so the area where the roots start to flare outward from the trunk are level or 1-2 inches above the surrounding soil surface.

7. Avoid drought stress. The most common plant stress is caused by drought. Because we see flowers wilt when they lack water, people understand the importance of frequently watering flower beds. Trees, shrubs and perennials are also weakened by prolonged water stress. In fact, adequate soil moisture may be the most important factor in maintaining ornamental plants. Drought stress encourages insect and disease problems that may then require a pesticide. Water new trees as directed on the plant label.

How to control invasive pests while protecting pollinators and other beneficial insects

Pesticides should never be applied unless they are necessary to maintain plant health. Using preventive cover sprays, where pesticides are sprayed several times a year on a calendar basis, has been shown to create more pest problems than it solves. Not only do cover sprays create potential for pesticide runoff and increased human and pet exposure, they actually create pest problems by suppressing predators, parasitoids and diseases that keep plant pests under control. It is common to see outbreaks of spider mites, aphids and scale insects where pesticides are used. Only spray one plant at a time, and only if it is necessary.

Some key points about pollinator biology are good to remember if you have to use a pesticide, even if you are only treating one or two trees, shrubs or perennials. First, most bees and other pollinators forage during the day, so if you can spray at night or in the early morning, you can reduce the risk of accidentally spraying them. Second, pollinators are attracted to flowers. Anything that has flowers or is about to flower is a higher risk than a plant that is past bloom. If you can remove the flowers by mowing or pruning from around the treated plant, and anywhere your application may drift, you can significantly reduce risk to bees and other pollinators.

Use low impact pesticides

Choose insecticides that are highly selective to a specific type of insect and so have low toxicity for others (signal word of Caution on the label or EPA Reduced Risk product). Other characteristics of low impact pesticides are those that break down rapidly after application and therefore have minimal impact on pollinators and natural enemies. However, using these products requires some knowledge about their relative toxicity to beneficial insects and their potential to cause leaf or flower injury (phytotoxicity). The following types of products have a minimal impact on beneficial insects.

Insecticidal soaps. Insecticidal soaps are applied as a foliar application (sprayed on plant leaves) and are effective on a wide range of plant pests when the soap spray comes into contact with the pest. Most commercially available insecticidal soaps are made of potassium salts of fatty acids and kill by disrupting the structure and permeability of insect cell membranes. Insecticidal soaps are most effective on soft-bodied insects such as aphids, adelgids, lace bugs, leafhoppers, mealybugs, thrips, sawfly larvae, spider mites and whiteflies. They are not effective on pests as a residue on the plant surface, and therefore are not toxic to pollinators after the spray dries. They can be safely used at any time to control pests on plants that are not attractive to pollinators. However, on pollinator-attractive plants, spray at dawn or dusk when pollinators are not present.

Generally, concentrations of insecticidal soaps exceeding 3% may cause some leaf or flower injury, and concentrations as low as 1.5% may injure sensitive plants. Read the product label for a list of sensitive plants and avoid spraying those. If uncertain of a plant's sensitivity, spray a few leaves or flowers first and wait at least three days to watch for symptoms of spray injury, which include yellow, black or brown spots, brown (necrotic) edges on leaf and petal tips, scorch or discoloration. Some landscape plants known to be sensitive to insecticidal soap are horse chestnut, mountain ash, Japanese maple, sweet gum, jade plant, lantana, gardenia, bleeding heart, sweetpeas, crown-of-thorns and some cultivars of azaleas, begonias, chrysanthemum, fuchsias and impatiens.

It is best to purchase a commercial product formulated for use on plants rather than prepare your own spray from dish-washing detergents or other household cleaners because homemade recipes may be more toxic to plants. Most such products are detergents rather than true soaps, which can damage your plants. Only use products that are specifically formulated and labeled for use as insecticide. For more information on using insecticidal soaps, see Miller (1989), Gill and Raupp (1990) and Pundt (2004) in the reference section of this publication. Many insecticidal soap products are listed by the Organic Materials Review Institute (OMRI) at www.omri.org.

Horticultural oils. Horticultural oil is a term for the various oils used for pest control on plants. Most horticultural oils are lightweight and petroleum-based, but some are made from grains, vegetables or neem tree seeds. Like insecticidal soap, horticultural oils work best when the spray comes in contact with the pest.


Deb Vadnais from Pixabay.com

Redbud

Once the oil spray dries, it does not have much effect and becomes safe for pollinators and other beneficial insects. Horticultural oil can be safely used at any time to control pests on plants that are not attractive to pollinators. However, on pollinator-attractive plants, spray at dawn or dusk when pollinators are not present.

Horticultural oils give excellent control of armored scales, such as Euonymus scale and oystershell scale, and can also be used for aphids, whiteflies, spider mites, true bugs, caterpillar and sawfly larvae and more. The recommended concentration of horticultural oils for pest control is usually 2%. However, even at 2%, some plants are sensitive to oils, including Japanese maple, red maple, hickory, black walnut, plume and smoketree (*Cotinus coggygria*). Plants reported as somewhat sensitive are Colorado blue spruce, redbud, juniper, cedar, cryptomeria and Douglas fir. Applying oils during high humidity or high temperatures may have a toxic effect on plant growth. Plant injury symptoms following an application of horticultural oil are discoloration, yellowing, leaf or flower browning (necrosis), black spots and terminal or branch dieback. It is best to spray a few plants first and observe them for three days for these phytotoxicity symptoms. Many horticultural oil products are listed by the OMRI.

Microbial or biopesticides. Several pesticides sold are derived from naturally occurring pathogens such as bacteria or fungi. These microbial or bio-pesticides vary in their toxicity to bees, butterflies and other beneficial insects. Some bioinsecticides, such as those derived from the fungus *Beauvaria bassiana*, are toxic to bees and should not be used where pollinators are present. Other bioinsecticides may have low impact on pollinators due to their low toxicity or short residual, which allows them to be applied in the evening or at dawn when bees are inactive.

Considerations for using certain biopesticides

The following active ingredients are found in products that have minimal impact on bees and other beneficial insects.

***Bacillus thuringiensis* (B.t.).** Products containing B.t. are made from a naturally-occurring soil bacterium. Many different B.t. products are available for landscape professionals and homeowners. Different strains of B.t. target specific pest groups, making them selective pesticides. For example, spores and crystals of *Bacillus thuringiensis* var. *kurstaki* (B.t.k.) are highly toxic when ingested by butterfly and moth larvae (caterpillars). The crystals containing the toxin dissolve only at an extremely high pH found in the caterpillar's gut. B.t.k. is not toxic to bees. However, avoid spraying or allowing spray to drift onto favored food plants of caterpillars such as milkweed, the sole food source for monarch butterfly caterpillars.

Another strain of B.t., *B.t. galleriae* (B.t.g.), targets several species of beetles in the adult and larval stages including scarab beetles (e.g., Japanese beetle), flat headed beetles (e.g., emerald ash borer), weevils and leaf beetles. B.t.g. is not toxic to bees or butterflies, but applications should be avoided where predatory beetles are active. B.t. galleriae is now available at garden centers and recent testing indicates that it will control Japanese beetle adults for two weeks after it is sprayed. It will not harm pollinators, but it is toxic to monarch caterpillars.

While a B.t. strain works well for its target pest, it also breaks down quickly in sunlight, becoming ineffective after a few days. This makes B.t. very safe for pollinators, predatory insects and mammals. B.t. can be sprayed even when bees or butterflies are present. Many B.t. products are OMRI listed.

Metarhizium. The fungus *Metarhizium anisopliae* is found naturally in soils and infects and kills insects. Commercially available products of *M. anisopliae* (e.g., Met52) target thrips, weevils, whiteflies and mites on ornamentals, and ticks in turf. Once the product is sprayed on the foliage or drenched in the soil, the spores attach to the surface of the insect, germinate and penetrate the insect, multiply and kill it. *M. anisopliae* does not detrimentally impact honey bees and is being studied as a bio-insecticide of *varroa* mites, a pest of honey bees.

Chromobacterium subtsugae. This naturally occurring bacterium is used in a fermentation process that

Steven Katovich, USDA Forest Service, Bugwood.org

Monarch caterpillar on a common milkweed. Milkweeds are its sole source for food.

produces a product with insecticidal properties (e.g., Grandevo PTO). It is a broad spectrum bio-insecticide/miticide that controls or suppresses insect and mite pests on ornamentals and turf. It has multiple modes of action including oral toxicity (stomach poison), repellency and reduced reproduction. This product is applied as a foliar application and targets numerous caterpillar species in addition to aphids, whiteflies, thrips, psyllids, lace bugs, chinch bugs, mites and certain beetles. It suppresses a broad number of caterpillar species and should not be sprayed or allowed to drift in known habitats for threatened or endangered species of caterpillars and butterflies, such as fields with milkweed where monarch butterfly caterpillars feed. This product may repel bees for up to six days, so time applications to avoid disrupting pollination. Grandevo PTO (active ingredient *C. subtsugae*) is an OMRI listed product.

Azadirachtin. Azadirachtin is the active ingredient extracted from seeds of the tropical neem tree. Bio-insecticides with azadirachtin act as an insect growth regulator (IGR) in addition to being an anti-feedant and repellant to insects. It is effective at controlling insect immature stages and is broadly labeled for adelgids; aphids; caterpillars such as budworms, tent caterpillars and webworms; beetles such as Japanese beetles, emerald ash borers, weevils and elm leaf beetles; leafhoppers; leafminers; mealybugs; psyllids; sawflies; scales; thrips; and whiteflies. Azadirachtin must be ingested to be toxic and, when applied as a foliar spray, has short residual activity, making it unlikely bees and other pollinators will be affected (no longer toxic after about two hours for bees). Direct contact has shown no effect on worker honey bees. Azadirachtin products can be safely used at any time to control pests on plants that are not attractive to pollinators. However, on pollinator-attractive plants, spray during late evening, night or early morning

Erwin Elsner, MSU Extension

A butterfly visits an ironweed flower.

when pollinators are not present to minimize contact with adult bees that could potentially bring azadirachtin back to the nest where larvae are present. Many azadirachtin products are OMRI listed.

Spinosad. Spinosad is derived from a soil bacterium and affects the nervous system of insects and mites. It has contact activity, but is even more active when ingested. Several products containing spinosad are labeled for ornamental (e.g., Conserve) and agricultural uses to control a broad spectrum of pests including caterpillars, sawfly larvae, leaf beetle adults and larvae, thrips, leafminer and gall-making flies and emerald ash borer beetles. Spinosad is highly toxic to bees. However, toxicity is greatly reduced once the product has dried on the foliage, within three hours to one day depending on the product. Therefore, avoid use if bees are active, and if applications are needed, apply in the evening when bees are not active and product has time to dry. This product suppresses a broad number of caterpillar species and should not be sprayed or allowed to drift in known habitats for threatened or endangered species of caterpillars and butterflies. Some spinosad products are OMRI-listed and on the EPA Reduced Risk list.

Use EPA Reduced Risk products

In 1994, EPA established a Reduced Risk Program to expedite review and approval of conventional pesticides that pose less risk to human health and the environment than existing pesticides. (See www.epa.gov/pesticide-registration/reduced-risk-and-organophosphate-alternative-decisions-conventional.)

Reduced risk status is granted to products demonstrating one or more of the following attributes: low impact on human health; lower toxicity to non-target organisms; low potential for ground and surface water contamination; low use rates; low pest resistance potential; or compatibility with IPM practices. EPA does not require a signal word on the label of Reduced Risk products. Although not all EPA Reduced Risk products are harmless to pollinators and other beneficials, many do have reduced impacts.

The following active ingredients are found in products on the EPA Reduced Risk list and should have minimal impact on bees and other beneficial insects. One limitation to this list, and the bee warning labels on insecticides, is nearly all the pollinator data required by EPA before registration of a pesticide is fulfilled through toxicology tests with one species: the honey bee (*Apis mellifera*). Recent studies have shown native bees or wild bees are sometimes more susceptible to insecticides than honey bees. Another list of reduced-risk pesticides is the Xerces Society's "Organic-approved pesticides minimizing risks to bees," which is available at their website.

Chlorantraniliprole. This EPA Reduced Risk chemical interrupts the normal muscle contraction of insects, resulting in paralysis and death. It has limited systemic activity (moves internally within the plant) and can be applied as a foliar spray or through the soil. It is labeled against turf pests including caterpillars, white grubs, crane flies, billbugs, annual bluegrass weevils and spittlebugs, and ornamental pests including leaf-feeding caterpillars, lace bugs, aphids and birch leafminers, and as a bark spray for clearwing borers. Due to the activity of chlorantraniliprole against caterpillars and its long residual activity, applications should not be made on larval host plants of butterfly and moth pollinators. Chlorantraniliprole has negligible toxicity to bees, and is shown to have no impact on bumble bees. It has no direct impact on natural enemies, and so is compatible with IPM programs.

Acetamiprid. This neonicotinoid is classified as Reduced Risk by EPA. It kills insects by disrupting the nerve function. Acetamiprid is systemic and absorbed through the foliage or when applied as a basal bark spray. It is labeled to control a broad range of pest insects on ornamental plants including aphids, adelgids, caterpillars, European pine sawflies, mealybugs, leafhoppers, armored and soft scales, plant bugs, whiteflies, fungus gnat larvae, thrips and leafmining flies. Because acetamiprid is toxic to multiple caterpillar species, this product should not be sprayed or allowed to drift into known habitats for threatened or endangered species of caterpillars and butterflies. Although acetamiprid is less toxic to bees than other neonicotinoids, it is still toxic to bees directly exposed to the chemical. Apply acetamiprid in the evening, night or early morning when bees are not visiting blooming plants and the residue will not be harmful to bees. When the fungicide fenbuconazole is combined with acetamiprid, the mixture is about fivefold more toxic to honey bees than acetamiprid alone.

Tebufenozide. This EPA Reduced Risk chemical is an IGR that disrupts the molting of early instar caterpillars following ingestion. Tebufenozide is a selective chemical specific to caterpillars. It is only labeled for use in nurseries and on Christmas trees for a broad range of caterpillars. Tebufenozide is selective, making this product nontoxic to bees and most natural enemies. However, caution should be used to avoid application or drift to larval (caterpillar) food plants of butterfly and moth pollinators.

Pyriproxyfen. Pyriproxyfen is an EPA Reduced Risk chemical that acts as an IGR disrupting the molting process of immature insects (juvenile hormone disrupter). It has translaminar activity (moves through the leaves) and ovicidal activities. Pyriproxyfen provides very good control of certain scale insects including black scale, California red scale, euonymus scale, Florida wax scale, San Jose scale and snow scale. It also controls spotted tentiform leafminer and whiteflies, and suppresses aphids and mealybugs. Pyriproxyfen has low to moderate toxicity to bees. Be careful to avoid spraying or drift near honey bee hives and bumble bee nests. There should be little impact on butterflies or other beneficial insects. Phytotoxicity has been observed on the following plants: Salvia (*Salvia* spp.), ghost plant (*Graptopetalum paraguayense*), Boston fern (*Nephrolepis exaltata*), Schefflera (*Schefflera* spp.), Gardenia (*Gardenia* spp.) and coral bells (*Heuchera sanguinea*).

Pymetrozine. This EPA Reduced Risk pesticide disrupts the normal feeding behavior of aphids and whiteflies on ornamentals. The Endeavor label (active ingredient pymetrozine) states no precautions for honey bees and bumble bees. However, some toxicity has been observed in field studies. As a caution, apply pymetrozine in the evening, night or early morning when bees are not visiting blooming plants. Since this product is selective for aphids and whiteflies, there should be no impact on other pollinators or natural enemies.

Spiromesifen. Spiromesifen is a mite IGR labeled as an EPA Reduced Risk chemical. It is a lipid biosynthesis inhibitor and targets all stages of a broad range of mite species including spider, false spider, rust and tarsonemid mites and immature stages of whitefly species. The Forbid label (active ingredient spiromesifen) states no precautions for bees, but there are concerns about the systemic nature of this product and the potential exposure of bee larvae to this class of insecticide. Due to this concern, spiromesifen should be applied after bloom for flowering plants attractive to bees.


Erwin Elsner, MSU Extension

A dandelion draws a butterfly to its blossom.

Acequinocyl. This EPA Reduced Risk miticide is a metabolic poison that kills spider mites by affecting energy production. It provides quick knockdown and long residual control for spruce spider mites and twospotted spider mites. Plants should be tested for sensitivity to acequinocyl, especially roses and impatiens. The Shuttle label (active ingredient acequinocyl) states no precautions for bees. Acequinocyl is considered nontoxic to bees and can be applied at any time. Since acequinocyl is selective for mites, other pollinators and natural enemies should not be affected.

Flupyradifurone. This EPA Reduced Risk insecticide is a novel butenolide insecticide that kills insects by disrupting nerve function. Flupyradifurone, marketed as Altus, is systemic and can be applied as a foliar spray or soil drench. It is labeled to control a broad range of sucking insects on ornamental plants including aphids, lace bugs, scales, leafhoppers, psyllids, mealybugs and whiteflies. Flupyradifurone is compatible with many beneficials and has no adverse effects on honey bees and bumble bees and can be applied before, during and after bloom. It is compatible with IPM programs.

Low-impact miticides and insecticides not on the EPA Reduced- Risk list

Hexythiazox. This mite growth regulator disrupts mites' normal development. It is effective against immature spider mites and eggs, has long residual activity and is applied at low rates. Hexygon (active ingredient hexythiazox) is selective for spider mites in the Tetranychidae family, which includes arborvitae spider mites, European red mites, honeylocust spider mites, Pacific spider mites, Southern red

Rebecca Finneran, MSU Extension

A bee finds a coneflower.

mites, spruce spider mites, strawberry spider mites, twospotted spider mites and Willamette mites. There is no bee precautionary statement on the Hexygon label and it is generally considered nontoxic to bees, although there is a caution about a potential short residual effect (about two hours) on alfalfa leafcutting and alkali bees. As a caution, apply hexythiazox in the evening, night or early morning when bees are not visiting blooming plants. Since hexythiazox is selective for mites, other pollinators and natural enemies should not be affected.

Buprofezin. Buprofezin is an IGR effective against nymphal stages of soft and armored scales (crawler stage), whiteflies, psyllids, mealybugs, planthoppers and leafhoppers. It works by inhibiting chitin synthesis, suppressing oviposition of adults and reducing egg viability. It is nontoxic to bees and is not disruptive to other beneficial insects and mites.

Etoxazole. Etoxazole is a selective miticide effective against most plant-feeding mites, but fairly safe for most predatory insects and mites. Etoxazole is practically nontoxic to adult honey bees.

Do not spray pollinator-attractive plants with insecticides when open flowers are present

It is clear to most people that insecticides sprayed onto open flowers can be highly toxic to bees, even if they are sprayed early in the morning or at night when bees are not present. However, some may not realize insecticides sprayed in the two-week period before a tree flowers can also be toxic to bees. Insecticides that tend to volatilize, like chlorpyrifos, can vaporize off the leaf surface and contaminate flowers after they open. Although this level of contamination is very low, it may still affect bees because some insecticides, like the neonicotinoids, can affect bees at concentrations as low as 10 ppb (part per billion). Also, some systemic insecticides like most of the neonicotinoids may be partially absorbed by sprayed leaves and move systemically in the plant. Only a very small amount of residue is absorbed into leaf tissue, not enough to provide control of insect pests, but it may be enough to cause sublethal effects to bees if it moves into the pollen or nectar. Recent studies on cherry trees indicate if they are sprayed with imidacloprid after the flowering period is over, the amount of imidacloprid found in nectar the following year (1 to 6 ppb) is not a serious threat to pollinators.

Basal applications of systemics such as imidicloprid that inadvertently land on nearby ground cover plants become a resource of pesticide-laden pollen and nectar. Deadhead these plants before bloom to avoid contact.

Potential impact of mosquito and nuisance insect sprays on pollinators

Fogging or spraying for mosquitoes or biting flies around the yard and garden with an insecticide can be very harmful to pollinators. Even if flowering plants are avoided and applications are made after sunset, insecticides applied as a fog or mist can drift onto flowering plants within 100 meters or more depending on the wind speed and direction. The insecticide drift could contaminate pollen and nectar collected by bees for several days or weeks after it is applied, and the residue on leaves can be toxic to caterpillars for weeks or months. Caterpillars of some species of butterflies are extremely sensitive to insecticide residue on leaves.

A recent research study that analyzed pollen collected by honey bees in rural Indiana found fairly high levels of two pyrethroid insecticides often used for mosquito or nuisance insect control. It is not known how the insecticides were applied or for what purpose, but it does point out the need for more research on the impact of mosquito and nuisance insect sprays on pollinators, including bee larvae fed contaminated pollen, and caterpillars feeding on sprayed leaves.

Mosquito control or abatement programs in the United States' north central region play an important role in monitoring for equine encephalitis, west Nile virus and other mosquito-borne diseases, and in suppressing mosquito populations by minimizing breeding habitats. For example, the state of Illinois has 21 public mosquito abatement districts. Most programs make the reduction of breeding sites for mosquito larvae a top priority, followed by treatment of spring flood pools and other breeding sites with *Bacillus sphaericus* (B.s.), *Bacillus thuringiensis* var. israelensis (Bti) and *Saccharopolyspora spinosa* (Spinosad). These larvicides are very selective and pose little risk to people, pets, pollinators and other non-target organisms.

Most programs also monitor adult mosquito activity and apply a broad-spectrum pyrethroid insecticide with truck-mounted ultra-low volume sprayers. In some programs nearly every inhabited neighborhood in the district is treated. Many programs attempt to minimize the impact on pollinators by spraying in the late evening when mosquitoes are active and bees have stopped visiting flowers. They may also avoid spraying trees and shrubs that are flowering.

The number of sprays applied for adult mosquitoes each year varies considerably depending on the district, abundance of breeding sites and weather conditions. As an example, the 2018 annual report of one mosquito district in Illinois sprayed prallethrin or sumithrin for adult mosquitoes on 22 nights in 2018. The truck-mounted sprayers in this district treated 75,000 acres and covered 2,081 miles of road.

Research studies with caged honey bees or honey bee hives have demonstrated that the ultra-low volume (ULV) applications made in the evening after bees are done foraging cause very little bee mortality. However, applications made during the day or to highly attractive flowers can be harmful to honey bees and other pollinators. It is not well-understood how much mosquito sprays affect native bees, but research with pesticides in agricultural systems consistently indicate that bumble bees and other native bees tend to be more sensitive than honey bees. Mosquito sprays are known to be harmful to monarch butterfly caterpillars feeding on milkweed plants within a 100 meters of the spray path, and in the Florida Keys, they have caused declines in populations of at last three species of butterflies.

Biting fly control around livestock rearing facilities are critical to the health and comfort of farm animals and farmers. Insecticidal ear tags and coat treatments have little impact on pollinators. Because pollinators are not frequent visitors to livestock holding areas pyrethroid sprays applied for fly control are unlikely to have much impact unless the spray drifts onto flowering plants or milkweed. Applying insecticides for biting flies under calm conditions and not when the wind will cause significant drifting can help minimize the impact on pollinators.


Kurt Stepnitz, MSU Photography

Bees can carry bring pollen containing pesticides back to the hive.

Considerations for disease management

It was previously thought that fungicides and bactericides are harmless to honey bees and other pollinators, and in fact, most fungicides are still considered relatively safe, even while spraying when pollinators are present. However, about a third of the fungicides and bactericides used in horticulture production or landscape maintenance can be harmful to honey bees or native bees. Consult the table in Appendix 1 for a list of products that provide precautionary statements when spraying flowers on plants attractive to pollinators. Although these fungicides are rarely toxic enough to cause mortality due to contact or ingestion after spraying, they may impact bees in the following ways.

Mortality. Very few fungicides or bactericides cause bee mortality with contact or ingestion, but eight (boscalid, captan, chlorothalonil, fosetyl AL, iprodione, manocozeb, neem oil, pyridaben + sulfer) have been reported to be harmful to honey bee larvae when consumed in pollen or bee bread. Seven additional are directly toxic to adults or are suspected for impacting honey bee colonies.

Synergy. Nine fungicides disable the detoxification enzymes of insects, which can greatly increase the toxicity of certain insecticides to bees. In other words, when bees consume pollen or nectar with specific mixtures of fungicides and insecticides, the insecticides become more toxic because the bees can't break down the active ingredients like they normally would. For example, when propiconazole is mixed with pyrethroid insecticides, it may increase the toxicity of the insecticide to bees. Also, when propaconizole and other DMI fungicides such as tebuconazole, myclobutanil and triflumizole are mixed with acetamiprid, the solution becomes fivefold more toxic to bees than acetamiprid by itself.

Managing emerald ash borer on ash trees

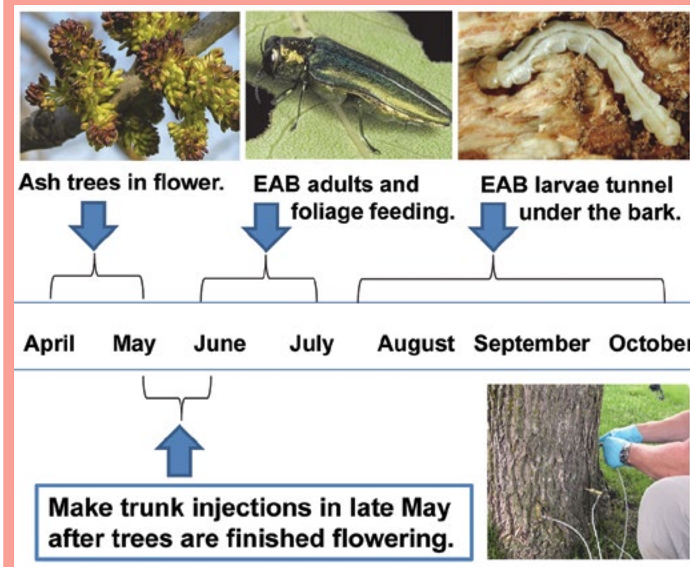


Figure photo credits: Ash tree flowers - forestry.ohiodnr.gov; EAB adults - David Smitley, MSU Entomology; EAB larva - Dave Cappaert, MSU.

Natural defenses and bee bread. Several types of fungi grow in hives, such as *Aspergillus, Penicillium, Cladosporium* and *Rhizopus*, and they function as a natural defense against bee diseases like chalkbrood (*Ascosphaera apis*). These bee-defense fungi also play an important role in producing bee bread, a fermentation product of pollen. Bee bread is a critical protein source for bee larvae and adults. Closely related cousins to these bee-defense fungi also cause plant diseases such as leaf spots and post-harvest decline. Fungicides are implicated in reduction of fungal diversity in hives and reduction in bee bread, but specific active ingredient impacts have not been determined for bee-defense fungi.

Other than noted above, fungicides are usually considered to be safe for bees. Please see the table in Appendix 1 (end of this document) for a list of known impacts and those fungicides considered unlikely to impact bees. For non-pollinator attractive plants, products should be applied according to label directions to manage pathogens. For pollinator attractive plants, follow label directions along with the additional cautions below when plants are blooming. Fungicides applied before flowers open or after petals fall off are not expected to be harmful.

Best Management Practices

Most pesticide applications by tree care professionals are due to a few exotic pests. Because our native trees may lack natural resistance to these invasive pests and we do not have the right species of predators and parasitoids to keep them under control, good cultural practices may not be enough to save the trees and shrubs they attack. For the following invasive pest species, consider replacing the host tree with a tree that does not have an invasive pest problem. Or, follow the Best Management Practices (BMPs) listed for each invasive pest. These practices are designed to save the infested tree while minimizing harmful effects of pesticides on pollinators and other beneficial insects. Each section starts with a summary of the importance of the host tree or shrub as a food source for pollinators or beneficial insects. BMPs are most important to implement for trees and shrubs that are important food plants for pollinators.

Protecting susceptible trees and shrubs from invasive pests

Ash trees (*Fraxinus* spp.)

Importance to pollinators: Ash trees can be an important source of pollen for bees during a two-week period in early spring when they bloom. Ash trees do not produce nectar.

Invasive pest: Emerald ash borer.

BMPs: Emerald ash borer is steadily spreading in the Eastern U.S. and into some western states. It is killing all ash trees in natural and managed landscapes. Insecticides can be used to preserve individual trees, but all are potentially toxic to pollinators if the insecticide moves into ash pollen.

Ash is wind-pollinated and does not produce nectar, but honey bees may collect ash pollen, and some native bees will fill larval chambers with up to 25% ash pollen during late April and early May when ash flowers. In Ohio and Michigan, white and green ash begin flowering at 190 degree-days, peaking at 240 degree-days, coinciding with flowering of many crabapples. Flowering times based on degree-days should be similar in most of the north central U.S.

No information is currently available on the amount of imidacloprid, dinotefuran or emamectin benzoate that moves into ash pollen following treatments for emerald ash borer. Based on research with other types of trees, it is likely trunk injections, trunk sprays or basal soil drenches of systemic insecticides applied before bloom will result in some insecticide in the pollen. To minimize the impact on pollinators, wait until after ash trees are done blooming, typically mid-May in our region, to make treatments. We will update the information here when research findings on insecticide residue in ash pollen is available.

Hemlocks (*Tsuga* sp.)

Importance to pollinators: Hemlock trees produce large amounts of pollen in the spring, but this pollen is not a nutritious food source for bees. However, because hemlock pollen may dust all the surrounding plants for several weeks, bees may be exposed to trace amounts that mix with the pollen of more preferred plants. Hemlocks do not produce nectar.

Invasive pest: Hemlock woolly adelgid.

BMPs: Because hemlock pollen is not usually collected by bees, it is unlikely that standard insecticide treatments of hemlock trees to protect against hemlock woolly adelgids will impact pollinators. However, because abundant amounts of pollen may be produced, contamination of other types of pollen can be minimized by treating hemlock trees with systemic neonicotinoid insecticides in late spring after trees have finished flowering. Also, recent research indicates that imidacloprid is much less likely than dinotefuran to appear in pollen and nectar the year after treatments are made. Another concern is neighboring flowering plants may pick up systemic insecticides from soil treatments of hemlocks, if the plants' root systems overlap.

A treatment method that mitigates this risk is to apply systemic insecticides through trunk injection or as a basal bark spray. A single application of a systemic insecticide typically provides at least two and up to seven years of protection of hemlocks from injury by hemlock woolly adelgids, and consequently, is a very efficient treatment option.

Frequent sprays with insecticidal soap or horticultural oil have been suggested as alternative products for controlling hemlock woolly adelgids because they are less harmful to pollinators. However, these products tend to be less effective as the soap or oil must contact the insect and are impractical for treating large trees.

Evergreen Euonymus (*Euonymus* spp.), Pachysandra (*Pachysandra* spp.) and bittersweet (*Celastrus* spp.)

Importance to pollinators: Euonymus, pachysandra and bittersweet pollen can be collected by bees, but they are not considered an important source of pollen.

Invasive pest: *Euonymus* scale.

BMPs: Susceptible types of *Euonymus* sp. are almost guaranteed to become infested with euonymus scale, decline slowly and become thin and unsightly. The most effective insecticide treatments for euonymus scale are an IGR (Pyriproxyfen) or horticultural oil applied as a foliar spray during crawler emergence in late spring. Pyriproxyfen is not harmful to adult bees or butterflies, but it is not known if it affects bee larvae fed with tainted pollen. A 2% concentration of horticultural oil applied during crawler emergence is the safest treatment for pollinators. Avoid spraying when bees are present.

Roses (*Rosa* spp.), Lindens (*Tilia* spp.), raspberries (*Rubus* spp.), blueberries (*Vaccinium* spp.), birch (*Betula* spp.) and many others

Importance to pollinators: Hybrid tea roses, rugosa roses and the popular Knock out roses are weak nectar and pollen producers. In a survey in Colorado, most *Rosa* spp. in gardens were observed to be "rarely visited by bees," but a few rose plants were "frequently visited by bees." Linden trees, birch trees, raspberries and blueberries are highly attractive to bees.

Invasive pest: Japanese beetle.

BMPs: Rugosa rose foliage is not skeletonized by Japanese beetles, but the beetles may feed on flowers. Flower feeding on rugosa roses is not nearly as much of a problem as it is on hybrid tea roses.

Managing Japanese beetles on linden trees

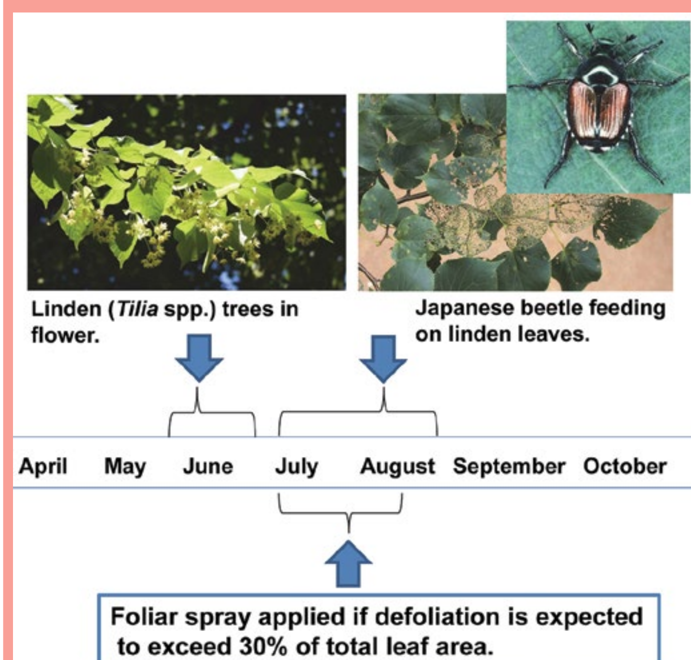


Figure photo credits: Linden flowers - Np holmes, Wikimedia Commons; Linden leaves - Steven Katovich, USDA Forest Serv., Bugwood.org; Japanese beetle - Courtesy Clemson Univ. USDA Coop. Ext. Slide Series.

Standard insecticide sprays used to protect hybrid tea roses (carbaryl, bifenthrin, cyfluthrin and other pyrethroids) are highly toxic to pollinators and other beneficial insects. Chlorantraniliprole is an alternative insecticide that provides good control of Japanese beetles as a foliar spray, but is much less toxic to bees. Chlorantraniliprole is the preferred product to use for Japanese beetles to protect bees, even if some drift is expected to other flowers. If carbaryl, bifenthrin, cyfluthrin or another pyrethroid insecticide is used, do not spray for Japanese beetles until after all flowers have dropped (usually after July 1 in Michigan), and avoid any drift to other flowers or food plants for caterpillars is suspected. Dimilin is toxic to all caterpillars and persists for at least two months after application.


Zachary Huang, MSU Entomology

A bee gathers pollen from a magnolia.

Viburnum (*Viburnum* sp.)

Importance to pollinators: Viburnum flowers are often mentioned as being attractive to bees. Some types of viburnum may be more attractive than others. Two species described as very attractive to bees are *Viburnum plicatum* and *Viburnum davidii*.

Invasive pest: Viburnum leaf beetle**.**

BMPs: Viburnum leaf beetle adults and larvae are active from late spring to early summer. Because of a lack of natural enemies, extensive feeding injury can defoliate viburnum shrubs. Avoid spraying when viburnum plants are flowering, or use chlorantraniliprole during bloom to minimize impact on pollinators. An insecticide applied after the flowering period is over will not be harmful to bees unless there is some drift to nearby flowering weeds or perennial flowers.

Oaks (*Quercus* sp.), birch (*Betula* sp.) and poplar (*Populus* sp.)

Importance to pollinators: Bees are often observed collecting pollen from oak and birch catkins in May in Michigan. Oak, birch and poplar flowers are wind-pollinated and do not produce nectar.

Invasive pest: Gypsy moth.

BMPs: The most widely used insecticide for protecting oak, birch and poplar trees from defoliation by gypsy moth caterpillars is B.t., which is not harmful to bees or butterfly adults. However, B.t. is toxic to all butterfly larvae (caterpillars). B.t. does not persist more than seven to 10 days after it is sprayed and should not be harmful to caterpillars that hatch more than two weeks after it is sprayed. The IGR dimilin is also used to protect trees from gypsy moth caterpillars. It is not harmful to adult bees or adult butterflies, but a negative impact on bee larvae fed tainted pollen

Magnolia (*Magnolia* sp.)

Importance to pollinators: Some types of flowering magnolia are highly attractive to bees for their pollen and nectar, but bee activity on early blooming (April) species depends on the daily temperature, with little activity when the temperature is below 55 degrees Fahrenheit. Species and cultivars vary in attractiveness, but the most fragrant cultivars tend to be the most attractive.

Invasive pest: Magnolia scale.

BMPs: Magnolia scale does not affect tree health unless the sugary waste excretion (honeydew) drips onto leaves under the scale insects causing a black fungus (sooty mold) to grow that may completely cover leaves. Most infestations can be ignored. If trees become unsightly, a 2% solution of horticultural oil can be sprayed after magnolias are done flowering in spring to suppress magnolia scale, but this approach is not always successful.

One practice that is being used by some arborists is applying a dilute solution of imidacloprid or dinotefuran around the base of infested trees (a basal soil drench). Both of these insecticides are highly toxic to bees and should not be applied until trees are done blooming. This will minimize any potential impact on pollinators the following year. Dinotefuran degrades more rapidly and is less likely to be present at harmful concentrations in pollen and nectar the following spring. Acetamiprid may be used as a basal spray for systemic control of insects and is much less toxic to bees than either dinotefuran or imidacloprid.

Protecting imported and native trees from native pests

European white birch (*Betula pendula*)

Importance to pollinators: Although birch is a wind-pollinated tree, the spring catkins produce a lot of pollen that may be collected by bees.

Native pest: Bronze birch borer.

BMPs: The best option is to grow species of birch native to North America because they are resistant to bronze birch borer. However, many garden centers still carry European white birch, *Betula pendula*, which is very susceptible to bronze birch borer. In fact, European white birch trees will very likely die within 20 years of when they are planted due to borer injury. The standard practice to preserve European white birch trees is to use a trunk injection of emamectin benzoate every third year, or a trunk injection or soil drench of imidacloprid each year. Trunk injections should be made in late May after birch trees are done flowering. We do not know at this time how much, if any, insecticide will be in the pollen the following year.

Basal soil drenches of imidacloprid applied after flowering, will also protect birch trees while minimizing the impact on pollinators the following year. Dinotefuran is not recommended because it may appear in pollen the following year.

Austrian pine (*Pinus nigra*) and Scots pine (*Pinus sylvestris*)

Importance to pollinators: The pollen of Austrian pine, Scots pine, all pine and spruce trees is not used by bees, and therefore is not important to pollinators.

Native pest: Zimmerman pine moth.

BMPs: There is little risk to pollinators because bees do not use pine pollen. However, the standard practice of spraying trunks and large branches in April or May could result in insecticide spray drift to nearby flowers. Most of the bark-applied insecticides persist a long time, so it would be best to spray in late March or early April before most trees and shrubs bloom, and before most bees become active. Honey bees will sometimes use pine tree sap to make propolis, which acts like a glue to hold the hive together. Check to make sure bees are not on the trunks or branches before spraying.

Arborvitae (*Thuja* sp.)

Importance to pollinators: Arborvitae pollen is not used by bees.

Native pest: Bagworm.

BMPs: If a spray is used, avoid drift to surrounding plants. If surrounding trees or shrubs are attractive to bees, and the roots grow into the arborvitae root zone, apply basal soil drenches after the surrounding trees have bloomed.

Cherry trees (*Prunus* sp.)

Importance to pollinators: The flowers of nearly all *Prunus* species are highly attractive to bees.

Native pest: Eastern tent caterpillar.

BMPs: Eastern tent caterpillars can be removed by scraping the caterpillar-filled tent off the tree and putting it into soapy water. They can also be controlled by spraying the tree canopy with B.t. or chlorantraniliprole, which are not harmful to bees. If any other insecticide is used, spray after the cherry trees have bloomed and avoid drift onto nearby flowers.

BMPs for spring defoliators

A number of different types of caterpillars feed on trees in spring and may be referred to as spring defoliators. Fall and spring cankerworm, gypsy moth, forest tent caterpillar and eastern tent caterpillar are some of the more common ones. With the exception of gypsy moth in outbreak areas, spring defoliators rarely cause enough feeding damage to justify using an insecticide. Shade trees can lose over one-third of their foliage from caterpillar feeding without any harmful effects on tree health.

If trees are losing more than a third of their entire canopy, a B.t or chlorantraniliprole spray will stop caterpillar feeding without harming pollinators. These are the only two products that can be used when trees are flowering without harming bees. Spinosad or diflubenzuron sprayed after the tree is done blooming will also minimize any impact on beneficial insects in the area.

BMPs for apple scab on crabapples

Protecting susceptible crabapple trees from apple scab without harming pollinators will require carefully timed sprays. Gradually replacing susceptible crabapples with resistant ones or another type of tree is the best long-term strategy. The problem is that several commonly used fungicides can be toxic to bee larvae when they are fed tainted pollen. Avoid using captan, ziram, iprodione, chlorothalonil and mancozeb when they are in bloom, and during the last week before the flowers open. Other fungicides may not be as harmful to pollinators, but can still inhibit beneficial fungi that ferment bee bread in honey bee hives.

Managing apple scab on crabapple trees

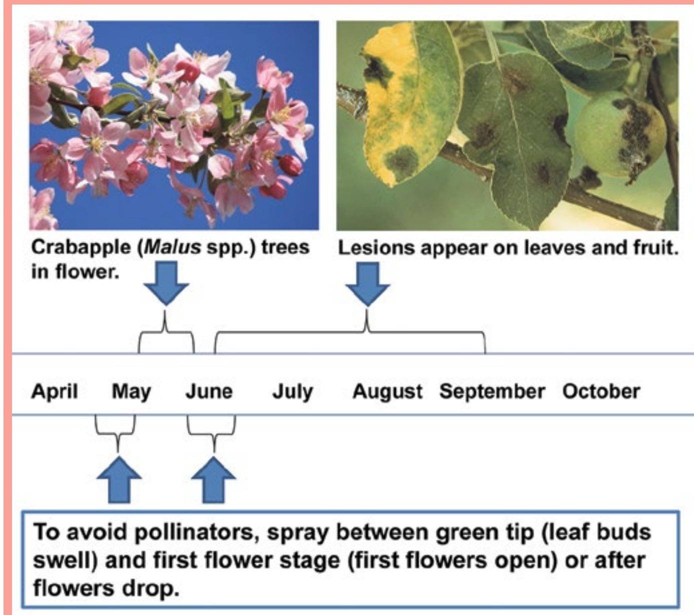


Figure photo credits: Crabapple flowers - www.photos-public-domain.com. Lesions - A.L. Jones, MSU.

Unfortunately, fungicide sprays to prevent apple scab are usually recommended to be applied between green tip (just before the leaves open) and petal fall, which includes the time when flowers are open. The best schedule to protect trees while minimizing impacts on pollinators is to spray when leaves begin to open before the first flowers open. Then spray again when the flowers are done blooming and the petals fall off. This is the best schedule for pollinators regardless of which fungicide is used. Still, it is best to avoid using the fungicides listed above that are known to be harmful to bees before the flowers open. After petal fall they are unlikely to affect bees, unless the spray drifts onto the flowers of nearby trees and shrubs, or onto perennials, wildflowers or flowering weeds below the trees.

Accurate knowledge of bloom period for selecting trees and shrubs and timing pest management strategies

The phenological sequence table on the next page gives accurate bloom periods for some of the best flowering trees and shrubs for pollinators grown in the Midwest. Because weather conditions may vary considerably from year to year, trees and shrubs may bloom several weeks earlier or later than usual in any given year. This makes calendar dates an unreliable way to predict when trees will bloom or insect pests emerge.

Throughout this publication we have noted that an important key to protecting pollinators is to avoid spraying plants with insecticides when plants are blooming, and to wait until after plants have bloomed before applying systemic insecticides. When birds migrate, when wildflowers and trees bloom, and the seasonal appearance of insects are examples of phenological events that have been recorded for centuries. Research has shown the first appearance of an insect pest in spring can be matched with a popular type of tree or shrub that blooms at the same time. A tree or shrub in bloom is easier for most to see compared to the emergence of an insect.

A biological calendar to predict when pests are active, when pollinators will be visiting plants and when to schedule pesticide applications to avoid impact on pollinators can be created by comparing when trees bloom and in what order with the insect activity. This order of phenological events, called the phenological sequence, does not change from year to year even when weather patterns differ greatly. Long-term studies in Ohio and Michigan have confirmed this to be the case. With the accompanying table about phenological sequences, pest management activities can be scheduled to protect pollinators.

For example, emerald ash borer adults begin emerging very predictably when black locust trees are blooming. In northern Ohio, the ideal time to treat ash for emerald ash borer with a systemic insecticide is after ash blooms in late April to early May and before black locust blooms in late May. Japanese beetle adults first emerge as little-leaf linden begins to bloom. To protect pollinators, you would not want to treat lindens for Japanese beetle adults until after linden is done blooming.

The biological calendar is presented in the accompanying phenological sequence table as a tool for your decision-making. The table includes growing degree-days (GDD), a measure of heat accumulation used to predict plant and animal development rates such as the date that a flower will bloom or a crop will reach maturity.

Check with your state's extension service for a source of GDDs for your area. For those in Michigan, GDDs are available throughout the growing season for over 80 locations at MSU's Enviro-weather: [www. enviroweather.msu.edu](http://www.enviroweather.msu.edu). In Ohio, accumulation of GDDs and the progression of phenological sequence can be tracked in real-time for any zip code at: https://www.oardc.ohio-state.edu/gdd/.

Phenological sequence table for selecting trees and shrubs and timing pest management to protect pollinators

Phenological sequence of plant blooming and pest activity for Wooster, Ohio, including average date of occurrence and cumulative degree-days. **Pest species are indicated in bold type.** Degree-days were calculated using the modified sine-wave method with a base temperature of 50 degrees Fahrenheit and a starting date of January 1 (adapted from Herms 2004).

Good Trees and Shrubs for Pollnators When Flowering	Phenological Event	Average Date in Wooster OH	Average Cumulative Degree-Days in most of Midwest
Red maple	first bloom	21-Mar	46
Red maple	full bloom	28-Mar	74
Sargent cherry	first bloom	5-Apr	126
Bradford callery pear	first bloom	10-Apr	142
Weeping higan cherry	first bloom	10-Apr	143
PJM Rhododendron	first bloom	12-Apr	146
Allegheny serviceberry	first bloom	12-Apr	154
Sargent cherry	full bloom	13-Apr	157
Bradford callery pear	full bloom	15-Apr	163
Allegheny serviceberry	full bloom	19-Apr	175
Weeping higan cherry	full bloom	19-Apr	180
PJM Rhododendron	full bloom	19-Apr	182
Koreanspice viburnum	first bloom	20-Apr	189
Eastern redbud	first bloom	21-Apr	189
Common chokecherry	first bloom	21-Apr	190
Gypsy moth	**egg hatch**	**22-Apr**	**198**
Spring snow crabapple	full bloom	23-Apr	212
Koreanspice viburnum	full bloom	24-Apr	214
Birch leafminer	**adult emergence**	**25-Apr**	**217**
Coral burst crabapple	first bloom	26-Apr	224
Common chokecherry	full bloom	28-Apr	231
Wayfaringtree viburnum	first bloom	29-Apr	236
Tatarian honeysuckle	first bloom	29-Apr	238
Sargent crabapple	first bloom	29-Apr	238
Common lilac	first bloom	29-Apr	239
Persian lilac	first bloom	30-Apr	244
Eastern redbud	full bloom	1-May	249
Snowdrift crabapple	full bloom	2-May	256
Flowering dogwood	first bloom	4-May	273
Blackhaw viburnum	first bloom	4-May	272
Red chokeberry	first bloom	6-May	284
Wayfaringtree viburnum	full bloom	7-May	297
Pine needle scale	**egg hatch - 1st generation**	**7-May**	**302**
Cooley spruce gall adelgid	**egg hatch**	**7-May**	**304**
Red horsechestnut	first bloom	7-May	305
Persian lilac	full bloom	8-May	310
Vanhoutte spirea	first bloom	8-May	311
Common llac	full bloom	9-May	319
Blackhaw viburnum	full bloom	9-May	325


Rob Routledge, Sault College, Bugwood.org

Red maple


Paul Wray, Iowa State University, Bugwood.org

Common chokecherry


Bill McNee, Wisconsin Dept. of Natural Resources, Bugwood.org

Gypsy moth first instar larvae


Dow Gardens, Bugwood.org

Wayfaringtree viburnum

Good Trees and Shrubs for Pollnators When Flowering	Phenological Event	Average Date in Wooster OH	Average Cumulative Degree-Days in most of Midwest
Winter king hawthorn	first bloom	9-May	327
Lilac borer	**adult emergence**	**11-May**	**343**
Doublefile viburnum	first bloom	12-May	358
Black cherry	first bloom	13-May	371
Lesser peach tree borer	**adult emergence**	**15-May**	**381**
Vanhoutte spirea	full bloom	16-May	405
Winter king hawthorn	full bloom	16-May	407
Euonymus scale	**egg hatch - 1st generation**	**16-May**	**409**
Catawba rhododendron	first bloom	17-May	414
Black cherry	full bloom	18-May	418
Miss Kim Manchurian lilac	first bloom	18-May	421
White fringetree	first bloom	20-May	435
Snowmound nippon spirea	first bloom	20-May	441
Doublefile viburnum	full bloom	20-May	445
Red horsechestnut	full bloom	21-May	456
Black locust	first bloom	22-May	464
Miss Kim Manchurian lilac	full bloom	25-May	503
Catawba rhododendron	full bloom	26-May	515
White fringetree	full bloom	26-May	526
Arrowwood viburnum	first bloom	28-May	540
Emerald ash borer	**first emegence**	**28-May**	**550**
Bronze birch borer	**adult emergence**	**28-May**	**553**
Multiflora rose	first bloom	29-May	554
Black locust	full bloom	28-May	554
Mountain-laurel	first bloom	31-May	580
Japanese tree lilac	first bloom	3-Jun	618
Arrowwood viburnum	full bloom	3-Jun	627
Bumald spirea	first bloom	4-Jun	637
Washington hawthorn	first bloom	4-Jun	639
Multiflora rose	full bloom	4-Jun	645
Northern catalpa	first bloom	7-Jun	679
American elderberry	first bloom	8-Jun	706
Greater peach tree borer	**adult emergence**	**8-Jun**	**707**
Fuzzy deutzia	first bloom	8-Jun	722
Japanese tree lilac	full bloom	13-Jun	810
Northern catalpa	full bloom	13-Jun	819
Mountain-laurel	full bloom	14-Jun	826
Panicle hydrangea	first bloom	14-Jun	866
Fall webworm	**egg hatch**	**14-Jun**	**868**


Richard Webb; Bugwood.org

Black cherry


Vern Wilkins, Indiana University, Bugwood.org

Black locust


Steven Katovich, USDA Forest Service, Bugwood.org

Bronze birch borer


Jan Samanek, Phytosanitary Administration, Bugwood.org

American elderberry


John Ruter, U of GA, Bugwood.org

Fuzzy deutzia

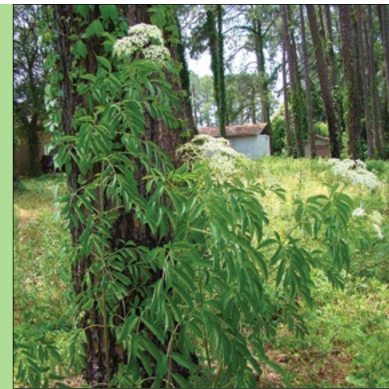

deniseellsworth from Pixabay

Japanese lilac tree

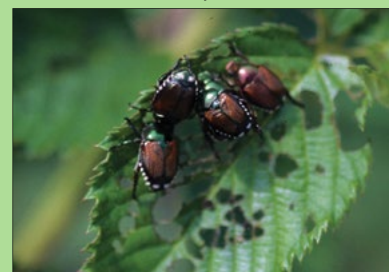

John Ruter, U of GA, Bugwood.org

Panicle hydrangea

Good Trees and Shrubs for Pollnators When Flowering	Phenological Event	Average Date	Average Cumulative Degree-Days
Mimosa webworm	**egg hatch - 1st generation**	**14-Jun**	**882**
Fuzzy deutzia	full bloom	18-Jun	896
Greenspire littleleaf linden	first bloom	18-Jun	898
American elderberry	full bloom	19-Jun	915
Winterberry holly	full bloom	19-Jun	917
Dogwood borer	**adult emergence**	**19-Jun**	**918**
Winged euonymus scale	**egg hatch**	**19-Jun**	**918**
Panicled goldenraintree	first bloom	19-Jun	923
Southern catalpa	first bloom	19-Jun	924
Azalea bark scale	**egg hatch**	**22-Jun**	**970**
Japanese beetle	**adult emergence**	**22-Jun**	**979**
Rosebay rhododendron	first bloom	23-Jun	1,008
Greenspire littleleaf linden	full bloom	24-Jun	1,043
Bottlebrush buckeye	first bloom	28-Jun	1,167
Rose-of-Sharon	first bloom	9-Jul	1,372


Rebekah D. Wallace, University of Georgia, Bugwood.org

American elderberry


Gerald Holmes, Calif Polytech St Univ, San Luis Obispo, Bugwood.org

Japanese beetles


Doug Landis, MSU Entomology

A welcoming yard for pollinators.

Protecting pollinators during home lawn grub control

The most widely used insecticides for grub infestations of lawns are neonicotinoid insecticides, which are toxic to pollinators if they are sprayed over flowers. If lawns are mowed first to remove any weed flowers, or if there are no flowers in the lawn, it is unlikely that grub control products will be harmful to bees unless there is some spray drift onto flowers.

A recent study in Kentucky demonstrated that if lawns with clover were mowed to remove clover flowers just before insecticide application, there was no impact on bumble bees caged over the clover when it bloomed again a few weeks later. A widely-used insecticide for grub control, chlorantraniliprole, is safe for pollinators, even when applied to lawns with flowering weeds.

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Appendix 1

Table 1. Bee impact and recommendations for use for fungicides and bactericides.

Bee Impact Level	Active Ingredient	Trade Name	Cautions
Mortality	copper hydroxide	Champ, CuPro, Kocide	Avoid applications when bees are foraging
	copper oxychloride	COC DF	Avoid applications when bees are foraging
	copper sulfate	Phyton-27	Avoid applications when bees are foraging
	copper sulfate + lime	Bordeaux Mix	Avoid applications when bees are foraging
	lime sulfur/calcium polysulfide	Brandt Lime Sulfur, Rex Lime Sulfur, Sulforix	Avoid applications when bees are foraging
	pcnb	Terraclor	Avoid applying when bees are present
	sulfur	Microthiol, Kumulus, Thiolux	Avoid applications when bees are foraging
Mortality - Larvae feeding toxicity	boscalid	Emerald (Turf use only)	Avoid applications when bees are foraging
	boscalid + pyraclostrobin	Pageant	Avoid applications when bees are foraging; Avoid applying tank mixtures with insecticides during bloom period
	captan	Captan	Avoid applications when bees are foraging
	chlorothalonil	Daconil	Avoid applications when bees are foraging; Avoid applying tank mixtures with insecticides during bloom period
	fosetyl aluminum	Aliette	Avoid applications when bees are foraging
	iprodione	Chipco 26GT	Avoid applications when bees are foraging
	neem oil	Triact	Avoid applications when bees are foraging
Synergy	boscalid + pyraclostrobin	Pageant	Avoid applications when bees are foraging; Avoid applying tank mixtures with insecticides during bloom period
	chlorothalonil	Daconil	Avoid applications when bees are foraging; Avoid applying tank mixtures with insecticides during bloom period
	fenarimol	Rubigan	Avoid applying tank mixtures with insecticides during bloom period
	metconazole	Tourney	Avoid applying tank mixtures with insecticides during bloom period
	myclobutanil	Eagle	Avoid applying tank mixtures with insecticides during bloom period
	propiconazole	Banner	Avoid applying tank mixtures with insecticides during bloom period
	tebuconazole	Torque	Avoid applying tank mixtures with insecticides during bloom period
	triadimefon	Bayleton, Strike	Avoid applying tank mixtures with insecticides during bloom period
	triflumizole	TerraGuard	Avoid applying tank mixtures with insecticides during bloom period

Table continues on next page.

Table 1. Bee impact and recommendations for use for fungicides and bactericides (*continued*)

Bee Impact Level	Active Ingredient	Trade Name	Cautions
No known impact on bees	ampelomyces quisqualis	AQ 10	No precautions related to bees
	aureobasidium pullulans	Botector	
	azoxystrobin	Heritage, Mika	
	bacillus amyloliquefaciens	Triathlon, Double Nickel	
	bacillus subtilis strain qst 713	Cease	
	bacillus thuringiensis ssp. israelensis	Gnatrol, VectoBac	
	chitosan	Elexa, NuPro, Biorend	
	cinnamaldehyde	Cinnacure, Seican	
	cyprodinil + fludioxonil	Palladium	
	dazomet	Basamid	
	dicloran	Botran	
	dimethomorph	Stature	
	famoxadone + cymoxanil	Tanos	
	fenamidone	Fenstop	
	fenhexamid	Decree	
	fludioxonil	Medallion, Emblem	
	fluopicolide	Adorn	
	fluopyram + trifloxystrobin	Broadform	
	flutolanil	Prostar	
	fluxapyroxad + pyraclostrobin	Orkestra	
	harpin protein	Messenger	
	mancozeb	Dithane, Protect	
	mandipropamid	Revus	
	maneb	Micora	
	mefenoxam	Subdue MAXX	
	metam sodium	Vapam	
	mineral oil/paraffinic oil	JMS Stylet Oil	
	phosphorous acid	Alude, BioPhos, K-Phyte, Vital	
	piperalin	Pipron	
	polyoxin d	Endorse, Verando O	
	polyoxin d zinc salt	Affirm	
	potassium bicarbonate	MilStop, Kaligreen	
	prohexadione calcium	Apogee, Kudos	
	pyraclostrobin	Empress, Insignia	
	reynoutria sachalinensis	Regalia	
	sodium tetraborohydrate decahydrate	Borax	
	streptomyces lydicus wyec 108	Actinovate, Actino-Iron	
	streptomycin	Agri-Mycin, Firewall	
	thiophanate-methyl	3336, 6672	
	thiram	Thiram	
	thyme oil + methyl salicylate + wintergreen oil	Proud 3	
	trichoderma asperellum strain icc 012 + trichoderma gamsii strain icc 080	Obtego, Remedier	
	trichoderma harzianum rifai strain krl-ag2	PlantShield HC, RootShield WP	
	trichoderma harzianum strain t-22	PlantShield HC, RootShield WP	
	Trichoderma harzianum T-22 + Trichoderma virens G-41	RootShield Plus WP (aka BW240)	
	trifloxystrobin	Compass	

August 1, 2019, minor updates:
Page 10: “Herbaceous plants attractive to butterflies” table.
Page 21: New text for emerald ash borer BMPs.

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