Protecting and enhancing pollinators in urban landscapes

for the US North Central Region

Rebecca Finneran, MSU Extension

MSU Extension bulletin E3314

By David Smitley, Michigan State University Department of Entomology; Diane Brown and Erwin Elsner, Michigan State University Extension; Joy N. Landis, Michigan State University IPM; Paula M. Shrewsbury, University of Maryland Department of Entomology; and Daniel A. Herms, The Ohio State University Department of Entomology

Introduction

For the past 30 years or more, most tree care professionals, landscapers, urban foresters and many informed property owners have been managing destructive insects by minimizing pesticide use and encouraging predators and parasites that naturally keep pests under control. This approach is referred to as Integrated Pest Management (IPM), and it includes using Best Management Practices (BMP) 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 the 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.

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 species of North American plants for two reasons: (1) our North American plants may lack natural defenses (resistance) to invasive pests from Europe or Asia, and (2) invasive pests 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 roses, 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.

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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, and natural ecosystems need pollinators to ensure healthy plant populations. For fruit and vegetable crops, honey bees, which are from Europe, are the most important pollinators because they can

Jason Gibbs, MSU Entomology

This cellophane bee is a native pollinator.

be brought in and out of orchards and fields easily. Honey bees have been estimated to pollinate 30 to 90 percent of many fruit crops, with native bee species accounting for most of the remaining 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.

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 of 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 percent of its honey bee colonies, and winter losses since 2006 are generally around 30 percent every year. Beekeepers consider annual losses of 15-20 percent to be acceptable, and losses greater than this make it difficult or impossible to remain profitable. The Xerces Society reports that in recent years monarch populations have declined by more than 80 percent 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 parasites, pathogens, loss of habitat or flowers that provide pollen and nectar, and pesticide exposure. 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. Flowerless landscapes like mowed lawns with strict weed control, 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 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, although long-term exposure to low doses has not been investigated for many types of pesticides. 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.

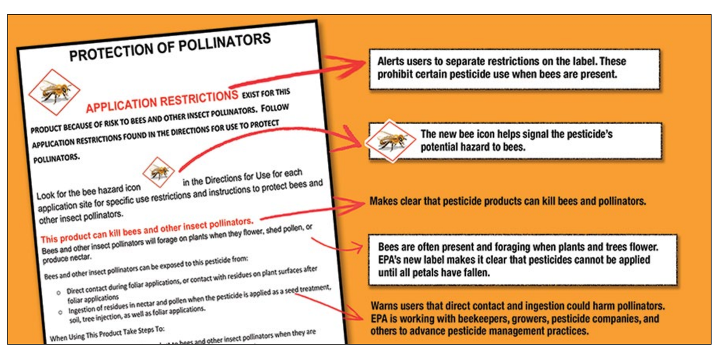
One group of pesticides, the neonicotinoids, has recently been studied intensively by scientists to determine their impact on bees, primarily because of their widespread agricultural use on field crops. However, neonicotinoids are also used by homeowners in yards and gardens. Neonicotinoids are a class of insecticide that acts on the insect's nervous system. They are more selective, having greater toxicity

Rebecca Finneran, MSU Extension

Help pollinators by planting more flowers.

for insects than mammals, and safer for humans to use than most old classes of insecticides. They are toxic 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 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.



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

Bees and other pollinators can also collect contaminated pollen or nectar from the 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 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 not kill bees directly, but it can 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**.

Creating and maintaining pollinator-friendly habitat

Many types of insects feed on pollen and nectar, although two types of pollinators have received the most attention: bees and butterflies. The best way to encourage bees and butterflies is to grow lots of different types of flowering plants that produce nectar and pollen. Consider how much lawn you maintain and whether any of it could be planted or managed to support more flowers. 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, 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. Below are lists of plants that provide pollen and nectar for bees and butterflies.

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

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 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.

Better habitat for bees

Annuals attractive to bees

In general, herbs and garden perennials are good for bees while annual bedding plants are not as attractive to them. Annual flowers like petunias 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. Below are some annuals that may be more difficult to find, but 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.

Annuals attractive to bees table

Common name	Genus species (scientific name)
Ageratum	*Ageratum houstonianum*
Anise-scented sage	*Salvia guaranitica*
Aster	*Callistephus chinensis*
Black-eyed susan or gloriosa daisy	*Rudbeckia hirta*

Annuals attractive to bees table (continued)

Common name	Genus species (scientific name)
Blue salvia (mealycup sage)	*Salvia farinacea*
Borage or starflower	*Borago officinalis*
Calendula	*Calendula officinalis*
Clary sage	*Salvia sclarea* (biennial)
Common lantana	*Lantana camara*
Common sunflower	*Helianthus annuus*
Cornflower	*Centaurea cyanus*
Cosmos	*Cosmos bipinnatus*
Dahlia (open types)	*Dahlia* cv.
Garden heliotrope	*Heliotrope arborescens*
Mignonette	*Resedaodorata*
Pentas	*Pentas* spp.
Pineapple sage	*Salvia elegans*
Popcorn plant	*Cassia didymobotrya*
Snapdragon	*Antirrhinum majus*
Spider flower	*Cleome* spp.
Sweet William (biennial in southern parts of north central region)	*Dianthus barbatus*
Sweet alyssum	*Lobularia maritime*
Tithonia	*Tithonia rotundifolia*
Vervain	*Verbena bonariensis*
Zinnia	*Zinnia elegans*

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/).

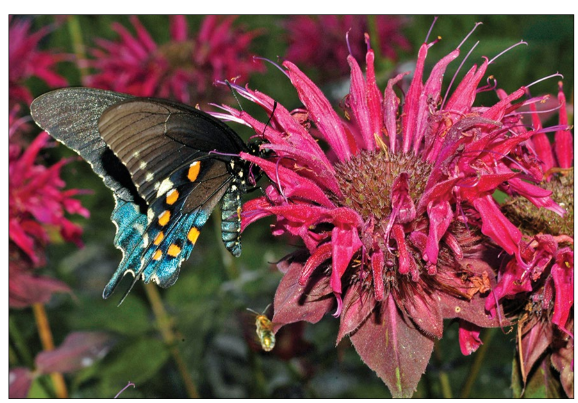
Herbaceous perennials attractive to bees

Common name	Genus species (scientific name)
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.
Butterfly weed	*Asclepias tuberosa*
Calamint	*Calamintha nepeta*
Carolina lupine	*Thermopsis villosa*
Catmint	*Nepeta* spp.
Chrysanthemum (open types)	*Chrysanthemum*


Diane Brown, MSU Extension
Anise hyssop


Erwin Elsner, MSU Extension
Butterfly weed


Diane Brown, MSU Extension
Butterfly bush


Erwin Elsner, MSU Extension
Bee balm

Herbaceous perennials attractive to bees (continued)

Common name	Genus species (scientific name)
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*
(various names)	*Eryngium* spp.
Fennel	*Foeniculum vulgare*
Foxglove or beardtongues	*Penstemon* spp.
Garden speedwell	*Veronica longifolia*
Globe thistle	*Echinops ritro*
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.
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'

Lupine

Sunflower

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*
Stiff-leaved aster	*Ionactus linariifolius*
Stokes aster	*Stokesia laevis*
Sunflower	*Helianthus*
Swamp milkweed	*Asclepias incarnata*
Sweet alyssum	*Lobularia maritima*
Thyme	*Thymus* spp.
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 (Mach and Potter 2016)

Common name	Genus species (scientific name)
Black chokeberry	*Aronia melanocarpa*
Bottlebrush buckeye	*Aesculus parviflora*
Buttonbush	*Cephalanthus occidentalis*
Common witch-hazel	*Hamamelis virginiana*
Cotoneaster	*Cotoneaster*
Dwarf fothergilla	*Fothergilla gardenia*
Eastern ninebark	*Physocarpos opulifolius*
Elderberry	*Sambucus* spp.

Shrubs attractive to bees (Mach and Potter 2016) (continued)

Common name	Genus species (scientific name)
Holly: American, box-leaved, Merserve hybrid, winterberry	*Ilex* spp.
Mockorange	*Philadelphus coronarius*
Potentilla (bush cinquefoil)	*Potentilla fruiticosa*
Privet	*Ligustrum vulgare*
Raspberry, blackberries	*Rubus* spp.
Silky, gray, redosier dogwoods	*Cornus* spp.
Spicebush	*Lindera benzoin*
Spirea	*Spiraea* spp.
Sumacs	*Rhus* spp.
Summersweet, sweet pepperbush	*Clethra alnifolia*
Viburnums	*Viburnum* spp.
Wild prairie rose	*Rosa arkansana*


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, *Rhus Aromatica*.

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 following table.


T. Davis Sydnor, The Ohio State University, Bugwood.org

Catalpa

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
Serviceberry	*Amelanchier* spp.	May
Willow	*Salix* spp.	May


Diane Brown, MSU Extension

Serviceberry

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

Common name	Genus species (scientific name)	Bloom
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
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 below. 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 above. 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 is maintained by the American Horticultural Society, and is organized by state (http://www.ahs.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 www.shop.msu.edu. Wildflowers described in E2973 are marked with an asterisk (*) in the following table.


Diane Brown, MSU Extension
Goldenrod


Diane Brown, MSU Extension
Joe-Pye weed

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.
Coneflower	*Ratibida columnifera**
Culver's root	*Veronicastrum virginicum**
Cup plant	*Silphium perfoliatum**
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*
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**
Thimbleweed herbaceous perennial	*Anemone cylindrica**
White wild indigo, false indigo	*Baptisia alba*
Wild quinine, American feverfew	*Parthenium integrifolium*
Yellow coneflower	*Ratibida pinnata**
Yellow giant hyssop	*Agastache nepetoides**

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

Wildflowers attractive to bees (continued)

Common name	Genus species (scientific name)
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 species of plants, 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 United States. Plants that are also hosts for butterfly caterpillars are noted. One of the goals of the President's national plan to protect pollinators is to increase milkweed habitat for monarch butterfly larvae. Planting milkweed in the yard and garden 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 the references of this document.

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 far 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.

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	*Echinacea purpurea*	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	*Veronia* spp.	No
Joe-Pye weed	*Eupatorium* spp.	No
Lantana		
Milkweeds	*Asclepias* spp.	Yes
Mints	*Mentha* spp.	No
Orange hawkweed	*Hieracium aurantiacum*	No
Phlox	*Phlox* spp.	No
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


Diane Brown, MSU Extension

Lantana


Ashley Bennett, MSU Entomology

Prairie phlox


Margaret Pooler, Bugwood.org

Lilac bush

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.

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

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							■	■	■

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.

Diane Brown, MSU Extension

Blooming sedum

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 the next 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).

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

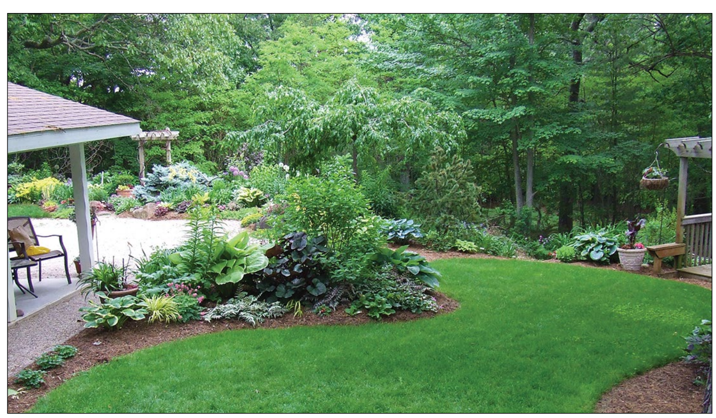
Tree common name	Scientific name	Potential problems of concern
Ash	*Fraxinus* spp.	All North American *Fraxinus* spp. (ash) are susceptible to emerald ash borer, and once the borer is present they will not survive without insecticide treatments.
Austrian pine	*Pinus nigra*	Susceptible to Diplodia tip 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.

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 the failure of tree roots 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 www.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 not unusual to observe 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.

Erwin Elsner, MSU Extension

Bee on a cherry blossom.

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, but 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, sweet-peas, 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. 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, but on pollinator-attractive plants they should be sprayed 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.


Steven Katovich, USDA Forest Service, Bugwood.org

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

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.

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 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 they should be sprayed during late evening, night or early morning 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.


Erwin Elsner, MSU Extension

A butterfly visits an ironweed flower.

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.

Erwin Elsner, MSU Extension

A dandelion draws a butterfly to its blossom.

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

Rebecca Finneran, MSU Extension

A bee finds a coneflower.

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.

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.

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

Hexythiazox and buprofezin are growth regulators that interfere with the molting of spider mites and sucking insects, respectively. Because they are specific for spider mites, they will have little impact on bees and other beneficial insects.

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 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 there may be a 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 highly attractive plants with insecticide before or during flowering

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.

Avoid spraying flowers with fungicides

At one time most fungicides were thought to be mostly harmless to honey bees and other pollinators. However, recent research indicates fungicide brought back to the hive on contaminated pollen or on workers' bodies interferes with the function of beneficial fungi in the hive. Several types of fungi, such as *Aspergillus, Penicillium, Cladosporium* and *Rhizopus*, grow in hives and the chemicals they secrete provide a natural defense against bee diseases like chalkbrood (*Ascosphaera apis*). They also play an important role in producing bee bread, a fermentation product of pollen which requires fungi.

Bee bread is a critical protein source for bee larvae and adults. Recent studies have shown bees exposed to fungicides do not produce as much bee bread in their hives. Some fungicides are more active against the fermentation fungi than others, but until more research is done, it is best to avoid spraying fungicides over open flowers of plants that are highly attractive to bees.

Jason Gibbs, MSU Entomology

Honey bee collecting pollen.

Fungicides applied before flowers open or after petals fall off are not expected to be harmful. Furthermore, certain fungicides can disable the detoxification enzymes of insects, which can greatly increase the toxicity of certain insecticides to bees (e.g., acetamiprid). Several studies have reported pollen contaminated with captan, ziram, iprodione, chlorothalonil and mancozeb may be harmful to bee larvae when they eat it.

Some mixtures of fungicides with insecticides may be more toxic to bees than the insecticide alone. When propiconazole is mixed with pyrethroid insecticdes, it may increase the toxicity of the insecticide to bees. Also when propaconizole and other DMI fungicides (e.g., tebuconazole, myclobutanil and triflumizole) are mixed with acetamaprid, the solution becomes fivefold or more toxic to bees than acetamaprid by itself.

Other than inhibiting beneficial fungi in the hive, and the six fungicides listed above as harmful when bee larvae consume contaminated pollen, fungicides are usually considered to be safe for bees.

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 throughout all of Eastern United States and into some western states. It is killing all the ash trees in forests, woodlots and managed landscapes. Insecticides are available to homeowners and professionals that will preserve individual trees, but all of these insecticides are potentially toxic to pollinators and beneficial insects. Because ash trees flower in early spring, pesticide movement into pollen can be minimized by waiting until ash trees are finished flowering (mid- to late May) before applying a basal soil drench or making a trunk injection.

At this time we do not have adequate data on the amount of systemic pesticide that will move into ash pollen one year after application, but treating ash trees after they are done flowering will minimize the impact on pollinators the following year. When considering which product to use, dinotefuran usually does not persist in treated trees as long as imidacloprid, and therefore is less likely to appear in pollen the following spring. The same principle applies to dinotefuran and imidacloprid applied as a basal soil drench, trunk injection or as a bark spray. Emamectin benzoate persists for at least two years following a trunk injection, but no data is available at this time on how much, if any, emamectin benzoate moves into pollen.

Watch for updates on pollinator impacts from treating ash trees for emerald ash borer as more research on this topic is completed. Currently, there are no insecticide products that are effective against emerald ash borer that are also not potentially harmful to bees.

Managing emerald ash borer on ash trees

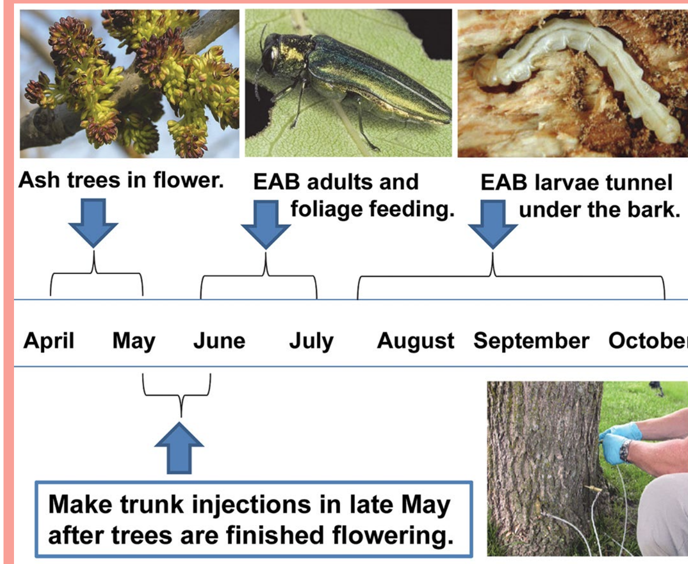


Figure photo credits: Ash tree flowers - forestry.ohiodnr.gov; EAB adults - David Smitley, MSU Entomology; EAB larva - Dave Cappaert, MSU.

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. An additional 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 since 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. 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.

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*.

Managing Japanese beetles on linden trees

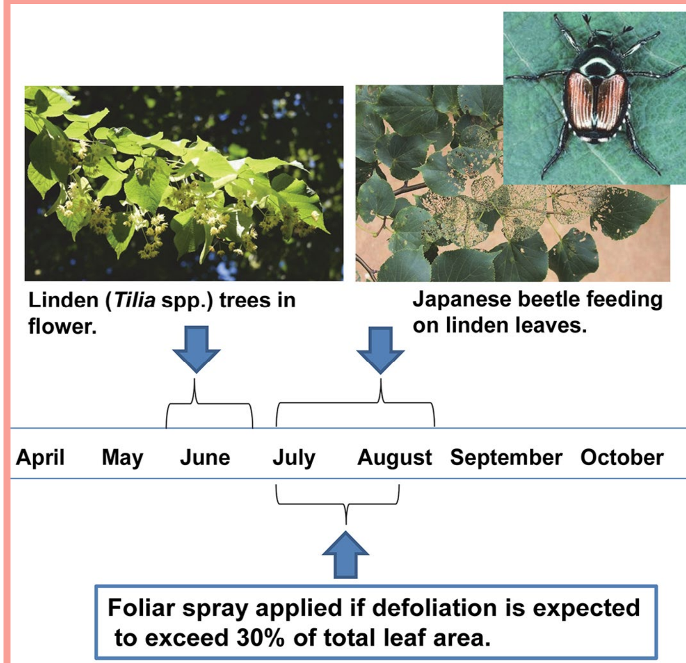


Figure photo credits: Linden flowers - Np holmes, Wikimedia Commons; Linden leaves - Steven Katovich, USDA Forest Serv., Bugwood.org; Japanese beetle - Courtesy Clemson Univ. USDA Coop. Ext. Slide Series.

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 is suspected. Dimilin is toxic to all caterpillars and persists for at least two months after application.

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

A bee gathers pollen from a magnolia.

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 or dinotefuran, applied after flowering, will also protect birch trees while minimizing the impact on pollinators the following year. Dinotefuran is less likely to persist into the next year.

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

Importance to pollinators: Austrian pine, Scots pine and all pine and spruce trees have pollen that 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. Eastern tent caterpillars 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.

Scott Bauer, USDA Agricultural Research Service, Bugwood.org

Gypsy moth larva.

Managing apple scab on crabapple trees

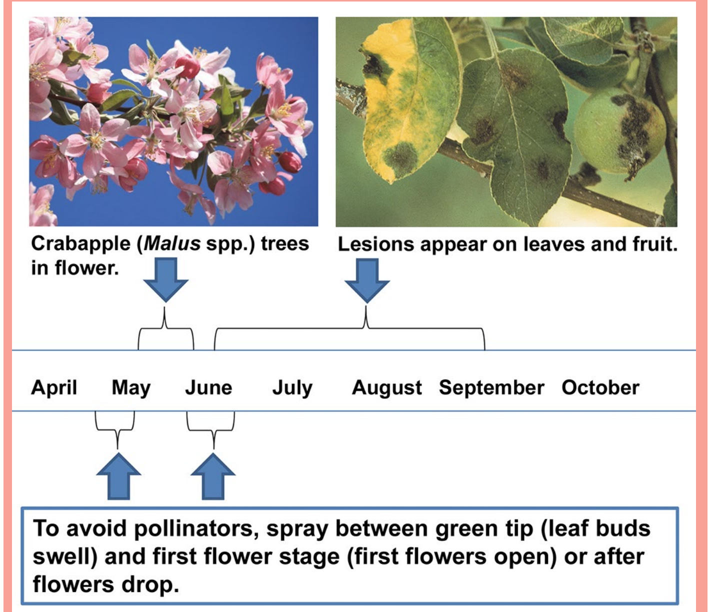


Figure photo credits: Crabapple flowers - www.photos-public-domain.com. Lesions - A.L. Jones, MSU.

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.

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.

Plant and insect phenology as a tool to protect pollinators

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. Phenology is the study of recurring biological phenomena and their relationship to weather. 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 that 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 littleleaf linden begins to bloom. To protect pollinators, you would not want to treat lindens for Japanese beetle adults until after linden is done blooming.

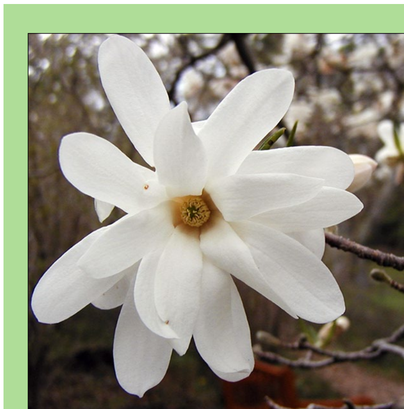
The biological calendar is presented in the accompanying phenological sequence table as a tool for your decision-making. The table includes growing degree-days (GDD), which are a measure of heat accumulation used to predict plant and animal development rates such as the date that a flower will bloom or a crop will reach maturity. For those in Michigan, GDDs are reported throughout the growing season for over 80 locations at MSU's Enviro-weather: www.enviroweather.msu.edu. Check with the extension service in your state to find a source of GDDs for the area where you live or work.

Phenological sequence table for timing pest management activities while protecting 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 a base temperature of 50 F and a starting date of January 1.

Phenological sequence table

Species	Phenological Event	Average Date	Average Cumulative Degree-Days
Silver maple	first bloom	1-Mar	32
Corneliancherry dogwood	first bloom	14-Mar	39
Silver maple	full bloom	17-Mar	42
Red maple	first bloom	21-Mar	46
Red maple	full bloom	28-Mar	74
Star magnolia	first bloom	1-Apr	83
White pine weevil	**adult emergence**	**1-Apr**	**84**
Border forsythia	first bloom	1-Apr	85
Corneliancherry dogwood	full bloom	3-Apr	98
Norway maple	first bloom	4-Apr	115
Border forsythia	full bloom	5-Apr	121


Dow Gardens, Bugwood.org

Star magnolia


Steven Katovich, USDA Forest Service, Bugwood.org

White pine weevil

Phenological sequence table (continued)

Species	Phenological Event	Average Date	Average Cumulative Degree-Days
Sargent cherry	first bloom	5-Apr	126
Saucer magnolia	first bloom	6-Apr	131
Inkberry leafminer	**adult emergence**	**10-Apr**	**141**
Bradford callery pear	first bloom	10-Apr	142
Weeping higan cherry	first bloom	10-Apr	143
PJM Rhododendron	first bloom	12-Apr	146
Star magnolia	full bloom	12-Apr	147
Spruce spider mite	**egg hatch**	**12-Apr**	**154**
Allegheny serviceberry	first bloom	12-Apr	154
Sargent cherry	full bloom	13-Apr	157
Bradford callery pear	full bloom	15-Apr	163
Norway maple	full bloom	15-Apr	165
Boxwood psyllid	**egg hatch**	**16-Apr**	**173**
Allegheny serviceberry	full bloom	19-Apr	175
Saucer magnolia	full bloom	19-Apr	176
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**
Snowdrift crabapple	first bloom	22-Apr	203
Spring snow crabapple	full bloom	23-Apr	212
Koreanspice viburnum	full bloom	24-Apr	214
Birch leafminer	**adult emergence**	**25-Apr**	**217**
Andromeda lace bug	**egg hatch**	**25-Apr**	**221**
Coral burst crabapple	first bloom	26-Apr	224
Alder leafminer	**adult emergence**	**27-Apr**	**225**
Elm leafminer	**adult emergence**	**27-Apr**	**225**
Common chokecherry	full bloom	28-Apr	231
Honeylocust spider mite	**egg hatch**	**28-Apr**	**232**
Honeylocust plant bug	**egg hatch**	**28-Apr**	**235**
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
Ohio buckeye	first bloom	1-May	248
Eastern redbud	full bloom	1-May	249
Snowdrift crabapple	full bloom	2-May	256
Common horsechestnut	first bloom	3-May	256
Hawthorn lace bug	**adult emergence**	**3-May**	**260**
Red buckeye	first bloom	4-May	266
Imported willow leaf beetle	**adult emergence**	**4-May**	**266**
Hawthorn leafminer	**adult emergence**	**4-May**	**268**
Flowering dogwood	first bloom	4-May	273
Blackhaw viburnum	first bloom	4-May	272

Paul Wray, Iowa State University, Bugwood.org

Common chokecherry

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

Gypsy moth first instar larvae

Lacy L. Hyche, Auburn University, Bugwood.org

Imported willow leaf beetle

T. Davis Sydnor, The Ohio State University, Bugwood.org

Red buckeye

Phenological sequence table (continued)

Species	Phenological Event	Average Date	Average Cumulative Degree-Days
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**
Eastern spruce gall adelgid	**egg hatch**	**7-May**	**304**
Red horsechestnut	first bloom	7-May	305
Umbrella magnolia	first bloom	8-May	308
Persian lilac	full bloom	8-May	310
Vanhoutte spirea	first bloom	8-May	311
Common llac	full bloom	9-May	319
Pink princess weigela	first bloom	9-May	322
Blackhaw viburnum	full bloom	9-May	325
Winter king hawthorn	first bloom	9-May	327
Redosier dogwood	first bloom	10-May	328
Lilac borer	**adult emergence**	**11-May**	**343**
Common horsechestnut	full bloom	12-May	357
Doublefile viburnum	first bloom	12-May	358
Common sweetshrub	first bloom	12-May	361
Red chokeberry	full bloom	12-May	360
Pagoda dogwood	first bloom	13-May	363
Red java weigela	first bloom	13-May	370
Black cherry	first bloom	13-May	371
Ohio buckeye	full bloom	14-May	375
Holly leafminer	**adult emergence**	**14-May**	**380**
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**
Tatarian honeysuckle	full bloom	16-May	409
Catawba rhododendron	first bloom	17-May	414
Beautybush	first bloom	17-May	417
Black cherry	full bloom	18-May	418
Miss Kim Manchurian lilac	first bloom	18-May	421
White fringetree	first bloom	20-May	435
Red prince weigela	first bloom	20-May	441
Snowmound nippon spirea	first bloom	20-May	441
Doublefile viburnum	full bloom	20-May	445
Redosier dogwood	full bloom	21-May	450
Pink princess weigela	full bloom	21-May	454
Red horsechestnut	full bloom	21-May	456
Red buckeye	full bloom	22-May	463
Black locust	first bloom	22-May	464
Scarlet firethorn	first bloom	22-May	468
Pagoda dogwood	full bloom	23-May	476
Common ninebark	first bloom	23-May	477


Dow Gardens, Bugwood.org

Wayfaringtree viburnum


Whitney Cranshaw, Colorado State University, Bugwood.org

Cooley spruce gall adelgid


Richard Webb, Bugwood.org

Beautybush


Vern Wilkins, Indiana University, Bugwood.org

Black locust

Phenological sequence table (continued)

Species	Phenological Event	Average Date	Average Cumulative Degree-Days
Sweet mockorange	first bloom	23-May	478
Smokebush	first bloom	24-May	495
Oystershell scale	**egg hatch**	**24-May**	**496**
Umbrella magnolia	full bloom	24-May	500
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**
Sweetbay magnolia	first bloom	28-May	553
Bronze birch borer	**adult emergence**	**28-May**	**553**
Multiflora rose	first bloom	29-May	554
Black locust	full bloom	28-May	554
Potato leafhopper	**adult arrival**	**29-May**	**558**
American holly	first bloom	29-May	561
Red java weigela	full bloom	29-May	569
Juniper scale	**egg hatch**	**29-May**	**574**
Scarlet firethorn	full bloom	31-May	574
Mountain-laurel	first bloom	31-May	580
Beautybush	full bloom	1-Jun	597
Chinese dogwood	first bloom	2-Jun	604
Common ninebark	full bloom	2-Jun	610
Smokebush	full bloom	3-Jun	616
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
Black vine weevil	**adult emergence**	**4-Jun**	**643**
American holly	full bloom	4-Jun	644
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**
Sweet mockorange	full bloom	8-Jun	715
Fuzzy deutzia	first bloom	8-Jun	722
Red prince weigela	full bloom	9-Jun	732
Washington wawthorn	full bloom	9-Jun	739
Calico scale	**egg hatch**	**9-Jun**	**749**
European fruit lecanium scale	**egg hatch**	**9-Jun**	**764**
Winterberry holly	first bloom	10-Jun	799
Japanese tree lilac	full bloom	13-Jun	810
Northern catalpa	full bloom	13-Jun	819
Mountain-laurel	full bloom	14-Jun	826
Oakleaf hydrangea	first bloom	14-Jun	846
Rhododendron borer	**adult emergence**	**14-Jun**	**857**
Cottony maple scale	**egg hatch**	**14-Jun**	**864**
Panicle hydrangea	first bloom	14-Jun	866
Fall webworm	**egg hatch**	**14-Jun**	**868**


Steven Katovich, USDA Forest Service, Bugwood.org

Bronze birch borer


Steve L. Brown, University of Georgia, Bugwood.org

Potato leafhopper


T. Davis Sydnor, The Ohio State University, Bugwood.org

American holly


Rob Routledge, Sault College, Bugwood.org

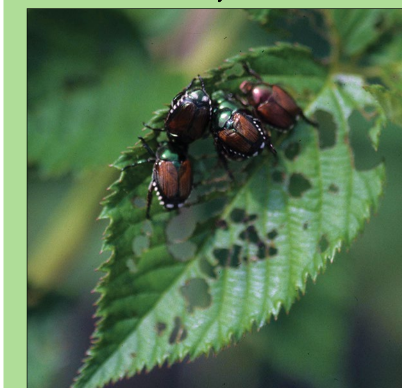
Common ninebark

Phenological sequence table (continued)

Species	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
Pine needle scale	**egg hatch - 2nd generation**	**10-Jul**	**1,390**
Euonymus scale	**egg hatch - 2nd generation**	**26-Jul**	**1,907**
Magnolia scale	**egg hatch**	**4-Aug**	**1,961**
Banded ash clearwing borer	**adult emergence**	**14-Aug**	**2,220**

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

American elderberry



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

Japanese beetles

BMPs for insecticides used for white grub control in lawns

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. Granular products may be less hazardous to bees than liquid insecticide sprays to lawns when both contain the same insecticide, unless insecticide dust or granules stick to weed flowers. Also, another widely-used insecticide for grub control, chlorantraniliprole, is safe for pollinators, even when applied to lawns with flowering weeds.

Doug Landis, MSU Entomology

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