WILD POLLINATORS *of* EASTERN APPLE ORCHARDS

& HOW TO CONSERVE THEM

SECOND EDITION

CITATION:

Park, M., et al. 2015. *Wild Pollinators of Eastern Apple Orchards and How to Conserve Them.* 2nd ed. Cornell University, Penn State University, and The Xerces Society. (www.northeastipm.org/park2012)

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SECOND EDITION (REVISED):

First published in 2012. The second edition was published in August 2015 by The Xerces Society and Penn State University. Updated in July 2015 by Mace Vaughan, The Xerces Society, and David Biddinger, Penn State University. Editing and revised layout: Sara Morris, The Xerces Society.

ACKNOWLEDGEMENTS:

Mia Park's time on the booklet was supported by Cornell University's College of Agricultural and Life Sciences Land Grant Graduate Fellowship. The pollinator plant list was based on work published by Eric Lee-Mäder, The Xerces Society, who refined the list for the booklet. Matthew Shepherd, The Xerces Society, provided photos and other photo sources. We also thank the following people who reviewed early drafts of this booklet: E.J. Blitzer, Jim Eve, Jason Gibbs, Shannon Hedke, Margarita Lopez-Uribe, Mary Park, and Eric Shatt. Cover and booklet illustrations: Frances Fawcett. Original booklet layout: Chris Cooley, CMCreative Design.

The development of this publication was supported, in part, with funding from the Northeastern IPM Center (NortheastIPM.org) and the USDA National Institute of Food and Agriculture.

SECOND EDITION

Financial support to the Xerces Society and Penn State University for the revision of this guide was provided by the USDA Specialty Crops Research Initiative (PEN04398, ICP-Project MICL05063) and the State Horticultural Association of Pennsylvania.

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FRONT COVER: Featured Bees

Common eastern bumble bee (*Bombus impatiens*)

Large mining bee (*Andrena regularis*)

Blue-green sweat bee (*Augochlora pura*)

Hornfaced bee (*Osmia cornifrons*)

Small mining bee (*Andrena nasonii*)

INTRODUCTION

There is no doubt that insect pollination is a vital service for agricultural systems. Without insect pollinators, roughly a third of the world's crops would flower, only to fade and then lie barren. Pollinators ensure abundant fruits and vegetables. Of all insect pollinators, bees are the most important. In the United States alone, the value of pollination services by bees is estimated to be $18 billion[1,2], but these services are threatened. Diversifying and protecting crop pollinators is crucial for long-term pollination success.

WHY CONSIDER WILD BEES AS POLLINATORS NOW?

Honey bees are the most widely used insect pollinator in agricultural systems, as they are easily managed. However, due to disease and competing demands, the cost of hive rentals continues to increase as supplies decrease. Farmers are aware of these challenges as evidenced by a 2009 mail survey where 65% of New York apple growers indicated that Colony Collapse Disorder of honey bees would negatively affect apple production[3]. For the same reason that diversified investing is safer than dependence on a single stock, relying on a single pollinator for this vital service may pose increasing risk. Honey bees will no doubt remain a key pollinator for agricultural systems, but research suggests more and more that wild bees are contributing to apple pollination.

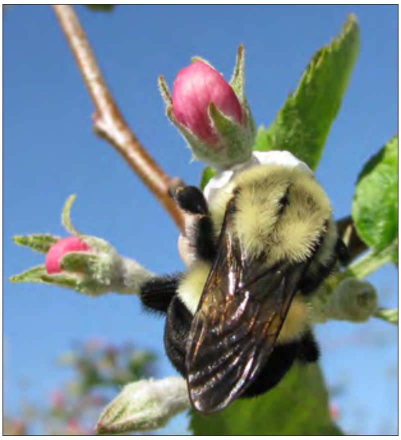
WHAT ARE WILD BEES AND HOW DO THEY BENEFIT ME?

Besides honey bees, about 450 other bee species live in the eastern United States. Over **100** of these wild bees visit apple orchards. Most of these bees are native to the region, while at least one—the hornfaced bee (*Osmia cornifrons*)—was introduced for fruit pollination. Mail surveys of New York and Pennsylvania apple growers reveal that, when abundant, wild bees provide all the pollination an orchard needs... and they do so for FREE[3,4]! Further, pollination studies have shown that wild bees can be more effective pollinators than honey bees on a per-visit basis[5,6,7], meaning they do not need to be as abundant as honey bees to provide the same level of pollination. Wild bees are a valuable orchard asset whose contributions are only now beginning to be fully appreciated.

WHY SHOULD I CARE ABOUT DIVERSITY?

Bee diversity stabilizes pollination services through time[8]. The more species in an area, the more likely there will be a species that can tolerate variable climatic conditions, like a cold and wet spring. Similarly when bee diversity is high, even if there is one species that is extirpated by disease, parasites, pesticides, or habitat loss, other species continue to thrive and pollinate.

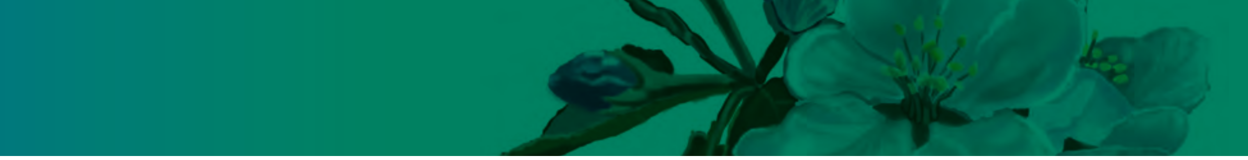
WIN-WIN FOR WILD BEES AND GROWERS?



Pollinators are declining worldwide, as are their pollination services[9]. Eastern orchards have a unique opportunity to simultaneously conserve wild bee populations and to benefit from their contribution to fruit pollination. The mixed eastern landscape, comprised of orchard blocks interspersed with woodlots, fallow fields, and hedgerows, provides bees with needed natural habitat in close proximity to orchards. Simply protecting bee resources that already exist on grower lands is an important first step in ensuring wild bee pollination. By encouraging wild bee abundance and diversity, agricultural growers may be able to buffer rising honey bee rental costs (a win for farmers), while creating an environment that better supports both wild and commercial bees (a win for all bees).

IN THIS BOOKLET YOU WILL FIND:

1. A photo guide to bees most important for apple production in the East
2. Steps to conserving, even optimizing, wild bee pollination in and around your orchard
3. Recommendations for plantings to enhance food for pollinators
4. Summary of bee toxicities for commonly used orchard pesticides
5. Links to other key resources for more information



WILD BEE BIOLOGY

WHY IS BEE POLLINATION SO IMPORTANT?

Apple is self-incompatible, meaning a tree's own pollen will not produce fertilized seeds or fruit. Because all trees within a variety are clones (i.e., genetically identical), pollen must move across varieties. Great flyers, adapted to collect pollen with their hairy bodies, bees cross-pollinate flowers as they move throughout the orchard feeding on nectar and pollen.

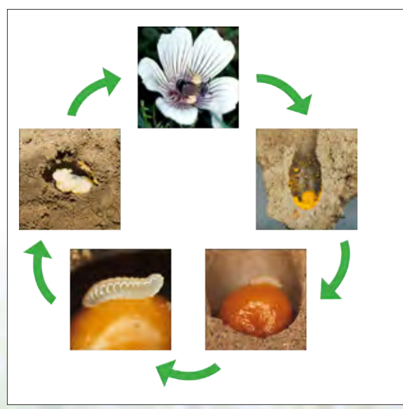
Large mining bee (*Andrena* sp.) pollinating apple blossoms. Mining bees are highly efficient pollinators, depositing over twice as much pollen as honey bees per visit.

WHAT DOES IT MEAN TO BE SOCIAL OR SOLITARY?

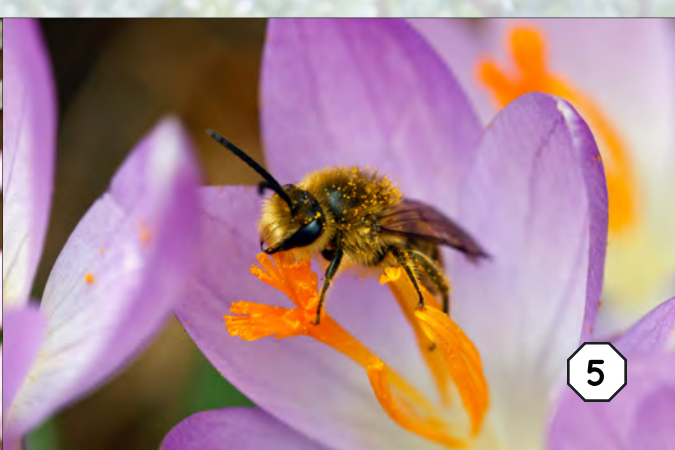
Honey bees and bumble bees live in social colonies with a queen—charged only with reproducing—and a force of workers, who take care of the colony. Only the workers forage outside the nest. In contrast, 90% of wild bee species live a solitary life in which each female makes her own nest and forages for food for her young.

THE LIFE CYCLE OF A SOLITARY GROUND-NESTING BEE

Almost 90% of the world's 20,000 bee species are solitary, and 70% of them live underground. Adult solitary bees are active for a relatively short time (weeks to months). During the active period, females construct a nest, consisting of a tunnel and a series of chambers (cells). They provision these chambers with a mix of pollen and nectar, and then lay a single egg in each. The egg is then sealed in the chamber and develops into a larva and then a pupa without parental care. After months underground, when its flight period returns, the adult solitary bee will dig its way out of the nest and restart the cycle.



Ground-nesting bees spend most of their lives underground before they emerge as adults in spring or early summer.



THE MOST COMMON BEES IN YOUR ORCHARD

GROUND-NESTERS

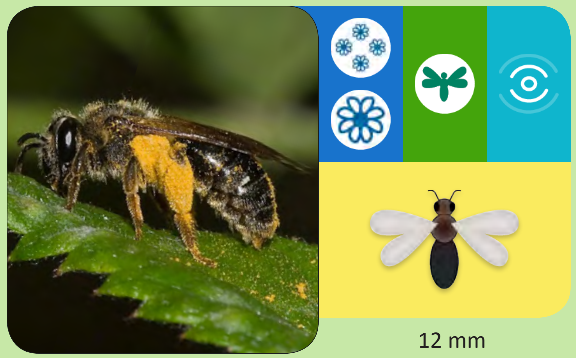
The most important wild pollinators of apple are ground-nesting bees. Ground-nesters excavate underground nests, comprised of tunnels and egg chambers where the young develop—a nesting strategy shared by 70% of bees worldwide. To avoid moisture-loving microbes that attack food and young, nests are built in well-drained soils. These nests are difficult to find because the entrance is normally a simple hole in the ground, just big enough for the bee to move in and out. *For more information on the nesting needs of ground-, cavity-, and tunnel-nesters, see* **PROVIDING SAFE NEST SITES** (*p.12*).

Cellophane bees (*Colletes inaequalis*)

12–13 mm

Named for the cellophane-like coating with which they line their nest walls, cellophane bees are solitary but nest in large aggregations in grass-covered, sandy soil.

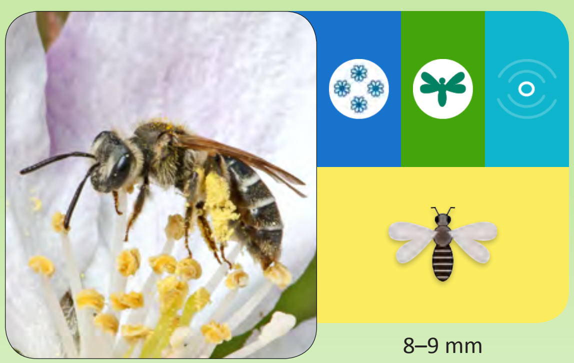
Large mining bees (*Andrena* spp.)



12 mm

At most sites, large mining bees are the most abundant and widespread native pollinators of apple, as well as blueberry. They deposit two to three times more pollen than honey bees per visit.

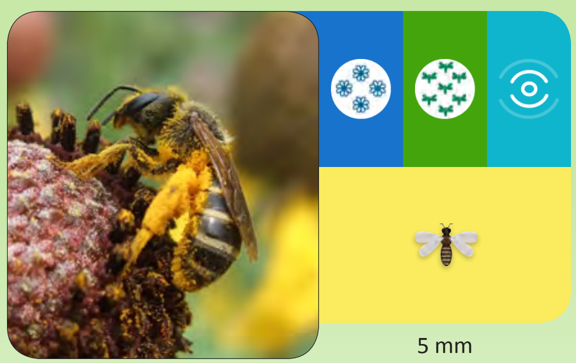
Small mining bees (*Andrena* spp.)



8–9 mm

Like their larger cousins, small mining bees nest in large aggregations (under optimal conditions) in sandy soil.

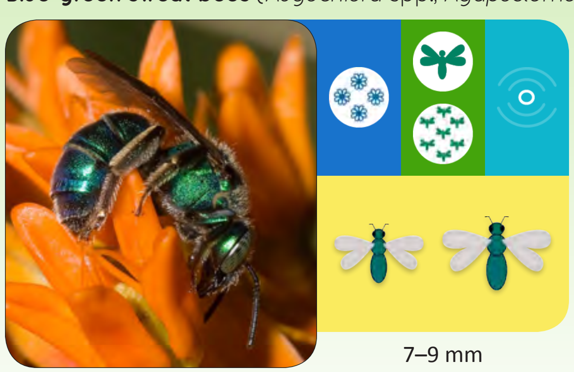
Dark sweat bees (*Lasioglossum* spp., *Halictus* spp.)



5 mm

So-called because they are attracted to the salt in sweat, these bees are so small that they are often overlooked.

Blue-green sweat bees (*Augochlora* spp., *Agapostemon* spp., *Augochlorella* spp.)



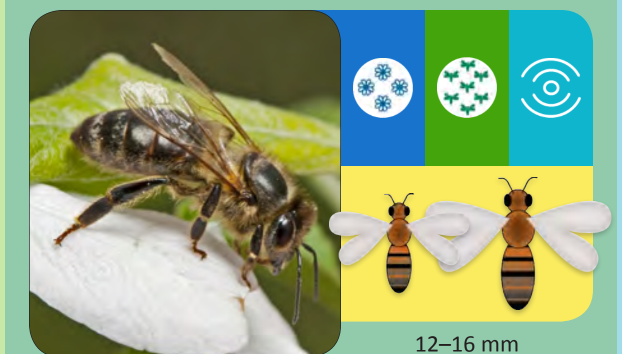
7–9 mm

Blue-green sweat bees can vary in coloration from having a green head and thorax to being solid metallic blue-green.

CAVITY-NESTERS

This bee group is most familiar to us and includes honey bees and bumble bees. Such bees do not excavate their own nest, but find existing cavities to house their social colonies and honey supplies. Because these bees are active all summer long, they require constant (or at least long-term) floral resources in the vicinity of the hive.

Honey bees (*Apis mellifera*)



12–16 mm

Honey bee color ranges from the familiar orange-brown to black, like the bee pictured above.

Bumble bees (*Bombus* spp.)

15–25 mm

Generally, only wild queen bumble bees are active during the apple bloom, as workers are produced after the colony is established. Commercial colonies are raised indoors and contain both a queen and mature workers.

TUNNEL-NESTERS

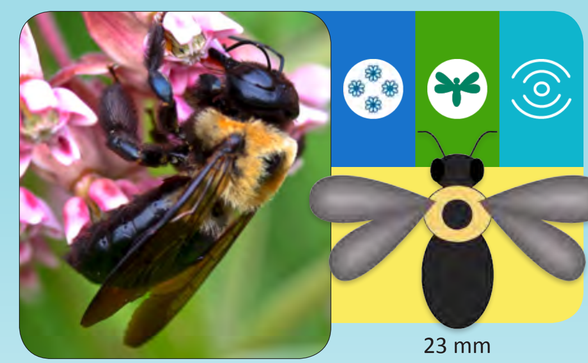
As their name implies, these bees either excavate tunnels in wood or use abandoned cavities, such as beetle burrows or cracks in masonry. Among the most important native and managed pollinators are mason bees—highly effective apple pollinators whose populations can be increased (see Bosch & Kemp 2001).

Mason bees (*Osmia* spp.)

8–12 mm

Mason bees use mud to partition cells within their nest. The introduced species *O. cornifrons* is common in Eastern apple orchards; whereas *O. lignaria* is often managed in Western orchards..

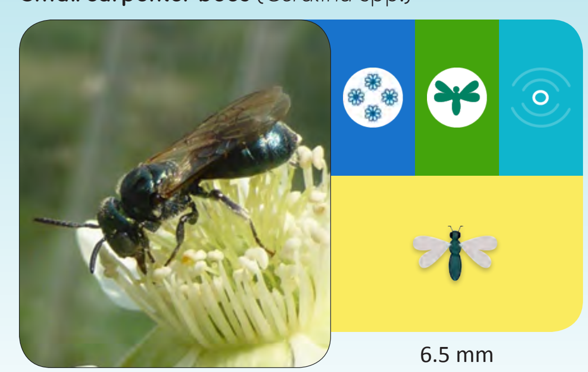
Large carpenter bees (*Xylocopa virginica*)



23 mm

Often considered pests because they tunnel into structural wood, carpenter bees are effective pollinators of apple.

Small carpenter bees (*Ceratina* spp.)



6.5 mm

Small carpenter bees excavate nests in pithy stems, such as bramble or raspberry canes.

KEY

FORAGING*: **SOCIALITY:** **FLIGHT RANGE†:** **ACTUAL SIZE:**

NOTES:

*Generalist or Specialist? These terms refer to the diet breadth of the bee. Generalists use many types of plants as a food source, while specialists only use a single species, genus, or family of plants. Crop pollinators are typically generalists.

†Flight ranges are often estimated from body size. The smaller the bee, the shorter the distance it can fly.

Actual Sizes are averages, individuals may vary. When one size is shown, it is the largest measurement.

THREE BASIC NEEDS MUST BE MET FOR WILD BEES TO THRIVE:

1. Adequate food
2. Safe nesting sites with access to clean water
3. Protection from pesticides

You may already take great care to provide these needs for honey bees, but wild bees are unique in that they cannot be taken in and out of the orchard at will, so their needs must be considered beyond the short bloom period. Moreover, wild bees are more vulnerable because—unlike honey bees whose queen remains in the hive—wild bee foragers are the reproducing individuals for that population.

PROTECT AND ENHANCE POLLINATOR FOOD SOURCES

Wild bees require a continuous and diverse source of pollen and nectar to sustain themselves and their young. Because they live longer than the short apple bloom (see **NATIVE BEE & ORCHARD BLOOM PHENOLOGY**, *p.9*), it is critical that other floral resources are available within flight distance from your orchard before and after the apple bloom. ***Here's what you can do:***

First, protect floral resources already available on your land:

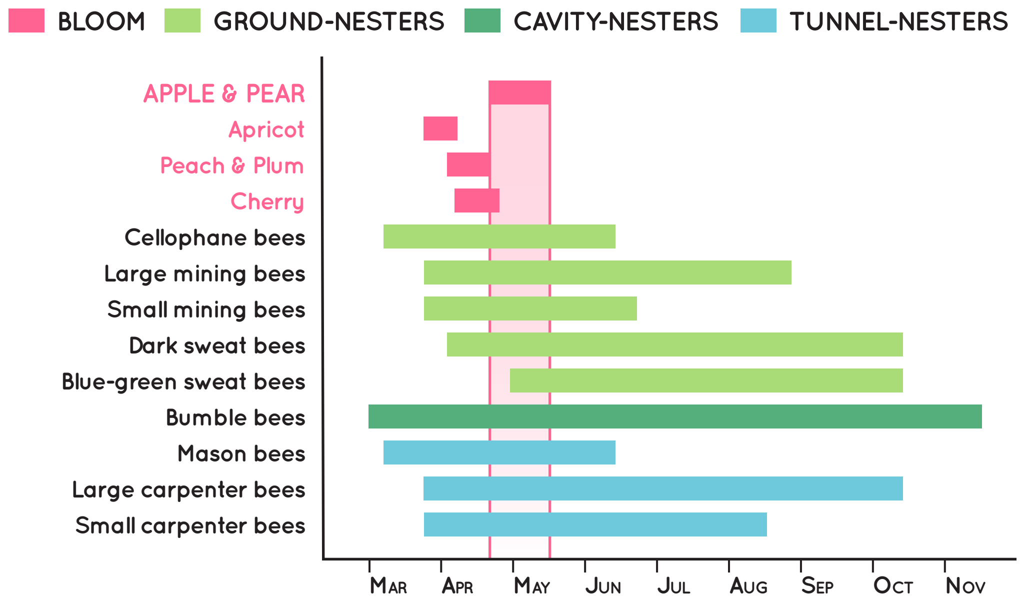
- Wild, flowering trees and shrubs that bloom in early spring (e.g., willow and red maple) and late spring/early summer (e.g., blackberries, raspberries, basswood), provide floral resources before and after the apple bloom.
- Flowering weeds along roadsides and on lawns
- Other early blooming fruit, such as cherry, plum, and raspberry
- Hedgerows
- Your home garden

Next, increase floral resources on your property to build pollinator populations. Floral plantings come in various forms:

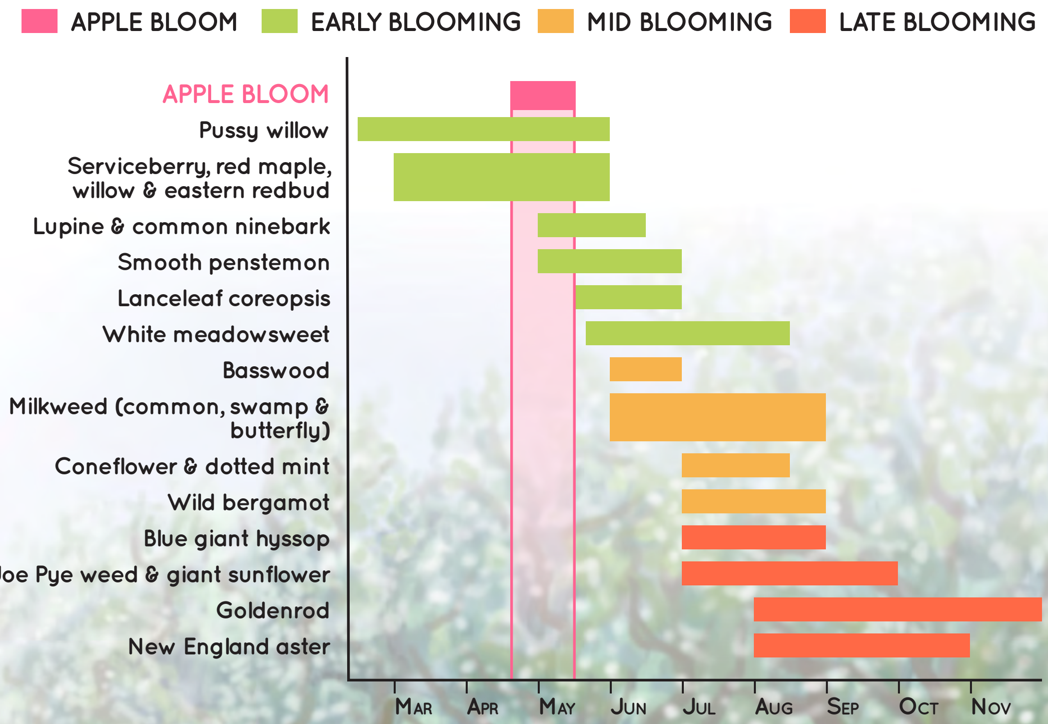
- Strips or scattered blocks at orchard margins
- Cover crops
- Expanded home gardens

USDA Plant Materials Centers, the Xerces Society, and university researchers are developing region-specific plant mixes for pollinators, and funding is available for such plantings on farms (*p.13*).

NATIVE BEE & ORCHARD BLOOM PHENOLOGY*



FORAGE PLANTS FOR WILD POLLINATORS BLOOM TIMES*



** Timing is generalized for the eastern U.S. and will vary according to your latitude and microclimate.*

FORAGE PLANTS FOR WILD POLLINATORS

Both wild and commercial bees would benefit from increased floral resources on your land. Choose combinations of plants, so that different flower types are available throughout the entire growing season—see **FORAGE PLANTS FOR WILD POLLINATORS BLOOM TIMES** (*p.9*).

The species recommended below are all eastern native perennials.

KEY

WATER NEEDS: Dry, Mesic, Wet

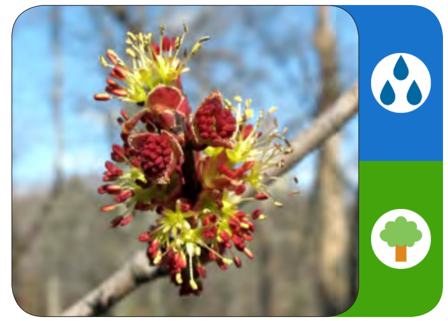
FORM: Tree, Shrub, Forb

EARLY

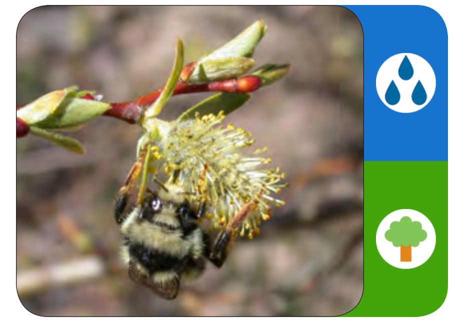
Pussy willow (*Salix discolor*)

Serviceberry (*Amelanchier* spp.)

Red maple (*Acer rubrum*)



Willow (*Salix* spp.)



Eastern redbud (*Cercis canadensis*)

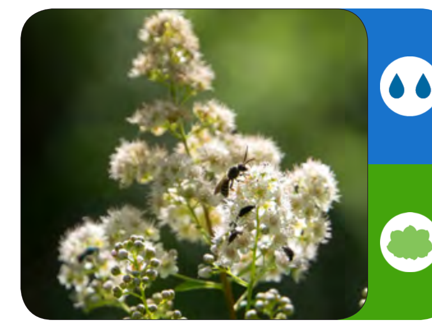
Lupine (*Lupinus perennis*)

Ninebark (*Physocarpus opulifolius*)

Smooth penstemon (*Penstemon digitalis*)

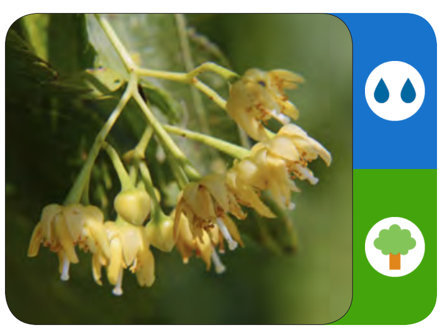
Lanceleaf coreopsis (*Coreopsis lanceolata*)

White meadowsweet (*Spiraea alba*)

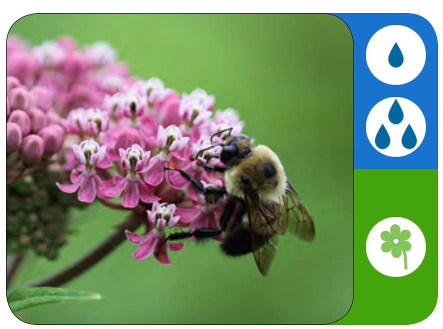


MID

Basswood (*Tilia americana*)



Milkweed (*Asclepias* spp.)



Coneflower (*Echinacea* spp.)

Dotted mint (*Monarda punctata*)

Wild bergamot (*Monarda fistulosa*)

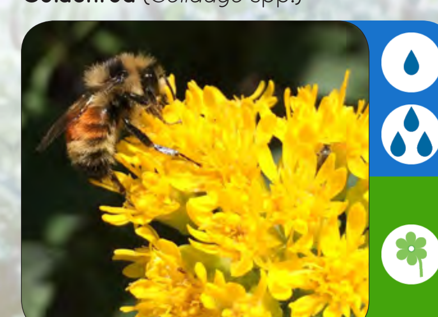
LATE

Blue giant hyssop (*Agastache foeniculum*)

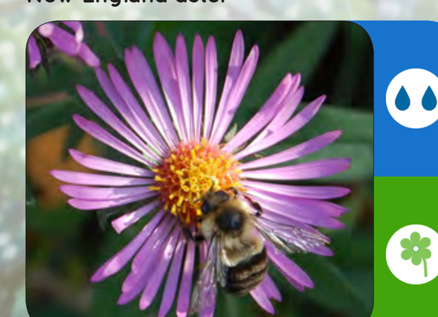
Joe Pye weed (*Eutrochium fistulosum*)

Giant sunflower (*Helianthus giganteus*)

Goldenrod (*Solidago* spp.)



New England aster*



*(*Symphyotrichum novae-angliae*)

CONSERVATION

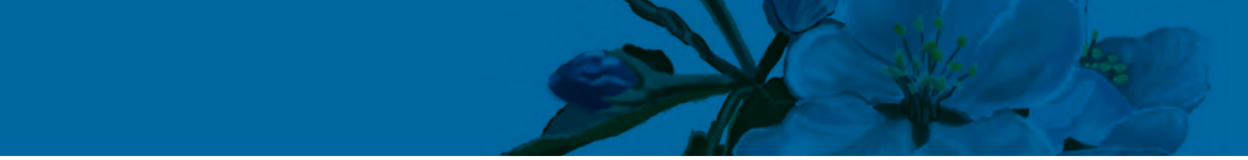
PROVIDING SAFE NESTING SITES

	NEST REQUIREMENTS	THREATS	CONSERVATION	CREATING NEW NESTING SITES
GROUND-NESTERS	Well-drained soil with access to bare or sparsely vegetated ground.	Tilling, mulching, toxic herbicides like Paraquat (trade name Gramoxone) Compaction	Protect nesting sites from threats and improve access to bare soil Provide floral resources through the growing season	Shallow till well-drained areas once and maintain bare ground with glyphosate
CAVITY-NESTERS	Cavities in trees, in wooden structures, or below ground.	Habitat loss (i.e., inadequate nesting and food sites) Pesticide drift	Protect or enhance adjacent, woody natural areas Provide floral resources through the growing season Establish 40'–60' buffer for drift	Pile old trees that are pulled near orchard Do not destroy rodent holes
TUNNEL-NESTERS	Stems, trees, rotting logs, wooden structures, or old masonry.	Habitat loss (i.e., not enough nesting sites) Pesticide drift	Protect or enhance adjacent, woody natural areas, and old stone walls Provide floral and nesting resources through the growing season Establish 40'–60' buffer for drift	Pile old trees that are pulled near orchard Place stem nests close to orchard—but safe from pesticide drift—starting small to see if tunnel-nesters are in your area (see Mader et al. 2010[10] for further information)

GROUND-NESTERS: cellophane bees emerging from their nests in bare (above) and grass-covered sandy soil (below).

CAVITY-NESTERS: bumble bee nests in an old mouse burrow (above) and in an abandoned birdhouse (below).

TUNNEL-NESTERS: commercial mason bee nest blocks in an apple orchard (above) being used by hornfaced bees (below).



GOVERNMENT COST-SHARE PROGRAMS

The USDA's Natural Resources Conservation Service (NRCS) and Farm Service Agency (FSA) provide funding opportunities for individual farmers to defray the costs of improving lands for pollinators:

1. **Environmental Quality Initiatives Program (EQIP)** supports conservation practices that improve environmental quality of land. See website for state-specific application instructions: www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financialeqip
2. **Conservation Reserve Program (CRP)** is a land retirement program that aims to enhance wildlife habitat. Contact your local USDA–FSA service center to apply: www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crp

For more information on 2014 Farm Bill programs, see *Using Farm Bill Programs for Pollinator Conservation*: www.xerces.org/guidelines/using-farm-bill-programs-for-pollinator-conservation

PROTECT BEES FROM PESTICIDES

Pesticides, including fungicides and even some herbicides, are a general danger to bees, but wild bees that are apple pollinators are more impacted because many species are univoltine (one generation per year) and, thus, reproduce more slowly. Here are some general guidelines to protect bees from pesticides:

- If you have a choice, use the least hazardous formulation.
- Avoid dusts and microencapsulated sprays; bees easily pick them up on their hairs or mistake them for pollen.
- Follow label guidelines.
- Minimize drift and direct exposure of chemicals to foraging bees. Apply sprays at night or very early when winds are usually calm and bees are not active. Non-toxic when dry, surfactants can physically drown pollinators if applied while bees are active.

In general, be mindful that wild bees are present on farms before and after the apple bloom and may even be nesting within tree rows. See **TOXICITY OF PESTICIDES TO BEES**, a table that ranks bee toxicity of pesticides most commonly used in orchards, for details (*p.14–15*).

Pollinator planting jointly established by the Xerces Society, USDA-NRCS, and the University of New Hampshire Extension.

TOXICITY OF PESTICIDES TO BEES

The following toxicity ratings are based on honey bee tests and wild bees may react at different levels. Ongoing research has recently shown that even the inert ingredients that are part of the pesticide formulation can be toxic to honey bees by impairing their ability to learn. Of the inert ingredients tested, organosilicone surfactants/adjuvants were most toxic. Other non-ionic surfactants showed some toxicity and crop oils were least toxic.

Disclaimer: These data mostly incorporate studies looking at acute, short-term adult toxicity. The effects on other life stages from feeding on contaminated pollen might be different with chronic exposure. For example, larvae exposed to some IGRs (e.g., Rimon and Esteem) could have developmental and reproductive effects including reductions in fecundity, fertility, and delayed development. Both of these compounds are known to be ovicidal to many types of insects and could possibly kill eggs laid on contaminated pollen. Some fungicides, like mancozeb, are known to be ovicidal to some insects at high rates as well, but the effects on bees are not known. Effects on non-honey bees (i.e., the majority of bees) and other non-bee pollinators—such as syrphid flies—are not well known.

CHEMICAL CLASS/GROUP	EXAMPLES OF COMMON NAMES	EXAMPLES OF TRADE NAMES†	TOXICITY LEVEL: NON	LOW	MEDIUM	HIGH
CARBAMATES	oxamyl*	Vydate*			■	
	carbaryl, methomyl*	Sevin, Lannate*				■
DIAMIDES	chlorantraniliprole, flubendiamide	Altacor, Belt	■			
	cyantraniliprole	Exeril				■
INSECT GROWTH REGULATORS (IGRs)	methoxyfenozide, tebufenozide	Intrepid, Confirm	■			
	pyriproxyfen	Esteem		■		
	buprofezin	Applaud/Centaur		■		
	novaluron	Rimon				■
MACROCYCLIC LACTONES	abamectin/avermectin, emamectin benzoate, spinetoram, spinosad	Agri-Mek, Proclaim, Delegate, Entrust/Success				■
MITICIDES	acequinocyl, clofentezine, cyflumetofen, etoxazole, fenpyroximate, fenbutatin-oxide, hexythiazox	Kanemite, Apollo, Nealta, Zeal, Fujimite/Portal, Vendex, Onager/Savey	■			
	bifenazate	Acramite			■	
	pyridaben	Nexter/Pyramite				■
	spirodiclofen	Envidor		■		
NEONICOTINOIDS	acetamiprid*, thiacloprid*	Assail*, Calypso*		■		
	flupyradifurone*	Sivanto*		■		
	clothianidin*, dinotefuron*, imidacloprid*, thiamethoxam*	Clutch*, Venom*/Scorpion*, Provado*, Actara*				■
	sulfoxaflor*	Closer*				■
ORGANOPHOSPHATES	chlorpyrifos, diazinon, dimethoate*, malathion, phosmet	Lorsban, Diazinon, Dimethoate*/Dimate*, Malathion, Imidan				■
PYRETHROIDS	bifenthrin, cyfluthrin, deltamethrin, esfenvalerate, fenpropathrin, lambda-cyhalothrin, permethrin	Brigade, Baythroid, Decis, Asana, Danitol, Warrior, Ambush/Pounce				■
	pyrethrum/pyrethrin	PyGanic			■	
OTHER INSECTICIDES	azadirachtin, horticultural mineral oils, indoxacarb, spirotetramat*	Aza-Direct/Neemix, Stylet Oil, Avaunt, Movento*			■	
	Bacillus thuringiensis, *Cydia pomonella granulosis* virus	Bt/Dipel, Carpovirusine/Cyd-X	■			
	flonicamid, kaolin clay, potassium salts of fatty acids/soap	Beleaf, Surround, M-Pede		■		
FUNGICIDES	captan, mancozeb	Captan, Dithane/Manzate/Penncozeb		■		
	lime sulfur, sulfur			■		
	sterol inhibitors*, strobilurins	Indar*/Nova*/Rally*/Rubigan*, Flint/Sovran	■			
PLANT GROWTH REGULATORS	ethephon, NAA/1-Naphthaleneacetic acid	Ethrel	■			

**Systemic*

†Example trade names of products registered for use on apple trees

APPENDIX A: ADDITIONAL RESOURCES

POLLINATOR CONSERVATION RESOURCES

WEBSITES:

The Xerces Society for Invertebrate Conservation

www.xerces.org/pollinator-conservation/

The Xerces Society's Pollinator Conservation Program is your one-stop online source for information about protecting pollinating insects and their habitat, with regional information on plants for pollinator habitat enhancement, habitat conservation guides, nest management instructions, bee identification and monitoring resources, and a directory of pollinator plant nurseries.

Penn State University Center for Pollinator Research

ento.psu.edu/pollinators

The Department of Entomology at PSU conducts research and outreach for wild and managed pollinators. The latest news on CCD and outreach information can be found here.

Cornell University Department of Entomology Extension

entomology.cals.cornell.edu/extension/wild-pollinators

The Wild Pollinators program serves as a portal to research and outreach about non-honey bee pollinators of crops and native plants in New York state.

Northeast Pollinator Partnership

www.northeastpollinatorpartnership.org

A partnership between scientists and apple growers to create a deeper understanding of the biodiversity, abundance, and value of wild bees.

RECOMMENDED PUBLICATIONS:

Bosch, J., and W. Kemp. 2001. *How to Manage the Blue Orchard Bee as an Orchard Pollinator*. 88 pp. Beltsville, MD: Sustainable Agriculture Network. [Available at: www.sare.org/Learning-Center/Books/How-to-Manage-the-Blue-Orchard-Bee]

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Mäder, E., M. Shepherd, M. Vaughan, S. H. Black, and G. LeBuhn. 2011. *Attracting Native Pollinators. Protecting North America's Bees and Butterflies*. 380 pp. North Adams, MA: Storey Publishing.

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Vaughan, M., J. Hopwood, E. Lee-Mäder, M. Shepherd, C. Kremen, A. Stine, and S. H. Black. 2015. *Farming for Bees: Guidelines for Providing Native Bee Habitat on Farms.* 4th ed. 76 pp. Portland, OR: The Xerces Society. [Available at: www.xerces.org/guidelines-farming-for-bees]

Vaughan, M., E. Lee-Mäder, J. K. Cruz, J. Goldenetz-Dollar, K. Gill, and B. Borders. 2015. *Conservation Cover (327) for Pollinators: Pennsylvania Installation Guide and Job Sheet* and *Hedgerow Planting (422) for Pollinators: Pennsylvania Installation Guide and Job Sheet*. Portland, OR: The Xerces Society. [Available at: www.xerces.org/pollinator-habitat-installation-guides]

NOTES

SOURCES

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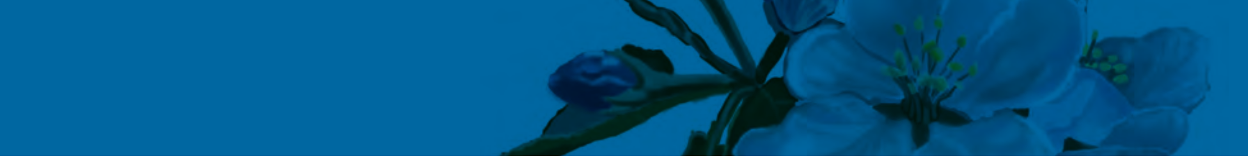

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