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Pollinator Conservation

Vera Krischik and Emily Tenczar, University of Minnesota, August 2014

Bees pollinate native plants so seeds can be produced. Bees pollinate many crops.

Native bees are threatened by habitat loss, lack of nectar and pollen plants, and insecticides.

Honey bees are threatedend by *Varroa* mites, management practices, lack of nectar and pollen plants, and insecticides.

You can help conserve bees by providing habitat for overwintering and summer nest sites. Also, provide heirloom and native plants for pollen and nectar.

Bees are Important Pollinators

Bees and other pollinators provide pollination services for 70 percent of all flowering plants, which result in seeds and fruits. Beyond agriculture, pollinators are keystone species in most terrestrial ecosystems. Fruits and seeds derived from insect pollination are a major part of the diet of birds, and of mammals ranging from red-backed voles to grizzly bears. However, many of our native bee pollinators are at risk, and the status of many more is unknown. Habitat loss, habitat alteration, and fragmentation, pesticide use, and introduced diseases all contribute to the declines of bees.

Bees can be divided into two groups by their lifestyles, either solitary or social. Only a few species of bees are social. Social bees share a nest, and divide the work of building the nest, caring for the offspring, and foraging for pollen and nectar. The principal social bees are the honey bee, which is not native to the U.S. and about forty-five US species of native bumble bees.

The life cycle of a typical bumble bee colony.
Illustration by David Wysotski, Allure Illustration.

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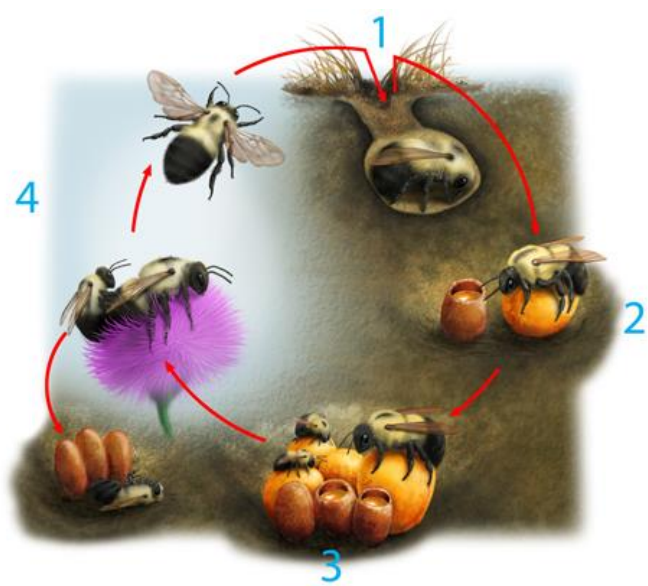


1. A queen emerges from hibernation in spring and finds a nest site, such as a mouse burrow. The queen forages for food until her first eggs hatch. Insecticides in pollen and nectar can cause disruption in behavior and cause reductions in colony health and new queen production.
2. Queens create wax pots to hold nectar and pollen, on which she lays and incubates her eggs.
3. When her daughters emerge as adults, they take over foraging and other duties.
4. In autumn the colony produces new queens who leave to find mates. Newly mated queens hibernate until the next spring.

Types of Bees: Learn How to Identify Common Native Bees in Landscapes

Bumblebees (*Bombus* species, Family Apidae)

Bumble bees are fat, hairy, bees about 10-23 mm in length that nest in the ground. Some species, such as *Bombus impatiens*, are used to pollinate greenhouse crops.

Pictured: *Bombus ternarius*
Rob Routledge, Sault College, Bugwood.org

Honey Bees (*Apis mellifera*, Family Apidae) introduced

The European honey bee is 10-15 mm in length and is used for pollination and honey production. Bees have perennial colonies and survive winter on stored honey.

Pictured: *Apis mellifera*
David Cappaert, Michigan State University, Bugwood.org

Digger and Long-Horned Bees (Family Apidae)

Digger bees are hairy bees that range from 5- 25 mm in length and carry pollen on the hind legs. Most species are solitary and nest in the ground or in vertical banks, often in sandy soil.

Pictured: *Melissodes bimaculata*
Johnny N. Dell, Bugwood.org

Carpenter Bees (Family Apidae)

Carpenter bees are 13-30 mm in length and chew out galleries in wood to lay their eggs. Most species are solitary, but a few species are semisocial and nest together.

Pictured: *Ceratina* species
Steve Nanz, University of Minnesota Extension Service

Leafcutter Bees (Family Megachilidae)

Leafcutter bees are 10-20 mm in length and nest in cavities. Most are solitary, but nests may be aggregated and use bits of leaves and flowers to wrap brood cells for their young.

Pictured: *Megachile* sp.
Whitney Cranshaw, Colorado State University, Bugwood.org

Mason Bees (Family Megachilidae)

The blue orchard bee (*Osmia lignaria*) is an important fruit pollinator. These solitary bees are 3-20 mm in length and use mud to divide brood cells.

Pictured: *Osmia lignaria*
Scott Bauer, USDA Agricultural Research Service, Bugwood.org

Mining Bees (Family Andrenidae)

Mining bees can be as small as 2 mm or as large as 25 mm in length. All species nest in the ground. Some species are important apple pollinators.

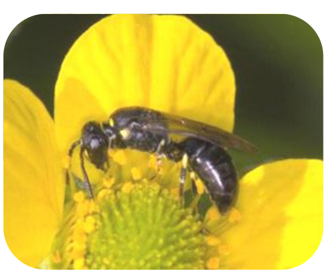
Pictured: Andrenid Bee
David Cappaert, Michigan State University, Bugwood.org

Sweat Bees (Family Halictidae)

These small bees are sometimes brightly colored and may be 3-23 mm depending on species. Most are solitary and nest in the ground or in wood.

Pictured: *Agapostemon* sp.
David Cappaert, Michigan State University, Bugwood.org

Polyester Bees (Family Colletidae)



These 5-15 mm solitary bees nest in the ground or in wood and line brood cells with a substance that resembles cellophane. These bees nest alone but may aggregate.

Pictured: *Hylaeus* sp.
David Cappaert, Michigan State University, Bugwood.org

Social Wasps (Family Vespidae)

Social wasps (yellowjackets, paper wasps, hornets) are sometimes mistaken for bees. These beneficial predators are often seen at picnics in late summer.

Pictured: *Vespula maculifrons*
Gary Alpert, Harvard University, Bugwood.org

Bees and Insecticides

Honey bees and native bees, such as bumble bees, pollinate 30% of the plants that produce the vegetables, fruits, and nuts that we consume. More than 100 crops in North America require pollinators. Pollination by bees contributes over $18 billion worth of additional crop yields. In addition, bees pollinate native plants that require seed to sustain future populations. Both native bees and managed honey bees are in decline due to habitat loss, loss of high quality pollen (protein), loss of nectar plants, pathogens, and pesticide use.

Honey bee colonies in Europe and North America have faced some difficult problems for a long time. Beekeepers have been battling the devastating effects of a parasite of bees called the *Varroa* mite, which was introduced into Europe in the 1970's and in the US in 1980's and is very difficult to control. Honey bees are also faced with a number of diseases and viruses that compromise their immune systems and health in general. Since WWII, with the increase in monocultures and herbicide use, there has been a serious decrease in flowering plants that bees depend on for food.

Beginning in 2006 a yearly die-off of honey bee colonies occurred throughout the US. The cause of this mortality is still unknown but was coined, colony collapse disorder. Most researchers now agree that honey bee decline is due to multiple, interacting causes, including the effects of bee specific diseases and parasites, lack of floral resources that provide good bee nutrition, and lethal and sub-lethal effects of pesticides. It is known that insecticide use in general can take a toll on honey bees and native bees when the bees are exposed to high enough concentrations.

However, it is unclear how much the neonicotinyl insecticides contribute to honey bee poor health or even mortality. Recent research indicates that bees exposed to relatively low doses of neonicotinyl insecticides (10 ppb) may have suppressed immune systems, which makes them more susceptible to some bee diseases. Research also shows that neonicotinoids can have multiple sublethal effects on bees, including disorientation, effects on learning and a reduction in pollen collection and storage. More research needs to be conducted to determine residue levels that bees are exposed to in agricultural and urban environments.

Neonicotinoid Insecticides Harm Pollinators

- The class of neonicotinoids insecticides (imidacloprid, dinotefuran, clothianidin, and thiamethoxam) are highly toxic to honey bees and other pollinators. They are systemic, meaning that they are taken up by a plant's vascular system and expressed through pollen, nectar and guttation droplets on leaf tips from which bees forage and drink.
- Research has shown that sublethal exposure to neonicotinoid insecticides causes significant problems for bee health, including disruptions in mobility, navigation, feeding, foraging, memory, learning, and overall hive activity.
- Pesticides are also suspected to affect honey bees' immune systems, making them more vulnerable to parasites and other pathogens.
- Seed treated crops usualy demonstrate less than 7.6 ppb in pollen or nectar. However, field treated crops and landscape plants use higher amounts of neonicotinoid insecticides.
- In landscape and greenhouses higher rates of neonicotinoids are used compared to seed treatments. A canola and corn seed seed is coated with 0.11 mg and 0.625 mg of imidacloprid. A 3 gallon pot in the nursery can have 300 mg applied according to the label.

Regulatory Issues

- For two years starting in January 2014, the Commissioner of the European Union restricted the use of 3 neonicotinoids (clothianidin, imidacloprid and thiametoxam) for seed treatment, soil application and foliar treatment on plants that are attractive to bees. Also, new practices must be developed to reduce clouds of neonicotinyl dusk at planting of seed- treated crops..
- EPA granted a conditional registration to the neonicotinoid clothianidin in 2003 without a required field study on pollinators on the basis that this study would soon be received. However, this requirement has not been met. EPA continues to allow the use of clothianidin nine years after acknowledging that it had insufficient basis for allowing its use.
- In March 2012, commercial beekeepers and environmental organizations filed an emergency legal petition with EPA to suspend use of clothianidin, asserting that EPA failed to follow its own regulations by allowing clothianidin to be used without the required adequate pollinator field study.

Recent Research Highlights Risks

- A 2013 Sussex University, UK study concluded that residue in agricultural fields contained sufficient neonicotinyl insecticides to reduce bumblebee colony health.
- A 2012 USDA study and a 2009 University of Padova, Italy study demonstrated that corn and cantaloupe seedlings drip fluids filled with very high amounts of imidacloprid and bees forage on these fluids.
- A 2012 Purdue University study and a 2012 University of Padova, Italy study revealed that bees were exposed to clothianidin through dust that is expelled from mechanical planters containing coated seeds.
- A 2012 from France showed that when bees were exposed to sublethal doses of thiamethoxam, foraging and feeding behavior were significantly degraded.
- A 2012 University of California at San Diegostudy found that small doses of imidacloprid depress the ability honey bees to communicate and effectively feed the colony.

Colony Collapse Disorder

What is Colony Collapse Disorder?

Colony Collapse Disorder (CCD) is the name given to the mysterious decline of honey bee populations around the world beginning in 2006. On average, the U.S. Department of Agriculture (USDA) reports that beekeepers have been losing over 30% of their honey bee colonies each year. While CCD appears to have multiple interacting causes, including pathogens, a range of evidence points to sublethal pesticide exposures as important contributing factors. Neonicotinoids are a particularly suspect class of insecticides, especially in combination with the dozens of other pesticides found in honey bee hives. Key symptoms of CCD include:

1) inexplicable disappearance of the hive's worker bees;

2) presence of the queen bee and absence of invaders;

3) presence of food stores and a capped brood.

Honey bee colonies can be moved across country to pollinate seasonal crops
Howard F. Schwartz, Colorado State University, Bugwood.org

How You Can Help: Provide Habitat and Nests for Summer and Winter

There are a number of things you can do to help conserve pollinators in your area:

1. Plant native and heirloom trees, shrubs, and flowers that bloom from April through September to create a consistent food supply so pollinators can complete their life cycles.
2. Minimize the use of broad-spectrum pesticides. These are toxic to bees and include neonicotinoids, pyrethroids, organophosphates, and others. If you must spray, choose a biorational chemical (safer to beneficials) and spray in early evening when most pollinators are less active. Planting insect- and disease-resistant varieties, proper irrigation and nutrition management, and allowing beneficial insects and spiders to visit plants may reduce the need for pesticides.
3. Provide or preserve nesting sites for native bees. Depending on species, bees may nest in the ground, in cavities, or in wood. Tunnel nests can be constructed with bamboo sticks or wooden blocks. For information on building your own nests for native bees, visit the Xerces Society Pollinator Conservation Program (http://www.xerces.org/pollinator-conservation/).

Pollinator conservation is essential for agriculture ornamental production, and natural landscapes

Pictured: Bumble bee (*Bombus impatiens*)
David Cappaert, Michigan State University, Bugwood.org

Bamboo insect hotel used by mason bees (*Osmia* spp.)
Magne Flaten [GFDL or CC-BY-SA-3.0-2.5-2.0-1.0], Wikimedia Commons

Nesting blocks in alfalfa field for use by alfalfa leafcutting bee (*Megachile rotundata*)
Whitney Cranshaw, Colorado State University, Bugwood.org

How You Can Help: Provide Habitat and Bee Plants

Pollinators require both nectar and pollen for their life cycles. Planting trees, shrubs, and flowers that bloom from April through September creates a consistent food supply so pollinators can complete their life cycles. Ground covers (such as *Ajuga*, squill, crocus, clover, and creeping Charlie) are also good bee plants. Visit a local plant nursery and select plants that are hardy for your zone. The first two rows below are native species; the last two rows are common garden species.

Early Season	Early-Mid Season	Mid Season	Mid-Late Season	Late Season
 **Serviceberry** **(*Amelanchier* species)**[1]	 **Wild rose** **(*Rosa* species)**[1]	 **Purple prairie clover** **(*Petalostemum candida*)**[1]	 **Anise hyssop** **(*Agastache foeniculum*)**[1]	 **New England aster** **(*Symphyotrichum novae-angliae*)**[2]
 **Pussy willow** **(*Salix discolor*)**[1]	 **Basswood, linden** **(*Tilia americana*)**[3]	 **Swamp milkweed** **(*Asclepias incarnata*)**[2]	 **Wild bergamot** **(*Monarda fistulosa*)**[2]	 **Goldenrod** **(*Solidago* species)**[1]
 **Carolina lupine** **(*Thermopsis villosa*)**[1]	 **Garden sage** **(*Salvia nemorosa*)**[2]	 **Billard's spiraea** **(*Spiraea x billardii*)**[4]	 **Sunflower** **(*Helianthus* species)**[1]	 **Korean angelica** **(*Angelia gigas*)**[5]
 **Siberian squill** **(*Scilla siberica*)**[6]	 **Catmint** **(*Nepeta x faassenii*)**[2]	 **Catnip** **(*Nepeta cataria*)**[7]	 **Globethistle** **(*Echinops* species)**[8]	 **Stonecrop** **(*Sedum* species)**[2]

1 Prairie Moon Nursery, www.prairiemoon.com
2 North Creek Nurseries, www.northcreeknurseries.com
3 Paul Wray, Iowa State University, Bugwood.org
4 Alfred Osterloh, [C-BY-NC-SA-3.0], Hortipedia Commons
5 Hardyplants at English Wikipedia, Wikimedia Commons
6 Heike Löchel, [CC-BY-SA-2.0-de], Wikimedia Commons
7 Theodore Webster, USDA Ag Research Service, Bugwood.org
8 Barbara Tokarska-Guzik, University of Silesia, Bugwood.org

How You Can Help: Understanding proper insecticide use

The conservation of beneficial insects, that includes bees, insect predators, parasitic wasps, and butterflies, is an essential part of Integrated Pest management (IPM) programs. IPM promotes multiple tactics to manage pests and to suppress the population size below levels that will damage the plant. IPM tactics include cultural control, sanitation, biological control, using insecticides friendly to beneficial insects, and finally the use of conventional insecticides. IPM recognizes that the few remaining pest insects will support beneficial predators and parasitic wasps. When scouting plants for pest insects, check for populations of both pest and beneficial insects, such as lady beetles and bees. If beneficial insects are present, wait to spray insecticides to see if the beneficial insects control the pest insects or use specific insecticides that only target the pest insect. Do not apply insecticides while plants are in full bloom. If possible avoid beneficial insects by spraying leaves in the evening when bees and lady beetles are not foraging.

Neonicotinoid systemic insecticides have been implicated in the decline of bees, butterflies, and other beneficial insects. The European Union banned the use of neonicotinoid insecticides from 2014-2016 on crops and plants that bee's visit. The concern was the residue in pollen and nectar and their negative effects on survival and foraging behavior of bees.

There are few systemic insecticides, while there are many systemic herbicides and fungicides. Systemic, neonicotinoid insecticides are the most widely used insecticides in the world, due to their low mammalian toxicity and the ability of the insecticide to move systemically from soil into the entire plant, including pollen and nectar. Application methods include seed treatments, foliar sprays, soil and trunk drenches, and trunk-injections. Flowers that open after being sprayed with contact insecticides do not contain insecticide residue, while toxicity to pests lasts for 1-3 weeks. However, flowers that open after systemic insecticides are sprayed can contain the insecticide residue for many months in both the leaves and pollen and nectar.

There are six neonicotinoid active ingredients, imidacloprid, dinotefuran, thiamethoxam, and clothianidin, of which acetamiprid and thiacloprid are the least toxic to bees. There is another systemic insecticide, fipronil that is used around structures that is also toxic to bees. You will find these active ingredients listed on the insecticide label in small print. The neonicotinyl class of insecticides is highly toxic to bees and kills bees at around 180 ppb in flower nectar or pollen. However, sublethal doses of neonicotinyl insecticide starting around 10 ppb, causes bees to lose navigation and foraging skills. The longevity and amount of the neonicotinoid in the pollen and nectar will depend on application method, concentration applied, and binding capacity of the soil.

The use of neonicotinyl insecticides as trunk injections and soil drenches for ash trees is important to slow the spread of the exotic, invasive Emerald Ash Borer and other invasive pests. As bees do not collect ash pollen in quantities, the risk to bee pollinators is low. In contrast, the use of neonicotinyl insecticides on flowering garden plants, shrubs and trees, including linden and basswood trees can kill bees and beneficial insects that utilize the flowers for pollen and nectar. It is wise to avoid using systemic neonicotinyl insecticides on flowering plants that bees visit regularly. Instead use spot treatments of contact insecticides.

The new EPA bee icon and bee advisory box on insecticide labels

PROTECTION OF POLLINATORS APPLICATION RESTRICTIONS EXIST FOR THIS PRODUCT BECAUSE OF RISK TO BEES AND OTHER INSECT POLLINATORS. FOLLOW APPLICATION RESTRICTIONS FOUND IN THE DIRECTIONS FOR USE

EPA has added new language to neonicotinyl insecticide products (imidacloprid, dinotefuran, thiamethoxam, and clothianidin) to protect bees and other insect pollinators. The bee icon above signals that the pesticide has potential to harm bees. The language in the new bee advisory box explains application restrictions to protect bees.

Bee and other insect pollinators can be exposed to the product from:
1. Direct contact during foliar application or contact with residues on plant surfaces after foliar application.

2. Ingestion of residues in nectar and pollen when the pesticide is applied as a seed treatment, soil, tree injection, as well as foliar application.

When using this product take steps to:
1. Minimize exposure when bees are foraging on pollinator attractive plants around the application site.

2. Minimize drift of this product onto beehives or to off-site pollinator attractive habitat. Drift of this product onto beehives can result in bee kills.

How You Can Help: Nursery and greenhouse growers have alternatives to systemic insecticides.

For the last 10 years the EPA has been registering selective, contact insecticides that conserve beneficial insects and pollinators.
Pymetrozine (Endeavor) stops mouthparts from feeding/working;
Flonicamid (Aria) stops mouthparts from feeding/working;
Pyriproxifen (Distance), diflubenzuron (Adept, Dimilin), or novaluron (Pedestal) IGR, insect growth regulator, stops larval growth;
Beauveria bassiana (Botanigard) microbial;
S-kinoprene (Enstar II), juvenile hormone mimic;
Spinosad (Conserve, Entrust) bee friendly when dried;
New miticides (Akari, Floramite, Hexygon, Judo, Sanmite)

Bee kills should be reported to Minnesota Department of Agriculture (www.mda.state.mn.us , type bee kill into search), National Pesticide Information Center (www.ipm.orst.edu), and the EPA (beekill@epa.gov)

How You Can Help: Understanding Pesticide Toxicity to Bees in Greenhouse and Landscape Insecticides

Chemical class	Examples of common names	Examples of trade names	Toxicity			
			Non	Low	Mod	High
Carbamates	carbaryl, methomyl	Sevin, Lannate				x
Neonicotinoids	Imidacloprid (I) thiamethoxam (T) clothianidin (C) dinotefuran (D) imid+bifenthrin (I,B)	Nurrsery/landscape Merit, Marathon, Flagship, Meridian, Arena, Aloft, Safari, Allectus, Field crops Gaucho (I), Poncho (C), Cruiser(T) (seed treatments), Admire/Provado (I), Venom (C), Platinum (T)				x
	Acetamiprid (A), thiacloprid (T)	Tristar (A), Assail (A), Calypso (T)		x		
Organophosphates	acephate, chlorpyrifos, dimethoate, malathion, phosmet	Orthene, Dursban/Lorsban, Dimethoate, Malathion, Imidan				x
Pyrethroids	bifenthrin, cyfluthrin, fenpropathrin, lambda-cyhalothrin, permethrin	Attain/Talstar, Tempo, Decathalon, Tame, Scimitar, Astro				x
Botanical	pyrethrum/pyrethrins azadirachtin, neem oil	Pyganic, Azatin, Ornazin, Triact				x
Insect growth regulators	diflubenzuron tebufenozide	Adept, Dimilin, Confirm			x	
	azadirachtin buprofezin pyriproxyfen	Aza-Direct, Azatin, Ornazin, Talus Distance		x		
	novaluron	Pedestal				x
	cyromazine	Citation				x
Juvenile hormone	s-kinoprene	Enstar II		x		
Diamides	chlorantraniliprole	Acelypryn		x		
Macrocyclic lactones	abamectin/avermectin, emamectin benzoate	Avid, Tree-Age				x
Miticides	acequinocyl, extoxazole, fenpyroximate, fenbutatin-oxide	Shuttle, TetraSan, Akari,Vendex	x			
	clofentezine, hexythiazox	Ovation, Hexagon		x		
	bifenazate	Floramite			x	
	pyridaben	Sanmite				x
Spinosyns	spinosad	Conserve/Entrust, less toxic dried		x		
Tetronic acids	spiromesifen	Judo, Kontos				
GABA-gated chloride channel	fipronil	Fipronil, Termidor,				x
Pyridine carboxamide	flonicamid	Aria, sucking mouthparts only	x			
Pyridine azomethines	pymetrozine	Endeavor, sucking mouthparts only	x			
Other insecticides	*Bacillus thuringiensis, Cydia pomonella* granulosis virus	Bt/Dipel, Carpovirusine/Cyd-X	x			
	flonicamid, potassium salts of fatty acids	Aria, M-Pede		x		
	horticultural mineral oils	Monterey			x	

How You Can Help: Understanding Pesticide Toxicity to Bees in Consumer Insecticides

This table lists the trade names of insecticides available to homeowners and other residents. The common names of the insecticides are followed by the commercial trade names. Not all products are listed in this table. Be sure to read the label.

Toxicity to bees: 1= highly toxic; 2= moderately toxic; 3= nontoxic to bees

Common name	Trade names	
1 acephate	Acephate Bonide Systemic Insect Control	Orthene
2 acetamiprid	Ortho Flower, Fruit & Vegetable Insect Killer	Ortho Rose & Flower Insect Killer
3 *Bacillus thuringiensis* var. *kurstaki* (bacterial toxin)	Dipel Green Step Caterpillar Control Safer Caterpillar Killer	Safer Garden Dust Thuricide
1 beta-cyfluthrin	Bayer Advanced Dual Action Rose & Flower Insect Killer (+imidacloprid) Bayer Advanced Home Pest Control Indoor/Outdoor	Bayer Advanced PowerForce Multi-Insect Killer Granules
1 bifenthrin	Bonide Eight Insect Control Flower & Vegetable Green Thumb Premium Insect Control Hi-Yield Bug Blaster II	Ortho Bug-B-Gon MAX Insect Killer for Lawns Ortho Bug-B-Gon MAX Lawn & Garden Insect Killer Scott's Super Turf Builder with Summerguard
canola oil 1 contact 3 residual	Bayer Advanced Natria Multi-Insect Control Earth-tone Horticultural Oil Earth-tone Insect Control (+pyrethrins)	Gardens Alive House Guardian Insect Spray (+pyrethrins) Ortho Elementals Garden Insect Killer (+pyrethrins) Gardens Alive Pyola (+pyrethrins)
1 carbaryl	Bayer Advanced Complete Insect Killer for Gardens Bonide Dragon Dust (+copper) Bonide Fruit Spray (+malathion, captan)	Bonide Rose Rx Rose & Flower Dust (+malathion, captan) Ortho® Bug-Geta Plus Snail, Slug & Insect (+metaldehyde) Sevin
1 chlorantraniliprole	Acelepryn	Grub-ex
clove oil 1 contact, 3 residual	Bonide Mite-X (+cottonseed oil, garlic extract)	EcoSmart Home Pest Control (+rosemary oil, peppermint oil, thyme oil)
cottonseed oil 1 contact, 3 residual	Bonide Mite-X (+clove oil, garlic extract)	Gardens Alive Oil-Away Supreme Insecticidal Spray
1 cyfluthrin	Bayer Advanced Vegetable & Garden Insect Spray	Bayer Advanced PowerForce Multi-Insect Killer Liquid
1 deltamethrin	Hi-Yield Kill-A-Bug II Dust Hi-Yield Kill-A-Bug II Indoor/Outdoor Spray	Hi-Yield Turf Ranger Insect Control Granules Hi-Yield Veg. & Ornamental Insect Control Granules
1 diatomaceous earth	Garden Safe Crawling Insect Killer	Natural Guard Crawling Insect Control
1 gamma-cyhalothrin	Spectracide Triazicide Once & Done Insect Killer	
3 garlic	Bonide Mite-X (+clove oil, cottonseed oil)	
3 halofenozide	Dow Mach II	
3 *Heterorhabditis bacteriophora*	**(insect-attacking nematode)** Gardens Alive Grub-Away Beneficial Nematodes	
1 imidacloprid Systemic Related neonicotinyls: • thiamethoxam (Flagship, Meridian) • clothianidin (Arena, Aloft) • dinotefuran (Safari) • imid+bifenthrin (Allectus)	Bayer Advanced All-in-One Rose & Flwr (+tebuconazole) Bayer Advanced Dual Action Rose & Flwr (+beta-cyfluthrin) Bayer Advanced Fruit, Citrus, & Veg. Insect Control Bayer Advanced Season-Long Grub Control Bayer Advanced 3-in-1 Insect, Disease, & Mite Control (+tau-fluvalinate, tebuconazole) Bayer Advanced 2-in-1 Systemic Rose & Flower Care Bayer Advanced 12 Mo. Tree & Shrub Insect Control Bayer Advanced 12 Mo. Tree & Shrub Protect & Feed Bayer Advanced 2-in-1 Insect Control +Fertilizer Spikes Bonide Annual Grub Beater	Bonide Annual Tree & Shrub Insect Control Bonide Borer-Miner Killer with Systemaxx Bonide Guard-N-Grow Bonide Rose Rx Systemic Drench (+tebuconazole) Bonide Systemic Insect Control with Systemaxx Ferti-lome Rose & Flower Food w/Systemic Insecticide Ferti-lome Tree & Shrub Systemic Hi-Yield Systemic Insect Granules Merit Ortho Max Tree & Shrub Insect Control Ortho Tree & Shrub Insect Control

Common name	Trade names	
insecticidal soap (potassium salts of fatty acids) **1 contact,** **3 residual**	Bayer Advanced Natria Insecticidal Soap Bonide Insecticidal Soap Concern Insect Killing Soap Concern Tomato & Vegetable Insect Killer (+pyrethrins) Earth Options by Raid Insecticidal Soap Earth-tone Insecticidal Soap Garden Safe Insecticidal Soap Ortho Elementals Insecticidal Soap	Safer End-ALL Insect Killer (+neem, pyrethrins) Safer Fruit & Vegetable Insect Killer Safer Insect Killing Soap Safer Rose & Flower Insect Killer Safer 3-in-1 Garden Spray (+sulfur) Safer Tomato & Vegetable Insect Killer (+pyrethrins) Safer Yard & Garden Insect Killer (+pyrethrins)
3 iron phosphate	Bayer Advanced Dual Action Snail & Slug Killer Bait Bayer Advanced Snail & Slug Killer Bait Bonide Bug & Slug Killer (+spinosad) Bonide Slug Magic	Ferramol Slug & Snail Bait Ortho Elementals Slug & Snail Killer Sluggo Gardens Alive Escar-Go
3 kaolin	Surround at Home Crop Protectant	
1 lambda-cyhalothrin	Bonide Beetle Killer Bonide Caterpillar Killer	Bonide Colorado Potato Beetle Beater Spectracide Triazicide Once & Done Insect Killer
2 malathion	Malathion Bonide Malathion Bonide Fruit Spray (+carbaryl, captan)	Bonide Rose Rx Rose & Flower Dust (+carbaryl, captan) Ortho Max Malathion Insect Spray
3 metaldehyde	Deadline Enforcer Everlast Snail & Slug Bait Hi-Yield Improved Slug & Snail Bait	Ortho Bug-Geta Plus Snail, Slug & Insect Killer (+carbaryl) Ortho Bug-Geta Snail & Slug Killer
2 neem oil	Bonide Bon-Neem II (+pyrethrins) Bonide Neem Oil Bonide Rose Rx 3-in-1 Concern Garden Defense Multi-purpose Spray Ferti-lome Fruit Tree Spray (+pyrethrins)	Ferti-lome Triple Action Plus Garden Safe Neem Oil Extract Green Light Fruit Tree Spray (+pyrethrins) Safer BioNEEM Insecticide & Repellent Safer End-ALL Insect Killer (+insect. soap, pyrethrins)
3 parasitic nematodes	Many trade names	
3 *Paenibacillus popilliae*	**(Milky spore disease)** Many trade names	Product is not very effective
1 permethrin	Bayer Advanced Complete Insect Dust for Gardens Borer-Miner Killer Bonide Eight Garden & Home Insect Control Bonide Eight Insect Control Garden Dust Bonide Eight Insect Control Vegetable, Fruit, & Flower Bonide Eight Insect Control Yard & Garden Bonide Total Pest Control Outdoor Enforcer Outdoor Insect Killer	Ferti-lome Indoor – Outdoor Multipurpose Insect Spray Green Thumb Flying Insect Killer (+d-trans allethrin) Hi-Yield Indoor Outdoor Broad Use Insecticide Hi-Yield Kill-A-Bug II Lawn Granules Hi-Yield Lawn, Garden, Pet, and Livestock Insect Control Hi-Yield Turf, Termite, and Ornamental Insect Control Ortho Bug-B-Gon MAX Garden Insect Killer Dust
petroleum oil **1 contact, 3 residual**	Bonide All Seasons Horticultural Spray Oil Bonide All Seasons Spray Oil	Horticultural Spray Oil Ortho Volck Oil Spray
1-3 pyrethrins principally from plant species *Chrysanthemum cinariaefolium*	Bayer Advanced Natria Insect, Disease, & Mite Control (+sulfur) Bonide Bug Beater Yard & Garden Bonide Citrus, Fruit, & Nut Orchard Spray (+sulfur) Bonide Garden Dust (+sulfur, copper) Bonide Japanese Beetle Killer Bonide Pyrethrins Garden Insect Spray Bonide Tomato & Vegetable 3-in-1 (+sulfur) Concern Tomato & Veg. Insect Killer (+insecticidal soap) Earth-tone Insect Control (+canola oil) Ferti-lome Quick Kill Home, Garden, and Pet Spray	Ferti-lome Triple Action Plus II Safer End-ALL Insect Killer (+neem, insecticidal soap) Safer Tomato & Vegetable Insect Killer (+insecticidal soap) Garden Safe Fruit & Vegetable Insect Killer Garden Safe Houseplant & Garden Insect Killer Garden Safe Multi-Purpose Garden Insect Killer Garden Safe Rose & Flower Insect Killer Gardens Alive Rose & Ornamental Plant Spray (+sulfur) Ortho Elementals 3-in-1 Rose & Flower Care (+sulfur) Gardens Alive Pyola (+canola oil) Safer Yard & Garden Insect Killer (+insecticidal soap)
3 sodium ferric EDTA	Safer Dr. T Slug & Snail Killer	
3 spinosad, when residue is dry	Bonide Bug & Slug Killer (+iron phosphate) Bonide Captain Jack's Deadbug Brew Gardens Alive Bulls-Eye Bioinsecticide	Conserve Ferti-lome Borer, Bagworm, Leafminer & Tent Caterpillar Spray
3 trichlorfon	Dylox	Bayer Advanced 24-Hour Grub Killer Plus

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Center for Urban Ecology and Sustainability
www.entomology.umn.edu/cues

University of Minnesota Extension Service

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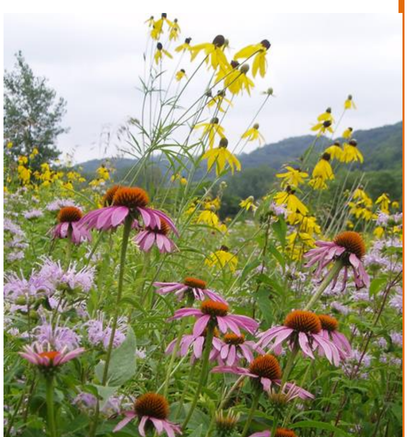

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Additional Resources

University of Minnesota Bee Lab
www.beelab.umn.edu/

CUES Pollinator Conservation
www.entomology.umn.edu/cues/pollinators/index.html

The Xerces Society for Invertebrate Conservation
www.xerces.org/

North American Pollinator Protection Campaign
pollinator.org/nappc/index.html

Pollinator Partnership
www.pollinator.org/index.html

EFSA, European Food Safety Authority
www.efsa.europa.eu/en/topics/topic/beehealth.htm

Befriending Bumble Bees: A practical guide to raising local bumble bees www.beelab.umn.edu/Bumblebee/index.htm

Wild Bees and Building Wild Bee Houses
www.beelab.umn.edu/Bumblebee/index.htm

Managing Alternative Pollinators: A Handbook for Beekeepers, Growers, and Conservationists
www.beelab.umn.edu/Bumblebee/index.htm

Pollinators of Native Plants by Heather Holm
www.pollinatorsnativeplants.com/

Lists of best plants for pollinators, butterflies, and beneficial insects

The University of MN Bee Lab, bulletin, plants for Minnesota bees
www.beelab.umn.edu/prod/groups/cfans/@pub/@cfans/@bees/documents/article/cfans_article_451478.pdf

CUES: Pollinator Conservation, plants for bees and other pollinators
www.entomology.umn.edu/cues/pollinators/plants.html

CUES: Poster, Save the bees plant flowers and trees
www.entomology.umn.edu/cues/pollinators/plantsposter.pdf

CUES: Bulletin, Plants for butterfly gardening
www.extension.umn.edu/garden/yard-garden/landscaping/butterfly-gardening/

CUES: bulletin, Plants that provide pollen and nectar for beneficial insects
www.entomology.umn.edu/cues/gervais/keytable.htm