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Pollinator Conservation

By Emily Tenczar & Vera Krischik, University of Minnesota, May 2013

Bees pollinate fruit, nut, berry, and vine crops.

Bees are threatened by habitat loss and pesticide use.

Providing nectar plants and protecting nest sites can help conserve bees.

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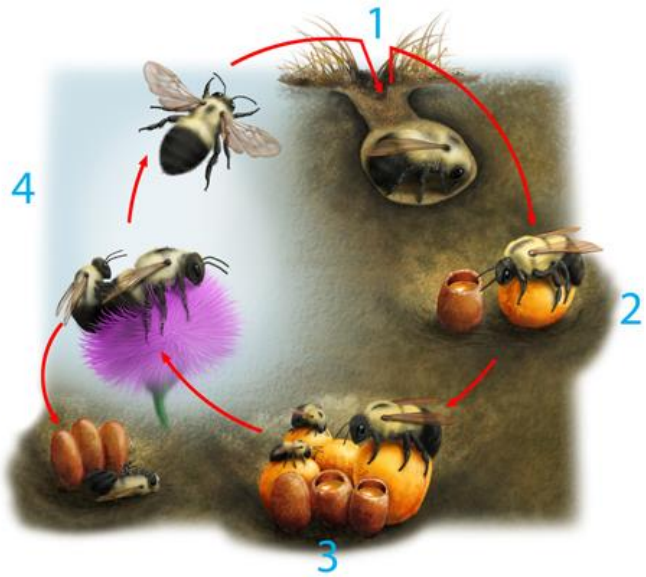
Bees are Important Pollinators

Bees are undoubtedly the most abundant pollinators of flowering plants in our environment. The service that bees and other pollinators provide allows nearly 70 percent of all flowering plants to reproduce; the fruits and seeds from insect pollinated plants account for over 30 percent of the foods and beverages that we consume. 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 approximately 25 percent of all 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, alteration, and fragmentation, pesticide use, and introduced diseases all contribute to declines of bees.

Bees can be divided into two groups by their lifestyles: solitary or social. Despite the fact that the stereotypical image is of a bee living in a hive, 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 (not native to the U.S.) and the bumble bees (about forty-five species in the U.S.).

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



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FOR INVERTEBRATE CONSERVATION

1. A queen emerges from hibernation in spring and finds a nest site, such as an abandoned rodent burrow.
2. She creates 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 and male bees, who leave to find mates. Newly mated queens hibernate and the rest of the bees die.

Types of Bees

Most of these bees are native. The honey bee is introduced. Learn to identify the bees in your garden or landscape!

Bumble Bees (*Bombus* species; Family Apidae)

Bumble bees are large (10-23 mm in length), hairy, ground-nesting bees. 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)

This European bee is 10-15 mm in length and is used for pollination as well as honey, propolis, and beeswax production. Bees survive the winter on stored honey.

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

Digger and Long-Horned Bees (Family Apidae)

These hairy bees 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 chew nests in wood. *Xylocopa* species are 13-30 mm in length and *Ceratina* species are 3 to 15 mm. Most are solitary but a few species are semisocial.

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

Leafcutter Bees (Family Megachilidae)

Leafcutter bees are solitary, 10-20 mm in length, and usually nest in cavities. Leafcutter bees 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)

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

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 Pesticides

FROM: BEYOND PESTICIDES

BEYOND PESTICIDES

*"**One in three bites of food** is reliant on honey bee pollination and threats to pollinators concern the entire food system."*

-Beyond Pesticides, Center for Food Safety, & PAN NA

The disappearance of the bees alerts us to a fundamental and systemic flaw in our approach to the use of toxic chemicals and highlights the question as to whether our risk assessment approach to regulation will slowly but surely cause our demise without a meaningful change of course. While admittedly uncertain and filled with deficiencies, risk assessments establish unsupported thresholds of acceptable chemical contamination of the ecosystem, despite the availability of non-toxic alternative practices and products. Why do we allow chemical-intensive practices in agriculture when organic practices that eliminate the vast majority of hazardous substances are commercially viable? Risk assessments, supported by environmental and public health statutes, in effect prop-up unnecessary poisoning.

Pesticides Harm Pollinators

- Neonicotinoids (clothianidin, thiamethoxam, imidacloprid) are a class of insecticides that 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 from which bees forage and drink.
- Neonicotinoids are particularly dangerous because, in addition to being acutely toxic in high doses, exposure also results in serious sublethal effects when insects are exposed to chronic low doses.
- Research has shown that neonicotinoid exposure causes significant problems for honey 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.

Regulatory Issues

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- As of April 29th, 2013, the Commissioner of the European Union will restrict the use of 3 neonicotinoids (clothianidin, imidacloprid and thiametoxam) for seed treatment, soil application (granules) and foliar treatment on bee attractive plants and cereals for two years, beginning on July 1st, 2013.
- 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.

PAN NORTH AMERICA

- 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 January 2012 Purdue University study reveals that honey bees were exposed to clothianidin through dust that is expelled from mechanical planters containing coated seeds.
- An April 2012 study out of France shows that when exposed to sublethal doses of thiamethoxam, honey bees' foraging and feeding behavior were significantly degraded.
- A study released in May 2012 by University of California at San Diego finds that small doses of imidacloprid depress honey bees' ability to communicate and effectively feed the colony.

Colony Collapse Disorder

FROM: BEYOND PESTICIDES

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- but some are losing many more times that number. 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

Bee Disappearance is Global

FROM: **European Food Safety Authority (EFSA)**

Bees in Decline

Over the past 10 to 15 years, beekeepers have been reporting unusual weakening of bee numbers and colony losses, particularly in Western European countries including France, Belgium, Switzerland, Germany, the UK, the Netherlands, Italy and Spain.

In May 2012, as part of its strategy for tackling declining bee numbers, the European Commission allocated €3.3 million to support 17 Member States carrying out surveillance studies aimed at gathering further information on losses of honey bee colonies.

EU framework

In 2010 the European Commission issued a Communication on Honeybee Health, which clarified the key issues related to bee health and the key actions that the Commission is taking to address them.

EFSA's activities

In 2009 EFSA launched a project to assess bee surveillance systems in the EU, and to collate and analyse data and publications related to honey bee colony mortality across Europe. The Agence Française de Sécurité Sanitaire des Aliments (AFSSA, forerunner of Anses) set up a consortium of seven European bee disease research institutes to answer the call for data and a literature review. The subsequent report Bee Surveillance and Bee Mortality in Europe, made a number of recommendations to improve surveillance as well as identifying consensus across the EU on the multifactorial origins of the decline in bee numbers. It also helped to shape the Commission's strategy for tackling the decline in bee numbers across Europe, which was clarified in a key communication on honey bee health published in 2010.

In February 2012 the Pesticides Unit reviewed the risk of thiamethoxam to honeybees, as requested by the European Commission, on the basis of new information submitted. Thiamethoxam is a member of the neonicotinoid group of insecticides, which some studies suggest could be a contributing factor to bee colony losses. The use of neonicotinoids is restricted in Germany, Italy, France and Slovenia.

Honey bee (*Apis mellifera*)
Jerry A. Payne, USDA Agricultural Research Service, Bugwood.org

How You Can Help

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

1. Plant 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

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

Pesticide Toxicity to Bees (by active ingredient)

Adapted from:

Krupke, C.H., *et al*. 2012. Beekeeping: Protecting Honey Bees From Pesticides. Purdue Extension E-53-W. URL: http://extension.entm.purdue.edu/publications/E-53.pdf

Park, M., *et al.* 2012. Wild Pollinators of Eastern Apple Orchards and How to Conserve Them. Cornell University, Penn State University, and The Xerces Society. URL: http://www.northeastipm.org/park2012

Chemical class or group	Examples of common names	Examples of trade names	Toxicity			
			Non	Low	Mod	High
Carbamates	oxamyl	Vydate			x	
	carbaryl, methomyl	Sevin, Lannate				x
Neonicotinoids	clothianidin, imidacloprid, thiamethoxam	Clutch/Poncho, Admire/Provado, Actara/Cruiser				x
	acetamiprid, thiacloprid	Assail, Calypso		x	x	
Organophosphates	acephate, azinphos-methyl, chlorpyrifos, dimethoate, malathion, methidathion, phosmet	Orthene, Guthion, Dursban/Lorsban, Dimethoate/Dimate, Malathion, Supracide, Imidan				x
Chlorinated hydrocarbons	endosulfan	Thiodan/Thionex			x	
Pyrethroids	bifenthrin, cyfluthrin, deltamethrin, esfenvalerate, fenpropathrin, lambda-cyhalothrin, permethrin	Brigade/Capture, Baythroid, Decis, Asana, Danitol, Warrior, Ambush/Pounce				x
Botanical	pyrethrum/pyrethrins	PyGanic/Nature		x		
Insect growth regulators	diflubenzuron, tebufenozide	Dimilin, Confirm	x			
	azadirachtin, buprofezin, methoxyfenozide, pyriproxyfen	Aza-Direct/Neemix, Applaud/Centaur, Intrepid, Esteem		x		
	novaluron	Rimon				x
Diamides	chlorantraniliprole	Altacor		x	x	
	flubendiamide	Belt	x			
Macrocyclic lactones	abamectin/avermectin, emamectin benzoate, spinetoram, spinosad	Agri-Mek, Proclaim, Delegate, Entrust/Sucess				x
Miticides	acequinocyl, extoxazole, fenpyroximate, fenbutatin-oxide	Kanemite, Secure/Zeal, Fujimite/Portal, Vendex	x			
	clofentezine, hexythiazox	Apollo, Onager/Savey		x	x	
	bifenazate, spirodiclofen, spiromesifen	Acramite, Envidor, Oberon			x	
	pyridaben	Nexter/Pyramite				x
Other insecticides	*Bacillus thuringiensis, Cydia pomonella* granulosis virus	Bt/Dipel, Carpovirusine/Cyd-X	x			
	flonicamid, kaolin clay, potassium salts of fatty acids	Beleaf, Surround, M-Pede		x		
	horticultural mineral oils	Stylet Oil			x	
	indoxacarb, spirotetramet	Avaunt, Movento			x	x
	formetanate HCl	Carzol				x
Fungicides	sterol inhibitors, strobilurins	Indar/Nova/Rally/Rubigan, Flint/Sovran	x			
	captan, mancozeb	Captan, Dithane/Manzate/Penncozeb		x		
	lime sulfur*, sulfur* (Repellent for more than one day)			x		
Plant growth regulators	ethephon, nAA/1-naphthaleneacetic acid	Ethrel	x			

Pesticide Toxicity to Bees (consumer products)

Ready to use consumer insecticides and their toxicity to bees
Krischik, V. A. and Tenczar, E. G. 2013. Department of Entomology, University of Minnesota, combined from:

Nixon, P.L. 2011. Names of General Use Insecticides. University of Illinois. URL: http://ipm.illinois.edu/hyg/insects/insecticide_trade_names_for_homeowners.pdf

Krupke, C.H., *et al*. 2012. Beekeeping: Protecting Honey Bees From Pesticides. Purdue Extension E-53-W. URL: http://extension.entm.purdue.edu/publications/E-53.pdf

Names of General Use Insecticides
This table lists the trade names of insecticides available to homeowners and other residents. The label on the container always lists these products by the common name or chemical name. The common names of the insecticides are followed by the commercial trade names; some products may be available under a variety of trade names that are not 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)** • **imid+cyfluthrin (Discus)**	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	Warning: 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	
1-2 spinosad	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

Additional Resources

Visit us on the web!

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

College of Food, Agricultural and Natural Resource Sciences
University of Minnesota

University of Minnesota Extension Service

Research and outreach supported by 2010 LCCMR "Mitigating Pollinator Decline"

Beyond Pesticides:
http://www.beyondpesticides.org/index.php

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

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

Pollinator Partnership:
http://www.pollinator.org/index.html

Prairie Moon Nurseries:
www.prairiemoon.com

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

University of Minnesota Department of Entomology:
http://www.entomology.umn.edu/

University of Minnesota Extension Service:
http://www.extension.umn.edu/

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

Photo © Prairie Moon Nursery