Guide to Integrated Pest Management (IPM)

A science-based approach for ecologically sound land management

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Entomology, Jan. 2020

INSIDE:

Find more on IPM and pollinator conservation at:
ncipmhort.cfans.umn.edu

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND
Legislative Citizen Commission on Minnesota Resources (LCCMR) Conservation Biocontrol 2017 - 2020

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The first and most important steps of IPM are to accept that plants can handle some pest and disease damage, and to determine your economic threshold.

Left: Regular inspection of plants for pests and disease.
photo: PFA 2020

Integrated Pest Management (IPM) is an ecosystem-based approach that employs long-term prevention of pests and pest damage through monitoring of plants, pests and weather to project ahead and plan. While pesticides simply respond to the pest, IPM addresses the source of pest problems. IPM strives to avoid chemicals harmful to pollinators and toxic to the environment.

It's important for land managers, homeowners and farmers to learn how to implement an IPM plan. Any individual or organization can adopt an IPM plan for spaces from backyards to public parks to farms. IPM plans should be updated annually, and staff need to be trained on pesticide use and best practices.

IPM promotes multiple tactics and controls to manage pests and to suppress the population size below levels that will damage the plant.

Cultural controls are practices that reduce pest establishment, reproduction, dispersal and survival. For example, the pest's environment can be disrupted by turning under garden soil, mowing, sterilizing tools and harvesting early. Composting, watering, mulching, pruning, fertilizing and ground covers can all help improve plant health, resulting in healthier plants that can tolerate some damage.

Regenerative farming systems use methods such as trees for wind blocks, cover crops, companion planting, trap crops, composting, and soil amendments to support biodiversity to control pest insects and plant disease.


Checking sticky traps for apple codling moth, Carpenter Nature Center

Chemical control is the use of pesticides. In IPM, pesticides are used only when needed, and in combination with other approaches for more effective, long-term control. Do not spray on a weekly schedule, rather only spray when pest numbers meet the threshold. Always use the least toxic option first, and if pest numbers are not lowered, then use a stronger control. Conventional insecticides kill all insects, while biorational insecticides target pests and not good bugs. ***Biorational pesticides*** are developed to conserve beneficial insects and include horticultural soaps and oils, corn gluten, spinosad, and *Bacillus thuringiensis.*

Pesticides should be selected and applied in a way that minimizes their harm to people, non-target organisms and the environment. Use pesticides only as a last resort, follow the label, and apply only when weather conditions permit. Spot-spray in the evening, and do not apply to flowers to avoid pollinators. Never spray without monitoring number of pests and beneficial insects first.

- Insecticides have lethal and sub-lethal effects on pollinators.
- Herbicides can kill pollinators and the plants pollinators use for food and shelter.
- Fungicides can kill pollinators.
- Additives and inert ingredients are part of the pesticide formulation and can be toxic to pollinators.
- Systemic insecticides such as neonicotinoids are absorbed into the plant's vascular system, and move into the pollen and nectar, leaving the entire plant toxic to both target and non-target species. Systemics stay in the plant longer than contact insecticides. Contact insecticides are formulated to decompose in approximately one week, while residue from systemic insecticides lasts months to years.
- Organic management allows only OMRI listed products to be used, derived from plants or natural products, which does not make them less toxic to beneficial insects and pollinators.

Mechanical and physical controls kill pests directly, block pests out, or make the environment unsuitable for them. Sticky traps are an example of mechanical control. Physical controls include steam sterilization of soil for disease control, or barriers like high tunnels to keep birds and insects out.


Wait to mow pollinator lawns until 4" or taller


Checking sticky trap for pest insects


Kaolin clay sprayed on fruit (not blossoms)

Biological controls include insect predators and parasitoids, such as lady beetles and braconid wasps, and are mainly free-living species that kill pest insects. Pathogens are disease-causing organisms including bacteria, fungi, and viruses. They kill or debilitate their host and are relatively specific to certain insect groups. Pest insects and weeds have many natural enemies. Land managers can foster conservation biocontrol by planting biodiverse habitat to support natural enemies. Heirloom and native plants provide pollen and nectar to attract many beneficial natural enemies already at work such as lady beetles and lacewings.

Why insects versus pesticides

- Conservation of natural enemies of insects (predators and parasitoids) and pollinators (such as bees and beetles) around the farm, garden and green spaces can help suppress pests and increase crop yields.
- Some pest insects can develop pesticide resistance with increased use of pesticides.
- Pesticides kill both good and bad (target and non-target) insects including predator bugs, as well as important soil dwelling insect predators.
- Beneficial insects are cost-effective and safe for humans, birds, wildlife and the environment.

Predatory lady beetle *(Coccinellidae)* feeding on Milkweed aphid *(Aphis nerii)*. *Photo: Pavlos Skenteridis, Bio-insecta*

Weed Control (compatible w/beneficial insects)	**Pest Controls** (compatible w/beneficial insects)
Hand weeding	Spinosad, Bt
Solarization	Insecticidal soaps and oils, neem oil
Smothering	Contact instead of systemic insecticides
Compost, mulch	Biocontrols such as beneficial insects
Cover crops	Flower borders serve as insectaries to boost natural enemies
Corn gluten, natural preen, white vinegar	Biorational insecticides: Bt for mosquitos, Btk for moths, Btg for beetles, spinosad for eating sawflies & mosquitos, *Beauveria bassiana* for aphids & thrips, nematodes for grass insects, insect growth regulars (IGR) to kill larval stages, some miticides.
Fungicides	**Soil**
Microflora bacillus, chromo bacterium	Improve plant health with healthy soil through cultural treatments such as compost, bio fertilizers, and aeration.
Bio fungicides	

Integrated Pest Management plans include multiple practices

1. Inspection and monitoring: Regular and close examination of plants is essential to diagnose pest problems. Monitoring includes devices such as traps, and practices such as observation and recordkeeping. Track numbers of good bugs and pest bugs. If a pesticide must be used, use a biorational pesticide which is less harmful.

2. Forecasting: Weather and plant growth cycles (called plant phenology) help predict potential pest outbreaks. Properly timed pesticide applications will be more effective and reduce need for re-application.

3. Thresholds: Set thresholds for pest populations and plant damage. Before insecticide use, wait until pest populations reach a determined level that could cause economic or irreversible plant damage. Use hardy plants that are naturally resistant to pests to avoid exceeding pest thresholds.

4. Education: Regularly update the IPM plan and pesticide/treatment list so it remains effective. All staff should be educated and updated on IPM and best management practices.

5. Recordkeeping: Keep updated records to compare year to year and for decision-making. Track data including weather patterns, when pests appear, number of pests, plant damage, and practices that work and don't work. Always count pests before and after pesticide application to determine if application was successful.

Biorational instead of systemic insecticides for pest control

For most pests that eat leaves, use contact insecticides that sit on the leaf surface for a few days, but does not move into the plant tissue. In contrast, systemic insecticides move from the leaves or soil into other plant parts such as nectar and pollen. Flowers that open after systemic insecticides are sprayed can absorb the insecticide and the residue in leaves and flowers, and can last for many months. For insects that bore into trunks or branches, a systemic insecticide will kill borers.

Managing plants for insects

For leaf feeding insects, use spot treatments of the appropriate biorational insecticide that does not kill the good bugs, such as predators. Biorational insecticides include: spinosad and chlorantraniliprole which kill many leaf-feeding larva, Neem oil for aphids, pyrethrin insecticides, and different Bt formulations for beetles, moths, and flies. For mosquitoes in ponds use the biorational *Bacillus thuringiensis var israelensis*. **Never spray on flowers or when bees are foraging.**

Practices for healthy turf

- For healthy turf, use cultural practices that decrease thatch and bring new nutrients to the soil such as aerating the lawn to make holes in the fall. Applying high rate fertilizers and herbicides each spring will not result in sustainable, healthy turf. Instead of applying herbicides, it is best to improve turf density, root depth, and resistance to diseases through healthy soil.
- In the spring top dress with compost, micronutrients, and turf boosters and over seed bare spots with varieties of fescues rather than Kentucky blue grass. Use lower rate fertilizer such as 10-0-10 and milorganite with iron in the spring and fall at least two times. By increasing the nutrients and soil texture, turf can grow more vigorously and outcompete weeds.
- Kill existing weeds by cutting them out or spot treating with corn gluten. Then, add compost and grass seed in the resulting holes.
- Creeping Charlie is a mint that bees visit for nectar. It grows vigorously in shade and moist areas. It may spread to sunny areas if turf is not growing vigorously. Leaving Creeping Charlie in shady, moist areas where most grasses will not grow keeps the area free of mud that can get on the feet of pets and people.

Managing turf for brown spots and Japanese beetles

If your turf is plagued with brown patches, do not assume it is a grub like Japanese beetle. Most brown spots in turf are due to fungus, which are hard for even lawn care professionals to identify and manage, as different diseases require different fungicides. You may need to take a sample to the University of MN plant disease clinic to learn pest species and how to manage it (https://pdc.umn.edu/ 612-625-1275.) For Japanese beetle grubs in the soil use GrubEx, and for adults feeding on plants, use Acelepryn, both contain biorational chlorantraniliprole. For all grubs use Bt galleriae or grubgone. Native insect predators cannot kill enough grubs and adult Japanese beetles to manage their populations. **Remember: Never spray any pesticide on flowers or when bees are foraging.**

The conservation of beneficial insects, including bees, insect predators, parasitic wasps, and butterflies, is an essential part of IPM programs. Natural predators can be divided into two groups – predators and parasitoids. Many are attracted to flowering plants for pollen and nectar and contribute to pollination services. Conserve them with habitat containing native and heirloom plants that provide pollen and nectar. Natural predators are a long-lasting, natural, non-toxic solution that will further the ecological diversity of your green space. If using pesticides, do judicious spot treaments.

Cicada Killer Wasps (Family Crabronidae) **predator**

These very large wasps are docile and mild mannered. Females paralyze and drag cicadas to their ground nest for their young. Only active for about 1 month, July and August.

Photo: Elizabeth Sosa, iNaturalist.org

Spider wasp (Family Sphecidae) **predator**

These efficient pollinators feed on nectar and spiders. With their long legs, they search for spiders, paralyze them and drag them to their nest for their young. They are usually deep purple and flick their wings.

Photo: Laurie Schneider

Lacewing (Family Chrysopidae) **predator**

Lacewing larvae are also known as aphid lions. They seize aphids with their sucking jaws and paralyze them before draining body fluids and killing them.

Photo: Dvoribird, Bugguide.com

Lady beetle (Family Coccinellidae) **predator**

Lady beetles or ladybugs can consume many aphids, insect eggs and larvae (50 in a day, or 5,000 in a lifetime).

Photo: Ward Upham, Bugwood.org

Beneficial nematodes **predator**

Nematodes are the most numerous multicellular animals on earth. A handful of dirt can contain thousands of microscopic worms that attack ground dwelling insects.

Photo: Wikimedia

Pirate bug (Hemiptera) **predator**

Aggressive thrip predators for crops, landscape and greenhouse. These "true" bugs kill egg and adult thrips and many species of small insects.

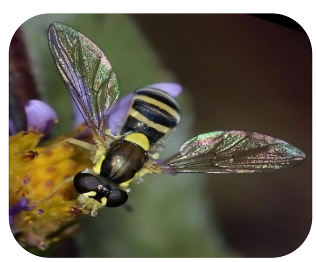
Photo: Alice Abela, BugGuide

Braconid wasps (Family Braconidae) **parasitoid**

There are 2000+ species of these tiny, non-stinging wasps. Females lay eggs in or on the host, which then kills the insect when they hatch. Most every pest insect has a parasitoid that can kill it.

Photo: David Cappaert, Bugwood.org

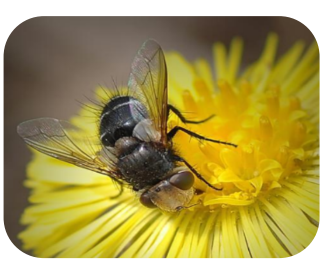
Syrphid flies (Family Syrphidae) **pollinator / predator**



Syrphid fly or hoverfly adults can hover over flowers and are efficient pollinators. The larvae eat a wide range of aphids, scale insects, thrips and caterpillars.

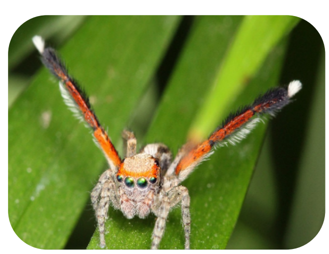
Photo: Kildale, Bugguide

Tachinid flies (Family Tachinidae) **pollinator / parasitoid**



Fly larva develop within or on their hosts, consuming and killing the host. Hosts include larvae of beetles, moths, earwigs, sawflies, grasshoppers and true bugs. Adults feed on nectar and pollen. Photo: Jon Yuschock, Bugwood.org

Spider (Arthropod / Arachnids) **predator**



Spiders are arthropods related to insects which eat insects at any stage from egg to adult. They have a wide generalist diet and don't eat plants. Spiders use venom to paralyze their prey.

Photo: Kaldari, Wikimedia

Federally Endangered Species

Poweshiek skipperling butterfly
Photo: Owen Boyle

Karner blue butterfly
Photo: Wikimedia

Rusty-patched bumble bee
Photo: Marcie Forsberg

Federally Threatened Species

Dakota skipper butterfly
Photo: Eric Rundquist

Yellow-banded bumble bee
Photo: iNaturalist.org

Monarch butterfly
Photo: Laurie Schneider

Other Resources

Integrated Pest Management of Midwest Landscapes *by Vera Krischik, University of Minnesota*
Center for Urban Ecology and Sustainability, *University of Minnesota*
Midwest Organic & Sustainable Education Service, *Continuing Education, IPM*
Value of Habitat for Pest Management, *USDA NRCS East National Technology Support Center*
Cover Cropping for Pollinators and Beneficial Insects, *Sustainable Agriculture Research & Education*
Greenhouse Pest Identification *by Vera Krischik, University of Minnesota*
Habitat Development for Beneficial Insects, *USDA/NRCS Colorado*
VIDEO: Integrated Pest Management tactics and strategies, *University of California, Pete Goodell*
Understanding Pesticide Toxicity to Pollinators *by Vera Krischik, University of Minnesota*

Native Plant & Seed Suppliers

BluPrairie Native Plant Nursery, bluprairie.com	**Native Sun**, nativesunseedsandplants.com
Glacial Ridge Growers, glacialridgegrowers.com	**Natural Shore Technologies**, naturalshore.com
Hammarlund Nursery, hammarlundnursery.com	**Northstar Seed & Nursery** 507-334-6288
Hayland Woods Nursery, haylandwoods.com	**Outback Nursery**, outbacknursery.com
Kinnickinnic Natives, kinnicnatives.com	**Prairie Moon Nursery**, prairiemoon.com
Landscape Alternatives, landscapealternatives.com	**Prairie Restoration**, prairieresto.com
Minnesota Native Landscapes, mnnativelandscapes.com	**Sogn Valley Farm**, sognvalleyfarm.com/native-plants
Morning Sky Greenery, morningskygreenery.com	**Sunrise Native Plants**, sunrisenativeplants.com

Bolded insecticides are not permitted by MDA on bee-friendly plants. Highlighted in gray are less toxic.

Chemical class/MOA	Common name / MOA	Trade name	Toxicity to honeybees**			
			LD50*ug/bee	Non	Moderate	Highly
Carbamates/1A	carbaryl	Sevin	0.014			x
	methomyl	Lannate	0.816			x
Neonicotinoids/4	imidacloprid	Merit, Marathon	0.004			x
	thiamethoxam	Flagship, Meridian	0.004			x
	clothianidin	Arena, Aloft	0.005			x
	dinotefuran	Safari, Venom	0.023			x
	imid+bifenthrin	Allectus	0.004			x
	imid+cyfluthrin	Discus	0.004			x
	flypyradifurone	Altus	1.2			x
	sulfloxaflor+spinetoram	XXpire - cancelled	0.02+0.1			x
	acetammiprid	Tristar, Assail	14.5	x		
	thiacloprid	Calypso	27.8	x		
Organophosphates/1B	acephate	Orthene	0.1082			x
	chlorpyrifos	Dursban/Lorsban	0.06			x
	dimethoate	Dimethoate	0.038			x
	malathion	Malathion	0.16			x
	phosmet	Imidan	0.1			x
Pyrethroids/3A	bifenthrin	Attain/Talstar	0.1			x
	cyfluthrin	Tempo, Decathalon	0.001			x
	fenpropathrin	Tame	0.05			x
	lambda-cyhalothrin	Scimitar	0.038			x
	permethrin	Astro, Pounce	0.029			x
	resmethrin	foggers	0.065			x
Botanical/3	pyrethrin	Pyganic	0.15			x
Insect growth regulators	diflubenzuron/15	Adept, Dimilin	25	x		
	tebufenozide/18	Confirm	234	x		
	azadirachtin/UN	Aza-Direct, Azatin	2.5		x	
	neem oil		163	x		
	buprofezin/16	Talus	100	x		
	pyriproxyfen/7C	Distance, Fulcrom	100	x		
	novaluron/15	Pedestal	150	x		
	cyromazine/17	Citation	25	x		
Juvenile hormone /7A	s-kinoprene	Enstar II	35	x		
Anthranilic Diamides/28	chlorantraniliprole	Altacor, Acelepryn	>104	x		
	cyantraniliprole	Mainspring	0.116			x
Macrocyclic lactones/6	abamectin	Avid, Sirocco	0.009			x
	emamectin-benzoate	Tree-age, Enfold	0.41			x
Miticides	acequinocyl/20B	Shuttle	>100	x		
	etoxazole/10B	TetraSan, Beethoven	200	x		
	fenpyroximate/21A	Akari, Vendex	162	x		

Bolded insecticides are not permitted by MDA on bee-friendly plants. Highlighted in gray are less toxic.			**Toxicity to honeybees****			
Chemical class/MOA	**Common name/MOA**	**Trade name**	**LD50*ug/bee**	**Non**	**Moderate**	**Highly**
	fenbutatin-oxide/12B	Mach II	3982	x		
	halofenozide/18		100	x		
	clofentezine/10A	Ovation	111	x		
	hexythiazox /10A	Hexygon	200	x		
	bifenazate/20D	Floramite	7.8		x	
	bifenazate/20D+	Sirocco	0.009			x
	abemectin/6		002			
	pyridaben/21A	Sanmite	0.024			x
	chlorfenapyr/13	Pylon	0.12			x
	fenpyroximate/21A	Akari	0.15			x
	fenazaquin/21A	Magus, Magister	4		x	
	tebufenpyrad/21A	Engulf	60		x	
	cyflumetofen/25A	Sultan	102	x		
Spinosyns/5	spinosad	Conserve/Entrust, less toxic dried	0.05			x
	spinetoram	Radiant	0.14			x
Tetronic acids/23	spirotetramat	Kontos	107	x		
	spiromesifen	Judo, Forbid	200	x		
GABA-channel	fipronil/2B	Fipronil, Termidor	0.004			x
Pyridine carboxamide	flonicamid/29	Aria	60.5	x		
Pyridine azomethines/9B	pymetrozine	Endeavor	158.5	x		
	pyrifluqinazon	Rycar	1			x
Unknown	pyridalyl	Overture	6.16		x	
Microbial/11	*Bacillus thuringiensis/*11A *Moth larvae*	Bt/Dipel		x		
	B. thuringiensis isrealensis/11A Mosquitos, flies	Mosquito dunks, Mosquito beater		x		
	B. thuringiensis galleriae11A Japanese beetle	Grubgone, grubhalt		x		
	Chromobacterium/11A	Granevo		x		
Microbial	*Cydia pomonella granulovirus*	Carpovirusine, Cyd-X, Madex HP		x		
	Burkholderia rinojensis	Venerate XC		x		
	Isaria fungus	Preferal, Ancora		x		
Unknown	potassium salts fatty acids soaps	Surround, M-Pede		x		
	horticultural oils, soaps	Monterey Oil		x		

The information given herein is supplied with the understanding that no discrimination is intended and no endorsement by University of Minnesota Extension. Remember, the label is law.

**Toxicity Category I: Highly toxic to bees, Acute Contact LD50 is < 2 µg/bee
Toxicity Category II: Moderately toxic to bees, the LD50 is 2-10.99 µg/bee
Toxicity Category III: Relatively nontoxic, NT, to bees, the LD50 is 11-100 µg/bee

1. Protecting honeybees from pesticides, Purdue Extension, E-53W, Krupke, C.,G. Hunt, and R. Foster, 6/2014
2. Pesticide Environmental Stewardship
3. Farmland birds, list of EPA 2011 pesticides and LD50
4. University of PPDB Hertfordshire, pesticide properties database