EC 1532 • June 2001
$2.00

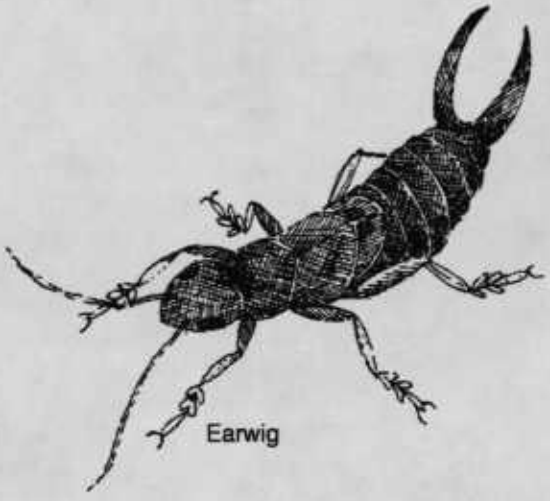
Gardening with Fewer Pesticides:
Using Integrated Pest Management

G. Gredler

All gardeners experience pest problems from time to time. Insects, plant diseases, weeds, slugs, and other animals can cause significant plant damage. How you react to a pest problem depends on the value of the affected plants, the cost of treatment, the toxicity of available controls, and your personal gardening philosophy.

Many gardeners are concerned about the use of pesticides. Some pesticides, if not used, stored, and disposed of carefully, can harm the applicator, the environment, children, pets, or other nontarget organisms.

You can address these concerns by implementing integrated pest management (IPM) practices in your garden. Thoughtful, well-researched pest management choices will reward you, the environment, and the beneficial organisms with which you share your garden.


Earwig

What is IPM?

IPM is a systematic approach to pest management that focuses first on preventing problems. It involves monitoring pest populations, identifying pests, and choosing a combination of tactics to keep pest populations at an acceptable level. Tactics may include cultural, mechanical, biological, and chemical methods of pest management. IPM stresses trying the least toxic methods first. See pages 14–15 for a list of least-toxic control methods for several common garden pests.

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Originally published as part of *Sustainable Gardening: The Oregon-Washington Master Gardener Handbook*, EM 8742.

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EXTENSION SERVICE

Developing an IPM program

Monitoring

Don't wait for trouble to happen. Regularly check your plants for signs and symptoms of pest damage. During the height of the growing season, check each plant two or three times per week. Because many pests prefer sheltered sites, inspect the undersides of leaves and the inner parts of plant canopies. Occasionally, check your plants at night with a flashlight.

Look closely at any plant that is missing leaves, flowers, or fruit. Also look for plants whose color, texture, or size looks unusual. Compare each plant to others of the same variety and to what it looked like in previous years during the same season.

Take notes on what you find. Record the date, damage present, and any pests seen. In subsequent years, your records will help you know when to look for signs and symptoms of specific pests and how to recognize them when you see them.

Several tools will help you do a good job of monitoring. A 6–15X hand lens can be very useful when checking for spider mites, fungal fruiting bodies, and other small signs and symptoms. Plastic bags and glass jars are good for collecting pests and examples of damage. A flashlight is another useful tool, as many pests are active at night.

Some insect pests can be dislodged by laying a sheet below the infested plant and gently shaking the plant. Other insects can be monitored with traps. See "Physical methods," page 5, for more information.

Identifying pests

Most plant problems in home gardens are due to a nonliving factor such as poor growing conditions, temperature extremes, poor water management, soil compaction, or mechanical injury. When you discover a plant problem, the first step is to rule out these factors as the cause.

If you conclude that you do have a pest problem, the next step is to find the pest itself or typical signs and symptoms associated with it. Remember that many organisms do no damage, and many others are beneficial. Make sure the organism you identify actually is the one doing the damage and not just one that happens to be present.

Many resource materials can help with pest identification. (See "For more information," page 16.) If you are stumped or need to confirm an identification, ask your county office of the OSU Extension Service for assistance.

Don't stop with correct identification. Try to determine at which point in its life cycle the pest is most susceptible to control measures. For example, an insect may be soft-bodied as a larva and hard-bodied as an adult. Typically, soft-bodied insects are controlled more easily than hard-bodied ones. Thus, timing of controls might be critical.

Establishing your tolerance level

Establish an acceptable injury level by considering how much damage both you and your plants can tolerate. A small amount of plant damage is not inherently undesirable. For a pest's natural enemies to survive, they must have a pest population on which to feed.

If you are a meticulous gardener, you might not be willing to tolerate much damage. If so, you need to be aggressive in monitoring and managing pests. Less meticulous gardeners are willing to accept more damage. The amount of time, energy, and money you are willing to invest in pest management also will affect your tolerance level.

Also consider how much damage each plant can tolerate. Some plants can tolerate quite a bit of defoliation without exhibiting decreased yields or permanent damage. Seedlings are less able to withstand pest damage than are mature plants.

Developing a pest management strategy

After you have identified a pest and decided its damage is unacceptable, you need to develop a pest management strategy. Your strategy might involve the use of more than one tactic. The rest of this publication focuses on tactics for managing insects, diseases, slugs, and snails.

Evaluating results

Evaluation is an important and often overlooked part of a pest management program. Did your strategy work? Was the pest controlled to your satisfaction? You can answer these questions by continuing to monitor your plants carefully. Again, record your observations.

Cultural methods

Some cultural pest management methods prevent pest problems by keeping plants healthy and growing vigorously. Others directly address specific pest problems.

Choosing resistant or tolerant varieties

Your selection of plants strongly influences what pests you are likely to encounter. When possible, choose plants that are not prone to serious pest problems.

Most garden plants are available in more than one variety (*cultivar*). Some varieties are genetically *resistant* to attack by certain diseases and insects. Other varieties can tolerate a lot of damage without a significant decrease in appearance or yield. These plants are termed *tolerant.* Consult seed and plant catalogs, nurseries, and your county Extension office for suggested varieties.

Putting the right plant in the right place

Place plants in an environment where they will grow well. A few plants will grow in a wide variety of environments, but most require fairly specific conditions. Consider neighboring plants; soil pH, moisture, and drainage; and exposure to sun and wind when choosing plants for a specific site.

Starting with healthy transplants

Buy only plants that are free of pests, wounds, and symptoms of insect or disease problems. Choose healthy-looking plants with good color. Container plants should be in a sterilized potting medium and should be well rooted but not pot-bound.

Give plants a good start by planting them properly. Space plants according to mature size. Crowded plants invite pests.

Keeping plants healthy

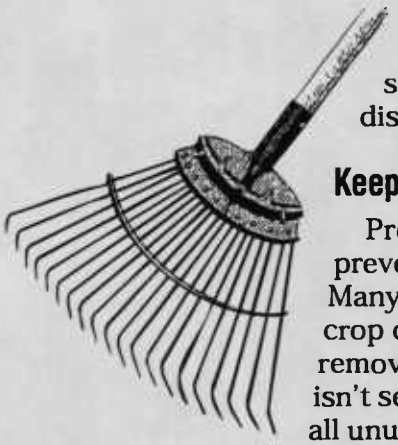
Plants growing well are less likely to suffer a pest attack than are stressed plants and are better able to withstand pest damage if an infestation does occur.

Know your plants' nutrient needs and fertilize accordingly. An underfertilized plant is stressed and vulnerable to pest attack, and an overfertilized plant may have excess succulent growth that can invite disease and insect pests.

Provide adequate but not excessive irrigation. Drought-stressed plants are more susceptible to pest attack. Plants in excessively wet soil suffer from a lack of soil oxygen and are vulnerable to attack by root-disease organisms that prefer wet soil.

Soil pH also is important to plant health. Most plants do well in slightly acid soil (pH of 6.0 to 7.0). Acid-loving plants such as azaleas, blueberries, and rhododendrons prefer a pH of 4.5 to 6.0.

Adding organic matter to soil helps retain water and nutrients in sandy soil and improves drainage in clay soil. It also encourages beneficial soil microorganisms. These microbes break down organic matter and make nutrients available to



plants. There also is evidence that microbes and fatty acids in compost can suppress certain soilborne diseases.

Keeping your garden clean

Proper sanitation can prevent many pest problems. Many pests live and breed in crop debris, so promptly remove any vegetation that isn't serving a purpose. Remove all unused fruit and nuts immediately.

Remove pest-infested leaves and fruit as soon as you see them. If an annual plant is badly infested with insects or disease, remove the entire plant. Prune out diseased and dead branches of woody plants. Add disease- or insect-infested plant parts to your compost pile only if you are hot composting. Otherwise, destroy them.

Keep your garden as weed-free as possible during the growing season. Weeds harbor insects and diseases in addition to competing with garden plants.

Eliminate hiding places for slugs and snails by removing boards, plastic sheeting, unused plant pots, and plant debris from your garden. Regularly check for pests under containers and in other hiding spots.

Clean your gardening tools, especially pruning tools, regularly. Use rubbing alcohol, a disinfectant such as Lysol, or a solution of 1 part bleach to 9 parts water. If you are pruning diseased plants, make sure to disinfect tools between each plant.

Rotating annual plants

When the same plants are grown in the same soil each year, insect and disease populations build up. Many pests overwinter in the soil and move to a specific type of host plant in the spring. By growing different plants in different places each year, you deprive pests of their hosts. This technique works best for annual flowers and vegetables since they are replanted each year.

Since insects and diseases often infest members of the same plant family, it is best to rotate to a member of a different family (Table 1).

A similar principle holds true for perennials. If you remove a perennial plant because of a soilborne insect or disease, plant something from a different family in its place.

Companion planting and intercropping

Companion planting involves growing two or more specific types of plants together in the hope that the combination will discourage disease and insect pests. Unfortunately, relatively little research has been done on this topic, and many claims of positive results have not been substantiated.

Experiment in your garden and take careful notes. Over several seasons, you

Table 1.—Plant families for rotations.

Plant family	Representative members
Apiaceae	Carrot, celery, fennel, parsley, parsnip
Asteraceae	Chicory, endive, globe artichoke, lettuce
Brassicaceae	Bok choy, broccoli, brussels sprout, cabbage, cauliflower, collard, kale, kohlrabi, mustard, radish, rutabaga, turnip
Chenopodiaceae	Beet, spinach, Swiss chard
Cucurbitaceae	Cucumber, melon, pumpkin, squash
Fabaceae	Bean, pea, vetch
Liliaceae (Alliums)	Chive, garlic, leek, onion, shallot
Solanaceae	Eggplant, pepper, potato, tomatillo, tomato

may notice that certain plants have fewer pests when grown close to another specific type of plant. Keep in mind that even if a particular combination of plants reduces pest problems, competition between the plants might decrease crop yields.

Intercropping involves mixing plants to break up pure stands of a single crop. The physical separation of individual plants of one type by those of another might interrupt the movement of insects and diseases. However, although this patchwork planting approach might discourage pests that feed on a narrow range of plants, it might encourage generalist feeders such as cutworms, cucumber beetles, and aphids.

Physical methods

Physically blocking, removing, or trapping pests can be very successful and causes little disruption of your garden's ecosystem.

Hand picking

Hand picking large, clearly visible, or slow-moving insects, slugs, and snails can reduce pest populations in small plantings. For example:

- Pick off large beetles and caterpillars. (Make sure they really are pests!) Crush the insects or drop them into a container of soapy or oily water.
- Rub off scale insects with your fingernail or a plastic scrub pad.
- Shake insects such as asparagus beetles onto a sheet and destroy them.
- Remove and destroy entire leaves infested with leafminers.
- Lift spittlebugs out of their foam and destroy them.

Asparagus beetle

These techniques require careful observation of affected plants, including the undersides of leaves. You must hand pick most species every few days to keep damage at an acceptable level.

The best time to collect most insects is early morning, when temperatures are cool and insects are sluggish. Use a flashlight at night to find slugs, snails, and other pests that feed at night and hide during the day.

Spraying with water

A forceful stream of water can dislodge, injure, or drown small, soft-bodied pests. This technique is useful for aphids, mites, lacebugs, mealybugs, and spittlebugs. The water must hit the pests directly, so you might need to spray the undersides of leaves. Spray early in the day so plants have a chance to dry before evening. You might need to spray every few days to remove returning pests.

Pruning

If pests are concentrated at one or two sites on a plant, you might be able to prune them out. For example, aphids often cluster on new growth. Tent caterpillars and fall webworms gather in webs; prune out and burn the entire web, if practical. Remove cane borers in raspberries and roses by pruning the affected canes while the insects are inside. Cankers on landscape and fruit trees sometimes can be removed by pruning as well.

In addition, regular pruning makes a plant less dense, which allows beneficial insects to locate their prey more easily. It also improves air circulation, which decreases the incidence of foliage diseases.

Before pruning for pest control, evaluate whether potential pest damage is greater than potential pruning damage.

Using barriers

Row covers, plant cages, plant collars, sticky barriers, metal barriers, and diatomaceous earth physically shield plants from insect, slug, and snail damage.

Row covers

Row covers are sheets of synthetic material that cover individual plants or an entire row of plants. They can exclude migrating pests such as root maggots, cucumber beetles, flea beetles, whiteflies, aphids, leafminers, and cabbage loopers.

Row covers should allow air, water, and light to reach plants. Apply them before seedlings emerge or when setting out transplants.

Floating row covers are among the easiest to use. Simply place them over plants, leaving enough slack to allow for plant growth. Bury the edges to make certain insects can't enter.

Check under covers frequently for intruders. Pests that do get in are protected from their natural enemies and can do a lot of damage. Remove covers if it gets too hot underneath, if plants require insect pollination, or when plants are large enough to withstand some insect damage.

Plant cages

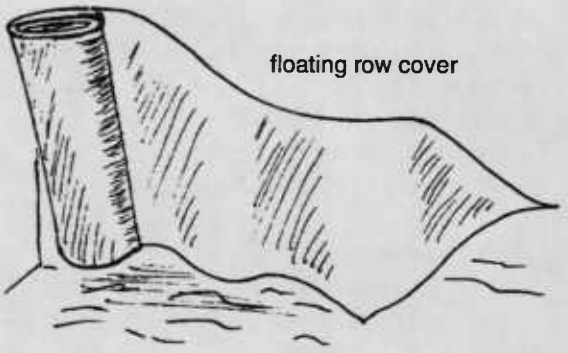
You can make protective cages by attaching screen or row cover material to wood, wire, or PVC-pipe frames. These cages should last several seasons.

Another way to make a cage is to shape a piece of screen into a cone and staple the edges together. Place cones over seedlings until plants are large enough to tolerate some damage.

Always sink cages about 1 inch deep in the ground.

Plant collars

Collars can protect seedlings from cutworm damage. Use toilet paper tubes or cut the ends out of tin cans, plastic soft drink bottles, or paper cups to form a tube. Place a tube over each seedling. Bury the edge of the tube 1 inch deep.



To protect against root maggots, cut tar paper into disks at least 3 inches in diameter, cut a slit in the disk for a plant stem, and slip the disk around a seedling so the tar paper lays on the soil surface. Flies then are unable to lay eggs next to the seedling.

Sticky barriers

Sticky materials can be used to catch climbing insects as they make their way up a plant's stem. This technique is effective against adult root weevils on ornamentals, ants on fruit trees, and climbing caterpillars and beetles.

Rather than applying the sticky adhesive directly to the plant, first wrap the stem or trunk with a 3- to 4-inch-wide band of paper or plastic. Then apply the adhesive to the wrap. Add more adhesive as soon as the trap is covered with insects, dust, or debris.

Metal barriers

You can edge a garden bed, container, or group of plants with strips of copper (or a combination of copper and zinc) to repel slugs and snails. When these pests try to cross a copper strip, they are repelled by a chemical reaction that occurs between the copper and their slime. The strip should be at least 6 inches wide to keep large slugs and snails from "hopping the fence."

Diatomaceous earth

Another barrier to insects is diatomaceous earth, which is made of the fossilized remains of diatoms (a type of tiny algae). This material has microscopic, sharp edges that cut an insect's cuticle (outer "skin") and cause dehydration and death. It also can be used for slugs and snails.

The main drawback to diatomaceous earth is that it is not effective after it becomes wet, so its use is limited in the Pacific Northwest. You can use it as a dust on plants during the dry season if you do not use overhead irrigation. Always wear a dust mask when using diatomaceous earth.

Vacuuming

Use a hand-held, wet-dry vacuum to suck pests from infested plants. Vacuuming works best with insects such as whiteflies and spider mites that congregate in groups and do not scatter when disturbed. For best results, vacuum early in the morning when pests are lethargic. Seal the vacuum contents in a bag, freeze overnight if possible, and discard.

Mulching

Many disease organisms (*pathogens*) overwinter in the soil. When the weather warms in the spring, they become infectious and can be splashed or blown onto plants by rain or wind. A layer of new mulch laid down in early spring can protect emerging plant tissue from these organisms. For example, this technique can protect roses from the pathogens that cause black spot.

Rototilling

Although rarely used strictly for pest control, tilling does help control certain pests such as slugs, symphylans, and cutworms. Tilling kills some individuals, buries some so deeply they can't crawl back to the surface, and exposes others to predators and extreme weather conditions.

Trapping

Many pests can be attracted to and caught by traps. Some traps kill large numbers of pests. Others are used as monitoring devices; by knowing when a pest is present, you can time control measures effectively.

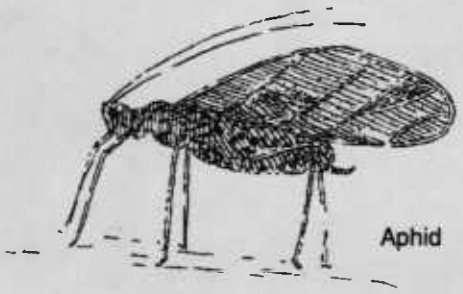
Traps are unlikely to completely rid your garden of a pest species. They simply are a way to reduce pest populations. They can easily be used in conjunction with other techniques.

Colored sticky traps

Some insects are attracted to certain colors. Take advantage of this fact by placing colored, adhesive-coated traps near a pest infestation. The insects are attracted by the color and then caught in the adhesive. Yellow traps attract fruit flies, whitefly adults, winged aphids, psyllids, fungus gnats, and some species of thrips. Blue traps attract some species of thrips. Red spheres attract cherry fruit flies and apple maggots, and green spheres attract walnut husk flies.

Sticky traps are available in most garden centers, or you can make your own. To make a flat sticky trap, paint a piece of ¼-inch plywood or other flat surface the appropriate color. For sphere traps, use a commercial trap or paint a croquet or tennis ball. Be sure to use waterproof paint.

Cover the painted trap with adhesive. You can use a commercial adhesive, motor oil, petroleum jelly, or a 50/50 mixture of petroleum jelly and dish soap. All of these adhesives can be cleaned off with vegetable oil.


Aphid

Set the trap on a pole near infested plants or hang it from a branch of an infested plant. Place the trap as close to the infestation as possible. If you want to catch a maximum number of insects, check the trap every few days and renew the adhesive as needed. If you are using the trap to monitor a pest's emergence or peak flight, check the trap as often as necessary to adequately interpret changes in the pest population.

Rolled newspapers

Moist, rolled newspapers can trap earwigs, sowbugs, and pillbugs. In the evening, lay the traps on the soil surface where pests are numerous. The next morning, tap the pests out of the traps into a pail of soapy water.

Codling moth traps

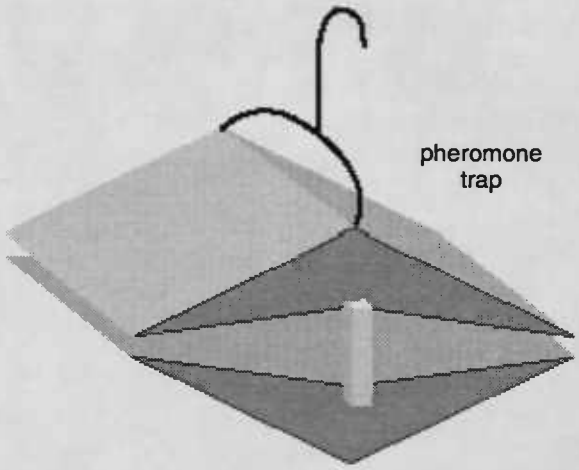
A band of corrugated cardboard around a tree trunk will capture codling moth larvae in the fall as they travel down the tree looking for a place to spend the winter under loose bark or fallen leaves. Wrap a 2-inch-wide band of large-core corrugated cardboard around the trunk at least 18 inches above ground. Place the band on the smoothest bark possible so larvae can't get under the band. The corrugations should be vertical (parallel to the tree trunk). When larvae move down the tree, they will enter and remain in the corrugations. Replace the band weekly.

Slug traps

These traps consist of a covered container filled with bait. You can buy slug traps at garden centers, but recycled pint plastic containers with an entrance hole cut in the side work just as well. Fill traps with beer or commercial bait to the level of the entrance hole and place them on the ground. Remove dead slugs every couple of days. Renew the bait as needed.

Pheromone traps

Some traps are baited with *pheromone* (a chemical that usually attracts a single species) and coated with adhesive to trap



pests. Often the pheromone is a synthetic version of the chemical used by females to attract males. Consequently, many pheromone traps capture only male insects.

Pheromone traps are used extensively in commercial agriculture to help farmers detect the presence of a pest species and time other control measures. This probably is their best use in gardens as well. You are unlikely to capture enough insects to prevent mating and egg laying.

If you have never had a particular pest, do not use the pheromone trap designed for it; you might end up attracting the pest to your yard.

Light traps

There are a number of light traps, also known as "bug zappers," on the market. These traps are not effective in controlling pests and actually end up killing far more beneficial and innocuous insects than they do pests.

Lady beetle (beneficial)

Biological methods

In a well-balanced ecosystem, insect pest populations are kept in check by natural enemies such as other insects, birds, bats, snakes, frogs, toads, and moles. Disease organisms often are kept under control by competition from other microorganisms.

You can use biological controls to help keep pest numbers low. Don't expect natural enemies to keep your garden pest-free, however.

Beneficial insects

Most insects are not pests. Only those that feed on desirable plants or transmit disease cause problems for gardeners. Many insects are very useful, and it is worth learning to recognize them.

Predatory insects eat large numbers of other insects. Common predaceous garden insects include lady beetles, praying mantids, green and brown lacewings, ground beetles, minute pirate bugs, damsel bugs, syrphid fly larvae, and snakeflies. Spiders, predaceous spider mites, and centipedes also are important predators in a garden ecosystem.

Parasitoids are insects that live on or in a host insect, feed on the host, and kill it in the process. These insects are not easily seen, but research shows they have an important impact on pest insect populations.

Figure 1 illustrates some common beneficial insects.

Protecting beneficial insects

Most insecticides available to home gardeners are broad-spectrum, meaning they kill a wide range of insects, including beneficials. If you decide to use an insecticide, take the following measures to protect beneficial insects:

- Choose the least toxic pesticide that will be effective. See "Chemical methods," page 11, for more information.
- Spot spray only infested plants.
- Do not spray plants in bloom.
- Spray early in the day when many insects are less active.

Creating habitat for beneficial insects

Invite beneficials to your yard by providing them with food. Pollinators and predators are attracted by a wide variety of blooming plants. By scattering flowering plants throughout your garden and landscape, you can attract beneficial insects.

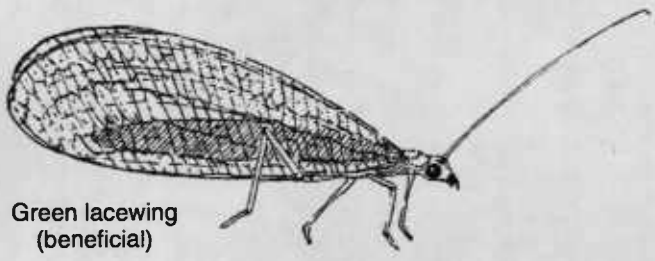
Buying and releasing beneficial insects

Some insect predators and parasitoids can be purchased. Common examples include lady beetle adults, praying mantid egg cases, green lacewing eggs, and parasitoid wasp pupae.

In general, releasing large numbers of beneficial insects has not proven to be an effective method of pest control in the

Drawings are not to scale.

Figure 1.—Common beneficial insects of the Pacific Northwest. (Reprinted by permission from Ralph E. Berry. Insects and Mites of Economic Importance in the Northwest, *2nd edition, 1998. 221 pp.)*



Green lacewing
(beneficial)

home garden. These insects tend to move around and often end up migrating out of the garden. If you try this method of control, make sure to order insects from a reliable source that can provide instructions for maximum success.

See *Encouraging Beneficial Insects in Your Garden*, PNW 550, for more information.

Microorganisms

Several microorganisms can be used to keep pest populations in check. As research continues, more products containing viruses, fungi, bacteria, protozoans, and parasitic nematodes will become available.

Bacillus thuringiensis (B.t.)

This bacterium contains a toxin that poisons some insects. When ingested by a susceptible insect, it paralyzes the insect's gut, causing the insect to stop feeding and eventually die.

B.t. has two important advantages over conventional insecticides. First, it affects only a narrow range of insects, thus sparing most beneficials. Second, it is nontoxic to humans, plants, and other animals and has no adverse environmental effects. *B.t.* is registered for use on all plants and can be used up to harvest on edible plants.

There currently are three strains of *B.t.* available to gardeners, and others are in development:

- *B.t. kurstaki* is active against lepidopterous larvae (butterflies and moths) such as cabbage loopers. Do not use it on plants that provide habitat for desirable butterflies and moths. A few insects have developed resistance to this strain.
- *B.t. israelensis* is active against mosquito and fungus gnat larvae, but is not harmful to other aquatic organisms.
- *B.t. san diego* is active against Colorado potato beetles and elm leaf beetles.

A pest must ingest *B.t.* to be killed. Apply *B.t.* when young larvae are feeding since they eat the most and are most easily killed. Thoroughly cover all plant surfaces. Many insects feed on the undersides of leaves, so make sure to spray or dust there as well. Apply *B.t.* on an overcast day or late in the day, as it breaks down in sunlight. Most formulations are effective for only a few days, so repeat applications might be necessary.

Parasitic nematodes

These microscopic roundworms kill all stages of certain soil-dwelling insects. When applied properly and at the correct time, parasitic nematodes are active against more than 200 insect species, including root weevil larvae, European cranefly larvae, cutworms, and pest beetle grubs.

One of the most useful applications for parasitic nematodes in the Pacific Northwest is an early fall application to control root weevil larvae. Known infestations of European cranefly in turf also can be treated in the fall with nematodes.

In order for nematodes to be effective, soil temperature should be at least 55°F. Thus, they might not be effective against early-season pests.

The soil must be moist for nematodes to be active. Water thoroughly before applying and lightly after applying. Keep the soil moist, but not soggy, for several weeks. Do not apply in direct sunlight, as ultraviolet light kills the nematodes. Dusk or dawn applications are ideal.

Parasitic nematodes do not adversely affect humans, plants, or earthworms. However, they kill some soil-dwelling beneficial insects.

Parasitic nematodes have a finite shelf life, so make sure to check the expiration date. They also have a short-term effect in

the soil. Several weeks after application, nematode activity drops off considerably.

Other animals

Certain species of birds, bats, snakes, frogs, and toads also eat insects. Garter snakes, frogs, and ducks are predators of slugs and are particularly welcome on the west side of the Cascades.

You can encourage beneficial animals to live in your garden by meeting their habitat needs. Water features (especially those with circulating water), plants that provide food and cover, grassy areas, and bird feeders all attract these predators.

Chemical methods

Chemical methods of pest control raise concerns about human safety, toxicity to nontarget organisms, runoff, leaching, disposal problems, and possible residue on food crops. Thus, consider chemical controls only if other techniques do not result in adequate pest control. Some chemical controls can be used in concert with other techniques.

When choosing a chemical, always make certain it is labeled for the plant where it will be used. Choose the chemical that meets the following criteria:

- Least harmful to the environment
- Least toxic to the applicator
- Most specific to the pest
- Least harmful to beneficial organisms

Labels give a general idea of toxicity by the use of signal words. Pesticides labeled "Caution" are the least toxic, those labeled "Warning" are more so, and those labeled "Danger–Poison" with a skull and crossbones symbol are the most toxic.

Insecticidal soap

Sodium or potassium salts of fatty acids are the active ingredient in insecticidal soap. Soap kills insects primarily by damaging their cuticle. It is useful against soft-bodied pests such as aphids, thrips, whiteflies, spider mites, scales, leafhopper nymphs, spittlebugs, and some caterpillars.

Insecticidal soap is virtually nontoxic to humans and biodegrades rapidly. It may kill predatory insect larvae that are feeding on pests when soap is applied. Otherwise, it is safe for most beneficials.

Insecticidal soap must contact pests directly to kill them. It is effective only while still wet; there is no residual activity after it dries. It usually does not kill insect eggs, so repeat sprays often are necessary to control newly hatched pests.

Soap can damage certain plants. Use it according to label directions and do not use it on water-stressed plants or if the weather is very hot. Another way to avoid damage is to spray plants, let the soap dry, and then rinse it off with a spray of water.

There are many homemade recipes for insecticidal soap made from liquid dishwashing detergent. These sprays are risky to use because different detergents have different concentrations of active ingredient. If spray is too concentrated, it might harm plants. It is best to use a commercial product that has been tested thoroughly on a variety of plants.

Horticultural oils

Horticultural oils are made from petroleum products, vegetable oil, or fish oil. They kill pests and their eggs by suffocation. Oil sprays can control aphids, scales, whiteflies, mealybugs, spider mites, lacebugs, caterpillars, adelgids, and leafhoppers. They also can protect plant tissue from disease pathogens. Because oils kill on contact, good spray coverage is essential.

Horticultural oils are nontoxic to humans and wildlife, although they can cause eye and skin irritation. They degrade rapidly, mostly through evaporation.

Oil sprays fall into two categories: dormant oils and summer oils. *Dormant oils* are heavier and are used on woody plants during the dormant season to kill overwintering pests and eggs and to protect against disease. *Summer oils* are lighter and more refined. They can be used year-round because they are less likely to damage plants. *Ultrafine oils* are highly refined summer oils and are least likely to cause damage.

To prevent plant damage when using oils, carefully follow label directions, especially dilution rates. Do not use on water-stressed plants or if relative humidity is high. Do not use when the air temperature is below 40°F or above 90°F. Do not use oils on blue evergreens because they break down these plants' waxy coating and turn them green.

Praying mantis (beneficial)

Botanical insecticides

Botanical insecticides are derived from plant material. Most botanicals are less damaging to the environment than synthetic insecticides because they break down to nontoxic compounds rapidly, usually within a day or two of application. Thus, there is less chance for environmental contamination or residues on food crops.

Botanicals are not necessarily less toxic to humans, however. Some, such as nicotine sulfate and rotenone, are more toxic than common synthetic garden insecticides. Other botanicals, such as azadirachtin (neem extract), are nontoxic to humans and other nontarget organisms.

Because botanicals break down so rapidly, it is important to time application carefully. Apply the chemical when and where it will reach the greatest number of pests.

Inorganic insecticides and fungicides

A number of mineral-based compounds are toxic to insects and plant diseases. For example, sulfur is both an insecticide and a fungicide. It protects many plants from foliage diseases such as powdery mildew, black spot, and scab. It also is used as an insecticide against thrips and aphids and is a powerful miticide. It is not toxic to humans. Do not use sulfur in conjunction with horticultural oil sprays or when the air temperature is above 85°F. Under these conditions, it can cause plant damage.

Copper is another broad-spectrum fungicide used on fruits, nuts, ornamentals, and a few vegetables. Copper-based fungicides protect plants against a wide array of fungal and bacterial diseases. Copper is toxic to fish and earthworms.

Synthetic pesticides

Many garden pesticides are produced synthetically. Common synthetic products include insecticides such as carbaryl, malathion, and acephate; fungicides such as captan, chlorothalonil, and triforine; herbicides such as glyphosate, 2,4-D, and dichlobenil; and molluscicides such as metaldehyde.

Toxicity and the potential for environmental damage from these products vary widely. Evaluate each pesticide on its own merits and drawbacks.

When considering using a chemical to control a pest, carefully evaluate the situation and try cultural, physical, and biological controls first.

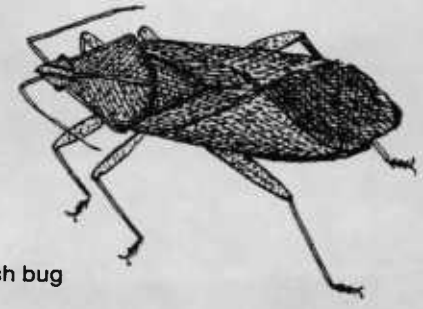
If you determine that a chemical is necessary, spot spray infested plants with the least toxic effective chemical. Read the product label carefully and follow all suggested safety practices.

Least-toxic pest control methods for common garden pests

Problem	Controls
Aphids	Pick off, mash, or wash away insects; use biological control agent; use yellow sticky traps; treat plant (especially undersides of leaves) with insecticidal soap.
Asparagus beetles	Shake foliage over a tray and discard the insects.
Cabbage maggots	Use collars, floating row cover, or biological control agent.
Cabbage worm	Use floating row cover; hand pick and destroy; use biological control agent.
Carrot rust fly	Use floating row cover.
Colorado potato beetles	Hand pick and destroy; use floating row cover or biological control agent.
Corn earworms	Apply mineral oil during silking to prevent infestation.
Cucumber beetles	Use floating row cover; hand pick and destroy; use biological control agent.
Cutworms	Use cutworm collars or biological control agent.
Earwigs	Eliminate hiding places; trap in rolled, moist newspaper.
Flea beetles	Use floating row cover or biological control agent.
Leaf diseases	Plant resistant varieties; space plants adequately for better air circulation; control weeds; remove and destroy plant debris; avoid wetting foliage.
Leafminers	Use floating row cover; remove and destroy infested leaves.
Mealybugs	Wash away insects; use biological control agent.
Nematodes	Plant resistant varieties; rotate; remove diseased plants.
Potato scab	Use certified seed potatoes; use tolerant varieties; avoid using limestone or wood ashes where potatoes will be grown.
Root diseases	Plant resistant varieties; destroy affected plants; rotate; plant in well-drained area; do not overwater; remove and destroy plant debris.
Root maggots	Use floating row cover.
Root weevils	Use predators, baits, sticky barrier, or beneficial nematodes.

Least-toxic pest control methods for common garden pests (continued)

Problem	Controls
Scale insects	Rub insects off plant; use biological control agent; spray with dormant oil during winter to destroy eggs; use insecticidal soap.
Slugs	Eliminate hiding places; hand pick and destroy; use slug barriers, diatomaceous earth, or bait.
Sooty mold (fungus that grows on honeydew substance secreted by aphids and other insects)	Identify insects; if aphids, hose down tree with a powerful spray of water; use biological control agent or insecticidal soap.
Sowbugs, pillbugs	Eliminate hiding places; trap in rolled, moist newspaper.
Spider mites	Wash away insects; use predatory mites or insecticidal soap.
Spittlebugs	Lift insects from foam and destroy; wash away insects; use insecticidal soap.
Squash bugs	Hand pick and destroy; use floating row cover (remove cover for pollination when plants bloom).
Thrips	Use floating row cover, sticky traps, or biological control agent; apply insecticidal soap.
Whiteflies	Use floating row cover or yellow sticky traps; apply insecticidal soap.



squash bug

For more information

OSU Extension publications

Beneficial Organisms Associated with Pacific Northwest Crops, PNW 343 (reprinted 1999). $1.00

Controlling Diseases and Aphids on Your Roses, EC 1520 (2000). $2.00

Encouraging Beneficial Insects in Your Garden, PNW 550 (2001). $1.00

Preventing Plant Disease in Your Garden and Landscape, FS 242 (revised 2000). No charge.

Slugs, FS 277 (reprinted 2000). No charge.

To order copies of the above publications, send the complete title and series number, along with a check or money order for the amount listed, to:

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The following publication is available only on the Web or from county offices of the OSU Extension Service:

El control de insectos en los huertos y jardines (Controlling Insects in Vegetable and Flower Gardens), EM 8766-S (2000). No charge.

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Berry, R. *Insects and Mites of Economic Importance in the Northwest* (published by the author, Corvallis, OR, 1998). 221 pp.

Bobbitt, V., A. Antonelli, C. Foss, R. Davidson, R. Byther, and R. Maleike. *Pacific Northwest Landscape IPM Manual* (Washington State University and Washington State Department of Ecology, 1996). 208 pp.

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Dreistadt, S.H., J.K. Clark, and M.L. Flint. *Pests of Landscape Trees and Shrubs: An Integrated Pest Management Guide*, Publication 3359 (University of California Division of Agriculture and Natural Resources, Davis, 1994). 327 pp.

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This publication was produced and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914. Extension work is a cooperative program of Oregon State University, the U.S. Department of Agriculture, and Oregon counties.

Published June 2001.