IPM for Rodents in Schools

INTRODUCTION

Rats and mice often enter schools and warehouses in search of food and shelter. The most common rodent pests are the commensal rats and mice. These are Old World rodents that have adapted to live with humans. They include the roof rat, Norway rat, and house mouse. These commensal rodents have been carried by humans to every corner of the Earth. Rats and mice consume or contaminate large quantities of food and damage structures, stored clothing, and documents. They also serve as reservoirs or vectors of numerous diseases, such as rat bite fever, leptospirosis (Weil's disease), murine typhus, rickettsial pox, plague, trichinosis, typhoid, dysentery, salmonellosis, hymenolepis, tapeworms, and lymphocytic choriomeningitis (Mallis, 1997).

In most cases of rodent infestation, the pest animals can be managed without having to resort to the use of poisons. Practicing good sanitation and exclusion will prevent most problems. If rodents do find their way indoors, small populations can be easily eliminated with various nontoxic methods. Rodenticides (rodent baits) need only be used in cases of large or inaccessible infestations. Trapping rodent pests is often preferable to using baits. Traps prevent rodents from dying in inaccessible places and causing odor problems. Traps also can be used in situations where baits are not allowed.

RODENT ECOLOGY

The **house mouse** is the most common commensal rodent invading schools. It is primarily nocturnal and secretive. The presence of mice is usually indicated by sightings, damage caused by gnawing into food containers, or presence of droppings. In the wild, house mice feed primarily on seeds. In the school, they prefer grain products, bird seed, and dry pet food. They tend to nibble on many small meals each night. House mice are inquisitive and actively explore anything new. They also are good climbers. However, they have a small home range and usually stay within 10 to 30 feet of their nest. Nests usually are built in structural voids, undisturbed stored products or debris, or in outdoor burrows. Mice and rats are very nervous about moving in the open. The more cover they have, the more comfortable they are. They would rather run behind an object or along the baseboard of a wall than across an open space.

The **roof rat** or **black rat** is more commonly encountered in buildings in the south, but is sometimes found in Pennsylvania. These rats are excellent climbers and often nest in attics, wall voids, and hollow trees. They prefer to travel off the ground and enter houses from nearby trees or along power lines. Roof rats prefer fruit, but will eat any type of human, pet, or livestock food. Rats usually fear new items in their environment and avoid them for several days. This means that traps should be left in place for at least 1 week before they are moved to a new location. The presence of roof rats can be determined by gnawing damage, the presence of droppings, sightings, sounds of scratching, squeaking, or gnawing in walls or ceilings, and characteristic dark, greasy rub marks along frequented paths along walls and on rafters. Rats have large home ranges and may travel more than 50 yards to reach food or water. Concentrating traps along rat runways or favorite routes of travel is most effective.

Rats occupying buildings and sewers in Pennsylvania are generally **Norway rats**. These rats are strong burrowers, but can also climb well. They are excellent swimmers and can swim under water for up to 30 seconds. They can enter buildings by coming up toilet pipes. These rats usually dig burrows along building foundations and under debris piles. They have a strong preference for meat and fish, but will do well on any type of human or pet food. Raw or cooked meat and fish, especially sardines, are excellent baits, but peanut butter also works well. Like the roof rat, the Norway rat is cautious around new objects and has a very large home range, more than 50 yards in radius. The Norway rat is very aggressive and will drive roof rats out of an area. However, both species of rats may be found in the same building, with roof rats in the attic and Norway rats in the basement.

SANITATION AND EXCLUSION

Proper sanitation will do a great deal to manage rodent pests. All animals have three requirements for life: food, water, and cover. Removing any one of these will force an animal to leave. Removing debris, such as piles of waste lumber or trash, used feed sacks, and abandoned large appliances, will substantially reduce the harborages for rodent pests. Trim trees, vines, bushes, grass, and weeds at least 12 to 18 inches from all buildings to decrease cover for rodent runways and prevent hidden access to buildings.

Most of the information in this chapter was modified from Kern, W. H., Jr. and P. G. Koehler, *Nonchemical Rodent Control*. University of Florida School IPM Web site at **schoolipm.ifas.ufl.edu/tp9htm**. March 1998.

Stacked firewood stored for long periods provides good harborage for all three commensal rodents. Store pet food and seeds, such as wild bird seed, in rodent-proof glass or metal containers to eliminate rodent access to these food sources. Collect and remove fallen fruit from backyard trees and orchards. Keep lids on trash cans and close dumpsters at night to make an area less attractive to rats and mice. The drainage holes in dumpsters should be covered with hardware cloth to keep rodents out.

Exclusion is also called *rodent-proofing*. This involves making your structure a fortress that rodents cannot breach. Rodents can squeeze through any opening that their head can fit through. A $\frac{1}{4}$-inch opening can admit mice, and a $\frac{1}{2}$-inch opening can give access to rats. Young rats and mice are the dispersing individuals, so these are the ones most likely to invade new areas, like schools. Any opening that a pencil can fit through will admit a mouse.

Below is a list of recommended materials for excluding rats and mice.

- Galvanized, stainless, or other non-rusting metal.
- Sheet metal, 24 gauge or heavier.
- Expanded metal, 28 gauge or heavier.
- Perforated metal, 24 gauge or heavier.
- Hardware cloth, 19 gauge or heavier, $\frac{1}{4}$-inch or smaller mesh.
- Cement mortar with a 1 part cement: 3 parts sand mix or richer.
- Concrete with a 1 part cement: 2 parts gravel: 4 parts sand mix or richer. Broken glass added to mortar or concrete will deter rodents from tunneling through a patched hole before the material hardens.
- Brick, concrete block, tile, or glass will exclude rodents if in good repair.
- Wood will exclude rodents if no gnawing edges are present.

TRAPS

There are four main types of rodent traps: snap traps, multicatch traps, single-catch live traps, and glue boards. (Some people consider live trapping the least humane method of killing rodents, claiming psychological stress on the animal. The most humane method of killing them would be rodenticides, followed by snap traps, glue boards, and live traps).

Snap traps include both the classic rodent traps with the wood base and the newer metal clothespin traps. They are designed to kill the trapped animal quickly and humanely. Snap traps should not be set where children or pets will come in contact with them. They have three different types of triggers: wood/prebaited, metal for holding bait, and expanded trigger, which is used in runways. The expanded trigger is the most versatile, since it also can be baited. Older snap traps with other types of triggers can be modified to produce an expanded trigger.

Traps should be placed where rodents are likely to be. Rodents are creatures of habit and prefer to follow the same runways they usually use. It is important to identify these runways and place traps there. Runways can be identified by sprinkling a fine layer of flour or baby powder in suspected areas and looking for tracks. This is a safe diagnostic method for determining rodent activity, but should not be confused with the use of rodenticide tracking powders, which require a restricted-use pesticide license. Rodents often run along edges, so traps should be set along walls, especially where objects such as a box or appliance will guide them into the trap. Traps for mice should be set 6 to 10 feet apart. Roof rats prefer to travel above the ground and are easier to trap along these precarious pathways than on the ground.

The type of bait used depends on the species of rodent pest. Peanut butter, pieces of fruit or nut meats are the best baits for roof rats. Peanut butter or gum drops stuck to the trigger or rolled oats or bird seed sprinkled on the trap are good baits for house mice. When food is abundant, nesting material, such as a cotton ball, tied to the trigger can act as an effective lure.

Multicatch traps are designed to repeatedly catch mice and reset themselves for another capture. These traps have the ability to capture several mice with one setting, and the scent from the captured mice entices others to the trap. However, these traps are expensive. Also, the captured mice are still alive and must be dealt with. Methods of dealing with the captive rodents include submerging the entire trap in a bucket of water and drowning them, using drowning attachments available for some traps, placing glue boards in the holding compartment of the trap, or finding someone with a pet snake that eats mice. Releasing captured rodents outside is not a solution, since they will quickly find a way back into the structure. Trap-wise rodents also are more difficult to trap than naive ones. Like any other trap, multicatch traps must be checked regularly to prevent the captured rodents from starving or dying of thirst and creating an odor problem. Available multicatch traps include the Kness “Ketch-All” Automatic Mouse Trap, the Victor Tin Cat Repeating Mouse Trap, and the “Mini-Mouser.”

Single-catch live traps are rodent-sized cage traps of various styles. These traps capture the rat or mouse alive and unharmed, but you have to deal with the captured rodent. Rodents should not be released, because they will return to buildings. Rodents caught in these traps are best dispatched by submerging the entire trap in a bucket of water. These traps should be placed against walls or in runways. The most effective bait for mice with this type of trap is rolled oats (uncooked oatmeal) sprinkled inside the trap, with a fine trail leading out. Rat-sized live traps are produced by Havahart, Kness Manufacturing, Mustang Live-catch Traps, Safeguard Live Animal Traps, Sherman Live Traps, and Tomahawk Live Traps. Mouse-sized live traps are produced by Havahart, Sherman Live Traps, Tomahawk Live Traps, and Trap-Ease Mouse Live Trap.

Glue boards are used just like snap traps. While both rat- and mouse-sized glue boards are made, these traps are most effective against juvenile mice. Rats are often strong enough to pull themselves free from glue boards. Glue boards should not be set in wet or dusty areas, because these conditions render the traps ineffective. Wet feet and fur will not stick to the glue, and dust coats the glue until it is no longer sticky. These traps also should not be set where children or pets will come into contact with them. Glue boards are not hazardous to children or pets, but an encounter will create a frustrating mess. If that happens, clean up hands with room-temperature cooking oil and clean surfaces with paint thinner or mineral spirits. The best glue boards have at least a $\frac{1}{8}$- to $\frac{1}{4}$-inch layer of glue. Do not set glue boards near open flames or above carpets. Glue boards should be secured with a tack or small nail, wire, or double-sided tape if they are placed on ledges, pipes, or rafters over food preparation surfaces or carpets.

ULTRASOUND DEVICES

The principle behind ultrasonic devices is to create a loud noise above the range of human hearing (above 18 to 20 kHz) that is unpleasant to pest species. The problems with ultrasound devices are numerous. Animals can adapt to most situations, and in a short time they become accustomed to the sound. If the original attractant, such as food, is still present, the rodents will return. The short wavelengths of ultrasound are easily reflected, creating sound shadows. The rodents simply shift their activity to these low-noise shadows.

Ultrasonic devices will not drive rodents from structures if food, water, and shelter are available. However, they may have a part to play in rodent integrated pest management. Ultrasonic devices may increase trapping effectiveness by altering the normal movement patterns of individual rodents. Traps set in the sound-shadow areas will become more effective since the rodents will be concentrated in these areas. The high cost of the units must be weighed against the increase in trapping effectiveness to determine if they are cost-effective.

IPM for School Lawns

INTRODUCTION

School lawns often cover several acres and serve important roles as athletic fields, picnic lunch sites, outdoor classrooms, and general recreational areas for the community at large.

Heavy use of lawns and athletic fields causes stress that predisposes grass to attack by a variety of weeds, pest insects, pathogens, and vertebrates such as moles. As a result, most pesticides used on school grounds are applied to lawns and athletic fields.

Because the bodies of children and youths are often in direct contact with the grass, using pesticides on lawns increasingly raises concerns among parents and health professionals. On the other hand, coaches and school administrators are under pressure to ensure quality turf for use by students and by community athletic leagues. In addition, the competence of landscape maintenance staff is often judged by the aesthetic appearance of the lawns that surround most schools. These various viewpoints often come into conflict when pests threaten lawns and athletic fields.

The key to lawn IPM is regular scouting. Cultural practices that optimize growth of grasses and minimize conditions favorable to pest insects, weeds, or pathogens are vital to an IPM program. The following discussion describes how to implement an IPM approach to lawn care. Since specific methods for managing all possible lawn pests is beyond the scope of this chapter, a general IPM approach is described, followed by complete management programs for a typical lawn pest, chinch bugs.

DETECTION AND MONITORING

An IPM approach to lawn management begins with a monitoring program. Monitoring entails making *regular* inspections of the lawn to gather and record site-specific information on which to base pest management decisions. Monitoring enables pest managers to do the following:

- identify the pest(s)
- identify any natural enemies of the pest(s)
- apply preventive methods to reduce the occurrence of pest problems
- determine *if* any treatment is needed
- determine where, when, and what kind of treatments are needed
- evaluate and fine-tune treatments as the pest management program continues over the seasons

Tools Used to Monitor Lawns

The following tools are useful for monitoring lawns. They can be carried in a sturdy bag designed to transport baseball equipment (available at most sporting goods stores). The soil probe with its extension fits snugly in the bottom pocket designed for baseball bats, and everything else fits into an upper zippered area.

- soil probe
- pH meter
- soil thermometer
- 10X hand lens (magnifying glass)
- watering can and bottle of detergent
- plastic bags for collecting specimens
- clip board and forms for recording data
- a ball of twine or clothesline for taking transects
- a small hand trowel and knife
- camera
- field guides for identifying pests and natural enemies (*Turfgrass Insect and Mite Manual*, by Shelton, Heller, and Irish, 1983)
- pheromone traps for cutworms, sod webworms, and other pests

Background Information on Local Pests

When beginning a monitoring program, some effort should be made to become familiar with the common pest insects, weeds, and lawn pathogens in the local area. Learn about their life cycles and how to recognize them. Table 6 on page 77 lists common lawn pests in Pennsylvania along with Web sites that provide more information about each. Additional information can be obtained from the Penn State Cooperative Extension office in your county. It also is important to learn to recognize the natural enemies of common lawn pests and factor their presence into deciding if treatments are needed and which ones to use.

Most of the information for this chapter was modified from:
IPM for Schools: A How-to Manual. United States Environmental Protection Agency. EPA 909-B-97-001. March 1997.
Additional chinch bug information is from: Hoover, G. A. *Chinch bugs*. The Pennsylvania State University. Entomology-Turf-2. 1992.

TABLE 6.

Common Pennsylvania Turf Pests and Web Sites

Common Name	Scientific Name	Web sites for more information
Diagnosing Turfgrass Problems		www.agronomy.psu.edu//Extension/Turf/Diagnose.html
Ant, Nuisance	*Formicidae* spp.	www.ento.psu.edu/extension/factsheets/ants_in_lawns.htm
Black Cutworm	*Agrotis ipsilon*	ianrwww.unl.edu/ianr/entomol/turfent/documnts/cutworms.htm
Bluegrass Billbug	*Sphenophorus* spp.	ohioline.osu.edu/hyg-fact/2000/2502.html
Hairy Chinch Bug	*Blissus leucopterus hirtus*	ohioline.osu.edu/hyg-fact/2000/2027.html
Sod Webworm	*Crambinae* spp.	ohioline.osu.edu/hyg-fact/2000/2011.html
White Grub in Turfgrass	Scarabaeidae	ohioline.osu.edu/hyg-fact/2000/2500.html www.ento.psu.edu/extension/factsheets/white_grubs.htm
Asiatic Garden Beetle	*Maldera castanea*	bugs.osu.edu/~bugdoc/Shetlar/factsheet/turf/Asiaticgardenbeetle.htm
Black Turfgrass Ataenius	*Ataenius spretulus*	www.agry.purdue.edu/turf/agry210/insects/ataenius.htm
European Chafer	*Rhizotrogus majalis*	www.uvm.edu/extension/publications/el/el199.htm
Green June Beetle	*Cotinus nitida*	www.aces.edu/department/extcomm/publications/anr/anr-991/anr-991.htm
Japanese Beetle	*Popillia japonica*	ohioline.osu.edu/hyg-fact/2000/2001.html
Northern Masked Chafer	*Cycolcephala* spp.	ohioline.osu.edu/hyg-fact/2000/2505.html
Oriental Beetle	*Exomala orientalis*	www.leapipm.org/Oriental.htm
May/June Beetle	*Phillophaga* spp.	iaa.umd.edu/umturf/Insects/May_June_Beetle.html

Gathering Background Data on the Site

The next step in a monitoring program is to map all lawn areas, noting locations of existing pest problems or conditions that can produce pest problems, such as bare spots or broken sprinkler heads. Identify the lawn grasses in each area and record the maintenance history of the turf and current horticultural practices. Soil should be tested at representative sites to assess fertility status and requirements. If any pest organisms are present, be sure to get an accurate identification. Many unnecessary pesticide applications can be traced to mistaken identification of pests.

Next, give each major section of lawn an identifying number. Prepare a monitoring form for recording ongoing maintenance activities and information about pests and their management in each section.

You will need to compile an inventory of existing lawn maintenance equipment. In addition to mowers, do you have an aerator, dethatcher, and fertilizer spreader that can handle organic materials? Is there a spring-tooth harrow for removing weeds from infields and running tracks? These are useful tools in nonchemical lawn management. Inspect the condition of the equipment, too. Are mower blades kept sharp? Can mowing height be adjusted easily? Does the equipment have flotation tires to reduce soil compaction? Prepare a list of equipment needs so they can be worked into the budget process.

Developing Pest Tolerance Levels

Most lawns can tolerate some pest presence without compromising appearance or function. The challenge for the pest manager is to determine how much damage is tolerable and when action is needed to keep pest damage within tolerable levels. Since the users of the lawn must be taken into account when deciding whether or not treatments are warranted, it is a good practice to involve representatives of these interest groups in setting pest tolerance levels for lawn areas.

One approach is to work with an IPM advisory committee to develop pest tolerance levels for lawns at each school site. Tolerance levels will differ depending on location and uses of the lawns. For example, tolerance for pest presence on lawns at the front of the school in public view may be lower than tolerance for playing fields behind school buildings. Tolerance levels may also differ depending on the particular pest. For example, tolerance for damage by pest insects or pathogens that can kill large areas of turf, leaving bare soil, may be lower than tolerance for weeds that displace grasses but nevertheless continue to cover soil and serve as a playing surface.

Tolerance levels can be quantified in a number of ways. The Transect Method for Monitoring Weeds in a Lawn, discussed on page 79, describes a method for quantifying the amount of weeds growing in a lawn. This permits expression of tolerance levels by percentage of weeds. For example, "Up to 25 percent weed growth is tolerable on the back lawn at the elementary school; only 10 percent is tolerable on the football field at the high school."

Tolerance for insect damage can be correlated with numbers of insects present and amount of visible damage. For example, white grubs can be monitored by examining several areas of soil underneath the grass. A spade is used to cut three sides of a 1-foot square of grass. The grass is carefully folded back, using the uncut edge as a hinge. Soil from the roots is removed, and the number of exposed grubs is counted. Then the grass can be folded back into place, tamped, and watered in. In well-managed lawns, depending on the species, up to 15 grubs per square foot can be present without causing any appreciable damage to the turf. In stressed or poorly managed lawns, however, 15 grubs per square foot might seriously damage the grass.

By setting tolerance levels, pest managers and groundskeepers can gear their management efforts to keeping pest populations within tolerable levels, and apply treatments only if, when, and where necessary. Involving members of the school and community in setting treatment guidelines can minimize confrontations and help develop broad support for the IPM program.

Evaluating Pest Management Practices

When actions are taken to reduce pest presence, monitoring data should be used to evaluate the effectiveness of the treatment. Did pest numbers go down sufficiently to prevent intolerable damage? Were treatments cost-effective? Is the problem likely to recur? Can conditions causing chronic pest problems be altered or removed? If not, can other ground covers better suited to site conditions replace the lawn?

MANAGEMENT OPTIONS

When pest numbers threaten to exceed tolerance levels (in other words, when the action level is reached), a wide variety of strategies and tactics is available to solve any lawn pest problem. The first approach is to address conditions causing stress to lawns.

Stress and Pests

The pest problem of greatest concern on school lawns—and the target of highest pesticide use—is the growth of weeds, such as dandelions (*Taraxacum officinale*) or crabgrass *(Digitaria* spp.). Presence of weeds is a symptom of a lawn undergoing stress or poor management, a common occurrence on school lawns and athletic fields. Lawn stress can contribute to the development of insect and disease problems as well.

Sources of stress include levels of use unsuited to the grass species that has been planted, compacted soils, improper mowing heights, too much or too little irrigation or fertilization, accumulation of thatch, and uneven grading.

Knowing the identity of the pest and something about its biology often reveals the specific source of stress. Relieving the stress can reduce or eliminate the pest problem. For example, the weed yellow nutsedge (*Cyperus esculentus)* often grows in waterlogged soils, so its presence could indicate a faulty or broken irrigation valve or a low spot in the lawn. The presence of chinch bug *(Blissus* spp.) damage, on the other hand, indicates drought stress. Brown patch disease, caused by the fungus *Rhizoctonia solani*, suggests excessive fertilization with soluble nitrate or slow-release fertilizers, especially during hot, wet conditions.

The Transect Method for Monitoring Weeds in a Lawn

1. At the beginning and at the end of the season, establish three parallel transect lines along the length of the field. Use the center of the field and two imaginary lines on either side.

   Note: Three transects will give sufficient data to indicate the percentage of weed cover in the total turf area. If time is limited, information recorded from one transect across a representative area of turf (for instance, down the center of the field) may give sufficient indication of weed trends for management purposes.

2. Calculate the number of paces you will walk between samples.
   a. Measure the length of one of your transect lines in feet (e.g., 360 feet).
   b. Measure the length of the pace of the person doing the transect. To do this, slowly walk a known length (e.g., 20 feet), count the number of paces it takes to cover this distance (e.g., 10 paces), and divide the distance by the number of paces (20 feet ÷ 10 paces = 2 feet per pace). This figure represents the average length of the pace.
   c. Divide the length of the field by the length of the pace (360 feet ÷ 2 feet per pace = 180 paces). This establishes the number of paces it takes to walk the transect.
   d. Divide the number of paces by the number of samples to be recorded (a minimum of 20 samples is recommended): 180 paces ÷ 20 samples = 9 paces per sample. Thus, in this example, a sample will be taken every 9th pace along the transect.

3. Stretch lines of string along the three transect lines, laying the string directly on the ground.

4. Beginning at one end of the first transect, walk the calculated number of paces (9 paces in the above example), stop and look at a 3-by-3-inch area (this is about the circumference of a softball or the lid to a 1-pound coffee can) immediately in front of your toe.

   If this area contains part or all of a weed, check the 'yes' box on the first line under 'Transect A' on the monitoring form (see Figure). If you know the identity of the weed, write it down.

   If the toe sample area contains grass, check the 'no' box on the monitoring form. If 25 percent or more of the toe area sample is bare soil, check the box marked 'bare.' If less than 25 percent is bare, but a weed is present, check 'yes.'

   Continue pacing the transect line and marking the monitoring form. Repeat along the two other transect lines.

5. To calculate the average percentage of weeds, total the number of boxes marked 'yes' in each column and multiply by 100. Divide this number by the total boxes in all columns. The resulting figure represents average percent weed cover in the turf. Do the same calculation with the boxes representing bare ground. This will indicate percent area that will become weedy if not seeded to grass.

6. By collecting data from the transects at the beginning and end of each season, the turf manager can spot emerging problem areas. For example, if several boxes in succession are marked 'yes,' indicating weed presence, a closer look at this area on the transect is warranted. Usually such 'clumping' of weed growth indicates exceptionally heavy wear on the turf, although structural problems, such as severely compacted soil, a broken irrigation line, inoperative sprinkler head, or scalping of the turf due to uneven grade, also may be indicated.

   By monitoring the turf area from season to season, the manager can tell if weed populations are rising, falling, or remaining relatively stable. This information will indicate whether or not current turf management practices are keeping weeds at or below the agreed-upon tolerance level. If weed populations are rising, changes in management practices are indicated.

Weed Monitoring Form for Turf

Location of Turf _____ Date _____
Data collected by _____ Length of pace _____
Distance between sampling points on transect _____
(*for example, every nine paces*)
Number of transects _____ Length of transects _____
Sketch of location of transects

	Transect A				Transect B				Transect C			
	Yes	No	Bare	Weed ID	Yes	No	Bare	Weed ID	Yes	No	Bare	Weed ID
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												

Average % weed growth _____ Average % bare area _____

Total the number of boxes marked 'Yes' in each column. Multiply this number by 100 and divide by 60 (the number of samples taken). The result is the average percentage of weeds growing in the turf area. Follow the same procedure to calculate percentage of bare area.

Reducing Stress on Lawns

The best way to reduce stress on lawns is to use good horticultural practices during lawn installation and maintenance. Even where budgets are limited, key sources of stress can be avoided or diminished by minor changes in maintenance practices, such as raising the mowing height or changing fertilizer formulations. The following lawn care suggestions will help keep pest problems to a minimum.

Maintaining Healthy Soil

The most vigorous lawn growth occurs in loose, loamy soils teeming with beneficial microorganisms, insects, worms, and other organisms. These organisms play critical roles in transforming thatch and grass clippings into humus. Humus slowly releases nutrients and buffers grass roots from extremes of drought or other stresses. Soil organisms also play an important role in biological pest management. For example, certain beneficial microorganisms protect lawn roots from attack by soil pathogens or insects such as white grubs.

The presence of humus in the soil is key to a healthy soil ecosystem. One way to improve poor soils and maintain healthy soils is to ensure that organic matter is routinely replenished by leaving grass clippings to decompose, and fertilizing or topdressing with organic materials such as sludge or composted manure. To prevent buildup of an organic layer, the organic material can be incorporated into the soil using an aerator equipped with hollow tines and a heavy drag mat attached. This operation is best performed during cool, moist seasons when grass is actively growing. On smaller areas, a grass rake can be used to incorporate the materials.

Planting Appropriate Grass Species

School lawns are subject to high levels of use and wear, and maintenance budgets are usually low, so it is important to select blends of grass species tolerant to such conditions and resistant to local pest problems. The Penn State Cooperative Extension office in your county can recommend grass species suited to local climate and conditions. In Pennsylvania, tall fescue (*Festuca arundinacea*) is recommended for school situations.

Reducing Soil Compaction

When lawns are heavily used, or simply mowed on a regular basis, the soil eventually becomes compacted, and the pore spaces that allow water and air to pass through the soil become compressed, creating adverse conditions for root growth. Compaction can be reduced through core aeration and amending soils with organic matter.

Core aeration involves removing plugs of grass to improve air exchange and water penetration into the soil. Ideally, heavily used turf should be aerated at least two times per year, although even a single aeration is better than none.

After aeration, and before seeding the desired lawn grass, drag the lawn with a heavy drag mat to break up cores of soil left by the aerator and to fill in holes.

Mowers and other maintenance equipment compact the soil. By rotating the point of mower entry onto the lawn from week to week, compaction at entry points can be minimized.

Increasing the Mowing Height

Most temperate grasses used on school lawns (tall fescues, perennial ryes, bluegrasses, and others) can be mowed at a height of 2½ to 3 inches without sacrificing vigor or function as ball fields or recreational areas. The taller the grass can be kept and the denser the canopy, the greater the interception of available sunlight. Because taller grass shades the soil, weed seeds are less likely to germinate.

Adjust mowing frequency to changes in the growing season. Weekly intervals may be appropriate when grasses are growing vigorously, but when grasses are semidormant, 14 days or longer may be more appropriate. The right interval between mowings allows grasses to recover from the previous cut.

Careful Irrigation

Too much or too little water stimulates pest problems. For example, many lawn diseases result from excessive irrigation. Development of a disease can often be arrested by letting the lawn dry out, then keeping irrigation to a minimum. On the other hand, chinch bugs require hot dry conditions for optimal survival and reproduction. Irrigation during the spring and early summer may increase the incidence of pathogen spread, especially the lethal fungus, *Beauveria* spp. The adults can withstand water because of the protective hairs on the body but the nymphs readily get wet and can be damaged by large water droplets.

The length of time needed to adequately water lawns is determined by the time it takes to wet it to the depth of the root system. Most lawn grass roots extend 4 to 6 inches in the soil, but because grasses and soil conditions differ, irrigation schedules must be tailored to individual lawns and adjusted for seasonal changes. Infrequent, deep irrigation is best, since frequent, shallow watering promotes shallow rooting. Use a soil probe or a pointed tool, such as a screwdriver, to determine when soil is wet 4 to 6 inches below the soil. This will indicate how long to leave sprinklers on at each irrigation.

Irrigation equipment should be checked to ensure that it is in good repair and that all areas of the lawn receive adequate coverage. Low spots should be leveled or drained to avoid waterlogged soils that favor weeds and pathogens.

Keeping Thatch to a Minimum

Thatch is the accumulation of dead but undecomposed roots and stems that collect in a layer at the soil surface. If the thatch becomes excessively deep—greater than $^{3}/_{4}$ inch—water and nutrients do not penetrate the soil adequately. When water puddles on thatch, it enhances the habitat for disease organisms. Regular aeration keeps thatch at an acceptable level. Excessive nitrogen applications may result in organic matter production rates that exceed breakdown, encouraging thatch accumulation. Excessive layers of thatch can be removed with dethatching rakes, or with power dethatchers available from equipment rental companies. It is wise to seed the area with desired grasses wherever lawns are thinned by dethatching procedures.

Fertilizing with Restraint

Excessive nitrogen fertilizer produces weak grass that is susceptible to disease attack. A soil test should be obtained before planning annual fertilization programs. Only the levels of nutrients needed should be applied. Split applications (one in spring, one in fall) should be used, rather than a heavy single application in the spring. Use slow-release fertilizer to prolong the availability of nutrients throughout the growing season.

Fertilization can be used to directly suppress weeds and lawn pathogens. A study by Ohio State University Extension Service researchers in the 1940s showed that an application of 20 pounds of composted poultry manure per 1,000 square feet of lawn in late fall and early spring stimulated early spring growth of lawn grasses, enabling them to crowd out crabgrass. In this study, crabgrass was reduced by up to 75 percent within one year.

Direct Pest Suppression

When the horticultural methods listed above are not sufficient to solve the pest problem, direct suppression methods, including physical, biological, and chemical tactics, can be integrated into the program.

Physical controls include using a flamer to spot-treat weeds, or using a bamboo pole to flick off dew from grass blades in the early morning to deny nourishment to lawn pathogens. Biological controls include applying microscopic, insect-attacking nematodes to kill soil-dwelling white grubs, or topdressing lawns with microbially enhanced soil amendments to kill lawn pathogens.

Chemical controls are available. Check with the Penn State Cooperative Extension office in your county for information about pesticides appropriate for your pest problems.

IPM Plan for Hairy Chinch Bugs

Hairy chinch bugs *(Blissus leucopterus hirtus*) are the most important of the "true bugs" (order Hemiptera) that become pests on lawns. Heavily infested areas may contain as many as 200 to 300 chinch bugs per square foot.

IDENTIFICATION AND BIOLOGY

Adult chinch bugs overwinter in dry grass and other debris that offers them protection. In spring or early summer, depending on temperature and moisture, overwintering females lay from 200 to 300 eggs on leaves of grass, or push them into soft soil and other protected places. Young nymphs (the immature stages) emerging from the eggs are bright red with a distinct white band across the back. The red changes to orange, orange-brown, and then to black as the nymph goes through five growth stages in 30 to 40 days.

Nymphs range from about $^{1}/_{20}$ inch soon after hatching to nearly the size of the $^{1}/_{4}$-inch-long adult. The nymphs mature into adults, which are black with a white spot on the back between the wing pads.

DAMAGE

Chinch bugs suck the juices from grass leaves with their needle-like mouthparts. They also inject a toxic saliva into the plant that disrupts the plant's water-conducting system, causing it to wilt and die. Most damage is caused by nymphs and adults concentrated in limited areas and feeding on the same plants until all the available juice has been extracted from the grass. This feeding pattern results in circular patches of damaged grass that turn yellow and then brown as they die. In the yellow stage, the grass superficially resembles grass that is drought-stressed. As it dies, the chinch bugs work outward from the center of the infestation, destroying a larger area as they advance.

Populations of chinch bugs increase under hot, dry conditions. In wet, cool years, or when lawns are kept properly irrigated and not overfertilized, chinch bug populations decrease significantly because the moisture encourages the growth of the lethal fungus, *Beauveria* spp., a pathogen of chinch bugs.

DETECTION AND MONITORING

Lawns can be protected from damage by chinch bugs through regular monitoring. The objective is to detect pests while their populations are still small and determine whether their natural controls—such as adverse weather, other insects, and diseases—will keep the population low enough to prevent damage.

Any lawn can tolerate a low population of chinch bugs and most other pests without sustaining significant damage. If the monitoring techniques described below indicate that there are fewer than 10 to 15 chinch bugs per square foot, generally no action is needed.

It is a good idea to begin monitoring as early as mid-May, before overwintering adults have finished laying their spring eggs. A quick check of the lawn once a month until September should be sufficient in most areas.

Since nymphs tend to congregate in groups, it is important to check several areas of the lawn. Infestations often begin on the edges of lawns, particularly in sunny, dry spots, so check these areas carefully. Spread the grass apart with your hands and search the soil surface for reddish nymphs or black adults. Chinch bugs may also be seen on the tips of grass blades, where they climb during the day. Be certain to distinguish between the chinch bugs and their predator, the big-eyed bug, which they superficially resemble.

A second detection method requires a metal container (such as a coffee can) with both ends removed. Insert this can into the ground and fill it three-quarters full with water. Stir the duff at the bottom of the container. Count the number of adults and nymphs floating to the surface over a period of 10 minutes. Repeat this procedure in 3 to 5 locations in the lawn where damage is present, or in adjacent areas.

MANAGEMENT OPTIONS

Physical Controls

Chinch Bug-Resistant Grass Cultivars

If chinch bugs are a chronic problem, it may be advisable to replace existing grass with a type that is resistant to chinch bugs. Endophytic enhanced grasses may be used to repel insect pests. An endophyte is a fungus that grows inside a plant, and research has shown that turfgrass species containing endophytes have enhanced resistance to surface feeding insects, including chinch bugs, sod webworms and bill bugs. Try perennial ryegrass varieties such as Repell or Score, or a Kentucky bluegrass variety such as Baron.

Habitat Management

Chinch bugs are attracted to lawns that have an excessive buildup of thatch, are insufficiently irrigated (often due to soil compaction), or have either too little or too much nitrogen. The discussion of good lawn culture provided at the beginning of this section includes suggestions on overcoming these problems. Proper habitat management will go a long way toward suppressing these bugs.

Manual Removal

Small populations of chinch bugs can be removed from the lawn using the soap solution and white flannel cloth method described below. This is particularly appropriate when damage is just beginning to appear, since at this stage chinch bug nymphs are still congregated in specific locations and can be collected efficiently. Small vacuums also may be helpful.

Biological Controls

One of the primary tactics for the biological control of chinch bugs is conserving its natural enemies. At least two beneficial organisms often move in to feed on chinch bugs: the big-eyed bug and a tiny wasp. The big-eyed bug *(Geocoris* spp.) superficially resembles a chinch bug, so pest managers must learn to distinguish between the two. According to Ohio State University turf specialist Harry Niemczyk, “the body of the chinch bug is narrow, the head small, pointed, triangular-shaped, with small eyes, while the body of the big-eyed bug is wider, the head larger, blunt, with two large prominent eyes. Big-eyed bugs run quickly over the turf surface and are much more active insects than the slower-moving chinch bugs.” (Niemczyk, 1981).

Although big-eyed bugs cannot be purchased from insectaries at this writing, recent research indicates that members of this genus can be reared easily and inexpensively, so they may become commercially available in the near future.

Soap-and-Flannel-Trap Method for Chinch Bugs

Put 1 fluid ounce of dishwashing soap in a 2-gallon sprinkling can and drench a 2-square-foot area of lawn where you suspect there are chinch bugs. Watch the area for 2 or 3 minutes. Larger areas can be covered by putting the detergent in a hose attachment designed to hold pesticides for spraying the lawn. If chinch bugs are present, they will crawl to the surface of the grass.

Next, lay a piece of white cloth, such as an old bedsheet or a piece of white flannel, over the area treated with the soapy water. Wait 15 to 20 minutes, then look under the cloth to see if chinch bugs have crawled onto it as they attempt to escape the soap. Their feet tend to get caught in the flannel's nap. Pick up the cloth and either vacuum it or rinse it off in a bucket of soapy water to remove the bugs. The vacuum bag should be disposed of so that the bugs will not return to the lawn.

This method can also be used to monitor for other insects such as lawn caterpillars, mole crickets, and beneficial insects that feed above the soil, but it will not bring soil-inhabiting grubs or pillbugs to the surface.

Chemical Controls

If nonchemical methods alone prove insufficient to solve the problem, then integrating a pesticide into your management program may be warranted. **Pennsylvania law allows pesticide applications in schools only by certified applicators, registered technicians, or by non-certified applicators or non-registered technicians under the direct supervision of a certified applicator. Notification must be given to all staff and parents or guardians of students who request it 72 hours prior to pesticide use. Warning signs must also be posted in the vicinity 72 hours prior to and for 48 hours after the application. The law also mandates a 7-hour reentry period for common access areas whenever pesticides are applied.**

If pesticide use seems necessary to bring a serious chinch bug infestation under control, insecticidal soap or pyrethrin should be considered.

IPM for Silverfish, Firebrats, and Booklice in Schools

INTRODUCTION

Silverfish, firebrats, and booklice are discussed together here because they occur in the same or similar habitats. They prefer dark, moist environments with a supply of starchy foods or molds. Although they are all found in similar environments, silverfish and firebrats are not closely related to booklice. These nuisance pests can feed on wallpaper pastes, natural textiles, books, and manuscripts. They also feed on molds growing on various surfaces.

Silverfish, firebrats, and booklice can live both indoors and outdoors. They are frequently introduced into a building with boxes of materials that have been stored in damp basements or attics, but they also can wander in from the outside. Silverfish and firebrats are fast-moving and can travel throughout buildings. Once these insects find a good source of food, however, they stay close to it. In general, they cause little damage, but may cause people to take radical action based on their fear of insects.

SILVERFISH AND FIREBRATS

Identification and Biology

Silverfish and firebrats belong to an insect order called Thysanura. Insects in this order characteristically have three long, tail-like appendages about as long as the body. These insects are wingless, with chewing mouth parts, long antennae, and a body covered with scales. The mouthparts of silverfish and firebrats are used for biting off small particles or for scraping at surfaces. The most common species inhabiting buildings are in the genera *Lepisma* (silverfish) and *Thermobia* (firebrat). The silverfish (*Lepisma saccharina*) is about $\frac{1}{2}$ inch long when fully grown and covered with silvery scales. It is grayish to greenish in color and its body has a flattened-carrot shape. The firebrat (*Thermobia domestica*) has a mottled appearance with patches of white and black, and is shaped like the silverfish.

Silverfish and firebrats eat material high in protein, sugar, or starch, including cereals, moist wheat flour, starch in book bindings, sizing in paper, and paper under which there is glue or paste. These insects often attack wallpaper, eating irregular holes through the paper to get at the paste. Silverfish may bite very small holes in various fabrics, including cotton, linen (they can digest cellulose to some extent), and silk. Firebrats will feed extensively on rayon, whereas silverfish usually damage it only slightly.

Characteristics of the silverfish:

- lays eggs in any season, usually in secluded places
- has a 3- to 4-month life cycle from egg to adult
- prefers moist areas (75 to 97 percent humidity) and moderate temperatures (70° to 80°F)
- is active at night or in dark places, and is rarely seen unless disturbed during cleaning
- may be found throughout the building—sometimes in boxes and books, or in glass utensils and sinks they have fallen into
- leaves yellowish stains on fabric
- outdoors, lives in nests of insects, birds (especially pigeons), and mammals, and under the bark of trees

Characteristics of the firebrat:

- lays eggs in cracks and crevices
- has a 2- to 4-month life cycle from egg to adult
- prefers moist areas with temperatures above 90°F
- is active at night or in dark places
- found where heat and starches are present (for example, in bakeries); also found in furnace rooms, steam pipe tunnels, and partition walls of water heater rooms

BOOKLICE (PSOCIDS)

The most common booklouse (*Liposcelis* spp.) is a small, grayish, soft-bodied insect with chewing mouthparts and long antennae. It is flat and superficially resembles the shape of the head louse. The common house-dwelling booklouse is wingless. The size of an adult is approximately $\frac{1}{25}$ to $\frac{1}{12}$ inch. Because they feed chiefly on mold, booklice cause little direct damage to plants and wood. They are commonly found in confined areas like the bindings of books, where they eat the starch sizing in the bindings and along the edges of pages.

Characteristics of the booklouse:

- has a life cycle from egg to adult lasting about 110 days
- prefers warm, moist conditions that are conducive to the growth of mold and mildew and require humidity of at least 60 percent

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Most of the information in this chapter was modified from:

Powell, T.E. *IPM for Silverfish, Firebrats, and Booklice in Schools*. University of Florida School IPM Web site at **schoolipm.ifas.ufl.edu/tp12.htm**. May 1998.

Jacobs, S. B. *Booklice*. The Pennsylvania State University. Entomology-NP-2. 1998.

Jacobs, S. B. *Silverfish*. The Pennsylvania State University. Entomology-SP-3. 1998.

- found in books and paper products
- sometimes found on houseplants, where they may be feeding on honeydew (a protein-rich substance excreted by plant-eating insects such as aphids), or more likely, on the sooty mold that grows on the honeydew

DETECTION

Silverfish are found in bookcases, on closet shelves, behind baseboards, and in wallpaper, window or door frames, wall voids, attics, and subfloor areas. They prefer bathrooms and kitchens because of the moisture. Firebrats will be found in similar but warmer areas. Both silverfish and firebrats molt as many as 50 times during their life, so the appearance of cast skins can be used to detect their presence. Booklice prefer damp and warm habitats, so they are most numerous during the spring and summer. New buildings are not immune to booklice infestation.

If you suspect that damage to books, carpets, curtains, or other materials is due to silverfish or firebrats, confirm your suspicions using the following test:

- Mix flour and water to the consistency of house paint.
- Coat one or more 3-by-5-inch index cards with the paste.
- Let the cards dry, and place them where you have spotted the damage.
- If silverfish or firebrats are in the vicinity, they will be attracted to the card and will feed on the paste. Characteristic feeding marks appear as minute scrapings in irregular patterns. In addition, the edge of the card may be notched.

If you see groups of small, whitish insects in damp areas, suspect booklice, particularly if mold is present or the area smells moldy. Remember that booklice are considerably smaller than silverfish, and lack the telltale three long bristles at their hind end.

Silverfish, firebrats, and booklice also can be detected by placing sticky cockroach traps in the area where damage is occurring. When the insects are caught, they should be preserved in alcohol for professional identification.

MANAGEMENT OPTIONS

Physical Control

Dehumidifying

Booklice, silverfish, and firebrats are living indicators of excessive moisture. If the moisture is not eliminated, it may bring more serious problems, such as termites, carpenter ants, and wood rot.

Dehumidifying reduces the moisture content of the air. Some methods for dehumidifying an area include:

- Mending leaking pipes.
- Ventilating closed rooms and attics.
- Eliminating standing water.
- Using a dehumidifier.
- Replacing any single-glazed windows that repeatedly accumulate condensation with double-glazed windows.
- Using anhydrous calcium carbonate or silica gel to absorb free moisture. Do not use these agents in areas open to children.

Drying Stored Articles

Periodic airing and drying of articles stored in damp areas may help reduce the mold on which booklice feed. Disposing of moldy articles is often the simplest way of removing an infestation in an area.

Chemical Control

If nonchemical methods alone do not solve the problem, then integrating a pesticide into your management program may be warranted. Pesticides must be used in accordance with their EPA-approved label directions. Some insecticides are registered for managing silverfish and firebrats and/or booklice indoors, whereas others are registered for outdoor use only. **Pennsylvania law allows pesticide applications in schools only by certified applicators, registered technicians, or by non-certified applicators or non-registered technicians under the direct supervision of a certified applicator. Notification must be given to all staff and parents or guardians of students who request it 72 hours prior to pesticide use. Warning signs must also be posted in the vicinity 72 hours prior to and for 48 hours after the application. The law also mandates a 7-hour reentry period for common access areas whenever pesticides are applied.**

Diatomaceous earth, borate-based insecticidal dust products, and silica aerogel can be used to kill these insects. Diatomaceous earth and borate-based products must be kept dry to be most effective.

Dusts should be applied only in cracks and crevices, crawl spaces, and other areas that are relatively inaccessible to humans and pets. Wear a dust mask or professional-quality respirator to provide proper lung protection when applying any dust.

Some baits for ants, crickets, and roaches are also labeled for silverfish and may be useful in some situations.

Residual sprays are labeled for silverfish and firebrats and can be applied where the pests are most commonly seen.

Products commonly found in schools, such as bleach, ammonia, and salt, can be mixed with water and used to kill molds on surfaces where booklice feed.

IPM for Spiders and Ticks in Schools

Spiders

INTRODUCTION

Despite their small size, spiders have evoked fear and revulsion in humans throughout history. Nursery rhymes and horror films malign them, but fears about spiders are largely unwarranted since most spiders are too small or have venom too weak to harm humans. In fact, they provide a great benefit to mankind by consuming vast numbers of insects in and around our homes and schools.

Spiders have 8 legs and 2 body regions, the cephalothorax (a head joined with a thorax) and abdomen. They lack wings and antennae. Almost all spiders have fangs and venom, but only a few are considered dangerous to humans, so it is important to be able to differentiate between relatively harmless spiders and those that should be avoided and/or controlled.

The species of spider that causes the most concern in the home or school environment in Pennsylvania is the black widow spider. Since there have been reports of the brown recluse spider being found in Pennsylvania, some information concerning it will be included. Both of these spiders are potentially dangerous to humans, and their bites may cause severe reactions or even death. However, these spiders usually will bite only if provoked, and then only under certain circumstances.

Other spiders that may produce painful bites or be of health importance may be grouped as:

1. Active hunters: some wolf spiders, jumping spiders and sac spiders.
2. Web builders: some cobweb spiders and funnel weavers (Mallis, 1997).

It is prudent to use caution when handling any larger spiders, even though most are harmless. Generally, spiders are not aggressive. Most bites occur when a spider accidentally becomes trapped against the skin or when a person picks it up.

REMOVING A RELATIVELY HARMLESS SPIDER

Most spiders found in and around a school can be used as an educational opportunity to teach some interesting facts about these fascinating creatures. If any spider found in the classroom creates anxiety on the part of the teacher or children, and the teacher wishes to remove it, invert a container of some sort over the spider, slide a stiff piece of paper over the mouth of the container, and then release the spider outside.

GENERAL SPIDER MANAGEMENT

You can manage the number of spiders in an area by reducing their food supply. If flies are getting in, screens should be installed or repaired. Security lighting may attract insects at night, and spiders feed on them, so outside lighting should not be placed directly over a doorway. Insects also may be attracted to poorly stored food or mishandled organic wastes. Eliminating the food source for these insects will reduce the food source for the spiders.

Removing debris and excess clutter also will reduce the number of harborage sites available. Debris and stacks of wood, pallets, blocks, and similar materials should be moved a distance from schools and elevated off the ground as much as possible. Vegetation should be removed from the sides of buildings and grass should be kept mown. For spiders already in residence, removing their webs and egg sacs discourages subsequent infestation. In most cases, vacuuming and reducing the spiders' food source will be sufficient to manage the problem.

The two potentially dangerous spiders—the black widow and the brown recluse—nest in undisturbed areas, often near the floor; therefore, thorough vacuuming in these areas from time to time also can help in their control.

A wide variety of chemicals are available for the control of spiders. **Pennsylvania law allows pesticide applications in schools only by certified applicators, registered technicians, or by non-certified applicators or non-registered technicians under the direct supervision of a certified applicator. Notification must be given to all staff and parents or guardians of students who request it 72 hours prior to pesticide use. Warning signs must also be posted in the vicinity 72 hours prior to and for 48 hours after the application. The law also mandates a 7-hour reentry period for common access areas whenever pesticides are applied.** Misapplied chemical treatments may cause more harm than the real or perceived threat from spiders. Crack and crevice treatments may be necessary for the hunting spiders.

Black Widow Spiders

IDENTIFICATION AND BIOLOGY

There are several species of widow spiders in the United States, but the black widow (*Latrodectus mactans*) is the only native species found in Pennsylvania.

Most of the information in this chapter is from:
IPM for Schools: A How-to Manual. United States Environmental Protection Agency. EPA 909-B-97-001. March 1997.
Green, S. G., and C. W. Rutschky. *Poisonous Spiders*. The Pennsylvania State University. Entomology-Public Health 85-1.

Illustrations on pages 87–89, by Cristol Gregory.

The adult female black widow is normally a shiny, jet-black spider about ½ inch in body length. With legs extended, the female measures about 1½ inches long. The female has the well-known reddish hourglass marking on the underside of her abdomen. Because their webs are near the ground and the spiders hang upside down in the web, their distinctive marking is readily apparent. The adult male, which is not dangerous, is small (about ⅙ inch long) and patterned with black and white body markings.

Black widows like dry, undisturbed places, such as lumber and rock piles, stacked pots or baskets, rodent burrows, water meters, the underside of bricks and stones, and dry crawl spaces. Females stay in the web.

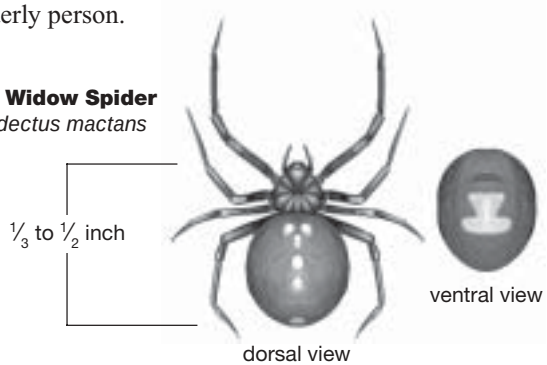
The female black widow spider spins an irregular, tangled web. The webs are typically constructed in quiet, undisturbed locations that are usually—but not always—close to the ground. The female spends her entire life in the web. If disturbed, she may drop to the ground to escape. Her eggs are placed in white, spherical sacs within the web. After hatching, the young spiders stay near the sac for a few hours to several days, and then climb to a high point, wait for suitable air currents, and spin a silken thread so they can float on the breeze like a kite. This method of "ballooning" distributes them over a considerable distance. Once they land, the spiders begin to construct their own webs. The abdomen of a young black widow is patterned with red, white, and yellow, but has the black legs and general appearance of the adult.

BITES

Black widows are shy, retiring creatures that bite reluctantly, and then only in self-defense when threatened. However, when a female is defending her egg sac, she can become quite aggressive.

A bite may not cause pain at first. However, after a few minutes, the bite site becomes quite painful. Symptoms from the bite of a black widow include headache, general body ache, nausea, chills, slight fever, shortness of breath, intense muscle pain, and rigidity of the abdomen and legs. Seek medical attention. If reactions are mild, treatment usually is not administered. However, medicine is available if symptoms do become severe. The bite of the black widow is usually more serious for a small child or an elderly person.

Black Widow Spider
Latrodectus mactans



First Aid for Spider Bites

Wash the area around the bite, calm the victim, and consult a doctor as soon as possible. Those particularly at risk are the very young, the elderly and sick, or people with high blood pressure. Although the illness and lesions from bites of some of the spiders discussed here can be serious, deaths are rare.

If possible, capture the spider so the specimen can be taken to a doctor. Proper treatment may depend on identifying the species. Even the squashed remains of the spider can be useful for identification purposes.

DETECTION AND MONITORING

Monitor for black widows at night with a flashlight or headlamp. This is the time when they move to the center of their webs and will be most visible. When making your inspections, focus on areas that are dark and undisturbed during the day, but not necessarily close to the ground.

Look in and around the following places:

- small crevices anywhere from the foundation to the eaves of buildings
- the undersides of outdoor wooden furniture (for example, beneath the seats in the corners where the legs are braced)
- piles of wood, bricks, stones, or similar materials
- the openings of rodent burrows
- water meters
- cellar doors
- outhouses
- storage rooms

Black widow webs have high tensile strength and, with a little experience, can be identified by the way they "pop" when broken. An experienced pest manager can use this information to find webs during the day.

Brown Recluse Spiders

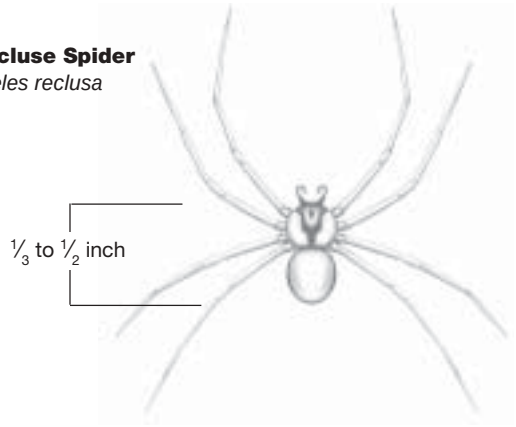
IDENTIFICATION AND BIOLOGY

Brown recluse spiders (*Loxosceles* spp.) are extremely uncommon in Pennsylvania and probably are found only in boxes brought in from the south. One species, *Loxosceles rufescens,* may be found in basements and utility tunnels. Brown recluse spiders, *L. reclusa*, are identified by their long, thin legs, an oval-shaped abdomen which is light tan to dark brown in color, and a very distinctive violin-shaped mark on their back. This marking, with the

violin "body" near the eyes and the "stem" of the violin extending backwards gives rise to their other common name, violin spiders. They have six eyes in three groups of two. Their overall size is ¾ inch to 1¼ inches long with the legs extended. The males are slightly smaller than the females.

As the common name "recluse" suggests, these spiders are shy, retreating from humans when possible. They prefer to build their webs in dark, undisturbed places on or near the ground. Unlike the black widow, brown recluse spiders hunt for prey some distance from their webs. They usually come into contact with humans because they have taken temporary refuge in clothing or bedding. Items left lying undisturbed on the floor, such as supplies, toys, or clothing, are perfect daytime refuges for these spiders. Such objects should be shaken out thoroughly if they have been on the floor for any length of time, particularly in regions where the brown recluse is prevalent.

Brown Recluse Spider
Loxosceles reclusa



BITES

Brown recluse spiders avoid areas of human activity. Bites are rare and are usually the result of unused rooms suddenly being put to use, or accidental contact resulting from pressing the spider between the body and either clothing or sheets. The bites are almost always very unpleasant, producing an ulcerous wound called a necrotic lesion that turns dark within a day and takes a long time to heal. Young children, the elderly, and the infirm are most likely to be affected severely. Victims should seek medical attention.

DETECTION AND MONITORING

The brown recluse spider wanders at night searching for prey. It seeks dark, uninhabited areas for protection. Brown recluse spiders usually are found on floors and baseboards. Only rarely are they seen on desks and tables.

Searches for this spider should concentrate on uninhabited areas close to the floor, particularly in boxes, around piles of paper, clothing, and debris, in closets, and under furniture. Periodic checks outdoors should focus on storage sheds, piles of debris or wood, cracks in the soil or in foundations, walls, and window wells, especially if small children play near these places. Employing sticky traps in monitoring is useful in establishing the extent of brown recluse infestations, and also is helpful in providing a measure of control.

AVOIDING SPIDER BITES

If either of these spiders is found around your school, it is important to be cautious when working near these places. Gardeners and custodians should be careful about where they put their hands when doing outdoor work, and wear gloves and a long-sleeved shirt when working around woodpiles and other items stored outdoors that are likely to harbor the spiders.

Make sure students and staff can identify any dangerous spiders in your area and know their likely nesting and hiding places. Children should be taught not to tease spiders in their webs or poke at them, and not to put their hands in dark crevices without looking first. The dangers of spider bites should be explained without exaggeration to avoid unnecessary fears. Teach students and staff that black spiders they see walking around are not likely to be black widows, since the females do not travel away from their webs and the males are not dangerous.

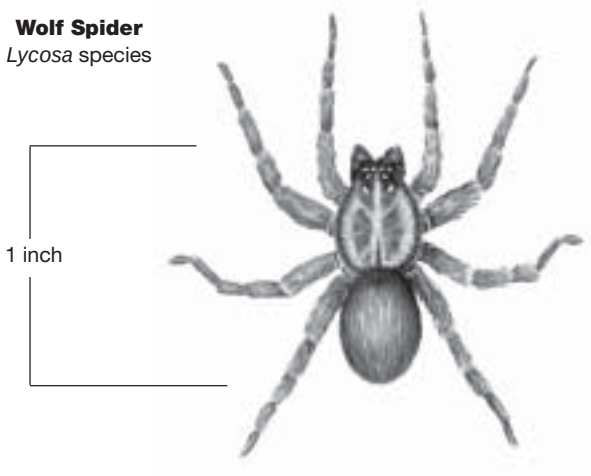
Other Spiders of Concern

Wolf spider (Lycosidae)

These large spiders are sometimes found indoors in basements in late summer and fall when cooler temperatures arrive. They do not construct webs, but run rapidly after prey. They are not aggressive, but may bite if handled. The bite is generally not dangerous.

These and other spiders are best managed by cleaning and exclusion—keep screens in good repair, fix gaps around doors, and caulk cracks around window frames, as well as around pipes and wires coming into the building.

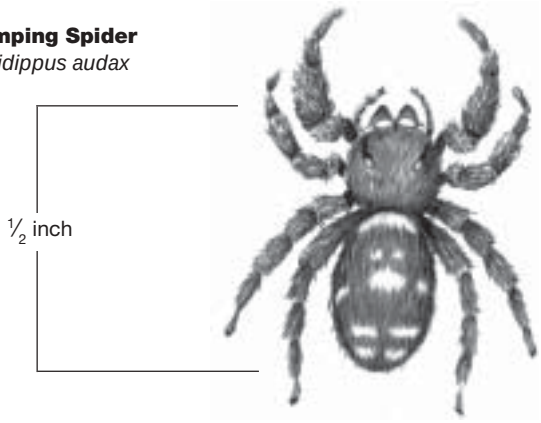
Wolf Spider
Lycosa species



Jumping spider *(Phidippus audax)*

These spiders move in jumps or short rapid runs. They are hairy, stocky, and about ½ inch long. This species is black with spots of orange or red on the top surface of the abdomen. At times, they are confused with black widow spiders, which are not at all hairy. Active during the day and usually outdoors, sometimes they are found inside on walls, windows, and screens. They can bite. Generally, they do not appear in large numbers and can be removed individually.

Jumping Spider
Phidippus audax



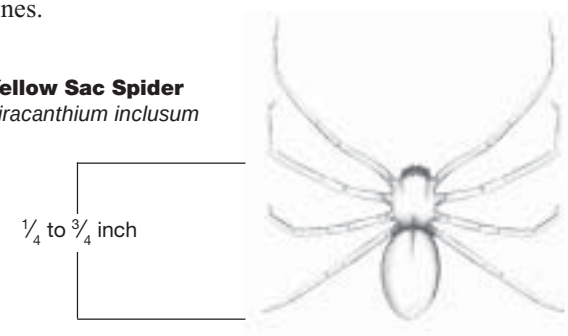
Yellow sac spider *(Chiracanthium* spp.*)*

These spiders have been associated with numerous cases of spider bites and cause a small irritating spot which may not heal for 8 to 10 days. They are suspected of being responsible for most indoor bites (Lyon, 1995).

This yellow spider, which is about ¼ to ¾ inch long, may have a greenish tinge to the abdomen. The jaws are brown and the legs are very smooth, with the front legs longer than the rear. The egg sac is a white, paper-like disk usually placed in a protected area, such as under a stone.

They enter buildings principally in the early fall and are active for several months. They make small white webs in confined spaces where they spend the winter. In spring, they usually emerge from their white web cells and find their way outside. Outdoors, they do not build webs but instead construct a flat tubular sac opened at both ends inside rolled leaves or crevices, or under loose bark or stones.

Yellow Sac Spider
Chiracanthium inclusum



MANAGEMENT OPTIONS

Physical Controls

To achieve some kind of permanent control of black widow spiders, you must attempt to eliminate not only the spiders but their preferred habitats as well. If this is not accomplished, another black widow may locate the same habitat and move in. If black widows regularly build their webs in certain locations indoors, try to modify these areas by increasing the light, caulking crevices, or reducing the insect population the spiders are feeding upon. As previously mentioned, check window and door screens for holes that give insects access, and make sure that foods and organic wastes are stored properly to prevent insect infestations. To reduce or eliminate possible web sites outdoors, debris and litter should be removed and discarded. All crevices in foundations and walls that are child-height and wide enough to stick a finger into should be caulked closed.

Because many spiders prefer undisturbed places for nesting and hiding, periodic, thorough cleaning can help reduce their numbers. Floors should be kept well vacuumed. Boxes of paper and other items stored in closets, or anywhere else that is dark and undisturbed, should be handled carefully when first inspected. A small hand-held, battery-powered vacuum also can be used while checking through stored items. If a spider is vacuumed up, the vacuum bag can be placed into a plastic bag and then into a freezer. Most bites from spiders probably occur when a spider is disturbed or handled. Wearing leather gloves while searching through stored items can help prevent bites.

Ticks

INTRODUCTION

Ticks are important because they can transmit human diseases. They are not insects but relatives of spiders. Adult ticks have 8 legs and insects have 6. Ticks are ectoparasites, and thus must take a blood meal from a host for each stage of their life cycle in order to survive and reproduce. Their life cycle includes egg, larva, nymph, and adult stages. The larval stage has 6 legs, but when it molts to the nymph stage, there are 8 legs. Ticks cannot fly or jump. Many tick species can transmit organisms such as parasitic worms, viruses, bacteria, spirochetes, and rickettsias to humans. The most important of these diseases in Pennsylvania are Lyme disease, caused by a spirochete, and Rocky Mountain spotted fever, a rickettsia. Some other diseases for which ticks are vectors include tularemia, babesiosis, ehrlichiosis, Powassan encephalitis, tick-borne typhus, and tick paralysis. Information about these diseases is available from many sources.

TICK LIFE CYCLE

Ticks have few natural enemies and a wide range of hosts. They typically take one blood meal in each of the three parasitic stages: larva, nymph, and adult. Both sexes are blood feeders, with the female becoming greatly distended with blood after mating and then producing many eggs.

Larvae. Normally thousands of tiny larvae ("seed ticks"), with only 6 legs, hatch from an egg batch and crawl randomly in search of a host. When they find a small mammal or other host, they attach themselves and feed for a few hours up to three days, depending on the species. During feeding, the host wanders and the tick is transported where, when engorged, it drops off.

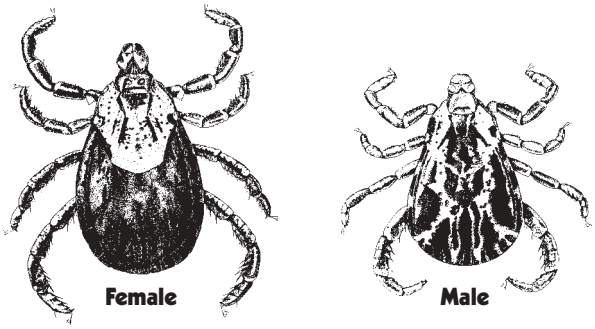
Nymphs. After molting, nymphs have 8 legs and climb grass leaves or plant stems to wait for a host to walk by. Because they are higher than ground level, they tend to attach to larger hosts than before. After several days of feeding they drop off and again molt.

Adults. Ticks sometimes can wait for months to more than a year for a suitable host. They seek the host by climbing vegetation and wait for vibrations or shadows to announce the presence of a host. The first pair of legs is extended and used to grasp the host when contact is made. This behavior is known as questing. The height at which questing occurs determines the size of the host. When finally engorged, they drop off to lay as many as 6,000 to 7,000 eggs.

When feeding, the tick uses its "teeth" (chelicerae) to cut the victim's skin and then inserts its mouthparts. The feeding tube (hypostome) has many rows of barbs that anchor the tick to its host, making it difficult to withdraw by external force. Blood is pumped by a muscular pharynx and the salivary glands produce an anticoagulant that allows long periods of feeding without the host's blood coagulating. Pathogenic organisms are most often introduced into the host in the tick's saliva.

TYPES OF TICKS

Four species of ticks are most commonly encountered in Pennsylvania. They are the American dog tick, *Dermacentor variabilis*, the blacklegged tick, *Ixodes scapularis*, (formerly known as the deer tick), the lone star tick, *Amblyomma americanum*, and a groundhog tick, *Ixodes cookei*.



American Dog Tick ***(Dermacentor variabilis)***

(Illustrations from *Ticks of Veterinary Importance*. USDA Ag Handbook No. 485.)

American dog tick is the most commonly encountered tick in Pennsylvania. The immature stages often are found on rodents, while the adults frequently are found on dogs. The American dog tick has distinctive white markings on its back and is about 5 mm long with short, stout mouthparts. When feeding, the adult becomes greatly engorged.

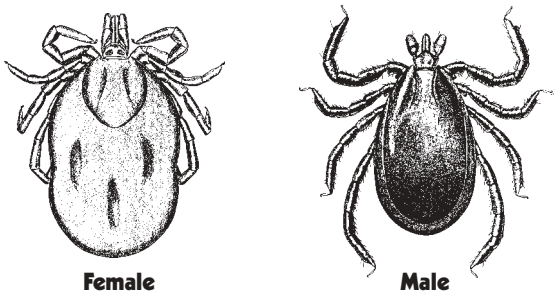
The American dog tick is the major carrier of Rocky Mountain spotted fever. It can also transmit tularemia, and cause tick paralysis. It cannot transmit Lyme disease spirochetes.

Some of this material has been adapted from:

Jacobs, S. B. *Four Common Ticks of Pennsylvania*. The Pennsylvania State University. **www.ento.psu.edu/extension/factsheets/common_ticks.htm**. 1998.

Klass, C. *Integrated Pest Management for the Deer Tick*. Cornell University.

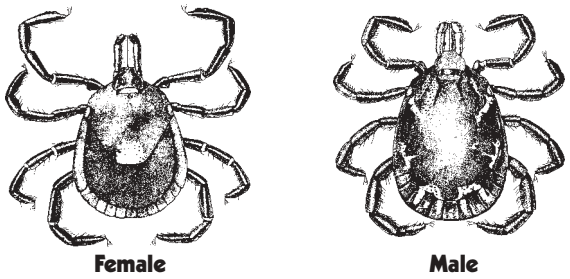
Public Health Pesticide Applicator Training Manual. University of Florida. American Mosquito Control Association Public Health Pest Control Web site: **vector.ifas.ufl.edu**



Blacklegged Tick *(Ixodes scapularis)*
(Illustrations from *Ticks of Veterinary Importance*. USDA Ag Handbook No. 485.)

Blacklegged tick is found in over half of the counties in Pennsylvania. Larvae and nymphs feed on small animals and birds such as squirrels, mice and grouse. Adults prefer deer. Any stage can feed on humans. The adult female is reddish and is about 2–3 mm in length with long mouthparts.

This tick is well known as the vector of Lyme disease and has been known to carry babesiosis, an uncommon, generally mild febrile disease. This tick typically requires more than 24 hours of attachment before it can transmit the Lyme disease spirochete.



Lone Star Tick *(Amblyomma americanum)*
(Illustrations from *Ticks of Veterinary Importance*. USDA Ag Handbook No. 485.)

Lone star tick is found most often in the southern counties of Pennsylvania. The larvae feed on small animals, while the nymphs feed on many small and larger animals. Adults are usually found on larger animals, and all stages can be found on deer and will feed on humans. This tick is light reddish brown, and most adult females have a central white spot on the back. This tick is about 5 mm in length with long mouthparts.

The lone star tick is known to be a vector of tularemia, ehrlichiosis, tick-borne typhus, Rocky Mountain spotted fever, and causes tick paralysis.

Groundhog tick is the least commonly encountered of the four species listed here. It resembles the blacklegged tick and is about the same size. It is host-specific for groundhogs, but can be found on birds, small animals, or humans. It is not considered to be an important vector of diseases since it tends to feed mostly on groundhogs, although it has been found to be a vector of Powasson encephalitis.

MONITORING FOR TICKS

Dragging and Flagging

Monitoring for ticks is routinely done with a tick drag, a soft, white 3' x 3' cloth stapled to a dowel to which a cord is attached, with a second dowel or board at the end to weigh the cloth down. Questing ticks grab onto the cloth as it is dragged over grass and brush. The drag is inspected for ticks at fixed intervals; for example, 10 paces in an area of relatively high tick density or 100 meters in less dense infestations. Tick drags will not work when the vegetation is damp or wet.

Flagging is similar, but a smaller cloth, the flag, is attached to one end of a pole with the other end used as a handle. The flag is brushed over higher vegetation such as thick understory in wooded areas and brush and shrubs in open areas, or in edge habitats and along property borders where vegetation is thicker. Ticks are usually found within 18 inches of the ground.

Drag or flag sampling will collect only 1 of 10 ticks in an area. Repeated sampling at different times will increase the likelihood of finding a tick. Be sure to heed the suggestions in the following section on "Prevention" if you plan to sample for ticks.

MANAGING TICKS

Prevention

- Wear light-colored clothing to make spotting ticks easier.
- In areas infested by ticks, wear long sleeves and long pants tucked into boots or socks.
- Walk in the center of paths, and avoid brushing against vegetation.
- Repellents greatly enhance protection. Repellents containing DEET have been found to be most effective.
- Examine yourself carefully for ticks after leaving the woods or tick-infested areas. Check especially the hair, shoulders, armpits, waist, and inner thighs.

Removal of ticks

- Use forceps or tweezers to remove attached ticks. Firmly grasp the tick where it attaches to the skin and pull with a slow steady motion until it is removed. It may be firmly attached; continue to pull patiently until it is out.
- Disinfect the bite with rubbing alcohol.
- Avoid removing the tick with bare fingers. If you squeeze the tick, it can force the stomach contents back up through the hypostome.
- Do not apply mineral oil, petroleum jelly, heat, or anything else to remove the tick as this may cause it to inject a pathogen into the wound.
- Save the tick for future identification should you later develop disease symptoms. Preserve it by placing it in a clean container (such as a vial or Ziploc bag) and keep it in the freezer. Identification of the tick will help a physician diagnose the disease, since many tick-borne diseases are transmitted only by certain species.

Sanitation and Exclusion

- Manage the landscape to lower the humidity where ticks are likely to be found.
- Reduce cover for mice, the principal reservoir host of the Lyme disease spirochete. Eliminate wooded, brush-covered habitat; prune lower branches of bushes to reduce habitat for mice; and clean up storage areas, woodpiles and junk piles.
- Immature ticks are most abundant in areas where deer are abundant. Keep deer away by reducing deer habitat or fencing them out.
- Remove leaf litter and plant grass under shade trees to help reduce tick abundance.

Blacklegged ticks require high humidity. Heavily shaded, damp (but not flooded) areas covered with leaf litter are ideal. Sites where host animal activity is concentrated are also important. Blacklegged ticks are often found in woodlots or wooded areas between lots, along edge habitats, and especially in unmaintained borders as well as along rock walls, woodpiles and brushpiles. Sites generally have a heavy understory of growth. All stages are rare on maintained lawns and are rarely found in open sunny areas.

Chemical Control:

Appropriate acaricides applied at the peak of nymphal populations can reduce tick populations significantly. A second application in later September or early October may control the adult ticks.

Pennsylvania law allows pesticide applications in schools only by certified applicators, registered technicians, or by non-certified applicators or non-registered technicians under the direct supervision of a certified applicator. Notification must be given to all staff and parents or guardians of students who request it 72 hours prior to pesticide use. Warning signs must also be posted in the vicinity 72 hours prior to and for 48 hours after the application. The law also mandates a 7-hour reentry period for common access areas whenever pesticides are applied.

IPM for Trees and Shrubs on School Grounds

INTRODUCTION

Landscapes vary so greatly that it would be impossible to provide specific management suggestions for all the pest problems on the many trees and shrubs that might be encountered on school grounds. Instead, we will try to provide a basic framework that will enable you to solve your own problems using information from your specific site. At the end of this manual are references to Penn State publications about lawns and landscaping in Pennsylvania. They may help with specific problems.

PLANT HEALTH CARE MANAGEMENT

Plant health care management (PHC) is a new concept in managing landscapes that was developed from the concept of integrated pest management (IPM). Many arborists, horticulturists, and landscape managers have long felt that IPM's focus on "pests" is too narrow when applied to landscape plants. More than half of the problems encountered in landscapes or gardens probably are not caused by insects, mites, or disease; instead, they are the result of compacted soil, drought stress, overwatering, frost damage, and many other factors. To manage landscapes effectively, plant health and the ecosystem in which the plant is growing must be taken into consideration. PHC takes just this kind of broad approach. PHC incorporates all the principles of IPM, including monitoring, record keeping, and integrating treatments, but PHC emphasizes plant health and proper horticultural practices. PHC is *plant* management, not just *pest* management. By focusing only on pests, we often overlook the horticultural or environmental factors that affect plant growth and health.

COMPONENTS OF A PHC PROGRAM

Van Bobbitt, community horticulture coordinator for Washington State University Cooperative Extension, lists the following 5 components of a PHC program (Bobbitt, 1994):

- Know your plants.
- Determine key problems.
- Study your landscape ecosystem.
- Promote plant health.
- Consider a variety of strategies to manage pests.

Know Your Plants

Before you can properly care for the trees and shrubs on your school grounds, you must know what they are. Make a map of the grounds and identify every tree and shrub. There are books that can help you with this, or you can take a specimen to a nursery, the Penn State Cooperative Extension office in your county, or a landscaping professional.

Once you know the names of all your plants, do some research on each one. Talk to nursery personnel and horticulturists, and read about your plants in gardening books. From your research, you should be able to answer the following questions:

- What kind of soil does the plant prefer?
- How much water does it need?
- When should it be fertilized?
- How should it be pruned?
- Does it prefer shade or sun?
- How much heat or cold can it tolerate?
- What are its most common pest problems?
- What environmental problems—soil compaction, air pollution, salt damage, and others—is it susceptible to?

Your research and your experience can help you identify key plants that are prone to problems and need more of your time and attention than other plants. If there are many trees and shrubs on the school grounds, this information can help you focus your maintenance activities. You also may want to use this information to remove plants that are not suited to their sites, that have too many problems, or that require too much care.

Determine Key Problems

Many things affect the health of a tree or shrub. They are generally divided into biotic factors and abiotic factors. Biotic factors are living organisms, such as diseases, insects, mites, and deer. Abiotic factors include maintenance practices (fertilizing, pruning, irrigation), weather, soil quality, amount of sunlight, and human activities such as vandalism or soil compaction caused by constant foot traffic. These abiotic factors probably are responsible for the majority of landscape plant problems.

Most of the information in this chapter is from *IPM for Schools: A How-to Manual.* United States Environmental Protection Agency. EPA 909-B-97-001. March 1997.

Determining key problems involves deciding which situations or factors are most likely to affect the health of your plants. Ask yourself if the problem is a serious threat to plant health, a minor threat, or just an aesthetic problem. Your research and your experience will help you answer these questions. For instance, one plant disease may kill a tree, but another disease may cause premature leaf drop year after year without seriously affecting tree health.

It is likely that you will have not only key problems, but also key problem sites. For example, perhaps the heavy equipment used in remodeling the school last year severely compacted the soil in several areas, or perhaps drainage is poor in one corner of the schoolyard because of heavy clay soil. These sites will need special attention, and most likely special plants, too.

Learn as much as you can about your key problems. If they are living organisms, learn about their life cycles, how to identify various stages of the pest, and how to recognize symptoms of damage. Do enough research to help you decide which management options are both safe and effective.

You also will need to research abiotic problems. Are there specific symptoms that you can learn to recognize? What techniques are available for solving the problem? Which solutions can you afford and which are best suited to the particular site? Are there specific plants that can tolerate the abiotic factors?

Study Your Landscape Ecosystem

The grounds of your school make up an ecosystem with complex relationships among the plants, animals, water, soil, sunlight, weather, and other components. Because of these complex relationships, there are many things you will need to pay attention to when promoting plant health. Questions you will need to answer include:

- What is your climate? What are the maximum and minimum temperatures?
- Are there microclimates in the school yard that might affect plant growth?
- Where do the prevailing winds come from? Are they unusually strong?
- What are your seasonal patterns of precipitation?
- Where are the sunny and shady parts of the yard? (These will change over time as plants grow and die.)
- What are the characteristics of the soil in each part of the yard?
- What are the drainage patterns?
- What is the history of each area in the school yard? What plants were grown there? (This can be an important factor for some plant diseases.) Was the area covered with asphalt or concrete at some point? Did a road or path go through the site?
- Are animals such as squirrels, deer, and dogs having an impact on the landscape? (The salts in dog urine can be very damaging to plants.)
- What human activities are having an impact on the landscape? Are children vandalizing plants? Are lawns growing right up to the trunks of trees so that mowers regularly damage the trees? Are city de-icing operations salting up the soil?
- What kind of irrigation system is installed in the landscape, and is it in working order? Are plants getting too little or too much water?
- Is air pollution a problem in your area? (Air pollution affects plants as well as animals.)

Since landscapes are constantly changing, you will need to monitor frequently in order to detect problems early. Monitor at least every two weeks during the growing season. In mild climates, you also should monitor once a month during the winter. Focus your monitoring efforts on your key plants and your key problems. Be aware that plants growing in poor conditions are under stress and are often more likely to suffer from insects and disease. As you monitor, look for the kinds of damage symptoms you learned about in your research.

Promote Plant Health

Proper plant care is the foundation of a PHC program. Healthy plants mean healthy landscapes, and healthy landscapes have fewer problems and require less special attention. The following points will help you to minimize cultural and environmental problems, as well as pest problems.

- Match the plant to the site. For example, you cannot grow a subtropical swamp plant in a cold, dry site. Some plants cannot grow in full sun, and some plants are better adapted to salty or compacted soil or soil with poor drainage. For help with finding plants for your area or for problem sites, talk to local gardening clubs, nurseries, or extension personnel, or consult books on regional gardening.
- Select pest- and disease-resistant species.
- Know what kind of care each plant needs, and pay special attention to how you water, prune, and fertilize them.

- Plant a diversity of species so that a single pest problem will not devastate your landscape.
- Include "insectary" plants in your landscapes. These are plants that attract and feed beneficial insects with their nectar and pollen; for example, sweet alyssum *(Lobularia* spp.), flowering buck-wheat *(Eriogonum* spp.), members of the parsley family (*Apiaceae*) such as fennel and yarrow, and members of the sunflower family (*Asteraceae*), such as sunflowers, asters, daisies, marigolds, and zinnias.
- Use proper planting techniques when installing vegetation.
- Improve the soil with organic matter and mulches.

Consider a Variety of Strategies

If you determine that a problem needs to be treated, it is important to consider a variety of strategies and to integrate those strategies into a comprehensive program. Treatment strategies can be divided into several general categories:

Education
This can include educating students and teachers about respect for landscape plantings; the more that students can be involved in the planting and care of various portions of the school yard, the less they will vandalize these areas. Education can also involve training maintenance staff in various aspects of plant care and plant selection.

Cultural controls
These usually include modifying horticultural practices to prevent plant problems or to improve plant health.

Biological controls
Biological control uses other organisms to combat pests. More and more beneficial organisms are becoming commercially available, and by planting "insectary" plants (see above), you can attract beneficial insects already in your area.

Chemical controls
Chemicals are not prohibited in a PHC program, but they are used as a last resort, and then they are used judiciously and in the least toxic formulations. Always spot-treat to minimize the amount of active ingredient used. **Pennsylvania law allows pesticide applications on school grounds only by certified applicators, registered technicians, or by non-certified applicators or non-registered technicians under the direct supervision of a certified applicator. Notification must be given to all staff and parents or guardians of students who request it 72 hours prior to pesticide use. Warning signs must also be posted in the vicinity 72 hours prior to and for 48 hours after the application.**

No action
This can be a valid strategy in many situations when the problem does not seriously affect the health of the plant. Your research will help you understand which problems are serious and which are minor or simply aesthetic problems.

IPM for Weeds on School Grounds

INTRODUCTION

A "weed" is commonly defined as a plant growing in a place where it is not wanted. Plants can be unwanted because they compete with desired species, because they cause harm to people or structures, or because their appearance or odor is offensive. The designation "weed" can be quite subjective. For instance, the dandelion can be considered a weed in one setting and a wildflower or culinary herb in another.

On school grounds, there is usually consensus on the weedy nature of certain plant species, such as thistles, docks, crabgrass, and poison ivy, that spring up where they are not wanted. These species have common characteristics that enable them to "take over" when conditions are right. Landscapes can be designed and maintained in ways that minimize conditions suited to weed growth, reducing or eliminating the need for herbicides. The goal is to encourage desirable plants to outcompete weeds in habitats where plant growth is acceptable (shrub beds, turf areas, tree wells, student gardens), and to remove conditions conducive to weeds in areas where vegetation is not wanted (in pavement cracks, on running tracks, under fences). A review of basic principles of weed biology and ecology will help identify conditions that promote weed growth and suggest methods for encouraging competitive desirable vegetation and discouraging weeds. Extensive information concerning weeds in turf, identification and control can be found at: **www.agronomy.psu.edu/Extension/Turf/WeedMgmt.html**. (*The management of weeds in turf is discussed in the section on school lawns on page 76.*)

IDENTIFICATION AND BIOLOGY

Weeds can be found among both broadleaf plants and grasses. Like all plants, weeds are classified within 3 general categories according to the duration of their life cycle and their methods of reproduction.

Annuals

These are the most common weeds; they live 1 year and reproduce by seed. These plants have a rapid life cycle that enables them to germinate, shoot up, blossom, set seed, and die within the space of a few weeks or months. Their rapid life cycle allows them to thrive on a minimum of nutrients and water.

Biennials

These weeds live 2 years, and reproduce both vegetatively and by seed.

Perennials

These weeds live more than 2 years. Although perennials produce seeds, the main means of reproduction is usually vegetative; for example, by forming new plants from bulbs or corms, or by producing new top growth from buds located on underground stems (rhizomes).

Weed Habitats

Weeds tend to grow in places where the soil is bare or disturbed:

- areas that have been cultivated (shrub and flower beds)
- trampled or close-mowed lawns
- unpaved play areas and paths
- sports fields
- fence lines
- graded roadsides
- cracks in sidewalks or other pavement
- areas where the same herbicide has been used repeatedly and plants tolerant to that material have moved in

Weedy areas found on school grounds tend to be hot, dry, sunny habitats—often with low nutrient levels and soil moisture. Certain plants, such as thistles, knotweeds, plantains, and barnyard and crab grasses, take advantage of these conditions. As they grow, die, and decompose, the soil is stabilized, erosion is reduced, and the soil environment becomes more moist and fertile. Under these improved conditions, plant species with less weedy characteristics may eventually displace the weeds. Thus, a meadow left undisturbed may eventually become a forest.

DETECTION AND MONITORING

The purpose of monitoring is to determine if, when, where, and why weeds are growing or posing a problem, and to assign priorities for habitat change and least-toxic weed suppression. The components of effective weed monitoring are described here.

Most of the information in this chapter is from *IPM for Schools: A How-to Manual.* United States Environmental Protection Agency. EPA 909-B-97-001. March 1997.

Mapping Weed Habitats

The first step in monitoring is to map areas where weeds are growing. This does not need to be a detailed, time-consuming process—a rough map will do. For areas to monitor, see the list under Weed Habitats above.

Identifying Weed Species

It is important to accurately identify the most common weed species on your school grounds in order to determine appropriate management methods. Knowing the scientific name of the weed makes it much easier to obtain information from research professionals and the scientific literature. Assistance is available from county Penn State Cooperative Extension personnel or pictorial weed guides. A method for preserving weed samples is described in the box to the right.

Learn about the growing conditions required by the weed as well as its growth characteristics and methods of reproduction. Weeds can be indicators of soil conditions that need to be changed to discourage weed growth. For example, yellow nutsedge (*Cyperus esculentus*) often grows in waterlogged soils, indicating excessive water perhaps due to a broken irrigation pipe or valve. Conversely, prostrate knotweed (*Polygonum aviculare*) indicates dry, compacted soil that requires aeration and addition of organic matter. Changing the conditions indicated by the weed can discourage these unwanted plants from growing.

Record Keeping

It is important to record the time of year a particular weed species appears, its abundance, and its impact on the landscape. This information will help determine:

- which weeds and how many of each can be tolerated in a specific area without the weeds impairing the function of the landscape or its aesthetic appeal
- whether or not management strategies are effective
- whether weed populations are rising, falling, or staying about the same from year to year
- whether new species of weeds are becoming a problem (as often happens as a result of weed management efforts)

Without this information, it is impossible to determine the long-term effectiveness of management methods.

Collecting and Preserving Plant Specimens for Identification

If you want to have a damaged plant inspected or a weed identified, collect an adequate sample since a small part of a plant may not include all the signs and symptoms needed to make an accurate diagnosis. Plant material that has been dead for an extended time is generally useless in determining the identity of the causal agent of a disease. For plant identification purposes include leaves, stems, roots, and flowers or seed-bearing portions. A single leaf or leaflet is not an adequate sample for plant identification purposes.

Place green leaves between dry paper towels and enclose them in a plastic bag *without adding moisture*. Carefully shake excess soil from roots. Place roots in a plastic bag with *moist* (not water-logged) wood shavings or similar material to prevent drying. Wrap fruits separately in paper and mail without adding moisture. If you are unable to deliver the specimen in person, place the bag in cardboard mailing tubes, boxes or padded mailing envelopes reinforced with cardboard sheets and send it to your Penn State Cooperative Extension county office.

Establishing Weed Tolerance Levels

School landscape maintenance budgets rarely stretch far enough to suppress all weeds, even if that were desirable. Aesthetic standards should be adjusted to take this into account. Assigning tolerance levels helps prioritize budget allocations, facilitate long-term plans, and provide justification for weed management action—or lack of action.

Identify areas where weeds pose potential health or safety hazards or threaten damage to facilities, and distinguish these locations from those where weeds are considered aesthetic problems alone. For example, poison ivy can cause severe skin rashes and itching, and weeds growing in playing fields or running tracks can pose tripping hazards. Assign low tolerance levels to weeds in such areas, and place high priority on their management. On the other hand, assign higher tolerance levels—and lower priority for management—to weeds growing in shrub beds or along fence lines.

Since most weed tolerance levels are subjective, one way to establish them is to invite a representative group to tour the school grounds and decide where weed levels are

acceptable and where they are not. Such a group might include the school principal, coach, landscape maintenance supervisor, PTA officers, students, and parents. It is important that this group reach consensus on overall weed management objectives for various school sites, and that weed tolerance and action levels derive from this agreement. Weed tolerance levels can be reevaluated on an annual basis.

Long-Term Weed Management Plans

Long-term plans should focus on making changes to the habitat to permanently exclude weeds in areas where weed tolerance levels are low. In some cases this may require augmented budget allocations. Developing plans can help spread budget needs over several years.

Evaluation of Weed Management Programs

The availability of herbicides has often helped perpetuate poor landscape designs and inappropriate maintenance practices, because herbicides could be used to compensate for them. Gathering monitoring data can pinpoint the underlying causes of weed presence. The data can be used to change design specifications for landscapes, sport fields, playgrounds, and pavement to avoid encouraging weeds.

The long-term costs, risks, and benefits of various weed management approaches also should be evaluated. A one-time cost to install concrete or asphalt mow strips under backstops and fence lines and thereby permanently remove weed habitat may be less costly in the long run than repeated herbicide use that may pose a potential health risk, possibly resulting in lawsuits and poor public relations.

MANAGEMENT OPTIONS

Horticultural Controls

This approach involves manipulating plant selection, planting techniques, and cultural practices so that desired vegetation grows so densely and vigorously that weeds are crowded out.

Planting beds can be rototilled and irrigated to force weed seeds to germinate. As soon as sprouted weeds appear as “green fuzz” on top of the soil, they can be killed by a second cultivation with the tiller set at 1 inch. Shallow cultivation prevents weed seeds from being moved to the top 2 inches of soil—the germination range. This will reduce weed growth while ornamental plants are becoming established.

Plant Selection

In shrub beds, you can include ground covers with rapid, spreading growth habits that can outcompete weeds.

Competitive Interplanting

When shrubs or ground covers are installed, weeds often colonize the spaces between individual plants before the ornamentals can spread and shade them out. These weed habitats can be eliminated by overseeding newly planted areas with fast-growing annual flowers such as sweet alyssum (*Lobularia maritime*), farewell-to-spring (*Clarkia amoena*), and scarlet flax (*Linum grandiflorum* var. *rubrum*).

Mulching

Mulches are used primarily to exclude light from the soil, thus limiting weed seed germination. Mulches can be composed of organic materials (compost, wood chips), stones or gravel, or synthetic landscape fabric. Landscape fabric is preferred over black plastic, since it allows air and water to move through the soil to benefit ornamental plant roots, but excludes light at the soil surface to thwart weeds.

To be effective, mulches should be applied immediately after plants are installed. Bark or compost mulches should be 3 to 4 inches deep to exclude light. If landscape fabric is used, it should be covered with an inch or two of bark, stones, etc. to improve the aesthetic appearance of the planting area and reduce degradation of the fabric by sunlight. Landscape fabric can last for years if properly maintained.

Physical Controls

Hand-pulling, cultivation, and using string trimmers and mowers are very effective weed suppression techniques. If labor is in short supply, make good use of parent and student volunteers, community service groups, and youth groups. Classrooms can adopt a flower bed or a section of the schoolyard to maintain and beautify. If students are involved in grounds maintenance, they will be more careful around the plants and take pride in a clean, well-maintained schoolyard.

Weeds on baseball infields, running tracks, and other bare soil areas can be suppressed by periodic shallow cultivation with a tractor-mounted rotary harrow, also called a rotary hoe or power rake (Rhay, 1994). In areas with heavy clay soils, this method can be combined with adding sawdust to reduce the crusting and puddling characteristics of these soils.

Eliminate Weed Habitat

Creating a "mow strip" under and immediately adjacent to fence lines can solve a common weed problem. When fences surround paved playing surfaces such as basketball courts, the steel fence posts can be installed directly into the paving material, 8 to 12 inches to the inside of the paving edge. The paving prevents weeds from growing under or adjacent to the fence, and provides a paved strip for the wheel of a mower which can keep adjacent grass trimmed. The strip also provides access for use of string trimmers when shrub beds abut the fence line.

Pouring a 16-inch-wide concrete or asphalt strip to cover the soil under and beside the fence can modify existing cyclone fence lines. This retrofit can be performed in stages over several years as budgets permit. The one-time paving cost will produce many years of savings in weed management.

Use asphalt or cement crack filler to fill cracks in paved areas where weeds are a problem.

Flaming

Flamers are used by a growing number of parks and school districts to treat weeds in pavement cracks, under picnic tables and benches, along fence lines, and similar places. This technique uses a small gas- or propane-fired torch to sear the tops of young weeds. The heat raises the temperature of the sap in the plant cells, the cell walls rupture, and the weed wilts and dies. Flaming is most effective on young annual and perennial weeds in the seedling (4- to 5-leaf) stage, because at that point the fragile root system is killed along with the top growth. Grasses are difficult to kill by flaming because a protective sheath covers their growing tips.

Keep the torch about 6 inches above the vegetation and pass it slowly over the plants. Hold the flamer over each plant briefly so the plant is heated but not actually burned. The leaves may lose their usual green color, but there may not be any evidence of wilting, let alone plant death, for several to many hours. Leaves that have been heated sufficiently to burst cell walls will feel very soft to the touch and may turn a purplish color.

Soil Solarization

This technique uses a covering of clear plastic to raise soil temperatures high enough to destroy weeds and their seeds. For solarization to be effective, daytime temperatures should average 85°F or more, so it should be done during the hottest and sunniest time of the year. Solarization can kill annual or perennial weeds as well as soil pathogens and nematodes. Solarization can also be used to destroy weed seeds and other soil pests in rototilled beds scheduled for new plantings.

To solarize a section of soil, do the following:

- Mow any existing vegetation to the ground.
- Cultivate to incorporate the vegetation into the soil.
- Provide a smooth surface by raking the soil so it is level.
- Encourage weed seeds to germinate by irrigating the soil 1 to 2 weeks before covering it.
- Irrigate again just before laying down the plastic.
- Use UV-stabilized plastic 2 to 4 mils thick.
- Anchor the tarp by burying its edges in a small soil trench around the area to be solarized.

Chemical Controls

When nonchemical weed management methods are not sufficient to solve weed problems, herbicides are available for integration into the program. There are many herbicides on the market. For information on the efficacy and hazards of various herbicides and on how to select an appropriate product for your situation, consult the Penn State Cooperative Extension office in your county.

Whenever possible, apply herbicides as spot-treatments to the target weeds. For example, a tool called a "rope wick applicator" can be used to wipe a small amount of herbicide on a single plant or patch of weeds. This reduces human exposure and helps to protect nontarget vegetation and beneficial soil organisms that can be damaged or killed by herbicide residues. Wick applicators are available as hand-held versions or as attachments to small tractors and riding mowers.

When applying herbicides, use a colorant to mark the treated area. This will not only ensure even coverage, but also will help passersby see and avoid the treated area. Do not allow children to play or lie on the treated area—rope it off and post a sign.

Herbicides must be used in accordance with their EPA-approved label directions. **Pennsylvania law allows pesticide applications on school grounds only by certified applicators, registered technicians, or by non-certified applicators or non-registered technicians under the direct supervision of a certified applicator. Notification must be given to all staff and parents or guardians of students who request it 72 hours prior to pesticide use. Warning signs must also be posted in the vicinity 72 hours prior to and for 48 hours after the application.** All labels and Material Safety Data Sheets (MSDS) for the pesticide products authorized for use in the IPM program should be maintained on file. Never apply these materials where they might wash into the storm drains, sanitary sewer, creeks, ponds, or other water sources.

IPM for Wood-Damaging Pests in Schools

INTRODUCTION

The job of maintaining a building includes detecting structural pest problems before they become severe. Early detection means less costly repairs. Although the discovery of wood-destroying insects often generates panic and premature decisions, these pests are slow to cause new damage. There is ample time to accurately identify the pest and decide on an appropriate IPM program. Some of the work can be done by school personnel and the rest contracted out to a professional, or the entire job can be contracted out to professionals.

This section will discuss wood-attacking fungi, termites, and wood-boring beetles.

IDENTIFICATION AND BIOLOGY

Wood-Attacking Fungi

Fungi reproduce from spores present in the air and soil. Thread-like structures called hyphae grow from the spores and penetrate directly into wood. A mass of hyphae, called a mycelium, is frequently visible on the surface of the wood. A mycelium often takes the shape of a fan or a fluffy mat. Optimal growth occurs at temperatures between 50°F and 95°F on wood containing at least 20 percent moisture.

The three major groups of wood-attacking fungi are **surface-staining fungi** (molds and mildews), **sap-staining fungi** (wood stains), and **decay fungi** (wood rots). Surface-staining and sap-staining fungi do not cause loss of structural strength and will not be discussed here; however, they are evidence of moisture problems that need to be corrected. The third group, decay fungi, attacks the cellulose and lignin in wood and causes structural weakness. They are hard to detect in their early stages; however, advanced stages are quite evident from the changes in the wood's appearance.

Brown Rot

- characterized by white mycelial mats
- causes wood to crack into small cubical pieces perpendicular to the wood grain
- wood rapidly loses its strength and eventually crumbles to powder
- wood changes color to a distinctive brown

Dry Rot or Water-Conducting Rot

- a special kind of brown rot most often found in new construction
- can disperse rapidly throughout wood, destroying large amounts in 1 to 2 years
- characterized by large, papery, white-yellow mycelial fans
- forms large tubes called rhizomorphs that are up to an inch in diameter and can conduct water to 25 feet
- rhizomorphs are dirty white to black, and grow out and away from the moisture source
- rhizomorphs allow the fungus to extend its growth into dry wood containing less than 20 percent moisture
- wood surface may appear sound but wavy, even though the interior is heavily decayed
- relatively rare problem

White Rot

- makes wood look bleached
- affected wood feels spongy when probed and is stringy when broken
- no abnormal shrinkage
- wood strength gradually diminishes

Soft Rot

- seldom encountered in buildings, except where wood is in contact with constantly wet soil
- develops in marine habitats in wood that is too wet for other decay fungi
- attacks wood surfaces and produces a gradual softening inward

IDENTIFICATION AND BIOLOGY

Termites

Although there are a number of groups of termites in the United States, only the eastern subterranean (*Reticulitermes flavipes*) and southeastern subterranean (*Reticulitermes virginicus*) termites are indigenous to Pennsylvania, with the eastern subterranean being the most common. They are social insects and form colonies that contain several castes. These castes differ greatly in their form and function.

Most of the information in this chapter is from:
IPM for Schools: A How-to Manual. United States Environmental Protection Agency. EPA 909-B-97-001. March 1997.
Jacobs, S. B. *Eastern Subterranean Termites*. Penn State Cooperative Extension. 1992.

During the first 6 months of the development of a new colony, the queen deposits only 6 to 20 eggs. The total number of eggs deposited by a queen can be tens of thousands during her lifetime. Nymphs hatch in 6 to 12 weeks. As the nymphs increase in size and number, castes are formed. The worker caste maintains and feeds the colony, and many species have a soldier caste that defends the colony. The darkly pigmented, winged reproductive caste (kings and queens) serves only to reproduce and start new colonies. Reproductives "swarm," or fly away from their original colony, only at certain times of the year.

Subterranean Termites *(Reticulitermes flavipes)*

- Subterranean termites must be in regular contact with moisture, which in most cases means they must stay in contact with the soil. (In rare cases, they live in the wood above the soil, getting their moisture from a leaky air-conditioner, regular condensation, or some other constant moisture source).
- They construct distinctive earthen tubes to bridge the distance between the soil and wood.
- The passageways protect them from predators and help prevent desiccation as they travel. These tubes are important visible clues to subterranean termite presence.
- Initially, subterranean termites tunnel into soft spring wood, but as the infestation grows, they remove more and more wood until most of it is gone.
- They reinforce their excavations with "carton," a mixture of wood fragments and fecal material held together by saliva.

R. flavipes usually swarm in Pennsylvania between February and June. These black, winged termites are the stage most commonly seen, since the other castes do not expose themselves to light. Winged termites are attracted to light, and when they emerge within buildings, they swarm about doors and windows. After crawling or fluttering about for a short time, the termites break off their wings and locate a mate. Each pair attempts to locate moist wood in contact with the soil to start a new colony, but few succeed. Most reproduction is due to secondary or supplementary reproductives within the colony. No damage is done by the winged forms.

IDENTIFICATION AND BIOLOGY

Wood-Boring Beetles

Although some wood-boring beetles can cause serious damage, there is always time to identify the type of beetle present before taking action. When dealing with wood-boring beetles, it is important to know whether or not they will reinfest a piece of wood. Some beetles cannot, and seeing their holes in wood means they have done their damage and left. See Table 7 on page 102 for more information to help you identify some of the most important beetles.

Anobiid Beetles (sometimes called death-watch or furniture beetles)

These beetles are small ($\frac{1}{8}$ to $\frac{1}{4}$ inch long), reddish-brown to black, and elongate with a very rounded back. Wood moisture content of 13 to 30 percent is required for development, so anobiids are more frequently a problem in areas with higher temperatures and humidity. Furniture kept in centrally heated living spaces is usually too dry for them to infest.

Anobiids attack both hardwoods and softwoods and will feed on either newly seasoned or older wood. In Pennsylvania, they are the most common structure-infesting beetle. Although they feed mainly on the sapwood, they also can damage heartwood that is close to the sapwood. In the wild, they live in dead tree limbs or in bark-free scars on the trunks.

The females lay their eggs in small cracks or crevices on the surface of the wood. When the larvae hatch, they bore a short distance into the wood, then turn at a right angle and tunnel with the grain. Their tunnels get larger as the larvae grow. Eventually the tunnels become so numerous that they intersect, and the wood becomes a mass of fragments. Tunnels are packed with fecal pellets from the larvae. It may take 2 to 3 years for larvae to complete their development.

Lyctid Powderpost Beetles

These are small ($\frac{1}{8}$ to $\frac{1}{4}$ inch long), slender beetles that vary from reddish-brown to black. Lyctids attack only the sapwood (outer wood) of hardwoods.

Females lay an average of 20 to 50 eggs in exposed areas of partially seasoned lumber with a high starch content. The hatched larvae bore down the vessels of the wood, making straight tunnels that then turn and become irregular. Most species complete their life cycle in 9 to 12 months, but they can develop more quickly if the temperature and starch content of the wood are favorable. The larvae pupate near the surface of the wood, and the emerging adults drill a hole through the wood to get out.

TABLE 7.

Characteristics of Damage Caused by Common Wood-Boring Beetles

	Wood Attacked		Recognizing Damage			
Type of Borer	**Part and Type**	**Condition**	**Exit Holes**	**Galleries (tunnels)**	**Frass**	**Reinfest?**
Anobiid powderpost beetles Anobiidae	Sapwood of hardwoods and softwoods; rarely in heartwood	Newly seasoned or older wood	Circular, 1/16 to 1/8 inch diameter	Circular, up to 1/8 inch diameter; numerous; random	Fine powder with elongate pellets conspicuous; loosely packed in isolated clumps of different sizes; tends to stick together	Yes
Bostrichid powderpost beetles Bostrichidae	Sapwood of hardwoods primarily; minor in softwoods	Seasoning and newly seasoned	Circular, 3/32 to 9/32 inch diameter	Circular, 1/16 to 3/8 inch diameter; numerous; random	Fine to coarse powder; tightly packed, tends to stick together	Rarely
Lyctid powderpost beetles Lyctidae	Sapwood of ring- and diffuse-porous hardwoods only	Newly seasoned with high starch content	Circular, 1/32 to 1/16 inch diameter	Circular, 1/16 inch diameter; numerous; random	Fine, flour-like, loose in tunnels	Yes
Round-headed borers (general) Cerambycidae	Sapwood of softwoods and hardwoods; some in heartwood	Unseasoned, logs and lumber	Oval to circular, 1/8 inch to 3/8 inch diameter	Oval, up to 1/2 inch diameter; size varies with species	Coarse to fibrous; may be mostly absent	No
Old house borer *Hylotrupes bajulus*	Sapwood of softwoods, primarily pine	Seasoning to seasoned	Oval, 1/4 to 3/8 inch diameter	Oval, up to 3/8 inch diameter; numerous in outer sapwood, makes ripple marks on walls	Very fine powder and tiny pellets; tightly packed in tunnels	Yes
Flat oak borer *Smodicum cucujiforme*	Sapwood and heartwood of hardwoods, primarily oak	Seasoning and newly seasoned	Slightly oval; 1/16 to 1/12 inch diameter	Oval, up to 1/12 inch diameter	Fine granules	No
Flat-headed borers Buprestidae	Sapwood and heartwood of softwoods and hardwoods	Seasoning	Oval, 1/16 to 1/2 inch diameter	Flat oval, up to 3/8 inch long diameter; winding	Sawdust-like; may contain light and dark portions if under bark; tightly packed	No
Bark beetles Scolytidae	Inner bark and surface of sapwood only	Unseasoned, under bark only	Circular, 1/16 to 3/32 inch diameter	Circular, up to 3/32 inch diameter; random	Coarse to fine powder; bark-colored; tightly packed in some tunnels	No
Ambrosia beetles Scolytidae	Sapwood and heartwood of hardwoods and softwoods	Unseasoned, logs and lumber	Circular, 1/50 to 1/8 inch diameter	Circular; same diameter as holes; across grain; walls stained	None present	No
Wood-boring weevils Curculionidae	Sapwood and heartwood of hardwoods and softwoods	Slightly damp, decayed	Raggedly round or elongate, 1/16 to 1/12 inch diameter	Circular, up to 1/16 inch diameter	Very fine powder and very tiny pellets; tightly packed	Yes

Adapted from Moore, 1995

You are unlikely to see adult beetles during an inspection, and the larvae are always inside the wood. There is no outside evidence of infestation on wood that has been attacked for only a short time; however, once adult beetles emerge, you will see their small exit holes in the wood. You may also see piles of the fine, flour-like frass (beetle excrement) that sifts from the holes.

Larvae usually pupate in the spring. The newly emerged adults bore holes straight out of the wood, and a large proportion of the females lay eggs in the same wood from which they emerged.

Old House Borer *(Hylotrupes bajulus)*

These beetles are brownish black, slightly flattened, and about $\frac{5}{8}$ to 1 inch long. The segment just behind the head is marked by a shiny ridge and two shiny knobs that suggest a face with two eyes. These beetles have become very common in Pennsylvania.

Despite being called the "old" house borer, this insect is also very common in new construction. This beetle attacks coniferous wood, such as pine, spruce, hemlock, and fir. The female lays her eggs in cracks and crevices on the surface of wood, and the hatched larvae sometimes crawl around before finding a place through which they can bore into the wood. They remain near the surface, feeding on the sapwood and only gradually penetrating deeper as they grow. They do not feed on heartwood.

The larval period may be completed in 2 to 3 years, but it can take as long as 12 or 15 years in dry wood, such as that found in attics. Old house borer tunnels have a distinctive rippled appearance on the inside. Unless the moisture content is high, the tunneling proceeds slowly. The larvae, while chewing with its hard jaws, emit a rasping or clicking sound (very similar to the sound produced by clicking fingernails).

Although this beetle can reinfest wood, the likelihood of this happening in buildings that are occupied, heated, and well ventilated is small.

DETECTION AND MONITORING

It is important to determine exactly which organisms are present and causing damage before deciding on treatment strategies. The actual damage caused by structural pests occurs slowly over a period of months or years, so there is time to study the situation and make a decision. Correct identification of the pest is critical to determining appropriate management strategies. The diagnostic key on the next page will help you identify the pest that is causing the problem. Note that in some cases more than one kind of wood-damaging pest may be present. The diagnostic key describes the major groups of wood-boring beetles and the damage they cause. Wood-boring beetles can be distinguished from one another by the type of frass they produce and the size and shape of the holes they create. It is important to distinguish between those species of beetles that can reinfest wood, causing extensive damage, and those beetles whose damage is limited to one generation.

If you are uncertain about which pest is present, get a professional identification from the Penn State Cooperative Extension office in your county or a pest management professional. The time and potential expense needed to correctly identify the pest will be compensated by the fact that you will be able to develop an effective management program for your school.

Regular Monitoring

Monitoring means looking for signs of damage to the wooden parts of the structure on a regular basis. Information gathered from these regular site inspections should be written down. Include a map of the site with notes about problem areas. Monitoring should show whether a pest problem is getting worse and requires treatment, and whether the treatment has been effective.

TABLE 8.

Diagnostic Key to Wood-Attacking Organisms Based on Symptoms

Fungi: Wood damaged and discolored with shrinkage and/or loss of structural strength. Colored stains or dusty coating on underside of floor, on walls, or on ceilings.

Specific Symptoms	Probable Cause
Blue stain visible in sapwood.	**Blue stain fungus**
Fan-shaped white fungal mat with large, 1-inch-wide, dirty white, brown, or black thread-like strands (mycelia).	**Poria fungus**, or "**dry rot**"
Soft decayed wood with mycelia and checking (cracking) at right angles to the grain of the wood, particularly on floor or perimeter joists. Wood looks brown and crumbles to a powder when touched.	**Brown rot**
White mycelial mass covered with irregular specks or pocks.	**Fomes fungi**

Insects: Holes, tunnels, galleries, or chambers on or beneath the surface of the wood.

Specific Symptoms	Probable Cause
Holes greater than ½ inch in diameter.	**Carpenter bees**
Holes less than ½ inch in diameter.	**Wood-boring beetles**
Galleries or chambers found in wood. The wood surface is easily penetrated with a screwdriver or ice pick.	**Termites**
Earthen tubes or tunnels running from soil to wood.	**Termites**
Swarming winged insects at base of fence post, foundation, or indoors, or a collection of wings but no insect specimens.	**Ants** or **Termites**
Large bumble bee-like insects flying around exterior near the eaves of the house. Some enter large holes. Damage mostly confined to siding or outer boards.	**Carpenter bees**
Sawdust or tiny wood scraps on floor.	**Carpenter ants**

Monitoring for structural pests should be regarded as an ongoing responsibility, repeated every 1 to 5 years depending on the kind of problems in your area. Early detection of structural pest activity will result in considerably less expensive treatment later.

School Staff Responsibilities for Monitoring

All personnel responsible for maintaining wooden structures should be trained to identify the conditions that can lead to infestation by wood-damaging pests. (See the inspection checklist at the end of this chapter.) On page 105 is a list of equipment needed for monitoring.

If monitoring by school personnel indicates signs of termite or wood-boring beetle activity, a more thorough inspection should be made by a pest management professional. These staff members should also be trained to recognize obvious signs of damage, such as those listed under symptoms in Table 8. Although major structural pest management decisions should be based on the recommendations of a trained inspector, having someone on the school district staff who is knowledgeable about structural pests and can supervise outside contractors may improve the quality of pest management and contain costs.

Tools and Safety Equipment for Monitoring Termites and Other Wood-Boring Insects

- Flashlight with spare batteries and bulbs
- Screwdriver or ice pick for probing wood suspected of being infested
- Hammer or similar instrument for hitting wood and listening for indications of hollowness
- Ladder for inspecting roof trim and other off-ground areas
- Moisture meter with a range of at least 15 to 24 percent moisture
- Pencil, clipboard, graph paper, and measuring tape; with these, records can be made precisely on the floor plan or elevation of the building where moisture is evident or wood is damaged
- Tools for opening access entrances into crawl spaces
- Hacksaw blade for checking earth-filled porches adjacent to crawl spaces; when inserted under the sill, the thin portion of the blade should not penetrate beyond the sill or headers
- Good-quality caulk, such as silicone seal, and a caulking gun to plug suspicious exterior cracks and crevices; silicone seal is also available in a thinner consistency that can be applied with a brush

Using a Pest Management Service

When contracting for structural pest management services, the choice of a company should be based partially on their willingness to provide monitoring services for a fee separate and distinct from treatments. Some pest management professionals offer free termite inspections with the expectation that the inspection cost will be covered by the fees for the treatments that follow.

You can use the checklist at the end of this chapter to confirm the thoroughness of an inspection performed by a professional. Inspect both the inside and the outside of the buildings.

If a professional is hired to do the inspection, ask to see locations that were infested and/or were found to have damaged wood. Discovering subterranean termite tubes or beetle damage is not necessarily evidence of an active infestation. Termite tubes or beetle exit holes or frass indicate only that termites or beetles were there at one time. In the case of beetles, the adults that made the exit holes may have been the last beetles that will ever emerge if they are from a species that does not reinfest wood. Treatment of inactive infestations would be an unnecessary expense. Ask for confirmation that living termites or beetles are present, as some companies do not make this confirmation normal practice.

Detection Techniques for Termites

There are several ways to identify termite activity. The observation of swarming reproductives is an indication of a current termite infestation in the area, but simply finding a pile of discarded wings can be misleading. Winged termites are attracted to light and so could come from other areas. If only swarming insects are seen, a distinction must be made between ants and termites. The easiest way to distinguish between the two is to look at their waists. A termite has a broad waist, while an ant has a narrow, wasp-like waist. The four wings of the termite are all of equal length and nearly twice as long as its body, while the front and hind wings of an ant are unequal in length and not twice as long as its body length.

The discovery of a mud tube extending from the soil up to the wood is an indication of probable subterranean termite infestation (these tubes are described on page 101). If only one tube is located, monitoring for other tubes should begin immediately. Break open tubes to see if the termites are active or if the tubes are deserted; an active tube will be rebuilt within a few days. Finding soil in cracks and crevices can also be an indication of subterranean termites.

It isn't always possible to detect damaged wood by looking at the surface. An ice pick can help you probe the wood, and listening for sound differences while pounding on the wood surface can help you find the hollow areas.

For many years the only structural pest detection method available was visual observation by trained, experienced pest management professionals. This method has been improved by such inspection tools as the moisture meter.

The Pick Test

When monitoring your building, use an ice pick or screwdriver to probe wood you think might be decayed based on its color or other changes you detect. Insert the pick about ¼ inch into the wood and press sharply downward perpendicular to the grain. If the wood is sound, a long splinter will pull out of the wood along the grain (as shown in the figure to the right). If the wood is decayed, the splinter will be brittle and break into short pieces across the grain, especially at the point where the pick enters the wood and acts as a lever. You can also detect decayed wood by its lack of resistance relative to sound wood. Mud-sills (wood installed on footings) can be pick-tested without producing excessive visual or structural damage, since they are not visible from outside the crawl space. Sometimes wood treated with a preservative on the surface is decayed inside. The pick test can help reveal these hidden pockets of decay.

Moisture Meters

A moisture meter with a 15 to 24 percent range (to detect favorable conditions for anobiids) will help determine whether or not the moisture content of the wood is high enough to support the growth of wood-inhabiting fungi, wood-boring beetles, or subterranean termites. The needles of the meter should be inserted along the grain of wood to give the most accurate readings. Temperature corrections should be applied to readings taken below 70° and above 90°F (correction tables are supplied with meters). The meters should not be used in wood treated with water-borne wood preservatives or fire retardants.

Monitoring for Beetle Infestations

When wood-boring beetle larvae mature into adults inside the wood, they bore exit holes to the surface to get out. Table 8 on page 104 can help you determine what kind of insect created the holes you find. If it is a beetle, the information in Table 7 on page 102 will help to identify the kind of beetle and whether or not it is capable of reinfesting. Consulting with a professional is also advised.

Discovering beetle damage is not necessarily evidence of an active infestation. Signs that the infestation is still active include fresh frass the color of new-sawn wood and live larvae or adults in the wood. Where you suspect an infestation of the kind of beetles that do not emerge for several years (such as old house borers), you can confirm their presence by listening for the chewing sounds they make inside the wood. To amplify the sounds, use a doctor's stethoscope or a cardboard tube from a roll of paper towels. You can also place a cloth or piece of paper underneath the suspicious area for a week or two to monitor for the fresh debris and frass that are indications of activity for some beetles.

MANAGEMENT OPTIONS

Habitat Modification *(All Wood-Damaging Pests)*

No structural pest management program is complete unless the conditions that favor the survival of the pest are modified. Moisture in or on wood is the single most important predisposing condition for wood damage and structural failure.

Reduce the Moisture Level of the Wood

The investment in installing, fixing, or relocating gutters, siding, roofing, vents, drains, downspouts, and vapor barriers will pay for itself in long-term protection against termites, wood-boring beetles, and fungi. Leaking pipes, drains, sinks, showers, or toilets should be repaired. For wood-boring beetles and fungi, often the only management measures necessary are fixing leaks, installing vapor barriers, and using central heating to dry out wood and keep it dry. The most common wood-boring beetles cannot establish themselves in wood with a moisture content below 8 percent, and the old house borer probably needs more than 10 percent moisture. Wood must contain at least 20 percent moisture before it will support the growth of fungi. Few species of fungi can extend their growth into dry wood, and these fungi are relatively rare.

In cases where wood is excessively damp or difficult to dry out, an immediate treatment by a professional may be necessary.

Ensure Proper Drainage Under Buildings

If the soil under buildings is constantly wet or becomes wet after it rains, this problem should be corrected. Equip downspouts with plastic extensions to direct water away from foundations. Grade the soil around the building to slope gently away from the structure. Installation of a vapor barrier under the building will correct many situations, but more serious moisture accumulations need

other measures. Coat foundation walls with rubberized asphalt membranes to reduce moisture under the building. Extreme cases may require the installation of a sump pump and/or Power Temp-Vent. French drains can also be installed. French drains are lengths of perforated pipe covered with crushed stone placed around and below the foundation footings to catch and conduct water by gravity to a free flowing outlet or sump pump. The drains are normally covered with a building paper or straw before being backfilled with soil to the normal surface grade.

Improve Irrigation or Landscape Practices to Decrease Water Collection Near Buildings
Remember that water that falls on the sides of buildings from sprinklers can cause as many problems as natural rainfall.

Eliminate Direct Contact Between Wood and Soil
Ideally, wood should be at least 8 inches above the soil to prevent direct access by subterranean termites, prevent wood from absorbing excessive moisture, and facilitate the inspection process. Wood in contact with the soil must be replaced with concrete. If wood is too close to the soil, remove some of the soil and grade it so that it slopes away from the building.

Replace Damaged Wood with Treated Wood
After managing the pest problem, if wood must be replaced, especially wood in vulnerable areas, it can be treated with borates (see discussion under Chemical Controls) to protect it from fungal decay and make it less attractive to termites. Whenever wood will be exposed to the weather, it is important to paint a water repellent on the bare wood before it is stained or painted. Depending on the product, water-sealed wood must dry for a few days to over a month before being painted. Studies show that wood treated in this manner resists weathering and decay many years longer than wood that is only painted or stained.

Replace Moisture-Prone Wood with Aluminum, Concrete, or Vinyl
Sometimes it is more cost-effective to eliminate wood altogether from the most vulnerable areas of the building.

Remove Tree Stumps and Wood Debris
Decaying stumps, construction debris, and wood scraps near or under the building can be a source of termite infestation. Remove all wood debris and stumps within 10 feet of foundations. Never bury wood pieces; they can become termite nesting areas. Small pieces of wood debris containing live termites can be soaked in soapy water to kill the insects. Wood debris containing live termites should be taken to a landfill or other area where the natural decomposing abilities of termites are useful.

Store Woodpiles Properly
Firewood or lumber piles should be constructed so that no wood rests directly on the ground. Use cinder blocks or concrete as a base on which to pile lumber or firewood and inspect the pile periodically. Large piles should be as far from the building as is practical; smaller amounts of wood can be moved closer to the building as they are needed, but do not store logs inside or in a place where they can touch the building or a wooden deck.

Plant Trees Away From Buildings
Because trees and shrubs used in landscaping are often planted when young, a common mistake is to site them too close to a structure. Roots, branches and eventually decaying stumps provide avenues for termite, carpenter ant, and wood-boring beetle infestations. Trees and large shrubs may also provide roof rats, squirrels, and other animals nesting places and access to the upper portions of the building. Leaves clog gutters and can lead to water damage.

Mulch
Using termite-resistant mulches may reduce the incidence of termite activity; however, opinions vary on their effectiveness.

Maintain Buildings in Good Repair
The most effective indirect strategy for managing structural pests is keeping buildings in good repair. Keep the skin of the structure sealed using paint, putty, and caulk. Repair cracked foundations by injecting cracks with various materials (patching compounds). Cracks should be chiseled out to a $\frac{1}{2}$-inch depth and $\frac{3}{4}$-inch width before patching. Injectable bonding materials have some elasticity to resist cracking, whereas cement mixes are likely to crack if soil heaving or settlement is causing ongoing foundation movement.

Inspect Lumber
Lumber and other wood items should be carefully examined for wood-boring beetle damage, such as small holes, sawdust, or fine wood fragments, before using or storing. Wooden furniture should be examined carefully for current beetle infestations before placement in the building.

Use Kiln-Dried or Air-Dried Lumber
Although close visual inspection of wood is essential, it is not a guarantee against beetle infestation. Some infestations can go undiscovered for years before damage is seen. Kiln-dried or air-dried lumber should be used in all construction projects.

Physical Controls

For termites, heavily damaged wood should be replaced with sound wood. Wherever possible, use lumber treated with wood preservatives such as borates (see Chemical Controls below). Dispose of infested wood as described above.

For wood-boring beetles, simply removing and replacing infested wood should be the first treatment option you consider. Carefully inspect wood in contact with the pieces that are removed to see if there is further infestation. In some situations, this may not be practical because the wood is inaccessible or labor costs are prohibitive. If any wood has been damaged to the point of structural weakness, it must be replaced or reinforced, no matter what treatment is used.

Chemical Controls

If nonchemical methods alone prove insufficient to solve the problem, then integrating a pesticide into your management program may be warranted. For information on pesticides and on how to select an appropriate pesticide for your situation, consult the Penn State Cooperative Extension office in your county.

Pesticides must be used in accordance with their EPA-approved label directions. **Pennsylvania law allows pesticide applications in schools only by certified applicators, registered technicians, or by non-certified applicators or non-registered technicians under the direct supervision of a certified applicator. Notification must be given to all staff and parents or guardians of students who request it 72 hours prior to pesticide use. Warning signs must also be posted in the vicinity 72 hours prior to and for 48 hours after the application. The law also mandates a 7-hour reentry period for common access areas whenever pesticides are applied.** All labels and Material Safety Data Sheets (MSDS) for the pesticide products authorized for use in the IPM program should be maintained on file. Do not apply these materials in common access areas when occupied, and never apply them where they might wash into a drain or sewer unless otherwise labeled.

Always post durable signs where pesticides have been used in attics and crawl spaces so that future inspectors and repair technicians can identify and avoid the areas where possible.

Borate-Based Wood Treatments (Subterranean Termites and Wood-Attacking Fungi)
Borates are fungicides and slow-acting insecticides. They are not repellent to insects (termites will construct tubes over borate-treated wood), but do act as anti-feedants, which means that pests prefer not to feed on wood treated with borates. When insects feed on wood treated with borate or, in the case of wood-boring beetles, chew emergence holes through treated wood, the borate acts as a stomach poison to kill the insects over a number of days. Borates also act as fungicides by inhibiting the growth of wood-attacking fungi.

Borates are used both in the pretreatment of lumber for the construction industry and in remedial treatment of lumber in existing buildings. Use pretreated lumber to replace existing lumber and prevent reinfestation in areas of potential termite activity or in areas vulnerable to rot. Crawl spaces and attics can be treated by a professional using a borate fogger, by spraying or painting liquid solutions directly on the wood, or by pressure-injecting the solution into the wood. A larger amount must be used in a fogger to get the same coverage as painting or spraying on the solution. Borates can be effective as an insecticide to eliminate small termite and wood-boring beetle infestations.

Since borates are water-soluble, they cannot be used to treat exterior wood unless the finish (paint or stain) or sealant is removed from the wood before treatment, and then a finish or sealant subsequently applied after treatment. Since borates can move easily through the soil and leach away from the area of application, they should not be used in close proximity to lakes, streams, ponds, or areas where there is standing water. High concentrations of borates are toxic to plants, so treatments of the perimeter of buildings can result in inadvertent poisoning of plants and shrubs near the building.

Desiccating Dusts Such as Diatomaceous Earth and Silica Gel (Wood-Boring Beetles)
Desiccating dusts can help prevent future infestations of wood-boring beetles. They are particularly useful in confined spaces such as attics and wall voids where they can remain effective for the life of the building. Desiccating dusts alone are effective and safe. They act primarily as physical, not chemical, agents, but they are commonly combined with pyrethrins.

Desiccating dusts act by abrading the oily or waxy outer layer that coats the body of an insect. Water inside an insect is contained by this waterproof coating, and loss of the coating leads to the death of the insect from dehydration.

Diatomaceous earth has been used against termites as a repellent, but the use of silica gel for termite control is more common. Diatomaceous earth can be easier to handle because it is composed of larger particles than the silica gel. It is important to note that the product described here is not the glassified diatomaceous earth used for swimming pool filters, but rather "amorphous" diatomaceous earth.

Termite Barriers

Using insecticides as termite barriers in the soil relies on uniform distribution in the soil. In some cases, soil characteristics or structural defects may prevent this, and barriers will fail. A pest management professional can provide conventional termite treatments. (For more information on this extensive process, refer to Mallis, 1997, pp. 285–298.)

Termite Baits (Subterranean Termites)

The termite baiting strategy involves two steps: finding termites by placing baits in appropriate sites and then exposing them to a slow-acting toxicant. The toxicant must be slow-acting so that termites have time to go back to the nest to spread the toxicant among their nest mates through food sharing and through mutual grooming. Since termites habitually wall off members of the community and/or galleries when they sense a problem with their food supply, the toxicant must work slowly enough that it goes undetected until a good portion of the colony has been exposed.

Baiting may eliminate a termite colony over a number of months (conventional chemical barrier treatments only try to prevent termites from entering a structure), but elimination may not be practical or necessary. Baiting is an ongoing process—you may eliminate one colony or portion of it, but another colony may eventually attack the structure in the future. Adequate control can probably be achieved by reducing the colony enough that no termites are seen in structures and no professional pest management call-backs are necessary.

Safety of Baits

Much smaller amounts of active ingredient are used in baits than are used in chemical barrier treatments, so there is less risk. Most of the active ingredients used in termite baits have low acute toxicity, and the concentrations in which they are used are generally low. Manufacturers are designing bait stations to be self-contained and tamper-resistant to protect children and animals from accidental exposure.

When to Bait

Because termite activity is seasonal, baiting is more effective at certain times of the year than other times. The best time to bait the eastern subterranean termite *(R. flavipes)* is in the late spring and early summer. Less activity is expected from November to February, although active termites have been found in bait stations in December and January.

Two Types of Baiting Strategies

There are two general types of food baiting that can be used: perimeter baiting or interceptive baiting. If the whereabouts of the termites are unknown, perimeter baiting is used. Wooden stakes, bait blocks, or plastic monitoring stations are set around the perimeter of a structure either in a continuous circle or in a grid pattern. Perimeter baiting relies on the certainty that termites foraging at random will eventually discover the bait. Once termites have been located, either by perimeter baiting or by finding shelter tubes or active galleries, interceptive baiting can be used. Here, actively foraging termites are intercepted with a bait. Interceptive baiting of structures has a disadvantage in that quite often termite damage already has been done, and even though the colony is eliminated, the wood may have to be replaced.

Inspection Checklist for Detecting Structural Decay and Pest Damage

INTRODUCTION

Check the following locations for structural decay and pest damage. Check both visually and by probing with a pointed tool, such as an ice pick (see page 106). Look for signs of moisture, damaged wood, insect frass, and termite earthen tunnels and/or fecal pellets.

ROOF, OVERHANGS, GUTTERS, EAVES, TRIM, AND ATTIC

Check the roof for cracks, missing shingles, and other openings where moisture might enter. Shingles should extend ¾ inch or more beyond the edge of the roof and should form a continuous drip line at the eave and end rafters, or at the rake boards that cover the end rafters.

Remove leaves from the roof surface, and replace any missing shingles. Install flashing or an aluminum drip edge under the first course of shingles to divert rainwater from the fascia board and walls of the building.

Be careful not to block eave vents. Install flashing; it should curl over the forward edge of the fascia board about 2 inches and then run about 6 inches beyond a vertical line drawn from the inside face of the wall studs.

Check for the formation of masses of ice on the roof near the gutters, which can lead to water filtration and/or excessive condensation on interior attic walls.

Gutters

Check for poorly sloped, clogged, rotted, or leaking gutters that can lead to eave, overhang, or siding leaks and rots. Remove leaves and twigs that absorb moisture and cause rot. Flush gutters with a hose before the rainy season. Install downspout leaf strainers and gutter guards.

Attics

Extra effort is needed to inspect areas that are difficult to see or reach. Use a good light source and a probe. Search for rain seepage or decay around vent pipes, antennas, wall-top plates, skylights, and other vents.

Eaves, Overhangs, and Fascia Boards

Make sure there is at least 18 inches of overhang to allow proper water runoff. Extend short overhangs. Search for soft, tunneled, cracked, or exposed areas. Check areas where algae, moss, lichens, or discoloration occurs; these symptoms may indicate moisture problems and termites.

Flashings

Make sure areas around vents, chimneys, and dormers are flush and well sealed. Rusty or broken nails can cause problems in flashings. Aluminum or galvanized nails are required to prevent electrolysis (a chemical reaction between dissimilar metals that causes the nails to disintegrate). Seal nail head and flashing joints with marine-quality caulk or silicone (tar preparations are cheapest, but they crack after a few years in the sun).

Damaged or Discolored Areas

Search for exposed areas that are soft, tunneled, cracked, rotted, or blistered. Check for algae, moss, lichens, or discoloration, since these areas indicate potential openings for fungi and/or insects. Locate the sources of moisture and make the necessary repairs.

OUTSIDE WALLS

Rusty Nails

Check for rusty nails or nail-staining, which indicates moisture within the wall and/or the use of nongalvanized nails. Replace rusty nails with aluminum or galvanized nails or screws.

Deteriorating Paint

Look for signs of deteriorating paint, such as loss of paint sheen and bubbling and peeling. Scrape and sand affected surfaces and repaint. If the wood seems soft, weak, or spongy, scrape out the spongy parts. If holes are smaller than ½ inch in diameter, fill them with caulk. Larger holes can be filled with epoxy wood-filler. If holes are very large, replace the wood.

Stained or Buckled Siding

Stained or buckled siding (with or without peeling paint) is a symptom of underlying moisture, rot, or insects. Check for moisture caused by splashing rain or lawn sprinklers. If possible, remove the source of the moisture and refinish or replace the damaged wood. Consider using a more durable material, such as aluminum siding. Pressure-treated woods are treated with toxic materials, and their use should be minimized.

Most of the information in this chapter is from *IPM for Schools: A How-to Manual.* United States Environmental Protection Agency. EPA 909-B-97-001. March 1997.

Damaged Wood Junctions

Moisture and insect problems often occur where wood pieces join or abut, particularly when there is shrinkage, splintering, or settling. Corners, edges of walls, roof/siding intersections, and siding/chimney contacts are particularly vulnerable. Apply water repellent and caulk to these joints, and monitor them regularly for building movement.

Weathering of Exposed Lumber/Beam Ends

Check for expanded, split, or cracked lumber ends, which provide access for moisture and insects. Even previously treated wood is subject to attack if the openings are deep enough. Caulk cracks and monitor for further developments.

Cracked or Loose Stucco

Search for cracks in stucco, especially stress cracks around windows and doors. These conditions can provide access to moisture, termites, and decay organisms. Caulk cracks. If they are large, consider replacing the old stucco.

Moisture Accumulation Around Laundry Facilities, Especially Dryer Vents

Check for signs of moisture accumulation around the vent. Modify the vent to direct exhaust air away from the building.

Moisture Associated with Pipes and Ducts

Check for moisture where ducts pass through wooden parts of a building. Also check downspouts during heavy rains for leakage and proper drainage. Insulate ducts, install splash guards below downspouts, repair the spouts, and direct water away from buildings.

Moist Window Sills, Windows, or Doors

Check for cracked sills and casings, and poorly fitted windows and doors. Badly fitted doors may indicate warping of the door or its casing from excessive moisture or uneven settling. Moisture problems can alter door jambs. Warped and cracked sills and poorly fitted windows and doors allow water access, which aids decay and provides initial insect habitat.

Caulk cracks and monitor for further development. Warped door thresholds and jambs may need replacement, and casings may need repair if the cracks are too large to caulk effectively.

FOUNDATION AND GRADE

Soil Surface

Make sure the soil surface slopes away from the school building in order to carry water away from the foundation. Seepage under the foundation will cause it to crack and settle. Add fill to direct the water away from the building, but make sure there is at least 8 inches between the top of the fill and the sill. If clearance is small, consider installing foundation "gutters." Install splash blocks and perforated pipe. Check their performance during rains, or test the system with a hose. A sump pump also can be used to move water away from the foundation.

Low Foundation Walls and Footings Allowing Wood-to-Soil Contacts

Check for wood in contact with the soil. Wood should be at least 8 inches, and preferably more, above the soil surface. Low foundation walls or footings often permit wooden structural members to come in contact with the soil, providing access for subterranean termites. Repair these areas or install subgrade concrete "gutters" where the building sills sit too close to ground level. Remove wood that comes in contact with the soil and replace it with concrete.

Foundation Cracks

Check for cracks that give decay organisms access to wood. Cracking may also indicate uneven settling. Monitor cracked walls for discoloration and seepage during rains. Termites use cracks to gain access to wood hidden from view. If the problem is serious, the foundation may need repair.

Brick Veneer or Stucco Applied to the Foundation

Check the bond between the veneer or stucco and the foundation wall. If it is failing, moisture and termites may have a hidden entrance to wooden portions of the building. Remove the loose covering and explore the extent of decay.

CRAWL SPACE, BASEMENT, AND FOUNDATION

Make sure enclosed crawl spaces are vented to allow moist air to escape. Milder climates are especially vulnerable to dry-rot fungus. In humid climates, the subfloor can be wet from condensation from interior air-conditioning. Shrubbery or other obstacles that block airflow through foundation vents cause air underneath the building to stay warm and moist—an ideal environment for termites.

Clean existing vents of dust, plants, and debris. Foundation vent openings should equal 2 square feet of

opening for each 25 linear feet of outside wall. An opening should occur within 5 feet of each corner. Add more vents if needed. The top edge of the concrete under all vents should be at least 6 inches above the finished grade to allow sufficient ventilation. Vents located below grade may require wells to prevent surface water from entering subfloor and basement areas. Divert roof drainage away from vents.

Corners of the Building

Check for moisture accumulation and stains at junctions of wood surfaces in these areas. Install additional cellar or crawl space vents.

Enclosed Areas

Check for proper ventilation under staircases, porches, and other enclosed areas, since these are vulnerable to moisture accumulation. Look for decayed, discolored, or stained areas. Adjust or add venting.

Vapor Barriers

Check for condensation on the subfloor and/or sill, which may indicate the need for vapor barriers on the subfloor and on the soil surface in the crawl space. Such barriers can be installed to reduce the moisture resulting from poor soil grading, unexpected seepage, or high rainfall.

Cover the crawl space soil surface with a 6-mil polyethylene vapor barrier. Use polyethylene instead of roofing paper, which can rot. A slurry of concrete can be placed over the plastic to protect it from rodents. Where condensation continues, consider installing extra vents or electric-powered vents whose fans and openings are operated automatically (Power Temp-Vents). A sump pump can be installed to remove standing water.

Wood-to-Stone or Wood-to-Concrete Contacts

Check to see whether the wood is pressure-treated (look for perforation marks from the chemical injection on the surface of the wood). Replace untreated wood with rot-resistant or pressure-treated wood. Be sure sealing material is used between the wood and stone or concrete, and place a metal washer between posts and footings.

Leaky Pipes or Faucets

Even small leaks keep the wood or soil underneath continuously moist, thereby setting up ideal conditions for termites. Areas where rain splashes on walls should be protected with rain guards. Do not allow sprinklers to spray the side of the building. Fix all leaks, and change irrigation practices where necessary.

Water- or Space-Heating Units

Check to see whether the heating unit is insulated. If the soil near the flame is kept warm throughout the year due to lack of insulation, microbial and insect development will be accelerated. Insulate the heater and cover the soil with concrete.

Paper Collars Around Pipes

Since paper is almost pure cellulose, it is extremely attractive to termites and should be removed and replaced with other insulating materials that termites can not eat.

Miscellaneous Openings

Meter boxes, bathroom inspection doors, pet doors or openings, milk delivery doors, and air exhaust vents should be checked for water access, cracks, termite pellets, and soft areas.

EXTERNAL AREAS

Porches

Check for wooden steps touching the soil, and inspect for possible decay or termite access. The porch surface must slope away from the building to carry rain away quickly. If the porch does not slope away from the building, check siding for moisture and termites. Tongue-and-groove flooring is a water trap.

If there is a space between the porch and the building, check for drainage problems.

Caulk and repair cracks. Fill spaces between tongue-and-groove floorboards with caulk or resurface and refinish with wood-sealing compounds and appropriate paint. Another floor can be placed over the first.

Earth-Filled Porches

Soil should be at least 8 inches, and optimally 12 to 18 inches, below the level of any wooden members. Remove the excess soil where possible, regrade to enhance drainage, and redesign the porch to eliminate earth/wood contact.

Planter Boxes

Check planter boxes that are built against the building. Move them 6 inches away from the building. If they are in direct contact with the building, they allow direct termite access to unprotected veneer, siding, or cracked stucco. One remedy is to allow a 6-inch space between the planter and the building to allow for air circulation and visual inspection. This air space must be kept free of debris.

Trellises and Fences

Check for wooden portions of the trellis that touch the soil and are connected to the building, since they provide a direct link to the building for wood rot and termites. Check fence stringers and posts for decay. Cut off the decay and install a concrete footing for trellises and fence posts. Replace decayed stringers and leave a small gap between the stringers to allow air circulation. Separate wood and concrete with metal washers.

Wooden Forms Around Drains

These are sometimes left in place after the concrete foundation is poured, providing termites with access routes to inner walls. Areas and joints around pipes rising from slabs should be sealed with tar or other adhesive to prevent water and termite access. Caulk the holes and monitor them for decay and excess moisture.

Gate Posts, Fence Tie-ins, Abutments, and Columns

Inspect these for weakness and rot, especially around areas adjacent to the soil. Exposed areas can provide cracks for termite invasion. If wooden posts go through concrete into the soil below, check the posts for evidence of termite attack. The bottoms of these posts should be cut and replaced with a concrete footing. Cut post tops at an angle to promote runoff and prevent water from penetrating the vulnerable end grain.

Balconies and Landings

Surfaces should be sloped away from the building. Check the junction of floor and siding for moisture and insects.

Wood Debris Under and Around Buildings

Pieces of wood, particularly partially buried tree roots or construction lumber, can help support a termite colony until the population grows large enough to attack the building itself. Since cardboard boxes are very attractive to termites, they should be removed from crawl spaces or basements with earthen floors.

INTERIOR LOCATIONS

Areas with water stains or mold growth indicate excessive moisture and should be analyzed for corrective action. Pay special attention to areas listed below.

Kitchen Pipes

Look for condensation and leaks, especially where pipes enter walls. Repair leaks and insulate pipes where condensation is excessive.

Counter Areas

Check around and below sink surfaces for moisture and decay. Caulk or otherwise protect wall surfaces from moisture. Subsurface areas damaged by water leaking from above may be tolerated if the surface leaks are repaired.

Exhaust Vents

Check for moisture leaks from outside. Repair with caulk or water-resistant sealing material, or replace the vent and the rotted wood around it. Use extra flashing to fill the gap.

Toilets

Check the integrity of the floor around each toilet base by thumping lightly with a hammer. Check the wax seal for leakage at the floor/toilet pedestal intersection. If you detect leakage, check the cellar or crawl space beneath the toilets to see whether it has caused damage. Replace the wax seal if necessary, and repair the surrounding water damage.

Showers and Sinks

Check all sinks and showers for a sound caulk seal. Look for splash-over on the floors from inadequate water barriers or user carelessness. If moisture is visible from crawl spaces, it may indicate a crack in the floor or in drainage pipes. If moisture is visible in the ceiling, it may indicate cracks in the delivery pipes.

Repair or replace flooring materials, pipes, drains, or sink basins if necessary. Sealing compounds may be useful when leaks are relatively recent and small, especially if termites have not been found; however, regular monitoring is necessary if sealing materials are used.

Tile Walls

Check for mildew stains. Make sure the grout in tile walls has a silicone coating to prevent water penetration. Clean the walls regularly to remove mildew and improve ventilation.

Ceilings

Check for blistered areas, since these can indicate moisture leaks in the area above or inadequate installation of a vapor barrier. Repair leaks and faulty vapor barriers.

Windows

Check for moisture accumulation and/or water stains on window frames and walls. Search for evidence of decay or insect attack next to glass areas where condensation accumulates, at edges where moldings meet walls and casings, and in window channels and door jambs.

Gaps between window and door casings may be avenues for hidden moisture and insect access. Check interior walls beneath windows, especially if they are regularly wetted by garden sprinklers.

Open windows when feasible to improve air circulation. Install double- or triple-glazed windows when replacement is necessary. Use aluminum frames if wooden frames are decaying. Adjust or move sprinklers so water does not hit windows.

Closets

Check coat and storage closets for dampness. A light bulb left burning continuously in a damp closet often will generate enough heat to dry it out, but make sure the bulb is far enough away from stored materials to avoid creating a fire hazard. Containers of highly absorbent silica gel, activated alumina, or calcium chloride also remove moisture from the air in enclosed spaces. These agents should be placed out-of-reach to avoid accidental exposures. Avoid use of silica gel where children may tamper with the containers. These chemicals can be reused after drying them in the oven. Small exhaust fans also can improve closet ventilation.

Floors

Sagging or buckling floors can indicate shrinkage or rot from excessive condensation or water leaks. Gaps between floor and baseboards can indicate wood damage from insects, fungi, or water-triggered swelling and shrinkage.

IPM for Yellowjackets and Hornets in Schools

INTRODUCTION

Yellowjackets and hornets are both beneficial and problematic wasps. They are important predators and scavengers, helping to manage pests and recycle organic materials, but they also can sting humans and their pets. Although often grouped together with bees, yellowjackets pose a more serious threat to people. Yellowjackets can sting repeatedly, while a bee can sting only once. Multiple stings from yellowjackets are common, because they aggressively defend their nest when it is disturbed.

IDENTIFICATION AND BIOLOGY

"Yellowjacket" and "hornet" are the common names given to wasps in the genera *Dolichovespula*, *Vespula*, and *Vespa*; but for the sake of simplicity, the term "yellowjacket" will be used. Note that these common names are not reliable indicators of whether or not they are pests.

Yellowjackets are relatively short and stout, and hold their legs closer to their bodies than other wasps do. Paper wasps are more slender and have long dangling legs. All yellowjackets are either black and white or black and yellow. They are rapid fliers, and are more aggressive than other types of wasps. Their nests are always enclosed with a papery envelope and can be found in the ground, hanging from eaves or tree branches, and occasionally in wall voids.

The queen begins her nest by building a small comb of chewed wood. She lays eggs in the cells and, after the eggs hatch, tends the larvae herself. Once the larvae develop into adult workers, they expand the nest into tiers, built one on top of the other. In the late summer or early fall, males and new queens are produced. After mating, the queens seek a sheltered place to spend the winter and all the workers die. The nest is not reused and eventually disintegrates.

Early in the warm season, colonies are small and yellowjackets are usually not a problem. Later in the season, when colonies are at their peak, these insects become pestiferous. In their search for protein and carbohydrate sources, they are attracted to garbage cans, dumpsters, lunch counters, and playgrounds, where they scavenge for food.

TABLE 9.

Distinguishing Among Bees, Wasps, Yellowjackets, and Hornets

Name	Appearance	Habits	Nests	Feeding Behavior
Bees	Hairy, stout bodies with thick waists; workers and reproductives are winged	Noisy flight; sting mainly while defending nest; foraging workers seldom sting	In hives, trees, or buildings	Collect pollen and nectar; feed pollen to young and share food with other adult bees
Solitary wasps	Thin- or thick-waisted	Visit flowers and other vegetation; relatively docile	In mud, or in holes in ground	Predators; provision nests with prey for young to feed on
Yellowjackets and hornets	Stout, colorful; mostly black and yellow or black and white	Rapid fliers; aggressive individuals capable of inflicting multiple stings; social in large colonies, which they defend vigorously	Multilayered, papery nests mostly in ground, although some aerial or in structures; nests have an outer papery covering called an "envelope"	Mostly beneficial predators, but scavenger species become pestiferous
Paper (umbrella) wasps	Long bodies with thin waists, long dangling legs	Social; search vegetation for prey; visit flowers for nectar; not particularly aggressive	Single layered, papery nests without an envelope; attached to fences, eaves, boards, branches; shaped like an umbrella	Beneficial predators; feed prey to developing young in nest

Adapted from the *IPM for Schools: A How-to Manual*. United States Environmental Protection Agency. EPA 909-B-97-001. March 1997.

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STINGS

Insect stings are the leading cause of fatalities from venomous animals in the United States. The people who die from yellowjacket or bee stings are people who experience large numbers of stings at once or who suffer severe allergic reactions to the inflammatory substances in the insect venom. These allergic reactions include soreness and swelling, not only at the site of the sting, but also on other parts of the body that may be distant from the site. Other symptoms include fever, chills, hives, joint and muscle pain, and swelling of the lymph glands and small air passageways. In severe cases, the individual may suffer a sudden drop in blood pressure and lose consciousness. While many individuals who experience allergic reactions have become sensitized over time by previous stings, half of all fatalities occur in individuals stung for the first time.

Ordinary reactions to stings include localized pain, itching, redness, and swelling for hours to a day or two after the event.

NEST DISTURBANCE

Yellowjackets that are foraging for food usually will not sting unless physically threatened, such as being squashed or caught in a tight place. But if they feel their nest is in danger, they will vigorously defend it. All wasps defend their colonies, but some yellowjackets are more sensitive to nest disturbance and more aggressive in their defense. Disturbing a yellowjacket nest can result in multiple stings. This can occur when someone accidentally steps

Avoiding and Treating Stings

Children should be taught to stay calm when confronted by a foraging yellowjacket, because quick, jerky motions will frighten wasps and make them more likely to sting. Stillness, or slow, gentle movements, will greatly decrease the probability of being stung. Slowly and carefully brushing off a yellowjacket that has landed on someone, or waiting until it flies off, is better than hitting or constraining it since aroused yellowjackets will sting. Avoid smashing yellowjackets, because when crushed they give off an alarm pheromone that can cause other yellowjackets to attack.

If soft drinks or fruit juices are being consumed on school grounds where there are many yellowjackets, warn children to look into their cups or cans before each sip, because someone can accidentally drink in a wasp and get stung in the mouth or throat. Tell them not to panic if they find a wasp taking a drink. Ideally, all sweet drinks should be in containers with secured lids, and the children can use straws for drinking. It may become necessary to prohibit eating and drinking outside during the peak of the yellowjacket season.

First Aid for Stings

- If the sting is to the throat or mouth, medical attention must be sought immediately, because swelling in these areas can cause suffocation. *Dial 911 immediately* and give the victim an ice cube to suck.

For hypersensitive individuals

- Anyone who is hypersensitive or who experiences difficulty breathing, wheezing, fainting, dizziness, or color changes (turning blue) should be treated by the school nurse and taken to a hospital emergency room immediately. The nurse should have an emergency kit containing preloaded syringes of epinephrine for use with hypersensitive individuals.
- Keep the affected portion of the body below the level of the victim's heart.

For all others

- Wash the area around the sting with soap and water and apply an antiseptic. Washing can help remove the venom from the wound, which will help reduce the pain and swelling from the sting.
- As soon as possible, treat the sting either with ice contained in a cloth or plastic bag or with commercially available products for easing the pain of wasp or bee stings. Ice will help reduce the swelling, and the commercial products will relieve both pain and swelling. Some people claim a paste made of meat tenderizer helps reduce swelling and pain.
- Antihistamines given every few hours, according to label directions, also can prevent pain and swelling.

Have the victim rest.

Do *not* administer sedatives.

on an underground nest opening or disturbs a nest in a shrub or building. Sometimes merely coming near a nest, especially if it has been disturbed previously, can provoke an attack.

Underground nests can be disturbed simply by vibrations. Thus, mowing lawns or athletic fields can be hazardous, and operators may need to wear protective clothing when mowing during the late summer season when colonies are large. It can be very frightening to be the victim of multiple wasp stings. If there are only one or two wasps, back slowly away from them until they stop attacking you. Otherwise, it is best to run away from a colony rapidly, protecting your face and eyes as much as possible.

It is important to educate children about the beneficial role of these wasps (they feed on pest insects, particularly caterpillars) and to remind them repeatedly of ways to avoid stings. Since problems with yellowjackets are most common in late summer and fall, teachers can be provided with this information at the beginning of the fall term. See the box on page 116 for tips on avoiding and treating stings.

DETECTION AND MONITORING

If there is a chronic problem with yellowjackets around outdoor lunch areas or school athletic fields, inspect the area methodically to locate the nests. Nests can be found in the ground, under eaves, and in wall voids of buildings. Ground nests are frequently—but not always—located under shrubs, logs, piles of rocks, and other protected sites. Entrance holes sometimes have bare earth around them. Nest openings in the ground or in buildings can be recognized by observing the wasps entering and leaving.

MANAGEMENT OPTIONS

The objective of a yellowjacket management program should be to reduce human encounters with the wasps, but not to eliminate them from the entire area since they are beneficial predators of insects. The two most productive and least environmentally destructive ways to do this are to modify the habitat to reduce yellowjackets' access to food in the vicinity of human activities, and to use physical controls such as trapping and nest removal. Area-wide poison baiting should be used only as a last resort when other methods have failed and stings are frequent.

Physical Controls

Habitat Modification

Garbage containers on school grounds should have tight-fitting lids. The cans should be emptied frequently enough to prevent the contents from impeding the closure of the lid. The lids and cans should be periodically cleaned of food wastes. Disposable liners can be used and replaced when soiled or damaged.

When these practices are not followed, school garbage (and the flies around it) becomes a food source for yellowjackets in the area. If a large number of wasps are around garbage containers, students may be afraid to get close enough to place garbage all the way inside, and spilled food will attract more wasps.

Dumpsters should be cleaned frequently by washing them with a strong stream of water. If the dumpster service company has a cleaning clause in their contract, make sure it is enforced.

To limit yellowjacket infestations inside the school buildings, repair windows and screens and caulk holes in siding. Building inspections for yellowjackets can be done at the same time as inspections for other pests, such as rats, mice, and termites. Inspections should be conducted monthly to ensure that developing nests are found before they get large enough to be problematic.

Trapping

Trapping with a sturdy trap and an attractive bait can significantly reduce yellowjacket numbers if a sufficient number of traps are used. There are a variety of traps on the market. In general, cone-type traps are more useful for long-term trapping that will last many weeks. In some schools, unbaited yellow sticky traps (like those used to catch whiteflies) affixed to fences near underground nests have provided sufficient management to protect children from stings.

A homemade, cone-type fly trap can be used to catch yellowjackets simply by using the captured flies inside the trap as bait. (See page 61 for instructions on making the fly trap). The yellowjackets enter the trap to get the flies and become trapped themselves (see Tips on Trapping Yellowjackets in a Homemade Cone-Type Fly Trap on page 118). If you use baits such as dog food, ham, fish, or other meat scraps, or fermenting fruit and jelly, **make sure the traps are placed in areas inaccessible to students, because large numbers of yellowjackets may be attracted to the baits.**

However, the traps should be placed near the nest if it can be found, and/or near the area where the yellowjackets are troublesome. Teachers can be instructed to make a short presentation on the purpose of the traps to satisfy the curiosity that students will undoubtedly have. Show students the traps, explain how they work, and try to impress upon them the importance of the traps in maintaining the safety of the playground. Then be sure to move the traps to an area inaccessible to students.

When traps are full they can either be placed in a freezer for a day to kill the wasps or enclosed in a heavy-duty plastic garbage bag and placed in the direct sun for several hours. A third way of killing the wasps is to submerge the traps in a bucket of soapy water until the wasps drown.

The traps should be out only during the period that yellowjackets are a problem, usually late summer and early fall. When the traps are taken down for the year, they should be cleaned with soap and water and stored.

Tips on Trapping Yellowjackets in a Homemade Cone-Type Fly Trap

Yellowjackets can be caught in a cone-type fly trap using only the trapped flies as bait. The following tips will help improve yellowjacket trapping:

- Use this trapping method where students cannot gain access to the traps or at a time when students are not in school.
- Mix the fly bait according to the instructions on pages 62 and 63.
- Set up the fly trap with the fly bait in the area where the yellowjackets are a nuisance.
- If the trap is still attracting only flies after a day or two, move the trap to a new spot around the perimeter of the nuisance area.
- If your trap stops catching yellowjackets at some point, but is still catching flies, try switching to a sweet bait such as fruit punch or jam.

Note: To avoid being stung, you should replenish the fly bait or move the trap in the cool parts of the day—early morning or late evening. To kill everything in the trap before emptying, put the trap into a large plastic garbage bag and seal the bag. Place the bag in direct sunlight for several hours or in a freezer overnight.

Nest Removal

A nest can be destroyed through physical removal (vacuuming) or by using a pesticide (see Chemical Controls). Either way, great care must be exercised, because any disturbance around a nest can cause multiple stings. It is best to have a pest management professional or other experienced person remove the nest. Nest removal should take place at night, when the children are out of school and the yellowjackets are in the nest. When illumination is needed, use a flashlight covered with red acetate film so it will not disturb the wasps.

Adequate protective clothing and proper procedures can minimize problems and stings. It is important to wear protective clothing when removing wasp nests. Complete body coverage is essential, because yellowjackets and other wasps can find even the smallest exposed area. Use clothing made for beekeepers. This includes:

- A bee veil or hood that either contains its own hat or can be fitted over a light-weight pith helmet or other brimmed hat that holds the veil away from the head. A metal-screen face plate that extends around the head is a desirable feature. Check the veil carefully for tears before each use.
- A bee suit or loose-fitting, heavy-fabric coverall with long sleeves. This is worn over regular pants and a long-sleeved shirt to provide extra protection from stings.
- Sturdy, high-topped boots. Secure pant legs over the boots with duct tape to prevent wasps from getting into trousers.
- Gloves with extra-long arm coverings so sleeves can be taped over them to protect the wrists.

Vacuuming

Vacuuming out entire nests is not recommended unless it is done by a pest management professional experienced in handling stinging insects.

Vacuuming is particularly effective when nests occur in wall voids, in emergencies where nests have already been disturbed, and in environmentally sensitive areas where nests should not be treated with insecticides.

Some pest management professionals in some cities will perform this service for free so they can collect the wasps to sell to pharmaceutical companies for their venom. If the school is interested in this option, take time to find a company that will perform this service for you.

Chemical Controls

If nonchemical methods prove insufficient to solve the problem, then integrating a pesticide into your management program may be warranted.

Pesticides must be used in accordance with their EPA-approved label directions. Applicators should always wear protective gear during applications. All labels and Material Safety Data Sheets (MSDS) for the pesticide products authorized for use in the IPM program should be maintained on file. **Pennsylvania law allows pesticide applications in schools only by certified applicators, registered technicians, or by non-certified applicators or non-registered technicians under the direct supervision of a certified applicator. Notification must be given to all staff and parents or guardians of students who request it 72 hours prior to pesticide use. Warning**

signs must also be posted in the vicinity 72 hours prior to and for 48 hours after the application. The law also mandates a 7-hour reentry period for common access areas whenever pesticides are applied.

When an insecticide is considered necessary for the management of yellowjackets, the best approach is to confine it to the nest itself. Anyone applying insecticides should use special clothing that protects against the chemical as well as against wasp stings. Insecticides should be applied in the evening or very early morning when children are absent, the wasps are inside the nest, and cooler temperatures reduce insect activity.

A number of insecticides are registered for use against yellowjackets. The following are most appropriate for use in schools:

Silica Aerogel and Pyrethrins
Silica aerogel combined with pyrethrins is an effective insecticidal dust that can be used to destroy an underground nest or a nest in a wall void. Silica aerogel is made from sand and works by abrading the outer waxy coating on insect bodies. Once this coating is damaged, the insects cannot retain water and die of dehydration.

Products with Components That "Freeze" Wasps
Pyrethrins can be used to quickly knock down guard wasps at the nest entrance and to kill yellowjackets in an aerial nest when they must be destroyed in the daytime. These aerosol products are designed to project a stream of spray 10 to 20 feet and contain highly evaporative substances that "freeze" or stun the yellowjackets.

Do Not Use Gasoline
Gasoline should never be poured into underground nest holes. This dangerous practice creates a fire hazard, contaminates the soil, and prevents the growth of vegetation for some time. A ground application of gasoline poses greater harm to children and the environment than a yellowjacket nest.

Avoid Area-Wide Control Measures
Mass control measures are seldom, if ever, necessary, and they are expensive due to the labor involved in the frequent mixing and replacement of bait. The effectiveness of bait mixtures is also questionable, since the baits face considerable competition from other food sources that are more attractive to scavenging yellowjackets.