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 86 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 89 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.

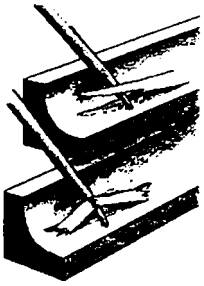
The discovery of a mud tube extending from the soil up to the wood is an indication of probable subterranean termite infestation (these tubes are described on page 85). If only one tube is located, monitoring for other tubes should begin immediately. Break open tubes to see if the termites are active 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 88 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 86 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 noncertified applicators or nonregistered technicians under the direct supervision of a certified applicator. 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.