Chapter 4
Selecting Treatment Strategies

IPM is not simply a matter of substituting "good" pesticides for "bad" pesticides. Too often we want an easy solution, a "magic bullet" that will solve all our problems in one shot. Unfortunately, pest management is complicated, and we cannot always expect a simple solution to pest problems. IPM is based on the fact that combined strategies for pest management are more effective in the long run than a single strategy. A good pest manager considers as many options as possible and tries to combine them into an effective program. The best pest managers have ideas for new and creative ways to solve pest problems. Wherever possible, IPM takes a preventive approach by identifying and removing, to the degree feasible, the basic causes of the problem rather than merely attacking the symptoms (the pests). This prevention-oriented approach is also best achieved by integrating a number of treatment strategies.

Criteria For Selecting Treatment Strategies

Once the IPM decision-making process is in place and monitoring indicates a pest treatment is needed, the choice of specific strategies can be made. Choose strategies that are

- least hazardous to human health
- least disruptive of natural controls in landscape situations
- least toxic to non-target organisms other than natural controls
- most likely to be permanent and prevent recurrence of the pest problem
- easiest to carry out safely and effectively
- most cost-effective in the short- and long-term
- appropriate to the site and maintenance system

Least hazardous to human health

It is particularly important around children to take the health hazards of various strategies into consideration.

Example: Aerosol sprays can kill cockroaches; however, they can also pose potential hazards to humans because the pesticide volatilizes in the air, increasing the likelihood of respiratory or lung exposure of students and staff. In addition, aerosol sprays may leave residues on surfaces handled by students and teachers. When cockroach baits are used instead, the pesticide is confined to a much smaller area, and if applied correctly, the bait will be out of reach of students and staff. Baits volitilize very little so lung exposure is not a problem.

Least disruptive of natural controls

In landscape settings, you want to try to avoid killing off the natural enemies that aid in controlling pest organisms. Unfortunately and for a number of reasons, natural enemies are often more easily killed by pesticides than are the pests. When choosing treatment strategies, always consider how the strategy might affect natural enemies. When choosing a pesticide, try to use one that has less effect on natural enemies. For help in determining this, see the resources listed in Appendix G.

Least toxic to non-target organisms

The more selective the control, the less harm there will be to non-target organisms.

Example: Aphid populations in trees often grow to high numbers because ants harvest the honeydew (sweet exudate) produced by the aphids, and protect them from their natural enemies. The ants that protect these aphid pests are often beneficial in other circumstances, aerating the soil and helping to decompose plant and animal debris. By excluding the ants from the tree with sticky bands around the trunk, it is often possible to achieve adequate suppression of the aphids without harming the ant populations.

Most likely to be permanent and prevent recurrence of the problem

Finding treatments that meet this criteria is at the heart of a successful IPM program because these controls work without extra human effort, costs, or continual inputs of other resources. These treatments often include changing the design of the landscape, the structure, or the system to avoid pest problems. The following are examples of preventive treatments:

- educating students and staff about how their actions affect pest management

- caulking cracks and crevices to reduce cockroach (and other insect) harborage and entry points
- instituting sanitation measures to reduce the amount of food available to ants, cockroaches, flies, rats, mice, etc.
- cleaning gutters and directing their flow away from the building to prevent moisture damage
- installing a sand barrier around the inside edge of a foundation to prevent termites from crawling up into the structure
- using an insect growth regulator to prevent fleas from developing in an area with chronic problems

Easiest to carry out safely and effectively

While the application of pesticides may seem comparatively simple, in practice it may not be the easiest tactic to carry out safely or effectively. Use of conventional pesticides often involves wearing protective clothing, mask, goggles, etc. In hot weather, people are often reluctant to wear protective gear because of the discomfort this extra clothing causes. By choosing not to wear the protective clothing, applicators not only violate the law, but also risk exposure to toxic materials.

Most cost-effective in the short- and long-term

In the short-term, use of a pesticide often appears less expensive than a multi-tactic IPM approach; however, closer examination of the true costs of pesticide applications over the long-term may alter this perception. In addition to labor and materials, these costs include mandatory licensing, maintaining approved pesticide storage facilities, disposing of unused pesticides, liability insurance, and environmental hazards.

Other factors to consider are whether a particular tactic carries a one time cost, a yearly recurring cost or a cost likely to recur a number of times during the season. When adopting any new technology (whether it be computers or IPM), there will be some start-up costs. Once the program is in place, IPM generally costs less than or about the same as conventional chemically-based programs (see the discussion on “Assessing Cost Effectiveness” in Chapter 3).

In addition, parental and community concern about the use of conventional pesticides may make <u>any</u> use of pesticide in and around schools problematic. A public relations headache can develop over comparatively innocuous incidents, and require substantial amounts of time from the highest paid employees of the school district to attend meetings, prepare policy statements, etc. These costs should also be factored into the pest control equation.

Appropriate to the weather, soils, water, and the energy resources of the site and the maintenance system

Skillfully designed landscapes can reduce pest problems as well as use of water and other resources. We cannot stress enough the importance of choosing the right plant for the right spot. Plants that are forced to grow in unsuitable sites where they are unable to thrive will be a continual source of problems. When plants die on the school site, take the time to find a replacement that is suited to the landscape.

Timing Treatments

Treatments must be timed to coincide with a susceptible stage of the pest and, if at all possible, a resistant stage of any natural enemies that are present. Sometimes the social system (i.e., the people involved or affected) will impinge on the timing of treatments. Only monitoring can provide the critical information needed for timing treatments and thereby make them more effective.

Example: To control scales on plants using a low-toxic material such as insecticidal soap or horticultural oil, it is necessary to time treatments for the period (often brief) when immature scales (crawlers) are moving out from under the mother scales, seeking new places to settle down. It is at this stage that scales are susceptible to soaps and oils.

Spot Treatments

Treatments, whether pesticides or non-toxic materials, should only be applied when and where needed. It is rarely necessary to treat an entire building or landscape area to solve a pest problem. By using monitoring to pinpoint where pest numbers are beginning to reach the action level and confining treatments to those areas, costs and exposure to toxic materials can be kept to a minimum.

Summary of Available Treatment Options

The following is a list of general categories of treatment strategies. We have included some examples to help illustrate each strategy. The list is not intended to be exhaustive since products change, new ones are discovered or invented, and ingenious pest managers develop new solutions to old problems every day.

Education

Education is a cost-effective pest management strategy. Information that will help change people's behaviors—particularly how they dispose of wastes and store food—plays an invaluable part in managing pests like cockroaches, ants, flies, yellowjackets, and rodents. Education can also increase people's willingness to share their environment with other organisms so that people are less likely to insist on toxic treatments for innocuous organisms. Teaching children about IPM will have a long-term effect on the direction of pest management in this country as these students grow up to become consumers, educators, policy makers, and researchers.

Habitat Modification

Pests need food, water, and shelter to survive. If the pest manager can eliminate or reduce even one of these requirements, the environment will support fewer pests.

Design or Redesign of the Structure

Design changes can incorporate pest-resistant structural materials, fixtures, furnishings, etc. Sometimes these changes can entirely eliminate pest habitat. For example, buildings designed without exterior horizontal ledges will reduce pigeon problems. Inside, industrial, stainless steel wire shelving mounted on rolling casters helps reduce roach habitat and facilitates cleanup of spilled food.

Sanitation

Sanitation can reduce or eliminate food for pests such as rodents, ants, cockroaches, flies, and yellowjackets.

Eliminating Sources of Water for Pests

This involves fixing leaks, keeping surfaces dry overnight, and eliminating standing water.

Eliminating Pest Habitat

How this can be done will vary depending on the pest, but some examples are caulking cracks and crevices to eliminate cockroach and flea harborage, removing clutter that provides roach habitat, and removing dense vegetation near buildings to eliminate rodent harborage.

Modification of Horticultural Activities

Planting techniques, irrigation, fertilization, pruning, and mowing can all affect how well plants grow. A great many of the problems encountered in school landscapes are attributable to using the wrong plants and/or failing to give them proper care. Healthy plants are often likely to have fewer insect, mite, and disease problems. It is very important that the person responsible for the school landscaping have a good foundation of knowledge about the care required by the particular plants at the school or be willing to learn.

Design or Redesign of Landscape Plantings

- choosing the right plant for the right spot and choosing plants that are resistant to or suffer little damage from local pests. This will take some research. Ask advice of landscape maintenance personnel, local nurseries, local pest management professionals, and County Extension agents or the master gardeners on their staffs
- including in the landscape flowering plants that attract and feed beneficial insects with their nectar and pollen, e.g., sweet alyssum (Lobularia spp.) and flowering buckwheat (Eriogonum spp.), species from the parsley family (Apiacae) such as yarrow and fennel, and the sunflower family (Asteraceae) such as sunflowers, asters, daisies, marigolds, zinnias, etc.
- diversifying landscape plantings—when large areas are planted with a single species of plant, a pest can devastate the entire area

Physical Controls

Vacuuming

A heavy duty vacuum with a special filter fine enough to screen out insect effluvia (one that filters out particles down to 0.3 microns) is a worthwhile investment for a school. Some vacuums have special attachments for pest control. The vacuum can be used not only for cleaning, but also for directly controlling pests. A vacuum can pull cockroaches out of their hiding places; it can capture adult fleas, their eggs, and pupae; and a vacuum can be used to collect spiders, boxelder bugs, and cluster flies.

Trapping

Traps play an important role in non-toxic pest control; however, in and around schools, traps may be disturbed or destroyed by students who discover them. To prevent this, place them in areas out of reach of the students in closets, locked cupboards, etc. Another strategy is to involve students in the trapping procedures as an educational activity so they have a stake in guarding against trap misuse or vandalism.

Today a wide variety of traps is available to the pest manager. Some traps are used mainly for monitoring pest presence. These include cockroach traps and various pheromone (insect hormone) traps, although if the infestation is small, these traps can sometimes be used to control the pest. Other traps include the familiar snap traps for mice and rats, electric light traps for flies, and flypaper. There are also sticky traps for whiteflies and thrips, cone traps for yellowjackets, and box traps for skunks, raccoons, and opossums.

Barriers

Barriers can be used to exclude pests from buildings or other areas. Barriers can be as simple as a window screen to keep out flying and crawling insects or sticky barriers to exclude ants from trees. More complicated barriers include electric fences to keep out deer and other vertebrate wildlife and L-shaped footings in foundations to exclude rodents.

Heat, Cold, Electric Current

Commercial heat treatments can be used to kill wood-destroying pests such as termites. A propane weed torch can be used to kill weeds coming up through cracks in pavement. Freezing can kill trapped insects such as yellowjackets before emptying traps, kill clothes moths, and kill the eggs and larvae of beetles and moths that destroy grain. The "Electrogun®", which passes an electric current through wood, can be used for killing termites.

Removing Pests by Hand

In some situations removing pests by hand may be the safest and most economical strategy. Tent caterpillars can be clipped out of trees, and scorpions can be picked up with kitchen tongs and killed in soapy water or in alcohol.

Biological Controls

Biological control uses a pest's natural enemies to attack and control the pest. We use the word "control" rather than "eliminate" because biological control usually implies that a few pests must remain to feed the natural enemies. The exception to this is a separate category of biological control called microbial control which includes the use of plant and insect pathogens. Microbial controls are generally used like pesticides to kill as many pests as possible. Biological control strategies include conservation, augmentation, and importation.

Conservation

Conserving biological controls means protecting those already present in the school landscape. To conserve natural enemies you should do the following:

- Treat only if injury levels will be exceeded.
- Spot treat to reduce impact on non-target organisms.
- Time treatments to be least disruptive in the life cycles of the natural enemies.
- Select the most species-specific, least-damaging pesticide materials, such as Bacillus thuringiensis, insect growth regulators that are specific to the pest insect, and baits formulated to be attractive primarily to the target pest.

Augmentation

This strategy artificially increases the numbers of biological controls in an area. This can be accomplished by planting flowering plants to provide pollen and nectar for the many beneficial insects that feed on the pest insects or purchasing beneficials from a commercial insectary. Examples of the best known commercially available natural enemies include lady beetles, lacewings, predatory mites, and insect-attacking nematodes. These are but a very small part of the large and growing number of species now commercially available for release against pests. Learning when to purchase and release them and how to maintain them in the field should be emphasized in any landscape pest management program.

Importation

People often ask if parasites or predators can be imported from another country to take care of a particularly disruptive pest in their area. It is true that the majority of pests we have in North America have come from other parts of the world, leaving behind the natural enemies that would normally keep them in check. "Classical" biological control involves searching for these natural enemies in the pest's native area and importing these natural enemies into the problem area. This is not a casual adventure: it must be done by highly trained specialists in conjunction with certain quarantine laboratories approved by the USDA. Permits must be obtained and strict protocols observed in these laboratories.

The whole process takes a good deal of money to pay for the research, travel, permits, etc. Unfortunately, there is a dwindling amount of money for biological control research and importation, and what money there is goes to the biggest pests; therefore, unless there is an increase in funding in the near future, few of the pests that plague schools will become the object of biological control importations. Public knowledge about the value of importation projects can help stimulate funding and additional importations. Once the imported natural enemies become established in their new home, they usually provide permanent control of the pest. Patience is needed, however, because establishment can take several years.

Microbial controls

Microbial controls are naturally occurring bacteria, fungi, and viruses that attack insects and weeds. A growing number of these organisms are being sold commercially as microbial pesticides. Because each of these microbial pesticides attacks a narrow range of pests, non-target organisms are much less likely to be affected.

The most well-known microbial insecticide is *Bacillus thuringiensis*, or "BT." The most widely sold strain of BT kills caterpillars. Another strain kills only the larvae of black flies and mosquitoes, and a third strain kills only certain pest beetles.

Microbial herbicides made from pathogens that attack weeds are commercially available for use in agricultural crops. In the near future, there may be commercial products for use in urban horticultural settings.

Least-Toxic Chemical Controls

The health of school residents and long-term suppression of pests must be the primary objectives that guide pest control in school settings. To accomplish these objectives an IPM program must always look for alternatives first and use pesticides only as a last resort.

Many people are familiar with insecticides such as malathion, fungicides such as benomyl (Benlate®), and herbicides such as 2,4-D. These and similar materials have engendered controversy over possible hazards they pose to human health and the environment. There are many other chemical products to choose from that are relatively benign to the larger environment and at the same time effective against target pests.

"Least-toxic" pesticides are those with all or most of the following characteristics: they are effective against the target pest, have a low acute and chronic toxicity to mammals, biodegrade rapidly, kill a narrow range of target pests, and have little or no impact on non-target organisms. More and more such products are reaching the market. These include materials such as the following:

- pheromones and other attractants
- insect growth regulators (IGRs)
- repellents
- desiccating dusts
- pesticidal soaps and oils
- some botanical pesticides

Pheromones

Animals emit substances called pheromones that act as chemical signals. The sex pheromones released by some female insects advertise their readiness to mate and can attract males from a great distance. Other pheromones act as alarm signals.

A number of pheromone traps and pheromone mating confusants are now commercially available for insect pests. Most of the traps work by using a pheromone to attract the insect into a simple sticky trap. The mating confusants flood the area with a sex pheromone, overwhelming the males with stimuli and making it very difficult for them to pinpoint exactly where the females are.

Insect Growth Regulators (IGRs)

Immature insects produce juvenile hormones that prevent them from metamorphosing into adults. When they have grown and matured sufficiently, their bodies stop making the juvenile hormones so they can turn into adults. Researchers have isolated and synthesized some of these chemicals and when they are sprayed on or around certain insects, these insect growth regulators prevent the pests from maturing into adults. Immature insects cannot mate and reproduce, so eventually the pest population is eliminated. The IGRs methoprene and fenoxycarb are used to suppress fleas, and hydroprene is used against cockroaches.

Since humans and other mammals don't metamorphose as insects do, our bodies do not recognize juvenile hormones.

Repellents

Some chemicals repel insects or deter them from feeding on treated plants. For example, a botanical insecticide extracted from the neem tree (Azadirachta indica) can prevent beetles and caterpillars from feeding on treated rose leaves. Current research shows that neem has a very low toxicity to mammals. A number of neem products are currently available.

Desiccating Dusts

Insecticidal dusts such as diatomaceous earth and silica aerogel, made from natural materials, kill insects by absorbing the outer waxy coating that keeps water inside their bodies. With this coating gone the insects die of dehydration.

Silica aerogel dust can be blown into wall voids and attics to kill drywood termites, ants, roaches, silverfish, and other crawling insects.

Pesticidal Soaps and Oils

Pesticidal soaps are made from refined coconut oil and have a very low toxicity to mammals. (They can be toxic to fish, so they should not be used around fish ponds.) Researchers have found that certain fatty acids in soaps are toxic to insects but decompose rapidly leaving no toxic residue. Soap does little damage to lady beetles and other hard-bodied insects but could be harmful to some soft-bodied beneficials. A soap-based herbicide is available for controlling seedling stage weeds; the soap kills the weeds by penetrating and disrupting plant tissue. Soap combined with sulfur is used to control common leaf diseases such as powdery mildew.

Insecticidal oils (sometimes called dormant oils or horticultural oils) also kill insects and are gentle on the environment. Modern insecticidal oils are very highly refined. Unlike the harsh oils of years ago that burned leaves and could only be used on deciduous trees during the months they were leafless, the new oils are so "light" they can be used to control a wide variety of insects even on many bedding plants.

Note that it as always wise to test a material on a small portion of the plant first to check for damage before spraying the entire plant.

Botanical Pesticides

Botanical pesticides, although they are derived from plants, are not necessarily better than synthetic pesticides. Botanicals can be easily degraded by organisms in the environment; however, plant-derived pesticides tend to kill a broad spectrum of insects, including beneficials, so they should be used with caution. The most common botanical is pyrethrum, made from crushed petals of the pyrethrum chrysanthemum flower. "Pyrethrins" are the active ingredient in pyrethrum, but "pyrethroids" such as resmethrin and permethrin have been synthesized in the laboratory and are much more powerful and long-lasting than the pyrethrins. Neem, another botanical pesticide, is discussed above under "Repellents." Some botanicals, such as nicotine or sabadilla, can be acutely toxic to humans if misused, and rotenone is very toxic to fish. The same care must be used with these materials as with conventional insecticides.

How to Select a Pesticide for an IPM Program

When contemplating the use of a pesticide, it is prudent to acquire a Material Safety Data Sheet (MSDS) for the compound. MSDS forms are available from pesticide suppliers and contain some information on potential hazards and safety precautions. See the Recommended Readings section of this manual for other reference materials on pesticides. Appendix G lists organizations that provide information on pesticide toxicity.

The following criteria should be used when selecting a pesticide: safety, species specificity, effectiveness, endurance, speed, repellency, and cost.

Safety

This means safety for humans (especially children), pets, livestock, and wildlife, as well as safety for the overall environment. Questions to ask are as follows:

- What is the acute (immediate) and chronic (long-term) toxicity of the pesticide? Acute toxicity is measured by the "LD_{50}," which is the lethal dose of the pesticide required to kill 50% of the test animals (measured in milligrams of pesticide per kilogram of body weight of the test animal). The higher the LD_{50} value, the more poison it takes to kill the target animals and the less toxic the pesticide. In other words, high LD_{50}= low toxicity. Chronic toxicity refers to potential health effects from exposure to low doses of the pesticide for long periods of time. Chronic effects can be carcinogenic (cancer-causing), mutagenic (causing genetic changes), or teratogenic (causing birth defects). Sources of information on health effects of pesticides are provided in Appendix G.
- How mobile is the pesticide? Is the compound volatile, so that it moves into the air breathed by people in the building? Can it move through the soil

into the groundwater? Does it run off in rainwater to contaminate creeks and rivers?

- What is the residual life of the pesticide? How long does the compound remain toxic in the environment?
- What are the environmental hazards listed on the label? What are the potential effects on wildlife, beneficial insects, fish, or other animals?

Species Specificity

The best pesticides are species-specific; that is, they affect just the group of animals or plants you are trying to suppress. Avoid broad-spectrum materials that kill many different organisms because they can kill beneficial organisms that keep pests in check. When broad-spectrum materials must be used, apply them in as selective a way as possible by spot-treating.

Effectiveness

This issue is not as straightforward as it might seem, since it depends on how effectiveness is being evaluated. For example, a pesticide can appear to be very effective in laboratory tests because it kills 99% of the test insects. But in field tests under more realistic conditions, it may also kill 100% of the pest's natural enemies. This will lead to serious pest outbreaks at a later date.

Endurance

A pesticide may have been effective against its target pest at the time it was registered, but if the pest problem is now recurring frequently, it may be a sign that the pest has developed resistance to the pesticide or, stated otherwise, that the pesticide has lost its endurance.

Speed

A quick-acting, short-lived, more acutely-toxic material might be necessary in emergencies; a slow-acting, longer-lasting, less-toxic material might be preferable for a chronic pest problem. An example of the latter is using slower-acting boric acid for cockroach control rather than a quicker-acting but more toxic organophosphate.

Cost

This is usually measured as cost per volume of active ingredient used. Some of the newer, less-toxic microbial and botanical insecticides and insect growth regulators may appear to be more expensive than some older, more toxic pesticides. But the newer materials tend to be effective in far smaller doses than the older materials—one container goes a long way. This factor, together with their lower impact on the environment, often makes these newer materials more cost effective.

Notification and Posting

School systems have the responsibility to inform occupants when they may be exposed to pesticides. Unless it is an emergency situation, the applications should be performed when only maintenance staff are present and the building is otherwise unoccupied. Notifications of all pending treatments using a pesticide should be sent home to the students' parents and be distributed to all school staff prior to the treatment.

Schools should direct concerned parents to the school pest manager for more specific information. A voluntary registry of individuals with medically-documented problems that could be adversely affected by exposure to pesticides should be kept at each school's office and in the pest manager's office for special contact in emergency situations.

Post all areas to be treated or that have been treated. If posting is a new practice at the school, the new policy should be explained in the context of the IPM program so that all affected parties will understand that the posting is part of a new overall effort to reduce pesticide use and not the result of new or heavier pesticide use.

Pesticide Use Guidelines

In addition to becoming informed about the characteristics of the material itself, it is important to develop guidelines to be followed each time a pesticide is used. Prepare a checklist to be used each time an application is made. The following are important items to include on the checklist:

- Make sure the pesticide is registered for use in the state. (Pesticides can be registered in some states and not in others.) What are the laws regarding its use?

- READ THE PESTICIDE LABEL. Follow its restrictions and directions for use, labeling, and storage exactly.
- If required, secure a written recommendation from a licensed pest control adviser for using the pesticide.
- Make sure that all safety equipment and clothing (e.g., neoprene gloves, goggles, respirator, hat, and other protective coverings as necessary) is available and worn when the pesticide is used.
- Verify that the person doing the application is certified and/or qualified to handle the equipment and material chosen and has been adequately trained.
- Make sure application equipment is appropriate for the job and properly calibrated.
- Confine use of the material to the area requiring treatment (spot-treat).
- Keep records of all applications and copies of MSDS sheets for all pesticides used.
- Monitor the pest population after the application to see if the treatment was effective and record results.
- Be prepared for all emergencies and compile a list of whom to call for help and the kinds of first aid to be administered before help arrives. Place the list in an accessible area near a phone.
- Dispose of pesticides properly. DO NOT pour pesticides down the drain, into the toilet, into the gutter, or into storm drains! If you are unsure about how to dispose of the pesticide, call the manufacturer or your local utility company that handles sewage and storm drains.

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