SECTION 3

Monitoring Pest Populations and Damage

IPM is based on consistently inspecting and monitoring for pests. The purpose of monitoring is to supply recent, accurate information with which appropriate decisions for managing pests can be made. Guidelines for making appropriate decisions can be established prior to monitoring (see section 4 on "Setting Injury and Action Levels"). Since each site is different, pest management decisions will depend on the circumstances encountered.

Monitoring as part of IPM was originally developed for agriculture. Over the years, this concept has been adapted for gathering information on pests of landscapes and structures in urban settings.

A regular and ongoing monitoring program will help answer the following questions:

- What is the extent of existing pest problems?
- Where are they located?
- What other pest problems exist?
- How are pests entering the building?
- What are the pests' sources of food, water, and shelter?
- Are there conditions conducive to future pest problems that can be corrected?

This section provides a general overview of how to set up and operate a monitoring program. Detailed discussions on monitoring techniques for individual pests are provided in Part 2.

3.1 What Is Monitoring?

Monitoring is the planned, regular visual inspection of an ornamental planting, landscape or structure for detecting pests, pest damage or conditions conducive to pests or pest damage. Monitoring should take place in areas where pest problems do or might occur. Monitoring frequently includes the use of pest traps, such as sticky traps for cockroaches. Information gathered from these inspections is always written down to help determine what actions to take. Examples of monitoring forms are provided in **Appendix M**. An inspection checklist for detecting structural decay and structural pest damage is provided in **Appendix N**.

3.1.1 Not Enough Time or Money?

Time and money will constrain what will realistically be possible. The most important thing is to go out and look at the problems, and write down what is observed. Figure out how monitoring can be included along with routine maintenance activities to ensure that this will be done. Make sure that personnel who are asked to monitor understand what to look for and how to record the information. Supply them with easy-to-use monitoring forms whenever they go out. If the school is contracting out its pest control services, give the pest control company copies of these forms to use or have them develop their own forms subject to the approval of the school's pest manager.

3.1.2 Levels of Effort Used in Monitoring

Monitoring need not be time consuming. The idea is to match the level of monitoring effort to the importance of the problem. Monitoring can vary from the extremely casual to the statistically strict, depending on what is most appropriate. The levels of effort are:

1. Reports from other people's (e.g., teachers) informal observations. This can be useful if used with a pest-sighting log to record verbal reports.
2. Monitoring as part of other tasks, with written observations. This serves to catch pest problems as they begin.
3. Careful inspection with written observations should be conducted when pest problems are significant.
4. Regular written observations and quantitative descriptions are appropriate when working on a pest problem related to public health.

3.2 Why Monitor?

A monitoring program increases familiarity with the workings of the target system. This knowledge allows anticipation of conditions that can trigger pest problems, and thus prevent them from occurring or catch them before they become serious. Monitoring enables intelligent decisions to be made about pest management actions, such as sealing cracks or setting traps.

Monitoring helps determine if action is needed. Is the pest population getting larger or smaller? If plants are being monitored, is the natural enemy population getting larger or smaller? These questions affect whether or not treatment is needed. These answers depend on inspection of the problem sites on several different occasions. How many pests or how much pest damage can be tolerated? This is also referred to as setting injury and action levels, which is discussed in detail in section 4. Even when tolerance for pest presence is at or near zero, as in the case of rats, monitoring will result in early pest detection, reducing the likelihood of unexpected pest outbreaks.

Monitoring helps determine where, when, and what kind of treatments are needed. This includes preventive treatments such as pest proofing and sanitation. Monitoring will show where these are most needed. It is unnecessary (and expensive) to treat all parts of a building or all plants on the school grounds for a pest when not all areas may be equally infested. Monitoring will pinpoint infestations and problem areas. On plants, monitoring will help time treatments to target the most vulnerable stage of the pest. The vulnerable stage may vary depending on the type of treatment used.

Monitoring allows evaluation of pest management actions. Monitoring after an action will show the success or failure of that action, so that future actions can be modified.

- Did the action reduce the number of pests below the level that causes intolerable damage?
- How long did the effect last?
- Did the action have to be repeated?
- Were there undesirable side effects?
- Do pest management action plans need to be adjusted?

3.3 What to Monitor?

Monitoring plants and their pests includes the regular observation and recording of:

- The condition of the plants (their vigor and appearance).
- The kind and abundance of pests (e.g., insects, mites, moles, and weeds) as well as natural enemies (e.g., ladybugs, spiders, lacewing larvae, and syrphid fly larvae).
- The amount of plant damage.
- Weather conditions (record any unusually dry, hot, wet, or cold weather in the last few weeks).
- Human behaviors that affect the plants or pests (e.g., foot traffic that compacts the soil, physical damage to plants caused by people, and insistence on having certain plants grow in inappropriate situations).
- Cultural practices (e.g., pruning, fertilizing, mulching, and treating pests) and their effects on the plants and the pest population.

Tables 3-1 and **3-2** provide more information to help quantify monitoring information. Using the abundance ratings in **Table 3-2** will make monitoring faster and easier, and will help standardize observations. If data that is more precise is needed, count the number of pests or their signs in a given area or on a certain number of leaves.

Monitoring weeds should be a seasonal activity timed to determine new weed pests or those that escaped treatment.

- Evaluate cultural practices that may favor weeds such as mowing, aeration, fertilizer use and irrigation practices.
- Review foot traffic patterns that may increase weeds.
- Monitor in spring and summer when most weeds are present and can be identified.

Monitoring structures involves the regular observation and recording of:

- The conditions of the building inside and out (e.g., structural deterioration, holes that allow pests to enter, and conditions that provide pest harborage).
- The level of sanitation inside and out (e.g., waste disposal procedures, level of cleanliness inside and out, and conditions that supply food to pests).
- The amount of pest damage and the number and location of pest signs (e.g., rodent droppings, termite shelter tubes, and cockroaches caught in traps).
- Human behaviors that affect the pests (e.g., working conditions that make it impossible to close doors or screens, food preparation procedures that provide food for pests, etc.).
- Management activities (e.g., caulking, cleaning, setting out traps, and treating pests) and their effects on the pest population.

Table 3-3 provides specific information on monitoring tools for both plants and structures.

3.4 Identifying the Target Pest

It is extremely important to correctly identify the problem pest and the cause of the pest problem. A pest cannot be effectively managed without knowing what it is or why it is present. For instance, putting out mousetraps to control what is really a rat problem can only result in failure. Setting out ant baits without caulking

their entry point will not prevent more ant problems later. The UC IPM Pest Notes in Part 2 provide information that will help identify some of the most common pests found in and around schools. Take a specimen to a professional for identification for unusual pests. **Appendix K** describes how to properly collect and preserve an insect or plant specimen when seeking identification.

Once the pest is identified, read about its life cycle, food sources, habitat preferences, and natural enemies. Part 2, the UC IPM Pest Notes, will provide this information for the common pests, but if the pest is not included here, check the *Recommended Reading* section, **Appendix H**, at the end of this manual for books that can help. Knowing the life habits of the pest will give clues about what to look for when monitoring and help decide how to best manage the pest.

If only damage symptoms and not the pest itself are visible, a sleuthing job is in order. More observation or observation at a different time of day may be necessary. Talk to other pest management professionals, local gardeners, nursery personnel, Cooperative Extension staff, or university researchers.

3.5 Timing Monitoring Activities

Timing and frequency of monitoring differs depending on the site and the pest(s). Outdoors, monitoring usually begins when plants put out new leaves in spring, and ends when leaves fall in autumn. Plants with annually recurring pest problems receive more attention than relatively pest-free plants. Monitoring can be incorporated into routine grounds maintenance activities such as weekly mowing, or can be a separate activity that occurs bi-weekly, monthly, or less frequently, depending on plant, pest, site, weather, and other factors.

Indoors, monitoring might occur weekly during the early stages of solving a serious pest infestation, then taper off to monthly, once the pest problem is under control. Some pests are more active at night than during the day, thus, some monitoring may need to occur after dark. This is usually only necessary when trying to identify a nocturnal pest or trying to determine its travel routes and feeding habits. Once this is known, nighttime monitoring can often be replaced by daytime inspection of traps and plant foliage for signs of pest presence.

3.6 Recordkeeping

A monitoring program is only as useful as its recordkeeping system. Records serve as the memory of the IPM program. Written records should be kept since they are more accurate and detailed than human memory. Use of written records can avoid erroneous conclusions when comparing effects of treatment or other variables on the pest problem.

Recordkeeping is important to the pest manager because:

- Written observations about the specific pests and their management increase the pest manager's knowledge.
- More can be learned about the specific pest problems because details, such as past treatment success or failure, won't be forgotten.

Recordkeeping is important to the school system and the IPM program because:

- Monitoring records form the basis for making decisions on the most sensible distribution of available resources to the areas most in need of attention or observation.

- Information can be easily and accurately passed from one employee to another.
- Information is not lost when employees leave or retire.

What Should the Records Show?

The record should always show:

- **What** is being monitored—name of the pest (common name and scientific name, if possible), stage of the pest (immature, adult), and for landscape pests, the name of the plant.
- **Where** monitoring is done—a map is always useful.
- **When** monitoring occurs—date and time.
- **Who** is doing the monitoring?

The rest of the information to record is listed under "What to Monitor," above. As mentioned before, the information in **Tables 3-1** and **3-2** will help to standardize some of the observations. **Table 3-1** is specifically for plants, but **Table 3-2** can be used for structural pests as well as plant pests.

It is also important to standardize the format and the process by which the records are kept in order to maintain continuity from season to season and person to person. See **Appendix M** for sample forms. Design forms with boxes to be checked off so less writing will be necessary.

Pest patterns emerge quickly when data gathered during monitoring are made visual, facilitating decision-making. This can be done by hand on graph paper, or by using one of the many graph-making features included in spreadsheet software. **Figure 3-1** shows fluctuations in cockroach trap counts.

No Time for Recordkeeping?

Try to make recordkeeping as easy and practical as possible. A person who is on the site frequently should be the person who monitors and keeps records. Try other solutions such as:

- Asking an interested parent to help record monitoring information, either by following the pest manager or by interviewing the person later.
- Setting up a small student project to follow pest managers around and record what they do.
- Having a quarterly or monthly meeting to discuss monitoring and using a cassette recorder to record the information.

3.7 Evaluating the Actions

Without evaluating the actions taken to reduce the pest problem, it will not be possible to improve the management program from year to year. Ask the following questions:

- Was the pest problem a significant one?
- Were the actions taken necessary or would the problem have gotten better if left alone?
- Did the actions taken and the least-hazardous treatments used adequately solve the problem?
- Could the problem be managed better next time? If so, how?
- Is more or better information needed to make treatment decisions in the future?

See **Appendix L** for sample pest management assessment of a school IPM program.

Table 3-1: Plant Condition Rating*

	Indicators of Plant Condition			
Plant Condition Rating	Leaf Color	Amount/Size of Growth	Damaged Plant Parts	Presence of Pest Problems
EXCELLENT	Good	Adequate	None to few	No major ones
GOOD	Good	Slightly reduced	Few to common	A few minor ones
FAIR	Poor	Much reduced	Common to abundant	Either major or minor ones occurring frequently
POOR	Poor	Severely reduced	Innumerable	Both major and minor ones occurring frequently

Leaf Color: Note that there are healthy plants that do not have bright green leaves. Leaves can be purple, yellow, or sometimes a mottled yellow and green (variegated). "Good" leaf color will not always be the same; it will depend on the kind of plant.

Amount/Size of Growth: This refers to the length of the new growth for the season as well as the number of new leaves, and the size of the leaves, flowers, or fruit.

Damaged Plant Parts: Look at the whole plant. Are there leaves with holes, spots, or discolorations? Are there wilted or dead leaves? Are there dead twigs or branches? Is the damage only on old leaves while new leaves look perfectly healthy?

Presence of Pest Problems: A major pest problem is one that has seriously affected or injured the plant and requires management. A minor pest problem may or may not have affected or injured the plant and may or may not require management.

*Adapted from Michigan State University, 1980

Table 3-2: Pest and Plant Damage Abundance Rating*

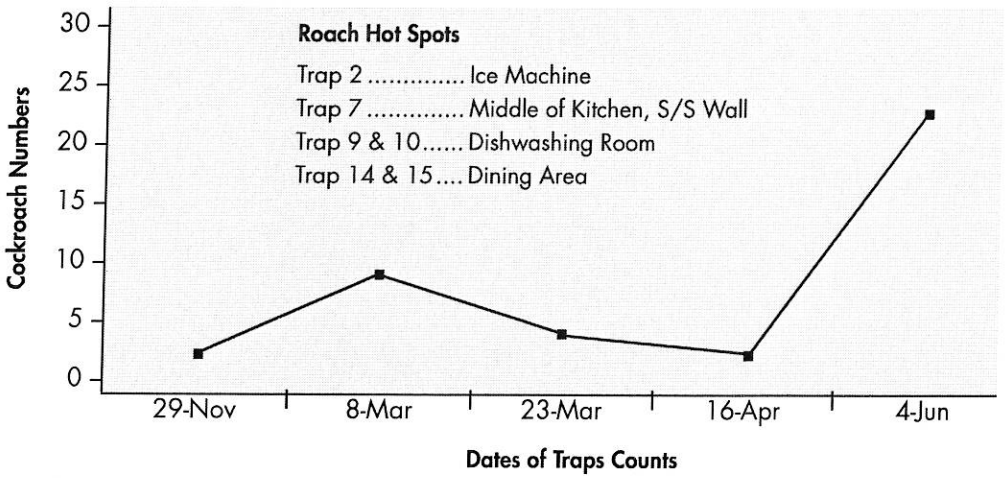
Abundance Rating	**Indicators of Abundance**
Few	Organisms or plant damage occasionally found, but only after much searching
Common	Organisms or plant damage easily found during typical searching
Abundant	Organisms or plant damage found in large numbers—obvious without searching
Innumerable	Organisms or plant damage extremely numerous—obvious without searching

*Adapted from Michigan State University, 1980

Table 3-3: Tools Used in Monitoring

Tools	Use	Plants	Structures
Monitoring forms	to write down what is seen	X	X
Maps or site plans of the buildings or grounds	to mark where pests are found and where traps are placed	X	X
Clipboard	to hold the monitoring forms and maps	X	X
Flashlight with a halogen bulb	to detect nighttime pest activity and for viewing darkened areas (e.g. under counters, in closets) during the day. A black light bulb can be substituted to detect scorpions.	X	X
Sticky traps (for many insects the color of the trap is important, e.g., thrips are attracted to blue; whiteflies prefer yellow). Glue boards are used for monitoring rodents.	to monitor a variety of insects, mites, and small rodents.	X	X
Hand lens (a small magnifying glass)	to help to see mites and small insects A lens that magnifies things at least 10 times (=10X) is usually adequate. A 15X lens can be used to distinguish among various mite species and other similarly small pest organisms such as thrips.	X	X
Plastic bags or small vials	to hold specimens for later examination or identification.	X	X
Small knife or screwdriver	to dig up weeds for specimens or for control, to probe damaged wood and to extract insect droppings from wood.	X	X
Ladder	for examining hard-to-reach spaces	X	X
Camera	for documenting pest damage to plants or structures before and after IPM methods have been applied	X	X

Figure 3-1: Fluctuating Cockroach Trap Counts



SECTION 4

Setting Injury and Action Levels

Total eradication of pest organisms is virtually impossible to achieve. A more realistic goal is to determine the injury level—the number of pests or the amount of pest-related damage that can be tolerated without suffering an unacceptable medical, economic, or aesthetic loss. The action level—the number of pests necessary for treatment to occur to prevent the injury level being reached—depends largely on pest biology and environmental conditions supporting the pest.

4.1 Determine Injury Levels First

Before determining the action level, first determine the injury level. This is the level of damage or the level of the pest population that causes unacceptable injury. The injury level will be higher than the action level (see **Figure 4-1** for sample thresholds).

4.1.1 Three Types of Injury

There are three types of injury relevant to school IPM programs:

- *Aesthetic injury* applies mainly to plants. This refers to injury that affects the appearance without affecting the health of the plant. There are few indoor pests or pests of structures that cause only aesthetic damage.
- *Economic injury* refers to pest damage that causes monetary loss, e.g., clothes moths destroying band uniforms or a plant disease that causes the death of a tree.
- *Medical injury* relates to human health problems caused by pests such as rodents, flies, yellowjackets, and poison oak.

4.1.2 Injury Levels Differ Depending On The Pest And Its Location

The number of pests or amount of pest damage that can be tolerated (another way to think of injury level) will depend on the kind of pest and its location. A column of ants marching through an unused outbuilding is an entirely different situation from an ant invasion in the cafeteria. Many thousands of aphids can usually be tolerated on a tree, but one louse or nit on a child's head cannot.

Some pests are perceived as more frightening or disgusting than other pests, which in turn influences the number people will tolerate. Most people prefer crickets to cockroaches and find pigeons more acceptable than rats. Education and information can sometimes modify a person's tolerance level of a particular pest.

State, county, or local public health codes will have an impact on injury and action levels for pests such as rats, mice, cockroaches, and flies in areas where food is stored or prepared. In a public health emergency such as an outbreak of rabies or bubonic plague, government agencies may legally mandate control of certain pests. Consult the County Health Department for more information.

Box 4-1: Is a Response to an Existing Pest Population Needed?

To determine whether a response is needed, ask the following questions:

- Are there state or county health codes requiring control of the pest problem (i.e., pests in areas where food is stored, prepared, or served)?
- Is the pest population growing?
- Are the pests located in a sensitive area (i.e., kitchens, cafeteria, or sick rooms)?
- Are the pests posing a health threat to humans?
- Are the pests damaging school property?
- Are the pests annoying or worrying students, faculty, and staff?
- Are the pests causing unacceptable aesthetic damage?

4.1.3 Don't Set the Level Too Low

One of the major causes of unnecessary treatments for pests is an unrealistically low tolerance level. Obviously, there is little leeway in tolerance for pests that have consequences for human health or the school budget, but for many other pests, the range of tolerance can be very wide. By understanding what damage is serious and by simply changing the way we view pests and pest damage, we can avoid many unnecessary treatments. For instance, most trees and shrubs can support substantial populations of caterpillars, aphids, psyllids, or leafhoppers without coming to any harm. Lawns can still be very attractive and functional even though the grass is not all of one kind and there are a number of weeds mixed in (as long as they don't pose a tripping hazard).

4.1.4 Determining the Injury Level

We all have intuitive, unspecified notions of injury level in various pest management situations, but these may not be accurate. In an IPM program, the aim is to try to make injury levels clear and precise. Monitoring is the only way to do this. It also takes knowledge and experience to understand the life cycles of pests, how fast their populations grow, and whether their damage will have serious consequences.

Example: Weeds in lawns are often only an aesthetic problem, but in other instances weaken ornamental plants. You may decide to set an aesthetic injury level in a lawn at 15 percent, or treat weeds in landscaped areas as soon as they begin to compete with ornamentals.

4.2 Determine Action Levels Based on Injury Levels

The action level is the level of pest damage or number of pests that triggers a pest management action to prevent pest numbers from reaching the injury level. The action is not necessarily a pesticide application. The action level will be lower than the injury level (see **Figure 4-1** for sample thresholds). Determining action levels involves making educated guesses about the likely impacts of numbers of pests present in a given place at a given time. In other words, an estimate of how high the pest population can grow before action is needed to prevent unacceptable injury. The action level must be determined and treatments applied before the injury level is reached.

Example: From previous experience, if more than ten cockroaches are found in a sticky trap in a classroom, teachers and students will complain. At one cockroach per trap, no one notices that roaches are present. When there are between

two and ten roaches per trap, the treatment may consist of tracking down the infestation, sealing holes and cracks near the infestation, fixing leaks, and applying cockroach bait. At the same time, review food storage, sanitation, and trash handling procedures with the teacher. If catches exceed ten roaches per trap, check equipment and other inaccessible areas for harborage; vacuum and thoroughly clean the room; and ask the teacher to remove clutter and straighten all storage areas.

4.2.1 Set Conservative Action Levels in the Beginning

During the beginning phase of an IPM program, it is wise to be conservative when establishing an initial action level. Set it low enough (i.e., low numbers of pests trigger treatments) to insure a wide margin of safety while learning monitoring methods. The initial action level should then be compared with other action levels for the same pest at different sites or locations. This is necessary to determine if the action level is set too high or too low, if treatments were necessary or not, and if they were properly timed.

The easiest way to collect comparative data is to set aside a portion of a school that remains untreated at the time another area is treated, or to monitor two schools where different action levels are applied to the same pest. By monitoring both sites, and comparing records, adjustment of the initial action level up or down can be evaluated.

Periodically, the action level should be re-evaluated for each pest and for each site. Changes in weather conditions, plant cultivars grown, horticultural practices, level of IPM experience of employees and building renovations can affect the setting of injury levels. See **Table 4-1** for example action levels for common school pests.

4.2.2 Avoid "Revenge" Treatments

Sometimes action takes place after the injury level has been reached and the pest population has begun to decline naturally, such as with seasonal changes (**Figure 4-2**). These "revenge" treatments are generally useless at controlling pests, are damaging to the environment, and an unnecessary expenditure of time and resources.

4.3 Declaring an Emergency Under the Healthy Schools Act

In the Healthy Schools Act, "emergency conditions" are defined as "circumstances in which the school designee deems that the immediate use of a pesticide is necessary to protect the health and safety of pupils, staff, or other persons, or the schoolsite." (Education Code section 17608(c))

Before an emergency occurs, the IPM coordinator (pest manager) must establish a communication "tree" with the names and phone numbers of people to contact in a crisis. Each contact should have a set of clearly defined responsibilities. For instance, the IPM coordinator notifies the public information officer who then handles the concerns of parents and the public. The IPM coordinator also notifies school administrators who decide who to notify at higher levels. The IPM coordinator must communicate effectively with all those involved in the emergency and must choose information that is appropriate for each person with whom he or she communicates. For instance, the superintendent will not need to be informed of specific mixing instructions for the pesticide, and the pesticide applicator will not need to know the names of the students and staff involved.

It is important to thoroughly document the emergency condition. Ask the following questions:

- **Who** is the person who is warning about the emergency? Is the person credible? Does he or she have the necessary knowledge to make a determination of an emergency?
- **What** is the problem? Find out as much as possible about the problem and what is causing it. What kind of pest is involved? Is the problem one of health and/or safety?
- **Where** is the problem? Is the location such that it is an immediate threat to health and safety? Can the area be cordoned off to prevent further problems?
- **When** did the problem occur? Is it happening at this moment, or did it happen two weeks ago, and is just now being reported?
- **How** did the problem occur? What are the circumstances surrounding the incident?
- **Why** did the problem occur? What factors contributed to the creation of the problem?

Once an emergency is declared and the channels of communication are open, the next step to take is assessing the possible options for solving the problem and choosing the most effective one. Once the treatment has been chosen, the IPM coordinator should communicate this decision. When the emergency is over, it is important to assess the effectiveness of the chosen course of action (see section 5 for more information) and to make adjustments in the pest management system so that the problem doesn't recur. This evaluation and the changes that are made should be reported to those involved in the emergency.

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 works because combined strategies for pest management are more effective in the end 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. As defined by the Healthy Schools Act, 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 combining a number of treatment strategies.

Table 4-1: Examples of Action Levels* for Schools

Pest	Classrooms/ Public Areas	Maintenance Area	Infirmary	Kitchen	Grounds
Ants, Argentine	5/room	5/100 ft² in 2 successive periods	1/room	3/room	1 nest within 25 ft of bldg.
Ants, carpenter	3/room	3/room	1/room	2/room	1 nest within 25 ft of bldg.
Bees, honey	1/room	3/room	1/room	1/room	If children threatened
Bees, bumble	1/room	3/room	1/room	1/room	If children threatened
Bees, carpenter	1/room	3/room	1/room	1/room	If children threatened; 1 carpenter bee/5 linear ft
Cockroaches	2/room	5/room	1/room	1/room	If noticeable or invading
Crickets	3/room	10/room	1/room	2/room	If nuisance
Grain & flour pests	1/package or container	N/A	N/A	1/package or container	N/A
Houseflies	3/room	5/room	1/room	1/room	5/trash can or 10 dumpster
Landscape Pest (general)	N/A	N/A	N/A	N/A	whenever damage approaches 10% per plant
Lawn pest (insects, nematode, disease)	N/A	N/A	N/A	N/A	whenever visible damage approaches 10% in any 100 ft² area
Lice (head or body)	Take no action, refer to nurse				
Mice	1/room	1/room	1/room	1/room	burrows or activity in any student area
Pigeons	Public area or roof: whenever droppings accumulate more than 1 inch or nests obstruct gutters or equipment. Roof ledges: 10/building for 3 consecutive inspections				
Poison Oak	Outdoor student activity areas: 1 plant Wooded areas: no control necessary unless near path or student activity area				
Rats	1/room	1/room	1/room	1/room	any burrow/activity
Silverfish	1/room	2/room	1/room	1/room	NA
Spiders, poisonous	1/room	1/room	1/room	1/room	1/activity area
Spiders, others	1/room	3/room	1/room	1/room	only if nuisance
Weeds	Lawns: whenever weeds approach 15% in any 100 ft² area Ornamental plantings: whenever competing with ornamental plans or whenever aesthetically displeasing				
Yellow jackets	Inside: 1/room; outside: 10/10 minutes at trash (this triggers more frequent trash pickup and/or search for nests) Outside in traps in early spring: 30 to 40 in 4 hours in a trap (this triggers area wide baiting)				

* The specific action levels mentioned in this table are offered as examples only. They are not required by regulation or law. Each school using action thresholds should develop action levels of their own, suited to specific conditions at the school.

This table was adapted from Pinto and Kraft, 2000.

Figure 4-1: Injury and Action Levels

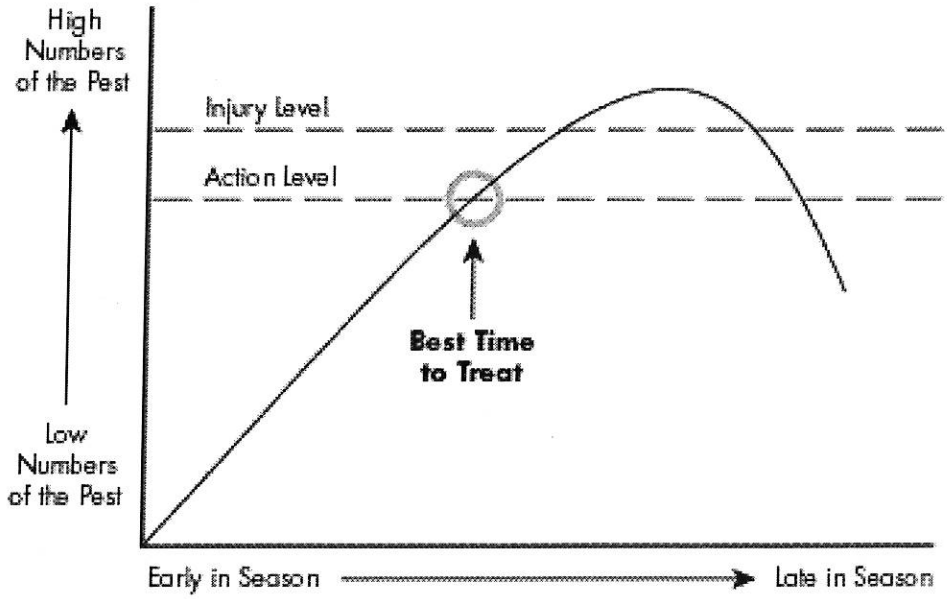
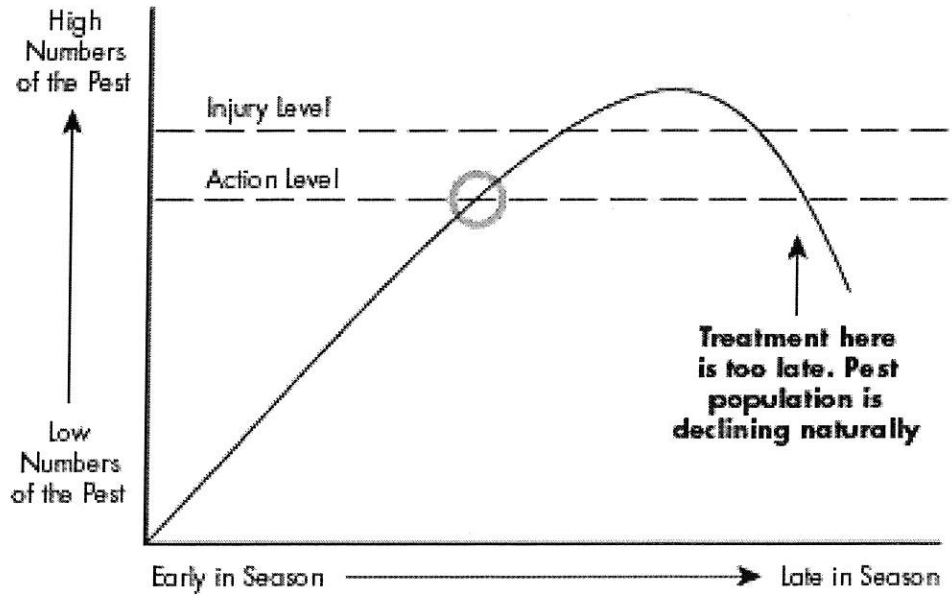


Figure 4-2: Effect of "revenge" treatments.



SECTION 5

Selecting Least-hazardous Pest Control Practices

5.1 Criteria for Selecting Least Hazardous Pest Control Practices

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

- Least hazardous to human health.
- Least disruptive of natural controls in landscape situations.
- Least toxic to non-target organisms.
- 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 weather, soils, water, and the energy resources of the site and the maintenance system.

5.1.1 Least Hazardous to Human Health

It is particularly important around children to take the health hazards of various strategies into consideration. Hazard refers to the extent and type of negative effects of the strategy in question.

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 volatilize very little so lung exposure is not a problem. Cockroach baits manage cockroach populations much more effectively than aerosol sprays.

5.1.2 Least Disruptive of Natural Controls

In landscape settings, 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**.

5.1.3 Least Toxic to Non-Target Organisms

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

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.

5.1.4 Most Likely to Be Permanent and Prevent Recurrence of the Pest Problem

Finding treatments that meet this specification 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, and other pests.
- 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.
- Applying an insect growth regulator to prevent fleas from developing in an area with chronic problems.

5.1.5 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, and goggles. 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 hazardous materials.

5.1.6 Most Cost-Effective in the 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 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. IPM frequently costs less than, or about the same, as conventional chemically based programs, once the program is in place (see section 2.9.2 for a discussion on "Assessing Cost-Effectiveness").

In addition, parental and community concern about the use of conventional pesticides may make *any* use of pesticides 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 and other pest management duties. These costs should also be factored into the pest control equation.

5.1.7 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. UCCE Master Gardeners are available in many counties for local planting recommendations. Look in the Yellow Pages under Government or go to http://ucanr.org/ to find the local County Cooperative Extension Office.

5.2 Timing Treatments

Treatments must be timed to coincide with a susceptible stage of the pest and, if 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 ground squirrels using traps or bait stations, it is usually best to focus control in mid-May through mid-July, as native vegetation and food sources are drying. In some areas, ground squirrels aestivate (summer sleep) during the hottest summer months (mid-July through August). This is a poor time to attempt control. Fall is also a good time for baiting as ground squirrel foraging activity peaks in September and October prior to hibernation.

5.2.1 Spot Treatments

Treatments, whether pesticides or non-hazardous materials, should be applied only 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 hazardous materials can be kept to a minimum.

5.3 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.

5.3.1 Education

Education is a cost-effective pest management strategy. Information that will help change people's behaviors—particularly how they store food and dispose of garbage—plays an invaluable part in managing pests like cockroaches, ants, flies, yellow jackets, 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 hazardous treatments for innocuous organisms. Teaching children about IPM will have a long-term effect on the direction of pest management as these students grow up to become consumers, educators, policy makers, and researchers. See **Appendix O** for training and licensing opportunities and **Appendix F** for IPM-related curricula and resources for the classroom.

5.3.2 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, and furnishings. Sometimes these changes can eliminate pest habitat. For example, buildings designed without exterior horizontal ledges will reduce pigeon problems. Inside, heavy-duty, stainless steel wire shelving mounted on rolling casters helps reduce roach habitat and facilitates cleanup of spilled food. For more information, a guide to pest management through prevention, "Pest Prevention: Maintenance Practices and Facility Design," can be located on the DPR School IPM Web site at www.cdpr.ca.gov/schoolipm.

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. Fixing any leaks has the added benefit of saving 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.

5.3.3 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 or failing to give them proper care. Healthy plants are likely to have fewer insect, mite, and disease problems. It is very important that the person responsible for the school landscaping knows (or is willing to learn) about the care required by the particular plants at the school.

Designing/Redesigning of Landscape Plantings

- Choose the right plant for the right spot and choose 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.
- Include 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 and zinnias.
- Diversify landscape plantings. A pest can devastate the entire area when large areas are planted with a single species of plant.

5.3.4 Physical Controls

Vacuuming

A heavy-duty vacuum with a special filter fine enough to screen out insect effluvia (one that filters out particles as small as 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 and can capture adult fleas, their eggs, and pupae. A vacuum used outside can be used to collect spiders, box elder bugs, and cluster flies.

Trapping

Traps play an important role in least-hazardous 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 or locked cupboards. 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. Barriers that are more complicated include electric fences to keep out deer and other vertebrate wildlife and L-shaped footings in foundations to exclude rodents.

Heat and Cold

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.

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.

5.3.5 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 conventional chemical 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 the 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 (also called insectary 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. See the DPR Publication "Suppliers of Beneficial Organisms in North America" for commercial suppliers of biocontrol organisms (available online at http://www.cdpr.ca.gov/ under *News and Publications*).

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 venture: it must be done by highly trained specialists in conjunction with certain quarantine laboratories approved by the United States Department of Agriculture. Permits must be obtained and strict protocols observed in these laboratories. 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 of the natural enemies can take several years.

5.3.6 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. Non-target organisms are much less likely to be affected because these microbial pesticides selectively attack pests.

The most well known microbial insecticide is *Bacillus thuringiensis*, or B.t. The most widely sold strain of B.t. 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.

5.3.7 Least-Hazardous Chemical Controls

The health of school occupants 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. There are many chemical products to choose from that are relatively benign to the larger environment and at the same time effective against target pests. To find out whether a specific pesticide product is exempt from the right-to-know requirements of the Healthy Schools Act, see **Appendix B**.

"Least-hazardous" 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. There are many least-hazardous products being registered in California, including 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 some 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. These hormones do not affect us since humans and other mammals don't metamorphose as insects do.

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 but as with all pesticides, it is important to use them according to label instructions to ensure success and safety.

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. Although these materials are not poisonous to humans directly, the fine dust travels freely through the air and can be irritating to the eyes and lungs: always use a dust mask and goggles during application.

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 fishponds. 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 may 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: 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

Although botanical pesticides are derived from plants, they are not necessarily better or safer 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" have been synthesized in the laboratory, and are much more long lasting and powerful than the pyrethrins. Pyrethroids are toxic to fish and other aquatic invertebrates. Neem, another botanical pesticide, is discussed previously 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 pesticides.

5.4 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 **Appendix H**, the

Recommended Readings section of this manual, for other reference materials on pesticides. **Appendix G**, Pesticide Information Resources, lists organizations that provide information on pesticide toxicity. You will find links to MSDS sites on the California School IPM Web site at www.cdpr.ca.gov/schoolipm. Some pesticide products are exempt from the recordkeeping, notification, and posting requirements of the Healthy Schools Act. Use the worksheet "Pesticides exempted from Healthy Schools Act right-to-know requirements" (**Appendix B**) to determine if a specific product is exempt. DPR's School HELPR Web page is a guide to choosing the optimal pest management action, depending on the situation. In addition, there are some pesticides that are prohibited from use in schools. See http://apps.cdpr.ca.gov/schoolipm/school_ipm_law/prohibited_prods.pdf to view the list of pesticide products prohibited from use in schools and child care facilities.

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

5.4.1 Safety

This means safety for humans (especially children), pets, livestock, and wildlife, as well as safety for the overall environment. Read the pesticide label. Pesticide labels contain information to protect your health. Every label displays a "signal word" that indicates the level of acute (immediate) toxicity of the formulated pesticide product. See **Box 5-1** for explanations of the signal words. Questions to ask about safety are:

- What is the acute (immediate) and chronic (long-term) toxicity of the pesticide?

  Acute toxicity is the toxicity of the chemical after a single or limited exposure. It is measured by the lethal dose (LD_{50}) or the lethal concentration (LC_{50}) which causes death in 50 percent of the test animals (measured in milligrams of pesticide per kilogram of body weight of the test animal). The higher the LD_{50}/LC_{50} value, the more poison it takes to kill the target animals and the less toxic the pesticide. In other words, a high LD_{50}/LC_{50} value equals low toxicity. The LD_{50}/LC_{50} does not reflect any effects from long-term exposure that may occur at doses below those used in short-term studies.

  Chronic toxicity refers to potential health effects from exposure to low doses of the pesticide for long periods. 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** or online at www.cdpr.ca.gov/schoolipm.

- 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?

Box 5-1: Definitions of signal words for pesticides

Federal law and the acute toxicity data determine the signal words and precautionary statements that must appear on pesticide labels (40 Code of Federal Regulations 156.10). Always read pesticide labels thoroughly before using and be sure to follow label directions. Misuse of any pesticide is not only illegal, but may create a dangerous situation.

The signal word (see below) indicates the most severe level of anticipated acute (immediate) toxicity of the formulated pesticide product to humans based on at least one of five to six tests conducted with laboratory animals. The chronic (long-term) toxicity is not indicated on the label. Note that chronic toxicity may be important for pesticide products used frequently. You can obtain chronic toxicity information from several reputable sources such as U.S. EPA (http://www.epa.gov/iris) or the National Pesticide Information Center (http:/npic.orst.edu). Pesticide labels typically bear the warning "Keep out of reach of children."

Signal Word	**Toxicity category**	**Precautionary statements by toxicity category** Oral, inhalation or dermal toxicity	Skin and eye local effects
Danger — Poison Danger	I	Fatal (poisonous) if swallowed [inhaled or absorbed through skin]. Do not breathe vapors [dust or spray mist]. Do not get in eyes, on skin, or on clothing. [Front panel statement of practical treatment required]	Corrosive, causes eye and skin damage [or skin irritation]. Do not get in eyes, on skin, or on clothing. Wear goggles or face shield and rubber gloves when handling. Harmful or fatal if swallowed. [Appropriate first aid statement required].
Warning	II	May be fatal if swallowed [inhaled or absorbed through skin]. Do not breathe vapors [dust or spray mist]. Do not get in eyes, on skin, or on clothing. [Appropriate first aid statement required].	Causes eye [and skin] irritation. Do not get in eyes, on skin, or on clothing. Harmful if swallowed. [Appropriate first aid statement required].
Caution	III	Harmful if swallowed [inhaled or absorbed through skin]. Avoid breathing vapor [dust or spray mist]. Avoid contact with skin [eyes or clothing]. [Appropriate first aid statement required].	Avoid contact with skin, eyes or clothing. In case of contact, immediately flush eyes or skin with plenty of water. Get medical attention if irritation persists.
[No signal word]	IV	[No precautionary statements required]	[No precautionary statements required]

If no signal word occurs on the label, then the product has the lowest toxicity category or contains active ingredients that are exempt from federal and California registration; however, it may cause slight skin or eye irritation.

Products you select must be registered or exempted from registration*. Note that some products are neither registered nor exempted, and are, therefore, illegal to use. If chemical control is necessary, select legal products with no signal word or with caution as a signal word when available.

For information about products exempt from registration, see* **Appendix B *and California Notice to Registrants 2000-6, which is available on our Web site at www.cdpr.ca.gov under Programs and Services, Pesticide Registration Branch.*

5.4.2 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.

5.4.3 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 percent of the test insects. In field tests under more realistic conditions, however, it may also kill 100 percent of the pest's natural enemies. This will lead to serious pest outbreaks later.

5.4.4 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, in other words, that the pesticide has lost its endurance.

5.4.5 Speed

A quick-acting, short-lived, more acutely toxic material might be necessary in emergencies; a slow acting, longer lasting, less-hazardous 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 hazardous organophosphate.

5.4.6 Cost

This is usually measured as cost per volume of active ingredient used. Some of the newer, less-hazardous microbial and botanical insecticides and insect growth regulators may appear to be more expensive than some older, more hazardous pesticides. The newer materials, however, 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.

5.5 Pesticide Use, Disposal, and Storage

In California, pesticide use, disposal, and storage are governed by laws in the California Food and Agricultural Code (FAC) and regulations in Title 3 of the California Code of Regulations (CCR). The laws and regulations concerning pesticide use have become increasingly complicated over the past few years. See the Pesticide Safety Information Series N in **Appendix P** for more detailed information regarding pesticide use in California schools. Pesticide applicators in schools must follow state and federal laws regarding pesticide use, disposal and storage in addition to following the requirements of the Healthy Schools Act.