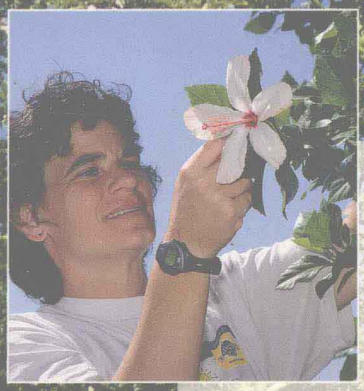

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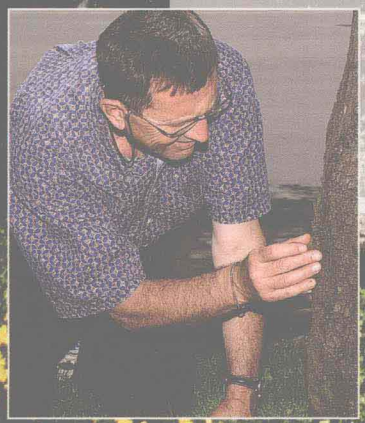

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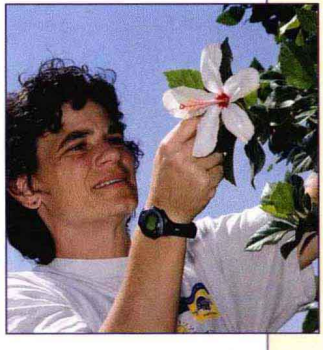

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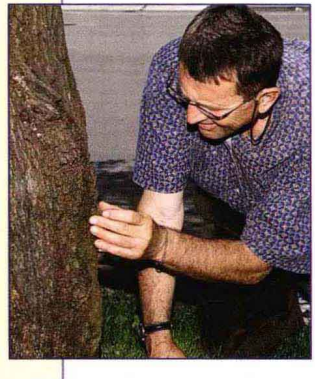

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Second Edition

PRECAUTIONS FOR USING PESTICIDES

Pesticides are poisonous and must be used with caution. READ THE LABEL BEFORE OPENING A PESTICIDE CONTAINER. Follow all label precautions and directions, including requirements for protective equipment. Use a pesticide only on the plants or site specified on the label or in published University of California recommendations. Apply pesticides at the rates specified on the label or at lower rates if suggested in this publication. In California, all agricultural uses of pesticides must be reported, including use in many non-farm situations, such as cemeteries, golf courses, parks, roadsides, and commercial plant production including nurseries. Contact your county agricultural commissioner for further details. Laws, regulations, and information concerning pesticides change frequently, so be sure the publication you are using is up-to-date.

Legal Responsibility. The user is legally responsible for any damage due to misuse of pesticides. Responsibility extends to effects caused by drift, runoff, or residues.

Transportation. Do not ship or carry pesticides together with food or feed in a way that allows contamination of the edible items. Never transport pesticides in a closed passenger vehicle or in a closed cab.

Storage. Keep pesticides in original containers until used. Store them in a locked cabinet, building, or fenced area where they are not accessible to children, unauthorized persons, pets, or livestock. DO NOT store pesticides with foods, feed, fertilizers, or other materials that may become contaminated by the pesticides.

Container Disposal. Consult the pesticide label, the County Department of Agriculture, or the local waste disposal authorities for instructions on disposing of pesticide containers. Dispose of empty containers carefully. Never reuse them. Make sure empty containers are not accessible to children or animals. Never dispose of containers where they may contaminate water supplies or natural waterways. Offer empty containers for recycling if available. Home use pesticide containers can be thrown in the trash only if they are completely empty.

Protection of Nonpest Animals and Plants. Many pesticides are toxic to useful or desirable animals, including honey bees, natural enemies, fish, domestic animals, and birds. Certain rodenticides may pose a special hazard to animals that eat poisoned rodents. Plants may also be damaged by misapplied pesticides. Take precautions to protect nonpest species from direct exposure to pesticides and from contamination due to drift, runoff, or residues.

Permit Requirements. Certain pesticides require a permit from the county agricultural commissioner before possession or use.

Plant Injury. Certain chemicals may cause injury to plants (phytotoxicity) under certain conditions. Always consult the label for limitations. Before applying any pesticide, take into account the stage of plant development, the soil type and condition, the temperature, moisture, and wind. Injury may also result from the use of incompatible materials.

Personal Safety. Follow label directions carefully. Avoid splashing, spilling, leaks, spray drift, and contamination of clothing. NEVER eat, smoke, drink, or chew while using pesticides. Provide for emergency medical care IN ADVANCE as required by regulation.

Worker Protection Standards. Federal Worker Protection Standards require pesticide safety training for all employees working in agricultural fields, greenhouses, and nurseries that have been treated with pesticides, including pesticide training for employees who don't work directly with pesticides.

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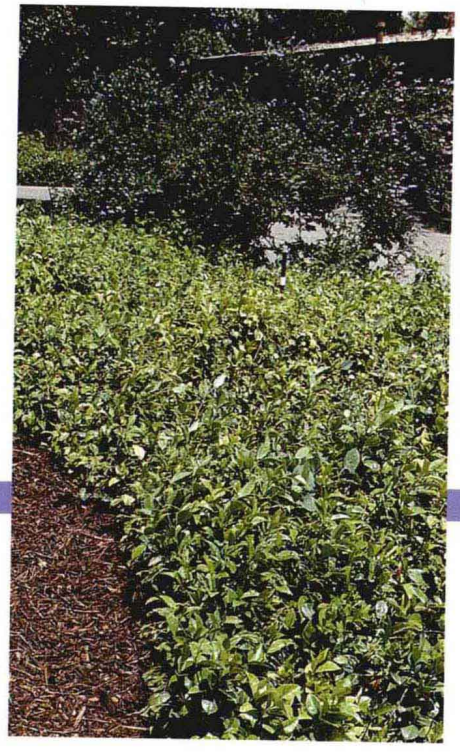
Contents

trees and shrubs occurring in California and other western landscapes.

The *UC Guide to Solving Garden and Landscape Problems* (Flint et al. 2000) is another good source of information with hundreds of color photographs. For identification and biology of pests affecting herbaceous ornamentals and flowers, consult publications such as *Integrated Pest Management for Floriculture and Nurseries* (Dreistadt 2001). Commercial ornamental growers can consult that publication and *Floriculture and Ornamental Nurseries Pest Management Guidelines* (Raabe et al. 2002) for management recommendations. Home fruit and vegetable garden pest management is discussed in *Pests of the Garden and Small Farm* (Flint 1998) and several *UCIPM Pest Notes*.

A list of references, suggested reading, a glossary, an index, and information on ordering UC IPM publications are provided at the back of the book.



CHAPTER TWO

Designing an IPM Program

LANDSCAPE PROFESSIONALS and home gardeners have many opportunities to prevent or minimize serious pest problems. This ecological approach to avoiding unacceptable pest presence and damage is called integrated pest management (IPM).

Integrated pest management is a strategy that avoids or prevents pest damage with minimum adverse impact on human health, the environment, and nontarget organisms. To apply IPM, managers use knowledge of plant and pest biology to take actions that reduce the environment's suitability for pest establishment and population increase. IPM employs careful monitoring techniques and combinations of biological, chemical, cultural, mechanical, and physical (also called environmental) control. Pesticides are used only if monitoring reveals that they are needed. If pesticides are necessary, they are chosen and applied in a way that avoids disrupting other IPM practices.

Which Organisms Are Pests?

Many types of organisms can damage trees and shrubs or otherwise be undesirable inhabitants of landscapes. Landscapes are also damaged by abiotic disorders caused by adverse environmental conditions and inappropriate cultural practices. Abiotic factors and pest organisms often work in combination to damage plants.

Common pests include insects, mites, mollusks, nematodes, pathogens, vertebrates, and weeds. However, in each of these groups there are many related species that are beneficial or do not harm desirable plants; in fact, the great majority of organisms in the landscape are desirable components of the ecosystem.

Even the presence of organisms with the potential to become pests may not be cause for concern. For example, many fungi and other microorganisms that can cause disease are continually present in the environment; they usually become damaging only when conditions are favorable for disease development or unfavorable for plant growth, such as when poor cultural practices weaken a plant. Insects, mites, and nematodes that can cause damage when they are abundant can be harmless or even beneficial when their numbers are low; the presence of a few of these plant-feeding pests provides food to maintain natural enemies that help to prevent outbreaks.

Organisms are pests primarily because they compete with, feed on, or infect

desirable organisms. Some organisms are pests because of their excrement or by-products, such as sticky aphid honeydew. Pests reduce landscape quality and function, and range in severity from problems that are merely annoying or unattractive to organisms that threaten the survival of desirable plants.

Many states and countries impose quarantines to prevent the introduction of exotic pests, species that do not occur within the jurisdiction imposing the quarantine. Quarantines may prohibit the movement across borders of potentially infested plants, such as nursery stock. To avoid quarantines or induce other jurisdictions to remove their quarantines, agricultural authorities may implement pest eradication programs, such as those targeting exotic gypsy moths or fruit flies inadvertently introduced into suburban landscapes.

Organisms that are harmless in landscapes sometimes become pests if they move to nearby gardens or crops. For example, the bacterium *Xylella fastidiosa* apparently does not seriously damage many ornamental plants in which it occurs, but it causes the serious Pierce's disease of grapes, and a different strain damages oleander as discussed in the section "Bacterial Leaf Scorch and Oleander Scorch." *Xylella fastidiosa* is vectored by certain leafhoppers, and Pierce's disease is controlled partly by replacing nearby noncrop host plants with alternative plant species that do not host the bacterium. Similarly, beet curly top virus (vectored by certain leafhopper species different from those that spread Pierce's disease) is a serious pathogen of beans, melons, peppers, spinach, and tomatoes. The virus can persist without causing symptoms in some ornamentals such as certain buckwheat, ceanothus, and willow species. Avoid using landscape, hedgerow, and insectary plant species that host serous pests of nearby crops.

The extent to which insects, fungi, weeds, and other organisms are landscape pests depends mostly on how much they interfere with the specific purposes for which plants are grown. Location, plant vigor, the species of plant-feeding organisms present, and the attitude and knowledge of people using the landscape also influence whether certain organisms are a pest problem.

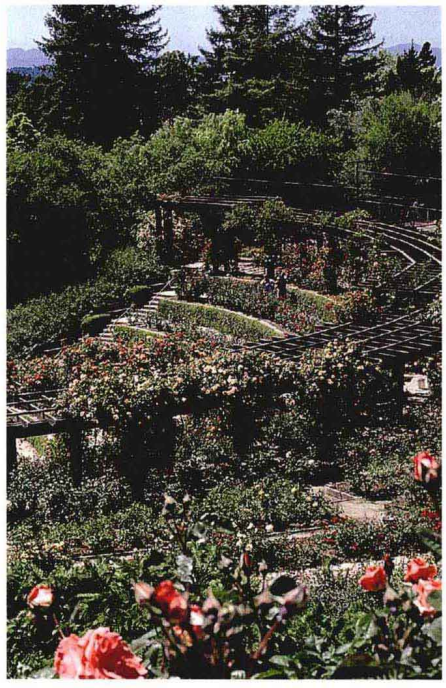
IPM Program Components

Effective, environmentally sound pest management requires considerable forethought, knowledge, and observation. Most landscape pest problems can be avoided by taking several steps: choose pest-resistant cultivars and species that are well adapted to local conditions, correctly prepare sites before planting, use proper planting techniques, and provide appropriate cultural care to create optimal conditions for plant growth.

Take action to prevent problems in established landscapes. If you wait until a tree or shrub is nearly dead or heavily damaged by pests, the only options might be to spray it with a fast-acting pesticide, which normally does not permanently correct the problem, or to replace the plant. Plan for possible problems before they occur. Learn the potential pest problems and damage symptoms of plants in your landscape areas by reviewing the section "Tree and Shrub Pest Tables" at the back of this book and by consulting other resources and experts. Talk to Cooperative Extension advisors, master gardeners, knowledgeable homeowners, garden centers with a certified nursery-person, and landscape professionals in your area to learn of their experience with local growing conditions and particular plant species.

Examine valued plants regularly for pests, damage, and inappropriate cultural practices; keep records of any problems you encounter. Learn to recognize when a plant appears abnormal or when pest abundance or damage is approaching levels that require control. Select control methods that are effective under your growing conditions and least likely to cause adverse effects on the environment. Often, more than one method can be employed to give the most reliable control. Five components are key to successful integrated pest management (Figure 2-1):

- prevention
- pest and symptom identification
- regular surveying for pests and problems
- action thresholds and guidelines
- appropriate management methods



Landscape planners can choose from among many plant species and cultivars, choices that will minimize or promote pest problems. For example, rose cultivars resistant to pests such as black spot and powdery mildew are good choices when planting roses in landscapes.

PREVENTION

Prevention is the most important component of IPM. Most pest problems can be avoided by careful landscape design, thoughtful plant selection, good site preparation, proper planting, and appropriate cultural practices such as irrigating and mulching. Applying recommended cultural practices is probably the single best way to avoid problems. Irrigation, fertilization, pruning, and other plant care practices are directly linked to many pest problems. Many insect and disease pests and

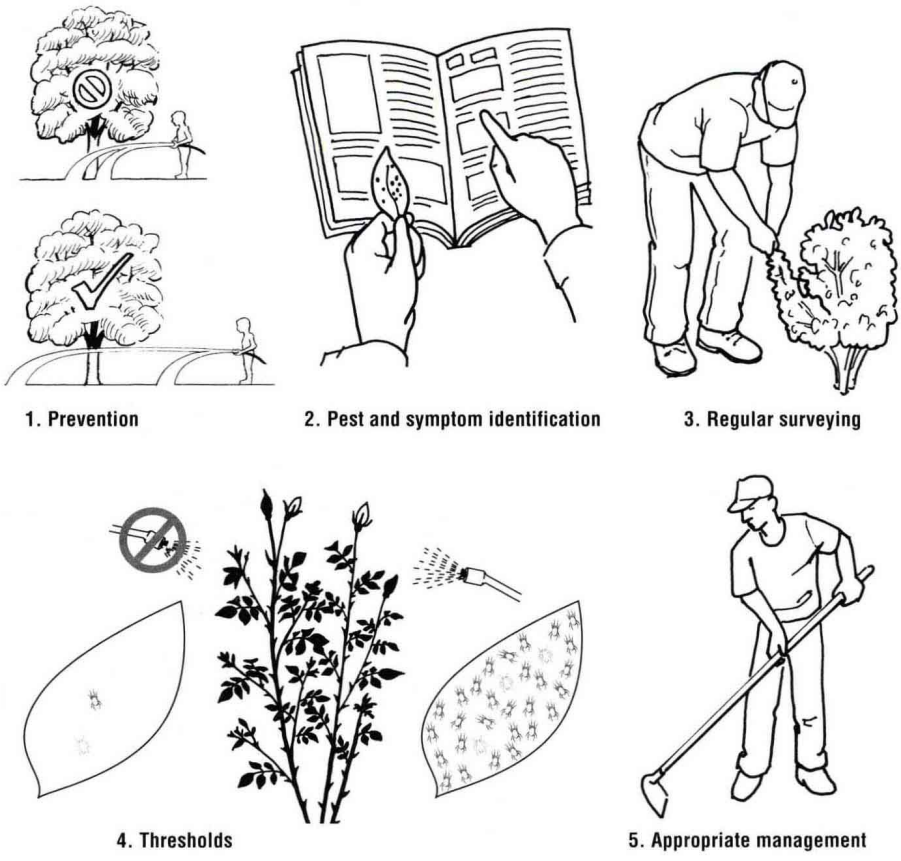


FIGURE 2-1. The major components of integrated pest management

1. Prevention, such as selecting plants well-adapted for that location, proper planting, and ongoing practices such as applying and maintaining mulch and providing appropriate cultural care, such as not irrigating established plants around the root crown, which promotes root rot pathogens;
2. Correct pest identification and diagnosis of the cause of plant damage symptoms;
3. Regular surveying of valued plants for damage, pests, and conditions that contribute to problems, such as inappropriate cultural practices;
4. Action thresholds and guidelines, which entail tolerating some level of pests and damage that does not threaten plants' long-term survival; and
5. Appropriate management, including a combination of biological, chemical, mechanical, and physical controls where needed, such as hoeing weeds.

abiotic disorders are caused by inappropriate irrigation (most commonly watering too frequently) or other maintenance practices that are not appropriate for the specific plants and conditions at that location. If the symptoms caused by poor cultural practices are incorrectly blamed on pathogens or insect pests, then unwarranted pesticide applications might be made, which can contaminate the environment and harm beneficial organisms. Plant health and survival will not be improved if the true causes of the problems are not remedied. Plants will continue to decline and may die prematurely while time and effort are wasted on ineffective actions.

Chapter 3 summarizes cultural practices essential for maintaining healthy plants and preventing pest problems. Also review the section "Tree and Shrub Pest Tables" at the back of this book to learn the specific pests to which your plants are susceptible. Seek advice from Cooperative Extension advisors and other experts. Consult additional resources such as those listed in Suggested Reading.

PEST AND SYMPTOM IDENTIFICATION

Many pests, or the damage caused by them, look similar, especially to the untrained eye. Some pests can be easily confused with beneficial or innocuous organisms. Frequently, people blame damage symptoms on insects or other organisms that happen to be on the plant at the time symptoms are observed when, in fact, those organisms are not causing the problem. The pest causing the damage may have left the site or may be hard to detect, such as pathogens within the roots or the plant's water-conducting vessels. Symptoms caused by factors other than pests, such as overwatering, unfavorable soil conditions, pesticide toxicity, air pollution, or choosing the wrong plant for that location, can be incorrectly blamed on insects, mites, or pathogens. Similar-looking symptoms may have very different causes; spotted leaves, for example, may result from abiotic disorders or disease-causing microorganisms as well as from certain insects. Plants also are frequently subject to more than one disorder or pest problem at a time. Diagnosing the specific causes that produce certain symptoms can be a challenge.

Proper pest identification is essential for choosing the right control actions. Even closely related species often require different management strategies, and some species require no action at all. Accurate identification of the cause of plant problems depends on a combination of experience, knowledge, observation, and available resources. The first step is to learn the cultural and environmental conditions required by each plant and to check that these are being adequately provided. Look for sometimes subtle differences between the appearance of unhealthy plants and healthy plants of the same species. Patterns in the symptoms may provide clues to the cause. Obtain information about the recent history of affected plants, environmental conditions, the site, and cultural practices. Use appropriate tools, including a soil sampling tube, pocket knife, hand lens or binoculars, sample collecting containers (plastic bags or vials), and reference material like this book.

The descriptions and photographs in this book will help you recognize many common pests of woody ornamental plants in California, other western states, and the United States. However, because of the broad scope of this book and because new plant and pest species are often introduced from elsewhere, some of the pests you may encounter are not pictured or described here. Consult *Abiotic Disorders of Landscape Plants: A Diagnostic Guide* (Costello et al. 2003), the *UC Guide to Solving Garden and Landscape Problems* (Flint et al. 2000), and other references at the back of this book for additional information. Other excellent publications on western landscapes include *Insects and Diseases of Woody Plants of the Central Rockies* (Cranshaw et al. 2000), *Landscape Plant Problems* (Byther et al. 2000), *Pacific Northwest Landscape Integrated Pest Management (IPM) Manual* (Bobbitt et al. 2002), and *Pests of the West* (Cranshaw 1988). *Insects That Feed on Trees and Shrubs* (Johnson and Lyon 1988) and *Diseases of Trees and Shrubs* (Sinclair, Lyon, and Johnson 1987) are especially useful publications of national scope.

Some pest problems can only be diagnosed reliably by experienced professionals; do not hesitate to seek their help. Your Cooperative Extension advisor, qualified horticultural consultant, certified arborist, or certified nurseryperson may be able to make an identification or direct you to professional diagnostic services.

Proper identification is essential. Some people may mistake this large hover fly (*Scaeva pyrastri*) larva for a caterpillar, but this beneficial insect eats aphids, not plants.

REGULAR SURVEYING FOR PESTS

Go out to the landscape on a regular basis and systematically check for pests, damage symptoms, and conditions and practices that can damage plants. Develop a routine that is adequate and efficient for the areas under your management. Although sophisticated sampling programs and monitoring techniques have been developed for use in agricultural crops and a few major landscape pests, monitoring in most landscape situations is a less formal process.

Learn the problems that commonly occur in your area on each species of plant that you manage so that you know what to monitor for and where to look on and around the plant. Learn to recognize the stages of common pests and to distinguish them from beneficial organisms. Check regularly for damage and adequate cultural care. Frequency of inspection varies with the season, potential problems, plant value, and resources. Weekly inspections may be needed for certain plants during times of the year when problems can develop quickly. Time invested in monitoring can avoid plant damage and reduce the extent of any necessary management actions. If problems are not detected until they become more obvious, your management options may be limited to pesticide use or replacing the plant.

Examine plants in a systematic manner. For example, start with any buds or flowers, then inspect succulent new growth, younger leaves, older leaves, main stems, the trunk, and the basal root crown. Be sure to examine both the upper and lower surfaces of leaves and temporarily remove soil to inspect the basal trunk. If problems such as root crown rot or vascular wilt disease are suspected, consider shaving off a thin slice of bark to inspect a portion of the cambial layer and wood just beneath cambium. In addition to inspecting them close-up, examine plants from a distance for subtle changes in canopy density and foliage color in comparison with surrounding plants and your knowledge of how healthy plants should appear. Use a predetermined pattern of inspection to collect information in the same manner each time, allowing you to compare results among inspection dates. Examine plants in locations with different environmental conditions, such as both sunny and shady sites. Check soil compaction and moisture conditions, for example by using a soil probe or tube.

Keep written monitoring records. Suggested monitoring forms are provided in this book for insects and weeds. Some

Examine valued plants regularly for pests, damage, and inappropriate cultural practices. Keep records of any problems that you encounter. Examine plants in a systematic manner, inspect all plant parts that may be infested or show symptoms, and view plants both close up and from afar.

If problems such as root crown rot or vascular wilt disease are suspected, remove soil from around the root crown and shave off a thin slice of bark. Inspect a portion of the cambium and wood for decayed or discolored tissue.

professional landscape managers enter these records into a computer and summarize and analyze them using a database or statistical software program. Professional managers of large numbers of plants can evaluate and compare the effectiveness of management practices in their situation by conducting field trials as discussed in publications such as *IPM in Practice* (Flint and Gouveia 2001).

Compare monitoring results from different dates to determine if problems are increasing or decreasing, whether control action is needed, and how effective were previous management activities. Record the date, specific location, host plant, pests, natural enemies, description of procedures, who sampled, and counts or results. Note pest management activities, such as any pesticide applications. Record other actions and weather that may influence pests. For example, the reproductive and feeding rates of most insects and mites increase with increasing temperature; monitoring temperature and time in units called degree-days helps when managing certain pests. Information available through the World Wide Web (the Web) at www.ipm.ucdavis.edu allows ready use of these tools. Degree-days and other specific monitoring methods are discussed in each section on particular pests.

ACTION THRESHOLDS AND GUIDELINES

A certain number of pest individuals and some amount of damage usually can be tolerated; this concept is fundamental to integrated pest management. The difficulty is in determining the action threshold—the point at which some action must be taken to prevent unacceptable damage.

Researchers have developed control action thresholds or guidelines for some pests in agriculture, especially insects and mites. Crops are grown for profit, so control action thresholds in agriculture are based largely on economic criteria; action is warranted when it will improve crop quality or yield and provide increased revenue that exceeds the extra cost of management.

Few formalized control action guidelines have been developed for pests on landscape trees and shrubs. There are several reasons for this, including a lack of research. However, the most important factor is the difficulty in defining what level of pests or damage is intolerable. Although the death of an attractive plant can be an economic loss to the property owner, the most common landscape pests are those that are annoying to some people or that make plants unsightly; many of these pests do not seriously damage or kill the plant. Even when dealing with pests that have the potential to threaten plant health or survival, people are often bothered by pests or their damage at levels well below those that threaten the plant. The pest population or damage level when action must be taken to deter undesirable damage to ornamental plants often depends on people's attitudes and is commonly referred to as the "aesthetic threshold."

Aesthetic tolerance varies with the attitude and knowledge of people using the landscape. For example, certain annual plants growing wild as ground covers are tolerated or enjoyed by one segment of the public, while another group considers them weeds and insists on bare soil beneath shrubs. Defining an aesthetic threshold that people can agree on is difficult and subjective. Damage that is acceptable on out-of-the-way plants may not be tolerable on prominent plants. Organisms such as gall-forming insects and mites or a few leaf-chewing caterpillars may cause no real harm to plants but can be annoying or even frightening to some people.

Despite the lack of numerical action guidelines for most landscape trees and shrubs, you will find recommendations throughout this book to help you determine whether actions may be needed and the best time to take action to avoid or reduce specific pest problems. Many plants are more vulnerable to pest damage at certain times in their development—especially during the first year or two after establishment or during certain seasons. These differences in susceptibility mean that the control action guidelines also differ over the growing season and as the plant develops. Other conditions affect a plant's ability to tolerate pest damage; for example, plants weakened by water stress, weed competition, root disease, adverse soil conditions, or injury must be more carefully protected because they are less tolerant of additional stresses or more pests.

Timing of actions is often critical for effective management. For example, once symptoms become apparent, it is often

People's aesthetic tolerance for pest damage varies. The yellow leaf blotches on this Chinese lantern are caused by abutilon mosaic virus. This virus causes no apparent harm to plants, and propagators deliberately select infected plants because many people like these variegated abutilon cultivars.

too late to control many plant diseases effectively. Sometimes the pest life stage that damages plants is not the life stage susceptible to control action. Many times the appropriate action is not to apply pesticide but to use cultural practices such as irrigating or pruning. If you are limited to methods that take several days or months to provide control or that kill a smaller fraction of the pests, you have to allow for more lead time than you would with faster-acting measures.

How To Establish Thresholds. Establish thresholds for highly valued or problem-prone plants by systematically monitoring landscapes, keeping good records, and judging the health and quality of plants in comparison with pest scouting and control records. Thresholds should be quantitative or numerical to be useful. For example, thresholds could be based on the percent of plants or leaves found to be damaged or infested during visual inspection or the number of pests dislodged per branch beat sample (a monitoring technique discussed in Chapter 4). Suggested numerical thresholds are provided for a few pests, such as in the sections "Aphids" and "Elm Leaf Beetle."

Control action guidelines or thresholds are helpful only when used with accurate pest identification and careful monitoring. Keep records of pests, how you determined when to treat, and the results of management activities. These records will help you to develop and refine action guidelines that work best for your situation in the future.

Experiment over time to develop thresholds appropriate for your situation. Be flexible in adjusting thresholds and adapting monitoring techniques and management methods as appropriate.

MANAGEMENT METHODS

Integrated pest managers must consider the interrelation of cultural practices, environmental conditions, and the biology of plants, pests, and beneficial organisms in order to provide healthy landscapes. Primary methods used specifically for pest management are biological, chemical, cultural, mechanical, and physical control.

Before applying these methods, determine whether action is needed and likely to be effective. If it is too late for control to be effective or if the problem is minor or does not threaten plant health, consider taking no action or applying other methods. When action is needed, whenever possible use more than one method in combination to provide more effective control. Methods are summarized below and detailed in later chapters.

Cultural Control. Cultural controls are modifications of normal plant care activities that reduce or avoid pest problems as detailed in Chapter 3. Some landscape designs, and selecting resistant species and cultivars, can minimize pest problems. Plant properly and irrigate, prune, and otherwise care for plants appropriately. Providing plants with proper cultural care is the single most important component of pest management. Many problems that threaten plant survival are caused by inappropriate cultural practices such as irrigating too frequently. Good care can prevent many pests from adversely affecting plants. For certain problems, such as root diseases and most wood-boring insects, cultural control is often the only effective method.

Mechanical Control. Mechanical controls use labor, materials not usually considered to be pesticides, and machinery to reduce pest abundance directly. For example, control weeds with mulch, mowing, weed eaters, flamers, and hand-pulling where appropriate (see Chapter 7). Install copper bands around trunks and planting areas to exclude snails and slugs. Apply sticky material around trunks to prevent canopies from being infested by ants, flightless weevils, and snails. Clip and dispose of foliage infested with insects that feed in groups, such as tentmaking caterpillars. Hand-pick snails or leaves infested with insects or disease. Prune out or rake up foliage and twigs infected with disease, such as leaf spots and anthracnose, to prevent pathogen propagules from spreading and infecting healthy plant tissue.

Physical Control. Physical controls (also called environmental controls) indirectly suppress or prevent pests by altering temperature, light, and humidity. Control black scale and possibly some other scale species by thinning plant canopies in hot areas of California, thereby increasing scale mortality due to heat exposure. Control certain foliar diseases by thinning the plant canopy or cutting back nearby plants to improve