Vertebrate Pest Management

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CHAPTER SIXTEEN

Vertebrate pests are likely to be found in nearly all nurseries, although they may not always present a significant problem. Damage caused by vertebrate pests in nurseries generally results in plant injury, thereby killing the plants or causing permanent damage that lowers productivity following the initial feeding. Several rodents and rabbits eat roots, stems, or bark and can kill young plants outright. Rodent burrows and mounds (such as those of pocket gophers and ground squirrels) interfere with nursery maintenance and inflict structural damage by gnawing on drip irrigation lines. Deer strip young trees and shrubs of foliage and can stunt or even kill saplings and young shrubs through rubbing. Additionally, birds can unearth and eat seeds and seedlings, resulting in crop failure.

This chapter will first discuss some basic guidelines regarding vertebrate pest management and the legal aspects of controlling vertebrates in California. Next, it will provide details on the management of specific vertebrate pests, including ground squirrels, pocket gophers, meadow voles, rabbits, deer, and birds. The vertebrate pest species presented in this chapter are common in California. Although this chapter does not address specific vertebrate pest issues outside of California, many of the same or similar species of pests are present in other states. Therefore, some aspects of this chapter will likely be relevant also to nurseries in states other than California.

General Guidelines for Vertebrate Pest Management

The efficiency and efficacy of a vertebrate pest management program can be enhanced by adhering to the following outline:

- Correctly identify the species causing the problem.
- Alter the habitat, when feasible, to make the area less favorable to the pest species.
- Take early action and use the control methods appropriate for the nursery and time of year, with due consideration for the environment.
- Establish a monitoring system to detect reinfestation so you can determine when additional corrective measures or controls are necessary.

Photo: J. K. Clark.

These points provide the framework for an effective management program and will be built upon for each species in further sections of this chapter.

Effective vertebrate pest management depends on the use of appropriate equipment and supplies (e.g., baits, fumigants, traps, deterrents). These materials can be found at local retail outlets such as farm supply and hardware stores. In addition, many county agricultural commissioners make certain rodent pesticides available to growers. For further information or sources of special control materials, consult your local Cooperative Extension advisor or county agricultural commissioner.

Legal Aspects of Vertebrate Pest Management

Under the California Fish and Game Code, if California ground squirrels, meadow voles, pocket gophers, or black-tailed jackrabbits are causing or about to cause a crop depredation, they may be lethally removed at any time by the owner or tenant of a property.

Pesticides mentioned in this chapter for vertebrate control in nurseries in California are subject to change. Only pesticides that are registered with the California Department of Pesticide Regulation (DPR), a division of the California Environmental Protection Agency (Cal/EPA), can legally be used for vertebrate pest control. Registered materials are listed in the DPR's database that is available online (see the References at the end of this chapter). You may also contact your county agricultural commissioner, Cooperative Extension advisor, or pest control adviser for information on registered materials. Pesticides for vertebrate control in gardens and landscapes are listed on the *UC IPM Pest Management Guidelines* website (see the References at the end of this chapter). These should be checked for registration status in nurseries before use. Always consult the pesticide registration label before use.

Trapping is often used to control vertebrate pests. In California, trapping most mammals, even for pest purposes, requires a trapping license issued by the California Department of Fish and Wildlife, although rats, mice, moles, voles, and gophers do not have this requirement. Additionally, you do not need a trapping license if trapping ground squirrels or rabbits on your own property for pest control purposes. However, if trapping either of these species for profit or for hire (e.g., pest control advisers or applicators), a trapping license is needed.

Because wild animals may carry infectious pathogens or parasites, do not handle them without rubber gloves. For disposal of burrowing rodents, you can bury carcasses inside their burrows. Alternatively, you can use a plastic bag slipped over your hand and arm as a glove, then grab the animal with your "bagged" hand and turn the bag inside out while slipping it off your arm and hand. Proceed to double-bag the carcass; then, dispose of it in the trash.

In some areas of California, nurseries are located within the range of federal and state protected endangered species. Species likely to be of concern include the San Joaquin kit fox, several species of rare kangaroo rats, and, where burrow fumigants are used, the blunt-nosed leopard lizard. Special guidelines apply to the use of traps, toxic baits, and fumigants for vertebrate pest control in these areas. See the composite map showing ranges of these species (fig. 16.1). Be aware that this map is not meant to be all-inclusive. Many additional species may be impacted by vertebrate pest control actions. You should contact your county agricultural commissioner if you have any doubts as to the presence or absence of threatened or endangered species associated with the area of desired application. The county agricultural commissioner's office has the latest detailed maps that show the ranges of endangered species and the latest information on restrictions that apply to pest control activities in those areas. You can also get more information on endangered species regulations from the DPR's Endangered Species Project website (see the References at the end of this chapter).

Common Vertebrate Pests

Ground Squirrels

The California ground squirrel *(Otospermophilus beecheyi)* is a medium-size rodent 14 to 20 inches long from its head to the tip of its long, slightly bushy tail (fig. 16.2). This species is responsible for major damage in nurseries throughout the state. California ground squirrels live in underground burrows and form colonies of 2 to 20 or more animals. Ground squirrels live in a variety of natural habitats. They adapt well to human activities and are found along road or ditch banks, fencerows, around buildings, and within or bordering many agricultural crops. They tend to avoid thick chaparral, dense woods, and very moist areas. Ground squirrels are active during the daytime and are easy to spot. During winter months most hibernate (fig. 16.3), but squirrels less than a year old may be active on warm, sunny winter days. Many adults go into a temporary summer sleep, called estivation, during the hottest parts of the year. Squirrels reproduce once yearly, in the early spring, and have an average litter of seven or eight young. The young are nursed in the burrow for about 6 weeks before they come aboveground to forage.

Ground squirrels are primarily herbivorous. During early spring, they consume a variety of green grasses and forbs. When these begin to dry and form seeds, the squirrels switch to seeds, grains, and nuts (see fig. 16.3).

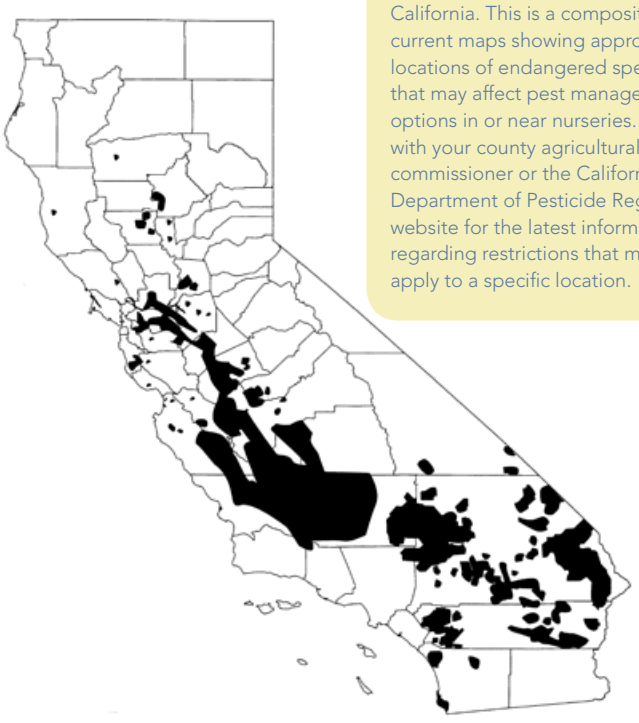

FIGURE 16.1. Distribution of endangered vertebrate species in California. This is a composite of current maps showing approximate locations of endangered species that may affect pest management options in or near nurseries. Check with your county agricultural commissioner or the California Department of Pesticide Regulation website for the latest information regarding restrictions that may apply to a specific location.

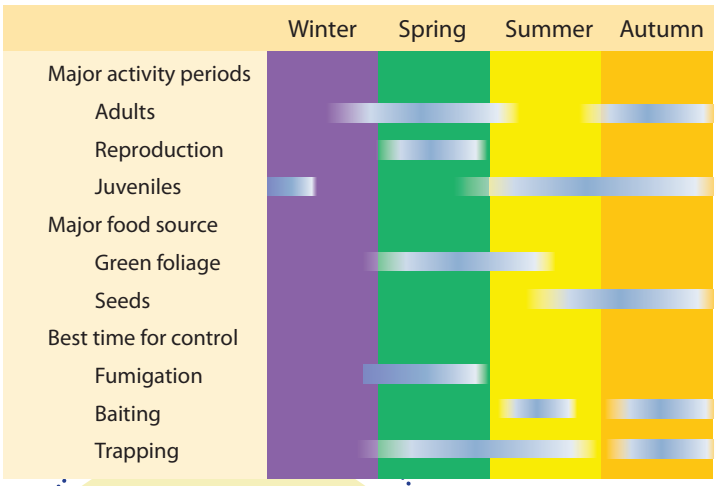

FIGURE 16.3. Activity periods and preferred food sources for the California ground squirrel. Activity periods vary somewhat from one growing area to another depending on local climate. To choose the most effective control action for ground squirrels and the proper timing, you need to know when they are active and what their preferred food sources are. *Source:* Adapted from Salmon et al. 2006.

FIGURE 16.2. California ground squirrel. *Photo:* J. K. Clark.

Damage

Ground squirrels often infest nurseries. When digging burrows, squirrels bring soil and rock to the surface and deposit it in mounds near burrow openings. They enlarge burrow systems each year by constructing new interconnecting tunnels, so the longer the squirrels occupy the burrow, the more extensive and complex it becomes. They create more entrances to serve a growing population. Large and numerous burrow openings and soil mounds are hard on nursery equipment. Ground squirrels frequently burrow around trees and damage the root systems; they can even kill trees (fig. 16.4). Bark gnawing on the trunks of young trees and on limbs of older trees is relatively rare but sometimes occurs (fig. 16.5). Squirrels also gnaw on surface-type drip irrigation pipes (fig. 16.6). They are not intimidated by people, and squirrel burrows are common beneath buildings and other structures made by humans. They are particularly fond of burrowing beneath concrete slabs.

Monitoring guidelines

Establish a plan for periodic monitoring of areas that ground squirrels are likely to invade, such as along ditch or road banks or in crops or rangelands adjacent to the nursery. The frequency of such monitoring activities depends on past problems with ground squirrels and the presence or absence of ground squirrels on adjacent properties. For example, if

FIGURE 16.4. Ground squirrel burrows at base of tree. *Photo:* R. A. Baldwin.

FIGURE 16.5. Ground squirrel gnawing on tree limbs. *Photo:* D. R. Haviland.

FIGURE 16.6. Ground squirrel gnaw marks on drip irrigation pipe. *Photo:* J. K. Clark.

you have had problems with ground squirrels in the past due to an uncontrolled population present at an adjacent property, then monitoring should be more frequent (perhaps every 1 to 2 weeks during the times of the year when ground squirrels are active). To monitor, observe squirrel haunts in midmorning when squirrels feed most actively. Where ground squirrels are a major problem, keep annual records of the dates that squirrels emerge from hibernation and when the first young are seen aboveground; changes in the general number of squirrels; and the controls used, dates of use, and their effect. Use these records as the basis for future management decisions.

Management guidelines

When even one or two ground squirrels are present in or immediately adjacent to a nursery, control them; otherwise, damage is inevitable. Fencing is practically useless against squirrels, and no feasible habitat modification within the nursery expels established animals. Unfortunately, ground squirrels are not responsive to chemical or physical repellent methods. Burrow fumigants, poison baits, and traps are the primary means of control.

Habitat modification. In natural habitat, ground squirrels generally feed in open areas where visibility is good (presumably to avoid their natural enemies), although they adapt to other situations. In nurseries, ground squirrels often burrow beneath long-standing piles of pruning refuse, wood, or rock, or use them as harborage. Removing such piles may make the area somewhat less desirable to them, but the base of trees, fence lines, and ditch banks still offer burrowing sites. As such, peripheral cleanup of cover may somewhat reduce the potential for squirrels, resulting in less expense for other more direct forms of control (i.e., trapping, baiting, and fumigation). In addition, it makes burrow detection and population monitoring easier and improves access to burrows during control operations.

Predation. Animals that prey on ground squirrels include coyotes, foxes, badgers, other mammalian carnivores, and several hawk species. Predation, however, is not a significant factor in keeping ground squirrel populations below the level that causes damage.

Trapping. Because trapping is time consuming, it is most practical for small infestations. Several types of kill traps, including modified pocket gopher box traps, tube traps, and Conibear traps, are effective. Place box-type (fig. 16.7) and tube traps on the ground near squirrel burrows or runways. Bait but do not set traps for several days so the squirrels become accustomed to them. After the squirrels are taking the bait, set the trap. Walnuts, almonds, oats, barley, and melon rinds are effective trap baits.

Set unbaited Conibear 110 traps in burrow openings so squirrels will pass through them and trip the trigger (fig. 16.8). Specially designed boxes are sometimes used with baited Conibear traps; the boxes permit the traps to be placed anywhere squirrels are active (fig. 16.9). As with all traps, take precautions to minimize capture of nontarget wildlife and pets.

Live-catch traps, such as wire-cage (fig. 16.10) and multiple-capture traps, can also be used to capture ground squirrels. As with box traps, walnuts, almonds, oats, barley, and

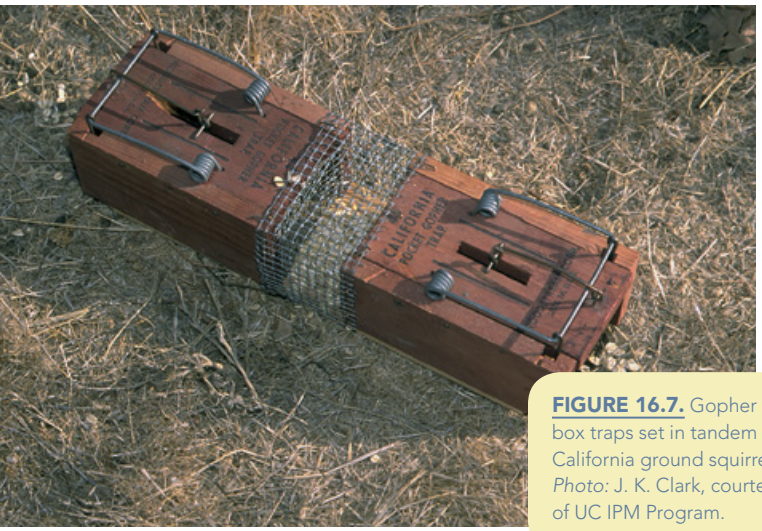

FIGURE 16.7. Gopher box traps set in tandem for California ground squirrels. *Photo:* J. K. Clark, courtesy of UC IPM Program.

FIGURE 16.8. Conibear 110 trap set at burrow entrance of California ground squirrel. *Photo:* R. A. Baldwin.

FIGURE 16.9. Conibear trap set in box with bait to capture California ground squirrels. *Photo:* R. E. Marsh.

FIGURE 16.10. Live-catch trap used to capture California ground squirrels. *Photo:* R. A. Baldwin.

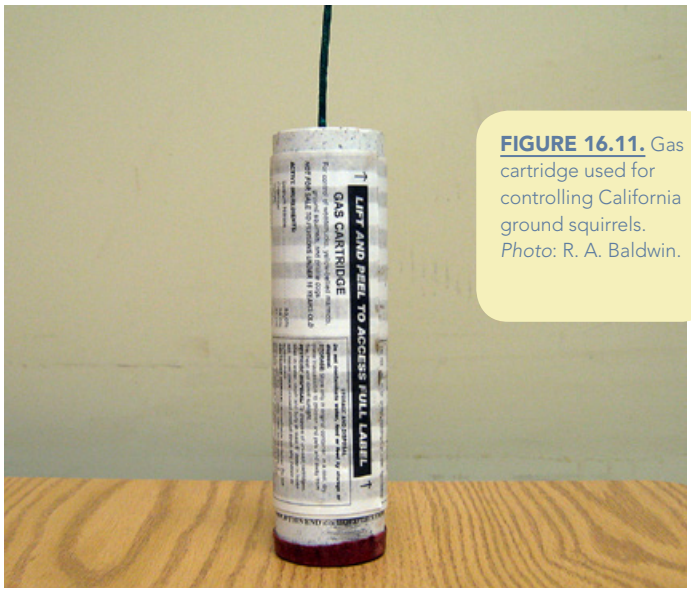

FIGURE 16.11. Gas cartridge used for controlling California ground squirrels. *Photo:* R. A. Baldwin.

many fruits and vegetables are all effective baits. Because these traps keep ground squirrels alive after capture, they are useful in areas where nontarget captures are a concern (e.g., areas with pets and children). However, ground squirrels must be euthanized by the trapper upon capture as translocation of ground squirrels is illegal, unloads your problem on others, and can spread disease such as bubonic plague. It is this extra step that limits the utility of live-trapping for some individuals. Methods of euthanasia considered humane by the American Veterinary Medical Association include gassing with carbon dioxide and shooting. Drowning is not an approved method of euthanasia.

Fumigation. Treating ground squirrel burrows with toxic gases can be a very effective control method when applied at the right time and in the correct manner. Late winter and early spring are the best times to fumigate for ground squirrels as moist soil is needed to hold toxic gases within the burrow system (see fig. 16.3). Conducting ground squirrel control prior to the birth of young will also dramatically increase the detrimental effect on the population. However, you must wait to fumigate until after ground squirrels have emerged from hibernation; ground squirrels wall themselves off in their burrows when hibernating, so fumigation is not effective at this time. Fumigation is also possible later in the year as long as sufficient soil moisture is present. However, it is ineffective when ground squirrels are estivating during the hottest times of the year, as ground squirrels again wall themselves off in their burrows. For safety and legal reasons, do not use fumigants in burrows that extend beneath occupied buildings; this limits the utility of fumigants in some nursery settings.

Two primary fumigants are used: gas cartridges and aluminum phosphide. Gas cartridges provide an easy and relatively safe way to fumigate ground squirrel burrows (fig. 16.11). They are available commercially and from some county agricultural commissioners' offices. Typically one or two gas cartridges are applied to each burrow that shows sign of activity; more than two may be needed for a large burrow system. For application, light the fuse on the gas cartridge and then quickly shove the ignited cartridge into the burrow using a shovel handle or stick. The burrow entrance should then be sealed with soil, taking care not to bury the gas cartridge with soil. Nearby burrow entrances should be watched for escaping smoke. If other burrow openings emit smoke, they should be treated and sealed as well. The larger and more complex the burrow system, the more smoke it takes to be effective. Gas cartridges do have the tendency to flare up. Therefore, to avoid fires, they should not be used around dry vegetation.

Aluminum phosphide (fig. 16.12) is also a very effective fumigant, often outperforming gas cartridges. When aluminum phosphide tablets come into contact with moist soil in the burrow, they produce phosphine gas, which is highly toxic to any animal. When using aluminum phosphide, treat every active burrow, fill the entrance with a wad of newspaper, and cover with soil. Aluminum phosphide is a restricted-use material in California, for which a permit is required for purchase or use. Application personnel must be trained regarding the material's proper use and potential hazards. The labels for aluminum phosphide are currently being revised to limit applications in residential and landscape settings, and this will

FIGURE 16.12. Aluminum phosphide tablets used to control California ground squirrels and pocket gophers. *Photo:* T. P. Salmon.

FIGURE 16.13. Bait scattered around California ground squirrel burrow using spot treatment method. *Photo:* T. P. Salmon.

likely have some influence on applications in nurseries. Be sure to read the current label to ensure proper application; contact your local county agricultural commissioner's office for further information on label changes.

Poison baits. Poison grain baits have been developed for ground squirrel control, although they tend to be ineffective from the time ground squirrels emerge from hibernation through late spring (see fig. 16.3). During this period, ground squirrels feed extensively on green vegetation and may not accept grain baits. Hence, the time of baiting is critical. In the Sacramento region and more northerly portions of the state, ground squirrels generally switch from eating vegetation to eating seeds, grains, and nuts around the later part of May. However, farther south, this may occur 2 to 6 weeks earlier depending on the amount and timing of spring rains. The month following this dietary switch is the best time for baiting, especially with zinc phosphide baits (see following paragraph). When much of the adult population goes into estivation during the hottest part of the summer, suspend baiting until after September 15. Continue baiting through the end of October. During this time, many squirrels again feed on grain baits until they go into winter hibernation. Various grain baits with one of several poisons are available from commercial distributors or the county agricultural commissioner's office.

Zinc phosphide, a single-dose poison bait, is the most cost-effective toxin for ground squirrels and generally produces results within 48 hours. However, it is a restricted-use material in California, thereby requiring a permit for purchase and use. When applying zinc phosphide, distribute bait by spot-baiting (scattering bait by hand on bare ground to cover 2 to 3 square feet at the side or behind each active burrow) (fig. 16.13) or by broadcasting (scattering bait relatively uniformly over the entire infested area). Broadcasting can be done by hand with a belly grinder-type seeder or with a vehicle equipped with a tailgate-type seeder. Consult the product label for recommended application methods and rates.

Multiple-dose baits (anticoagulant rodenticides such as chlorophacinone and diphacinone) provide effective control when squirrels ingest them in multiple feedings for 5 days or more. Death generally occurs from 5 to 14 days following the first feeding. Eating anticoagulant bait does not immediately affect the squirrel's feeding or activity. To be effective, multiple-dose baits must remain available; effectiveness is greatly reduced if 48 hours pass between feedings. The multiple feedings usually required for a fatal dose, the slow action of the anticoagulants, and the availability of an antidote (vitamin K1) make anticoagulant rodenticides safer to livestock, pets, and children than some other rodenticides.

Use anticoagulant baits in bait stations or, if the label permits, spread it by repeated spot-baiting or broadcast baiting. Bait stations are small structures designed to hold enough bait to provide multiple feedings and to allow the squirrel to enter and feed (fig. 16.14). Bait stations safeguard larger nontarget species by excluding them from the bait.

Historically, anticoagulant baits such as chlorophacinone and diphacinone have not been restricted-use materials. However, starting in 2011, their use became federally restricted. Therefore, you will need to obtain a permit to purchase and use these anticoagulant baits. It is best to consult your local county agricultural commissioner's office before using these anticoagulant baits to ensure that you are applying them appropriately.

FIGURE 16.14. Bait station used for controlling California ground squirrels. *Photo:* J. K. Clark, courtesy of UC IPM.

FIGURE 16.15. Pocket gopher. *Photo:* J. K. Clark.

FIGURE 16.16. Pocket gopher mound with typical fan-shaped appearance. *Photo:* R. A. Baldwin.

Pocket Gophers

Pocket gophers (*Thomomys* spp.) are stout-bodied, short-legged rodents (fig. 16.15). External fur-lined cheek pouches open outside the lips, on each side of the mouth, and are used extensively for carrying food. The head and body measure 6 to 8 inches. They have a short, scantily haired tail. In nurseries and other irrigated lands, females may produce two litters in a single year, with litters averaging about five young.

Pocket gophers are most common in areas of abundant plant growth. They feed primarily on succulent underground parts of herbaceous plants, but they are capable of pulling a 2-foot-tall plant underground to consume it.

This species lives almost entirely underground. Pocket gophers are antisocial and solitary except during breeding and when the young are being raised. Burrow systems may be extensive and include deep main burrows, shallow feeding tunnels, and side tunnels to push out dirt. They create characteristic soil mounds aboveground (fig. 16.16). Main tunnels are normally 10 to 12 inches under the surface but are frequently deeper. Some lead to deeper nests or food storage chambers. The animals plug burrow openings with soil so that the tunnel system is completely enclosed. As a result, the temperature and humidity in the burrow are stable and close to optimal.

Damage

Pocket gophers often invade nurseries, feeding on many garden crops, ornamental plants, vines, shrubs, and trees. A single gopher moving down a nursery row can inflict considerable damage in a very short time. Gophers also gnaw and damage plastic water lines and lawn sprinkler systems; their tunnels can divert and carry off irrigation water, which leads to soil erosion; and mounds on lawns interfere with mowing equipment and ruin the aesthetics of well-kept turf grass.

Monitoring guidelines

Because pocket gopher damage typically occurs belowground, it often goes undetected until plants exhibit stress. By that time the plant may be beyond saving. Gopher activity, however, is readily detected; simply look for fresh mounds of soil. The animals produce these in greatest numbers in the spring and fall when the soil is amply moist.

Management guidelines

Persistent efforts can control pocket gophers and even eliminate them. The preferred control methods are baiting, trapping, and fumigation. No chemical or mechanical repellents have been effective against pocket gophers.

Habitat modification. Permanent ground covers of herbaceous (e.g., clover) and certain grassy plant (e.g., nutsedge) species favor gophers. Removal of the permanent ground cover will do much to reduce their numbers, as food is generally the factor that limits populations. Deep cultivation destroys some burrows, making the nursery less habitable; clean cultivation removes cover for gophers and allows growers to detect new mounds easily. Controlling gophers along fencerows and roadways adjacent to nurseries is important, because young gophers will disperse from there into the nursery.

When portions of nurseries are flood irrigated, very young pocket gophers may be drowned and adults may be forced to the surface, where local natural predators or the irrigator's dog can kill them. By comparison, sprinklers or drip irrigation systems generally favor pocket gophers.

Predation. A variety of predators feed on pocket gophers, although their presence does not usually keep gopher populations low enough to prevent economic damage.

Exclusion. Underground fencing might be justified for valuable ornamental shrubs or landscape trees. To protect existing plantings, bury hardware cloth or ¾-inch mesh gopher wire at least 2 feet deep with an additional 6 inches of mesh or wire bent at a 90-degree angle away from the planting. This will help keep gophers from digging around the fencing boundary. Also extend the fencing at least 1 foot aboveground to deter gophers moving overland. This method is not perfect, however, because persistent gophers can burrow below the wire; also, the wire can restrict and damage root growth of trees.

You can protect small areas such as flower or nursery beds by complete underground screening of the bed's sides and bottom (fig. 16.17). When constructing raised beds, underlay the soil with wire to exclude gophers. To protect individual plants, install wire baskets, which you can make or buy commercially, at the same time as you are putting the plants into the ground. If you use wire, use one that is light gauge and use it only for shrubs and trees that will need protection while young. Leave enough room to allow for the roots to grow. Galvanized wire provides the longest-lasting protection. Six to 8 inches of coarse gravel 1 inch or more in diameter around underground sprinkler lines or utility cables also can deter gophers.

Trapping. Trapping is safe and one of the most effective although labor-intensive methods for controlling pocket gophers. Several types and brands of gopher traps are available. The most common type is a two-pronged, pincher trap such as the Macabee, Cinch, or Gophinator, which the gopher triggers when it pushes against a flat, vertical pan (fig. 16.18). Another popular type is the choker-style box trap. (For directions on trapping gophers, see the *UC IPM Pest Notes* website in the References at the end of this chapter.)

Fumigation. The burrows of pocket gophers are extensive. Portions of these are relatively near the surface; therefore, maintaining a lethal concentration of most burrow fumigants (poison gases) is difficult. Plus, pocket gophers can escape detectable fumigants quickly by plugging their burrows. However, one registered fumigant, aluminum phosphide, has produced very acceptable results. Aluminum phosphide is a restricted-use material, for which a permit is required for purchase or use. Application personnel must be trained regarding the material's proper use and potential hazards.

Poison baits. Single-feeding poison baits (e.g., strychnine and zinc phosphide) placed in the burrow tunnels are widely used for controlling gophers, although results are sometimes erratic. Multiple-feeding anticoagulant baits (e.g., chlorophacinone and diphacinone) are also available for use on pocket gophers. Previous studies indicated less success with anticoagulant baits, given that they require multiple feedings. These baits must be reapplied after the initial bait application to maintain a constant bait supply during the baiting period; this results in greater cost for treatment than with single-dose baits. Regardless of bait used, follow label directions for application methods and amounts. The two methods of bait application are hand-baiting and mechanical baiting.

Hand-baiting usually requires a metal probe that is used to locate one of the gopher's tunnels. With a pointed ¼-inch steel rod, probe near the fresh mounds or between two recent mounds to find the burrow. Then enlarge the probe opening with a larger rod or broomstick, and place the label-specified amount of grain-type bait in the burrow; a funnel can also be used to pour the bait into the tunnel. If gophers have infested a large area, use a hand-held bait applicator to speed treatment. Bait applicators are a combination of probe and bait reservoir (fig. 16.19). Once you have located a tunnel using the probe, a trigger releases a predetermined amount of bait into the tunnel. Generally, strychnine bait is used with such an applicator because it dispenses only a

FIGURE 16.17. Raised nursery bed lined with gopher wire to exclude gophers from plants. *Photo:* R. E. Marsh.

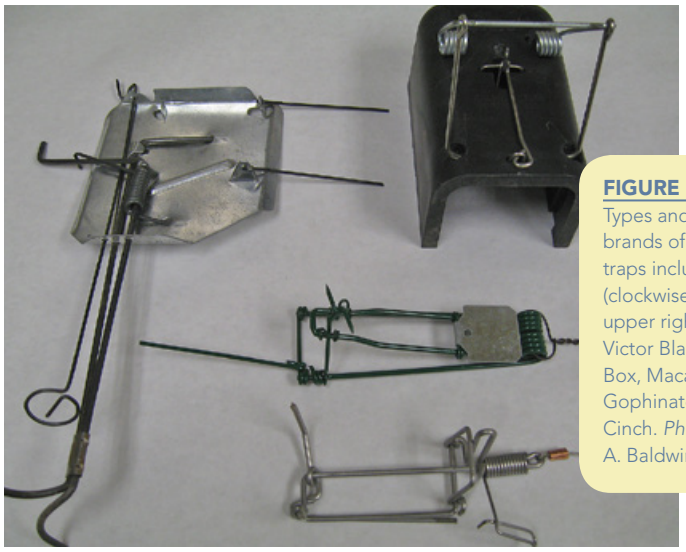

FIGURE 16.18. Types and brands of gopher traps include (clockwise from upper right) Victor Black Box, Macabee, Gophinator, and Cinch. *Photo:* R. A. Baldwin.

FIGURE 16.19. Combination probe and bait dispenser used to control pocket gophers. *Photo:* R. A. Baldwin.

FIGURE 16.20. Meadow vole. *Photo:* J. K. Clark.

FIGURE 16.21. Vole runway and burrow. *Photo:* R. A. Baldwin.

small quantity of bait at a time. Whichever of these hand-baiting methods you use, be sure to cover the probe hole with a dirt clod, rock, or some other material to exclude light. However, do not cover the hole with loose soil as this will bury the bait, thereby limiting gopher access.

Mechanical bait applicators are tractor drawn and offer an excellent alternative method for controlling gophers over large areas. The device constructs an artificial burrow beneath the soil and deposits poison grain bait within it at preset intervals and quantities. The machine is driven between the rows of nursery plants where pocket gopher activity is seen. The artificial burrow intercepts some of the gopher's natural burrows, or the gopher will soon discover an artificial one and consume the bait. When using the mechanical applicator, use a shovel to occasionally open a small section of the artificial burrow and inspect its depth and condition. Soil must be moist but not overly saturated to produce a well-formed, smooth, artificial burrow.

Meadow Voles

Meadow voles (*Microtus* spp.), also called meadow mice or field mice, are mouselike rodents somewhat similar in appearance to pocket gophers (fig. 16.20). They have a compact, heavy body, short legs, short-furred tail, small eyes, and partially hidden ears. The long, coarse fur is blackish brown to grayish brown. When fully grown they can measure 5 to 8 inches long, including the tail.

Although voles spend considerable time aboveground and may occasionally be seen scurrying about, most of their time is spent belowground in their burrow system. The clearest signs of their presence are the well-traveled, aboveground runways that connect burrow openings; the runways are usually hidden beneath a protective layer of grass or other ground cover (fig. 16.21). The maze of runways leads to multiple burrow openings that are each about 1.5 to 2 inches in diameter (fig. 16.22). If abundant ground cover is present, the runways can be easily found by pulling back overhanging ground cover. Fresh clippings of green grass and greenish-colored droppings (pellets) about 3⁄16 inch long in the runways and near the burrows are further evidence of voles. With age, the droppings lose their green color and turn brown or gray (fig. 16.23).

FIGURE 16.22. Vole burrow openings. *Photo:* R. A. Baldwin.

FIGURE 16.23. Vole pellets on runway. *Photo:* R. A. Baldwin.

Females may produce from 5 to 10 litters a year. A few females breed year-round, but the principal breeding time is during late winter and spring. Because voles mature rapidly and can bear multiple litters yearly, vole populations can increase quickly. Typically the numbers peak every 6 to 8 years, with populations as high as hundreds of voles per acre.

Damage

Voles cause damage by feeding on a wide range of outdoor garden plantings and by gnawing on the bark of many tree species. Vole damage to tree trunks normally occurs from a few inches aboveground to a few inches below ground (fig. 16.24). If the damage is belowground, you will need to remove soil from the base of the tree to see it. Although voles are poor climbers, if they can climb on to low-hanging branches, they may cause damage higher up on trees as well.

Gnaw marks about ⅛ inch wide and ⅜ inch long found in irregular patches and at various angles, taken in conjunction with other signs (droppings, runways, and burrows), indicate vole damage. If voles gnaw completely around the trunk or roots, the tree's flow of nutrients and water will be disrupted; this is called girdling. Girdling damage on trunks and roots can kill trees. Signs of partial trunk or root girdling may include a prolonged time before young trees bear fruit, reduced fruit yield, abnormal yellowish leaf color, and overall poor vigor. Where snow cover is present, damage to trees may extend a foot or more up the trunk. Damage that occurs under snow cover often escapes notice until it is too late.

Monitoring guidelines

Be alert for the presence of voles. Look for fresh trails in the grass, burrows, droppings, and evidence of feeding in the nursery and surrounding area. Pay particular attention to adjacent areas that have heavy vegetation, as such areas are likely sources of invasions.

Management guidelines

To prevent vole damage, you need to manage the population in an area before it reaches high numbers. This can often be achieved by removing or reducing the vegetative cover, thus making the area unsuitable to voles. Removing cover also makes detecting voles and other rodents easier. It is important to act before vole numbers increase rapidly, as the damage these pests do to nursery plants and trees can be quite severe.

Habitat modification. One way to effectively deter vole populations is to make the habitat less suitable to them. Weeds, heavy mulch, and dense vegetative cover encourage voles by providing food as well as protection from predators and environmental stresses. If you remove this protection, their numbers will decline. You can reduce the base area from which voles can invade nurseries by regularly mowing, spraying with herbicides, grazing, or tilling grassy areas along ditch banks, rights-of-way, or field edges adjacent to planted areas. If feasible, weed-free strips can also serve as buffers around areas to be protected. The wider the cleared strip, the less apt voles will be to cross and become established in planted areas. A minimum width of 15 feet is recommended, but even that can be ineffective when vole numbers are high. A 4-foot-diameter circle around the base of young trees or vines that is free of vegetation, or a buffer strip of 4 feet or more along a row of trees, can reduce problems, because voles prefer not to feed in the open.

Predation. Predators such as coyotes, foxes, badgers, weasels, owls, and hawks feed on meadow voles; however, predation is rarely, if ever, a major factor in controlling a rapidly increasing vole population.

FIGURE 16.24. Girdling damage caused by meadow voles. *Photo:* J. K. Clark, courtesy of UC IPM.

Exclusion. Wire fences at least 12 inches above the ground with a mesh size of ¼ inch or less will help to exclude voles from large areas. These fences can either stand alone or be attached to the bottom of an existing fence. Bury the bottom edge of the fence 6 to 10 inches to prevent voles from tunneling beneath it. A weed-free barrier on the outside of the fence will increase its effectiveness.

Cylindrical wire or plastic trunk guards can protect young trees from voles (fig. 16.25). To hinder burrowing, guards must extend at least 6 inches below the soil surface, but even then voles may dig beneath them. Meadow voles rarely climb over guards. On the other hand, trunk guards can encourage voles by giving them a sense of security. The voles often work beneath them or gnaw in seclusion behind them, where early damage goes undetected.

Trapping. When populations of voles are not overly numerous, trapping can be used to remove voles. Use a sufficient number of traps to control the population: for a

FIGURE 16.25. Tree cover used to protect trunk of tree from vole and rabbit damage. *Photo:* J. K. Clark, courtesy of UC IPM.

small area a dozen traps is probably the minimum number required, and for larger areas at least 50 or more may be needed. A simple, wooden mouse snap trap is all that is needed to capture voles, although trap placement is crucial. Voles seldom stray from their runways, so set traps along these routes. Look for burrows and runways in grass or mulch in or near the nursery. Place traps (bait is usually not necessary) at right angles to the runways with the trigger end in the runway. Examine traps daily and remove dead voles or reset sprung traps as needed. Continue to trap in one location until no further voles are caught, then move the trap to a new location 15 to 20 feet away. When possible, destroy old runways or burrows to deter immigration of new voles to the site. Bury dead voles or place them in plastic bags in the trash. Be sure to keep small children and pets out of the area where you have set traps.

Repellents. Chemical repellents are marketed for voles and have been tested, but no repellents have been effective in protecting nursery plants from voles.

Poison baits. Toxic grain baits are very effective in reducing meadow vole populations. For most effective control, apply bait in the voles' runways, where most feeding occurs. Spot-bait or broadcast bait over the entire infested area. Spot treatments involve spreading bait thinly around the burrow opening, making sure not to pile bait. For broadcasting, use a belly grinder–type seeder or a vehicle with a tailgate seeder. Broadcast application rates vary depending on estimated density of the vole population and type of toxicant. Both single-dose (e.g., zinc phosphide) and multiple-dose (e.g., chlorophacinone) poisons are used for vole control. Consult the product label for application methods and rates. For more specific instructions on vole baiting, go to the *UC IPM Pest Note* for voles on the UC IPM website (see the References at the end of this chapter).

Rabbits

Rabbits are a form of wildlife enjoyed by many people, but they can be very destructive to nurseries. Eight species of rabbits are found in California. Three of these species, the black-tailed hare, or jackrabbit, *(Lepus californicus)*, the desert cottontail *(Sylvilagus audubonii)*, and the brush rabbit *(S. bachmani)* are widespread and cause the majority of problems (fig. 16.26). Because of its greater size and abundance, the jackrabbit is the most destructive, although the cottontail may be a more frequent pest of nurseries.

The jackrabbit is about as large as a house cat, weighing 3 to 7 pounds, with a body length of 17 to 21 inches. It has a grayish brown body, long black-tipped ears, relatively long front legs, and even longer hind legs. The top of its tail is black. The desert cottontail rabbit and brush rabbit are distinguished from jackrabbits by their smaller size and shorter ears. The desert cottontail is 12 to 15 inches long, weighs 1.5 to 2.8 pounds, and has pale gray fur with yellow tints. The brush rabbit is slightly smaller at 11 to 13 inches long, weighs 1.3 to 1.8 pounds, and has brown fur.

A good sign that rabbits are present is coarse, circular fecal droppings, or pellets, found scattered over an area. Pellet

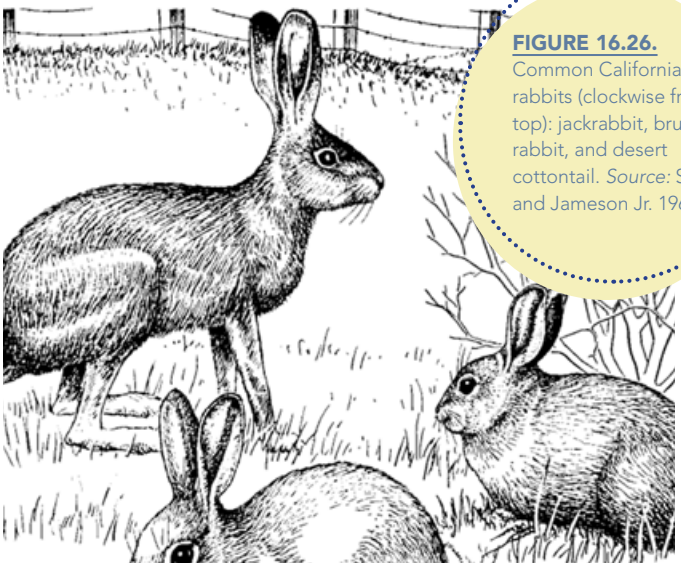

FIGURE 16.26. Common California rabbits (clockwise from top): jackrabbit, brush rabbit, and desert cottontail. *Source:* Storer and Jameson Jr. 1965.

size varies roughly with the body size of the species: jackrabbit pellets are about 0.5 inch in diameter, whereas pellets of the cottontail are closer to 0.25 inch.

Jackrabbits are usually found in open or semiopen areas of California valleys and foothills. They are seldom found in dense brush or woodlands. Within their preferred habitats, jackrabbits are quite adaptable and inhabit areas around the fringes of urban and suburban developments, green belts, golf courses, parks, airports, and agricultural lands. They make a depression in the soil, called a form, beneath a bush or other vegetation, and they use it for hiding and resting during the day.

The food habits of jackrabbits are variable, depending on location and the availability of appropriate plants. Rabbits prefer to eat succulent, green vegetation; grasses and herbaceous plants make up the bulk of their diet. In some areas rabbits eat leaves, bark, or seeds of woody shrubs. Feeding usually begins during the evening hours and continues throughout the night and into the early morning. Jackrabbits can survive without a supply of drinking water.

If food and other necessary resources are found in one place, jackrabbits exhibit no major daily movements. If food sources and areas for shelter are separated, jackrabbits will move between these areas in the morning and evening. Daily travel of 1 to 2 miles round-trip between areas is common. During dry periods, round-trips of up to 10 miles have been observed. These travels are habitually made on the same trails every day, producing noticeable paths through herbaceous vegetation.

Unlike jackrabbits, desert cottontails and brush rabbits generally inhabit places with dense cover such as brushy areas, wooded areas with some underbrush, or areas with piles of rocks or debris. Abandoned structures and sometimes cultivated fields are also used for cover. Open areas are used more at night, while dense cover is used more during the day. The brush rabbit, however, seldom feeds more than a few feet from its cover.

A good habitat, such as a nursery with a clump of low-growing junipers about 30 feet wide, may harbor 10 to 15

cottontails, but normal density is considerably less (an average of one rabbit per acre). Cottontails and brush rabbits do not exhibit the same magnitude of daily travel as seen in jackrabbits, although they do make habitual use of travel lanes within frequently used areas.

Damage

Rabbits can be very destructive in nurseries, particularly when nurseries are bordered by wild or uncultivated lands, as these wild areas provide resting and hiding cover during the day while being within easy travel distance to prime, irrigated food sources. Common foods of rabbits are wide ranging and include a variety of vegetable, tree, berry, herbaceous, and ornamental plantings. Rabbits also gnaw and cut plastic irrigation lines.

Most rabbit damage is close to the ground, except where snow allows rabbits to reach higher portions of plants. Rabbits use their incisors to make a characteristic diagonal 45-degree cut when clipping off woody twigs, buds from saplings, or flower heads. Twig clipping by rabbits is sometimes confused with deer browsing. Deer damage can be identified easily if it occurs above a height that rabbits can reach (about 2 feet) and by careful examination of the damaged twigs. Deer have no upper front teeth and must twist and pull when browsing, leaving a ragged break on the branch. Rabbits clip twigs off cleanly, as if with a knife.

Rabbits tend to gnaw the smooth, thin bark from young trees. The rough bark of older trees discourages gnawing, although old damage and gnaw marks are often present on old bark along with fresh patches of gnawing in areas of younger growth. Gnawing can completely girdle a tree, and clipping can remove the terminal shoot and lateral branches from plants. Damage by cottontails and brush rabbits is often concentrated in areas near escape cover. Jackrabbits, however, will feed far into open areas and can eat 0.5 to 1.0 pound of green vegetation each day.

Tularemia, or rabbit fever, may be carried by rabbits. This disease is relatively rare in humans but can be contracted by handling an infected rabbit with bare hands or by eating insufficiently cooked rabbit meat. Therefore, rabbits should never be handled with bare hands.

Monitoring guidelines

Rabbits are mostly nocturnal, but they are sometimes seen during the daylight hours in areas where they may simply be loafing. Rabbit signs, such as feeding damage, trails, and droppings, indicate their presence. Because few, if any, rabbits can be tolerated in a nursery setting, take appropriate action when the first sign of rabbits is observed. Rabbits that have been seen nearby frequently invade nurseries when the plantings become desirable to them. Therefore, consider exclusion methods or some other control program before serious damage occurs.

Management guidelines

Rabbit control in nurseries primarily includes exclusion, repellents, trapping, and poisoning where legal. Habitat modification can help reduce potential damage for cottontails but is less effective for jackrabbits. The choice of control method should depend on the urgency of the problem and the situation. Manage rabbit populations before severe damage occurs.

Habitat modification. Remove hiding cover to discourage cottontails and brush rabbits, especially in suburban habitats where alternate habitats may be limited. Remove brambles, piles of brush, stones, or other debris where rabbits might hide. Control vegetation along fencerows, ditch banks, or brushy areas. Keep in mind that vegetation management may affect other wildlife, notably songbirds. Removing cover will probably have little effect on jackrabbits because they can use cover that is often great distances from the feeding sites.

Exclusion. Where jackrabbits or cottontails are a constant and continuing threat to young plants, fencing the entire nursery may be the best management approach. If this is not feasible, constructing a fence around selected blocks or beds is also effective. To make an effective barrier, build a fence 36 inches high of woven wire or poultry mesh, using 1- to 1.5-inch-diameter mesh (fig. 16.27). After digging a trench 6 inches deep and 6 inches wide along the fence line, bury 48-inch-wide wire 6 inches deep, leaving a 6-inch lip turned outward at a right angle at the bottom. This will leave a 36-inch-high fence when backfilled with soil, which rabbits will normally not jump; burying the bottom prevents their digging beneath it. If you are constructing a deer-proof fence, the additional expense of a bottom roll of the smaller-mesh wire, properly buried to also exclude rabbits, may be worthwhile.

Temporary fences using silt fencing can be used to exclude rabbits in growing areas where a permanent fence is not required. As referenced above, the bottom must not have any access points where the rabbits can crawl under. Pinning with staples (e.g., those used for nursery ground cover fabric) every few inches or burying the bottom in a trench as previously described will exclude rabbits.

Electric netting (a type of electric fence) is also suitable for rabbit control. It is designed for ease of installation and frequent repositioning. Electric netting is intended for temporary use at any one site, making it ideal for small areas in nurseries.

Predation. There are a number of predators that will feed on rabbits, including coyotes, bobcats, and raptors. However, these predators are rarely able to control rabbit populations to sufficient levels to mitigate damage.

Trapping. Cottontails can be trapped fairly easily using live traps (see fig. 16.10), although capturing jackrabbits in the same manner is much more difficult given their reluctance to enter confined spaces. When using live traps, captured rabbits must be euthanized in a humane manner; relocation of captured animals is not allowable under the California Fish and Game Code. Euthanasia via a carbon dioxide chamber is the preferred method for dispatching rabbits, although

FIGURE 16.27. Woven wire fence used to exclude rabbits. *Photo:* J. K. Clark, courtesy of UC IPM.

shooting (if in an area where shooting is allowed) is another method. Often individuals are not comfortable euthanizing captured rabbits. If this is the case, consider using kill traps or hiring a wildlife pest control operator to remove the rabbits for you.

A few kinds of kill traps are effective for cottontails; Conibear 110 or 120 traps placed in a trap box are a common example. Other less common kill traps are available but may need to be specially ordered. These traps should be prebaited in target areas before setting. Common baits include fruits, vegetables, barley, or whatever foods the rabbits are consuming in the nursery. Once rabbits begin to actively consume the baits, set traps and check daily for captures. On occasion, traps may severely injure but not kill the rabbit. It is very important that the rabbit be euthanized as soon as possible. Also, coyotes or other carnivorous species may try to run off with the trap, to carry the rabbit away; checking traps daily to remove dead rabbits helps to reduce this occurrence. Multiple traps will be needed per site; one trap is rarely enough to capture rabbits. Be aware that traps may present a potential hazard to nontarget species, so use caution and good judgment when setting kill traps.

Repellents. Various chemical repellents can reduce or prevent rabbit damage. They are most useful when applied to trees, vines, or ornamentals. Repellents can be classified as area (odor), taste, or contact (sticky) repellents. Research has shown that repellents with putrescent whole-egg solids are among the best at reducing browsing by rabbits.

Apply repellents before damage occurs and reapply them frequently, especially after a rain, heavy dew, or sprinkler irrigation, or when new growth occurs. In all cases, follow the label directions for the repellent you are using. Effectiveness of repellents often depends on availability of alternative food sources. If additional food sources are abundant, repellents sprayed on target plants may be effective. If additional food sources are scarce, repellents may have little effect.

Poison baits. Poison baits offer an economical way to control large numbers of rabbits in large areas, although results are sometimes erratic. Only multiple-dose poisons (e.g., diphacinone) are registered for use against rabbits, and they come in grain or pelletized formulations. Previously, these baits were registered solely for use on jackrabbits. However, recent changes to some labels now allow for baiting of cottontails in nurseries as well. Be sure to consult the label to verify the legality of using a toxicant for rabbit control.

Place multiple-dose anticoagulant baits in a covered or enclosed self-dispensing feeder or a covered or enclosed nursery flat. Position the feeders in areas frequented by rabbits, such as trails and resting and feeding areas. If rabbits fail to feed after a few days, move feeders to where bait is readily accepted. Keep bait available until all feeding ceases, which may be from 1 to 4 weeks.

Place poisoned bait where other vertebrates—especially children—will not have access. Be aware of all wildlife in the area, such as doves or quail, and take precautions to protect them from poisoning. Carcasses of poisoned rabbits should be picked up and disposed of by deep burying, burning, or by double-bagging in a trash bag and then disposing in the garbage.

Deer

Deer *(Odocoileus hemionus)* (fig. 16.28) can cause significant damage to a nursery where the habitat adjacent to the nursery supports moderate to high populations. Foothill and coastal districts with brush or woodlands that provide cover for deer usually experience the most problems. Nurseries near stream bottoms may also suffer. State wildlife management laws limit options for control. Therefore, controlling deer damage can be difficult and expensive.

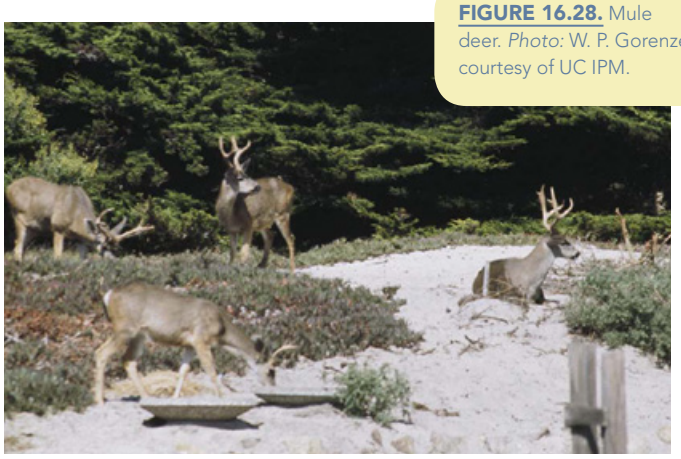

FIGURE 16.28. Mule deer. *Photo:* W. P. Gorenzel, courtesy of UC IPM.

Damage

Deer eat a variety of vegetation including woody plants, grasses, and forbs. They also consume fruit, nut, and ornamental trees, as well as shrubs, vines, and vegetables. Deer trample plants and damage young trees and shrubs by rubbing their antlers on trunks and limbs.

Monitoring guidelines

Although deer are large and easily seen, their nocturnal habits may make it necessary to check the nursery at night with a flashlight. Also look for physical signs of deer such as tracks, droppings, trails, and damage to foliage from deer browsing.

Management guidelines

The California Fish and Game Code classifies deer as game animals. If you find them damaging nursery plants, you may request a permit from your local game warden to shoot them, although this method is not generally recommended for problems around residential areas and nurseries. Traps and poisons are illegal and cannot be used. Deterrents such as fences, barriers, frightening devices, and various repellents are recommended and can all be used without a permit. Physical exclusion is by far the best and most reliable way to protect nursery plantings from deer.

Habitat modification. Eliminating suitable cover for bedding and other survival needs is rarely feasible. Deer are highly mobile and may travel ½ mile or more to reach nurseries, especially when they have become accustomed to feeding there.

Exclusion. Fencing is the most effective method for excluding deer from a nursery. A 7-foot-high wire fence usually works. A 6-foot-high mesh fence can be heightened to 7 feet by adding two or three strands of barbed or smooth wire on top (fig. 16.29). Deer may occasionally clear a 7-foot fence when being chased or if the fence is on steep, sloping ground. Electric fences have been used successfully in some areas. Check deer fences periodically to be sure they remain intact; damaged wire, broken gates, soil washout beneath fences, and so on, permit access and must be repaired immediately. Deer that manage to circumvent the fence and get inside may have to be removed by shooting if they cannot be driven out; a depredation permit would be required for this removal. The *UC IPM Pest Note* website for deer has more specific details on fencing (see the References at the end of this chapter).

In many places, protecting individual blocks of container plants or individual field-grown trees may be more practical and economical than fencing an entire area. For example, young field-grown fruit or nut trees can be individually fenced until primary branches grow above the deer's reach, usually 5 to 7 feet above the ground. Poultry wire, heavier woven wire, or strong plastic netting can be attached to two stakes to form a circle around the tree. Plastic trunk protectors are especially useful for young vines and trees. Inspect individual protectors regularly because they can restrict plant growth. In addition, care must be taken to ensure that the protector itself does not damage the vine or tree by causing an accumulation of excess heat or moisture.

FIGURE 16.29. Deer-proof fence. *Photo:* J. K. Clark, courtesy of UC IPM.

Repellents. Many chemical repellents have been tested, but deer usually adjust to them rapidly, especially when hungry. When deer populations increase, they compete fiercely for food, and repellents become totally ineffective. Taste or odor repellents can be somewhat effective, however, if applied to the foliage and treated again as new foliage develops or after rain or irrigation washes the repellent away. Noise-making devices, such as propane exploders and electronic alarms, have not been effective for more than a day or so because deer rapidly habituate to frightening devices.

Shooting. In circumstances where damage from deer is high, depredation permits may be obtained from the Department of Fish and Wildlife, but shooting is rarely a satisfactory solution to a significant deer problem. Additionally, many residential areas do not allow the discharge of firearms, thereby limiting shooting as a tool for deer management.

Birds

Many birds are frequent visitors to nurseries. Typically they cause little damage when foraging for insects and seeds. However, some species, such as white-crowned sparrows (*Zonotrichia* spp.) (fig. 16.30), horned larks *(Eremophila alpestris)*, crows (*Corvus brachyrhynchos)*, and house finches *(Carpodacus mexicanus)* (fig. 16.31), can become substantial pests when they unearth and eat seeds or feed on newly sprouted seedlings. Controlling damage in these situations is necessary to maintain nursery production.

Damage

Birds can reduce newly planted stands in field nurseries and in flats by feeding on seeds and young seedlings. They can also reduce seed germination in containers when seeds are directly sown, and they can damage newly planted plugs, liners, and transplants in containers. Young plants may be nipped off, or small holes may remain in the soil where the seedling was pulled. However, most damage occurs on young seedlings, before seedlings have two or three true leaves.

Horned larks feed on seeds of wild plants and on insects in open grasslands. They move into nurseries when natural forage is scarce or when nurseries are planted close to their habitat. They feed in flocks and can decimate newly planted areas in a few hours. They tend to feed well out into the field and do not concentrate along fencerows or wooded areas. In contrast, house finches and crowned sparrows feed along the edges of fields. Although house finches feed primarily along the field edges, they are often seen in open areas and tend to scatter to high, open perches when alarmed.

Monitoring guidelines

Closely watch newly planted or sprouted areas for bird damage (i.e., nipped seedlings and small holes where seedlings have been removed). Also, regular weekly monitoring through bird counts will help you determine when damage actually starts so you can take action early. Watch for movement of birds into or within the nursery. Keep track of species by count and location seasonally if you have had substantial damage in the past. These records will help you plan control strategies in advance and will provide information on the effectiveness of previous control actions.

Management guidelines

The U.S. Code of Federal Regulations classifies most birds that cause problems in nurseries as migratory nongame birds. As such, they are protected from indiscriminate control. Permits from either the county agricultural commissioner's office or the U.S. Fish and Wildlife Service are required for their removal from nurseries; who provides the permit depends on the depredating species. However, no permit is needed to frighten or exclude depredating or nuisance birds from the area unless they are nesting.

Of the several approaches to solving bird problems in nurseries, exclusion and frightening are the most commonly used. Anticipating the problem is critical because damage is often sudden and catastrophic. Birds may descend without warning and devour newly planted seeds or seedlings before you are aware of the birds' arrival. Preventive action is the key to success.

Habitat modification. Nurseries are attractive to birds, and not much can be done to modify the habitat to discourage them. Adequately pruning shrubs in the landscape or field to prevent overgrowth tends to reduce cover for some birds, as does eliminating brush piles, which can attract them. By observing the activity of the birds in your nursery, you may be able to identify and remove or modify the things that attract them.

Predation. A few raptor species prey regularly on crowned sparrows, horned larks, and house finches. In and around nurseries, however, the avian predators are not numerous enough to have a measurable effect on pest populations. Occasional mammalian predators capture birds when birds are feeding on the ground, but these kills mean little in terms of significant population reduction.

Exclusion. Exclusion is a consistently effective method of reducing or eliminating bird damage in the nursery. Purchase lightweight ¾-inch-mesh plastic netting for this purpose. Suspend the netting over berry vines or small trees to protect the fruit from bird damage.

FIGURE 16.30. White-crowned sparrow. *Photo:* J. K. Clark.

FIGURE 16.31. House finch. *Photo:* W. P. Gorenzel.

Build a frame out of plastic pipe or wood to support the netting above the seedbeds to keep the netting from reducing or interfering with plant growth. The netting can be loosened and folded back to permit harvest. This method can also protect crops from rabbits, squirrels, and neighborhood cats. Arches made of concrete reinforcement bar or long pliable wood also work well to support netting. These should be able to be lifted off, or the netting pulled back, to allow for attending to the plants. To keep birds from getting beneath the netting, make sure that the netting reaches the ground. Do not be careless in placing the net; keep it taut and tight fitting, as birds can become entangled in loose netting. Wire mesh or aviary wire row caps can also be effective for protecting rows of seedlings, and they are stiff enough to not require a support frame. The mesh should be secured to a wooden frame. Row caps can be lifted off as the plants mature and can be used year after year. Inverted plastic strawberry baskets can also serve the purpose. See pages 16 to 19 of Salmon et al. (2006) for additional details and diagrams of exclusionary devices for birds.

Frightening. Twisted reflective tape stretched 6 to 8 inches above the length of a row of seedlings can effectively frighten birds away when the wind causes the reflective tape to shimmer and shine. A row of tin can lids strung on a wire may also frighten birds, as can devices such as large scare-eye balloons. See pages 18 to 20 of Salmon et al. (2006) for additional details and diagrams of visual frightening devices for birds.

If a nursery is in a rural area, auditory devices such as propane cannons, electronic distress calls, shell crackers, and bird bombs can be effective at dispersing some bird species. However, these are noisy devices and not usually acceptable in residential or urban settings. When using auditory frightening devices, do not rely on any single device but rather on a combination of treatment approaches. For example, you may decide to use propane cannons for 5 to 7 days, then switch to bird bombs for the following week. Combining these auditory devices with visual repellents such as scare-eye balloons and reflective streamers may also increase their effectiveness. The most innovative and varied approach to frightening birds will usually be the most effective, as birds rapidly habituate to the same auditory and visual stimulus.

Trapping. Trapping is rarely the solution to bird problems in a nursery, as birds are highly mobile and new arrivals quickly move in if the bird population is reduced. However, if a nursery and its surrounding neighbors are all willing to cooperate on a trapping program, it can be successful at reducing house finch and crowned sparrow populations. A modified Australian crow trap works well for both species (fig. 16.32). Use a combination of canarygrass and rapeseed for bait. Once a few birds are caught, they serve as decoys to attract others. Therefore, keep a few decoy birds in the trap with ample food and water. Trapped birds should be euthanized using carbon dioxide gas from a bottle. House finch and crowned sparrow trapping must be supervised by the county agricultural commissioner.

FIGURE 16.32. Modified Australian crow trap used to capture house finches and crowned sparrows. *Photo:* J. K. Clark, courtesy of UC IPM.

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