

PISTACHIO PRODUCTION MANUAL

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vertebrate pest management

VERTEBRATE PEST MANAGEMENT

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California ground squirrels, pocket gophers, meadow voles, rabbits, wild pigs, coyotes, and birds can be significant pests in pistachio orchards. They cause damage by feeding on nuts, tree roots, and bark, and can stunt tree growth or even kill young trees. Burrows, mounds, and depressions created by ground squirrels, pocket gophers, and wild pigs interfere with orchard maintenance, irrigation, and harvesting operations. In addition, rodents, rabbits, and coyotes gnaw on drip irrigation lines.

Vertebrate pest problems in a pistachio orchard are determined in large part by the orchard's location. Problems are often worse in orchards adjacent to rangeland, water ways, or unmanaged areas where pest populations are not controlled. Orchard management activities also have some effect; for example, flood irrigation and orchard floor cultivation may discourage some rodent populations.

The most successful approach to dealing with rodent and rabbit problems is to manage these populations at levels where significant damage never occurs. This preventative approach is of particular importance in organic orchards where options for reducing destructive populations are limited to labor intensive techniques such as shooting or trapping.

Management programs for vertebrate pests involve 4 basic steps:

- Correctly identify the species causing the problem. Signs such as tracks, feces, plant damage, and burrows may be used to identify which species is responsible for damage.
- Assess potential management options to determine practical control methods.
- Take early action and use control methods appropriate for the orchard and time of

year, with due consideration for the environment and non-target species.

- Establish a monitoring system to detect reinfestation to determine when additional corrective measures or controls are necessary

Regular monitoring of vertebrate pests in and around orchards should form the basis of a management program. Historical records of pest population levels, control measures implemented, and results from these control measures can be used to help determine the best management approach. For most pests, more than one control method is usually available, although their relative effectiveness may vary.

Vertebrate control equipment and supplies (baits, fumigants, etc.) are available at local retail outlets such as farm supply and hardware stores. In addition, many Agricultural Commissioner offices sell some rodent control materials. For further information on sources of control materials, consult your local University of California (UC) Farm Advisor or Agricultural Commissioner.

Control Actions

For most vertebrate pests, more than one control method is available to reduce damaging populations. Table 1 lists control options you can use against important vertebrate pests in pistachio orchards. Details on how to use these controls are given in the sections that follow. It is a good idea to consult your county Agricultural Commissioner before you use any controls to find out which procedures work best in your location and what the restrictions are on these techniques. The timing of control actions is often critical and is determined in large part by the life cycle of the target pest. Become familiar with the biology of the vertebrate pests

affecting your orchards and the available control options so you will be able to plan the most cost-effective management strategies.

You can take a number of steps when preparing and planting an orchard to prevent or reduce potential problems with certain vertebrates. Properly installed fencing protects young trees against rabbits and deer. Deep plowing and discing destroys or disperses resident vole populations, and it also destroys much of the burrow systems of pocket gophers, reducing the risk of reinvasion. A vegetation-free zone around the orchard reduces the risk of invasion by voles although the distance needed has not been researched. Take steps to eliminate pocket gopher and ground squirrel populations before you plant a new orchard; it is much easier to control them prior to planting than afterward. Trapping, baiting, shooting, or burrow fumigation can be used, depending on the pest involved and the situation. Once trees are planted, tree guards protect against damage by rabbits and, to some degree, by voles.

Once the orchard is in place, you should develop and implement a management program to address any vertebrate pest problems that may arise.

Biological Control

Vertebrate populations are affected most by availability of food and cover, while diseases and predators play a relatively minor role. A number of predators such as hawks, owls, foxes, coyotes, and snakes feed on some vertebrate pest species. However, natural enemies seldom keep vertebrate pests from reaching damaging levels and should not be relied on to prevent vertebrate damage to crops. Factors that limit the role of predators in rodent control include:

- the tendency of predators to modify their diet according to the relative abundance of prey species.
- the high reproductive rate of small rodents that allows rodent populations to compensate for loss to predation.
- predator-avoidance strategies developed by prey species.

Nonetheless, predators might be considered a small component of an integrated management program. Growers in favorable settings can enhance orchard habitat (e.g., via installation of nest boxes, raptor perches, etc.) to increase the probability that these predators will prey on rodents in the orchard. However, growers should be aware that there is little or no data to suggest that the installation of nest boxes or raptor perches will have any measurable effect on damage reduction. One study showed that despite quick acceptance of perches and an increase in raptors in study areas, rodent numbers in the immediate area did not change.

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.

Only pesticides that are registered with EPA's Department of Pesticide Regulation (DPR) can legally be used for vertebrate pest control. Registered materials are listed in DPR's database that is available online (<http://www.cdpr.ca.gov/>). You may also contact your Agricultural Commissioner for information on registered materials.

Trapping is often used to control vertebrate pests. In California, trapping mammals, even for pest purposes, requires a trapping license issued by the California Department of Fish and Game. Rats, mice, moles, voles and gophers do not have this requirement. Live traps are sometimes used for managing vertebrate pests. Under the California Fish and Game Code, it is illegal to trap and relocate any wildlife, including rodents. Live-trapped pest animals should be euthanized humanely. Methods considered humane by the American Veterinary Medical Association include: gassing with carbon dioxide, shooting, or by delivering a sharp blow to the head. Drowning is not an approved method of euthanasia.

In some areas of California, pistachio orchards are located within the range of federally- 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 lizard. See the composite map showing ranges of these species (Fig. 1). Special guidelines apply to the use of toxic baits and fumigants for vertebrate pest control in these areas. Your county Agricultural Commissioner 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 web site (<http://www.cdpr.ca.gov/docs/endspec/>).



Figure 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 pistachio orchards. Check with your county Agricultural Commissioner or the California Department of Pesticide Regulation web site for the latest information regarding restrictions that may apply to a specific location.

Rodents and Rabbits

CALIFORNIA GROUND SQUIRREL (*Spermophilus beecheyi*)

California ground squirrels feed on nuts and damage trees by chewing bark off limbs or tree trunks. Burrow systems in the orchard may interfere with orchard management activities and divert irrigation water. Problems also occur when ground squirrels chew on and damage drip lines (Plate 27A). In some areas, ground squirrels can pose as a health risk to humans through the spread of bubonic plague.

The adult ground squirrel has a head and body 9–11 inches (23–28 cm) long and a slightly bushy tail (Plate 27B). The fur is mottled dark and light brown or gray. Ground squirrels dig burrows along ditches and fencerows, around buildings, and within and bordering many agricultural crops. They tend to avoid flood irrigated orchards, thick chaparral, dense woods, very moist areas, and lands that are under complete and frequent cultivation. They will travel 100 yards (92 m) or more to feed in adjacent crops. In orchards, they often dig entrances to their burrow systems near the base of trees (Plate 27C). Ground squirrels live in colonies that may grow very large if left uncontrolled. Each ground squirrel burrow system can have several openings with scattered soil in front. Individual ground squirrel burrows may be 5–30 feet (1.5–9 m) long, 2.5–4 feet (0.75–1.2 m) below the surface, and about 4–6 inches (10–15 cm) wide. Burrows provide a place to retreat, sleep, hibernate, rear young, and store food.

Ground squirrels are active during the day with peak activity occurring in the morning and late afternoon. Ground squirrels are primarily herbivorous. In spring, ground squirrels consume a variety of green grasses and forbs. When these begin to dry and produce seed in early summer, the squirrels switch to seeds, grains, and nuts. Ground squirrels hibernate during the winter, emerging in late January or February. Some squirrels (usually young of the year) will be active year-round. Many adults go into a temporary dormant state called aestivation during the hottest parts of the year. Females have one litter in the spring averaging

8 young. The young emerge from the burrow after about 6 weeks. Figure 2 illustrates periods of activity for the California ground squirrel.

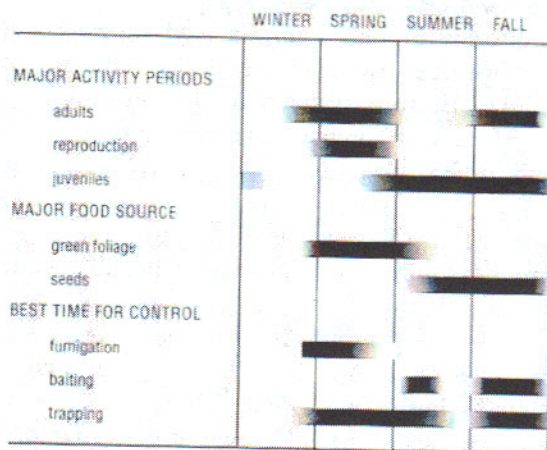


Figure 2. Activity periods and preferred food sources for the California ground squirrel. Activity periods vary somewhat from one growing area to another depending on local climate. To choose the most effective control action for ground squirrels and the proper timing, you need to know when they are active and what their preferred food sources are.

Management Guidelines

Ground squirrel activity should be monitored periodically (at least once a month) both inside and on the perimeter of the orchard in spring, summer, and fall when squirrels are active. Mid morning is usually the best time of day to observe squirrel activity. Controls should be implemented as soon as activity is first observed to keep numbers from increasing. Ground squirrels are extremely adaptable so habitat modification only has limited benefit in a management program. Burrow fumigants, poison baits, and traps currently are the most effective control methods. Where ground squirrels are a major problem, keep annual records of the dates that squirrels emerge from hibernation and when first young are seen aboveground; changes in the general number of squirrels; and control methods used, dates of use, and their effect. Use these records as the basis for future management decisions.

The type of control action needed for ground squirrels depends primarily on their activity patterns and feeding preferences during the time of year when control is to be

undertaken (see Fig. 2). The choice of control action is also influenced by the location of the infestation and the number of squirrels present. From a biological point of view, the most effective time of year to control ground squirrels is in early spring when adults have emerged but before they have reproduced. For best control, use burrow fumigation about 3 weeks after the first squirrels emerge from hibernation. Because squirrels are feeding nearly exclusively on green vegetation early in the season, poisoned grain baits are generally not effective until late spring and early summer. In late spring or summer where squirrels are moving from adjacent lands into the orchard to feed, baiting or trapping along the perimeter offers the most effective control if access to the neighboring property is not possible. While baiting can be done in summer and fall, squirrels are usually eating nuts at this time, leading to poor bait acceptance.

Habitat modification. Removing brush piles, stumps, and debris in and around the orchard may help limit buildup of squirrel populations, and will make it easier to monitor squirrel activity. Squirrels may quickly reinvade abandoned burrow systems. Deep plowing (ripping) along orchard perimeters will destroy burrow entrances and will help slow the rate of invasion.

Trapping. Trapping is an effective control method. However, it is quite labor intensive and is thus most practical for small infestations. Trapping can be implemented at any time of year when squirrels are active, but it is most effective in spring before reproduction increases the population. The most commonly used traps are kill traps such as Conibear or box traps.

Conibear traps are placed unbaited over the burrow entrance to capture squirrels as they leave the burrows (Plate 27D). Within the range of the San Joaquin kit fox, the trap must be placed in a covered box with an entrance no larger than 3-inches (7.6 cm) wide to exclude foxes. Box traps are also effective for ground squirrels and are baited with walnuts, almonds, oats, barley, or melon rinds (Fig. 3). The bait is placed inside the trap, either behind or tied to the trigger. Traps should be pre-baited for several days before setting the trigger

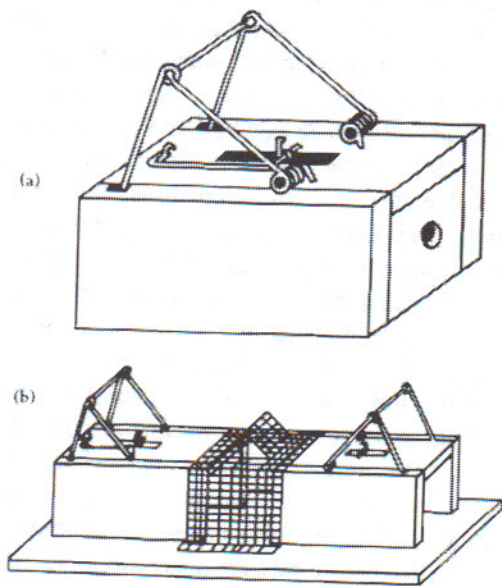


Figure 3. Single box-type traps (a) can be used for ground squirrels. They can be used in pairs by removing the backs, connecting the two traps with wire mesh, and attaching them to a board (b).

mechanism. Once ground squirrels have become accustomed to taking bait, the trigger mechanism can be set. As with all traps, steps should be taken to minimize the risk of capturing non-target wildlife and pets. For example, traps can be placed inside boxes with openings large enough for ground squirrels to enter (3 inches, 7.6 cm), but not large enough for other non-target species.

Fumigants. Fumigation can be very effective against ground squirrel populations and can be used prior to squirrels reproducing and during times when poison baits are relatively ineffective. The best time to fumigate burrows is in late winter or early spring after squirrels have emerged from hibernation but prior to breeding. Because ground squirrels seal themselves within nesting chambers, fumigation is not effective when squirrels are hibernating or aestivating. For fumigation, it is important that the soil is moist so that gases are retained in high concentrations within the burrow; dry soil allows gases to escape. When using a fumigant, be sure to treat all active burrow systems in and around the orchard. Re-check all areas a few days

after fumigation and retreat any burrows that have been reopened. Do not use fumigants in burrows that extend beneath occupied buildings and carefully follow the label directions for their use.

Gas cartridges provide an easy and relatively safe way to fumigate ground squirrel burrows. They are available commercially and from some Agricultural Commissioner's offices. Use one or two cartridges for each burrow that shows signs of activity. More than two may be needed for a large burrow system. Quickly shove the ignited cartridges into the burrow using a shovel handle or stick, and seal the burrow entrance with soil. Watch nearby burrow entrances; treat and seal any that begin to leak smoke. The larger and more complex the burrow system, the more smoke it takes to be effective.

Aluminum phosphide is a very effective fumigant when used early in the spring when soil moisture is high. However, aluminum phosphide is a restricted-use material; a permit is required for purchase or use. Application personnel should be trained in the material's proper use and on its potential hazards. When aluminum phosphide pellets 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. Do not add water or moist paper to the burrow during the application process.

Poison baits. Poison baits are usually the most cost-effective way of controlling ground squirrels, especially large populations and over large areas. Bait consists of grain or pellets treated with a poison registered for ground squirrel control. To be effective, the bait must be used at a time of year when ground squirrels are active and feeding on seeds (usually late spring-early summer and fall; Fig. 2). Before using baits, place small amounts of untreated grain (breakfast oats work fine) near burrows in the morning and check in the afternoon to see if the squirrels eat it. If the grain is taken, proceed with baiting, otherwise wait for several days to a week and try again. As nuts reach maturity, bait acceptance may decrease given the squirrels strong preference for nuts.

Therefore, nuts may need to be harvested before reinstating baiting programs. However, this may be too late for grower needs and reinforces the point that ground squirrel control is best implemented before squirrel densities become too high.

Poison baits registered for ground squirrel control include the acute poison, zinc phosphide (a restricted use material), and anticoagulant baits (diphacinone and chlorophacinone). Zinc phosphide can be applied as spot-treatments to control ground squirrels during the nonbearing season or outside of orchards. For spot treatments, 1 tablespoon of bait is scattered over a 2-3 square-foot (0.2-0.3 m²) area around each burrow opening. Alternatively, the bait may be broadcast over a larger area using a mechanical spreader at the rate of 6-10 pounds of bait per swath acre. Bait shyness can occur with zinc phosphide baits when squirrels ingest a sublethal dose, thereby becoming sick and learning to avoid the bait during future applications. This can result in low effectiveness of zinc phosphide baiting programs. Pre-baiting the area with untreated grain 2 to 3 days prior to the application of zinc phosphide may reduce the chances of bait shyness and improve the effectiveness of baiting programs. Control with zinc phosphide is usually achieved within 48 hours of the bait application.

With anticoagulant rodenticides, ground squirrels must ingest several doses of bait over a period of several days. Control is slower but there is less chance of squirrels becoming 'bait-shy'. Another advantage is the availability of an antidote (Vitamin K₁) in the event of accidental poisoning of non-target species. Anticoagulants can be applied in bait stations, as spot treatments near burrows, or broadcast over larger areas. Be sure to follow the label directions carefully to determine what application method is appropriate.

Bait stations are commonly used in and around orchards to provide bait for squirrels (Plate 27E). Various kinds of bait stations can be used, though all are designed to let squirrels in while excluding larger animals. One design utilizes openings that are 3 or 4 inches (7.6 and 10.2 cm) in diameter and incorporates baffles

to keep the bait inside the station (Plate 27E). Within the range of the San Joaquin kit fox, entrances to bait stations must not be greater than 3-inches (7.6 cm) wide. Special types of bait stations must be used within the ranges of endangered kangaroo rat species to ensure that these species are excluded. See your local Agricultural Commissioner or the DPR web site (<http://www.cdpr.ca.gov/docs/endspec/>) for the latest recommendations on use of poison baits and bait stations in areas that are within the range of endangered species.

Bait stations should be placed near runways or burrows and should be secured so that they are not easily tipped over. If squirrels are moving into the orchard from adjacent areas, place bait stations along the perimeter of the orchard where squirrels are invading, one station every 100 feet (30 m). Use more stations when the number of squirrels is high. Check bait stations daily at first, then as often as needed to keep the bait replenished. If bait feeding is interrupted, the bait's effectiveness is greatly reduced. Be sure to pick up any bait that is spilled and replace bait that is wet or moldy. Successful baiting usually requires 2-4 weeks. Continue to supply bait until feeding ceases and no more squirrels are observed; then properly dispose of unused bait.

Spot treatments and broadcast applications are permissible in orchards during the dormant season (read label for further specifications) and can be used at any time in non-crop areas. Spot treatments are most economical and effective for small populations. For spot treatments, scatter 1/3 cup of bait (ten placements to the pound) evenly over 40 to 50 square feet (3.7-4.7 sq m) near active burrows. Reapply in 4-5 days for a total of 2 applications to ensure squirrels are exposed to a continual supply of bait. Scattering takes advantage of the ground squirrels' natural foraging behavior and minimizes the risk to non-target species. Do not pile bait or spread on bare ground; this increases the hazard to livestock and non-target wildlife. Bait may also be applied using a mechanical broadcaster such as a seed spreader mounted on the back of an ATV. Usually, squirrels retreat back to burrows when sick, and will die there. Dispose of any visible carcasses to prevent poisoning of

any predators or scavengers. Burying is a good method as long as carcasses are buried deep enough to discourage scavengers.

POCKET GOPHERS (*Thomomys* spp.)

Pocket gophers are potentially serious orchard pests, especially in young orchards. They feed on the bark of tree crowns and roots, girdling and killing young trees and reducing the vigor of older trees (Plate 27F). Gophers may also damage drip irrigation lines. Burrow systems may divert irrigation water causing stress to young trees and may increase soil erosion. Mounds of soil associated with burrows can interfere with harvesting, mowing, or other orchard management activities.

An adult pocket gopher is 6–8 inches (15–20 cm) long and has a stout yellowish or grayish brown body, a short tail, and small ears and eyes (Plate 27G). External fur-lined cheek pouches open outside the lips on each side of the mouth and are used for carrying food. Pocket gophers are rarely seen aboveground, spending most of their time in a system of tunnels they construct 6–18 inches (15–46 cm) below the surface. Gophers are antisocial and solitary except during breeding and when young are being raised. A single burrow system can cover hundreds of square feet and consists of main tunnels with lateral branches used for feeding or to push excavated soil to the surface. The fan-shaped mounds that are formed over the openings of lateral tunnels are the most obvious signs of gopher infestation (Plate 27H). Pocket gophers plug burrow openings with soil so that the tunnel system is completely closed and the temperature and humidity in the burrow remains fairly constant. Gophers feed primarily on the roots of herbaceous plants, but may also dig lateral tunnels to feed on aboveground vegetation within a few inches of the tunnel opening. Once they have finished feeding, they plug these holes with soil.

In orchards and other irrigated lands, gophers may breed throughout the year with a breeding peak in late winter or early spring. Females may produce 3 litters per year with litters averaging about 5 young. When the young are mature, they leave the burrow to find a favorable location to establish their own

burrow. Some may take over burrow systems that recently have been vacated. Buildup of gopher populations in an orchard is favored by the presence of cover crops, especially those that contain clovers which are a favored food source. When cover crops dry up or are removed, gophers may feed on the bark of tree roots and crowns (Plate 27F). Cover crops also make detection of pocket gophers difficult.

Management guidelines

Pocket gophers are active throughout the year, and if left uncontrolled, a population can increase rapidly. Damage to orchard trees is almost always below ground and usually is not evident until trees show signs of stress such as yellow or brown colored leaves. It is therefore important to control gophers when activity is first detected. The typical fan-shaped mounds are a good indicator of gopher presence. These mounds are produced in greatest numbers in the spring and fall when soil is moist. Monitor for activity monthly in the spring and pay close attention to orchard perimeters where gophers may move in from adjacent infested areas. Gophers patrol and expand (dig) their burrows on a regular basis, so their activity can be determined by first “flattening” the mound, and then looking for new activity in 1–2 days. Mounds of darker color are also indicative of recent gopher activity. Special attention must be given to orchards with abundant ground cover given the increased probability of gopher use of these areas combined with the greater difficulty in detecting gopher activity in more densely vegetated areas. With persistent effort, pocket gophers can be controlled and even eliminated from an orchard. The most effective control methods are baiting, trapping and fumigation.

Habitat modification. Pocket gophers should be controlled prior to planting an orchard. The land can be deep-ripped so that most burrow systems are destroyed and many gophers are killed. Poison baits or traps can then be used to eliminate any remaining gophers. In established orchards, clean cultivation of the orchard floor reduces the food supply and may destroy some burrows, making the orchard less favorable for gophers. Clean cultivation also makes it easier to

monitor gopher activity. Flood-irrigated orchards may have fewer problems than orchards that are drip- or sprinkler-irrigated. Gophers should be controlled in adjacent areas to prevent orchards from being invaded.

Trapping. Traps are effective in controlling small infestations of pocket gophers but can be expensive and labor-intensive. Either pincher or box-type traps may be used. To place traps, you need to use a probe near a fresh mound to locate the main tunnel, which is usually on the lower side of the mound (Figs. 4 and 5). The main tunnel is usually 8–12 inches

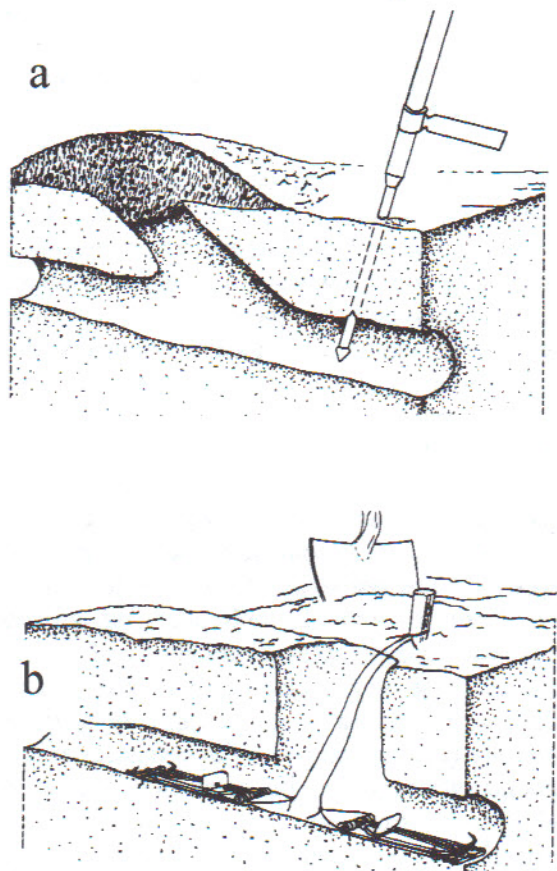


Figure 4. Use a probe to find gopher tunnels for placing traps (a). Begin probing 8–12 inches (20–30 cm) from the plug side of the mound. The probe will suddenly drop a few inches when you hit the main tunnel. Use a shovel to expose the main tunnel and place two traps in the tunnel, one in each direction (b). Tie the traps to a stake that is tall enough to be seen easily. Push each trap well back into the tunnel and cover the hole so that no light will enter.

(20–30 cm) below the surface. You will feel reduced resistance when pushing the probe through the burrow, with the probe dropping quickly about 2 inches (5 cm) when you find it. Two traps, one facing each direction should be set. Wire the pair of traps to a stake and cover the hole to keep light out. If the trap is not visited within 48 hours, move it to a new location.

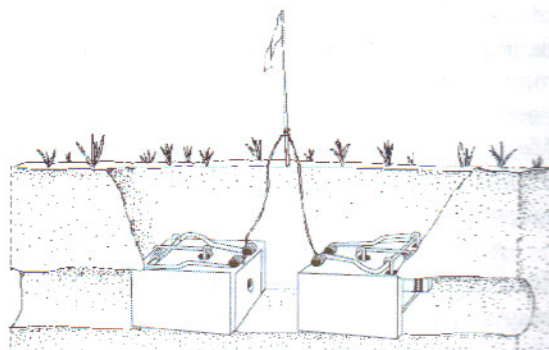


Figure 5. When placing box traps for gopher control, be sure to cover or fill in the openings carefully so that no light will get in after the traps are pushed tightly against the tunnel openings.

Fumigants. Most fumigants (such as gas cartridges) are not effective against pocket gophers. In extensive burrow systems, it is difficult to maintain a lethal concentration of the fumigant in the system, and pocket gophers quickly seal off their system when they detect poison gas. However, aluminum phosphide (aluminum phosphide is a restricted-use material; a permit is required for purchase or use) can be effective. It is most effective in late winter or early spring when soil moisture is high (high soil moisture prevents toxic gases from escaping through the soil) and prior to the gopher's breeding period. However, aluminum phosphide can also be effective later in the year when treatments following irrigation. Follow label instructions and all safety precautions given.

To use aluminum phosphide, probe to find the main tunnel, widen the probe opening, drop 2–4 tablets (read label for specific amount) into the burrow, and seal off the hole to prevent light from entering the tunnel. This process should be repeated for each burrow system

resulting in approximately 2 treatments per burrow system. As with any control method, keep monitoring for signs of renewed gopher activity and re-treat areas if you find any new mounds.

Poison baits. Baits may be applied by hand or with a mechanical applicator. Strychnine (restricted-use material), zinc phosphide (restricted-use material), and anticoagulant baits are registered for control of gophers. Bait must be applied below ground. Follow bait label directions carefully for application methods and amounts.

With hand baiting, locate the main tunnel of the burrow system by probing near fresh activity. Then enlarge the probe opening and place a small amount of bait in the burrow. This should be repeated 2 or 3 times for each burrow system. Hand-operated mechanical bait dispensers have a bait reservoir and bait release mechanism and permit probing and bait dispensing in one operation. These devices are substantially faster than hand baiting.

Mechanical burrow builders are tractor drawn and are an efficient way of controlling gophers over large areas (Plate 27I). The device constructs an artificial burrow beneath the soil and deposits strychnine within it at preset intervals and quantities. The artificial burrows are constructed between tree rows and should be made to intercept some of the pocket gophers natural burrows so that gophers will explore them and consume the bait. When using the mechanical burrow builder, periodically check to see that the artificial burrows are formed properly. Soil moisture must be right to produce a well-formed, smooth, artificial burrow. If possible, wait at least 10 days after baiting before running other equipment over treated areas. Mechanical burrow builders may not work well on rocky or sandy soils. In some mature orchards that have not been deep cultivated, surface roots may be damaged by the burrow builder. After you've used a mechanical burrow builder, follow-up with a program of trapping or hand baiting to control remaining gophers. Burrow builders should not be used in areas with a small or localized gopher population. Creating new burrows throughout the orchard creates a larger tunnel system for easier reinvasion.

MEADOW VOLES **(*Microtus californicus*)**

Meadow voles can cause serious damage to trees by feeding on bark at the base of the tree. Small trees are most susceptible to being completely girdled or killed by voles, but even large trees can suffer significant damage. Voles can also chew holes in irrigation lines. Vole populations often develop in areas where grass or other permanent vegetative cover remains year-round. Voles are most likely to cause problems in orchards with year-round cover crops or where vegetation is allowed to build up around the base of trees. Vegetation management and, when necessary, the proper use of trunk guards on young trees, usually keeps damage to a minimum. Baiting is used to control vole populations when populations reach damaging levels.

Meadow voles are small, stocky rodents with small ears and eyes, short legs, and short tails (Plate 27J). Their coarse fur is usually dark brown or grayish brown. Adults are larger than a house mouse but smaller than a rat. They are active year-round and during the day and night. Females produce several litters per year with peaks in reproduction in spring and fall. Because voles mature rapidly and can produce many litters annually, their populations can increase rapidly. Vole populations tend to cycle, peaking every 4–7 years followed by a rapid decline in population size. Voles can be detected through the presence of narrow runways in grass or other ground cover and numerous shallow burrows with openings about 1.5 inches (4 cm) in diameter. Voles seldom travel far from their burrows and runways.

Management guidelines

In mid-winter, begin to monitor monthly for active runways in cover crops or weedy areas in and around orchards. Look for fresh vole droppings and short pieces of clipped vegetation in runways. Look for burrow openings around the base of trees. Where burrow openings are present, check for tree damage. Characteristic damage is complete or partial girdling of tree trunks from just below the surface to as high as they can reach on the trunk (usually not more than 5 inches [13 cm];

Plate 27K). In some situations, voles climb higher on young trees. Be sure to check carefully; once a decrease in tree vigor is detected, it may be too late to prevent significant injury to the tree. Carefully monitor fence rows, ditchbanks, and other areas near the orchard where permanent vegetation is favorable for the buildup of vole populations.

Habitat modification. Controlling vegetative cover reduces or eliminates food and cover necessary for vole survival. Because voles do not travel more than a few feet from their burrows to obtain food, any significant destruction of food or cover results in burrow abandonment and/or mortality. Eliminating vegetative cover in adjacent areas reduces the potential for voles to invade the orchard. Clean cultivation or weed control within 3 feet (90 cm) of the trunks of trees makes the habitat unsuitable for voles. If you maintain ground cover in row middles, keep it mowed short.

Trunk guards. Cylindrical wire or plastic trunk guards can protect young trees from voles. An effective guard can be made of a cylinder of ¼- or ½-inch hardware cloth that is 24 inches (60 cm) wide and of sufficient diameter to allow several years growth without crowding the tree. Trunk guards must extend at least 6 inches (15 cm) below the soil surface to discourage voles from burrowing underneath. Plastic and other fiber materials can also make effective trunk guards, and are often less expensive, provide sunburn protection, and are more convenient to use. However, they may not provide as effective protection against voles. If you use any of these other materials, be sure to check underneath them periodically to make sure voles are not getting to the tree underneath the cover. Good herbaceous control around the base of the trees will increase the effectiveness of tree guards.

Poison baits. Poison grain baits can be very effective in reducing meadow vole populations within orchards and can be used to control vole populations in adjacent areas before they invade orchards. Single- (e.g., zinc phosphide) and multiple-dose (e.g., anticoagulants) baits are available, but there may be baiting restrictions in some areas to protect endangered species. It is extremely

important to understand and follow the label directions for use.

For small infestations, scatter bait around infested areas, focusing on runways and around burrows. When allowed by the bait's label, broadcast baiting can be used to treat larger areas. For noncrop land, apply bait in fall or spring before the reproduction peak. However, application within an orchard is restricted to the nonbearing season. Bait acceptance will depend on the time of year and availability of alternate foods.

BLACK-TAILED JACKRABBIT (*Lepus californicus*)

COTTONTAIL and BRUSH RABBITS (*Sylvilagus* spp.)

Jackrabbits, cottontails, and brush rabbits may damage nut orchards (Plates 27L and 27M), although damage is almost always limited to orchards less than 4 years old. Rabbits may remove bark from trees and clip off branches within their reach to eat buds and young foliage. Trunk girdling is usually higher on the trunk than damage caused by meadow voles. The damage appears as vertical lines or grooves in the bark. Rabbits may also gnaw on drip irrigation lines.

Although jackrabbits are the most common of rabbit-type pests, they are technically classified as a hare. Jackrabbits are about the size of a large house cat, have very long ears, short front legs, and long hind legs. They live in the more open areas of the Central Valley, coastal valleys, and foothills. They make depressions underneath bushes or other vegetation where they remain secluded during the day. Young are born fully haired, with open eyes, and become active within a few days. Cottontails and brush rabbits are smaller and have shorter ears. Young are born blind and hairless, and they stay in the nest for several weeks.

Rabbits usually breed, bear young, and live outside orchards. They are active all year but damage trees primarily in winter and early spring when other sources of food are limited. Common control methods for rabbits include fencing, tree guards, repellants, baiting,

trapping, and shooting depending on the species.

Management guidelines

Inspect young trees periodically for damage. If you find damage, look for droppings and tracks that indicate rabbits are the cause. Monitor the orchard perimeter in the early morning, late evening, or at night using a spotlight to identify the rabbit species responsible for the damage, the approximate number of depredating individuals, and the location where rabbits are entering the orchard. The method of rabbit control should depend on the urgency of the problem and the situation; depredating populations are best managed before severe damage occurs.

Habitat modification. Rabbits usually invade orchards from adjacent fields, but unless the land is under the grower's direct management, modification of the outlying habitat is usually impractical. The removal of rabbit foods such as orchard cover crops and weeds may reduce the number that visit the orchard and make rabbits easier to detect. However, removal of vegetative cover may temporarily increase tree damage as trees would be the only food source left for rabbits. Therefore, habitat modification to reduce damage within the orchard is rarely practical.

Exclusion. Where rabbits are a constant and continuing threat to young trees, fencing the entire orchard may be an effective management approach. Make the fence of woven wire or poultry netting at least 4 feet (1.2 m) wide and with a mesh diameter of 1 inch (2.5 cm) or less. Bury the mesh 6-inches (15 cm) deep with a 6-inch (15 cm) lip turned out at a 90-degree angle at the bottom to prevent rabbits from burrowing underneath. However, the cost of a rabbit fence may be prohibitive for a large orchard given the relatively short-term need for rabbit fencing.

Individual tree guards may provide a cheaper alternative and offer a practical way to prevent damage to replants in an established orchard. Guards may be solid or made of net or mesh materials such as metal, hardware cloth, plastic, or sturdy fibrous sheets. Make the cylinders at least 2.5-feet (75 cm) high to prevent jackrabbits from reaching foliage and

limbs by standing on their back legs (Plate 27N).

Poison baits. Poison baits offer a practical and economical way to control large areas with heavy jackrabbit infestations. Baits are not registered for control of cottontails or brush rabbits. Multiple-dose anticoagulant baits for jackrabbit control are available from most county Agricultural Commissioner's offices. Follow label directions carefully. These baits are placed in bait stations specifically designed for rabbits. Place bait stations containing 1–5 pounds (0.5–2 kg) of bait near trails and secure them so they cannot easily be tipped over. Use as many stations as is necessary to ensure that all jackrabbits have easy access to bait, spacing them 50–200 feet (15–60 m) apart along the perimeter where they are entering the orchard. Inspect bait stations every morning for the first several days to keep bait supplies replenished; it may take this long before jackrabbits become accustomed to feeding at the stations. Increase either the amount of bait in the stations or the number of stations if all the bait is consumed in a single night. Replace bait that becomes wet or moldy. It usually takes 2–4 weeks or longer before results are seen with anticoagulant bait. Continue baiting until feeding ceases and you no longer observe jackrabbits.

Bury or remove rabbit carcasses on a regular basis. Do not place bait where humans and livestock can access it. Protect diurnal seed-eating birds by covering or removing the bait during daylight hours. As always, follow baiting restrictions when endangered species are potentially present within the baiting area.

Repellents. Chemical repellents may provide temporary relief from rabbits. Spray or brush the repellent on tree trunks during the dormant season or on foliage or trunks during the growing season; proper application times are listed on the label. Additional applications may be necessary to renew repellency lost through rain or sprinkler irrigation or to protect new growth.

Trapping. Box-type traps can provide effective control of cottontails or brush rabbits when populations are small. Traps are ineffective for controlling jackrabbits, as they typically do not enter traps.

Shooting. When low numbers of rabbits are present and causing damage, shooting can be an effective control for all three types of rabbits. For best results, patrol systematically in the early morning or late evening.

WILD PIGS **(*Sus scrofa*)**

Wild pigs include both domestic hogs that have escaped (also known as feral hogs) and wild boar (Plate 27O). Wild pigs primarily cause damage by rooting up plants and insects. This rooting, combined with wallowing, can create shallow depressions in the soil, thereby interfering with the application of irrigation water and increasing soil erosion. Removal of cover vegetation can reduce the potential for wild pig damage by eliminating their primary food source. In some cases, heavy exclusionary fences may keep pigs out, though fences may not exclude highly determined pigs. Shooting and trapping can be effective for controlling pigs. Consult your local Agricultural Commissioner for details and restrictions on regulations for controlling wild pigs in your area.

COYOTE **(*Canis latrans*)**

Coyotes occasionally cause damage in pistachio orchards by chewing on irrigation lines (Plate 27P). Coyotes are classified as a non-game mammal and can be taken whenever they are causing a problem. Contact your Agricultural Commissioner for details about regulations and control options.

Birds

Most significant avian pests of pistachios belong to the family Corvidae and include ravens (*Corvus corax*), crows (*Corvus brachyrhynchos*; Plate 27Q), scrub jays (*Aphelocoma coerulescens*; Plate 27R), and yellow-billed magpies (*Pica nuttalli*; Plate 27S). Other depredating birds you might find in orchards include European starlings (*Sturnus vulgaris*), blackbirds (*Agelaius* spp., *Euphagus* spp.), and house finches (*Carpodacus mexicanus*). However, they typically only cause minimal damage in pistachio orchards.

Corvids can subsist on many kinds of food, including carrion, although their typical diet includes insects, acorns, wild berries, and fruits. Cultivated fruits and nuts are often easy to obtain, and birds take full advantage of these food sources. Scrub jays instinctively store food in the fall and carry away more fruit and nuts than they can eat. Thus, a single bird can account for considerable crop loss. Jays usually are solitary birds and occur singly or in pairs; rarely do they flock. In some orchard situations, with the ready availability of food, they have been known to occur in groups. In contrast, crows and ravens join into flocks for most of the year and establish a central roost, which can consist of thousands of birds. Each day crows fly from the roost to feeding areas. Magpies generally occur in smaller groups of a few to several dozen birds. Corvids cause the greatest amount of damage during the period from shell split to harvest. After harvest, these birds can remove mummy nuts left in the orchard. However, allowing undisturbed access after harvest may contribute to increased bird damage the following year by improving survival and encouraging nearby nesting in spring.

Regular monitoring will help you determine when damage actually starts so you can initiate control actions early. Birds are much more difficult to control once they have become used to feeding in a particular orchard. Become familiar with damaging species so you can distinguish them from the many nonpest birds that may frequent orchards. To monitor the occurrence of bird damage, it is easier to watch for movement of birds into or within the orchard than to see the damage itself. Observing movements into the orchard will also allow you to determine the source of bird invasions and can allow you to scare off invaders before their feeding patterns become established. With crows for example, scout birds often fly out in search of food sources during early morning and return to the flock to guide them to food sources. If scout birds can be deterred from an orchard, the flock will choose another food source.

Bird counts can help you decide when to take control actions and whether the controls you have used are having an effect. Once nuts

begin to develop, plan to drive through the orchards twice a week during the time of day you expect most bird activity and count the birds you see. Where birds are moving into the orchard from adjacent habitat, they can be counted by a stationary observer. Hand-held counters are useful for making these counts. Bird counts will tell you how severe the problem is and if it is increasing. Keep records of bird species, counts, and locations for each season; they will help you plan control actions in advance. This way you can have control devices on hand and in working order when they are needed.

Management Guidelines

Remove brush piles in or near orchards; they offer refuge and loafing sites for birds and may exacerbate problems. Removal of brushy vegetation adjacent to orchards may also reduce the potential for bird problems. Frightening devices (e.g., noisemakers and visual repellents) are the primary means of controlling bird damage in pistachio orchards. To be effective, several different methods should be used in rotation, and you should start using them as soon as birds appear. Once birds have become used to feeding in an orchard, they are much harder to frighten away.

Frightening. The most effective way to frighten birds from the orchard is to use a combination of noisemakers and visual repellents. If your orchard is near an urban area, check to see if there are any local ordinances that may restrict the use of noise-making devices. For maximum effectiveness, rotate from one type of frightening device to another; otherwise, birds will become used to it. Monitor bird activity while using frightening devices and switch to a different type if birds appear to be getting used to the technique you are using.

Roving patrols that fire shell crackers, bird bombs, or whistler bombs are among the most effective ways to frighten birds from orchards. Stationary noisemakers such as gas cannons (propane exploders) and electronic noisemakers are most effective if you use at least one device for every 5 acres (2 ha) and

elevate them above the level of the tree canopy. Move the devices to new locations every 3–5 days so the birds will take longer to get used to them. The effectiveness of most frightening devices is enhanced with occasional shooting. This reinforces the frightening stimulus.

The most commonly used visual repellents are mylar streamers and large “scare-eye” balloons. Attach balloons to poles so they are above the tree canopy and hang mylar streamers in trees. Use visual repellents in combination with noisemakers to increase their effectiveness. Use one type of visual repellent with each type of noisemaker and switch to a different visual repellent when you switch noisemakers.

The most effective bird frightening program makes use of as many different kinds of noisemakers and visual repellents as practical. Shooting is usually used to reinforce the various frightening methods. The following is an example of a diverse 4-week frightening program:

First week: Patrol orchard firing cracker shells.

Second week: Use stationary propane exploders.

Third week: Use stationary propane exploders and also patrol orchard firing cracker shells.

Fourth week: Install electronic noisemakers with “scare-eye” balloons or mylar streamers near trees where damage is most severe.

Shooting. Birds such as scrub jays and magpies that usually invade orchards in small numbers can often be controlled by shooting. A depredation permit is required if you want to shoot scrub jays or ravens. No permit is required to shoot crows or magpies that are causing damage. However, it is a good idea to check with authorities as regulations may change. Where permissible, shooting occasionally at a few birds will increase the effectiveness of your other noisemaking techniques, because the birds will begin associating loud noises with the real hazards of firearms.

Table 1. Control methods for vertebrate pests of pistachios.

Pest	CONTROL METHOD									
	Habitat modification	Trapping	Baiting	Fencing	Tree protectors	Repellents	Frightening	Shooting	Fumigating	
Ground squirrels	X	X	X					X	X	
Pocket gophers	X	X	X						X	
Voies	X		X		X					
Rabbits	X	X ¹	X	X	X	X		X		
Birds	X	X ¹					X	X ¹		

1. Useful for some species.