Book 2

Chapter 6

Vertebrate Pest Management

Authors: Rex E. Marsh and Terrell P. Salmon and Gary S. Bender

Authors for Coyote, UC ANR Pest Note 74135: ***R. M. Timm,*** UC Research & Extension Center, Hopland***; C. C. Coolahan,*** USDA-APHIS Wildlife Services, Sacramento, CA***.; R. O. Baker,*** emeritus, CA State Polytechnic Univ.-Pomona; and ***S. F. Beckerman,*** USDA-APHIS Wildlife Services, Springfield, IL.

Mammal pests of one kind or another are found in and around virtually every avocado grove in the state, although they may not always present a significant problem. Damage caused by birds is generally very limited and is usually seen only where crows and ravens peck open graft covers on top-worked trees, or break off the young grafts by landing on them. Tree injury by rodents, rabbits, or deer is often more serious, killing the tree outright or causing permanent damage that lowers yields for years following the initial feeding. Coyotes, especially the pups, may chew on irrigation tubing and sprinklers.

Several rodents and rabbits eat roots, fruit, or bark and can kill young trees outright. Rodent burrows and mounds (such as those of pocket gophers and ground squirrels) interfere with grove maintenance and harvesting operations and inflict structural damage by gnawing on drip irrigation lines. Deer strip young trees of foliage and can stunt or even kill saplings. Damage to irrigation systems by coyotes has been especially frustrating to growers because the animals may come back to the same irrigation line (after the grower has repaired the line) and chew it full of holes repeatedly. Occasionally bears (especially in the Goleta area of Santa Barbara County) have been known to break young avocado trees by rubbing on them.

A program incorporating the points that follow will not only result in fewer vertebrate pest problems, but make control more economical.

- 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 grove 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.

Vertebrate control equipment and supplies (baits, fumigants, propane exploders, traps and the like) are available 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 County Farm Advisor or Agricultural Commissioner.

GROUND SQUIRRELS

A California ground squirrel, *Spermophilus beecheyi,* is a medium-sized rodent 14 to 20 inches long from its head to the tip of its long, slightly bushy tail. This species is responsible for major damage in avocado groves 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, fence rows, 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, 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 7 or 8 young. The young are nursed in the burrow for about 6 weeks before they come above ground 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.

Damage

Ground squirrels often infest avocado groves, especially cut banks of grove roads and around the banks of reservoirs. They have been seen to climb trees but they do not seem to feed on avocado fruit. Damage by squirrels in avocado groves is mostly related to increased erosion due to rainwater channeling down through burrows and eventually collapsing a bank, sometime taking out trees if they slide into a ravine. Burrows are also dangerous to the pickers if they happen to step in one and twist an ankle.

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 dangerous to pickers during the harvesting operation. Ground squirrels frequently burrow around trees and damage the root systems; they can even kill trees. Bark gnawing on the trunks of young trees and on limbs of older trees is relatively rare but sometimes occurs. Squirrels gnaw on surface-type drip irrigation pipes also. 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 where ground squirrels are likely to invade, such as along ditch or road banks or in crops adjacent to the orchard. To monitor, simply observe squirrel haunts in mid morning, when squirrels feed most actively. Where ground squirrels are a major problem, keep annual records of the dates squirrels emerge from hibernation and when the first young are seen above ground; 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 an avocado grove, control them; otherwise, damage is inevitable. Fencing is practically useless against squirrels, and no feasible habitat modification within the grove expels established animals. Unfortunately, ground squirrels are not responsive to chemical or physical repellent methods. Burrow fumigants, poison baits, and traps are the current 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 groves, ground squirrels often burrow beneath longstanding piles of prunings, stacked firewood, or rocks, 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. Peripheral grove cleanup may somewhat reduce the potential for squirrels. In addition, it makes burrow detection and population monitoring easier and improves access to burrows during control operations.

Predation. Animals that prey on squirrels include coyotes, foxes, badgers, and 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 a modified pocket gopher box (fig. 1) and conibear traps, are effective.

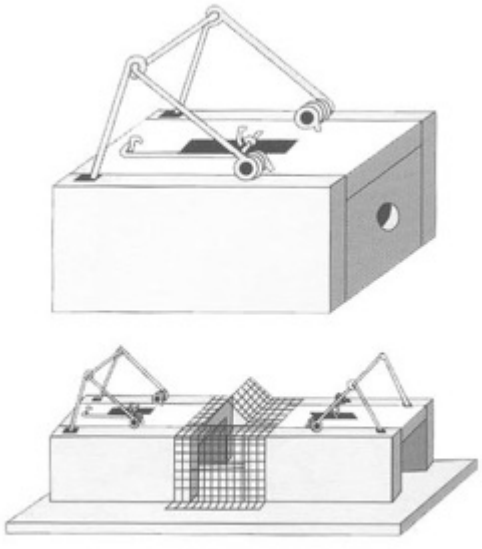


Figure 1. Box-type pocket gopher traps modified by reversal of the trigger mechanism make effective kill traps for ground squirrels (top). They can be used in pairs by removing the backs, securing them to a board at the base, and connecting the two with wire mesh (bottom).

Place box-type traps on the ground near squirrel burrows or runways. For several days bait them but do not set them, so the squirrels become accustomed to them. After the squirrels are taking the bait, rebait and 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. 2). Specially designed boxes are sometimes used with baited conibear traps—the boxes permit the traps to be placed anywhere squirrels are active (fig. 3). As with all traps, take precautions to minimize trapping of nontarget wildlife and pets.

Fumigation. Treating ground squirrel burrows with toxic gases (including smoke-generating cartridges) is an effective control method when used according to directions. It is most effective and selective in the spring or when the soil contains enough moisture to retain the toxic gas in high concentrations within the burrow. Fumigants are ineffective when animals are hibernating or estivating, because ground squirrels use a soil plug to seal themselves in their nest chamber. For safety reasons, do not use fumigants in burrows that extend beneath occupied buildings.

Poison baits. Poison grain baits have been developed for ground squirrel control. They tend to be ineffective after squirrels emerge from hibernation through late spring, however. During this period ground squirrels feed extensively on green vegetation and may not accept grain baits. Hence, the time of baiting is critical. Ground squirrels switch from eating vegetation to eating seeds, grains, and nuts in the latter part of May. Therefore, May and June are usually the best months for baiting. When a percentage of the adult population goes into estivation during the hottest part of the summer, suspend baiting until 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.

Single-dose poison baits are the most cost-effective for ground squirrels and generally produce results within 48 hours. 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) 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) provide effective control when squirrels ingest them in multiple feedings for 6 days or more. Death generally occurs from 6 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 K_1) make anticoagulant rodenticides safer to livestock, pets, and children than are some other rodenticides.

Use anticoagulant baits in bait boxes or, if the label permits, spread it by repeated spot or broadcast baiting. Bait boxes or stations are small structures designed to hold enough bait to provide multiple feedings and to allow the squirrel to enter and feed (fig. 4). Bait boxes, or stations, safeguard larger nontarget species by excluding them from the bait (fig. 5).

Figure 2. A Conibear — 110 trap set over a squirrel burrow entrance. The trap chain is secured to a stake.

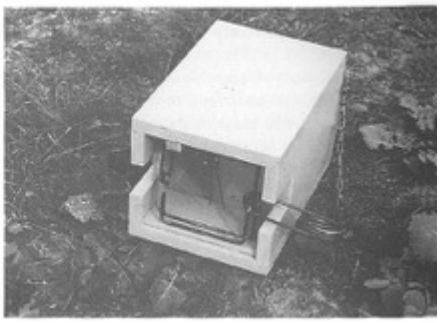


Figure 3. Conibear traps can be set in specially constructed boxes to make them more versatile.

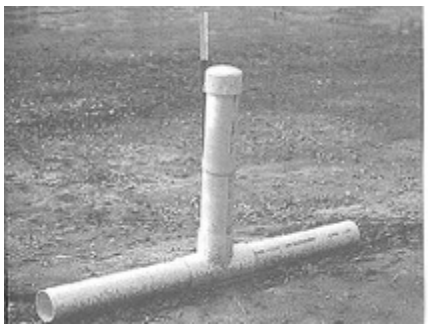


Figure 4. An inverted "T" ground squirrel bait station constructed of 4-inch plastic pipe.

Figure 5. A commercial bait station considered tamper-resistant if properly anchored to the ground.

RABBITS

Young trees are particularly susceptible to debarking and limb clipping by rabbits. Jackrabbits (*Lepus californicus*) are the major rabbit pest, although cottontails *(Sylvilagus* spp.) may cause problems in some areas. Jackrabbits breed from early spring to late summer. Females may produce more than one litter a year, especially where irrigated crops are available. The litter contains four young. Rabbits are active from early evening to early morning year-round. Rabbit populations sometimes fluctuate dramatically and often reach high levels every 5 to 10 years.

Damage

Rabbit damage to avocado trees is almost always limited to groves fewer than 4 years old. Rabbits may debark trunks during the first winter following planting, and clipping of small branches and leaves may be evident. Rabbits tend to partially girdle tree trunks rather than completely girdle

them. Girdling caused by rabbits is usually higher on the trunk than that caused by meadow voles.

Monitoring Guidelines

Rabbits usually breed, bear young, and live outside avocado groves. If they move into the grove only to feed, you may not see them during daylight hours. Inspect young trees periodically for debarking to catch a rabbit problem early. Tour the grove in early morning, late evening, or at night using a spotlight to look for rabbits.

Management Guidelines

Rabbit control in avocado groves includes exclusion, repellents, shooting, and poisoning. The choice of method should depend on the urgency of the problem and the situation. Manage rabbit populations before severe damage occurs. Habitat modification to reduce damage within the grove is rarely practical.

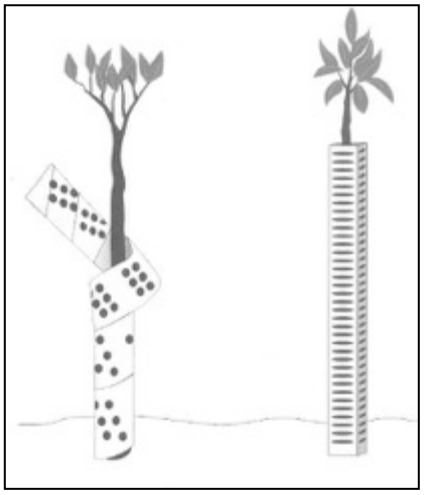


Figure 6. Various types of cardboard and plastic tree guards are available commercially for protecting the trunks of trees from rabbits.

Exclusion. Where jackrabbits or cottontails are a constant and continuing threat to young trees, fencing the entire grove may be the best management approach. To make an effective barrier, build a fence 36 inches high of woven wire or poultry netting, using 1½-inch diameter mesh. 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. When backfilled with soil this will leave a 36-inch high fence, 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.

Repellents. Chemical repellents may provide temporary relief from rabbits. Spray or paint the repellent you choose on the trunks or foliage, following label instructions. Repeat applications may be required to renew repellency lost through rain or sprinkler irrigation or to protect new growth.

Shooting. Under certain conditions shooting can be an effective control. Patrol systematically in early morning and late evening.

Poison baits. Poison baits offer a practical and economical way to control large numbers of rabbits in large areas, although results are sometimes erratic. Grains such as rolled barley, crimped oat groats, or alfalfa hay make effective baits.

Only multiple-dose poisons are registered for use against rabbits. Place multiple-dose anticoagulant baits in open self-dispensing feeders, shallow trays, or nursery flats. 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 are readily accepted. Keep bait available until all feeding ceases, which may be from 1 to 4 weeks.

Place poisoned bait where livestock and humans- especially children-cannot pick it up. Be aware of all wildlife in the area, such as doves or pheasants, and take precautions to protect them from poisoning. Protect diurnal seed-eating birds by removing or covering the bait during daylight hours, exposing it only at night.

Habitat modification. Rabbits usually invade groves from adjacent fields and unless the land is under the grower's direct management, modification of the outlying habitat is usually impractical. The removal of grove cover crops and weeds that serve as rabbit food may decrease the number of rabbits that routinely visit the grove. Removing vegetative cover may temporarily increase tree damage, however, because trees are all the rabbits have left to feed on. In any case, cover removal does make rabbit detection easier.

MEADOW VOLES

Meadow voles *(Microtus* spp.) — also called meadow mice, or field mice — can cause severe damage in avocado groves by feeding on the bark at the base of trees. Vole populations often develop in groves or on grove borders, roadsides, and fence lines — places where grass or other permanent vegetative cover remains year-round. Dense grass is their preferred habitat. Most susceptible to damage are groves that have cover crops or those in which grass and herbaceous plants are left to grow next to tree trunks.

Meadow voles are small, blunt-nosed, stocky rodents with small ears and eyes, short legs, and short tails. Their coarse fur is usually dark gray or grayish brown. When full grown they are larger than a house mouse but smaller than a rat. 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 when a population can be as high as

hundreds of voles per acre. Meadow voles' home ranges are relatively small; in search of food a vole usually travels less than 10 feet from its nest.

Damage

Characteristic damage by meadow voles is complete or partial girdling of tree trunks from just below the soil line to as far as they can reach on the trunk, usually no more, than 5 inches. In rare situations voles climb higher on young trees. The animals attack young trees more readily than older ones, and young trees sustain greater damage.

Monitoring Guidelines

Meadow voles are usually found first in localized areas marked by numerous 1- to 2-inch wide surface runways through dense or matted grass, and silver dollar-sized holes to their burrows. They are active all year, irrespective of weather, but do most damage to trees in winter or early spring, when many plants are more dormant than almond. Meadow voles feed night and day. Deposits of small, soft, brownish feces and short 1- to2-inch pieces of grass stems along the runways are evidence of their presence. Burrows frequently have numerous openings to the surface. They are relatively shallow and contain food and nesting chambers.

Starting in midwinter, inspect groves and surrounding fields for vole activity and population increases. Especially check areas with heavy vegetation; look for new vole runways, fresh droppings, burrow openings, and evidence of bark or grass feeding.

Management Guidelines

Vegetative cover provides food and protection from predators, so management of cover is important to meadow vole control. Fence rows or properties adjacent to the grove may harbor voles. As the vole population increases, young adults begin to disperse into new areas where the habitat is favorable. Eliminating vegetative cover in adjacent areas or providing a 30- to 40-foot wide buffer between it and the grove reduces the number of voles invading the orchard. Once you detect voles in the grove, clean cultivation of the entire grove, removal of all vegetation from immediately around the trees, or poison baits are generally the three most effective ways to deal with the problem.

Habitat modification. Cultural practices can significantly affect meadow vole populations. Clean cultivation or band weed control kills vegetation next to the tree, making the immediate habitat unsuitable and thus preventing damage. Maintaining weed-free fence rows, roadsides, and ditch banks is also an important preventive measure. Because voles do not travel more than a few feet from their burrows to obtain food, any significant destruction of their food and cover causes them to abandon their burrows or die away from them.

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.

Trunk guards. Cylindrical wire or plastic trunk guards can protect young trees from voles. 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, some believe that 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.

Chemical controls. Chemical repellents have been tested, but no repellents have been effective in protecting grove trees from voles. Poison grain baits, in contrast, are very effective in reducing meadow vole populations. For most effective control, apply bait in the voles' runways, where most feeding occurs. Spotbait or broadcast bait over the entire infested area. For broadcasting, use a belly grinder-type seeder; a vehicle with a tailgate seeder; or, in some situations, an airplane or helicopter. Broadcast application rates vary, depending upon estimated density of the vole population and type of toxicant. Both single- and multiple-dose poisons are used for meadow vole control. Consult the product label for application methods and rates.

POCKET GOPHERS

Pocket gophers *(Thomomys* spp.) are stout-bodied, short-legged rodents. 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 groves 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 (fig. 7). They create characteristic soil mounds above ground (fig. 8). 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 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 frequently live in groves. They are active throughout the year and, if uncontrolled and food is plentiful, a population can increase to 30 to 40 gophers per acre. (Pocket gophers are relatively slow reproducers, however, and population buildups are gradual year after year.) They cause tree damage or death by girdling roots or crown at or below the soil level.

Monitoring Guidelines

Because pocket gopher damage is frequently invisible, it often goes undetected until a tree exhibits stress. By that time the tree may be beyond saving. Gopher activity is readily detected,

however: Just 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.

Baits. Single-feeding poison baits placed in the burrow tunnels are widely used and effective for controlling gophers in large groves. Follow bait 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, which 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 a small amount of grain-type bait in the burrow.

Hand-operated mechanical bait dispensers have a bait reservoir and bait release mechanism. They permit probing and bait dispensing in one operation. These devices are substantially faster than hand-baiting. Mechanical bait applicators are tractor drawn and offer an excellent way of 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 tree rows, 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 moisture must be right to produce a well-formed, smooth, artificial burrow.

Trapping. Traps, either pincher or box type, are effective. But because trapping is labor-intensive, they are most commonly used where only a few pocket gophers are present. To locate the main runway or tunnel, probe with a steel rod a short distance in front of the low side of a fresh mound or between two fresh mounds (fig. 9A). After you find the main tunnel, dig a hole to intercept it (the hole will probably be 10 to 12 inches deep). Then clean out the burrow and set two traps in the runway, one facing each direction. Whether you use Macabee traps or traps similar to them, wire each pair to a stake so the captured gopher cannot drag them down the tunnel (fig. 9B). Replace the soil.

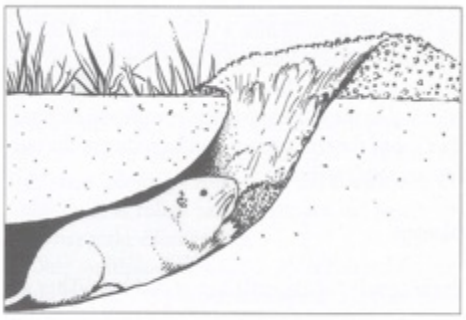


Figure 7. Pocket gophers push loose soil from main tunnels and dispose of it through lateral tunnels, creating surface mounds.

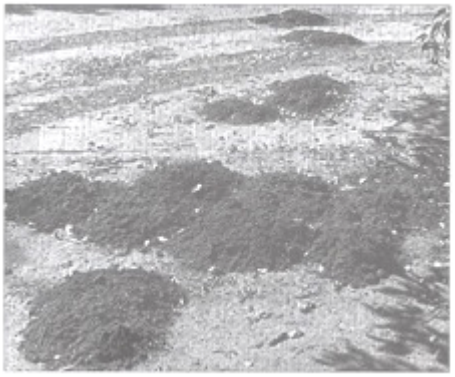


Figure 8. Mounds of fresh soil indicate recent gopher activity.

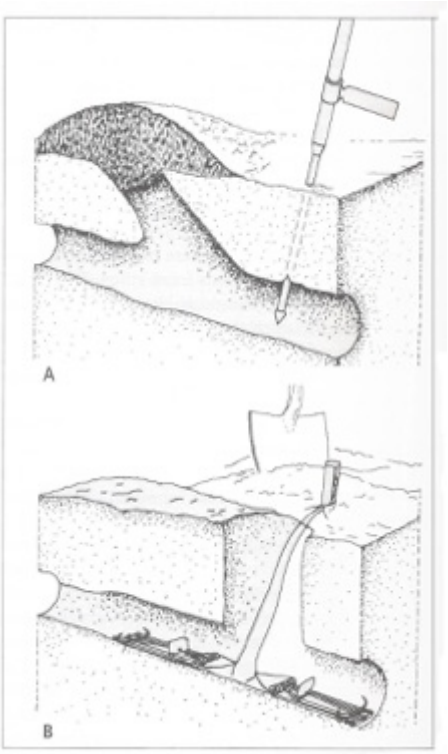


Figure 9. Use a steel probe to locate a main tunnel (A). With a shovel, excavate the soil to expose the tunnel and then insert two traps (B). Stake them and replace the soil.

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. In recent years, however, one registered fumigant, aluminum phosphide, has produced very acceptable results and more growers are using it. Repeat treatments if the initial treatment is ineffective.

Habitat modification. Permanent ground covers of herbaceous and certain grassy plant species favor gophers. Removal of the permanent ground cover will do much to reduce their numbers, because food is generally the factor that limits population. Deep discing destroys some burrows, making the grove less habitable; clean cultivation removes cover for gophers and allows growers to detect new mounds easily. Controlling gophers along fence rows and roadways adjacent to groves is important because young gophers will disperse from there into the grove.

When groves were flood-irrigated (before the advent of drip and mini-sprinkler irrigation in the 1970's), very young pocket gophers were usually drowned and adults would be forced to the surface where their natural avian predators or the irrigator's dog could kill them. By comparison,

sprinklers or drip irrigation systems generally favor pocket gophers by creating a soil moisture that is beneficial to burrowing, but not wet enough to drown the gopher.

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

DEER

Where habitat adjacent to an avocado grove supports moderate to high populations of deer *(Odocoileus hemlonus),* deer can cause significant damage to young trees. Foothill and coastal districts with brush or woodlands that provide cover for deer usually experience the most frequent depredation. Some valley groves near stream bottoms may also suffer. State game-management laws limit the control methods available to growers and make combating deer damage expensive.

Damage

Deer can completely defoliate young trees. They can distort, or kill a tree by repetitive browsing. Buck deer, when they rub their antlers on trunks and lower limbs, can severely scar the bark of young trees. (This is relatively rare.) Deer may browse on older trees, but the damage to them is usually less severe than that caused to young trees.

Monitoring Guidelines

In bushy areas deer usually stay out of sight during the daytime. They move into groves at night to browse. Feeding evidence and hoofprints in the orchard indicate their presence. Evening or early morning sightings are possible where deer are numerous.

Management Guidelines

Exclusion. Fencing is the most effective method of excluding deer from an orchard. 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. 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 the like 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.

Shooting. In some circumstances depredation permits may be obtained from the Department of Fish and Game, but shooting is rarely a satisfactory solution to a significant deer problem. Encouraging deer hunting in the area can lower the overall deer population and thus reduce deer depredation.

Repellents. Growers have tried many odor repellents, 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 retreated 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 scaring devices.

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

COYOTES

Coyotes are medium-sized members of the dog family, larger than foxes but smaller than wolves. Native to western North America, they are extremely adaptable. Coyotes have increased in numbers and have increased their geographical range during the past fifty years, due in part to human modification of the landscape. Coyotes now are found almost everywhere in North America. Coyotes can be particularly troublesome in avocado groves because they may chew irrigation lines and sprinklers and the damage may go undetected unless the grower is looking at the lines during every irrigation event. Avocado fruit fallen on the ground are a favorite food of coyotes.

Identification and Biology

Males are larger and heavier than females, typically weighing 20 to 35 lbs when full-grown, while females are about 18 to 25 lbs. They stand approximately 18 inches high at the shoulders. Coloration is usually a blend of rust-colored to brown to gray. The coyote resembles a small German shepherd dog, but with a longer, narrower snout and a bushy black-tipped tail.

Breeding occurs once annually, typically in late January and in February, with pups born in March and April. Parents and offspring continue to remain in a family group for about six months. Before giving birth, the adults excavate one or more dens in the soil, occasionally expanding the burrows of other animals, but sometimes using hollow logs, rock piles, or culverts. Typically, even when denning in suburban areas, they choose sites where human activity is minimal. If disturbed, the parents may move the litter to an alternate den site. Litter size is normally 4 to 7 pups and may depend on the female's nutritional status, which is a function of food availability and coyote population density.

Pups emerge from the natal den at about 3 weeks of age and grow quickly, relying primarily on their parents to provide them with food for the first few months. By late fall, juveniles may disperse to live independently, although if food resources are adequate, they can remain with their parents through the next year. Coyotes can be heard vocalizing (barking and howling) in the evening and night throughout most of the year, but they vocalize less when in the early stages of pup-rearing.

Space Use and Food Habits
Coyotes can live in almost any habitat in California, from arid deserts in the south to wet meadows and foggy coastal regions in the north. They are not as common in densely forested regions or in agricultural environments planted mainly to annual crops, because they find few food resources in these situations. In recent decades, they have become more numerous in many suburban environments where an ample food supply is available. Some of the highest population densities on record occur in suburban Southern California.

While some coyotes may be nomadic or transient and travel over wide areas, others occupy distinct territories that they defend, particularly during breeding and pup rearing. Where food is abundant, territories are smaller than where food is scarce. Coyote territories can be greater than 15 square miles in arid areas where food is scarce, to 1 to 3 square miles in oak woodland livestock rangelands typical of California's Coast Range, to as small as one quarter of a square mile in the suburbs of Los Angeles. Dominant, territorial pairs may share their space with their juvenile offspring or other related coyotes when food resources are sufficient to support these expanded family groups. Coyotes are generally regarded as less social with each other than are wolves. While they can live successfully as solitary individuals or pairs, and often do so, they can form packs of up to 10 individuals in environments where abundant food is present. Therefore, dense populations of suburban coyotes may not appear to be highly territorial.

Coyote diets are diverse and adaptable, varying according to local or seasonal availability of resources. Rodents or rabbits are often a major portion of their diet, when available. However, at times coyotes will rely on insects (such as grasshoppers), fruits (including avocados), berries, songbirds, and carrion. They readily scavenge on carcasses of large wild or domestic animals and also are capable predators, able to attack and kill full-grown deer and other large prey. Because domestic animals such as poultry, sheep, goats, and calves lack effective natural defenses against wild predators, they are easy prey for coyotes. Some coyotes learn to kill livestock and pets and will do so repeatedly unless corrective action is taken. When preying on poultry and livestock, coyotes often kill more than they can consume.

Behavior around Humans
Normally, coyotes are elusive animals that avoid contact with humans. Most active after dusk and before daylight, they are typically seen only at a distance. This trait may be a response to hunting, trapping, and other efforts to control coyote predation. Indeed, coyotes have been harassed and killed ever since settlers first arrived in western North America with their livestock. In most areas of California, coyotes continue to behave in ways that minimize their contact with humans.

In areas where predator control activities are practiced, coyotes are particularly wary of humans and of changes in their environment. Similarly, they are also wary of humans in places where sport hunters pursue or shoot at coyotes. Their excellent sense of smell and their tendency to avoid new objects makes it very difficult to capture or even to study them, as they often recognize and evade traps, snares, and cameras.

Within urban and suburban areas in California, however, some coyotes have adapted to residential neighborhoods, parks, and open spaces, and seemingly have lost their fear of humans. This may be a result of behavioral changes that have occurred over several generations of coyotes, in localities where predator control is no longer practiced. Coyotes thrive in such areas because food, water, and shelter are abundant, and coyotes living in these environments may come to associate humans with food and protection. Once attracted to suburban areas, they prey on the abundant rodents, rabbits, birds, house cats, and small dogs that live in residential habitats. They also will feed on household garbage, pet food, and seeds and fruits of many garden and landscape plants. In some localities, this has resulted in the development of local coyote populations that seemingly ignore people, while a few coyotes have become increasingly aggressive toward humans. They will stalk and even attack children or adults, or attack pets being walked on a leash by their owners. More than 160 such attacks have occurred in California since the 1970s, and they are becoming more frequent, particularly in suburban areas of Southern California. While only one attack has been fatal (to a 3-year-old girl, attacked in her front yard in 1981), a number of attacks have resulted in serious injuries.

Recognizing Problem Coyote Behavior

As coyote numbers increase in cities, they become accustomed to the presence of people, especially if the people do not harass them. Studies of coyote attacks on pets and on humans have revealed a predictable pattern of change in coyote behavior in these environments (Table 1). This progression is accelerated when coyotes are provided abundant food, either unintentionally or intentionally, in residential areas. When it reaches the point where pets are being attacked or coyotes are seen in neighborhoods in early morning or late afternoon, area-wide corrective actions are recommended to prevent an escalation to attacks on humans. If coyotes are seen near your home, teach your children to identify them, recognize the potential for danger, and know what to do if they come in contact with a coyote. (See Responding to Coyote Aggression and Attack.)

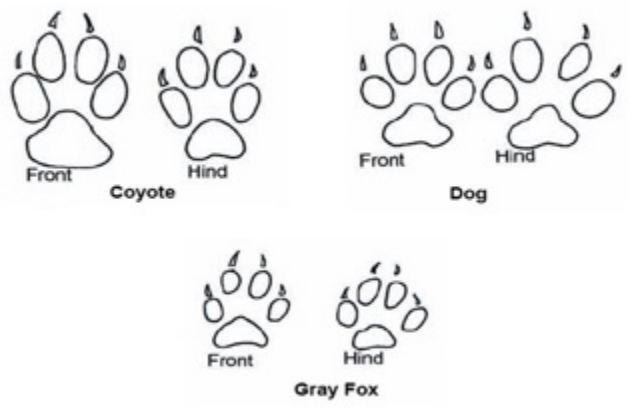
Table 1. Sequence of increasingly aggressive coyote behaviors

1. Increase in coyotes on streets and in yards at night
2. Increase in coyotes approaching adults and/or taking pets at night
3. Coyotes on streets, and in parks and yards, in early morning/late afternoon
4. Coyotes chasing or taking pets in daytime
5. Coyotes attacking and taking pets on leash or near owners; chasing joggers, bicyclists, other adults
6. Coyotes seen in and around children's play areas, school grounds, and parks in midday
7. Coyotes acting aggressively toward adults in midday

Identifying Coyote Damage

Coyotes come into conflict with humans in a variety of ways, from chasing and attacking pets in suburban and agricultural areas, to chewing plastic drip irrigation systems in groves, killing livestock on rangelands, or killing other valued wild animals. The first step in solving any conflict with wildlife is to identify the wildlife species causing the problem. Because coyote damage often is not seen by humans as it is happening, heavy reliance must be placed on indirect evidence at the damage site. Inspect the area for "coyote sign" such as tracks, hair, droppings, or tooth marks on irrigation pipe.

Tracks. Coyote tracks can often be distinguished from those of dogs by their shape and appearance. Coyote tracks tend to be more oval-shaped and compact than those of common dog breeds. Nail marks of coyotes are less prominent, and the tracks tend to follow a straight line more closely than those of dogs. Tracks of large coyotes can be up to 3 by 1-3/4 inches.



Hair. Coyote hair may be found in fence wire, particularly at locations where coyotes have dug a "slide" to crawl under a chain-link or woven-wire fence. A close look at the hair will reveal bands of color on individual hairs (but many other animals also have hair with bands of color). Hairs from a coyote's back are often black-tipped.

Droppings. Coyote droppings or "scats" are typically about the diameter of a cigar, sometimes tapering at one end. Scats are deposited along trails and roadsides and will vary in appearance depending on the animal's diet and on the age of the scat. The scat may contain hair, feathers, bones or other animal parts, as well as plant materials such as grass or seeds. Scats are typically black to light gray in color, becoming bleached out as they remain exposed to sunlight and the elements.

Tooth Marks. Drip irrigation pipe and other such materials, when chewed by coyotes, have the appearance of having been compressed and shredded as if chewed by dogs. This is in contrast to chewing damage done by rodents or rabbits, where the pipe is scraped or gnawed repeatedly and often shows evidence of the presence of paired incisor tooth marks.

Drip irrigation pipe and other such materials, when chewed by coyotes, have the appearance of having been compressed and shredded as if chewed by dogs. *Photo by Craig Coolahan*

Holes chewed in a microsprinkler drip line by California ground squirrel, *Spermophilus beecheyi*.
Photo by Jack Kelly Clark.

Prey Remains. When prey killed by coyotes is found and examined before it can be consumed or scavenged by other species, the appearance of the carcass may give clear evidence that coyotes were responsible. Coyotes usually kill small mammalian prey such as rabbits, young kid goats, and small lambs by biting them through the head or neck. The size and spacing of puncture wounds from the coyotes' canine teeth is sometimes apparent; the spacing between a coyote's canine teeth is typically 1 to 1-3/8 inches. A coyote's carnassial ("cheek") teeth are capable of making clean, knifelike cuts through carcasses, as coyotes sometimes dismember prey in order to transport portions to their den to feed pups. Municipal authorities and homeowners have sometimes found remains of dead house cats and mistakenly assumed they were mutilated by people practicing animal sacrifices, when in fact they were killed by coyotes.

Larger prey such as large lambs, large kid goats, and adult sheep and goats are usually attacked at the throat and may show puncture wounds on the side of the head or on the lower part of the neck. Skinning the neck may reveal substantial hemorrhaging in the area of the attack that is not visible externally. In contrast, dogs usually kill such prey by attacking the hindquarters, flanks, and head, often mutilating prey and leaving a "messy" kill. Because inexperienced or young coyotes sometimes do not make typical or "clean" kills, and some dogs may kill in a manner resembling coyotes, it is important to seek additional evidence at the site before reaching a conclusion.

Because coyotes will scavenge carcasses, it is important not to assume coyotes have killed every animal they might feed on. Livestock and other prey can die from a variety of causes. However, the presence of hemorrhaging and bruising on the skin around tooth punctures or bites indicates the animal was alive when it was attacked by a predator.

Predator Damage Management, Past and Present

During the twentieth century, livestock producers and government predator control agents often were able to control losses by suppressing coyote numbers, at least locally, through use of toxicants, traps, shooting, and other techniques. Population models reveal that to control coyote numbers through removal, more than three-quarters of all coyotes must be killed annually, and even then, their elimination would take decades of effort. As regulations on predator control tools and materials increased and society's attitudes toward predators changed, it has become increasingly difficult to control coyote numbers or slow their range expansion into new areas. Today, toxicants are highly restricted for use in controlling coyotes, leghold traps are banned in some states including California, and shooting is not safe or legal in many situations, especially in suburban areas. Modern strategies to manage coyote damage integrate a number of nonlethal and preventive techniques, relying on lethal removal only when other techniques are ineffective or impractical.

While coyote removal often results in a void that is quickly filled by coyotes moving in from surrounding areas, this does not mean that coyote removal is ineffective in reducing or stopping damage. Coyotes moving in to fill a void may have different travel patterns and preferences for

prey, thus reducing conflicts with humans, pets, or livestock. Recent research, as well as decades of practical field experience, suggests that removal of dominant coyote pairs at the beginning of breeding season may substantially reduce predation on livestock for up to a year. Removal of coyotes from a population may result in more resources being available to remaining coyotes, thus increasing litter sizes and pup survival. However, coyote removal does not result in higher coyote populations over the long term, as numbers are largely regulated by food availability.

Legal Status. Coyotes have no special protection in California and may be killed by any method that is not prohibited by federal, state, or local statutes. Since the passage of a state ballot initiative measure in November 1998, leghold traps cannot be used to capture coyotes except in situations where a human health and safety emergency has been declared by designated officials, or in selected situations where the existence of an endangered species is threatened by predation. Toxicants or poisons used to control coyotes are illegal, with the exception of fumigant cartridges available only to predator control specialists to asphyxiate coyote pups in their dens. No chemical repellents are registered for use in repelling coyotes from property or from livestock.

The situations in which coyotes cause damage are quite variable, and therefore strategies and solutions to resolve these problems also must be tailored to individual situations. Professional wildlife damage management specialists who are employed by federal, state, or county agencies can be very helpful in evaluating coyote damage and in assisting landowners to develop appropriate management strategies for specific situations. Contact your county agricultural commissioner or county Cooperative Extension office to obtain information about professionals who can control coyotes, or telephone the United States Department of Agriculture, California Wildlife Services state office at 916-979-2675, or see their website at *www.aphis.usda.gov/ws/ca/*

Exclusion. Coyotes have the physical ability to go under, through, or over many types of fences. While coyotes generally prefer to dig under fences or go through fence gaps at gates or washouts, some coyotes have the inclination to jump or climb fences, particularly at corners or where cross-braces provide a foothold.

While it is expensive and difficult to construct a completely coyote-proof fence, a fence that discourages coyotes will have the following design characteristics. Fence height should be a minimum of 5-1/2 feet and should be built higher on sloping terrain. Net wire-mesh should be no larger than 6 inches between stays. To deter digging under, bury a galvanized wire-mesh apron, attached securely to the bottom of the fence, 4 to 6 inches below the soil and extending outward at least 15 inches. An extra degree of protection against coyotes scaling a fence can be obtained by installing a wire-mesh overhang of at least 18 inches, slanted outward, or roller-type devices designed to be attached to the top of a fence, which prevent coyotes from getting a foothold in their attempts to climb or jump over. In general, truly coyote-proof fences are so expensive to build and maintain that they are economically viable only to protect very valuable commodities.
Electric fences of various designs have been effective in excluding coyotes. Retrofitting existing fences by adding electrified wires may provide an added degree of effectiveness. Electric fencing can be less expensive to construct than conventional woven-wire fence, but it requires

substantially more maintenance to keep it in working condition. Additionally, electrical fencing may be inappropriate for use or illegal in residential or suburban areas.

Close off crawl spaces under mobile homes, porches, decks, and garden sheds, as coyotes can use these areas to rest and to rear their young. While quality fencing may not prevent all coyotes from entering an area, it will often result in coyotes leaving evidence of where and how they penetrated the fence, which will enable you to determine what other methods of management will be most effective to stop the damage.

Hazing and Behavior Modification. Using sound or visual stimuli to keep coyotes away from livestock or other resources will provide only temporary effectiveness, if any. Such efforts are likely to work best in localities where coyotes are wary as a result of continuing predator control efforts and where the stimuli can be frequently varied in type and location. In the absence of any real threat, coyotes quickly adapt or habituate to sounds, flashing lights, propane cannons, scarecrows, and so on. A strobe-siren device, developed by researchers to keep coyotes away from sheep flocks at night, was effective only for several weeks to a few months at most locations where it was tested. Because of the disturbance such devices cause, they are impractical for use in suburban areas.

When coyotes first venture into a suburban area, they likely have some degree of wariness toward humans. In this situation, certain hazing techniques may, when combined with modifications to make the environment less attractive, reduce the chance that coyotes will lose their wariness of humans. Suburban residents who see a coyote in their neighborhood should attempt to frighten it away by shouting, throwing rocks, squirting it with a water hose, blowing portable air horns, or otherwise acting aggressively in order to reinforce its fear of people. Motion-sensitive lights on houses or outbuildings may deter coyotes from approaching.

Certain breeds of guard dogs, as well as llamas and donkeys, may effectively exclude coyotes from pastures. Livestock operators who have had the best success with guard animals typically place them in small, flat, fenced pastures where the guard animal can see and challenge any intruding coyotes. Guard animals are most effective when they are behaviorally bonded to the sheep or goats they are protecting. However, there are occasions when guard animals are of limited effectiveness, and multiple coyotes or mountain lions may even attack guard animals. In suburban areas, there have been instances of groups of coyotes attacking large dogs such as Labrador retrievers, even in the presence of their owners.

Habitat Management in Suburban Areas. Areas with lush landscaping provide ample food, water, and shelter for coyotes. Suburban coyotes can reach densities far greater than they do on rangeland or undeveloped wildlands. Homeowners can reduce the attractiveness of their property to coyotes by clearing or thinning thick vegetation and by removing brush and dense weeds from the landscape, thereby depriving coyotes and their prey of shelter and cover. In particular, prune back the lower limbs and branches of shrubs and small trees to a height of 2 feet, to deprive coyotes of cover where they can easily hide. Avoid using landscape plants that produce fruits and seeds, and pick fruit from trees before it falls to the ground to avoid attracting coyotes. Coyotes are attracted to ripening fruits of many kinds, and they will also readily consume the fruits of some plants commonly used for landscaping (Table 2). Install quality fencing around garden plots to exclude coyotes, as they will eat many common garden fruits and

vegetables. Compost piles should be managed carefully so they will not encourage rodents or other prey attractive to coyotes, and they should be fenced or contained to exclude coyotes from foraging for grubs and worms. Eliminate available water sources for coyotes and other wildlife; for example, remove ponds or fountains, or install net wire fences around their perimeter. Manage bird feeders carefully to avoid spillage that attracts rodents and rabbits, which are attractive coyote prey.

Table 2. Landscape plants having fruits or seeds often preferred by coyotes

Common name	**Scientific name**
Indian laurel fig	*Ficus microcarpa* var. *nitida*
Ornamental strawberry	*Fragaria chiloensi*
Date palm	*Phoenix dactylifera*
Passion fruit, Passion vine	*Passiflora* spp.
Lychee	*Litchi chinensis*
Sugar bush	*Rhus ovata*
Strawberry bush	*Euonymus americanus*
Strawberry tree	*Arbutus unedo*
Jujube, or Chinese date	*Ziziphus jujuba*
Brush cherries	*Eugenia* spp.
Elderberry	*Sambucus* spp.
Avocado	*Persea americana*
Fig	*Ficus carica*
Guava	*Psidium guajava*
Loquat	*Eriobotrya japonica*

Habitat Management in Semi-rural Areas. In areas where residential dwellings are on small acreages or where homeowners may keep livestock as hobby animals, consider installation of quality fencing to deter coyotes. Confine livestock and poultry from dusk to dawn, and use lights above corrals. Control rodents, especially any that are living in and around your livestock facilities or residence. Be particularly attentive when lambs or kid goats are present, as well as during the coyotes' pup rearing season (March through August), when their food needs are highest.

Pet Management. Cats and dogs should be fed indoors, or if fed outdoors, food dishes should be promptly emptied and removed after pets have eaten. Store pet food indoors or in sealed heavy-duty containers. Use refuse containers that have tight-fitting lids to prevent raccoons, dogs, or coyotes from having access to household garbage. Keep small pets such as cats, rabbits, and small dogs, indoors, or if outdoors, keep them within enclosed kennels. Large dogs should be brought

inside after dark. Never allow cats or dogs to run free at any time, as they are easy prey. Because coyotes that come in contact with domestic animals may transmit diseases, vaccinate all pets for rabies, distemper, parvovirus, and other diseases, as recommended by a veterinarian.

When exercising your dog, always use a leash, and walk only in populated areas of high pedestrian traffic. You may want to carry a walking stick or cane that you can use to fend off an attack. Try not to establish a regular routine in terms of route or time of day, as coyotes can learn your schedule and have been known to lie in wait to attack. Avoid walking pets at dawn or dusk, and avoid areas of dense vegetation or cover. Coyotes are more likely to attack dogs during the pup-rearing season, if dogs come too near the den site. If coyotes establish a den site near a residential area, attempts should be made to harass the coyotes so that they move their pups to an alternative, more remote den site.
Never intentionally feed or provide water to coyotes, as this causes them to quickly lose their fear of people and become aggressive. Anyone who intentionally feeds coyotes is putting the entire neighborhood's pets and children at risk of coyote attack and serious injury.

In addition, ask your neighbors to also follow the described methods in order to reduce the potential for conflicts with coyotes.

Responding to Coyote Aggression and Attack. If you or your pets are approached by an aggressive or fearless coyote, try to frighten it away by shouting in a deep voice, waving your arms, throwing objects at the animal, and looking it directly in the eyes. Stand up if you are seated. If you are wearing a coat or vest, spread it open like a cape so that you appear larger. Retreat from the situation by walking slowly backward so that you do not turn your back on the coyote.

If you are bitten or scratched by a coyote, wash the affected area thoroughly with soap and water and then seek immediate medical attention. Although most problem coyotes are healthy, the risk of rabies is always present. Rabies can occur from a bite or scrape from an infected coyote, or if you handle your pet after it has been attacked and the coyote's saliva comes into contact with broken skin or mucous membranes. Because rabies infections in humans are nearly always fatal, medical authorities typically recommend post-exposure immunization whenever a person comes into contact with a wild coyote during an attack.

Report any incidents of coyote aggression or attack to local authorities including your local animal control agency and the California Department of Fish & Game. Report any attacks on livestock to your county agricultural commissioner.

Coyote Removal in Suburban Areas. Once coyotes have lost their fear of humans or have started behaving aggressively, a health and safety hazard exists. Usually it can be remedied only by removal of one or more of the coyotes. Typically, coyote removal in urban or suburban areas is conducted by predator control professionals who shoot coyotes or capture them in padded leghold traps or snares. Captured coyotes must be destroyed, as relocating problem coyotes would incur unacceptable liability and risk on the part of the agency involved, and relocation is illegal without prior approval of the California Department of Fish & Game. Management

experience has shown that removal of only a few problem coyotes from a population will reinstill fear of humans in the remaining population, often solving coyote problems in that locality for months or even years. Because other coyotes quickly move in to occupy vacant territories, removal of several animals has no long-term impact on coyote numbers.

Following coyote removal, local agencies or authorities should evaluate the entire neighborhood and recommend preventive measures that homeowners should take in order to make the area less attractive to coyotes, thus preventing recurrence of the problem.

Coyote Removal in Rural Areas. In semi-rural settings or in agricultural lands, coyote damage to livestock, drip irrigation systems, and other resources often cannot be solved by habitat management or livestock management efforts alone. Professional assistance is usually required to remove the responsible coyotes as selectively and as efficiently as possible.

Wildlife management specialists employed by United States Department of Agriculture Wildlife Services or by individual counties are available to assist landowners in most areas within California. Contact your county agricultural commissioner to obtain a referral, telephone the United States Department of Agriculture, California branch of Wildlife Services at 916-979-2675, or see their website at www.aphis.usda.gov.ws/ca/ . Wildlife Services professionals have experience in dealing with problem coyotes, which can be wary and difficult to capture. They can also use certain tools and methods that are not generally available to the public. There are also private "nuisance" wildlife control firms in some areas that specialize in dealing with suburban wildlife problems.

OTHER MAMMAL PESTS

Roof Rats

Avocado trees may be a food source for roof rats, or black rats *(Rattus rattus),* which inhabit and nest is some branches. Roof rat damage to fruit is relatively minor, rarely is there more than one or two fruit per bin that show typical chewing damage from roof rats. Damage is not considered severe enough to warrant control measures.

Birds

Birds are generally <u>not</u> a problem in avocado groves. However, there is one exception where bird damage can be substantial. Crows and ravens have caused the death of many young grafts on top-worked trees by knocking off the paper graft covers and exposing the young buds to sun, or by pecking out the young buds and breaking off the tender new grafts. If birds are a serious problem, and there are just a few young grafts to protect, the grafter may have to erect chicken

wire netting over the grafts supported by stakes nailed to the stumps. If there are a considerable number of trees to protect, the grafter may have to try some sort of frightening technique.

Frightening Birds

Not surprisingly, shooting to produce noise is the most frequently used frightening technique because it uses commonly available equipment and is immediate. What is not commonly known, however, is that shooting-with live ammunition, cracker shells, or whistle bombs-consists of two elements of harassment: periodic loud blasts and the presence of humans and, if used, their vehicle. After the shooting technique has been employed for a while, some birds, like crows, often disperse as soon as they see the shooter or the shooter's vehicle approach. They may return as soon as they see the human and the vehicle leave.

The major problem with all frightening techniques is that, when used day in and day out, most birds habituate, or become accustomed, to them. Thus, their effectiveness diminishes with time. Their effectiveness diminishes also as more growers in the same general area use the same techniques. The grower with the most innovative frightening strategies has the advantage.

To prolong the effectiveness of the frightening methods you choose, introduce as many variations as are practical. For example, if a shooter normally rides around the orchard on an ATV, he or she should occasionally abandon the vehicle and walk through the orchard shooting. Instead of using normal shotgun ammunition, occasionally use cracker shells, which produce a second blast above the birds.

Employ variations intermittently. Rather than using exploders and an Av-Alarm system simultaneously, employ them in a rotational scheme. Use the Av-Alarm system for 5 to 7 days, and then use the gas exploders for the next 5 to 7 days. Compared to simultaneous use, rotation usually results in superior and longer-lasting bird dispersal, reduced operating costs, and extended equipment life. Determine the number of days in each sequence by observing the birds' response. In, terms of the preceding example, some type of visual stimulus along with the Av-Alarm might improve control. The grower might suspend large, bright balloons above the treetops, for example. This combination would only be used with the Av-Alarm system and taken down when the propane exploders were in operation. In general, reports show, Av-Alarm systems are less effective than propane exploders.

Legal Status and Restrictions

Crows are considered migratory nongame birds; however, a federal permit is not required to kill them when birds depredate or are about to depredate a crop, but check first with your local Fish and Game officer because regulations change frequently. When crows cause crop depredations, the California Fish and Game Code allows them to be taken (killed) by landowners, tenants, or persons authorized in writing by landowners or tenants.

LITERATURE CITED

Bekoff, M., and E. M. Gese. 2003. Coyote. In G. A. Feldhamer, B. C. Thompson, and J. A. Chapman, eds. *Wild Mammals of North America: Biology, Management, and Conservation.* Johns Hopkins University Press, Baltimore. pp. 467-481.

Clark, J. P. 1986. *Vertebrate pest control handbook.* Sacramento: California Department of Food and Agriculture Division of Plant Industry.

Cummings, M. W., and R. E. Marsh. 1978. Vertebrate pests of citrus. In W. Reuther, E. C. Calavan, and G. E. Carman (eds.), *The Citrus Industry,* volume IV, 237-73.,. Berkeley: University of California Division of Agricultural Sciences Publication 4088.

Green, J. S., F. R. Henderson, and M. D. Collinge. 1994. Coyotes. In S. E. Hygnstrom, R. M. Timm, and G. E. Larson, eds. *Prevention and Control of Wildlife Damage.* Univ. of NE Cooperative Extension, Lincoln. pp. C51-C76.

Marsh, R. E., and M. W. Cummings. 1976. *Pocket gopher control with mechanical bait applicator.* University of California Agricultural Extension Service Leaflet 2699.

Salmon, T. P., A. C. Crabb, and R. E. Marsh. 1986. Bird damage to pistachios. *Calif. Ag.* 40(5,6):5-8.

Salmon, T. P., and R. E, Lickliter. 1984. *Wildlife pest control around gardens and homes.* Oakland: University of California Division of Agriculture and Natural Resources Publication 21385.

Timm, R. M., R. O. Baker, J. R. Bennett, and C. C. Coolahan. 2004. Coyote attacks: an increasing suburban problem. *Trans. No. Amer. Wildlife & Natural Resources. Conf.* 69:67-88.

UC Statewide IPM Project. 1985. *Integrated pest management for almonds.* Oakland: University of California Division of Agriculture and Natural Resources Publication 3308.

Blank Page