Foothill Wine Grape Day
August 3, 1996

VERTEBRATE PESTS IN VINEYARDS

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Introduction

There are a number of vertebrate pest species that currently cause damage of economic significance in vineyards. These include pocket gophers, meadow voles, ground squirrels, rabbits and deer. Pocket gophers are probably the most widespread and significant pests with economic losses resulting from their feeding on the roots of vines, their gnawing on irrigation lines and their burrows interfering with irrigation and other management practices. Meadow voles, ground squirrels, rabbits and deer may also cause significant damage through their feeding on vines.

Location of a vineyard and the surrounding habitat determine to a large extent which vertebrate species may be involved in crop damage. For example, vineyards in the foothills or adjacent to rangeland are more likely to experience deer or jackrabbit damage. The potential for damage may also be influenced by management practices in the vineyard. In the past, tillage or herbicide application to eliminate weed growth have been recommended as a way of reducing vertebrate pest population levels and minimizing damage. Removal of weeds reduces the suitability of the habitat to some vertebrate species by limiting the amount of shelter and food available. The practice of cover cropping improves the quality of habitat in vineyards to most vertebrate pests and makes their sign more difficult to detect. This practice may therefore lead to a significant increase in damage and efforts spent on control programs.

A regular monitoring program for early detection of damage is essential. In addition to monitoring pest populations and damage in the vineyard, surrounding areas should also be routinely checked for animal sign so that the potential for reinfestation can be assessed.

As control techniques vary depending on the pest species, it is important to correctly identify the species that is causing the damage. The type of damage, accompanying animal sign (feces, tracks, and burrow systems) and observations of animal activity in and around the vineyard should be used to determine this. Once the species has been identified, it is then possible to implement a control procedure that is based on an understanding of the animals' biology and behavior as well as knowledge of the cost-effectiveness of the control program. The effectiveness of a control program may also be enhanced if pest populations are also controlled in areas surrounding the vineyard and the program coordinated with neighboring growers. In that way, the potential for rapid reinvasion of the vineyard by the pest is minimized.

In many situations it may be possible to manipulate the habitat to make it less favorable to the pest species. For example, maintaining a cover free strip along vine rows may result in a lower level of damage due to voles. However, if the preventative approach proves unsatisfactory or unfeasible, other lethal control techniques such as traps, toxic baits or fumigants may have to be used.

A summary of the vertebrate pest species which cause damage of economic significance is given in Table 1.

Table 1. Vertebrate pest species, damage and control recommendations.

Species	Identification and Damage	Most effective control method
Pocket gopher *Thomomys* spp.	Plugged burrow systems Earth mounds Girdling of vines below ground Damage to irrigation lines	Flood irrigation Toxic baits Trapping
Meadow vole *Microtus* spp.	Runways and open burrow entrances Presence of scats Girdling of vines above ground	Cultural controls Exclusion Toxic baits
Black-tailed Jackrabbit *Lepus* spp.	Feeding on foliage and fruit Girdling or complete cutting of vines above ground Observation of activity in morning and evening	Exclusion Vine guards Toxic baits Shooting
Cottontail rabbit *Sylvilagus* spp.	Feeding on foliage and fruit Girdling or complete cutting of vines above ground Observation of activity in morning and evening	Exclusion Vine guards Shooting
Ground squirrel *Spermophilus beecheyi*	Girdling of vines above ground Feeding on foliage and fruit Gnawing on irrigation lines Observation of activity during the day Burrow systems, especially on perimeter of vineyard	Toxic baits Burrow fumigation
Deer	Stripping of foliage from vines Breakage or scarring of young vines	Exclusion fences

Note: The practice of cover cropping may potentially benefit all vertebrate species which are currently considered important pests in vineyards. If prompt action is not taken to control these pests, damage and economic losses may be significantly increased.

Pocket Gophers (*Thomomys* spp.)

Pocket gophers are probably the most common and economically significant vertebrate pest in vineyards. They are active throughout the year and if left uncontrolled can achieve very high population numbers. Pocket gophers cause severe damage to vines, irrigation systems and their burrowing can interfere with management operations.

Pocket gophers are fossorial (burrowing) rodents whose name is derived from the pair of large, external, fur-lined cheek pouches in which they can carry food and nest material. They range in size from six to eight inches (15 to 20 cm) and have bodies well adapted to an underground existence. They are powerfully built in the forequarters, are equipped with large claws for digging, have a short neck and a fairly small and flattened head. Gophers have small external ears, small eyes and lips that close behind their large incisors, thereby enabling them to keep soil out of the mouth while burrowing. Gophers use their short whiskers and tails to help navigate tunnels. They seldom travel above ground; however they may sometimes be seen feeding or pushing dirt out of their burrow system. They have a keen sense of smell which they use to locate food. They are generally more active excavating soil in the spring and fall than they are during the heat of summer. They do not hibernate. In uncultivated and non-irrigated areas the female normally produces one litter per year during the rainy season when green forage is plentiful. At lower elevations and under irrigated conditions, such as in alfalfa plantings, pocket gophers may breed all year round. Average litter size is 5 or 6 young and births generally occur from March through June where only one litter is produced. Pocket gophers have a maximum life span of about five years.

Pocket gophers are extremely territorial and antisocial. As soon as young are weaned, they leave their mother's burrow to establish their own territory. The burrow system can cover an area from a few hundred feet up to more than 1000 square feet. Territories are generally smaller for younger individuals or in areas with abundant food such as alfalfa fields. Tunnels are two to three inches in diameter and most are from 8 to 12 inches below the ground, but nests and food storage chambers may be more than six feet deep. Tunnels are usually deeper in sandy soils than in clay soils. One gopher may create several mounds in a day or as many as 200 mounds per year. Crescent shaped mounds of fresh soil indicate their presence. These are formed as the animals push soil out of their burrows through lateral tunnels up to the surface. They plug the burrow soon after digging it to preserve fairly constant temperatures and humidity within the burrow system. Gophers may dig secondary tunnels off the main burrow for occasional aboveground grazing. In these cases, no distinctive mounds are formed. Fresh mounds of loose, finely textured soil indicate an active pocket gopher system.

Pocket gophers are strict vegetarians, feeding primarily on roots, bulbs, corms, and tubers of plants. However, they may also emerge from their burrows to feed on the above-ground parts of plants. There are few plants that pocket gophers will not eat but they exhibit a preference for fleshy-stemmed and bulbous-rooted plants, especially legumes, rather than fibrous species such as grasses.

Damage

Damage to grapevines results when gophers cut roots or gnaw bark from the roots or trunk. Vines are commonly completely girdled a few inches below the soil line in a relatively short

time. Newly planted vineyards are most at risk to large scale damage resulting from pocket gophers. Damage by pocket gophers can usually be distinguished from rabbits and meadow voles because it normally occurs several inches below ground. Because damage is frequently not visible, it often goes undetected until a vine exhibits stress and is beyond help.

Pocket gophers can also cause problems with irrigation systems. They gnaw on plastic irrigation pipe and their burrows divert irrigation water, sometimes leading to extensive soil erosion.

Early detection of increasing populations is imperative if damage is to be minimized. Population buildup is indicated by an increase in the number of mounds. Where cover crops are present, gophers are presented with a year-round food source and their populations may grow significantly throughout the course of a year. As mounds are difficult to detect under heavy cover, in areas where pocket gophers are likely to be a problem, regular mowing of the cover crop may facilitate detection of new mounds.

Management guidelines

Determination of when the population has reached a level at which control is required depends on grower experience. As significant damage can result from very low infestations, control is recommended as soon as fresh mounds are detected. Controlling pocket gophers in areas adjacent to the vineyard is also necessary as young gophers will disperse from there into the vineyard.

A successful pocket gopher control program therefore depends on early detection of increasing populations and application of control measures appropriate to the location and situation. Since individual burrow systems must be treated to control gophers, the cost of control increases in proportion to the number of gophers present.

Pocket gophers can be controlled effectively and even eliminated from vineyards by continuous, persistent effort. Unfortunately, there are no cultural techniques that provide effective control of pocket gophers. Most growers rely on poison baits for control. Where populations are low or poisoning has been ineffective, traps may be used. Control efforts should be concentrated in late winter to early spring before the gophers have given birth.

It is important to be able to differentiate between mounds formed by pocket gophers and those formed by moles. Pocket gophers create soil mounds by pushing soil out of their tunnels at an angle to the surface. Their mounds are typically fan-shaped with a plug of soil at the entrance to the burrow. Moles create mounds by pushing soil upwards at a 90 degree angle to the surface. Their mounds are circular and have no visible plug. Moles are strict carnivores, their chief food items including earthworms, grubs and other invertebrates which they find below the surface of the ground. Damage associated with moles results from their digging in search for food. Their digging exposes plant roots to desiccation, can up-root small seedlings and disrupt ground covers. In an established vineyard, damage due to moles is generally minimal. In a young planting, small plants may be susceptible to some level of damage if moles are present. Given the current vigor of most grape varieties, the period of time over which moles could be considered a potential problem is relatively limited.

Cultural techniques
Flood irrigation may reduce the potential for large populations to occur. Normal furrow, sprinkler or drip irrigation does not detrimentally affect them because the water filters around and not into their burrow systems.

Predators
A number of predators including coyotes, foxes, cats, various raptors and owls prey on pocket gophers. However, they are rarely, if ever, considered a reliable means of control of pocket gophers. Predator attraction should be viewed in the larger context of a gopher management scheme which involves other lethal and non-lethal management options, i.e., trapping, baiting, cultivation, etc.

Toxic Baits
A number of rodenticides are currently registered for pocket gopher control. Of these, the best and most widely used is strychnine, an acute poison presented on grain. Anticoagulant baits are also available but are generally less cost effective as the gopher must ingest multiple doses over time. The bait is placed in the pocket gophers' main burrow runways. Depending on the level of infestation and the area to be treated, baits may be applied either by hand or mechanically using the burrow builder.

Hand-baiting is extremely time-consuming and is generally only undertaken when the level of infestation is low and only a small area needs to be treated. Bait is placed by using either a special hand-operated bait dispenser probe or by making an opening to the burrow system with a probe and then placing the bait. The key to success of these methods depends on accurately locating the gopher's main burrow. The main burrow is generally found 8 to 12 inches (20 to 30.5 cm) away from the plug on fresh, fan-shaped mounds. Once this is located, 15 ml (a rounded tablespoon) of the bait is placed into the burrow and the hole closed with a rock, clod or some other material to exclude light and prevent soil from falling on the bait. Two or three different places in the burrow system should be treated. If gopher activity continues for more than two days after treatment, the burrow should be treated again. Read and follow label instructions for recommended amounts and application rates.

When pocket gophers are numerous, mechanical burrow builders provide the most economical method of control. The burrow builder or baiter is a tractor-drawn device that constructs an artificial burrow at a depth similar to burrows created by pocket gophers and deposits poison bait at preset intervals and quantities. It is operated down any row where gophers are present and therefore intercepts most natural burrows. The pocket gophers readily explore these artificial tunnels and consume the poisoned bait. In some situations 0.5% strychnine bait will give effective pocket gopher control when applied using the burrow builder. However, where it is not giving good control there is a registered 1.8% strychnine bait that may give superior results. The 1.8% bait should not be used for hand baiting.

Successful control using this method depends largely on soil moisture. If the soil is too wet, the tunnel may not close and allow sunlight to penetrate the burrow. If the soil is too dry, the burrow may collapse. The burrow builder should only be used in areas where gophers are present, not as a preventative measure. As gophers seek areas with low resistance to digging, building a burrow

where gophers are not present may actually facilitate the spread of those not poisoned by the treatment.

Traps
Trapping may provide economical and satisfactory control on small areas or to remove those animals remaining after a poisoning control program. It is generally more effective in spring and fall when pocket gophers are most active. Several types and brands of gopher trap are available, the most common of these being the two-pronged pincer trap (Macabee) and the box type traps, several of which are available. Two traps facing opposite directions are placed in the main tunnel. This placement will intercept a pocket gopher coming from either direction. The hole made to set the traps is then covered to exclude light from the burrow system and the traps wired to a stake to prevent loss of the trap. Traps should be inspected at least twice a day and moved to a different location if three days elapse without catching a gopher.

Other methods
Fumigating burrows is generally unsatisfactory because gophers can detect the gases and quickly plug up the burrow to exclude them. Porous soils may also make it difficult to maintain a toxic concentration in the burrow system.

Meadow voles (*Microtus* spp.)

Meadow voles, also known as meadow mice or field mice, may kill or cause significant damage to vines. Under favorable environmental conditions, vole populations increase rapidly and damage can be severe enough to kill many vines, especially in young plantings. Damage is highest where grass or cover crops build up around vines, therefore providing them with food and shelter.

Meadow voles have a body length of 4 to 6 inches (10 to 15 cm) when mature, heavy bodies, short legs and tail, small eyes and small partially hidden ears. Their soft, dense fur is blackish brown to greyish brown. Voles are active year round.

They dig short, shallow burrows and make underground nests of grass, stems and leaves. A good indication that there are significant numbers of voles is the presence of well-worn trails two inches (5 cm) wide leading to unplugged entrance holes. Voles reproduce very rapidly with a female capable of producing between two and five litters per year. Peak breeding usually occurs in spring in response to high abundance of green plant food. A second shorter breeding period occurs in fall. Populations fluctuate considerably. Their numbers usually peak about every four years, then fall abruptly to relative scarcity. A heavily infested field may support a peak population of 1000 to 3000 animals per acre.

Damage
Meadow voles feed on vegetation including stems, roots, bark and seeds of many plants. They damage or kill grapevines by eating through the bark to the cambium layer. Characteristic damage is complete or partial girdling of the trunk from just below the soil line up as far as they can reach on the trunk. Most damage to vines occurs in winter or early spring.

Management Guidelines

Monthly inspections of vineyards and surrounding fields is essential for detecting vole activity and population increases. The number of runways, the amount of freshly cut vegetation and the amount of fresh droppings found in runways indicate the level of infestation. Any sign of activity calls for measures to prevent vine damage.

Cultural techniques

Vegetative cover provides both food and protection from predators. Any practice that results in a reduction in cover in the field and surrounding areas can be effective in preventing serious vole problems. These practices include controlling weeds, cultivating fence rows, roadsides and ditchbanks and reducing ground cover in adjacent orchards. These areas often provide a habitat from which the voles invade a vineyard.

Cover crop management should be designed to eliminate contact between the vines and the cover crop where voles have the potential for becoming a problem. In areas where voles have the potential for rapid population increase, mid-row, summer disking should be considered to prevent the buildup of cover that may provide harborage. In the event that vole numbers should increase substantially, clean culture cultivation and plowing should be considered, along with lethal control options, to eliminate them.

Mowing to reduce cover has demonstrated limited success with voles in orchards. Mowing both removes protective cover exposing voles to predation and more importantly, it allows detection of their presence. Cover crops should be mowed to a height that insures soil protection but minimizes protection afforded by the cover. During summer months, when the threat of severe soil erosion has passed, cover crops should be mowed or cultivated to remove *all* protective cover.

Herbicides may also be used to minimize cover for voles. Band treatments below vines and field buffers reduces habitat and also facilitates monitoring of their populations and damage.

Predators

Predators such as coyotes, foxes, badgers, weasels and owls prey on voles. However, due to the rapid rate at which voles reproduce and populations increase, predators are not effective in controlling this pest.

Exclusion

Young vines can be protected with cylindrical wire guards (which also protect against rabbits). They are made of 1/4- to 1/2-inch mesh hardware cloth, 24 inches wide and with a diameter sufficient for several years of uncrowded vine growth. To prevent voles from burrowing under them, guards must be buried about six inches below the soil surface. Trunk guards made of plastic, cardboard and other fibrous materials, although often less expensive and more convenient to use, do not usually afford much protection against voles.

Toxic Baits

Where vole problems are serious, applying bait is the only effective measure. Zinc phosphide is registered for use in vineyards and surrounding areas. Bait may be applied mechanically or by

hand. Anticoagulant baits may also be used but to be effective, bait must be available for voles to consume over a period of several days.

Hares (*Lepus* spp.) and Rabbits (*Sylvilagus* spp.)

Young vines are particularly susceptible to damage by rabbits and hares. The black-tailed jackrabbit, actually a hare, is the most common rabbit-like pest in California vineyards. The jackrabbit has very long ears, short front legs and long hind legs. The cottontail, a true rabbit, is a pest in local areas. Cottontails are smaller than jackrabbits and have much shorter ears.

Jackrabbits are active from early evening to early morning throughout the year. Jackrabbits breed from early spring to late summer, although breeding may continue where winters are mild. Females may produce more than one brood a year, especially on irrigated land providing a nutritious food source year round. The gestation period is about six weeks and average litter size is three or four. Larger litters are produced in the spring. An adult female may produce fourteen or more young per year. Their populations undergo distinct cycles, reaching peak levels every five to ten years.

Rabbits and hares are classified as game mammals and can be taken by legal sport hunting methods during hunting seasons. If they follow Fish and Game Code, owners and tenants of agricultural lands may take rabbits or hares that cause agricultural damage.

Damage

Most damage results from the animals feeding on the foliage and fruit of a grapevine. In some instances, hares and rabbits may also gnaw on the trunks of vines and girdle or even totally cut vines.

Management Guidelines

Rabbit populations should be controlled before a severe problem develops. An inspection of the vineyard in the early morning or late afternoon to look for rabbits or evidence of feeding will help alert the grower to a potential problem. Control of rabbits and their damage in vineyards can be achieved through exclusion, poisoning or shooting. Choice of the method used depends on the severity of the problem.

Cultural techniques

Rabbits often invade vineyards from adjacent fields. Consequently, manipulation of a cover crop has little effect on populations or damage. However, a reduction in cover around vines may make damage due to rabbits easier to detect and aid in determining the severity of the problem.

Predators

Predators of rabbits include hawks, owls, coyotes, bobcats, foxes and weasels. However, predators are seldom numerous enough to provide adequate control.

Exclusion

Fences, although expensive, are often the only effective means of minimizing damage due to rabbits. Rabbit fences should be made out of one inch woven wire mesh and be at least 36 inches

high and supported by posts. The bottom six inches of fence should be bent at a right angle away from the vineyard and buried six inches under the soil to prevent rabbits from digging underneath.

Vine guards
Vine guards can be made from metal, hardware cloth, plastic, paper, cardboard or other fibrous materials. Cylinders of wire mesh sometimes provide more protection from debarking. These can be made from one inch mesh poultry netting formed around the vine with ends joined and extending high enough so that rabbits cannot reach the vines. If 1/4-inch or 1/2-inch hardware cloth is used and the wire is set several inches in the soil, the vines are also protected in part from voles.

Toxic Baits
Anticoagulant baits (Diphacinone and Chlorophacinone) are registered for use in bait stations against rabbits and hares. As they will not enter enclosed stations, the bait should be presented in a feeder in areas frequented by rabbits such as runways, resting or feeding areas. Prebaiting with untreated bait may allow rabbits and hares to become accustomed to feeding from the station. Once they feed on the untreated bait (usually after 3 to 5 days) and begin to consume all untreated bait in a single night, this bait can be replaced with poison baits. Bait should be provided until all evidence of feeding has ceased. Bait stations are frequently covered during most daylight hours to exclude non-target animals from the bait.

Shooting
Under certain conditions, shooting can be an effective control method. Systematic patrolling in early morning and late afternoon may effectively reduce the population and suppress damage in a localized area.

Ground Squirrels (*Spermophilus beecheyi*)

The California ground squirrel is a serious pest of a wide array of field, row, orchard and vine crops. Their gnawing can cause damage to drip irrigation systems and burrowing can increase erosion problems and present hazards to farm machinery. In addition they carry several diseases, including plague, which are transmissible to humans.

An adult California ground squirrel weighs between one to two and one half pounds (0.5 to 1.1 kg) and has flecked and mottled fur. Unlike pocket gophers, ground squirrels are extremely social animals and are frequently visible, spending much of their time sunning, feeding or socializing in and around fields. They live in colonies and their underground burrows can form extensive interconnecting systems. Burrows provide protection as well as a place to sleep and rest, rear young and store food. Ground squirrel burrows are much larger in diameter than pocket gopher burrows, and their burrow entrances are always unplugged. Considered good runners and climbers, ground squirrels can often be seen foraging in trellises and trees. However, when frightened, they always retreat to their burrows for escape.

The California ground squirrel naturally inhabits grasslands and oak-savannah type habitats. They are, however, very adaptable and live in and around crop land and man-made facilities.

They tend to disappear from land which is under complete and frequent cultivation, but remain along fence lines, road rights-of-ways and in other suitable uncultivated areas. They may travel 100 yards or more to feed in adjacent crops.

Ground squirrels have a unique annual life cycle. Most hibernate in the winter. Males generally emerge from hibernation before the females and breeding commences shortly after emergence. Breeding is relatively synchronized, with most females conceiving within about a six week period. Gestation is between 28 to 32 days with the young born in a nest chamber within the burrow system. Litters average seven to eight young. Young are nursed for 6 to 7 weeks after which they begin to forage above ground. Only one litter is produced annually. Squirrels become reproductively active at about one year of age.

During the hottest and driest part of the summer, many adult squirrels go into a resting state (estivation) until temperatures become more favorable in the fall. Because of these periods of inactivity, ground squirrel numbers may often appear to be much greater in spring and early fall than at other times of the year.

Along with a unique life cycle, abrupt changes in the squirrels' diet occur. Following emergence from hibernation, they feed almost exclusively on the available green vegetation. This diet continues throughout the breeding, gestation and nursing periods. When annual grasses and forbs begin to produce seed and dry up, there is a dramatic dietary shift in most squirrels, from the vegetative portions of the plant to eating seeds and fruits as well as bark from vines and trees.

Damage

Ground squirrels gnaw vines, particularly young ones, removing bark and often girdling the trunk, as well as feeding on vines and fruit. Further damage can occur as a result of their gnawing on surface irrigation pipe.

Their burrowing can also be destructive. They create large mounds which often present hazards to farm machinery and make harvesting difficult. Their burrowing around vines can damage root systems and possibly kill the plant.

Management Guidelines

Squirrel populations should be monitored and controls applied in areas such as ditch or road banks, or other adjacent lands from which ground squirrels are likely to invade the vineyard. Monitoring can be accomplished by observing the number of squirrels in those areas during the morning hours when squirrels are most active.

Poison baits, burrow fumigants and trapping represent the three major control options available for ground squirrels. The success of these practices in controlling ground squirrels is largely dependent on timing as a result of the life cycle of the squirrel. Cultural methods including habitat modification and exclusion have limited value in control programs due to the squirrels' adaptability. Efforts to encourage predators have also not proven to be a viable solution.

Cultural methods

Ground squirrels can be somewhat limited by deep plowing or disking. However, they often compensate by living on the margins of fields beyond cultivated boundaries. Research has

demonstrated that deep plowing or disking of existing burrow systems is an effective way of inhibiting re-invasion of ground squirrels following control operations. Tillage of burrow systems has proven far more superior to limiting re-invasion than simply filling in the openings with dirt.

Removing piles of prunings and other debris from fields and their margins may reduce the suitability of the habitat for ground squirrel. This also makes detection of squirrels and their burrows easier, helps in monitoring the population and improves access to burrows during control operations.

Predators
Such predators as coyotes, foxes, badgers and other carnivores may feed upon ground squirrels but predation rarely, if ever, is a major factor in reducing their populations.

Toxic Baits
Poison baits are the most commonly used control tool. The acute rodenticide, zinc phosphide, and the anticoagulants diphacinone and chlorophacinone are currently registered for ground squirrel control in California. As the baits consist of treated grains, they are most effective in the late spring and fall when seeds are the preferred food of the ground squirrel. Control using zinc phosphide is achieved by scattering a tablespoon quantity of bait on bare ground to cover two to three square feet at the side each active burrow entrance. The effectiveness of this strategy is enhanced by pre-baiting with clean grain for several days before the bait is applied. This allows squirrels to become accustomed to feeding on the bait and reduces the risk of it only taking a sublethal dose of zinc phosphide in the baiting program and becoming "bait shy". Anticoagulants must be consumed over a period of several days for the squirrel to obtain a lethal dose. They are generally presented in bait stations which are designed to contain enough bait for the required multiple feedings and to reduce the risks to non-target wildlife.

Fumigation
Burrow fumigation can be extremely effective in controlling the California ground squirrel. It is most successful in the spring or after irrigating when soil moisture is high because moist soil closes up surface cracks and helps retain a high toxic level of gas in the burrow. Fumigation is not effective during periods in the summer and winter when the ground squirrels are inactive. At these times the squirrels plug their burrow systems behind them and aren't exposed to the gas. There are a number of fumigants currently registered for ground squirrel control. Gas cartridges (smoke bombs) and aluminum phosphide (Phostoxin and Fumitoxin) are easy and relatively safe fumigants to use. Cartridges are placed in burrows that show evidence of recent squirrel activity. After the cartridge fuse has been ignited, it's pushed deep into the burrow with a shovel or stick and the burrow entrance plugged quickly with soil to seal in the toxic gas. Aluminum phosphide tablets react with the atmospheric and soil moisture to produce phosphine gas. These tablets are also placed deep into the opening of each burrow and the entrance sealed.

Traps
Trapping ground squirrels sometimes provides satisfactory control of small numbers of squirrels. A number of kill traps (Conibear trap, Modified pocket gopher trap) are available for squirrels.

Other methods
Frightening devices (e.g., propane exploders, flagging etc) and chemical repellents are ineffective management tools. Shooting may be useful in some situations as where population levels are low or to control survivors of other control operations, but is seldom effective when dealing with large ground squirrel populations.

Deer

Deer can cause significant damage to vineyards in areas where nearby habitat, especially wooded or brushy areas provide cover. As deer are night feeders and may not be observed in fields, footprints, scat and damage are often the first evidence of their activities.

Deer usually seek shelter in wooded or brush areas but they may also live within the vineyard. Some are permanent residents of the areas, while others are migratory and spend winter and spring around the vineyard and summer and fall at higher elevations.

Damage
Deer may almost completely strip vines of foliage. Severe stunting of vines can result from repetitive deer browsing. Breakage or scarring of young vines may result from bucks rubbing their antlers on the trunks or branches.

Management Guidelines
Deer are classified as game mammals. They may be hunted during the regular sport hunting season following all appropriate regulations. This should be encouraged where deer are an ongoing problem. Outside of the hunting season, depredation permits to shoot deer may be issued by local game wardens. A variety of regulations must be followed to comply with permit requirements. All other methods of destroying deer, including the use of traps or poisons are illegal.

Exclusion
The best way to minimize damage by deer is to permanently exclude them from the vineyard. Generally, fences provide the best and most consistent level of protection, but it is important to remember to **close the gate!!!** Standard woven wire fences, and a variety of electric fence designs, though expensive, are a permanent solution to chronic deer problems.

Standard Fencing: A standard woven wire fence must be a minimum of 8 feet high if it is to exclude deer. In many cases the 8 foot minimum is achieved by using six feet of woven wire material with 2 or 3 strands of spaced barbed wire at the top. Since most gates are not this high, extensions need to be fabricated and added in order to achieve this height. Deer will continually check a fence for entrance points. The wire should be taught and close to the ground. Culverts, ditches, ravines, creeks, or any other low point must be fenced to follow the grade in order to inhibit deer from crawling underneath the wire.

Electric Fencing: Several configurations of electric fencing are available from fencing contractors, farm supply co-ops, and U.C. Cooperative Extension offices. Generally seven or nine-wire, high tensile electric fences are considered sufficient to exclude deer. Similarly with

standard fencing, electric fences must also include areas of low grade that would allow deer to crawl beneath the wire. In most cases, high tensile, electric fence designs are significantly less expensive to build that standard woven wire fences.

Frightening

Noisemaking devices and lights sometimes discourage deer, but results are erratic and long-term effectiveness is unlikely. One of the key components to a successful approach using frightening devices is to take action at the first sign of a problem. It is difficult to change the movements or behavioral patterns of deer once they have been established. Propane exploders, pyrotechnics, or tethered dogs will at times provide some temporary relief from deer. However, over time these methods will have reduced impacts on the animals. To maximize their effectiveness, frightening devices should be moved and rotated through the vineyard every few days.

Repellents

Because of the cost of commercial repellents, limitations on their use and applications and variability of their effectiveness they are not considered economically feasible for use in vineyards.