Managing Burrowing Pests in California Agriculture

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Introduction

Although many vertebrate pests cause problems in agriculture, perhaps the most frequent offenders in California are California ground squirrels (*Spermophilus beecheyi*), pocket gophers (*Thomomys* spp.) and meadow voles (also known as meadow mice; *Microtus* spp.). Ground squirrels are 9 to 11 inches in length (excluding tail), mottled grayish-brown in color, and have a semi bushy tail. They dig extensive burrows that may be 5 to 30 feet long, 2.5 to 4 feet below the surface, and about 4 to 6 inches wide. Pocket gophers are short, stout burrowing rodents, usually 6–8 inches in length. They spend most of their time below ground where they use their front legs and large incisors to create extensive burrow systems. Meadow voles are small, blunt nosed stocky rodents with small eyes and short ears and legs. They are typically dark grayish brown in color with size intermediate to that of a house mouse and a rat.

Ground squirrels reproduce only once per year, but average 8 young per litter. Pocket gophers will breed anywhere from 1 to 2 times per year, although in more southern irrigated alfalfa fields, they may reproduce up to 3 times per year. Female voles may produce from 5 to 10 litters per year. Therefore, continuous monitoring and control of all these burrowing rodent populations is needed to keep their numbers low. Ground squirrel young are born in early to mid spring. Gophers and voles can breed at different times throughout the year; however, there is typically a pulse in reproduction toward the middle of spring. As such, control measures implemented before reproductive pulses of all burrowing rodents will often be more effective as there will be fewer individuals to control at that time. Additionally, because voles mature rapidly and can bear many litters annually, vole populations can increase rapidly. Typically, their numbers peak every 6 to 8 years when population numbers can be as high as hundreds of voles per acre.

If left unchecked, burrowing rodents will cause extensive damage including consumption nuts, fruits, and other vegetative plant parts that result in direct loss of crop production; consumption of tap roots and girdling of stems, trunks, and vines that results in a loss in vigor of the plant; loss of irrigation water down burrow systems; and chewing on irrigation lines lines. Mounds and burrow openings can also result in additional problems including serving as weed seed beds, burying of plants, and causing damage to farm equipment.

A number of options are currently available for controlling burrowing rodents although most management programs center on toxic baits, fumigants, and trapping. Other control options are available as well, although their efficacy is less clear. I will briefly detail each of these approaches in the following sections.

Toxic baits

Ground squirrels.—Toxic baits are usually the most cost-effective way for controlling ground squirrels, especially large populations and over large areas. Bait consists of grain or pellets treated with a toxin registered for ground squirrel control. To be effective, the bait must be used

at a time of year when ground squirrels are active and feeding on seeds (usually late spring through early summer and again in autumn). Toxic baits registered for ground squirrel control include the acute toxin, zinc phosphide, and anticoagulant baits (diphacinone and chlorophacinone). Zinc phosphide can be applied through spot-treatments or broadcast applications. Spot treatments are used when a small number of burrow systems are treated. This approach involves lightly scattering bait around each active burrow opening. Alternatively, the bait may be broadcast over a larger area using a mechanical seed spreader. Bait shyness can occur with zinc phosphide baits when squirrels ingest a sublethal dose, thereby becoming sick and learning to avoid the bait during future applications. This can result in low efficacy of zinc phosphide baiting programs. Pre-baiting the area with untreated grain 2 to 3 days prior to the application of zinc phosphide may reduce the chances of bait shyness and improve the effectiveness of baiting programs. Control with zinc phosphide is usually achieved within 48 hours of the bait application.

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

Bait stations are commonly used to provide bait for squirrels. Various kinds of bait stations can be used, though all are designed to let squirrels in while excluding larger animals. Bait stations should be placed near runways or burrows and should be secured so that they are not easily tipped over. If squirrels are moving into fields from adjacent areas, bait stations should be placed along the perimeter where squirrels are invading, with one station placed approximately every 100 feet (30 m), although more stations may be used when the number of squirrels is high. Bait stations should be checked daily at first, then as often as needed to keep the bait replenished. A continuous bait supply is important because if bait feeding is interrupted, the bait's effectiveness is greatly reduced. Any bait that is spilled should be collected, and wet or moldy bait should be replaced. Successful baiting via bait stations usually requires 2 to 4 weeks. Therefore, bait should continue to be supplied until feeding ceases and no more squirrels are observed.

Spot treatments and broadcast applications of anticoagulants follow the general procedure described for zinc phosphide application. However, with anticoagulants, bait must be reapplied 3 to 5 days after the initial treatment to ensure that squirrels are exposed to a continual supply of bait. Usually, squirrels retreat back to burrows when sick and will die there, although up to 20 to 30% of ground squirrels may die aboveground. As such, be sure to dispose of any visible carcasses to prevent poisoning of any predators or scavengers. Burying within existent burrow systems is a good method as long as carcasses are buried deep enough to discourage scavengers. All rodenticides for aboveground field application are now restricted-use materials, so be sure you are fully versed on all current restrictions for their use before applying for ground squirrel control. Your County Agricultural Commissioner's office is your best source for this information.

Pocket gophers.—There are three baits for pocket gopher control: 1) strychnine, 2) zinc phosphide, and 3) anticoagulants (e.g., chlorophacinone and diphacinone). Both strychnine and zinc phosphide are considered acute toxicants. This means that they kill after a single feeding. Strychnine has typically been promoted as the most effective of the two. Strychnine comes in two concentrations in California: 0.5% and 1.8%. The 0.5% concentration is typically used for hand baiting, while the 1.8% concentration is used both for hand baiting and in a burrow builder. Zinc phosphide is also available for pocket gopher control; it comes in a 2.0% concentration. Bait acceptance can be an issue with zinc phosphide, as it has a distinctive odor and taste that gophers are often averse to. Anticoagulants such as chlorophacinone and diphacinone are multiple feeding toxicants. With these rodenticides, gophers must consume the bait multiple times over the course of 3 to 5 days to receive a toxic dose. This means larger amounts of bait are required to maintain a ready bait supply over this time period. Because of this, acute toxicants are typically preferred over anticoagulants for pocket gopher control. However, there are several new products on the market that contain these same toxicants but utilize a different delivery mechanism for providing the toxicant to the gopher. As such, some of the newer products may be more effective and should be tested.

There are two primary methods for baiting in fields: 1) hand baiting with an all-in-one probe and bait dispenser, and 2) a burrow builder. Hand baiting can be effective if you have relatively few gophers in a field. For this approach, an all-in-one probe and bait dispenser is used to locate a gopher burrow. Once the burrow is located, the bait is directly deposited into the tunnel. The opening left by the probe is then covered up with a dirt clod or rock to prevent light from entering the burrow. When using this method, be sure not to bury the bait with loose dirt as this will limit access to the bait. Typically, it is recommended that burrow systems be treated at least twice to maximize efficacy.

Although hand baiting can be effective for smaller gopher populations, the burrow builder can be a more practical method for treating larger areas. The burrow builder is a device that is pulled behind a tractor on a 3-point hitch and creates an artificial burrow at a set depth. Bait is then deposited at set intervals along the artificial burrow. While engaging in normal burrowing activity, gophers will come across these artificial burrows and consume the bait within. This device must be used when soil moisture is just right. If the soil is too dry, the artificial burrow will cave in, but if it is too wet, the burrow will not seal properly and will allow light to filter in; gophers will not travel down burrows if they are not sealed. Although convenient to treat large areas, the efficacy of this method has varied quite extensively from grower to grower. Experimentation is key to determining the applicability of this approach for each grower.

Voles.—Toxic baits are often the primary management option for controlling voles. Both zinc phosphide and anticoagulants can be used depending on the crop, and both are restricted-use materials for vole control. For voles, baits are applied directly to burrows and runways through spot treatments or broadcast applications. Spot treatments are used when only a few burrows are to be treated. Otherwise, broadcast applications are more efficient. If zinc phosphide is overused, problems with bait shyness can occur. As such, zinc phosphide can only be applied once or twice per year depending on the crop. This problem is not present with anticoagulant baits.

Fumigation

Burrow fumigants can be very effective at controlling ground squirrels and pocket gophers, but are not typically used for voles given the shallow nature of their burrow systems combined with their numerous burrow openings. Primary burrow fumigants are aluminum phosphide and gas cartridges. However, as of January 1, 2012, carbon monoxide producing machines can now be used to apply carbon monoxide to burrow systems. Given the fact that they just became legal in California, researchers are still in the process of collecting data on their efficacy.

Ground squirrels.—Late winter and early spring are the best times to fumigate for ground squirrels as moist soil is needed to hold toxic gases inside the burrow system. Conducting ground squirrel control prior to the birth of young will also dramatically decrease their detrimental effect on the population. However, you must wait to fumigate until after ground squirrels have emerged from hibernation; ground squirrels wall themselves off in their burrows when hibernating so fumigation is not effective at this time. Fumigation is also possible later in the year as long as sufficient soil moisture is present, although it is ineffective when ground squirrels are estivating during the hottest times of the year as ground squirrels again wall themselves off in their burrows. For safety reasons, do not use fumigants in burrows that may extend beneath buildings.

Two primary fumigants are used: gas cartridges and aluminum phosphide. Gas cartridges provide an easy and relatively safe way to fumigate ground squirrel burrows. Typically, one cartridge is used for each burrow that shows signs of activity, although larger burrow systems may require two or more cartridges. For application, the cartridges are ignited and shoved into the burrow fuse first using a shovel handle or stick. The burrow entrance is then sealed with soil to hold the toxic gases within. After sealing the burrow, the applicator should watch nearby burrow entrances; if smoke is observed escaping from other entrances, this means the burrows are connected. If the burrow is believed to be small, then this additional entrance only needs to be sealed. If the burrow appears to be large, an additional cartridge may need to be inserted following the above-outlined protocol.

Aluminum phosphide is a very effective fumigant, often outperforming gas cartridges. When aluminum phosphide tablets come into contact with moist soil in the burrow, they produce phosphine gas, which is highly toxic to any animal. When using aluminum phosphide, treat every active burrow, fill the entrance with a wad of newspaper, and cover with soil. Aluminum phosphide is a restricted-use material for which a permit is required for purchase or use. Application personnel should be trained in the material's proper use and on its potential hazards.

Pocket gophers.—Aluminum phosphide is the primary fumigant used for gopher control; it is quite effective and has a very low material cost. Aluminum phosphide is a restricted-use material; it can only be used by or under the direct supervision of a Certified Applicator. The primary method for applying aluminum phosphide is similar to that of hand baiting. You use a probe to find a gopher tunnel, and drop the label designated number of tablets into the probe hole. The opening is then sealed up with a rock or dirt clod to eliminate light from entering and the toxic gases from exiting the tunnel. Be careful not to bury the tablets with loose soil as this will render them ineffective. Typically, you treat each burrow system twice to maximize efficacy. The key with aluminum phosphide treatments is to only apply when soil moisture is

relatively high. Because of this, fumigation is typically most effective in late winter and early spring. However, fumigation after irrigation can also be a good strategy.

Trapping

Ground squirrels.—Because trapping is time-consuming, it is most practical for small infestations of ground squirrels. Several types of kill traps, including modified pocket gopher box traps, tube traps, and Conibear traps, are effective. Box-type and tube traps are typically placed on the ground near squirrel burrows or runways. Efficacy of these traps is usually increased by prebaiting, which is an activity where bait is supplied for a period of several days before activating the trigger mechanism. Once squirrels are actively taking the bait, the trap is rebaited and the trigger is activated. Walnuts, almonds, oats, barley, and melon rinds are effective trap baits. Another effective trap is the Conibear 110. These traps can be placed in burrow openings so that when squirrels pass through them, they trip the trigger and are captured. As with all traps, take precautions to minimize trapping of non-target wildlife and pets.

Live-traps, such as wire-cage and multiple-capture traps, can also be used to capture ground squirrels. As with box traps, walnuts, almonds, oats, barley, and many fruits and vegetables are all effective baits. Because these traps keep animals alive after capture, they are useful in areas where non-target captures are a concern (e.g., areas with pets, children, etc.). However, ground squirrels must be euthanized by the trapper upon capture as translocation of ground squirrels is illegal.

Pocket gophers.—Trapping is safe and one of the most effective although labor intensive methods for controlling pocket gophers. Nonetheless, the cost and time for application may be offset by effectiveness. Several types and brands of gopher traps are available. The most common type is a two-pronged, pincher trap such as the Macabee, Cinch, or Gophinator, which the gopher triggers when it pushes against a flat, vertical pan. Another popular type is the choker-style box trap, although these traps require extra excavation to place and may be a bit bulky to be practical in a large field setting.

Traps are placed into main tunnels or lateral tunnels. Main tunnels are found by probing near a fresh mound, usually on the side closest to the plug in the mound. The main tunnel is usually 6 to 12 inches below ground; the probe will drop quickly about 2 inches when you find it. Traps are then placed in as many tunnels as are present as you will not know which side the gopher currently is using. Traps should be staked down to ensure that no predators run off with your traps. If there is no evidence that a gopher has visited the trap within 24 hours, the trap may be moved to a new location.

Pincer-type traps can also be placed in lateral tunnels, which are tunnels that lead directly to the surface. To trap in laterals, the plug should be removed from a fresh mound, and a trap placed into the tunnel so that the entire trap is inside the tunnel. Gophers will come to the surface to investigate the lateral tunnel opening and will be caught. This approach is quicker and easier to implement than trapping in the main tunnel. However, trapping in lateral tunnels may be less effective at certain times of the year (e.g., summer) and for more experienced gophers.

Voles.—Trapping is not typically used to control vole populations. Voles can easily be captured with standard mouse snap-traps, but the amount of labor, time, and resources required to remove voles from fields is counter-productive.

Other control approaches

Biocontrol.—This approach relies on natural predation to control rodent populations. From a management perspective, this typically involves the use of owl boxes to encourage owl predation of gophers and voles, or raptor perches to encourage hawk predation of ground squirrels. Unfortunately, no scientific study has ever been able to show that raptors substantially reduce rodent populations in agricultural fields. Raptors do eat a large number of rodents per year, but do so over a wide enough area that they are not able to reduce rodent populations to low enough levels to constitute effective control.

Cultural practices.—Habitat modification is an example of a cultural practice. This approach involves altering rodent habitat to reduce its desirability for that site. This can be a good approach for reducing rodent populations in many situations. For ground squirrels, removal of brush or pruning piles will eliminate preferred burrow locations and can increase overall effectiveness of management programs. Gophers prefer nitrogen-fixing plants and plants with big fleshy taproots. Removing these plants can reduce the habitat potential of a given area for gophers. Likewise, cover removal can greatly reduce, and in some cases eliminate, vole populations given their extreme need for vegetative cover to avoid predation.

Cultivation is another example of an effective cultural practice. If you have a field that you are going to replant, deep ripping will eliminate many of the extant burrow systems and will kill some of the rodents in the process. Destroying the burrow systems helps slow down potential reinvasion into fields, and when combined with an aggressive burrowing rodent control program post-cultivation, can provide a "clean slate" for a newly planted field.

Flood irrigation.—Where still feasible, flood irrigation can help control burrowing rodent populations. When a field is flooded, the rodents must come to the surface or drown. When at the surface, they can be picked off by a number of predators; growers and their dogs can also actively seek out rodents at this time to further reduce populations of these damaging pests.

Gas explosive device.—This is an instrument that injects a mixture of propane and oxygen into the burrow system and then ignites this mixture thereby potentially killing the burrowing rodent through a concussive force. This approach has the added benefit of destroying the burrow systems which should slow down reinvasion rates by burrowing rodents. However, initial studies have not shown it to be overly effective for ground squirrels or gophers. Additionally, there are potential hazards associated with this device including damage to buried pipes and cables, injury to the user, and the potential to catch things on fire. Additionally, these devices are quite loud; as such, they are not practical for use in or around residential areas.

Repellents.—No scientific data has been reported to show that current chemical repellents effectively keep rodents from inhabiting fields although a new repellent designed for use in irrigation tubing has yet to be thoroughly tested. I hope to test it in the near future. Frightening rodents with sound or vibrations also does not appear to be effective.