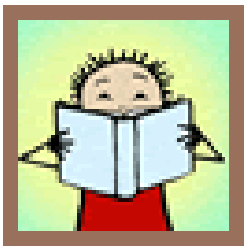
BIOLOGY, LEGAL STATUS, CONTROL MATERIALS, AND DIRECTIONS FOR USE

Pocket gophers

Family: Geomyidae

Fig. 1. Botta's pocket gopher (*Thomomys bottae*)

Fig. 2. Pocket gopher mound



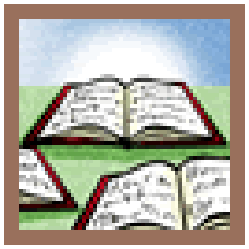
Introduction: Pocket gophers are burrowing rodents that get their name from the fur-lined external cheek pouches, or pockets, that they use for carrying food and nesting materials. They are well equipped for a digging, tunneling lifestyle with powerfully built forequarters, large-clawed front paws, fine short fur that doesn't cake in wet soils, small eyes and small external ears, and highly sensitive facial whiskers to assist movements in the dark. In California, the Botta's pocket gopher (*Thomomys bottae*) is the most common species (Fig. 1). Pocket gophers live alone in an extensive underground burrow system that can cover an area of several hundred to several thousand square feet.

Identification: Pocket gophers range in length from 6 to 12 inches. They are stout bodied, short legged rodents. Their eyes and ears are quite small, and their front claws are curved. The pocket gopher's lips close behind its four large incisor teeth, keeping dirt out of its mouth when it uses its teeth for digging.

Pocket gophers rarely travel above ground except for when the young are dispersing to new sites, although they are sometimes seen while feeding and pushing dirt out of their burrow system. Because they spend little time above ground, their mounds of freshly excavated soil are used to detect their presence. Pocket gopher mounds are usually crescent or horseshoe shaped with a plug located toward the lower portion of one side of the mound (Fig. 2); they are located at the ends of short lateral tunnels branching from the main burrow system. One pocket gopher may push up several mounds in one day. They are active by day and night throughout the entire year. Note that a lack of fresh mounding is not an indication that pocket gophers are not present and active, since gophers at times fail to produce mounds and in turn backfill old tunnels with excavated soil from other tunnel branches. This is particularly prevalent during summer when hot, dry conditions make mound creation more difficult.

Pocket gopher and mole (Talpidae) mounds are often confused. Mole mounds are volcano or conical shape in appearance (Fig. 3). It is very important that one can discern the difference between pocket gopher and mole mounds as implementation of management options can differ substantially between the two species. See the mole chapter for details on managing these species.

Fig. 3. Mole mound



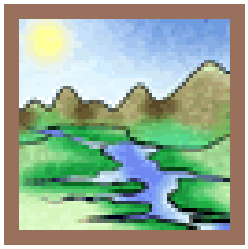
Legal Status: Pocket gophers are classified as nongame mammals by the California Fish and Game Code. Nongame mammals which are found to be injuring growing crops or other property may be taken at any time or in any manner by the owner or tenant of the premises. They may also be taken by officers or employees of the California Department of Food and Agriculture or by federal or county officers or employees when acting in their official capacities pursuant to the provisions of the Food and Agricultural Code pertaining to pests.

Damage: Pocket gophers can be serious pests. They are active throughout the year and if uncontrolled and food is plentiful, can increase to 30 to 40 individuals per acre; in alfalfa they can reach even greater densities. Pocket gopher damage tends to be greatest in alfalfa. They will consume all parts of the plant, but damage is often centered on the roots and crown of the plant. This damage can cause serious stand decline leading to a shorter harvest life for many fields statewide. Pocket gopher mounds can also cause extensive damage to hay equipment, and dirt from the mounds can lower hay quality. Tunnel systems often lead to a loss or diversion of irrigation water and may lead to severe erosion.

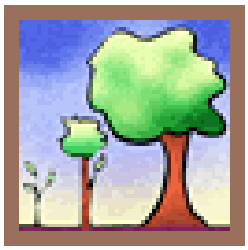
While herbaceous cover crops are their preferred food, pocket gophers also feed on the bark of tree crowns and roots, particularly when cover crops or weeds dry up. Bark consumption may be extensive enough to completely girdle and kill young vines or trees or reduce the vigor of older vines or trees. Usually pocket gophers feed on trees, shrubs, and vines from underground so the damage may not be evident until they show signs of stress. Pocket gophers also feed on the roots of vegetable and berry plants. Plants with more fibrous root systems often suffer minimal damage; plants with large tap roots are most susceptible. Pocket gophers sometimes gnaw on plastic irrigation lines. These holes lead to uneven water distribution, with some areas receiving too much water, and other parts not receiving any. Fixing pocket gopher punctures of subsurface drip tape can be time-consuming and quite expensive. It bears emphasizing that if using subsurface drip irrigation, a zero-tolerance policy should be implemented for pocket gophers given the extreme damage they can cause to these systems.

Range: The five species of pocket gopher found in California occupy all areas except parts of dry deserts, very rocky areas, and the highest mountain meadows. Botta's pocket gopher has the widest range within California covering most agriculturally important areas west of the Sierra crest. Mountain pocket gophers occur at elevations above 5,000 feet in parts of the Sierra Nevada Mountains from Fresno County north. They are also found in parts of Modoc and Siskiyou Counties. Northern pocket gophers occur in various localities east of the Sierra Nevada Mountains from Mono County north. They also occupy large portions of Lassen and Modoc Counties, as well as portions of northeastern Siskiyou County. Townsend's pocket gophers have the most limited range of any pocket gopher species in California, occurring only in a few valleys of the northern Great Basin. Western pocket gophers (also referred to as Mazama pocket gophers) occur throughout a large swath of the Klamath and western Cascade Ranges.

Botta's Pocket Gopher
Mountain Pocket Gopher
Northern Pocket Gopher
Townsend's Pocket Gopher
Western Pocket Gopher



Habitat: Many agricultural and residential properties are ideal habitats for pocket gophers given the abundance off vegetation associated with regular irrigation and relatively deep, friable soils. In natural areas, valleys and mountain meadows are the most typical pocket gopher habitats. More specifically, Botta's pocket gophers are found in most meadow or valley habitats as well as open forests. Mountain pocket gophers use a variety of habitats including mountain meadows, grasslands, open forests and brushlands, as well as alpine dwarf-shrub areas. The northern pocket gopher inhabits grassy prairies, brushy areas, and open pine forests. Townsend's pocket gophers are relegated to wet meadow and desert scrub habitats in California, while western pocket gophers prefer open, grassy areas.



Biology: At altitudes of 5,000 feet or higher, breeding mainly occurs in June and July. In irrigated lands, pocket gophers breed throughout the year. In most irrigated areas, females have one or two litters per year, but in irrigated areas in southern California, females may bear three litters in a year. An average of five to six young are born per litter, but litter sizes can vary from one to thirteen. The frequency of pregnancies increases with age and size of females. The gestation period for Botta's pocket gopher is about 19 days and the young remain in the nest for several weeks. After weaning, the young are expelled by the mother to wander overland to start tunnels in new places. They are particularly vulnerable to predation at this time. Hawks, owls, gopher snakes, badgers, foxes, weasels, and coyotes prey on pocket gophers. Pocket gophers rarely live beyond three years.

Pocket gophers remain active year-round. Surface activity decreases on hot, dry lowlands during summer and during and after heavy rains. Gnawing or girdling of young orchard trees is most likely to occur during late summer when the ground is dry and green vegetation is scarce. They continue their burrowing at ground level when snow covers the ground, retreating underground as the snow melts. Pocket gopher burrow systems are sometimes used by other animals including salamanders, toads, snakes, mice, weasels, and some arthropods.

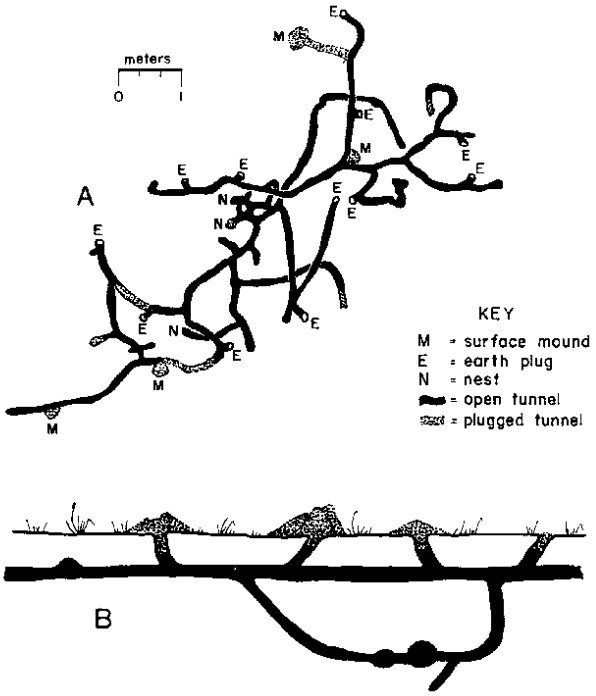
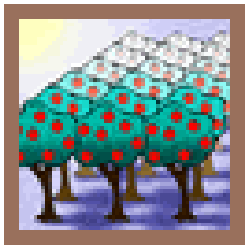


Fig. 4. Overhead (A) and cross-sectional (B) view of pocket gopher tunnel system.

Food for pocket gophers consists mainly of the underground parts of plants, especially the succulent portions. Forbs, however, are often cut back above ground, around the mouth of a burrow, or pulled down through the surface soil into the burrow system. Stems are cut in short lengths and transported in the cheek pouches to storage chambers in the burrow system. Bark from young trees is also an important food source, particularly when succulent foods are scarce.

Pocket gophers lead an almost completely subterranean existence, venturing above ground only to push dirt out of the burrow, seek new territory after weaning, or to graze on succulent plants near a burrow entrance. Except during the breeding

season, pocket gophers are anti-social; intruding individuals are aggressively repelled. Burrow entrances are plugged to prevent entry by predators and to stabilize temperature and moisture within the burrow system. Each pocket gopher establishes its own territory covering from a few hundred square feet for a young pocket gopher to several thousand square feet for old, established individuals (Fig. 4). Burrows are dug mainly with long claws, although the incisor teeth are used to cut roots or dislodge small stones. The burrow system consists of main tunnels 2 to 2.5 inches in diameter, running more or less parallel with the soil surface. However, size of tunnels will vary depending on the size of the individual and the longevity of the tunnel (i.e., deeper, more permanent tunnels are often larger in diameter than shallower, short-term feeding tunnels). Pocket gophers push accumulated soil from their excavations out lateral exits, forming characteristic crescent-shaped mounds of soil which are soon plugged with fresh soil. Nearly vertical feeding laterals are also dug, but these are shallowly plugged. The nest consists of a hollow ball of finely shredded plant fibers commonly filling a chamber about eight inches in diameter. The nest is often, but not always, deeper in the ground than most of the tunnels (Fig. 4). Food is stored near the nest or in enlarged chambers.



Damage Prevention and Control Methods

Because of the nature of pocket gopher damage, a successful management program depends on early detection and prompt action. Pocket gopher management can be particularly effective in late fall through late winter when mounding activity is high. Additionally, because numbers are usually lowest during winter, management during this time of year can be more practical than after pocket gopher reproduction occurs (there is usually a pulse in reproduction during late winter through early spring). Furthermore, growers often have the most time to commit to pocket gopher management during winter, so strong consideration should be given to managing pocket gophers during this time-period.

The following section details a number of different management tools that might be used to manage pocket gophers. These discussions are focused on individual techniques. However, it is important to remember that the most effective long-term strategy for managing pocket gophers will employ multiple techniques. This approach, termed Integrated Pest Management or IPM, minimizes the likelihood that a local population will adapt to a particular strategy, thereby maximizing efficacy. IPM also reduces the time commitment necessary to manage pocket gophers, and it lowers the risk to the environment by minimizing pesticide applications. For this reason, IPM strategies are the preferred and predominate approach to managing pocket gophers.

It is also important to point out that if removal techniques are used to reduce damage in an area, multiple removal sessions will likely be needed. Pocket gophers do not constantly create new mounds; sometimes there can be a one to two week interval between the creation of new mounds. Because effective management relies on the identification of new mounds, a single treatment session may miss a certain subset of the population (previously estimated to be up to 25% of the individuals in a population), but subsequent treatment sessions separated by one to two weeks have resulted in removal of ≥93% of the pocket gophers in treatment fields. As such, multiple treatment sessions should be planned for pocket gophers. Once pocket gopher damage has been controlled, a system should be established to monitor the area for reinfestation. A monitoring program is important to limit the impact of reinvading pocket gophers from adjacent areas. Because of the likelihood of reinvasion, strong consideration should be given to managing pocket gophers in those adjacent areas to reduce this threat. It is generally far easier, less expensive, and less time consuming to control pocket gophers before their numbers build up.

Exclusion: Because of expense and limited practicality, exclusion is only effective in limited areas. Small areas such as bulb beds, and occasionally entire lawns, may be protected from pocket gophers by complete underground screening with wire mesh if wire mesh is placed deep enough so that root growth is not restricted. Raised beds also offer excellent protection when the bottom of the bed is lined with wire mesh. For such screening, ½ to ¾ inch wire mesh works best. Galvanized or stainless steel mesh is often a better option than conventional wire given that it will not rust through for a much longer period of time.

Plants and bulbs can also be protected by using wire mesh baskets. Larger wire baskets can be made to accommodate fruit trees, but the basket might interfere with root growth. One way to install the basket is to line the planting hole with wire mesh. A common recommendation is a hole as deep as the root ball and twice its diameter. For bare root planting, the hole should be large enough so the roots can be planted without restriction. For the best protection, at least 6 inches of the wire basket should project above ground level; pocket gophers can move across ground and gain access to excluded areas without the aboveground portion of the barrier.

Exclusionary fencing buried around the perimeter of fields has also been suggested as an effective tool for slowing pocket gopher movement into fields. However, both historical and recent testing has shown this benefit to be minimal and likely not worth the logistical difficulties in implementing, nor the cost associated with such fencing.

Habitat modification: The following methods utilize knowledge of pocket gopher habitat requirements and feeding behavior to reduce or eliminate damage.

Crop varieties: The use of certain crop varieties can sometimes reduce the incidence of pocket gopher damage. For example, because pocket gophers feed on taproots of plants, growing alfalfa varieties with multiple taproots can reduce damage.

Crop rotation and buffers: Depending on the crop system involved, rotation with grain crops can be a good strategy for removing pocket gophers from an area; their underground structures do not supply enough food for pocket gophers year round. Furthermore, planting a 50-foot buffer of grain around hay fields provides unsuitable habitat for pocket gophers and can minimize immigration into the field.

Weed control and cover crops: Chemical or mechanical control of forbs can limit pocket gopher populations in rangeland situations. Nitrogen-fixing plants and plants with large, fleshy taproots are preferred food sources, so removing these pocket gopher food sources from cover crops can lower carrying capacity for a given area. Complete removal of a cover crop would provide even greater relief. However, it should be noted that removing these food sources in an orchard or vineyard with an existent pocket gopher population could increase crop damage short-term given the removal of alternative food sources. In such situations, fields should be depopulated before removing preferred food sources.

Deep tillage: When fields are taken out of production, deep tillage before replanting can destroy old burrow systems, potentially slowing reinvasion. A tillage depth of at least 12 inches is generally required, although prevailing depth of burrow systems will dictate the required depth.

Frightening: The use of sounds, vibrations, electromagnetic devices, or other means has not proven effective in driving pocket gophers from an area or preventing their damage.

Fumigants: Some fumigants, such as gas cartridges, have not typically proven effective for a variety of reasons including the extensive length and horizontal complexity of the burrow system, the chance for leakage of gas through porous soils, the closeness of the main tunnels to the surface of the ground, and the fact that pocket gophers may quickly plug off their burrows when a poisonous gas is detected. Various gas cartridges or smoke bombs are sold for pocket gopher control., but in general they are not very effective.

Aluminum phosphide tablets, however, have proven extremely effective, with an 81 to 100% success rate if soil conditions are proper for a good gas seal. Aluminum phosphide is a Restricted Use Material, and a permit is required for purchase and use; it can only be used by or under the direct supervision of a Certified Applicator. Sites must also be posted for 48-hours following application. That said, it is quite effective and has a low material cost if used over small areas. The primary method for applying aluminum phosphide is similar to that of hand baiting. You use a probe to find a pocket gopher tunnel, then wiggle the probe to enlarge the opening (if the probe hole is not already large enough to allow passage of the aluminum phosphide tablets into the tunnel), and drop the label-specified number of tablets or pellets into the tunnel. You then seal up the opening with a rock or dirt clod to eliminate light from entering and the toxic gases from exiting the tunnel. Care must be taken not to bury the tablets with loose soil as this will render them ineffective. Typically, each burrow system is treated twice to maximize efficacy. The key with aluminum phosphide treatments is to only apply when soil moisture is relatively high. If you can ball up a clump of soil at the burrow depth and it maintains that ball in your hand, then soil moisture is high enough to fumigate; if the clump falls apart in your hand, it is too dry. Because of this, fumigation is typically most effective in late winter and early spring. However, fumigation after irrigation can also be a good strategy.

In addition to aluminum phosphide, carbon monoxide generating machines can now be used to manage pocket gophers in California. As their name implies, these devices generate carbon monoxide and inject it into the burrow systems which then asphyxiates the inhabitants. Examples of these machines include the Pressurized Exhaust Rodent Controller (PERC; H & M Gopher Control, Tulelake, CA), the Cheetah rodent control machine (Cheetah Industries, Paso Robles, CA), and the Gopher X (El Cajon, CA). Initial trials with the PERC machine indicated that this approach is moderately effective (56–68%), although efficacy was less than typically observed with trapping, aluminum phosphide, and strychnine. Additionally, equipment can be expensive to purchase. However, if using the PERC machine, many more burrow systems can be treated during a day of application, so these machines likely have utility moving forward, particularly for growers and pest control professionals who have large acreage to treat or limitations on where they can apply aluminum phosphide or bait applications.

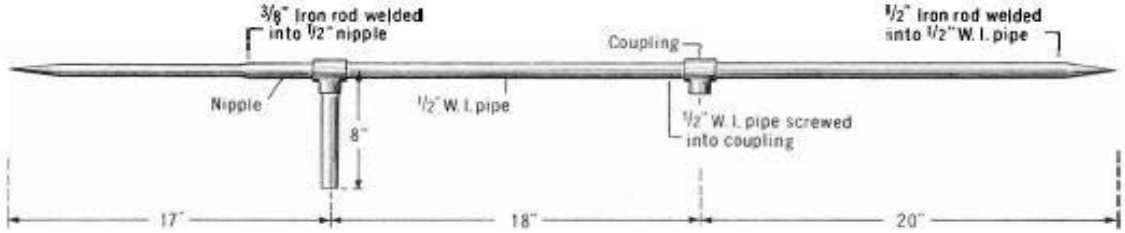
Gas explosive device: The use of a gas explosive device that combines propane with oxygen has been developed to kill pocket gophers through a concussive force. This device has the added benefit of destroying part or all of the pocket gopher's tunnel system, potentially slowing reinvasion rates. However, studies on the efficacy of this device have not been positive (~30% removal rate). Alternative options such as burrow fumigation, trapping, and baiting appear to be more effective. If you decide to use these devices, be sure to exercise caution given the potential for unintended damage to property, injury to users and bystanders, potential for starting fires in dry environments, and destruction of turf. These devices are also quite loud, making them unsuitable in residential areas.

Repellents: Repellents are not effective in protecting areas from pocket gopher damage.

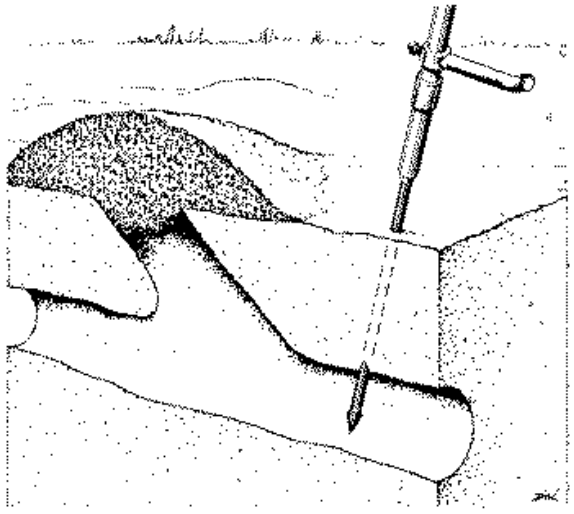
Toxic bait: There are three primary toxic baits for pocket gopher control: 1) strychnine, 2) zinc phosphide, and 3) first-generation anticoagulants (e.g., chlorophacinone and diphacinone). Both strychnine and zinc phosphide are acute toxicants, meaning they kill after a single feeding. Strychnine has typically been promoted as the more effective of the two. Until 2012, strychnine came in two

concentrations in California: 0.5% and 1.8%. However, the 1.8% strychnine is no longer available, and the 0.5% product can be difficult to find due to supply shortages. Zinc phosphide is also available for pocket gopher control; it often comes in a 2.0% concentration. Bait acceptance can be an issue with zinc phosphide, as it has a distinctive odor and taste that pocket gophers are often averse to. Anticoagulants are multiple feeding toxicants. With these rodenticides, pocket 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 supply over this time period. Because of this, acute toxicants have often been preferred over anticoagulants for pocket gopher control. Extensive laboratory trials have shown that strychnine products are far more efficacious than other rodenticides currently registered for pocket gophers. Subsequent field trials with 0.5% strychnine indicated 100% removal of pocket gopher populations across three vineyards, so strychnine does still appear to be highly efficacious. However, pocket gophers do develop a behavioral or physiological resistance to strychnine if repeatedly used over time. Therefore, strychnine baiting should be used only as one part of an IPM program.

All pocket gopher bait is applied below ground. There are three primary methods for baiting: 1) hand baiting via the funnel and spoon method, 2) an all-in-one probe and bait dispenser, and 3) a mechanical burrow builder. Hand baiting can be effective if you have relatively few pocket gophers in an area (e.g., backyard). For this approach, a probe is used to locate main tunnels so bait can be placed underground where pocket gophers will find it. A variety of tools can be used as a probe including long screwdrivers, long pieces of rebar, and commercially available probes. If extensive probing is required, some growers and pest control professionals will manufacture their own probes using the following specifications:



A tunnel usually runs in a straight line between two mounds at a depth of 6 to 8 inches. Probing activities should be focused around fresh mounds; tunnels may no longer be active around old mounds. When a tunnel is located, the probe will give way and drop about 2 inches. The opening to the runway often must be enlarged by rotating the probe or by using the larger end of the probe. Bait (amount will vary depending on the product used) is then deposited into the tunnel through the use of a measuring device and a funnel. The application approach is the same when using an all-in-one probe and bait dispenser except that this device allows the user to deposit a preset amount of bait directly into the tunnel, thereby saving the user substantial time during application. As such, all-in-one probe and bait dispensers are generally used when larger areas must be treated.



Once bait has been applied, the opening left by the probe should be covered up with a dirt clod or rock to prevent light from entering the burrow. When using this method, care must be taken 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. Recent research has shown that the experience of the individual who applies the bait is very important; those applicators who have been properly trained on how to use the equipment, and who can detect the difference between extant versus back-filled tunnels, are more than twice as efficacious as those individuals who have not received proper training.

Although hand baiting and the use of an all-in-one probe and bait dispenser can be effective for certain areas, a mechanical burrow builder may be more practical for treating very large areas. The burrow builder is a device that is pulled behind a tractor on a 3-point hitch. This device creates an artificial burrow at a set depth; bait is deposited at set intervals along the artificial burrow. While engaging in normal burrowing activity, pocket gophers 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; pocket gophers will not travel down burrows if they are not sealed. The depth of the burrow builder must also be adjusted for each field (and occasionally within the same field) to ensure that the artificial burrows are created at the depth where most tunnels occur within that field. The artificial burrows must also be checked regularly to ensure that bait is applied; the applicator often plugs, and if no bait is deposited, the process will obviously not work. Although convenient to treat large areas, the efficacy of this method has varied extensively from grower to grower. Experimentation is key to determining the applicability of this approach for each grower.

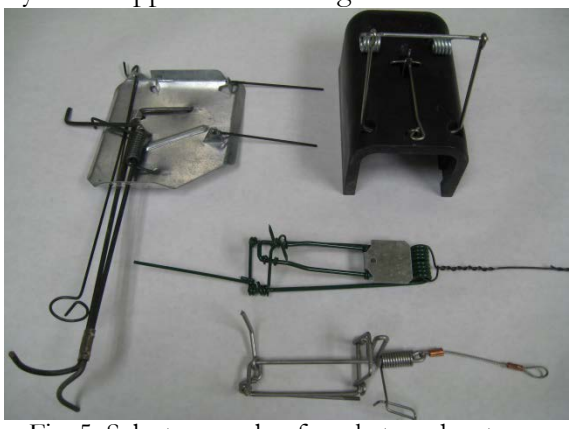


Fig. 5. Select example of pocket gopher traps.

Trapping: Trapping is safe and one of the most effective (>90% removal rate after two trapping sessions) although labor intensive methods for controlling pocket gophers. Nonetheless, the cost and time for application is often offset by effectiveness. In fact, a recent study in the Klamath Basin showed trapping to be more cost-effective than burrow fumigation. Several types and brands of pocket gopher traps are available. The most common type is a two-pronged, pincher trap such as the Macabee, Cinch, or Gophinator (Fig. 5), which the pocket gopher triggers when it pushes against a flat, vertical pan. Another popular type is the choker-style box trap (Fig. 5), although these traps require extra excavation to place and may be a bit bulky to be practical in a large field setting. Of trap types tested, the Gophinator trap (Trapline Products, Menlo Park, CA) appears to be one of the most effective. In particular, it has proven more effective than the Macabee trap (The Macabee Gopher Trap Co., Los Gatos, CA), which is likely the most commonly used pocket gopher trap in the western U.S. The increased effectiveness of the Gophinator is due to its ability to capture larger individuals at a greater rate. If an individual has old stock piles of Macabee traps, their effectiveness can be increased by placing a cable restraint (0.06 inch in diameter, 9 inch in length) to the front of the Macabee trap to help keep

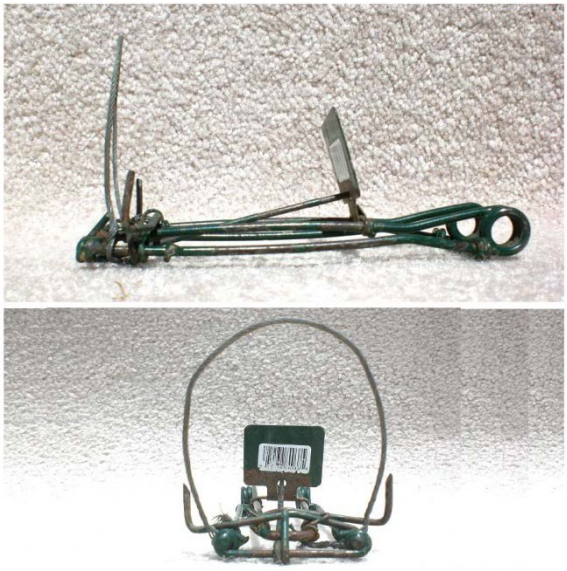


Fig. 6. Modified Macabee trap.

larger individuals from escaping (Fig. 6). However, the Gophinator trap is still more effective.

For trap placement, the first step is to probe near a fresh mound to find the main tunnel, which often is on the side closest to the plug of the mound. The main tunnel usually is 6 to 8 inches deep; the probe will drop quickly about 2 inches when the tunnel is encountered. Traps will then need to be placed in as many tunnels as are present as you will not know which side the pocket gopher currently is using. After placing the traps, you can cover the hole to keep light out of the tunnel. However, covering trap sets only marginally increases capture efficiency when temperatures are high (perhaps >85°, although the exact impact of temperature is not known) and provides no increase in capture success at other times. Therefore, if setting a large number of traps, a substantial amount of time in setting and checking traps can be saved if the trap-holes are left uncovered. Various attractants have been tested to see if they will increase capture success. They do not appear to increase capture success, although if using covered trap sets, there could be a slight increase in capture success when using an attractant such as peanut butter. Human scent also does not influence capture success, so there appears to be little reason to worry about handling traps with bare hands. Trap sets are typically operated for 24 hours. If no activity is present in that timeframe, they should be moved to a new location to maximize capture probabilities.

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 is removed from a fresh mound and a trap placed into the lateral tunnel so that the entire trap is inside the tunnel. Pocket gophers will come to the surface to investigate the 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 pocket gophers (e.g., adult males).

Flood irrigation: When irrigated croplands and orchards are periodically flooded, some pocket gophers are either drowned or forced out by the incoming water. Some survive in burrows in the levees or berms, while others are driven into the open where they are susceptible to predation.

Predators: Pocket gophers are prey for a number of predators including hawks, owls, herons, snakes, badgers, bobcats, weasels, and coyotes. Relatively little data exists to indicate that predators can maintain or reduce pocket gopher populations to levels acceptable to many growers and land managers. However, this is dependent on what population levels are acceptable. Research continues in this area, particularly with respect to the ability of barn owls to manage pocket gopher populations.

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