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AN INTRODUCTORY OVERVIEW TO CALIFORNIA GROUND SQUIRREL CONTROL

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ABSTRACT: Techniques for controlling California ground squirrels (Spermophilus beecheyi) include trapping, shooting, acute toxicants, anticoagulants, and fumigants. These techniques are described and compared and the available information on their efficacy and economics is discussed. This kind of analysis is essential if growers are to make logical decisions regarding the various control options.

INTRODUCTION

There are a variety of methods which can be used for reducing California ground squirrel (Spermophilus beecheyi) populations. Trapping, shooting, poisoning with anticoagulants and acute (single-dose) toxicants, or fumigants all remove some ground squirrels (Dana 1962, Clark 1975). However, the primary objective of ground squirrel control programs is to reduce the squirrel population below some economic threshold level, and to maintain it at or below that level. Simply removing some squirrels may or may not actually reduce the population over time. More ground squirrels are born each year than will survive, and removal of these surplus squirrels which would die anyway has very little effect on the population as a whole (Fitch 1948, Storer 1949, Dana 1962). An effective ground squirrel control program must reduce the overall population to some tolerable level, and then keep it there.

Every control situation requires decisions to be made about which control techniques are likely to be most effective. Such decisions should consider local conditions (such as soil moisture and rainfall), potential hazards, labor availability, past experience with squirrel control, and economic considerations. Economic considerations include both labor and material costs and projected economic losses, with and without control (Salmon and Lickliter 1983).

This overview will discuss alternatives for reducing California ground squirrel populations when they are judged to be a pest. An outline of available control methods, along with a discussion of how to choose a particular method, should prove useful in the decision-making process.

METHODS FOR CONTROLLING CALIFORNIA GROUND SQUIRRELS

Many control methods have been used for solving ground squirrel problems (Jacobsen 1918). Several techniques are currently in use for controlling California ground squirrels. Each has advantages and disadvantages and these must be considered when developing a control program.

Shooting--Shooting is not generally considered effective for removing large numbers of squirrels (Storer 1949). Where legal and safe, it can be effective for removing limited numbers of squirrels, such as a few invading individuals in an orchard, squirrels exposed when flood-irrigating a field, or as a clean-up technique supplementing other control efforts. It is considered a labor-intensive control technique. A .22-caliber rifle equipped with a 4x scope is an effective gun. Shooting a few squirrels often results in the remaining squirrels becoming extremely wary and difficult to shoot (Dixon 1925).

Trapping—Trapping is labor-intensive and practical only for removing ground squirrels from localized areas or when other techniques are either ineffective or undesirable. It can also be used as a clean-up method for eliminating the few remaining individuals which escape control from poison baits or fumigants.

Ground squirrels are generally not difficult to trap unless they are feeding on highly preferred foods, such as young forbs, vegetables, or nut crops. Unless you can bait your trap with a food more desirable to the squirrels than the food they are already eating, trapping success will be poor. Common baits include walnuts, almonds, oats, barley, melon rinds, raisins, prunes, and slices of oranges.

Both live-catch traps (Tomahawk Nos. 102, 103, 104; Havahart Nos. 1,2) and kill-traps (Conibear No. 110; small, leg-hold traps Nos. 0,1,1-1/2; modified wooden California-44 gopher trap) will capture ground squirrels. Publications by Clark (1975) and Salmon (1981) describe these traps and their correct placement in more detail.

Live-catch traps are not generally recommended although they do have the advantage that nontarget animals can be released if accidently caught. Baited traps can be placed on the ground near a burrow or runway, then periodically inspected. The capture efficiency of live-catch traps is generally increased if the trap is temporarily wired in the "open" position and baited. After squirrels have visited a trap and become accustomed to it (when the bait is taken), the trap can be reset.

A major disadvantage of live-catch traps is dealing with the live squirrel. Because ground squirrels are serious agricultural pests and are potential carriers of plague and other diseases, it is illegal in California to release trapped squirrels at another location. It is best to dispatch the

animal humanely. Methods include asphyxiating the squirrel with either car exhaust or carbon dioxide from dry ice or a CO_2 cylinder, or by immersing both the trap and squirrel in enough water to cover the trap completely so tne animal can drown quickly.

Kill-traps eliminate the need for handling live animals, but they have the disadvantage of taking nontarget animals. Care must be taken when placing these traps to minimize the capture of nontarget animals, yet. maximize the chances of capturing ground squirrels. Some kill-traps such as the Conibear can be placed in the entrance of active squirrel burrows. These traps must be secured to the ground to deter predators and scavengers from carrying off the traps with dead squirrels and to keep ground squirrels from withdrawing into their burrows after capture. Bait placed on the far side of Conibear traps placed in burrows sometimes increases trap success. Since several burrow openings may service the same system, closing burrow openings and rechecking at a later time can give an indication of which burrows are most active. By first identifying active burrows, labor costs and number of traps needed may be reduced.

Since squirrels sometimes carry diseases that are transmittable to humans, dead squirrels should be handled with gloves, and carcasses should be burned, buried, or placed in a plastic bag and disposed of properly.

Acute toxicants--Acute toxicants require only one feeding to be lethal. They are often the preferred control method whenever a population of ground squirrels needs to be reduced quickly with a minimum of labor and expense. In California, acute toxicants registered for ground squirrel control include zinc phosphide, strychnine, and Compound 1080 (sodium fluoroacetate) (Salmon and Gorenzel 1981). Most formulations of these rodenticides require a permit issued by the County Agricultural Commissioner for purchase and use. Compound 1080 can only be used under the direct supervision of a representative of the Agricultural Commissioner's office. In all cases, accompanying labels must be read and followed carefully.

Acute toxicants work best when acceptance of seeds and grains by ground squirrels is highest and when the aboveground squirrel activity is at a maximum. These periods are limited to late spring when young have been born and are aboveground (March-June) and fall, when summer estivation is over and activity is again high (September-October). Specific periods of peak activity vary by county, with activity in southern counties peaking earlier and activity in northern counties reaching a maximum later (Fitch 1948, Tomich 1962, Stroud 1982). Since the first squirrels to emerge from hibernation in the spring are males, shooting a sample of ground squirrels at that time will allow you to judge the emergence of females. When the sex ratio approaches 1:1, activity is close to its peak. Inspection of developing embryos will also allow you to judge when the females will return to their burrows to give birth (Dana 1962).

Acute rodenticides are useful for achieving rapid reduction of a high squirrel population. When an acute toxicant is used repeatedly in the same locality, however, a bait- and/or poison-shy population of ground squirrels may develop. This can make future control operations more difficult and increase costs. It is best to change the bait and poison periodically and not use the same acute toxicant more than twice a year, preferably only once (Dana 1962).

Zinc phosphide, Compound 1080, and strychnine-treated grains can be used for spot-treating infested areas (Clark 1975). They are applied by scattering tablespoon amounts over 2 to 3 square feet of ground around the burrow. Grain should never be piled up in front of the burrow (Quayle 1912). Ground squirrels tend not to feed on grain right in front of or inside their burrows, and scattering the grain decreases the chances that livestock, pets, and other nontarget species will pick up a lethal dose (Clark 1975). Scattering the bait also takes advantage of the natural foraging tendencies of ground squirrels.

Zinc phosphide and Compound 1080 can also be broadcast by hand, machine spreader, or, in special instances, by aircraft at the rate of 6 pounds per swath acre through the infested area (Marsh 1968, Clark 1975, Schilling 1976). Because of safety considerations, broadcast baiting of strychnine is not recommended (Clark 1975).

Ground squirrels absorb strychnine through their cheek pouches much more rapidly than through the gut (Dixon 1925). Because of susceptibility and behavioral differences to strychnine, the Fisher and the Beechey subspecies of ground squirrels (S. b. fisheri and S. b. beecheyi) are not generally controlled effectively with strychnine baits. These squirrels are found south of an imaginary line eastward from San Francisco. Zinc phosphide- or Compound 1080-treated baits are more effective for the Fisher and the Beechey ground squirrels.

Anticoagulants--The use of anticoagulants for field rodent control has increased in recent years (Clark 1978). Their safety to humans and nontarget species, low environmental contamination and hazard, and high degree of efficacy has justified their higher costs in many situations.

Anticoagulants currently registered in California for ground squirrel control include chlorophacinone, diphacinone, Fumarin, Pival, and warfarin (Salmon and Gorenzel 1981). These chemicals interfere with an animal's blood-clotting system, leading to internal hemorrhaging and eventually death. Most anticoagulants are effective only when consumed in several feedings over a period of 5 or more days, without gaps of 48 hours or longer. These features, in addition to an effective antidote (Vitamin K_1), make the use of anticoagulant baits relatively safe for humans and domestic animals.

Since individual squirrels differ in their susceptibility to anticoagulants, and because some squirrels may not start feeding immediately on the bait, effective control may require that bait be available for 3 weeks or longer.

Like all control methods, anticoagulants are most effective at seasons of peak squirrel activity. Anticoagulants are most readily accepted when squirrels are feeding on seeds or grains. Unlike the acute toxicants, reluctance in accepting the bait will not jeopardize control (by creating bait-shyness). It will, however, delay control until adequate acceptance is achieved.

Anticoagulant baits can be used in two ways: in bait boxes or by repeated spot-baiting. Bait boxes are small structures which hold adequate bait for multiple feedings, protect the bait from the weather, and restrict accessibility of the bait to rodents, which must enter the box to eat the bait. This is the preferred baiting method around homes and other areas where children, pets, and livestock are present. Bait boxes can be purchased commercially or made of any durable material in many designs (Clark 1975, Salmon 1981).

Bait boxes containing 1 to 5 pounds of bait (according to label instructions) should be placed in areas frequented by ground squirrels (near runways, burrows, or feeding areas). If more than a single station is needed, they should be spaced at intervals of 100 to 200 feet. Initially, bait stations should be inspected every day, and bait should be added as necessary. The amount of bait is increased if all is eaten overnight. Moldy or old bait will not be eaten by squirrels and must be replaced as necessary. Baiting should be continued for 2 to 4 weeks, or until all feeding ceases and no squirrels are observed. Unused bait is then picked up and disposed of in accordance with label instructions. Since eating an anticoagulant does not immediately affect the squirrel's feeding or activity, apparently healthy squirrels will be noticed feeding at the bait stations for several days. These animals will soon be affected but it is important that they continue to have a supply of fresh bait available. It may also take a number of days before squirrels become accustomed to the bait box and enter it. If 48 hours go by without bait consumption, the squirrel can recover. In this case, the baiting program would have to be repeated.

Repeated spot- and broadcast-baiting with anticoagulants can be effective in controlling ground squirrels. These methods can only be used if permitted on the product label instructions. For spot-baiting, a handful of bait (about 10 placements per pound) is scattered evenly over 40 to 50 square feet near active burrows or runways. This takes advantage of the squirrel's natural foraging habits. Three or four treatments, rebroadcasting the bait every other day, should provide an uninterrupted supply of bait. As in the case of acute toxicants, bait should never be piled on the ground or placed in burrows. Piles of bait may increase the hazards to livestock and other animals, and squirrels will not readily feed on bait placed inside their burrows.

Fumigants--Fumigants, or toxic gases, can be very effective for killing ground squirrels. Labor and material costs can be high but, if used properly, highly effective control can result. Fumigation is generally done in the spring. At this time soil moisture is high and all squirrels are active. High soil moisture is needed so the gas will be contained in the burrow system and will not diffuse into the surrounding soil as would happen if the soil were dry. Fumigation is not recommended during periods of estivation or hibernation because squirrels often plug their burrow system with internal plugs of soil, preventing the fumigant from reaching the squirrel.

Fumigants registered in California include aluminum phosphide, carbon bisulfide, methyl bromide, and gas cartridges (gas bombs) (Salmon and Gorenzel 1981). All but gas cartridges require a Restricted Use Permit from the County Agricultural Commissioner.

The gas cartridge, when ignited, gives off a dense cloud of smoke and toxic gases (mostly carbon monoxide). Instructions for use are relatively simple (Clark 1975). The cartridge is placed in the burrow as far back as possible and lit. With a shovel handle or stick, the ignited cartridge can be pushed down the burrow and the opening quickly sealed with soil. If burrows are connected underground, smoke will be seen escaping; these openings should also be sealed. Larger burrow systems usually require two or more cartridges placed in the same or connected burrow openings. The area can be inspected 2 to 3 days later and any burrows that have been reopened can be retreated at that time.

Gases emitted from the cartridge occasionally ignite, creating some fire danger. Therefore, gas cartridges should never be used where a significant fire hazard exists (such as under wooden buildings or near dry grass or other flammable material).

Aluminum phosphide is an extremely effective burrow fumigant when used properly (Salmon et al. 1982). The material is formulated as solid tablets or pellets which are placed in the squirrel burrow. The tablets decompose and release hydrogen phosphine gas when in contact with moisture. The higher the temperature and moisture levels inside the burrow, the faster the rate of decomposition. Two to four tablets are placed in each active burrow opening, which is then covered with a wad of newspaper and sealed tightly by shoveling dirt over the entrance. The newspaper prevents soil from covering the tablets, and tests have shown that efficacy will be reduced if newspaper is not used (Salmon et al. 1982). All reopened burrows should be retreated 3 to 4 days later. Aluminum phosphide is not toxic to plants and fire hazard is minimal. Disposal and storage instructions for this chemical are described on the label.

Carbon bisulfide is a liquid which volatilizes quickly into a heavier-than-air gas which can flow to the lowest parts of a rodent burrow. The "waste ball" method of treatment involves using balls of

cotton or jute 2 inches in diameter. Sixty waste balls are placed in a bucket and 1 gallon of carbon bisulfide is poured over them. Each ball is drained for 1 or 2 seconds as it is lifted from the bucket, then placed in an active burrow. Two waste balls are used in large burrows. Burrow openings are then sealed with soil and packed tightly. All reopened burrows are retreated 3 to 4 days later.

Carbon bisulfide is phytotoxic. Igniting the carbon bisulfide fumes is believed to reduce the toxic hazards to trees but, for safety reasons, this is not recommended. Carbon bisulfide is extremely flammable and very explosive. Around trees or other valuable plants, an alternative fumigant (gas cartridge or aluminum phosphide) can be used effectively.

Methyl bromide is a nonflammable heavy gas that liquifies under pressure and is toxic to both rodents and rodent fleas. It is packaged in pressurized containers which can be attached to commercially available applicator devices. The hose of the applicator device is inserted 15 to 18 inches into the burrow opening and the entrance is plugged with dirt. After applying the fumigant at the rate of 10 to 13 cc per burrow (15 to 20 doses per 1-1/2 pound can), the hose is withdrawn and the burrow opening is sealed tightly. Again, opened burrows are normally retreated after 3 to 4 days.

Methyl bromide is phytotoxic. In treating burrows at the base of trees, aluminum phosphide, gas cartridges, or traps are good alternatives. Fumigants should never be used beneath buildings occupied by humans, pets, or livestock.

COSTS OF CALIFORNIA GROUND SQUIRREL CONTROL

Once a ground squirrel problem has been defined, economic considerations become very important in determining a control strategy (Salmon and Lickliter 1983). For example, Figure 1 gives two hypothetical comparisons of economic considerations when controlling California ground squirrel damage in almond orchards during the spring and summer months. Note that although labor and material costs should remain relatively constant during both seasons, the efficacy of control materials during specific periods is the major factor in determining the projected economic benefit of control. For example, although an acute toxicant such as 1080-treated grain may be less expensive than trapping on a per-hectare basis, if squirrels are not accepting grain baits at the time of control, it is a waste of money and time to attempt to control squirrels with Compound 1080.

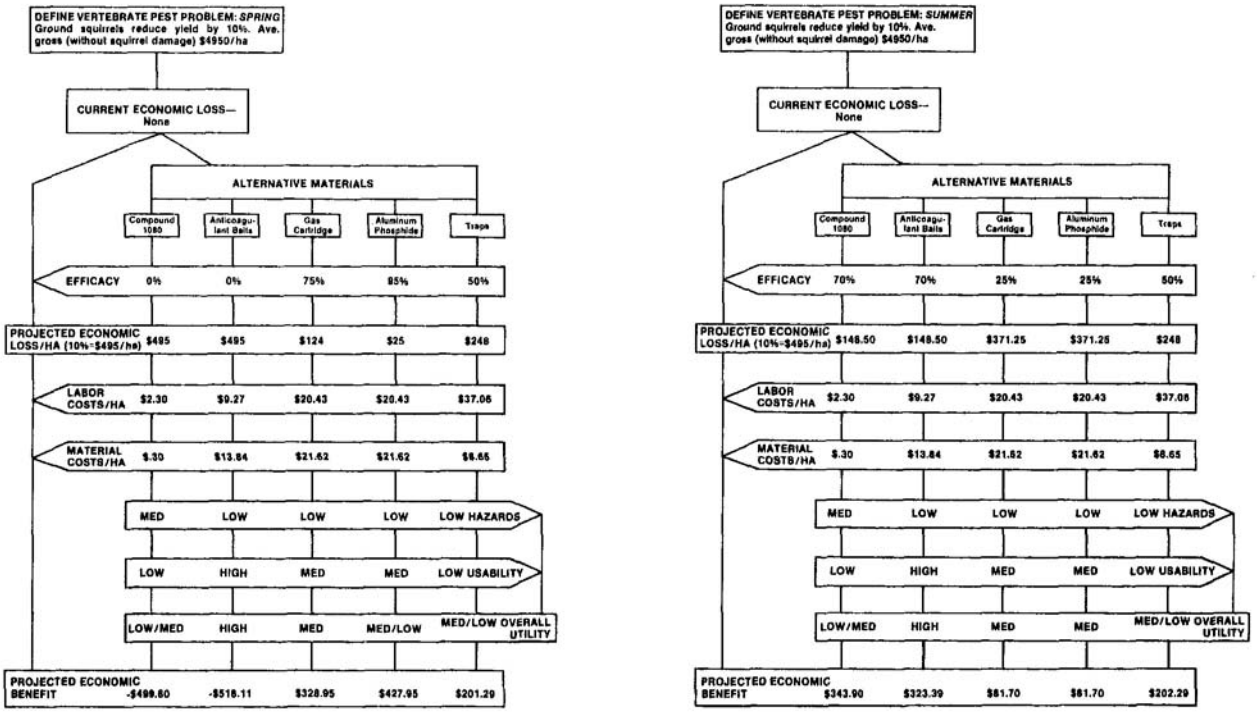

Figure 1. Hypothetical comparison of control materials when controlling California ground squirrel damage in almond orchards during the spring and summer months (from Salmon and Lickliter 1983).

In general, acute single-dose toxicants are the least expensive control methods to use on a per-hectare basis (Albert and Record 1981). Trapping is the most expensive technique because of the high labor costs, although the costs of the traps themselves can be prorated over the life of the traps. Shooting also has high labor costs.

Anticoagulants and fumigants are more expensive than acute toxicants but do not have labor costs as high as trapping does. The cost of anticoagulant bait stations, like traps, can be prorated over a number of seasons. Their cost depends on whether they were obtained commercially or homemade. Anticoagulant bait costs may be very similar to the cost of acute toxicants on a per unit weight basis; but because anticoagulants require multiple feedings, overall bait costs will be higher.

Fumigants vary in their costs and in the amount of labor required for proper use. For example, one study indicated that aluminum phosphide treatments took 1.4 to 1.6 minutes per burrow, while gas cartridges took 2.2 minutes per burrow for treatment (Salmon et al. 1982). If 200 burrows were treated with aluminum phosphide, this could result in a savings of 2 hours over treatment with gas cartridges. This kind of information, together with efficacy data and fumigant cost information, should enable the grower to choose the correct and most cost-effective fumigant to use.

On a per-squirrel basis, a ranking of control methods from least expensive to most expensive is 1) acute toxicants, 2) fumigants and anticoagulants, and 3) trapping and shooting. However, selection of control methods is dependent upon crop value per unit area, squirrel density, and the size of the area to be controlled, including a buffer zone, if appropriate. It is assumed that potential for ground squirrel damage has already been assessed and that control is recommended. Consideration of these factors (crop value, squirrel density, and control area) enables the grower to make a logical decision relating control material efficacy with economic considerations.

Figure 2 summarizes control options as a function of crop value, squirrel density, and control area. It can be used for determining which methods of control may be feasible in various situations. For example, a large almond orchard may have a severe squirrel problem covering a significant portion of its area (high value, high density, large area). Preferred control methods would be acute toxicants or anticoagulants. Deciding which of these two methods to use is based on time of year and past history (are squirrels accepting grain baits; have they been exposed to a particular toxicant recently), potential hazards to humans and pets, and availability of materials, labor, and capital for the control operation. After this initial control, the squirrel situation will change; perhaps now there are only a few squirrels scattered throughout the orchard (high value, low density, large area). Fumigants now become an effective option, and a good alternative if toxicants were used previously.

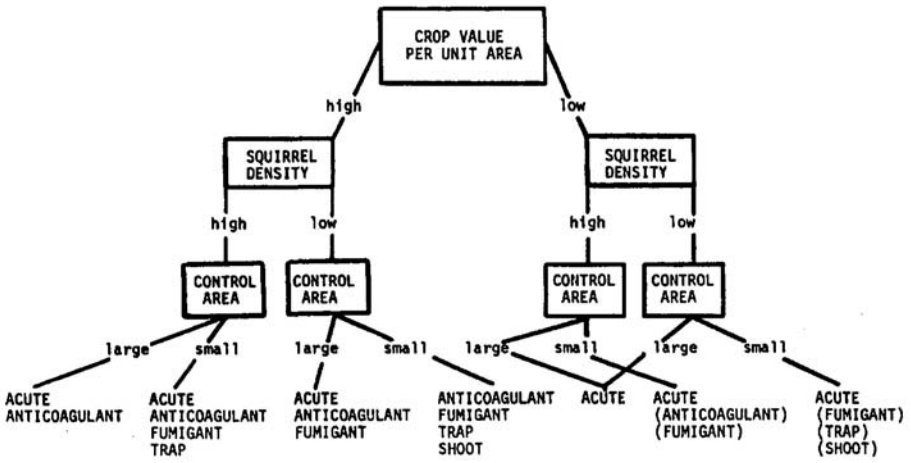

Figure 2. Control options for California ground squirrels, based upon the value of a crop per unit area, density of the squirrels, and size of the area to be treated. Options enclosed in parentheses may not be cost effective.

And finally, after this operation, the area infested with squirrels will be further reduced (high value, low density, small area). Continued use of anticoagulants or fumigants would be effective; trapping and/or shooting may be preferred methods. Again, a particular choice depends upon the on-site evaluation of potential hazards, costs, labor and material requirements, and timing constraints. All control operations need to be conducted with a concern and lookout for potential future problems.

The efficacy of control materials for California ground squirrels varies according to season, locality, formulation, and use patterns (Salmon and Lickliter 1983). As part of the decision-making

process, a grower must consider not only the efficacy of control materials, but also their usability and labor requirements, anticipated costs, and associated hazards. To a grower, the benefits of choosing the correct control option are a reduction in damage and a minimization of both control costs and potential hazards.

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