

## MANAGEMENT OF POCKET GOPHERS IN SACRAMENTO VALLEY ALFALFA

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Pocket gophers have long been thought to damage alfalfa. Besides certain knowledge that gophers consume alfalfa, gopher mounds are often seen around places of plant loss or stand thinning. For these reasons, gophers have been subjected to control programs, which usually include the application of strychnine baits into artificial tunnels made with a tractor-drawn implement -- the burrow-builder. However, the association of gopher mounds with damage in alfalfa is confounded by the multiple factors that accompany their presence. Gophers share alfalfa with voles, jackrabbits, and in some places, ground squirrels. All of these species consume alfalfa, so damage caused by gophers is difficult to distinguish from that caused by other species. Another confounding factor is the usual arrangement of gopher burrow systems along irrigation borders, where stand thinning and other types of damage (e.g., use of burrow-builder) tend to occur more frequently than in the checks. Careful examination of bare stretches on borders usually reveals no gopher sign until the ends of such stretches, where alfalfa thrives on the burrow systems.

In natural environments, gophers have effects on soil properties that facilitate plant growth. Their burrow systems also house a variety of predatory invertebrates, many of which might prey on arthropod pests in alfalfa. Also, gophers in alfalfa are an important food source for birds of prey, which prey on other vertebrate pests, and their predation spills over into other crops. The gopher's potential positive and negative effects in alfalfa have never been reconciled.

The gopher control programs applied so far have been unsatisfactory. Explanations for poor control efficacy have included: (1) strychnine tolerance; (2) weak concentrations of strychnine in baits; (3) improper bait; and (4) strychnine is an inferior toxicant to some others that are no longer available. However, previous research by the senior author showed that a low concentration of strychnine on two types of grain baits was very effective at reducing gopher populations in managed plots. Our landscape study strongly suggests gopher control in individual fields is at a scale too small to defeat the scale at which the gopher population functions. Alfalfa fields rarely stand alone in the farming landscape; nearby are other alfalfa fields or irrigated pasture or other source areas from which gophers can disperse. Irrigated perennial crops are tremendous, year-round, breeding grounds, from which dispersal will give no respite. Clearing territorial, adult gophers from an alfalfa field only prepares the vacant burrow systems for food-stressed, sub-adult immigrants. Without accounting for the landscape effects on gopher movement and population function, or for the ecosystem effects of gophers in alfalfa, gopher control might often be a wasted investment, or even detrimental to the goals of alfalfa production.

## METHODS

In May 1992, we were awarded a two year grant from the USDA's National Research Initiative Competitive Grants Program, for which we are grateful. Since then, we have studied gopher populations in 45 alfalfa fields in the Sacramento Valley, mostly on the west side. We have mapped gopher burrow systems within each field for comparison to characteristics of the field, the surrounding landscape, and cultural practices (e.g., flow direction and source of flood irrigation water). These maps were made that spring and late summer/fall, and in the spring and summer of 1993. These four maps have been made for each field, which ranged in age from just planted to seven years old, and which varied in gopher control programs, irrigation schedule and amount, number of cuts, soil type, surrounding landscape and intensity of use by birds of prey. The success of our research depended entirely on access and information provided by the growers, to whom we are grateful.

We also compared yield and gopher density at three spatial scales: (1) among fields; (2) among parts of fields (bail counts); and (3) on and off individual gopher burrow systems at multiple sites throughout the fields. At this smallest scale we sometimes extracted soil cores at 20-40 and 60-80 cm depths. These cores were analyzed for percent moisture content and porosity (amount of soil remaining from 20 cm core after drying).

## RESULTS

Most alfalfa growers use flood irrigation, and some claim they use it for gopher control. While flood irrigation likely drowns many gophers, we observed intense predation on gophers by birds of prey as gophers sought above-ground refuge from the water. Many birds of prey in the Sacramento Valley cue on alfalfa fields that are being irrigated, lead by the group-foraging Swainson's Hawk (*Buteo swainsoni*). When irrigation is begun in alfalfa, Swainson's Hawks often arrive within half an hour, followed by many other birds of prey which seem to follow the Swainson's Hawks. Despite the mortality inflicted on gophers during the 6-14 irrigations per growing season, gopher populations were never lowered for long in any one field during 1992. During 1993, we noticed gopher population declines in many fields, but we don't yet know what caused these declines.

About 30% of the growers used strychnine baits during 1992. Control efficacy varied widely in these fields, but gopher populations never were reduced to levels that would persist greater than several months. In the process, growers damaged or killed alfalfa plants along the length of the artificial tunnels made by the burrow-builder. In one field, the intense rains of 1993 caused many sink holes along the artificial tunnels, thus damaging the field extensively. In most treated fields, soil mounds of invading gophers often occurred along artificial tunnels following control. Once the baits deteriorate (usually within several weeks), the artificial tunnels can be used like the burrow systems of killed, former residents. Most of the 70% of growers who didn't use control told us they quit trying to control gophers out of frustration from failures and costs. One grower claimed gophers helped his yield.

During 1993 vole populations increased dramatically from the previous year. Where gophers were killed by control programs, predation or flooding (some fields flooded during the heavy winter/spring rains), voles took over the tunnels of the vacant burrow systems. Vole sign could be recognized by small droppings, white-wash and bare ground around open gopher holes or along the tracks of artificial tunnels made by the burrow-builder. Often, two-inch long alfalfa clippings (crown and stem) were visible just inside these holes. We could not determine whether voles were increasing bare ground around their holes, or they established residence in vacant gopher burrows that were already under bare ground. But we did determine that reductions of gophers in fields lead to increased numbers of voles.

The age of the stand is the strongest influence on gopher density in alfalfa. Gophers usually invade slowly into newly planted fields, but by 20-24 months the population increases quickly until it saturates the field by 36-42 months. Because gophers are territorial, no more can fit into a "saturated" alfalfa field unless the resident adult population is eliminated. Then sub-adult dispersers can take residence, and until they are adults, they can live at higher densities because their home ranges are smaller.

The surrounding landscape also influences invasion rates into alfalfa fields. Dispersing gophers move along linear elements of the landscape, such as dirt roads and canal banks. They enter a field where these elements intersect it, usually at field corners. From places of field entry they sometimes spread into the field in a wave-like pattern, but they usually follow linear elements of the field, such as field edges or borders. New alfalfa stands planted next to stands of 3 or more years will be invaded more quickly than isolated stands. Gophers disperse from source areas, or areas where reproductive rates are high. Source areas other than older alfalfa fields can be irrigated pasture, natural areas or some orchards. Standing water can act as barriers to dispersal. Growers can predict where and when gophers will invade an alfalfa field, and can adjust management plans accordingly. Gopher control can be concentrated at field corners when the field is young, or the grower can establish drift fence or a narrow trench lined with hardware cloth at places of predicted field entry (gophers disperse above ground and don't bother to tunnel under such barriers).

Gopher control might not always be cost-effective management in alfalfa. We found gopher burrows increase soil porosity and water infiltration, especially below 60 cm. Soil in Sacramento Valley alfalfa fields is so compact, extraction of soil cores below 60 cm was nearly impossible, even during the week after irrigation. This compaction reduces water infiltration to the deep roots of alfalfa, and it reduces gas exchange at the roots. Gophers constantly turn the soil over, aerate it, and funnel water through their tunnels, which often extend 6 feet deep to their nest chambers and food caches. In summary, percent soil moisture content and porosity at 60-80 cm depth decreased dramatically the farther from gopher burrow systems. Yield strongly increased with both these variables in a 1 year-old stand, but less so in a 3 year-old stand. Yield samples on gopher burrow systems averaged 19% greater than those off burrow systems, but this difference lessened with stand age. The number of bails per acre increased with gopher density within fields, but total yield among fields did not vary in response to total yield. Instead, total yield and gopher density both responded to age of stand and amount of water applied.

The surrounding landscape and availability of raptor perches also influences the visitation to alfalfa fields by agents of natural biological control -- birds of prey. We have found hawk visitation to be severely limited by lack of certain tree species (e.g. oaks, cottonwoods, willows, American Elm) and types of telephone poles. Fields near natural areas, especially rivers and streams with riparian habitat, attract more hawks than do other fields. Most hawk visitation occurs during winter when hawks from the Western states and Mexico migrate into California's Great Central Valley. We believe more Red-tailed Hawks would stay in the Valley through the summer if they had greater availability of food resources, principally through greater acreage of alfalfa, relaxed vertebrate pest control and more perches.

The greatest impediment to long-lasting, effective gopher management is the spatial scale at which it is applied. The surrounding landscape always generates sub-adult, dispersing gophers that are seeking gopher-free alfalfa. The single field is not the scale at which the gopher population functions; it functions at the landscape scale. Effective, long-lasting gopher control can only occur if growers of multiple commodities coordinated their control efforts.

## DISCUSSION

Our results are valid within the Sacramento Valley under the conditions we experienced. Other places and conditions might have produced different results. We do believe, however, that we have achieved greater generality than any previous study, because none has involved so many fields, so intensively and for so long a time period. The limitations of our study must be overcome with additional research if alfalfa growers are to manage gophers at reasonable cost and effectiveness. Present management is based on grossly inadequate scientific research, and entering a time when its tools will no longer be available due to the increasing restrictions on rodenticide.

Our findings of increased yield on gopher burrow systems was totally unexpected. As ecologists, we should have predicted the gopher's positive effects on soil properties. Although we repeated our tests on a number of alfalfa fields and at different periods of the growing season, many growers will have trouble with our counter-conventional results. Indeed, there might be soils where the gopher's effects might be quite different. We would appreciate having our attention brought to any place where gophers interact with alfalfa in ways we have not yet observed. However, in these times of rodenticide restrictions and increasingly marginal profits in alfalfa production, we need to consider all possible solutions to perceived management problems. Our preliminary assessment of gopher control in Sacramento Valley alfalfa is that it usually should not happen; it usually fails to meet its goals, while it increases production costs, often damages plants, removes a positive influence on soil properties that facilitate plant growth, and reduces the food supply of birds of prey, whose natural regulation of multiple vertebrate species is far more important than consumption of alfalfa by gophers.