

CURRICULUM FOR BURROWING RODENTS—OUTLINE

TIME REQUIRED: 4 hours
NUMBER OF SESSIONS: One per year
SUGGESTED CLASS SIZE: Up to 20 participants

Objectives

- 1) Identify and understand the biology of pocket gophers, California ground squirrels, voles, other vertebrate pests and their predators.
- 2) Use integrated pest management (IPM) practices to manage burrowing rodent pests. Use outdoor exercises to (a) practice monitoring techniques and data recording, (b) characterize the site, (c) evaluate management alternatives, and (d) handle pest management tools and equipment.

Lecture and Discussion

A. Introduction, page 4

Class defines these terms	Further activities
<i>vertebrate</i> and <i>invertebrate</i>	List animals with and without backbones and school's outdoor vertebrate pests Determine the top three pests from the list
<i>pest</i>	Discuss <i>exotic</i> versus <i>indigenous</i> .
<i>predator</i>	Discuss <i>limiting factors</i> to understand how predators influence population size.

B. Identification, pages 4–5

Distinguish rodents from other mammals and recognize the different species. Show different types of mounds or nests useful to pest identification. Distinguish different species based on their mounds, burrows, or nests. Discuss types of damage caused by burrowing vertebrate pests.

Writers—Michael Baefsky,¹ Nita Davidson,² Belinda Messenger² & Angelica Welsh.² 2nd printing, October 2004.

Acknowledgments—Thank you to the following DPR staff for reviews and suggestions: Sewell Simmons, Lisa Ross, Tom Babb, Nan Gorder, Chris Geiger, Madeline Brattesani, David Duncan and Veda Federighi.

¹ Baefsky & Associates, P.O. Box 311, Orinda, California 94563 - mbaefsky@igc.org

² Department of Pesticide Regulation, 1001 I Street, Sacramento, California 95814 - school_ipm@cdpr.ca.gov

Disclaimer: Permission is granted to reprint and reproduce this document if author attribution and affiliation is given. Excerpts from this document may not be used in a manner that alters the originally intended meaning. The mention within this document of commercial products, their source, or their use is not to be construed as either an actual or implied endorsement. Mention is made of some representative products, but the Department of Pesticide Regulation does not recognize any product as superior to any other.

School IPM Curriculum—Burrowing Rodents

C. Biology and Management, pages 6–12

Review each pest's biology. Describe the pest's niche, problems it causes, typical habitat, and discuss thresholds if available. Discuss characteristics of rats and mice, range, food preferences, and habits.

Rodent species	Highlights	pages
Pocket gophers, <i>Thomomys</i> spp.	Botta's pocket gopher Tripping hazard	7–9
California ground squirrel, <i>Spermophilus beecheyi</i>	Inactive during very hot weather	10–11
Vole (meadow mouse), <i>Microtus californicus</i>	Prefer meadows and grasslands with friable soil	12
All of the above: Monitoring guidelines, suggested treatment thresholds, and IPM.		

D. Exercises

Divide class into groups and assign an area of athletic field or grounds to each.

Preliminary to exercises

- Census active ground squirrels
- Find active gopher burrows or likely locations

Exercise 1. Install a Gopher Trap, p. 13

- Learn how to set up a Macabee trap

Exercise 2. Checklist for Gophers and Ground Squirrels, p. 14

- Evaluate the habitat—grounds and athletic fields—and figure out how to make modifications so vertebrate pests will stay away.

Materials

Appendices

1. UC IPM Pest Notes, Pocket Gophers, Publication 7433.
<http://www.ipm.ucdavis.edu/PDF/PESTNOTES/pnpocketgophers.pdf>
2. UC IPM Pest Notes, California Ground Squirrel, Publication 7438.
<http://www.ipm.ucdavis.edu/PDF/PESTNOTES/pngroundsquirrel.pdf>
3. UC IPM Pest Notes, Voles (Meadow Mice), Publication 7439.
<http://www.ipm.ucdavis.edu/PDF/PESTNOTES/pnvoles.pdf>
4. Chemical Control of Gophers, California Ground Squirrels, and Voles.
5. Explanation of Pesticide Toxicity Categories
6. Rodenticide Alternatives
7. Newspaper Article—Owl Box Construction for Schools

School IPM Curriculum—Burrowing Rodents

Books

Ali, A.D., and C.L. Elmore. 1989. *Turfgrass Pests*. Cooperative Extension. UC Division of Agriculture and Natural Resources. (Pub. 4053) Oakland, Calif. 121 pp.

Salmon, T.P. and R.E. Licklitter. 1984. *Wildlife Pest Control Around Gardens and Homes*. Cooperative Extension, UC Division of Agriculture and Natural Resources (Pub. 21385), Oakland, Calif.

Visual aids

Slides and images of gophers, ground squirrels, and voles

Slides and images of monitoring and management alternatives (trapping, baiting, exclusion and other management practices)

Overheads of gopher life cycle and IPM program

Supplies

- | | |
|------------------------------------------------------------|--------------------------------------------------------------------|
| <input type="checkbox"/> Rodent exclusion wire | <input type="checkbox"/> Gopher and/or mole repellent (castor oil) |
| <input type="checkbox"/> Carbon monoxide gas fitting | <input type="checkbox"/> Inflatable snake |
| <input type="checkbox"/> Gopher basket and/or chicken-wire | <input type="checkbox"/> Sour clover—gopher stopper |
| <input type="checkbox"/> Hawk kite | <input type="checkbox"/> Stakes (5–6) |
| <input type="checkbox"/> Interlocking root barriers | |

Specimens

Mounted animals from local taxidermy sources (e.g., nature centers and museums)

Tools and equipment

Traps for gophers, ground squirrels, rats and mice

Gopher run probes (make from galvanized pipe or small diameter steel rods) (5–6)

Rodent baiting probe (5–6)

Baiting station for gophers, ground squirrels, rats and mice

Products

Rodenticides in labeled packages

Display a variety of rodenticide alternatives commonly used at the training site and several that may have more limited uses (see **Appendix 6** for examples).

CURRICULUM FOR BURROWING RODENTS— LESSON PLAN

A. Introduction

Ask class to define vertebrate and invertebrate

Vertebrate = An animal with a backbone; e.g., rodents, humans, fish, birds

Invertebrate = An animal without a backbone; e.g., insects, worms

In California, the top three outdoor burrowing vertebrate pest problems at school sites are gophers, ground squirrels, and voles (= meadow mice). These are all rodents, mammals with extremely large, continuously growing incisors. Rats and mice are reviewed in the *Curriculum for Structural Pests*, although information about their burrows and the damage they cause are included here. (We also include burrow and damage information for moles, which are not rodents.)

Ask class to define terms

Pest = an organism found in the wrong place; competes with people for food and fiber, attacks people or livestock directly, or annoys or otherwise affects aesthetic human values. It is a subjective definition according to personal attitudes, perceptions, or values.

Exotic = introduced from elsewhere, as opposed to **indigenous**, native to the area.

Discuss population forces with class

POPULATION FORCES

Population size of a pest is determined by **population forces** (reproduction, mortality and movement into and out of an area) and by **limiting factors** (environment, predation and competition).

Identify population forces and limiting factors that affect vertebrate pests at different school sites. Are there any specific predators that help limit the pest population? (See Appendix 7, *Owl Box Construction for Schools*.)

B. Identification

1. Ask class how to recognize different species

- ▶ If you can see the culprit, then based on appearance it isn't difficult to tell the difference between a rat, mouse, mole, vole, ground squirrel or pocket gopher. Look around the room and point out mounted examples.
- ▶ If you don't see the animal, use indirect means, examining signs or evidence that they've visited. Have class list signs.
 - Droppings (= scat) ▪ Footprints
 - Type of damage ▪ Mounds or nests

School IPM Curriculum—Burrowing Rodents

2. Types of mounds or nests

One way to identify a hidden pest is by the type of hole or burrow it uses and the mounds of soil on the ground. Show photos of the mounds described below (From *Wildlife Pest Control Around Gardens and Homes*).

Table 1. Types of vertebrate mounds, burrows, or nests.

Pest	Description
Pocket gophers; pp. 21, 62–63	Numerous open burrows 3–5” in diameter, with crescent- or horseshoe-shaped mounds, holes off to one side and plugged. Vegetation cut down and ground bare around burrow openings.
Ground squirrels; pp. 15–16, 42	Holes 4” in diameter; not always mounds, not plugged, and tracks running out from the holes, which are usually in bare soil or located in brush piles or debris piles.
Voles; pp. 18–19, 52	1–2” diameter burrow openings and runways in vegetation.
Moles; pp. 20, 58	1–2” diameter burrow openings, difficult to find. Mounds loose; cone-shaped mounds and up-thrust ridges.
Rats, pp. 76–77	Norway rats build nests in underground burrows with 2–4” diameter openings; roof rats build them in trees or elevated areas. Paths leading out from the burrows are called runs.
Mice, p. 76	House mice make very small openings, ≤ 1” in diameter in the ground, no mounding. Runs smaller than rat runs.

* Page numbers refer to photographs and line drawings pictured in *Wildlife Pest Control Around Gardens and Homes*

Table 2. Types of damage caused by burrowing vertebrate pests, rats, and mice.

Pest	Description
Pocket gophers, pp. 21– 22	Cut and destroy roots, root crowns, and stems of plants. Gnaw and girdle tree roots. Aesthetic damage. Tripping hazard.
Ground squirrels, pp. 15–17	Carry rodent-borne diseases (e.g., plague). Cause ditch and creek bank erosion. Create large mounds of dirt that can bury and kill grass and other plants, create a tripping hazard , and make turf difficult to mow.
Voles, pp. 18–19	Destroy root crowns and lower stems of clovers, grasses. Girdle orchard trees, grapevines, other woody plants. Riddle turf with small holes and runways.
Moles, p. 20	Disfigure turf with tunneling. Dislodge plants by digging.
Rats, p. 25	Vector diseases (e.g., Leptospirosis, salmonella); gnawing causes structural damage, contaminate food, make mess and produce bad smell
Mice, p. 25	Damage buildings, contaminate food, make mess and produce bad smell.

* Page numbers refer to photographs and line drawings pictured in *Wildlife Pest Control Around Gardens and Homes*

C. Biology and Management

Table 3. General Biology of Rodent Pests

Pest	Niche	Problems	Habitat	Threshold
Gophers	Soil mixers Plant movers Prey	Create tripping hazard	Meadows, lawns	2
Ground squirrels	Soil mixers Plant movers Prey	Can vector plague Create tripping hazard	Grasslands Eroding soils	Subjective
Voles	Soil mixers Seed movers	Girdle young trees and shrubs	Grasslands Meadows	Subjective
Rats	Organic material breakdown Prey	Can vector diseases Make a mess Frighten people Smell bad	Human, disturbed	1 near food 1 in buildings Subjective in landscape
Mice	Organic material breakdown Seed movement Prey	Can vector diseases Make a mess Frighten people Smell bad	Human, disturbed, open field	1 near food 1 in building Subjective in landscape

Table 4. Characteristics of Rats and Mice

	Norway rat <i>Rattus norvegicus</i>	Roof rat <i>Rattus rattus</i>	House mouse <i>Mus musculus</i>
Range	<ul style="list-style-type: none"> Best suited for temperate zones. Found everywhere in United States. 	<ul style="list-style-type: none"> Best suited for tropical and semitropical zones Found along Pacific Coast, in Hawaii, Gulf states, lower ½ of East Coast 	<ul style="list-style-type: none"> Throughout United States and SW Canada north to central British Columbia, and along Pacific Coast to Alaska
Food Preferences	<ul style="list-style-type: none"> Meats, fish, flour, grains, fruits, vegetables Eats almost anything; eats ¾–1 oz food/day Drinks ½ to 1 oz water per day. Requires water daily to survive 	<ul style="list-style-type: none"> Seeds, fruits, vegetables, grains, eggs Eats ½ to 1 oz food/day. Drinks up to 1 oz of water each day. Water not essential if food high in moisture 	<ul style="list-style-type: none"> Omnivores. Cereal grains, seeds, fruits, vegetables, meats. Seeds preferred food Feed at multiple sites (20–30), eating small amounts at each site; eats 1/10 oz/day
Habits	<ul style="list-style-type: none"> Usually nests in basements, lower floors Extensively burrows in soil; nocturnal. Good climber; excellent swimmer Strong social hierarchy; biggest and strongest get best food and harborage. 	<ul style="list-style-type: none"> Usually enters and nests in upper portions of buildings May nest outside in trees (especially palm) or ivy Burrows very little Excellent climber Active at night 	<ul style="list-style-type: none"> Found in cultivated fields, at or below ground level or in upper stories of skyscrapers Excellent climber Inquisitive; explores home range daily

Management of Pocket Gophers, *Thomomys* spp.

Biology

What is the gopher's ecological niche (or what do gophers do in the environment?) Gophers actually have multiple roles. Their burrowing activity aids in mixing of soils and percolation of water. They're an important food source for snakes, owls, foxes and other predators, and they feed primarily on herbaceous plants.

Where are they found in the wild? They live in perennial meadows, and most riparian, deciduous, and conifer forests while still in the grass and forb stage. (Forbs are small broad-leaved flowering plants.). They're less common in mature stages of forest habitats.

What do they eat? Gophers are herbivores, feeding on roots, tubers, bulbs, stems and leaves of forbs and grasses. They may occasionally eat tree and shrub seedlings. They're named a pocket gopher because of their fur-lined cheeks, which they use to carry food to underground storerooms. (The fur imparts protection from pesticide absorption.) They probably obtain water from food plants.

When are they active? Pocket gophers are active primarily at dusk, and spend most of their lives underground, coming to the surface briefly to forage, find mates, disperse to new areas, or to push soil out of their tunnels.

How is gopher territory best described? Pocket gophers are both solitary and territorial, and live in burrows and tunnels plugged with earth to keep out intruders, and regulate temperature and humidity. Gophers leave the main tunnel open and plug lateral feeding tunnels. Territories break down during mating season. Males occupy about 2,700 ft² (average), but this could vary from 900–4,800 ft². Females occupy 1,300 ft² (average), ranging from 250–2,600 ft². They create maternity dens that abruptly angle downward from the main run, and are usually 18-24" deep.

Annual Cycle for Pocket Gophers

- Reproduce February through April and more often in irrigated areas
- Young usually disperse mid-May
- Build mounds year round in irrigated areas; spring and fall in non-irrigated areas

Botta's pocket gopher (*Thomomys bottae*) is the most common of five gopher species found in California.

- Strong claws on front feet; large center nails grow up to 3.6" per year.
- Each upper incisor grows 9" per year; lower ones 14". Incisors remain outside mouth even with lips closed, keeping dirt out.
- Generally have mottled brown fur with whitish feet and tail. Short, thick tail; ears and cheek pouches small.
- Head and body 4⁴/₅–7" long; tail 2–3³/₄" long.



Photo by Jack Kelly Clark © 2000 UC Regents

They are larger than food dens and lined with soft plant material and fur.

Gophers may occur in densities of up to 20 animals per acre (43,560 ft²). For instance, up to ten gophers can live in a football field measuring 300 feet x 75 feet (a little less than a half acre).

School IPM Curriculum—Burrowing Rodents

Management

Monitor gophers monthly at all sites *not* being treated and take action when hazard threshold is reached. At sites where treatment is being carried out, monitor after 3–4 hours to once weekly.

Pocket Gopher Reproduction

- Peaks of breeding activity late February through March. Young born in April; disperse within 60 days.
- In some areas there is also breeding in July and August, and November to December.
- Females may produce up to three litters/ year.
- One to twelve young per litter, averaging four to five.
- Sexually mature in one year
- May live to three years

Gopher Population Tripping Hazard and Action Thresholds

Use Table 5 to determine potential tripping hazard. First decide the use rating (left side of table), then estimate how much of the athletic field is infested (right side of table). Add both scores to get the tripping hazard potential (see box below). Finally, see the recommended actions (Table 6) for that tripping hazard potential.

Table 5. Potential tripping hazard for athletic fields

Use Rating		Infestation rating	
Level of use	Score	Field infestation %	Score
1–2 days per week	1	0–32%	1
3–4 days per week	2	33–64%	2
5–7 days per week	3	Over 65%	3

Tripping hazard potential = Level of use rating
+ infestation percentage rating

- High hazard = 5–6
- Medium hazard = 3–4
- Low hazard = 1–2

School IPM Curriculum—Burrowing Rodents

Table 6. Recommended actions to manage gopher populations

Actions	Low hazard	Medium hazard	High hazard
Monitoring	Bimonthly	Weekly	Monthly
Exclusion		Install exclusion fencing	Install exclusion fencing
Habitat modification	Reduce broadleaf weeds	Reduce broadleaf weeds	Renovate field Deep rip to destroy burrow system
Trapping and control	Trap when populations are at their lowest—fall and winter Install owl-nesting boxes along perimeter	Trap on a one-to-three-day cycle until population drops	Trap on a one-to-three-day cycle until population drops

Biological control

Predators, especially owls, eat pocket gophers. Although owls, hawks, snakes, and coyotes can make a dent in a local gopher population, a single gopher can dig up a field within days. Nevertheless, owls, hawks, and gopher snakes should be encouraged.

- ▶ Construct barn owl nesting boxes
- ▶ Build rock and debris piles for gopher snake habitat
- ▶ Encourage hawk perches along fences

Physical control

Trapping

Use box traps or wire traps. See box at right, *IPM Tips for Gophers*.

Exclusion

Install galvanized hardware cloth (½" mesh), plastic, concrete, or sheet metal fencing along field perimeters and/or existing fences. Install at least 24" below ground, and up to 12" above ground.

Cultural control (habitat modification)

- ▶ Reduce broadleaf weeds, especially clover in turf areas
- ▶ Encourage dense tree plantings
- ▶ Plant gopher-repellent clover, *Melilotus indica*

IPM Tips for Gophers

- Trapping is an effective means of controlling gophers.
- Locate live burrows, find runs, and excavate for traps.
- Place two traps, one facing each direction, in the burrow.
- Wear gloves when handling traps, as human scent will make the traps less effective.
- Owls and bull snakes are the leading predators of gophers. Barn owl boxes may attract barn owls to the area.

Management of California Ground Squirrels, *Spermophilus beecheyi*

Biology

What's the ecological niche of ground squirrels (or what do they do in the environment?)

Ground squirrels mix (aerate) soil. They're prey for coyotes, rattlesnakes, owls, and eagles.



UC Statewide IPM Project
© 2000 Regents, University of California

California ground squirrel

Photo by Jack Kelly Clark © 2000 UC Regents

What do ground squirrels look like? Head and body measure 9" to 11", somewhat bushy tail 5" to 9" in length. The fur is brownish gray and speckled with off-white along the back; the sides of the head and shoulders are light gray to whitish. Ground squirrels are similar in appearance to tree squirrels, but when frightened always retreat to a burrow.

What problems do they cause? In addition to occasionally vectoring plague, ground squirrels damage plants and will strip nut trees of fruit. Their burrow openings pose a tripping hazard.

What do they eat? Ground squirrels forage on ground and in low shrubs and trees, often digging up plants. They're omnivores, eating leaves of grasses and forbs, seeds, nuts, fruits, bulbs, fungi, insects, and bird eggs. They require very little water.

How is their territory best described? Burrows have 6–20 entrances (average length = 35 feet), and are

excavated in friable soil near rocky areas under trees or logs. They range from 3 to 138 feet apart. Home range is less than a 450-foot radius around the burrow, and averages 225 feet. The home range for males averages 0.4 acres (17,000 square feet), and for females 0.6 acres (26,000 square feet). Ground squirrels live alone or in small, dispersed colonies of one or more families. They may occupy small territories during breeding season.

Where do they live? Ground squirrels are widespread throughout almost all habitats in early successional stages and disturbed areas such as roadsides, croplands and grazed meadows. Ground squirrels prefer herbaceous sites, and openings in brush and forest habitats. They require friable soils, avoid thick chaparral, and do not build dens in heavily wooded and wet areas.

When are they active? Ground squirrels are diurnal. Adults become torpid when food is scarce and temperatures extreme (late summer–fall and winter). Most adults are inactive during the hottest time of the year.

Ground Squirrel Reproduction

- Build cup-shaped nests of dried vegetation in burrow.
- Mating December through July, depending on location
- Thirty-day gestation period
- Litters range from 3–15 young, averaging 6–7
- One litter per year
- Young weaned in 55 days, full grown in 7–8 months

School IPM Curriculum—Burrowing Rodents

Management

Emphasize an IPM program based on monitoring and setting action thresholds.

Biological control

Predators, including hawks, eagles, rattlesnakes, gopher snakes and coyotes, eat ground squirrels, but in most cases they are unable to keep ground squirrel populations below the level at which they become pests.

Cultural control (habitat modification)

Remove brush piles and debris and intensify irrigation and plantings of woody plants.

Physical control

Trapping

Dispose of live traps

Bait with walnuts, almonds, oats, barley, melon rinds

Inspect daily

Handle carcasses with protective gear

Ripping

Deep rip with a tractor and a ripping bar to at least 20 inches

Chemical control

See Appendix 2, UC IPM Pest Notes, California Ground Squirrel

IPM Tips for Ground Squirrels

- Monitor for ground squirrels by looking for them poking their heads out of their burrows and surveying the landscape.
- Use rat, mouse, and modified wooden gopher traps to catch both adult and young ground squirrels.
- Bait the traps with peanut butter, grain, or nuts (fasten nuts to the trigger so they can't be removed.)
- Use traps only when children will not be present or while grounds crews are working on and supervising an area.

Management of Meadow Mice or Voles, *Microtus californicus*

Biology

Ecological niche. Voles move seeds around and serve as prey for birds, mammals, and snakes.

Identification. Short tail and heavy, compact body with short legs, small eyes, and partially hidden ears. Fur long, coarse blackish to grayish brown. Body measures 5–8" long including tail.

Vole Reproduction

- Breed throughout year. Nest of dried grass in shallow underground burrow.
- 2–5 litters per year; gestation 21 days
- Litter size ranges from 1 to 9, averaging four
- Females sexually mature at 35–40 days

Problems caused.

Gnaw bark and roots of trees and tunnel through meadows.

Food preferences. Feed on the leafy parts of grasses, sedges and forbs; obtain all the water they need from the plants they eat.



California vole

Photo by Jack Kelly Clark © 2001 UC Regents

Territory occupied. Prefer open areas such as meadows and grasslands. Seek cover in dense grass, beneath plant residues, in brush piles, beneath logs, and in underground burrows constructed in soft soil. A network of runways lead from the burrow. Home range varies by region. Several voles can occupy a burrow system.

Management

Biological control

Predators, especially raptorial birds, eat meadow voles. Predators rarely keep vole populations below damaging levels.

Cultural control (habitat modification)

Reduce weeds, heavy mulch, and dense vegetative cover. Establish weed-free buffer strips 4–15 feet long; and at least a 4-foot radius around trees.

Destroy old runways and burrows

Physical control

Exclusion

Place $\leq 1/4$ " hardware cloth or metal barrier along fence, 12" above ground, buried 6–10"

Wrap hardware cloth cylinders around trunks

Trapping

Use wooden mouse traps with peanut butter–oatmeal mix or apple slices

Set traps along runways at right angles and examine daily

IPM Tips for Voles

- Mow the area around trees frequently; maintain a grass-free area around young trees to reduce damage and destroy hiding places.
- Place $1/4$ -inch mesh hardware cloth around the base of young trees to prevent voles from feeding on plants. Submerge hardware cloth at least 2–3" beneath and 18" above ground. Check hardware cloth yearly; replace if necessary to avoid vole damage to trees.
- Bait mouse (snap) traps with peanut butter, oatmeal, or apple slices to help limit vole populations. *Make sure children will not be present while trapping occurs.*

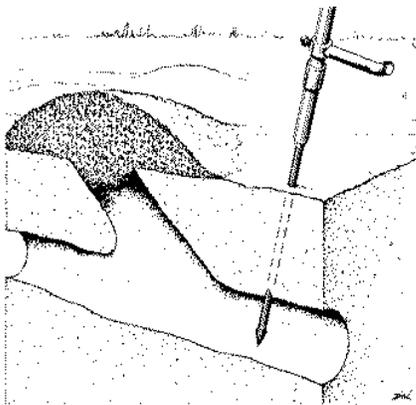
School IPM Curriculum—Burrowing Rodents

D. Exercises

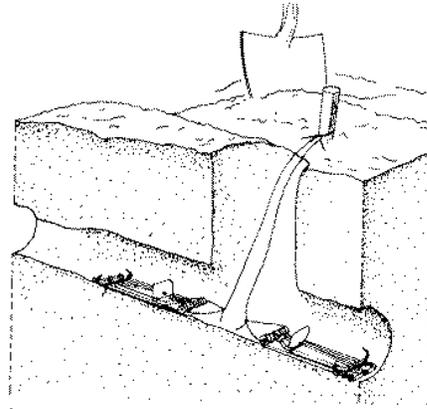
Preliminary to exercises census active ground squirrels and find active gopher burrows or likely locations.

EXERCISE 1. Installing a Gopher Trap

- 1) Locate fresh mound (plugged opening of lateral tunnel). Look for dark, moist, freshly churned soil.
- 2) Find main burrow by probing 8–12" from the plug side of the mound, usually 6–12" deep. When you locate the burrow, there will be a sudden, noticeable drop of about two inches.
- 3) Open the tunnel using a shovel or trowel, and set two traps, one facing in each direction.
- 4) Attach a wire and stake.
- 5) Cover the burrow up with soil to exclude light.



Probe inserted in gopher burrow



Macabee traps placed in gopher burrow

From Salmon, T.P. & R.E. Licklitter. 1984. Wildlife Pest Control Around Gardens and Homes. UC Div. Agric. Nat. Res., Pub. 21385, Oakland, Calif.

EXERCISE 2. Burrowing Vertebrate Checklist: Habitat Evaluation and Modification

Procedure: Divide class into teams of two to three. Assign an area of athletic field or grounds for each team to evaluate. What are the **outside sources** of pests? (That is, where are the pests coming from?) What's bringing them to the site? (That is, what are possible **attractants**?) How can outside sources and attractants be changed to reduce infestation?

Potential Outside Sources and Attractants

Gophers

Outside Source

- | | | |
|------------------------------------------------|-----------------------------------------------|----------------------------------------------|
| <input type="checkbox"/> residential landscape | <input type="checkbox"/> open space/grassland | <input type="checkbox"/> open space/forest |
| <input type="checkbox"/> bare slopes | <input type="checkbox"/> eroding slopes | <input type="checkbox"/> neglected landscape |

Attractants

- clover or other broadleaf herbaceous plants ___% in turf
- irrigated turf = new tree/shrub plantings bare soil ___% bare
- eroding slope ____angle of slope

Ground Squirrels

Outside Source

- | | | |
|------------------------------------------------|-----------------------------------------------|----------------------------------------------|
| <input type="checkbox"/> residential landscape | <input type="checkbox"/> open space/grassland | <input type="checkbox"/> open space/forest |
| <input type="checkbox"/> bare slopes | <input type="checkbox"/> eroding slopes | <input type="checkbox"/> neglected landscape |
| <input type="checkbox"/> debris piles | <input type="checkbox"/> dead and dying trees | <input type="checkbox"/> other _____ |

Modifications of Source Areas and Attractants

Gophers

- | | |
|------------------------------------------------------|----------------------------------------------------------------------------------------------|
| <input type="checkbox"/> reduce irrigated areas | <input type="checkbox"/> install new trees and shrubs in gopher baskets |
| <input type="checkbox"/> deep rip/cultivate | <input type="checkbox"/> install gopher barriers along field perimeters |
| <input type="checkbox"/> remove dead and dying trees | <input type="checkbox"/> plant dense shelterbelts of trees and shrubs along field perimeters |
| <input type="checkbox"/> vegetate bare slopes | <input type="checkbox"/> notify neighbor(s) or adjacent properties of nuisance |
| <input type="checkbox"/> vegetate eroding slopes | <input type="checkbox"/> add plantings on trees, shrubs or non-herbaceous groundcover |
| <input type="checkbox"/> remove debris piles | <input type="checkbox"/> other(s) _____ |

Ground Squirrels

- | | |
|--------------------------------------------------------------------------------|-----------------------------------------------|
| <input type="checkbox"/> notify neighbor(s) or adjacent properties of nuisance | <input type="checkbox"/> deep rip/cultivate |
| <input type="checkbox"/> vegetate eroding slopes | <input type="checkbox"/> vegetate bare slopes |
| <input type="checkbox"/> remove dead and dying trees | <input type="checkbox"/> remove debris piles |

POCKET GOPHERS

Integrated Pest Management for Home Gardeners and Landscape Professionals

Pocket gophers (*Thomomys* spp.) 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. An unusual adaptation is the gopher's lips, which can be closed behind the four large incisor teeth to keep dirt out of its mouth when it is using its teeth for digging.

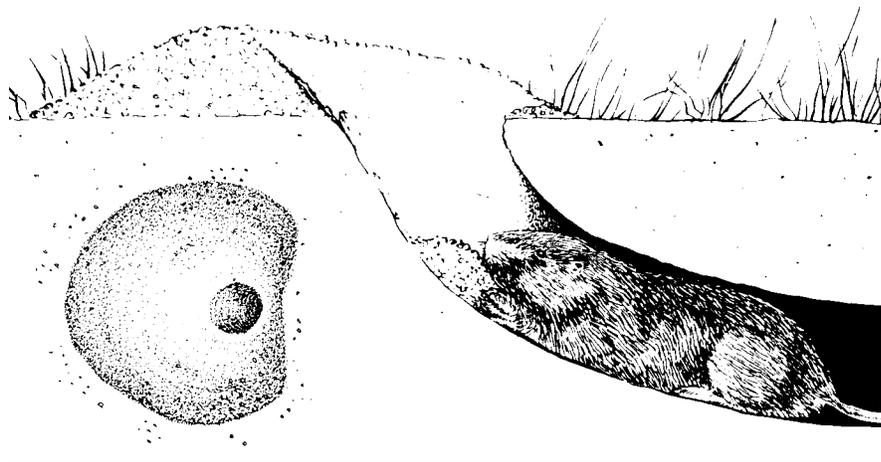


Figure 1. Top and side views of an unplugged pocket gopher mound.

IDENTIFICATION

Five species of pocket gophers are found in California, with Botta's pocket gopher (*Thomomys bottae*) being most widespread. Depending on the species, they may range in length from 6 to 10 inches. Although they are some-

times seen feeding at the edge of an open burrow, pushing dirt out of a burrow, or moving to a new area, gophers for the most part remain underground in the burrow system.

Mounds of fresh soil are the best sign of gopher presence. Mounds are formed as the gopher digs its tunnel and pushes the loose dirt to the surface. Typically mounds are crescent- or horseshoe-shaped when viewed from above (Fig. 1). The hole, which is off to one side of the mound, is usually plugged. Mole mounds (Fig. 2) are sometimes mistaken for gopher mounds. Mole mounds, however, appear circular and have a plug in the middle that may not be distinct; in profile they are volcano-shaped. Unlike gophers, moles commonly burrow just beneath the surface, leaving a raised ridge to mark their path.

One gopher may create several mounds in a day. In nonirrigated areas,

mound building is most pronounced during spring or fall when the soil is moist and easy to dig. In irrigated areas such as lawns, flower beds, and gardens, digging conditions are usually optimal year round and mounds can appear at any time. In snowy regions, gophers create burrows in the snow, resulting in long, earthen cores on the surface when the snow melts.

BIOLOGY AND BEHAVIOR

Pocket gophers live in a burrow system that can cover an area of 200 to 2,000 square feet. The burrows are about 2½ to 3½ inches in diameter; feeding burrows are usually 6 to 12 inches below ground, whereas the nest and food storage chamber may be as deep as 6 feet. Gophers seal the openings to the burrow system with earthen plugs. Short, sloping lateral tunnels connect the main burrow system to the surface and are created during construction of the main tunnel for pushing dirt to the surface.

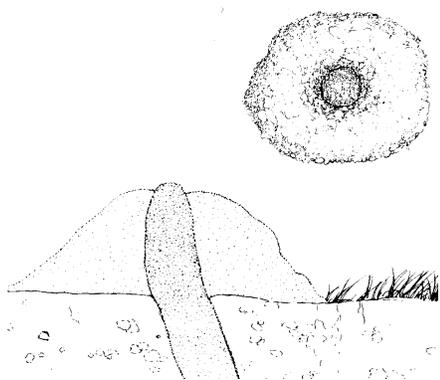


Figure 2. Top and side views of a mole mound.

Gophers do not hibernate and are active year-round, although fresh mounding may not be seen. They also can be active at all hours of the day. Gophers usually live alone within their burrow system, except for females with young or when breeding, and may occur in densities of up to 16 to 20 per acre.

Gophers reach sexual maturity at about 1 year of age and can live up to 3 years. Females produce one to three litters per year. In nonirrigated areas, breeding usually occurs in late winter and early spring, resulting in one litter per year, whereas in irrigated sites, up to three litters per year may be produced. Litters usually average five to six young.

Pocket gophers are herbivorous, feeding on a wide variety of vegetation, but generally preferring herbaceous plants, shrubs, and trees. Gophers use their sense of smell to locate food. Most commonly they feed on roots and fleshy portions of plants they encounter while digging. However, sometimes they feed aboveground, venturing only a body length or so from their tunnel opening. Burrow openings used in this manner are called "feed holes." They are identified by the absence of a dirt mound and a circular band of clipped vegetation around the hole. Gophers will also pull entire plants into their tunnel from below. In snow-covered regions gophers may feed on bark several feet up a tree by burrowing through the snow.

DAMAGE

Pocket gophers often invade yards and gardens, and feed on many garden crops, ornamental plants, vines, shrubs, and trees. A single gopher moving down a garden row can inflict considerable damage in a very short time. Gophers also gnaw and damage plastic water lines and lawn sprinkler systems. Their tunnels can divert and carry off irrigation water and lead to soil erosion. Mounds on lawns interfere with mowing equipment and ruin the aesthetics of well-kept turfgrass.

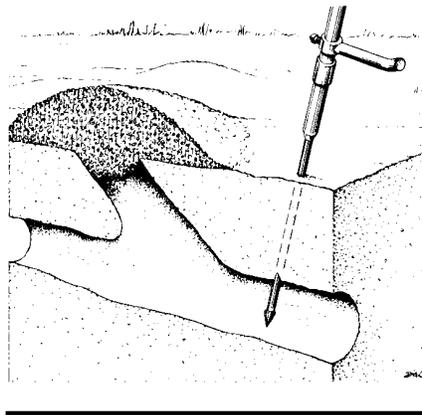


Figure 3. A gopher probe.

LEGAL STATUS

Pocket gophers are classified as non-game mammals by the California Fish and Game Code. This means that if they are found to be injuring growing crops or other property, including garden and landscape plants, they may be controlled at any time and in any legal manner by the owner or tenant of the premises.

MANAGEMENT

To successfully control gophers, the sooner you detect their presence and take control measures, the better. Most people control gophers in lawns, gardens, or small orchards by trapping and/or by using poison baits.

Probing for Burrows

Successful trapping or baiting depends on accurately locating the gopher's main burrow. To locate the burrow, you need to use a gopher probe (Fig. 3). Probes are commercially available or can be constructed from a pipe and metal rod. An enlarged tip that is wider than the shaft of the probe is an important design feature that increases the ease of locating burrows. Probes made from dowels or sticks may work in soft soil, but are difficult to use in hard or dry soils.

First, locate areas of recent gopher activity based on fresh mounds with dark, moist soil. Fresh mounds that are visible aboveground are the plugged openings of lateral tunnels. The main

burrow can be found by probing about 8 to 12 inches from the plug side of the mound (i.e., to the right of the mound in Fig. 1); it is usually located 6 to 12 inches deep. When the probe penetrates the gopher's burrow, there will be a sudden, noticeable drop of about 2 inches. You may have to probe repeatedly to locate the gopher's main burrow, but your skill will improve with experience. Because lateral tunnels may not be revisited by the gopher, trapping and baiting in them is not as successful as in the main burrow.

Trapping

Trapping is a safe and effective method to control pocket gophers. Several types and brands of gopher traps are available. The most commonly used is a two-pronged pincher trap, such as the Macabee trap (Fig. 4), which is triggered when the gopher pushes

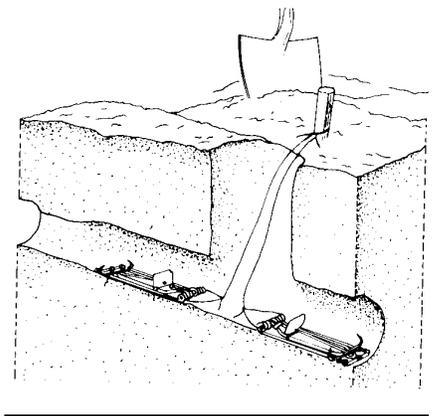


Figure 4. Macabee traps.

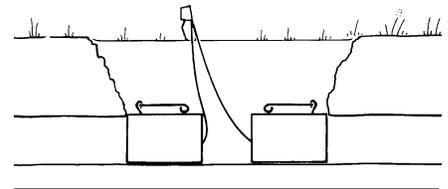


Figure 5. When putting box traps in place, cut the face of the hole smooth so that the traps can be pushed tightly against the tunnels. Cover the traps completely with about 1 inch of soil.

against a flat vertical pan. Another popular trap is the choker-style box trap.

To set traps, locate the main tunnel with a probe, as previously described. Use a shovel or garden trowel to open the tunnel wide enough to set traps in pairs facing opposite directions (Figs. 4 and 5). By placing traps with their openings facing in opposite directions, a gopher coming from either end of the burrow can be intercepted. The box trap is easier to use if you've never set gopher traps before, but setting it requires more excavation than if you are using the Macabee trap, an important consideration in lawns and some gardens. Box traps are especially useful when the diameter of the gopher's main burrow is small (less than 3 inches) because to use the Macabee-type wire traps, small burrows must be enlarged to accommodate them.

It is not necessary to bait a gopher trap, although some claim baiting gives better results. Lettuce, carrots, apples, or alfalfa greens can be used as bait. Place the bait at the back of a box trap behind the wire trigger or behind the flat pan of a Macabee-type trap. Wire your traps to stakes so they can be easily retrieved from the burrow, as shown in Figures 4 and 5. After setting the traps, exclude light from the burrow by covering the opening with dirt clods, sod, cardboard, or some other material. Fine soil can be sifted around the edges to ensure a light-tight seal. If too much light enters, the gopher may plug the burrow with soil, filling the traps and making them ineffective. Check traps often and reset them when necessary. If a gopher is not caught within 3 days, reset the traps in a different location.

Baiting with Toxic Baits

The key to an effective toxic baiting program is bait placement. Always place pocket gopher bait in the main underground tunnel, not the lateral tunnels. After locating the main gopher burrow with a probe, enlarge the opening by rotating the probe or inserting a larger rod or stick. Following label

directions, place the bait carefully in the opening using a spoon or other suitable implement that is used only for that purpose, taking care not to spill any on the ground surface. A funnel is useful for preventing spillage.

Strychnine-treated grain bait is the most common type used for pocket gopher control. This bait generally contains 0.5% strychnine and is lethal with a single feeding. Baits containing anticoagulants are also available. When using anticoagulant baits, a large amount of bait (about 10 times the amount needed when using strychnine baits) is required so that it is available for multiple feedings. Although generally less effective than strychnine baits, anticoagulant baits are preferred for use in areas where children and pets may be present. When using either type of bait, be sure to follow all label directions and precautions.

After placing the bait in the main burrow, close the probe hole with sod, rocks, or some other material to exclude light and prevent dirt from falling on the bait. Several bait placements within a burrow system will increase success. Tamp down existing mounds so you can distinguish new activity. If new mounds appear for more than 2 days after strychnine baiting or 7 to 10 days after anticoagulant baits have been used, you will need to rebait or try trapping.

If a large area is infested with gophers, a hand-held bait applicator will speed treatment. Bait applicators are a combination probe and bait reservoir. Once a burrow is located using the probe, a trigger releases a measured amount of bait into the tunnel. Generally, strychnine bait is used with such a bait applicator because the applicator dispenses only a small quantity of bait at a time.

Exclusion

Underground fencing might be justified for valuable ornamental shrubs or landscape trees. To protect existing plantings, bury hardware cloth or 3/4-inch mesh poultry wire 2 feet deep and extended at least 1 foot aboveground

to deter gophers moving overland. This method is less than perfect, however, because gophers may burrow below the wire; also, the wire may restrict and damage root growth of trees. Small areas such as flower beds may be protected by complete underground screening of sides and bottoms. When constructing raised vegetable or flower beds, underlay the soil with wire to exclude gophers. Wire baskets to protect individual plants can be made at home or are commercially available and should be installed at the time of planting. If you use wire, use light-gauge wire for shrubs and trees that will need protection only while young. Leave enough room to allow for the roots to grow. Galvanized wire provides the longest lasting protection.

Six to 8 inches of coarse gravel 1 inch or more in diameter around underground sprinkler lines or utility cables may deter gophers.

Natural Controls

Because no population will increase indefinitely, one alternative to a gopher problem is to do nothing, letting the population limit itself. Experience has shown, however, that by the time gopher populations level off naturally, much damage has already been done around homes and gardens.

Predators, including owls, snakes, cats, dogs, and coyotes, eat pocket gophers. Predators rarely, however, remove every prey animal, but instead move on to hunt at more profitable locations. In addition, gophers have defenses against predators. For example, they can escape snakes in their burrows by rapidly pushing up an earthen plug to block the snake's advance.

The idea of attracting barn owls to an area for gopher control by installing nest boxes has been explored. Although barn owls prey on gophers, their habit of hunting over large areas, often far from their nest boxes, and their tendency to hunt areas with abundant prey, make them unreliable for gopher control. When a single gopher, which is capable of causing damage rapidly,

invades a yard or garden, a gardener cannot afford to wait for an owl to arrive. Effective action, usually trapping or baiting, must be taken immediately.

Habitat Modification

Reduction of gopher food sources using either chemical or mechanical methods may decrease immigration of gophers. If feasible, remove weedy areas adjacent to yards and gardens to create a buffer strip of unsuitable habitat.

Other Control Methods

Pocket gophers can easily withstand normal garden or home landscape irrigation, but flooding can sometimes be used to force them from their burrows where they can be dispatched

with a shovel or caught by a dog. Fumigation with smoke or gas cartridges is usually not effective because gophers quickly seal off their burrow when they detect smoke or gas. But if you are persistent with and use repeated treatments, some success may be achieved.

No repellents currently available will successfully protect gardens or other plantings from pocket gophers. Plants such as gopher purge (*Euphorbia lathyris*), castor bean (*Ricinus communis*), and garlic have been suggested as repellents but these claims have not been substantiated by research. Although there are many frightening devices commercially available to use on pocket gophers (vibrating stakes, ultrasonic devices, wind-powered pinwheels, etc.), pocket gophers do not frighten easily, probably because of their repeated exposure to noise and vibrations from sprinklers, lawnmowers, vehicles, and people moving about. Consequently, frightening devices have not proven to be effective. Another ineffective control method is placing chewing gum or laxatives in burrows in hopes of killing gophers.

Follow-up

Once pocket gophers have been controlled, monitor the area on a regular basis for reinfestation of the land. Level all existing mounds after the control program and clean away weeds and garden debris so fresh mounds can be

seen easily. It is important to check regularly for reinfestation because pocket gophers may move in from other areas and damage can reoccur within a short time. If your property borders wildlands, vacant lots, or other areas that serve as a source of gophers, you can expect gophers to reinvade regularly. Be prepared to take immediate control action when they do; it is easier, cheaper, and less time-consuming to control one or two gophers than to wait until the population builds up to the point where the gophers are causing excessive damage.

REFERENCES

- Case, R. M., and B. A. Jasch. 1994. Pocket gophers. In S. E. Hygnstrom, R. M. Timm, and G. E. Larson, eds. *Prevention and Control of Wildlife Damage*. Vol. 1. Lincoln: Univ. Neb. Coop. Ext. pp. B.17-29.
- Chase, J. D., W. E. Howard, and J. T. Roseberry. 1982. Pocket gophers. In J. A. Chapman and G. A. Feldhamer, eds. *Wild Mammals of North America*. Baltimore: Johns Hopkins Univ. Press. pp. 239-255.
- Ingles, L. G. 1965. *Mammals of the Pacific States: California, Oregon, Washington*. Stanford: Stanford Univ. Press. 506 pp.
- Salmon, T. P., and R. E. Lickliter. 1984. *Wildlife Pest Control around Gardens and Homes*. Oakland: Univ. Calif. Agric. Nat. Res. Publ. 21385. 90 pp.

For more information contact the University of California Cooperative Extension or agricultural commissioner's office in your county. See your phone book for addresses and phone numbers.

AUTHORS: T. P. Salmon and W. P. Gorenzel
 EDITOR: B. Ohlendorf
 TECHNICAL EDITOR: M. L. Flint
 DESIGN AND PRODUCTION: M. Brush
 ILLUSTRATIONS: Figs. 1, 2, 3, 4: from Salmon, T. P., and R. E. Lickliter. 1984. *Wildlife Pest Control around Gardens and Homes*. Oakland: Univ. Calif. Agric. Nat. Res. Publ. 21385. Fig. 5: from *IPM for Almonds*, 2nd ed. Oakland: Agric. Nat. Res. Publ. 3308.

Produced by IPM Education and Publications, UC Statewide IPM Project, University of California, Davis, CA 95616-8620

This Pest Note is available on the World Wide Web (<http://www.ipm.ucdavis.edu>)



This publication has been anonymously peer reviewed for technical accuracy by University of California scientists and other qualified professionals. This review process was managed by the ANR Associate Editor for Pest Management.

To simplify information, trade names of products have been used. No endorsement of named products is intended, nor is criticism implied of similar products that are not mentioned.

This material is partially based upon work supported by the Extension Service, U.S. Department of Agriculture, under special project Section 3(d), Integrated Pest Management.

WARNING ON THE USE OF CHEMICALS

Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in the original labeled containers in a locked cabinet or shed, away from food or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.

Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits or vegetables ready to be picked.

Do not place containers containing pesticide in the trash nor pour pesticides down sink or toilet. Either use the pesticide according to the label or take unwanted pesticides to a Household Hazardous Waste Collection site. Contact your county agricultural commissioner for additional information on safe container disposal and for the location of the Household Hazardous Waste Collection site nearest you. Dispose of empty containers by following label directions. Never reuse or burn the containers or dispose of them in such a manner that they may contaminate water supplies or natural waterways.

The University of California prohibits discrimination against or harassment of any person employed by or seeking employment with the University on the basis of race, color, national origin, religion, sex, physical or mental disability, medical condition (cancer-related or genetic characteristics), ancestry, marital status, age, sexual orientation, citizenship, or status as a covered veteran (special disabled veteran, Vietnam-era veteran, or any other veteran who served on active duty during a war or in a campaign or expedition for which a campaign badge has been authorized). University policy is intended to be consistent with the provisions of applicable State and Federal laws. Inquiries regarding the University's nondiscrimination policies may be directed to the Affirmative Action/Staff Personnel Services Director, University of California, Agriculture and Natural Resources, 300 Lakeside Dr., Oakland, CA 94612-3350; (510) 987-0096.

CALIFORNIA GROUND SQUIRREL

Integrated Pest Management for Home Gardeners and Landscape Professionals

The California ground squirrel, *Spermophilus beecheyi* (Fig. 1), is one of the most troublesome pests to homeowners and gardeners. It is found in nearly all regions of California except for the Owens Valley southward into the desert regions.

IDENTIFICATION

Ground squirrels are easily identified as they forage aboveground near their burrows. The ground squirrel's body measures 9 to 11 inches and its semi-bushy tail adds another 5 to 9 inches in length. The fur is brownish gray and speckled with off-white along the back; the sides of the head and shoulders are light gray to whitish. One subspecies that occupies most of northern California has a dark, triangular-shaped patch on its back between the shoulders; this patch is missing from other species. While ground squirrels are similar in appearance to tree squirrels and may climb trees, when frightened they will always retreat to a burrow, whereas tree squirrels will climb a tree or tall structure and never use a burrow.

BIOLOGY AND BEHAVIOR

Ground squirrels live in a wide variety of natural habitats but usually avoid thick chaparral, dense woods, and wet areas. Populations may be particularly high in grazed rangelands and in areas disturbed by humans such as road or ditchbanks, fence rows, around buildings, and in or bordering many crops.

Ground squirrels live in a burrow system where they sleep, rest, rear young, store food, and avoid danger. The burrow openings are about 4 inches in diameter, but can vary considerably.

The burrows may be 5 to 30 feet or more in length and may go 2 to 4 feet below the soil surface. Often there is more than one opening in a burrow system. Ground squirrels live in colonies that may include several dozen animals in a complex of burrows. More than one squirrel may live in a burrow.

Ground squirrels are active during the day, mainly from mid-morning through late afternoon, especially on warm, sunny days. Ground squirrels have two periods of dormancy during the year. During winter months most ground squirrels hibernate, but some young may be active at this time, especially in areas where winters are not severe. During the hottest times of the year most adults go into a period of inactivity, called estivation, that may last a few days to a week or more. During these periods, the burrow appears open at the entrance but the squirrel plugs it with soil near the nest.

Ground squirrels breed once a year, averaging seven to eight per litter. Timing of breeding varies with location: in southern California breeding begins in December, in the Central Valley in February through April, and somewhat later in the mountain ranges. Aboveground activity by adults is at a maximum at the height of the breeding season. The young are born in the burrow and grow rapidly; by about 6 weeks of age they usually emerge from the burrow. At 6 months of age they resemble adults.

Ground squirrels are primarily herbivorous. Their diet changes with the season. After emergence from hiberna-



Figure 1. California ground squirrels.

tion, they feed almost exclusively on green grasses and herbaceous plants. When annual plants begin to dry and produce seed, squirrels switch to seeds, grains, and nuts, and begin to store food. Ground squirrels usually forage close to their burrows. Their home range typically is within a 75-yard radius of their burrow.

DAMAGE

Ground squirrels damage many food-bearing and ornamental plants. Particularly vulnerable are grains and nut and fruit trees such as almond, apple, apricot, orange, peach, pistachio, prune, and walnut. Ground squirrels will enter gardens and devour vegetables in the seedling stage. They may damage young shrubs, vines, and trees by gnawing bark, girdling trunks, eating twigs and leaves, and burrowing

around roots. Ground squirrels will gnaw on plastic sprinkler heads and irrigation lines. They also eat the eggs of ground-nesting birds and may limit attempts to attract quail to the yard.

Burrowing can be quite destructive. Burrows and mounds make it difficult to mow, and they present hazards to machinery, pedestrians, and livestock. Burrows around trees and shrubs can damage and desiccate roots, and sometimes topple trees. Burrows beneath buildings and other structures sometimes necessitate repair.

Ground squirrels can harbor diseases harmful to humans, particularly when squirrel populations are dense. A major concern is bubonic plague transmitted to humans by fleas carried on the squirrels. Ground squirrels are susceptible to plague, which has wiped out entire colonies. If you find unusual numbers of squirrels or other rodents dead for no apparent reason, notify public health officials. Do not handle dead squirrels under these circumstances.

LEGAL STATUS AND LEGAL CONSIDERATIONS

Ground squirrels are classified as non-game mammals by the California Fish and Game Code. Nongame mammals injuring growing crops or other prop-

erty may be controlled in any legal manner by the owner or tenant; tree squirrels, on the other hand, are classified as game animals and have a hunting season.

Note that the Mohave ground squirrel (*S. mohavensis*) and the San Joaquin antelope squirrel (*Ammospermophilus nelsoni*) are classified as *threatened* by the U.S. Fish and Wildlife Service and are protected. Although neither of these relatively small squirrels is likely to be misidentified as the much larger California ground squirrel, their ranges could overlap in some areas. The endangered San Joaquin kit fox (*Vulpes macrotis mutica*), several endangered species of kangaroo rats, the riparian brush rabbit (*Sylvilagus bachmani riparius*), riparian wood rat (*Neotoma fuscipes riparia*), as well as some endangered amphibians and reptiles, are also found within California ground squirrels' range and could be impacted by some squirrel control techniques. Before using pesticides for ground squirrel control, *read the product label* to determine if any restrictions exist on rodent control within the ranges of these and other endangered and protected animals. Also, if the kit fox is found in your county (for a range map, see the California Department of Pesticide Regulation's Web site listed in

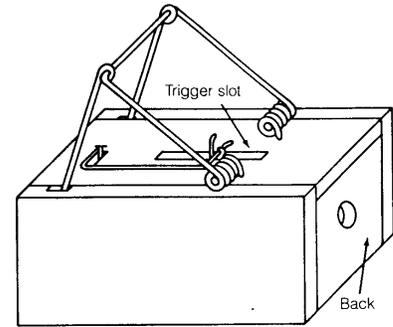


Figure 3. Box trap.

“References”), contact your county agricultural commissioner for additional information.

MANAGEMENT

The selection of control procedures is heavily influenced by the unique life cycle and behavior of the ground squirrel. For example, baiting with treated grain is effective in summer and fall because squirrels primarily feed on seeds during this period. Fumigation is most effective in spring when soil is moist, which helps seal gasses in the burrow system. Fumigating at this time also is more effective because squirrels are removed before they can reproduce. Figure 2 shows the yearly activities of the California ground squirrel and times when baiting, trapping, and fumigation are most effective.

Trapping

Traps are practical for control when squirrel numbers are low to moderate. Live-catch traps are not recommended because they present the problem of how to dispose of the live animals. Because ground squirrels carry diseases and are agricultural pests, the California Fish and Game Code specifies that it is illegal to release them elsewhere without a written permit.

There are several types of traps that kill ground squirrels, including box traps, Conibear traps, and tunnel traps. Box traps (Fig. 3) should be placed on the ground near squirrel burrows or

	winter	spring	summer	fall
Major activity periods				
adult reproduction		██████████	██████████	██████████
juveniles	██████████		██████████	██████████
Major food sources				
green forage		██████████	██████████	
seeds			██████████	██████████
best time for control				
fumigation		██████████	██████████	
baiting			██████████	██████████
trapping		██████████	██████████	██████████

Figure 2. The best time for a specific type of control depends on the activity periods and food sources of the ground squirrel.

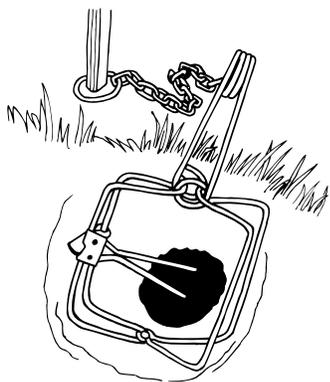


Figure 4. To use a Conibear trap, dig a slice of soil from the entrance so the trap will fit flush to the edges of the burrow entrance.

runways. Bait these traps with walnuts, almonds, oats, barley, or melon rinds. Place the bait well behind the trigger or tied to it. Bait the traps but do not set them for several days so the squirrels become accustomed to them. After the squirrels are used to taking the bait, rebait and set the traps.

To reduce hazards to children, pets, poultry, and nontarget wildlife, place box-type traps in a covered box with a 3-inch diameter entrance. Put the box near active burrows with signs of recent diggings. Inactive burrows will be filled with leaves, old straw, or have cobwebs across the entrance.

The Conibear trap (No. 110) with a 4½-by-4½-inch jaw spread is also an effective kill trap (Fig. 4). The wire trigger can be baited but is usually left unbaited. Place the trap directly in the burrow opening so the squirrel must pass through it, tripping the trigger. It may be necessary to partially fill in the burrow entrance around the outer edges of the trap with soil to prevent the squirrel from slipping around the outside of the trap. Closing all other burrows with soil may hasten success by directing the squirrel to the remaining open burrow with the trap. Attach the Conibear trap to a stake to prevent a scavenger from carrying off the trap

and squirrel. With this type of trap, leaving the trap baited but unset has little effect on trapping success.

Inspect traps at least once a day and remove dead squirrels. Do not handle the carcasses without protective gear. Use a plastic bag slipped over each hand and arm as a glove. Once the squirrel is removed from the trap, hold the animal with one hand and turn the bag inside out while slipping it off your arm and hand. If possible, keep small children and pets out of the area while traps are in use. In kit fox areas, spring all Conibear traps before nightfall and reset them the following morning.

Fumigation

Fumigation is a relatively safe method of control. As with any pesticide, *read and follow label instructions* with particular regard for nontarget species and safety factors. With some fumigants, flames may be produced, creating a fire danger. Do not use such fumigants where a significant fire hazard exists, such as near buildings, dry grass, or other flammable materials. To avoid the accumulation of fumes in enclosed areas, never fumigate beneath buildings or in burrows that may open under occupied buildings.

Be aware of the signs of nontarget species inhabiting inactive ground squirrel burrows. Kit foxes will use an old burrow, enlarging the opening, often creating a keyhole-shaped entrance. Active pupping dens may be littered with prey remains, droppings, and matted vegetation, and show signs of fresh paw prints. The burrowing owl (*Athene cunicularia*) is another potential occupant of abandoned ground squirrel burrows. Only fumigate active ground squirrel burrows; county agricultural commissioners can provide additional information on how to recognize these. Do not treat a burrow if you suspect a nontarget animal is present.

Many county agricultural commissioners' offices sell USDA gas cartridges,

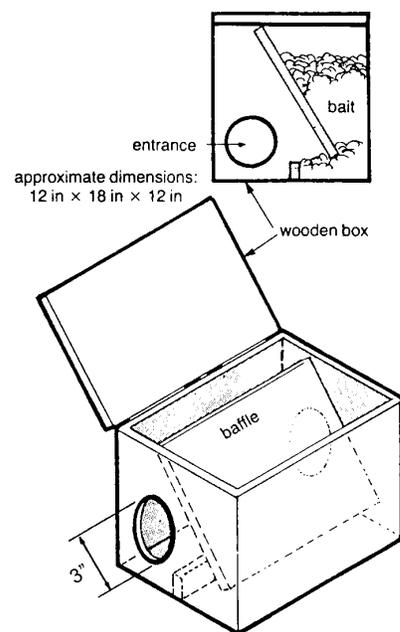


Figure 5. A bait box.

which are designed for fumigating burrowing rodents. Other types of fumigation cartridges are also available at retail outlets. Fumigation is most effective in spring or other times when soil moisture is high, which helps to contain the gas within the burrow system. Do not fumigate in summer or when the soil is dry because the gas more readily diffuses into small cracks present in dry soil. Do not fumigate during hibernation because the squirrel plugs its burrow with soil, preventing fumes from reaching the nest chamber. The plug cannot be seen by examining the burrow entrance.

Treat all active burrow systems when fumigating. When using a USDA gas cartridge, puncture the end with a nail or screwdriver at the points marked and rotate the nail to loosen the material inside. Insert the fuse into the center hole. Place the cartridge in the burrow as far as possible and light the fuse. With a shovel handle or stick, push the lighted cartridge down the burrow and quickly seal the opening with soil, tamping it down. Fill in connected burrows if smoke is seen escap-

ing. Larger burrow systems usually require two or more cartridges placed in the same or connecting burrow openings. After 24 hours, check for reopened burrows and re-treat as needed.

Toxic Baits

Anticoagulant baits, available at county agricultural commissioners' offices, are recommended for controlling ground squirrels. To be effective, anticoagulants must be consumed in several feedings over a period of 5 or more days. These features, as well as an antidote (vitamin K₁), make anticoagulant baits relatively safe for humans and pets. Keep pets out of treated areas, check the areas daily, and remove and dispose of any carcasses. Dogs are more likely to consume the pelletized cereal-based baits than the loose grain baits. Pelletized baits are prohibited in kit fox areas.

Anticoagulant baits can be used in bait boxes or by repeated spot baiting. Bait boxes are small structures that the squirrel must enter to eat the bait. Boxes contain sufficient bait for repeated feedings. They are the preferred baiting method around homes and other areas where children, pets, and poultry are present.

Unless a bait label specifies otherwise, bait boxes can be constructed from any durable material and in a variety of designs. If you design a bait box, make the entrance hole(s) about 3 inches across to allow access to squirrels but not to larger animals (Fig. 5). Construct a lip to prevent bait from spilling out of the box when squirrels exit. Provide a lock on the box or devise some other method that will make it difficult for children to open. Secure the bait box so it cannot be turned over or easily removed. A self-feeding arrangement insures that the pest gets a continuous supply of bait. Never fill a bait box with more than 5 pounds of bait.

Place bait boxes near runways or burrows. If squirrels are present over a large area, space the boxes at 100-

200-foot intervals. Initially, inspect bait stations daily and add bait as needed. Increase the amount of bait if all is eaten by the end of the day. Fresh bait is important; replace moldy or old bait. Do not use old, leftover bait. It may take a number of days before squirrels become accustomed to the bait box and enter it. Anticoagulant bait generally requires 2 to 4 weeks or more to be effective. Continue baiting until all feeding ceases and no squirrels are observed. While few ground squirrels will die aboveground, those that do should be picked up and disposed of as described in the section above on *Trapping* and in accordance with label directions. Also, pick up and dispose of unused bait (according to label instructions) upon completion of the control program.

Habitat Modification

Ground squirrels generally are found in open areas, although they sometimes use available cover. Remove brush piles and debris to make an area less desirable to ground squirrels. This also aids in detection of squirrels and their burrows, and improves access during control operations.

Ground squirrels can reinvade a site by moving into vacant burrows. Destroy old burrows by deep ripping them to a depth of at least 20 inches, using a tractor and ripping bar(s). Simply filling in the burrows with soil does not prevent reinvasion as ground squirrels easily find and reopen old burrows.

Other Control Techniques

Shooting squirrels with a .22 rifle may provide some control but is very time-consuming. Shooting is recommended only when it can be safely done in rural locations where squirrel numbers are very low. There are no effective frightening devices or repellents that will cause ground squirrels to leave their burrows or avoid an area or crop.

Natural Control

Many predators, including hawks, eagles, rattlesnakes, and coyotes, eat ground squirrels. In most cases, preda-

tors are not able to keep ground squirrel populations below the level at which they become pests for the home gardener. Dogs may prevent squirrels from entering small areas, but they cannot control established squirrel populations.

Follow-up

For those who live next to wildlands or other areas where squirrels are common, an ongoing control program will be necessary. Squirrels will reinvade over time. Once ground squirrels have been controlled, periodically monitor the area for reinfestation. Check for new burrows. Start control actions as soon as new squirrels are noticed. It is easier and less expensive to control a small population.

REFERENCES

- California Department of Pesticide Regulation. 1995. *Protecting Endangered Species: Interim Measures for San Joaquin Kit Fox*. Sacramento: Pestic. Regis. Branch, Pestic. and Toxic Substances H-7506. 13 pp. For online information, see <http://www.cdpr.ca.gov/docs/es/espdfs/sjkfall.pdf> or <http://www.cdpr.ca.gov/docs/es/espdfs/sjkfden.pdf>
- Clark, J. P. 1994. *Vertebrate Pest Control Handbook*. 4th ed. Sacramento: Div. Plant Industry, Calif. Dept. Food and Agric. 350 pp.
- Marsh, R. E. 1994. Belding's, California, and rock ground squirrels. In S. E. Hygnstrom, R. M. Timm, and G. E. Larson, eds. *Prevention and Control of Wildlife Damage*. Vol. 1. Lincoln: Univ. Neb. Coop. Ext. pp. B.151-158.
- Salmon, T. P. and R. E. Lickliter. 1984. *Wildlife Pest Control around Gardens and Homes*. Oakland: Univ. Calif. Agric. Nat. Res. Publ. 21385. 90 pp.
- Tomich, P. Q. 1982. Ground squirrels. In J. A. Chapman and G. A. Feldhamer, eds. *Wild Mammals of North America: Biology, Management, and Economics*. Baltimore: Johns Hopkins Univ. Press. pp. 192-208.

For more information contact the University of California Cooperative Extension or agricultural commissioner's office in your county. See your phone book for addresses and phone numbers.

AUTHORS: T. P. Salmon and W. P. Gorenzel
 EDITOR: B. Ohlendorf
 TECHNICAL EDITOR: M. L. Flint
 DESIGN AND PRODUCTION: M. Brush
 ILLUSTRATIONS: Fig 1: from T. P. Salmon. 1981. *Controlling Ground Squirrels Around Structures, Gardens, and Small Farms*. Univ. Calif. Div. Agric. Nat. Res. Leaflet 21179; Figs. 2, 3, 5: adapted from Salmon, T. P., and R. E. Licklitter. 1984. *Wildlife Pest Control Around Gardens and Homes*. Oakland: Univ. Calif. Agric. Nat. Res. Publ. 21385. Fig. 4: Seventeenth Street Studios

Produced by IPM Education and Publications, UC Statewide IPM Project, University of California, Davis, CA 95616-8620

This Pest Note is available on the World Wide Web (<http://www.ipm.ucdavis.edu>)



This publication has been anonymously peer reviewed for technical accuracy by University of California scientists and other qualified professionals. This review process was managed by the ANR Associate Editor for Pest Management.

To simplify information, trade names of products have been used. No endorsement of named products is intended, nor is criticism implied of similar products that are not mentioned.

This material is partially based upon work supported by the Extension Service, U.S. Department of Agriculture, under special project Section 3(d), Integrated Pest Management.

WARNING ON THE USE OF CHEMICALS

Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in the original labeled containers in a locked cabinet or shed, away from food or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.

Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits or vegetables ready to be picked.

Do not place containers containing pesticide in the trash nor pour pesticides down sink or toilet. Either use the pesticide according to the label or take unwanted pesticides to a Household Hazardous Waste Collection site. Contact your county agricultural commissioner for additional information on safe container disposal and for the location of the Household Hazardous Waste Collection site nearest you. Dispose of empty containers by following label directions. Never reuse or burn the containers or dispose of them in such a manner that they may contaminate water supplies or natural waterways.

The University of California prohibits discrimination against or harassment of any person employed by or seeking employment with the University on the basis of race, color, national origin, religion, sex, physical or mental disability, medical condition (cancer-related or genetic characteristics), ancestry, marital status, age, sexual orientation, citizenship, or status as a covered veteran (special disabled veteran, Vietnam-era veteran, or any other veteran who served on active duty during a war or in a campaign or expedition for which a campaign badge has been authorized). University policy is intended to be consistent with the provisions of applicable State and Federal laws. Inquiries regarding the University's nondiscrimination policies may be directed to the Affirmative Action/Staff Personnel Services Director, University of California, Agriculture and Natural Resources, 300 Lakeside Dr., Oakland, CA 94612-3350; (510) 987-0096.

VOLES (MEADOW MICE)

Integrated Pest Management for Home Gardeners and Landscape Professionals

Six species of voles of the genus *Microtus* occur in California. They are collectively called meadow mice or voles. Two species of voles are responsible for the majority of damage. The California vole (*Microtus californicus*) is the most widespread vole in the state, found in the Owens and Central valleys and nearly the entire length of the coast range. The montane vole (*M. montanus*) inhabits northeastern California and the eastern Sierra slope. Voles do not commonly invade homes, and should not be confused with the house mouse, *Mus musculus*.

Voles are intriguing small mammals because some populations regularly go through cycles from low to high numbers with occasional irruptions that can send numbers soaring (up to several thousand per acre).

IDENTIFICATION

Voles are mouselike rodents somewhat similar in appearance to pocket gophers (Fig. 1). They have a compact, heavy body, short legs, short-furred tail, small eyes, and partially hidden ears. The long, coarse fur is blackish brown to grayish brown. When fully grown they can measure 5 to 8 inches long, including the tail.

Although voles do spend considerable time aboveground and may occasionally be seen scurrying about, most of their time is spent below ground in their burrow system. The clearest signs of their presence are the well-traveled, aboveground runways that connect burrow openings (Fig. 2); the runways are usually hidden beneath a protective layer of grass or other ground cover. The maze of runways leads to

multiple burrow openings that are each about 1½ to 2 inches in diameter. The runways are easily found by pulling back overhanging ground cover. Fresh clippings of green grass and greenish-colored droppings about ¾ inch long in the runways and near the burrows are further evidence of voles. With age, the droppings lose the green coloring and turn brown or gray.

BIOLOGY AND BEHAVIOR

Voles are active day and night, year-round. They are normally found in areas with dense vegetation. Voles dig many short, shallow burrows and make underground nests of grass, stems, and leaves. In areas with winter snow, voles will burrow in and through the snow to the surface.

Several adults and young may occupy a burrow system. Home-range size varies with habitat quality, food supply, and population levels, but in most cases it is no more than a few hundred square feet.

Vole numbers fluctuate from year to year; under favorable conditions their populations can increase rapidly. In some areas their numbers are cyclical, reaching peak numbers every 3 to 6 years before dropping back to low levels. Voles may breed any time of year, but the peak breeding period is spring. Voles are extremely prolific with females maturing in 35 to 40 days and having five to ten litters per year. Litter size ranges from three to six. However, voles seldom live past 12 months of age.

Voles are mostly herbivorous, feeding on a variety of grasses, herbaceous

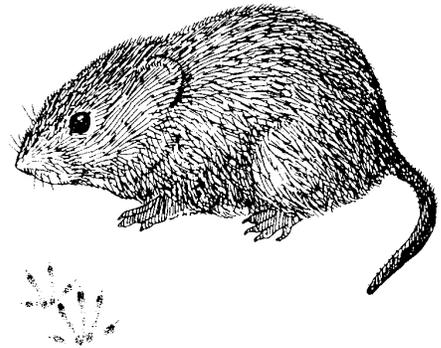


Figure 1. Meadow mouse.

plants, bulbs, and tubers. They eat bark and roots of trees, usually in fall or winter. Voles store seeds and other plant matter in underground chambers.

Voles are poor climbers and do not usually enter homes or other buildings. Instead, they inhabit wildlands or croplands adjacent to buildings, or gardens and landscaped sites with protective ground cover. Most problems around homes and gardens occur during outbreaks of vole populations.

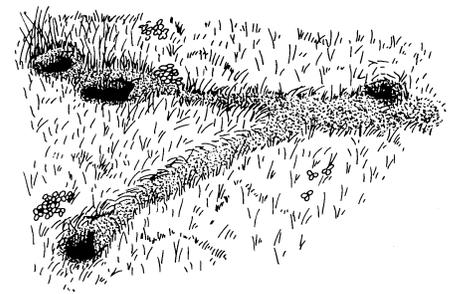


Figure 2. Runways, burrows.

DAMAGE

Voles cause damage by feeding on a wide range of garden plants including artichoke, beet, Brussels sprouts, cabbage, carrot, cauliflower, celery, lettuce, turnip, sweet potato, spinach, and tomato. Turf and other landscape plantings such as lilies and dichondra may be damaged. Voles will gnaw the bark of fruit trees including almond, apple, avocado, cherry, citrus, and olive. Vole damage to tree trunks normally occurs from a few inches above-ground to a few inches below ground. If the damage is below ground, you will need to remove soil from the base of the tree to see it. Although voles are poor climbers, if they can climb on to low-hanging branches they may cause damage higher up on trees as well.

Gnaw marks about $\frac{1}{8}$ inch wide and $\frac{3}{8}$ inch long found in irregular patches and at various angles, taken in conjunction with other signs (droppings, runways, and burrows), indicate vole damage. If voles gnaw completely around the trunk or roots, the tree's flow of nutrients and water will be disrupted; this is called girdling. Girdling damage on trunks and roots can kill trees. Signs of partial trunk or root girdling may include a prolonged time before young trees bear fruit, reduced fruit yield, abnormal yellowish leaf color, and overall poor vigor. Where snow cover is present, damage to trees may extend a foot or more up the trunk. Damage that occurs under snow cover often escapes notice until it is too late.

LEGAL STATUS

Voles are classified as nongame mammals by the California Fish and Game Code. Nongame mammals injuring or threatening growing crops or other property may be controlled at any time and in any legal manner by the owner or tenant of the premises.

MANAGEMENT

To prevent vole damage, you need to manage the population in an area before it reaches high numbers. This can

often be achieved by removing or reducing the vegetative cover, thus making the area unsuitable to voles. Removing cover also makes detecting voles and other rodents easier. It is important to act before vole numbers increase rapidly because the damage these animals do to ornamental and garden plants and trees can be quite severe.

Monitoring Guidelines

Be alert for the presence of voles. Look for fresh trails in the grass, burrows, droppings, and evidence of feeding in the garden and surrounding area. Pay particular attention to adjacent areas that have heavy vegetation because such areas are likely sources of invasions.

Habitat Modification

One way to effectively deter vole populations is to make the habitat less suitable to them. Weeds, heavy mulch, and dense vegetative cover encourage voles by providing food and protection from predators and environmental stresses. If you remove this protection, their numbers will decline.

You can reduce the base area from which voles can invade gardens or landscaped areas by regularly mowing, spraying with herbicides, grazing, or tilling grassy areas along ditch banks, right-of-ways, or field edges adjacent to gardens. If feasible, weed-free strips can also serve as buffers around areas to be protected. The wider the cleared strip, the less apt voles will be to cross and become established in gardens. A minimum width of 15 feet is recommended, but even that can be ineffective when vole numbers are high. A 4-foot-diameter circle around the base of young trees or vines that is free of vegetation, or a buffer strip 4 feet or more along a row of trees, can reduce problems because voles prefer not to feed in the open.

Exclusion

Wire fences at least 12 inches above the ground with a mesh size of $\frac{1}{4}$ inch or

less will help to exclude voles from entire gardens. These fences can either stand alone or be attached to the bottom of an existing fence (Fig. 3). Bury the bottom edge of the fence 6 to 10 inches to prevent voles from tunneling

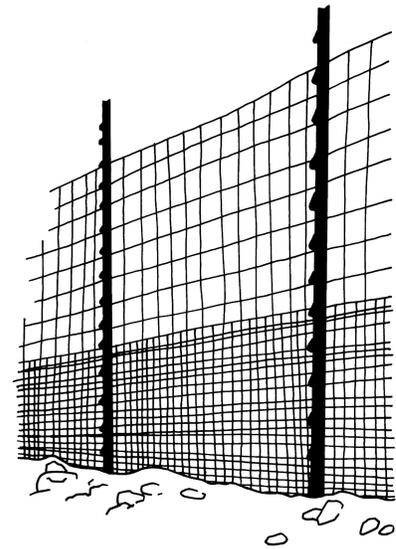


Figure 3. Wire fence.

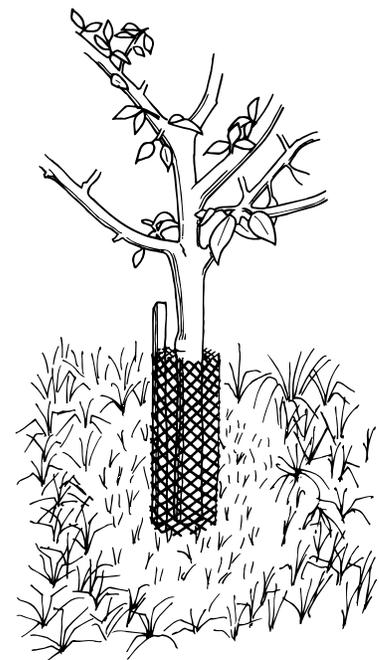


Figure 4. Trunk protection.

beneath it. A weed-free barrier on the outside of the fence will increase its effectiveness.

Young trees, vines, and ornamentals can also be protected from girdling with cylinders made from hardware cloth, sheet metal, or heavy plastic that surround the trunk (Fig. 4). Support or brace these devices so that they cannot be pushed over or pressed against the trunk. Also, make sure they are wide enough to allow for tree growth and, in areas with snow, are tall enough to extend above snow level. Bury the bottom of the protective device below the soil surface to prevent voles from digging under it. Individual milk cartons, tin cans, or plastic soda bottles can also be cut at both ends to fit over small plants. Be sure to *frequently* check protective devices to make sure meadow mice have not gnawed through or dug under cylinders and are hidden by the tree guard while they feed on the tree.

Trapping

When voles are not numerous or when the population is concentrated in a small area, trapping may be effective. Use a sufficient number of traps to control the population: for a small garden a dozen traps is probably the minimum number required, and for larger areas at least 50 or more may be needed. A simple, wooden mouse trap baited with a peanut butter-oatmeal mixture or apple slices is commonly used. Often, no bait is needed because voles will trigger the trap as they pass over it.

Trap placement is crucial. Voles seldom stray from their runways, so set traps along these routes. Look for burrows and runways in grass or mulch in or near the garden. Place baited traps at right angles to the runways with the trigger end in the runway. Examine traps daily and remove dead voles or reset sprung traps as needed. Continue to trap in one location until no further voles are caught, then move the trap to

a new location 15 to 20 feet away. Destroy old runways or burrows to deter immigration of new voles to the site.

Bury dead voles or place them in plastic bags in the trash. Because voles may carry infectious pathogens or parasites, do not handle them without rubber gloves; you can use a plastic bag slipped over your hand and arm as a glove. Once the vole is removed from the trap, hold it with your "bagged" hand and turn the bag inside out while slipping it off your arm and hand. Be sure to keep small children and pets out of the area where you have set traps.

Baiting

When voles are numerous or when damage occurs over large areas, toxic baits may be the quickest and most practical means of control. Take necessary measures to ensure the safety of children, pets, and nontarget animals; follow all product label instructions carefully.

Anticoagulants, often referred to as multiple-feeding baits, interfere with an animal's blood-clotting mechanisms, eventually leading to death. They are probably the safest type of rodent bait for use around homes and gardens because they are slow acting, must be consumed over a period of 5 or more days to be effective, and there is an effective antidote, vitamin K₁. Anticoagulant baits are available at many county agriculture commissioners' offices as well as at retail stores.

Some anticoagulants such as brodifacoum and bromadiolone cannot be used for voles because of the potential risk they pose to predators such as cats and dogs; check the label carefully to ensure that the bait has voles or meadow mice listed.

Because the pest must feed on anticoagulant baits over a period of 5 days, the bait must be available until the vole population is controlled. Usually bait-

ing every other day for three applications is effective. As with trapping, bait placement is very important. Place the recommended amount of bait in runways or next to burrows so voles will find it during their normal travels. Generally, spot treating (placing bait in a specific place, such as a runway) is the preferred method of baiting, but if there is a heavy ground cover or if the area to be treated is quite large, broadcasting might be a better option if the label allows it. When broadcasting bait, be sure to spread it evenly over the infested area. If you use this technique, you will probably have to broadcast every other day for a total of three or four applications.

Repellents

Commercial repellents are available for protecting plants from voles but their effectiveness is questionable and their use is often not practical. They must be applied before damage occurs. Voles usually damage plants at or just beneath the soil surface, making adequate coverage difficult or impossible. Do not apply repellents to food crops unless such use is specified on the product label.

Natural Control

Many predators, including coyotes, foxes, badgers, weasels, cats, gulls, and especially hawks and owls, eat voles. However, in most cases predators cannot keep vole populations below damaging levels. Many predators simply do not hunt close to homes and gardens where control is needed. Most predators have a broad-based diet and readily shift to alternative prey when the number of voles declines. Predators rarely, if ever, take every last vole; thus, a residual population remains. With their extremely high reproductive potential, any remaining voles could repopulate an area in a short period. With this potential for severe damage, a homeowner or gardener cannot afford to wait for a predator to appear, but must take immediate action to prevent the loss of valuable plantings.

Effective, immediate action usually involves baiting or trapping and habitat modification.

As with all animals, natural constraints limit vole numbers. Because populations will not increase indefinitely, one alternative is to do nothing and let nature limit the voles. Experience has shown, however, that around homes and gardens the natural population peak is too high and damage will be above tolerable limits.

Other Control Methods

Burrow fumigants are not effective for the control of voles because the vole's

burrow system is shallow and has numerous open holes. Electromagnetic or ultrasonic devices and flooding are also ineffective against voles.

REFERENCES

- Giusti, G. A. 1994. *Protecting Your Garden from Animal Damage*. San Ramon, Calif.: The Solaris Group. 96 pp.
- Ingles, L. G. 1965. *Mammals of the Pacific States: California, Oregon, Washington*. Stanford: Stanford Univ. Press. 506 pp.
- Johnson, M. L., and S. Johnson. 1982. Voles. In J. A. Chapman and G. A.
- Feldhamer, eds. *Wild Mammals of North America: Biology, Management, Economics*. Baltimore: Johns Hopkins Univ. Press. pp. 326-354.
- O'Brien, J. M. 1994. Voles. In S. E. Hygnstrom, R. M. Timm, and G. E. Larson, eds. *Prevention and Control of Wildlife Damage*, Vol. 1. Lincoln: Univ. Neb. Coop. Ext. pp. B.177-182.
- Salmon, T. P. and R. E. Lickliter. 1984. *Wildlife Pest Control around Gardens and Homes*. Oakland: Univ. Calif. Agric. Nat. Res. Publ. 21385. 90 pp.

For more information contact the University of California Cooperative Extension or agricultural commissioner's office in your county. See your phone book for addresses and phone numbers.

AUTHORS: T. P. Salmon and W. P. Gorenzel
 EDITOR: B. Ohlendorf
 TECHNICAL EDITOR: M. L. Flint
 DESIGN AND PRODUCTION: M. Brush
 ILLUSTRATIONS: Fig. 1: Anonymous;
 Fig. 2, 3, 4: Seventeenth Street Studios

Produced by IPM Education and Publications, UC Statewide IPM Project, University of California, Davis, CA 95616-8620

This Pest Note is available on the World Wide Web (<http://www.ipm.ucdavis.edu>)



This publication has been anonymously peer reviewed for technical accuracy by University of California scientists and other qualified professionals. This review process was managed by the ANR Associate Editor for Pest Management.

To simplify information, trade names of products have been used. No endorsement of named products is intended, nor is criticism implied of similar products that are not mentioned.

This material is partially based upon work supported by the Extension Service, U.S. Department of Agriculture, under special project Section 3(d), Integrated Pest Management.

WARNING ON THE USE OF CHEMICALS

Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in the original labeled containers in a locked cabinet or shed, away from food or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.

Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits or vegetables ready to be picked.

Do not place containers containing pesticide in the trash nor pour pesticides down sink or toilet. Either use the pesticide according to the label or take unwanted pesticides to a Household Hazardous Waste Collection site. Contact your county agricultural commissioner for additional information on safe container disposal and for the location of the Household Hazardous Waste Collection site nearest you. Dispose of empty containers by following label directions. Never reuse or burn the containers or dispose of them in such a manner that they may contaminate water supplies or natural waterways.

The University of California prohibits discrimination against or harassment of any person employed by or seeking employment with the University on the basis of race, color, national origin, religion, sex, physical or mental disability, medical condition (cancer-related or genetic characteristics), ancestry, marital status, age, sexual orientation, citizenship, or status as a covered veteran (special disabled veteran, Vietnam-era veteran, or any other veteran who served on active duty during a war or in a campaign or expedition for which a campaign badge has been authorized). University policy is intended to be consistent with the provisions of applicable State and Federal laws. Inquiries regarding the University's nondiscrimination policies may be directed to the Affirmative Action/Staff Personnel Services Director, University of California, Agriculture and Natural Resources, 300 Lakeside Dr., Oakland, CA 94612-3350; (510) 987-0096.

APPENDIX 4. Chemical Control of Burrowing Vertebrate Pests

Pocket gophers

See **Appendix 5, Signal Words for Pesticides**, on page A-3 for an explanation of the pesticide categories and signal words.

ACTIVE INGREDIENT	COMMENTS
Category III (CAUTION)	
Diphacinone (see label for formulation)	Anti-coagulant for all warm-blooded animals including humans. Reduces blood clotting and thins blood. Multiple doses needed over 2-week period. Bodies may die outside of burrow.
Zinc phosphide (see label for formulation)	<i>Restricted-use pesticide: for use only by certified applicators</i> except “products labeled only for home, structural, industrial, institutional or public agency vector control districts uses.” Mixed with water in the animal’s mouth and stomach it creates phosphine gas, which is toxic to all warm-blooded animals, including humans. Can be used in tunnels
Chlorophacinone (see label for formulation)	Anti-coagulant for all warm-blooded animals, including humans. Reduces blood clotting and thins blood. Multiple doses needed over 2-week period. Bodies may die outside of burrow.
Category II (WARNING)	
Sodium nitrate gas	Fire hazard from cartridge. Not effective for gophers because they plug holes so rapidly Recommended for ground squirrels, but user must diligently plug up holes
Zinc phosphide (see label for formulation)	See zinc phosphide above.
Chlorophacinone (see label for formulation)	See chlorophacinone above.
Category I (DANGER)	
Alkaloid strychnine	<i>Restricted-use pesticide: for use only by certified applicator</i> except “products labeled only for home, structural, industrial, institutional or public agency vector control districts uses.” (0.5% = homeowner use) Commercial bait (milo or hard wheat grain) not attractive to pocket gophers. Secondary poisoning danger. Check every three hours.
Aluminum phosphide	<i>Restricted-use pesticide: for use only by certified applicators.</i> Very effective in irrigated, medium-to-dense soil. Collect kickouts the same day Phosphine gas very toxic to all warm-blooded animals including humans. 90% kill with one treatment, two monthly follow-up treatments may be necessary for high populations

Burrowing Rodents—Appendix

Ground squirrels

Fumigation	<ul style="list-style-type: none"> ▪ Need high soil moisture (e.g., early spring) and distance from buildings ▪ Treat multiple entrances ▪ Don't fumigate during hot summer weather because adults aestivate (hibernate) and plug their burrows, preventing fumes from reaching them ▪ Relatively safe suffocating gas cartridge available through county agricultural commissioner's offices. No permit required for use. ▪ Toxic baits (rodenticides) are most effective in summer and fall because ground squirrels feed on seeds during this period. Use anticoagulants, which interfere with blood clotting, but be aware that these affect all warm-blooded animals.
Bait boxes	<ul style="list-style-type: none"> ▪ 2–4 week program requires daily inspection and fresh bait ▪ See Appendix 2 (UC IPM Pest Notes for ground squirrels) for details
Anticoagulants plus bait	<ul style="list-style-type: none"> ▪ Can be used in bait boxes
Broadcast baiting	<ul style="list-style-type: none"> ▪ Pelletized baits prohibited in kit fox areas

Voles

Toxic bait	<ul style="list-style-type: none"> ▪ Toxic baits often used when vole population is high and damage occurs over a large area
Anticoagulants plus bait	<ul style="list-style-type: none"> ▪ Available from many county agricultural commissioner's offices. Check label to see if use for voles is legal.
Repellents	<ul style="list-style-type: none"> ▪ Variably reliant; must be applied before damage occurs

Burrowing Rodents—Appendix

APPENDIX 5: Signal Words for Pesticide Products

Federal law and the acute toxicity data determine the signal words and precautionary statements that must appear on pesticide labels (40 Code of Federal Regulations 156.10). Always read pesticide labels thoroughly before using and be sure to follow label directions. Misuse of any pesticide is not only illegal, but may create a dangerous situation.

The signal word (see below) indicates the most severe level of anticipated acute (immediate) toxicity of the formulated pesticide product to humans based on at least one of five to six tests conducted with laboratory animals. The chronic (long-term) toxicity is not indicated on the label. Note that chronic toxicity may be important for pesticide products used frequently. You can obtain chronic toxicity information from several reputable sources such as U.S. EPA

(<http://www.epa.gov/iriswebp/iris/index.html>) or the National Pesticide Information Center (<http://npic.orst.edu>). Pesticide labels typically bear the warning “Keep out of reach of children.”

Signal Word	Toxicity category	Precautionary statements by toxicity category	
		Oral, inhalation or dermal toxicity	Skin and eye local effects
Danger—Poison Danger	I	Fatal (poisonous) if swallowed [inhaled or absorbed through skin]. Do not breathe vapors [dust or spray mist]. Do not get in eyes, on skin, or on clothing. [Front panel statement of practical treatment required]	Corrosive, causes eye and skin damage [or skin irritation]. Do not get in eyes, on skin, or on clothing. Wear goggles or face shield and rubber gloves when handling. Harmful or fatal if swallowed. [Appropriate first aid statement required].
Warning	II	May be fatal if swallowed [inhaled or absorbed through skin]. Do not breathe vapors [dust or spray mist]. Do not get in eyes, on skin, or on clothing. [Appropriate first aid statement required].	Causes eye [and skin] irritation. Do not get in eyes, on skin, or on clothing. Harmful if swallowed. [Appropriate first aid statement required].
Caution	III	Harmful if swallowed [inhaled or absorbed through skin]. Avoid breathing vapor [dust or spray mist]. Avoid contact with skin [eyes or clothing]. [Appropriate first aid statement required].	Avoid contact with skin, eyes or clothing. In case of contact, immediately flush eyes or skin with plenty of water. Get medical attention if irritation persists.
[No signal word]	IV	[No precautionary statements required]	[No precautionary statements required]

Burrowing Rodents—Appendix

If no signal word occurs on the label, then the product has the lowest toxicity category or contains active ingredients that are exempt from federal and California registration; however, it may cause slight skin or eye irritation.

Products you select must be registered or exempted from registration*. Note that some products are neither registered nor exempted, and are, therefore, illegal to use. If chemical control is necessary, select legal products with no signal word or with caution as a signal word when available.

*For information about products exempt from registration, see the California Notice to Registrants 2000–6, which is available at www.cdpr.ca.gov under Programs and Services, Registration Branch.

Examples

Category I → alkaloid strychnine

Category II → sodium nitrate gas

Category III → diphacinone (some formulations: check label)

Burrowing Rodents—Appendix

APPENDIX 6: Examples of Alternatives to Rodenticides not Covered in the Lesson Plan

Information adapted from Pest Notes: Pocket Gophers, UC ANR Publication 7433, revised January 2002. By T. P. Salmon, Wildlife, Fish, and Conservation Biology, UC Davis and W. P. Gorenzel, Wildlife, Fish, and Conservation Biology, UC Davis. See the main part of the *Lesson Plan for Burrowing Vertebrate Pests* for information on biological, physical, and cultural control (habitat management).

Flooding

Pocket gophers can easily withstand normal garden or home landscape irrigation, but flooding can sometimes be used to force them from their burrows.

Fumigation

Fumigation with smoke or gas cartridges is usually not effective because gophers quickly seal off their burrow when they detect smoke or gas. But if you are persistent with and use repeated treatments, some success may be achieved.

Repellents

No repellents currently available will successfully protect gardens or other plantings from pocket gophers. Plants such as gopher purge (*Euphorbia lathyris*), castor bean (*Ricinus communis*), and garlic have been suggested as repellents, but these claims have not been substantiated by research.

Frightening devices

Although there are many frightening devices commercially available to use on pocket gophers (vibrating stakes, ultrasonic devices, wind-powered pinwheels), pocket gophers do not frighten easily, probably because of their repeated exposure to noise and vibrations from sprinklers, lawnmowers, vehicles, and people moving about. Consequently, frightening devices have not proven to be effective.

Exploding devices

The Rodex 5000 injects a mixture of oxygen and propane into the underground tunnel system of gophers and ground squirrels. The gas is then ignited and the resulting blast instantly destroys the tunnel and any rodents within it.

Unlike toxic baits such as strychnine, the Rodex kills rodents immediately. However, repeated explosions are often necessary, and there have been some reports of grass fires and potential injury to applicators. At the event (shown right), a smoldering underground fire ignited by one of several Rodex explosions shot up through the hollow trunk of a heritage bay laurel tree. The fire burned for about an hour and damaged the tree.



Urban myths

Studies have not shown that chewing gum or laxatives placed in burrows will kill gophers.

Burrowing Rodents—Appendix

APPENDIX 7: School District Builds Nesting Boxes to Attract Gopher-eating Barn Owls

Reprinted from the Fresno Bee, December 26, 2003

SCREECHING TO A HALT: CLOVIS UNIFIED HOPES NESTING BOXES WILL ATTRACT OWLS TO EAT GOPHERS.

By Erin Kennedy

Like the turf-obsessed greenskeeper in “Caddyshack,” Doug Buchanan is at war with gophers that are ruining Clovis Unified’s playing fields, damaging \$35,000 school-district mowers with their mounds, and even biting students. Buchanan tried poisoning, trapping, drowning and flaming them out, just as Bill Murray’s movie character did.

Now, Clovis Unified’s pest manager is turning to a natural ally—the owl. Buchanan says this rodent controller could lighten his work load, be nearly cost-free, have no messy or dangerous side effects, and take care of a few other pests as well.

He’s putting up 12 nesting boxes at six Clovis schools in hopes of attracting owls. The first went up on a pole last week at Temperance-Kutner Elementary School. If even half the boxes attract owls, Buchanan figures he’ll be making a dent in the problem because gophers make up 65% of local barn owls’ diet.

Buchanan trapped about 400 gophers last year, most of them at the district’s rural schools. But the gophers are out-breeding his efforts. “I feel like I’m banging my head against a wall.” Buchanan describes his efforts: “We funnel propane and oxygen into the holes and light it. It shakes windows in the area and it does damage to the turf, but it opens up their [tunnel] system. “Traps are effective, but I have to stay close to them and monitor them and keep the kids away. I have a two- to three-hour window in the mornings, and I usually can get five to 10 gophers.” Buchanan got the idea for owls from a seminar this fall and after seeing nesting boxes in local farmers’ fields.

This newest rodent remedy has students and teachers excited and asking to help. Many hope to use the owls for science studies. Students in Clovis East High School’s agriculture-engineering classes built a few wooden owl boxes using Buchanan’s specifications.

Then student Katheryn Cehrs brought in a biology project she did on owls. “After hearing her, we decided we could build better boxes that are more family-oriented,” says Matt Actis, who teaches carpentry and welding skills. Students added a side wing with no outside entrance so baby owls will be protected from drafts. And the new boxes have perches for the owls to watch for prey.

On their sides, the redesigned boxes look like L’s with perches sticking out over the bases. If an owl drops its meal, the food will fall on the roof of the added-on room. “With this project, we integrated biology and engineering for integrated pest management,” Actis says. “I’m always trying to teach kids: If they can think in multiple disciplines, they’ll be ahead.”

Burrowing Rodents—Appendix

The owl project perfectly illustrates that concept, he says. Students aren't done. They're planning to study which design attracts owls first and to track how effective the owls are at ridding Clovis schools of rodents. Actis says the project mirrors how the agriculture industry is seeking alternatives to pesticides as a way to combat rodents, which consume 25% of grain worldwide. But, he says, using owls "isn't done elsewhere much."

Fifth-graders in Chip Welter's class learned last week how much and what an owl can eat. The Temperance-Kutner students carefully picked apart regurgitated owl pellets to find mouse, vole, rat and gopher bones, bits of feathers and lots of fur.

"Look at this!" exclaimed 11-year-old Kellie Millard, holding up a tiny skull pointing out rows of back teeth and two long incisors. Reluctant at first, Kellie had become enthusiastic about picking through the digested remains. "I thought at first they came out the other end, and I didn't want to touch them."

Welter told the class that the pellets, collected in western Fresno County, had been spit out. "After years of observing, I've found that the color of the casting can indicate how much food the owl has available," Welter says. "Darker pellets mean more food. Pellets near Dos Palos at Eagle Field are real dark and mushy. But when I go out to Kearney Park, I get gray pellets, and they're almost dry."

Welter explains: Owls have two stomachs. When food is plentiful, it doesn't stay long in the second stomach where nutrients are extracted. About 12 hours after eating, the undigested bits are regurgitated, much like a cat coughs up a fur ball. Welter and other teachers now hope to collect those pellets from their playgrounds for class study.

Owls are very effective hunters, faster than most birds, with wings designed for silent swooping, acute hearing, sharp talons and the largest eyes of any bird—good for seeing tiny, moving prey at night. "Owls will eat anything small and crawling on the ground that they can get down in one piece," Welter says. "And owls can eat one and a half times their weight every day."

It's estimated that a barn owl family with six owlets may eat as many as 1,000 rodents during a 10-week nesting period. That's what school officials are counting on. Fernando Avina, 11, knows why this is a good way to get rid of pests. "If you poison gophers, the owls will eat them and die." A recent California law prohibits schools from using poisons or pesticides that could also harm children [sic].

Attracting owls is Buchanan's best hope for winning the battle with gophers. And the barn owls' eerie hiss-screams and high-pitched shrieks over school yards would be music to his ears.