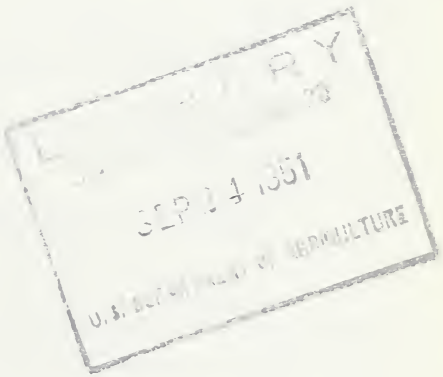
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The Dalles Pocket Gopher and Its Influence On Forage Production of Oregon Mountain Meadows

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CONTENTS

POCKET GOPHERS ON MOUNTAIN MEADOWS

Pocket gophers abound in many places throughout western range lands. They inhabit many types of range and are especially common on meadows in the mountainous areas of the West. Mountain meadows, generally of higher grazing value than other western range types, are in many stages of range condition. Some meadows, which produce principally annual weeds and grasses,[2] are seriously depleted. Their grazing capacities are as low as 0.1 or less animal-unit month per acre (5).[3 4]

[1] Mr. Moore conducted the rodent phases of the study and Mr. Reid the plant and forage evaluations. Mr. Reid was then on the staff of the Pacific Northwest Forest and Range Experiment Station, Portland, Oreg.

[2] Common and scientific names of plants and animals mentioned are listed on p. 35.

[3] One animal-unit month as used here is equivalent to 1 month's grazing by 1 cow or 5 sheep.

[4] Numbers in parentheses refer to Literature Cited, p. 34.

Others support denser stands of perennial grasses and forbs or weeds and have per acre grazing capacities as great as two or more animal-unit months. Pocket gopher numbers on these mountain meadows vary from a few widely scattered individuals to dense populations. The presence of a few scattered gophers is not always apparent to a casual observer, but dense populations can be easily recognized by the numerous soil mounds (fig. 1).

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FIGURE 1.—Part of a mountain meadow in eastern Oregon, showing Dalles pocket gopher soil mounds. Pocket gophers are active all year, but their presence is usually more noticeable in the fall when herbage has been grazed and the soil is moist.

Many range technicians, stockmen, and others concerned with range management have long advocated the control of pocket gophers, because they believe that the gophers cause poor forage condition on meadows. Some believe that pocket gophers become more abundant as a range deteriorates from good condition and the perennial grasses are replaced by annual weeds and perennial forbs.

Other observations also point to the need for gopher control. As it is known that gophers eat both the tops and the roots of many plants, it may be concluded that on a heavily grazed meadow they consume forage needed by livestock. Greater net returns from hay fields, orchards, gardens, or fields of row crops where gophers have been controlled strengthen this conclusion. Soil mounds of the gopher cover up forage that could be used by livestock and big-game animals, and cause some

plants to die. Close inspection of an infested range may reveal gullies where gopher runways have been caved in by livestock, as well as sheet erosion where roots of grass clumps are exposed.

On the other hand, pocket gophers are of positive as well as negative value. Gopher activity results in better aerated, looser, and more thoroughly tilled soils. The earthworm has been noted for similar activities in soil formation. Darwin (*3*) found that earthworms may bring up enough soil to cover the ground 1 inch thick in 5 years. Somewhat parallel is the observation by Seton (*7*) that in some places pocket gophers completely plow the surface of the land, turning it all over at least once in 2 years. The desirability of such active soil disturbance may be questioned. Soil displaced by pocket gophers on subalpine range in 1 year, according to Ellison (*4*), covered 3.5 percent of the ground surface.

Pocket gopher control on western mountain meadow ranges began as an experiment on the Ochoco National Forest in 1914, when the gophers were reported to be destroying grass sod on meadows. The following year control work on western ranges was organized on a project basis and continued until World War II. Results of gopher control on the Ochoco and in other sections of the West have not been clearly determined, and the need for control has often been questioned.

METHODS OF STUDY

To develop a basis for judging the need for pocket gopher control and the results to be expected from it, a cooperative study was made by the Fish and Wildlife Service and the Forest Service from 1931 through 1948. The life history of the Dalles pocket gopher was studied, as well as the effect of gophers on the composition, density, and value of mountain meadow vegetation.

The life history study consisted of (1) the excavation or partial excavation over the 17-year period of about 200 burrow systems to observe burrow construction, food storage, and nesting habits; (2) examination of 97 specimens for weight and size, and of 154 specimens for sex ratio; and (3) feeding trials with 5 pocket gophers to determine the amount of plant material they would consume and their relative preference for 9 common native plant species.

The study of the effect of the Dalles pocket gopher on vegetation was conducted on two adjacent mountain meadows, separated by a running stream, on the Ochoco National Forest in the Blue Mountains of eastern Oregon (fig. 2). The meadows were typical of depleted mountain meadows in eastern Oregon, and both appeared to have a heavy pocket gopher population. The meadows were in poor range condition, because sheep from a nearby stock driveway had grazed them heavily for many years. The driveway was moved in 1931, and from then until the end of the study the meadows were grazed by sheep as part of a regular national forest allotment. About 30 deer used the meadows during the first years of the study, but their numbers were greatly reduced toward the end.

To study the effect of the presence or absence of pocket gophers on range vegetation, four similar quarter-acre plots were marked out, two on meadow A and two on meadow B. One plot in each pair was fenced against sheep and deer; the other was left open to grazing. The four plots were treated as follows:

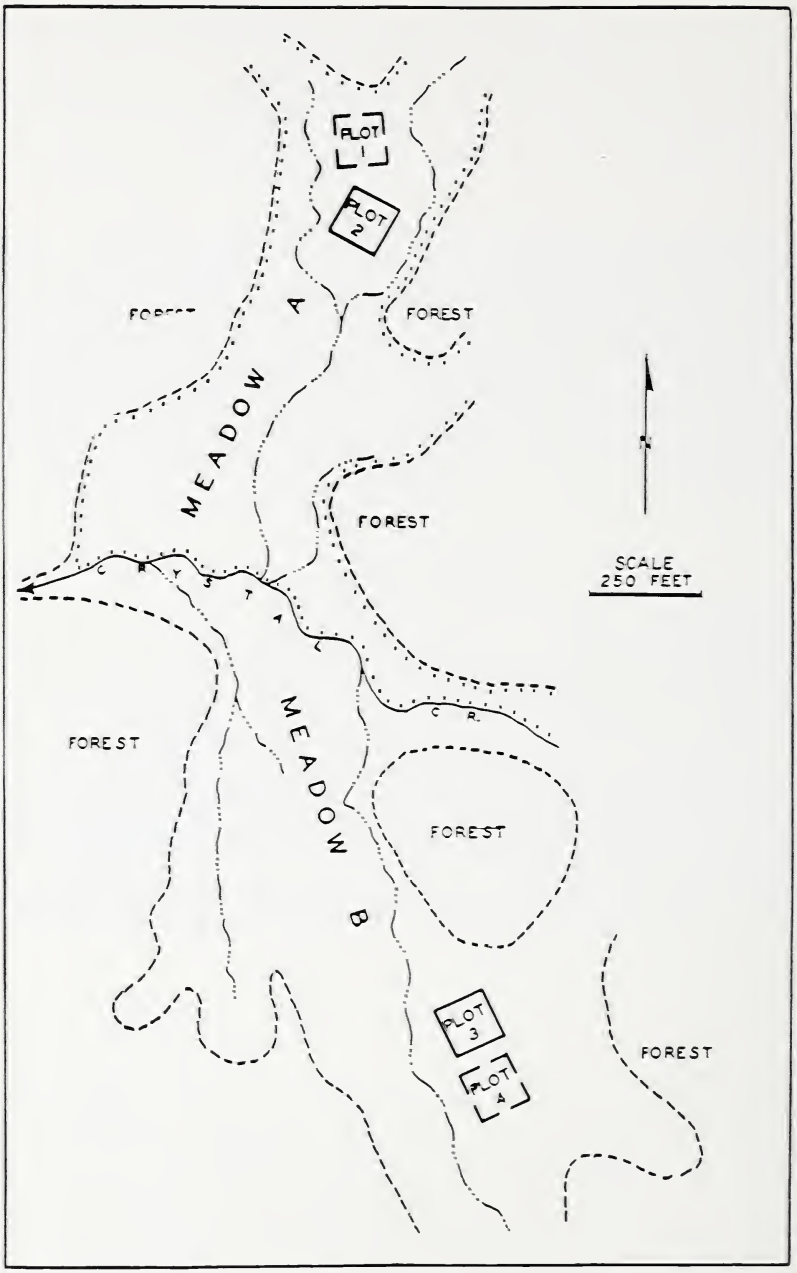

FIGURE 2.—Lay-out of meadows studied on Ochoco National Forest. Invasion of gopher-free area from the infested area was minimized by distance between gopher-free and gopher-infested plots, partial barrier afforded by Crystal Creek, and yearly trapping and poisoning.

Plot 1, meadow A.—Grazed area free of pocket gophers from fall 1931 until 1940. Gophers reintroduced in 1940 at the rate of 16 per acre and kept there for the remainder of the study. The number reintroduced was sufficient to form a gopher population which was average for Oregon meadows.

Plot 2, meadow A.—Ungrazed area freed of pocket gophers from fall 1931 until 1940. Gophers reintroduced during 1940 as in plot 1 and kept for the remainder of the study.

Plot 3, meadow B.—Grazed area with pocket gophers from 1931 until 1940 and then freed of the gophers for the remainder of the study.

Plot 4, meadow B.—Ungrazed area with pocket gophers from 1931 until 1940 and then freed of the gophers for the remainder of the study.

From 1932 through 1940 photographs were taken every 2 years of eight quadrats permanently staked at random on each of the four plots, and the plant species there were recorded. This record furnished qualitative information on vegetation composition or change.

Beginning in 1940, and for the remainder of the study,[5] estimates of vegetation density were made on the 4 plots by averaging density on 16 permanently staked 100 square-foot circular samples. Density was determined for each species by the square-foot-density method (*8*). This made possible quantitative comparison of vegetative changes on the plots from 1940 to 1948, inclusive. Photographing the 8 quadrats on each plot was continued until the close of the study.

Throughout the study, meadows A and B were kept practically free of all rodents, other than pocket gophers, by poisoning. The rodents, principally Oregon ground squirrel and meadow mouse, were kept at a minimum so as to restrict the effect of the mammal population on the meadows to pocket gophers, sheep, and deer.

THE DALLES POCKET GOPHER

The Dalles pocket gopher[6] is a robust animal, with a short neck and short legs (fig. 3). Average body length of the adult male is 5.6 inches; its sparsely haired tail is 2.6 inches long; and its hind feet, 1.08 inches long. The average October weight of 33 adult males was 107.8 grams; the largest one weighed 138.8 grams. Thirty-eight females had an average weight of 84.8 grams, the largest weighing 113.3 grams. Young gophers develop rapidly—the average weight of 26 October specimens between 5 to 6 months old was 70.8 grams, with the greatest weight 92.7 grams.

The coloring of the soft hair of the Dalles pocket gopher is alike in both sexes. In the summer the upper parts of the animal are light russet, the nose and the area around the ears are blackish, and the tail is brown with a nearly white tip; its belly is buff and more lightly furred than the upper parts. The skin is so loose that it gives the impression that the animal can turn within it or that it is suitable for a larger animal. Young gophers[7] are of a lighter shade than the adults, and their pelage

[5] Estimates were made on all plots when the Kentucky bluegrass was in the boot—in 1940, 1943, 1945, 1946, 1947, and 1948.

[6] For a discussion of the habits and economic status of pocket gophers generally, see (*1*) and (*6*).

[7] Newborn gophers are helpless, hairless, and gray. They emit tiny squeaks, the only vocal sound the gopher ever makes.

FIGURE 3.—The Dalles pocket gopher.

has a ragged appearance. Fur-lined cheek pouches, into which one may easily place a thumb, on each side of the jaws, are used for carrying food. They extend from immediately back of the incisors to just in front of the ears. The dental arrangement is incisors $\frac{1}{1}$, canines $\frac{0}{0}$, premolars $\frac{1}{1}$, molars $\frac{3}{3}$ =20. As in all rodents, the incisors grow continuously from the base.

RANGE

The range of Dalles pocket gopher in relation to that of other kinds of pocket gophers in Oregon is shown in figure 4. Dalles pocket gopher is relatively common in most of the sagebrush plains and bordering mountain areas of eastern Oregon. Its range extends into northwestern Nevada, northeastern California, and southern Washington. This gopher is most abundant along streams and in valley bottoms, especially on meadowlands where there is some moisture and green vegetation, and is absent from wide stretches of arid uplands. It prefers the more open places and shuns densely forested areas. As the forests are opened up by logging, however, the pocket gophers move into them.

BURROWING HABITS

The Dalles pocket gopher lives in a burrow made up of underground runways and cavities. Where snow persists burrow systems may be extended above the ground into the snow. Usually each adult gopher has its own burrow system, not connected with those of its neighbors.

Runways are 2 to 3 inches in diameter and vary up to several hundred feet in length. Main runways are roughly parallel to the ground surface,

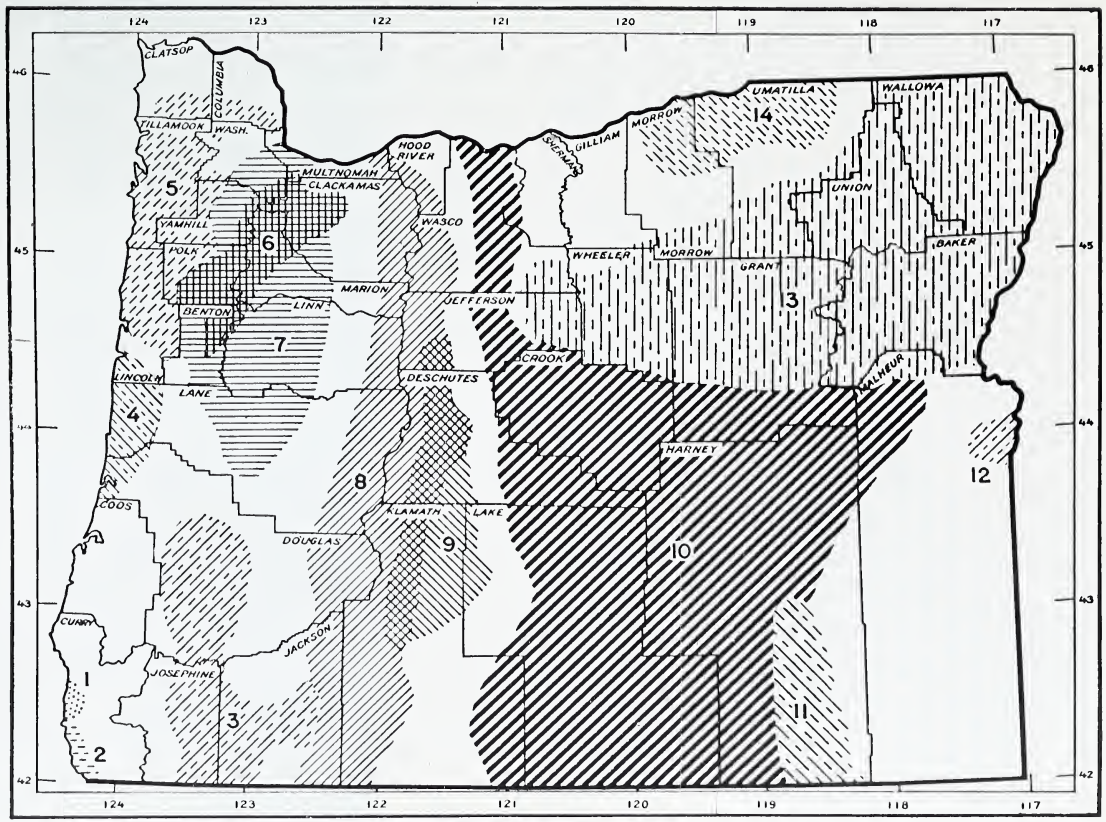

FIGURE 4.
Recorded distribution of pocket gophers in Oregon.

1. Heller's.
2. Humboldt Bay.
3. White-toothed.
4. Black.
5. West coast.
6. Oregon.
7. Willamette Valley.
8. Mazama.
9. Deschutes.
10. Dalles.
11. Nevada.
12. Townsend's.
13. Brown.
14. Columbia.

at a depth usually of 4 to 8 inches, although they may be shallower or deeper. Feeding tunnels are relatively near the ground surface. In sparsely vegetated areas, where extensive digging is required to obtain adequate food, feeding tunnels are more numerous and extensive than where vegetation is plentiful. Such activity tends to give the appearance of a heavier gopher population than actually exists.

Each burrow system contains one or more nest cavities 4 to 6 inches in diameter. Runways adjoining these cavities are deeper than the feeding runways, their depth varying with individual gophers, drainage, and the soil profile. A vertical shaft extends from the feeding runways downward, usually 1½ to 2½ feet, but sometimes 5 feet or more, to the cavities. Cavities usually have more than one entrance near the vertical shaft. The nest itself is made of finely shredded dead grass and weed stalks in the form of a pad on the cavity floor. Occasionally hollow balls of shredded material are used as nests in the snow. The pocket gopher is an excellent housekeeper and does not leave refuse in the runways. Small pockets or cavities near the nests are used as middens where undesired food particles and fecal matter are deposited.

The gopher digs with its front feet and, where the soil is exceptionally hard, with its teeth, occasionally leaving incisor marks on pieces of the softer stones. As it digs its extensions, it pushes the dirt behind it in the tunnel. Later it removes this excavated dirt through a short gentle-slope tunnel that opens on the surface of the ground. In the process, it uses its head and shoulders in bulldozerlike manner, pushing the loose dirt ahead of it. Sometimes it uses its front feet to put the dirt on the

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FIGURE 5.—Dalles pocket gopher at entrance to burrow, around which a medium-sized soil mound has been built.

mound. In the tunnels, it can travel backward as fast as forward, its thinly haired tail, with a rather blunt tip, acting as a feeler.

Mounds vary in size from small repair plugs in the mouth of the holes to piles containing more than a bushel of soil (fig. 5). Where snow persists, tunnels are forced through it. These are often filled with excavated dirt, which remains in the form of casts or ropes when the snow disappears. In the looser soils gophers may force their way through and seldom make mounds.

As evidenced by soil mounds, the Dalles pocket gopher is more active in the fall than in the spring. This may be due partly to the relative scarcity of succulent forage during the late season, which makes active burrow extension necessary to obtain food, and partly to the fact that the season's young are also active. The Dalles pocket gopher excavates very little in soil that is wet and soggy, differing in this respect from the Willamette Valley pocket gopher of western Oregon, which sometimes rolls small mud balls out to form mounds.

When young gophers are slightly more than half-grown they build living quarters of their own by burrowing off from the parent system. At first their mounds appear helter-skelter and are quite small, but after several weeks, they are difficult to distinguish from those of an adult.

Reproduction

The principal breeding season of Dalles pocket gophers is spring and early summer, the beginning coinciding with the emergence and development of spring vegetation. For example, of 32 females examined from May 1 to 10, 1934, 17 were carrying young, 3 had recently given birth to young, and 12 were in breeding condition. Of the many gophers trapped on the study area, none was found to be breeding in late summer or early fall.

The average number of young, as determined from counts of uterine sacks and scars, was 6.6. The greatest number was 10 and the smallest 5. This checks closely with earlier work by Wight (*9*), who found an average of 6.5 fetuses per pregnant female. Wight found actual litters of 2, 3, and 4 most common. During excavation work in this study one litter of 4 half-grown gophers was uncovered.

The general rate of increase may be rather low for rodents, but 26 of a group of 97 gophers fall-trapped on the study area were current year's young. The sex ratio of males to females was found to be 1:1.5. The young reproduce the year following birth.

Feeding Habits

The gopher is more active at night than during the day, most of the feeding runways being extended then. During spring, summer, and fall it forages both under and above ground; in winter it includes burrowing through the snow in its foraging habits. It feeds mainly on surface vegetation in the immediate vicinity of the opened side runways and on fleshy roots and underground stems. Plants near the burrow entrances are cut off, dragged into the runways, and consumed there. Others are

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cut into small pieces, placed in the cheek pouches with the front feet, carried to the nest, and eaten there. Stores or caches of food are seldom made by this gopher.

The pocket gopher probably eats most of the succulent plant species growing in its range. Observations, however, showed definite preferences for some of the more common broadleaved plants. Roots of common dandelion are probably this gopher's favorite food. Other underground parts favored include those of bluegrasses, oniongrasses, yampa, American bistort, and agoseris, often called mountain dandelion. Bulbs of onions, yellow fritillary, lambstongue fawnlilly (dogtooth violet), and brodiea are readily taken. The gopher also feeds on young pines, quaking aspen, and other trees and shrubs in its foraging range. Use of the woody-type food, however, is more prevalent under cover of snow.

To determine how much food a gopher will consume, five caged Dalles pocket gophers were fed freshly harvested native plants, sweetpotatoes, and carrots for a 3-day period. The average daily food consumption per gopher was 71.25 grams green weight (table 1). This empirical figure for the amount of forage consumed by pocket gophers is not a measure of their total drain on vegetation. Much of a plant that the animal cuts into small pieces for stowing in its cheek pouches is wasted. Unconsumed plants often die when their roots are cut by burrowing gophers.

TABLE 1.—*Food consumption of five caged Dalles pocket gophers for a 3-day period, June 14–16, 1938*

Date of feeding and plants fed[1]	Amount fed per gopher	Green weight of vegetation consumed by—					
		Gopher No. 1	Gopher No. 2	Gopher No. 3	Gopher No. 4	Gopher No. 5	Average
June 14, 9 a. m.:	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*
Common dandelion	10	8.5	7.8	9.4	9.1	8.3	8.62
Vetch	10	8.9	7.8	7.8	8.8	8.1	8.28
Lupine	10	4.3	6.4	5.9	6.0	7.4	6.00
June 14, 4 p. m.:							
Vetch	20	19.6	20.0	19.9	19.7	19.9	19.82
Groundsel	20	20.0	20.0	20.0	17.9	20.0	19.58
Carrotleaf leptotaenia	20	17.8	20.0	18.6	15.8	19.2	18.28
June 15, 10 a. m.:							
Groundsel	20	10.0	10.8	11.4	7.3	12.8	10.46
Agoseris	20	6.6	11.3	11.0	11.7	8.6	9.84
Western yarrow	20	5.7	5.4	6.2	7.7	4.4	5.88
June 15, 6 p. m.:							
Common dandelion	30	30.0	30.0	30.0	30.0	29.6	29.92
American bistort	30	8.6	24.6	24.4	20.1	6.7	16.88
Cinquefoil	20	6.6	5.5	5.7	8.1	12.2	7.62
June 16, 1 p. m.:							
Vetch	40	7.6	13.9	9.9	9.3	7.0	9.54
Common dandelion	40	17.7	15.2	19.1	11.3	14.1	15.48
June 16, 7 p. m.:							
Sweetpotato[2]	50	15.4	13.3	11.0	13.2	9.6	12.50
Carrot (roots only)	50	21.6	11.0	19.4	14.6	8.6	15.04
Average	—	69.6	74.3	76.6	70.2	65.5	71.25

[1] With the exception of the last feeding, all materials consisted of plant tops.
[2] Animals were fed sweetpotatoes for several days prior to test.

INFLUENCE OF POCKET GOPHERS ON PLANT DENSITY AND COMPOSITION

Pocket gophers affect plant composition in many ways. Perhaps the most important effect results from eating the plants themselves. Gophers gradually remove favored food plants from the vegetation, and these are replaced by other plants, usually less attractive to the gophers. They take not only the older established plants but also the young plants and shoots, preventing them from becoming established. A second major effect results from covering the vegetation with soil excavated from runways. The covered vegetation is either weakened or killed. On the other hand, the mounds offer barren areas of good seedbed on which other plants, usually annuals and often unwanted, can become established. This results in a constant fluctuation of vegetation on gopher-infested areas. Other effects include the influence of gopher tillage on tilth, aeration, and other soil factors. The burrows provide avenues for water percolation. Abandoned gopher runways furnish housing for other herbage- and seed-eating mammals, such as meadow mice and white-footed mice.

Vegetation at Start of Study in 1931

The vegetation on the two meadows studied was similar at the start of the experiment (figs. 6 and 7), and it was relatively sparse for meadow vegetation. Agoseris, littleflower collinsia, common dandelion, little oniongrass, Kentucky bluegrass, violet, and western yarrow were prominent on both meadows. A few species were prominent on one meadow and not on the other. Those prominent only on meadow A were cinquefoil and great straightbeak buttercup. Those prominent only on meadow B were wild onion, American bistort, longstalk clover, and bicolor biscuitroot. Similarity of vegetation on meadows was the result of heavy grazing and trampling by large numbers of driveway sheep before the study was begun. The meadows were depleted to the point where they were in poor range condition (*5*) and were low in grazing capacity.

Vegetation in 1940 on Gopher-Free Meadow

In 1940, after 9 years of gopher control, the vegetation on meadow A was relatively dense (fig. 8). On the plot where sheep and deer grazing had been excluded, the vegetation density had increased to 25 percent; that is, the vegetation covered one-fourth of the soil surface (table 2). The vegetation was predominantly perennial forbs—71 percent—and perennial grasses—26 percent. Annual weeds made up only 2 percent of the plant cover, and annual grasses were absent. One percent of the vegetation was rushes.

Among the predominant species on the ungrazed plot were many of high forage value to sheep, particularly on meadows. These included slender wheatgrass, Kentucky bluegrass, agoseris, Oregon checkermallow, common dandelion, and cinquefoil. Also important in the vegetation were red fescue, mountain brome, and western yarrow, species of moderate value as sheep forage, and small bluebell, a species of little value. The vegetation on this plot in 1940, having a predominance of

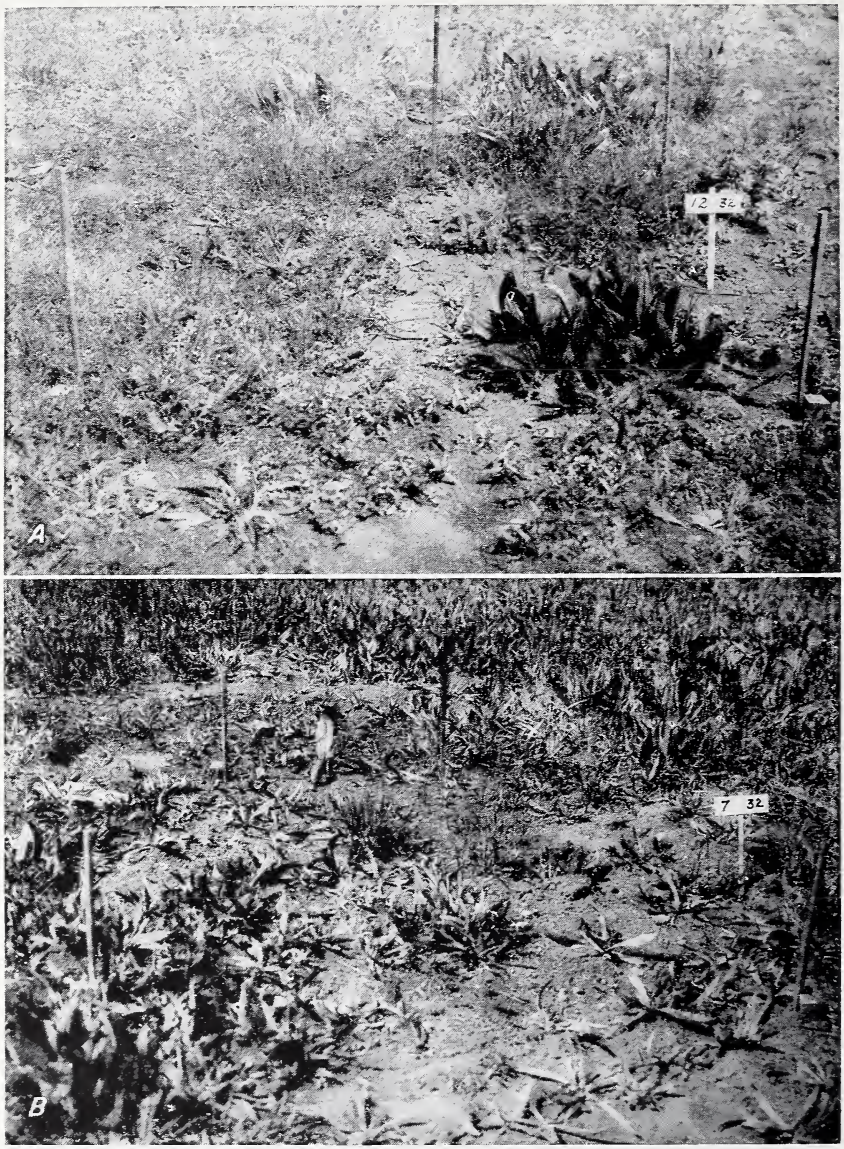

FIGURE 6.—Meadow A in 1932, gopher free: *A*, Ungrazed plot; *B*, grazed plot. The vegetation on both plots was sparse; it was composed principally of perennial forbs.

perennial forbs and grasses, was in a grass-weed stage of meadow succession, a stage that is considered to be fair range condition.

The vegetation on the plot grazed by sheep and deer on gopher-free meadow A was very similar to that on the ungrazed plot. Average density of the vegetation had also increased until it was 26.32 percent, about the same as the 25.00 percent density on the ungrazed plot. Perennial forbs

B—58174, B—58179

FIGURE 7.—Meadow B in 1932, gopher infested: *A*, Ungrazed plot; *B*, grazed plot. The vegetation on these plots, like that on meadow A, was sparse and composed principally of perennial forbs.

or weeds predominated, making up 65 percent of the vegetation; perennial grasses made up 29 percent; rushes, 4 percent; and annual weeds, 2 percent.

B—59388, B—59383

FIGURE 8.—Meadow A after 9 years of gopher control: *A*, Ungrazed plot; *B*, grazed plot. A relatively dense stand of perennial forbs and grasses had become established. (Same quadrats shown in fig. 6.)

Individual species differed somewhat in amount on the grazed and ungrazed plots. Kentucky bluegrass, common dandelion, and Columbia groundsel, species of high forage value as sheep forage on meadows, and little oniongrass, fleabane, and Wyethia, species of low value as sheep forage, were more abundant on the grazed plot than on the ungrazed

plot. Slender wheatgrass, Oregon checkermallow, cinquefoil, and western yarrow, species of moderate to high value as sheep forage, were more abundant on the ungrazed plot than on the grazed plot. However, the character and value of the vegetation on both plots was very similar, both areas having improved from a poor to a fair range condition.

TABLE 2.—*Average density[1] of vegetation by class and species in 1940 on meadow A, gopher-free from 1931 to 1940, and on gopher-infested meadow B*

Class and species	Gopher-free meadow A		Gopher-infested meadow B	
	Ungrazed plot	Grazed plot	Ungrazed plot	Grazed plot
	Percent	*Percent*	*Percent*	*Percent*
Perennial grasses:				
Bluegrass, Kentucky	1.69	2.00	0.06	0.62
Bluegrass, Sandberg	.03	.44	—	—
Brome, mountain	.97	.16	—	.19
Fescue, red	1.44	1.65	—	.44
Needlegrass, Lemmon	.56	.41	(2)	.12
Oniongrass, little	.28	2.25	.09	.31
Wheatgrass, slender	1.47	.22	.16	.38
Other	—	.41	.34	.72
Total	6.44	7.54	.65	2.78
Annual grasses	—	—	.19	1.00
Rushes	.22	1.18	—	—
Annual weeds:				
Collinsia, littleflower	.09	.22	(2)	.12
Tarweed, cluster	—	—	6.63	2.31
Other	.40	.28	2.00	.03
Total	.49	.50	8.63	2.46
Perennial forbs or weeds:				
Agoseris	2.63	2.41	.66	1.22
Aster	.78	.31	—	—
Biscuitroot, bicolor	—	—	1.00	.72
Bistort, American	—	—	2.22	5.70
Bluebell, small	2.95	2.34	.25	—
Buttercup, great straightbeak	.03	.50	—	—
Checkermallow, Oregon	2.97	(2)	.16	.06
Cinquefoil	3.38	.22	—	.03
Clover, longstalk	—	(2)	.19	1.03
Dandelion, common	1.62	2.25	(2)	1.16
Fleabane	—	3.01	—	—
Groundsel, Columbia	.03	1.06	.06	.84
Penstemon, royal	.03	.19	.03	—
Vetch	.16	.44	.09	—
Violet	.62	.31	(2)	(2)
Wyethia, whitehead	.16	2.44	—	—
Yarrow, western	2.00	.97	.84	.72
Other	.49	.65	.12	.25
Total	17.85	17.10	5.62	11.73
All vegetation	25.00	26.32	15.09	17.97

[1] Square feet per hundred of ground covered.

[2] Less than 0.005.

Vegetation in 1940 on Gopher-Infested Meadow

In marked contrast with the rather desirable conditions on gopher-free meadow A in 1940 were those of meadow B, where pocket gophers had been allowed to remain from 1931 until 1940 (fig. 9). On the un-

B—59423, B—59428

Figure 9.—Meadow B after 9 years of gopher infestation: *A*, On the ungrazed plot the perennial forbs are drastically thinned, and annual weeds, especially cluster tarweed, greatly thickened; *B*, on the grazed plot there is a thinner stand of perennial forbs and more annual weeds. (Same quadrats shown in fig. 7.)

grazed plot in this meadow the average density of all vegetation was only 15.09 percent. The vegetation consisted of 57 percent annual weeds, 37 percent perennial forbs or weeds, and 4 percent perennial grasses. It also contained 1 percent of annual grasses. Species of high forage value were present in very minor amounts.

The principal species on the ungrazed plot was cluster tarweed, an annual that is very abundant on badly depleted meadows of the western mountain ranges and is worthless as forage for sheep. Tarweed alone made up 44 percent of all the vegetation. This plant first became apparent in 1935 and quickly established itself in abundance. Other species of annual weeds were also abundant on this plot. The second most abundant species was American bistort, a perennial forb of little value as sheep forage. The vegetation, having such a high proportion of annual weeds, had declined appreciably in value during the 9 years, until it was representative of very poor range conditions on mountain meadows.

In 1940 the vegetation on the grazed plot on meadow B, where pocket gophers had remained for 9 years, was intermediate in both total density and composition, between that on gopher-free meadow A and that on the ungrazed gopher-infested plot on meadow B. The average total density was 17.97 percent. Perennial forbs predominated, making up 65 percent of the vegetation. Perennial grasses made up 15 percent of the vegetation; annual grasses, 6 percent; and annual weeds, 14 percent.

This plot had not become dominated by the worthless tarweed to the same extent as the adjacent ungrazed plot, which had about three times as much. Other annual weeds were also far more abundant on the ungrazed plot. The grazed plot contained a great deal more of several perennial forbs and grasses than the ungrazed plot. On the grazed plot dandelion had a density of 1.16 percent but on the ungrazed its amounts were too small to be estimated. Other worth-while perennial forbs more abundant on the grazed plot included longstalk clover, Columbia groundsel, and agoseris. The low-value American bistort was the most abundant species on the gopher-infested grazed plot.

The grazed plot contained fewer annual weeds and more perennial weeds or forbs and grasses than the ungrazed plot. This difference may have resulted from trampling by sheep, which caved in gopher runways and made conditions more favorable for perennial plants where otherwise the drying effects of the runways would have made conditions more suitable for early maturing annuals. Grazing, as compared with its absence, produces conditions less favorable for gophers and tends to reduce their effect on the vegetation. The grazed plot on meadow B was still classed as in poor range condition in 1940, the vegetation having been changed from that in 1931 principally by the influx of annual species.

Thus, pocket gophers clearly had an adverse effect on the poor-condition range on which they were permitted to remain from 1931 to 1940. They encouraged an increase in low-value annual weeds. They retarded or prevented the increase of most perennial grasses and perennial forbs or weeds. The cluster tarweed, which invaded the area infested with pocket gophers, was absent where pocket gophers were absent. Low-value American bistort became the dominant perennial species where gophers were present. In other words, gopher-infested

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meadow B failed to improve and was still in poor range condition where sheep and deer grazed, and it declined to very poor condition where sheep did not graze.

On the other hand, the total vegetation density, the density of worthwhile perennial grasses, and the density of valuable perennial forbs were much greater where gophers were absent. After 9 years of gopher control on meadow A the range had improved to fair condition.

Vegetation 1940 to 1948 on Gopher-Free Meadow

The removal of pocket gophers from meadow B in 1940 and maintenance of that meadow gopher-free until 1948 brought about a marked improvement in plant composition. The species favored by the pocket gopher as forage made especially large increases (fig. 10).

Figure 10.—The grazed plot on meadow B in 1946, showing the relatively dense stand of vegetation dominated by common dandelion. This species became established after pocket gophers were removed in 1940.

On the ungrazed plot the average density of all vegetation had doubled by 1948, being 31.84 percent as compared with 15.09 percent in 1940 (table 3). The density of perennial grasses was 4.56 percent, representing an increase of 7 times the 1940 density. Kentucky bluegrass increased from a low average density of 0.06 percent in 1940 to 3.53 percent in 1948. None of the other grass species showed much change.

The total density of perennial forbs or weeds was 26.19 percent, nearly five times the 1940 density. Most important of those of high forage value were agoseris, bicolor biscuitroot, Oregon checkermallow, longstalk clover, and common dandelion. Species of moderate to low forage value were western yarrow, small bluebell, and American bistort.

TABLE 3.—*Average density[1] of vegetation, by class and species, on grazed and ungrazed plots of meadow B, gopher-free from 1940 to 1948*

UNGRAZED PLOT

Class and species	1940	1943	1945	1946	1947	1948
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Perennial grasses:						
Bentgrass, thin	—	0.12	0.07	0.03	0.06	0.09
Bluegrass, Kentucky	0.06	.55	1.31	1.09	1.06	3.53
Bluegrass, Sandberg	—	—	—	—	—	—
Brome, mountain	—	.03	.03	.06	.06	.16
Fescue, red	—	—	(2)	—	—	—
Needlegrass, Lemmon	(2)	(2)	—	.03	.03	—
Oniongrass, little	.09	.09	.06	.09	.06	.06
Wheatgrass, slender	.16	.06	.06	.03	.06	.12
Other	.34	.34	.69	.24	.41	.60
Total	.65	1.19	2.22	1.57	1.74	4.56
Annual grasses	.19	—	—	—	—	—
Annual weeds:						
Collinsia, littleflower	(2)	.09	.06	—	(2)	—
Tarweed, cluster	6.63	5.91	3.16	2.94	1.19	.84
Other	2.00	.28	.56	.06	—	.25
Total	8.63	6.28	3.78	3.00	1.19	1.09
Perennial forbs or weeds:						
Agoseris	.66	.66	3.09	3.62	1.56	2.25
Aster	—	—	.22	.16	.12	.12
Biscuitroot, bicolor	1.00	1.06	2.44	3.81	3.19	3.72
Bistort, American	2.22	3.72	3.16	3.94	2.59	4.09
Bluebell, small	.25	1.12	2.53	2.69	1.25	1.53
Checkermallow, Oregon	.16	.38	.44	.56	.56	1.03
Cinquefoil	—	(2)	.03	(2)	(2)	.12
Clover, longstalk	.19	.88	3.41	3.00	3.56	4.59
Dandelion, common	(2)	.16	.66	1.22	.97	2.19
Fleabane	—	—	—	—	—	—
Groundsel, Columbia	.06	.31	.37	.25	.25	.25
Penstemon, royal	.03	(2)	(2)	.03	.03	(2)
Vetch	.09	.03	—	.09	.34	.28
Violet	(2)	.09	.22	.22	.09	.19
Wyethia, whitehead	—	—	—	—	—	—
Yarrow, western	.84	.88	1.78	1.66	1.72	4.97
Other	.12	.58	1.09	1.19	.91	.86
Total	5.62	9.87	19.44	22.44	17.14	26.19
Total, all vegetation	15.09	17.34	25.44	27.01	20.07	31.84

See footnotes at end of table.

TABLE 3.—*Average density[1] of vegetation, by class and species, on grazed and ungrazed plots of meadow B, gopher-free from 1940 to 1948—Con.*

GRAZED PLOT

Class and Species	1940	1943	1945	1946	1947	1948
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Perennial grasses:						
Bentgrass, thin	—	0.69	0.50	0.53	0.34	0.44
Bluegrass, Kentucky	0.62	1.09	1.75	1.56	1.62	3.19
Bluegrass, Sandberg	—	—	—	—	—	.66
Brome, mountain	.19	.34	.13	.09	.06	(2)
Fescue, red	.44	—	(2)	—	—	—
Needlegrass, Lemmon	.12	.03	(2)	(2)	.03	.09
Oniongrass, little	.31	.44	(2)	.12	.03	.09
Wheatgrass, slender	.38	.25	.09	.03	.09	.03
Other	.72	.91	.53	.16	.28	.03
Total	2.78	3.75	3.00	2.49	2.45	4.53
Annual grasses	1.00	—	—	—	—	—
Annual weeds:						
Collinsia, littleflower	.12	.06	.06	—	—	—
Tarweed, cluster	2.31	1.56	1.56	.91	.50	.50
Other	.03	.94	.09	.06	.03	.03
Total	2.46	2.56	1.71	.97	.53	.53
Perennial forbs or weeds:						
Agoseris	1.22	.62	3.03	3.50	1.34	1.66
Aster	—	—	—	—	—	—
Biscuitroot, bicolor	.72	1.03	4.16	5.09	3.18	8.09
Bistort, American	5.70	4.22	2.44	3.28	1.25	4.91
Bluebell, small	—	—	(2)	—	—	—
Checkermallow, Oregon	.06	.03	.13	.09	.16	.12
Cinquefoil	.03	.06	.03	.03	.09	.25
Clover, longstalk	1.03	7.22	7.50	5.12	4.81	5.09
Dandelion, common	1.16	2.12	6.66	9.84	6.12	4.72
Fleabane	—	—	—	—	.03	.03
Groundsel, Columbia	.84	1.53	1.56	1.03	1.25	1.75
Penstemon, royal	—	—	—	—	—	—
Vetch	—	—	—	—	(2)	—
Violet	(2)	—	—	(2)	(2)	(2)
Wyethia, whitehead	—	—	—	(2)	.03	.03
Yarrow, western	.72	.62	.22	.25	.25	.94
Other	.25	.52	.53	1.84	.28	.19
Total	11.73	17.97	26.26	30.07	18.79	27.78
Total, all vegetation	17.97	24.28	30.97	33.53	21.79	32.84

[1] Square feet per hundred of ground covered. [2] Less than 0.005.

Annual weeds decreased steadily in both amount and proportion of the vegetation. In 1948 the density of annual weeds was only 1.09 percent, or one-eighth that in 1940. The decrease resulted principally from a reduction of the unpalatable cluster tarweed, but the density of other annual weed species also decreased markedly.

These changes in plant composition, which occurred when pocket gophers were absent, represented improvement in range condition of the ungrazed plot from very poor to between poor and fair.

Similar improvement resulted from removing gophers in 1940 from the grazed plot of meadow B. Although the grazed plot was in better condition than the ungrazed plot that year, having fewer annual weeds and more perennial forbs and grasses, this difference was largely elim-

inated by 1948 (fig. 11). Density of perennial grasses on both plots was about 4.5 percent in 1948. Density of perennial forbs was 26.19 percent and 27.78 percent for the ungrazed and the grazed plots, respectively; annual weeds were 1.09 percent on the ungrazed plot and 0.53 percent

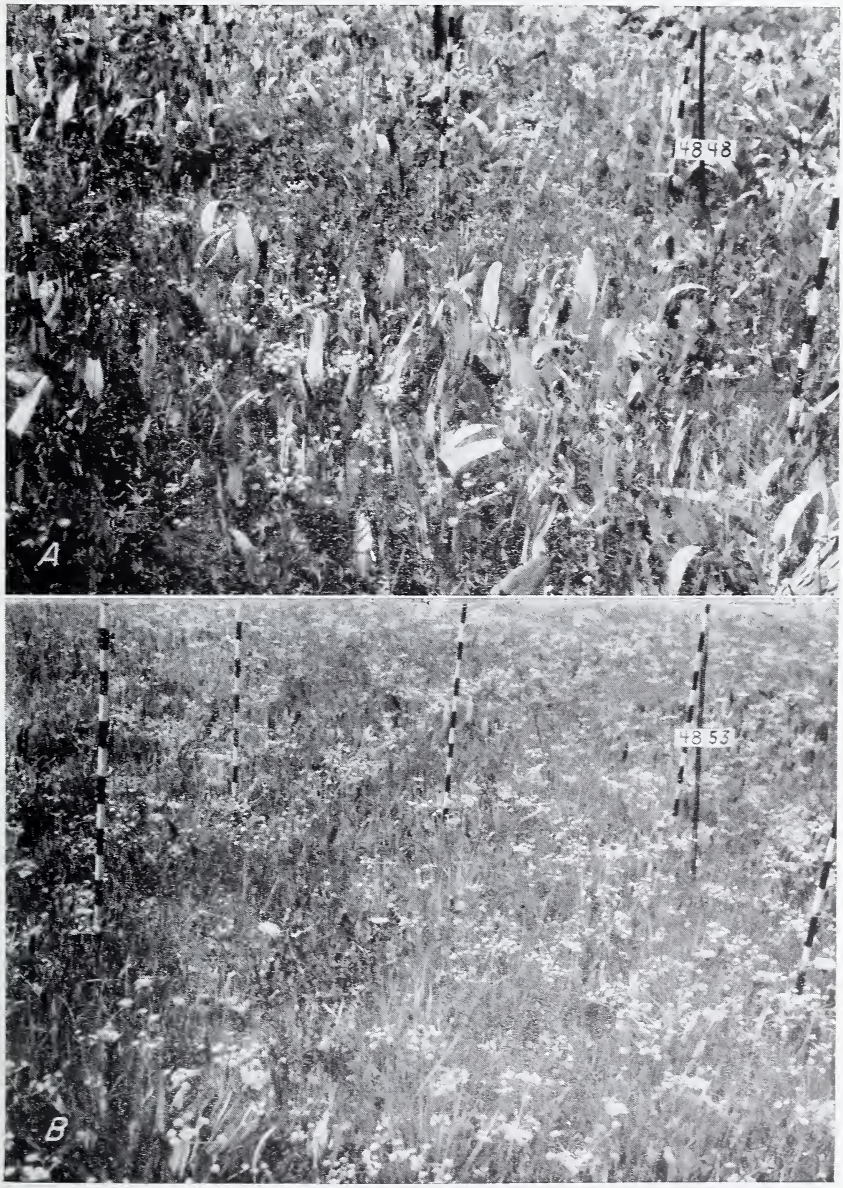

FIGURE 11.—Meadow B in 1948, 8 years after gopher control. *A*, Ungrazed plot; *B*, grazed plot. The vegetation on both plots is much alike, being principally perennial forbs. (Same quadrats shown in fig. 9.)

on the grazed. Likewise the total plant cover was very similar, being 31.84 percent on the ungrazed plot as compared with 32.84 percent on the grazed.

Individual species that increased materially in density on meadow B from 1940 to 1948 were much the same for both grazed and ungrazed plots. Kentucky bluegrass became the principal perennial grass. Longstalk clover made a very rapid increase following gopher removal, increasing sevenfold in 3 years. Common dandelion increased rapidly for about 6 years. Bicolor biscuitroot became important. The low-value cluster tarweed decreased from 2.31 percent to 0.50 percent. Annual grasses, principally cheatgrass brome, disappeared from the vegetation by 1943, 2 years after gophers were removed.

The increase of total density and of perennial forbs and grasses and the decrease of annual weeds and grasses, noted on the grazed plot after it was gopher-free for 8 years, indicates an improvement in range condition. The rapid increase of some species of perennial forbs—for example, longstalk clover and common dandelion—followed by a gradual decrease, is a change characteristic of improvement in mountain meadow vegetation that is in poor condition: perennial forbs ordinarily become dominant and then decrease as perennial grasses increase. Even with this improvement, the range was still in only poor to fair condition in 1948.

Vegetation 1940 to 1948 on Gopher-Infested Meadow

The introduction of 16 pocket gophers per acre in meadow A in 1940, when it was in fair condition, did not materially affect the general trend of vegetation development (fig. 12). Despite some variations from year to year, the density of all vegetation and of perennial grasses and perennial forbs in 1947 was little different from that in 1940. But in 1948, a year of good moisture, there were significant increases over 1940 densities of these plant groups (table 4). The increases in perennial grasses were somewhat more pronounced than those in perennial forbs.

In the period 1940–48 the amounts of some individual species on the meadow changed. The density of several species increased steadily. Most prominent were Kentucky bluegrass, aster, Oregon checkermallow, and Columbia groundsel. On the other hand, density decreased noticeably in many species, including little oniongrass, agoseris, Lemmon needlegrass, and common dandelion. These changes of individual species, with the possible exception of the increase in Columbia groundsel, are characteristic of vegetation on a meadow in the grass-weed stage as it improves in range condition. The conclusion, therefore, is that the gophers did not affect the general trend of vegetation development.

Even though some species would normally be expected to decrease when a meadow is allowed to improve under the conditions that existed, it was concluded from this study that density decreases in some instances were the direct result of pocket gopher foraging. This was particularly true of species that are favored pocket gopher forages. Little oniongrass, agoseris, common dandelion, and small bluebell are plants in this category. The marked and relatively steady reduction of common dandelion, for example, from a density of 2.25 percent in 1940 to 0.31 percent in 1948 on the grazed plot, and from 1.62 percent in 1940 to 0.12 percent in 1948 on the ungrazed plot, resulted directly from the active use of

this species by the gophers. Likewise, the reduction of little oniongrass on the grazed plot from 2.25 percent in 1940 to 0.09 percent in 1948 was brought about by the intensive use of corms of that species by the gophers.

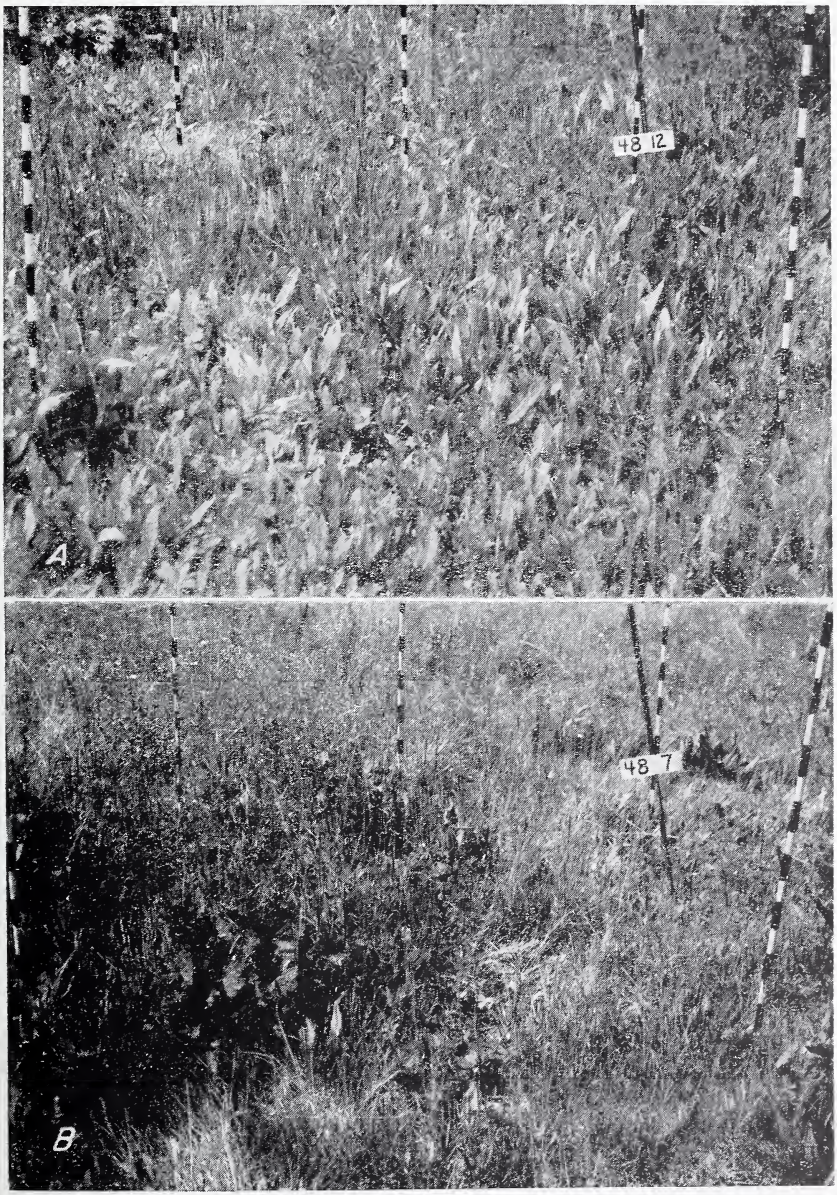

FIGURE 12.—Meadow A in 1948, 8 years after gophers were reintroduced to area: *A*, Ungrazed plot; *B*, grazed plot. Vegetation development differs little from that shown for the same quadrats in figure 8.

One effect of pocket gophers on a few plant species was not brought out by measurement of the vegetation. Kentucky bluegrass on meadow A, for example, maintained a good stand on areas where pocket gophers were abundant, even though it was heavily used by them. The gophers worked on the established colonies of bluegrass, leaving only a few living plant fragments. These fragments in time spread and replaced the old stand on the newly worked soil. As a result, the location of bluegrass colonies on the meadow shifted from place to place, and there was an over-all increase in the total amount.

TABLE 4.—*Average density[1] of vegetation, by class and species, on grazed and ungrazed plots of meadow A on which pocket gophers were introduced in 1940*

UNGRAZED PLOT

Class and species	1940	1943	1945	1946	1947	1948
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Perennial grasses:						
Bentgrass, thin	—	0.66	1.06	0.88	0.69	0.53
Bluegrass, Kentucky	1.69	1.93	3.44	2.38	2.03	4.16
Bluegrass, Sandberg	.03	—	—	—	—	—
Brome, mountain	.97	1.00	1.59	1.62	1.72	1.78
Fescue, red	1.44	.53	.72	.44	.25	.28
Needlegrass, Lemmon	.56	—	—	—	—	—
Oniongrass, little	.28	.09	.03	(2)	(2)	—
Wheatgrass, slender	1.47	1.88	2.13	1.22	1.88	1.94
Other	—	.19	.28	.18	.37	.75
Total	6.44	6.28	9.25	6.72	6.94	9.44
Annual grasses	—	—	—	(2)	—	—
Sedges	—	.09	.09	.09	.06	.06
Rushes	.22	.44	1.00	.53	.69	.84
Annual weeds::						
Collinsia, littleflower	.09	.38	2.00	.47	.06	.09
Tarweed, cluster	—	.09	—	—	—	—
Other	.40	1.91	.44	1 22	.88	.75
Total	.49	2.38	2.44	1.69	.94	.84
Perennial forbs or weeds:						
Agoseris	2.63	.16	.16	.03	(2)	—
Aster	.78	1.09	2.98	5.62	6.69	6.66
Biscuitroot, bicolor	—	—	—	—	—	—
Bistort, American	—	.62	—	1.03	—	—
Bluebell, small	2.95	5.88	3.00	2.59	.88	2.16
Buttercup	.03	.16	—	.06	(2)	—
Checkermallow, Oregon	2.97	2.81	3.22	3.75	4.53	4.12
Cinquefoil	3.38	2.94	2.22	2.62	2.59	2.56
Clover, longstalk	—	—	—	—	—	—
Dandelion, common	1.62	.84	.28	.44	.25	.12
Fleabane	—	—	—	.09	.09	.06
Groundsel, Columbia	.03	.12	.31	.28	.25	.47
Penstemon, royal	.03	(2)	.03	.12	.22	.28
Vetch	.16	—	—	(2)	.03	(2)
Violet	.62	.22	.37	.22	.12	.53
Wyethia, whitehead	.16	.22	.19	.09	.06	.09
Yarrow, western	2.00	1.22	2.19	1.50	1.78	3.19
Other	.49	.12	.14	—	—	.02
Total	17.85	16.40	15.09	18.44	17.49	20.26
Total, all vegetation	25.00	25.59	27.87	27.47	26.12	31.44

See footnotes at end of table.

TABLE 4.—*Average density[1] of vegetation, by class and species, on grazed and ungrazed plots of meadow A on which pocket gophers were introduced in 1940—Con.*

GRAZED PLOT

Class and Species	1940	1943	1945	1946	1947	1948
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Perennial grasses:						
Bentgrass, thin	—	1.14	2.15	2.47	2.06	2.25
Bluegrass, Kentucky	2.00	.91	2.97	2.41	2.78	4.84
Bluegrass, Sandberg	.44	.09	1.06	.59	.44	.47
Brome, mountain	.16	.31	.44	.19	.44	.16
Fescue, red	1.65	.19	.19	.38	.34	.41
Needlegrass, Lemmon	.41	.06	.06	.19	.28	.12
Oniongrass, little	2.25	.78	.44	.25	.03	.09
Wheatgrass, slender	.22	(2)	.09	.19	.19	.25
Other	.41	.24	.53	.50	.44	.63
Total	7.54	3.72	7.93	7.17	7.00	9.22
Annual grasses	—	.22	1.12	.22	2.12	.06
Sedges	—	.28	.16	.19	.12	.16
Rushes	1.18	1.19	1.85	1.60	.97	1.06
Annual weeds::						
Collinsia, littleflower	.22	.50	.41	.56	(2)	.34
Tarweed, cluster	—	.12	.03	—	—	—
Other	.28	1.63	.25	1.90	.31	.50
Total	.50	2.25	.69	2.46	.31	.84
Perennial forbs or weeds:						
Agoseris	2.41	.97	.87	.59	.03	—
Aster	.31	.34	1.12	1.47	.94	.81
Biscuitroot, bicolor	—	—	—	.02	—	—
Bistort, American	—	—	—	—	—	—
Bluebell, small	2.34	5.31	3.13	3.06	1.56	2.72
Buttercup	.50	1.00	.59	.81	.28	.31
Checkermallow, Oregon	(2)	.16	.25	.16	.34	.19
Cinquefoil	.22	.03	.34	.25	.50	.56
Clover, longstalk	(2)	.09	—	(2)	(2)	—
Dandelion, common	2.25	.75	1.22	.91	.44	.31
Fleabane	3.01	—	—	.53	1.80	2.03
Groundsel, Columbia	1.06	1.31	1.50	1.72	1.53	3.03
Penstemon, royal	.19	.22	1.13	.94	.62	1.00
Vetch	.44	.03	(2)	(2)	(2)	(2)
Violet	.31	(2)	.16	(2)	(2)	.06
Wyethia, whitehead	2.44	1.88	3.12	3.22	4.25	4.25
Yarrow, western	.97	.78	.91	1.09	.59	1.84
Other	.65	.72	1.06	.66	.53	1.11
Total	17.10	13.59	15.40	15.43	13.41	18.22
Total, all vegetation	26.32	21.25	27.15	27.07	23.93	29.56

[1] Square feet per hundred of ground covered. [2] Less than 0.005.

Another characteristic vegetative change resulting from gopher activity on meadows in fair condition was a fluctuating population of annual weeds and grasses. Annual plants became established on newly worked soil the year following the working, but seldom remained the second year. Thus an ever-shifting population of annual plants occurred, the location and species changing greatly from year to year. Species of littleflower collinsia, willowweed, knotweeds, nemophilas, tarweed, and cheatgrass brome are examples of such plants. This resulted in relatively higher densities of annual weeds and grasses for most years following the introduction of pocket gophers into meadow A.

Even though range condition improved gradually from 1940 to 1948, the vegetation on meadow A was still only in a grass-weed stage, fair range condition, at the end of the study. The adverse effect of reintroducing pocket gophers into meadow A when it was in fair range condition was not so noticeable as the effect of their presence for 9 earlier years on meadow B, but still it was very real. On meadow A they contributed to the continued presence of annual weeds and to serious decreases, in some instances elimination, of Lemmon needlegrass, agoseris, and common dandelion, all species of moderate to high forage value for sheep on Oregon mountain meadows.

On the other hand, the control of pocket gophers on meadow B, beginning in 1940 when parts of it were in poor and very poor condition, enabled the range both under grazing and without to improve in condition. Agoseris, which was eliminated on gopher-infested meadow A increased markedly on this gopher-free meadow, and there was a greater increase in Kentucky bluegrass, considering that it started with much lower density in 1940. Annual weeds were drastically reduced.

INFLUENCE OF POCKET GOPHERS ON VALUES OF MEADOW FOR LIVESTOCK GRAZING

Pocket gophers utilize forage all through the year. Sheep, on the other hand, graze mountain meadows for 3 or 4 months in the summer. A typical grazing season for sheep on mountain meadows in Oregon is July 1 to September 30. However, a band of sheep might graze a meadow only once during the summer for about a week. It is apparent therefore that pocket gophers graze mountain meadows over a much longer period than domestic livestock; their consequence as a foraging animal, therefore, is greater than would be expected from their small size. They are also of more consequence than other foraging rodents, for example the Oregon ground squirrel that remains dormant in its burrow about 8 months each year.

The adverse effect of pocket gopher activity on grazing values is shown by comparing the estimated grazing capacities in sheep months per acre for the grazed and ungrazed plots on meadows A and B:

	Grazing capacity per acre in sheep months	
	Meadow A	*Meadow B*
Grazed plot:		
1940	2.59	1.31
1943	1.70	2.86
1945	2.77	4.50
1946	2.70	4.49
1947[1]	2.41	3.28
1948[2]	5.25	7.41
Ungrazed plot:		
1940	3.50	.59
1943	2.95	.97
1945	3.76	2.65
1946	4.18	2.85
1947[1]	4.62	2.53
1948[2]	8.25	6.56

[1] Driest spring during study; year of poor vegetation growth.
[2] Exceptionally moist year; year of good vegetative growth.

The grazing capacities are based on the sum of the products of density and the relative grazing value (5) of the individual species growing on the meadows each year. Although only indicative, these values reflect differences in value of the vegetation as sheep forage in 1940 after 9 years of gopher control on meadow A and continued infestation on meadow B. They also reflect changes in value following the introduction of pocket gophers on meadow A and the removal of the gophers from meadow B in 1940.

The estimated grazing capacities in 1940 give some idea of the seriousness of permitting pocket gophers to remain on a mountain meadow in poor condition. The grazed plot of meadow A, after 9 years of protection from pocket gophers, had a grazing capacity of 2.59 sheep months per acre, about twice the 1.31 sheep months for the grazed plot of gopher-infested meadow B. This represents the difference in grazing capacity that would result in a period of 9 years from gopher-control measures on a properly grazed meadow in poor condition.

On the ungrazed plots the spread in estimated grazing capacity was even greater. The grazing capacity for gopher-free meadow A was 3.50 sheep months per acre, six times the 0.59 sheep months for gopher-infested meadow B. This greater spread was due to the better vegetation on meadow A in the absence of both gophers and grazing and the poorer conditions on meadow B where gophers occurred on ungrazed areas.

Another striking example of increased grazing capacity resulting from pocket gopher control is obtained by comparing the 1940 grazing capacities of meadow B with those of the unfavorable growing year 1947 and the favorable growing year 1948 after gophers were removed in 1940. The grazing capacities for sheep on this meadow in 1947 were 3.28 sheep months per acre on the grazed plot and 2.53 sheep months on the ungrazed plot. This represents grazing-capacity increases of 2.5 times on the grazed plot and 4.3 times on the ungrazed plot during the 7-year period.

The spread between the grazing capacities for 1940 and those for 1948 was much greater, the estimated grazing capacity in 1948 being 7.41 sheep months per acre on the grazed plot and 6.56 sheep months on the ungrazed plot. Thus, the elimination of Dalles pocket gophers in 1940 from a grazed range in poor condition, with a grazing capacity of only 1.31 sheep months, increased the grazing capacity almost 5.7 times. And elimination of gophers from the plot of ungrazed range in very poor condition and capable of supporting only 0.59 sheep per acre per month in 1940 increased its grazing capacity 11 times.

Grazing capacity increases on meadow B began rather soon after pocket gophers were controlled. The increases were brought about by an increase in species of relatively high value as forage for sheep and a decrease in relatively low-value species. Species that ordinarily would have 40 percent or more of their herbage removed, when properly grazed by sheep, had more than doubled in density on the grazed plot by 1943 and increased nearly 4 times by 1945 (table 5). Species that ordinarily would have from 20 to 39 percent of their herbage used showed essentially no change, and those that would be used less than 20 percent or remain ungrazed were greatly reduced.

The increases in value on meadow B were by succulent species that tend to mature and dry up early. Although they are of high grazing

TABLE 5.—*Density and composition of vegetation on grazed plot of meadow B, by value[1] as forage for sheep, in specified years 1940–48[2]*

Year	High value		Moderate value		Low value	
	Density[3]	Percent of composition	Density[3]	Percent of composition	Density[3]	Percent of composition
1940	6.94	39	1.56	9	9.47	52
1943	14.42	60	1.80	7	8.06	33
1945	25.38	82	1.32	4	4.27	14
1946	26.45	79	1.81	5	5.27	16
1947	18.94	87	.83	4	2.03	9
1948	25.59	78	1.72	5	5.53	17

[1] *High value:* Species that ordinarily would have 40 percent or more of their herbage removed when meadow is properly grazed.
Moderate value: Species that ordinarily would have 20 to 39 percent of their herbage removed when meadow is properly grazed.
Low value: Species that ordinarily would have less than 20 percent of their herbage removed, or remain ungrazed, when a meadow is properly grazed.
[2] Pocket gophers were removed from meadow in fall of 1940.
[3] Square feet per hundred of ground cover.

value, they have a rather restricted period of use. Further improvement in the meadow would have been through replacement of the succulent weeds with slower maturing grasses that remain green longer. Such a condition existed on meadow A, which was further along in range improvement as a result of gopher control from 1931 to 1940.

The 1947 grazing capacities on meadow A were 2.41 sheep months per acre on the grazed plot and 4.62 sheep months on the ungrazed plot. This represents about a 7-percent reduction (grazed plot) and 32-percent increase (ungrazed plot) in the grazing capacities of the two plots prior to the introduction of gophers in 1940. During 1948, because of the greater vegetative growth, grazing capacities of both plots were much higher.

The relationship between the presence of pocket gophers and changes in forage value of meadow vegetation in fair condition may be studied by comparing the proportion of plants of low, medium, and high forage value on the grazed plot of meadow A (table 6). As is to be expected on a mountain meadow, the actual and relative amount of vegetation in each forage-value class fluctuated from year to year. This was due in part to differences in growing conditions. However, from 1940 to 1948 no adverse trend in forage value resulted from the introduction of the pocket gophers, except possibly immediately after the introduction and in the dry year of 1947.

Forage values were reduced somewhat during the first 3 years after the gophers were introduced; the density of species of high and moderate value decreased markedly, while species of low value increased. This accounts for the drop in grazing capacity between 1940 and 1943. However, in the years following 1943 there was a gradual trend toward an increase in the combined amounts of species of high and moderate forage value and a decrease in species of low forage value. By 1948 the density of both high- and moderate-value species exceeded their 1940 densities, and the density of low-value species was about a third lower.

Results of the effect of pocket gophers on grazing values of meadows A and B, together with the life history studies of the gopher, suggest

TABLE 6.—*Density and composition of vegetation on grazed plot of meadow A, by value[1] as forage for sheep, in specified years 1940–48[2]*

Year	High value		Moderate value		Low value	
	Density[3]	Percent of composition	Density[3]	Percent of composition	Density[3]	Percent of composition
1940.....	10.16	39	9.99	38	6.17	23
1943.....	6.08	29	5.45	26	9.31	45
1945.....	11.61	43	8.06	30	7.35	27
1946.....	10.48	39	9.26	34	7.27	27
1947.....	8.40	35	10.70	45	4.83	20
1948.....	12.50	42	12.39	42	4.66	16

[1] *High value:* Species that ordinarily would have 40 percent or more of their herbage removed when meadow is properly grazed.

Moderate value: Species that ordinarily would have 20 to 39 percent of their herbage removed when meadow is properly grazed.

Low value: Species that ordinarily would have less than 20 percent of their herbage removed, or remain ungrazed, when a meadow is properly grazed.

[2] Pocket gophers were introduced into the meadow in fall of 1940.

[3] Square feet per hundred of ground cover.

certain conclusions on their occupancy and effect on mountain meadows and the need for their control. When a meadow is in poor or very poor condition—low in the production of plants suitable for forage for either pocket gophers or livestock—a few gophers may use such a high proportion of the plants that the range cannot improve in grazing capacity. On the other hand, when a meadow is in fair condition or better, having much more palatable forage than a meadow in poor condition, the plants used by a few pocket gophers would be a relatively small portion of all the vegetation on the meadow.

Because each pocket gopher has an individual burrow system that takes up considerable space, and generally burrow systems of different gophers do not overlap, there is a maximum population of pocket gophers per acre on a meadow. Because more forage is available on a meadow in fair or good condition, the foraging range of an individual gopher is somewhat less than on a meadow in poorer condition. A higher gopher population may result. However, the tendency of the gopher to live alone and prevent intrusion on his area may limit the population on such a meadow, even though forage production is sufficient to support a much greater number. Therefore, when forage production is high on a mountain meadow, gopher control may not be needed as a range improvement measure unless it is desired to make the forage they would use or destroy available for livestock or game. When forage production is low, however, and gopher populations high, control measures are definitely needed to allow the range to improve from both a forage and a watershed standpoint.

CONTROL OF POCKET GOPHERS

Natural Checks

There are many natural checks on pocket gophers. They are important because they prevent the building up of gopher numbers to infestation proportions. Where natural checks are not sufficient, however, artificial measures are required.

One of the most important natural checks on pocket gophers apparently is water. Beaver dams raise the water table in some places and provide moist meadows. As a result, pocket gophers are driven or drowned out by the rising ground water. Those that survive reestablish themselves on the drier margins of the meadows. Much the same results have been observed where water tables were raised by artificially damming gullies running through meadows. In years of high precipitation or of heavy stream flows, flood waters spreading over the meadows flood burrow systems and drown the gophers.

FIGURE 13.—An owl's pellet containing a pocket gopher skull.

Animals, insects, and diseases help control pocket gophers. Predators include hawks, owls (fig. 13), coyotes, bobcats, badgers, weasels, and snakes. However, these predators probably are less numerous than they were before livestock came into the country and may not be as effective a check as they were under undisturbed conditions. Gophers on the study area were not examined for internal parasites, but fleas, ticks, and mites were found to be common. Occasionally a warble was found under the skin in late summer and fall. One individual carried on its back a fully developed warble and four fresh warble scars. Newborn young in some nests had decomposed navel areas, a condition apparently aggravated by rainy springs and damp nest material.

ARTIFICIAL CONTROL ON MOUNTAIN MEADOWS

The safest and most effective method of controlling pocket gophers on mountain meadows[8] is the use of strychnine-treated sweetpotatoes or carrots.

CAUTION: **Strychnine is poisonous. Always keep poison baits out of the reach of children and livestock.**

Poisoning can be done most effectively on mountain meadows in the fall, when rains have softened the soil and the gophers are most active. Their mounds are located more easily at that time because livestock will have grazed the rank vegetative growth that hides the mounds in the summer. Spring work is not satisfactory because surface indications of gopher work are so limited that it is difficult to find the runways.

Baits are prepared by cutting large sweetpotatoes or carrots into pieces 1½ inches long and ½ inch square. Sweetpotatoes are more effective as bait because they remain attractive to the gophers longer than

[8] For a detailed description of methods to be used when controlling pocket gophers on other lands see reference (*2*).

carrots. On 2 quarts of bait sift 1/8 ounce of powdered strychnine alkaloid[9] and mix thoroughly by tossing gently in a pail. Baits that are properly prepared have a grey cast.

The runways are located by probing the soil with a gopher probe (fig. 14); care should be taken not to break in the runway by trampling. A single bait is dropped through the probe hole into the burrow and the hole is covered with a clod, a handful of moist dirt, or some object that will shut off the light. Each burrow system should be baited at two or three places, and only those portions of the system showing fresh workings should be treated.

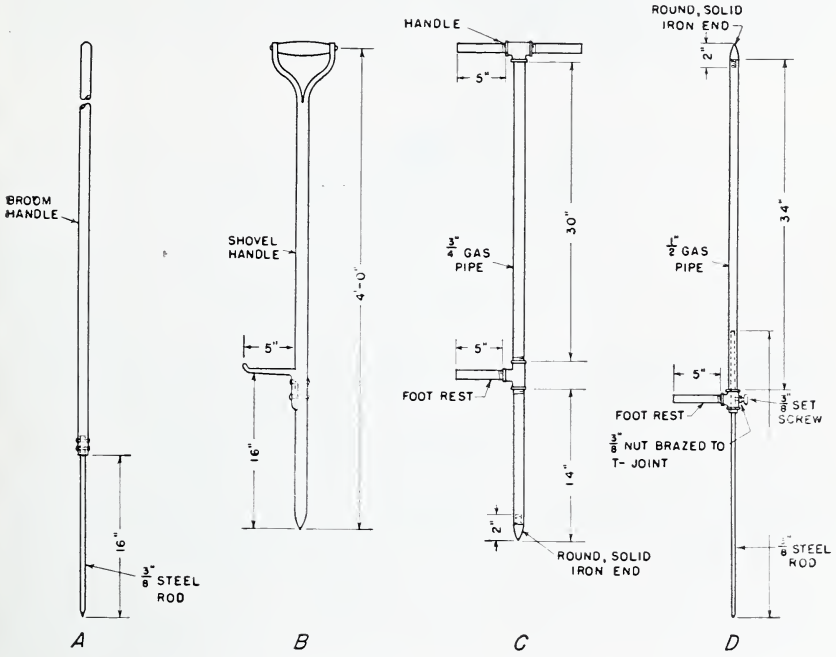

FIGURE 14.—Runway probes used to reach burrows when trapping or poisoning pocket gophers: *A*, Made from broom handle and steel rod; *B*, from shovel handle; *C*, from gas pipe, for use in soft soil; and *D*, preferred type of probe, from gas pipe with steel rod, for use in hard soil.

Success in eradication depends largely on keeping bait clean and placing it correctly (fig. 15). Bait that is placed in side runways or in holes in the floor of main runways is not likely to be found by the gophers. Even when bait is correctly placed, an occasional gopher may refuse to take it. Trapping may then be necessary. Several inexpensive types of pocket gopher traps are on the market. However, the use of traps exclusively in a control operation is much more costly than poisoning.

[9] Strychnine sulfate may be substituted for strychnine alkaloid but, being water soluble, it is more readily washed or leached from the baits and therefore is often less effective.

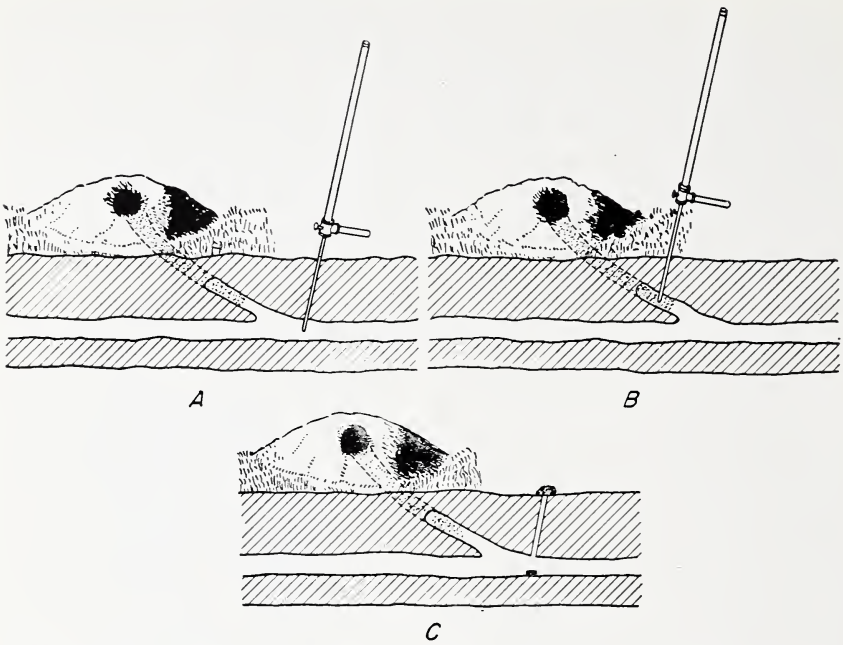

FIGURE 15.—How to use runway probe: *A*, Right way, forcing probe into main runway just deep enough to make an opening and to avoid punching a hole in the floor; *B*, wrong way, placing bait in a side runway; *C*, placing bait correctly.

COST AND RETURNS FROM CONTROL

A measure of the value of pocket gopher control as a range-improvement practice is obtained by comparing the cost of control with the value of the increased forage yield. The results obtained in this study, in which plots were maintained virtually 100 percent gopher-free by treatment twice each year, and by trapping to remove persistent individuals, are not entirely comparable to results that would be obtained from gopher-control projects. They do serve, however, as a guide to what can be expected from control measures.

Control on a project basis, with an efficient crew and thorough treatment of an area, should give at least a 90-percent kill of gophers. This should be followed by maintenance treatment each year, at about 10 percent of the cost of the first treatment, until the effect of the gopher is overcome. Obviously, poisoning an area and then allowing repopulation of the gophers by failing to carry out any subsequent measures would not be effective control.

Recent estimates of costs for large-scale gopher control projects are not available, because there have been none since World War II. Based on records of earlier projects, present costs of control in the most accessible areas having moderate gopher populations are estimated to be about 40 cents per acre. However, costs vary considerably between areas because of such factors as accessibility and population density. Under heavy infestation and other conditions, costs may be increased several times.

In the study described here, the grazed plot of meadow B had a capacity of 6.10 sheep months per acre greater in 1948 than in 1940, primarily as a result of gopher control. For purposes of comparison, the value on a rental basis of the additional forage produced can be placed at 17 cents per sheep month. On this basis the value of the forage produced by the grazed plot was $1.04 greater per acre in 1948 than in 1940. A similar comparison between 1940 and 1947, the latter being an unfavorable year for forage production, shows the value of the forage produced in 1947 to be 33 cents per acre greater. While the increase in forage value due to gopher control was slow, the estimated cost of control measures was amortized within a few years. Beginning with the fifth year of this study, the value of the increased grazing capacity for any one year was equal to or greater than the estimated cost of control.

SUMMARY

Pocket gophers are scattered throughout western range lands, and are abundant in many places. They are especially common on the mountain meadows of the West, where range values vary from 0.1 or less animal-unit month per acre to 2 or more animal-unit months. To determine the value of pocket gopher control as a range-improvement practice, the Fish and Wildlife Service and the Forest Service conducted a 17-year study of the Dalles pocket gopher, its life history, and influence on plant composition and grazing values on mountain meadows.

The study area was on two adjacent mountain meadows (meadows A and B) in the Blue Mountains of eastern Oregon. At the beginning of the study both meadows were in poor range condition, with a sparse vegetation composed principally of perennial forbs, and Dalles pocket gophers were relatively abundant. Meadow A was freed of gophers and kept free from 1931 to 1940, while gophers were allowed to remain on meadow B. Then in 1940 the treatments were reversed, the gophers being trapped out of meadow B and introduced onto meadow A at the rate of 16 per acre. This situation was maintained through 1948. Two quarter-acre plots were established on each meadow for detailed study, one of each pair being open to sheep and deer grazing and the other closed to such grazing.

The following observations on the life history of the Dalles pocket gopher were obtained from the study:

1. It prefers open areas and is most abundant in mountain meadows. It avoids dense forests, but gradually spreads into them as the canopies are thinned by logging.

2. Although it is active throughout the year, its activities are more easily observed in the fall, when fresh soil mounds are numerous and the vegetation is grazed. Control measures are, therefore, applied more easily at that time.

3. It feeds mainly on roots and underground stems, and on surface vegetation in the immediate vicinity of its opened side runways. It shows a definite preference for some of the more common broadleaved herbs, but also feeds on grasses, young pine, quaking aspen, and other trees.

4. Of 97 fall-trapped gophers, only 26 were current year's young, indicating that the general rate of increase is low for a rodent.

The relatively heavy gopher population from 1931 to 1940 on meadow B, which was in poor range condition at the beginning of the study, prevented its improvement where grazed by sheep and caused its deterioration where ungrazed. During the same period, gopher-free meadow A improved in range condition, progressing from a vegetation dominated by perennial forbs to one dominated by perennial grasses and forbs or weeds, both where sheep grazed and where they did not graze.

As a result of removing the gophers from meadow B in 1940, annual weeds and grasses decreased and desirable perennial forbs and grasses increased greatly. Estimated grazing capacities for the grazed plot of the meadow increased from 1.31 sheep months per acre in 1940 to 7.41 sheep months in 1948; and for the ungrazed plot, from 0.59 sheep months in 1940 to 6.56 sheep months in 1948.

Following the introduction of pocket gophers, in 1940, into meadow A, the previously gopher-free meadow in fair condition, a reduction in grazing capacity was noted in 1943. This was followed by an increase, except in the dry year of 1947, until in 1948 the grazing capacity of 5.25 sheep months per acre on the grazed plot was about double the 1940 capacity. This increase, however, was materially less than that for the grazed plot of gopher-free meadow B, which had increased its capacity 5.7 times between 1940 and 1948 from a poor-condition start. The ungrazed plot of gopher-infested meadow A, starting with the highest grazing capacity in 1940 of 3.5 sheep months per acre after being free of gophers for 9 years, more than doubled its capacity. Except for a decline in 1943, it showed a steady increase and had the highest capacity of any plot in 1948.

These results indicated that Dalles pocket gopher control is necessary as a range-improvement practice to obtain satisfactory improvement of infested mountain meadows that are in poor range condition. However, where pocket gophers infest mountain meadows in fair range condition, their control may not be necessary. In such a situation, the main value of control is either to make available to livestock or game the forage the gopher would use or destroy, or to permit more rapid restoration of the range.

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COMMON AND SCIENTIFIC NAMES OF PLANTS AND RODENTS MENTIONED

PLANTS

Annual grasses:	
Brome, cheatgrass	*Bromus tectorum*
Perennial grasses:	
Bentgrass, thin	*Agrostis diegoensis*
Bluegrasses	*Poa* spp.
Bluegrass, Kentucky	*P. pratensis*
Bluegrass, Sandberg	*P. secunda*
Brome, mountain	*Bromus carinatus*
Fescue, red	*Festuca rubra*
Needlegrass, Lemmon	*Stipa lemmoni*
Oniongrass, little	*Melica fugax*
Wheatgrass, slender	*Agropyron trachycaulum*
Grasslike plants:	
Rushes	*Juncus spp.* (Principally *J. balticus*)
Sedges	*Carex* spp.
Annual weeds:	
Collinsia, littleflower	*Collinsia parviflora*
Knotweeds	*Polygonum* spp.
Nemophila	*Nemophila* spp.
Tarweed, cluster	*Madia glomerata*
Willowweeds	*Epilobium* spp.
Perennial forbs (native):	
Agoserises	*Agoseris* spp.
Asters	*Aster* spp.
Biscuitroot, bicolor	*Lomatium leptocarpum*
Bistort, American	*Polygonum bistortoides*
Bluebell, small	*Mertensia longiflora*
Brodieas	*Brodiaea* spp.
Buttercup, great straightbeak	*Ranunculus maximus* (=*R. orthorhyncus platyphyllus*)
Clover, longstalk	*Trifolium longipes*
Checkermallow, Oregon	*Sidalcea oregana*
Cinquefoils	*Potentilla* spp.
Dandelion, common	*Taraxacum officinale*
Fawnlily, lambstongue	*Erythronium grandiflorum*
Fleabanes	*Erigeron* spp.
Fritillary, yellow	*Fritillaria pudica*
Groundsel, Columbia	*Senecio columbianus*
Leptotaenia, carrotleaf	*Lomatium dissectum multifidum* [=*Leptotaenia multifidum*]
Lupines	*Lupinus* spp.
Onions	*Allium* spp.
Penstemon, royal	*Penstemon speciosus*
Vetches	*Vicia* spp.
Violets	*Viola* spp.
Wyethia, whitehead	*Wyethia helianthoides*
Yampa	*Perideridia gairdneri*
Yarrow, western	*Achillea lanulosa*

PLANTS—continued

Perennial forbs (cultivated):	
Carrot, garden	*Daucus carota sativa*
Sweetpotato	*Ipomoea batatas*
Shrubs and trees:	
Aspen, quaking	*Populus tremuloides*
Pines	*Pinus* spp.
Sagebrush	*Artemisia* spp.

RODENTS

Ground squirrel, Oregon	*Citellus oregonus*
Meadow mouse	*Microtus spp.*
Whitefooted mouse	*Peromyscus spp.*
Pocket gopher:	
black	*Thomomys monticola niger*
brown	*T. talpoides wallowa*
Columbia	*T. talpoides columbianus*
Dalles	*T. talpoides quadratus*
Deschutes	*T. monticola nasicus*
Heller's	*T. monticola helleri*
Humboldt Bay	*T. bottae detumidus*
Mazama	*T. monticola mazama*
Nevada	*T. townsendii nevadensis*
Oregon	*T. monticola oregonus*
Townsend's	*T. townsendii townsendii*
West coast	*T. monticola hesperus*
white-toothed	*T. bottae leucodon*
Willamette Valley	*T. bulbivorus*

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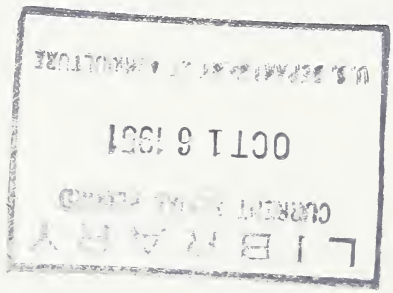

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