Placement of Bait

Baits of any kind are placed in main runways by use of a gopher probe (Fig. 5), with which burrows can easily be located and the baits placed with a minimum of disturbance. The gopher probe is rather easily constructed. The main shaft is of 1/2-inch pipe about 40 inches long. On one end a conical point of solid metal is welded, which is the same diameter as the pipe. To the opposite end, a 12-inch length of 7/16-inch steel rod is welded. The free end of the rod is enlarged by adding a "hard suface" steel and grinding it to a carrot-shaped tip about 1/2 inch in diameter at the base and tapering to a sharp tip. To work in soils that are sandy or otherwise quite loose, the base may be slightly larger, and for very hard soil, the base may be omitted. One or two side arms are welded in place or connected by means of pipe T's. The side arms may be attached by use of a collar and set screw to permit adjustment from one end of the probe or the other to apply pressure with either hand or foot. A length of rubber hose may be slipped over each side arm as a convenience to the user.

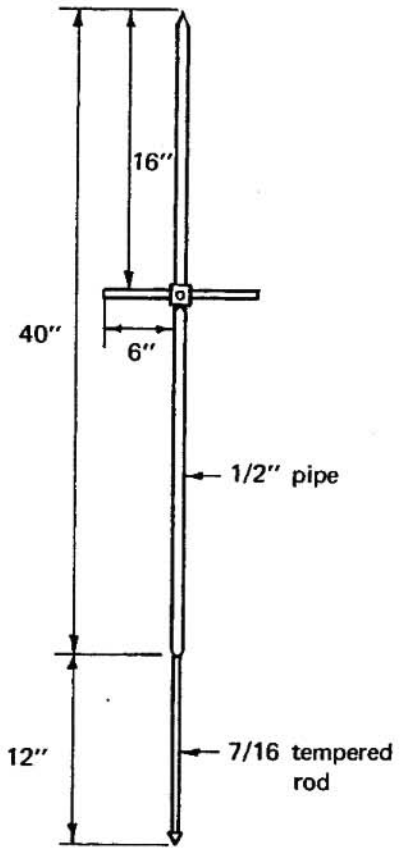

Figure 5. Gopher Probe

Locate the main runway by probing into the soil 12-18 inches back from the mound on the side where the horseshoelike depression is found. When the tunnel is struck, the probe will drop suddenly about 2 inches. Enlarge the opening by rotating the probe or by using the opposite larger end so that the poisoned bait may be easily dropped into the burrow. After placing the bait, carefully cover the hole made by the probe with your heel. Success is often much greater if two baits are placed in each tunnel at separate places. As bait is being placed, trample down or level off the tops of mounds. It is then easy to detect activity of gophers that escaped the previous treatment and to place baits only where they are needed.

Nearly 50 percent more baits are taken when a probe is used for placement than when main runways are opened with a shovel or spoon. A trained man using a probe can treat several hundred holes, over as much as 40 acres per day. The probe is easiest to use when the soil is damp and soft down to the level of the burrows and sometimes quite difficult in hard soils. It is unsatisfactory when used in sand. In finely cultivated fields, scrape back the dry surface soil before closing the hole; this can easily be done with a soil clod.

The best time to probe is in the fall during the first cool weather or just following the first good rains, and in the spring months. Main runways are easier to locate when mounds are conspicuous, before the vegetation becomes tall and abundant. The land should be gone over thoroughly at this time of the year. Alfalfa fields, due to the abundant and continuous food supply, are oftentimes more difficult to treat than orchards or open fields.

Gophers are most apt to gnaw on and girdle orchard trees during late summer, after the vegetation has become dry and green food is scarce. Therefore, when the gopher is doing the most serious damage, and quick destruction is most desired, the probing method is most difficult. At this time the operator may have to dig down to the main runways to place poisoned baits.

In dry soils, where the use of a probe is not practicable, the main runways can be opened in the same manner as for setting traps. By using slender, sharp sticks, poisoned baits can be placed about a foot back in each direction of the runway, which is then closed tightly. Open the hole two days later. If the bait has been removed and the hole remains opened, the gopher is probably dead.

Poisonous Gases

Poisonous gases have not proven to be consistently effective in controlling pocket gophers. Factors which cause the ineffectiveness of toxic gases are the extent of the burrow system, the leakage of gas through the loose soil of lateral runs, the nearness of the soil surface of main runways, and that pocket gophers may quickly plug a burrow system when poisonous gases are detected. In general, the use of poisonous gases have not proven to be economical or as effective as trapping or the use of toxic baits.

Several gopher "bombs" have been developed and are available for sale. When lighted and placed in burrow systems, the "bombs" generate a toxic gas. In general, these have not proven to be satisfactory for gopher control.

Exclusion

Small flower beds, vegetable gardens, and orchards, which are adjacent to wild lands often require special protective measures against invasion by pocket gophers either by burrowing or overland migration. Fences of small mesh, sheet metal, or concrete which extend 24 inches below the soil surface and about 12 inches above the soil surface are usually effective in protecting against pocket gophers. In light soils greater depth is often required.

Cementing ditches is effective where gophers are active in burrowing through the banks. Such costly preventive measures are advisable only where the usual control methods are ineffective.

Protection of young trees may be accomplished by use of a cylinder of wire netting (1 inch mesh or smaller). The cylinder, which should be at least 12 inches in diameter and 18 inches long, is sunk in the hole around the tree when it is planted. The top of the wire mesh should be just under the soil surface to avoid later difficulty in mowing and cultivating.

Trenching is successful for small-scale operations. A steep or vertical-walled ditch which is 18 inches wide and 24 inches deep is dug around the area that is to be protected. Five-gallon cans, with the tops removed and spaced at 25-foot intervals, are sunk into the soil so that the tops are level with the ditch bottom. Pocket gophers that get into the ditch are likely to fall into the cans and cannot escape.

Mechanical Bait Applicator

The mechanical, gopher-bait applicator offers a fast, inexpensive method of controlling large populations of pocket gophers with a once-over operation. This machine has largely replaced large-scale trapping and hand-baiting methods of control, which were time-consuming, costly, and oftentimes inadequate.

The bait applicator can be used in established pastures, alfalfa fields, and many rangelands, as well as orchards, vineyards, and open fields. It has also been used in cemeteries, golf courses, parks, and play areas. With proper adjustment, the damage caused by the machine is negligible in alfalfa fields, sod, and cover crops. For rangeland and forest use, there are more sturdy models available.

This tractor-drawn machine constructs an artificial burrow beneath the soil surface and deposits poisoned baits within the tunnels at preset quantities. The machine is driven back and forth across the field at regular intervals which makes a series of parallel burrows. The artificial burrows that are formed intercept, one or more times, the pocket gophers' tunnel system. Gophers, by nature, readily explore these artificial burrows and consume the bait they find within them.

Several commercial manufacturers[1] now build mechanical gopher-bait applicators. All of these machines operate on the same principle. Costs range from about $500.00 to $1,000.00 depending on on model and construction (Fig. 6).

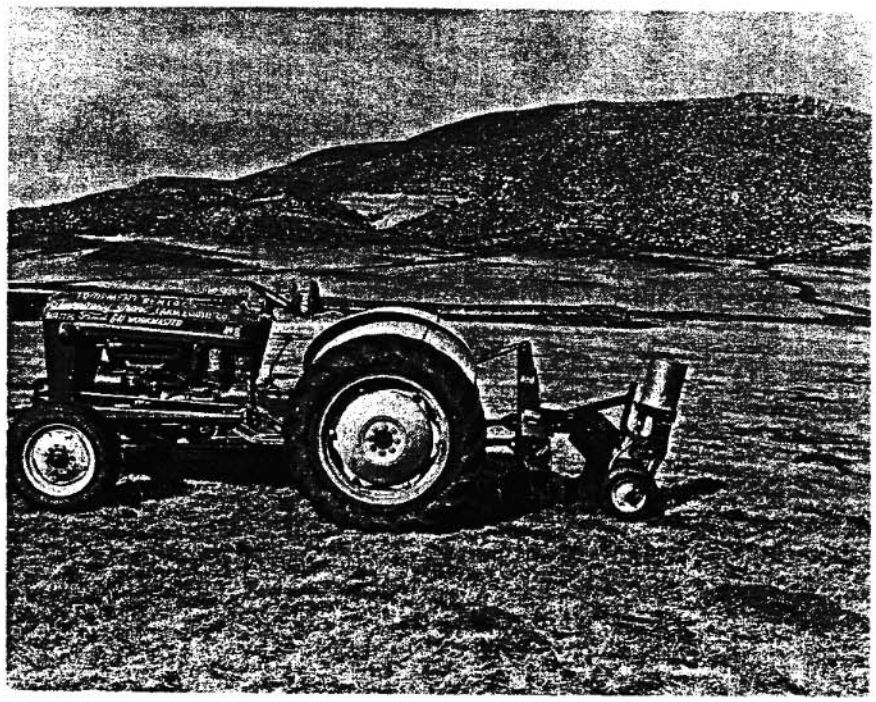

Figure 6. Burrow-builder as it would appear in operation.

[1] Mechanical-bait applicators which are commonly available throughout the west are manufactured by the following firms: Blackwelder Manufacturing Company, Rio Vista, California; Elston Co., Inc., Minneapolis, Minnesota; and Schneidmiller Industries, Fort Collins, Colorado.

Regardless of the manufacturer, all bait applicators consist of the same four basic components in addition to the supporting frame. These four basic components are (1) a depth-adjustable, burrow-forming shank, (2) a rolling coulter to cut surface litter and shallow roots ahead of the shank, (3) a bait-metering device, and (4) a press wheel to drive the bait-metering unit and to close the knifelike cut made by the upper portion of the shank (Fig. 7). The bait is dropped into the artificial burrow through a tube built or cast into the rear portion of the burrow-forming device. Special adaptations have been made for specific situations and for unusual local conditions. Figure 8 is a detailed drawing of the applicator.

Based on many trials and experience, it has been found that chromeplating is superior in wearing ability to hard-facing the shank, and in addition, provides improved scouring of the point, creating a better artificial burrow. Soil type is of prime importance in the wearability of the shank. Sandy and sand-clay soils cause the most abrasion.

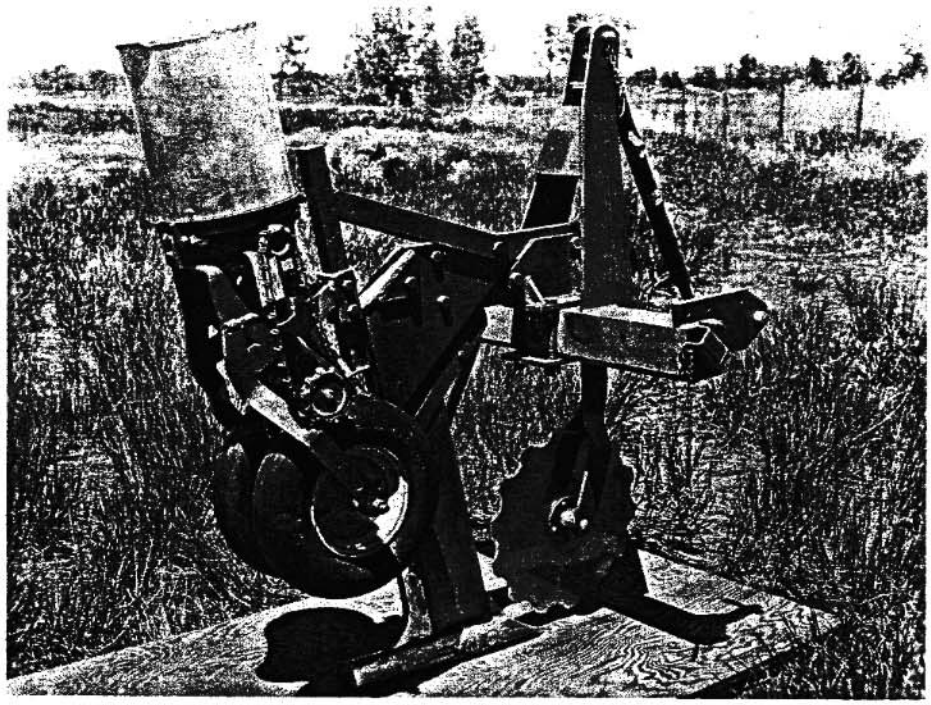

Figure 7. Burrow-builder

The bait-metering device is a conventional seed-planter hopper. Application rates and the intervals between bait discharges can be adjusted by changing the seed plates or the ratio between the press wheel and the seed hopper. Manufacturers generally provide instructions so that one can determine the rate most suited to the locality and types of baits that can be obtained.

The bait-applicator machines are designed to be mounted on a tractor having a conventional hydraulic, three-point hitch or tool bar, or mounted on wheels and pulled from the tractor' drawbar. The shanks for burrow forming on wheel-mounted machines are usually designed to be lifted out of the soil hydraulically. Consult manufacturers or distributors to determine the most suitable model for your needs.

One man operating the mechanical-bait applicator and a wheel-type tractor (a minimum of 25 horsepower) can treat from 5 to 10 acres per hour, depending on conditions and the distance between burrows. Tractor speeds of 2 1/2 to 3 1/2 mph (220 to 308 feet per minute) are commonly used. Faster speeds are possible with some of the sturdier models and tractors with

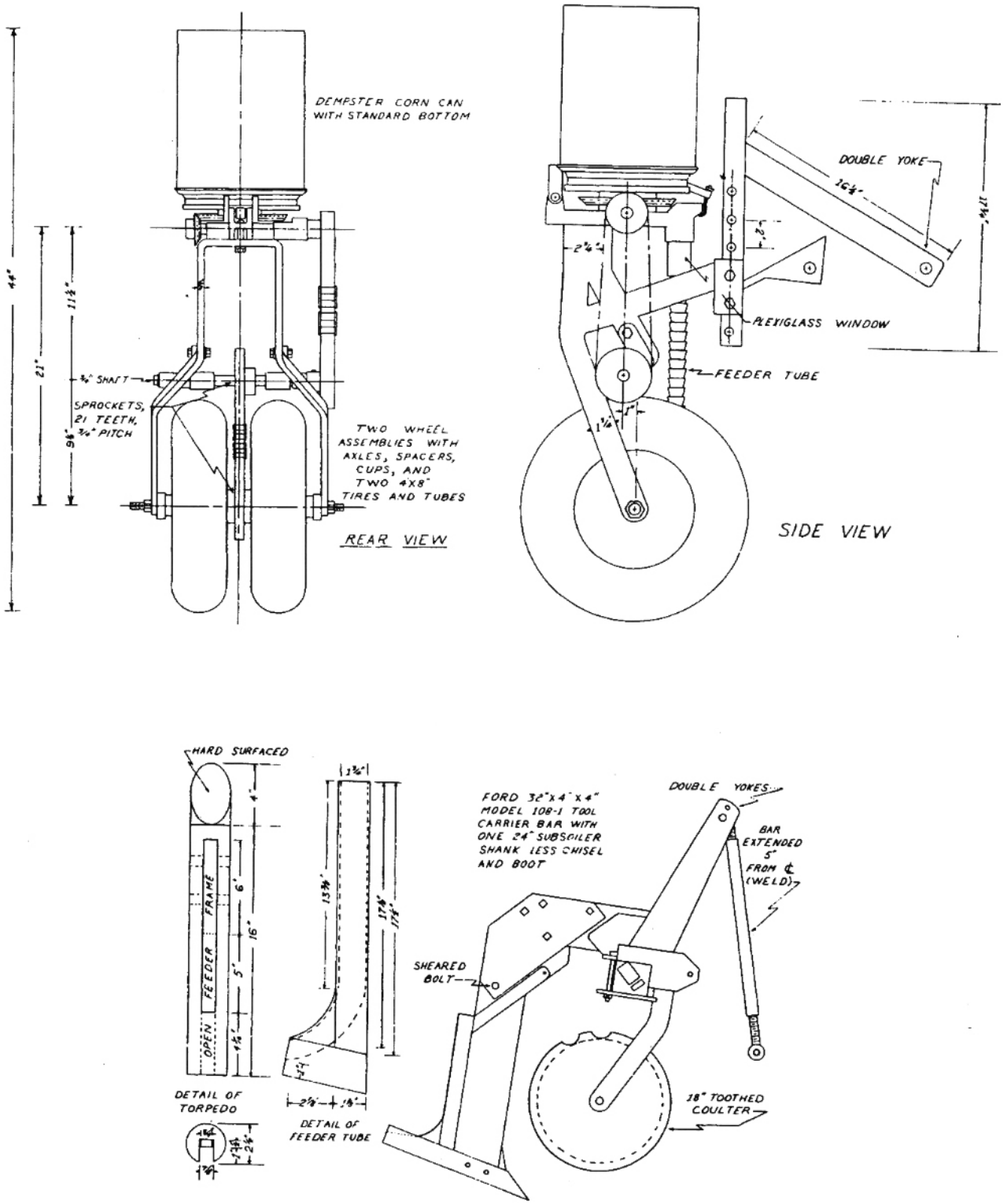

Figure 8. Parts of the burrow-builder.

sufficient horsepower, provided soil conditions are such that clean burrows can be made. The formation of clean burrows is important to good control and should not be sacrificed for speed. This is an important consideration in sandy or light soils.

While learning to operate bait-applicator machines, it is desirable to open a small section of the artificial burrow with a shovel to inspect the depth and condition of the burrow. A few trial runs may be needed to determine that the machine is adjusted properly.

Bait-applicator machines can be used in any area where soil condition and physical aspects of the land permit the formation of good artificial burrows 8 to 10 inches deep. For satisfactory results, the soil should be fairly firm below the top 3 or 4 inches and moist enough so that clean, smooth burrows are formed. Well-formed, artificial burrows are important in achieving a high degree of gopher control. In orchards, it is usually desirable to treat for gophers before spring discing. Orchard or vineyard cover crops do not ordinarily hinder the operation. The importance of proper soil moisture cannot be overemphasized. In normal situations, the soil moisture should be near the upper limit of the range for good plowing or cultivating. A handful of soil should retain its shape when squeezed but should not be so wet that it is sticky. Soils that are too wet tend to ball up the press wheel or cause a loss of traction. If the soil is too dry, the burrow will tend to be unstable and cave in. In most unirrigated croplands, the optimum soil moisture conditions for bait-applicator use prevail in the rainy months. On irrigated lands, the machine can be used at any time soil conditions are proper. However, in extremely sandy soils this is only a day or two following irrigation. If possible, avoid use of other implements for at least 10 days following treatment.

A distance of about 20 to 25 feet between artificial burrows will result in good control in most situations (Fig. 9). The burrows may be placed closer together where gopher populations are exceedingly high. In flood-irrigated croplands, gophers tend to concentrate along the levees, and therefore, parallel burrows should be made along one or both sides of the levee, or, if soil

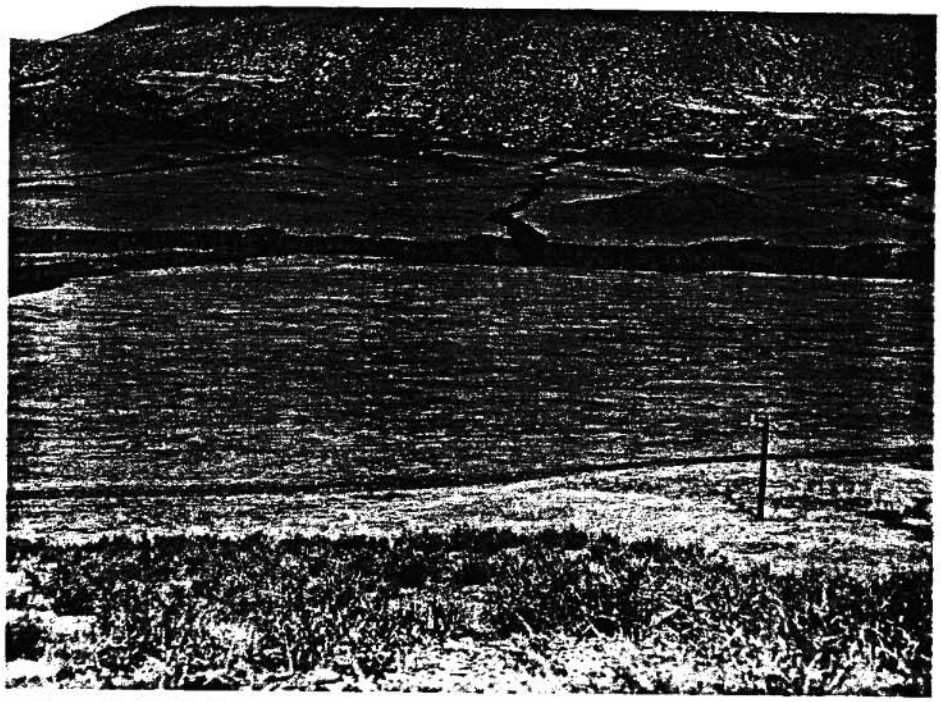

Figure 9. Field after treatment with burrow-builder, showing surface disturbance.

moisture is adequate, along the tops of the levees. In mature orchards, artificial burrows are placed in the center between each row of trees. In young orchards, it is often desirable to place the burrows fairly close to the trees but not so near as to cause root damage. The rows of grapes in vineyard plantings are often much closer together, and good control can be obtained with burrows being placed every second or third row. Burrows do not need to be continuous as short backs caused by having to raise the shank to avoid obstructions, or to free litter materials, will not adversely affect control. It is often desirable to make one or two additional burrows around an entire field to reduce invasion by gophers from adjacent areas. If a field is being treated for the first time by a mechanical bait-applicator, it is recommended that the entire acreage be covered. However, where previous control has nearly rid a field of gophers, re-treatment may be required only in isolated gopher-infested areas of the field.

The depth to the bottom of the artificial burrow should average 8 to 10 inches for most areas. The ideal depth can be determined by measuring the depths of natural burrows of presently active gophers and then adjusting the machine accordingly (Fig. 10). For formation of a smooth open artificial burrow, the depth should seldom if ever be less than 6 inches. Since the depth is less important than a well-formed burrow, it is better to set the shank too deep than too shallow. Numerous obstructions, such as rocks and tree roots, may limit the use of the machine in some forest and rangeland situations.

Figure 10. Artificial burrow intercepting natural pocket gopher burrow.

The rate of bait application within the artificial burrow, which is usually expressed in pounds per 1000 feet of burrow, is determined by two features: (1) the size (number of kernels) of each bait drop, and (2) the interval (distance) between bait drops. The machine can be adjusted for either one or both of these features to obtain the desired rate of bait application. Avoid heavily rolled, large-kerneled grains, or other large baits which do not readily pass through the

TABLE 1. Bait application computations for determining pounds of bait required per acre.

Pounds of bait applied per 1,000 feet of burrow	Spacing between rows of artificial burrows (feet)													
	10	12	14	16	18	20	22	24	26	28	30	32	34	36
0.1	.44	.36	.31	.27	.24	.22	.20	.18	.17	.16	.15	.14	.13	.12
0.2	.87	.73	.62	.54	.48	.44	.40	36	.34	.31	.29	.27	.26	.24
0.3	1.3	1.1	.93	.82	.73	.65	.59	.54	.50	.47	.44	.41	.38	.36
0.4	1.7	1.5	1.2	1.1	.97	.87	.79	.73	.67	.62	.58	.54	.51	.48
0.5	2.2	1.8	1.6	1.4	1.2	1.1	.99	.91	.84	.78	.73	.68	.64	.61
0.6	2.6	2.2	1.9	1.6	1.5	1.3	1.2	1.1	1.0	.93	.87	.82	.77	.73
0.7	3.0	2.5	2.2	1.9	1.7	1.5	1.4	1.3	1.2	1.1	1.0	.95	.90	.85
0.8	3.5	2.9	2.5	2.2	1.9	1.7	1.6	1.5	1.3	1.2	1.2	1.1	1.0	.97
0.9	3.9	3.3	2.8	2.5	2.2	2.0	1.8	1.6	1.5	1.4	1.3	1.2	1.2	1.1
1.0	4.4	3.6	3.1	2.7	2.4	2.2	2.0	1.8	1.7	1.6	1.5	1.4	1.3	1.2
1.1	4.8	4.0	3.4	3.0	2.7	2.4	2.2	2.0	1.8	1.7	1.6	1.5	1.4	1.3
1.2	5.2	4.4	3.7	3.3	2.9	2.6	2.4	2.2	2.0	1.9	1.7	1.6	1.5	1.5
1.3	5.7	4.7	4.0	3.5	3.1	2.8	2.6	2.4	2.2	2.0	1.9	1.8	1.7	1.6
1.4	6.1	5.1	4.4	3.8	3.4	3.0	2.8	2.5	2.3	2.2	2.0	1.9	1.8	1.7
1.5	6.5	5.4	4.7	4.1	3.6	3.3	3.0	2.7	2.5	2.3	2.2	2.0	1.9	1.8
1.6	7.0	5.8	5.0	4.4	3.9	3.5	3.2	2.9	2.7	2.5	2.3	2.2	2.0	1.9
1.7	7.4	6.2	5.3	4.6	4.1	3.7	3.4	3.1	2.8	2.6	2.5	2.3	2.2	2.1
1.8	7.8	6.5	5.6	4.9	4.4	3.9	3.6	3.3	3.0	2.8	2.6	2.4	2.3	2.2
1.9	8.3	6.9	5.9	5.2	4.6	4.1	3.8	3.4	3.2	3.0	2.8	2.6	2.4	2.3
2.0	8.7	7.3	6.2	5.4	4.8	4.4	4.0	3.6	3.4	3.1	2.9	2.7	2.6	2.4
2.1	9.1	7.6	6.5	5.7	5.1	4.6	4.2	3.8	3.5	3.3	3.0	2.9	2.7	2.5
2.2	9.6	8.0	6.8	6.0	5.3	4.8	4.4	4.0	3.7	3.4	3.2	3.0	2.8	2.7
2.3	10.0	8.3	7.2	6.3	5.6	5.0	4.6	4.2	3.9	3.6	3.3	3.1	2.9	2.8
2.4	10.5	8.7	7.5	6.5	5.8	5.2	4.8	4.4	4.0	3.7	3.5	3.3	3.1	2.9
2.5	10.9	9.1	7.8	6.8	6.1	5.4	5.0	4.5	4.2	3.9	3.6	3.4	3.2	3.0
2.6	11.3	9.4	8.1	7.1	6.3	5.7	5.1	4.7	4.4	4.0	3.8	3.5	3.3	3.1
2.7	11.8	9.8	8.4	7.4	6.5	5.9	5.3	4.9	4.5	4.2	3.9	3.7	3.5	3.3
2.8	12.2	10.2	8.7	7.6	6.8	6.1	5.5	5.1	4.7	4.4	4.1	3.8	3.6	3.4
2.9	12.6	10.5	9.0	7.9	7.0	6.3	5.7	5.3	4.9	4.5	4.2	3.9	3.7	3.5
3.0	13.1	10.9	9.3	8.2	7.3	6.5	5.9	5.4	5.0	4.7	4.4	4.1	3.8	3.6

Example: To determine the amount of bait that will be required if a mechanical baiter set to apply 0.5 poun per 1,000 feet of burrow is to be used between rows with 22-foot spacings, read down row spacing column 2 until opposite the designated 0.5 pounds. The answer (to the nearest hundredth) is 0.99 pounds.

delivery tube into the burrow. The quantity of toxic bait deposited in the artificial burrow determines how easily the entering gopher will find a lethal dose. The size of the holes in the hopper dispensing plate governs the amount of bait dropped, which can be adjusted as desired by changing plates. The intervals between bait drops are determined for some machines by the number of holes in the dispensing plate and on all machines by the sprocket ratio between the bait hopper and the drive-press wheel. The distance between bait drops is generally between 1

and 48 inches, depending on the desired application. The manufacturers usually provide the necessary instructions for presetting the machine to apply the desired rate. Where there is no information on the preset rate of bait application, the machine may be checked for the desired calibration by placing a weighed amount of clean, unpoisoned bait in the hopper and making a sample burrow for 1000 feet. The amount of bait applied can be determined by weighing the remaining bait in the hopper. If necessary, adjustments can be made to correct the rate of bait flow. By use of Table 1, the amount of bait per acre can be determined for any desired burrowing spacing.

Because of the gopher's solitary habits, the rate at which the bait is dispensed within the artificial burrow is independent of the gopher populations. Where populations are dense, more gopher systems are intercepted by the bait applicator. However, the distance between the burrows should be less, if possible, where large populations exist. In instances of high populations where inadequate control is achieved on the first treatment, a second application may be made; however, it is advisable to wait at least two weeks before re-treating an area. Table 1 can be used to determine the necessary pounds of bait required to treat each area of land.

Machine Operation Suggestions

In absence of specific manufacturer's instructions, the following suggestions may be of help when operation difficulties occur.

1. The burrow-forming shank must be thoroughly scoured before it will form a smooth burrow. The shank will scour more quickly if the coulter is temporarily set to cut shallow in the ground.
2. Adjust the machine so that the burrow-forming portion of the shank is drawn through the soil parallel to the surface.
3. Carefully align the coulter wheel to cut directly in front of the burrow-forming shank at a depth of from 4 to 6 inches to minimize soil and vegetation disturbances.
4. The press wheel should run firmly on the soil surface to close the narrow slits in the soil formed by the upper portion of the burrow-forming shank.
5. Lower the shank into the ground while the machine is in a forward motion; likewise remove it while still moving forward.
6. Raise the machine out of the soil to make turns. Some models will permit moderate turns; however, with all models, raise the shank out of the soil to make sharp turns.
7. Avoid stopping the tractor on an uphill pull with the shank buried, as a slight backward movement can clog the bait outlet.

Moles

Moles are abundant in suitable habitat (especially in moist, fertile, highly organic soils) throughout western Washington and Oregon. Additionally, they occur in local areas of central and eastern Washington and Oregon.

The Pacific Northwest is the home of three species of moles. Townsend's mole *(Scapanus townsendi)* is the largest mole in the United States and is found generally throughout western Washington and Oregon. The Coast mole *(Scapanus orarius)* is generally distributed in the coastal fog belt and in

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Prepared by David M. Baumgartner, Extension Forest Resources Specialist, Cooperative Extension Service, Washington State University, Pullman.

sections of southeastern Washington and northeastern Oregon. Townsend's and Coast moles, when found in the same locality, seem to live in close association. Townsend's mole is usually the more adundant of the two. The Klamath mole *(Scapanus latimanus)* is found in southcentral Oregon. Also, the Sheffer and Gibbs moles are found in eastern Washington and British Columbia.

Identification

Moles are primitive mammals belonging to the order Insectivora. They have velvety, blue-black to gray, mohair-like fur. The snout is slender and sparsely haired, with long slim jaws and abundant needlelike teeth. The tail is short and nearly hairless. The stout, short forearms are tipped with outwardly-turned flattened feet and claws. The hind feet are much smaller than the fore feet Ears and eyes are inconspicuous. Townsend's mole is 8 to 9 inches long. The Coast mole averages 6 to 7 inches.

Habits

Moles live in underground runways. These runways, in heavily infested areas, form a vast network of interconnecting highways. Runways are dug to search for food and to provide protection and living space for travel, resting, and nesting.

Some runways are major lanes of travel used by several moles. Major runways are often found under fence lines, leading to watering areas, under roads or along sidewalks, or in other generally protected situations. The main runways are usually about 6 inches under ground level, but may be as shallow as 2 inches or as deep as 20 inches.

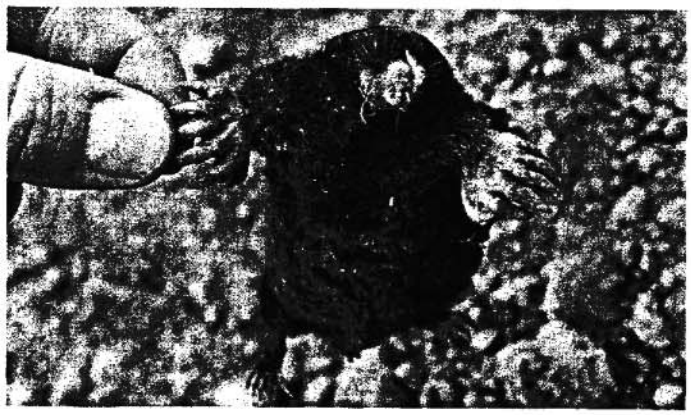

Figure 11. Mole

Extremely shallow runways, immediately under lawn turf, for instance, are feeder offshoots from a main runway and are probably used only once.

The annoying mole hills are external evidence of the moles' underground tunneling activities. Moles eject surplus dirt from tunnel workings through a lateral chimney to the surface.

Moles come to the surface occasionally, mainly at night, to search for food, water, and nesting material. Migrations may occur overland also. Moles are most active in the months of June and July.