March 1976

CONTROL OF THE OREGON GROUND SQUIRREL (Spermophilus beldingi oregonus)

Warren C. Sauer
California Department of Food and Agriculture, Redding, California

CONTROL OF THE OREGON GROUND SQUIRREL (Spermophilus beldingi oregonus)

WARREN C. SAUER, Biologist, California Department of Food and Agriculture, Redding, California 96001

ABSTRACT: Attempts to reduce populations of Spermophilus beldingi oregonus have centered around the application of Compound 10.80 and strychnine baits. Additional population reduction techniques were investigated for possible employment into the squirrel program. Techniques which show much promise are: hand baited chopped gree bait (.01% chlorophacinone) broadcast (10 pounds per acre) and hand baited grain bait with .01% chlorophacinone and .05% fumarin, and bait stations using .01%, .05% chlorophacinone grain bait (100 and 200 foot spacing) and .05% fumarin grain bait (100 foot spacing).

In addition, the concentration of Compound 1080 on chopped green bait can be reduced to 1/4 oz. of 1080 per 250 pounds of chopped green bait broadcast at 10 pounds per acre.

Preliminary investigation in damage assessment using exclusion cylinders resulted in 123 squirrels per acre removing an average of 1,790 pounds (spring growth alfalfa - downy broom) per acre in 44 days. Stomach content weights were determined over a 3 1/2 month period. Feeding behavior and average daily food consumption is greater early in the year (May) than later (July).

INTRODUCTION

The Oregon ground squirrel (Spermophilus beldingi oregonus) is one of three subspecies of Belding's ground squirrel.

The present Oregon ground squirrel control programs center around Compound 1080 and are under the supervision of the county agricultural commissioners. The carrier baits used are chopped cabbage in Modoc County and squirrel oat groats in Siskiyou County. Other toxicants used and made available under permit to the land owners is strychnine bait.

With the wide diversity of rangeland, pasture, and cropland in which control measures must be taken to reduce ground squirrel populations, there is a limited choice of control techniques. To have a greater variety of techniques in the control programs enables the operator to do control work more effectively and safely as per control situation. No one technique or toxicant can cover all bases.

To more effectively use any control technique, the biology of the target species must be known. This knowledge can result in finding weakness which may be utilized to control the squirrels. Timing of a control program in relation to breeding, emergence of young, and food preference greatly increases the degree of control.

Part of the justification to control Oregon ground squirrels is the damage they do. Although damage to crops, cropland and equipment is very obvious visually, no quantitative damage assessment has been done.

It is the purpose of this paper to add to the diversity of control techniques, and further understand the biology of the Oregon ground squirrel. It is also intended to shed light on the economic impact of the Oregon ground squirrel.

LIFE HISTORY

In the agricultural areas of northeastern California, Oregon ground squirrels emerge from hibernation between mid-February to mid-March, depending on geographic location and weather. Earlier or later emergence times have been noted but are typical.

Oregon ground squirrels are sexually mature at one year of age and breed but once a year. Breeding begins shortly after emergence. Our observations have been that adult females, two years and older, breed up to 5 weeks before one year old females.

The gestation period is approximately 28 days (Turner, 1972). In our collections the embryos have been discernible as lumps in the uterine horns for approximately 23 days. This, plus the time from conception to the lumpy appearance in the uterine horns, supports

a 28-day gestation period. Litter size, based on our collections, ranges from 1 to 17, but average 6 to 8. At approximately 21 days post partum, young emerge from the burrow. During the first few days of above ground activity, young will nurse and eat green vegetation, the primary food of the Oregon ground squirrel. At this time young can survive without parental care.

The young grow very rapidly and by 8 weeks of age it is often difficult to visually distinguish adults from young by size.

Oregon ground squirrels are not known to store food (Turner, 1972); therefore, during the time of seasonal activity the squirrels must attain enough body fat to sustain them through estivation and hibernation. In most regions of northeastern California seasonal activity starts to decline in July as the adults start in estivation. Generally, by late August practically all squirrels are estivating. In this subspecies estivation extends into hibernation as there is no fall activity.

We have concluded from our observations that adults go into estivation weighing between 400 and 550 grams and depending on length of estivation-hibernation time, emerge weighing between 250 and 350 grams. Young go into estivation weighing about 250 grams. White (1972) has suggested that because of expanded agricultural practices, in more recent years, the Oregon ground squirrels have more body fat when they go into estivation.

DAMAGE

Oregon ground squirrel damage to agriculture occurs in two forms: 1) vegetation reduction by feeding, and 2) land being taken out of production by squirrel burrowing and trampling activities. A preliminary study was conducted by personnel from California Department of Food and Agriculture, Modoc County Department of Agriculture and the Modoc County Agricultural Extension Service which indicated damage to cropland by ground squirrels (feeding and trampling) is significant. in this study four (4) cylinder exclosures, 42" in diameter, were constructed of 1/4 in. mesh hardware cloth 3 feet high. The exclosures were staked down in a predominately alfalfa (Medicago sativa) and downy bromegrass (Bromus tectorum) area. The site had a high population of both young and adult ground squirrels (122.5 per acre as determined by Lincoln index. See appendix 1 and 2 for Table and calculation). The exclosures were in place 44 days (April 24 to June 9, 1975). Vegetation was then harvested at ground level from inside and from comparable areas near each cylinder. Green and air dry weights were taken. The weight in grams of the vegetation from a 42" diameter area when multiplied by 10 approximates the production in ponds per acre. The difference between the vegetation weight inside and outside the cylinder (Table 1) was attributed to ground squirrel pressure such as direct feeding, vegetation clipping, and general trampling during the squirrels' daily activity. The average dry weight difference was 1,790 pounds per acre. There were no cattle in the test area. Population levels of other rodent and Lagamorph species were negligible.

Table 1. Oregon ground squirrel damage assessment using exclusion cylinders.

Cylinder Area	Green Weight (Grams)			Dry Weight (Grams)			Loss (Dry Weight)
	Inside	Outside	Diff.	Inside	Outside	Diff.	Pounds Per Acre
1*	393	433	-50	99	106	-7	--
2	1813	633	1180	438	134	304	3040
3	793	293	500	253	72	181	1810
4	433	133	300	124	72	52	520

*Squirrels gained entry into exclusion cylinder.

Quantifying vegetation clipping and trampling damage by ground squirrels is difficult. However, a study concomitant to the exclusion cylinder study was conducted to determine squirrel stomach content. The stomach content study was designed to not the general daily feeding behavior and quantify daily food consumption of a population of squirrels. Squirrels were collected by shooting them with .22 caliber rifles throughout the daily activity period. Squirrels were collected in the vicinity of the exclusion cylinder study. Animals were collected from April 29 to August 7, 1975. All animals were sexed and weighed (body intact) to the nearest 5 grams. Stomachs were removed, weighed to the nearest gram, and then the contents were extracted and the empty stomachs re-weighed to the nearest gram. Figure 1 gives a graphic presentation of the two stomach collections in early May and early July.

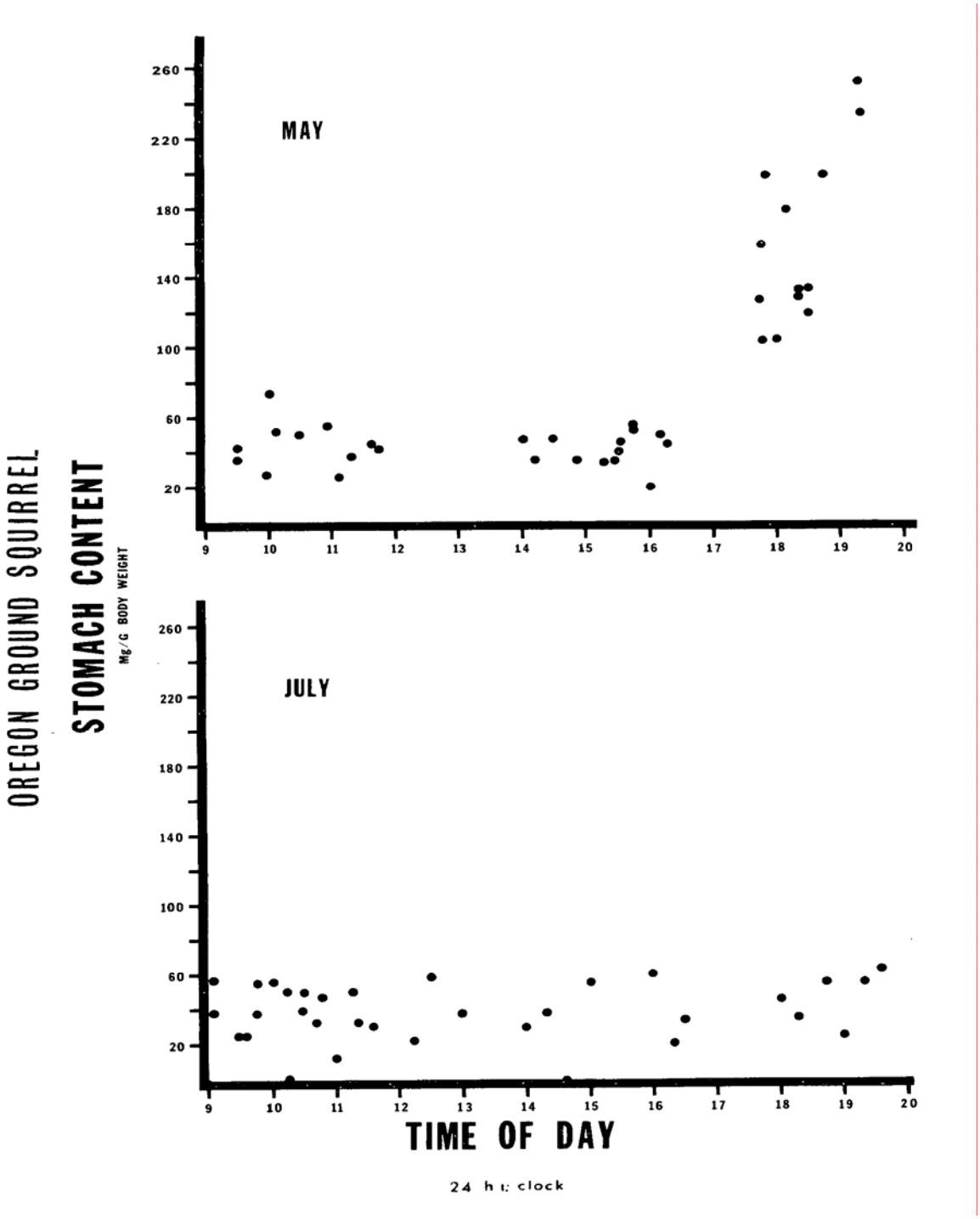

Figure 1. Oregon ground squirrels shot in late afternoon of early May had heavier stomach contents (mg/g body weight) than those collected in early July.

These data indicate the squirrels consumed more food earlier in the season than during the later part of the season. This conclusion is in conflict with the studies which indicate ground squirrels eat more as they approach estivation (McKeever, 1963). One explanation is that early m the season but post partum, squirrels build up fat reserves which were depleted during hibernation. Later they maintain this weight or at least have accumulated enough fat for the winter, making future weight gains unnecessary. It must also be realized that the present study was conducted in a different vegetation habitat than McKeever's work

Turner (1972) found the stomach contents of an adult female squirrel in August weighed 50 grams. Ginnell and Dixon (1918) found the average stomach contents of six adults to be 15 grams; while the stomachs of six juveniles averaged 5.4 grams. They speculated that an estimated 112 squirrels per acre would remove over 6 pounds of vegetation per acre per day. Our data suggests more damage than this occurs.

An attempt was made to estimate a squirrel's total daily consumption; however, the rate of digestion must be known. In a field study, this type of determination is difficult without supporting laboratory studies. By dividing the weight of the stomach contents at the end of the day (average individual content for the last 1/2 hour) by the elapse time from end of one day's activity to the beginning of the next, it was assumed minimal food depletion rates could be determined. This is a time of no ingestion and the stomachs are empty at the beginning of the next day's activity. (This stomach depletion estimation is minimal because the period of time during the night when the stomach is actually emptied is as yet unknown.) These depletion estimates (Table 2) plus the total stomach content at the end of the day is a minimal approximation for the average daily consumption.

In addition to the above quantity of vegetation ingested, there also appeared a quality variance. Inside exclusion cylinders, after 12 days protection, several small alfalfa plants were visible. Outside the cylinders no alfalfa was found. It was evident that the squirrels preferred alfalfa over the other available plant species.

Table 2. Estimate of total average daily food consumption per adult Oregon ground squirrel collected on different dates.

Date	Stomach Content at End of Day (g)	Est. Stomach Depletion Rate g/hr.	Total Depletion in Grams	Total Food Consumed in Grams
4-29	44.2	3.7	27.8	72.0
5-7	74.7	6.2	56.8	131.5
6-6	12.8	1.0	9.0	21.8
6-27*	19.0	1.6	14.4	33.4
7-10*	15.0	1.3	12.0	27.0
7-17*	13.0	1.1	9.9	22.9
8-7 *	14.3	1.2	10.8	25.1

*Young were included due to their near adult size.

CONTROL

Current control techniques for most species of ground squirrels are primarily based on the applications of toxic grain baits. Many problems have been confronted in attempting to reduce Oregon ground squirrel populations. Oregon ground squirrels emerge early in the year and begin breeding soon after emergence. Early control is often enhanced because cold weather keeps the vegetation stunted, leaving bait easier to find by the squirrels. In addition, either young squirrels have not been born or have not emerged, leaving fewer squirrels to control. However, at this time of year, weather problems are formidable. Wind, rain, snow and their assorted combinations are common, making ground and aerial application of rodent baits at times difficult, if not impossible. In conjunction with the above, squirrel oat groats has not been a good bait in Modoc County in recent years. Consistent acceptance of either clean or treated broadcast grain bait is totally lacking. White (1972) has discussed the historical bait acceptance problems in Modoc County.

HISTORY OF OREGON GROUND SQUIRREL CONTROL

Ground squirrel control in Modoc County dates back to 1915. Local ranches used strychnine on dandelions which were collected by hand. Mechanization gradually resulted in a methyl bromide fumigation program being conducted by County personnel. Though this technique was very effective in reducing squirrel populations, the time and labor required made an extensive County program difficult. Mechanization also resulted in ground and aerial application of grain bait. However, it was not long before bait acceptance problems curtailed the program. Because of the squirrels' apparent preference for green bait, Modoc County Agricultural Commissioner, Loring White (retired) planted and cultivated four acres of dandelions for use as ground squirrel bait. Even though dandelion was and is an excellent bait, weather conditions early in the spring hinder dandelion growth; thus, the

supply is limited. This problem was solved in about 1965 by the use of chopped cabbage as the green bait. By 1972 chopped cabbage was the principle bait used in the Modoc County ground squirrel program. In 1972, Agricultural Commissioner Kenneth Wright and Paul Macy of Macy's Flying Service began experimenting with aerial application of chopped green cabbage bait. The main problem of putting out a uniform swath was solved in 1974 after extensive modification of the hopper mechanism. The application rate is presently restricted to 20 pounds per swath acre (10 pounds per actual acre). Further development on uniform size of bait and mechanical feeding of bait through the hopper should result in reducing the amount of bait applied. Swaths are 45 feet wide and are spaced 45 feet apart. The original bait formulation (for ground application see Appendix 3) was 4 oz. of Compound 1080 per 260 pounds of bait.

PRESENT CONTROL PROGRAM

Compound 1080

When it became evident that cabbage could be applied from an aircraft, a series of test plots were established in 1974 to determine if the concentration of Compound 1080 could be reduced without affecting control. The .5 acre plots using 1080 treated chopped cabbage were put out at 10 pounds of bait per acre (20 pounds per swath acre). The concentrations were 4 oz. of 1080 per 250 pounds (lg 1080 per kg cabbage) of chopped cabbage; 2 oz. of 1080 per 250 pounds (0.5g per kg) of bait; and 1 oz. per 250 pounds of bait (0.25g per kg). *Pre-* and post-treatment visual observations were made to determine population reduction. Where 2 and 4 oz. of 1080 were used, the reduction was 98%, but only 95% reduction occurred with the 1 oz. bait. It was determined that the concentration of 1080 could be reduced to 2 oz. per 250 pounds without any significant difference in control, so it was used for the rest of the 1974 season. At the beginning of the 1975 treatment season, the 1 oz. of 1080 per 250 pounds concentration was tried on a large treatment area. Population reduction was satisfactory so the concentration was kept at 1 oz. for the 1975 treatment period.

Because of the above results, it was decided to examine the possibility of further reducing the amount of 1080 on cabbage. In April and May of 1975, with participation from the California Department of Fish and Game, Modoc County Agricultural Extension Service, Modoc County Department of Agriculture and California Department of Food and Agriculture, a series of test plots were established to determine if 1/2 oz. and 1/4 oz. of Compound 1080 per 250 pounds of chopped cabbage (.125g and .O63g 1080 per kg cabbage respectively) would effectively reduce ground squirrel populations. Bait was broadcast over 5 acres at a rate of 10 pounds per acre using a mechanical bait blower. Pre- and post-treatment activity counts of ground squirrels were made within a 100 x 100 foot census area in each plot. In the 1/2 oz. per 250 pound plot a maximum of 15 adult squirrels were in the census plot before treatment and no squirrels were seen in the census plot up to 22 days after treatment. Even in the entire plot (five acres) no squirrels were seen for six days after treatment. By 22 days post-treatment, a few squirrels had immigrated into the plot area. However, vegetation at this time was too tall for accurate censusing. In the 1/4 oz. plot, control was comparable to the 1/2 oz.

Two additional plots were established which simulated an operational control program. Chopped cabbage was broadcast over two 20 acre treatment areas with a mechanical bait blower. A 1080 concentration of 1/2 oz. was applied to one while 1/4 oz. per 250 pounds of cabbage was the other treatment. Bait was applied at 10 pounds per acre only in areas of squirrel activity. Pre-observations for determining population activity were made in a 100 x 100 foot area within each treatment plot. After treatment no squirrels were observed in the 100 x 100 foot census area of either plot. In addition, after treatment, no squirrels or active burrows were observed in two larger areas within the plots (5.4 acres in the 1/2 oz. plot and 4.9 acres in the 1/4 oz. plot). Table 3 gives the observation data for the 1080 plots. These concentrations appear to be effective for use on an operational basis. (The concentration for the 1976 season will be reduced to 1/2 oz. 1080 per 250 pounds of cabbage.)

Anticoagulants

Another series of plots were established using anticoagulant treated chopped cabbage. These plots were designed to determine if anticoagulants (chlorophacinone .01% and .005% and fumarin .05% and .025%) on chopped cabbage could reduce ground squirrel populations when broadcast one time at 10 pounds of bait per acre. Pre- and post-treatment activity counts were made in a 100 x 100 foot census plot within the treatment plots (Table 4).

Table 3. Oregon ground squirrel control with 1080-treated cabbage.

Plots	Oz. 1080 Per 250#	Date Treated	Plot Size	Pre-treatment Activity
1	.25	4-16	5A	lost
2	.5	4-16	6.5A	5-15(10)
3	.25	4-23	20A	1-3 (9)
4	.5	4-23	20A	1-5 (15)
5	check	--	1A	3-6 (11)

Post-Treatment Observations

	Dates						
Plots	4-17	4-18	4-22	5-7	4-24	4-28	5-7
1	1	1	1	few (1)			
2	0	0	0	few (1)			
3					0	0	0 (2)
4					0	0	0 (3)
5							3-7 (10)

The table gives the range of squirrels counted and the number of squirrel counts (in parentheses) made for each census plot.

1) Vegetation too high for accurate count.
2) Three squirrels seen in treatment plot.
3) One squirrel seen in treatment plot.

Table 4. Oregon ground squirrel control with broadcast anticoagulant-treated cabbage.

Plot	Percent Toxicant	Pre-Treatment Counts	Post-Treatment Counts	
1	.025 fumarin	lost	4-10 (9)	same treatment plot
	.025 fumarin	1-5 (11)	1-4 (15)	
2	.05 fumarin	4-7 (10)	7-10 (16)	
3	.01 chlorophacinone	6-12(9)	5-10 (9)	
4	check	3-6 (11)	3-7 (10)	
5	.005 chlorophacinone	1-5 (12)	1-6 (18)	same treatment plot
	.005 chlorophacinone	2-8 (10)	2-5 (20)	

The table gives the range of squirrels counted and the number of squirrel counts (in parentheses) made for each census plot.

This mechanically broadcast anticoagulant bait failed to reduce the squirrel populations. Lack of control was attributed to rapid bait consumption or underbaiting. Most of the bait in all plots was consumed on the first day. Anticoagulants must normally be consumed over a period of time to be lethal.

Plots were also established where chopped cabbage was applied by hand. These plots were designed to determine if anticoagulants (chlorophacinone .01% and furmarin .05%) would reduce ground squirrel populations. Small (approximately 1/3 cup) baits were scattered near each main squirrel mound either once or twice, on April 15 and 17, 1975. Pre- and post-treatment activity counts were made in a 100 x 100 foot census plot within the treatment plot (Table 5).

Table 5. Oregon ground squirrel control with hand baited anticoagulant-treated cabbage.

Plot	Toxicant	Times Treated	Pre-Treatment Count	Post-Treatment Count
1	Fumarin .05%	1	1-5 (7)	2-4 (7)
2	Chloro-phacinone .01%	1	1-6 (8)	0-3 (11)
3	Chloro-phacinone .01%	2	2-8 (10)	*
4	Fumarin .05%	2	5-12 (9)	1-4 (12)
5	check	0	3-6 (11)	3-7 (10)

*Census plot flooded by irrigation water.

The table gives the range of squirrels counted and the number of squirrel counts (in parentheses) made for each census plot.

During the course of the study census plot (in treatment plot 3) was flooded by irrigation water and no post-treatment data collected. However, no squirrels were seen in the remaining treatment plot area. The only squirrels noted were at the margin of the plot and these were believed to be from outside the treatment area. This trial suggests that two baitings in 3 days with chlorophacinone (.01%) treated chopped cabbage could be effective in controlling Oregon ground squirrels.

SISKIYOU COUNTY OPERATIONS

The Siskiyou County Department of Agriculture uses squirrel oat groats as the bait in their Oregon ground squirrel control program. They have not had the bait acceptance problems that Modoc County has.

Anticoagulant Studies

In 1974 personnel from the California Department of Food and Agriculture and the Siskiyou County Department of Agriculture established a series of test plots using anticoagulant treated squirrel oat groats. The plots consisted of broadcasting anticoagulant and Compound 1080 treated baits. These plots were designed to determine the effectiveness of squirrel oat groats treated with an anticoagulant (chlorophacinone .01% and fumarin .05%) and compare them with Compound 1080 bait. The anticoagulant treated grain baits were broadcast at 10 pounds per acre while the Compound 1080 grain bait (20-6: 6 oz. 1080 per 100 pounds grain diluted with 400 pounds clean grain) was broadcast at 5 pounds per acre (standard application rate). Population reduction obtained with the anticoagulants was compared with the Compound 1080 treated baits (Plots 1 to 8 of Table 6). Because of the small size of the plots there appeared to be movement of squirrels from the check plots to the treatment plots thus obscuring the results. No significant population reduction was noticed in the anticoagulant plots until the sixth day after treatment. In this initial trial, squirrel control with anticoagulant grain bait appeared comparable to the control achieved with the Compound 1080 grain bait.

Additional plots (Plots 9 and 10 of Table 6) utilized the technique of placing bait near each burrow. These plots were designed to test the control efficacy of chlorophacinone .01% and fumarin .05% treated squirrel oat groats. A teaspoon quantity of bait was lightly scattered near each main squirrel mound on two consecutive days. The plots were each 100 x 100 feet. Observations of squirrel activity were recorded. This baiting appeared to be effective in controlling Oregon ground squirrels.

Bait Stations

No record could be found of bait stations containing anticoagulant baits being used to control Oregon ground squirrels. In this study, bait stations were made from old automobile tires, cut in half across the diameter, and wired shut so the rim edges were touching (Figure 2). Stations were maintained with 32 oz. of anticoagulant treated squirrel oat groats bait, allowing constant availability. The bait was chlorophacinone .01% and fumarin .05%. Bait consumption (Table 7) and relative activity observations (Table 8)

Table 6. Oregon ground squirrel population reduction using anticoagulant and 1080 grain bait.

Plot	Toxicants	Date Treated	Relative Activity* Dates - May 1974					
			14	15	16	17	20	24
1	Chlorophacinone .01%	14	1	1	1	1	3	3
2	Check	14	1	1	1	1	3	3
3	Fumarin .05%	14	1	1	1	1	3	3
4	Check	14	1	1	1	1	3	3
5	Chlorophacinone .01%	15	-	2	2	2	4	4
6	Check	15	-	2	2	2	3	3
7	Fumarin .05%	15	-	2	2	2	2	3
8	1080 (20-6)	15	-	2	3	3	4	4
9	Chlorophacinone .01%	14 & 15	1	1	1	1	3	4
10	Fumarin .05%	14 & 15	1	1	1	1	4	4

*See Appendix 4 for verbal description of population levels: 1 = very high population; 2 = high population; 3 = medium population; and 4 = low population.

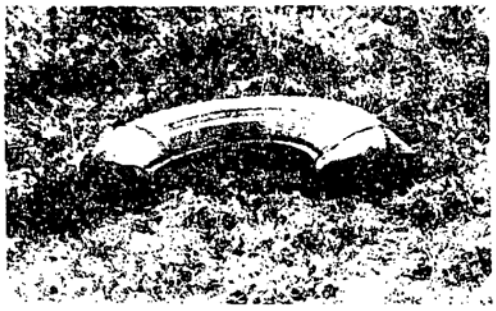

Figure 2. Oregon ground squirrel bait station made from half an automobile tire wired so the rims are held close together.

Table 7. Bait consumed by Oregon ground squirrels per station per day (measurement is in volume ounces).

Stations	Percent Toxicant	Date - May							
		14	15	16	17	20	22	24	TOTAL
1	Chlorophacinone .01	12	32	32	32	32	32	32	204
2	Chlorophacinone .01	2	32	32	32	32	32	32	194
3	Chlorophacinone .01	1	13	8	20	32	28	32	134
4	Fumarin .05	2	16	24	28	32	32	32	166
5	Fumarin .05	8	12	20	30	32	32	32	166
6	Fumarin .05	1	12	20	30	32	32	32	159

Table 8. Oregon ground squirrel relative activity per bait station.

Station	Percent Toxicant		Observation Dates in May 14	15	16	17	20	22	24
1	Chlorophacinone	.01	1	1	1	1	4	4	5
2	Chlorophacinone	.01	1	1	1	1	4	4	5
3	Chlorophacinone	.01	2	2	2	2	4	4	4
4	Fumarin .05		1	1	1	1	4	4	4
5	Fumarin .05		1	1	1	1	4	4	4
6	Fumarin .05		2	2	2	2	4	4	4

See Appendix for verbal descriptions of population levels. 1. Very high population. 2. High population. 3. Medium population. 4. Low population. 5. Very low population.

were recorded. Stations were operational from May 8 to May 24, 1974. There was little or no use by squirrels during the first week of exposure. However, after May 15, the stations were extensively used. On one occasion 8 squirrels (mostly young) were observed using one station at the same time. The final results of this plot amply demonstrated that Oregon ground squirrels will utilize bait stations.

Because of the excellent bait acceptance from bait stations, further testing was done in 1975. These plots were designed to determine which concentration of two different anti-coagulants applied to grain bait (chlorophacinone and fumarin) would be most effective. The bait stations were made from automobile tires. Stations were exposed from May 8 to June 5, 1975. The anticoagulant baits used were: 0.005% and 0.01% chlorophacinone and .025% and .05% fumarin. Stations were placed in grids 100 and 200 feet apart. Each anticoagulant concentration at 100 feet spacing had 16 stations (4 rows of 4 stations). Each anticoagulant concentration of 200 feet spacing had 12 stations (3 rows of 4 stations). Stations were maintained making bait available at all times. Table 9 gives the percent reduction of activity based on the number of squirrels seen in a 100 x 100 foot census area at the center of each plot. These results clearly show that bait stations have a place in controlling Oregon ground squirrels. The squirrels in the check plot were shot by local hunters.

Table 9. Population reduction using anticoagulant-treated grain in bait station giving the range of squirrels counted and the number of times squirrels were counted (in parentheses) for each census plot.

Spacing	Percent Toxicant	Pre-Treatment 5-8-75	During Treatment 5-21-75	6-5-75	Percent Activity Reduction
100 ft.	.025 fumarin	20-33 (6)	6-21 (13)	3-5 (4)	85
100 ft.	.05 fumarin	15-35 (5)	13-28 (11)	2-3 (3)	92
100 ft.	.005 chloro-phacinone	17-31 (5)	3-8 (8)	0	100
100 ft.	.01 chloro-phacinone	14-22 (4)	4-13 (11)	0	100
200 ft.	.025 fumarin	19-35 (7)	6-11 (14)	4-9 (3)	74
200 ft.	.05 fumarin	10-15 (7)	6-13 (14)	3-4 (4)	73
200 ft.	.005 chloro-phacinone	10-22 (7)	1-10 (15)	1-3 (4)	86
200 ft.	.01 chloro-phacinone	20-34 (11)	3-7 (5)	1 (2)	97
	check*				

*Squirrels in check area were shot by local hunters

LITERATURE CITED

GRINNEL, J., and J. DIXON. 1918. Natural History of the Ground Squirrels of California. Calif. St. Comm. Hort. Bull. 7:597-709.

MC KEEVER, S. 1963. Seasonal Changes in Body Weight, Reproduction Organs, Pituitary, Adrenal Glands, Thyroid Gland and Spleen of the Beldingi Ground Squirrel (Citellus beldingi). Am. Jour. Anat. 113:153-173.

TURNER, L.W. 1972. Autocology of the Belding Ground Squirrel in Oregon. Ph.D. Thesis, University of Arizona. 149 PP.

WHITE, L. 1972. The Oregon Ground Squirrel in Northeastern California; its Adaptation to a Changing Agricultural Environment. Proceedings, Fifth Vertebrate Pest Conference. 82-84.

APPENDIX 1

Age-sex breakdown of ground squirrels collected in Lincoln Index study.

	Audlt Males	Adult Females	Young Males	Young Females	Total	Recaptures
Marking	25	36	18	22	98*	9
Recaptured Unmarked	9	21	5	13	48	-
Recaptured Marked	5	6	0	1	12	

*One adult squirrel was marked but not sexed.

APPENDIX 2

Lincoln Index calculation and confidence limits.

$\lambda = N.M$
N = Population estimate
M = Total initially captured, marked and released
n = Total during recapture (note marked and unmarked)
X = Number of individuals marked at recapture
NL = Lower 95% confidence limit
Nu = Upper 95% confidence limit

$$N = \frac{\lambda}{X} = \frac{n.M}{X}$$

$$N = \frac{60 \cdot 98}{12}$$

$$N = 490$$

$NL = \lambda\ (.042)$
$NL = n.M\ (.042)$
$nL = 60.98\ (.042)$
$NL = 245$

$Nu = \lambda\ (.l47)$
$Nu = n.M\ (.147)$
$Nu = 60.98\ (.147)$
$Nu = 864$

These data estimate that there were 490 squirrels in the 4 acre exclusion hoop plot area. .042 and .147 obtained from Table 21.1, page 412 of Wildlife Management Techniques, published by The Wildlife Society, 1969, ed. by R.H. Giles.

APPENDIX 3

Example of 1 oz. 1080-treated cabbage formulation. (Other formulations used 2 or 4 oz. of 1080).

Mix 1 ounce of 1080; 55 ounces of syrup; 8 ounces of starch; and 196 ounces of water. This 260 ounces of mix is added to 260 pounds (4160 ounces) of cabbage. These 4420 ounces of ingredients are used to treat 27 acres, at 10 pounds per acre put on in strips, 45 feet treated, 45 feet not treated.

APPENDIX 4

Verbal description of population levels listed in Table 6.

1 - Very high population. Squirrels prevalent everywhere. Two or more squirrels often seen at a mound. Squirrels close together often feeding side by side. Squirrels seen close to all mounds.

2 - High population. Squirrels quite obvious but seemingly more spaced. On occasion more than one squirrel seen at one mound. Close feeding seen but not often. Many mounds with squirrels close by.

3 - Medium population. Squirrels noticeable but widely spaced. Close feeding not seen. Often most mounds have no squirrels by them.

4 - Low population. Occasional squirrel noticeable. Individual squirrels widely scattered.

5 - Very low population. Squirrels seen only by close observation.

*There appeared to be movement from the check plots to the treatment plot thus partially obscuring the results.