EFFECTS OF HERBICIDE-INDUCED HABITAT CHANGES ON POCKET GOPHERS IN SOUTHWESTERN OREGON

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Damage to conifer seedlings by pocket gophers (Thomomys spp.) is a major threat to reforestation in the pine region of the Pacific Northwest (Dingle 1956, Hermann and Thomas 1963, Black et al. 1969, Barnes et al. 1970, Hooven 1971). In a review of methods of reducing gopher-caused damage to conifers seedlings, Barnes (1973) concluded that vegetation management had the most potential for accomplishing effective, long-term control. Because of its importance to these rodents as food, vegetation largely controls population size (Turner et al. 1973). For example, pocket gopher populations declined after reduction of perennial forbs with 2,4-D in Colorado (Keith et al. 1959, Teitjen et al. 1973). Pocket gophers also responded successfully to vegetative changes associated with disturbed conditions (Barnes 1974).

The purpose of our research, which was conducted from 1972 to 1976, was to study the interaction between pocket gophers and coniferous seedlings as conditioned by vegetative cover. Specific objectives were to study the effects of herbicide-induced vegetative changes on the abundance and feeding activities of pocket gophers and to evaluate the response of several species of coniferous seedlings to gophers and to changes in vegetative cover. The response of small-mammal communities also was studied (Black and Hooven 1974).

In this paper, we summarize the responses of pocket gopher populations to herbicide-induced changes in habitat and the performance of conifer seedlings under these same conditions.

STUDY AREA

This study was conducted on the Medford District of the Bureau of Land Management at two locations (Conde Creek and Keno Road) on the Dead Indian Plateau in southwestern Oregon, at an elevation of about 5,000 feet (1,520 m). Stands were comprised principally of white fir (Abies concolor (Gord. & Glend.) Lindl.), Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco), incense cedar (Libocedrus decurrens Torr.), and ponderosa pine (Pinus ponderosa Laws.), before clearcutting of alternate 20-acre (8.1-m) blocks in about 1960. Repeated efforts to reforest these areas had failed principally because of pocket gopher damage and severe drought in summer. The cutover areas on Conde Creek had been mechanically scarified (terraced) after clearcutting. Clearcuttings were occupied by dense, herbaceous vegetation about equally

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divided between grasses and forbs, with scattered shrubs. Cutover areas were unstocked in 1972.

METHODS

Atrazine (2-chloro-4-(ethylamino)-6-(isopropyl amino)-s-triazine) and simazine (2-chloro-4,6-bis(ethylamino)-s-triazine) were applied to control grasses, 2,4-D ((2,4-dichlorophenoxy) acetic acid) was applied to control forbs and shrubs, and all three herbicides were combined for complete control of vegetation. Broadcast application of herbicides was made on each of three units at both locations (no broadcast treatments were made on control area) in 1972, and was repeated in 1973 and 1974 as follows:

Treatments 1 and 3. Two pounds (0.9 kg) of atrazine 80W and 3 pounds (1.4 kg) of simazine 80W diluted in 20 gallons (76 l) of water, per acre, were aerially applied in October 1972, 1973, and 1974.

Treatments 2 and 3. Four pounds (1.8 kg) of 2,4-D diluted in 17 gallons (63 l) of water and 2 gallons (7.6 l) of diesel oil, per acre, were aerially applied in July 1972, October 1972 (Keno Road only), and October 1973 and 1974.

Treatment 4. No broadcast application of herbicides. A spot-treatment of atrazine diluted in water was applied by hand-sprayer, at a rate equivalent to about 5 pounds (2.3 kg) 80W per acre, after planting of conifer seedlings in November 1972.

Conde Creek		Keno Road	
Unit	Treatment	Unit	Treatment
1	4	1	4
2	1	2	1
3	3	3	2
4	2	4	3

Plot Lay-out and Sampling Schedule

On each unit, 100 sampling plots were systematically located in two blocks of 50 each. In addition, a circular trapline consisting of 40 trapping stations spaced 25 feet (7.5 m) apart were centrally located on each unit. At each sampling point, clusters of seedlings were planted and estimates were made of pocket gopher activity and vegetative cover. Survival and growth of seedlings, gopher activity, animal damage to seedlings, and vegetative cover were observed twice a year in spring and fall. Annual censuses of small-mammal populations were made by continuous removal trapping for 15 days in June each year from 1972 to 1975.

Conifer Plantings

Conifer seedlings were planted in clusters of four or five on each sampling plot; 100 clusters of seedlings were planted on each unit.

The first planting was made in November 1972, with four species of conifer-ponderosa pine (PP); sugar pine (SP), Pinus lambertiana Dougl.; Douglas-fir (DF); and white fir (WF). Few seedlings from the first planting survived because of gopher damage, drought, and other factors, so plots were replanted in 1973-74. In the second planting, sugar pine was replaced with incense cedar (IC). This planting also failed, and a third planting was made in November 1974 on a new series of plots, adjacent to the first series. Five species of conifers were planted in clusters on each sampling plot: PP, IC, DF, WF, and lodgepole pine (LP), Pinus contorta var. latifolia Engelm. A fourth planting from the same lots of seedlings was made in May 1975; seedlings were replanted in the first series of plots.

Vegetative Cover

Plant cover was analyzed, in part, by estimating percentage cover occupied by grasses, forbs, and shrubs on 1-mil-acre (0.0004-ha) circular plots centered around each seedling cluster. Cover classes were assigned as follows:

Cover class	Cover, percent
1	0 - 5
2	5 - 25
3	25 - 50
4	50 - 75
5	75 - 100

Pocket Gopher Activity

We determined presence or absence of gopher activity within 1/100-acre (0.004-ha) circular plots centered around each seedling cluster. We considered fresh mounds, plugged and open holes, and fresh snow casts as evidence of recent activity.

PRELIMINARY RESULTS

Effects of Herbicide Treatments

Mean cover of grasses and forbs combined was roughly comparable on all units on both areas before treatment, although forbs were slightly more abundant on Conde Creek (Table 1).

In spring 1973, cover on all treated units was reduced; cover was decreased most on units treated with atrazine, simazine, and 2,4-D and least on units treated with 2,4-D alone. Units treated with a combination of 2,4-D, atrazine, and simazine were nearly devoid of all vegetation, except for small amounts of a few herbicide-resistant species such as common mullein (Verbascum thaspus L.), spring-flowering species that were not exposed to 2,4-D (and not susceptible to atrazine and simazine), and plants protected by slash or overhanging vegetation. Treatment with atrazine and simazine, only, reduced both grass and forb cover; atrazine

and simazine apparently inhibited germination of forbs, which caused a marked reduction in their abundance in the year after initial application. Treatment with 2,4-D alone killed or suppressed most forbs initially, but it had little effect on combined cover of grasses and forbs after the initial treatment in 1972. Although forb cover on areas treated with 2,4-D was lower in spring 1973 than before treatment, grass cover was much higher. Because of repeated herbicide treatments in 1973 and 1974, little change in cover or composition of herbaceous vegetation was observed on treated areas in spring 1975 and 1976.

Cover on untreated areas remained fairly constant throughout the study, although more yearly variation in cover was observed on Keno Road; these differences probably were related to phenology, especially in spring 1975.

Response of Pocket Gophers

Gopher activity was fairly evenly distributed on all units on both areas in spring 1972, before application of herbicides (Table 2). Gopher activity showed no marked changes in fall 1972, after 2,4-D was applied to two units on each area in July 1972. In spring 1973, after herbicide treatment in the previous summer, fall, or both, gopher activity still showed no marked response to herbicide-induced habitat changes, although all treated units on Keno Road showed a decline in gopher activity. In fall 1973, however, gopher activity had nearly disappeared on units on both areas that had received a combination of atrazine, simazine, and 2,4-D. On Keno Road, activity continued to decline on units treated with atrazine and simazine, and with 2,4-D. In spring 1974 after the second successive year of herbicide treatments, activity on all treated units on both areas was greatly reduced from levels observed in spring 1972. An unexplained decrease in gopher activity on the untreated unit on Keno Road also occurred in spring 1974, although activity on this unit soon returned to normal. By fall 1974, gopher activity increased slightly on all treated units and, on the 2,4-D-treated unit on Conde Creek, gopher activity was above pretreatment level.

Overall, gopher activity declined markedly on all units in spring 1975. Populations recovered in the fall, although activity on all units on Keno Road remained low--populations were always higher in the fall than in the spring at both locations, reflecting the annual cycle in gopher abundance. Gopher activity on all units remained low in spring 1976, and it was probably lower than when the study began in 1972. The principal change in gopher activity in fall 1976, after three successive years of vegetation management with herbicides, was the recovery of gopher populations on all treated areas at both locations. The marked increase in gopher activity on the areas treated with atrazine and simazine was probably related to the presence of moderate shrub cover and the recovery of perennial grasses; resprouting of shrubs and recovery of herbaceous vegetation also favored an increase in gopher activity on the area of Conde Creek that had received a combination of atrazine, simazine, and 2,4-D. Gopher activity on treated and untreated areas on Keno Road remained about the same as in fall 1975.

Table 1. Herbaceous cover in spring on Conde Creek and Keno Road areas before and after treatment with herbicides in 1972, 1973, and 1974.

Unit	Treatment	Mean herbaceous cover, percent				
		1972	1973	1974	1975	1976
		CONDE CREEK				
1	Untreated	68	67	71	71	78
2	A + S	67	27	13	13	14
3	A + S + 2,4-D	69	7	7	5	6
4	2,4-D	66	58	67	71	75
		KENO ROAD				
1	Untreated	62	50	62	33	56
2	A + S	52	11	7	4	11
3	2,4-D	54	43	42	24	37
4	A + S + 2,4-D	54	6	4	5	9

Table 2. Pocket gopher activity on the study areas on Conde Creek and Keno Road. Data indicate percentage of 1/100-acre (0.004-ha) circular plots with recent gopher sign (mounds, plugs, or open holes) on each unit during annual observations in spring and fall.

Unit	Treatment	Active plots, percent							
		1972		1973		1974		1975	1976
		Spring	Fall	Spring	Fall	Spring	Fall	Fall	Fall
		CONDE CREEK							
1	Untreated	78	52	40	62	65	89	68	75
2	A + S	69	66	62	56	37	42	36	76
3	A + S + 2,4-D	65	51	41	2	0	10	7	22
4	2,4-D	67	61	57	57	18	80	71	84
		KENO ROAD							
1	Untreated	55	84	82	68	25	64	36	59
2	A + S	63	96	57	32	9	14	3	19
3	2,4-D	57	77	50	29	19	38	15	40
4	A + S + 2,4-D	58	85	45	10	13	20	3	15

Pocket Gopher Damage to Seedlings

Data reported here were condensed to show the principal impact of gophers on conifer seedlings. Complete analysis of all data on seedling performance--occurrence of gopher damage (including an analysis of gopher feeding preference among species of conifers tested), survival, and growth--will be included in a later report.

Within less than 6 months after planting, pocket gophers destroyed about one-third of all seedlings planted in November 1972 (Table 3). Damage consisted primarily of root and stem clipping, and in most instances the seedlings had been completely removed by the gophers. Susceptible broad-leaved vegetation had been suppressed by treatment with 2,4-D in July 1972, but effects of treatments with atrazine and simazine made just before planting were only beginning to become evident when the seedlings were examined in May 1973 (Table 1).

Table 3. Occurrence of pocket gopher damage to conifer seedlings from planting in November 1972 to May 1973.

Unit	Treatment	Seedlings destroyed, percent				
		Ponderosa pine	Sugar pine	Douglas-fir	White fir	Mean
		CONDE CREEK				
1	Untreated	10	16	11	13	12
2	A + S	38	32	30	25	31
3	2,4-D + A + S	29	27	21	22	25
4	2,4-D	31	35	21	22	24
	Mean	27	27	21	20	23
		KENO ROAD				
1	Untreated	64	67	61	59	63
2	A + S	53	52	50	50	51
3	2,4-D	32	20	19	15	21
4	2,4-D + A + S	28	27	25	31	28
	Mean	44	41	39	39	41

On the Keno Road area, gophers destroyed fewer seedlings on 2,4-D-treated units. But initial effects of herbicide treatments were negligible at Conde Creek where, unaccountably, few trees were damaged on the untreated unit. Pocket gophers showed no marked feeding preferences among the four species of conifers planted in 1972, although pines were taken more frequently than Douglas-fir and white fir. Results from the second planting of seedlings, made in 1973-74, were omitted because of plantation failure--most seedlings died because of problems related to planting, storage, or both.

Occurrence of gopher damage to conifer seedlings planted in November 1974 (third planting) was in marked contract to results observed in spring 1972 (Table 4). Gopher damage was greatly reduced on units treated with atrazine and simazine on both areas, although units treated with atrazine, simazine, and 2,4-D had the least damage. Treatment with 2,4-D alone was least effective in reducing gopher damage. In 1972, gopher

damage was higher on the Keno Road area, presumably related to the greater amount of gopher activity seen there. In 1975, the pattern of gopher activity and seedling damage was reversed. That is, after 1974, gopher activity and tree damage were both higher at Conde Creek than at Keno Road.

Pocket gophers showed no differences in feeding preferences among the pines and firs tested, although fewer incense cedar seedlings were taken during the first dormant season after planting (Table 4).

Table 4. Occurrence of pocket gopher damage to conifer seedlings (third planting) from planting in November 1974 to June 1975 at Conde Creek.

		Seedlings destroyed by gophers, percent					
Unit	Treatment	Ponderosa pine	Incense cedar	Douglas-fir	White fir	Lodgepole pine	Mean
1	Untreated	55	31	49	53	55	49
2	A + S	20	8	16	20	18	16
3	A + S + 2,4-D	3	1	5	6	4	4
4	2,4-D	56	34	53	48	61	50
	Mean	33	18	31	32	34	30

Seedling Performance

Seedlings survived best on areas with complete control of vegetation. Poorest survival occurred on areas without control of grass--very few seedlings survived on these areas. Pine and incense cedar seedlings survived better than firs.

The beneficial effects of vegetation management are revealed clearly in Table 5, which summarizes seedling survival (third planting, Conde Creek) after the first growing season. Combined losses caused by gopher damage, principally during the growing season, reduced seedling survival markedly on the untreated unit and on the unit treated only with 2,4-D.

Analysis of data from the fourth planting, made in May 1975 is incomplete. Although these plantations performed better than the plantations established in November 1974 (fewer trees were damaged by gophers and losses caused by drought were less), results were similar to those observed in the third planting.

Table 5. Seedling survival (third planting) 1 year after planting, from November 1974 to October 1975 at Conde Creek.

Unit	Treatment	Seedling survival, percent					
		Ponderosa pine	Incense cedar	Douglas-fir	White fir	Lodgepole pine	Mean
1	Untreated	24	36	4	6	20	18
2	A + S	71	85	59	55	73	69
3	A + S + 2,4-D	94	62	63	49	88	71
4	2,4-D	6	6	2	3	10	5
	Mean	49	47	32	28	48	41

SUMMARY AND CONCLUSIONS

Selective control of grasses only, forbs and shrubs only, or all vegetation was obtained with herbicides. A reduction in species of grasses and forbs and marked reduction in ground cover occurred on all broadcast-treated areas (with exception of the areas treated with 2,4-D), within 1 year after treatment. Nearly all herbaceous vegetation and shrubs were suppressed on areas treated with atrazine, simazine, and 2,4-D, although resprouting of shrubs occurred on 2,4-D-treated areas in 1975 and 1976. These changes in vegetative cover were maintained for more than 3 years, although shrubs resprouted and herbaceous cover increased after herbicide treatments were discontinued.

Pocket gopher activity declined in response to vegetation management, but lagged about 1 year after application of herbicides. The greatest reduction in gopher activity occurred on areas with complete control of vegetation. On areas treated with atrazine, simazine, and 2,4-D, gopher activity was only about one-tenth of that observed on untreated areas.

Gopher activity and seedling survival were related to the reduction in vegetative cover, especially of perennial grasses. Thus, as the cover declined, the environment became less favorable for gophers and more favorable for tree survival; occurrence of gopher damage and losses to drought (caused by moisture stress) were reduced and seedling survival improved.

These preliminary results demonstrated that reforestation problems caused by pocket gophers, moisture stress, or both may be alleviated by vegetation management with herbicides. Response of pocket gophers to herbicide treatments will vary somewhat with conditions of herbicide application and composition and density of vegetation. Thus, prevention of damage may require handbaiting or other measures, in addition to vegetation management.

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