SITE PREPARATION AS RELATED TO GROUND COVER DENSITY IN NATURAL REGENERATION OF PONDEROSA PINE

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Surface disturbance of the forest floor by mechanical means is recognized as a cultural measure for aiding establishment of conifer seedlings. Present harvesting practices in the ponderosa pine type create favorable seedbed conditions to a limited extent during the normal course of logging, but purposeful seedbed preparation has not been the rule. More information on the effect of competing vegetation on germination and early establishment of pine would aid greatly in planning treatments for adequate restocking.

The Experiment

Accordingly, a study was designed as a preliminary test in securing natural regeneration of ponderosa pine (Pinus ponderosa Laws.) and Jeffrey pine (P. jeffreyi Grev. and Balf.) in the eastside pine region of California. Ground scarification was used to simulate fresh logging disturbance on bare ground and to remove vegetation elsewhere.

The specific factors chosen for study were:

1. Germination and survival of seedlings as related to ground cover density on scarified seedbeds.

2. Comparative height growth of seedlings on areas of varying ground cover density.

The experiment was conducted on the Blacks Mountain Experimental Forest in northeastern California during the years 1948 to 1952.

Selection of Study Areas

In 1948 six areas, each of varying ground cover density, were selected for scarification and rodent poisoning. These areas satisfied certain conditions. First, each represented a natural regeneration area

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1/ Formerly Forester, California Forest and Range Experiment Station; now with the Intermountain Forest and Range Experiment Station. Analyzed data for first three years and submitted thesis to the University of California in partial satisfaction of the requirements for the Degree of Master of Science.

2/ Forester (Silviculture). Aided in field work and continued the study through the fourth year.

as prescribed under the unit area control form of management[3/] when applied to the eastside ponderosa pine type. Second, the areas had to be sufficiently large and properly shaped--generally larger than 0.2 acre and any shape except extremely long and narrow. Third, the trees bordering the areas had to be bearing a satisfactory cone crop during seedbed preparation so that seed would be supplied soon after.

Scarification

The forest floor on the plots was scarified two weeks before seedfall with an offset disc-harrow pulled by a wheeled farm tractor. The disc-harrow had two sets of discs with 22-inch blades. By adjusting the rear set of discs to cut between the furrows made by the forward set, maximum disturbance was attained. This machine scarified strips four and one-half feet wide. It performed well on open bare areas and on areas with very light cover of low vegetation. However, it was not heavy enough to break through and tear up a duff layer or thick bunch-grass roots, and in slash the equipment hung up on limbs and chunks. A definite need exists for developing scarification equipment which can cope with these impediments as well as the stony soil surfaces of the eastside type.

Rodent Poisoning

Poisoning was aimed at three seed-eating rodents: Ground-squirrels (Citellus spp.), chipmunks (Eutamias spp.) and white-footed mice (Peromyscus spp.). No attempt was made to control pine squirrels (Tamiasciurus spp.) and California gray squirrels (Sciurus griseus griseus Ord.) since activity of these animals in the study areas was negligible during the period of cone development. Rodent populations were not determined by trapping, but observations indicated that each of the three kinds of rodents toward which the poisoning was directed was present before seedfall in substantial numbers on all study areas.

The lethal bait consisted of oat groats treated with sodium fluoroacetate, also known as "1080". Three ounces of "1080" were added to every 100 pounds of groats. In all, 810 acres were treated at a cost of 26 cents per acre[4/].

3/ Hallin, William E. 1951. Unit area control in California forests. U. S. Forest Serv., Calif. Forest and Range Expt. Sta. Research Note 77, 6 pp.

4/ Cosens, Richard D. and David Tackle. 1950. Costs of rodent control in pine regeneration in California. U. S. Forest Serv., Calif. Forest and Range Expt. Sta. Research Note 73, 5 pp.

Seedfall

An abundant seed crop occurred in 1948. Seedfall was not measured on the study areas, but 120 seedtraps on three comparable logged plots nearby caught sound pine seed at the rate of 130,000 seed per acre.

Germination and Survival Counts

Seedling germination and survival were sampled on milacre quadrats arranged in transects. These transects ran through all degrees of ground-cover density present on the six locations.

Each milacre quadrat was classified by the type and visible surface density of ground cover. If the quadrat had one-tenth or less of its surface covered, it was classified as bare; if more than one-tenth but not greater than four-tenths, light; more than four-tenths but not over seven-tenths, medium; and if more than seven-tenths, heavy.

Germination, survival and height growth were analyzed by the original quadrat classifications. In 1951 each quadrat was reclassified to detect any changes in surface density. No appreciable change was found for either vegetation or duff. On some quadrats slash had settled nearer the ground but the overall density remained unchanged.

Height Growth Measurements

If stocking is adequate, seedling vigor determines how soon, if ever, the desired reproduction will dominate competing vegetation and establish a forest cover. Therefore, seedling vigor, best measured by height growth, is another measure of regeneration success. To obtain comparisons, heights of all seedlings not damaged by deer, rodents, cattle, or other agents, were recorded for a randomly selected sample of quadrats from each of the four ground-cover density groups.

Results

Germination

The greatest number of seed per acre germinated on seedbeds described as bare. Here over 33,000 seed germinated per acre. As ground-cover density increased, germination declined, with greater disparity between germination on bare and light densities of cover than between germination on medium and heavy densities. Seedbeds with light, medium, and heavy ground cover had 11,420 seedlings, 3,816 seedlings, and 2,914 seedlings per acre, respectively. Roughly similar trends are indicated for the density range within each type of ground cover (Table 1). For example, 5,062 seed per acre germinated on quadrats with light squaw carpet cover, 3,091 seed per acre on medium squaw carpet, but only 1,774 seed per acre germinated on heavy squaw carpet.

Table 1.--Germination by type and density of ground cover

Ground-cover density	Type of ground cover: Squaw carpet[1/]	Grass	Woolly mules-ears[2/]	Duff	Slash	All	Quadrat basis
	number seeds germinating per acre						number
Bare	--	--	--	--	--	33,329	164
Light	5,062	13,472	--	5,643	--	11,420	119
Medium	3,091	5,889	5,286	1,750	2,333	3,816	38
Heavy	1,774	5,944	--	2,286	1,428	2,914	70
Basis; number of quadrats	58	116	7	36	10	--	--

1/ Ceanothus prostratus Benth.

2/ Wyethia mollis Gray.

Variable effects of ground-cover types on germination are also shown. The most marked example of this is the germination obtained on grassy quadrats[5/]. On these, germination for any cover density class was much greater than for any other type of cover in the same density range.

First Year Survival

The effect of ground cover upon pine seedling survival was evident as early as the end of the first growing season. While 42 percent of the seedlings on bare areas survived, only 16 percent remained alive where the cover density was heavy (Table 2). The relatively low survival (26 percent on areas with only light cover shows that even a small amount of competition is unfavorable to seedling establishment.

5/ Species of bunch grasses and sedge distributed approximately as follows: Idaho fescue (Festuca idahoensis) - 71 percent, squirreltail (Sitanion hystrix) - 11 percent, western needlegrass (Stipa occidentalis) - 10 percent, little bluegrass (Poa sandbergii) - 4 percent, and sedge (Carex rossii) - 4 percent.

Table 2.--Percentages of seedling survival for the first and fourth years after germination by type and density of ground cover

Ground-cover density	Type of ground cover					
	Squaw carpet	Grass	Woolly mules-ears	Duff	Slash	All[1]
	percent survival					
FIRST YEAR						
Bare	--	--	--	--	--	42 (41.9)
Light	31 (4.1)[2]	26 (22.8)	--	27 (3.6)	--	26 (30.5)
Medium	9 (2.8)	19 (2.3)	27 (1.8)	14 (2.0)	29 (0.8)	19 (9.7)
Heavy	11 (7.9)	16 (4.6)	--	22 (3.6)	20 (1.8)	16 (17.9)
All[1]	20 (14.8)	25 (29.7)	27 (1.8)	24 (9.2)	24 (2.6)	38[3] (100.0)
FOURTH YEAR						
Bare	--	--	--	--	--	33
Light	19	11	--	7	--	11
Medium	0	0	8	7	14	4
Heavy	0	4	--	13	0	4
All[1]	9	10	8	8	12	24[3]

1/ Weighted by number of quadrats sampled in each category. Data are presented in this form to indicate the natural regeneration which can be expected after scarification, rodent poisoning, and seedfall as described in this report.

2/ Numbers in parentheses show the percent of ground area in each category.

3/ Includes data for bare ground.

First year seedling survival on a stocked quadrat basis--one or more seedlings per milacre quadrat (Table 3)--further demonstrates the effect of the density of ground cover. Stocking after the first year under medium and heavy cover by either stocked quadrats or number of seedlings per acre (Table 4) was well below that presently considered necessary for producing a fully stocked stand at maturity.

Survival During Early Establishment

Seedling survival diminished each year after germination (Tables 4 and 5). Reduction in survival between the first and fourth years on bare areas was decidedly lower than the reduction on areas of denser ground cover, whether numbers of seedlings (Table 5) or numbers of stocked quadrats (Table 3) are considered. If numbers of seedlings are used, the reductions in survival between the first and fourth years are 9 percent for bare, 15 percent for light, 15 percent for medium, and 11 percent for heavy densities. Though these losses are about the same percentage-wise, the loss for the heavy ground cover is more significant because far fewer seedlings survived there the first season. Reductions in stocked milacre quadrats during the same period for bare, light, medium, and heavy ground-cover densities were 20 percent, 33 percent, 23 percent, and 9 percent, respectively.

Height Growth

The height growth of seedlings also showed pronounced effects of ground-cover density. These differences increased markedly in the fourth year, the average total heights for all seedlings on bare, light, medium, and heavy cover densities being 5.6, 2.3, 3.2, and 2.5 inches, respectively (Table 6). When only the tallest seedlings (one per quadrat) were used, the average heights became 6.7, 3.0, 3.1, and 2.4 inches (Table 7).

Differences in height growth through the fourth year were compared by t-tests and were found to be highly significant between bare and light density covers for all seedlings; and significant for the tallest seedlings. The seedling height differences between light and medium cover densities were significant for all seedlings[6/]. No other differences were statistically significant.

6/ Height differences between seedlings growing on light and medium cover densities were not significant at the end of the third year. This discrepancy in statistical significance of height growth between the third and fourth growing seasons is a reflection of seedling mortality and field technique and not height growth per se. During the first three years heights were measured from cotyledon scars to tips of terminal buds. In the fourth growing season the cotyledon scars became indistinct on many seedlings so heights had to be measured from ground line to tips of terminal buds.

Table 3.--Milacre quadrat stocking percentages for first and fourth years by ground-cover density.

Ground-cover density	Stocked quadrats		Basis	
	First year	Fourth year	First year	Fourth year 1/
	percent		number	
Bare	90	70	164	115
Light	66	33	119	101
Medium	37	14	38	36
Heavy	17	8	70	63
All	65	39	391	315

1/ Sample size reduced by logging disturbance

Seedlings on bare areas were not only taller but were much more vigorous in appearance; they had greater needle complement, longer needles, and more robust stems, than seedlings on areas with greater cover density (Figures 1, 2, 3, 4, and 5).

Table 4.--Number of seedlings surviving per acre by type and density of ground cover, and year after germination

Ground-cover density and year		Type of ground cover					
		Squaw carpet	Grass	Woolly mules-ears	Duff	Slash	All
Bare	1 year	--	--	--	--	--	14,043
	2 year	--	--	--	--	--	13,122
	3 year	--	--	--	--	--	12,035
	4 year	--	--	--	--	--	11,017
Light	1 year	1,562	3,528	--	1,500	--	3,025
	2 year	1,312	2,575	--	917	--	2,178
	3 year	937	1,822	--	417	--	1,535
	4 year	937	1,493	--	417	--	1,277
Medium	1 year	273	1,111	1,428	250	667	710
	2 year	0	571	1,000	250	333	389
	3 year	0	286	571	125	333	222
	4 year	0	0	429	125	333	139
Heavy	1 year	194	944	--	500	286	457
	2 year	103	462	--	357	286	254
	3 year	34	231	--	357	0	143
	4 year	0	231	--	286	0	127
All	1 year	586	2,940	1,428	833	400	6,962
	2 year	428	2,129	1,000	529	300	5,584
	3 year	321	1,484	571	324	200	4,943
	4 year	267	1,204	429	294	200	4,473

Table 5.--Seedling survival, by ground-cover density

Ground-cover density	Years after seedfall			
	First	Second	Third	Fourth
	percent survival			
Bare	42	39	36	33
Light	26	19	13	11
Medium	19	10	6	4
Heavy	16	9	5	4
All	38	30	27	24

Table 6.--Average heights of seedlings, in third and fourth years, by ground-cover density

Ground-cover density	Third year: Basis: Quadrats	Third year: Basis: Seedlings	Third year: Average height[1]	Third year: Difference and significance[3]	Fourth year: Basis: Quadrats	Fourth year: Basis: Seedlings	Fourth year: Average height[2]	Fourth year: Difference and significance[3]
	number		inches		number		inches	
Bare	10	73	2.8	1.5 HS	8	61	5.6	3.3 HS
Light	10	38	1.3	0.1 N	9	26	2.3	0.9 S
Medium	6	8	1.2	0.1 N	4	5	3.2	0.7 N
Heavy	5	5	1.1		3	4	2.5	

1/ Measured from cotyledons to tip of terminal bud.
2/ Measured from ground line to tip of terminal bud.
3/ HS - highly significant
S - significant
N - not significant

Table 7.--Average heights of tallest seedlings (one per quadrat), in third and fourth years, by ground-cover density

Ground-cover density	Third year: Seedlings measured	Third year: Average height[1]	Third year: Difference and significance[3]	Fourth year: Seedlings measured	Fourth year: Average height[2]	Fourth year: Difference and significance[3]
	number	inches		number	inches	
Bare	10	3.2	1.7 S	8	6.7	3.7 S
Light	10	1.5	0 2 N	9	3.0	0.1 N
Medium	6	1.3	0.2 N	4	3.1	0.7 N
Heavy	5	1.1		3	2.4	

1/ Measured from cotyledons to tip of terminal bud.
2/ Measured from ground line to tip of terminal bud.
3/ HS - highly significant
S - significant
N - not significant

Discussion

Comparison of results for various ground-cover densities shows that ponderosa pine seedbed preparation should be aimed at eliminating all competing ground cover and exposing loose mineral soil, not necessarily over the whole ground surface but in enough evenly distributed spots for sufficient germination and early seedling survival to insure adequate future stocking. A search for reproduction on bare but unscarified ground within the poisoned area indicated that scarification is desirable even on bare ground. Seedbeds should be prepared in the same year as the seedfall to obtain the maximum benefit of loose mineral soil before it again becomes compacted.

Besides hindering germination and survival, small amounts of competing vegetation are detrimental to pine seedling development. Four years after seedfall, live seedlings on the bare soil averaged 1.8 to 2.4 times as tall as seedlings growing where ground cover was present. The dominant seedlings growing on bare soil were 2.2 to 2.9 times taller than dominant seedlings growing elsewhere. These differences are statistically significant. Visible surface cover density, therefore, appears to be a fairly good indicator of poor seedling height growth, at least for the first four years.

Some might argue that areas with light cover density have adequate stocking (1,277 seedlings per acre) three years after seedfall. However, the number of seedlings per acre becomes less impressive when we see that only 33 percent of the milacre quadrats are stocked, and when the poor height growth (Tables 6 and 7) is considered. The chance for seedlings to attain full growth potential in early life has been thwarted by only a small amount of competition or ground cover. Bare soil seems the only suitable condition for early maximum stand development.

Conclusions

Results of the study allow the following conclusions:

1. Duff, slash, and competing vegetation are all detrimental to establishment and development of seedlings in the eastside pine type of California.

2. Detrimental effects of ground cover become increasingly greater with time, at least for the first four years.

3. Proper site preparation aids seed germination and seedling survival, and minimizes the period needed by seedlings to dominate the ground and assure a new stand of trees.

Figure 1.--Bare soil quadrat. Five-year-old seedlings. Average height of 27 undamaged seedlings: 9.8 inches. Range of heights: 15.2 to 4.0 inches. Two seedlings damaged.

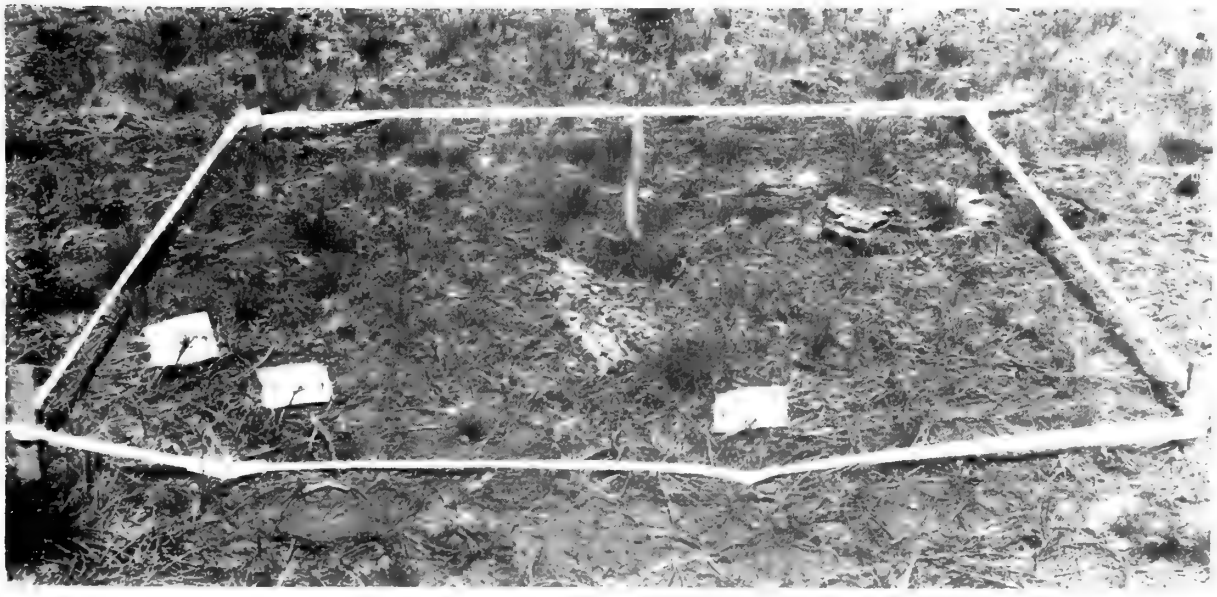

Figure 2.--Heavy grass quadrat. Five-year-old seedlings. Average height of 3 seedlings: 3.1 inches. Range of heights: 2.4 to 4.3 inches.

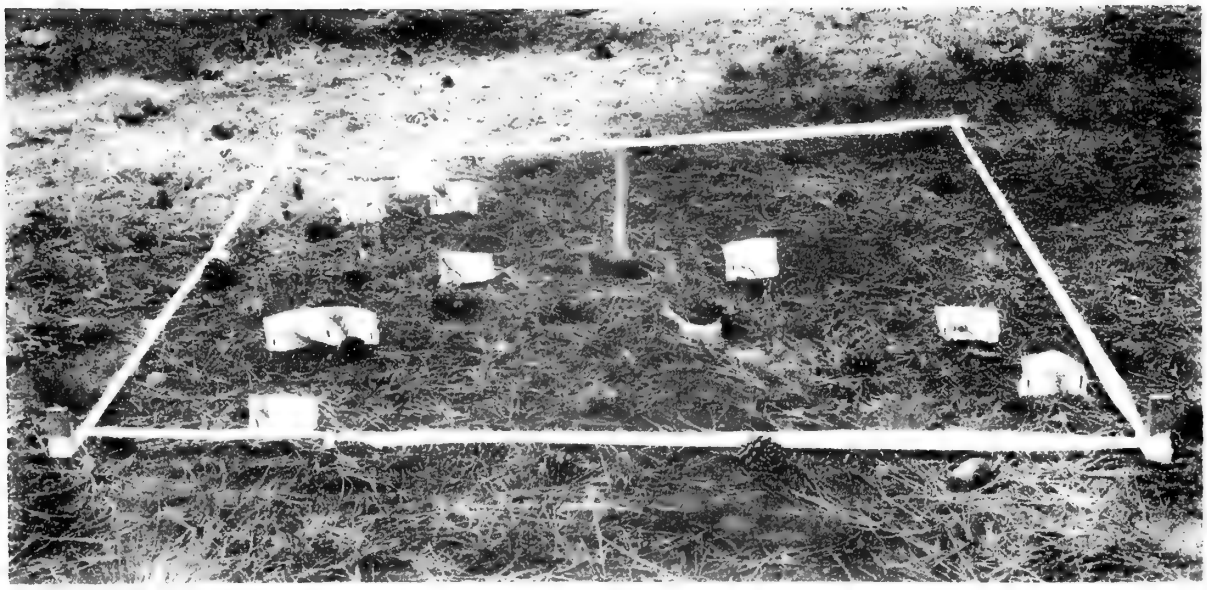

Figure 3.--Light duff quadrat. Five-year-old seedlings. Average height of 10 seedlings: 3.7 inches. Range of heights: 3.0 to 4.6 inches.

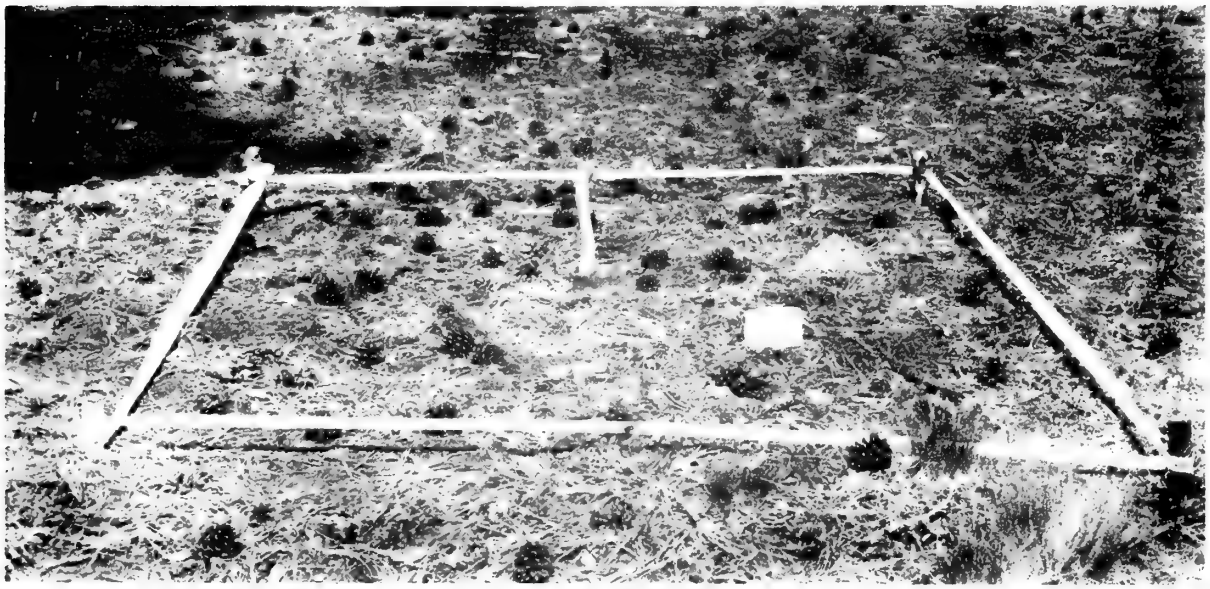

Figure 4.--Heavy duff quadrat. Five-year-old seedling. Height: 1.8 inches.

Figure 5.--A vigorous five-year-old seedling growing on bare soil. Total height: 26.0 inches. Height growth: fourth season -- 8.4 inches; fifth season -- 13.8 inches.