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# PONDEROSA PINE SEEDING TRIALS IN WEST-SIDE SIERRA NEVADA CLEARCUTS: some early results

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In direct-seeding trials on the Challenge Experimental Forest, Yuba County, California, 27 combinations of seeding rates, aspect, and site treatment were tested. The best results were obtained on northerly aspects on unburned mechanically disturbed seedbeds with a high proportion of exposed mineral soil when seed application rates were high. Sowing at least 1 pound of seed per acre (1.12 kg per ha) consistently resulted in 400 or more seedlings per acre (988 seedlings per ha). Baiting for rodent control and attempted seed covering by "dragging" did not improve results. If regeneration requirements will be met by 400 seedlings per acre, these procedures for operational testing are suggested: (1) prepare 100 percent of the site by piling and burning slash and residual vegetation; (2) use seed that has had the standard endrin-arasan-aluminum-dust pest repellent treatment, or equivalent; and (3) apply at least 1.5 pounds of seed (10,000 to 12,000 viable seed) per acre (1.7 kg, or 24,710 to 29,650 seed, per ha).

*Oxford:* 174.7 *Pinus ponderosa*:232.33(794).
*Retrieval Terms: Pinus ponderosa;* California; broadcast seeding; site treatments; rodent control; fire effects; winter damage.

Attempts to secure adequate stocking in seeding trials of ponderosa pine have frequently been unsuccessful. Ponderosa pine (*Pinus ponderosa* Laws.) seed sown by helicopter on the Challenge Experimental Forest[1] in March 1964 produced about 400 2-year-old seedlings per acre (988 per ha). The 400 seedlings were far short of our goal of 50 percent milacre (≅4 sq m) stocking, or 1375 well-distributed seedlings per acre (3398 per ha), 2 years after sowing. Subsequent seeding trials and associated studies have sought to explain and improve the results of the 1964 test.

Twenty-seven different combinations of seeding rates, aspect, and site treatment have been evaluated in two series of studies since the 1964 helicopter operation. One series was installed in 1965 and the other in 1966. Hall[2] has reported preliminary (first-year) results of the 1965 series. Briefly, the results were generally promising, and especially so with respect to the beneficial influence of dragging on seedling establishment.

This note reports second-year results of the 1965 tests and preliminary results of the less successful 1966 tests. Even though the goal of 50 percent milacre stocking has not been consistently achieved, we have developed procedures that should consistently produce at least 400 seedlings per acre, or about 70 percent stocking on a 4-milacre (≅16 sq m) quadrat basis. Procedures to achieve this stocking are described here.

## THE STUDY

The 27 treatments were applied to a total area of 212 acres (85.8 ha) in several small clearcuts logged in 1964, 1965, and 1966. The areas of individual cutting units (compartments) range from 9 to 38 acres (3.6 to 15.4 ha). The areas of the 27 individual treatment units (subcompartments) range from 0.25 to 24 acres (0.1 to 9.7 ha).

The 27 subcompartments evaluated include all but two of the 1965 and 1966 ponderosa pine seedings. Of the two compartments not included, one is considered adequately regenerated, but in it natural and artificial regeneration are confounded. The other compartment is considered a failure and is not included because the regeneration job was unique in several aspects, so that no basis for comparison with other compartments exists. The treatment of the failed compartment also did not meet two of the three conditions considered necessary for success described later.

The logged stands were predominantly 90- to 100-year-old Pacific ponderosa pine and Pacific ponderosa pine–Douglas-fir types.[3] Volumes per acre ranged from 9 to 38 M bd ft Scribner and averaged 18.5 M bd ft (22.2 to 93.9 M bd ft per ha, averaging 45.7 M bd ft). Soils are deep Aiken-like clay loams. Slopes range from level to 57 percent and elevations from 2500 to 3500 feet (762 to 1067 m). All aspects are represented. Site index averages 140 feet (42.7 m) at 100 years.[4] Annual precipitation averages 69 inches (175 cm).

All trees and brush that remained after logging were crushed and broadcast burned with the slash. Similar stands included in slash disposal studies on the Experimental Forest developed 50 to 110 tons of dry slash per acre (112 to 247 MT per ha)[5] of which 60 to 85 percent was removed by broadcast burning.[2,6]

All slash was scheduled for burning the fall after the winter and spring logging operation had been completed, but unfavorable weather caused delays as long as 1 year. These delays created several of the 27 treatments and required revision of original plans.

All subcompartments seeded in 1965 had been logged in early 1964 and burned a year later in February and April 1965. The 1966 seedings included areas logged in early 1965 and 1966, all of which were burned in November 1966, a few weeks before seeding.

All seeds were broadcast unstratified in December by standard hand-operated seeders. Seeding rates ranged from 0.35 pounds to 2.3 pounds per acre (0.39 to 2.58 kg per ha) except for an area of about 0.25 acres (0.10 ha) inadvertently sown at a rate of 17.6 pounds per acre (19.7 kg per ha) in 1966.

Throughout we used California Seed Zone II[7] seed from within 100 miles (161 km) of the Experimental Forest. The areas of Seed Zone II from which we obtained seed are in the new zones 524 and 525.[8] All seed had a pest-repellent coating of 1 percent active endrin,[9] arasan, and aluminum dust applied with an asphalt-emulsion sticker. Viable-seed-per-pound averaged 7,840 (17,284 seed per kg) in 1965 and 6,617 (14,588 seed per kg) in 1966.

In both seeding operations, some areas were baited with 1080 (sodium fluoracetate) treated oats for rodent control and other areas were not. A prebaiting rodent census indicated a need for rodent control in the 1965 areas, but no census was made for the 1966 seeding. The baiting operations were conventional. The 1965 baiting operation has been described previously.[2]

Some of the subcompartments seeded in 1965 were "dragged" after sowing for the purpose of increasing seedling establishment by covering the seed. The "drag" was a harrowlike device consisting of several pieces of steel rail towed by a tractor.[2]

Nineteen selected subcompartments in both the 1965 and 1966 seedings were sampled with temporary milacre plots in winter of 1967-68. The number of plots installed per subcompartment ranged from 40 to 89. Objectives were estimates of milacre stocking and numbers of seedlings per acre. The other eight subcompartments were sampled less intensively, with a minimum of 20 temporary plots.

In the 19 selected subcompartments, all variables but one were fixed in relation to other subcompartments. Therefore, each of the selected subcompartments could be compared with one or more other subcompartments. Specific comparisons dealt with seeding rates, aspect, effects of dragging, and effects of rodent baiting. Fourteen of the 19 subcompartments were seeded with ponderosa pine only; five subcompartments, all sown in 1965, were seeded with a combination of ponderosa pine and three other conifers. Only the ponderosa pine results from these mixed seedings are included in this report.

The 1967-68 sampling procedure in the intensively sampled subcompartments also included a detailed description of seedbed conditions on each sample milacre. The objective of this description was to find an explanation for the large differences in results previously observed between areas that seemed to be identical in conditions and treatments. First, we estimated the proportional amount of each of six disturbance-burn classes to the nearest 10 percent. Then, for each class present, the proportional amounts of two other seedbed conditions were separately estimated to the nearest quarter. These two conditions could simultaneously occur on any or all quarters. One condition was the amount of exposed mineral soil at the completion of slash disposal. The other was the amounts of both herbaceous and woody ground cover at the height of the growing season preceding the examination. In estimating the "nearest quarter," 0.00 to 12.5 percent of the disturbance-burn class area was 0 quarter, 12.5 to 37.5 percent was 1 quarter, and so forth. Species of competing vegetation were not recorded.

## RESULTS

The results of these seeding trials varied so widely that few definitive quantitative values were derived, although some trends were discernible. Among the various treatments tested, only baiting had no influence on the results. Except for dragging, all other treatment differences appeared to affect results consistently. Dragging appeared to influence results, but too erratically for conclusions. Examination of weather records suggests that unusual and unexpected differences in post-seeding weather may have influenced results strongly.

Though the study was not designed to estimate second-year mortality in the 1965 seedings or to compare first-year results, consideration of both was necessary to develop a satisfactory interpretation of the data.

### Baiting and Dragging

Baiting for rodent control did not benefit seedling stocking (*table 1*).

Stocking on the three pairs of dragged and undragged subcompartments 2 years after seeding did not conform to the first-year indications reported by Hall.[2] On the one pair of subcompartments compared in his report, first-year data indicated that dragging had a statistically significant beneficial influence. Second-year data from the same pair of subcompartments are included in the *table 1* values, which show an average of 7.7 percent less stocking in the dragged units. There were no statistically significant differences (at the 90 percent probability level) between the 1-year-after-seeding and the 2-years-after-seeding data for either subcompartment. The difference between these two subcompartments 2 years after seeding (the 1967-68 examination) also was not significant. Since the first- and second-year samplings were made on different temporary plots, the large variations recorded may be partly or wholly caused by a nonuniform distribution of conditions. (Uniform distribution within the individual subcompartments was assumed in both sampling plans.)

Second-year milacre stocking in the four subcompartments included in both examinations (one dragged and three undragged subcompartments) averaged less than 5.5 percent less than first-year stocking, and ranged from 12.9 percent less to 8.9 percent more. None of the differences was significant at the 90 percent probability level.

### Seeding Rates

Differences resulting from various seed application rates were fairly consistent—the more seed applied the more seedling stocking obtained (*table 1*). The differences are small, however, since tripling the amount of seed applied, from 0.75 to 2 to 2.5 pounds per acre, increased the stocking only about one-half, from 24.0 to 36.4 percent. And most of the stocking increase occurred with a doubling of the least amount of seed applied.

The seeding rate and seedling numbers and stocking relationships in the unpaired data for all 27 subcompartments (*table 2*) were similar to those in the data for the paired subcompartments (*table 1*). The

Table 1—*Paired comparisons of milacre stocking after broadcast seeding ponderosa pine under five sets of conditions, Challenge Experimental Forest, California, 1967-68*

| Paired conditions compared | | Average stocking | | Differences in stocking (2 minus 1) | | Basis[1] |
|---|---|---|---|---|---|---|
| 1 | 2 | 1 | 2 | Average | Range | |
| | | *Percent* | | | | |
| Unbaited | Baited[2] | 27.5 | 27.4 | −0.1 | −6.4 to +7.7 | 3 (380) |
| Undragged | Dragged[3] | 58.3 | 50.6 | −7.7 | −18.5 to +2.6 | 3 (407) |
| West aspect | North aspect[2] | 28.2 | 38.8 | +10.6 | −3.1 to +24.3 | 2 (286) |
| 0.75 lb/ac | 1.25 - 1.5 lb/ac[2] | 24.0 | 33.3 | +9.3 | −2.8 to +24.5 | 4 (488) |
| 1.25 - 1.5 lb/ac | 2 - 2.5 lb/ac[2] | 33.3 | 36.4 | +3.1 | +.1 to +8.7 | 4 (521) |

[1] Pairs of subcompartments compared; total number of milacre plots in parentheses.

[2] First-year results for seeding of December 1966.

[3] Second-year results for seeding of December 1965.

Table 2—*Stocking after broadcast seeding ponderosa pine on two aspect groups, by year of seeding and rate of application, Challe Experimental Forest, California, 1967-68*

| Year and seeding rate (lb/acre; avg. seeds/acre) | | North aspects | | | | | East, south, and west aspects | | | | | All aspects | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Basis | | | | | Basis | | | |
| | | Milacre plot percent stocking | Average number seedlings | Success ratio[1] | Subcompartments averaged | Total plots | Milacre plot percent stocking | Average number seedlings | Success ratio[1] | Subcompartments averaged | Total plots | Over-all milacre plot percent stocking | Calculated 1/250-acre plot percent stocking |
| 1965: | | | | | | | | | | | | | |
| 0.5 to 1.0 | 5,570 | 50.0 | 700 | 0.13 | 1 | 20 | 23.9 | 430 | 0.08 | 3 | 196 | 30.4 | 76.5 |
| 1.1 to 1.5 | 7,970 | 72.1 | 2,879 | .36 | 3 | 150 | – | – | – | – | – | 72.1 | 99.4 |
| 2.1 to 2.5 | 14,390 | – | – | – | – | – | 53.9 | 1,392 | .10 | 4 | 187 | 53.9 | 95.5 |
| 1966: | | | | | | | | | | | | | |
| <0.5 | 2,530 | 18.8 | 250 | .10 | 1 | 32 | 35.0 | 400 | .16 | 1 | 20 | 26.9 | 71.4 |
| 0.5 to 1.0 | 4,620 | 34.1 | 634 | .14 | 2 | 207 | 18.8 | 242 | .05 | 3 | 184 | 24.9 | 68.2 |
| 1.1 to 1.5 | 9,000 | 36.5 | 462 | .05 | 1 | 52 | 32.2 | 613 | .07 | 3 | 181 | 33.3 | 80.2 |
| 2.1 to 2.5 | 14,370 | 38.2 | 910 | .06 | 1 | 89 | 35.7 | 632 | .04 | 3 | 199 | 36.4 | 83.6 |
| 17.6 | 115,930 | 64.0 | 1,800 | .02 | 1 | 25 | – | – | – | – | – | 64.0 | 98.3 |

[1] Established seedlings divided by viable seeds.

*table 1* data are included in the *table 2* data. Though baiting and dragging differences apparently did not confound rate difference results, no other rate difference pairs were made available by ignoring them. In the 27 subcompartments generally, both stocking and numbers of seedlings increased as rate of application was increased, but each increased at a different rate and both increased at a rate slower than the increase in the rate of application. The ratios of seedling numbers to seedling milacre stocking conform closely to unreported ratios observed in seed-tree cuttings at Challenge Experimental Forest.

We achieved our goal (50 percent milacre stocking and/or 1375 well-distributed seedlings 2 years after seeding) in all but one case in the 1965 seedings when we used more than a pound of seed per acre (1.12 kg per ha). We failed to achieve this goal in all the 1966 seedings except possibly in the subcompartment accidentally seeded at the rate of 17.6 pounds per acre. However, we obtained 400 or more seedlings per acre in every case in which we used at least a pound of pest-repellent treated seed.

The 1/250-acre, or 4-milacre, stocking (*table 2*) is presented for those who base their regeneration standards on the 1/250-acre plot. The 1/250-acre stocking was calculated from the milacre stocking by the formula

$$S_b = 100\left[1 - \left(1 - \frac{S_a}{100}\right)^{\frac{b}{a}}\right]$$

in which

$S_a$ = stocking percent actually sampled

$S_b$ = calculated stocking percent for a different area base

a = size of plots sampled

b = size of stocking base for which stocking is calculated

In informal checks in other studies of 1-year old seedlings on completely prepared sites at the Experimental Forest, the actual 1/250-acre stocking has averaged about 3 percentage points less than the 1/250-acre stocking calculated from milacre stocking, which ranged from 15 to 88 percent. The accuracy of the calculated estimate probably depends on the uniform application of treatments.

## Aspect

The average 10.6 percent difference in results associated with aspect (*table 1*) can be weighted more than the large variations in the two paired comparisons might otherwise indicate. First, the average difference is consistent with the less severe site conditions of north aspects. Second, in the comparisons of aspects possible in *table 2,* the results on north aspects were generally better than those on other aspects. The slightly better results generally indicated for north aspects in the unpaired data (*table 2*) are consistent with the results of the paired comparisons (*table 1*).

### Weather Conditions

In the 1967-68 examinations, 1965 seedings (2-year-old seedlings) averaged about 20 percent higher milacre stocking than 1966 seedings (1-year-old seedlings) sown at similar rates on similar aspects (*table 2*). These differences probably were caused by the quite different weather sequences after seeding. The 1965 seedings were followed by a cold February and a warm April; after the 1966 seedings, February was warm and April was cold (*fig. 1*). The cold wet weather of April 1967 could have delayed germination too long, or killed seedlings that germinated during the preceding warm weather. The 39° F mean temperature for April 1967 was one of the lowest monthly means recorded at the Experimental Forest, and was below the normal midwinter mean temperature of about 41.5° F (*fig. 1*). Precipitation was considered adequate in both amount and distribution in both years.

### Seedbeds

The subcompartments were generally similar in seedbed distribution. The seedbed descriptions, therefore, did not help to explain differences in results.

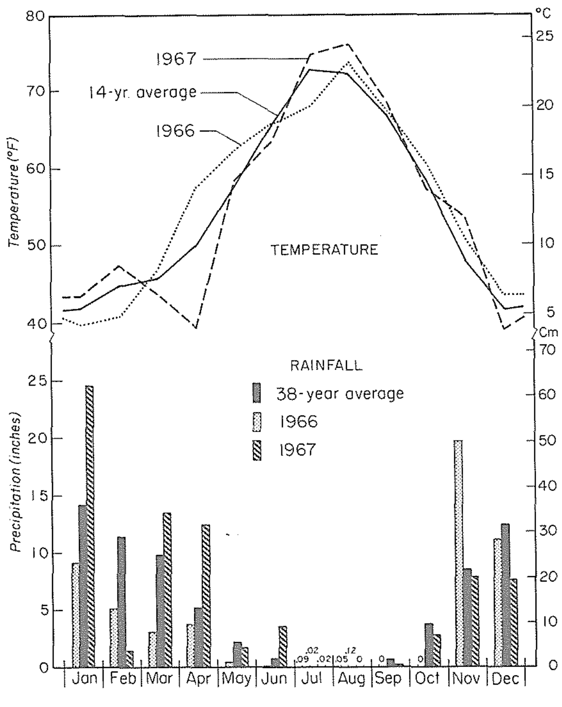


**Figure 1**—Monthly precipitation and mean temperatures at Challenge Experimental Forest headquarters for 1966 and 1967, with long-term averages.

But they did show relatively large and consistent differences in seedling establishment by seedbed type (*table 3*). Areas undisturbed by burning or mechanical means were virtually unavailable as seedbed. This was true even on the 2 percent of the area with exposed mineral soil before logging and slash disposal. Seedbeds with only mechanical disturbance were the best, with a seedbed efficiency (percent seedlings/percent area) of 1.42, and were almost three times as good as those that had only been burned. Seedbeds with mechanical disturbance plus burning were intermediate in efficiency. Seedbeds which had a hot burn were only about one-half as efficient as otherwise similar but lightly burned areas.

Seventy-five percent of the samples from all areas seeded had mechanically disturbed seedbeds. About half of these—35.9 percent—had only mechanical disturbance with two or more quarters (37.5 percent or more) of the plot area in exposed mineral soil. The other half had mechanical disturbance in combination with burning, lesser amounts of exposed mineral soil, or unknown burning and exposure conditions.

Seedling establishment varied with competition, and competition varied with time since seeding (1 or 2 years), but did not vary appreciably between areas seeded in a particular year. Hence the competition data do not help explain differences in results with similar treatments.

## DISCUSSION

The differences in weather after the 1965 and 1966 seedings were useful in providing samples of weather that were near, if not at, the extreme conditions of springtime temperature likely at this location. But the weather differences were also troublesome because they were so large—weather cannot be considered a part of the background common to the seeding operations. Since data on effects of weather on seeds and seedlings were not collected, these effects cannot be separated from those caused by other factors. The numerical values reported for stocking and seedlings, therefore, probably more nearly resemble maxima and minima than averages. Because the results of the two series of seedings have not been combined, however, the validity of conclusions about the results of other factors—whether differences are positive or negative and their relative magnitude—should not be affected.

No conclusions about the effects of baiting or dragging can be drawn from this study. Those treatments did not cause differences that could be evaluated. Foresters are divided in opinions about the need

Table 3–*Proportional area and efficiency index, by type, of available seedbed, averaged for 19 broadcast-burned subcompartments, broadcast seeded with ponderosa pine, Challenge Experimental Forest, California, 1967-68*

| Seedbed type | Proportion of available seedbed area[1] | Times observed | Proportion of established seedlings | Seedbed efficiency index[2] |
|---|---|---|---|---|
| | *Percent* | | *Percent* | |
| Mineral soil, ≥37.5%: | | | | |
| No mechanical disturbance:[3] | | | | |
| Unburned[4] | 2.0 | 49 | 0.2 | 0.08 |
| Light burn[5] | 9.8 | 245 | 4.7 | 0.48 |
| Hard burn[6] | 0.5 | 20 | 0.1 | 0.21 |
| Subtotal or average | 12.3 | 314 | 5.0 | 0.41 |
| Mechanical disturbance: | | | | |
| Unburned[4] | 35.9 | 628 | 50.9 | 1.42 |
| Light burn[5] | 26.6 | 611 | 24.4 | 0.92 |
| Hard burn[6] | 3.4 | 137 | 2.0 | 0.59 |
| Subtotal or average | 65.9 | 1376 | 77.3 | 1.17 |
| Mineral soil, <37.5% | 11.4 | 313 | 6.6 | 0.58 |
| Unclassified[7] | 10.4 | 192 | 11.1 | 1.06 |
| Subtotal or average | 21.8 | 505 | 17.7 | 0.81 |
| Total or average | 100.0 | 2195 | 100.0 | 1.00 |

[1] Total available area averaged 98.6 percent of total area. Most commonly, seedbed was unavailable because of stumps.

[2] Percent seedlings divided by percent area.

[3] Disturbance, if any, did not extend to mineral soil. Causes of disturbance include tractor activity, felled trees, skidded logs, etc.

[4] Both litter and uppermost soil layers essentially unchanged by slash burning.

[5] Litter layer changed but uppermost soil layer unchanged by slash burning.

[6] Litter layer removed and uppermost soil layers changed by slash burning.

[7] One or more elements of the seedbed type could not be determined because of alteration with time (0.6 percent of the total available area) or post-seeding dragging in three subcompartments (9.8 percent of the total available area).

for both baiting for rodent control and sowing seed treated with rodent repellent, but this note cannot shed any light on that subject because rodent population data are incomplete.

The purpose of dragging was to cover the seed and thereby improve germination and establishment. In a related study, half the seed were covered by hand before dragging. The results suggest that dragging may be beneficial even when the seed already are covered.[10] This in turn suggests that any beneficial effects of dragging are the results—at least partially—of something other than covering the seed. The possibility of improving broadcast seeding results by dragging, or otherwise treating the area after seeding, deserves further study.

Our results, when tabulated by rate of application, roughly indicate a rapid decrease in the rate of improvement of both percent stocking and number of seedlings as seeding rates increase beyond about 1.5 pounds of seed (10,000 to 12,000 viable seed) per acre (1.7 kg, or 24,710 to 29,650 seed, per ha). The different rates of increase indicated for percent stocking and numbers of seedlings are to be expected. Also, both these values may be expected to increase at an ever slower rate as application rates are increased. However, the reduction in the rate of increase in numbers of seedlings at our seeding rates was unexpectedly rapid.

The relationships between stocking and rate of application were similar for both the 1965 and 1966 seedings. This similarity suggests that under the conditions of this study, locations suitable for seedling establishment are limited in number and most of them are successfully seeded at low application rates.

If the proportion of the optimum seedbed condition were higher, it would be reasonable to expect both more seedlings and better stocking from any given rate of application. Furthermore, a slower decline in the rate of improvement at application rates above 1.5 lb per acre could be expected.

The differences in results associated with differences in seedbed indicate that burning improved a seedbed not otherwise disturbed, but that mechanical disturbance to mineral soil without burning developed the best seedbed. This suggests that piling or windrowing slash and residual vegetation before burning would be more beneficial than broadcast burning in direct seeding. The higher preburning preparation costs of windrowing would be partially offset, at least, by lower burning costs and improved results. Also, burning of windrowed slash can be done under safer conditions than broadcast burning–and would be less likely to be rained out. Even if burning had to be postponed, the area could still be seeded; windrows could be seeded or planted after burning. The improved over-all efficiency possible with windrowing, burning, and seeding may make it an economically more attractive technique than broadcast burning and seeding in spite of the possibly higher direct costs of the former.

The seeding trials of 1965 and 1966 described here were sown in December with unstratified seed. The earlier helicopter seeding was done in March with stratified seed. Seeding late in the season with stratified seed has the advantage of reducing the time seeds are exposed to adverse environmental influences, such as rodents. However, this advantage is offset to some extent, if not entirely, because in late seeding with stratified seed the weather, timing, and seed-handling procedures become more critical to success. Seeding so late that seed stratification is necessary considerably reduces the flexibility of operations that is one of the most attractive features of direct seeding. Seed can be sown any time during winter at the Challenge Experimental Forest. Stratification should not be necessary if seed is sown before March 1.

## RECOMMENDATIONS

Direct seeding for ponderosa pine regeneration should be tested operationally if conditions are similar to those at Challenge, and if 70 percent stocking of 1/250-acre (≅16 sq m) plots (about 400 well-distributed seedlings per acre or 988 per ha) is the regeneration goal. These procedures should be followed:

1. Prepare the site thoroughly by piling and burning all slash and residual vegetation.
2. Apply the standard pest-repellent treatment (endrin-arasan-aluminum dust) or an equivalent treatment to the seed.[9]
3. Sow at least 1.5 pounds of seed (10,000 to 12,000 viable seeds) per acre (1.7 kg, or 24,710 to 29,650 seeds, per ha).

On north aspects, and if weather is favorable, this prescription may sometimes produce over 70 percent milacre stocking and as many as 3000 seedlings per acre (7410 per ha). To date, however, we have not been able to achieve such results consistently.

### NOTES

[1] U. S. Forest Service research on the Challenge Experimental Forest, Yuba County, California, is conducted in cooperation with the Soper-Wheeler Company, Strawberry Valley, Calif.

[2] Hall, Dale O., 1967a. *Broadcast seeding ponderosa pine on the Challenge Experimental Forest . . . a progress report.* USDA Forest Serv. Res. Note, PSW-144, 4 p., illus. Pacific Southwest Forest and Range Exp. Stn., Berkeley, Calif.

[3] Society of American Foresters. 1954. *Forest cover types of North America.* 67 p. Washington, D.C.

[4] Meyer, Walter H. 1938. *Yield of even-aged stands of ponderosa pine.* U. S. Dep. Agric. Tech. Bull. 630, 59 p., illus. Rev. 1961.

[5] Sundahl, William E. 1966. *Slash and litter weight after clearcut logging in two young-growth timber stands.* USDA Forest Serv. Res. Note PSW-124, 5 p., illus. Pacific Southwest Forest and Range Exp. Stn., Berkeley, Calif.

[6] Hall, Dale O. 1967b. *Slash disposal burns in pine patch-cuttings . . . a dialogue.* USDA Forest Serv. Res. Note PSW-148, 6 p., illus. Pacific Southwest Forest and Range Exp. Stn., Berkeley, Calif. McDonald, Philip M., and Harry E. Schimke. 1966. *A broadcast burn in second-growth clearcuttings in the north central Sierra Nevada.* USDA Forest Serv. Res. Note PSW-99, 6 p., illus. Pacific Southwest Forest and Range Exp. Stn., Berkeley, Calif.

[7] Fowells, H. A. 1946. *Forest tree seed collection zones in California.* U. S. Forest Serv. Calif. Forest and Range Exp. Stn. Res. Note 51, 5 p., illus.

[8] Buck, John M., Ronald S. Adams, Jerrold Cone, and others. 1970. *California tree seed zones.* USDA Calif. Reg., Forest Serv., San Francisco, Calif., and Calif. Div. For., Sacramento, Calif.

[9] The standard repellent seed treatment at the time of this study was 1 percent active endrin; the Forest Service now allows only 0.5 percent active endrin in repellent coatings.

[10] Unpublished data on file at Pacific Southwest Forest and Range Experiment Station, Redding, Calif.

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