

PACIFIC SOUTHWEST Forest and Range Experiment Station

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DOUGLAS-FIR SURVIVAL AND GROWTH in response to spring planting date and depth

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The survival of Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco var. *menziesii*) seedlings planted in northwestern California has often been disappointing—particularly on hot, dry, south-facing cut-blocks. Ponderosa pine (*Pinus ponderosa* Laws.)—a more drought-resistant species—has sometimes been planted on these sites instead of Douglas-fir, but such a type conversion is not always desirable. If a site can produce high quality Douglas-fir, this species will likely yield the best returns as a future crop. And hence its regeneration on such sites should be favored whenever possible.

Various ways to reduce water loss and to lower surface temperature, and thereby improve the survival of planted Douglas-fir, have been tried. They include the use of antitranspirants, mulches, and artificial shading devices. Two other techniques—deep planting and stem shading—were tried by planting Douglas-fir seedlings on test plots on the Six Rivers National Forest, northwestern California. The results, after three growing seasons, suggest that these techniques did not increase survival, but may have helped height growth.

Deep planting has apparently not been tried extensively with Douglas-fir. In a study using 2-0 seedlings of this species in southwestern Oregon,¹ the technique failed to improve survival over that attained by planting at normal depth. Survival of the deep-planted trees was only 38 percent—about equal to that of planting at normal depth.

Trials of deep planting in the southern pine region of the United States have usually resulted in improved height growth, but not survival. Slocum and Maki², for example, found that burial of the seedling stem of loblolly pine (*Pinus taeda* L.) to one-quarter, one-half, or three-quarters of its length all resulted in greater height growth than when the seedling was

ABSTRACT: Douglas-fir seedlings were planted by four methods in late February and late March on hot, south-facing slopes in northwestern California. Besides standard planting, the techniques used included deep planting at two different depths, and shading the lower stem. The differences in survival after 3 growing seasons were not statistically significant, but deep planting had helped height growth. Excellent survival in all treatments was probably the result of good stock, careful handling and planting, proper site preparation, and timely rainfall the first spring.

OXFORD: 174.7 *Pseudotsuga menziesii* var. *menziesii*: 232.423[+ 232.324 + 561.1];

RETRIEVAL TERMS: *Pseudotsuga menziesii* var. *menziesii*; planting depth; seedling survival; height increment.

planted at normal depth, but survival was not improved. Shoulders³ also found an improvement in height growth of loblolly pine, as well as of slash pine (*Pinus elliottii* Engelm. var. *elliottii*), when both were planted with half their stems below ground level. And Swearingen⁴ found that a height growth increase could be achieved for slash pine by burying the entire stem to the base of the terminal bud. However, in another study involving slash pine,⁵ trees planted all the way to the bud showed poorer height growth than those planted at normal depth; trees planted halfway to the bud grew the best.

Maguire⁶ tried shielding only the lower portion of the stem of some 2-0 ponderosa pine seedlings planted on a hot southerly slope near Placerville, California. Although this treatment was tried with relatively few seedlings—being supplemental to a larger-scale test of other treatments—the results, in terms of improved survival of the pine, were encouraging.

STUDY SITE AND METHODS

In early 1965 the Pacific Southwest Station set up test plots on the Gasquet Ranger District, about 15 miles east-northeast of Crescent City, and 3 miles southeast of Gasquet. Before logging, the study site had supported a mixed stand of Douglas-fir and sugar pine (*Pinus lambertiana* Dougl.), with patches of young knobcone pine (*Pinus attenuata* Lemm.). Some tanoak (*Lithocarpus densiflorus* [Hook. & Arn.] Rehd.) was also present. The study site itself had been occupied primarily by young knobcone pines, which were cleanly removed by a bulldozer in 1964.

The plots lie just below the ridgetop on a south-facing slope (50-55 percent), at an elevation just under 2,000 feet. The soils here are unmapped, but those on the study site resemble the Neuns series, derived from Greenstone volcanic rock. The upper foot is a brown, moderately gravelly loam, with a pH of 5.6-5.8. The subsoil is more finely textured, but also gravelly. Limited sampling showed no bedrock within 4 feet of the soil surface.

The experiment was of a split-plot, randomized block design with three replications. Treatments included two planting dates—late February and late March—and four planting methods: (a) very deep planting (one-half of a seedling's stem buried); (b) deep planting (one quarter of a seedling's stem buried); (c) stem shading (seedling planted at normal depth, but with the lower portion of the stem protected from solar heating by a curved shield of heavy aluminum foil); and (d) control treatment

(normal depth used, with the root collar placed at groundline, and the stem left unshaded).

The effect of planting dates was tested on the main plots and methods of planting on the subplots. Each subplot consisted of a row of 20 Douglas fir seedlings hand-planted by a two-man crew. Each man planted half of the trees on each subplot. After planting, each tree was protected from deer and rabbit browsing by a cylinder of poultry netting stapled to two stakes (*fig. 1*).

Seedlings were normal-sized 2-0 Douglas fir which had been grown at the U.S. Forest Service's Humboldt Nursery at McKinleyville, California. They averaged 8 to 10 inches tall and were root-pruned to about 10 inches (standard nursery practice) before being bundled and placed in cold storage at 33-35°F. and 90-95 percent relative humidity.

To obtain some information about soil surface temperatures, groups of temperature pellets were periodically set out during the first two growing seasons. Tablets with melting points of 113°, 125°, 138°, and 150°F. were used. These were set out so that one series was completely shaded by an aluminum shield of the type used for the stem shading; a second series was placed in the open—about a foot away. Three replications of the paired tablet groups were set out at different locations and inspected monthly during each growing season.

Seedling survival and heights were recorded each fall for 3 successive years.

RESULTS

Survival was excellent for all treatments (better than 93 percent) (*table 1*). None of the special planting techniques resulted in any improvements over normal planting. Trees planted in February had a slightly higher rate of survival than those planted in March, but analysis of variance showed that the difference was not statistically significant.

Height growth, by contrast, was significantly influenced by planting date. After three growing seasons, the trees planted in February averaged 3 to 4 inches taller than those planted in March. Among methods within each planting date, however, there was no significant difference in total height reached after 3 years. It took that long for the trees which were planted deeper than normal to catch up to those which were planted at normal groundline.

When rate of growth rather than total height after 3 years is considered, differences among planting methods are more evident (*table 2*). Height growth of trees planted very deep (50 percent of stem buried)

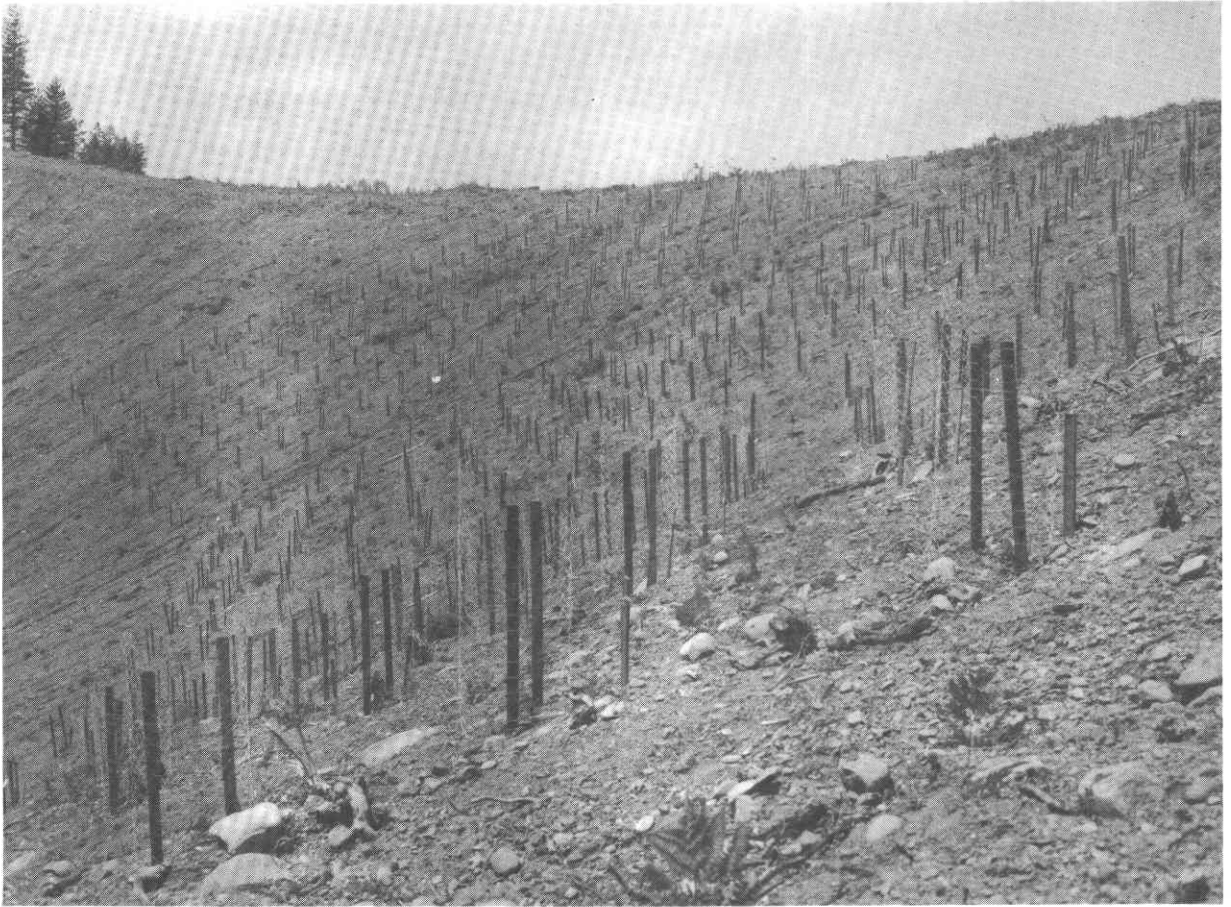


Figure 1—After Douglas-fir seedlings were planted, protective cages were installed to protect them from browsing damage.

Table 1—Survival and average height of 2-0 Douglas-fir seedlings planted in two different months by four different methods, northwestern California

Month and method of planting	Survival		Average height	
	After 1 yr.	After 3 yrs.	When planted	After 3 yrs.
	— Percent —		— Inches —	
February:				
Very deep ¹	100.0	100.0	4.9	20.2
Deep ²	100.0	100.0	6.1	20.3
Stem shaded	98.3	98.3	8.5	20.3
Control	98.3	98.3	8.3	19.0
March:				
Very deep ¹	95.0	93.3	5.5	16.2
Deep ²	96.7	95.0	6.8	16.0
Stem shaded	98.3	98.3	9.8	17.2
Control	98.3	96.7	9.3	16.1

¹50 percent of the stem buried.

²25 percent of the stem buried.

was about 1½ times greater than that of trees planted at normal depth (15.3 vs. 10.7 inches for the February planting; 10.7 vs. 6.8 inches for the March planting). Height growth of the deep-planted trees (25 percent of stem buried) and of the stem-shaded trees fell between these two sets of extremes.

Differences in 3-year height growth which could be attributed to planting method were statistically significant at the 1 percent level. Specific comparisons between individual subplot treatment means, using F tests with a single degree of freedom, however, showed that not all of the modified planting techniques produced a significant improvement in height growth over that of the control treatment.

Only the very deep planting produced a statistically significant improvement in 3-year height growth over the control seedlings for both planting dates (4.6 inches better for February planting; 3.9 inches better for March) (table 2). The deep planting treatment produced a significant improvement only

Table 2—Average height growth of 2-0 Douglas-fir planted in two different months by four different methods.

Month and method of planting	Average height growth			
	First year	Second year	Third year	3-year total ¹
	—Inches—			
February:				
Very deep ²	2.4	5.5	7.4	15.3
Deep ³	2.4	5.1	6.7	14.2
Stem shaded	1.8	4.3	5.7	11.8
Control	1.7	3.3	5.7	10.7
March:				
Very deep ²	2.5	3.3	4.9	10.7
Deep ³	2.3	2.9	4.0	9.2
Stem shaded	1.6	2.0	3.8	7.4
Control	1.8	1.6	3.4	6.8

¹Within each planting date, a difference in average 3-year height growth among planting methods which equals or exceeds 2.8 inches is significant at the 5 percent level of probability.

²50 percent of the stem buried.

³25 percent of the stem buried.

in the February planting (3.5 inches better than the control). Seedlings with stems shaded averaged slightly better height growth than seedlings on the control plots, but the difference was not statistically significant.

The very-deep-planted and the deep-planted trees grew faster than the control seedlings in each of the first 3 years (table 2). In the first year, the growth superiority of trees very-deep-planted in February over the control trees was only 0.7 inch. This difference reached a peak in the second year, when the very-deep-planted trees outgrew the controls by 2.2 inches. In the third year, the difference dropped to 1.7 inches. The deep-planted trees showed a similar superiority over the controls, but of a lesser magnitude.

In the first two growing seasons, all temperature pellets which had melting points of 138°F. or less and were placed in full sunlight, melted before midsummer. But none of the pellets shaded by the aluminum shields melted. Thus, the maximum temperature attained at the soil surface in the open was somewhere between 138°F. and 150°F.; in the shade of the aluminum foil it never reached 113°F.

DISCUSSION

The excellent survival of seedlings on all plots, regardless of treatment, is considerably better than is normally achieved on production planting jobs on

cutover Douglas-fir lands in northwestern California. It might be explained by the (1) use of good planting stock; (2) careful handling of this stock from the time it was lifted until it was planted by two conscientious planters; (3) almost complete absence of competing vegetation for the first year or two after planting because of thorough site preparation; and (4) timely arrival of abundant rainfall in April, when the growing season began.

Neither soil moisture nor precipitation was measured at the study site itself, but it can be safely assumed that heavy midwinter rains had fully recharged soil moisture to field capacity before the end of January 1965. Subsequently, however, precipitation in February and March dropped below average, so that the upper 6 inches of soil had dried considerably by the end of March. April, on the other hand, was much wetter than normal, and this timely recharge of soil moisture, just as the growing season was starting, was apparently enough to carry most of the seedlings through the dry summer months.

In this study, planting date was inseparably linked with another variable which was not tested: length of storage. When it became apparent that the stock in the nursery beds might break dormancy before the March planting, all stock was lifted on February 22, 1965 and placed in cold storage. Half of it was removed the next day for the February planting; the remainder was left in cold storage for 35 more days for the March planting, when the trees in the nursery beds were no longer dormant.

To what extent the poorer growth in the March planting may be attributed to the later time of planting, or to the 5 weeks of cold storage, cannot be determined. All seedlings used were lifted at the same time, and so presumably they were all in similar physiological condition (except for random differences caused by genetic variation) at the time they were lifted and stored. Physiological changes occurring during storage may have affected subsequent height growth after field planting.

The superior height growth of the trees which were planted deeper than normal probably resulted from improved soil moisture conditions in the root zone. Soil moisture was not actually measured in this study, but it is well known that during prolonged dry periods, the upper 6 inches of soil dries out more rapidly than the soil at greater depths. The two deeper planting treatments placed a greater proportion of the root system below this zone of rapid surface drying.

It is too early to tell whether or not deeper-than-normal planting is a worthwhile modification on hot, dry aspects. The findings of this study suggest that it

does not improve the early survival of Douglas-fir seedlings which are not under severe moisture stress. And they suggest that trees planted deeper than normal take about 3 years to catch up in total height to trees planted at normal groundline.

Whether the trees planted deeper than normal will continue to grow at a faster rate than the control trees for several more years is a matter of conjecture. From a biological standpoint, there seems to be no reason to expect this superior rate of growth to continue indefinitely. Once the root systems of the trees planted at normal depth reach the same moisture (and perhaps nutrient) sources which presumably benefited the trees planted more deeply, they too should grow as well.

Trees whose stems were shaded averaged slightly greater height growth than the unshaded controls, but the difference was not statistically significant. This finding, coupled with the fact that stem-shading also failed to improve survival significantly, suggests that the technique is of no practical value under conditions similar to those in this study. Apparently soil surface temperatures in excess of 138°F. (indicated by the temperature pellets placed in the open) do not seriously harm 2-year-old Douglas-fir seedlings, although such high temperatures may kill natural seedlings less than 12 weeks old.^{7,8}

In this study the treatments were made on one particular site and in only one year. More conclusive evaluation would require testing them on a variety of sites, and should include planting in several different years.

NOTES

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