RESEARCH PAPER 42 DECEMBER 1980

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FIRST-YEAR PERFORMANCE OF 1-0 CONTAINERIZED DOUGLAS-FIR SEEDLINGS ON DROUGHTY SITES IN SOUTHWESTERN OREGON

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CONTENTS

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Acknowledgments

This study was conducted as a cooperative research project between Oregon State University's Southwest Oregon Forestry Intensified Research Program (FIR) and the Bureau of Land Management, Medford District. The authors express their gratitude to Susan Stafford, statistician at the Department of Forest Science, Oregon State University, for her assistance in the statistical analysis of the data.

FIR, established in October 1978, is a cooperative effort among Oregon State University, the Bureau of Land Management, USDA Forest Service, and southwest Oregon counties and timber industries. It is designed to help foresters and other specialists solve complex biological and management problems important to southwest Oregon, and it represents a determined effort by the southwest Oregon forestry community and county governments to find practical solutions to those problems.

SUMMARY

The effects of artificial shading and aspect on the performance of 1-0 container-grown Douglas-fir seedlings were evaluated 1 year after outplanting on four different aspects in southwest Oregon. The test areas, all characterized by steep slopes and shallow, skeletal soils with a surface mantle of loose rock and logging slash, have histories of repeated reforestation failure. Seedling survival was greatest on north and south slopes. Shadecards improved survival by 16 percent on the south slope and significantly increased height growth on the west slope. Artificial shading on east and west aspects produced seedlings with significantly smaller diameters than those without shading. Shadecards are recommended for south and west aspects with skeletal soils. Surface movement of debris and rock may be a significant factor in seedling survival during the first year. Protecting seedlings from animal damage and downslope movement of materials with Vexar tubes is recommended for sites where both problems exist.

INTRODUCTION

The reforestation of commercial forest lands in southwest Oregon is a difficult and challenging problem for foresters. Although the region produced one third of Oregon's harvested timber from 1970 to 1974 (Bassett 1979), the lack of prompt restocking of harvested areas is a problem that will undoubtedly have serious repercussions on future timber yields. The complex and varied reforestation problems of southwest Oregon stem from the environmental extremes of the diversified ecosystems ranging from the Oregon coast eastward to the summit of the Cascade Mountains.

Of central concern is the Siskiyou Uplands, much of which is characterized by a deeply dissected landscape, shallow, rocky soils, and a prolonged summer drought accompanied by high temperatures (Gratkowski 1961). The largest segment of commercial forest land in the Siskiyou Uplands lies in the Mixed-Evergreen and Mixed-Conifer Forest Zone

(Whittaker 1960, Franklin and Dyrness 1973). The ecology of this area has been described by Whittaker (1960), Gratkowski (1961), Waring (1969), and Franklin and Dyrness (1973). Reforestation of recently harvested lands or rehabilitated brushfields has been difficult and in many cases disappointing. The reasons for these failures are many, but in general they reflect the inability of seedlings to survive the high moisture stress brought about by low summer precipitation, high temperatures, shallow soils, and aggressive sclerophyllous brush competition (Gratkowski 1961, Waring et al. 1974, U.S. Department of the Interior 1978, Hobbs et al. 1979). Additional problems in the Siskiyou Uplands are deer and elk browsing and downhill movement of debris and rock on the steep slopes.

Hermann (1964) and Cleary et al. (1978) state that the ability of a seedling to survive on sites where moisture is limiting depends upon the absorptive capacity of the root system to meet the transpirational demands of the shoot. Hermann (1964) found that Douglas-fir seedlings with large, well-developed root systems had higher survival rates on a site in Oregon's Coast Range; and Lopushinsky and Beebe (1976), in a test of 2-year-old Douglas-fir and ponderosa pine seedlings in north-central Washington, determined that seedlings with lower shoot-root ratios had greater survival rates on dry sites.

We decided to examine the survival and growth of 1-0 containerized Douglas-fir seedlings on typical hard-to-regenerate sites in the Siskiyou Uplands. The container-grown seedling has two characteristics which make it a likely candidate for outplanting on droughty, skeletal soils: it is more easily planted in rocky soils, and the root system is less disturbed than that of bare-root planting stock (Stein and Owston 1975, Cleary et al. 1978). Also important, containerized seedlings usually have low shoot-root ratios which would appear to make them particularly adaptable to conditions in the Siskiyou Uplands.

This study had three major objectives. The first was to evaluate the performance of 1-0 containerized seedlings planted in shallow, skeletal soils subject to prolonged drought; the second was to examine the impact of aspect on containerized stock; and the third was to evaluate the effect of artificial shading on survival and growth.

STUDY AREA

Four test sites on the Galice Resource Area of the Bureau of Land Management, Medford District, were selected for outplanting. Except for aspect, the sites are relatively similar (Table 1). All are clearcut areas that were harvested between 1971 and 1976. Douglas-fir was the principal species removed. Attempts to reforest these areas by spot-seeding or with 2-0 bare-root stock have failed repeatedly, and the units are now occupied by tanoak [*Lithocarpus densiflorus* (H. & A.) Redh.], canyon live oak (*Quercus chrysolepsis* Liebm.), salal (*Gaultheria shallon* Pursh), western rhododendron (*Rhododendron*

TABLE 1.

CHARACTERISTICS OF STUDY SITES.

Aspect	Location (Willamette meridian)	Elevation (m)	Slope (%)	Soil
North	T34S, R9W Section 36	762	72	Dystric Xerochrept
East	T34S, R9W Section 36	792	70	Dystric Xerochrept Lithic Xerochrept[b]
South	T34S, R9W Section 35	701	70	Lithic Xerochrept Dystric Xerochrept[b]
West	T34S, R9W Section 36	823	65	Dystric Xerochrept

[a] Estimated.
[b] Occurs as an inclusion.

macrophyllum G. Don), and golden evergreen chinkapin [*Castanopsis chrysophylla* var. *minor* (Benth.) A. DC.]. Brush coverage on each of the four test sites was 40 percent or less of the surface area, with the exception of the brushier south site.

Mean annual precipitation ranges from 178 to 203 cm in the immediate area adjacent to the study sites (U.S. Department of Agriculture 1979). Gratkowski (1961) noted that in the Siskiyou Uplands, only 18 percent of the precipitation falls during the most active period of plant growth (April-September). Other data from surrounding weather stations indicate that only 0 to 6 percent of the mean annual precipitation occurs between June and August (U.S. Department of the Interior 1978).

Soils, either of the Beekman or Vermisa Series (U.S. Department of Agriculture 1980), are classified as loamy-skeletal, mixed, mesic Dystric Xerochrepts and loamy-skeletal, mixed, mesic Lithic Xerochrepts, respectively (U.S. Department of Agriculture 1975). These markedly similar soils are often found in association.

Rock (%)[a]	Dominant vegetation
55-60	Golden evergreen chinkapin, tanoak, salal, western rhododendron
65-70	Canyon live oak, tanoak
40-45	Canyon live oak, tanoak
60-65	Canyon live oak, tanoak

PROCEDURE

A split-plot experimental design in a randomized complete block configuration was the basis for the field layout and subsequent statistical analyses. Aspect was considered the whole-plot effect and use of shadecards the subplot effect. In each replication, 30 seedlings were artificially shaded with 8 x 12-inch cardboard panels, and an equal number were left unshaded. The two subplot treatments were replicated three times on each site. The south site was manually brushed to create adequate planting space. (By early November 1979, all four sites had equivalent amounts of brush due to the rapid and prolific resprouting that took place on the south site.)

One-year-old Douglas-fir seedlings grown in Ray Leach Single Cell containers were outplanted on all sites in

TABLE 2.

ANALYSIS OF VARIANCE OF PERFORMANCE OF 1-0 CONTAINERIZED DOUGLAS-FIR SEEDLINGS 1 YEAR AFTER OUTPLANTING.

	Survival (%)			
Source of variation	d.f.	Mean square	F-value	d.f.
Whole plot				
Blocks	2	58.5716		2
Aspect	3	2,376.2501	11.86*	3
Error	6	200.3693		6
Subplot				
Shade	1	315.4583	1.81	1
Shade x aspect	3	47.3442	0.27	3
Error	8	173.9876		8

*Statistical significance at the P = 0.05 probability level spring 1979. Mean seedling height was 13.67 cm (standard error of the mean 0.1125) and mean seedling diameter 2.08 mm (standard error of the mean 0.0200). Seedlings were from the same seedlot, seed zone 081, 762-m elevation. Trees were hoe-planted after the planting spots were scalped with a 60-cm swath, the ravel removed, and a bench created in the mineral soil with the planting hoe. The seedlings were then tagged with identification numbers, protected from animal damage and ravel with Vexar tubes, and shaded, if appropriate. Two 30-cm metal pins anchored the Vexar tubes to the ground, and a 76-cm metal pin inserted on the uphill side provided more support.

In early November 1979, all seedlings were evaluated for survival and growth. Individual seedling height, caliper, and general physical condition were recorded. Dead seedlings were excavated and examined to determine if they had been poorly planted.

First-year data were initially screened by analysis of variance (Table 2). Duncan's New Multiple-Range Test and

Height		Diameter		
Mean square	F-value	d.f.	Mean square	F-value
3.0491		2	0.0158	
13.6353	5.27*	3	0.2261	5.48*
2.5873		6	0.0412	
2.3224	5.45*	1	0.0523	6.40*
3.8672	9.08*	3	0.0202	2.47
0.4260		8	0.0081	

Student's t-test (Steel and Torrie 1960) were used to further explore the data in order to identify more specific differences on a site-by-site basis (Tables 3 and 4).

TABLE 3.

EFFECT OF ASPECT ON SEEDLING GROWTH IN UNSHADED AND SHADED PLOTS.

	Aspect*			
Growth	North	East	South	West
		UNSHADED		
Mean height (cm)	21.85[a]	18.80	22.74[a]	20.15
Mean diameter (mm)	3.03[bc]	2.85[b]	3.15[cd]	3.32[d]
		SHADED		
Mean height (cm)	22.45[e]	19.07	21.43[e]	22.38[e]
Mean diameter (mm)	3.02[f]	2.64	3.16[f]	3.07[f]

*Like letters (a through f) indicate no significant difference between means at the P = 0.05 probability level.

RESULTS

Percent of survival, height, and diameter growth revealed significant effects due to aspect--survival being the most strongly influenced (Table 2). Artificial shading did not significantly affect survival at the P = 0.05 probability level, though survival increased 16 percent with the use of shade cards on the south aspect (Figure 1). F-test values indicated that shading did have an impact on height and diameter growth. Height growth was the only seedling characteristic significantly affected by the shade x aspect interaction.

Mean height growth of unshaded seedlings on north and south aspects was similar. Unshaded seedlings on the east and west sites grew significantly less (Table 3). Shaded seedlings on the north, south, and west sites increased in height but were not significantly different from one another. Diameter growth of shaded seedlings grouped similarly to height growth; seedlings on the east site grew significantly less in diameter and height (Table 3).

Analysis of growth of unshaded and shaded seedlings on each aspect using Student's t-test also identified significant differences in height and diameter (Table 4). Artificial shading significantly increased height growth on the west site, but unshaded seedlings grew significantly taller on the south site. Diameter growth for shaded seedlings on

TABLE 4.

EFFECT OF ARTIFICIAL SHADING ON SEEDLING GROWTH WITHIN ASPECTS.

Aspect	Unshaded	Shaded	$\hat{t}$
	MEAN HEIGHT (cm)		
North	21.85	22.45	1.13
East	18.80	19.07	0.52
South	22.74	21.43	-2.46*
West	20.15	22.38	4.17*
	MEAN DIAMETER (mm)		
North	3.03	3.02	-0.18
East	2.85	2.64	-2.75*
South	3.15	3.16	0.10
West	3.32	3.07	-3.33*

*Statistical significance with 8 d.f. at the P = 0.05 probability level.

east and west aspects was significantly less than that of unshaded trees.

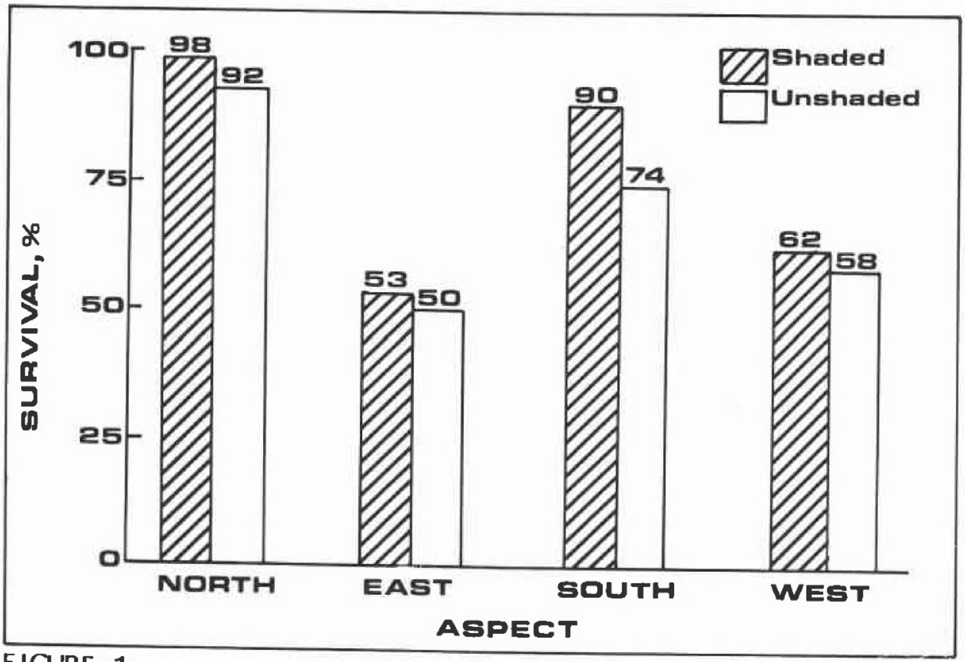

FIGURE 1.

PERCENT SURVIVAL OF 1-0 CONTAINERIZED DOUGLAS-FIR SEEDLINGS ONE GROWING SEASON AFTER OUTPLANTING.

DISCUSSION

Similarities in seedling survival and growth on north and south aspects were unexpected. Early in the growing season, soil moisture conditions on the south site may have been comparable to those on the north site because of the lower rock content and the removal of competing vegetation to create adequate planting spaces. Although vigorous brush resprouting brought south-site vegetation coverage to a level similar to the other three sites by November 1979, initial control probably enhanced seedling performance. This is conjecture, however, because we lack temporal soil-moisture data from the study sites necessary to support our speculation. Seedling performance was consistently poorest on the east site, though we would have expected seedling survival and growth to be better there than on south or west sites because of afternoon shading during the hottest part of the day.

Though shadecards did not improve height growth on the south aspect, the increased survival rate may be a justifiable trade-off. Shadecards also appear to be appropriate on west slopes, despite a mere 4-percent increase in survival, because of significant gains in height growth.

The improvement in seedling survival and height growth with the use of shadecards should not overshadow the associated decrease in diameter growth. In the first year after outplanting, little significance might normally be attached to diameter growth, but in steep terrain where surface movement of rock and debris (ravel) is a problem (Franklin and Rothacher 1962), diameter is an important factor in seedling stability. Lack of a significant increase in diameter during the first year can be offset by adequate protection from ravel. Staking Vexar tubes on the uphill side with an additional 76-cm metal pin or wooden stake provides sufficient support to enable the tube to withstand surface movement of debris. Had we not taken this extra protective measure, many of the study trees would have been buried. Ravel is a serious problem in many areas of the Siskiyou Mountains and should be considered in the reforestation prescription.

CONCLUSIONS

The most important preliminary result of this study is that significant numbers of Douglas-fir 1-0 containerized seedlings survived and added growth on sites with histories of repeated reforestation failure. Survival during the first year, however, does not constitute establishment. Consequently, we intend to continue the study several more years. Nonetheless, the initial results are encouraging. The first growing season after outplanting is critical.

Seedlings must be able to withstand environmental stress and extend their root systems into the mineral soil, particularly on sites typical of those described in this study. On sites with shallow, rocky soils in steep terrain where surface ravel is a problem, 1st-year mortality can be minimized by these practices:

- Plant only vigorous, healthy seedlings with a balanced shoot-root ratio and well-developed root systems.
- Scalp ravel from the soil surface and construct a bench into the mineral soil with a planting hoe.
- Where animal damage and ravel occur, protect seedlings with Vexar tubes. Provide supplemental support with a long, metal pin or wooden stake. On sites where animal damage is not a potential problem, a wooden stake may be adequate to protect the seedling from ravel.
- Use shadecards on south- and west-facing slopes to protect newly planted seedlings from direct sunlight.

This study, applying current research-based technology to historically difficult reforestation sites in the Galice area of the Siskiyou Mountains, has shown that seedlings can survive the crucial 1st-year after outplanting. Prerequisite are adequate care and attention to detail in the planning and operational phases of reforestation.

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One-year-old container-grown Douglas-fir seedlings were outplanted on four severe sites in the Siskiyou Mountains with north, east, south, and west exposures. Aspect had a statistically significant effect on seedling survival and growth. One-half of the seedlings on each test site were artificially shaded with shadecards. Shadecards improved seedling survival by 16 percent on a south exposure and significantly increased seedling height growth on the west exposure. Seedlings protected with shadecards grew less in diameter than unshaded trees on east and west slopes. Seedling protection against the down-slope movement of debris and rock is essential on steep, skeletal soils in the Siskiyou Mountains.

KEYWORDS: Douglas-fir, containerized seedling, shoot-root ratio, aspect, shadecards, ravel.

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BRITISH/METRIC CONVERSIONS

1 millimeter (mm) = 0.03937 inches (in.)
1 centimeter (cm) = 0.3937 inches
= 0.0328 feet (ft)
1 meter = 3.281 feet

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