Survival and Growth of Planted Douglas-Fir *(Pseudotsuga menziesii* (Mirb.) Franco) and Ponderosa Pine *(Pinus ponderosa* Dougl. ex Laws.) on a Hot, Dry Site in Southwest Oregon[1]

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*After two growing seasons on a hot, dry site at low elevations in southwest Oregon, survival rates were 88 percent for 1 +0 plug Douglas-fir (*Pseudotsuga menziesii *(Mirb.) Franco), 99 percent for 2+0 bareroot Douglas-fir, 91 percent for 1 +0 plug ponderosa pine (*Pinus ponderosa *Dougl. ex Laws.), and 98 percent for 2+0 bareroot ponderosa pine. Survival of the bareroots was significantly greater than that of the plugs (P = 0.05). Stress testing ranked all four stock types as excellent. Relative volume growth was greatest for the pine. The initially smaller 1 +0 plug pine nearly equaled the size of the 2+0 bareroot Douglas-fir after 2 years. (Tree Planters' Notes 36(4):3-6; 1985)*

Foresters in southwest Oregon have debated whether Douglas-fir (*Pseudotsuga menziesii* Mirb. Franco) or ponderosa pine (*Pinus ponderosa* Laws.) is the better suited for planting on lower elevation sites where both species occur naturally. These sites are typically located below 1,000 meters (3,300 feet) of elevation and receive less than 1,000 millimeters (40 inches) of precipitation annually. These sites are typical of the interior valley zone and lower elevation portions of the mixed evergreen zone (5). At least 10,000 hectares (49,000 acres) of public land and many small, private woodlands share these characteristics.

Both conifer species are available as 1-year-old container-grown seedlings (plugs) and as 2-year-old nursery-grown bareroot seedlings. The container-grown seedlings are of smaller diameter and cost more, but their roots have been better protected and they are often easier to plant (1, 10).

This study was conducted to compare survival and growth of Douglas-fir and ponderosa pine 1 +0 plug and 2+0 bareroot seedlings on a low-elevation, low-rainfall site. Interim results will help to determine which species and stock types offer the greatest chances for reforestation success on such sites, as well as their relative cost effectiveness. This is part of a larger study addressing the potential for reforestation on difficult-to-reforest lands withdrawn from the allowable-cut land base.

Study Area

The study area is located on a 35-percent slope facing west on Tin Pan Peak near Rogue River, OR (lat. 123°10' W., long. 42°25' N.). The soil is classified as a loamy-skeletal, mixed, mesic Typic Haploxeralf (Beekman series), 60 to 90 centimeters (24 to 36 inches) deep (3). The site receives less than 760 millimeters (30 inches) of precipitation annually and less than 130 millimeters (5.1 inches) between May 1 and September 30 (6, 8). Potential direct-beam insolation was estimated at approximately 245,500 gram-calories/square centimeter annually and at 137,100 gram-calories/square centimeter from May 1 to September 30 (4).

The study site and environs supported Pacific madrone (*Arbutus menziesii* Pursh), California black oak (*Quercus kelloggii* Newb.), greenleaf manzanita (*Arctostaphylos patula* Greene), wedgeleaf ceanothus (*Ceanothus cuneatus* (Hook.) Nutt.), western poison-oak (*Toxicodendron diversilobum* (Torr. & Gray) Greene and occasional large overstory ponderosa pine. This land, on Bureau of Land Management holdings, had been withdrawn from the allowable-cut base because of reforestation problems.

On September 15, 1981, the Tin Pan Peak area burned in a wildfire. The burn was seeded with a grass-legume forage mix in October 1982. A large portion of the burn, including the study area, was operationally planted in January 1982 with 2+0 bareroot ponderosa pine.

[1]Paper 1976 of the Forest Research Laboratory, Oregon State University. Financial support for this research was provided by the USDI Bureau of Land Management and the USDA Forest Service under the auspices of the Southwest Oregon Forestry Intensified Research (FIR) Program (grant PNW-80-85).

[2]The author thanks Dr. Susan Stafford for advice on statistics, Rod Slagle for help with computer-based analyses, BLM personnel for timely field assistance, and the specialists and research assistants of the Adaptive FIR Program.

Methods

The four combinations of species and stock type used in this study were planted on February 3, 1982. The Douglas-fir plugs were grown in 164-cubic-centimeter (10-cubic-inch) Ray-Leach tubes and the pine plugs in 66-cubic-centimeter (4-cubic-inch) Ray-Leach tubes. Random samples from all four seedling lots were stress tested (7).

Fifty seedlings of each stock type were planted in 0.02-hectare (0.05-acre) plots in a 4-by-4 Latin square design. Planting started at 9:00 a.m. in fog (97 percent relative humidity) and ended in sunshine at 1:00 p.m. (85 percent relative humidity). Each row of the Latin square was planted by a different planter. The planters were experienced and conscientious. Before planting, standing dead hardwoods were felled and removed from the study site.

Weeds were controlled with herbicides applied before and after planting. During the winter before planting, atrazine was aerially applied for grass control at 4.5 kilogram/hectare (4 pounds/acre). Because of spotty application, glyphosate was applied with a backpack sprayer at 0.89 kilogram/ hectare (1 .0 pounds/acre) on May 5, 1982. The test seedlings were protected with paper bags, but the ponderosa pine seedlings that had been planted operationally in January were not protected. The Pacific madrone and California black oak stumps produced sprouts ranging from 100 to 150 centimeters (40 to 60 inches) in height by August. The basal 30 centimeters (12 inches) of all hardwood sprouts within the study area were sprayed with 2 percent triclopyr ester in diesel oil. Flat fan nozzles and 0.1-megaPascal pressure settings were used. The nozzles were held within 30 centimeters (12 inches) of the sprouts with the spray directed away from adjacent conifer seedlings, which were not covered. In 1982, the study plots were baited twice with strychnine-treated oats in order to control pocket gophers (*Thomomys* spp.).

Seedling heights and diameters (2 centimeters above the soil) were measured after planting, and along with survival, at the end of the first two growing seasons. The data were analyzed as a Latin square design; analysis of variance and the Ryan-Einot-Gabriel-Welsch multiple Ftest (9) were used. Survival data were corrected with the arcsine transformation (2). Values were calculated for individual seedlings as diameter squared times height (D^2H). Relative growth (RG) was calculated for individual seedlings by determining the difference between the current and previous year's sizes and dividing by the previous year's size.

Results and Discussion

The atrazine and glyphosate kept herb cover below 5 percent through the second growing season. All of the unprotected, operationally planted ponderosa pine were damaged by glyphosate, but more than 50 percent were alive at the end of the second growing season. The glyphosate did not detectably damage the covered test seedlings. The triclopyr killed all hardwood sprouts and prevented resprouting in 1983. Two Douglas-fir seedlings were probably killed by triclopyr. Both seedlings were within 20 centimeters (8 inches) of a sprayed clump. No seedlings were destroyed by pocket gophers. Stress testing rated the four seedling lots as "excellent." No seedlings died during stress testing.

Survival in the field after 2 years was excellent. It averaged 94 percent across all four combinations of species and stock type. For both growing seasons, survival was nearly identical for the two species but differed significantly by stock type. After two growing seasons, the 2+0 bareroot seedlings averaged 98 percent survival, which was significantly greater than the 89 percent survival of the plugs (table 1).

The cost of surviving seedlings can be calculated for each stock type by dividing the initial purchase price by the survival rate. In 1984, 2+0 bareroot seedlings typically cost $120 per thousand, 166-cubic-centimeter (10-cubic-inch) plugs cost $210 per thousand, and 66-cubic-centimeter (4-cubic-inch) plugs cost $110 per thousand. When divided by survival after 2 years, the cost of surviving 1 +0 plug Douglas-fir ($238 per thousand) is nearly twice that of bareroot Douglas-fir ($121 per thou

Table 1—*Percentage survival of the planted seedlings at the end of the first (1982) and second (1983) growing seasons*[1]

	Douglas-fir		Ponderosa pine	
Year	1+0 plugs	2+0 bareroots	1+0 plugs	2+0 bareroots
1982	90a	99b	92a	98b
1983	88a	99b	91a	98b

[1]Means within a row followed by the same letter do not differ at p = 0.05.

sand). The costs of surviving pine are nearly equal for the two stock types (plugs, $121 per thousand; bareroots, $122 per thousand) and are nearly the same as the cost of bareroot 2+0 Douglas-fir.

At planting, the 1 +0 plugs were significantly smaller in diameter, height, and volume than were the 2+0 bareroots (table 2). But the seedlings with the smallest starting size-the 1 +0 plug pines-grew the most in volume and tended to increase the fastest in diameter and height as well. These seedlings increased in volume 13.76 times by the end of the first year (table 3). After 2 years, they reached a volume nearly equal to that of the 2+0 bareroot Douglas-fir.

Table 2—*Diameters, heights, and volumes (D^2H) of the seedlings at planting and at the end of the first (1982) and second (1983) growing seasons*[1]

	Douglas-fir		Ponderosa pine	
Measurement	1+0 plugs	2+0 bareroots	1+0 plugs	2+0 bareroots
Diameter (mm)				
Planting	2.6a	5.5b	2.3a	5.1b
1982	4.5a	7.2b	6.2c	8.4d
1983	8.8a	12.3b	13.6b	16.3c
Height (mm)				
Planting	215a	274b	151c	155c
1982	301a	359b	226c	250c
1983	427a	489b	357c	395a
Volume (cu mm)				
Planting	1,521a	9,197b	899a	4,225c
1982	6,095a	18,611b	8,687a	17,640b
1983	36,745a	79,023b	72,604b	114,629c

[1]Means within a row followed by the same letter do not differ at p = 0.05.

Overall, the pine outgrew the Douglas-fir. After 2 years, the 2+0 bareroot pine were significantly larger in volume than the 2+0 bareroot Douglas-fir despite a smaller starting size. Their relative growth was greater than that of the Douglas-fir stock types in diameter, height, and volume for 1982 and 1983. Similarly, the 1 +0 plug pine tended to grow faster than the 1 +0 plug Douglas-fir in diameter and volume, but this trend did not hold true for height. At the end of 2 years, 1 +0 plug pine had almost twice as much volume as did 1 +0 plug Douglas-fir.

If relative growth rates continue, the pine stock types will clearly be larger than the Douglas-fir in all growth variables after one more year. In an operational plantation, this superiority could give pine an advantage in withstanding competition from weeds, which often encroach after the second growing season.

Conclusions

These results indicate that sites similar to Tin Pan have the potential to be quickly reforested with Douglas-fir or ponderosa pine. The key elements appear to be planting stock of good quality, good planting practices, and vigorous control of weeds and rodents. Given the equal survival of the two species, selection of species for planting can be based more confidently on such considerations as long-term productivity. For the short run, the greater initial growth rates of the pine sug-

Table 3—*Relative growth[1] of the planted seedlings in diameter, height, and volume at the end of the first (1982) and second (1983) growing seasons[2] (based on means of seedling ratios)*

	Douglas-fir		Ponderosa pine	
Measurement	1+0 plugs	2+0 bareroots	1+0 plugs	2+0 bareroots
Diameter				
1982	0.78a	0.33a	1.91b	0.69a
1983	1.00ab	.72c	1.20a	.94b
Height				
1982	.42ab	.32a	.50b	.69c
1983	.43ab	.37a	.58bc	.60c
Volume				
1982	3.88a	1.40a	13.76b	4.04a
1983	5.07a	3.21b	6.91c	5.17a

[1]RG = $X_{n+1} - X_n$ where X = size and n = measurement year.
[2]Means within a row followed by the same letter do not differ at p = 0.05.

gest that it may be able to withstand subsequent competition better than will Douglas-fir.

The stock types tested, all of which were high quality, have almost equally good potential for high survival on hot, dry sites on which competing vegetation has been controlled for the first 2 years. The greater cost and somewhat lower survival of the Douglas-fir 1+0 plugs make them the least cost-effective after 2 years. But their very good survival makes them a feasible choice for reforestation when stock types of lower cost are unavailable. The differences in survival among stock types corresponded to characteristic differences in initial size. This pattern suggests that on hot, dry sites, size and stock type are better indicators of initial seedling survival than species.

Literature Cited

1. Cleary, B.D.; Greaves, R.D.; Hermann, R.K. Regenerating Oregon's forests. Corvallis: Oregon State University Extension Service; 1978. 286 p.
2. Cochran, W.G.; Cox, G.M. Experimental designs. 2nd ed. New York: John Wiley and Sons; 1957. 611 p.
3. DeMoulin, L.A.; Pomerening, J.A.; Thomas, B.R. Soil inventory of the Medford District. Portland, OR: U.S. Department of the Interior, Bureau of Land Management; 1975. 250 p.
4. Frank, E.C.; Lee, R. Potential solar beam irradiation on slopes: tables for 30° to 50° latitude. Res. Pap. RM-18. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station; 1966. 116 p.
5. Franklin, J.F.; Dryness, C.T. Natural vegetation of Oregon and Washington. Gen. Tech. Rep. PNW-8. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1973. 417 p.
6. Froehlich, H.A.; McNabb, D.H.; Gaweda, F. Average annual precipitation in southwest Oregon, 1960-1980. EM 8220. Corvallis, OR: Oregon State University Extension Service; 1982. 8 p.
7. Hermann, R.K.; Lavender, D.P. Testing the vigor of coniferous planting stock. Res. Note 63. Corvallis: Oregon State University, Forest Research Laboratory; 1979. 3 p.
8. McNabb, D.H.; Froehlich, H.A.; Gaweda, F. Average dry season precipitation in southwest Oregon, May through September. EM 8226. Corvallis: Oregon State University Extension Service; 1982. 9 p.
9. SAS Institute, Inc. SAS user's guide: statistics. Ray, Alice Allan, ed. Raleigh, NC: SAS Institute, Inc.; 1982. 584 p.
10. Stein, W.I.; Owston, PW. Why use container grown seedlings? In: Proceedings, Western Reforestation Coordinating Committee. Portland, OR: Western Forestry and Conservation Association; 1975: 119-122.