Performance of Three Douglas-Fir Stocktypes on a Skeletal Soil

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Two years after outplanting, survival of Douglas-fir 1-0 plug and plug—1 bare-root seedlings on a steep, skeletal soil in southwest Oregon exceeded that of 2-0 bare-root stock by 35 and 31 percent, respectively. Height and diameter growth did not differ despite large differences in the initial size of stocktypes.

In southwest Oregon, reforestation of skeletal soils (soils with at least 35 percent rock fragements by volume) is difficult, particularly where precipitation is low and temperatures are high during summer months. The difficulty is further compounded where steep terrain limits the use of machines for site preparation and where competition from sclerophyll brush is severe. These problems have resulted in withdrawal of commercial forest land from the allowable-cut base *(11)*. Unfortunately, few specific regeneration guidelines are available for such areas where, historically, 2-0 bare-root seedlings have been used with disappointing results. The performances of different stocktypes on skeletal soils have not been compared, though seedling morphological characteristics and stocktypes are recognized as being associated with field performance *(1, 3, 6).*

The lack of information on reforesting droughty, skeletal soils prompted us to initiate a study in 1980 on a severe site in the Siskiyou Mountains of southwest Oregon to compare performance of three Douglas-fir *(Pseudotsuga menziesii* (Mirb.) Franco) stocktypes: the widely used *2-0* bare-root stock; 1-0 plugs, because it had been suggested that they may perform well in rocky soils *(9)*; and plug—1 seedlings, a newer stocktype whose field performance is relatively unknown.

Methods

The study site is a nonstocked clearcut in the Mixed-Evergreen Forest Zone *(2)* of the Siskiyou Mountains on which previous reforestation attempts with 2-0 bare-root Douglas-fir seedlings and spot seeding with sugar pine *(Pinus lambertiana* Dougl.) have failed. Average annual precipitation is 229 centimeters, of which 22 centimeters occur between May and September.[1] Located at 1,067-meter elevation with a southeast exposure and a 75-percent slope, the area typifies many that are particularly difficult to reforest. The soil is a loamy skeletal Xerochrept with an unstable surface mantle of rock fragments (ravel) as much as 20 centimeters deep. Rock fragment content in the mineral soil is estimated to range from 50 to 60 percent of the total volume. Sclerophyll species on the site, tanoak *(Lithocarpus densiflorus (H.* & A.) Redh.), golden evergreen chinkapin *(Castanopsis chrysophylla* var. minor (Benth.) A. DC.), and canyon live oak (*Quercus chrysolepsis* Liebm.), were handslashed before planting.

A randomized complete-block experimental design with five blocks was used for field layout and subsequent statistical analysis. The stocktypes tested were 1-0 plug seedlings grown in 164-cubic-centimeter Leach cells, 2-0 bare-root seedlings, and plug—] bare-root seedlings initially grown in 66-cubic-centimeter Leach cells and then transplanted into the nurserybed for 1 year. Before outplanting, 30 seedlings of each stocktype were randomly selected for measurements of dry-weight biomass and shoot-root ratio. One hundred seedlings per stocktype *(20* per block), hoe-planted in March *1980* and protected from big-game browsing with flexible Vexar tubes, were used for survival and growth measurements. Seedling height and diameter were measured immediately after outplanting and in the fall of *1980* and *1981.* An additional 100 seedlings per stocktype were planted for measuring xylem pressure potential with the pressure chamber technique described by Waring and Cleary *(12).* Predawn xylem pressure potential levels

[1] McNabb, David H. Department of Forest Engineering, Oregon State University. Personal communication. May 14, 1982.

were determined every 3 weeks during summer 1980 on 10 seedlings randomly selected from each stocktype. We excavated seedlings that were destructively sampled for xylem pressure potential readings on the same morning to examine their root systems for root initiation and growth.

Total 2-year height and diameter growth were analyzed for treatment effects by covariance analysis *(5)*. Initial seedling height and diameter of stocktypes, which were dissimilar at outplanting, were used as covariates.

Results and Discussion

Measurements of dry-weight biomass of the three stocktypes at outplanting showed well-balanced shoot-root ratios. Only the 1-0 plug had more root than shoot biomass. Mean shoot-root ratios and corresponding standard errors were:

1–0 plug	0.79 ± 0.04
2–0 bare-root	1.59 ± 0.05
Plug–1 bare-root	1.66 ± 0.06

Mean predawn xylem pressure potential was lowest in 1-0 plug seedlings throughout the measurement period, except on August 19 when 2-0 seedlings registered a dramatic drop, probably because of an unusually low air temperature (7.7° C) and the formation of heavy dew during predawn hours (fig. 1). Predawn xylem pressure potential levels of 2-0 stock varied most; that of the other two stocktypes increased more gradually with increasing drought as the summer progressed.

Differences in patterns of predawn xylem pressure potential may have been related to new root development. Although not quantified, differences in root initiation and growth were obvious among stocktypes. Development was greatest in 1-0 plug seedlings, followed by that of plug-1 stock. In 2-0 stock, it was sparse. In droughty environments, rapid root elongation is critical to seedling survival and growth as newly planted seedlings must maintain root contact with receding soil moisture *(8, 10)*. We believe that inadequate root growth in the 2-0 stock may have resulted in greater seedling water deficits.

Container-grown 1-0 seedlings had the best survival (91 percent) after 2 years, followed closely by the plug-1 seedlings (87 percent). Only 56 percent of the 2-0 stock

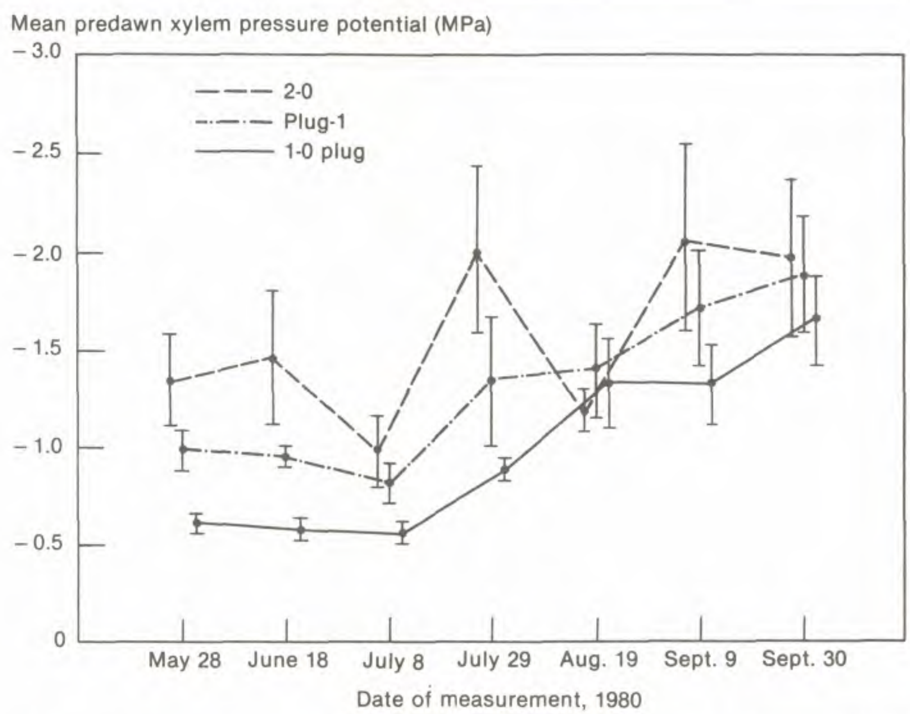

Figure 1.—*Mean predawn xylem pressure potential of three Douglas-fir stocktypes. (Vertical bars indicate one standard error.)*

remained alive (table 1). Regardless of stocktype, drought was the primary cause of mortality, most of which occurred during the first year. Population levels appeared to stabilize by the end of 1981. Survival rates corresponded inversely with the first-year xylem pressure potential levels, which may have been associated with differences in root development, as previously noted.

Analysis of covariance showed that treatment effects on growth were not significant. The lack of significant differences among stocktypes may be attributed, in part, to early elimination of individuals in poor physiological condition and in less favorable microsites. This is particularly true for 2-0 stock, which had growth equivalent to that of the other stocktypes after 2 years despite high mortality (table 1).

Performance of plug-1 seedlings was good after 2 years. Initially, they were as large as many 2-1 transplants, but had better developed root systems. Like the 1-0 plug stock, plug-1 seedlings used for xylem pressure potential measurements had good root initiation and growth during the 1980 growing season.

These results reinforce earlier reports of the performance of container-grown Douglas-fir in droughty environments (4, 7) and offer encouraging information on plug-1 Douglas-fir seedlings. Root growth during the first year after outplanting appears to have been important to seedling survival, as shown by decreased xylem pressure potential in 1-0 plug and plug-1 stocktypes. Reasons for the relatively poor survival of 2-0 stock, characteristic of its performance in other plantings in similar southwest Oregon environments, are not known; however, low root growth capacity may be a major factor.

Table 1.—*Performance of three Douglas-fir stocktypes after planting on a droughty, skeletal soil*

Measurement	1–0 plug	2–0 bare-root	Plug–1 bare-root
Survival		%	
August 1980	100	74	97
November 1980	95	63	93
May 1981	93	57	91
October 1981	91	56	87
Mean height (± s.e.[1])		*Cm*	
Initial	14.32±0.30	19.22±0.51	32.88±0.65
2-year growth	12.10± .66	12.61±1.00	11.39± .59
Mean diameter (± s.e.)		*Mm*	
Initial	2.71±0.06	5.46±0.15	6.65±0.11
2-year growth	1.91± .11	1.50± .15	1.49± .12

[1]S.e. = standard error.

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