Effects of Stocktype, Shading, and Species on Reforestation of a Droughty Site in Southwest Oregon

Abstract

On hot, dry sites, shading may differentially increase survival of planted Douglas-fir according to seedling size, and Douglas-fir may differ from ponderosa pine in early survival and growth. We compared the survival and growth on a droughty, south-facing clearcut of Douglas-fir seedlings (1-0 container-grown plug and larger diameter 2-0 bareroot Douglas-fir seedlings, unshaded or shaded with cardboard shadecards at planting) and unshaded 2-0 bareroot ponderosa pine. Shading did not significantly increase survival of plugs, possibly because of a wetter than normal first summer, nor did shading affect growth of either stocktype 5 years after planting. According to linear contrasts, Douglas-fir bareroots remained significantly larger than plugs, but relative growth rates for the initially smaller plugs were significantly greater for diameter and volume. Survival and growth of pine tended to be better than that of Douglas-fir. Both species have potential for reforestation of similar harsh sites.

Introduction

Heat and drought have been perceived as barriers to reforestation with Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) in southwest Oregon (Franklin and Dyrness 1973). Heat kills planted conifer seedlings because of high soil surface temperatures that damage stem tissue near the soil surface (Moulopoulos 1947). South-facing sites are regarded as most likely to develop lethal soil temperatures. Although shelterwood overstories can reduce heat loads to below lethal levels on these sites (Childs and Flint 1987), clearcutting is sometimes preferred for reforestation because of pest management, cost, or other considerations. On clearcuts, silviculturists have shaded planted seedlings with cardboard shadecards to increase survival (Lewis et al. 1978). However, the need for shadecards may vary with seedling size, as well as with the seedling's environment. For example, in Greece, with a similarly dry growing season, larger conifer seedlings were damaged less by heat than were small seedlings (Moulopoulos 1947).

In southwest Oregon, two stocktypes of Douglas-fir are commonly planted: 1-0 seedlings (plugs) grown in containers for 1 year in a greenhouse, and larger 2-0 bareroot seedlings grown for 2 years in an outdoor nursery bed. The literature reports that shade from shadecards has increased survival of each stocktype individually (Hobbs 1982, Helgerson 1990), but 1-0 plugs and 2-0 bareroots have not been compared side by side to see whether they respond differently to shading under otherwise similar conditions. Our first objective was to determine whether shadecards affected survival and growth of these two stocktypes differently. This information could help foresters to more efficiently prescribe planting and shading of these two stocktypes.

Douglas-fir and ponderosa pine (Pinus ponderosa Laws.) typically occur together on low- to mid-elevation sites in southwest Oregon. Because of its greater resistance to drought (Franklin and Dyrness 1973), ponderosa pine is often regarded as better suited than Douglas-fir for reforestation of such sites. Our second objective was to determine whether the two species differed in their early survival and growth on a droughty south-facing slope. Little information exists comparing early survival and growth of these conifer species when planted on droughty sites.

Methods

The Salt Creek study site is located on holdings of the Medford District, Bureau of Land Management. It is within a south- to southwest-facing, 18-ha clearcut at 975 m elevation in the foothills of the Cascade Mountains, about 26 km northeast of Medford, OR. Slopes in our test area range from
20 to 30 percent. The area receives approximately 760 mm of precipitation annually (Froehlich et al. 1982), with only about 1130 mm falling between May 1 and September 30 (McNabb et al. 1982).


The site is located in the Mixed-Conifer Zone (Franklin and Dyrness 1973), belonging to the PSME/RHDI/CYGR Association of the Douglas-fir Series (Atzet and McCrimmon 1990). Douglas-fir site index (McArdle et al. 1961) was estimated at 60 feet on a 100-year base (personal communication, Terry Tuttle, Medford District, BLM, data on file). This site had been classified by the Medford District as difficult to reforest because of heat and drought; it is typical of other foothill areas.

The site was clearcut and burned for site preparation in 1982. In 1983, five seedling treatments were set out as a randomized complete block design with three replications (Sokal and Rohlf 1981). The five treatments consisted of Douglas-fir 1.0 plugs and 2.0 bareroot seedlings, either unshaded or shaded with shadecards at planting, and 2.0 bareroot ponderosa pine (unshaded). The plugs were grown in 164-cm³ containers.

Seed for all seedlings came from within the surrounding seed zone; that for the Douglas-fir plugs came from 790 m elevation and that for all other seedlings from 760 m. The seedlings were planted on March 8, 1983, at approximate 2.4-m spacing within each 20- by 20-m treatment plot. Fifty seedlings were tagged in each treatment plot for subsequent recording of survival and growth; thus each of the five treatments was represented by 150 seedlings. Shadecards were installed within 1 week of planting. Weed presence was reduced shortly after planting by application of atrazine with a backpack sprayer to control herbs, and near the start of the 1985 and 1987 growing seasons by installations of paper mulches around seedlings and by cutting woody vegetation within test plots.

Survival, seedling heights (to distal end of uppermost live bud), and diameters (25 mm above soil) were measured on live seedlings immediately after planting and at the end of each of the first five growing seasons. We first ascertained treatment effects by analysis of variance, regarding time of measurement as a subplot of seedling treatment to determine whether treatment means changed according to measurement time (Cochran and Cox 1957). The planned comparisons between shading and stocktypes for Douglas-fir, and between the pine and all Douglas-fir, were tested with linear contrasts (Sokal and Rohlf 1981). Unplanned differences among the five seedling treatments were identified with the Scheffé test (Sokal and Rohlf 1981). Dependent variables were: survival; height (H); diameter (D); stem volume (V, calculated according to the formula for a cone, \( V = \pi D^2H/12 \)); and relative growth rates (RGR) for D, H, and V. Here, \( RGR = \ln size_f - \ln size_p \), where size is size at the end of the fifth growing season and size_p is size at planting (Harper 1977). Survival means were arc-sine transformed (Sokal and Rohlf 1981), which increased the normality of the residuals. All analyses were conducted on SAS (SAS Institute 1987) and screened for statistical significance at \( p < .05 \).

Results and Discussion

Survival

A significant interaction between treatment and time (\( p < 0.05 \)) showed that seedling treatment affected survival over time. After five growing seasons, the linear contrast between Douglas-fir stocktypes showed that the 2.0 bareroots survived significantly better than the 1.0 plugs, but shading with shadecards did not significantly increase survival; shading had an effect only at the \( p = 0.16 \) level (Table 1). The linear contrasts between species showed that ponderosa pine survived significantly better than all Douglas-fir seedlings taken together.

This lack of shading effect was unexpected because, in previous separate studies, shading had increased survival of both Douglas-fir stocktypes (Hobbs 1982, Helgerson 1990). We expected the plugs, in particular, to benefit from shading because of their significantly smaller mean diameters at planting (3.6 mm for plugs vs. 5.8 mm for bareroots). The plugs did show a larger survival difference after five growing seasons—75 percent for shaded vs. 57 percent for unshaded plugs, compared with 86 vs. 84 percent for bareroots—but the interaction between shading and stocktype was not significant (Table 1).

The Scheffé comparison, a more conservative test than linear comparisons, showed two overlapping groups of 5-year survival means at the \( p = .05 \).
level: all seedling treatments other than the unshaded plugs; and all Douglas-fir, excluding the pine (Figure 1a). This division shows that the only significant difference in survival among the five seedling treatments was between the 2-0 bareroot ponderosa pine and the unshaded 1-0 Douglas-fir plugs.

On south-facing slopes, heat damage to planted seedlings usually occurs during July or August, when soil surface temperatures reach maxima (Childs and Flint 1987). However, the absence of anticipated heat damage may be attributable to wetter than normal growing conditions (Gordon 1970). Medford precipitation totals for the months of July and August, 1983, were respectively in the 86th and 97th percentiles, according to records from 1913 to 1988 (personal communication, Mike Brooks, Medford Office, U.S. Weather Service, NOAA; data on file). Thus, the effects of shading on survival of Douglas-fir might have been more pronounced had the 1983 summer been more typically dry (Flint and Childs 1987).

The post-planting application of atrazine could have reduced survival of the plugs by its entry into their porous rooting medium, and shade cards could have reduced the exposure of adjacent seedlings. Although the mortality expected from atrazine can be small (Bruce Kelpas, Northwest Chemical Corporation, Salem, OR, unpublished data), it is possible that increased exposure to atrazine contributed to the lower survival of the unshaded plugs.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Shade</th>
<th>Stocktype</th>
<th>Shade x stocktype</th>
<th>Douglas-fir vs. pine</th>
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</thead>
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<td>Survival</td>
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<td>.01</td>
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<td>.02</td>
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<tr>
<td>Height</td>
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<td>Diameter</td>
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<td>.36</td>
<td>.0001</td>
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<tr>
<td>Volume</td>
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<tr>
<td>RGR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>height</td>
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<td>.009</td>
<td>.95</td>
<td>.0007</td>
</tr>
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<td>RGR</td>
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<td>volume</td>
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**Growth**

Significant time by treatment interaction terms showed that seedling heights, diameters, and stem volumes varied significantly over time according to seedling stocktype and species. Linear contrasts showed no significant differences between unshaded and shaded Douglas-fir in mean height, diameter, volume, or growth (RGR) 5 years after planting (Table 1). This similarity suggests that shade cards did not affect 5-year growth of the Douglas-fir seedlings, a result that is consistent with other work (Helgerson 1990).

When planted, the bareroot Douglas-fir were significantly larger in diameter and volume (5.6 mm, 2.6 cm$^3$) than the plugs (3.6 mm, 1.0 cm$^3$), but were within 1 mm of the same height. After five growing seasons, significant linear contrasts (Table 1) showed that bareroots were significantly larger in height, diameter, and volume. According to significant contrasts of RGRs (Table 2), the bareroots outgrew the plugs in height, but the plugs outgrew the bareroots in diameter and volume.

When planted, the ponderosa pine were significantly shorter than the average of all Douglas-fir stocktypes, but pines had approximately the same diameter and volume as the 2-0 bareroot Douglas-fir. After five growing seasons, the linear contrasts (Table 1) of mean sizes (Figure 1) and RGRs (Table 2) showed that the pines were significantly larger and had grown more rapidly than Douglas-fir in height, diameter, and volume.

The more conservative Scheffé comparison did not show differences in sizes or RGRs associated with Douglas-fir stocktypes or shading after five growing seasons. However, it showed pine to be significantly larger than all Douglas-fir in diameter and volume and significantly taller than unshaded plugs (Figure 1b, 1c, 1d). The pine significantly surpassed the 1-0 plug Douglas-fir in height growth, and surpassed all 2-0 bareroot Douglas-fir in diameter and volume growth.

In 1986, the mean sizes of the 2-0 bareroot Douglas-fir and pine in our plots were very close to those for similar 2-0 bareroots on another portion of the site, where cattle grazing was intensive (Doescher et al. 1989). This similarity indicates that weed control by controlled cattle grazing and the repeated mulching and clipping of herbs and brush in our study may similarly affect early seedling growth.
Figure 1. (a) Mean survival (percent), (b) stem height (m), (c) diameter (mm), and (d) volume (cm³) at planting and at the end of the first five growing seasons. Letters denote differences among means at the \( p = 0.05 \) level according to the Scheffé comparison; vertical bars denote standard error \( (n = 31) \).

<table>
<thead>
<tr>
<th>Seedling Type</th>
<th>Height</th>
<th>Diameter</th>
<th>Volume</th>
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</thead>
<tbody>
<tr>
<td>1-0 Douglas fir, no shade</td>
<td>1.178a</td>
<td>1.813ab</td>
<td>4.940ab</td>
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<td>1-0 Douglas fir, shaded</td>
<td>1.203a</td>
<td>1.904a</td>
<td>5.139ab</td>
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<td>2-0 Douglas fir, no shade</td>
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<td>1.566e</td>
<td>4.505b</td>
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<tr>
<td>2-0 Douglas fir, shaded</td>
<td>1.394ab</td>
<td>1.625bc</td>
<td>4.757b</td>
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<td>2-0 ponderosa pine, no shade</td>
<td>1.613b</td>
<td>1.983a</td>
<td>5.596a</td>
</tr>
<tr>
<td>2-0 ponderosa pine, shaded</td>
<td>1.613b</td>
<td>1.983a</td>
<td>5.596a</td>
</tr>
</tbody>
</table>

*TABLE 2.* Mean relative growth rate (RGR) for stem height, diameter, and volume according to seedling type. Letters denote differences between means in each row at \( p = 0.05 \) according to the Scheffé test.
Conclusions

Both Douglas-fir and ponderosa pine appear to be suited for reforestation after clearcutting on the droughty sites typified by this study. The consistently better survival and growth of the pine five growing seasons after planting indicates that pine may become established more quickly than Douglas-fir.

For Douglas-fir, stocktype affected survival and growth more than did shading; the lower-cost 2-0 bareroots survived and grew better than the 1-0 plugs. When available, the bareroots appear to offer more cost-effective reforestation.

Literature Cited


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Reforestation, Stocktype, Shading, Species