Terrace Planting in the Oregon Coast Range

Some Implications

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SUMMARY

 Douglas-fir seedlings were planted in 1963 near Burnt Woods, Oregon, on land covered with grass, salal, or bracken to test the effects of terracing on regeneration. After 9 years, survival was best (about 95 percent) among seedlings machine-planted along the centers of the terraces and was better on south than on north slopes, although height of surviving seedlings was greater on north slopes. About half of the trees planted in the rough between terraces died, and the survivors attained only about one-half the height of trees planted by machine in the terrace centers.

 Planting in terraces should succeed on deep soil with slopes between 20 and 50 percent. Outward-sloping terraces are recommended to lessen soil disturbance, prevent ponding, and avoid need for water bars.
Terrace Planting in the Oregon Coast Range:
Some Implications

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This paper describes the performances of Douglas-fir plantations on some experimental terraces in the Oregon Coast Range. The terraces were established in 1963 for the purpose of reforesting a salal-dominated site. Terracing was accomplished by operating a crawler tractor equipped with a conventional angle blade along a sidehill to create a vegetation-free level spot on which a planting machine could be operated efficiently.

Terracing has been the subject of considerable controversy. Objections to this practice generally have been based on fear of erosion resulting from excessive soil disturbance, of planting trees on nutrient-poor subsoil, and on possible interference with the movements of wildlife. Opposing these arguments are the necessities for reforestation of difficult sites, the need for removal of competing vegetation to establish seedlings, and the need for nonchemical alternatives for site preparation. In designing these experiments, we recognized merits and drawbacks of this approach and directed our experimental procedures to determine how to get the most successful planting with the least environmental disturbance. In confining our observations to terraces made with ordinary machinery, we intended that findings be directly applicable.

PROCEDURES

Site Selection

The site selected for this study was a steeply rolling hillside and ridgetop, between 750 and 800 feet elevation, about ½ mile north of Burnt Woods, Oregon. The site had been in open grass, salal, or bracken fern since a fire in 1870 that destroyed the forests of the Burnt Woods area. Canopy height was about 2 feet in the salal-dominated areas and about 5 feet for most of the bracken fern. Slopes range from level to 40 percent. The deep forest soils, resembling Bohannon and Slickrock series and originating from headwalls and slumps on Tyee sandstone, are about Site II for Douglas-fir. Establishment of natural stands was hampered by dense vegetation and grazing by livestock. The area also supports large populations of blacktail deer and brush rabbits. Previous plantings with 2-0 Douglas-fir failed.

Terracing Operation

The area was terraced with a Caterpillar D-6 crawler tractor with an angle blade without teeth. On level portions, the terraces amounted to a scarification in which the blade was deep enough to uproot salal, but not enough to remove much soil. As slopes increased, a road had to be benched, which required cutting on the upslope and filling on the downslope. The terraces were about 9 feet wide and were spaced about 30 feet apart (Figures 1 and 2). Terraces on slopes included an inner cut in which subsurface soil was exposed. Toward the middle of the terrace, the original soil surface was exposed. Toward the berm, a deepening layer of unconsolidated soil culminated in the deepest loose soil at the berm. Depths of cuts and berms ranged to 2 feet (Figure 3).

Planting Experiments

Five different planting procedures were tested. Experiments were in a randomized block, split-plot design. The split-plot part of the experiment was based on a division between north
Figure 1. Terrace, showing four positions of planting, and cover, which consists of bracken stalks and salal.

Figure 2. Terracing perspective.
and south slopes. On each slope, five treatments were repeated five times. Each treatment included a planting of ten seedlings. In all, there were $2 \times 5 \times 5 \times 10$ seedlings, for a total of 500 seedlings in the experiment.

There were five specific treatments (Figure 3, A-E), each with 100 seedlings in ten rows of ten: A, hand planted in the rough cover between terraces; B, hand planted in the inner edge of the terrace surface, mostly in subsoil, but on level terraces in the A1 horizon; C, machine planted in the middle of the terrace where the original soil surface was exposed; D, hand planted also in the middle of the terrace; E, hand planted at the deepest point in the berm.

All seedlings were 2-0 Douglas-fir, treated with tetramethylthiuram disulfide (Thyram), and of local genetic stock. All planting was inspected to determine that the planting job was well executed. The machine used for planting was a roughland planter that was well adapted for deep planting in rugged terrain (Figure 4).

**FINDINGS**

This experiment was examined several times for 9 years to evaluate the evidence of changing performance. Now, after 9 years, we think that the present patterns of survival and growth have significant implications for long-term interpretation. At the end of 1 year, we observed that mortality was about 50 percent in all plantations in the rough. On the inner edge of the terraces, mortality was not so severe as in the rough. Browsing damage was heavy everywhere, but appeared to contribute to mortality more heavily in the rough than elsewhere. Substantial mortality also was noted in the outer berm, but for unknown reasons. Mortality in the middle of the terraces was low. Browsing was common, but less severe than elsewhere. Survival and browsing are recorded in Table 1 for the first-year field examination.

At the end of nine growing seasons, the general pattern of survival was similar to the first year, except that the differences were exaggerated. Survival and attrition rate are listed in Table 1. Table 2 lists mean heights for all treatments over a 9-year period.

The two significant factors in survival were aspect and the method and placement of planting. Survival was significantly better on the south than on the north slope. Site conditions apparently were not responsible for this difference, because the north slope was generally
slightly cooler than the south slope. Differences in soil and vegetation were minor. The major difference seemed to relate to animal activity, especially domestic livestock, on the terraces.

Among the comparisons of method and placement, the differences are not only significant, but they are important in management. The lowest survival was for seedlings planted in the rough. Failure of seedlings in the rough was largely associated with competition and domination by both salal and ferns. The surviving seedlings were weak, and they were subject to severe mechanical action from falling litter, especially fern fronds. They also were

Table 1. Changes in Percentage of Survival of 2-0 Douglas-Fir Between the First and Ninth Years as Influenced by Placement in Terraces, Method of Planting, Severity of Browsing, and Aspect.

<table>
<thead>
<tr>
<th>Position in terraces</th>
<th>Method of planting</th>
<th>Top browsing first year</th>
<th>Survival by year of observation</th>
<th>Change</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Percent</td>
<td>Percent</td>
<td>Percent</td>
<td>Percent</td>
</tr>
<tr>
<td>Rough</td>
<td>Hand</td>
<td>76</td>
<td>37</td>
<td>66b</td>
<td>76c</td>
</tr>
<tr>
<td>Inner edge</td>
<td>Hand</td>
<td>64</td>
<td>29</td>
<td>94d</td>
<td>96d</td>
</tr>
<tr>
<td>Middle</td>
<td>Hand</td>
<td>69</td>
<td>29</td>
<td>78c</td>
<td>90d</td>
</tr>
<tr>
<td>Middle</td>
<td>Machine</td>
<td>59</td>
<td>30</td>
<td>98d</td>
<td>96d</td>
</tr>
<tr>
<td>Outer berm</td>
<td>Hand</td>
<td>83</td>
<td>57</td>
<td>60a</td>
<td>94d</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>70.2</td>
<td>36.4</td>
<td>79.2e</td>
<td>90.4f</td>
</tr>
</tbody>
</table>

1Survival percentages followed by the same letters are not significantly different at the 5-percent level of probability, and those followed only by different letters are significantly different within the same year and hierarchical level. The least significant difference among survivals within years was 17 percent at the 1-percent level of probability.
Table 2. Mean Total Heights of Nine-Year-Old Douglas-Fir Plantings by Aspect, Planting Method, and Placement in Terraces.

<table>
<thead>
<tr>
<th>Position in terraces</th>
<th>Method of planting</th>
<th>Height in feet</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>North</td>
<td>South</td>
</tr>
<tr>
<td>Rough</td>
<td>Hand</td>
<td>6.02 a</td>
</tr>
<tr>
<td>Inner edge</td>
<td>Hand</td>
<td>8.86 bcd</td>
</tr>
<tr>
<td>Middle</td>
<td>Hand</td>
<td>10.59 cd</td>
</tr>
<tr>
<td>Middle</td>
<td>Machine</td>
<td>12.48 e</td>
</tr>
<tr>
<td>Outer berm</td>
<td>Hand</td>
<td>9.01 cd</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>9.40 f</td>
</tr>
</tbody>
</table>

Heights identified by the same letters within hierarchical levels are not significantly different at the 5-percent level of probability. Those not followed by the same letter are significantly different. The least significant difference at the 1-percent level of probability for treatments within aspects was 2.66 feet, and for treatment means on both aspects was 1.88 feet.

subjected to rabbit clipping. In contrast, no plantings on the terraces were subjected to rabbit damage or mechanical action as in the rough. Deer damage, however, was severe on all within-terrace treatments, irrespective of position. The differences in survival between the inner edge, the outer berm, and the hand-planted trees in the center of the terrace are negligible. Surprisingly, machine planting in the middle of the terrace had the best early and long-term survival. These general relations were consistent on both slopes and in all plots, although mortality occurred earlier on the north slope. Differences on north slopes were more pronounced than elsewhere, and any disadvantages there may have been amplified by browsing.

Height growth was greater on the north slope than on the south slope. Among planting treatments within slopes a strong relation existed between survival and height growth. Trees growing in the rough were about one-half the height of the machine-planted trees; the other treatments were intermediate. No appreciable difference existed between the performances of the hand-planted seedlings in the middle of the terrace or in the cut bank, but trees planted on the berm had a slight depression of growth.

Variation in height growth among trees within treatments was not the same in all treatments. Trees planted on the inner edge had more variation in their height growth than the trees planted by hand in the middle of the terrace. These, in turn, displayed more variation than the machine-planted trees in the middle of the terrace. The maximum-size trees in all three treatments were similar. The distribution of sizes, however, included many more small individuals in the cut slope than in the middle of the terrace and more small individuals among the hand-planted trees in general than among the machine-planted trees. Thus, the mean size and mean survival of trees in the machine-planted, midterrace treatment were greater, and the probability of any given tree surviving and reaching dominance was disproportionately greater.

Animals unquestionably used the terrace openings as thoroughfares and loafing areas. The trees planted in the terraces were subjected to substantially more browsing by deer and cattle but less by rabbits than were those in the rough. The excellent performance of the machine-planted treatments despite browsing suggests that animal browsing by itself was not limiting where low competition allowed rapid growth and seedlings were well planted.
The succession of the vegetation on the terraces bears comment. Little invasion of plant cover occurred on the terrace surfaces where the cuts were deep enough to disrupt salal and fern roots. On every terrace where substantial soil was moved, the old surface soil became exposed at a distinct zone in the middle of the terrace. Only at that point did the original cover reassert itself. The mulching effect of sidecast material on the outer side of each terrace was effective in suppressing shrub and fern in this zone. Subsoil exposed by terracing seldom was invaded by shrubs. Some development of grasses and forbs took place, but for some reasons, perhaps related to fertility, the subsoil did not support good growth. Thus, after 9 years, the trees surviving in the terrace are still free from major competition other than the line of original cover at the exposed center and from the scattered native Douglas-fir (Figure 5).

The soil characteristics on the terrace vary substantially with position and degree of slope. We expected to find poor tree performance on subsoils exposed by terracing on steeper slopes. We did not, in fact, observe this. The steeper slopes were associated with the best development among all trees planted on the inner edge of the terrace. The growth on the inner margin, in fact, was greater than on the outer berm where soil was much deeper and where there was also a large accumulation of borrowed soil from A1 horizon. Unfortunately, this effect could not be quantified because it was confounded with cattle damage. Despite the great depth of soil on the outer berm, the soil still was unconsolidated after 9 years and represented a moderately poor anchorage for the planted trees. Undoubtedly, this effect was physical because the fertility of the berm slopes logically would have been greater than for any of the other sites. Depth of the fill on which the trees were planted did not influence survival or growth.

Figure 5. Appearance of plantings after 9 years. A seedling planted in the rough appears on the left (A); seedlings planted along the inner edge (B) and the center (C) of a terrace also are visible.
DISCUSSION

Our observations suggest that terracing may prove environmentally advantageous in planting Douglas-fir seedlings on the Oregon coast range because chemical control of vegetation is avoided and soil fertility is maintained. We are not asserting that terracing as done in these experiments is the only way to achieve these environmental gains. The trees unquestionably benefited from long-term suppression of associated vegetation, especially with respect to physical domination. The trees also responded to the uniformly superior planting job done with the large roughland planter.

The topography and soils on which these experiments were conducted were clearly conducive to this type of work. On these slopes, to create terracing severe enough to impede the movements of animals was unnecessary. The soils were stable, water did not collect on the terraces, and erosion did not occur. Much less disturbance was produced than has been typical of controversial terracing in the Rocky Mountains and in California. Moreover, internal drainage was such that water did not accumulate on the surface, despite the 70-90 inches of rain annually.

Moisture content of soil has an important bearing on structural damage resulting from machine activity. This job was done during the winter when soil was at field capacity, or slightly moister than the point of maximum compactibility. We did not observe obvious damage to soil. Seedlings generally were not planted in the two track patterns, and terrace construction did not permit surface flow of water so as to stimulate erosion.

Bulldozer work of this nature is expensive. Presumably, the benefits from this general procedure could be achieved with the costs and severity of soil disturbance minimized. Two approaches are proposed to these ends. One would use a substantially smaller bulldozer with the ability to create a narrow terrace. The other would entail a front-mounted, side-casting rotavator. We consider a terrace 4½ feet wide adequate both for environmental objectives and for operation of a roughland planter. An outward sloping surface would permit minimum soil movement. Equipment design is outside the scope of this paper, but to rig some sort of device that would achieve the environmental objective of these practices with a minimum of cost, however, should not be difficult or expensive.

Operationally, this practice should achieve success on deep soils with slopes between 20 and 50 percent. We do not advocate its use on shallow soils, steep slopes, or droughty sites. Outward-sloping surfaces are recommended to minimize soil disturbance, prevent accumulation of water, and avoid the need for water bars. Plant cover dense enough to justify terracing should be adequate to prevent movement of stable soil types.