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Large Scalps Improve Survival and Growth of Planted Conifers in Central Idaho

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RESEARCH SUMMARY

Three conifer species were planted and compared on a large clearcut in central Idaho. Three scalp sizes were also compared. The study site is harsh and has a history of plantation failures due at least in part to a heavy coverage of elk sedge (*Carex geyeri* F. Boott).

Fifth-year results indicate that lodgepole pine (*Pinus contorta* var. *latifolia* Engelm.) had the best survival and height growth. Ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) was intermediate, while Douglas-fir (*Pseudotsuga menziesii* var. *glauca* [Beissn.] Franco) showed the poorest performance. On 2-ft (0.6-m) hand-made scalps, tree survival was lower and total height was less than on 4-ft (2.4-m) wide dozer strips. This was especially true for the pines.

It appears that on hot and dry sites where elk sedge or other grasses are extremely competitive, 4-ft scalps are the minimum site preparation required. Adequate site preparation along with matching of proper species to the site conditions as well as adequate control of livestock and gophers can help ensure success in reforesting these sites.

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INTRODUCTION

Competition for available soil moisture between associated vegetation and young trees must always be considered when planning reforestation efforts in Douglas-fir (*Pseudotsuga menziesii* var. *glauca* [Beissn.] Franco) and ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) forests of central and southern Idaho. Elk sedge (*Carex geyeri* F. Boott), pinegrass (*Calamagrostis rubescens* Buckl.), and other grasses are especially competitive with tree seedlings because the lateral extension of their root systems allows them to exploit the same soil zones as planted trees when located as far away as 2 ft (0.61 m) or more from the tree (Loewenstein and others 1968). Of these grasses, elk sedge is the most competitive in central Idaho (Spence and Woolley 1936).

Elk sedge is a fibrous-rooted species that produces a greater number of roots and penetrates the soil to a greater depth than its grass and herb associates (Spence 1937). It is a perennial that tolerates unfavorable conditions such as high moisture stress (Sampson 1917). The root system of elk sedge is much more extensive than the aboveground foliage (fig. 1). Although the plant diagrammed in figure 1 is only 12 inches (30 cm) tall and 10 inches (26 cm) wide, the roots spread 56 inches (142 cm) and reach a depth of 75 inches (190 cm). Because of elk sedge's extensive root systems and its ability to compete for soil moisture, the spaces commonly found between sedge plants are often occupied below ground and may not be good spots to plant trees.

Elk sedge is present in most inland Douglas-fir and ponderosa pine forests. Of 49 central Idaho forest habitat types that have Douglas-fir either as a climax species or a major seral species, 44 have elk sedge in the undergrowth (Steele and others 1981). In 10 habitat types, elk sedge was found in every stand sampled. Canopy coverage of elk sedge was estimated as high as 43 percent. Moreover, because of its extensive root systems, the effective site occupancy of elk sedge was much greater.

Other grasses with root systems less extensive than elk sedge can also be excessively competitive where coverage is high. In California, Baron (1962) planted ponderosa pine seedlings for three consecutive years in plots he had sown to big bluegrass (*Poa ampla* Merr.), hard fescue (*Festuca ovina duriuscula* L.), pubescent wheatgrass (*Agropyron trichophorum* K. Richter.), redtop (*Agrostis alba* L.), orchard grass (*Dactylis glomerata* L.), perennial ryegrass (*Lolium perenne* L.), tall oatgrass (*Arrhenatherum elatius* [L.] Presl.), and timothy (*Phleum pratense* L.). Establishment of the pine seedlings became less successful each year as competition from the grasses increased. Larson and Schubert (1969) showed that for ponderosa pine, both root and top growth was greater when seedlings were grown in the absence of competition from Arizona fescue (*Festuca arizonica* Vasey) and mountain muhly (*Muhlenbergia montana* [Nutt.] Hitchc.).

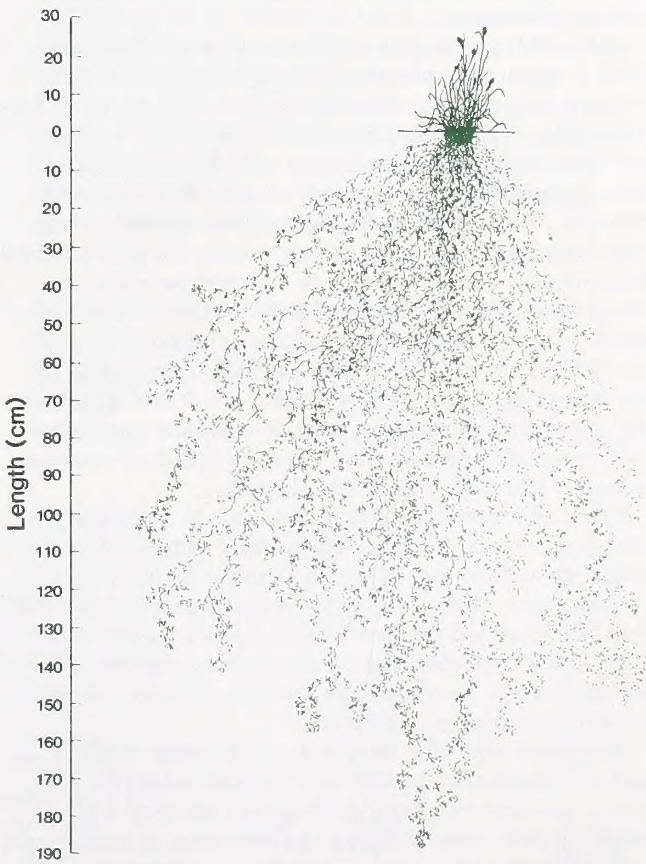

Figure 1.—Representative diagram of a fibrous root system of sedge (*Carex* sp.) from a north slope in the Boise River watershed, southwestern Idaho (Spence and Woolley 1936).

Control of competition from sedge and grass is often necessary for a successful plantation. But how large is the vegetation-free area needed by each tree to assure survival and a reasonable rate of growth?

According to Gutzwiler (1976), the primary considerations in determining the minimum effective size of cleared spots are the condition of the forest floor and the rooting characteristics of existing vegetation. When vegetation completely occupies a planting site, scalp size and depth must be increased in order to prevent competition from underlying roots. Lotan and Perry (1983) say that scalps must be a minimum of 18 inches by 18 inches (46 by 46 cm), and on droughty sites they should be larger. Stewart and Beebe (1974) found no significant increase in second-year ponderosa pine survival when they compared 2-ft (0.61-m) scalps to no site preparation in hard fescue and pinegrass on two different soils of central Washington. Heidmann (1963) tested scalp sizes on an Arizona site covered with mixed grasses consisting mainly of mountain muhly and Arizona fescue. He found that scalping as opposed to no site preparation significantly increased survival of ponderosa pine. However, survival differences between scalp sizes of 16-inch (41-cm) diameter, 26-inch (66-cm) diameter, and complete removal of all vegetation on the plot were not statistically significant.

Hall (1971) found that ponderosa pine seedling survival 5 years after planting was higher on 4-ft (1.2-m) scalps than on 2-ft or 6-ft (0.61-m or 1.8-m) scalps in central Idaho. Slit scalps 1.5 to 2 ft (0.46 to 0.61 m) long and 6 to 10 inches (15 to 25 cm) wide have sometimes been successful on pumice soils of central Washington (Stewart 1978). Loewenstein and others (1968) showed that scalping increased first-year ponderosa pine survival dramatically, but differences in survival between seedlings on scalps of 1, 3, and 5 ft (30, 91, or 152 m) were small. However, favorable moisture conditions throughout the season may have been partially responsible for the lack of significant differences. Larson and Schubert (1969) recommend that in order to establish ponderosa pine in the Southwest, grass must be killed or removed from the site before trees are planted.

Miller and Brewer (1984) found that, in northern Idaho, dozer scarification significantly reduced 3-year height growth of containerized Douglas-fir compared to no treatment where competing vegetation was light and first-year precipitation was above normal. Lotan and Perry (1983) maintain that discontinuous furrows or scarified strips are preferable because animals will use continuous strips as walkways.

This paper contains the results of a 5-year study comparing Douglas-fir, ponderosa pine, and lodgepole pine (*Pinus contorta* var. *latifolia* Engelm.) survival and height growth after planting in three sizes of hand-made and machine-made scalps. Though competition may also be reduced by other means such as spot applications of herbicides, this study involved only mechanical scalping.

STUDY SITE

The study site was within a large clearcut in the Grouse Creek drainage on the Mountain Home Ranger District of the Boise National Forest. Characterized by strongly dissected faulted bench land, Grouse Creek is in the southern part of the Idaho batholith. Well-drained, gravelly sandy loam skeletal soils of granitic genesis predominate. The amount of soil moisture available to young trees depends largely on summertime precipitation. The site is approximately 6,000 ft (1 830 m) in elevation and is a *Pseudotsuga menziesii/Berberis repens* habitat type (PSME/BERE; Douglas-fir/Oregongrape) (Steele and others 1981).

The PSME/BERE habitat type occurs mainly in southeastern Idaho and adjacent Utah, and extends into southern portions of central Idaho. The elk sedge phase of this type occurs mainly in the southern batholith section in central Idaho.

This habitat type has moderate to high timber yield capability (Steele and others 1981). It occupies a variety of aspects at lower to midelevations—4,500 to 7,700 ft (1 370 to 2 350 m)—of the forested zone. Usually Douglas-fir is the only tree species that grows on these sites, but in the elk sedge phase ponderosa pine is a major seral species within its elevational range. Lodgepole pine is an associated species in some areas.

The Grouse Creek study area has gently rolling topography with slopes generally less than 30 percent. Cold air appears to drain less rapidly here than in other areas of similar elevation, and extremes in temperature may be a major hinderance in regenerating Douglas-fir, especially in a large clearcut.

Coverage of elk sedge was estimated on 10 randomly located 4-milacre plots on each aspect of the study area. Coverage ranged from 10 percent on areas greatly disturbed during logging to 65 percent on areas with minimal disturbance. The average for each aspect was between 35 and 40 percent (fig 2).

Clearcuts in the area have been heavily grazed by sheep each year since logging in the early 1960's. Douglas-fir has been planted twice on the site with little success. Seven years separate the last planting and the beginning of this study.

Figure 2.—Grouse Creek study site with typical ground coverage of elk sedge.

METHODS

We repeated the scalping test on three aspects (northeast, southeast, and northwest) within the study area. Test sites on the northwest and southeast sites were fenced to exclude sheep grazing. The northeast site was left unprotected in order to determine effects of sheep grazing. We used a completely randomized block experimental design with five blocks on each aspect. We conducted 3×3×3 factorial analysis of variances for surviving trees, gopher-caused mortality, and height growth (measured from the ground to the top of the terminal bud or tallest lateral if no terminal) after the fifth growing season. Where significant differences were revealed, we did multiple comparisons of means using the studentized maximum modulus (Gabriel 1978).

Each block contained three experimental units (scalping treatments); each unit was 120 ft (37 m) long. One unit consisted of a single row of 2- by 2-ft (0.61- by 0.61-m) hand scalps spaced 4 ft (1.2 m) apart from center to center. Ten trees each of Douglas-fir, ponderosa pine, and lodgepole pine were planted in the scalps. The order of the species in the first three scalps was determined randomly. The same order was repeated in each subsequent group of three scalps. A second unit contained two rows of 4- by 4-ft (1.2- by 1.2-m) scalps made by a hydraulically operated 4-ft blade mounted on the rear of a small tractor. The two rows were 8 ft (2.4 m) apart with 8 ft between scalp centers within a row. The third unit was one row of trees planted 4 ft apart down the middle of an 8-ft-wide dozer-scalped strip. The three species were planted in the 4-ft scalps and dozer strips in the same alternating pattern described above for the 2-ft scalps. Each experimental unit contained 30 planted trees, 10 of each species. All three site preparation treatments removed up to 6 inches (15 cm) of topsoil from the immediate vicinity of the planted trees.

Trees (2-0 stock) were planted in spring 1975. Roots were pruned to 12-inch (30-cm) length at Lucky Peak Nursery and relatively uniform-sized trees of each species were selected for the study. The trees were hand planted in auger holes. The initial height of each seedling was measured and recorded as well as the height at the end of each of the first five growing seasons. Mortality was determined each year and the likely cause of death recorded.

The unfenced area on the northeast aspect was lightly grazed by a herd of 2,800 sheep once during the second growing season (1976). Again in the third growing season (1977), a herd of 2,865 sheep grazed through the unprotected blocks of the study. This time the grazing was slower and heavier. Finally, the unfenced blocks were very heavily grazed for a few hours in the fifth growing season (1979) by 2,074 sheep. Visible damage to seedlings caused by sheep was recorded in 1976, the first year of grazing, and each of the subsequent 4 years. (Erosion is not expected to be a problem with any of the three treatments. The 2-ft scalps have the least potential for erosion.)

We did not use an unscalped control plot because after two plantation failures it was apparent that the site required site preparation in order to establish tree seedlings. The 2-ft scalp was accepted as the standard for comparison.

RESULTS

At the end of the first five growing seasons, we gathered data on survival and mortality and on height growth and frost damage.

Survival

The 86 percent survival rate of the lodgepole pine was significantly greater than the 73 percent survival for ponderosa pine at the 95 percent level of confidence (table 1). In turn, ponderosa pine survival was significantly greater than the 65 percent survival of Douglas-fir. Survival of all species on the 2-ft (0.61-m) scalps was 61 percent, significantly less than on 4-ft (1.2-m) scalps (80 percent) and on dozer strips (83 percent). We found no significant difference in survival between the three aspects.

The difference between survival on the 2-ft scalps and the other two site treatments has widened each year since planting (fig 3). When the three species were combined, average first-year survival ranged from 95 percent in the 2-ft scalps to 98 percent on the dozer strips. At the end of the fifth year, average survival ranged from 63 percent on the 2-ft scalps to 82 percent on the dozer strips. For nearly all nine combinations of species and site preparation, the mortality rates declined sharply during the fifth growing season.

Table 1.—Fifth year survival and mean height of surviving trees

Tree species and treatment	Survival	Height
	Pct	*cm*
Douglas-fir		
2-ft scalp	49a[1]	20.2a
4-ft scalp	69bc	21.9a
dozer strip	77bcd	24.7ab
species total	65	22.3
Ponderosa pine		
2-ft scalp	59ab	20.8a
4-ft scalp	80cd	29.6bc
dozer strip	81cd	32.0cd
species total	73	27.5
Lodgepole pine		
2-ft scalp	75bcd	26.4abc
4-ft scalp	91d	36.1de
dozer strip	92d	39.9e
species total	86	34.1

[1]Means followed by the same letter are not significantly different, $\alpha = 0.05$. Mean comparisons methods according to Gabriel (1978).

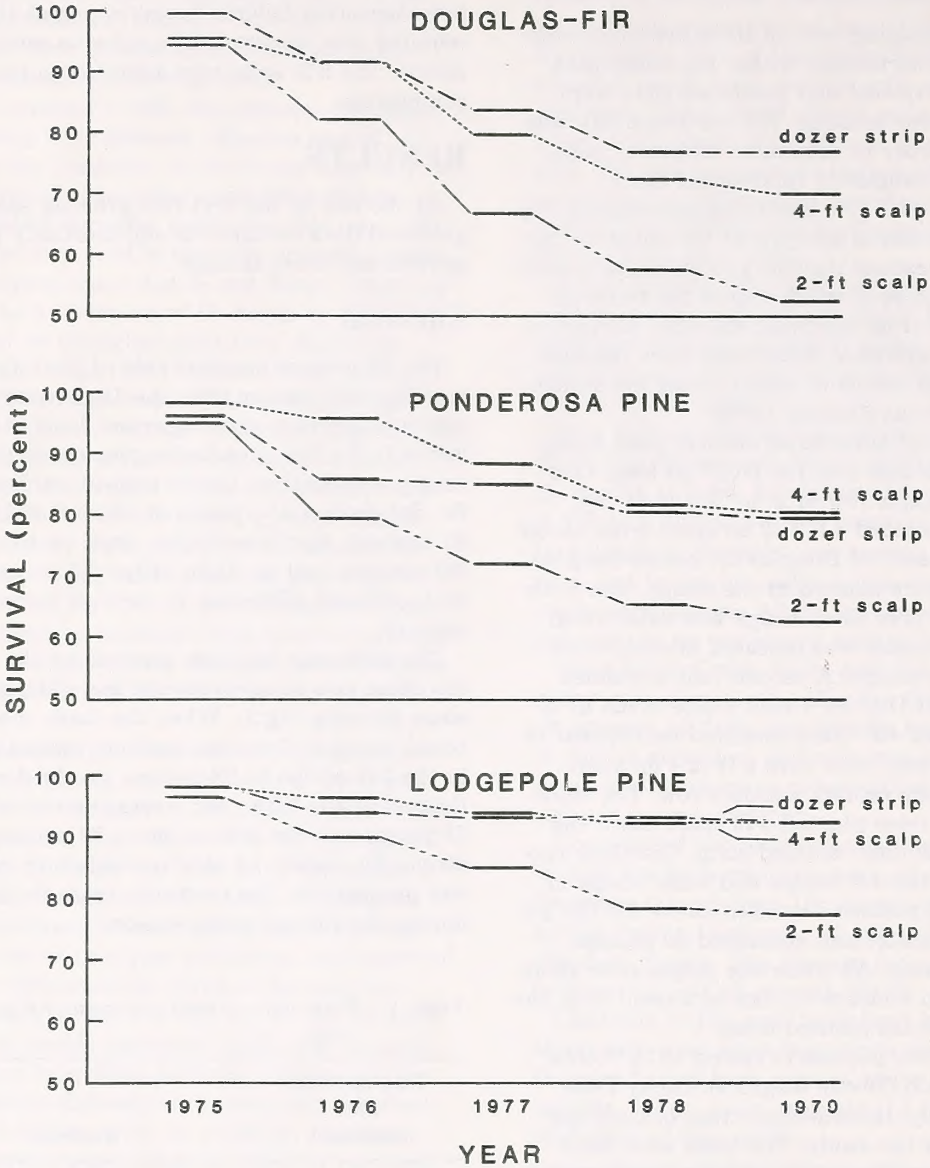

Figure 3.—Tree survival during the first 5 years after planting. The lines are averages for the three aspects.

Causes of Mortality

More than half the seedling mortality on all three aspects was not identifiable at the time of measurement. The primary cause of unidentified mortality is likely to have been moisture stress due to poor root growth after planting and gopher damage to the root system.

A 3×3×3 analysis of variance revealed significant differences in the number of seedlings killed by gophers among the different aspects and among species (tables 2 and 3). Gopher kill was significantly greater on the northwest aspect than on the northeast ($\alpha = 0.01$), with the southeast intermediate (fig. 4). Gophers killed significantly more ponderosa pine than lodgepole pine, with Douglas-fir intermediate ($\alpha = 0.05$). There was no apparent relationship between the number of trees killed by gophers and the site preparation treatment.

Because the northeast aspect was the only unfenced area, it was the only aspect where trees were killed by sheep. During the small amount of grazing, sheep killed 20 trees (19 percent of the total mortality on that site), most of which were trampled or browsed. About half the trees killed were Douglas-fir. Ponderosa pine mortality was almost as high, but only three lodgepole pine trees were killed by the sheep.

Table 2.—The average number of trees killed by gophers on each aspect during the 5-year period after planting

Aspect	Trees killed
	No.
Northwest	1.22a[1]
Southwest	0.93ab
Northeast	0.36b

[1]Values shown are means for 45 experimental units, each containing 10 trees. Means followed by the same letter are not significantly different, α = 0.01.

Table 3.—The average number of trees of each species killed by gophers during the 5-year period after planting

Aspect	Trees killed
	No.
Ponderosa pine	1.20a[1]
Douglas-fir	0.82ab
Lodgepole pine	0.49b

[1]Values shown are means for 45 experimental units, each containing 10 trees. Means followed by the same letter are not significantly different, α = 0.05.

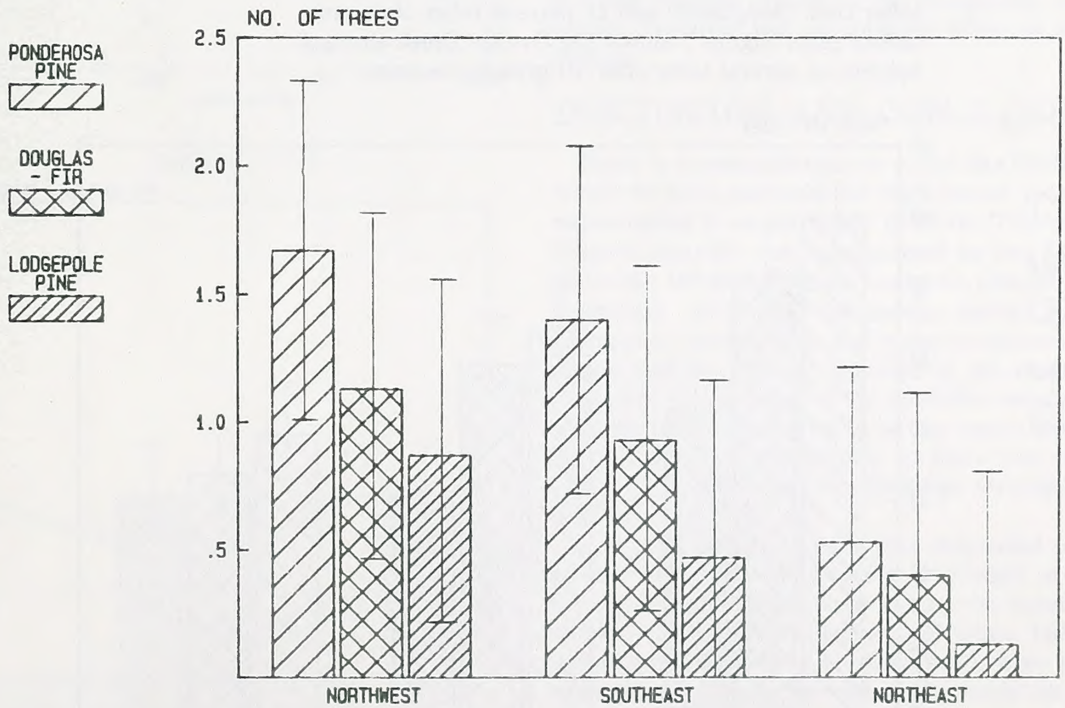

Figure 4.—Average number of trees killed by gophers. Bars depict the number killed by gophers per 10-tree plot. Lines depict mean comparison intervals by Gabriel (1978). Treatment means with lines that overlap are not significantly different.

Height Growth

Our analysis of variance for the mean total height at the end of the fifth growing season showed several significant relationships at the 95 percent level of confidence (table 1). Lodgepole pine seedlings were taller (13.4 inches or 34.1 cm) than ponderosa pine (10.8 inches or 27.5 cm), which, in turn, were taller than Douglas-fir (8.8 inches or 22.3 cm). Trees were tallest on the dozer strips (12.7 inches or 32.2 cm), and those on the 4-ft (1.2-m) scalps (11.5 inches or 29.2 cm) were taller than on the 2-ft (0.61-m) scalps (8.9 inches or 22.5 cm).

For both lodgepole and ponderosa pine the heights were significantly taller on the dozer strips and 4-ft scalps than on the 2-ft scalps (fig. 5). For Douglas-fir, the differences were not statistically significant.

The initial height of Douglas-fir averaged 5.1 inches (13 cm) with a range of 2 to 9 inches (5 to 23 cm). Ponderosa pine initial tree height averaged 3.2 inches (8 cm) and ranged from 2 to 5 inches (5 to 13 cm), while that of lodgepole pine averaged 4.7 inches (12 cm) with a range of 2 to 7 inches (5 to 18 cm). We plotted fifth-year heights over initial heights and found no apparent relationship.

At the end of the fourth growing season, the rate of terminal leader elongation was increasing faster on the dozer strips for all three species (fig. 6). The next fastest rate increase was on 4-ft scalps for the pines. The Douglas-fir rate of terminal leader elongation was similar for 4-ft and 2-ft scalps.

After five seasons, lodgepole pine averaged 55 percent taller than Douglas-fir and 25 percent taller than ponderosa pine. Figure 7 shows the Grouse Creek site and heights of several trees after 10 growing seasons.

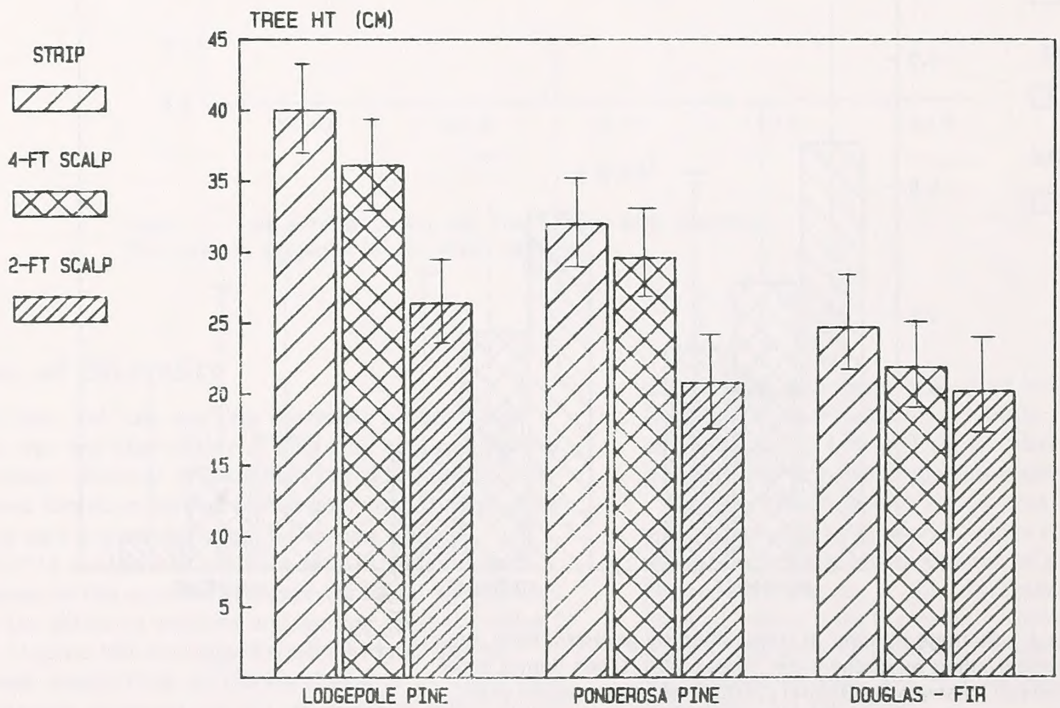

Figure 5.—Average tree heights. Bars depict tree heights in centimeters. Lines depict mean comparison by Gabriel (1978). Treatment means with lines that overlap are not significantly different.

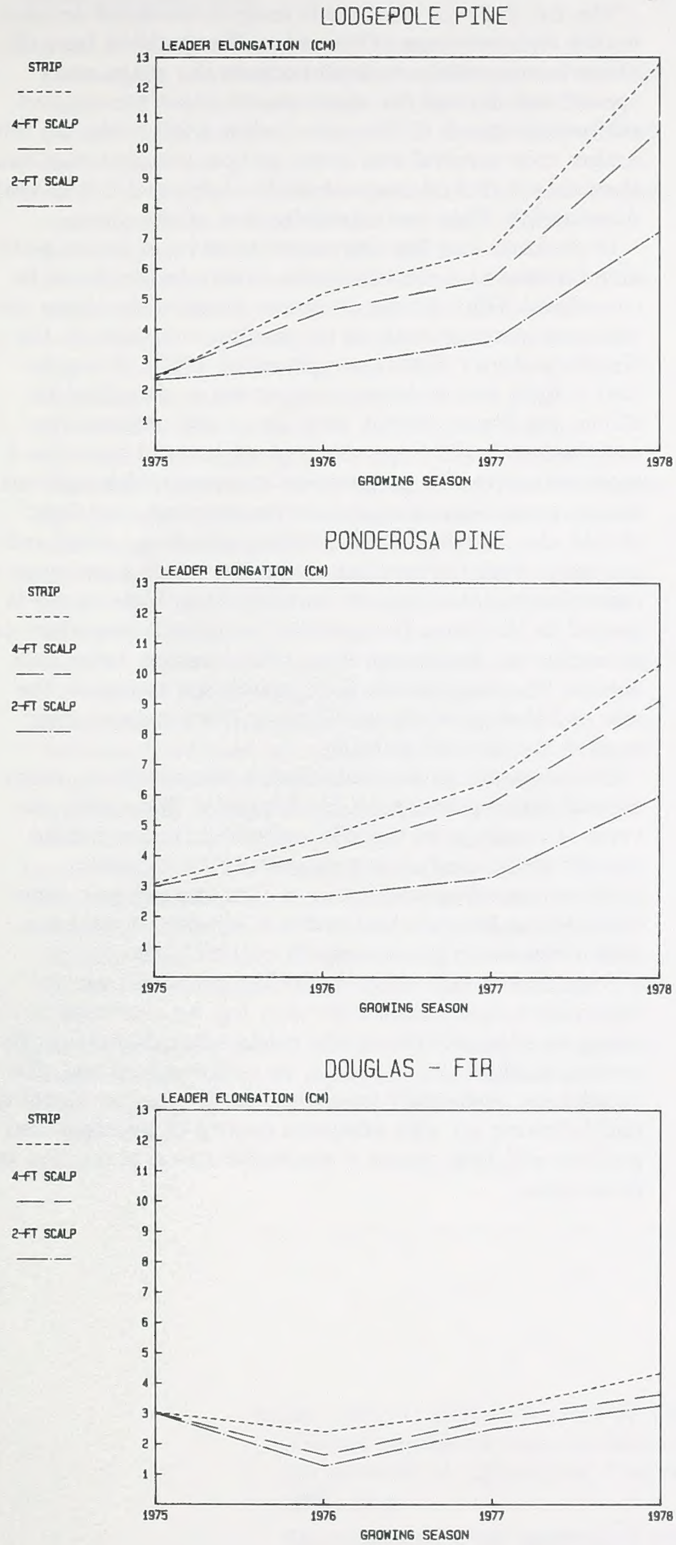

Figure 6.—Leader elongation for species and site treatments during the first four growing seasons.

Frost Damage

A severe frost in June of 1976 did not directly cause mortality in this study, but frost was credited with preventing 19 percent of the Douglas-fir seedlings from making leader growth during the second growing season. Of the Douglas-fir seedlings, 22 percent in both 2-ft and 4-ft (0.61- and 1.2-m) scalps and 14 percent in dozer strips were frost damaged severely enough to prevent leader growth. The extent of frost damage to Douglas-fir on the three aspects was similar. This frost damage may have reduced the fifth-year mean heights of Douglas-fir, but had minimal effects on the comparison of site treatments. The frost had no apparent effect on the two pine species.

Figure 7.—Grouse Creek study site in 1984 after 10 growing seasons.

DISCUSSION AND CONCLUSIONS

There is a contradiction on a site like Grouse Creek where we have potential for high timber productivity yet regeneration is so extremely difficult. This seemingly illogical situation can be explained by two factors (Running 1982): (1) the microclimate changes when a site is clearcut, and (2) physiologically, mature trees are more tolerant of temperature and moisture extremes than are young seedlings. Since clearcutting, elk sedge has expanded to use most of the available summertime moisture resource, considered to be the major limiting plant growth factor on the site. So, to allow tree seedlings a share of the moisture, the elk sedge coverage must be decreased.

Lodgepole and ponderosa pine responded more to the larger scalps than did Douglas-fir. Height growth on the 4-ft (1.2-m) scalps and dozer strips was superior to that on the 2-ft (0.61-m) scalps for both pines, but the differences in height growth for Douglas-fir were not statistically significant. At the end of the study the differences in height growth on the three site preparations were widening at an increasing rate for the pines. The growth rate for Douglas-fir on the dozer strips was increasing at a slightly faster rate than on the 4-ft and 2-ft scalps.

The chances of seedling survival were higher on the dozer strips and 4-ft scalps than on the 2-ft scalps for all three species.

Although there was no significant difference in survival between the three aspects, the causes of mortality differed widely. Gophers were responsible for 48 and 35 percent of the total mortality on the northwest and southeast aspects, respectively. The northeast aspect had only 15 percent gopher-kill. Of the mortality on the northeast aspect, 19 percent was caused by sheep grazing. From the data collected in this study we cannot explain why we got less gopher damage on the northeast aspect.

A small amount of frost damage to Douglas-fir did occur during this study, but the data were too limited to determine if any of the site preparations increased the chances of frost damage.

Because the site preparation treatments tested in this study removed up to 6 inches (15 cm) of topsoil from the immediate vicinity of the planted trees, we suspect that the increased height growth was a response to less competition for available soil moisture rather than for nutrients. We need to test a toothed scalping blade that would remove the vegetation but leave most of the topsoil on the scalped area. Another possible method would be use of herbicides to create scalps yet leave topsoil in place. We would expect greater height growth response from both methods, but the more fertile topsoil may allow a quicker invasion of scalps by vegetation.

As expected, the climax species, Douglas-fir, tended not to perform as well in the large clearcut as the two seral species, ponderosa pine and lodgepole pine. At 6,000 ft (1 830 m) ponderosa pine is nearing its upper elevational limit in that part of Idaho. Had the plantation been 500 ft (150 m) lower, ponderosa pine may have performed better. In large clearcuts of this nature, unprotected Douglas-fir seedlings are susceptible to frost damage. Where lodgepole pine is an associated species on this habitat type, large clearcuts can be most readily regenerated by planting lodgepole. Douglas-fir and ponderosa pine can also be established, but perhaps at greater costs. Regeneration of Douglas-fir on this kind of site would be more successful in small clearcuts, group selection cuts, or shelterwood cuts (Steele and others 1981; Ryker and Losensky 1983).

The 2-ft (0.61-m) hand-made scalp is too small on sites with a high coverage of elk sedge. Competition from elk sedge is not greatly reduced because the sedge roots spread well beyond the aboveground plant canopy and still occupy much of the space below a 2-ft scalp. On 2-ft scalps, tree survival was lower and total height was less than on 4-ft (1.2-m) machine-made scalps and 8-ft (2.4-m) dozer strips. This was especially true of the pines.

In deciding how big the scalps must be to insure seedling survival at a minimum cost, many factors must be considered. High temperature and plant water stress are the most common reasons for seedling mortality in the Northern Rocky Mountains (Running 1982). If vegetation is light and moisture is adequate as described by Miller and Breuer (1984), little or no site preparation may be required. It appears that on hot and dry sites a more extensive site preparation is needed. Although not as important here, competition for nutrients and light should also be considered. Scalping removes topsoil and nutrients from the seedling microsite, which may cause a reduction in initial growth on some sites. More study is needed in this area. Competition for light is important to remember on sites supporting taller grasses, forbs, and shrubs. The best we can do is match the species to the site and then give the seedlings as much help as they need at the time of planting.

Elk sedge seems to create severe competition in many central Idaho plantations. Each year of this study, survival of seedlings in the 2-ft scalps fell further behind the 4-ft scalps and strip treatments. The dramatic decline in seedling survival on 2-ft scalps, as seen especially in the first to third years, is similar to what has been observed in plantations of central Idaho.

Even though elk sedge and other grasses of central Idaho are tough competitors they can be overcome by doing an adequate job of site preparation. Matching the cutting method to the species as well as stand and site conditions, adequately preparing the site before planting, and following up with adequate control of livestock and gophers will help ensure a successful forest plantation on these sites.

REFERENCES

Baron, Frank J. Effects of different grasses on ponderosa pine seedling establishment. Research Note 199. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1962. 8 p.

Gabriel, K. Ruben. A simple method of multiple comparisons of means. Journal of the American Statistical Association. 73(364): 724-729; 1978.

Gutzwiler, Jerry R. Mechanical site preparation for tree planting in the inland northwest. In: Conference proceedings, tree planting in the Inland Northwest; 1976 February 17-19; Pullman, WA. Pullman, WA: Washington State University; 1976: 117-133.

Hall, Dale O. Ponderosa pine planting techniques, survival, and height growth in the Idaho batholith. Research Paper INT-104. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1971. 28 p.

Heidmann, L. J. Effects of rock mulch and scalping on survival of planted ponderosa pine in the southwest. Research Note RM-10. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station; 1963. 7 p.

Larson, M. M.; Schubert, G. H. Root competition between ponderosa pine seedlings and grass. Research Paper RM-54. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station; 1969. 12 p.

Loewenstein, H.; McConnel, L. P.; Pitkin, F. H. Root development and survival of planted ponderosa pine seedlings as influenced by competing vegetation. Station Paper No. 5. Moscow, ID: University of Idaho, Forest, Wildlife, and Range Experiment Station; 1968. 13 p.

Lotan, James E.; Perry, David A. Ecology and regeneration of lodgepole pine. Agriculture Handbook 606. Washington, DC: U.S. Department of Agriculture; 1983. 51 p.

Miller, Daniel L.; Breuer, David W. Effects of site preparation by burning and dozer scarification on seedling performance. Forestry Technical Paper TP-84. Lewiston, ID: Potlatch Corporation; 1984. 7 p.

Running, Steven W. Insolation and heat effects on tree seedlings on newly cleared sites. In: Symposium proceedings, site preparation and fuels management on steep terrain; 1982 February 15-17; Spokane, WA. Pullman, WA: Washington State University; 1982: 87-92.

Ryker, Russell A.; Losensky, Jack. Ponderosa pine and Rocky Mountain Douglas-fir. In: Burns, Russell M., tech. comp. Silvicultural systems for the major forest types of the United States. Agriculture Handbook 445. Washington, DC: U.S. Department of Agriculture, Forest Service; 1983: 53-55.

Sampson, A. W. Important range plants: their life history and forage value. Bulletin 545. Washington, DC: U.S. Department of Agriculture; 1917: 34-36.

Spence, Liter E. Root studies of important range plants of the Boise River Watershed. Journal of Forestry. 35(8): 747-754; 1937.

Spence, L. E.; Woolley, S. B. Root systems of important range plants of the Boise River Watershed. 1936. Unpublished paper on file at: U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Forestry Sciences Laboratory, Boise, ID.

Steele, Robert; Pfister, Robert D.; Ryker, Russell A.; Kittams, J. A. Forest habitat types of central Idaho. General Technical Report INT-114. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1981. 138 p.

Stewart, Ronald E. Site preparation (Chapter 7). In: Regenerating Oregon's forests. Corvallis, OR: Oregon State University Extension Service; 1978: 99-134.

Stewart, R. E.; Beebe, T. Survival of ponderosa pine seedlings following control of competing grasses. In: Proceedings of the Western Society of Weed Science. 27: 55-58; 1974.

Sloan, John P.; Ryker, Russell A. Large scalps improve survival and growth of planted conifers in central Idaho. Research Paper INT-366. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station; 1986. 9 p.

Responses of three species of conifers were assessed in a large clearcut in central Idaho. Survival and height growth of Douglas-fir, lodgepole pine, and ponderosa pine for 5 years after planting were related to 2-ft and 4-ft scalps and dozer strips on a *Pseudotsuga menziesii* var. *glauca/Berberis repens* habitat type.

KEYWORDS: Douglas-fir, lodgepole pine, ponderosa pine, site preparation, plantation protection, *Carex geyeri*, *Pseudotsuga menziesii* var. *glauca/Berberis repens* h.t., central Idaho, survival, height growth

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INTERMOUNTAIN RESEARCH STATION

The Intermountain Research Station provides scientific knowledge and technology to improve management, protection, and use of the forests and rangelands of the Intermountain West. Research is designed to meet the needs of National Forest managers, Federal and State agencies, industry, academic institutions, public and private organizations, and individuals. Results of research are made available through publications, symposia, workshops, training sessions, and personal contacts.

The Intermountain Research Station territory includes Montana, Idaho, Utah, Nevada, and western Wyoming. Eighty-five percent of the lands in the Station area, about 231 million acres, are classified as forest or rangeland. They include grasslands, deserts, shrublands, alpine areas, and forests. They provide fiber for forest industries, minerals and fossil fuels for energy and industrial development, water for domestic and industrial consumption, forage for livestock and wildlife, and recreation opportunities for millions of visitors.

Several Station units conduct research in additional western States, or have missions that are national or international in scope.

Station laboratories are located in:

Boise, Idaho

Bozeman, Montana (in cooperation with Montana State University)

Logan, Utah (in cooperation with Utah State University)

Missoula, Montana (in cooperation with the University of Montana)

Moscow, Idaho (in cooperation with the University of Idaho)

Ogden, Utah

Provo, Utah (in cooperation with Brigham Young University)

Reno, Nevada (in cooperation with the University of Nevada)