BRUSH COMPETITION RETARDS EARLY STAND DEVELOPMENT OF PLANTED PONDEROSA PINE: UPDATE ON A 24-YEAR STUDY.

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ABSTRACT

Growth of ponderosa pine (Pinus ponderosa) was monitored for 24 years after planting at five different square spacings (6, 9, 12, 15, and 18 ft) in the presence or absence of competing brush on the westside Sierra Nevada. Spacing strongly influenced both mean dbh and basal area/ac. In plots maintained free of brush, diameters ranged from 5.1 in. at the 6-ft spacing to 11.4 in. at the 18-ft spacing after 24 years. Over all spacings, brush reduced mean dbh by 20% and basal area/ac by 37%. Projections of mean dbh suggest that yield losses resulting from brush competition depend on the objective and intensity of management. A long rotation and low intensity of management would result in a negligible reduction in final yield on this productive site. If, however, an intermediate harvest and short rotation are planned, yield losses will be substantial.

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INTRODUCTION

Initial spacing has long been recognized as a fundamental question in silviculture and widely reported in the literature (Evert 1973; 1984; Sjolte-Jorgensen 1967). But reports on initial spacing of ponderosa pine are few, especially those dealing with the influence of tree spacing and brush on long-term growth on a productive site. Results of a 24-year study on a productive site on the west slope of the northern Sierra Nevada in California are reported here which supplement 12-, 16-, and 20-year results reported earlier (Oliver 1979; McDonald and Oliver 1984; Oliver In press). Yields are projected to 50 years to illustrate the ability of the test spacings to meet timber management objectives.

STUDY ENVIRONMENT

Trees were planted within a 15-acre clearcut on the Challenge Experimental Forest, Yuba County, California, at 2650-ft elevation, near the lower boundary of the mixed-conifer forest type. High temperatures and abundant precipitation have created a deeply weathered soil classified as Aiken, a Series found extensively in the Sierra Nevada and Cascade Range of California and Oregon. The profile is more than 5 ft deep, overlaying greenstone. Site Index is estimated to be 110 ft at 50 years (Powers and Oliver 1978).

FIELD DESIGN AND ESTABLISHMENT

In March 1966, 1-0 ponderosa pine from the appropriate seed zone was planted in two randomized blocks. In these blocks, each containing five rectangular plots, trees were planted at five different square spacings---6, 9, 12, 15, and 18 ft. The effect of brush on tree growth at these spacings was tested by splitting each plot in half. On one half, chosen randomly, brush was allowed to develop naturally. The other half was kept brush-free. Each divided plot contained 12 trees to be measured and was surrounded by a buffer of at least 24 ft, minimally containing two rows of trees. Therefore, split plots with buffer varied in area from 0.11 ac for 6-ft spacings to 0.36 ac for 18-ft spacings. The entire experiment covered 4.31 ac.

Dominant species on the split plots where brush was allowed to develop were whiteleaf manzanita (*Arctostaphylos viscida*), Indian manzanita (*A. mewukka*), deerbrush (*Ceanothus integerrimus*), small numbers of Sierra gooseberry (*Ribes roezlii*), and sprouts of California black oak (*Quercus kelloggii*) and tanoak (*Lithocarpus densiflora*). The forbs and bracken fern (*Pteridium aquilinum* var. *lanuginosum*), which occupied the understory in the split plots kept brush free, probably retarded growth by about 10% (Data on file at the Pacific Southwest Forest and Range Experiment Station, USDA Forest Service, Redding, CA).

MEASUREMENTS AND ANALYSES

The trees were measured for stem diameter at breast height (dbh) after the 6th through 20th and the 24th growing seasons. Brush was sampled in the 10th, 14th, and 20th years in the treated plots. Circular 0.0025-ac plots were established at random locations within the area containing trees to be measured. Because 25% of each area containing trees to be measured was sampled, the number of sample brush plots varied with tree plot size. Within each plot, brush was measured for mean maximum crown diameter (two readings taken at right angles) and mean crown height.

Mean dbh, basal area/ac, and their standard errors were calculated for five spacings both with and without competing brush (Table 1), and a split-plot analysis of variance with and without competing brush was calculated for the entire experiment at age 24.

Table 1. Mean dbh and basal areas (with their standard errors) of ponderosa pine 24 years after planting to five spacings with and without competing brush.

Square spacing	Without brush Mean dbh	Without brush Basal area	With brush Mean dbh	With brush Basal area
ft	in.	ft^2/ac	in.	ft^2/ac
6	5.1±0.1	150±26	4.5±0.1	124±15
9	7.3±0.3	157±11	6.3±0.2	116±7
12	8.8±0.8	129±2	6.9±0.8	80±17
15	9.7±0.4	99±8	7.1±0.1	51±2
18	11.4±0.2	94±4	8.7±0.4	56±5

RESULTS

Mortality was light and had little effect on results. In the first year, 23 trees in the experiment, or 1.5% of all trees planted, died. These trees and those that died during the next 2 years were replaced. After 24 years, six measurement trees were dead, three of which were in one 6-ft spacing plot.

Brush seeds germinated abundantly, and seedlings grew rapidly on plots where they were allowed to develop. By the 10th year, brush coverage had reached 77% on the average and stabilized at that amount during the next 10 years. Brush plants continued to grow in height, however, from 4.6 ft in the 10th year to an average of 8.5 ft in the 20th year. Few ponderosa pines were overtopped by brush owing to both the rapid growth in height of the pines and the complete site preparation that had eliminated all existing brush and nearly all hardwood sprouts.

Spacing strongly influenced both mean dbh and basal area/ac 24 years after planting in plots maintained free of brush ($p < 0.05$). Diameters now decrease with each increase in spacing and have since about year 14. Mean stand dbh at age 24 was 5.1 in. for brush-free plots with trees spaced 6 by 6 ft, but mean stand dbh was 11.4 in. for plots with trees spaced 18 by 18 ft (Table 1). By comparison, competing brush reduced the influence of spacing. The range in diameters for the brush-choked plots was 4.5 in. to 8.7 in. Over all spacings, diameters of trees in brush-choked plots were 80% of the diameter of trees in brush-free plots.

In contrast to mean dbh, basal area/ac tended to be negatively correlated with spacing with the following exceptions: (1) in brush-free plots basal area/ac of the 9-ft spacing exceeded that of the 6-ft spacing---150 ft^2 compared with 157 ft^2; and (2) in brush-choked plots the basal area/ac of the 18-ft spacing exceeded that of the 15-ft spacing---56 ft^2 compared with 51 ft^2. Over all spacings, basal areas in brush-choked plots were only 63% of those in brush-free plots.

DISCUSSION

The presence of competing brush has slowed growth and stand development markedly at all spacings. A comparison of current annual increment against mean annual increment of basal area/ac for both brush-free and brush-choked plots graphically illustrates this delay in stand development for the 12-ft spacing (Figure 1). Besides the slower growth in brush-choked plots, mean annual basal area increment has culminated in brush-free plots but has not culminated in brush-choked plots.

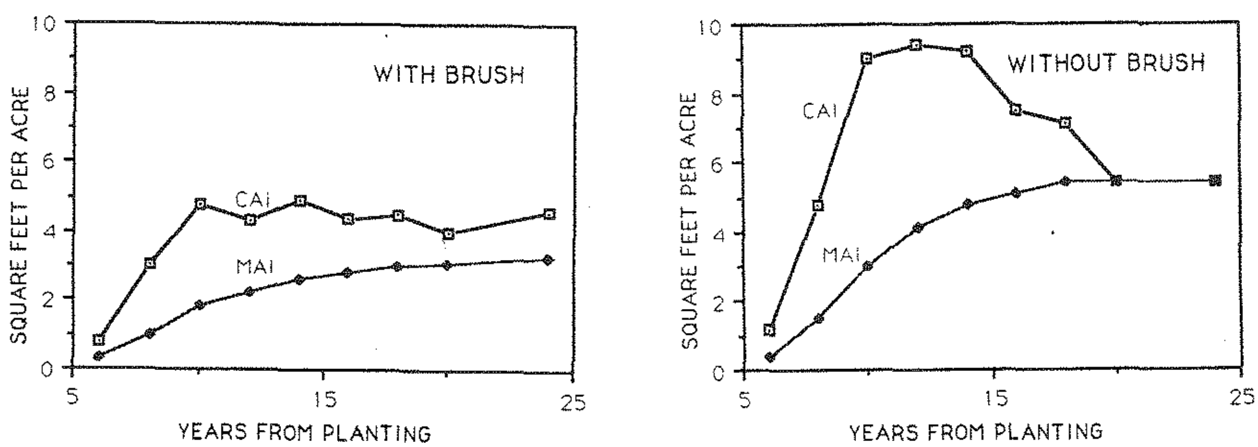

Figure 1. Mean annual increment (MAI) and current annual increment (CAI) in basal area/ac of ponderosa pine planted at a 12-ft spacing with and without competing brush.

The practical significance of this loss in growth and stand development depends on the objective and intensity of management. Whether because of a decline in the competitive influence of brush, greater intertree competition in brush-free plots, or a combination of both, growth rates of trees in brush-choked plots now almost equal that of trees in brush-free plots. In the 12-foot spacing plots, for instance, the growth rate has been about equal since the 18th year (Figure 2) and follows the early part of the Type I growth response of Snowdon and Waring (1984).

These relative increases in growth rate can be illustrated by plotting current diameter growth rate of trees competing with brush as a percentage of that rate for trees without brush over all spacings (Figure 3). As the brush understory was developing to its maximum coverage, growth rates of the competing trees fell further and further behind that of brush-free trees. At about year 10, brush coverage had stabilized, and comparative growth rates of brush-choked trees increased. Currently, at age 24, diameter growth rates for trees competing with brush in all spacings average about 95 percent of that of trees in brush-free plots.

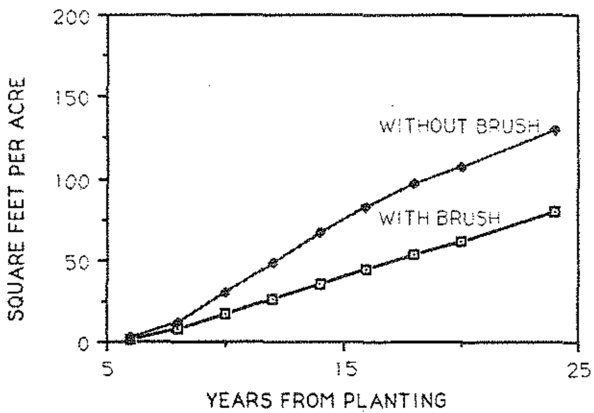

Figure 2. Basal area/ac for ponderosa pine planted at a 12-ft spacing with and without competing brush.

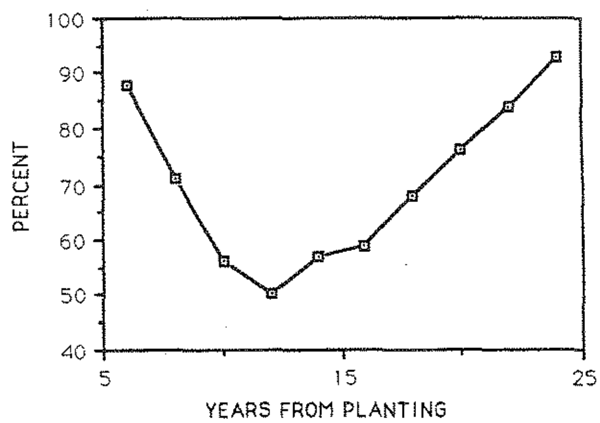

Figure 3. Mean stand dbh of ponderosa pine with competing brush as a proportion of that of trees growing free of brush competition.

We know that, when tree crowns close and shade the brush, the brush dies and releases the full resources of the site to the trees. Neither the timing of brush death nor the subsequent growth rate of the trees is known. But I presume that growth rates of previously brush-choked plots would equal those of brush-free plots at comparable stages of stand development. In the absence of thinning and significant mortality, therefore, yields from both brush treatments could be equal sometime in the future. The major impact of brush competition on this productive site, therefore, is a time delay in reaching targeted timber yields.

The importance of this delay depends on the objectives of the forest manager. If the plantation is to be managed for wood products on a short rotation, however, yield losses could be substantial. For example, one possible management scenario would be to thin from below, leaving 100 trees/ac when stands reach a mean dbh of 10 in. Such thinnings are prevalent today to provide fuel for biomass energy plants. For this scenario, mean dbh was projected to 50 years by SYSTUM-1 (Powers, Ritchie and Ticknor 1989) with and without thinning by using data on trees and brush at age 20 from Oliver (In Press) (Table 2).

Table 2. Mean dbh at 50 years as predicted by SYSTUM-1 of plots thinned at a mean dbh of 10 inches to 100 trees/ac and of plots left unthinned.

Square spacing	Without brush		With brush	
	Thinned	No thinning	Thinned	No Thinning
ft	inches			
6	17.1	11.3	12.7	10.2
9	21.0	14.3	18.3	12.1
12	23.6	16.4	17.7	12.9
15	23.8	18.1	17.5	12.7
18	--	20.8	--	14.9

This projection of yield illustrates the inability of the spacing extremes tested to produce trees that meet likely timber management objectives. At the 6-ft spacings, the proposed biomass thinning is delayed until so late in the rotation that much potential growth is lost through intertree competition. A costly precommercial thinning would be the only solution. The situation for the 9-ft spacing is similar but less severe. At the other extreme, the 18-ft spacing is too lightly stocked to support a biomass thinning. The forest manager would lose this income opportunity, and mean dbh at 50 years would be reduced by about 3 in. Either the 12- or 15-ft spacings seem to meet the proposed management scenario. They produced similar yields.

Similar losses in yield resulting from brush competing with ponderosa pine have been reported elsewhere. Barrett (1982) demonstrated a loss of production equivalent to 20 Meyer site index units or 32% in yield at 40 years in central Oregon. Losses of 69% were found in a brush-choked plantation on a marginal timber site in California's North Coast Range (Oliver 1984) (Data on file at the Pacific Southwest Forest and Range Experiment Station, USDA Forest Service, Redding, CA). Losses tend to be proportionally greater on poorer sites (McDonald and Oliver 1984).

Projections of mean dbh suggest that yield losses resulting from brush competition on this productive site depend on the objective and the intensity of management. A long rotation and low intensity of management would result in a negligible reduction in final yield; however, an intermediate harvest and short rotation would result in substantial losses in yield.

LITERATURE CITED

Barrett, J. W. 1982. Twenty-year growth of ponderosa pine saplings thinned to five spacings in central Oregon. USDA For. Serv. Res. Pap. PNW-301. 18 p.

Evert, F. 1973. Annotated bibliography on initial tree spacing. Can. For. Serv. For. Manage. Inst. Inform. Rep. FMR-X-50. 149 p.

Evert, F. 1984. An update (1970/71-1982) of the annotated bibliography on initial tree spacing. Can. For. Serv. Petawawa Natl. For. Inst. Inform. Rep. PI-X-44. 157 p.

McDonald, P. M., and W. W. Oliver. 1984. Woody shrubs retard growth of ponderosa pine seedlings and saplings. p. 65-89. In: Proc. 5th Ann. Forest Vegetation Management Conference, Nov. 2-3, 1983, Sacramento, Ca. Forest Vegetation Management Conference, Redding, CA.

Oliver, W. W. 1979. Early response of ponderosa pine to spacing and brush: Observations on a 12-year-old plantation. USDA For. Serv. Res. Note PSW-341. 7 p.

Oliver, W. W. 1984. Brush reduces growth of thinned ponderosa pine in northern California. USDA For. Serv. Res. Pap. PSW-172. 7 p.

Oliver, W. W. [In press]. Spacing and shrub competition influence 20-year development of planted ponderosa pine. West. J. Appl. For.

Powers, R. F., and W. W. Oliver. 1978. Site classification of ponderosa pine stands under stocking control in California. USDA For. Serv. Res. Pap. PSW-128. 9 p.

Powers, R. F., M. W. Ritchie, and L. O. Ticknor. 1989. SYSTUM-1: Simulating the growth of young conifers under management. p. 101-115. In: A Decade of qorest Vegetation Management. Proc. 10th Ann. Forest Vegetation Management Conference, Nov. 1-3, 1988, Eureka, Ca. Forest Vegetation Management Conference, Redding, CA.

Sjolte-Jorgensen, J. 1967. The influence of spacing on the growth and development of coniferous plantations. p. 43-94. In: Int. Rev. For. Res. vol. 2.

Snowdon, P. and H. D. Waring. 1984. Long-term nature of growth responses obtained to fertilizer and weed control applied at planting and their consequences for forest management. p. 701-711. In: Proc. symp. on site and productivity of fast growing plantations. vol 2. IUFRO. Pretoria, S. Afr.