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EARLY BRUSH CONTROL PROMOTES GROWTH OF PONDEROSA PINE planted on bulldozed site

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Abstract: Test plots in a brushfield near Mount Shasta, California, were cleared by bulldozing in 1961, and planted with ponderosa pine seedlings in 1962. Brush regrowth was subjected to varying levels of control by spraying with herbicides. In the first 5 years, brush control definitely promoted the growth of pine seedlings. And this early control also promises to reduce the amount of hazardous brush fuels in the plantations for an indefinite period.

Oxford: 174.7 *Pinus ponderosa* (794): 232.4:187 X 424.5:268.44.
Retrieval Terms: Pinus ponderosa; stand establishment; brush control; California.

On California brushland sites, adequate brush control is needed for satisfactory establishment and growth of pines.[1] Bulldozing is an effective method for initial brush removal.[2] But within 2 years a dense stand of competitive brush plants commonly becomes established.[3] This new brush cover can be controlled by applying herbicides either before or after the pine has been planted.

The immediate objective of brush control is to promote growth of young pine seedlings at or near the site potential. Another goal would be to reduce the shrubby vegetation to an open stand of scattered plants for an indefinite period.[3] An open brush stand helps prevent future buildup of continuous woody fuel—dead brush, plus dead pine branches—near ground level. A fuel bed of this nature presents an impossible firefighting situation. And dense impenetrable underbrush stymies thinning or pruning operations.

One approach to brush control—developed since 1962 for use in new pine plantations—is to spray herbicide in the first or second year after bulldozing, and to repeat applications as needed to develop an open brush stand within 5 years after initial brush clearing.[3] This schedule is needed because small brush seedlings and young sprouts are easier to kill—and at a lower cost—than well established older plants.

This emphasis on early control of brush has raised such questions as: Will maintenance of relatively bare soil surface benefit or deter growth of small pine seedlings on recently bulldozed areas? If beneficial, what level of brush control is needed during the first 5 years to enhance pine survival and growth? Will early brush control determine ultimate production from a plantation?

We obtained information on the first two questions at Mount Shasta, in northern California, on a bulldozed area planted with ponderosa pine (*Pinus ponderosa* Laws.) in 1962. In 1966, we measured the

volume of brush on sprayed plots and unsprayed plots. We compared heights of pine seedlings in 1966 with amounts of brush present 5 years after clearing. Brush volume was expressed as an index value obtained for each plant by multiplying crown height times crown area. On the sprayed plots having an average brush crown volume less than 10,000 cubic feet per acre in 1966, the pines averaged about 35-inches tall. On plots having more than 20,000 cubic feet per acre of brush, the pines averaged only 20 to 28-inches tall. These results show that reduction of new brush cover can improve growth of young pine in addition to providing other benefits expected from early control.

STUDY SITE

The plantation is at 4,000 feet elevation. Terrain is gently sloping. The soil—Shasta loamy sand—is of volcanic origin with rock-free surface. Yearly precipitation averages nearly 38 inches, about equally divided as rainfall and snow. Little precipitation falls during the warm summer months, although there are occasional short periods of cloudy weather with effective rainfall. Site index for ponderosa pine is estimated at low III.

A dense stand of native brush was removed by bulldozing in autumn 1961. The brush plants, including most root crowns, along with 6- to 12-inches of surface soil were pushed into windrows. This left a soft surface devoid of woody material.

The 2-0 pine seedling stock was machine planted in spring 1962 in rows 10 feet apart, with 8-foot spacing between pines in each row.

A dense stand of new brush seedlings became established in 1962, mostly greenleaf manzanita *(Arctostaphylos patula* Greene*)* and snowbrush *(Ceanothus velutinus* Dougl.*)*. Manzanita seedlings were numerous, but snowbrush plants were larger. Additional seedlings, mainly manzanita, became established each successive year. Root sprouts of sierra plum *(Prunus subcordata* Benth.*)* grew on many plots. Occasional sprouting plants of bush chinkapin *(Castanopsis sempervirens* [Kell.] Dudl.*)* and other species remained after bulldozing.

We measured the brush regrowth and the pines in 1966 on 45 plots, each 66 by 132 feet, that were typical of the study site. Brush control treatments on these 45 plots had been chosen at random in 1962. On 10 plots brush was not sprayed. The other 35 plots were sprayed in 1962-63 by a variety of treatments that differed in method and number of applications, date of spraying, and kind and rate of herbicides. And all 35 had been sprayed in September 1964 with butoxy ethanol ester of 2,4,5-T (2,4,5-trichlorophenoxyacetic acid) at 4 pounds, acid equivalent, per acre.

On each plot we systematically selected 20 pines for measurement, usually every third tree in the center four rows. On sprayed plots the selected trees had been shielded with paper bags or protected by other means from direct spraying in 1962-63. The spray was applied directly over these trees in 1964. The tree locations, well distributed over each plot, were used as center points for milacre quadrats within which the brush stand was measured in 1966, when the pines had not influenced brush growth to any apparent degree. The brush measurements were judged as representative of the entire plot, within the limits of sampling error.

Within each milacre quadrat we measured the brush stand by a procedure that compares the effects of different herbicide treatment.[4] Number of plants, by species, were counted within size classes based on crown volume. For each species and for all species combined, we tallied plants, by size classes, and calculated total crown volume per acre.

We compared heights of pines with total crown volume of brush per acre—the single measurement that we consider best describes the brush stand. To obtain the general relationship between pine height and brush crown volume, we arrayed the 45 plots from lowest to highest average crown volume and divided them into nine groups of five plots, each group having 100 pines and 100 brush quadrats.

RESULTS

Brush Cover

By 1966—5 years after bulldozing—the 45 plots represented a wide range in density and size of brush plants. Among the nine groups of plots, the major differences in brush cover appeared to be caused by degree of control from the various spray treatments. Within each group, differences in brush cover apparently were caused in part by inherent site differences and by variable amounts of brush and soil scraped from the plots during bulldozing. Such differences were most apparent among the unsprayed plots where brush growth had not been influenced by spray treatment. No attempt was made to evaluate effects of these differences, but they were equalized to some extent by combining five widely spaced plots within each group.

The average crown volumes *(table 1)* for groups 1 to 6, which included only sprayed plots, ranged from 1,210 to 10,610 cubic feet per acre. For groups 7 and 8, which included both sprayed and unsprayed plots,

Table 1–*Average crown volume index of each major species and for all species as cubic feet per acre and as percent of total cover for the nine plot groups 5 years after bulldozing, Mount Shasta, California*

Group	Greenleaf manzanita		Snowbrush		Sierra plum		Other		All species
	Cu. ft./acre	Pct.	Cu. ft./acre	Pct.	Cu. ft./acre	Pct.	Cu. ft./acre	Pct.	Cu. ft./acre
1	230	19	910	75	60	5	10	1	1,210
2	160	6	2,460	88	160	5	20	1	2,800
3	130	3	3,310	90	250	7	0	–	3,690
4	360	6	4,880	87	390	7	0	–	5,630
5	760	10	6,550	87	160	2	40	1	7,510
6	660	6	8,560	81	1,370	13	20	–	10,610
7	2,381	17	8,640	63	2,800	20	0	–	13,820
8	10,677	45	9,205	38	2,920	12	1,118	5	23,920
9	24,710	63	13,830	35	720	2	0	–	39,260

the average brush covers were 13,820 and 23,920 cubic feet per acre. Brush cover on the unsprayed plots in group 9 averaged 39,260 cubic feet per acre.

Greenleaf manzanita had been held in check on most of the sprayed plots but formed dense stands on unsprayed plots in 1966. Snowbrush was dominant in all of the sprayed plots, especially in the thin brush stands on plots where best control had been obtained by heavy spraying in 1962 and 1963. Snowbrush also had high crown volume indexes of about 10,000 cubic feet, or greater, in the unsprayed plots. Sierra plum was most abundant in those plots that were first sprayed during late fall in 1962 after leaves had dropped from this deciduous species. The late spray date gave fair control of manzanita but poor control of snowbrush. Growth of sierra plum appeared to be suppressed by 1966 in the unsprayed plots having dense stands of manzanita.

Pine Heights

The brush seedlings did not noticeably affect growth of the small pine seedlings during the first 2 years after planting on the cleanly bulldozed area. After the third season, however, vigor of the pines was obviously reduced by brush competition in the unsprayed plots. The pines were shorter, lighter in color, and generally less thrifty than pines in the plots with good brush control. The most conspicuous effect was the small diameter of terminal leaders on pines in unsprayed plots.

Reduced growth of pines in unsprayed plots became more apparent each year. When the brush cover was measured in 1966 the pines were greatly suppressed, and a few had died, in plots with the heaviest brush cover. As an average for the 100 pines in each group sample, the 1966 pine heights were about 35 inches for the six plot groups having less than 10,000 cubic feet of brush crown volume per acre *(fig. 1)*. But average pine height dropped off sharply for the plot groups having average crown volumes from about 15,000 to 40,000 cubic feet per acre.

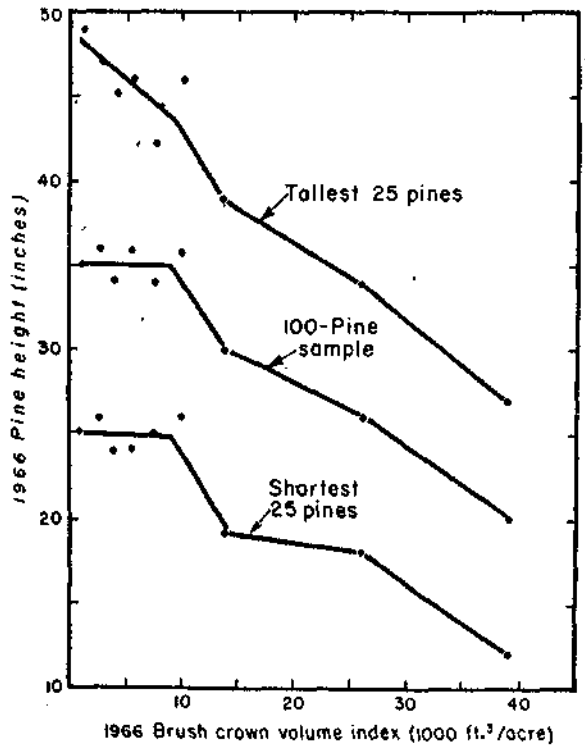

Figure 1–*Heights of pine seedling measured in 1966 were inversely related to crown volume of brush in the fifth growing season.*

Separate analyses were made for the five tallest trees in each plot sample in 1966, for the five shortest trees, and for the 10 intermediate trees. For each plot group, the samples included 25 tallest, 25 shortest, and 50 intermediate pines. Average heights of the intermediate pines were essentially the same as for the 100-pine samples. The shortest 25 pines and the entire group samples showed about the same relationship between pine height and brush crown volume in all the plots having brush volumes less than 10,000 cubic feet per acre. However, for the tallest 25 pines in each group the heights were greater on plots with brush crown volume less than 5,000 cubic feet than on plots with average crown volumes of 5,000 to 10,000 cubic feet *(fig. 1)*.

The data show clearly that brush control during the first 5 years promoted growth of ponderosa pine seedlings planted on a cleanly bulldozed area. The 100-pine samples did not indicate any benefit in pine growth from reducing the brush volume index below 10,000 cubic feet per acre at age 5 years. But heights of the tallest 25 percent of the pine stand suggested that more brush control during the first 5 years might promote early growth of pine seedlings.

In this study, the competitive effects of brush regrowth 5 years after bulldozing could be expressed as an index value obtained from measuring total brush crown volume per acre. However, total brush crown volume probably has limitations in comparing competitive effects of two brush covers made up of greatly different species. One reason is that the various brush species have crowns of different shapes and different foliage densities. Perhaps conversion factors can be used to make crown volumes of the various species more comparable for expressing their competitive potential. One possible approach is to develop factors related to crown leafage instead of total space occupied by the crown.

From other sampling studies at Mount Shasta we could approximate weights of leaves on four shrub species. Weights of total crown—leaves, twigs, and stems—in pounds dry weight per 1,000 cubic feet of crown had been determined as: greanleaf manzanita, 177.2; bush chinkapin, 143.5; snowbrush, 82.1; and bittercherry *(Prunus emarginata* [Dougl.] Walp.*)*, 37.7.[4] For each species the proportion of the crown weight made up by leaves had been determined for different sizes of plants. For plant sizes most common on the plantation in which pine heights had been measured, the relative leaf weights (pounds per 1,000 cubic feet of crown) were approximately as follow: manzanita, 88.6; chinkapin, 78.8; snowbrush, 34.5; and bittercherry, 13.2. By applying these values to the data in *table 1* we calculated the average pounds of dry leafage per acre for each of the plot groups. Sierra plum was assumed to have leaf weights comparable to bittercherry; "other species" were mainly chinkapin.

In graphic comparison of the data from crown volumes and from leaf weights, the scales were adjusted so that the two values for group 7 fell on the same point *(fig. 2)*. By this procedure, pine heights showed the same relationship to total brush crown volume as to total brush leaf weight for the plot groups having lightest brush cover. We would expect this consistent relationship because brush species composition of groups 1 to 7 was much the same, with snowbrush making up 63 to 90 percent of average crown volumes *(table 1)*. However, the relationship was different for groups 8 and 9 in which the brush cover was dominated by greenleaf manzanita.

In this study the competitive effects of brush could be illustrated by either total crown volume or by total leaf weight of brush because the brush covers were rather uniform through the density levels critical for growth of pines. But the data indicate that weighting of group averages according to species composition would have been needed if the brush covers had been highly variably over the full range of brush densities to be evaluated.

Comparison of 1966 and 1968 pine heights *(fig. 2)* shows that the 5-year levels of brush control had continuing marked effects on growth of pines during their seventh year. The 1968 heights indicate that the levels of brush control producing less than 5,000 cubic feet of brush per acre at age 5 years were beneficial for growth of young pines.

DISCUSSION

This study clearly showed the need for adequate followup brush control after the brushfield test site was bulldozed. For without such control, ponderosa pine seedlings were greatly stunted, and many died during their seventh year of growth The dead pines had been attacked by pine reproduction weevil *(Cylindrocopturus eatoni* Benth.*)*. One fourth of the pines measured in 1966 in plot groups 8 and 9 were dead in 1968. For these groups—which included eight unsprayed plots and two sprayed plots with poor brush control—the average 1968 heights in *figure 2* were based on the surviving pines. In group 7 only 3 of the 100 pines had died; and all pines had survived in the samples for groups 1-6.

In plot groups 1-6, the total brush regrowth by 1966 represented less than one-half ton dry weight of

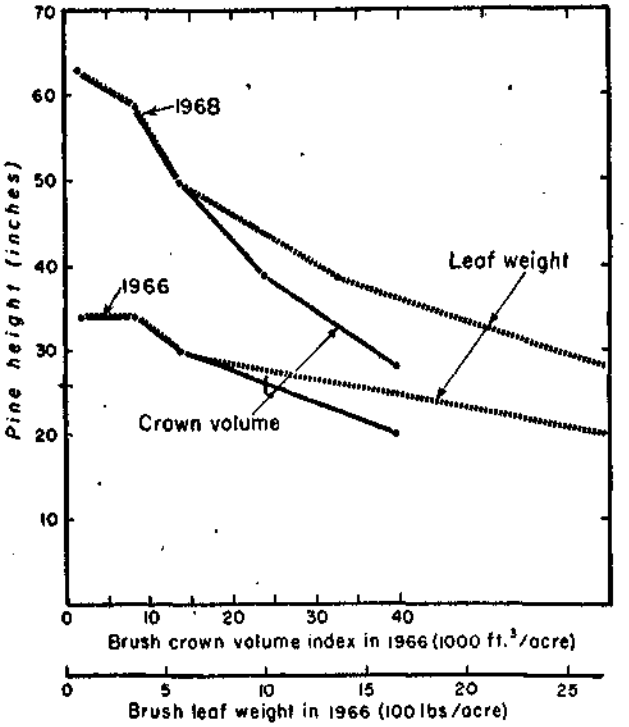

Figure 2–*Heights of pines in 1966 and 1968 were compared to brush crown volumes and to brush leaf weights in 1965–5 years after planting.*

woody material per acre. This limited amount of potential fuel mainly was in scattered large plants of snowbrush. But small brush plants were sufficiently numerous in most plots for future development of relatively continuous covers if all plants grow to their normal mature size. However, the brush may be retarded and finally choked out by the pines, which had increased 70 percent in height from 1966 to 1968. At present we can only guess at the final fuel situations in the plots having different levels of brush control in 1966. Studies are needed on different sites to tie down more closely the effects of early brush control on final development of woody fuels.

We estimate that in the plots with less than about 5,000 cubic feet of brush crown volume in 1966 the brush stand will remain fairly open and will for the next 25 years present minimum fire hazard. The potential fuel situation on plots having intermediate brush densities in 1966 is uncertain. For the unsprayed plots and other plots with continuous brush covers in 1966, a dense brush cover appears certain for the future if no additional brush control is attempted. By 1966, brush had produced less than 3 tons dry weight per acre. Potential production is estimated at nearly 20 tons dry weight of brush mixed with a thin stand of pines that may survive the early brush competition. Brush control obviously has a place in modifying the future fire hazards within these young ponderosa pine plantations.

NOTES

[1]Schubert, Gilbert H., and Ronald S. Adams. *Reforestation practices for conifers in California.* (in press)

[2]Buck, J. M. *Site preparation for forest regeneration in California.* Calif. Region, Forest Serv., San Francisco. 26 p., illus. 1959.

[3]Bentley, Jay R., and Kenneth M. Estes. *Use of herbicides on timber plantations.* Calif. Region, Forest Serv., San Francisco; and Pacific SW. Forest & Range Exp. Sta., Berkeley, Calif. 57 p. 1965.

[4]Bentley, Jay R., Donald W. Seegrist, and David A. Blakeman. *A technique for sampling low shrub vegetation by crown volume classes.* USDA Forest Serv. Res. Note PSW-215, Pacific SW. Forest & Range Exp. Sta., Berkeley, Calif. 4 p., illus. 1970.

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