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Thinning Stagnated Ponderosa and Jeffrey Pine Stands in Northeastern California: 30-Year Effects

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Response to precommercial thinning in stagnated 55-year-old ponderosa (*Pinus ponderosa* Dougl. ex Laws.) and Jeffrey pine (*P. jeffreyi* Grev. and Balf.) stands in northeastern California was rapid and long-lasting. During the first 5 years after thinning, average annual diameter at breast height (d.b.h.) and height growth of trees on the thinned plot was 167 percent and 62 percent greater, respectively, than that of crop trees on the unthinned plot. During the final 12-year measurement period, average annual d.b.h. and height growth of trees on the thinned plot was 43 percent and 38 percent greater, respectively, than that of crop trees on the unthinned plot. Over the 30-year measurement period, d.b.h. and height growth of trees on the thinned plot was 91 percent and 39 percent greater, respectively, than that of crop trees on the unthinned plot; the average live crown ratio of trees on the thinned plot was 31 percent greater than that of crop trees on the unthinned plot. Mortality among crop trees was low on both plots, with some indication that crop trees on the unthinned plot are slowly differentiating crown classes despite 85 years of stagnation. Although this study was limited to one treatment plot, the results indicate that stagnated, relatively old, sapling-sized stands can quickly respond to release by increasing height and diameter growth.

Retrieval Terms: thinning, release, stagnation, ponderosa pine, Jeffrey pine

The interior ponderosa pine forest type (SAF #237) covers roughly 3.5 million acres of the Modoc Plateau in northeastern California.[1] Tree growth is typically slow due to poor soils and low precipitation, with stands of ponderosa (*Pinus ponderosa* Dougl. ex Laws.) and Jeffrey pine (*P. jeffreyi* Grev. and Balf.) commonly stagnating in dense, patchy thickets of up to 17,000 trees per acre (TPA) (42,000 trees per hectare [TPH]). Despite slow tree growth, the economic value of the region as a source of forest products is expected to increase since much of the area will probably remain as a tree-growing, livestock- and wildlife-producing region with little loss of land to homesites and recreational development.

Previous studies have demonstrated the range of growth responses from pole-sized stands precommercially thinned to different densities,[2,3] but the effects of thinning older, sapling-sized, stagnated natural stands have not been previously investigated in northern California. The thinning response of such stands is of interest since precommercial thinning costs typically increase as average stand diameter increases. Furthermore, the response to releasing older, stagnated stands commonly found in the interior ponderosa pine forest type is important in defining the range of treatment opportunities available to forest managers.

This note reports the results of a small-scale experiment on the Blacks Mountain Experimental Forest to evaluate the growth response of stagnated, sapling-sized ponderosa and Jeffrey pine to precommercial thinning in northern California. At the time of initial thinning in 1957, the subject stands were 55 years old and averaged less than 2.0 inches (5.1 cm) in diameter at breast height (d.b.h.).

METHODS

Study Area

The Blacks Mountain Experimental Forest is located on the east slope of the southernmost tip of the Cascade Range in Lassen County, California. Annual precipitation averages 10 to 20 inches (25 to 51 cm), most of which falls as snow during the winter months. The soils of the study area are stony and shallow, with frequent rock outcrops.

Blacks Mountain is typical of the interior ponderosa pine forest type. Found at elevations of 4,500 to 7,000 feet (1,372 to 2,134 m) on California's northeastern plateau, the forest type is characterized by variable mixtures of ponderosa and Jeffrey pine, incense-cedar (*Calocedrus decurrens* (Torr.) Florin) and California white fir (*Abies concolor* (Gord. and Glend.) Lindl. ex Hildebr.).[4] Site index on the study area for ponderosa and Jeffrey pine is 72 feet (22 m) (base age 100 years).

Procedure

Study plots were established in 1957 as part of a larger study assessing the costs and production rates of precommercial thinning.[5] The area thinned in the original study covered 519 acres (210 ha). Because of funding limitations, only two plots were established to evaluate the effects of thinning on subsequent tree growth. As a result,

A

B

Figure 1—Plot before (a) and after (b) thinning, 1957.

Figure 2—Thinned plot, first remeasurement, 1962. The trees have grown 62 percent taller than crop trees on the unthinned plot.

Figure 3—Thinned plot, third remeasurement, 1987. The trees have grown 39 percent taller than crop trees on the unthinned plot.

caution should be exercised when interpreting the results of the study since the lack of replication precluded statistical analysis of the data.

The two plots were located in mixed ponderosa-Jeffrey pine sapling stands without overstory competition. One 0.04-acre plot (162 m^2) was chosen at random and precommercially thinned from 11,000 TPA (27,181 TPH) to a density of about 700 TPA (1730 TPH) (*fig. 1*). Crop trees were selected to maintain an average spacing of 7.9 feet (2.4 m) and were tagged to allow periodic remeasurement; all other trees were felled. On the unthinned plot (0.03 acre) (121 m^2) carrying 13,000 TPA (32,123 TPH), the equivalent of 700 TPA (1,730 TPH) were similarly tagged; the remaining trees were left uncut. Measured crop trees analyzed in this study were located within the boundaries of the stands to avoid any edge effects.

In July 1957, the d.b.h. and total height of tagged crop trees on the two plots were measured. To ensure that future remeasurements were consistently located, a nail was driven into the base of each tree, at a point one foot (0.3 m) above ground level, to serve as a permanent reference point. D.b.h. and height measurements were repeated in August 1962 (*fig. 2*), July 1975, and September 1987 (*fig. 3*). Height to the

base of the live crown was measured in 1987 to determine live crown ratio. The initial thinning response after 5 years was reported earlier.[6]

RESULTS

Diameter Growth

At the time of plot establishment in 1957, tagged crop trees on the thinned and unthinned plots averaged 2.1 inches d.b.h. (5.3 cm) *(table 1)*. During the 30 years following thinning, d.b.h. growth of trees on the thinned plot was 91 percent greater than that of crop trees on the unthinned plot *(fig. 4)*. Crop trees on the thinned and unthinned plots averaged 6.3 (16.0 cm) and 4.3 inches (10.9 cm) d.b.h., respectively, in 1987.

Average annual d.b.h. growth was greater on the thinned plot during each of the three subsequent measurement periods *(table 2)*. Limited sampling near the thinned plot showed a marked increase in radial growth the year following thinning, indicating an immediate response to release. Average annual d.b.h. growth of trees on the thinned plot has declined since the 1963-1975 measurement period (0.17 to 0.10 inch/year) (0.43 to 0.25 cm/year), but it was still 43 percent greater than that of the unthinned plot during the last 12-year measurement period. Crop trees on the unthinned plot had a relatively constant average annual d.b.h. growth of 0.06 to 0.08 inch per year (0.15 to 0.20 cm/yr) over the 30-year observation period.

Height Growth

The average height of tagged crop trees in 1957 was 8.0 feet (2.4 m) on both the thinned and unthinned plots *(table 1)*. On both plots, average annual height growth was variable over the 30 years following thinning, increasing from the first measurement period to the second, but then decreasing in the last period *(table 2)*. Despite this temporal variability, trees on the thinned plot consistently averaged 35 to 62 percent more in annual height growth than crop trees on the unthinned plot. Over the 30-year observation period, height growth of trees on the thinned plot was 39 percent greater than that of crop trees on the unthinned plot *(fig. 5)*. In 1987, tagged trees on the thinned and unthinned plots averaged 24.0 (7.3 m) and 19.5 feet (5.9 m) in height, respectively *(table 1)*.

Table 1—*Stand characteristics of Blacks Mountain experimental thinning plots, 1957-1987 measurements*

		Treatment[1]			
		Unthinned		Thinned	
Measurement	Year	Mean	N	Mean	N
		inches		*inches*	
D.b.h.[2]	1957	2.1 (0.21)	21	2.1 (0.42)	27
	1962	2.4 (0.22)	21	2.9 (0.37)	27
	1975	3.5 (0.26)	21	5.1 (0.31)	27
	1987	4.3 (0.29)	20	6.3 (0.31)	26
		feet		*feet*	
Height[3]	1957	8.0 (0.14)	21	8.0 (0.29)	27
	1962	9.3 (0.14)	21	10.1 (0.29)	27
	1975	15.7 (0.23)	21	18.7 (0.27)	27
	1987	19.5 (0.25)	20	24.0 (0.27)	26
		pct		*pct*	
Live crown ratio	1987	54	20	71	27

[1]Coefficient of variation shown in parentheses.
[2]Arithmetic mean.
[3]Measured from an established point one foot above ground level.

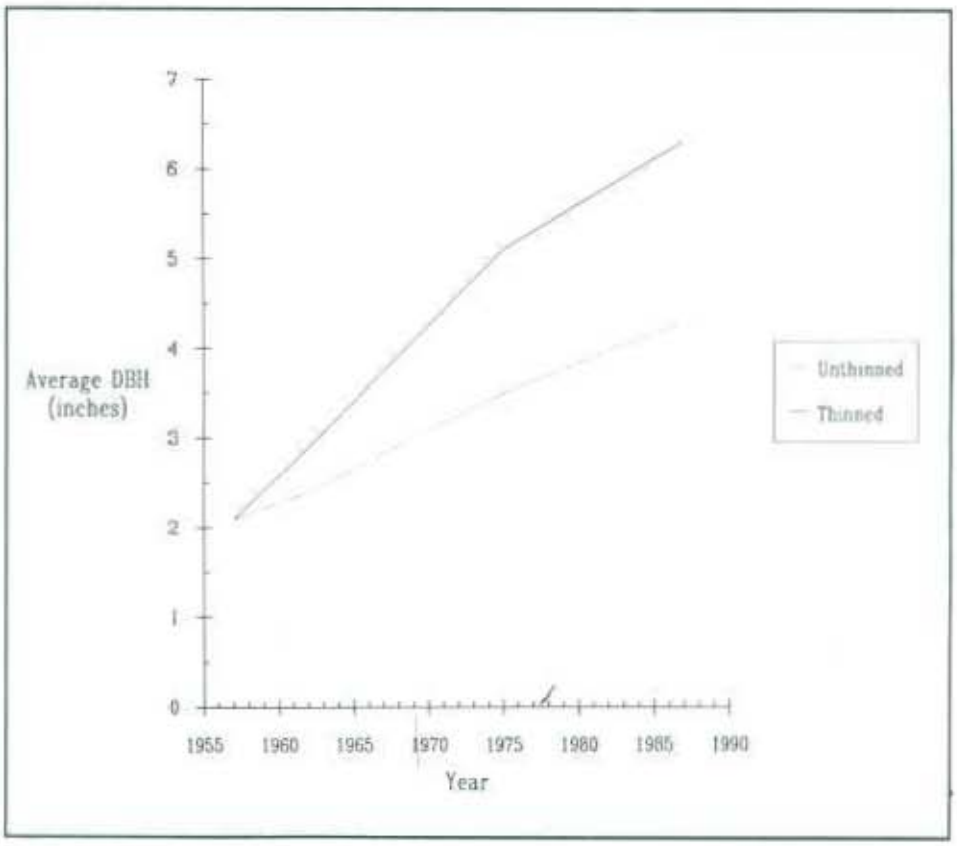

Figure 4—Average diameter at breast height of crop trees on thinned and unthinned plots.

Table 2—*Periodic height and diameter at breast height (d.b.h.) growth in experimental thinning plots at Blacks Mountain*

Growth period and measurement	Treatment		
	Unthinned	Thinned	Change
Average 30-year growth:	*inches*	*inches*	*pct*
D.b.h.[1]	2.2	4.2	91
	feet	*feet*	
Height	11.5	16.0	39
Average annual growth:	*inches*	*inches*	
D.b.h.[1]			
1958-1962	0.06	0.16	167
1963-1975	0.08	0.17	113
1976-1987	0.07	0.10	43
	feet	*feet*	
Height			
1958-1962	0.26	0.42	62
1963-1975	0.49	0.66	35
1976-1987	0.32	0.44	38

[1]Periodic d.b.h. growth is an arithmetic mean.

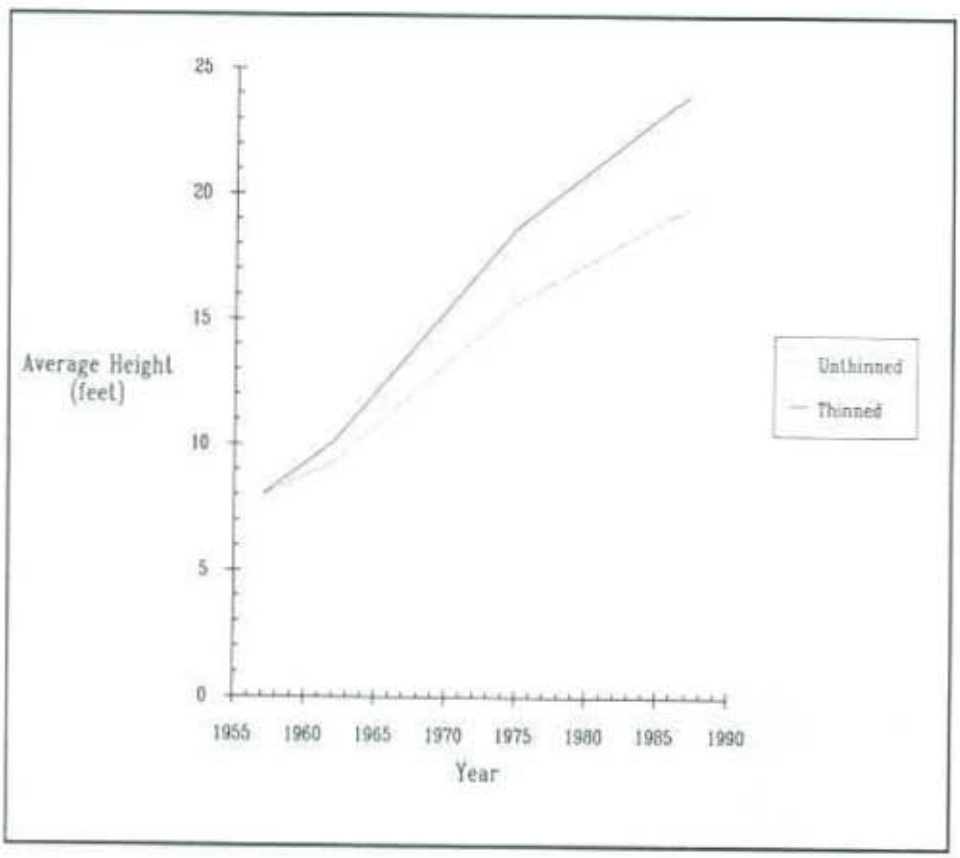

Figure 5—Average height of crop trees on thinned and unthinned plots.

Live Crown Ratio, Mortality and Stand Dynamics

Thirty years after thinning, the live crown ratios of tagged crop trees averaged 71 percent and 54 percent, respectively, on the thinned and unthinned plots. The average live crown ratio of crop trees on the unthinned plot is relatively high considering the age and density of the stand. The conditions under which these trees survive no doubt contribute to the tendency of stands to stagnate.

Mortality on the thinned plot has been light; only one tree died over the 30-year observation period. Despite the high initial density of the unthinned plot, mortality among crop trees was limited to only one tree; mortality among the untagged trees on the unthinned plot, while not measured, was considerably greater.

Consistent increases in successive estimates of the coefficient of variation (CV) of crop tree height and d.b.h. on the unthinned plot may indicate that the unthinned stand is slowly overcoming the extended period of stagnation *(table 1)*. In contrast, in the thinned plot, the CV of tree d.b.h. is decreasing and the CV of tree height has remained relatively constant. The unthinned stand will need to be monitored for a longer period of time, however, to determine whether changes in crop tree CV in tree height and d.b.h. signal the onset of increased tree mortality in the lesser crown classes and greater crown differentiation among tagged crop trees.

DISCUSSION AND CONCLUSIONS

Barrett[7,8] reported no significant response in height growth to thinning pole-sized ponderosa pine in the Pacific Northwest. Similarly, Schubert found no significant response in pole-sized ponderosa pine in northern Arizona.[9] Oliver first reported the ability of ponderosa pine to respond to thinning through increased height growth.[2] The 5- to 6-year lag time he observed between thinning and the onset of increased height growth was attributed to the belief that trees must first build up crown area in order to produce the additional food required for more rapid height growth.

This study, while limited to a single treatment plot, indicates that stagnated, relatively old, sapling-sized stands can quickly respond to release. During the first 5 years after thinning, average annual height

growth of trees on the thinned plot was 62 percent greater than that of tagged crop trees on the unthinned plot. During the same period, average annual d.b.h. growth of trees on the thinned plot was 167 percent greater than that of crop trees on the unthinned plot.

The effect of thinning was also found to be long-lasting. During the last measurement period (18 to 30 years after thinning), average annual d.b.h. and height growth of trees on the thinned plot was 43 percent and 38 percent greater, respectively, than that of the tagged trees on the unthinned plot. Growth rates on the thinned plot declined during the last measurement period, however, indicating crown closure and increased stand competition. On the unthinned plot, increased variability in tagged tree height and d.b.h. suggest that trees are slowly differentiating crown classes despite 85 years of stagnation.

END NOTES AND REFERENCES

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