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USDA Forest Service

Rocky Mountain Forest and  
Range Experiment Station

## Periodic Annual Increment in Basal Area and Diameter Growth in Partial Cut Stands of Ponderosa Pine

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Five-year basal area and diameter growth were measured on one set of stands partially cut to growing stock levels (GSL) 60, 80, 100, and an uncut control of GSL 150. Basal area growth in the partially cut GSLs 60, 80, and 100 was almost double that of the control. Mean diameter growth was inversely related to growing stock level, being greatest in the GSL 60 and least in the control.

**Keywords:** Ponderosa pine, basal area, growth

Management of ponderosa pine, *Pinus ponderosa* Lawson, stands for timber production depends on satisfactory knowledge of tree growth under various stand and site conditions. Substantial information is available on growth responses after thinning of densely stocked, even-aged, immature stands (Boldt and Van Deusen 1974). Thinning increased the average annual diameter growth rate on trees 2 to 6 inches in diameter but decreased the growth rate on trees 8 to 10 inches in diameter (Stuart and Roeser 1944). In Stuart and Roeser's stands, thinning stimulated diameter growth and the diameter growth rate doubled in thinned stands with diameters of 1 to 3 inches (Myers 1958). Basal area growth in thinned stands with average diameters of 4 to 5 inches exceeded that of comparable unthinned stands by more than 3 square feet per acre per year (Boldt 1970).

Considerably less published information is available on the growth responses of densely stocked, even-aged stands with average diameters of 8 to 10 inches. In the study of growing stock levels in the Black Hills, periodic annual basal area increments for 7 to 9 inch d.b.h. stands were 2.61, 2.26, 2.08, and 1.63 square feet per acre for growing stock levels 60, 80, 100, and 120, respectively, and periodic annual average diameter growths for the same stands were 0.17, 0.14, 0.13, and 0.10 inches, respectively (Oliver and Edminster 1988; C. B. Edminster 1990, unpublished data on file).

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Growth responses of stands of various growing stock levels (GSLs) will become more readily available in the future because partial cutting of stands with mean diameters of 8 to 10 inches is showing promise as a means of reducing tree mortality caused by the mountain pine beetle, *Dendroctonus ponderosae* Hopkins. As partial cutting becomes an integral part of beetle management, growth and yield models will have more data on which stand responses to various stocking levels can be based. This note reports on the basal area and diameter growth response of one set of GSL plots partially cut to GSLs of 60, 80, and 100 as compared to an uncut control.

### Methods

The GSL plots are located in the northern Black Hills of South Dakota about 9 miles southeast of Lead, SD. The Brownsville plots (so named because they are near a place called Brownsville) were installed in September 1985 and were cut in May 1986. They consist of three 2.5-acre plots partially cut to GSLs of 60, 80, and 100. A fourth uncut 2.5-acre plot with an original GSL of 146 served as a control. The three partially cut plots had GSLs between 130 and 135 before cutting.

During installation, the central one-half of each plot was inventoried. The diameter outside bark at breast height was measured for each tree to the nearest 0.1 inch. Each tree was tagged with a metal tag to facilitate future identification and measurement. After the plots

were inventoried, GSL, basal area per acre, and mean diameter were calculated. Mean diameter was computed as the diameter of average basal area.

The plots were reinventoried on September 12, 1990. The diameter of each live tree was measured and the trees classified as live or dead. From these measurements, GSL, basal area per acre, and mean diameter for live trees were calculated.

Basal area and mean diameter growth were determined by comparing the 1990 data to the 1985 data. Diameter growth by 1-inch diameter class was determined by comparing the mean diameter of trees in a specific class in 1985 to that of the same trees in 1990.

Because basal areas of the partially cut plots were slightly less than the basal area of the control and stand density influences tree growth, we took increment cores from trees in each of the four plots to determine their growth patterns over the last 15 years. One increment core was taken at breast height from six 11-inch and six 14-inch trees in each plot. Annual radial increment for each of the last 15 years was measured to the nearest 0.001 inch on each core. Mean annual radial increment was computed for years 1-5, 6-10, and 6-15 for each core. Years 1-5 represent the growth since the plots were cut, and years 6-10 and 6-15 represent tree growth 5 and 10 years prior to cutting. Mean annual radial increment for each diameter class in each of the four stocking levels for each time period were compared in a

one-way analysis of variance testing for significant variation among GSLs,  $\alpha = 0.05$ . Tukey's test was used to determine which means were different.

## Results and Discussion

Basal area growth in the three partially cut plots was almost double that of the uncut control (table 1). The greatest increase occurred in the GSL 60, followed by the GSLs 80 and 100.

Mean annual radial increment for 11-inch trees in the GSLs 60 and 80 for years 1-5 was significantly greater than for 11-inch trees in the GSL 100 and the control. Similarly, mean annual radial increment for 14-inch trees in all partially cut GSLs was significantly greater than for 14-inch trees in the control. For years 6-10 and 6-15, mean annual radial increment was not significantly different among the four GSLs. Thus, trees in all GSLs were growing at similar rates before the partial cutting and the growth rates increased significantly in all partially cut GSLs after cutting except for the 11-inch trees in the GSL 100.

Mean diameter growth increased similarly to basal area growth. Diameter growth in each of the three partially cut stands was at least triple that of the uncut control (table 1). Increases in mean diameter growth were inversely related to GSL.

Table 1.—Periodic annual increment (P.A.I.) in basal area and mean diameter by growing stock level.

GSL	Basal area (ft <sup>2</sup> /acre)			Mean diameter (inches)		
	1986	1990	P.A.I.	1986	1990	P.A.I.
60	60.5	66.8	1.26	12.4	13.1	0.14
80	80.8	86.9	1.22	11.5	12.0	.10
100	100.7	106.6	1.18	12.8	13.1	.06
Control	146.1	149.3	0.64	12.7	12.8	.02

Table 2.—Periodic annual increment in diameter (inches) by 1-inch diameter class by growing stock level. Numbers in parentheses represent the number of trees sampled per diameter class.

Diameter class	Growing stock level			
	60	80	100	control
4.6- 5.5				0.01 (1)
5.6- 6.5				-.01 (4)
6.6- 7.5				-.08 (1)
7.6- 8.5		0.11 (4)		-.01 (3)
8.6- 9.5	0.06 (1)	.11 (13)		.03 (3)
9.6-10.5	.14 (3)	.08 (24)	0.09 (6)	.04 (14)
10.6-11.5	.15 (15)	.09 (36)	.06 (24)	.05 (30)
11.6-12.5	.14 (33)	.09 (29)	.07 (39)	.06 (40)
12.6-13.5	.14 (24)	.11 (21)	.07 (34)	.05 (41)
13.6-14.5	.15 (11)	.10 (6)	.08 (23)	.06 (29)
14.6-15.5	.14 (2)	.10 (2)	.08 (11)	.07 (18)
15.6-16.5		.04 (1)	.08 (3)	.06 (14)
16.6-17.5		.12 (1)		.08 (1)
17.6-18.5				
18.6-19.5				-.06 (1)

Diameter growth by 1-inch diameter class was also inversely related to GSL; i.e., within a specific diameter class, the greatest growth was observed in the lowest GSL and the least growth was in the uncut control (table 2). Within each GSL, diameter growth was fairly uniform across all diameter classes except in the control (table 2). In the control, negative and insignificant changes reflect errors in measurement as well as the effects of competition among the trees in the dense stand. The nonuniform growth rates within GSLs 60 and 80 reflect a single sample for that specific class.

The basal area and mean diameter growth for the GSLs 60, 80, and 100 are both less than the average for comparable stands in the study of growing stock levels in the Black Hills (Edminster, unpublished data). We believe the lower growth rates in our stands were caused by below average precipitation mainly during 3 years of the 5-year growth period but also during the 2 years of above average precipitation, when precipitation was deficient by 15% or more during the critical months of May to August. When precipitation meets or exceeds the average values for the critical growth months, we would expect growth rates to be substantially greater.

In addition, the stands in the levels of growing stock study in the Black Hills Experimental Forest had been thinned twice in its 25-year history, and trees in the plots have had time to adjust to available growing space. Because the stands in this study were cut just 5 years prior to remeasurement, some of the growth during the 5-year period may have been directed toward occupying available growing space. Growth rates may increase for these

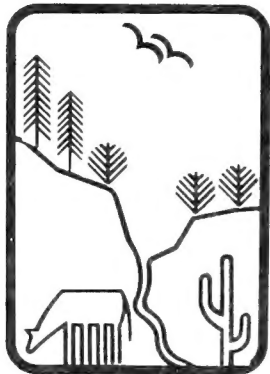
plots in subsequent measurement periods so the reader is cautioned not to draw long-term conclusions from this study.

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## Rocky Mountain Forest and Range Experiment Station

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