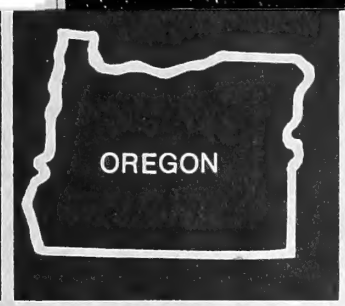

PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION

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RESPONSE OF PONDEROSA PINE 8 YEARS AFTER FERTILIZATION

by

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Abstract

Diameter and volume growth of individual ponderosa pine trees in thinned stands continues to respond to fertilizer 8 years after application in three of four study areas. Height growth is not responding to fertilization. Removal of bitterbrush in one study area decreased volume growth in the seventh and eighth growing seasons. Apparently brush removal stimulated fescue growth, increasing water and nutrient competition.

KEYWORDS: Fertilizer response (forest tree), fertilization (forest), increment (volume), volume increment, increment (diameter), diameter increment, thinning (tree), ponderosa pine, *Pinus ponderosa*, bitterbrush, brush control, growing season.

Metric Conversion Factors

1 pound/acre	= 1.121 kilograms/hectare
1 acre	= 0.405 hectare
1 foot	= 0.3048 meter
1 inch	= 2.54 centimeters
1 square foot	= 0.092903 square meter
1 cubic foot	= 0.028317 cubic meter
1 mile	= 1.61 kilometers

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Introduction

Response of individual ponderosa pine (*Pinus ponderosa*) trees to fertilization during the first four growing seasons after application was reported in an earlier note (Cochran 1973). As then outlined, 1/10-acre areas around dominant or codominant sample trees in thinned stands were fertilized. These stands are located in Sumpter Valley near Baker in northeastern Oregon and in central Oregon on the Fort Rock Ranger District, the Pringle Falls Experimental Forest, and 5 miles west of the Experimental Forest along Road 1808. The three central Oregon locations were chosen to represent areas differing in effective moisture. The Fort Rock and Road 1808 locations were thought to be the driest and wettest respectively.

In three of these four areas, 24 sample trees were selected so treatments could be replicated eight times. Treatments equivalent to 0, 200, and 400 pounds of nitrogen (N) per acre in the form of urea were used in Sumpter Valley. In addition to the control, the two levels of fertilizer application per acre in central Oregon were: (1) 200 lbs N, 100 lbs phosphorus (P), 30 lbs sulfur (S) and 1.88 lbs boron (B) and; (2) 400 lbs N, 200 lbs P, 60 lbs S, and 3.75 lbs B.

In the Fort Rock area 48 sample trees were selected so a shrub vegetation removal treatment for the 1/10-acre area could be superimposed on the fertilizer treatments used in the other two central Oregon areas. The experimental design is a randomized complete block. In the Sumpter Valley area blocks were chosen so that trees in each block were on the same slope and aspect and were the same distance from an abandoned irrigation canal. Blocks in the central Oregon areas were assigned on the basis of similar tree diameters. Some test tree and stand parameters established at the beginning of the study of the four areas are present in table 1.

During the first 4 years after application, fertilization increased height growth significantly at the Sumpter Valley and Road 1808 locations;

Table 1--*Some test tree and stand parameters at the beginning of the study*

Location	Mean starting values				Stand spacing	Stand age
	Diameter[1/]	Height	Basal area	Volume		
	Inches	Feet	Feet^2	Feet^3	Feet	Years
Sumpter Valley	10.0	51	0.556	9.66	15 x 15	64
Pringle Falls	10.2	52	.591	11.02	14 x 14	78
Road 1808	14.6	65	1.258	31.43	12 x 12	68
Fort Rock	12.2	47	.836	13.25	variable[2/]	variable[3/]

[1/] This diameter is the actual mean diameter of the test tree and not the diameter equivalent to the average basal area.

[2/] 10 x 10 feet to very open.

[3/] Stand consists of residual trees left after railroad logging in the 1920's and reproduction immediately after.

but there was no significant difference between the two levels of fertilization. The effect of fertilization on height growth tended toward significance in the other two areas, and results may have been confounded with top damage. Tree diameter and basal area growth were increased by fertilization in all the areas, but there was no difference among levels of application. Volume growth was also increased significantly by fertilization except in the Fort Rock area where the effect of fertilization was almost, but not quite, significant at the 5-percent level. This study was continued beyond the first 4-year period after fertilization to obtain more information about duration of response.

Current Methods of Study

Fire destroyed the Silviculture Laboratory and the records for this study 2 years after measurements were taken for the previous report (Cochran 1973). Fortunately, a copy of the study plan and increment core measurements taken at the end of the first 4-year period were available from Pacific Northwest Forest and Range Experiment Station headquarters. Original diameters and heights and those for the end of the 4-year period were lost. Records of increment borings for each tree from all study areas, showing the diameter growth 4 years previous to treatment and 4 years after treatment, were retrieved. Trees were measured with optical dendrometers following the sixth and eighth growing seasons after treatment. Increment borings were again made on two opposite sides of every tree to determine diameter growth during the 4-year period previous to treatment and the first and second 4-year periods after treatment. The increment measurements were then compared with those previously taken and used to identify the treatments given each tree.

Because diameter growth was significantly increased by fertilization during the 4 years after initiation of the study, identification of the control trees for each replication in each area was certain. Separation of the test trees for the two levels of fertilization was questionable for some of the replications. Therefore, analyses of possible differences in responses between levels of fertilization were not attempted. Identification of the shrub removal treatments in the Fort Rock stand was certain because the outline of the 1/10-acre area was clearly visible and no shrubs had reinvaded the areas.

Height and volume growth for the seventh and eighth growing seasons after treatment were obtained from dendrometer readings subjected to the STX program (Grosenbaugh 1964). This program incorporated a modification of Brickell's equation (Brickell 1970) for diameter outside bark to diameter inside bark conversion developed by Cochran (1976). Diameter growth was determined from the increment borings.

Diameter and volume growth were subjected to analysis of covariance using diameter growth for 4 years previous to treatment as the covariate. Height growth was subjected to a standard analysis of variance.

Results and Discussion

Height growth during the seventh and eighth growing seasons after initiation of the study was not increased significantly (at the 5-percent

level of probability) by fertilization or shrub removal (table 2). A significant increase in height growth at the Pringle Falls location would have occurred if the probability level was increased to 8 percent.

Table 2--*Average annual height growth for the seventh and eighth growing seasons*

Location	Treatments		F values[1/]
	Control	Fertilized	Control vs. fertilized
	- - - - Feet - - - -		
Sumpter Valley	0.7	0.9	1.1575
Pringle Falls	.6	.85	3.8039
Road 1808	.7	.6	.2588
Fort Rock	.6	.6	.0040
	Shrubs present	Shrubs removed	Shrubs present vs. Shrubs removed
Fort Rock	.65	.6	.1121

[1/] F values have 1 and 14 degrees of freedom except for the Fort Rock location where both F values have 1 and 35 degrees of freedom.

Diameter growth during the second 4 years after treatment was significantly increased by fertilization except in the Road 1808 stand (table 3). The increase in diameter growth due to fertilization would have been significant at the Road 1808 location if the probability level was raised to 11 percent. Shrub removal did not significantly influence diameter growth in the Fort Rock area.

Volume growth during the seventh and eighth growing seasons after treatment was increased significantly (at the 5-percent level of probability) by fertilization except in the Road 1808 area (table 4). Even though in the Road 1808 area large differences in adjusted means for volume growth occurred, the probability level would have had to be 13 percent to be significant. This is due to large variation among replicates within treatments. The dense Road 1808 stand has more volume on each 1/10 acre and some of the test trees are codominants with other trees on the 1/10 acre. The competition of the other trees with the test tree for nutrients and water may be greater and more variable than in the other study areas.

Removal of shrubs (all shrubs were bitterbrush (*Purshia tridentata*)) on the Fort Rock area significantly decreased volume growth during the seventh and eighth growing seasons, but no significant interactions of shrub removal and fertilization occurred. A decrease in volume growth due to shrub removal is difficult to explain and seems contrary to other published work. Barrett (1970) found that removal of all understory vegetation (shrubs plus grasses and sedge) increased growth of thinned pine in a study on the Pringle Falls

Table 3--*Average annual diameter growth for the fifth, sixth, seventh, and eighth growing seasons after treatment. Values calculated using adjusted means obtained from covariant analysis*

Location	Treatments		F values[1]
	Control	Fertilized	Control vs. fertilized
	- - - Inches - - -		
Sumpter Valley	0.16	0.20	10.6619[2]
Pringle Falls	.16	.23	18.6377[2]
Road 1808	.16	.19	3.0100
Fort Rock	.13	.18	33.0581[2]
	Shrubs present	Shrubs removed	Shrubs present vs. Shrubs removed
Fort Rock	.17	.16	.0058

[1] F values have 1 and 13 degrees of freedom except for the Fort Rock location where both F values have 1 and 34 degrees of freedom.

[2] Indicates significance at the 5-percent level of probability.

Table 4--*Average annual volume growth for the seventh and eighth growing seasons after treatment. Values calculated using adjusted means obtained from covariant analysis*

Location	Treatments		F values[1]
	Control	Fertilized	Control vs. fertilized
	- - - Feet^3 - - -		
Sumpter Valley	0.47	0.83	9.5161[2]
Pringle Falls	1.22	2.00	5.3055[2]
Road 1808	1.33	2.19	2.7515
Fort Rock	1.02	1.43	4.5419[2]
	Shrubs present	Shrubs removed	Shrubs present vs. Shrubs removed
Fort Rock	1.50	1.09	5.8442[2]

[1] F values have 1 and 13 degrees of freedom except for the Fort Rock location where both F values have 1 and 34 degrees of freedom.

[2] Indicates significance at the 5-percent level of probability.

Experimental Forest. Gordon (1962) found that understory vegetation adversely affected growth of ponderosa and Jeffrey pine poles. He further concluded that perennial grass had a greater effect than broad leaved plants. Although production was not measured in the Fort Rock area, it appears that removal of the bitterbrush stimulated the grass production, particularly fescue (*Festuca idahoensis*). An increase in the overall competitive affect may have occurred.

Summary and Conclusions

Diameter growth as well as the volume growth of trees in thinned stands are still responding to fertilization 8 years after treatment in three of four study areas. Height growth is no longer responding to fertilization in the Sumpter Valley and Road 1808 areas where significant differences occurred during the first 4 years after treatment.

Shrub removal alone in the presence of fescue did not reduce competition to overstory but produced a situation where fescue apparently was competitive to tree growth.

This study shows that foresters can expect significant responses, visibly noticeable on increment cores, to fertilization in thinned stands of pines which will last at least 4 to 8 years.

Further work is underway to correlate response with kinds and amounts of fertilizer and various kinds of soils in different plant communities. Other work in preparation for publication suggests that P, S, and B in combination with N do not stimulate volume growth in the field. For land managers wishing to fertilize thinned ponderosa pine stands now, the tentative recommendation of 200 pounds of elemental nitrogen per acre in the form of urea is offered.

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