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UREA FERTILIZER INCREASES GROWTH OF 20-YEAR-OLD, THINNED DOUGLAS-FIR ON A POOR QUALITY SITE

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ABSTRACT

In 20-year-old, site V Douglas-fir in southwest Washington, fertilizing with nitrogen increased average 5-year diameter and height growth of concurrently released dominant trees by about 85 percent. There was no additional response when phosphorus, potassium, and sulfur were added with the nitrogen fertilizer. Thinning with no other treatment in this moderately stocked plantation did not increase 5-year diameter growth, and it reduced height growth by about 25 percent. Although this reduced height growth will probably be offset by increased growth in the future, managers of nitrogen deficient sites should consider fertilizing shortly before or after thinning to accelerate response to release.

KEYWORDS: Fertilizer response (forest tree), increment (height), increment (diameter), nitrogen fertilizer response, urea, site class, thinning (tree).

In spring 1970, we fertilized individual, dominant Douglas-fir trees in a recently thinned stand on the Wind River Experimental Forest in southwest Washington. We report the 5-year results from this simple field trial to inform local land managers and to augment information collected from more comprehensive trials on other soils and for other stand conditions.

METHODS

The site V stand is located on Soil 44, a moderately deep, sandy loam derived from ash and pumice.[1] Slope gradient is about 10 percent, aspect easterly; elevation is about 2,100 feet.[2] The stand was planted in spring 1952, at approximately 8- by 8-foot spacing, following clear-cutting of old growth. Supplemented with natural fill-in, the plantation subsequently developed a clumpy distribution of groups of trees intermingled with openings where trees had not survived. After the 1969 growing season, when the planted trees were 20 years old from seed, the stand contained about 500 trees per acre, with trees averaging about 2.9 inches in d.b.h. and 20 feet in height.

Prior to precommercial thinning in March 1970, we installed two adjacent 1/5-acre plots (fig. 1). One plot plus a 27-foot-wide buffer

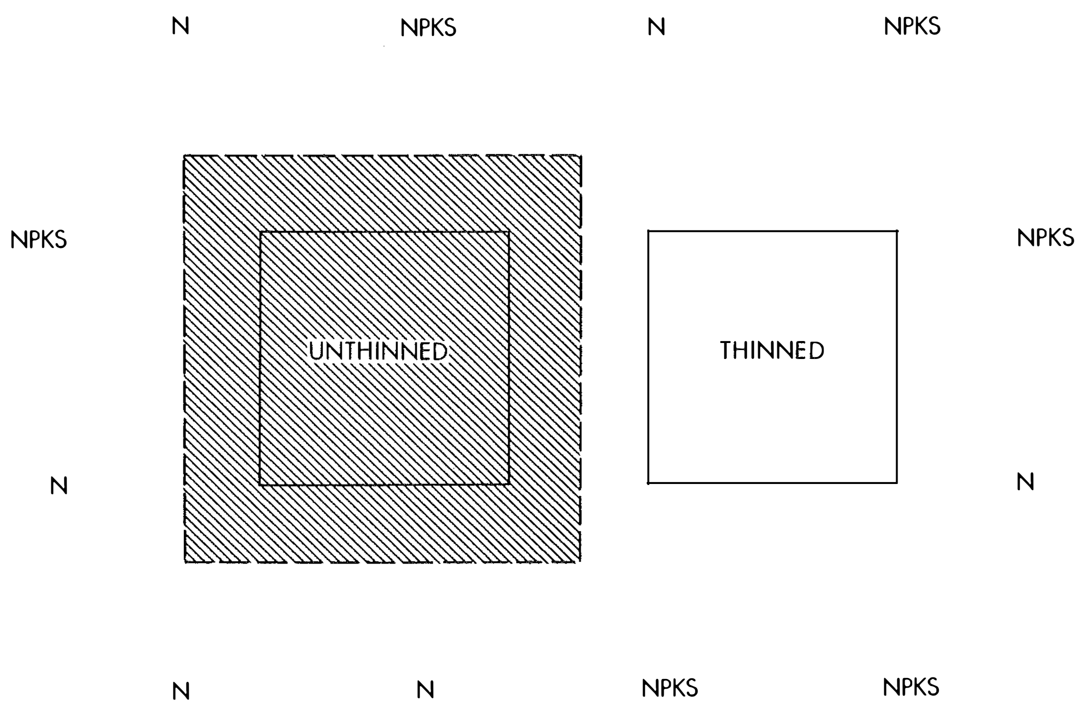

Figure 1.--Layout of study area.

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[1] U.S. Forest Service, Gifford Pinchot National Forest. [n.d.]. Soil resources atlas of maps and interpretive tables. 31 p., illus. Vancouver, Wash.

[2] Metric conversions: inches X 2.54 = centimeters; feet X 0.304 = meters; square feet X 0.093 = square meters; acres X 0.405 = hectares; pounds per acre X 1.12 = kilograms per hectare.

was left unthinned. Thinning of the other plot and surrounding portion of the stand removed 34 percent of the trees (155 trees per acre) and 20 percent of the basal area (table 1). Trees had not yet attained a large enough size to be strongly competitive, so the thinning was not expected to have much immediate effect on growth.

Table 1--*Stand characteristics of 20-year-old trees on two 1/5-acre plots, Wind River Experimental Forest, Washington*

(Per-acre basis)

D.b.h. class	Unthinned plot[1]	Thinned plot[2]		
		Before thinning	Cut	After thinning
Inches	Number of trees			
1	65	25	15	10
2	185	150	95	55
3	195	195	45	150
4	110	70	0	70
5	5	10	0	10
6	5	0	0	0
Total	565	450	155	295
Basal area, square feet	25.2	20.4	4.4	16.1
Average d.b.h., inches	2.9	2.9	2.3	3.2

[1] Site index (100-year base), 80.

[2] Site index (100-year base), 77.

For assessing response to fertilization, we selected 12 dominant trees within the thinned portion of the stand immediately surrounding the plots (fig. 2). After random assignment of treatment, six of these

Figure 2.--A fertilized sample tree in the pre-commercially thinned plantation.

trees were fertilized in April 1970 with 300 pounds of elemental nitrogen (N) per acre as urea; the other six were fertilized with the same fertilizer and dosage, but with additional fertilizers to provide phosphorus (P), potassium (K), and sulfur (S) (table 2). Fertilizer was spread on a 1/40-acre area (18.6-foot radius) around each tree to insure fertilization of competing trees.

Table 2--*Fertilization treatments of 12 trees in a thinned portion of a stand, Wind River Experimental Forest, Washington*

Treatment	Elemental				Source	Analysis
	N	P	K	S		
	--Pounds per acre[1/]--					
Thinning plus N (6 trees)	300	0	0	0	Urea	46-0-0-0
Thinning plus N, P, K, and S (6 trees)	300	0	0	0	Urea	46-0-0-0
	0	42	0	50	Golden treble superphosphate	0-38-0-20
	0	108	0	0	Treble superphosphate	0-45-0-0
	0	0	100	0	Potassium chloride	0-0-60-0

1/ Pounds per acre X 1.12 = kilograms per hectare.

Our fertilizer treatments were based on prior chemical analysis of current foliage composited from four dominant trees on each plot. In October 1969, the nitrogen content of 1969 foliage averaged 0.91 percent for the plot selected for thinning and 1.03 percent for the one to be left unthinned; this strongly suggested nitrogen deficiency. Chemical analyses also suggested deficiencies of P and K.

Five years after treatment, we compared height and diameter growth of the 12 fertilized trees (6 per treatment) with growth of 6 trees each on the unfertilized thinned and unthinned plots. These plot trees were matched by d.b.h. to the fertilized trees, but not by other tree characteristics in the field.[3/]

3/ Although the unfertilized trees were grouped and thus not located on a completely random basis, data were analyzed as a completely random design. Treatment means were adjusted by covariance for initial differences in tree size and then tested in three orthogonal comparisons to contrast the average growth of untreated vs. treated, thinning vs. thinning and fertilizing, and fertilizing with N vs. N, P, K, and S. A 5-percent probability of a Type I error ($P<0.05$) was accepted as statistically significant.

RESULTS AND DISCUSSION

Crown and Needle Changes

Color and length of needles improved markedly in fertilized trees in the first growing season. Although we did not repeat our foliar analysis to measure changes in chemical content of foliage, we observed that darker green foliage and longer lateral branch growth persisted for at least three growing seasons.

Diameter Growth

During the 5 years after treatment, average diameter growth of fertilized (and thinned) trees was about 85 percent greater than that of their thinned-only counterparts (table 3). Average diameter growth did not differ significantly between trees receiving the N or the NPKS

Table 3--*Average diameter and annual growth of sample trees by treatment, Wind River Experimental Forest, Washington*

Treatment[2/]	Quadratic mean d.b.h.		Average annual growth[1/]	
	1969	1974	Absolute	Relative to thinned only
	Inches			Percent
Untreated	3.9	5.1	0.23	104
Thinning	3.6	4.7	.22	100
Thinning plus N	4.1	6.2	.42	191
Thinning plus N, P, K, and S	3.7	5.7	.40	182

1/ Treatment means adjusted by covariance to a common, pretreatment d.b.h.

2/ See table 2 for amounts of fertilizer and source.

treatment. Among the unfertilized trees (untreated or thinned-only), diameter growth was significantly correlated with initial d.b.h.; larger trees grew more than smaller trees. A lack of correlation among the fertilized trees (r=0.02 and 0.04) apparently resulted from more variable diameter growth among fertilized trees and from smaller trees growing about the same as larger trees.

Thinning evidently did not improve diameter growth during the first 5 years after thinning. Growth of thinned trees was similar to growth of untreated trees (table 3); moreover, relative radial growth for the 5-year period before and after thinning did not differ in a subsample of increment cores from both plots. We assume that this lack of initial response is explained by the relatively low intensity of competition before thinning. Despite limited thinning and release, however, "thinning shock" may have contributed to lack of response.

Height Growth

Fertilized-and-thinned dominant trees averaged about twice as much height growth as thinned-only dominants during the 5 years after treatment (table 4). Average height growth did not differ significantly

Table 4--*Average height and annual growth of sample trees by treatment, Wind River Experimental Forest, Washington*

Treatment	Mean height		Average annual growth[1/]	
	1969	1974	Absolute	Relative to thinned only
	- - - - - Feet	- - - - -		Percent
Untreated	24.0	31.6	1.51	157
Thinning	21.1	25.9	.96	100
Thinning plus N	23.9	34.6	2.13	222
Thinning plus N, P, K, and S	20.5	31.0	2.11	220

[1/] Treatment means adjusted by covariance to a common, pretreatment height.

between dominants receiving the N or the NPKS treatment. Height growth was not correlated with initial height among the untreated, thinned-only, and thinned plus NPKS trees. In contrast, height growth of trees fertilized with N was correlated with initial height ($P<0.001$); shorter trees apparently responded more to this fertilization than did taller trees. The absence of a corresponding statistically significant correlation among trees additionally fertilized with PKS was due to greater variation in height growth among these trees than among those fertilized with N alone. Depressed height growth on two trees with unusually heavy cone crops contributed strongly to this variation. These two trees had the least height growth of the six-tree sample and produced about 20 and 40 cones in 1971 (year 2) and 0 and 50 cones in 1974 (year 5) compared with 0 to 3 cones in the remaining trees in the same years.

At other locations, nitrogen fertilizer improved height growth of site IV and V Douglas-fir in the sapling-to-small-pole stage on soils developing from glacial materials of the Puget Sound lowlands (Gessel and Walker 1956, Crossin et al. 1966) and on soils developing from pyroclastics within a few miles of this study area (Miller and Pienaar 1973). In the latter area, the 7-year improvement in height growth with 280 pounds of N per acre as ammonium nitrate averaged 76 percent for all crown classes in an unthinned plantation.

During the 5 years after thinning, height growth of the six-tree sample in the thinned plot averaged 36 percent less than that of its counterpart in the unthinned plot (table 4). We were concerned about the representativeness of this sample, because it included several trees with unusually small, prethinning height growth. Thus, our small sample could have overestimated the actual reduction caused by thinning. Our concern was substantiated by comparisons of all trees measured for height in the two plots (15 trees per plot), which used either initial height or 3-year pretreatment height growth as a covariate. Both analyses indicated that thinning significantly reduced height growth by about 25 percent instead of 36 percent. If this lesser reduction in height growth after thinning is assumed, fertilizing the thinned stand increased height growth by about 84 percent rather than 120 percent.

Others have also reported reductions in Douglas-fir height growth in initial years after precommercial thinning on poor sites (Staebler 1956, Williamson 1976). In the latter report, height growth of dominant trees released by thinning was less than that of their counterparts in an unthinned portion of the stand; however, this was reversed in years 3 through 6. As reported by Staebler (1956), thinning a 25-year-old plantation to densities ranging from 50 to 350 trees per acre reduced growth about 50 percent during the first 2 years. Height growth of released trees began exceeding control growth about 10 years after thinning.[4/] Thus, previously reported reductions in height growth after precommercial thinning have been of short duration and have been compensated for by subsequent improvement in height growth.

CONCLUSIONS

1. Fertilizing a concurrently thinned, site V stand clearly improved diameter and height growth of dominant trees. Compared with thinned-only trees, thinned-and-fertilized trees grew about 85 percent more in diameter and height.

2. There was no additional response when P, K, and S were added with the nitrogen fertilizer.

3. During the 5-year period after thinning with no other treatment, diameter growth in this moderately stocked plantation did not increase and height growth was reduced by about 25 percent. Although this reduction will probably be offset by increased growth in the future, managers of nitrogen-deficient sites should consider fertilizing shortly before or after thinning to accelerate response to release.

4. This field trial strongly suggests that similar stands on Soil 44 and related soils of the Gifford Pinchot National Forest are likely candidates for operational fertilization with nitrogen. Based on this and other field trials, our recommendation is 200 pounds of nitrogen per acre as either urea or ammonium nitrate.

4/ Unpublished data on file at the Forestry Sciences Laboratory, Olympia, Washington.

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