

**Two-Year Basal Area Response to Multi-Nutrient Re-fertilization for
Douglas-fir in South-Central Washington (Klickitat)**

Preliminary Results

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SUMMARY

Six fertilization study sites located in the Klickitat region of south-central Washington were established and fertilized in 1990 and then re-fertilized in 1998. Six-year plot response by treatment from the initial fertilization was analyzed and presented in 1997. Two-year re-fertilization plot response by treatment is presented here in short summary form with a final report to follow after further analysis. A brief introduction with site characteristics (Table 1), treatments (Table 2) plot response by treatment tables (Tables 3-6) and vector analysis interpretation and diagnosis (Figures 1) follow this summary.

Two-years after re-fertilization the average gross basal area response overall sites combined was -3.7%, -3.7% and 0.1% for N, N+S and N+S+Micro applications, respectively (Table 3). In comparison, overall six-year volume response reported by Garrison (1997) was positive but was also poor with 10.3% and 8.4% response on the N and N+K applications, respectively (Table 4). Comparison of geologic parent materials underlying the sites showed that four installations occur on Wanapum basalt, one on Grande Ronde basalt and one on landslide olivine basalt. The Wanapum basalt and olivine basalt responded poorly but the single installation which occurred on a Grande Ronde basalt responded very well, with 30.7%, 36.0% and a significant ($p \leq 0.10$) 61.3% for N, N+S and N+S+Micro applications, respectively (Table 5). Similarly, six-year volume response also showed this pattern with sites on Wanapum and olivine basalt responding poorly (data not shown, Garrison et al, 1997) while Grande Ronde basalt response was good with 35.7% and 30% for the N and N+K applications (Table 6). It appears that all the significant ($p \leq 0.10$) positive re-fertilization effect was due to the growth response of the Grande Ronde basalt. Notably, the addition of micro nutrients in the 1998 re-fertilization increased response over the N+S treatment by 25.3%. Notably, other IFTNC sites located on Grande Ronde and Wanapum parent materials show similar response trends. Grande Ronde sites almost always respond well to fertilization while Wanapum sites almost always respond poorly to fertilization.

Vector analysis of foliar response (Shaw and Moore, 1999) also diagnosed Grande Ronde basalt as the best responder to fertilization (Figure 1). Furthermore, vector analysis diagnosed good foliar response for Wanapum and olivine basalts, however, this good foliar response did not translate into good two-year basal area growth response for these two rock types. Perhaps nutrients other than those that were applied in the fertilizer mix were deficient and in-turn reduced response on the Wanapum and olivine basalts. For

example, vector analysis identified possible Ca deficiencies for olivine basalt and P deficiencies for Wanapum basalt (Figure 1). Further testing needs to be done to determine the validity of Ca and P deficiencies or other possible growth reducing site factors.

Many “site induced” confounding factors have complicated the results given in this report. In response, additional analysis is now being performed and will be presented in a final report.

INTRODUCTION

This study is located in the Klickitat region of south-central Washington on the east slopes of the Cascade Mountains. The study sites were installed in cooperation with the Intermountain Forest Tree Nutrition Cooperative. Installation names, vegetation series, parent material types and ownerships are shown in Table 1. The study sites were initially installed and fertilized in the fall of 1990 and then re-fertilized in 1998. Nutrient treatment rates for the establishment fertilization and the re-fertilization are given in Table 2.

Table 1. Ownership and site characteristics for six Douglas-fir Klickitat study sites installed in 1990 and re-fertilized in 1998 in south-central Washington.

Ins	Name	Ownership	Veg.Series	Basalt type
307	Franz Creek	Champion Timberlands	Grand fir	Wanapum
308	Harmon Springs	Champion Timberlands	Grand fir	Wanapum
309	B.Z. Corner	Washington DNR	Grand fir	Grand Ronde
310	Trout Lake	Washington DNR	W. Red Cedar	Landslide dep., olivine basalt
311	Snowden	Longview Fibre	Grand fir	Wanapum
312	Appleton	Longview Fibre	Grand fir	Wanapum

Table 2. Nutrient element rates for 1990 establishment and 1998 re-fertilization Douglas-fir sites in the Klickitat area of south-central Washington.

Nutrient	1990 Rate (lbs/ac)	1998 Rate (lbs/ac)
Nitrogen	200	300
Potassium	170	0
Sulfur	0	100
Boron	0	5
Copper	0	10

Table 3. Overall two-year absolute gross basal area response for 1998 re-fertilization Douglas-fir sites in the Klickitat area of south-central Washington.

Treatment	Growth (ft ³ /ac)	Contrast	Response		
			(ft ³ /ac)	p	%
Control	10.9				
N	10.5	N - Control	-0.4	(0.64)	-3.7
N+S	10.5	N+S - Control	-0.4	(0.56)	-3.7
N+S+Micro	11.0	N+S+Micro - Control	0.1	(0.95)	0.1

Table 4. Overall six-year absolute gross volume growth and response for 1990 initial establishment Douglas-fir sites in the Klickitat area of south-central Washington.

Treatment	Growth (ft ³ /ac)	Contrast	Response		
			(ft ³ /ac)	p	%
Control	1788				
2N	1973	2N - Control	185	(.02)	10.3
2N+2K	1938	2N+2K - Control	150	(.06)	8.4

Table 5. Absolute gross basal area growth and response for 1998 re-fertilization Douglas-fir sites in the Klickitat area of south-central Washington, grouped by parent material type.

Treatment	Growth (ft ³ /ac)	Contrast	Response		
			(ft ³ /ac)	p	%
<i>Wanapum basalt</i>					
Control	11.0				
N	10.0	N - Control	-1.0	(0.36)	-9.1
N+S	9.8	N+S - Control	-1.2	(0.20)	-10.9
N+S+Micro	9.9	N+S+Micro - Control	-1.1	(0.23)	-10.0
<i>Grande Ronde</i>					
Control	7.5				
N	9.8	N - Control	2.3	(0.31)	30.7
N+S	10.2	N+S - Control	2.7	(0.17)	36.0
N+S+Micro	12.1	N+S+Micro - Control	4.6	(0.02)	61.3
<i>Landslide Olivine Basalt</i>					
Control	14.1				
N	13.0	N - Control	-1.1	(0.63)	-7.8
N+S	13.5	N+S - Control	-0.6	(0.74)	-4.3
N+S+Micro	14.1	N+S+Micro - Control	0	(1.00)	0

Table 6. Absolute six-year gross volume growth and response for 1990 initial establishment Grande Ronde parent material Douglas-fir study site in the Klickitat area of south-central Washington.

Treatment	Growth (ft ³ /ac)	Contrast	Response		
			(ft ³ /ac)	p	%
Control	1888				
2N	2561	2N - Control	673	(.07)	35.7
2N+2K	2454	2N+2K - Control	566	(.07)	30.0

Evidence of Foliar Nutrient Deficiencies Derived from Vector Analysis

		Nutrients								
Basalt Rock Type										
	N	P	K	S	Ca	Mg	Cu	B	Zn	
Grande Ronde	N	N	N	N	M	Y	-	N	M	
Olivine	Y	N	N	Y	M	N	-	?	N	
Wanapum	Y	P	N	Y	N	N	-	Y	N	

Y = Yes **M = Maybe**
N = No **P = Probable**

Figure 1. Summary of foliar nutrient deficiencies by rock type derived through vector analysis for Douglas-fir in south-central Washington (Shaw and Moore, 1999).