Four Year Response to N and K Fertilization for Douglas-fir in South-Central Washington (Klickitat)

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SUMMARY

Four years after fertilizer treatments were applied, the average gross ft^3 volume per acre increased 13% on those plots receiving 200 lb. nitrogen (N) acre and 10% on those plots receiving 200 lb. N acre plus 200 lb. potassium (K) acre. Absolute and relative gross and net volume response show similar treatment effects. The addition of K in the fertilizer mix did not directly increase volume growth over the controls, but K did decrease mortality. In addition, results from this study show that K significantly increased tree height growth.

Methods

Study Area

The study area is located on the east slopes of the Cascade Mountains in the Klickitat area of south-central Washington. The cooperative fertilization project is located on private and state lands in the Klickitat region. The land owners are: Champion Timberlands, Longview Fibre and Washington Dept. Natural Resources. Appendix A. shows regional and area installation locations in south-central Washington.

Design and Treatments

The six study sites (36 plots) were established in October, 1990 and consist of six square 0.1 acre plots. The plots were grouped into two blocks of three plots each, based on tree and site similarities and by treatment. Fertilization treatments were control, 200 lb. N /acre and 200 lb. N/acre plus 200 lb. K/acre. Nitrogen was applied in the urea form and K in the murate of potash form. All live trees larger than 3 inches in diameter were tagged

and then measured for total height and diameter. Site characteristics and tree measurements were taken before the application of the treatments. Diameters were measured every two years after treatment, while heights were measured four years after treatment. In addition, any incidence of damage or mortality along with probable cause was noted. Foliage samples were collected from the upper crown of the two dominant or codominant trees on each plot in the Fall, 1991 and analyzed by Camas Analytical Lab, Missoula, Montana. Detailed information for each installation on foliar nutrient levels one year after treatment and on stand characteristics at time of establishment, two years and four years after treatment are provided in Appendix B and C. Tree volumes were estimated using regional species-specific volume equations from Prognosis Model (Wykoff, 1982).

Data Analysis

Relative and relative periodic annual volume increment (PAI) growth was calculated using these two formulas:

$$\%Growth = \frac{Growth}{Volume_0} X100 \qquad \%PAI = \frac{PAI}{Volume_0} X100$$

The experimental design model used for the four-year net and gross volume growth and response took the general form of a covariate model:

$$Growth = F\ (Installation,\ Block,\ Treatment,\ BA_0)$$

where: Growth - net and gross volume (cu. ft/acre)

BA_0 - initial basal area as a covariate variable

General linear contrasts and differences between means by treatment for the volume growth were determined by using the least-squares routine of the general linear models procedure (PROC GLM) of the Statistical Analysis System (SAS Institute Inc. 1985).

The analysis of variance for absolute, relative and relative periodic gross and net volume growth and response, plus height growth and response are given in Tables 1, 2, 3 and 4. The contrasts between treatment means are considered as average growth responses to the treatments. The growth responses are smoothed estimates which are adjusted for a common initial basal area of 192 ft^2/acre.

Table 1. Absolute gross and net volume growth and response for Douglas-fir sites in the Klickitat area of south-central Washington.

	Growth		Response		
Treatment	cu/ft/ac.	Contrast	cu/ft/ac.	*p*	%
		Gross Volume			
Control	1145				
200 # N	1291	200N-Control	146	(0.01)	12.8
200 # N+K	1260	200N+K-Control	115	(0.03)	10.0
		200N+K-200N	-31	(0.54)	2.4
		Net Volume			
Control	1088				
200 # N	1204	200N-Control	116	(0.13)	10.7
200 # N+K	1231	200N+K-Control	143	(0.07)	13.1
		200N+K-200N	27	(0.73)	2.2

Four-year gross volume growth was significantly ($p \leq 0.05$) higher on the plots receiving the fertilizer treatments than on the unfertilized control plots (Table 1). The average growth response for the N alone treatment was 146 cu. ft./ac. (12.8%), and 115 cu. ft./ac. (10.0%) for the N plus K treatment (Figure 1a). The K gross volume growth response (-2.4%) was insignificantly negative (Figure 1a). For net volume response, the difference between the two fertilizer treatments was not statistically significant. Although, the net volume growth on the N plus K treatments was significantly ($p \leq 0.1$) higher than the controls.

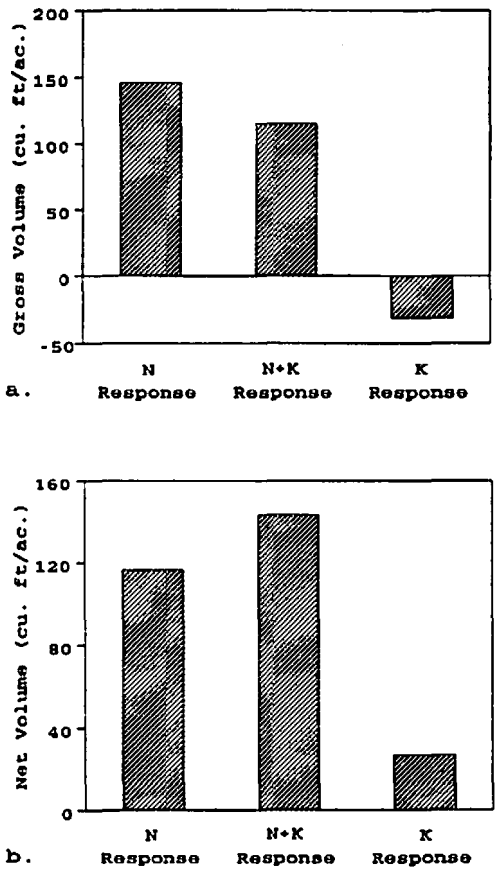

Figure 1. Overall four-year absolute gross and net growth response (cu. ft/ac.) to fertilization for Douglas-fir sites in Klickitat area, south-central Washington.

The results for relative volume response (expressing the growth as a percentage of the initial volume) on the Douglas-fir sites parallel the absolute results (Table 2). Relative response to the N alone treatment was higher for gross volume but lower for net volume than the N plus K treatment (Figure 2). Although the differences between treatments were not significant, the results agree with the Douglas-fir "regionwide" trials showing relationships between K and mortality rates within stands.

Table 2. Relative gross and net volume growth and response by treatment for Douglas-fir sites in the Klickitat area of south-central Washington.

	Growth		Response		
Treatment	% of Initial Density	Contrast	Increase in Relative Growth Rate	*p*	% Change in Relative Growth Rate
		Gross Volume			
Control	21.3				
200 # N	23.0	200N-Control	1.7	(0.03)	8.0
200 # N+K	22.8	200N+K-Control	1.5	(0.05)	7.0
		200N+K-200N	-0.2	(0.84)	0.9
		Net Volume			
Control	20.6				
200 # N	21.6	200N-Control	1.0	(0.31)	4.8
200 # N+K	22.3	200N+K-Control	1.7	(0.10)	8.2
		200N+K-200N	0.6	(0.49)	2.8

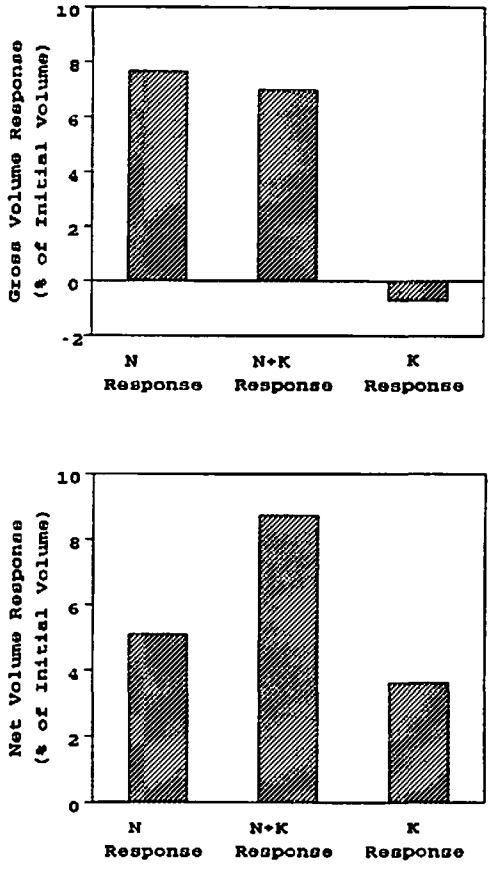

Figure 2. Relative response in gross and net volume relative growth rates to fertilization for Douglas-fir sites in the Klickitat area, south-central Washington.

Gross relative periodic growth response to the fertilizer treatments was significant ($p \leq 0.10$) for both two-year growth periods after fertilization (Table 3). Relative gross volume response was nearly 4% higher on the N alone treatments and 1.6% higher on the N plus K treatments in years 3 and 4 than in years 1 and 2 (Figure 3a). The relative net volume response when K is added to the fertilizer mix shows that K decreased mortality for both periods (Figure 3b), although not significantly.

Table 3. Relative periodic gross and net growth and response for Douglas-fir sites in the Klickitat area of south-central Washington.

Treatment	Periodic Annual Growth % of Initial Density	Contrast	Response: Increase in Periodic Annual Growth Rate	*p*	Response: % Change in Periodic Annual Relative Growth Rate
---------- Gross Volume (Period 1) ----------					
Control	5.19				
200 # N	5.48	200N-Control	0.29	(0.10)	5.6
200 # N+K	5.48	200N+K-Control	0.29	(0.11)	5.6
		200N+K-200N	0.00	(0.98)	0.0
---------- Gross Volume (Period 2) ----------					
Control	4.93				
200 # N	5.40	200N-Control	0.47	(0.01)	9.5
200 # N+K	5.32	200N+K-Control	0.39	(0.05)	7.2
		200N+K-200N	-0.08	(0.63)	1.5
---------- Net Volume (Period 1) ----------					
Control	5.08				
200 # N	5.25	200N-Control	0.17	(0.54)	3.3
200 # N+K	5.48	200N+K-Control	0.40	(0.17)	7.9
		200N+K-200N	0.23	(0.42)	4.4
---------- Net Volume (Period 2) ----------					
Control	4.67				
200 # N	5.00	200N-Control	0.33	(0.22)	7.1
200 # N+K	5.10	200N+K-Control	0.43	(0.12)	9.2
		200N+K-200N	0.10	(0.69)	2.0

The K effect was larger during the first two-year period; however, both gross and net N response was greater in the second two years.

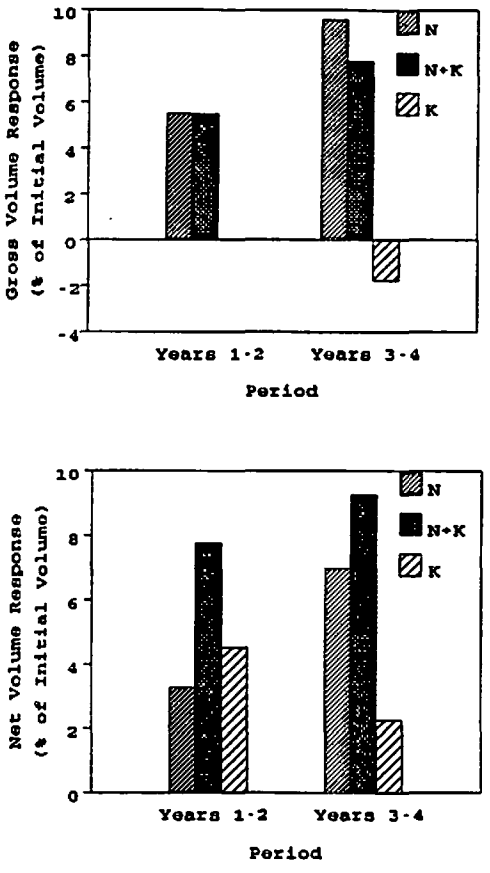

Figure 3. Percent change in periodic annual growth as a percent of initial density due to fertilization for Douglas-fir sites in Klickitat area, south-central Washington.

Interestingly the addition of K to the fertilizer mix did not produce any effect on gross or net growth, but it did produce a significant four-year average height growth response (Figure 4). Height growth response was 7.3% on the N alone treatment and 14.2% on the N plus K treatment; however, the response differences between the two treatments was not significantly different, the addition of K to the fertilizer mix tended to increase height growth (Table 4).

Table 4. Average height response to N and K fertilization for Douglas-fir sites in the Klickitat area of south-central Washington.

Treatment	Growth ft.	Contrast	Response ft.	*p*	%
Control	5.6				
200 # N	6.0	200N-Control	0.4	(0.21)	7.1
200 # N+K	6.4	200N+K-Control	0.8	(0.02)	14.3
		200N+K-200N	0.4	(0.23)	6.7

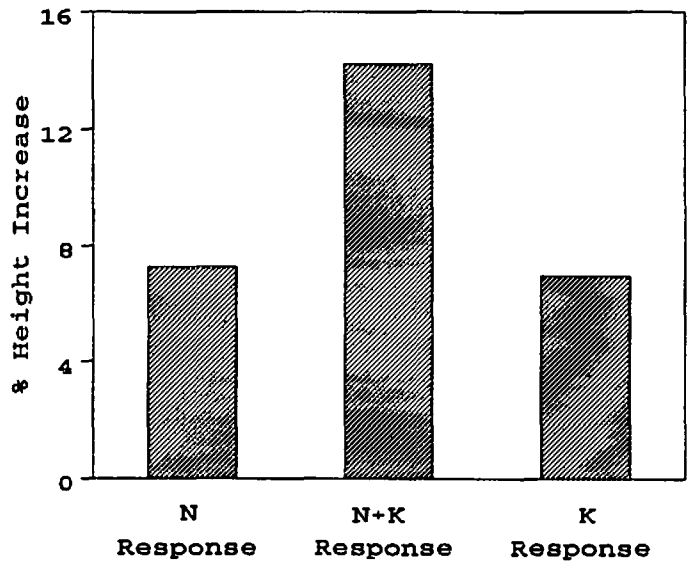

Figure 4. Four-year average height response to N and K fertilization for Douglas-fir sites in Klickitat area, south-central Washington.

Although K may not have a direct affect on growth (McDonald, 1991), the trend for K treated plots to have higher height growth could be attributed to indirect K influences.

Potassium affects many plant processes (such as water relations, production of defensive compounds or carbohydrate transport) other than photosynthesis. Including K along with N may have increased height growth through indirect means such as improved water use efficiency.

The results from the Klickitat Douglas-fir sites show that volume growth was significantly increased by nitrogen fertilization. However, these sites did not respond as much as other IFTNC sites in the central Washington region. Potassium fertilization decreased mortality rates, although not significantly, and increased height growth over a four-year period after treatment.

Literature Cited

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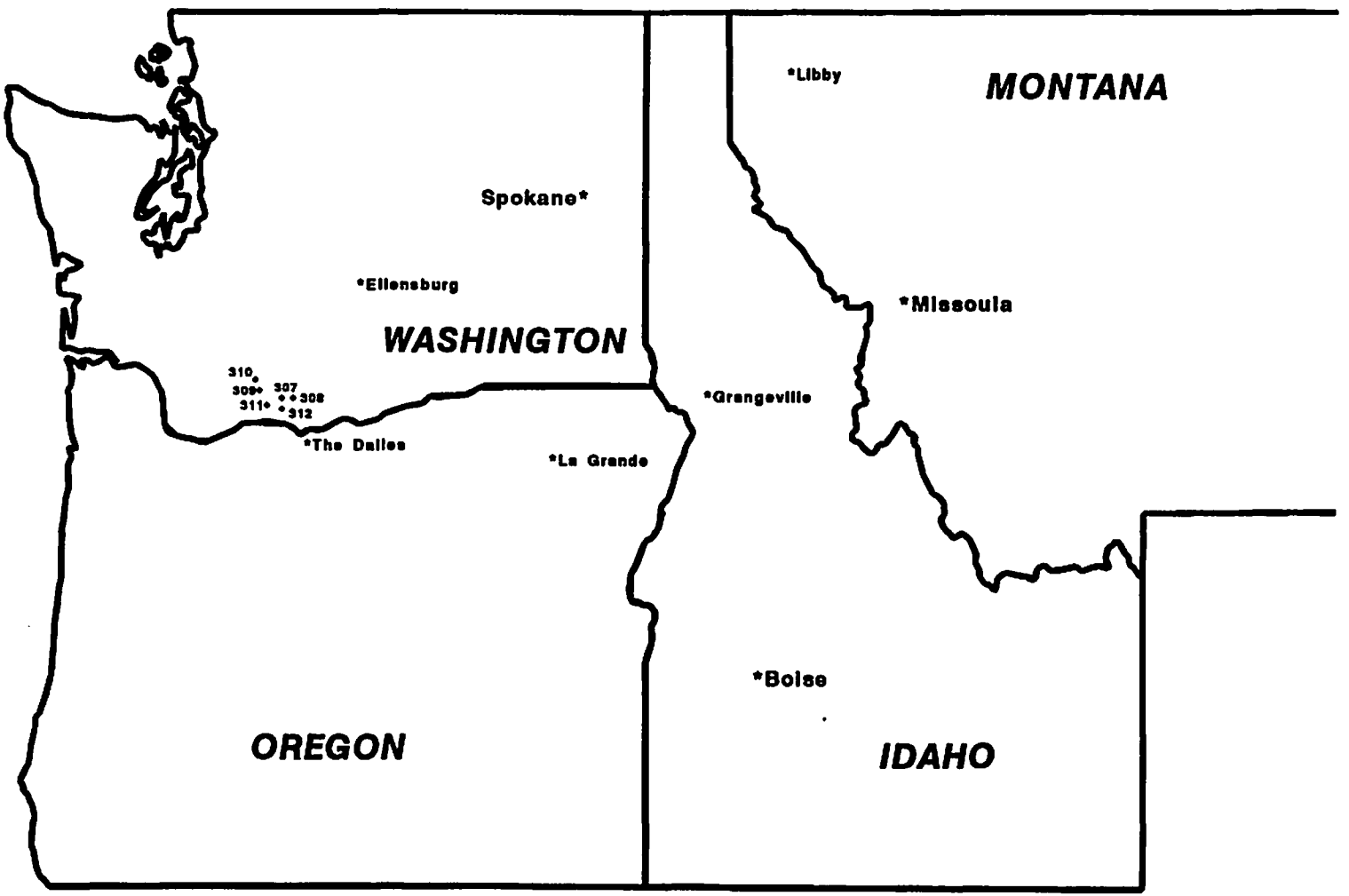
SAS Institute Inc. 1985. SAS User's Guide: Statistics, Version 5 Edition. SAS Institute Inc., Cary NC. p. 433-506.

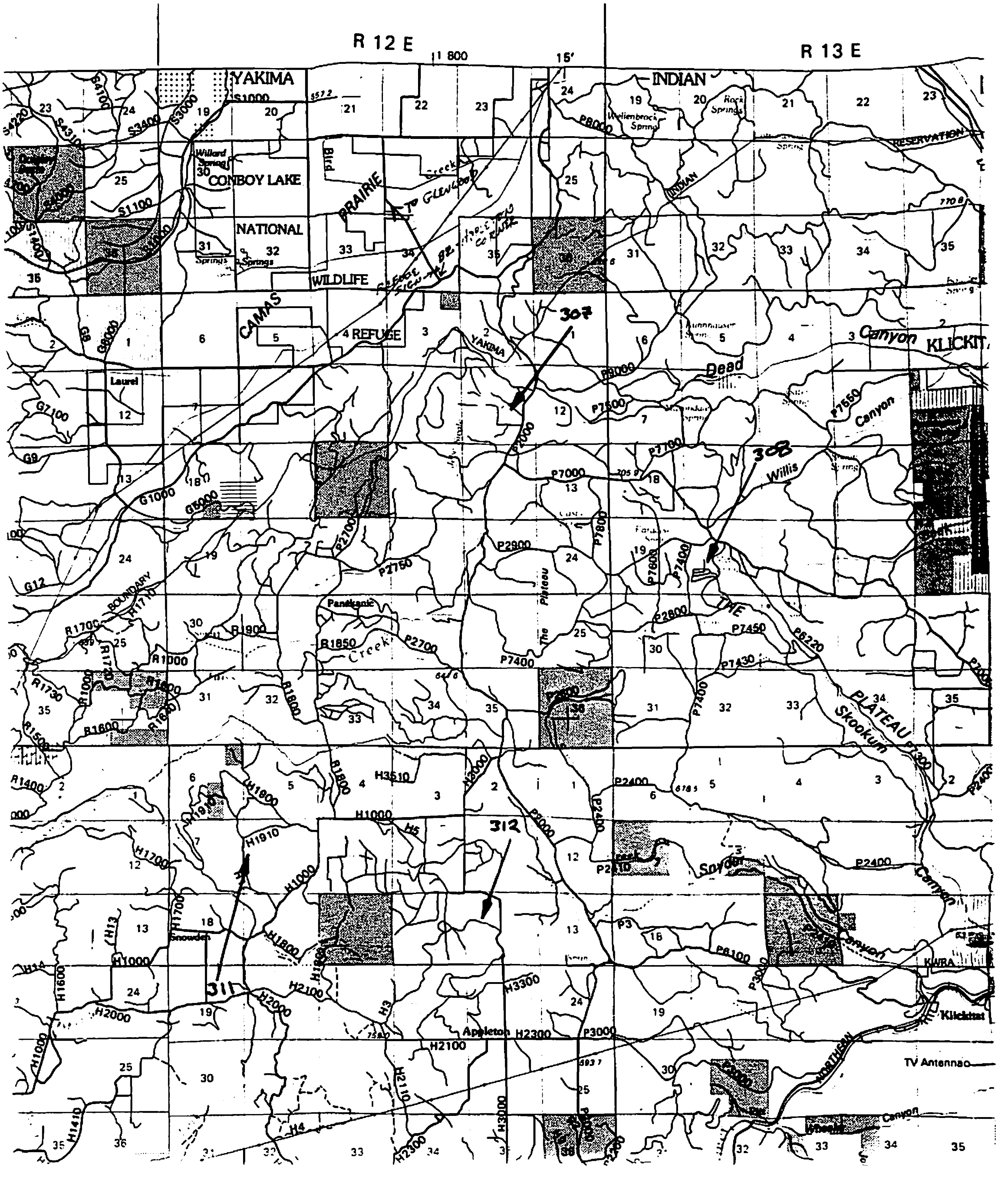
Wykoff, W.R., N.L. Crookston and A.R. Stage. 1982. User's Guide to the Stand Prognosis Model. Gen. Tech. Rep. INT-133. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Exp. Sta. p. 81-84.

Appendix A

INTERMOUNTAIN FOREST TREE NUTRITION COOPERATIVE



DF klickitat Study Site


R 12 E
R 13 E
15'
YAKIMA
INDIAN
RESERVATION
CONBOY LAKE
NATIONAL
WILDLIFE
REFUGE
CAMAS
PRAIRIE
Laurel
BOUNDARY
Dead
Canyon
KLICKITAT
Willis
The Plateau
THE PLATEAU
Skookum
Snyder
Canyon
Appleton
Klickitat
TV Antennae
NORTHERN
307
308
311
312
S1000
S3000
S3600
S1100
P8000
P7500
P7550
P7700
P7000
P2000
P2900
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P7400
P2750
P2800
P7450
P6220
P7430
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P2400
P3000
P2410
P6100
G1000
G6000
G7100
G8000
R1700
R1900
R1850
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R1800
R1600
H3510
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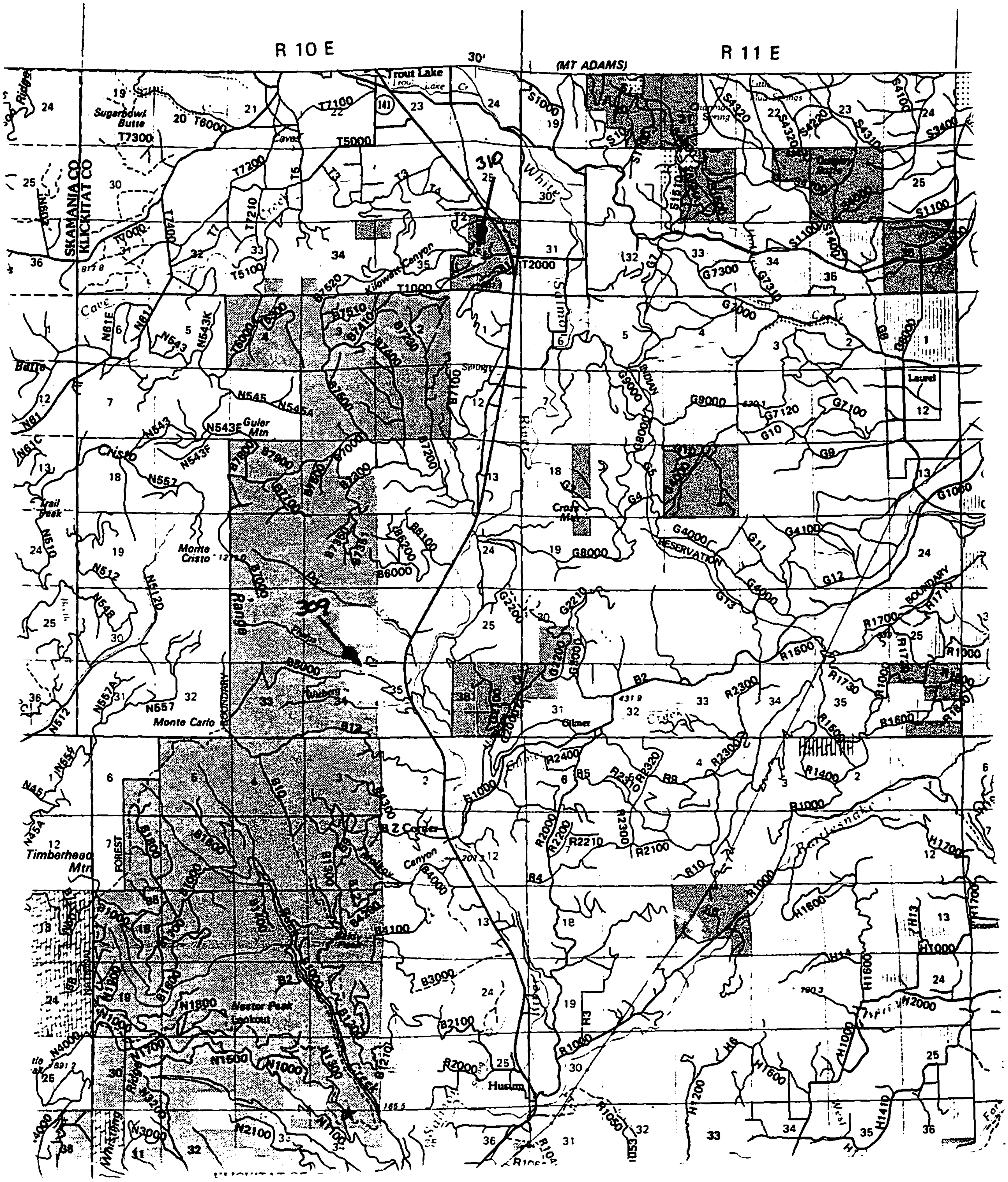
H2110
H4
H1600
H1410


R 10 E
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30'
(MT ADAMS)
Trout Lake
Sugarbowl Butte
SKAMANIA CO
KLICKITAT CO
Kilowatt Canyon
White
Salmon
Springs
Guler Mtn
Cristo
Trail Peak
Monte Cristo
Cross Mtn
RESERVATION
BOUNDARY
Range
Monte Carlo
Gilmer
R Z Corner
Canyon
Timberhead Mtn
FOREST
Nestor Peak Lookout
Husum
Laurel
Whistling
Ridge
310
309

Appendix B

Foliar Nutrient Concentrations Summary Report

INSTALLATION 307 Franz Creek
Region: Central Washington Ownership: Champion
Legal Description: T05N R12E Section 11 Meridian: Willamette

	Plot Number					
	1	2	3	4	5	6
Treatment	N + K	CONT	200#N	N + K	200#N	CONT
Foliar Nutrient Concentrations: (in micrograms per gram)						
Nitrogen	12516	10857	11452	14896	12936	12530
Phosphorus	2235	2237	2385	2884	2141	2614
Potassium	10939	9195	11794	10425	11509	8093
Calcium	1905	3448	3542	3452	2786	2208
Magnesium	1306	1457	2008	1733	1682	1605
Manganese	423.6	477.5	380.0	449.2	455.3	265.1
Zinc	105.9	28.5	38.4	42.4	34.2	30.6
Iron	130.2	112.6	133.9	120.8	92.3	144.7
Boron	22.3	30.2	37.7	42.1	28.5	24.6
Copper	3.15	2.95	3.20	2.50	3.65	3.65
NEEDLE WEIGHT (G/100 NEEDLES)	0.72	0.51	0.67	0.75	0.72	0.72

	Treatment Type			
	CONTROL	200 #N	N + K	OVERALL
Nitrogen	11694	12194	13706	12531
Phosphorus	2425	2263	2559	2416
Potassium	8644	11651	10682	10326
Calcium	2828	3164	2678	2890
Magnesium	1531	1845	1519	1632
Manganese	371.3	417.6	436.4	408.4
Zinc	29.5	36.3	74.1	46.6
Iron	128.6	113.1	125.5	122.4
Boron	27.4	33.1	32.2	30.9
Copper	3.30	3.43	2.83	3.18
NEEDLE WEIGHT (G/100 NEEDLES)	0.61	0.70	0.74	0.68

Foliar Nutrient Concentrations Summary Report

INSTALLATION 308 HARMON SPRINGS
Region: Central Washington Ownership: CHAMPION
Legal Description: T05N R13E Section 20 Meridian: WILLAMETTE

	Plot Number					
	1	2	3	4	5	6
Treatment	CONT	N + K	200#N	200#N	N + K	CONT
Foliar Nutrient Concentrations: (in micrograms per gram)						
Nitrogen	11067	14378	12691	13643	13160	15673
Phosphorus	2681	2104	2041	2243	2625	2383
Potassium	10747	8236	9276	9924	9469	10586
Calcium	2575	2577	4104	3155	3460	4783
Magnesium	1583	1493	1721	1812	1814	1786
Manganese	626.3	517.7	629.9	618.4	700.5	874.0
Zinc	31.6	30.2	38.5	44.9	44.9	36.7
Iron	97.9	76.8	109.4	95.0	80.2	78.3
Boron	23.8	24.5	32.5	28.6	30.4	32.7
Copper	1.45	6.80	5.80	6.05	5.85	3.00
NEEDLE WEIGHT (G/100 NEEDLES)	0.64	0.70	0.63	0.70	0.67	0.53

	Treatment Type			
	CONTROL	200 #N	N + K	OVERALL
Nitrogen	13370	13167	13769	13435
Phosphorus	2532	2142	2364	2346
Potassium	10666	9600	8853	9706
Calcium	3679	3629	3019	3442
Magnesium	1685	1766	1653	1701
Manganese	750.1	624.2	609.1	661.2
Zinc	34.1	41.7	37.5	37.8
Iron	88.1	102.2	78.5	89.6
Boron	28.3	30.6	27.5	28.8
Copper	2.22	5.92	6.32	4.82
NEEDLE WEIGHT (G/100 NEEDLES)	0.59	0.66	0.69	0.65

Foliar Nutrient Concentrations Summary Report

INSTALLATION 309 B.Z. CORNER
Region: Central Washington Ownership: WASHINGTON DNR
Legal Description: T05N R10E Section 34 Meridian: WILLAMETTE

	Plot Number					
	1	2	3	4	5	6
Treatment	200#N	N + K	CONT	N + K	CONT	200#N
Foliar Nutrient Concentrations: (in micrograms per gram)						
Nitrogen	14371	17108	11235	14881	11445	12292
Phosphorus	1305	1786	2058	1946	1957	1846
Potassium	9422	9691	8572	10391	8743	10110
Calcium	4119	2978	3473	3203	3355	2318
Magnesium	1574	1592	1904	1737	1601	1547
Manganese	372.0	649.0	605.7	586.5	348.4	687.0
Zinc	27.2	27.6	26.1	29.2	28.1	24.3
Iron	72.2	86.7	74.0	75.2	81.9	72.1
Boron	36.5	31.7	30.7	38.0	28.6	37.9
Copper	5.25	4.45	2.50	2.25	6.90	6.30
NEEDLE WEIGHT (G/100 NEEDLES)	0.66	0.67	0.66	0.72	0.59	0.75

	Treatment Type			
	CONTROL	200 #N	N + K	OVERALL
Nitrogen	11340	13332	15995	13555
Phosphorus	2007	1576	1866	1816
Potassium	8657	9766	10041	9488
Calcium	3414	3218	3091	3241
Magnesium	1752	1560	1664	1659
Manganese	477.1	529.5	617.8	541.5
Zinc	27.1	25.7	28.4	27.1
Iron	77.9	72.2	81.0	77.0
Boron	29.6	37.2	34.8	33.9
Copper	4.70	5.77	3.35	4.61
NEEDLE WEIGHT (G/100 NEEDLES)	0.62	0.70	0.69	0.67

Foliar Nutrient Concentrations Summary Report

INSTALLATION 310 Trout Lake
Region: Central Washington Ownership: Washington DNR
Legal Description: T06N R10E Section 35 Meridian: Willamette

	Plot Number					
	1	2	3	4	5	6
Treatment	CONT	N + K	CONT	N + K	200#N	200#N
Foliar Nutrient Concentrations: (in micrograms per gram)						
Nitrogen	12061	13594	11375	13636	13454	13230
Phosphorus	2262	2872	2589	4105	2420	2451
Potassium	8406	9464	11714	12010	10699	9217
Calcium	3049	3362	3581	3215	3234	3459
Magnesium	1131	1578	1675	1725	1652	1758
Manganese	384.5	350.0	342.5	377.8	359.2	349.6
Zinc	19.5	32.4	38.5	31.3	34.2	36.0
Iron	92.9	112.2	121.5	139.7	98.8	118.7
Boron	24.0	32.7	29.4	31.8	25.6	24.5
Copper	3.55	5.55	4.90	6.45	4.60	5.20
NEEDLE WEIGHT (G/100 NEEDLES)	0.78	0.85	0.74	0.78	0.80	0.86

	Treatment Type			
	CONTROL	200 #N	N + K	OVERALL
Nitrogen	11718	13342	13615	12892
Phosphorus	2426	2435	3488	2783
Potassium	10060	9958	10737	10251
Calcium	3315	3346	3288	3316
Magnesium	1403	1705	1652	1586
Manganese	363.5	354.4	363.9	360.6
Zinc	29.0	35.1	31.8	32.0
Iron	107.2	108.7	126.0	114.0
Boron	26.7	25.1	32.3	28.0
Copper	4.23	4.90	6.00	5.04
NEEDLE WEIGHT (G/100 NEEDLES)	0.76	0.83	0.82	0.80

Foliar Nutrient Concentrations Summary Report

INSTALLATION 311 SNOWDEN
Region: Central Washington Ownership: LONGVIEW FIBER
Legal Description: T04N R12E Section 8 Meridian: WILLAMETTE

	Plot Number					
	1	2	3	4	5	6
Treatment	200#N	N + K	CONT	CONT	N + K	200#N
Foliar Nutrient Concentrations: (in micrograms per gram)						
Nitrogen	14098	14896	13020	11403	14595	13587
Phosphorus	2225	2330	2399	2175	1883	1895
Potassium	9429	9807	10096	9594	10060	10122
Calcium	3169	5239	3869	3146	2766	3161
Magnesium	1732	2243	1886	1577	1443	1379
Manganese	444.1	541.9	508.9	251.8	375.2	568.0
Zinc	87.4	89.5	73.5	65.1	53.5	59.6
Iron	105.2	101.2	70.8	78.8	104.5	98.8
Boron	33.7	32.2	31.6	35.9	29.7	28.6
Copper	7.00	5.90	6.45	7.75	6.90	6.35
NEEDLE WEIGHT (G/100 NEEDLES)	0.79	0.80	0.62	0.69	0.66	0.77

	Treatment Type			
	CONTROL	200 #N	N + K	OVERALL
Nitrogen	12212	13843	14746	13600
Phosphorus	2287	2060	2106	2151
Potassium	9845	9776	9933	9851
Calcium	3507	3165	4002	3558
Magnesium	1731	1556	1843	1710
Manganese	380.3	506.1	458.6	448.3
Zinc	69.3	73.5	71.5	71.5
Iron	74.8	102.0	102.9	93.2
Boron	33.7	31.2	31.0	32.0
Copper	7.10	6.67	6.40	6.72
NEEDLE WEIGHT (G/100 NEEDLES)	0.65	0.78	0.73	0.72

Foliar Nutrient Concentrations Summary Report

INSTALLATION 312 Appleton
Region: Central Washington Ownership: Longview Fiber
Legal Description: T04N R12E Section 14 Meridian: Willamette

	Plot Number					
	1	2	3	4	5	6
Treatment	200#N	N + K	CONT	CONT	N + K	200#N
Foliar Nutrient Concentrations: (in micrograms per gram)						
Nitrogen	14168	12187	10976	10010	14560	12236
Phosphorus	2107	2091	2856	2833	2012	1506
Potassium	10799	9536	9443	11966	9708	8392
Calcium	2708	2441	2653	5193	2938	3748
Magnesium	1266	1295	1419	2013	1766	1907
Manganese	446.1	324.8	453.2	610.1	411.7	675.0
Zinc	55.3	30.7	30.1	35.2	46.7	38.1
Iron	114.5	146.8	156.8	149.5	134.2	136.4
Boron	30.5	15.8	23.8	28.9	31.2	32.9
Copper	6.90	3.80	4.60	4.15	5.85	6.70
NEEDLE WEIGHT (G/100 NEEDLES)	0.93	0.78	0.62	0.39	0.62	0.60

	Treatment Type			
	CONTROL	200 #N	N + K	OVERALL
Nitrogen	10493	13202	13374	12356
Phosphorus	2845	1806	2051	2234
Potassium	10704	9596	9622	9974
Calcium	3923	3228	2690	3280
Magnesium	1716	1587	1530	1611
Manganese	531.6	560.6	368.3	486.8
Zinc	32.7	46.6	38.7	39.3
Iron	153.1	125.5	140.5	139.7
Boron	26.4	31.7	23.5	27.2
Copper	4.38	6.80	4.83	5.33
NEEDLE WEIGHT (G/100 NEEDLES)	0.50	0.76	0.70	0.66

Appendix C

Plot Summary Report

Installation 307 Franz Creek
Region: Southcentral Washington Ownership: Champion
Legal Description: T05N R12E Section 11 Meridian: Willamette

Plot Number	1	2	3	4	5	6
Treatment	N+K	0#N	200#N	N+K	200#N	0#N
Site Characteristics:						
Slope (%)	14	14	10	11	15	8
Aspect (degrees)	194	236	170	168	168	166
Mensurational Characteristics:						
At Time of Treatment (1990)	Stand Age =	59				
Live Trees Per Acre	190	230	190	210	150	270
Live Basal Area (sq.ft/a)	181.1	167.2	170.6	149.8	216.7	187.5
Live Total Volume (cu.ft/a)	5320	4779	5053	4470	7801	5494
Crown Competition Factor	185	184	176	160	206	209
Relative Density Index	49.8	49.2	47.6	44.3	53.7	55.8
Mean Diameter (in)	13.2	11.5	12.8	11.4	16.3	11.3
Average Crown Ratio (%)	61	56	59	54	64	55
Average Crown Length (ft)	46.7	40.0	45.6	41.2	58.6	39.2
Site Height (ft--40 tpa)	88.6	80.9	85.1	89.8	99.2	84.0
Species Composition (% of BA)						
Douglas-fir	99.7	91.0	99.8	99.2	70.5	75.2
Grand Fir	0.3	9.0	0.2	0.8	29.5	24.8
2 Years After Treatment (1992)						
Live Trees Per Acre	190	230	190	210	150	270
Live Basal Area (sq.ft/a)	191.2	178.3	181.5	160.7	226.7	200.6
Live Total Volume (cu.ft/a)	5842	5300	5594	4959	8468	6089
Crown Competition Factor	192	194	184	169	213	221
Relative Density Index	54.8	54.4	53.0	49.0	58.0	62.5
Mean Diameter (in)	13.6	11.9	13.2	11.8	16.6	11.7
Site Height (ft--40 tpa)	92.0	84.2	88.7	93.0	103.2	87.0
Dead Trees Per Acre	0	0	0	0	0	0
Dead Basal Area (sq.ft/a)	0.0	0.0	0.0	0.0	0.0	0.0
Dead Total Volume (cu.ft/a)	0	0	0	0	0	0
4 Years After Treatment (1994)						
Live Trees Per Acre	190	230	190	200	150	270
Live Basal Area (sq.ft/a)	201.8	188.0	193.0	168.6	236.8	213.4
Live Total Volume (cu.ft/a)	6385	5814	6175	5406	9192	6717
Crown Competition Factor	199	201	192	173	221	232
Relative Density Index	54.0	53.7	52.2	47.8	57.4	61.5
Mean Diameter (in)	14.0	12.2	13.6	12.4	17.0	12.0
Average Crown Ratio (%)	51	47	43	43	49	44
Average Crown Length (ft)	40.9	36.4	34.3	35.0	48.8	33.1
Site Height (ft--40 tpa)	95.6	87.9	93.1	96.9	107.3	90.5
Dead Trees Per Acre	0	0	0	10	0	0
Dead Basal Area (sq.ft/a)	0.0	0.0	0.0	3.9	0.0	0.0
Dead Total Volume (cu.ft/a)	0	0	0	104	0	0

Plot Summary Report

Installation 308 Harmon Springs
Region: Southcentral Washington Ownership: Champion
Legal Description: T05N R13E Section 20 Meridian: Willamette

Plot Number	1	2	3	4	5	6
Treatment	0#N	N+K	200#N	200#N	N+K	0#N
Site Characteristics:						
Slope (%)	10	3	8	7	9	3
Aspect (degrees)	30	316	356	31	18	330
Mensurational Characteristics:						
At Time of Treatment (1990)	Stand Age =	67				
Live Trees Per Acre	240	200	210	300	240	260
Live Basal Area (sq.ft/a)	163.6	178.8	173.2	188.2	139.4	212.4
Live Total Volume (cu.ft/a)	4418	5120	5306	5628	4028	6972
Crown Competition Factor	179	161	176	212	157	221
Relative Density Index	48.9	50.0	49.4	57.5	43.4	60.7
Mean Diameter (in)	11.2	12.8	12.3	10.7	10.3	12.2
Average Crown Ratio (%)	58	58	56	56	57	57
Average Crown Length (ft)	39.7	39.1	42.2	41.8	41.9	47.5
Site Height (ft--40 tpa)	73.1	83.2	88.5	92.9	83.5	96.8
Species Composition (% of BA)						
Douglas-fir	79.6	49.7	85.9	97.2	90.2	98.7
Grand Fir	4.9	0.0	1.0	0.0	0.0	0.3
Ponderosa Pine	15.6	50.3	13.1	2.8	9.8	1.0
2 Years After Treatment (1992)						
Live Trees Per Acre	240	200	210	300	240	260
Live Basal Area (sq.ft/a)	173.0	189.7	182.9	197.9	148.9	220.0
Live Total Volume (cu.ft/a)	4862	5672	5814	6137	4479	7474
Crown Competition Factor	186	169	183	220	166	227
Relative Density Index	53.4	55.4	54.4	61.3	48.8	64.8
Mean Diameter (in)	11.5	13.2	12.6	11.0	10.7	12.5
Site Height (ft--40 tpa)	76.6	87.1	92.2	96.6	87.2	100.5
Dead Trees Per Acre	0	0	0	0	0	0
Dead Basal Area (sq.ft/a)	0.0	0.0	0.0	0.0	0.0	0.0
Dead Total Volume (cu.ft/a)	0	0	0	0	0	0
4 Years After Treatment (1994)						
Live Trees Per Acre	230	200	210	290	230	260
Live Basal Area (sq.ft/a)	181.1	201.4	193.2	203.2	159.3	228.5
Live Total Volume (cu.ft/a)	5294	6245	6342	6545	4987	8017
Crown Competition Factor	191	177	191	224	175	233
Relative Density Index	52.2	54.6	53.6	60.4	47.5	64.1
Mean Diameter (in)	12.0	13.6	13.0	11.3	11.3	12.7
Average Crown Ratio (%)	48	55	49	43	46	44
Average Crown Length (ft)	36.0	38.9	39.1	34.4	36.3	39.2
Site Height (ft--40 tpa)	79.7	90.3	95.0	100.9	90.8	104.0
Dead Trees Per Acre	10	0	0	10	10	0
Dead Basal Area (sq.ft/a)	1.3	0.0	0.0	5.7	2.4	0.0
Dead Total Volume (cu.ft/a)	27	0	0	151	54	0

Plot Summary Report

Installation 309 BZ Corner
Region: Southcentral Washington Ownership: Washington DNR
Legal Description: T05N R10E Section 34 Meridian: Willamette

Plot Number	1	2	3	4	5	6
Treatment	200#N	N+K	0#N	N+K	0#N	200#N
Site Characteristics:						
Slope (%)	12	18	12	14	14	9
Aspect (degrees)	152	186	96	104	116	143
Mensurational Characteristics:						
At Time of Treatment (1990)	Stand Age =	63				
Live Trees Per Acre	230	250	320	250	300	370
Live Basal Area (sq.ft/a)	301.1	231.7	266.9	312.9	285.9	185.5
Live Total Volume (cu.ft/a)	10904	7764	9266	11637	10228	5444
Crown Competition Factor	280	227	275	296	284	209
Relative Density Index	76.5	64.2	75.9	80.4	78.6	59.9
Mean Diameter (in)	15.5	13.0	12.4	15.1	13.2	9.6
Average Crown Ratio (%)	66	57	57	62	55	48
Average Crown Length (ft)	64.6	47.3	50.6	62.9	51.7	32.8
Site Height (ft--40 tpa)	111.8	100.6	105.2	111.9	107.0	87.8
Species Composition (% of BA)						
Douglas-fir	100.0	100.0	100.0	100.0	100.0	100.0
2 Years After Treatment (1992)						
Live Trees Per Acre	220	240	320	250	300	350
Live Basal Area (sq.ft/a)	310.9	243.8	277.4	326.0	294.6	198.2
Live Total Volume (cu.ft/a)	11704	8476	9887	12522	10841	6024
Crown Competition Factor	285	235	283	304	290	217
Relative Density Index	80.7	69.3	80.2	85.3	80.6	66.5
Mean Diameter (in)	16.1	13.6	12.6	15.5	13.4	10.2
Site Height (ft--40 tpa)	115.5	104.5	108.1	116.0	110.4	91.5
Dead Trees Per Acre	10	10	0	0	0	20
Dead Basal Area (sq.ft/a)	2.0	0.6	0.0	0.0	0.0	1.5
Dead Total Volume (cu.ft/a)	38	8	0	0	0	30
4 Years After Treatment (1994)						
Live Trees Per Acre	220	240	310	240	280	350
Live Basal Area (sq.ft/a)	323.6	255.8	284.8	335.5	295.3	212.4
Live Total Volume (cu.ft/a)	12691	9215	10508	13366	11279	6673
Crown Competition Factor	293	243	286	308	287	230
Relative Density Index	79.9	68.4	79.1	83.9	79.2	65.4
Mean Diameter (in)	16.4	14.0	13.0	16.0	13.9	10.5
Average Crown Ratio (%)	46	40	37	42	35	40
Average Crown Length (ft)	48.1	34.7	34.7	45.5	34.6	29.7
Site Height (ft--40 tpa)	120.9	108.8	111.8	119.9	113.8	95.0
Dead Trees Per Acre	10	10	10	10	20	20
Dead Basal Area (sq.ft/a)	2.0	0.6	3.2	4.2	8.4	1.5
Dead Total Volume (cu.ft/a)	38	8	76	100	207	30

Plot Summary Report

Installation 310 Trout Lake
Region: Southcentral Washington Ownership: Washington DNR
Legal Description: T06N R10E Section 35 Meridian: Willamette

Plot Number	1	2	3	4	5	6
Treatment	0#N	N+K	0#N	N+K	200#N	200#N
Site Characteristics:						
Slope (%)	1	1	1	1	3	1
Aspect (degrees)	40	40	325	330	346	25
Mensurational Characteristics:						
At Time of Treatment (1990)	Stand Age =	48				
Live Trees Per Acre	260	200	170	130	270	300
Live Basal Area (sq.ft/a)	165.3	125.4	117.1	158.4	171.5	208.1
Live Total Volume (cu.ft/a)	4453	3326	2951	4429	4142	5701
Crown Competition Factor	190	140	134	154	187	225
Relative Density Index	50.3	38.3	34.9	41.0	52.2	62.0
Mean Diameter (in)	10.8	10.7	11.2	14.9	10.8	11.3
Average Crown Ratio (%)	55	51	57	66	54	52
Average Crown Length (ft)	37.2	32.6	34.6	50.7	31.9	33.9
Site Height (ft--40 tpa)	79.2	76.0	65.2	82.4	69.0	78.4
Species Composition (% of BA)						
Douglas-fir	92.7	82.9	54.5	100.0	91.5	82.1
Grand Fir	7.3	12.9	36.4	0.0	1.1	11.8
Ponderosa Pine	0.0	4.2	9.1	0.0	7.3	6.1
2 Years After Treatment (1992)						
Live Trees Per Acre	260	200	170	130	270	300
Live Basal Area (sq.ft/a)	180.2	138.7	129.4	173.3	189.6	223.8
Live Total Volume (cu.ft/a)	5085	3861	3429	5085	4786	6416
Crown Competition Factor	202	152	145	164	201	238
Relative Density Index	58.3	45.6	41.3	47.2	61.5	70.5
Mean Diameter (in)	11.3	11.3	11.8	15.6	11.3	11.7
Site Height (ft--40 tpa)	83.4	79.5	68.8	87.0	72.6	81.7
Dead Trees Per Acre	0	0	0	0	0	0
Dead Basal Area (sq.ft/a)	0.0	0.0	0.0	0.0	0.0	0.0
Dead Total Volume (cu.ft/a)	0	0	0	0	0	0
4 Years After Treatment (1994)						
Live Trees Per Acre	260	200	170	130	270	300
Live Basal Area (sq.ft/a)	195.8	153.2	141.8	186.6	207.2	241.0
Live Total Volume (cu.ft/a)	5782	4464	3927	5768	5450	7230
Crown Competition Factor	215	166	156	173	215	252
Relative Density Index	57.1	44.5	40.3	46.3	60.2	69.2
Mean Diameter (in)	11.8	11.9	12.4	16.2	11.9	12.1
Average Crown Ratio (%)	48	53	61	62	53	50
Average Crown Length (ft)	36.5	36.5	40.6	52.9	34.5	36.0
Site Height (ft--40 tpa)	87.2	85.2	71.4	91.8	79.4	85.8
Dead Trees Per Acre	0	0	0	0	0	0
Dead Basal Area (sq.ft/a)	0.0	0.0	0.0	0.0	0.0	0.0
Dead Total Volume (cu.ft/a)	0	0	0	0	0	0

Plot Summary Report

Installation 311 Snowden
Region: Southcentral Washington Ownership: Longview
Legal Description: T04N R12E Section 8 Meridian: Willamette

Plot Number	1	2	3	4	5	6
Treatment	N+K	200#N	0#N	0#N	200#N	N+K
Site Characteristics:						
Slope (%)	4	4	4	5	3	4
Aspect (degrees)	236	274	290	342	282	320
Mensurational Characteristics:						
At Time of Treatment (1990)	Stand Age = 57					
Live Trees Per Acre	280	400	350	450	160	410
Live Basal Area (sq.ft/a)	237.6	255.7	199.3	254.7	164.6	236.0
Live Total Volume (cu.ft/a)	7660	7837	6076	7429	5016	7293
Crown Competition Factor	235	274	213	278	159	262
Relative Density Index	67.3	77.7	62.4	79.8	44.4	73.6
Mean Diameter (in)	12.5	10.8	10.2	10.2	13.7	10.3
Average Crown Ratio (%)	59	54	53	51	57	54
Average Crown Length (ft)	46.0	38.7	37.0	34.5	43.3	39.0
Site Height (ft--40 tpa)	93.9	98.1	93.4	91.8	94.0	93.8
Species Composition (% of BA)						
Douglas-fir	100.0	98.9	95.3	99.2	100.0	96.3
Grand Fir	0.0	1.1	1.6	0.8	0.0	3.7
Ponderosa Pine	0.0	0.0	3.2	0.0	0.0	0.0
2 Years After Treatment (1992)						
Live Trees Per Acre	280	390	340	440	160	410
Live Basal Area (sq.ft/a)	250.0	256.8	201.4	268.0	175.2	247.1
Live Total Volume (cu.ft/a)	8393	8188	6396	8120	5547	7916
Crown Competition Factor	243	273	214	288	167	270
Relative Density Index	73.2	80.0	64.4	85.5	49.7	79.7
Mean Diameter (in)	12.8	11.0	10.4	10.6	14.2	10.5
Site Height (ft--40 tpa)	97.9	102.6	97.2	95.8	97.7	97.8
Dead Trees Per Acre	0	10	10	10	0	0
Dead Basal Area (sq.ft/a)	0.0	10.8	6.3	0.7	0.0	0.0
Dead Total Volume (cu.ft/a)	0	298	143	11	0	0
4 Years After Treatment (1994)						
Live Trees Per Acre	260	370	320	420	160	400
Live Basal Area (sq.ft/a)	262.0	265.1	207.9	277.9	187.1	258.4
Live Total Volume (cu.ft/a)	9160	8799	6846	8776	6172	8615
Crown Competition Factor	250	274	217	294	175	278
Relative Density Index	71.1	78.3	62.9	83.7	48.9	78.3
Mean Diameter (in)	13.6	11.5	10.9	11.0	14.6	10.9
Average Crown Ratio (%)	42	44	44	43	46	41
Average Crown Length (ft)	35.1	33.2	30.9	29.9	37.6	30.3
Site Height (ft--40 tpa)	102.3	107.3	100.8	100.2	102.5	101.4
Dead Trees Per Acre	20	30	30	30	0	10
Dead Basal Area (sq.ft/a)	1.7	16.1	9.4	6.8	0.0	0.7
Dead Total Volume (cu.ft/a)	40	442	223	159	0	16

Plot Summary Report

Installation 312 Appleton
Region: Southcentral Washington Ownership: Longview
Legal Description: T04N R12E Section 14 Meridian: Willamette

Plot Number	1	2	3	4	5	6
Treatment	200#N	N+K	0#N	0#N	N+K	200#N
Site Characteristics:						
Slope (%)	4	4	5	5	7	2
Aspect (degrees)	114	266	310	342	342	342
Mensurational Characteristics:						
At Time of Treatment (1990)	Stand Age =	56				
Live Trees Per Acre	240	160	240	130	140	270
Live Basal Area (sq.ft/a)	145.0	143.2	167.8	171.2	104.4	188.1
Live Total Volume (cu.ft/a)	4237	3718	4898	5237	2870	6061
Crown Competition Factor	161	149	177	160	112	191
Relative Density Index	44.7	40.0	49.9	43.4	30.5	56.0
Mean Diameter (in)	10.5	12.8	11.3	15.5	11.7	11.3
Average Crown Ratio (%)	54	52	50	59	50	48
Average Crown Length (ft)	35.9	34.0	32.7	49.1	34.7	31.6
Site Height (ft--40 tpa)	84.8	78.7	89.6	88.9	77.5	99.4
Species Composition (% of BA)						
Douglas-fir	78.2	86.0	83.5	100.0	92.4	72.0
Grand Fir	19.0	14.0	12.9	0.0	0.0	18.9
Ponderosa Pine	2.8	0.0	3.6	0.0	7.6	9.1
2 Years After Treatment (1992)						
Live Trees Per Acre	240	160	240	130	140	260
Live Basal Area (sq.ft/a)	161.0	154.5	180.7	185.4	115.4	199.7
Live Total Volume (cu.ft/a)	4877	4163	5459	5878	3290	6659
Crown Competition Factor	174	158	187	169	120	198
Relative Density Index	52.2	45.1	55.9	49.5	35.8	59.0
Mean Diameter (in)	11.1	13.3	11.7	16.2	12.3	11.9
Site Height (ft--40 tpa)	88.1	81.4	93.1	92.5	80.7	102.9
Dead Trees Per Acre	0	0	0	0	0	10
Dead Basal Area (sq.ft/a)	0.0	0.0	0.0	0.0	0.0	2.0
Dead Total Volume (cu.ft/a)	0	0	0	0	0	49
4 Years After Treatment (1994)						
Live Trees Per Acre	230	160	240	130	140	220
Live Basal Area (sq.ft/a)	173.9	164.6	191.4	199.1	125.4	203.3
Live Total Volume (cu.ft/a)	5487	4613	5975	6534	3724	7076
Crown Competition Factor	182	165	195	178	128	195
Relative Density Index	50.7	44.4	55.0	48.6	35.0	56.3
Mean Diameter (in)	11.8	13.7	12.1	16.8	12.8	13.0
Average Crown Ratio (%)	48	48	47	55	54	44
Average Crown Length (ft)	34.3	32.9	32.3	48.8	41.1	29.8
Site Height (ft--40 tpa)	91.9	85.2	96.4	96.0	84.7	106.6
Dead Trees Per Acre	10	0	0	0	0	50
Dead Basal Area (sq.ft/a)	3.6	0.0	0.0	0.0	0.0	10.8
Dead Total Volume (cu.ft/a)	96	0	0	0	0	294