Effects of Fertilization Treatments on Klickitat Douglas-fir Sites in South-Central Washington

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Fertilization treatments, (control, 200 lb N/acre, and 200 lb N + 200 lb K /acre), were applied to six Douglas-fir installations (36 plots) in the Klickitat area of south-central Washington, in October, 1990. Measurements were taken before the application of the treatments and again in the Fall of 1992. All live plot trees were tagged and measured for total height and diameter for pre-treatment and diameter only for post-treatment. Foliage samples were collected in Fall, 1991 and analyzed by Camas Analytical Lab, Missoula, Montana. The detailed information about stand characteristics and foliar nutrients for each installation are provided in Appendix A and B.

The objective of the statistical analysis is to investigate the treatment effects on stand basal area growth and response. Additional analyses were conducted to relate stand basal area response to pre and post treatment foliage nutrient status.

I. Statistical Analysis for Two-Year Basal Area Growth and Response.

The experimental design model took the general form of a covariance model:

$$\text{GROWTH} = F\ (\text{INSTALLATION, BLOCK, TREATMENT, } BA_0)$$

where: GROWTH - the growth includes gross and net basal area growth (ft^2/acre) for two-year after treatment.

BA_0 - initial basal area as a covariate variable.

The analysis of variance for gross and net basal area growth and response are provided in Table 1 and illustrated in Figures 1 and 2. The contrasts between treatment means are considered as the average growth responses to the treatments. The growth responses are smoothed estimates which were adjusted for initial basal area.

Table 1. Gross and net basal area growth and response for Douglas-fir sites in the Klickitat area of central Washington.

	Growth		Response		
Treatment	ft^2/a	Contrast	ft^2/a	p	%
---------- Gross Basal Area ----------					
Control	11.4				
200 # N	12.7	200N-Control	1.3	(0.05)	11.4
200 # N+K	12.0	200N+K-Control	0.6	(0.40)	5.3
		200N+K-200N	-0.7	(0.27)	5.5
---------- Net Basal Area ----------					
Control	10.8				
200 # N	11.5	200N-Control	0.7	(0.49)	6.5
200 # N+K	12.0	200N+K-Control	1.2	(0.20)	11.1
		200N+K-200N	0.5	(0.69)	4.3

Gross BA growth response to 200 lb N/acre was 11.4% and statistically significant ($\alpha \approx 0.05$). Addition of K in the fertilizer mix did not increase gross BA growth response.

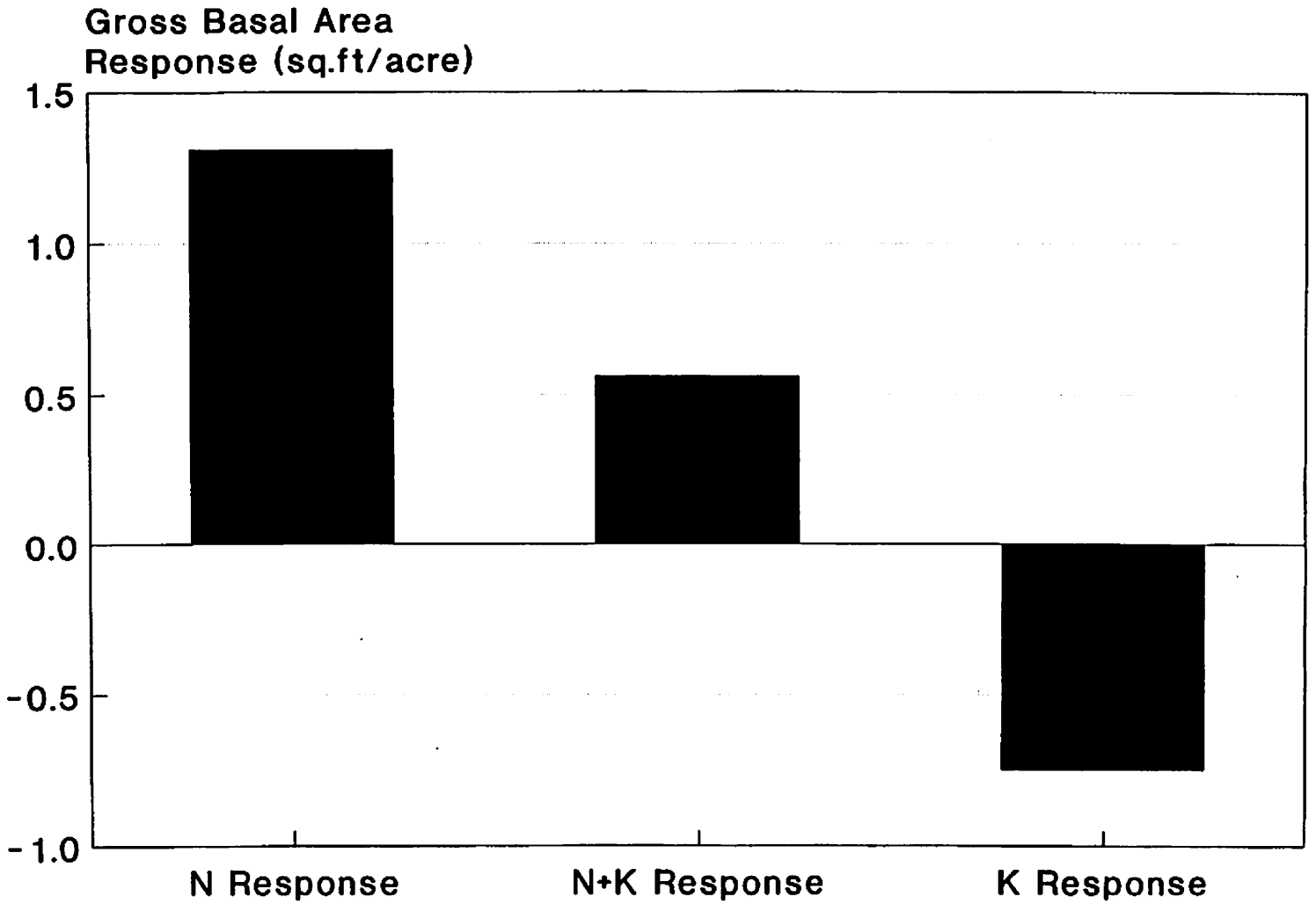

Figure 1. Overall 2-year gross basal area growth response to fertilization for Douglas-fir sites in Klickitat area, south-central Washington.

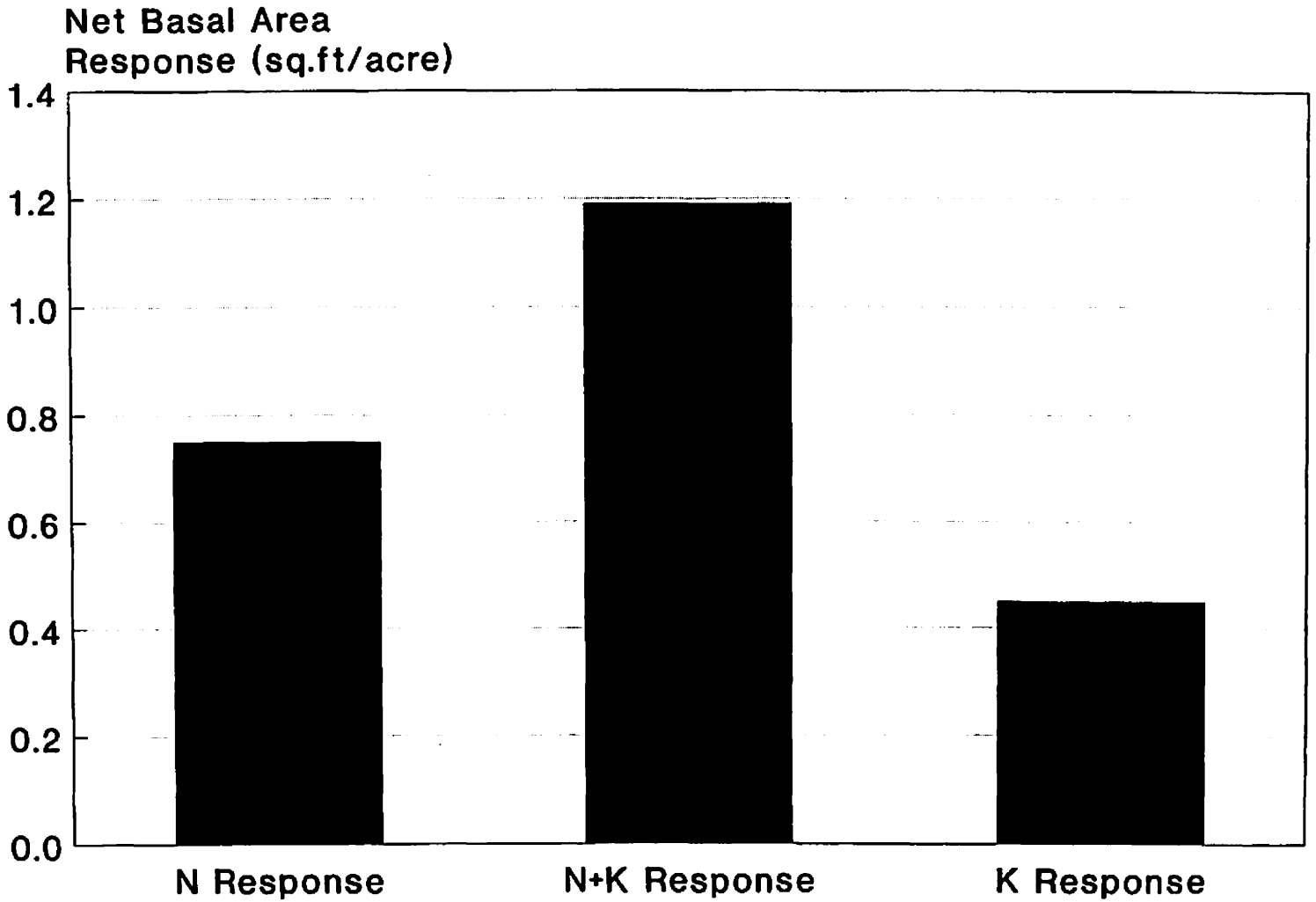

Figure 2. Overall 2-year net basal area growth response to fertilization for Douglas-fir sites in Klickitat area, south-central Washington.

II. The Relationship of Fertilization Response and Foliar Nutrients

Nitrogen response is defined as the difference between the 200 N treated plots versus the Control plots. Figure 5 shows a significant trend of increasing N response versus increasing pretreatment foliar K concentration. Sites that had higher K concentrations responded better to fertilization with N. Nitrogen response increases as foliar K/N ratio decreases after treatment (Figure 6). This is counter to previous IFTNC results for the Ponderosa pine experiment. Perhaps an explanation is that the change in K/N ratio is dominated by the change in foliar N after treatment. The largest change in the K/N ratio occurred on those sites that had the highest K/N ratio initially.

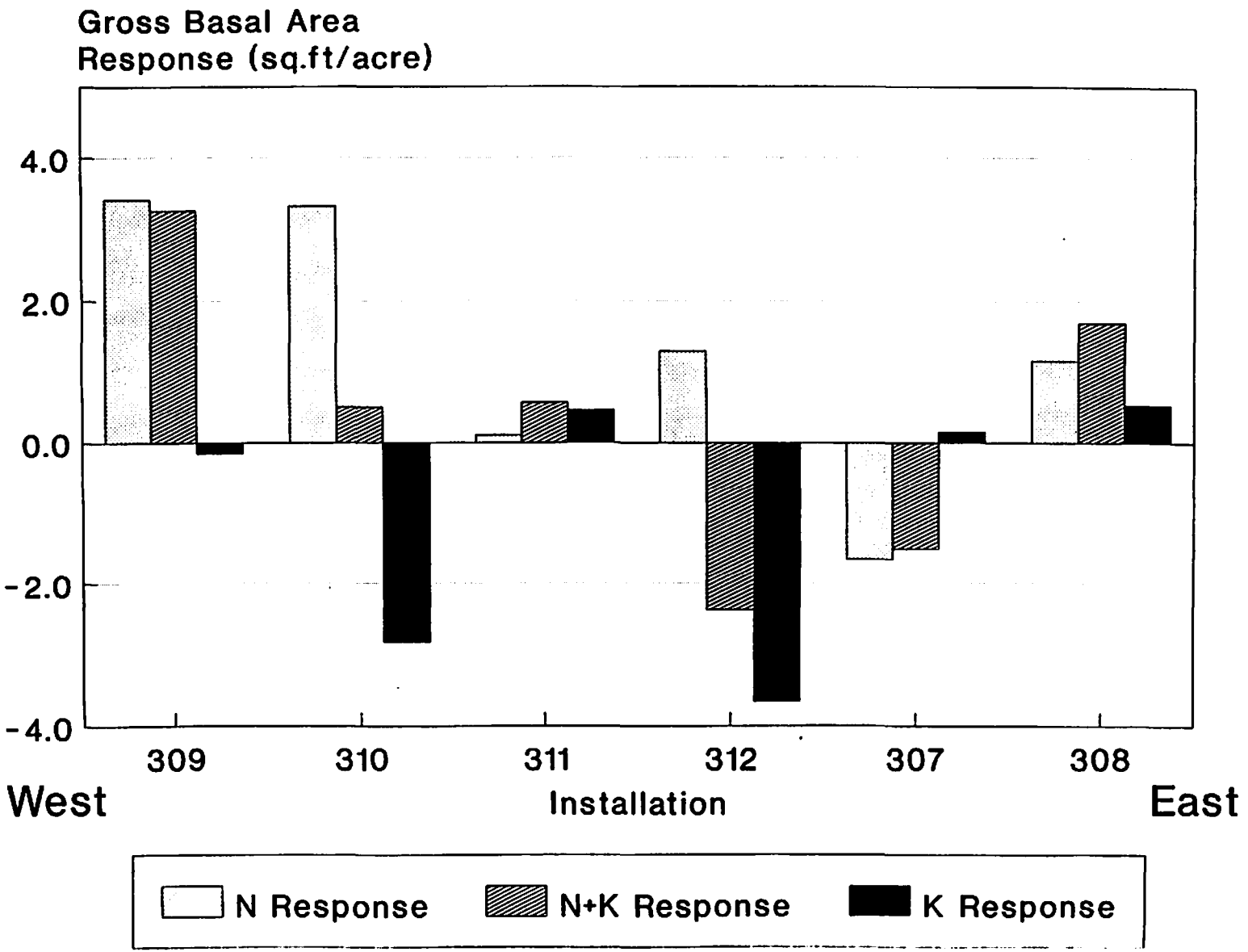

Figure 3. Overall 2-year gross basal area growth response to fertilization for Douglas-fir sites: western sites versus easter sites.

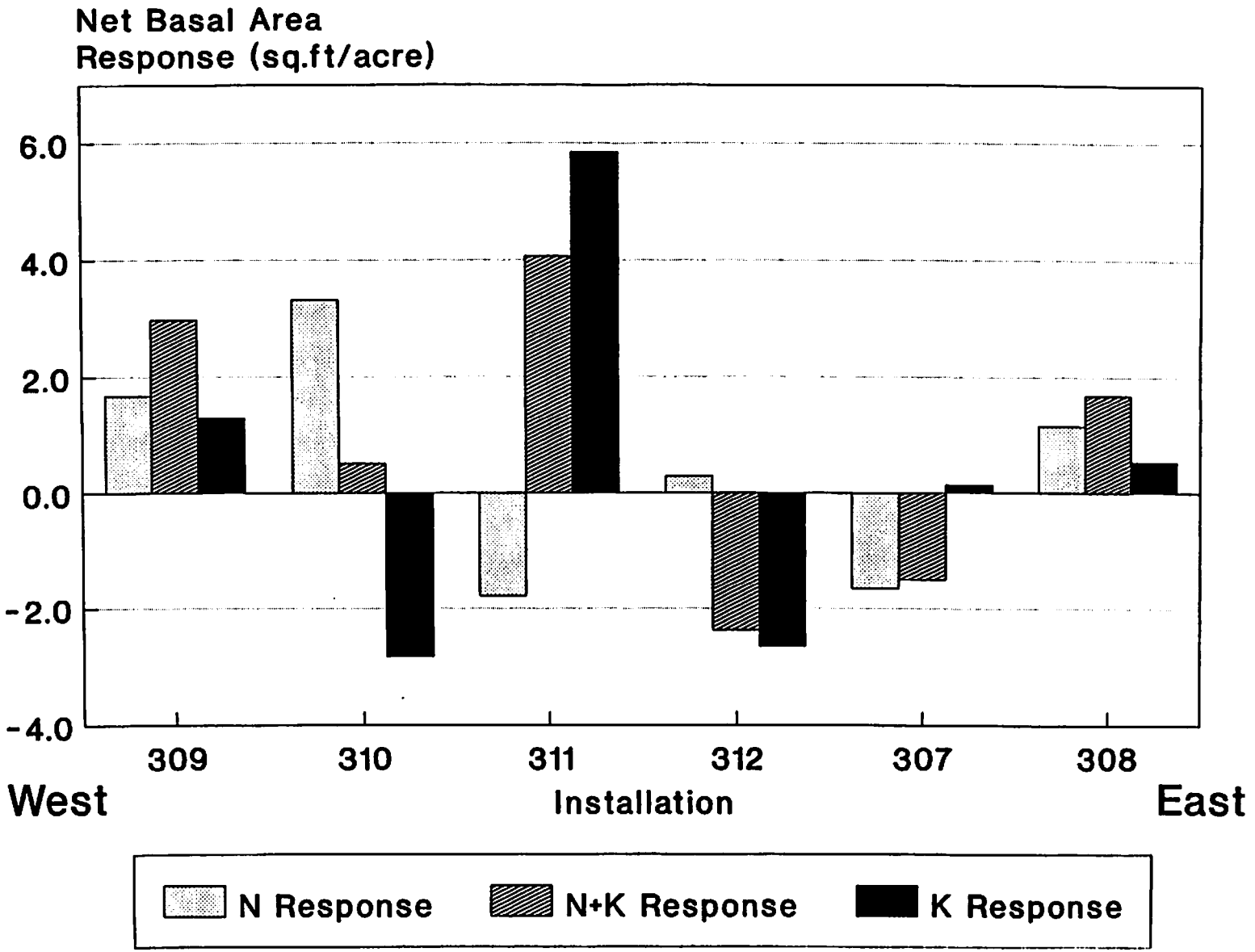

Figure 4. Overall 2-year net basal area growth response to fertilization for Douglas-fir sites: western sites versus eastern sites.

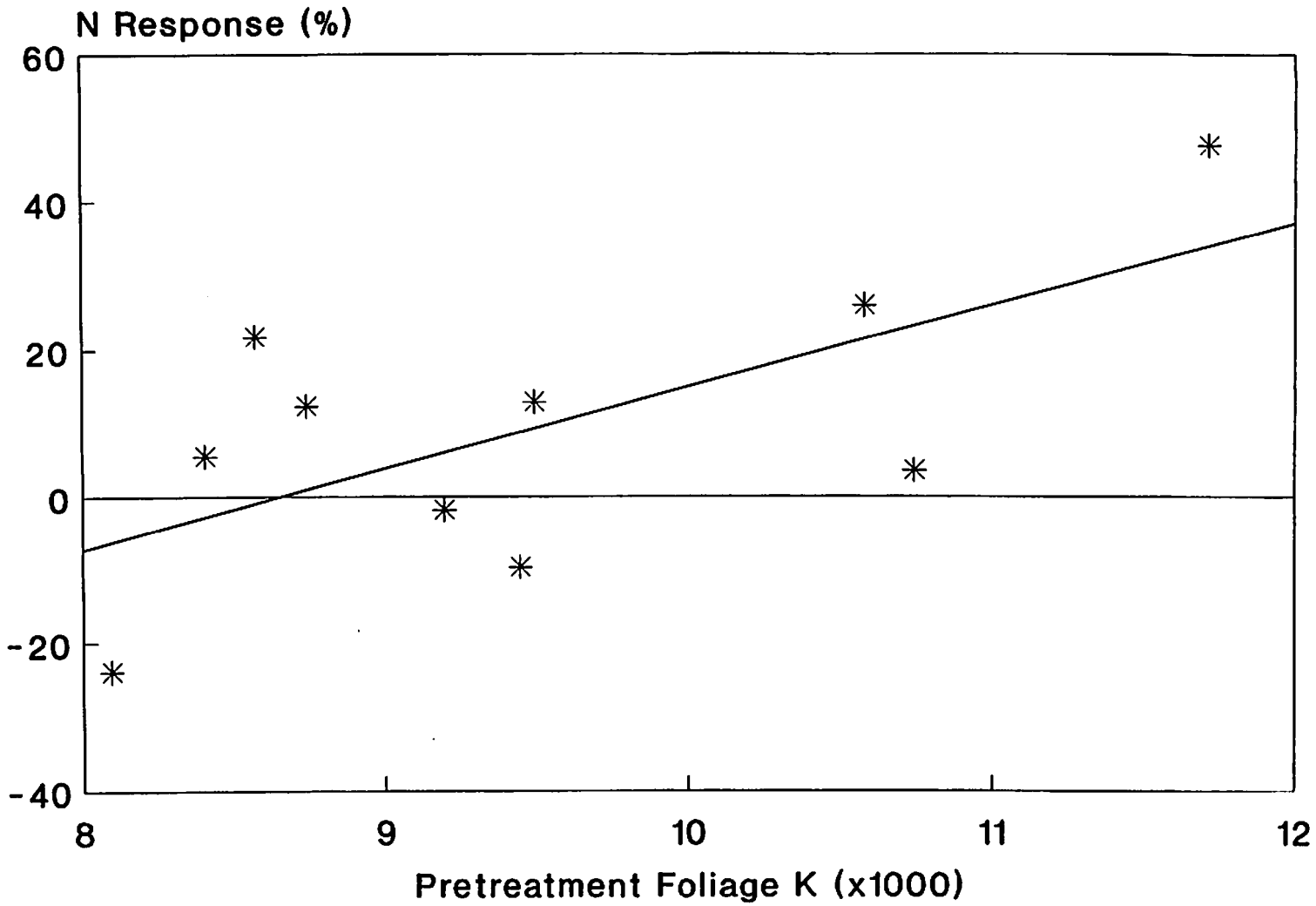

Figure 5. Nitrogen response versus pretreatment foliar K concentration.

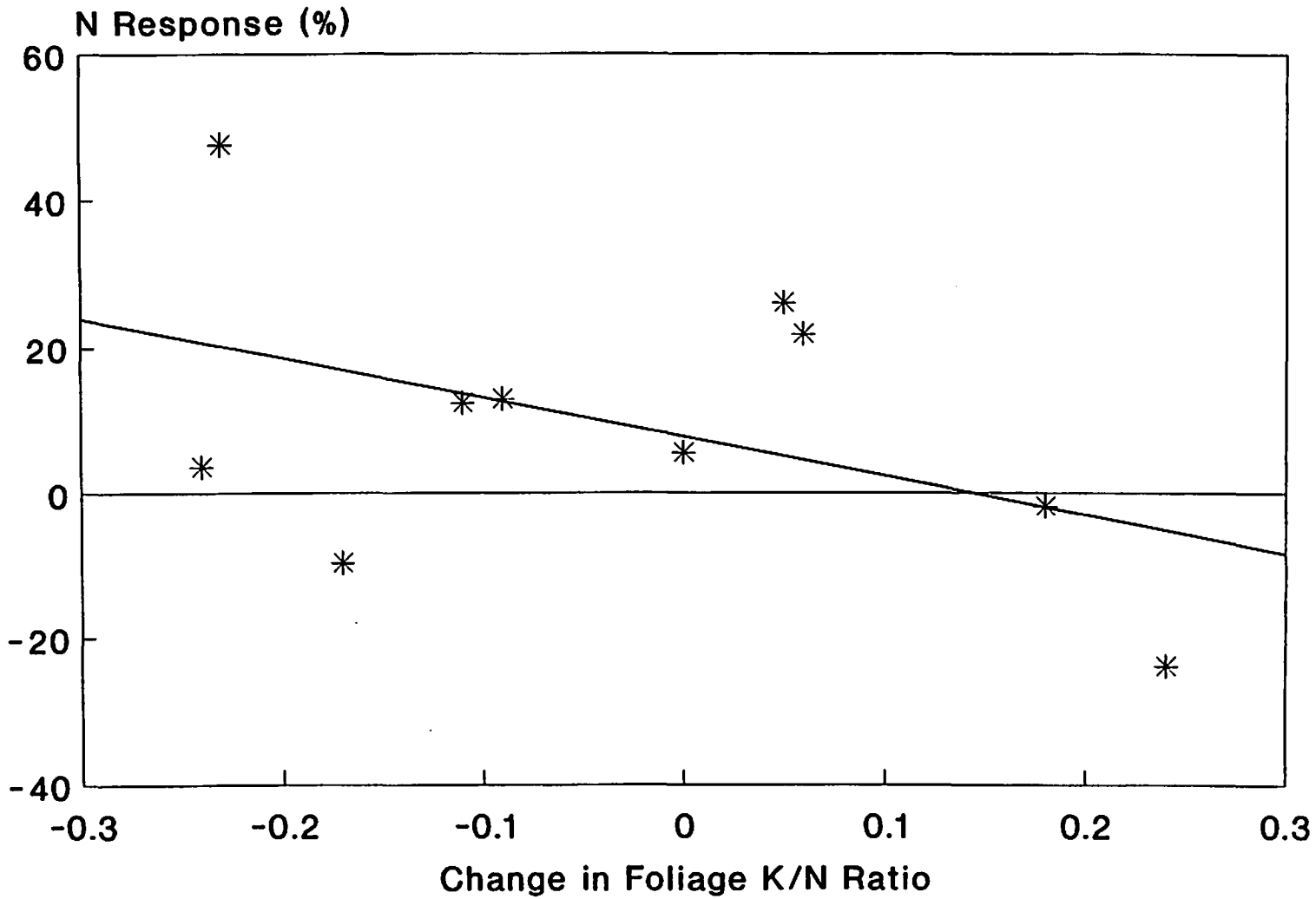

Figure 6. Nitrogen response versus change in foliar K/N ratio.

Potassium response is defined as the difference between the 200 N+K treated plots and the 200 N treated plots. Figure 7 shows that K response decreases as pretreatment K/N ratio increases. Adding K to the fertilizer mix produced the most K response on these sites that initially had lower K/N ratio, although all the Klickitat sites had high K concentration (compared to the overall Douglas-fir experiment) and abnormally high K/N ratios as a result.

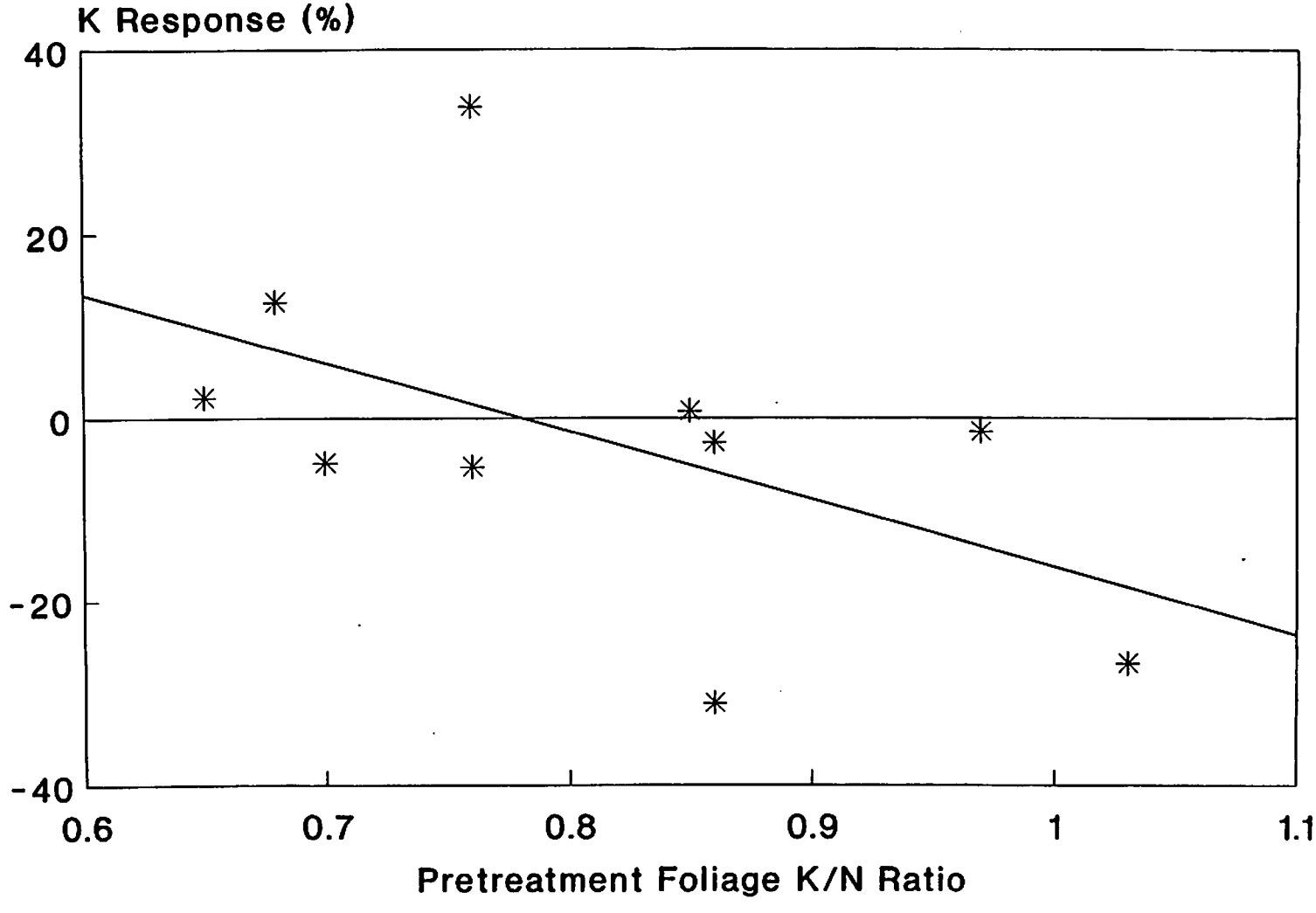

Figure 7. Potassium response versus pretreatment foliar K/N ratio.

Appendix A.

Stand Characteristics of Six Installations in the Klickitat Area of South-Central Washington

PLOT SUMMARY REPORT

INSTALLATION 307 FRANZ CR.
REGION: SOUTH CEN. 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
SITE HEIGHT (FEET)	88.6	80.9	85.1	89.8	99.2	84.0
SPECIES COMPOSITION (% OF BA)						
DOUGLAS-FIR	99.7	90.6	99.8	99.1	70.2	75.1
GRAND FIR	0.3	9.4	0.2	0.9	29.8	24.9
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
CROWN COMPETITION FACTOR	192	194	184	169	213	221
RELATIVE DENSITY INDEX	51.9	51.6	49.9	46.7	55.6	58.7
MEAN DIAMETER (IN)	13.6	11.9	13.2	11.9	16.6	11.7

PLOT SUMMARY REPORT

INSTALLATION 308 HARMON SPR.
REGION: SOUTH CEN. 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
SITE HEIGHT (FEET)	73.1	83.2	88.5	92.9	83.5	96.8
SPECIES COMPOSITION (% OF BA)						
DOUGLAS-FIR	79.7	50.1	85.9	97.1	90.2	98.7
GRAND FIR	5.0	0.0	1.0	0.0	0.0	0.3
PONDEROSA PINE	15.4	49.9	13.0	2.9	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
CROWN COMPETITION FACTOR	186	169	183	220	166	227
RELATIVE DENSITY INDEX	51.0	52.2	51.4	59.7	45.6	62.3
MEAN DIAMETER (IN)	11.5	13.2	12.6	11.0	10.7	12.5

PLOT SUMMARY REPORT

INSTALLATION 309 BZ CORNER
REGION: SOUTH CEN. 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
SITE HEIGHT (FEET)	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	243.7	277.4	326.0	294.6	198.2
CROWN COMPETITION FACTOR	285	235	283	304	290	217
RELATIVE DENSITY INDEX	77.5	66.0	78.1	82.9	80.4	62.1
MEAN DIAMETER (IN)	16.4	13.7	12.6	15.5	13.4	10.2

PLOT SUMMARY REPORT

INSTALLATION 310 TROUT LAKE
REGION: SOUTH CEN. 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
SITE HEIGHT (FEET)	79.2	76.0	65.2	82.4	69.0	78.4
SPECIES COMPOSITION (% OF BA)						
DOUGLAS-FIR	92.7	82.2	53.6	100.0	91.4	81.6
GRAND FIR	7.3	13.7	37.4	0.0	1.1	12.4
PONDEROSA PINE	0.0	4.1	9.0	0.0	7.5	6.0
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
CROWN COMPETITION FACTOR	202	152	145	164	201	238
RELATIVE DENSITY INDEX	53.7	41.3	37.6	43.8	56.3	65.4
MEAN DIAMETER (IN)	11.3	11.3	11.8	15.6	11.4	11.7

PLOT SUMMARY REPORT

INSTALLATION 311 SNOWDEN
REGION: SOUTH CEN. WASHINGTON OWNERSHIP: LONGVIEW FIBRE
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
SITE HEIGHT (FEET)	93.9	98.1	93.4	91.8	94.0	93.8
SPECIES COMPOSITION (% OF BA)						
DOUGLAS-FIR	100.0	98.9	95.4	99.2	100.0	96.3
GRAND FIR	0.0	1.1	1.5	0.8	0.0	3.7
PONDEROSA PINE	0.0	0.0	3.0	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
CROWN COMPETITION FACTOR	243	273	214	288	167	270
RELATIVE DENSITY INDEX	70.0	77.5	62.4	82.5	46.5	76.2
MEAN DIAMETER (IN)	12.8	11.0	10.4	10.6	14.2	10.5

PLOT SUMMARY REPORT

INSTALLATION 312 APPLETON
REGION: SOUTH CEN. WASHINGTON OWNERSHIP: LONGVIEW FIBRE
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
SITE HEIGHT (FEET)	84.8	78.7	89.6	88.9	77.5	99.4
SPECIES COMPOSITION (% OF BA)						
DOUGLAS-FIR	77.8	86.3	83.6	100.0	92.4	72.0
GRAND FIR	19.5	13.7	12.9	0.0	0.0	18.7
PONDEROSA PINE	2.7	0.0	3.5	0.0	7.6	9.3
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
CROWN COMPETITION FACTOR	174	158	187	169	120	198
RELATIVE DENSITY INDEX	48.3	42.4	52.7	46.1	32.9	58.0
MEAN DIAMETER (IN)	11.1	13.3	11.8	16.2	12.3	11.9

Appendix B.

Foliar Nutrients of Six Installations in the Klickitat Area of South-Central Washington

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