Fertilization Studies Summary:

Statistical Approach:

Both sets of data were analyzed as factorial designs using SAS® PROC MIXED with plot as a random variable. Sites and species were analyzed separately. All analyses were weighted based on the number of surviving seedlings within each plot. Comparisons among the least-squared means were made using Bonferroni's adjusted probabilities for multiple comparisons. For the slow release study, linear, quadratic, and cubic contrasts were tested when rate was significant. Data were transformed prior to analyses if first runs indicated a lack of homogeneity of variance. Analyses were run on survival, height, caliper, and stem volume index. For the stock type study, three analyses were performed. Bareroot and plugs were analyzed separately for fertilizer effect, and then nonfertilized seedlings were analyzed for stock type effect. For the slow release study, the Beatty site had different analyses than the other sites. Survival for Douglas-fir planted in the fall was too low to include the time effect in the ANOVA analysis. Also at Beatty, because of a fertilizer problem, the fall plantng for ponderosa pine was analyzed separately from the spring planting, and only the no fertilizer and highest fertilizer rates were included in the spring-planted analysis.

Stock Type Fertilizer Studies:

For the Boise Douglas-fir, within stock types, there were no differences related to stock or fertilization. When comparing the nonfertilized seedlings, 1+1 seedlings had greater survival than Styro 8 seedlings. Survival of container and plug+1 stock was poor at the Roseburg site. For the bareroot stock, nonfertilized seedlings had better survival than fertilized seedlings. For the plugs, the Styro 8 fertilized seedlings had the best survival. At the SPI site, survival of 1+1 stock was greater than plug+1 seedlings, and when comparing nonfertilized seedlings, survival of 1+1 stock was greater than Styro 20 survival. Fertilization did not significantly affect survival within stock type comparisons. Survival of Ponderosa pine was good for all stock types (> than 92%).

Significant differences among Douglas-fir stock types were found for height, caliper, and volume, and rankings varied by site. At the Boise site, there were no differences in size between the bareroot stock types, but the Styro 20 seedlings were significantly taller and larger than the Styro 8 seedlings. In the nonfertilized seedling comparison, the 1+1 seedlings were taller and larger than the Styro 8 seedlings. For the Roseburg and SPI sites, the 1+1 seedlings were significantly taller and larger than the plug+1 seedlings, and there were no differences between the plug stock types. At Roseburg, the 1+1 seedlings were taller than all other stock types when comparing the nonfertilized seedlings, and both the bareroot stock types were larger than the plug stock types.

For ponderosa pine, the plug+1 seedlings were taller and larger than the 1+1 seedlings, and Styro 20 seedlings were taller and larger than Styro 8 seedlings. The bareroot stock were taller and larger than the plug stock for the nonfertilized comparisons.

In general, there were no significant effects of fertilization on the size of Douglas-fir when comparisons were made for plug and bareroot stock types. For the pine, the fertilized bareroot seedlings were significantly taller than unfertilized seedlings. However, the difference was only 7 centimeters.

Percent survival for all sites and species

		Douglas-fir			Ponderosa Pine
Stock	**Fertilized**	Roseburg	SPI	Boise	Boise
1+1	Yes	60.8	61.6	83	100
	No	75.2	61.6	86	100
Plug+1	Yes	20.0	41.6	71	97.6
	No	33.6	40.8	77	96.8
Styro 20	Yes	4.8	48.8	58	94.4
	No	8.0	36.8	55	96.0
Styro 8	Yes	38.4	46.4	47	92.8
	No	3.2	39.2	48	94.4

Raw data means and standard errors for Boise Douglas-fir (n=4)

		Height (cm)		Caliper (cm)		Volume (cm^3)	
Stock	**Fertilized**	Mean	SE	Mean	SE	Mean	SE
1+1	Yes	96.5	11.3	2.25	0.18	583	125
	No	87.1	7.0	2.01	0.19	429	117
Plug+1	Yes	87.1	10.3	2.16	0.24	527	169
	No	80.6	4.7	1.97	0.08	376	59
Styro 20	Yes	72.5	2.7	1.67	0.10	262	28
	No	72.9	1.8	1.69	0.05	242	6
Styro 8	Yes	57.8	2.2	1.31	0.05	130	8
	No	63.9	5.3	1.37	0.13	150	42

Raw data means and standard errors for Roseburg Douglas-fir (n=5)

		Height (cm)		Caliper (cm)		Volume (cm^3)	
Stock	**Fertilized**	Mean	SE	Mean	SE	Mean	SE
1+1	Yes	59.2	1.8	1.72	0.06	210	29
	No	56.5	2.0	1.71	0.08	191	23
Plug+1	Yes	39.6	4.4	1.35	0.18	96	23
	No	45.0	3.5	1.42	0.14	113	31
Styro 20	Yes[1]	40.2	1.3	0.75	0.22	29	10
	No[1]	41.2	5.7	0.68	0.18	24	12
Styro 8	Yes	35.5	1.1	1.24	0.11	61	8
	No[2]	32.3	2.3	0.58	0.08	12	5

[1]n=4 [2]n=3

Raw data means and standard errors for SPI Douglas-fir (n=5)

		Height (cm)		Caliper (cm)		Volume (cm^3)	
Stock	**Fertilized**	Mean	SE	Mean	SE	Mean	SE
1+1	Yes	106.2	4.2	2.52	0.08	860	71
	No	104.4	8.9	2.36	0.20	711	171
Plug+1	Yes	95.7	4.6	2.49	0.13	701	113
	No	89.8	2.6	2.35	0.12	565	67
Styro 20	Yes	95.6	9.5	2.19	0.18	563	152
	No	83.2	6.5	1.78	0.14	375	77
Styro 8	Yes	78.9	6.2	1.74	0.13	300	57
	No	81.0	6.6	1.76	0.14	323	72

Raw data means and standard errors for Boise ponderosa pine (n=5)

		Height (cm)		Caliper (cm)		Volume (cm^3)	
Stock	**Fertilized**	Mean	SE	Mean	SE	Mean	SE
1+1	Yes	133.0	2.2	5.09	0.19	3814	328
	No	127.0	3.5	4.82	0.26	3315	369
Plug+1	Yes	150.7	4.0	5.54	0.23	4898	479
	No	142.1	2.3	5.45	0.23	4468	424
Styro 20	Yes	112.5	3.8	4.20	0.21	2275	248
	No	109.7	2.5	4.04	0.12	2051	149
Styro 8	Yes	98.2	2.7	3.63	0.17	1453	179
	No	97.2	3.9	3.42	0.14	1272	139

F and p values from ANOVAs for Boise Douglas-fir bareroot

		Survival		Height		Caliper		Volume	
Effect	**DF**	F	p	F	p	F	p	F	p
Stock	1,12	2.87	.1160	0.87	.3689	0.07	.7896	0.19	.6675
Fertilizer	1,12	0.53	.4817	1.09	.3172	2.18	.1652	1.82	.2023
Stock*Fert	1,12	0.06	.8129	0.12	.7325	0.14	.7160	0.14	.7194

F and p values from ANOVAs for Boise Douglas-fir plugs

		Survival		Height		Caliper		Volume	
Effect	**DF**	F	p	F	p	F	p	F	p
Stock	1,12	1.83	.2006	11.18	.0059	13.52	.0032	18.29	.0011
Fertilizer	1,12	0.02	.8829	2.23	.1613	0.23	.6437	0.02	.8821

Stock*Fert	1,12	0.09	.7686	1.63	.2252	0.21	.6537	0.48	.5002
Least-Square Means									
Styro 20				73.0	a	1.68	a	250	a
Styro 8				62.1	b	1.35	b	138	b

F and p values from ANOVA for Boise Douglas-fir non-fertilized seedlings

		Survival		Height		Caliper		Volume	
Effect	**DF**	F	p	F	p	F	p	F	p
Stock	3,12	7.20	.0051	4.50	.0246	7.08	.0054	6.66	.0067
Least-Square Means									
1+1		86	a	86.3	a	1.98	a	392	a
Plug+1		78	ab	80.2	ab	1.96	a	362	a
Styro 20		55	ab	72.9	ab	1.68	ab	241	ab
Styro 8		48	b	63.3	b	1.35	b	135	b

F and p values from ANOVAs for Roseburg Douglas-fir bareroots

		Survival		Height		Caliper		Volume	
Effect	**DF**	F	p	F	p	F	p	F	p
Stock	1,16	36.4	<.0001	30.1	<.0001	13.05	.0023	15.54	.0012
Fertilizer	1,16	4.87	.0422	1.13	.3029	0.94	.3456	0.42	.5277
Stock*Fert	1,16	0	.9702	2.53	.1302	1.11	.3084	0.75	.3980
Least-Square Means									
1+1		69	a	57.8	a	1.73	a	196	a
Plug+1		25	b	42.0	b	1.33	b	88	b
Fertilized		39	b						
Nonfert		55	a						

F and p values from ANOVAs for Roseburg Douglas-fir plugs

		Survival		Height		Caliper		Volume	
Effect	**DF**	F	p	F	p	F	p	F	p
Stock	1,12	4.86	.0424	3.35	.0922	0.52	.4860	0.31	.5853
Fertilizer	1,12	8.63	.0096	0.34	.5687	0.91	.3600	1.12	.3102
Stock*Fert	1,12	13.30	.0022	0.03	.8756	1.89	.1941	2.20	.1636
Least-Square Means									
Styro 20 Fert		4	b						
Styro 20 NF		6	b						

Styro 8 Fert		37	a						
Styro 8 NF		2	b						

F and p values from ANOVA for Roseburg Douglas-fir non-fertilized seedlings

		Survival		Height		Caliper		Volume	
Effect	**DF**	F	p	F	p	F	p	F	p
Stock	3,13	37.6	<.0001	7.77	.0032	10.23	.0010	10.84	.0008
Least-Square Means									
1+1		77	a	56.9	a	1.73	a	192	a
Plug+1		33	b	45.3	b	1.42	a	102	a
Styro 20		6	c	39.4	b	0.74	b	22	b
Styro 8		2	c	33.1	b	0.61	b	13	b

F and p values from ANOVAs for SPI Douglas-fir bareroot

		Survival		Height		Caliper		Volume	
Effect	**DF**	F	p	F	p	F	p	F	p
Stock	1,16	20.32	.0004	4.94	.0410	0.0	.9539	1.22	.2857
Fertilizer	1,16	0.01	.9307	0.67	.4257	1.42	.2515	2.21	.1567
Stock*Fert	1,16	0.01	.9307	0.08	.7810	0.04	.8453	0.12	.7325
Least-Square Means									
1+1		62	a	104.4	a				
Plug+1		41	b	92.4	b				

F and p values from ANOVAs for SPI Douglas-fir plugs

		Survival		Height		Caliper		Volume	
Effect	**DF**	F	p	F	p	F	p	F	p
Stock	1,16	0.0	1.00	1.64	.2191	2.35	.1445	2.65	.1231
Fertilizer	1,16	2.02	.1740	0.43	.5221	1.79	.2001	0.73	.4056
Stock*Fert	1,16	0.13	.7267	0.93	.3499	1.93	.1835	1.08	.3139

F and p values from ANOVA for SPI Douglas-fir non-fertilized seedlings

		Survival		Height		Caliper		Volume	
Effect	**DF**	F	P	F	p	F	p	F	p
Stock	3,16	4.63	.0163	2.44	.1024	4.77	.0147	2.89	.0680
Least-Square Means									
1+1		62	a			2.32	a[1]		

Plug+1		41	ab			2.34	a		
Styro 20		37	b			1.75	a		
Styro 8		39	ab			1.73	a		

[1]Adjusted probabilities result in p values>0.05 for means comparisons. Lowest p value is 0.0833 for Plug+1 and Styro 8 comparison

F and p values from ANOVAs for Boise ponderosa pine bareroots

		Survival		Height		Caliper		Volume	
Effect	**DF**	F	p	F	p	F	p	F	p
Stock	1,16	12.45	.0028	27.34	<.0001	5.51	.0321	11.02	.0043
Fertilizer	1,16	0.75	.3996	5.40	.0337	0.71	.4104	2.07	.1696
Stock*Fert	1,16	0.75	.3996	0.05	.8211	0.20	.6579	0.18	.6739
Least-Square Means									
1+1		100	a	129.8	b	4.93	b	3476	b
Plug+1		98	b	146.2	a	5.47	a	4603	a
Fert				141.4	a				
No Fert				134.2	b				

F and p values from ANOVAs for Boise ponderosa pine plugs

		Survival		Height		Caliper		Volume	
Effect	**DF**	F	p	F	p	F	p	F	p
Stock	1,16	0.08	.7769	16.43	.0009	13.01	.0024	21.55	.0003
Fertilizer	1,16	1.26	.2789	0.38	.5480	1.09	.3112	1.33	.2658
Stock*Fert	1,16	0.01	.9121	0.03	.8743	0.07	.7879	0.04	.8373
Least-Square Means									
Styro 20				110.8	a	4.10	a	2117	a
Styro 8				97.4	b	3.51	b	1324	b

F and p values from ANOVA for Boise ponderosa pine non-fertilized seedlings

		Survival		Height		Caliper		Volume	
Effect	**DF**	F	p	F	p	F	p	F	P
Stock	3,16	1.73	.2004	35.2	<.0001	21.8	<.0001	27.6	<.0001
Least-Square Means									
1+1				126.8	a	4.79	b	3212	a

Plug+1				142.0	a	5.43	a	4386	a
Styro 20				109.4	b	4.03	bc	2028	b
Styro 8				96.7	c	3.41	c	1243	c