

Improving the Establishment and Growth of Douglas-fir and White Fir On Dry Sites Through Fertilization and Stock Type

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Objectives: (1) To determine the partial contributions of stock size and fertilization to Douglas-fir and white fir survival, growth and total above ground biomass on dry sites in the interior Sierra Cascade region of northern California and southwest Oregon under vegetation-free conditions. (2) To determine the partial contributions of stock size and fertilization on initial root growth and total root volume (dry weights) after the first growing season in the field. (3) To determine differences attributable to site based on low and high precipitation zones.

Douglas-fir and white fir seedlings in four stock sizes will be subjected to two fertilization regimes and out-planted on three sites. Treatments will be replicated four times per site. Twenty-five trees will be planted per replication. Assume 3 years complete vegetation control for all treatments. Root volume measurements will be made at time of lifting and at the end of the first growing season in the field. Trees will be measured (ground-line diameter, height, survival) when planted and at years 1, 2, 3, 4, and 5. Foliar nutrient samples and dry weights per 100 needles will be collected and analyzed at years 1, 3, and 5.

Status: Seedlings were grown at Pelton Reforestation, Cal Forest Nurseries, PRT, IFA Nurseries, and Fowler Nursery for outplanting in the spring of 2003. Co-op members in this study include Roseburg Resources, Sierra Pacific Industries, and Boise Cascade.

Plot establishment and lay-out was completed on the first two sites in the fall of 2002 and on the third site prior to planting in February, 2003.

All three sites were planted during March, 2003. All sites had adequate soil moisture at time of planting and there was no snow on the ground. Each site received substantial moisture following the planting, so the seedlings got off to a good start.

The sites were set up according to the revised specifications: 10' X 10' spacing, 56 trees/plot, etc.

Preplanting measurements of caliper (1 inch above ground line) and height (from ground line to tip of bud) were taken on 50 randomly selected seedlings from each stock type/fertilization treatment for every species that was to be planted on each company's land. Twenty of these seedlings were taken back to Redding where they were oven dried and root/shoot ratios determined.

The two bare root stock types that were to receive the fertilization treatment were fertilized at the time of planting by placing one Wil-Gro briquette (9-9-4) in the bottom of the planting hole.

Boise Cascade

Two clearcut blocks were used for this installation – one for the pine and one for the Doug-fir. Both blocks are located near the town of Prospect, OR,

which is about 50 miles east of Medford, OR.

The plug-1s and the 1-1s were shovel planted; all other stock types were planted with hoedads. All pine stock looked fine, although the plug-1s were very large. With the Doug-fir, the plug-1s and the styro 8 unfertilized were slightly yellow; the rest of the stock types looked fine.

The pine block has 5 replications of each treatment. There was just enough room in the Doug-fir block for 4 replications of each treatment.

Sierra Pacific Industries

Two clearcut blocks were used at this site, also, one for the Doug-fir and one for the white fir. The blocks are located near the town of Feather Falls, CA which is east of Oroville. All stock types were shovel planted. The styro 8 Doug-fir (both fertilized and unfertilized) were slightly yellow.

The Doug-fir block has 5 replications of each treatment.

The 1-1 stock type for the white fir looked very poor. Size variability was large. There were not enough good trees to plant all the replications needing 1-1s, so only the 5 replications of the unfertilized treatment were planted. The 5 plots set up for the 1-1 fertilized treatment were left unplanted.

All styro 20 white fir were fertilized despite the boxes being labeled as fertilized or unfertilized. All boxes labeled as unfertilized were opened and sampled: all were fertilized. The boxes labeled as fertilized were also fertilized. The planting was done as if the labels on

the boxes were correct – seedlings from the boxes labeled unfertilized were planted in the 5 plots designated for the unfertilized treatment and seedlings from boxes labeled fertilized were planted in the 5 plots set up for that treatment. In reality, these 10 plots have the same treatment = fertilized styro 20 white fir.

The white fir styro 8 and plug-1 treatments each have 5 replications.

Roseburg Resources

Both species (Doug-fir and white fir) were planted in the same clearcut at this site. The planting site is located near Nubieber, CA.

All stock types were shovel planted.

The Doug-fir has 5 replications of each treatment.

As was the case with the stock for the Sierra Pacific site, the 1-1 white fir Roseburg stock looked very poor. There were not enough good seedlings to plant all replications needing 1-1s, so only the 5 plots of the unfertilized treatment were planted. The 5 plots designated to receive fertilized 1-1s were left unplanted.

The white fir plug-1 and styro 8 treatments each have 5 replications.

None of the styro 20 white fir were fertilized even though some of the boxes were labeled as being fertilized. A Wil-Gro briquette was placed in the bottom of the planting hole in the 5 plots designated to receive fertilized styro 20s. The 5 plots designated to receive unfertilized styro 20s received the proper seedlings.

In July, foliar samples for each species/stock type/treatment combination from all three study sites were collected. These samples were sent to the J.R. Peters Laboratory for nutrient analysis. In addition, dry weights per 100 needles were determined from these samples.

In October, representative seedlings from each species/stock type/treatment combination were dug up from each of the three sites. These samples were taken to Redding where they were washed and oven dried. Root/shoot ratios were determined from this procedure.

First year growth measurements were taken on all three sites during October – December. Measurements taken included caliper (at 1 inch above ground line) and height (ground line to tip of bud). Seedling volume will be calculated from these measurements. Survival was noted at this time as well as any pest problems.

The results from the various measurement and data collection operations that were done in 2003 are reported in nine tables found at the end of this narrative.

Table 1 shows dry weights of 100 needles by treatment and species collected from the sites at the end of the first growing season in August, 2003. In general, the fertilized treatments had the larger values when compared on a stock type basis.

Table 2 shows plant tissue analysis results for selected macro nutrients. These samples were collected at the end of the first growing season in August,

2003. Other macro nutrients and a full set of micro nutrients were run. A full data set is on file at PSW in Redding and is available on request.

Table 3 shows seedling survival by treatment and species at the end of the first growing season in August, 2003. The survival of the pine on the Boise Cascade site ranged from 94-100%; the Doug-fir ranged from 71-100%. The Doug-fir on the Roseburg site ranged from 38-96%; the Doug-fir on the Sierra Pacific site ranged from 42-68%. On the Roseburg site in 3 out of the 4 stock types, the seedlings in the unfertilized treatment had better survival than those in the fertilized treatment. This was reversed on the Sierra Pacific site where in 3 out of the 4 stock types, the seedlings in the fertilized treatment had a higher survival rate than did their unfertilized counterparts. On the Boise pine site, the seedlings that were fertilized generally had a lower survival rate than did the unfertilized ones in the various stock types. On the Boise Doug-fir site in two of the stock types the fertilized seedlings had a better survival rate than the unfertilized ones. In the remaining two stock types, the unfertilized seedlings survived better. There was only minor browsing damage to the seedlings on the Roseburg and Sierra Pacific sites. The Doug-fir on the Boise site showed browsing damage on 12 percent of the seedlings. The pine on the Boise site showed little browsing.

Table 4 shows root/shoot ratios by treatment and species at the time of lifting in February, 2003. Significant differences between treatments are indicated. The bare root fertilized treatments have no values as these

treatments were fertilized at the time of planting.

Table 5 shows root/shoot ratios by treatment and species at the end of the first growing season in October, 2003. Significant differences are indicated by letters following the numerical values. On the Boise and Roseburg Doug-fir sites there were no significant differences between the treatments. There are significant differences between treatments on the Sierra Pacific site and the Boise pine site.

Table 6 shows values for caliper, height, and volume at time of lifting in February, 2003. Significant differences within a stock type between fertilized and unfertilized seedlings are indicated. The 1-1 fertilized and the plug 1 fertilized treatments have no values as these treatments were fertilized at the time of planting. Volume is calculated by multiplying squared caliper by height. There were no significant differences in volume between fertilized and unfertilized treatments within a stock type for any species or land owner. All seedlings started out equal at planting time.

Table 7 shows values for caliper, height, and volume at the end of the first growing season, October, 2003. Significant differences within a stock type between fertilized and unfertilized seedlings are shown by letters following the numerical values. Only Boise Cascade pine showed any significant differences in volume within a stock type between fertilized and unfertilized seedlings. Plug 1 fertilized seedlings were significantly larger than their counterpart unfertilized ones. With this exception, as at time of lifting, at the end

of the first growing season, the seedlings within a stock type whether fertilized or not were still equal.

Table 8 shows significant differences between treatments for caliper, height, and volume at the time of lifting in February, 2003. Volume is calculated by multiplying squared caliper by height. Volume for the bare root treatments (1-1 fertilized and plug 1 fertilized) are missing as these two treatments were fertilized at time of planting. For all ownerships and all species, volume is always significantly higher for the bare root treatments than for the container treatments. With the exception of the Doug-fir on the Roseburg site where there is no difference, in all ownerships and species plug 1 volume is always significantly higher than 1-1 volume.

Table 9 shows significant differences between treatments for caliper, height, and volume at the end of the first growing season in October, 2003. As was the status at the time of lifting, for all ownerships and all species, volume is always significantly higher for the bare root treatments than for the container treatments. But different from the results at the time of lifting, in the bare root treatments, plug 1 volume is not always significantly higher than 1-1 volume at the end of the first growing season. By land owners, the treatments with the most and the least volume were: Boise Cascade pine = plug 1 fertilized and styro 8 fertilized; Boise Cascade Doug-fir = 1-1 fertilized and styro 8 fertilized; Sierra Pacific Doug-fir = plug 1 fertilized & nonfertilized and styro 8 fertilized; Roseburg Doug-fir = 1-1 fertilized and styro 8 unfertilized.

This study is scheduled for remeasurement at the end of its second growing season which would be the fall of 2004. In general, at the end of the first growing season, the treatments that had the biggest seedlings at the time of planting still have the biggest seedlings. The fertilized seedlings are not always larger than their unfertilized counterparts. Considering volume only, in about 60 percent of the time are fertilized seedlings larger than their counterpart unfertilized ones. Since several of the seedlings, although still alive, were not very thrifty when measured in October 2003, survival could continue to be an issue on the Roseburg and Sierra Pacific sites for the container treatments, both fertilized and unfertilized.

2004: Second year growth measurements were taken on all sites during the fall of 2004. Measurements taken included caliper (at one inch above ground line) and height (ground line to tip of bud). Seedling volume will be calculated from these measurements. Survival was noted at this time as well as pest problems.

Survival of container and plug-1 stock was poor on the Roseburg site (**Table 10**). Survival of bareroot Douglas-fir was significantly greater than container stock at the Boise site. At the Sierra Pacific site, survival of 1+1 stock was greater than the other three types.

Survival of ponderosa pine was good for all stock types (> than 92%).

Overall, there were no effects of fertilization on survival, although the styro 8 fertilized seedlings at Roseburg

has greater survival than the unfertilized styro 8 seedlings.

Significant differences among the Douglas-fir stock types were found for height, caliper, and volume, and rankings varied by site (**Table 11**). At the Roseburg and Boise Cascade sites, the 1+1 bareroot seedlings were larger than the plug-1; at the Sierra Pacific site, the 1+1 and plug-1 stock were similar in size. At all three sites, the container stock tended to be somewhat smaller than the transplant stock, although there were instances where the differences were not significant.

In general, there were no significant effects of fertilization on the Douglas-fir. As with survival, at the Roseburg site, the fertilized styro 8 seedlings were significantly larger in caliper and volume than the unfertilized seedlings.

For ponderosa pine, stock types were significantly different from each other for height, caliper, and volume (**Table 12**). The rankings, from largest to smallest, were plug-1, 1+1, styro 20, and styro 8.

For the pine, fertilized seedlings were significantly taller and larger in caliper and volume than unfertilized seedlings. At this point in time, the differences are slight.

Third year growth measurements will be taken in the fall of 2005. Survival of the styro 20 and plug-1 stock on the Roseburg site is very low. These treatments may fall out as viable treatments after the 2005 remeasurements.

Table 1—Dry weight values of 100 needles from seedlings of the Stock Type/Fertilization Proposal at end of the first growing season, August, 2003.

	Roseburg Doug-fir	SPI Doug-fir	Boise Doug-fir	Boise Pine
	Dry Weight/100 needles (grams)			
Plug 1 No/Fert.	0.16	0.18	0.24	1.68
Plug 1 Fert.	0.17	0.21	0.18	1.92
1-1 No/Fert	0.19	0.24	0.23	1.74
1-1 Fert.	0.19	0.23	0.26	2.12
Styro 8 No/Fert.	0.14	0.21	0.22	1.68
Styro 8 Fert.	0.20	0.23	0.24	1.57
Styro 20 No/Fert.	0.15	0.18	0.21	2.49
Styro 20 Fert.	0.19	0.23	0.28	2.83

Table 2—Plant tissue analysis results for selected macro-nutrients listed by the treatments showing the high and low values for seedlings of the Stock Type/Fertilization Proposal at the end of the first growing season, August, 2003.

	Nitrogen	Phosphorus	Potassium
	Percentage		
Boise Doug-fir			
Plug 1 F	2.25	Plug 1 N/F	0.188
St 8 F	1.50	1-1 F	0.109
		St 8 N/F	0.822
		Plug 1 N/F	0.511
Boise Pine			
St 8 F	1.59	St 20 F	0.194
1-1 N/F	1.05	1-1 F	0.134
		Plug 1 N/F	1.090
		1-1 F	0.972
SPI Doug-fir			
Plug 1 F	2.13	Plug 1 F	0.182
St 20 F	1.49	1-1 F	0.105
		St 8 N/F	0.738
		Plug 1 F	0.516
Roseburg Doug-fir			
Plug 1 F	2.64	St 20 N/F	0.190
St 8 N/F	1.47	1-1 F	0.121
		St 20 N/F	0.663
		1-1 F	0.519

F = fertilized; N/F = not fertilized.

Table 3—Seedling Survival by treatment and species for the Stock Type/Fertilization Proposal at end of first growing season, August, 2003.

	Roseburg Doug-fir	SPI Doug-fir	Boise Doug-fir	Boise Pine
	Percent Survival			
Plug 1 No/Fert.	61	47	85	98
Plug 1 Fert.	46	42	77	98
1-1 No/Fert	96	65	97	100
1-1 Fert.	86	68	100	99
Styro 8 No/Fert.	49	42	75	95
Styro 8 Fert.	82	56	71	94
Styro 20 No/Fert.	44	53	70	98
Styro 20 Fert.	38	58	78	94

Table 4 – Root/shoot ratios by treatment and species for seedlings from the Stock Type/Fertilization Proposal at time of lifting, February, 2003.

	Roseburg Doug-fir	SPI Doug-fir	Boise Doug-fir	Boise Pine
Ratio				
Plug 1 No/Fert.	1.61ab	1.58bc	1.40c	1.51b
Plug 1 Fert.	*	*	*	*
1-1 No/Fert.	1.91a	1.52c	1.90a	2.07a
1-1 Fert.	*	*	*	*
Styro 8 No/Fert.	1.42b	1.60bc	1.89a	1.56b
Styro 8 Fert.	1.38b	2.01ab	1.69abc	1.21bc
Styro 20 No/Fert.	1.74ab	2.12a	1.80ab	1.08c
Styro 20 Fert.	1.85a	2.20a	1.47bc	1.04c

* Fertilized at time of planting.

For land-owner and species, treatment means in each column followed by the same letter do not differ significantly at the 0.05 level.

Table 5 – Root/shoot ratios by treatment and species for seedlings from the Stock Type/Fertilization Proposal at end of first growing season, October, 2003.

	Roseburg Doug-fir	SPI Doug-fir	Boise Doug-fir	Boise Pine
Ratio				
Plug 1 No/Fert.	1.89a	1.86ab	1.72a	1.87b
Plug 1 Fert.	1.84a	1.55b	1.72a	1.71b
1-1 No/Fert.	1.82a	1.49b	1.73a	2.06b
1-1 Fert.	1.66a	1.59ab	1.94a	1.83b
Styro 8 No/Fert.	1.46a	1.65ab	1.87a	3.04a
Styro 8 Fert.	1.62a	2.25a	1.83a	2.47ab
Styro 20 No/Fert.	2.01a	1.60ab	1.92a	2.05b
Styro 20 Fert.	2.00a	1.61ab	2.00a	2.48ab

For land-owner and species, treatment means in each column followed by the same letter do not differ significantly at the 0.05 level.

Table 6—Values for caliper, height, and volume of seedlings for the Stock Type/Fertilization Proposal at time of lifting, February, 2003.

Boise Pine	Treatment	Caliper (cm)	Height (cm)	Volume (cm ³)
	1-1 No Fertilizer	1.05	24.51	29.93
1-1 Fertilizer	*	*	*	
Plug -1 No Fertilizer	1.53	36.04	89.56	
Plug -1 Fertilizer	*	*	*	
Styro 8 No Fertilizer	0.55b	25.82b	8.03a	
Styro 8 Fertilizer	0.43a	17.33a	3.37a	
Styro 20 No Fertilizer	0.54a	22.35a	6.72a	
Styro 20 Fertilizer	0.57a	20.46a	6.99a	

Boise Doug-fir	Treatment	Caliper (cm)	Height (cm)	Volume (cm ³)
	1-1 No Fertilizer	0.97	43.83	44.73
1-1 Fertilizer	*	*	*	
Plug -1 No Fertilizer	1.17	37.97	53.76	
Plug -1 Fertilizer	*	*	*	
Styro 8 No Fertilizer	0.37a	31.82a	4.46a	
Styro 8 Fertilizer	0.35a	29.27a	3.82a	
Styro 20 No Fertilizer	0.57a	37.57a	12.84a	
Styro 20 Fertilizer	0.56a	42.17b	13.94a	

* Fertilized at time of planting.

This table shows significant differences within a stock type between fertilized and non-fertilized seedlings. For land-owner and species, treatment means within a stock type followed by the same letter do not differ significantly at the 0.05 level.

Table 6 contd.

Roseburg Doug-fir		Caliper (cm)	Height (cm)	Volume (cm ³)
Treatment				
1-1 No Fertilizer		1.06	45.72	57.02
1-1 Fertilizer		*	*	*
Plug -1 No Fertilizer		1.12	35.76	49.50
Plug -1 Fertilizer		*	*	*
Styro 8 No Fertilizer		0.37a	22.11a	3.12a
Styro 8 Fertilizer		0.37a	23.00a	3.22a
Styro 20 No Fertilizer		0.56a	32.30a	10.73a
Styro 20 Fertilizer		0.52a	34.27a	9.73a
SPI Doug-fir		Caliper (cm)	Height (cm)	Volume (cm ³)
Treatment				
1-1 No Fertilizer		0.96	35.08	34.46
1-1 Fertilizer		*	*	*
Plug -1 No Fertilizer		1.17	39.70	63.24
Plug -1 Fertilizer		*	*	*
Styro 8 No Fertilizer		0.34a	21.86a	2.55a
Styro 8 Fertilizer		0.34a	26.13b	3.12a
Styro 20 No Fertilizer		0.54a	35.54a	11.01a
Styro 20 Fertilizer		0.55a	35.47a	11.28a

* Fertilized at time of planting.

This table shows significant differences within a stock type between fertilized and non-fertilized seedlings. For land-owners and species, treatment means within a stock type followed by the same letter do not differ significantly at the 0.05 level.

Table 7—Values for caliper, height, and volume of seedlings for the Stock Type/Fertilization Proposal at end of the first growing season, October, 2003.

Boise Pine	Treatment	Caliper	Height	Volume
		(cm)	(cm)	(cm ³)
	1-1 No Fertilizer	1.38a	30.17a	65.85a
	1-1 Fertilizer	1.49b	31.45a	77.08a
	Plug -1 No Fertilizer	1.65a	42.87a	125.37a
	Plug -1 Fertilizer	1.79b	45.11a	154.52b
	Styro 8 No Fertilizer	0.85a	30.11a	24.70a
	Styro 8 Fertilizer	0.83a	27.24a	20.29a
	Styro 20 No Fertilizer	1.04a	35.19a	41.19a
	Styro 20 Fertilizer	1.07a	33.79a	44.37a

Boise Fir	Treatment	Caliper	Height	Volume
		(cm)	(cm)	(cm ³)
	1-1 No Fertilizer	1.06a	44.56a	55.46a
	1-1 Fertilizer	1.10a	45.96a	60.95a
	Plug -1 No Fertilizer	1.07a	35.24a	46.84a
	Plug -1 Fertilizer	1.17b	36.41a	55.17a
	Styro 8 No Fertilizer	0.62a	31.43b	13.39a
	Styro 8 Fertilizer	0.54a	23.66a	7.97a
	Styro 20 No Fertilizer	0.76a	41.83a	26.30a
	Styro 20 Fertilizer	0.76a	39.20a	25.16a

This table shows significant differences within stock types between fertilized and non-fertilized seedlings. For land-owners and species, treatment means within a stock type followed by the same letter do not differ significantly at the 0.05 level.

Table 7 contd.

**Roseburg
Doug-fir**

Treatment	Caliper (cm)	Height (cm)	Volume (cm ³)
1-1 No Fertilizer	1.15a	45.53a	67.33a
1-1 Fertilizer	1.21a	48.91a	78.44a
Plug -1 No Fertilizer	1.13a	35.24a	55.21a
Plug -1 Fertilizer	1.06a	31.02a	39.92a
Styro 8 No Fertilizer	0.52a	23.64a	7.19a
Styro 8 Fertilizer	0.61a	27.49a	11.26a
Styro 20 No Fertilizer	0.69a	34.81a	18.57a
Styro 20 Fertilizer	0.64a	34.38a	16.00a

**SPI
Doug-fir**

Treatment	Caliper (cm)	Height (cm)	Volume (cm ³)
1-1 No Fertilizer	1.02a	40.88a	47.32a
1-1 Fertilizer	1.07a	39.75a	51.51a
Plug -1 No Fertilizer	1.20a	45.19a	77.01a
Plug -1 Fertilizer	1.28a	43.38a	78.92a
Styro 8 No Fertilizer	0.58a	26.59a	9.93a
Styro 8 Fertilizer	0.57a	26.96a	9.76a
Styro 20 No Fertilizer	0.67a	32.59a	16.45a
Styro 20 Fertilizer	0.79b	39.19b	26.40a

This table shows significant differences within stock types between fertilized and non-fertilized seedlings. For land-owners and species, treatment means within a stock type followed by the same letter do not differ significantly at the 0.05 level.

Table 8—Values for caliper, height, and volume of seedlings for the Stock Type/Fertilization Proposal at time of lifting, February, 2003.

Boise Pine	Treatment	Caliper (cm)	Height (cm)	Volume (cm³)
	1-1 No Fertilizer	1.05b	24.51bc	29.93b
	1-1 Fertilizer	*	*	*
	Plug -1 No Fertilizer	1.53a	36.04a	89.56a
	Plug -1 Fertilizer	*	*	*
	Styro 8 No Fertilizer	0.55c	25.82b	8.03c
	Styro 8 Fertilizer	0.43d	17.33e	3.37c
	Styro 20 No Fertilizer	0.54c	22.35cd	6.72c
	Styro 20 Fertilizer	0.57c	20.46d	6.99c
Boise Doug-fir	Treatment	Caliper (cm)	Height (cm)	Volume (cm³)
	1-1 No Fertilizer	0.97b	43.83a	44.73b
	1-1 Fertilizer	*	*	*
	Plug -1 No Fertilizer	1.17a	37.97b	53.76a
	Plug -1 Fertilizer	*	*	*
	Styro 8 No Fertilizer	0.37d	31.82c	4.46d
	Styro 8 Fertilizer	0.35d	29.27c	3.82d
	Styro 20 No Fertilizer	0.57c	37.57b	12.84c
	Styro 20 Fertilizer	0.56c	42.17a	13.94c

* Fertilized at time of planting.

This table shows significant differences between treatments. For land-owner and species, treatment means in each column followed by the same letter do not differ significantly at the 0.05 level.

Table 8 contd.

Roseburg Doug-fir		Caliper (cm)	Height (cm)	Volume (cm³)
Treatment				
1-1 No Fertilizer		1.06a	45.72a	57.02a
1-1 Fertilizer		*	*	*
Plug -1 No Fertilizer		1.12a	35.76b	49.50a
Plug -1 Fertilizer		*	*	*
Styro 8 No Fertilizer		0.37c	22.11c	3.12b
Styro 8 Fertilizer		0.37c	23.00c	3.22b
Styro 20 No Fertilizer		0.56b	32.30b	10.73b
Styro 20 Fertilizer		0.52b	34.27b	9.73b
SPI Doug-fir		Caliper (cm)	Height (cm)	Volume (cm³)
Treatment				
1-1 No Fertilizer		0.96b	35.08b	34.46b
1-1 Fertilizer		*	*	*
Plug -1 No Fertilizer		1.17a	39.70a	63.24a
Plug -1 Fertilizer		*	*	*
Styro 8 No Fertilizer		0.34d	21.86d	2.55c
Styro 8 Fertilizer		0.34d	26.13c	3.12c
Styro 20 No Fertilizer		0.54c	35.54b	11.01c
Styro 20 Fertilizer		0.55c	35.47b	11.28c

* Fertilized at time of planting.

This table shows significant differences between treatments. For land-owners and species, treatment means in each column followed by the same letter do not differ significantly at the 0.05 level.

Table 9—Values for caliper, height, and volume of seedlings for the Stock Type/Fertilization Proposal at end of the first growing season, October, 2003.

Boise Pine	Treatment	Caliper	Height	Volume
		(cm)	(cm)	(cm ³)
	1-1 No Fertilizer	1.38d	30.17d	65.85c
	1-1 Fertilizer	1.49c	31.45cd	77.08c
	Plug -1 No Fertilizer	1.65b	42.87a	125.37b
	Plug -1 Fertilizer	1.79a	45.11a	154.52a
	Styro 8 No Fertilizer	0.85f	30.11de	24.70ef
	Styro 8 Fertilizer	0.83f	27.24e	20.29f
	Styro 20 No Fertilizer	1.04e	35.19b	41.49de
	Styro 20 Fertilizer	1.07e	33.79bc	44.37d

Boise Fir	Treatment	Caliper	Height	Volume
		(cm)	(cm)	(cm ³)
	1-1 No Fertilizer	1.06b	44.56a	55.46ab
	1-1 Fertilizer	1.10ab	45.96a	60.95a
	Plug -1 No Fertilizer	1.07b	35.24cd	46.84b
	Plug -1 Fertilizer	1.17a	36.41c	55.17ab
	Styro 8 No Fertilizer	0.62d	31.43d	13.39cd
	Styro 8 Fertilizer	0.54d	23.66e	7.97d
	Styro 20 No Fertilizer	0.76c	41.83ab	26.30c
	Styro 20 Fertilizer	0.76c	39.20bc	25.16c

This table shows significant differences between treatments. For land-owners and species, treatment means in each column followed by the same letter do not differ significantly at the 0.05 level.

Table 9 contd.

**Roseburg
Doug-fir**

Treatment	Caliper (cm)	Height (cm)	Volume (cm ³)
1-1 No Fertilizer	1.15ab	45.53a	67.33ab
1-1 Fertilizer	1.21a	48.91a	78.44a
Plug -1 No Fertilizer	1.13ab	35.24b	55.21bc
Plug -1 Fertilizer	1.06b	31.02bc	39.92c
Styro 8 No Fertilizer	0.52d	23.64d	7.19d
Styro 8 Fertilizer	0.61cd	27.49cd	11.26d
Styro 20 No Fertilizer	0.69c	34.81b	18.57d
Styro 20 Fertilizer	0.64cd	34.38b	16.00d

**SPI
Doug-fir**

Treatment	Caliper (cm)	Height (cm)	Volume (cm ³)
1-1 No Fertilizer	1.02b	40.88ab	47.32b
1-1 Fertilizer	1.07b	39.75b	51.51b
Plug -1 No Fertilizer	1.20a	45.19a	77.01a
Plug -1 Fertilizer	1.28a	43.38ab	78.92a
Styro 8 No Fertilizer	0.58d	26.59d	9.93cd
Styro 8 Fertilizer	0.57d	26.96d	9.76d
Styro 20 No Fertilizer	0.67d	32.59c	16.45cd
Styro 20 Fertilizer	0.79c	39.19b	26.40c

This table shows significant differences between treatments. For land-owners and species, treatment means in each column followed by the same letter do not differ significantly at the 0.05 level.

Table 10 - Percent survival, all sites:

Stock	Fertilized	Douglas-fir			Ponderosa Pine
		Roseburg	SPI	Boise	Boise
1+1	Yes	74.4	61.6	93	99.2
	No	84.0	62.4	90	100
Plug+1	Yes	24.8	40.8	74	96.8
	No	37.6	44.8	77	97.6
Styro 20	Yes	7.2	49.6	69	93.6
	No	9.6	42.4	59	98.4
Styro 8	Yes	52.0	50.4	51	92.8
	No	16.0	40.0	59	93.6

Table 11a - Raw data means and standard errors for Boise Douglas-fir.

Stock	Fertilized	Height (cm)		Caliper (mm)		Volume (cm ³)	
		Mean	SE	Mean	SE	Mean	SE
1+1	Yes	71.9	2.66	18.4	1.23	71.7	9.83
	No	62.7	3.63	16.2	1.10	50.7	10.27
Plug+1	Yes	54.7	5.44	17.2	1.30	51.9	12.71
	No	48.5	2.08	14.9	1.08	33.5	6.36
Styro 20	Yes	52.0	1.32	11.9	0.53	25.0	2.36
	No	52.0	2.20	12.3	0.56	24.0	2.70
Styro 8	Yes	39.2	1.73	10.1	0.76	13.3	2.01
	No	42.8	3.88	9.8	1.03	14.5	3.51

Table 11b - Raw data means and standard errors for SPI Douglas-fir.

Stock	Fertilized	Height (cm)		Caliper (mm)		Volume (cm ³)	
		Mean	SE	Mean	SE	Mean	SE
1+1	Yes	63.5	1.56	17.8	0.74	64.2	6.77
	No	64.1	4.80	17.0	1.39	60.0	13.27
Plug+1	Yes	61.8	2.55	18.1	1.27	61.3	11.83
	No	60.9	2.65	17.5	0.78	57.4	7.78
Styro 20	Yes	60.0	3.82	14.2	1.25	37.4	9.57
	No	50.3	3.89	11.7	0.94	26.1	4.69
Styro 8	Yes	46.8	2.09	11.2	0.84	18.5	3.24
	No	47.9	3.75	11.7	0.90	21.5	4.36

Table 11c - Raw data means and standard errors for Roseburg Douglas-fir

Stock	Fertilized	Height (cm)		Caliper (mm)		Volume (cm ³)	
		Mean	SE	Mean	SE	Mean	SE
1+1	Yes	54.7	0.56	14.2	0.27	32.8	1.95
	No	54.5	1.92	15.1	0.96	39.1	5.69
Plug+1	Yes	38.4	2.06	11.4	0.95	16.8	3.43
	No	41.6	3.32	12.2	0.91	19.6	4.59
Styro 20	Yes	43.0	2.89	8.1	0.62	7.9	1.81
	No	40.8	0.94	8.9	1.00	10.4	2.83
Styro 8	Yes	31.6	1.51	8.2	0.23	6.7	0.72
	No	27.5	1.92	5.9	0.33	2.8	0.43

Table 11d – Boise Douglas-fir: F and p values from ANOVAs.

Effect	DF	Survival		Height		Caliper		Volume	
		F	p	F	p	F	P	F	p
Stock	3,24	20.30	<.0001	22.44	<.0001	23.89	<.0001	22.67	<.0001
Fertilizer	1,24	0.04	.8506	0.53	.4751	1.17	.2902	1.61	.2162
Stock*Fert	3,24	0.99	.4146	2.13	.1231	0.96	.4254	1.09	.3719
Least-Square Means									
1+1		91.9	a	66.8	a	17.1	a	57.3	a
Plug+1		76.1	b	51.6	b	16.1	b	40.0	ab
Styro 20		64.2	c	52.0	bc	12.2	c	24.5	bc
Styro 8		55.4	c	41.6	c	10.1	c	14.0	c

Table 11e – Sierra Pacific Douglas-fir: F and p values from ANOVAs.

Effect	DF	Survival		Height		Caliper		Volume	
		F	p	F	p	F	P	F	p
Stock	3,32	4.68	.0080	10.11	<.0001	18.82	<.0001	16.00	<.0001
Fertilizer	1,32	0.61	.4399	1.16	.2889	1.20	.2805	0.57	.4545
Stock*Fert	3,32	0.72	.5466	1.17	.3367	0.93	.4362	0.52	.6716
Least-Squared Means									
1+1		62.2	a	63.4	a	17.2	a	58.1	a
Plug+1		42.7	b	61.1	a	17.7	a	56.2	a
Styro 20		45.7	b	54.4	a	12.7	b	28.2	b
Styro 8		45.0	b	47.0	b	11.3	b	18.5	c

Table 11f – Roseburg Douglas-fir: F and p values from ANOVAs.

Effect	DF	Survival		Height		Caliper		Volume	
		F	p	F	p	F	p	F	p
Stock	3,31 ¹	88.21	<.0001	58.47	<.0001	62.20	<.0001	63.33	<.0001
Fertilizer	1,31	0.79	.3816	0.25	.6193	0.37	.5475	0.48	.4957
Stock*Fert	3,31	12.77	<.0001	1.21	.3222	4.48	.0100	4.34	.0115
Least-Square Means									
1+1		79.2	a	54.6	a	14.6	a	34.9	a
Plug+1		31.2	b	40.4	b	11.8	b	17.2	b
Styro 20		8.4	c	42.0	b	8.5	c	8.5	c
Styro 8		34.0	b	29.8	c	7.1	d	4.3	d
1+1	Fert	74.4	a			14.2	a	32.5	ab
	No	84.0	a			15.0	a	37.5	a
Plug+1	Fert	24.8	bc			11.5	abc	16.1	bc
	No	37.6	b			12.2	ab	18.5	bc
Styro 20	Fert	7.2	d			8.2	cde	7.6	cd
	No	9.6	d			8.9	bcde	9.5	c
Styro 8	Fert	52.0	b			8.3	d	6.7	d
	No	16.0	cd			6.0	e	2.8	e

Due to the low survival of container stock at the Roseburg site, data were re-analyzed with only the bareroot stock.

Table 11g – Roseburg Douglas-fir: F and p values from ANOVAs.

Effect	DF	Height		Caliper		Volume	
		F	p	F	p	F	p
Stock	1,16	45.45	<.0001	10.77	.0047	15.95	.0010
Fertilizer	1,16	0.96	.3410	0.86	.3673	0.78	.3895
Stock*Fert	1,16	0.97	.3390	0.02	.8950	0.01	.8950
Least-Square Means							
1+1		54.7	a	14.7	a	35.3	a
Plug+1		40.5	b	11.9	b	17.7	b

Treatment means in each column followed by the same letter are not significantly different at the 0.05 level.

Table 12a - Raw data means and standard errors for Boise Ponderosa Pine.

Stock	Fertilized	Height (cm)		Caliper (mm)		Volume (cm ³)	
		Mean	SE	Mean	SE	Mean	SE
1+1	Yes	77.9	2.23	31.4	0.73	221.2	16.04
	No	72.2	0.76	27.8	1.12	168.8	11.91
Plug+1	Yes	90.9	2.28	36.2	1.72	332.8	37.31
	No	84.0	1.67	34.1	1.50	276.3	29.67
Styro 20	Yes	65.3	1.34	26.1	0.68	135.6	10.58
	No	62.9	1.26	23.5	0.77	102.9	7.51
Styro 8	Yes	56.2	0.56	20.7	0.94	72.1	6.93
	No	54.2	2.26	19.7	1.29	63.3	8.93

Table 12a – Boise Cascade ponderosa pine: F and p values from ANOVAs.

Effect	DF	Survival		Height		Caliper		Volume	
		F	p	F	p	F	p	F	p
Stock	3,32	4.55	.0092	129.99	<.0001	59.20	<.0001	77.76	<.0001
Fertilizer	1,32	2.22	.1456	10.82	.0025	7.66	.0093	9.11	.0050
Stock*Fert	3,32	0.96	.4242	0.39	.7622	0.32	.8094	0.15	.9262
Least-Square Means									
1+1		100	a	74.9	b	29.5	b	191.0	b
Plug+1		98.7	ab	87.3	a	35.0	a	295.9	a
Styro 20		97.3	ab	64.0	c	24.7	c	116.6	c
Styro 8		95.4	b	55.2	d	20.1	d	65.4	d
Fertilized				71.3	a	27.9	a	160.9	a
No Fert				67.4	b	25.6	b	129.0	b

Treatment means in each column followed by the same letter are not significantly different at the 0.05 level.