Technical Note

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A Different Look at the Cooperative Animal Damage Study

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Abstract

The Coos Bay District of the Bureau of Land Management participated in a Northwest-wide Cooperative Animal Damage Survey (CADS) initiated in the 1963-64 planting season. In 1979, data from the ten existing plots which were established on the District were analyzed. More importantly, the plots themselves were relocated and measured. The original data indicate that at the end of the first five growing seasons, the caged seedlings overall had 10 percent greater survival and 1.0 feet greater height growth when compared to the uncaged seedlings. The 1979 remeasurement (16 growing seasons after field planting) indicates the caged seedlings had a 9 percent greater survival and 2.3 feet greater height growth when compared to the uncaged seedlings. Though volume differences between plots was highly variable, overall, caged seedlings currently have produced 20 percent more volume than uncaged seedlings. Other observations comparing seedling performance, etc., with other CADS plots and the District's tree improvement program are included.

A DIFFERENT LOOK AT THE COOPERATIVE ANIMAL DAMAGE STUDY

The concept of the Cooperative Animal Damage Survey (CADS) emerged from the Wildlife Problems Committee of the Northwest Forest Pest Action Council in the early 1960s. With assistance from the Pacific Northwest Forest and Range Experiment Station, CADS was designed to study the kind, amount, distribution, and significance of damage by mammals and birds to Douglas-fir and Ponderosa pine plantations in Oregon and Washington. Actual plantings were made during the planting season of 1963-64 and 1964-65. Fourteen major forest landholders, both public and private, cooperated to establish 194 sampling plots during those two years. A summary of the results of this study was reported in 1969 by Black, Dimock and others (1).

Each sampling plot consisted of 110 planted bare-root seedlings, 10 of which were to be caged to protect them from animal caused injuries. Caged seedlings were to be controls for evaluating survival and growth of unprotected seedlings. Occurrences of animal damage and height growth were recorded annually for five years following planting. Each plot consisted of four rows of staked seedlings

that formed a long, narrow, rectangular configuration. Seedlings were individually marked with numbered stakes. Each plot was referenced with a 4-inch square post near an easily locatable point. In general, seedlings were planted on an 8-foot spacing.

As mentioned, the seedlings planted in the study were Douglas-fir and Ponderosa pine. Some were two years old (2-0's or 1-1's) and some were three years old (2-1's or 3-0's). Seedlings planted in a given plot were of the same type and age class. The effect that planting different types and age classes had on overall survival and growth is not known, but knowing that survival and growth are generally better with larger seedlings (of the same quality), it's likely there was a difference.

The cages were of 1-inch chicken mesh wire, 4 feet in height. Each cage was made into a 3-foot diameter cylinder and staked perpendicularly after the tree had been planted. Four 2-inch square cedar stakes approximately 4 feet long were driven into the ground to hold the cage in an upright position.

Of the 54 plots occurring on lands administered by the Bureau of Land Management, 12 plots (all of which were Douglas-fir plots) were installed on the Coos Bay District. Two of those original plots were destroyed within the first two years. See Figure 1 for location of plots.

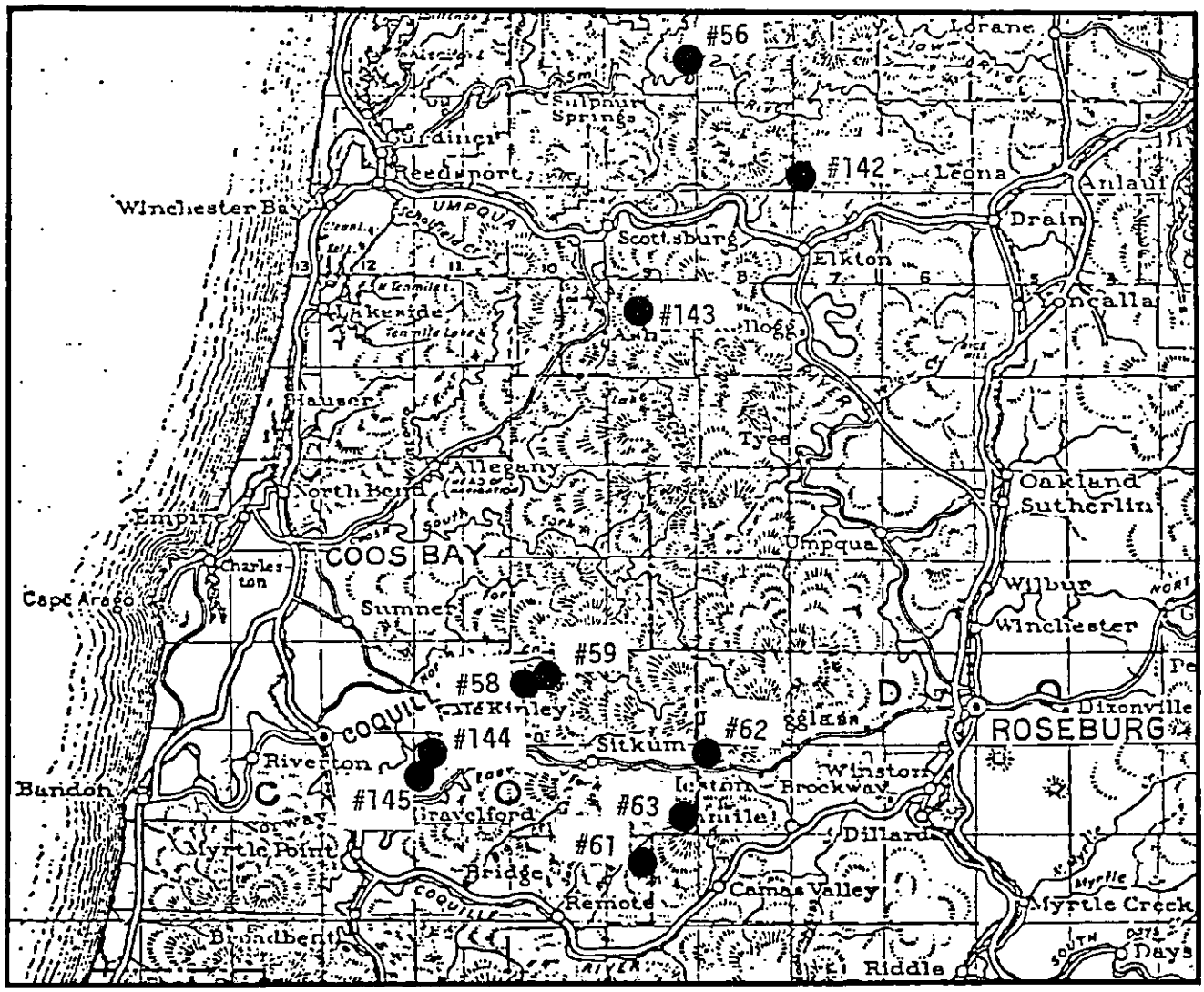


Figure 1. Location of Cooperative Animal Damage Survey plots on the Coos Bay District of the Bureau of Land Management

Reasons for Re-examination of the CADS Plots

A number of reasons led the authors to re-examine the CADS plots on the Coos Bay District. The foremost reason was to compare the original study's results made by Black, Dimock, Dodge and Lawrence, and those made later by Hahn and Brodie, with the results obtained on the Coos Bay District plots. Another reason was that since these plots contained trees that could be identified individually as being planted, the re-examination gave the authors an ideal opportunity to compare growth of known planted trees with growth predicted in the District's allowable cut plan. The re-examination also afforded an opportunity to obtain juvenile seedling mortality rates through 16 field growing seasons. In addition, it gave an opportunity to compare, on an extensive basis, the mortality and growth differences between prepared and unprepared sites.

Plot Description

Trees on the Coos Bay District plots are now 17-18 years old. Although the plots have little further value in analyzing animal damage, they are quite valuable in studying survival and growth. The plots are situated on a variety of sites, elevations, aspects and brush conditions, thus offering a further insight of the impact certain variables have on growth and survival.

Table 1 describes the plots. Generally, the plots can be separated into two groups--those on average site 3 land with medium to severe site brush problems (plots 56, 142, 143, 144), and those on good site 2 land with little brush competition and good site preparation (plots 58, 59, 61, 62, 53 and 145).

Plots 142 through 145 were planted one year later than the other plots. Therefore, to make meaningful summaries and comparisons using all plots, the average height and DBH of the 17-year-old plots was projected one year ahead to 18 years and then included in averages at 18 years of age (16 years in the field).

The data base is not sufficient to make conclusions on the effect of slope, aspect or elevation on growth and survival, other than some general observations. In coming years, remeasurement of these 500 trees will help us predict stand growth and to understand better the effects and interactions of various environmental conditions and treatments.

At the time of planting, information pertaining to planting stock, condition, elevation of seed, seedling height, and extent of site preparation, was recorded. The plots were first re-examined at budburst and then each year for five growing seasons. The type of animal damage (if any), seedling height and mortality were recorded at each re-examination.

Seed Source and Seedling Information

The authors found it difficult to trace

Table 1. Description of the Coos Bay District CADS Plots.

Plot No.	Elev. (ft.)	Slope %	Aspect	Resource Area	Brush Comp.	Site Class	Site Prep.
56	1000	50	W	SU	Medium	3	Burned
58	2000	70	N	BM	Low	2	Burned
59	2000	60	S	BM	Low	2	Burned
61	2400	20	N	MW	Low	2	Burned
62	1500	20	N	BM	Low	2	Burned
63	2000	10	S	MW	Low	2	Burned
142	1000	60	S	SU	Medium	3	None
143	1000	30	W	LL	Medium	3	None
144	800	70	SW	BM	Severe	3	None
145	800	20	N	BM	Low	2	Burned

the exact seed source for the Coos Bay District seedlings planted under the study. Available records indicate the seedlings were planted at the same zone and elevation from which the seed originated.

All seedlings planted in the Coos Bay BLM plots were 2-0 bare root stock, and all grown under contract at the D.L. Phipps State Nursery at Elkton, Oregon. Prior to leaving the nursery, all seedlings were treated with Thiram, a pesticide used to prevent deer browse. The effect that this treatment might have had on intensity and severity of browsing, especially during the first year, must be considered in analyzing the survival difference between caged and uncaged trees. Table 2 lists seed source and seedling information. All trees were planted with shovels by BLM force account personnel.

For some unknown reason, the seedlings planted on the Coos Bay plots in 1963-64 were planted in late March and April, a practice presently avoided. However, planting earlier the following year didn't have a positive effect on survival. Unseasonably dry weather explains the poor survival for the 1964-65 planting.

Seedling Survival

The first survival examination was conducted at budburst. Survival at this time then, would reflect not only the physiological condition prior to the onset of summer moisture stress condition of the planted tree seedlings, but also the effect of handling and planting. Mortality at budburst would include losses due to wildlife browse and trampling prior to budburst.

Overall, survival of caged trees at budburst on the Coos Bay plots (see Table 3) was slightly higher than all other plots in Oregon. Survival on uncaged trees, however, was slightly lower for the Coos Bay plots in comparison with plots statewide. This might reflect either more severe wildlife damage, or a relatively small sample. It could also reflect the effect of planting too late in the season.

Initial (first year) mortality among seedlings in the 1963-64 planting was lower for the Coos Bay plots than mortality occurring in the 1964-65 plots (see Figure 2). Survival differences were probably influenced by differences between the growing seasons in 1964 and 1965. Unseasonably warm weather and drought during the spring and summer of 1965 was possibly the

Table 2. Seed Source and Seedling Information for The Coos Bay District CADS Plots.

Plot No.	Seedling Lot No.	Seed Zone	Elevation	Date Lifted	Date Planted	Seedling Condition	Spacing	Age Class
	1963-64							
56	D-5083	-	1,500-2,500	2-24	3-27	Good	8 x 8	2-0
58	D-5083	-	1,500-2,500	2-24	3-24	Good	8 x 8	2-0
59	D-5083	-	1,500-2,500	2-24	3-25	Good	8 x 8	2-0
61	D-5083	-	1,500-2,500	2-24	4-22	Good	8 x 8	2-0
62	D-5083	-	1,500-2,500	2-10	4-27	Good	8 x 8	2-0
63	D-5083	-	1,500-2,500	2-10	4-27	Good	8 x 8	2-0
	1964-65							
142	D-5078	4	500-1,500	1-17	1-26	Good	7 x 7	2-0
143	E-6870	5	Medium	?	3-10	Good	?	2-0
144	D-5078	4	500-1,500	1-18	1-27	Good	8 x 8	2-0
145	D-5078	4	500-1,500	?	2-03	Good	8 x 8	2-0

Table 3. Survival of Caged and Uncaged Douglas-fir Seedlings on 1963-64 and 1964-65 Sample CADS Plots (Includes mortality by wildlife, natural causes, soils movements, etc.)[1/]

Area	Number	Treatment	Years Following Planting 0[2/]	1	2	3	4	5	16
			(Percent)						
Oregon (Total)	116	Caged	86.1	76.6	74.3	71.9	69.8	68.3	—
		Uncaged	83.5	65.4	60.8	56.8	54.2	52.6	—
Cascades	34	Caged	81.6	72.2	71.0	69.6	68.1	67.2	—
		Uncaged	79.2	63.7	59.1	55.9	53.2	51.9	—
Southwest	33	Caged	89.1	72.2	67.3	65.2	61.0	58.9	—
		Uncaged	83.2	54.0	48.5	46.0	43.6	41.8	—
Coast Range	49	Caged	87.3	82.6	81.2	78.1	76.9	75.5	—
		Uncaged	86.7	74.2	70.3	64.8	62.1	60.3	—
Coos Bay BLM	10	Caged	91.0	80.0	77.0	76.0	74.0	69.0	60.0
		Uncaged	76.6	71.7	66.9	65.6	63.3	58.8	51.0

[1/] All except Coos Bay BLM data is from Table 4, "Animal Damage to Coniferous Plantations in Oregon and Washington," Black, Dimock II, Evans and Rochelle.

[2/] Survival taken prior to summer moisture stress.

cause of the higher mortality. Variation in quality of stock and handling procedures may also have influenced survival. The statewide CADS report also reflected a wide difference in survival between the two planting seasons (1).

By the end of the third year, survival of uncaged trees on the Coos Bay plots was slightly greater than all plots categorized as Coast Range plots. Survival of caged trees was slightly less (2.1 percent) on the Coos Bay plots than for all plots categorized as Coast Range plots. At the end of five growing seasons, average survival of the uncaged trees on the Coos Bay plots was 1.5 percent below survival of the Coast Range plots. Average survival for caged trees on the Coos Bay plots was 69 percent at the end of five years compared to 75 percent for all caged Coast Range plots. From Table 3 it is readily seen that tree seedling survival on the Coos Bay plots, though slightly less than the Coast Range average, was greater than all other state plots as a whole. Table 4 gives a survival summary for all the Coos Bay CADS plots.

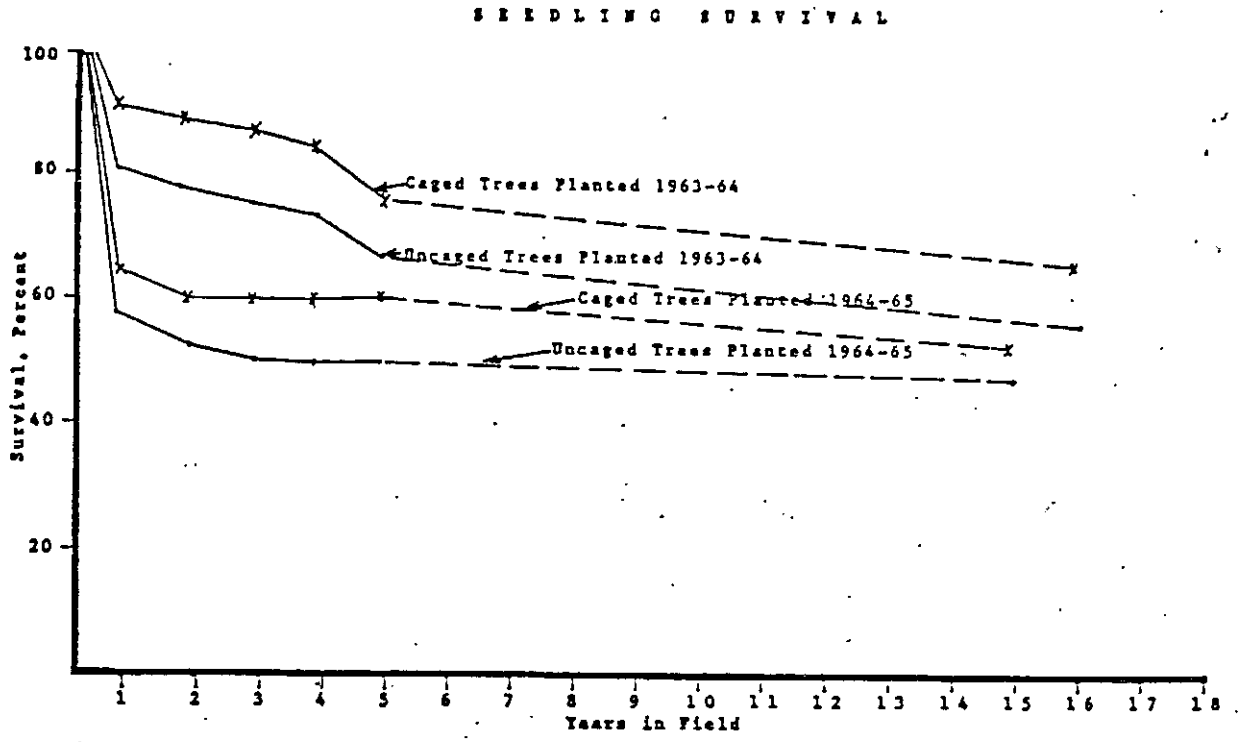


Figure 2. Seedling survival on the Coos Bay District BLM CADS plots. Includes seedling mortality regardless of cause.

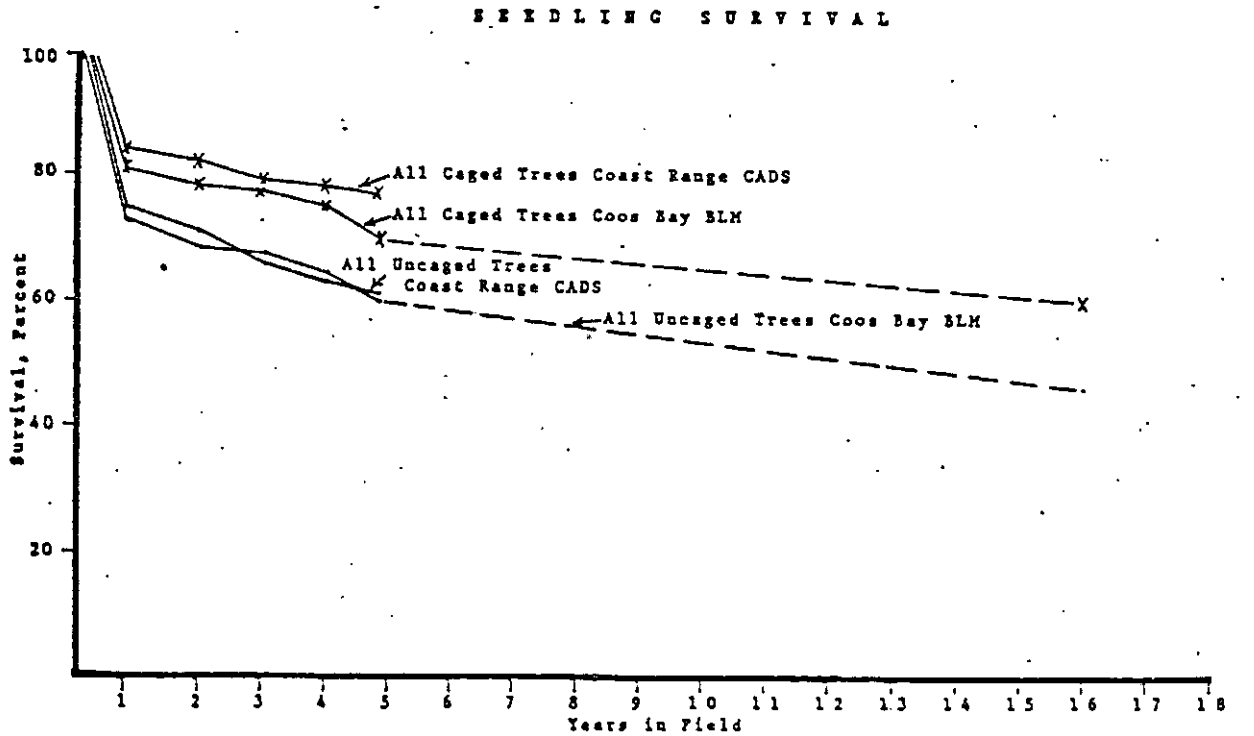


Figure 3. Comparison of seedling survival between Coast Range and Coos Bay BLM CADS plots. Includes natural seedling mortality regardless of cause. Trees removed in precommercial thinnings on Coos Bay plots are considered as being alive.

Table 4. - Survival of Caged and Uncaged Douglas-fir Seedlings on Coos Bay District CADS Plots (includes mortality by wildlife, natural causes, soil movements, etc.).

Plot No.	Site Index 2/	Treatment	1/ 0	(Years Following Planting) 1	2	3	4	5	16
					(Percent)				
56	150	Caged	100	100	90	90	90	90	40 3/
		Uncaged	96	82	78	76	71	67 3/	17
58	170	Caged	100	100	100	100	100	50	50
		Uncaged	100	83	78	73	72	31	21
59*	180	Caged	100	70	70	70	70	70	70
		Uncaged	100	86	82	82	82	82	79
61	170	Caged	100	100	100	100	100	100	100
		Uncaged	100	81	78	77	76	76	76
62*	170	Caged	100	80	80	80	60	60	60
		Uncaged	82	73	70	69	66	66	65
63*	170	Caged	100	90	90	80	80	80	70
		Uncaged	100	83	77	74	73	73	73
142*	140	Caged	50	50	50	40	40	40	40
		Uncaged	51	35	32	28	28	28	27
143	150	Caged	70	70	60	60	60	60	40
		Uncaged	69	51	41	37	37	37	28
144	150	Caged	100	60	60	60	60	60	60
		Uncaged	71	61	54	51	50	50	50
145	170	Caged	90	80	80	80	80	80	70
		Uncaged	87	82	79	79	78	78	76
		Average Caged	91	80	77	76	74	69	60
		Average Uncaged	77	72	67	65	63	59	51
		Average for all Trees	78	72	68	66	64	60	52

* Trees recently removed in precommercial thinning were considered as being alive.

1/ Survival taken prior to summer moisture stress.

2/ Based on McArdle's site index table, Bulletin 201. These site indices are approximately one site class lower than if determined using King's 50-year second growth tables.

3/ Heavy mortality was caused by large landslides.

Table 5 displays the progression of seedling mortality for the Oregon plots through the first five years. The seedling mortality progression for the Coos Bay plots was comparable with other state plot grouping.

Table 5 which displays the progression of seedling mortality, may aid the reader in visualizing what took place during the first five years of the CADS study.

Of the District's caged trees, 74.2 percent of the first five year's mortality occurred within the first two years. Of the uncaged trees, 81.3 percent of the first five year's mortality occurred within the first two years.

Table 5. Mortality Progression of Caged and Uncaged Douglas-fir Seedlings on Sample CADS Plots (includes mortality by wildlife, natural causes, soil movements, etc.).

Area	Number of Plots	Treatment	(Years Following Planting) 0-1	1-2	2-3	3-4	4-5	5-16
			(Percent)					
Oregon (Total)	116	Caged	23.4	2.3	2.4	2.1	1.5	—
		Uncaged	34.6	4.6	4.0	2.6	1.6	—
Cascades	34	Caged	27.8	1.2	1.4	1,5	0.9	—
		Uncaged	36.3	4.6	3.2	1.7	1.3	—
Southwest	33	Caged	27.8	4.9	2.1	4.2	2.1	—
		Uncaged	46.0	5.5	2.5	2.4	1.8	—
Coast Range	49	Caged	17.4	1.4	3.1	1.2	1.4	—
		Uncaged	25.8	3.9	5.5	2.7	1.8	—
Coos Bay BLM	10	Caged	20.0	3.0	1.0	2.0	5.0[1/]	10.0[1/]
		Uncaged	28.3	4.8	1.3	2.3	4.5	14.1

[1/] These unusual increases in annual mortality were caused by large landslides on Plots 58 and 56 in the 4th year and after the 5th year, respectively.

The effect site preparation by burning has on seedling survival is quite dramatic (see Figure 4). Tabular data for this treatment are given in Table 6.

Survival on plots with no site preparation was about 35 percent less than on burned plots. Interestingly, on the unburned plots, most of the mortality occurred before budburst. This could possibly be caused by heavy mountain beaver activity in the unburned areas. After budburst, annual mortality through the fifth year was about the same on unburned and burned plots. Between the fifth year and the 18th year there was 6 percent mortality on unburned sites compared to 1 percent on burned sites.

The effect of brush competition on survival is shown in Table 7 and Figure 5. Note the 35 percent difference in survival 16 years after planting, between uncaged seedlings where brush was a competitor and where brush was not in competition.

Typical chicken wire cage installation used on the CADS plots. After 16 years in the field, the cages, in general, were found to be in good condition. In addition to protecting the seedling from animal damage, the cage also protected the seedling from soil and debris movement.

Table 6. Differences Survival Between Plots Site-P:. ed by Burning and No Site Preparation - Coos Bay District CADS Plots. Survival in Percent Includes Mortality by Wildlife, Natural Causes, Soil Movements, etc.

Site Preparation	Number of Plots	Treat-ment	(Years Following Planting) 1/ 0	1	2	3	4	5	16
			(Percent Survival)						
Burned	7	Caged	100	88	87	86	83	76	66
		Uncaged	84	81	77	76	74	68	58
Unburned	3	Caged	70	60	53	53	53	53	47
		Uncaged	59	49	42	39	38	38	35

1/ Survival taken prior to summer moisture stress.

Table 7. Differences in Survival Between Plots Having Moderate to Heavy Brush Competition and Plots Having Little or No Brush Competition.

Competition	Number of Plots	Treat-ment	(Years Following Planting) 1/ 0	1	2	3	4	5	16
			(Percent Survival)						
Brush 2/	4	Caged	80	70	65	62	62	62	45
		Uncaged	72	57	51	48	46	45	30
None 3/	6	Caged	98	87	87	85	82	73	68
		Uncaged	95	81	77	76	74	68	65

1/ Survival taken prior to summer moisture stress

2/ Plots 56, 142, 143, 144

3/ Plots 58, 59, 61, 62, 63, 145

Animal Browse

The effect animal browse had on seedlings in the CADS study is reflected in seedling mortality, occurrence and amount of browse, height growth and volume growth. Seedling mortality attributed to animal browse, as discussed in the preceeding section was obtained by comparing the uncaged mortality with the caged seedlings. The occurrence of browsing (the number of times a seedling was browsed) can be helpful but needs to be considered with the degree of browse, quantity of material removed, and the portion browsed (tips verses laterals). The CADS study addressed the occurrence but not the quantity.

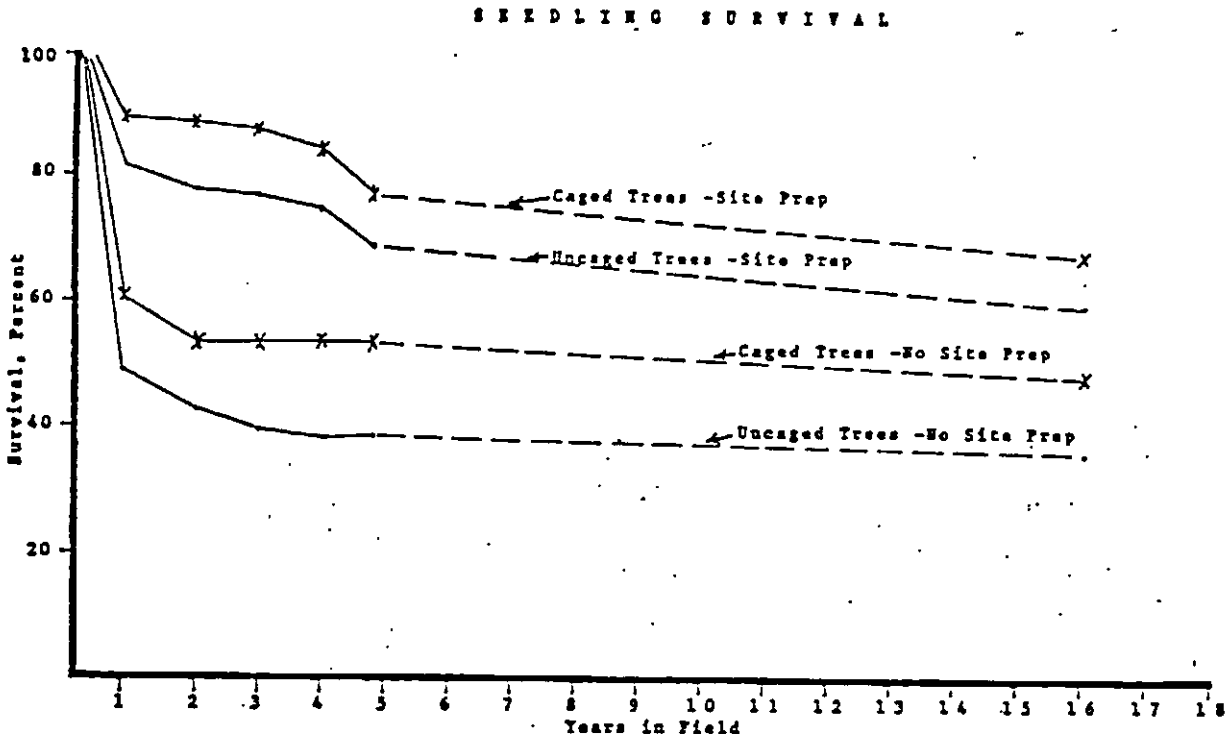


Figure 4. Effect of site preparation by burning on the Coos Bay BLM CADS plots.

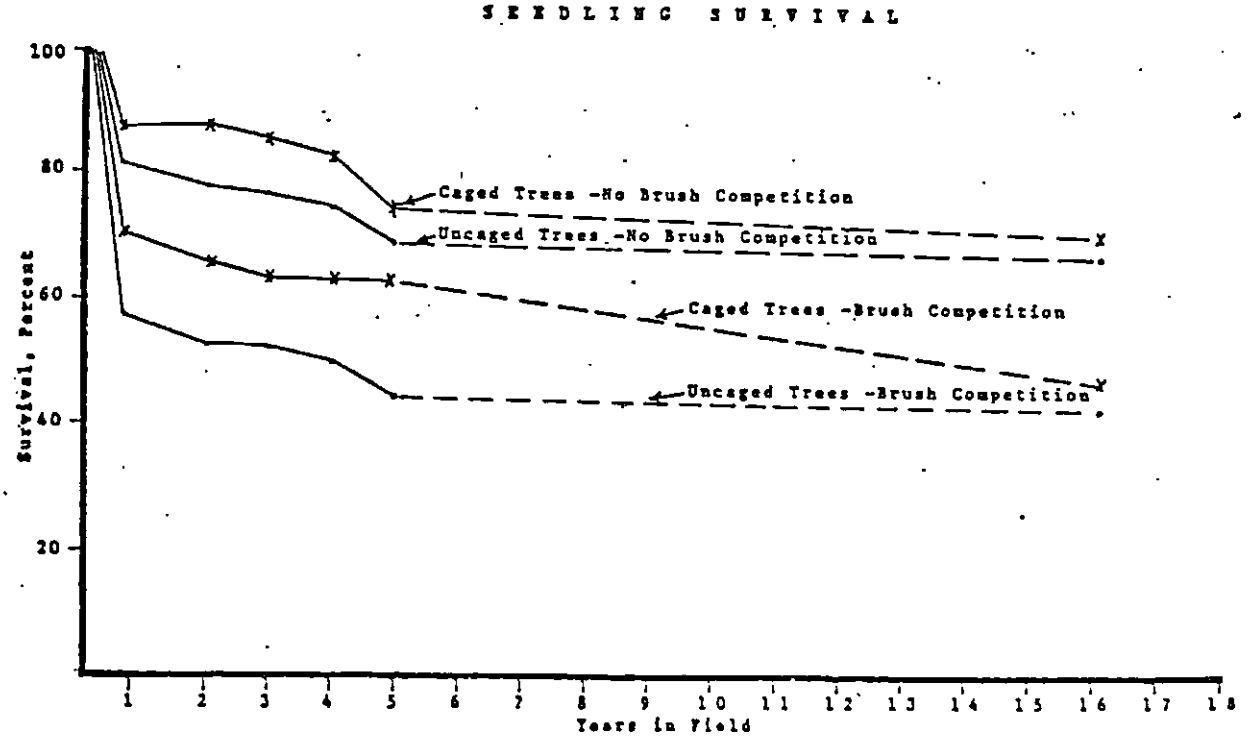


Figure 5. Effect of brush competition on seedling surival on the Coos Bay BLM CADS plots.

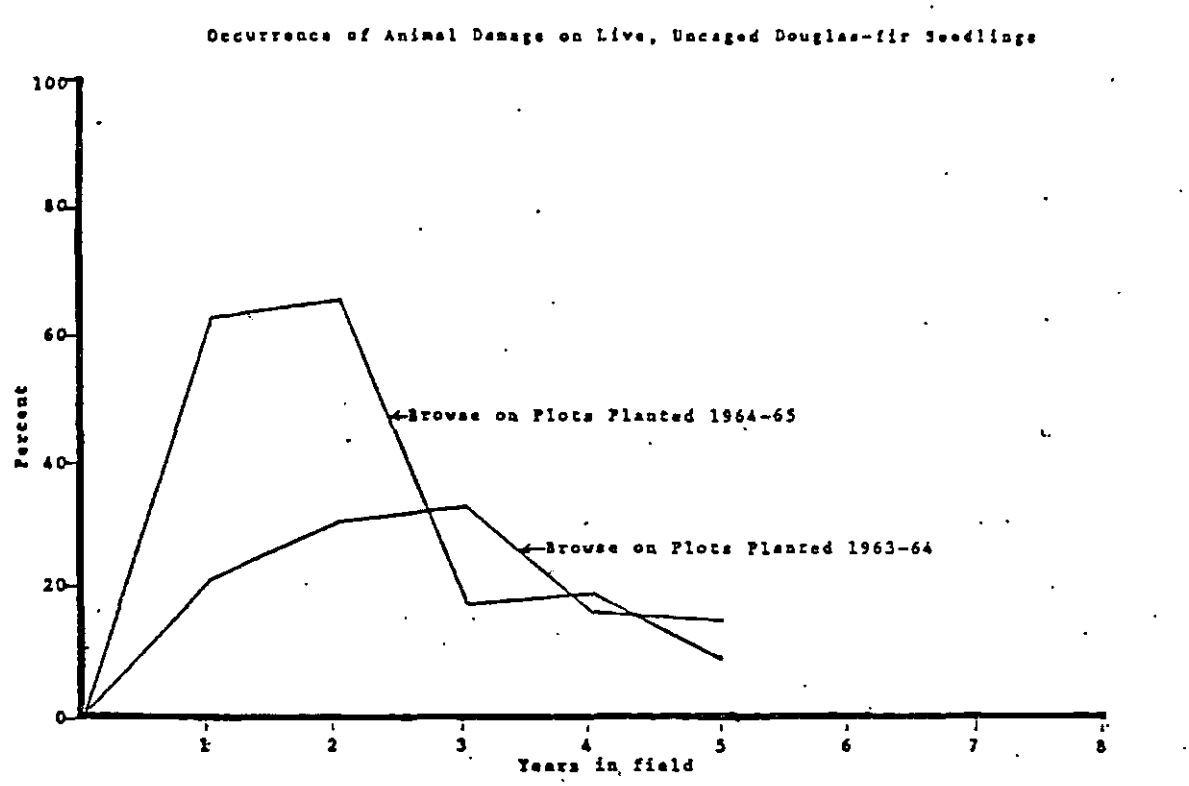


Figure 6. Difference of occurrence of animal damage on live, uncaged Douglas-fir seedlings on CADS plots (Coos Bay BLM District) established in 1963-64 and 1964-65. Occurrence in percent of trees browsed (by all animals).

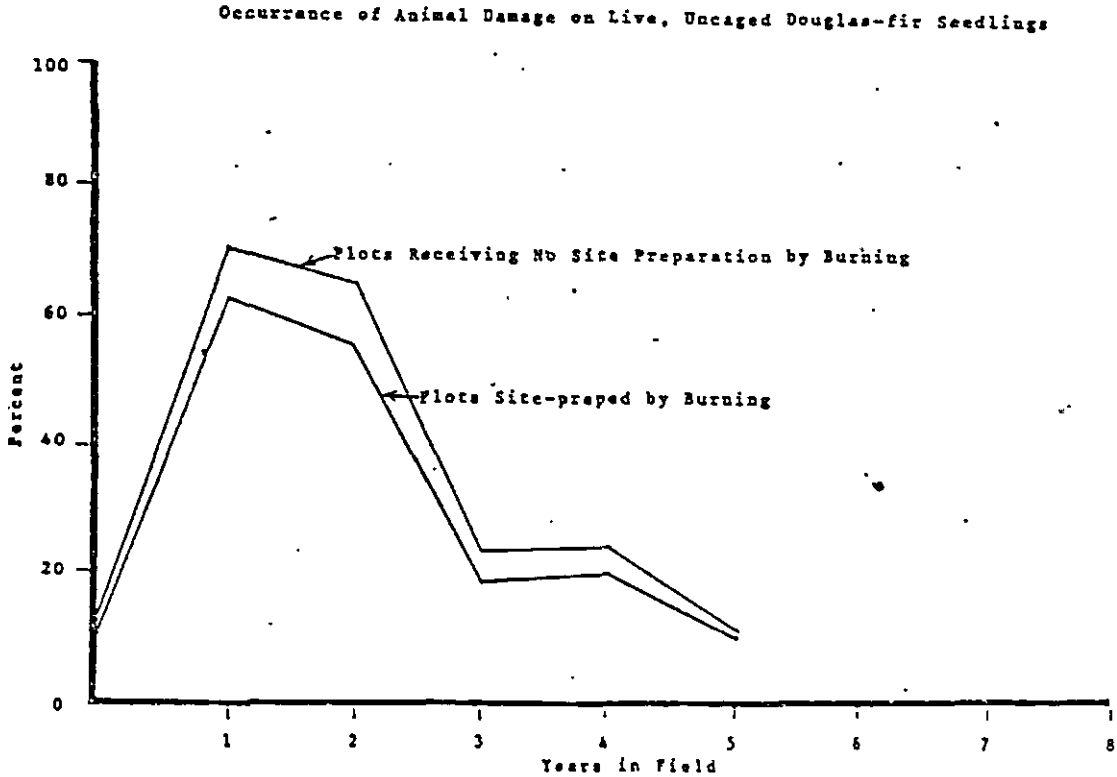


Figure 7. Effect of site preparation on occurrence of animal damage on live, uncaged Douglas-fir seedlings (Coos Bay BLM CADS plots). Occurrence in percent of trees browsed (by all animals).

Table 8. Occurrence of Animal Damage on Live, Uncaged Douglas-fir Seedlings on Coos Bay District BLM CADS Plots. Occurrence in percent of seedlings browsed.

Area	Number of Plots	Year of Planting	Treatment	Years Following Planting 0	1	2	3	4	5
				(Percent)					
Oregon 1/	70	1963-64	—	—	9.4	35.6	30.4	39.9	29.5
	46	1964-65	—	—	6.1	41.4	36.0	29.3	—
Coos Bay	6	1963-64	—	0.4	21.2	30.4	32.4	14.9	13.6
	4	1964-65	—	10.1	61.6	65.5	16.9	18.1	7.8
Average				3.6	33.2	40.4	28.1	15.8	11.8
Coos Bay	7	—	Burned	8.0	63.0	55.0	17.8	18.7	8.6
	3	—	Unburned	8.9	70.7	65.4	21.6	22.6	10.4

1/ Included for comparison purposes.

Browse occurrence on the Coos Bay BLM plots began at the time of planting and reached a peak between the second and third year after planting. By the fifth year, occurrence of browse averaged between 8 and 14 percent (see Table 8 and Figure 6). Statewide, occurrence of browse was less than on the District's plots. Data from District plots (Table 8 and Figure 7) indicate a higher occurrence of browse on units that were not burned as opposed to those that had been burned.

Figure 6 indicates a great variance in amount of browse from year to year and area to area during the first three years after planting. The variance might also reflect the incidence of browse at time of planting.

The effect the Thiram treatment had on occurrence of browse on the uncaged seedlings cannot be quantified from the study data, though it must be considered when making projections of occurrence to other plantations.

It is interesting to note that 64 percent of the trees alive in 1979 had received some animal damage in the first five years following planting. Also interesting is the fact that only 12 percent of all surviving trees were browsed three or more years (see Table 9). Noting the decline of seedling mortality after two years in the field and recurrence of browse, one concludes that even sustained browsing didn't cause a significant amount of mortality.

Table 9 also shows that there is no correlation between the percent of trees browsed in any of the first five years to the 1979 tree height (crown class). The difference in 1979 tree height between trees browsed 0 years and browsed 5 years was only 2 feet. The majority of animal damage was caused by elk and deer, though mountain beaver activity was heavy in plots 56 and 143.

Though it is assumed there was no animal damage to the caged trees, there was some minor damage noted during the remeasurement process. In general, though, the cages used did an excellent job in protecting the seedlings. A large percentage of the cages were still in place and in good condition 16 years after placement. The cedar stakes (2 inches square) that had been placed to hold up the cage (four per cage) were still solid. Where caged seedlings had died, the caged interior in many cases had become filled with natural vegetation which in itself was then protected from browse.

Table 9. Relationship between Present Crown Class (1979) of Uncaged Douglas-fir Seedlings and Animal Browse during the First Five Years.

Number of Times Browsing Occurred	Present Height in Feet	1979 Crown Class					Percent of Total
		Suppressed	Intermediate	Codominate	Dominate	Total	
		(Number of Trees Browsed)					
0 Years	35	9	40	100	31	180	36
1 Years	35	6	32	84	22	144	29
2 Years	23	3	24	74	14	115	23
3 Years	33	2	8	25	8	43	8
4 Years	32	0	4	7	3	14	3
5 Years	33	0	1	1	1	3	1
Total	34	20	109	291	79	499	100
% Browsed		55	63	65	61	64	

Height Growth

Seedling height growth measurements were taken on each seedling at the time of planting, at budbreak (prior to moisture stress), at the end of the first year's growth, and each succeeding year for the first five years following planting. In addition, the height was measured on the Coos Bay plots 16 growing seasons after planting (1979).

Table 10 summarizes mean height growth for the Coos Bay plots and the other

Table 10. Mean Height Growth and Height Growth Difference of Caged and Uncaged Douglas-fir Seedlings on Sample CADS Plots.

Area	Number of Plots	Treatment	Planting	Years Following Planting						
				0	1	2	3	4	5	16
				(Inches)						
Oregon	116	Caged	8.6	8.5	10.1	14.6	22.5	33.3	46.1	—
		Uncaged	8.6	8.4	8.8	11.3	16.1	23.9	33.9	—
		Ht. Diff*	0%	1%	15%	30%	40%	39%	36%	
Cascades	34	Caged	8.4	8.3	9.7	13.3	19.9	28.9	39.6	—
		Uncaged	8.2	8.2	8.4	10.4	14.3	20.7	28.8	—
		Ht. Diff*	2%	1%	15%	28%	39%	40%	38%	
Southwest	33	Caged	7.8	7.7	9.1	13.1	20.3	30.4	41.9	—
		Uncaged	7.9	7.9	8.4	10.6	14.8	21.5	30.9	—
		Ht. Diff*	-1%	-2%	8%	24%	37%	41%	36%	
Coast Range	49	Caged	9.3	9.1	11.0	16.5	25.6	38.1	53.3	—
		Uncaged	9.2	9.0	9.2	12.3	18.2	27.2	39.5	—
		Ht. Diff*	1%	1%	20%	34%	41%	40%	35%	
Coos Bay	10	Caged	7.9	7.8	10.2	16.2	28.0	44,4	62.7	432.0
		Uncaged	8.4	8.2	9.0	12.7	20.2	32.7	50.0	408.0
		Ht. Diff*	-6%	-5%	13%	28%	39%	36%	25%	6%

* Height difference as percent of uncaged trees.

Douglas-fir plots in the state of Oregon. After five years in the field, height of the seedlings on the Coos Bay plots (uncaged as well as caged) exceeded seedling height of all other plots in the state. Interestingly, it took all seedlings about two years in the field before height growth increased substantially (regardless of whether the seedling was caged or not). Thus it can be said that the seedlings received by the Coos Bay District were just as good and outperformed seedlings other cooperators in the study received. As you will recall, seedling survival for the Coos Bay plots was, for most years, higher than other Oregon grouped plots (see Table 3).

Mean seedling height growth for the Coos Bay BLM CADS Plots (Table 11) indicate much variation by site.

Table 11. Mean Height Growth and Height Differences of Caged and Uncaged Douglas-fir Seedlings on the Coos Bay District CADS Plots.

Plot Number	Site Index	Treatment	Years Following Planting 1/ 0	1	2	3	4	5	16
			(Inches)						
56	150	Caged	10.5	13.5	19.1	26.8	37.1	47.1	444.0
		Uncaged	9.0	11.0	14.6	19.1	25.5	33.7	336.0
		Ht. Diff.	14%	23%	31%	40%	46%	40%	32%
58	170	Caged	7.7	9.6	18.4	35.5	55.4	88.8	432.0
		Uncaged	7.8	8.5	12.7	19.8	34.9	52.3	384.0
		Ht. Diff.	-1%	13%	45%	82%	59%	70%	12%
59	180	Caged	7.3	10.3	21.1	39.7	64.1	93.6	492.0
		Uncaged	8.3	8.2	13.9	26.4	47.3	74.1	502.0
		Ht. Diff.	-12%	26%	51%	50%	36%	30%	-2%
61	170	Caged	7.6	11.8	16.2	27.7	44.9	63.3	468.0
		Uncaged	8.2	9.2	12.1	17.2	28.8	44.6	408.0
		Ht. Diff.	-7%	28%	34%	61%	56%	42%	15%
62	170	Caged	6.7	7.5	13.1	22.8	46.7	70.8	444.0
		Uncaged	8.4	10.2	14.1	22.1	37.0	56.6	444.0
		Ht. Diff.	-20%	-26%	-7%	3%	26%	25%	0%
63	170	Caged	5.7	9.0	13.4	21.1	33.2	57.0	432.0
		Uncaged	7.1	8.8	12.0	18.6	28.6	46.8	408.0
		Ht. Diff.	-20%	-2%	12%	13%	16%	22%	6%
142	140	Caged	7.2	7.8	10.6	18.5	26.2	37.2	264.0
		Uncaged	7.3	7.3	9.3	14.9	21.5	33.3	288.0
		Ht. Diff.	-1%	7%	14%	24%	22%	12%	-8%
143	150	Caged	8.6	9.4	12.5	22.5	34.7	45.5	456.0
		Uncaged	8.7	7.6	9.2	12.1	19.2	29.2	372.0
		Ht. Diff.	-1%	24%	36%	86%	81%	56%	23%
144	150	Caged	8.7	10.3	15.2	25.3	39.0	49.2	372.0
		Uncaged	9.3	7.8	9.6	15.4	23.8	37.2	312.0
		Ht. Diff.	-6%	32%	58%	64%	64%	32%	-19%
145	170	Caged	8.6	10.4	19.4	33.6	50.4	71.1	408.0
		Uncaged	8.3	9.7	15.0	26.7	41.6	64.3	468.0
		Ht. Diff.	4%	7%	29%	26%	21%	10%	-13%
Average		Caged	7.8	10.2	16.2	28.0	44.4	62.7	432.0
Average		Uncaged	8.2	9.0	12.7	20.2	32.7	50.0	408.0
Average		Ht. Diff.	-5%	13%	28%	39%	36%	25%	6%

1/ Height taken prior to summer moisture stress

Overall, it seems that the bare-root seedlings do not really adapt to their new environment until after their first or second year. Height growth differences (the percent difference between caged and uncaged seedlings as compared to uncaged trees) increases on most plots up to the fourth year after planting. By the 16th year maximum height growth difference was only 6 percent. Table 12 shows the progression of height growth difference during the first five years.

A comparison between mean height growth of caged and uncaged Douglas-fir seedlings for all Coos Bay BLM CADS plots is displayed in Figure 8. Caging does not appear to have had much of an effect on seedling height. However, it must be remembered that we are only looking at those seedlings that are alive. There were more uncaged seedlings than caged seedlings that had died which no doubt would have lowered the mean height growth, thus making the difference between caged and uncaged seedling height growth greater. A graphical display of the height growth given in Table 22 is shown in Figures 9 through 13.

Review of seedling height growth caused the authors to be curious about seedling heights at time of planting. It was thought that seedling mortality was possibly restricted to seedlings of certain size or sizes. To answer this

Table 12. Progression of Height Growth During the First Five Years Following Planting on Coos Bay BLM District CADS Plots.

Plot Number	Site Index	Treatment	Years Following Planting 0-1	1-2	2-3	3-4	4-5
			(Inches)				
56	150	Caged	3.0	5.6	7.7	10.3	10.0
		Uncaged	2.0	3.6	4.5	6.4	8.2
58	170	Caged	1.9	8.8	17.1	19.9	33.4
		Uncaged	.7	4.2	7.1	15.1	17.4
59	180	Caged	3.0	10.8	18.6	24.4	29.5
		Uncaged	-.1	5.7	12.5	20.9	26.8
61	170	Caged	4.2	4.4	11.5	17.2	18.4
		Uncaged	1.0	2.9	5.1	11.6	15.8
62	170	Caged	0.8	5.6	9.7	23.9	24.1
		Uncaged	1.8	3.9	8.0	15.1	19.6
63	170	Caged	3.3	5.6	7.7	12.1	23.8
		Uncaged	1.7	3.2	6.6	10.0	18.2
142	140	Caged	0.6	2.8	7.9	7.7	11.0
		Uncaged	0.0	2.0	5.6	6.6	11.8
143	150	Caged	0.8	3.1	10.0	12.2	10.8
		Uncaged	-1.1	1.6	2.9	7.1	10.0
144	150	Caged	1.6	4.9	10.1	13.7	10.2
		Uncaged	-1.5	1.8	5.8	8.4	13.4
145	170	Caged	1.0	9.0	14.2	16.8	20.7
		Uncaged	1.4	5.3	11.7	14.9	22.7

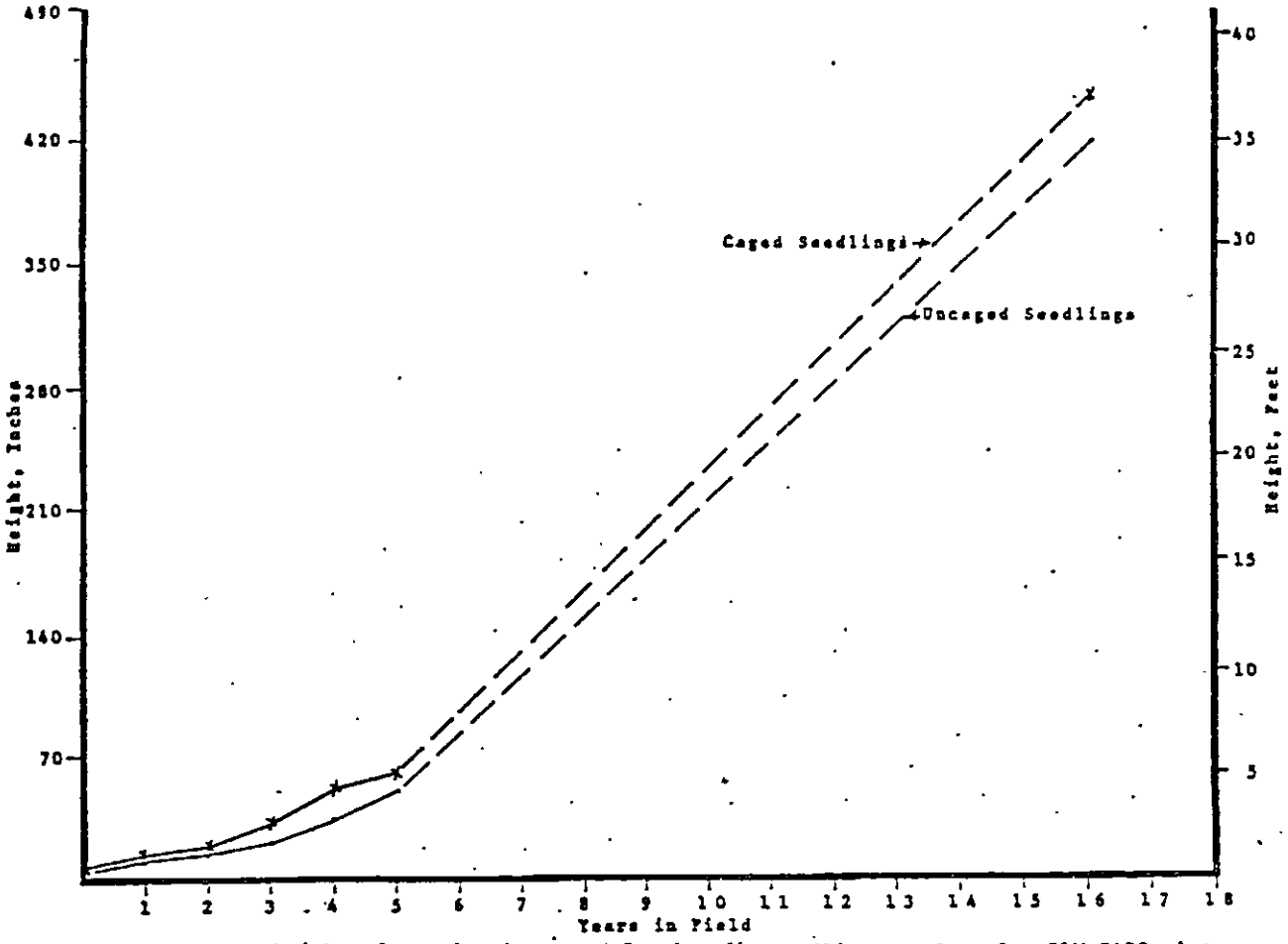


Figure 8. Mean height of caged and uncaged Douglas-fir seedlings on Coos Bay BLM CADS plots.

Figure 9. Mean height growth of caged and uncaged Douglas-fir seedlings on the Coos Bay District BLM CADS plots.

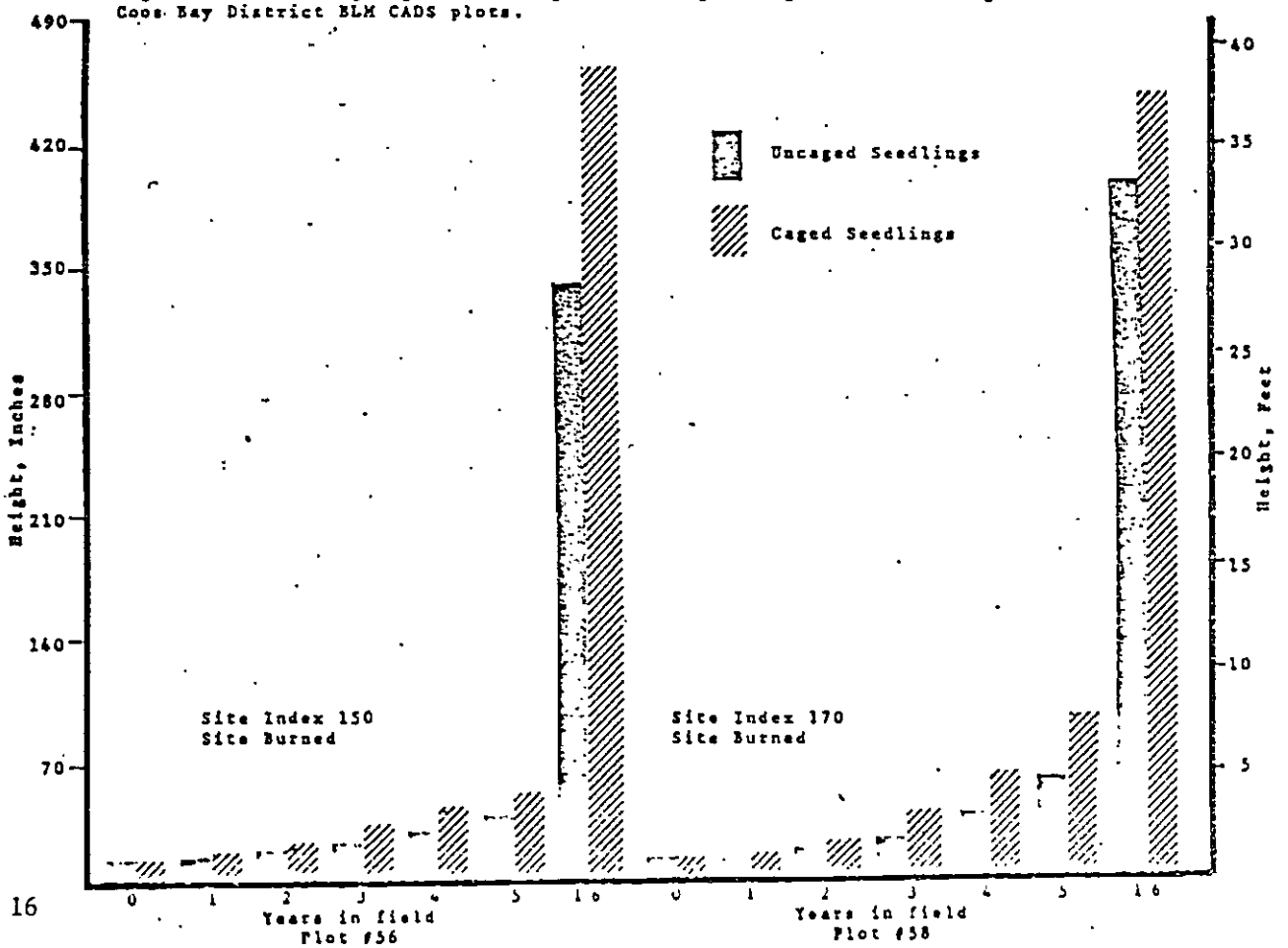


Figure 10. Mean height growth of caged and uncaged Douglas-fir seedlings on the Coos Bay District BLM CADS plots.

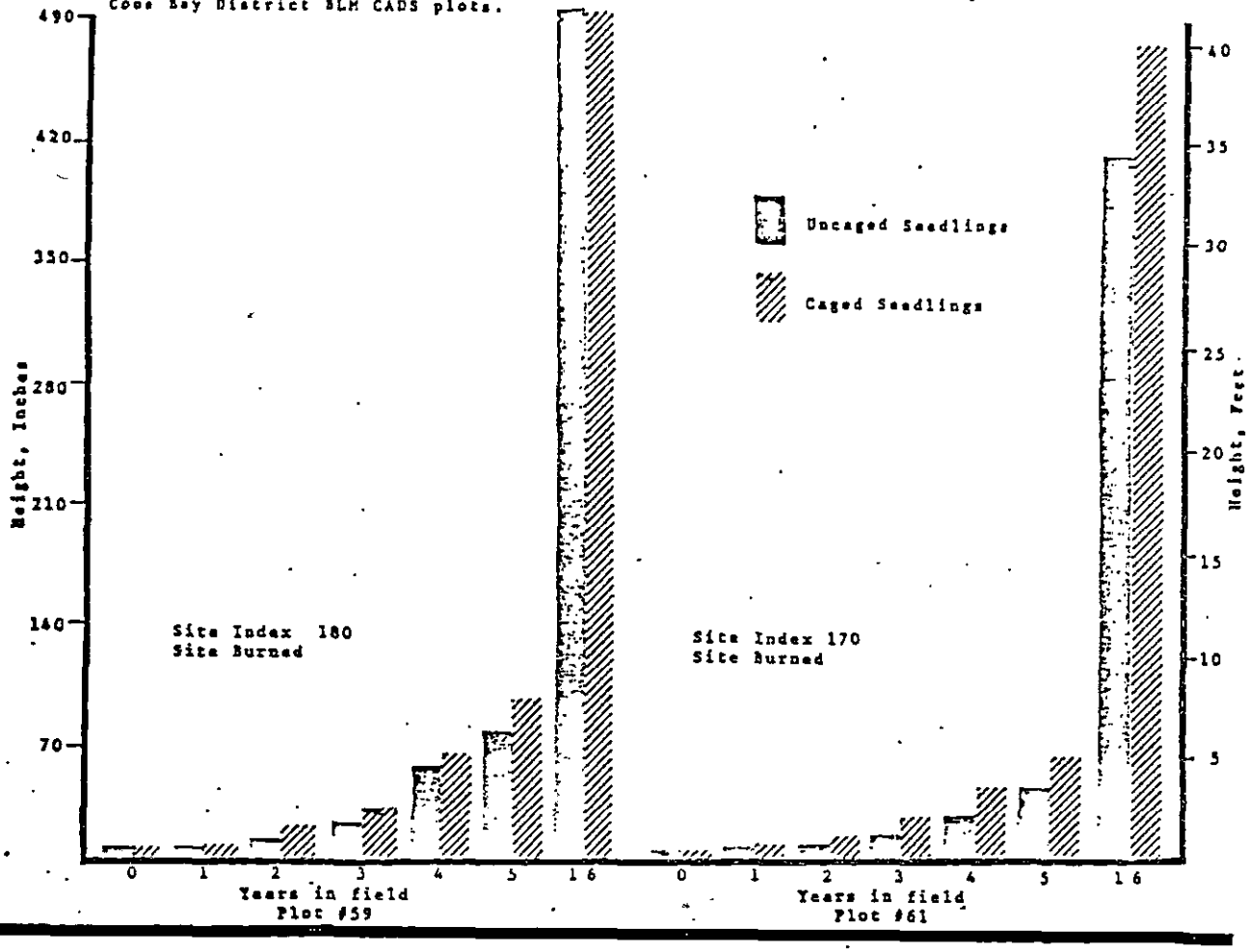


Figure 11. Mean height growth of caged and uncaged Douglas-fir seedlings on the Coos Bay District BLM CADS plots.

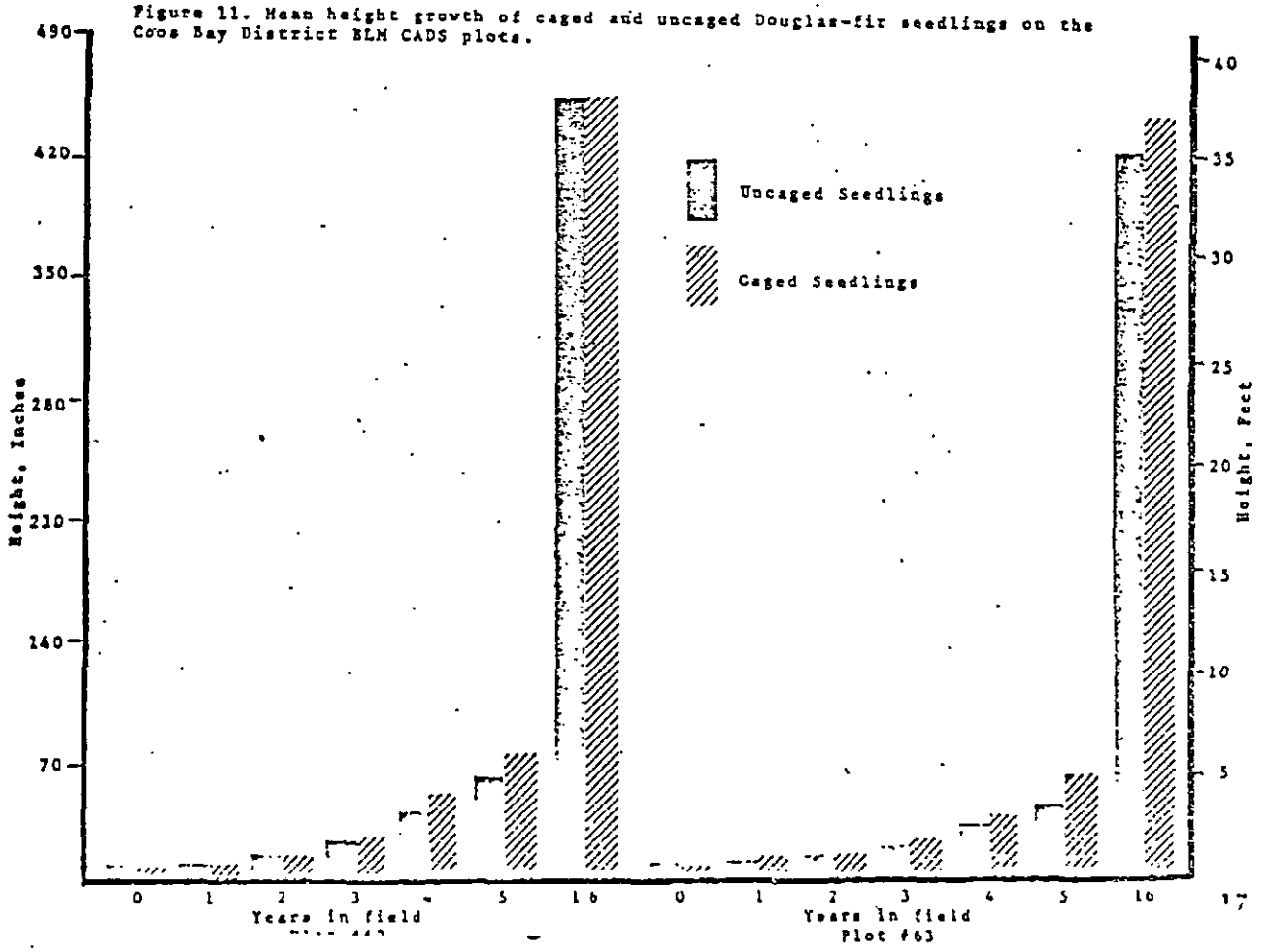


Figure 12. Mean height growth of caged and uncaged Douglas-fir seedlings on the Coos Bay District BLM CADS plots.

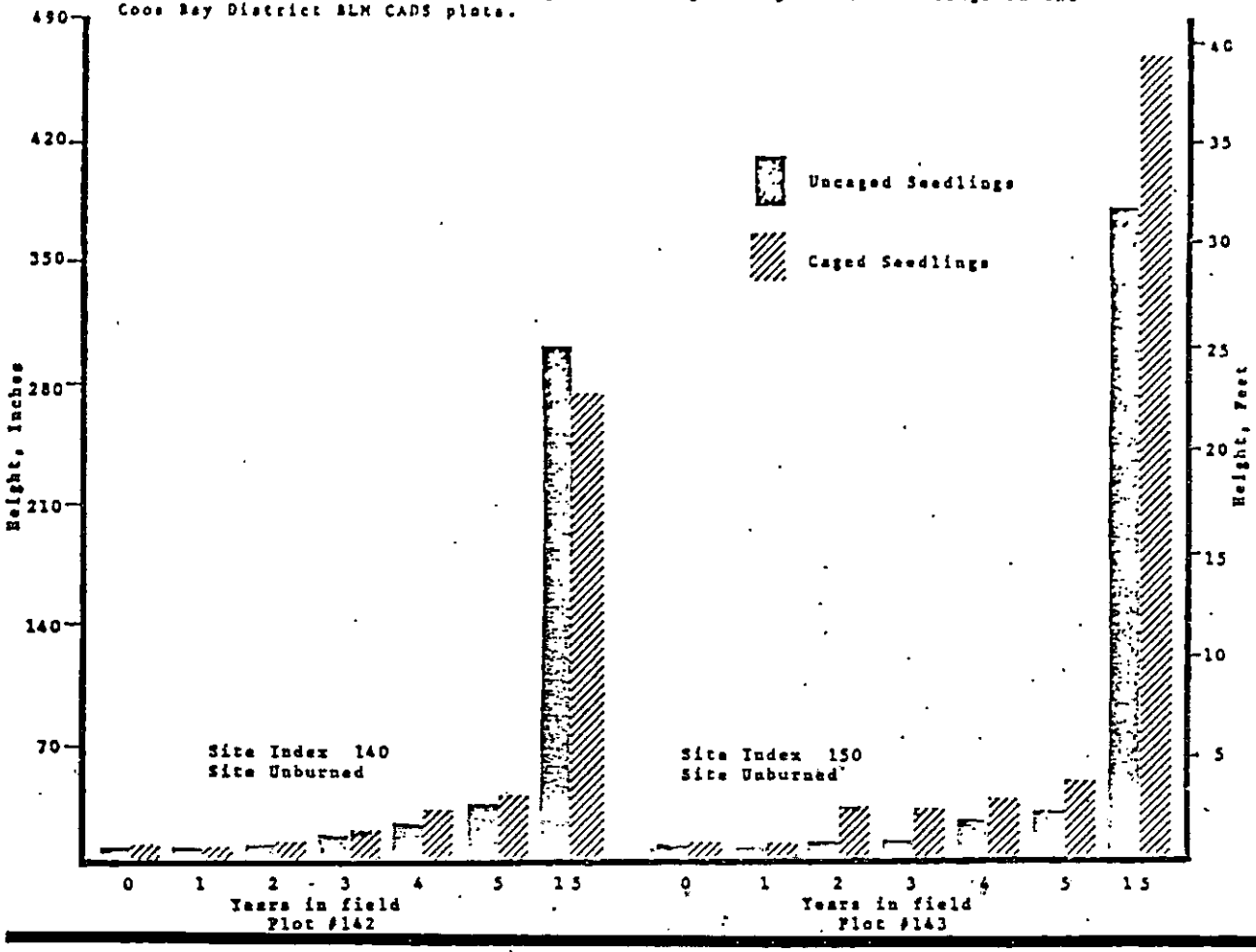
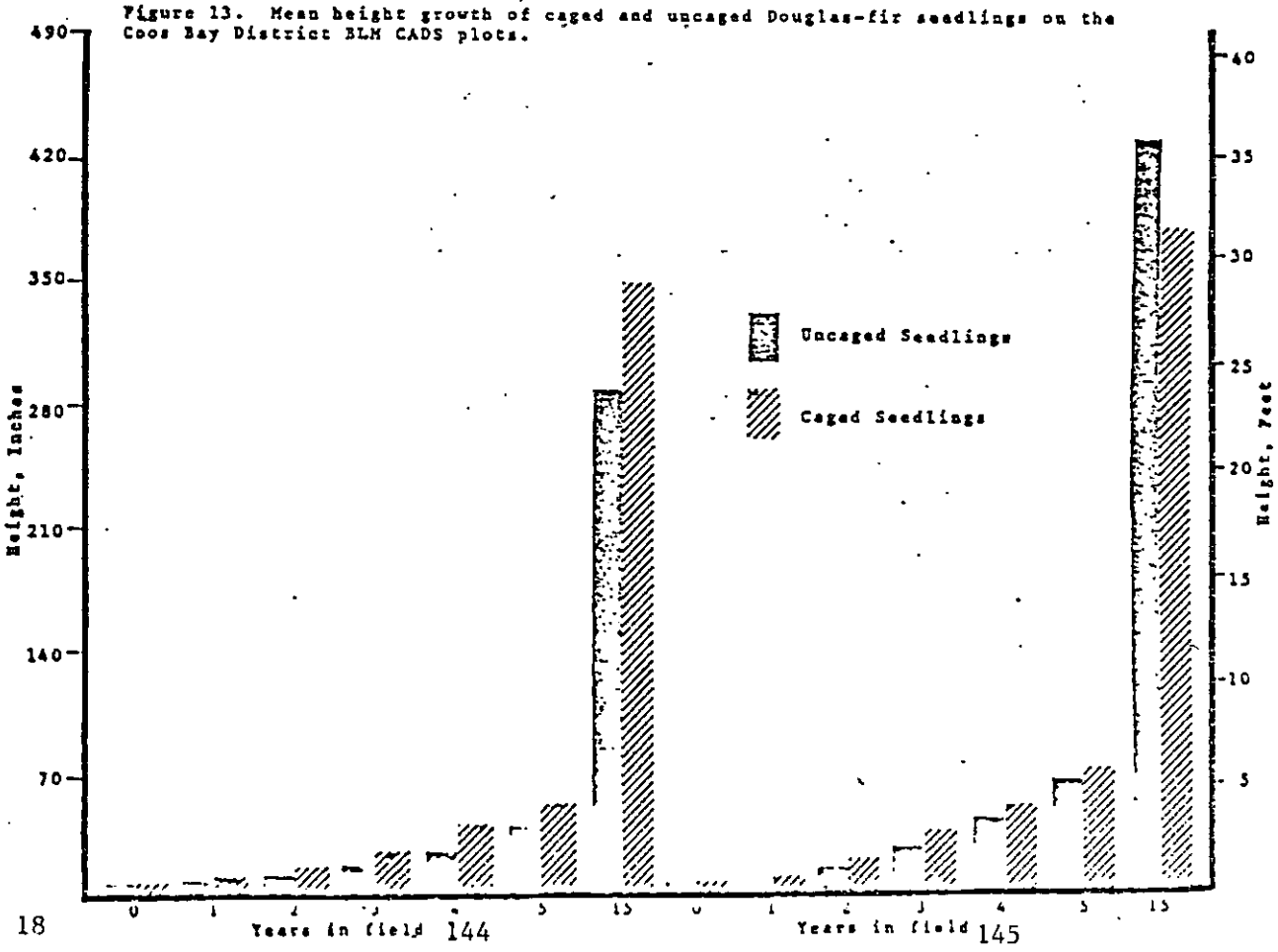


Figure 13. Mean height growth of caged and uncaged Douglas-fir seedlings on the Coos Bay District BLM CADS plots.



144
145

question, all seedlings were listed by height at time of planting (Table 13). Using the five year survival data, each seedling's survival status was tallied by seedling height at time of planting (see Table 14). Distribution of seedling heights indicated that most seedlings were between 6 and 10 inches in height at time of planting. Table 14 indicates that seedling mortality did not, in general, occur in any height grouping but was fairly well distributed throughout all height classes.

Table 13. Distribution of Seedlings by Height Class at Time of Planting on Coos Bay BLM CADS Plots.

	Number of Seedlings		
Height Class Inches	Caged	Uncaged	Total
2	1	3	4
3	2	2	4
4	4	42	46
5	6	40	46
6	18	219	237
7	9	106	115
8	18	216	234
9	11	81	92
10	16	139	155
11	8	32	40
12	3	56	59
13	1	30	31
14	—	28	28
15	1	5	6
16	—	8	8
18	1	3	4
20	—	1	1
	99	1011	1110

Table 14. Seedling Survival by Initial Seedling Height. Includes Survival Status Through the Fifth Year Following Planting.

	Percent Survival of Seedlings		
Height Class Inches	Caged	Uncaged	Average All Trees
2	100	67	75
3	50	50	50
4	100	43	48
5	50	58	56
6	72	51	52
7	67	59	60
8	83	61	63
9	54	67	65
10	75	60	61
11	50	69	65
12	67	66	66
13	100	67	68
14	—	64	64
15	100	80	83
16	—	87	87
18	100	67	75
20	—	100	100
Average	69	59	60

The effect of site quality on seedling height growth was also investigated. After determining site index of each plot based on Technical Bulletin 201 (2), seedlings were grouped by site index and initial height at time of planting. The result is displayed in Table 15. The table shows that the site on which a seedling of a given height is planted had more effect on overall height growth than did the initial height of the seedling. In other words, all seedlings (on the same site) except for differences in initial height, had grown about the same in height. If the same height seedlings were placed on different sites, more growth would be expressed on the higher sites than the lower sites.

Table 15. Effect of Site on Seedling Height. Seedling Height Five Years Following Planting.

Initial Seedling Height (Inches)	Treatment	Site Index 1/ 140	150	170	180	Total All Sites Caged	Uncaged
				(Inches)			
	Caged	—	—	66.0(1)	—	66.0	
2	Uncaged	—	—	23.0(1)	41.0(1)		35.0
	Caged	—	—	13.0(1)	—	13.0	
3	Uncaged	—	—	22.0(1)	—		22.0
	Caged	—	62.0(1)	61.5(2)	71.0(1)	64.0	
4	Uncaged	30.0(1)	22.0(2)	45.5(12)	82.0(3)		39.0
	Caged	—	—	62.3(3)	—	62.3	
5	Uncaged	24.0(2)	28.0(4)	54.4(14)	93.0(3)		52.5
	Caged	32.0(1)	50.0(1)	75.8(10)	98.0(1)	72.2	
6	Uncaged	27.3(3)	21.4(19)	47.9(77)	62.6(12)		44.4
	Caged	—	36.0(2)	67.0(4)	—	56.7	
7	Uncaged	44.6(5)	23.1(8)	52.5(40)	70.1(10)		50.9
	Caged	42.5(2)	35.2(5)	56.1(7)	84.0(1)	49.2	
8	Uncaged	28.9(8)	31.4(29)	51.3(73)	66.2(20)		47.8
	Caged	—	63.0(3)	70.0(1)	97.5(2)	75.7	
9	Uncaged	28.8(2)	47.4(18)	58.8(26)	85.0(8)		57.8
	Caged	32.0(1)	46.2(5)	66.0(4)	103.5(2)	61.2	
10	Uncaged	35.4(5)	34.3(35)	56.0(32)	78.1(11)		48.5
	Caged	—	49.0(1)	61.3(3)	—	58.2	
11	Uncaged	36.0(1)	34.9(10)	51.7(9)	60.0(2)		44.1
	Caged	—	—	100.5(2)	—	100.5	
12	Uncaged	—	40.0(15)	52.5(17)	79.2(5)		51.0
	Caged	—	30.0(1)	—	—	30.0	
13	Uncaged	—	40.7(7)	67.5(11)	98.0(2)		61.2
	Caged	—	—	—	—	—	
14	Uncaged	—	41.3(10)	95.0(4)	91.2(4)		64.3
	Caged	—	79.0(1)	—	—	79.0	
15	Uncaged	—	64.0(3)	—	14.0(1)		75.8
	Caged	—	—	—	—	—	
16	Uncaged	—	46.7(3)	58.5(4)	—		53.4
	Caged	—	55.0(1)	—	—	55.0	
18	Uncaged	—	—	89.0(2)	—		89.0
	Caged	—	—	—	—	—	
20	Uncaged	—	48.0(1)	—	—		48.0
	Caged	39.0	47.3	66.5	93.6	62.7	
TOTAL	Uncaged	32.8	31.6	52.9	73.9		50.0
	All Trees	33.4	33.4	54.4	75.5	51.4	

1/ Number in parenthesis refers to the number of seedlings sampled.

Seedling Height Comparison: Tree Improvement Vs. CADS

For interest, the height growth of the 2-0 Douglas-fir seedlings planted in the CADS study was compared to the height growth of the 2-0 Douglas-fir seedlings planted in the Vincent Creek and Smith River progeny plantations of the Umpqua Cooperative Tree Improvement Program. Since only sets 1 through 4 1/ in both progeny plantations were planted with 2-0 seedlings, only these four sets were used for comparison purposes.

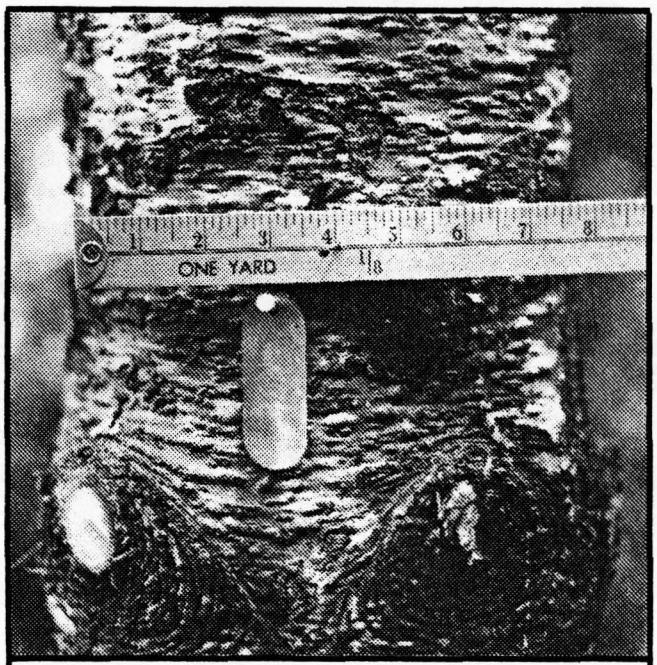
The progeny plantations were well scarified mechanically by tractor and were fenced to keep big game out. The progeny plantations, thus represented a browse-free environment as did the cages in the CADS study. As previously stated, the sites that the CADS plots occupied had been prepared by burning, though the intensity of burning cannot be quantified.

Besides site preparation differences, the progeny plantations generally occupy more gentle slopes and higher sites than do the CADS plots. For the comparison made in Table 16, only CADS plots of Site Index 170 were included since they are most similar to the two progeny plantations.

After five years in the field, height growth of the progeny test seedlings was slightly less than caged seedlings in the CADS plots (see Table 16).

Present and Future Volume Growth

Using DBH and height measurements obtained from the 1979 remeasurement,



Sixteen growing seasons following field planting the average D.B.H. of trees in plot 59, which includes this tree, was 7.6 inches. Twelve of the 53 trees in the plot were over 7 inches D.B.H., the largest being 9.0 inches.

Table 16. Seedling Height Comparison Between Progeny Test Seedlings and CADS Seedlings 5 years following planting.

Seedling Group	Height (in.)
Progeny Plantations (Vincent Crk. #1 and Smith River No. 3) Sets 1 - 4	67.1
CADS Study	
Caged	68.3
Uncaged	53.1

1/ A set contains approximately 480 seedlings.

present plot volumes were calculated. Then, based on the past five year's DBH and height growth, volumes were projected to tree age 30. To make the 1964-65 and the 1963-64 plots comparable in age, the growth measurements for plots planted in 1964-65 were increased an additional year. Thus all trees are considered to be 18 years old from seed. Table 17 shows average annual plot DBH and height growth. Table 18 gives the reader a summary of present stocking on the District plots. The number of trees per acre was calculated by multiplying the number of trees per plot by 6.188 (the number of plots per acre).

Present and future volume for each plot is shown in Table 19. Volume tables used were those constructed by David Bruce (3) using volume equations

Table 17. Current Annual DBH and Height Growth for Coos Bay BLM CADS Plots.

Plot No.	Treatment	Annual DBH Growth per Tree (Inches)	Annual Height Growth per Tree (Feet)
56	Caged	.48	3.45
	Uncaged	.39	3.41
58	Caged	.57	3.28
	Uncaged	.48	2.93
61	Caged	.55	3.62
	Uncaged	.52	3.34
62	Caged	.48	3.43
	Uncaged	.52	3.50
63	Caged	.58	3.23
	Uncaged	.55	3.30
142	Caged	.56	2.13
	Uncaged	.51	2.39
143	Caged	.62	3.55
	Uncaged	.58	3.06
144	Caged	.37	2.77
	Uncaged	.31	2.32
145	Caged	.35	3.09
	Uncaged	.43	3.34

Table 18. Present Stocking on Coos Bay District BLM CADS Plots.

Plot No.	Stocking Per Plot 1/	Trees Per Acre 1/
56	21	130
58	24	148
59	53	328
61	87	538
62	57	353
63	67	415
142	24	148
143	27	167
144	55	340
145	83	514

1/ Stocking includes only those trees planted in the CADS study; it does not include other naturals.

developed from second-growth Douglas-fir. Volume tables were interpolated to the nearest .1 inch DBH and to the nearest foot in height. The cubic foot volume table includes stump and total height to the tip. Total volume per plot was determined by multiplying the volume per tree by the number of trees. Total cubic foot volume per acre was calculated by multiplying the total volume per plot by 6.188.

Table 19. Present and Future Volume Growth. Coos Bay BLM CADS Plots.

	- Present Stand - 18 Years Old -					- Future Stand - 30 Years Old -				
Plot No.	Ave. DBH (in.)	Ave. Ht. (ft.)	Ave. Vol/Tree (cu. ft.)	Total Volume (cu. ft.)	Total Volume (cu. ft.) Per Acre	Ave. DBH (in.)	Ave. Ht. (ft.)	Ave. Vol/Tree (cu. ft.)	Total Volume (cu. ft.)	Total Volume (cu. ft.) Per Acre
56										
Caged	5.4	37.0	2.597	10.390		11.2	78.4	21.472	85.888	
Uncaged	4.5	28.0	1.792	30.469	255.369	9.2	68.9	13.300	226.100	1930.582
% Diff.	20	32	45			21	14	61		
58										
Caged	5.4	36.0	2.930	14.648		12.2	75.4	24.315	121.575	
Uncaged	4.5	33.5	1.960	37.239	324.294	10.2	68.7	15.942	302.898	2626.639
% Diff.	20	7	49			20	10	52		
59										
Caged	7.1	41.1	4.783	33.483		11.6	83.9	25.031	175.217	
Uncaged	6.6	41.9	4.425	203.555	1481.488	12.5	86.5	29.620	1362.520	9515.516
% Diff.	8	-2	8			-7	-3	-15		
61										
Caged	6.3	38.9	3.823	38.234		12.9	82.3	29.639	296.639	
Uncaged	5.5	34.4	2.649	203.982	1513.850	11.7	74.5	22.278	1715.406	12450.534
% Diff.	14	13	44			10	10	33		
62										
Caged	5.9	37.5	3.108	18.648		11.6	78.7	23.331	139.986	
Uncaged	5.9	36.7	3.224	164.445	1144.331	12.1	78.7	25.127	1281.477	8796.013
% Diff.	0	1	-4			-4	0	-7		
63										
Caged	6.7	36.4	3.840	26.878		13.6	75.2	29.359	205.513	
Uncaged	5.8	33.8	2.782	166.944	1211.388	12.4	73.4	24.292	1457.520	10290.848
% Diff.	16	8	38			10	2	21		
142										
Caged	4.2	23.6	1.040	3.120		11.6	51.3	14.185	42.555	
Uncaged	5.8	24.7	1.182	24.822	174.638	11.1	55.8	14.571	305.991	2156.803
% Diff.	-4	-4	-12			4	-8	-3		
143										
Caged	5.9	38.4	3.102	12.408		13.9	84.6	34.834	139.336	
Uncaged	5.2	31.4	1.981	45.563	362.300	12.7	71.2	24.480	563.040	4346.302
% Diff.	13	22	56			9	19	42		
144										
Caged	4.1	30.6	1.254	7.524		8.9	66.6	12.044	72.264	
Uncaged	3.3	24.9	.694	34.006	259.563	7.3	55.1	6.812	333.788	2512.650
% Diff.	24	23	81			22	21	79		
145										
Caged	4.8	34.4	1.899	13.293		9.3	74.6	15.896	111.272	
Uncaged	5.3	38.4	2.572	195.472	1304.781	10.9	81.9	21.802	1656.952	10941.770
% Diff.	-9	-11	-26			-15	-9	-27		

Growth Differences Between Caged and Uncaged Trees

Summarizing Table 19 for current growth differences between caged and uncaged trees yields the following information:

Treatment	No. of Trees	Ave. DBH (in.)	Ave. Ht. (ft.)	Ave. Vol. Per Tree (cu. ft.)	Ave. Trees Per Acre	Total Vol. Per Acre (cu. ft.)
Caged	59	5.7	36.2	3.028	311.2	803.202
Uncaged	439	5.3	34.4	2.520		
% Diff.	498	7%	5%	20%		

Assuming all trees were caged, caged trees would presently (18 years from seed) be producing on the average, 942.3 cu. ft. per acre. Uncaged trees under the same assumption, would be producing 784.2 cu. ft. per acre. Thus, 158 cu. ft. per acre is being lost because all trees were not caged.

Caging was effective from the standpoint of increasing volume. However, as Table 19 indicates, there is much variation in volume from plot to plot. Solely from the standpoint of gaining 158 cu. ft. per acre, caging cannot be justified as a practice that could be applied to all managed timberlands on the District.

In 1978, after remeasuring three plots established under the same study on Georgia-Pacific Corporation, Springfield Division lands, Hahn (4) determined that 263 cu. ft. per acre was lost by not caging. He concluded that this loss was not great enough to warrant this type of protection.

Growth Data Compared with the Allowable Cut

The Coos Bay District under the allowable cut plan for the period of 1971 through 1980 projected a yield at age 30 under normal reforestation practices of 10.1 M bd. ft. (International 1/8 rule) or 9.0 M bd. ft. (Scribner rule) per acre, and under a precommercial and commercial thinning regime (a final harvest volume) of 24.9 M bd. ft. International rule (or 22.2 M bd. ft. Scribner rule) per acre at age 30. As shown in Table 20, projected volumes indicate that most plots will reach the volume identified in the allowable cut plan. Those plots whose volume will not meet the allowable cut plan fall on sites that are below the average site class used in calculating the allowable cut. Conversion factors from cubic foot to Scribner are those listed on page 11, of "Conversion Factors for the Pacific Northwest Forest Industry" (5). To use the conversion table. our future stand average DBH was reduced by two inches to adjust the diameter to diameter inside bark at the small end.

Other Observations

Although the plots established in the study do not nearly represent the many sites and stand conditions found on the District, the fact that we have such good data on the planting and early

Table 20. Predicted Volume at Age 30 Cubic Foot - Board Foot Comparison on Coos Bay BLM CADS Plots.

Plot No.	Total Volume (Cubic Foot) Per Acre	Total Volume (Bd. Ft. Scrib.) Per Acre
56	1950	6942
58	2653	9206
59	9611	46037
61	12574	60229
62	8884	42554
63	10394	49787
142	2178	8995
143	4390	21028
144	2538	8781
145	11051	38347

development of each tree and the ability to have reidentified the trees makes the future maintenance of these plots worthwhile.

Certain plots are particularly interesting. For example, plots 58 and 59 are located only 200 feet apart. They occur on the same soil type, planted with the same stock on the same date. Slope gradients also are approximately the same. The one major difference, as far as geographical location is concerned, is that plot 59 occurs on a south aspect and plot 58 on a north aspect.

The dominants and co-dominants on the south aspect are 23 percent larger in diameter and 10 percent taller than their counterpart on the north aspect. Radial growth at present is about the same on both plots. Trees on the south aspect have grown 19 feet in height in five years, versus 15 feet on the north aspect. The eight tallest trees on the south aspect averaged 50 feet tall, versus 41 feet on the north aspect. Average DBH for the largest eight trees on the south plot was 8.5 inches. This is good growth for 17-year-old trees.

While analyzing data from the study, several regressions were tested to examine the relationship of parent tree height to the same tree's height at 1, 2, 3, 4, and 5 years following planting, and by present crown position. Generally, there was no significant correlation found until the 4th or 5th years.

To substantiate the indicated correlation, the trees were assigned a relative crown position at the 4th and 5th year, based on their relative heights--either dominant, codominant, or intermediate. Of the trees identified as either being dominants or codominants in the 4th year, 88 percent are still dominants or codominants at age 18. Fifth year data was nearly identical. These are trees that more than likely will be crop trees.

The data suggests that we can reliably choose the best "leave" trees even if a precommercial thinning were done as early as the 4th or 5th year, particularly in well-established stands not suffering from brush competition or heavy browsing by animals.

Summary

Caging of seedlings under the CADS study indicates that some additional volume can be gained by caging but that the amount is dependent primarily on browse intensities, site, etc. The study indicates that some "damage" in mortality and growth can be tolerated and still maintain projected yields. The resource manager must be willing to accept some damage from animal competition and must identify this competition prior to planting and/or protecting seedlings in any unit. Based on survey results the manager then needs to decide which of several protective measures would be the most economical.

We would recommend that if terminal browsing is anticipated or currently affects at least 30 percent of the trees, that protective measures be considered. As a general rule, local areas of active high mountain beaver populations need to be considered for protective measures.

The 1979 per tree volume differences between caged and uncaged trees were highly variable on a plot by plot basis. The lowest was a negative 26 percent to a positive 81 percent caged-to-uncaged volume ratio.

Before applying data obtained from this study to other locations one must consider: (1) the planting stock type used, (2) that the seedlings used under the study had been treated with Thiram, (3) cages used in the study are significantly different from tubing and netting presently being used, and (4) plots established for purposes of the study did not, in general, occur in areas of high mountain beaver populations.

Other observations from the CADS plot remeasurement that are worth mentioning include:

- Seedling survival was 45 percent higher on caged plots that had received site preparation treatment by burning than on unburned uncaged plots.

- Seedling survival and height growth for the plots was equal to or exceeded survival and height growth of other coastal and state plots established under the same study.

- Seedling mortality was fairly well distributed throughout all initial seedling height classes.

- Beyond the third year after planting, seedling mortality was less than 3 percent per year.

- There was little difference in mortality between caged and uncaged seedlings on the same plot.

- Beyond the third year after planting, occurrence of browse on the 2-0 Douglas-fir seedlings diminished to near zero.

- Five years after planting, height growth of seedlings in the study was slightly greater than seedlings planted in the District's tree improvement progeny plantations (where site index of the plots and progeny plantations were comparable).

- Two-year-old bare-root seedlings did not make significant height growth until the second growing season. This observation has been made by other cooperators and areas within the state.

- Some benefit was derived by caging, from the standpoint of restricting soil movement onto seedlings.

- The taller the initial seedling at time of planting, the less time the seedling will be vulnerable to damage by browsing animals.

- Areas to be reforested should be evaluated prior to planting to determine damage potential. Where heavy browse is expected, additional trees can be planted or protective devices installed.

- When the decision to protect seedlings is made, all means of protection should be considered. Economics should be considered in the analysis.

- Projected plot volumes to age 30 indicate that the current allowable cut volume for stands 30 years old can be met.

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