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Evaluation of Seedling Protection Materials in Western Oregon

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Contents

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Abstract

A 3-year comparison was made for six materials to protect Douglas-fir seedlings from damage by wildlife. No treatment materials were maintained after the initial application. Tests were run on BLM Districts in western Oregon. Materials included a nested plastic mesh tube, a split plastic mesh tube, a paper bud cap, a plastic mesh tube cap, BGR spray and BGR powder Big Game Repellent. Nested plastic mesh tubes provided the most protection and significantly better growth than other treatments. Split, small-diameter plastic mesh tubes protected seedlings better and generally provided more growth than bud caps or repellents. Bud caps and repellents provided some protection and growth depending on type of damage and season of damage. Costs and comparisons of seedling growth for different materials are reported for Resource Areas. Damage was primarily caused by mountain beaver, elk, and black-tailed deer.

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Introduction

The Bureau of Land Management (BLM) reforests thousands of acres of highly productive forest lands each year in western Oregon. Many planted conifer seedlings on these lands must be protected from animal damage to assure seedling survival and rapid seedling growth. Expensive planting stock which is being genetically improved for faster growth may most assuredly require protection from wildlife feeding injuries.

An analysis of wildlife-reforestation problems in western Oregon in the early 1980's revealed that BLM forest managers were using a wide variety of seedling protectors and repellents to protect their trees from wildlife (Campbell and Evans 1984. Wildlife Reforestation Problems and Seedling Protection in Western Oregon: Review and Current Knowledge. USDI, BLM Tech. Note OR-4, 46 p.). Many of those materials were unproven; some reputedly caused adverse effects on seedlings.

In 1983, BLM and the U.S. Fish and Wildlife Service (FWS) undertook a cooperative study to determine cost and effectiveness of six select seedling protection materials for reducing wildlife damage to Douglas-fir (*Pseudotsuga menziesii*). Selection of materials was based on commercial availability and reports of intended use by five BLM Districts and their Resource Areas in western Oregon.

Work by the FWS was cancelled in early 1985 before study completion when FWS terminated its forest-animal damage research program. The study was then picked up and completed by Wildlife Services Company, Olympia, Washington.

This report summarizes data on animal damage and growth of test seedlings through three dormant seasons and three growing seasons, from February 1983 through September 1985. Data includes costs of materials and application, tree height growth gain, survival, and animal damage for each protection method and for untreated controls. Overall comparisons are based on stocking levels of 400 trees per acre at time of planting.

Methods and Materials

Representative test sites were located and planted by BLM personnel in clearcuts on 10 Resource Areas (RA) in four western Oregon BLM Districts—Salem, Coos Bay, Roseburg, and Medford. The Umpqua RA of the Coos Bay District was set up primarily to test protection of seedlings from damage by mountain beavers (*Aplodontia rufa*). The other RA plots were used primarily for testing against elk (*Cervus elaphus*) or black-tailed deer (*Odocoileus hemionus columbianus*). We assumed that data from these plots would be indicative of effects from mountain beaver, elk, deer, hares (*Lepus sp.*) rabbits (*Sylvilagus sp.*), pocket gophers (*Thomomys sp.*), and other species on Douglas-fir plantations.

Trees were planted the winter of 1982-83 at one-half the normal spacing to help assure exposure of each pair of trees to animals. Test seedlings were 2-0 Douglas-fir except on the Umpqua RA where 2-1 trees were planted.

Thirty-eight test plots were installed as soon as possible after planting. Each plot had 48 treated seedlings paired with 48 untreated controls in a randomized block design for a total of 96 trees per plot.

Six protection materials were tested. Those used to protect the entire seedling included nested plastic mesh tubes supported by bamboo stakes and small-diameter split plastic mesh tubes packaged above the first lateral roots and planted with the trees and supported by the tree and soil. Materials tested to protect the tops of seedlings included bud caps constructed of waterproof paper, and plastic mesh tubes. Repellents were Deer-Away (BGR) liquid spray and powder. BGR spray was applied with hand sprayers on wet or dry foliage. BGR powder was dusted onto naturally wet foliage or on foliage sprayed with water to assure sticking. Each repellent was applied twice, once at time of planting and again on new foliage after bud burst. Other materials were not reapplied on tree seedlings. For standardization with most Resource Areas, we used two bamboo stakes to support plastic mesh tubes.

Comparative cost for materials and application was calculated using 1983 figures and time it took to install each treatment on newly planted Douglas-fir seedlings. Labor was conservatively estimated at $6.00 per hour. Costs for transportation of materials and extra travel costs for reapplying repellents after bud burst to assure foliage treatment are not included.

Trees were measured after the 1982-83, 1983-84, and 1984-85 dormant seasons and after the 1983, 1984, and 1985 growing seasons. Tree survival, heights, and condition, animal damage to stems or branches or materials, and condition of seedling protection materials were recorded during each measurement. There was no maintenance (replacement; straightening out) of any seedling protection materials during the study.

Results

General

Douglas-fir seedlings benefitted from most seedling protection materials tested. Amounts of damage caused by animals and site quality were important factors in determining growth and survival benefits on each of the 38 test plots. In general, animal problems were usually similar for those test plots within a Resource Area (RA). The seasons that damage occurred, growing or dormant, or both, were usually fairly consistent in each RA. Some test plots received little damage while some were heavily and repeatedly damaged throughout the 3 years.

Seedling Protection Materials

Comparative costs.—Table 1 lists comparative costs of applying materials to 100 newly planted Douglas-fir seedlings. Source of materials is also listed. Basically, nested tubes cost about three timed more than BGR.powder and about six times more than paper bud caps to use.

Effectiveness.—Greatest tree growth and survival was provided by Vexar-type plastic mesh seedling protectors. In a comparison of seedling protection treatments on all 38 test plots, nested tube plastic mesh material provided significantly (.05) more growth than all other treatments and untreated seedlings (Table 2). Seedlings treated with nested tubes also have significantly (.05) better survival

Table 1. Comparative material and labor costs for treating 100 seedlings. Cost of transportation of materials and travel to reapply repellents is not included. Labor cost is estimated at $6.00 per hour.

Seedling protection materials cost	Material cost	Labor cost	Total cost
Nested plastic mesh tube[a] (3" x 30"; $14/100); two natural bamboo supports/tube (36"; $11/200)	$25	$10	$35
Split plastic mesh tube[a] (1" x 24")	8	3	11
Paper bud cap[c] (1.5" x 8.5", stapled)	3	3	6
Plastic mesh tube cap[a] (1.5" x 12")	4	3	7
5% BGR spray[b] (5 ml per application)	6	2	8[d]
36% BGR powder[b] (1.5 g per application)	10	2	12[d]

[a]Forest Protection Products Co., Inc., Coos Bay, Oregon 97420.
[b]International Reforestation Suppliers, Eugene, Oregon 97405.
[c]J.L. Darling Corp., Tacoma, Washington 98421.
[d]Cost for two applications; does not include cost of spray equipment.

Table 2. Mean height growth and survival of Douglas-fir seedlings on 38 western Oregon BLM Resource Areas 3 years after planting and treatment with six seedling protection materials

Treatment (n)	Mean growth (cm)*	Mean survival (%)*
Nested tube	56.97 a	91.78 a
Split tube	46.70 b	87.57 a b
BGR powder	42.31 b c	79.04 c
Tube cap	42.30 b c	78.62 c
BGR spray	40.93 b c	79.75 c
Paper cap	39.95 c	80.92 b c
Untreated	38.12 c	78.90 c

*Treatment levels with a common letter are not significantly different at the .05 level of significance using Duncan's multiple-range test.

than all treatments except split tubes when all plots were compared. Again comparing all test plots together, split plastic mesh tubes, BGR powder, plastic mesh tube caps, and BGR spray were not significantly different from each other in producing growth. BGR powder, plastic mesh tube caps, BGR spray, paper caps and untreated seedlings were also not significantly different. The best determination of the value of any single method, however, was best related to the plots in each RA.

Productivity (feet per acre of hight growth) of each seedling protection method is shown in Table 3. This data is based on survival and growth data for each RA (Appendix A, Tables 1A through 10A). Those RA's that benefitted most from seedling protection included the Umpqua RA (mountain beaver), the Grants Pass and Myrtlewood RA's (elk), the Drain RA (deer and elk), and the Jacksonville RA (deer). Highlights for each BLM District and individual RA are given below and in Appendix A.

Coos Bay District

Umpqua Resource Area.—Mountain beaver damage was highest during the first two dormant seasons and some occurred during the growing season (Appendixes B & C). Some damage did occur as tubes grew above plastic mesh protectors. The large trees used in these plots grew well when protected despite dense vegetation, and the use of plastic mesh tubes appears justified on the Umpqua sites (Appendix A, Table 1A). Some damage from mountain beavers will probably continue. Damage from elk was noted for the first time in 1985.

Myrtlewood Resource Area.—Elk damage on Camas Creek plots continued throughout the test period. Tree growth above the tops of nested tubes was browsed. Mortality to unprotected trees occurred because of severe browsing damage during the 3 years. Some living trees remained shorter than

Table 3. Productivity (height growth) of Douglas-fir 3 years after planting and treating with seedling protectors on 10 BLM Resource Areas (based on height growth and survival rate of 400 trees per acre for each treatment)

Resource Area (RA) and main animals causing damage	Plastic mesh tubes		Bud caps		BGR repellents		Untreated
	Nested	Split	Tube	Paper	Spray	Powder	
	Feet per acre						
Umpqua RA mtn beaver	1298	924	440	263	473	771	392
Grants Pass RA elk	237	233	111	176	127	43	98
Myrtlewood RA elk	743	489	608	468	558	570	355
Tioga RA elk	818	728	582	689	670	588	596
Drain RA deer & elk	545	385	407	323	208	255	222
N. Umpqua RA deer	296	259	189	236	208	140	182
Jacksonville RA deer	306	248	195	165	145	127	125
Alsea RA deer, elk, mtn beaver	1086	964	788	840	768	715	859
Yamhill RA deer	603	495	566	472	535	481	469
Tillamook RA deer	637	503	348	423	447	474	450
Mean	657	523	423	406	414	415	375
SD	345	268	216	222	229	258	235

when originally planted. Short (18-inch) plastic mesh tubes should be placed on terminals of heavily browsed trees to allow recovery of height growth. Browse availability has been low on these plots.

On Chaney Bridge plots, browsing damage from elk and deer increased for unknown reasons in the 1985 growing season (Appendix C) and occurred until at least mid-summer. Tree growth, however, was good on this productive site because of rapid recovery of browsed trees.

Tioga Resource Area.—Trees on the Skeeter Camp and Shotgun Bench plots were lightly damaged during the dormant seasons and at moderate levels during the growing seasons. Damage by hares (or brush rabbits) occurred on one bracken fern covered plot, but mainly to lateral branches. Browsing damage, however, will probably continue at similar levels for several years until trees exceed the reach of elk.

Medford District

Jacksonville Resource Area.—Most plots had continued deer browsing during the 3 year period (Appendixes B & C). Trees in tubes grew better than other treatments or untreated seedlings (Appendix A, Table 7A).

Environmental conditions, principally drought, caused seedling mortality in all plots. Overall survival of control seedlings on Fawn Creek clearcut plots was 50%; survival on the White Rock partial cut plots was 73%. Nested tubes resulted in greatest seedling survival (81%) on Fawn Creek plots but showed no difference (75% survival) from controls on the White Rock plots. Based on this study, increase tree survival alone may justify use of nested tubes in many southwestern Oregon clearcut units. Other barriers—paper caps, tube caps—may be justifiable in partial cut units experiencing deer browse damage.

Grants Pass Resource Area.—Elk damage was generally high on the Old Rum Creek plot and was low on the Peggler Butte plot in spite of considerable deer and elk sign in the area. In 1985, browse damage in the Old Rum Creek plot occurred inside a New Zealand electric fence. The fence was removed in mid-summer 1985 because of high maintenance cost. Nested tubes and split tubes provided significantly greater seedling survival than most other treatments (Appendix A, Table 2A). Significant (.05) height growth differences occurred between the split tube treatment and other treatments and control seedlings. There was apparent competition with tree brush species, mainly chinkapin, tanoak, ceanothus, manzanita, and madrone on these plots.

Roseburg District

North Umpqua and Drain Resource Areas.—Growth by seedlings treated with split and nested tubes was equal to tube caps and significantly (.05) greater than other treatments and controls (Appendix A, Table 6A). Occurrence of growing season browse damage on the two North Umpqua study plots and four Drain plots increased the third year (1985) to the highest ever (Appendix C). Damage on North Umpqua's Gassy Creek plots (by deer) was 65% and 84%; a lack of palatable spring forbs and herbs combined with herbicide treatment of adjacent private lands may have contributed to the high browse rate. Damage on Drain's Andrews Creek 1 and Andrews Creek 3 plots was caused mainly by deer and elk. No direct evidence of cattle damage occurred on the Andrews Creek plots despite heavy use during the summer of 1985.

Nested and split tubes showed significant growth increases over the 3-year study (Appendix A, Tables 5A and 6A). Survival of trees in nested tubes was highest on the Drain RA but not significantly better than untreated seedlings or other treatments on either RA. Terminals of most tube-protected trees on the North Umpqua and Drain units have grown above the 30-inch-tall nested tubes in 1985 and were no longer protected. Placement of 12- to 18-inch Vexar tubes or tube caps over terminals could result in seedlings outgrowing further browse damage.

Salem District

Alsea Resource Area.—Growing and dormant season damage was generally low to moderate and most trees grew beyond heights normally browsed as the availability of forage increased. Mountain beavers continued to cause some damage and mortality on Alsea RA plots, much of it being caused by excavating and undermining trees. Despite moderate damage levels, nested tubes provided significantly greater growth than other treatments (Appendix A, Table 8A).

Yamhill Resource Area.—Expected damage by elk never developed at Nestucca Overlook but growth of nested tube-protected seedlings was significantly greater than untreated trees. Pocket gopher damage to roots of Douglas-fir increased at Nestucca Overlook plots and the abundance of pocket gophers appeared to be increasing throughout the plantation. Other mortality, possibly caused by disease, was intermixed with pocket gopher mortality. Tree mortality could become significant on this plantation despite low browsing damage. North Whipup plots had moderate to high browsing damage and are also subject to pocket gopher damage. Nested tubes again provided more growth than most other treatments (Appendix A, Table 9A).

Tillamook Resource Area.—Browse damage by deer and elk was low on all six study plots on the Tillamook RA (Appendix A, Table 10A). Nested tubes, however, still provided the most growth. There was considerable deer and elk sign but very little damage. Although trees in nested tubes grew best, no statistically significant (.05) growth or survival differences occurred between treatments and controls after three growing seasons. Mountain beavers did not occur in study plots but were causing considerable tree damage on other plantations. Pocket gopher damage was noted for the first time in 1985 (on the Big Ear study plots) and could become an increasing problem on the Tillamook Area.

Seedling Protection Costs and Benefits

Benefits of protecting seedlings were calculated for several Resource Areas by comparing costs of tree height growth based on the survival and height growth of treated and untreated trees. Resource Areas with different animal problems and amounts of damage are shown in Table 4. On the Umpqua RA, that was damaged by mountain beavers, tree height growth cost about one-half as much for nested tubes ($0.24/foot) as for untreated trees ($0.44/foot) and trees in nested tubes produced about three times as much growth per acre (1298 feet) as untreated trees (392 feet per acre). On the Tillamook RA, which had moderate deer browsing damage, tree height growth for nested tubes cost $0.45/foot while untreated tree growth cost $0.33/foot. However, growth produced per acre by nested tubes was nearly twice as much as by untreated trees.

Benefits for each Resource Area varied with kinds and amounts of animal damage and with site quality. Higher quality sites generally recovered more quickly from browsing damage. However, high

Table 4. Comparative costs for height growth of Douglas-fir 2-1 and 2-0 seedlings and production of height growth per acre for 3 years for seedling protection materials on four Resource Areas. Data is based on tree and planting costs[a] and protection costs for 400 trees per acre for areas of mountain beaver damage (Umpqua RA; 2-1 seedlings), deer and elk damage (Drain RA; 2-0 seedlings), and deer damage (Jacksonville RA and Tillamook RA; 2-0 seedlings).

	Umpqua RA		Drain RA		Jacksonville RA		Tillamook RA	
Treatment	Cost per ft	Ft produced per acre	Cost per ft	Ft produced per acre	Cost per ft	Ft produced per acre	Cost per ft	Ft produced per acre
Nested tube	$0.24	1298	$0.52	545	$0.94	306	$0.45	637
Split tube	0.23	924	0.50	385	0.77	248	0.38	523
Tube cap	0.45	440	0.43	407	0.89	195	0.50	423
Paper cap	0.75	263	0.53	323	1.04	165	0.40	406
BGR spray	0.43	473	0.87	208	1.24	145	0.40	414
BGR powder	0.29	771	0.77	255	1.54	127	0.41	416
Untreated	0.44	392	0.66	222	1.18	125	0.33	375

[a]Estimated costs for trees and planting: 2-1 seedlings = $173/acre (400 trees) and 2-0 seedlings = $148/acre (400 trees). This does not include site preparation costs.

quality sites may not recover from mountain beaver caused mortality.

Discussion and Recommendations

Effects of protection materials on tree growth and survival.—The growth and survival of seedlings protected with most materials was generally greater than for unprotected seedlings. Long-term protection was provided by nested plastic mesh tubes and small-diameter split plastic mesh tubes against mountain beaver. The shorter split tubes were more often browsed by deer and elk after trees grew out of the top of the tube. Plastic mesh tube caps and paper caps provided some protection until seedlings grew out of the top of the tubes, but both types were often blown off seedlings in windy sites. These seedling caps were often too heavy for newly planted seedlings and were not well supported by the seedlings. The BGR repellents tested were extremely different in concentration and most benefit was provided by the high concentration in BGR powder. Application of BGR powder was difficult because of the need to have wet foliage and the problem of wind blowing the powder when shaking it on the tree; this often required spraying seedlings with water from a hand sprayer and sheltering the tree with a cardboard or plastic shield during application of the powder.

Protection against animals.—In mountain beaver occupied sites, newly planted tree seedlings should be protected or the mountain beavers adequately controlled for a period of several years. Elk damage can be severe and seedlings should be protected in resident elk areas or where numbers are increasing. Protection against deer damage was most beneficial in the Roseburg and Medford Districts where there was more damage. Seedling protection against deer in the Salem District was beneficial but less increases in growth and survival were measured compared with other Districts.

Data on each seedling protection method for each Resource Area checked in this study should help managers determine what kind and amount of seedling protection is justified to meet stocking and growth requirements. Frequent examination of plantations for animal damage is recommended on all areas.

Alternative methods of animal damage prevention and control, including habitat manipulation and improved seedling protection methods, should be developed. There is also an apparent need to develop methods for managers to quantify animal control effectiveness.

For long-term effects, all plots should be maintained and remeasured for an additional 5 years or remeasured in 1990.

Appendix A

Table 1A. Comparison of mean survival, growth, and animal damage to Douglas-fir 3 years after planting four BLM Umpqua RA plots on the Coos Bay District. Trees were damaged primarily by mountain beavers during dormant seasons.

Treatment (n)	Mean Survival (%)*	Mean growth (cm)*	Tree stems damaged by animals (%)	Animal-caused Mortality (%)
Nested tube (32)	96.98 a	102.09 a	16.1	0.0
Split tube (32)	90.63 a b	77.71 a	33.3	0.0
BGR powder (32)	65.63 b c	89.51 a	67.7	32.3
BGR spray (32)	53.13 c d	67.89 a	47.7	38.7
Untreated (192)	49.48 c d	60.32 a	75.4	48.1
Tube cap (32)	43.75 d	76.58 a	70.0	53.3
Paper cap (32)	37.50 d	53.53 a	98.0	62.5

*Survival and growth for treatment levels with a common letter are not significantly different at the .05 level of significance using Duncan's multiple-range test.

Table 2A. Comparisons of mean survival, growth, and animal damage to Douglas-fir 3 years after planting on two BLM Grants Pass Resource Area plots on the Medford District. Trees were damaged primarily by elk during growing seasons.

Treatment (n)	Mean Survival (%)*	Mean growth (cm)*	Tree stems damaged by animals (%)	Animal-caused Mortality (%)
Nested tube (16)	93.75 a	19.25 a b	18.8	6.25
Split tube (16)	88.89 a	19.99 a	0.0	0.0
Paper cap (16)	75.00 a b	17.92 a b	28.6	0.0
BGR spray (16)	59.82 b c	16.18 a b	50.0	0.0
Untreated (96)	56.85 b c	13.20 a b	45.7	19.8
Tube cap (16)	50.00 c d	16.75 a b	10.0	0.0
BGR powder (16)	33.04 d	9.83 b	92.9	35.7

*Survival and growth for treatment levels with a common letter are not significantly different at the .05 level of significance using Duncan's multiple-range test.

Table 3A. Comparisons of mean growth, survival, and animal damage to Douglas-fir 3 years after planting on four Myrtlewood Resource Area plots on the Coos Bay District. Trees were damaged primarily by elk during both growing and dormant seasons.

Treatment (n)	Mean growth (cm)*	Mean Survival (%)*	Tree stems damaged by animals (%)	Animal-caused Mortality (%)
Nested tube (32)	58.42 a	96.88 a b	53.1	0.0
Tube cap (32)	46.34 a b	100.00 a	68.8	0.0
BGR powder (32)	46.33 a b	93.75 a b	90.0	6.2
BGR spray (32)	45.60 a b	93.30 a b	96.6	0.3
Paper cap (32)	40.77 a b	87.50 b	90.6	6.3
Split tube (32)	38.43 b	96.88 a b	65.6	0.0
Untreated (192)	30.65 b	88.28 a b	93.7	7.9

*Growth and survival for treatment levels with a common letter are not significantly different at the .05 level of significance using Duncan's multiple-range test.

Table 4A. Comparisons of mean growth, survival, and animal damage to Douglas-fir 3 years after planting on four BLM Tioga Resource Area plots on the Coos Bay District. Trees were damaged primarily by elk and black-tailed deer during both growing and dormant seasons.

Treatment (n)	Mean growth (cm)*	Mean Survival (%)*	Tree stems damaged by animals (%)	Animal-caused Mortality (%)
Nested tube (32)	64.34 a	96.88 a	16.1	0.0
Split tube (32)	57.25 a b	96.88 a	16.1	0.0
BGR spray (32)	52.75 a b	96.88 a	25.8	0.0
Paper cap (32)	52.47 a b	100.00 a	28.1	0.0
BGR powder (32)	49.47 b	90.63 a	38.7	6.5
Untreated (192)	48.48 b	93.75 a	47.0	3.2
Tube cap (32)	47.31 b	93.75 a	32.3	3.2

*Growth and survival for treatment levels with a common letter are not significantly different at the .05 level of significance using Duncan's multiple-range test.

Table 5A. Comparisons of mean growth, survival, and animal damage to Douglas-fir 3 years after planting on four BLM Drain Resource Area plots on the Roseburg District. Trees were damaged primarily by black-tailed deer and elk during growing and dormant seasons

Treatment (n)	Mean growth (cm)*	Mean Survival (%)*	Tree stems damaged by animals (%)	Animal-caused Mortality (%)
Nested tube (32)	45.86 a	90.63 a	51.6	0.0
Tube cap (32)	36.75 a b	84.38 a	66.7	3.3
Split tube (32)	36.08 b	81.25 a	59.3	0.0
Paper cap (32)	28.09 b c	87.50 a	71.9	3.1
BGR powder (32)	23.00 c	84.38 a	84.4	6.3
BGR spray (32)	22.13 c	71.88 a	96.7	13.3
Untreated (192)	21.26 c	76.69 a	96.2	11.4

*Growth and survival for treatment levels with a common letter are not significantly different at the .05 level of significance using Duncan's multiple-range test.

Table 6A. Comparisons of mean growth, survival, and animal damage to Douglas-fir 3 years after planting on two BLM North Umpqua Resource Area plots on the Roseburg District. Trees were damaged primarily by black-tailed deer during growing seasons.

Treatment (n)	Mean growth (cm)*	Mean Survival (%)*	Tree stems damaged by animals (%)	Animal-caused Mortality (%)
Split tube (26)	35.08 a	56.25 a	44.4	0.0
Nested tube (16)	32.78 a	68.75 a	27.3	0.0
Tube cap (16)	25.67 a b	56.25 a	88.8	0.0
Paper cap (16)	22.18 b c	81.25 a	53.8	0.0
BGR spray (16)	21.10 b c	75.00 a	84.6	0.0
Untreated (96)	20.49 b c	67.71 a	82.9	2.9
BGR powder (16)	15.53 c	68.75 a	66.7	0.0

*Growth and survival for treatment levels with a common letter are not significantly different at the .05 level of significance using Duncan's multiple-range test.

Table 7A. Comparisons of mean growth, survival, and animal damage to Douglas-fir 3 years after planting on four BLM Jacksonville Resource Area plots on the Medford District. Trees were damaged primarily by black-tailed deer during growing seasons.

Treatment (n)	Mean growth (cm)*	Mean Survival (%)*	Tree stems damaged by animals (%)	Animal-caused Mortality (%)
Split Tube (32)	30.32 a	62.50 a	29.6	7.4
Nested tube (32)	29.84 a	78.13 a	12.9	0.0
Tube cap (32)	22.67 ab	65.63 a	29.6	3.7
Paper cap (32)	19.16 b	65.63 a	31.0	0.0
BGR powder (32)	18.16 b	53.13 a	52.0	12.0
Untreated (192)	15.64 b	60.94 a	66.1	10.9
BGR spray (32)	15.33 b	71.88 a	57.1	3.6

*Growth and survival for treatment levels with a common letter are not significantly different at the .05 level of significance using Duncan's multiple-range test.

Table 8A. Comparisons of mean growth, survival, and animal damage to Douglas-fir 3 years after planting on four BLM Alsea Resource Area plots on the Salem District. Trees were damaged primarily by black-tailed deer, elk, and mountain beavers during dormant and growing seasons.

Treatment (n)	Mean growth (cm)*	Mean Survival (%)*	Tree stems damaged by animals (%)	Animal-caused Mortality (%)
Nested tube (32)	91.28 a	90.63 a	10.0	3.3
Split tube (32)	73.44 b	100.00 a	9.4	0.0
Untreated (192)	71.44 b	91.67 a	33.3	5.8
Paper cap (32)	70.59 bc	90.63 a	19.4	6.4
BGR spray (32)	66.86 bc	87.50 a	23.3	0.0
Tube cap (32)	63.66 bc	93.75 a	0.0	0.0
BGR powder (32)	60.13 c	90.63 a	25.8	3.2

*Growth and survival for treatment levels with a common letter are not significantly different at the .05 level of significance using Duncan's multiple-range test.

Table 9A. Comparisons of mean growth, survival, and animal damage to Douglas-fir 3 years after planting on four BLM Yamhill Resource Area plots on the Salem District. Trees were damaged primarily by black-tailed deer and elk during the growing seasons.

Treatment (n)	Mean growth (cm)*	Mean Survival (%)*	Tree stems damaged by animals (%)	Animal-caused Mortality (%)
Nested tube (32)	49.00 a	93.75 a	9.4	3.1
Tube cap (32)	45.99 a b	93.75 a	15.6	0.0
BGR spray (32)	43.48 a b	93.75 a	34.4	0.0
Split tube (32)	40.21 b	93.75 a	22.6	0.0
Paper cap (32)	39.66 b	90.63 a	36.7	0.0
BGR powder (32)	39.13 b	93.75 a	22.6	0.0
Untreated (192)	38.99 b	91.67 a	30.6	1.6

* Growth and survival for treatment levels with a common letter are not significantly different at the .05 level of significance using Duncan's multiple-range test.

Table 10A. Comparisons of mean growth, survival, and animal damage to Douglas-fir 3 years after planting on six BLM Tillamook Resource Area plots on the Salem District. Trees were damaged primarily by black-tailed deer during the growing season.

Treatment (n)	Mean growth (cm)*	Mean Survival (%)*	Tree stems damaged by animals (%)	Animal-caused Mortality (%)
Nested tube (48)	49.60 a	97.92 a	2.1	0.0
BGR powder (48)	42.32 a b	85.42 a b	23.3	2.3
BGR spray (48)	41.94 a b	81.25 b	7.3	0.0
Split tube (48)	41.78 a b	91.67 a b	17.8	2.2
Untreated (288)	39.02 a b	87.85 a b	19.1	0.4
Paper cap (48)	36.82 b	87.50 a b	18.2	2.3
Tube cap (48)	33.45 b	79.17 b	18.4	5.3

* Growth and survival for treatment levels with a common letter are not significantly different at the .05 level of significance using Duncan's multiple-range test.

Appendix B

Dormant season damage to untreated Douglas-fir seedlings during 1983, 1983-84, and 1984-85 on Bureau of Land Management Resource Areas in western Oregon

BLM District, Resource Area (RA), Plantation, Plot	Animal species causing most damage	Terminals or stems damaged (%)[1]		Dormant season
		Average	Range	
Coos Bay				
Umpqua RA	mtn. beaver	23	13-15	1983
Bear-Johnson	mtn. beaver	40	25-50	1983-84
Unit 1, Plot 1	mtn. beaver	7	0-13	1984-85
Plot 2	mtn. beaver	7	0-25	1983
	mtn. beaver	23	13-38	1983-84
	mtn. beaver	2	0-13	1984-85
Umpqua RA	mtn. beaver	38	13-63	1983
Bear-Johnson	mtn. beaver,	38	25-63	1983-84
Unit 2, Plot 1	hare, deer			
	mtn. beaver	2	0-13	1984-85
Plot 2	mtn. beaver	4	0-13	1983
	mtn. beaver	2	0-13	1984
	--	0		1985[2]
Myrtlewood RA	mtn. beaver	13	0-25	1983
Camas Cr.	elk	84	38-88	1983-84
Plot 1	elk	55	38-88	1984-85
Plot 2	--	0		1983
	elk	84	75-100	1983-84
	elk	69	38-88	1984-85
Myrtlewood RA	--	0		1983
Chaney Bridge	elk, deer	57	13-88	1983-84
Plot 1	elk, deer	7	0-13	1984-85
Plot 2	--	0		1983
	elk, deer	48	25-63	1983-84
	elk, deer	9	0-13	1984-85
Tioga RA	--	0		1983
Skeeter Camp	elk	4	0-13	1983-84
Plot 1	--	0		1984-85
Plot 2	--	0		1983
	elk, deer	4	0-13	1983-84
	--	0		1984-85
Tioga RA	--	0		1983
Shotgun Bench	elk	19	0-38	1983-84
Plot 1	--	0		1984-85
Plot 2	--	0		1983
	hare, deer	7	0-13	1983-84
	--	0		1984-85
Medford				
Jacksonville RA	--	0		1983
Fawn Cr.	--	0		1983-84
Plot 1	deer	15	0-38	1984-85
Plot 2	--	0		1983
	deer	4	0-13	1983-84
	deer	2	0-13	1984-85

Dormant season damage to untreated Douglas-fir seedlings during 1983, 1983-84, and 1984-85 on Bureau of Land Management Resource Areas in western Oregon (continued)

BLM District, Resource Area (RA), Plantation, Plot	Animal species causing most damage	Terminals or stems damaged (%)[1] Average	Range	Dormant season
Jacksonville RA	--	0		1983
White Rock	deer	11	0-38	1983-84
Plot 1	deer	8	0-25	1984-85
Plot 2	--	0		1983
	--	0		1983-84
	deer	4	0-13	1984-85
Grants Pass RA	--	0		1983
Peggler Butte	--	0		1983-84
Plot 1	--	0		1984-85
Grants Pass RA	deer, elk	15	0-25	1983
Old Rum Cr.	elk	11	0-25	1983-84
Plot 1	elk	9	0-25	1984-85 (inside electric fence in 1984-85)
Roseburg				
North Umpqua RA	--	0		1983
Gassy Cr.	deer	7	0-13	1983-84
Plot 1	deer	2	0-13	1984-85
Plot 2	--	0		1983
	--	0		1983-84
	deer	4	0-13	1984-85
Drain RA	deer	9	0-25	1983
Andrews Cr.	deer	59	50-75	1983-84
Unit 1, Plot 1	deer	42	25-63	1984-85
Plot 2	deer	21	0-50	1983
	deer	75	63-88	1983-84
	deer	4	0-13	1984-85
Drain RA	deer	13	0-25	1983
Andrews Cr.	deer	80	63-88	1983-84
Unit 3, Plot 1	deer, elk	9	0-25	1984-85
Plot 2	deer	21	0-50	1983
	deer	75	63-88	1983-84
	deer, elk	11	0-25	1984-85
Salem				
Alsea RA	--	0		1983
Little Lobster	deer, elk	17	0-50	1983-84
Plot 1	--	0		1984-85
Plot 2	--	0		1983
	mtn. beaver, deer, elk	25	13-38	1983-84
	mtn. beaver	11	0-25	1984-85
Alsea RA	--	0		1983
South Briar Cr.	deer	2	0-13	1983-84
Plot 1	--	0		198
Plot 2	mtn. beaver	9	0-13	1983
	--	0		1983-84
	--	0		1984-85

Dormant season damage to untreated Douglas-fir seedlings during 1983, 1983-84, and 1984-85 on Bureau of Land Management Resource Areas in western Oregon (continued)

BLM District, Resource Area (RA), Plantation, Plot	Animal species causing most damage	Terminals or stems damaged (%)[1]		Dormant season
		Average	Range	
Yamhill RA	--	0		1983
Nestucca Overlook	--	0		1983-84
Plot 1	--	0		1984-85
Plot 2	--	0		1983
	--	0		1983-84
	pocket gopher	4	0-13	1984-85
Yamhill RA	--	0		1983
N. Whipup	deer	2	0-13	1983-84
Plot 1	--	0		1984-85
Plot 2	--	0		1983
	--	0		1983-84
	--	0		1984-85
Tillamook RA	elk, deer	2	0-13	1983
Tucca Cr.	elk, deer	2	0-13	1983-84
Plot 1	elk, deer	2	0-13	1984-85
Plot 2	--	0		1983
	--	0		1983-84
	--	0		1984-85
Tillamook RA	--	0		1983
Stockpile	--	0		1983-84
Plot 1	elk, deer	2	0-13	1984-85
Plot 2	elk	7	0-13	1983
	--	0		1983-84
	--	0		1984-85
Tillamook RA	--	0		1983
Big Ear	--	0		1983-84
Plot 1	elk, deer	4	0-25	1984-85
Plot 2	--	0		1983
	--	0		1983-84
	--	0		1984-85

[1]Six groups of untreated trees were paired with trees treated with protection materials on each plot.

Appendix C

Growing season damage to untreated (control) Douglas-fir seedlings during 1983, 1984, and 1985 on Bureau of Land Management Resource Areas in western Oregon

BLM District, Resource Area (RA), Plantation, Plot	Animal species causing most damage	Terminals or stems damaged (%)[1] Average	Range	Dormant season
Coos Bay				
Umpqua RA	mtn. beaver	15	0-38	1983
Bear-Johnson	mtn. beaver	7	0-13	1984
Unit 1, Plot 1	--	0		1985[2]
Plot 2	mtn. beaver	13	0-38	1983
	mtn. beaver	7	0-13	1984
	mtn. beaver, elk	4	0-13	1985[2]
Umpqua RA	mtn. beaver	2	0-13	1983
Bear-Johnson	mtn. beaver	15	0-50	1984
Unit 2, Plot 1	--	0		1985[2]
Plot 2	mtn. beaver	4	0-13	1983
	mtn. beaver	2	0-13	1984
	--	0		1985[2]
Myrtlewood RA	elk	21	13-38	1983
Camas Cr.	elk	13	0-25	1984
Plot 1	elk	11	0-25	1985
Plot 2	elk	19	0-25	1983
	–	o		1984
	elk	4	0-13	1985
Myrtlewood RA	elk, deer	46	0-63	1983
Chaney Bridge	elk, deer	15	0-38	1984
Plot 1	elk, deer	36	13-50	1985
Plot 2	elk	19	0-25	1983
	--	0		1984
	elk, deer	67	25-87	1985
Tioga RA	elk	29	0-50	1983
Skeeter Camp	elk, deer	17	0-50	1984
Plot 1	elk, deer	23	13-25	1985
Plot 2	--	0		1983
	elk, deer	15	0-38	1984
	elk, deer	7	0-13	1985
Tioga RA	elk	17	13-25	1983
Shotgun Bench	elk, deer	8	0-25	1984
Plot 1	elk, deer	9	0-25	1985
Plot 2	hare, deer	17	0-38	1983
	hare, deer, elk	19	0-50	1984
	deer	15	0-38	1875
Medford				
Jacksonville RA	deer	4	0-13	1983
Fawn Cr. Plot 1	deer	42	13-75	1984
	deer	26	0-50	1985
Plot 2	deer	8	0-12	1983
	deer	4	0-13	1984
	deer	16	0-33	1985

Growing season damage to untreated (control) Douglas-fir seedlings during 1983, 1984, and 1985 on Bureau of Land Management Resource Areas in western Oregon (continued)

BLM District, Resource Area (RA), Plantation, Plot	Animal species causing most damage	Terminals or stems damaged (%)[1]		Dormant season
		Average	Range	
Jacksonville RA	deer	44	25-63	1983
White Rock	deer	15	0-25	1984
Plot 1	deer	26	0-71	1985
Plot 2	deer	40	13-63	1983
	deer	7	0-13	1984
	deer	57	33-80	1985
Grants Pass RA	deer, elk	13	0-25	1983
Peggler Butte	elk	2	0-13	1984
	–	0		1985
Old Rum Cr.	deer, elk	48	25-63	1983
	elk	13	0-13	1984
	deer, elk	14	0-33	1985[3]
Roseburg				
North Umpqua RA	deer	9	0-13	1983
Gassy Cr., Plot 1	deer	27	0-75	1984
	deer	84	63-100	1985
Plot 2	deer	19	0-38	1983
	deer	13	0-50	1984
	deer	65	40-100	1985
Drain RA	deer	15	0-25	1983
Andrews Cr.	deer	13	0-25	1984
Unit 1, Plot 1	elk, deer	79	63-100	1985
Plot 2	deer	19	13-50	1983
	deer	19	0-38	1984
	elk	70	25-100	1985
Andrews Cr.	deer	15	0-38	1983
Unit 3, Plot 1	deer	32	13-50	1984
	elk, deer	55	25-100	1985
Plot 2	deer	21	0-50	1983
	deer	13	0-25	1984
	elk, deer	41	25-57	1985
Salem				
Alsea RA	deer, elk	11	0-13	1983
Little Lobster	deer, elk	30	13-50	1984
Plot 1	deer, elk	17	0-38	1985
Plot 2	mtn. beaver, deer, elk	30	13-38	1983
	mtn. beaver deer, elk	21	0-38	1984
	deer, elk	2	0-13	1985
Alsea RA	deer	6	0-13	1983
South Briar Cr.	deer	6	0-25	1984
Plot 1	deer	6	0-25	1985
Plot 2	--	0		1983
	deer	2	0-13	1984
	--	0		1985

Growing season damage to untreated (control) Douglas-fir seedlings during 1983, 1984, and 1985 on Bureau of Land Management Resource Areas in western Oregon (continued)

BLM District, Resource Area (RA), Plantation, Plot	Animal species causing most damage	Terminals or stems damaged (%)[1] Average	Range	Dormant season
Yamhill RA	--	0		1983
Nestucca Overlook	elk, deer	2	0-13	1984
Plot 1	--	0		1985[4]
Plot 2	--	0		1983
	elk, deer	2	0-13	1984
	pocket gopher, elk	4	0-13	1985[4]
Yamhill RA	deer	15	13-25	1983
N. Whipup	deer	19	13-25	1984
Plot 1	elk, deer	9	0-13	1985
Plot 2	deer	21	13-38	1983
	deer, elk	50	25-63	1984
	deer, elk	41	25-75	1985
Tillamook RA	--	0		1983
Tucca Cr.	--	0		1984
Plot 1	deer	16	0-50	1985
Plot 2	--	0		1983
	--	0		1984
	--	0		1985
Tillamook RA	elk	4	0-13	1983
Stockpile	elk, deer	4	0-13	1984
Plot 1	deer	2	0-13	1985
Plot 2	--	0		1983
	--	0		1984
	deer	5	0-17	1985
Tillamook RA		0		1983
Big Ear	deer	13	0-38	1984
Plot 1	deer, pocket gopher	17	0-20	1985
Plot 2	deer	9	0-13	1983
	deer	27	13-50	1984
	deer	21	0-50	1985

[1]Untreated control seedlings were planted as pairs with each of the six seedling protection treatment materials.

[2]Tree mortality continued because of previous damage by mountain beavers.

[3]Plots were inside an electric fence from winter to summer in 1985, when the fence was removed.

[4]Douglas-fir seedlings were killed by disease, or possibly by drought, in addition to mortality caused by pocket gophers.