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animal damage to coniferous plantations in oregon and washington

part 1. a survey, 1963-1975

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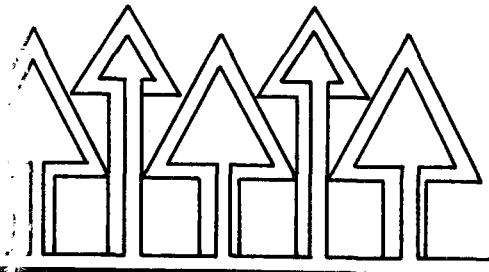

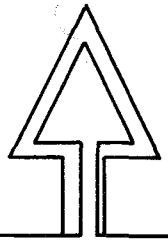

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contents

preface

The Cooperative Animal Damage Survey Committee conducted this survey in coordination with the Northwest Forest Pest Council and the Western Forestry and Conservation Association to gather information that forest-industry and forest-managing agencies needed on the nature and significance of mammal and bird damage to plantations of Douglas-fir and ponderosa pine.

This description of animal damage provides a benchmark for assessing future damage to forest plantations. Comparisons of caged and uncaged trees provide a measure of the survival and growth, disregarding animal damage, of reforested Douglas-fir and pine in Oregon and Washington.

An economic analysis and its implications, based on computer simulation models that project plantation development with varying amounts of animal damage, is contained in a second report, Part II, by J. Douglas Brodie, Hugh C. Black, Edward J. Dimock II, James Evans, Chiang Kao, and James A. Rochelle.

summary

This report evaluates the impact of animal damage on survival and growth of Douglas-fir [*Pseudotsuga menziesii* (Mirb.) Franco] and ponderosa pine (*Pinus ponderosa* Laws.) in Oregon and Washington. That evaluation draws on mammal and bird damage recorded on Douglas-fir and ponderosa pine plots randomly established in 1963-64, then observed for 5 to 10 years.

Forest land owners planting 50,000 or more seedlings during 1962-63 (first series) or 1963-64 (second series) were potential participants in the survey; plantations east of the Cascade Mountains were not sampled in the second series. In all, 194 sampling plots were installed. Ten of the 110 seedlings on each plot were caged to protect them from animals. All trees were marked with stakes, then examined after planting and after bud burst each year for 5 years. Observations of a selected sample of 45 Douglas-fir plots were continued for 10 years to study long-term patterns and effects of severe plantation damage.

Then survival and growth of caged trees were compared with the survival and growth of uncaged trees exposed to animal damage. The agents, kind, amount, and distribution of that damage were evaluated by state, by subregion, and by relation to site features.

types and causes

Animals damaged an average of 30 percent of all unprotected Douglas-fir trees each year on the 165 plots in Oregon and Washington. (Percentages are expressed in whole units throughout this text. Appendix tables give more refined data.) Browsing (22%) was by far the most common type of damage to Douglas-fir. Clipping (6%) and budding (3%) were also common and widespread. Trampling, barking, pulling of seedlings, root cutting, and miscellaneous damage (each less than 1%) were of minor importance.

Deer ranked first among causes of damage to individual trees, browsing about one of every five Douglas-fir trees each year. During the first 5 years after planting, agents of damage were (in descending order of incidence): deer (19%), hares and rabbits (4%), elk (3%), grouse (3%), mountain beavers (1%), pocket gophers (1%), voles and woodrats (1%), domestic stock (1%), and other animals (1%).

Damage to Douglas-fir varied considerably by subregions throughout Oregon and Washington. Budding by grouse (9%) and clipping by hares and mountain beavers (12%) were greatest in the Coast Range of Washington; browsing by deer and elk (11%) was least in the Cascade Mountains of Washington. On the 165 Douglas-fir plots in Oregon and Washington, damage predominated on private forest lands with high sites, unburned slash, south aspects, gentle slopes, and medium elevations of 1,100-1,500 feet (335-457 m).

During years 1-5, 15 percent of ponderosa pine trees were damaged each year on the 29 plots in Oregon and Washington. Browsing again was most common (10%), followed by clipping (4%), then barking, trampling, root cutting, and pulling of seedlings (each less than 1%). Other types of animal damage were insignificant. Deer ranked first (7%) among damaging animals, followed by pocket gophers (3%), domestic stock (2%), hares (2%), and elk and porcupines (each less than 1%). Damage by other animals was negligible.

On the 45 selected plots examined for 10 years, damage to Douglas-fir seedlings declined yearly. Although browsing continued as these stands developed, mean annual frequency of damage

dropped from 52 percent for the first 5 years to 41 percent for the second 5 years. Some changes in damage types and agents were related to animal or plant succession. For example, stem damage and budding decreased as stands developed, and minor damage by Douglas squirrels, wood rats, and black bears occurred for the first time on some of the older plantations.

impact on survival

Planted seedlings die from a variety of causes, especially during the first year after planting. Consequently, considerable mortality unrelated to animal damage was recorded for both caged and uncaged Douglas-fir seedlings soon after planting and throughout the first year.

After 5 years, survival on the 165 Douglas-fir plots in Oregon and Washington averaged 71 percent of caged trees and 57 percent of uncaged trees. We attributed this 14 percent difference to animal damage, chiefly clipping by hares, rabbits, and mountain beavers. Mean survival of caged and uncaged Douglas-fir trees was 77 percent and 66 percent, respectively, in Washington and 68 percent and 53 percent, respectively, in Oregon. Mean survival was highest (85% and 71%) in the Coast Range of Washington and lowest (59% and 42%) in southwestern Oregon.

Despite continued frequent injury, few additional caged and uncaged Douglas-fir trees died during years 6 to 10 on the 45 selected plots. Evidently trees established for 5 years can sustain repeated animal damage by browsing, budding, and clipping with negligible effect on survival. For caged and uncaged pine seedlings, mean survival decreased rapidly in the first 2 years, falling to 71 and 49 percent, respectively, after 5 years.

impact on height

On the 165 Douglas-fir plots in Oregon and Washington, mean height of caged trees exceeded that of uncaged trees by 12 inches (30 cm) after 5 years. Caged trees averaged 50 inches (127 cm) and uncaged trees 38 inches (97 cm), a 24-percent height loss equivalent to about 1.5 years' growth. Heights ranged from 58 inches (147 cm) in the Washington Coast Range to 29 inches (74 cm) in the Cascade Mountains of Oregon. Uncaged Douglas-fir averaged 12 inches (30 cm) taller in Washington than in Oregon.

On 29 plots in Oregon, heights of caged and uncaged pines averaged 23 and 18 inches (58 and 46 cm), respectively, less than half those of Douglas-fir after 5 years. That 5 inch (13 cm) difference was a proportional height loss of 22 percent, similar to that for Douglas-fir.

On the Douglas-fir plots in Oregon and Washington selected for 10-year study primarily because of heavy animal damage, caged and uncaged trees averaged 60 and 35 inches (152 and 89 cm), respectively, 5 years after planting—a difference of 25 inches (63 cm). Suppression of height continued, and the mean difference in height between the caged and uncaged trees increased until after the eighth year, when it apparently stabilized near 42 inches (107 cm).

After 10 years, heights of caged and uncaged trees on these plots averaged 171 and 129 inches (434 and 328 cm), respectively, a difference of 42 inches (107 cm) or about 2 years' growth. Heights of caged trees exceeded those of uncaged trees by identical amounts (42 in. or 107 cm) in both states, despite the fact that trees in Washington—by chance on better sites—averaged 66 inches (168 cm) taller at 10 years.

introduction

Animal damage, the result of any animal activity that reduces or delays total forest yield (Dimock and Black 1969), can determine the success of reforestation in Oregon and Washington (Moore 1940, Lawrence 1958). West of the Cascade Mountains, young Douglas-fir trees are injured by small rodents (such as voles and woodrats), sooty grouse, mountain beavers, snowshoe hares, brush rabbits, deer, elk, livestock, and black bears. East of the Cascade Mountains, ponderosa pine are damaged by pocket gophers, snowshoe hares and jack rabbits, deer, elk, livestock, and porcupines.

To define the nature and significance of such damage by mammals and birds and to estimate the economic consequences, the Cooperative Animal Damage Survey Committee undertook a 10-year study. Douglas-fir and ponderosa pine plantations established in Oregon and Washington in 1962 and 1963 were examined annually for 5 to 10 years. Sites regenerated by natural or artificial seeding, or with older age-classes, were excluded. All plantations reflected reforestation practices and stand-maintenance procedures of private land owners and of public forest-managing agencies from 1963 to 1975.

When the survey began in 1963-1964, reforestation in the Pacific Northwest was characterized by close planting, commonly at 8- by 8-ft (2.4 x 2.4 m) intervals; by Douglas-fir seedlings treated with Thiram animal repellent in the nursery bed; and by infrequent use of herbicides in stand maintenance. Reforestation was mainly on old burns or on recent clearcuttings where slash had been broadcast burned. Direct seeding was also an important method of regeneration.

However, forest-management practices are dynamic, responding to changing economic conditions and technology. Reforestation now calls for better planting stock, better handling and planting methods, wider spacing, less broadcast burning, and more intensive site preparation, including conversion of brushfields. Western hemlock and other conifer species less susceptible to animal damage are planted more frequently, and containerized stock has largely supplanted direct seeding. Seedlings increasingly are mechanically protected, chiefly by "Vexar" tubing (Campbell and Evans 1975b). Stand maintenance has intensified with increased herbicide spraying for release, precommercial thinning, and control of mountain beavers in precommercially thinned stands. For the most part, these practices have promoted establishment and growth of seedlings, while reducing seedling vulnerability to animal damage. But these trends have been partially offset by extensive planting of small, containerized stock especially susceptible to animal damage, by reduced use of Thiram (Anonymous 1975-76), and by more reforestation of converted brush fields with high potential for damage.

A preliminary report (Black et al. 1969) described animal damage by type and agent, temporal and spatial distribution of damage, and impact of damage on survival and growth of seedlings. This report summarizes the findings for 194 sampling plots during five growing seasons in the field. In addition, we describe the continued occurrence of damage and the growth response of 45 Douglas-fir plots that were selected from the original 165 Douglas-fir plots and examined annually for another 5 years. Histories of individual plantations illustrate the succession and impact of various damage agents.

The findings of this survey are most applicable to stands established and maintained under conditions similar to those described for the sample plots. However, exposure of conifer seedlings and saplings to animal damage can be expected to follow the patterns described here; the impact of damage will vary with management practices.

procedures

Only newly established plantations of more than 50,000 Douglas-fir or ponderosa and Jeffrey pine trees were surveyed. One sampling plot of 110 seedlings was installed for each 500,000 trees planted. To protect them from wildlife, 10 of the 110 seedlings on each plot (usually every 10th seedling) were caged in cylinders, 3 feet (1 m) wide and 4 feet (1.2 m) tall, of 1-inch (2.5 cm) mesh wire. Stakes supported the cages.

Plot location, marking, and examination are detailed by Black et al. (1969). A total of 194 sampling plots were installed in Oregon (142 or 73%) and Washington. Of the total, 112 were installed in 1963-64 (first series), and 82 were installed in 1964-65 (second series). Of the 194 plots, 163 (85%) were on public lands of the U.S. Forest Service (73 plots), Bureau of Land Management (54 plots), Oregon State Department of Forestry (26 plots), and Washington Department of Natural Resources (10 plots).

Species on the plots varied; 165 plots (85%) were in Douglas-fir, 4 plots (2%) in mixed Douglas-fir and ponderosa pine, and 25 plots (13%) in ponderosa pine, Jeffrey pine, or a mixture of both.

plot examination

The first examination was at time of planting (P), and the second examination was at bud burst in the spring or summer after planting (O). Thereafter, annual examinations during spring and summer recorded 1 year's growth from bud burst to bud burst.

Personnel of the agency or company installing a plot measured height immediately after planting; all other observations and measurements were made by a select group of wildlife biologists and foresters under the direction of the Cooperative Animal Damage Survey Committee. Height, recorded to the nearest inch, was measured from the ground to the base of new terminal growth; current growth was not measured.

Animal-caused injuries to seedlings were classified according to terminology in the illustrated *Guide to Wildlife Feeding Injuries on Conifers in the Pacific Northwest* (Lawrence et al. 1961).

Data for individual trees on each plot were recorded for each observation period. Direct transcription in the field proved unworkable, but notes were recorded in field notebooks and subsequently transcribed onto optical mark reader (OMR) forms so data could be automatically processed on magnetic tapes. Simplified programs summarized essential data. For plots observed more than 5 years, data were tablulated with hand calculators.

continued examination

To study the impact of animal damage after establishment and to monitor damage for a longer period, we chose a subset of 51 plots (47 Douglas-fir and 4 ponderosa pine) that—after 5 years—had experienced heavy damage (chiefly by deer), a marked difference between heights of caged and uncaged trees, and above average survival. About one-third of the 51 plots were on private lands, proportionally more than in the total sample because damage occurred more frequently under private ownership.

Observation of 45 of the Douglas-fir plots, referred to herein as **selected plots**, was continued through the 10th year; 30 of these were in Oregon (21 in the first series, 9 in the second), and 15 in Washington (7 in the first series, 8 in the second). Slash had been burned on 28 of these 45 plots. Most were at low to medium elevation, 18 at elevations of 1,000 to 1,500 feet (305-457 m), and only 2 were above 2,500 feet (762 m). This selected sample also was skewed to higher site classes; 19 plots were classified site 1 or 2 for Douglas-fir, 24 classified as site 3, and 2 classified as site 4. No site 5 classes were included.

In addition, one Douglas-fir plot in Oregon and one in Washington were observed through the 8th year, and four ponderosa pine plots in Oregon were observed through the 8th to 10th years. However, findings are summarized only for the selected plots. Individual histories of some selected plots and some of the other six plots are cited to show succession of animal damage and the effect of damage by various animals.

animal damage

Damage type was, of course, closely related to damage agent; for example, injury by deer correlated with browsing. Mean frequency of damage for all Douglas-fir plots peaked at 32 percent during the first year (third examination), remained at about that level for 2 more years, then decreased in years 4 and 5. Stem damage peaked at 29 percent the first year, then decreased gradually (Fig. 1).

Browsing, which averaged 21 percent each year, was the most common type of damage on Douglas-fir plots in all subregions of both states (Tables 1-3). Other damage was clipping (6%), budding (3%), and trampling, barking, pulling of seedlings, root cutting, and miscellany (each less than 1%). Deer (19%) ranked first as a damage agent, followed by hares and rabbits (4%), elk (3%), grouse (3%), mountain beavers (1%), and pocket gophers, microtine rodents, domestic stock, and miscellaneous agents (each less than 1%). On the average, more than one of every five live uncaged trees were browsed, mainly by deer. Porcupine damage was not recorded on any of the 165 Douglas-fir plots during the first 5 years of the study.

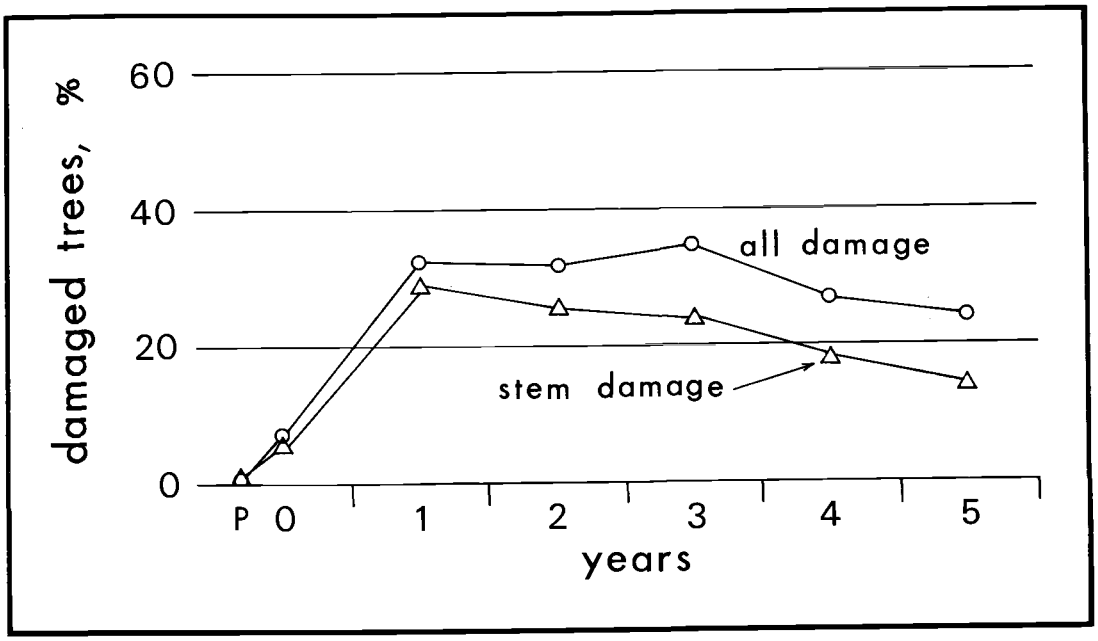

Figure 1.

Mean percent of uncaged Douglas-fir trees damaged by animals on 165 plots in Oregon and Washington, years 1-5 after planting.

Table 1.

ANIMAL-DAMAGED DOUGLAS-FIR PLOTS, YEARS 1-5 AFTER PLANTING.
(mean annual percent)

Damage	OREGON				WASHINGTON			BOTH STATES
	Coast Range (49)[a]	Cascade Mountains (24)	South-west (33)	All (116)	Coast Range (24)	Cascade Mountains (25)	All (49)	(165)
TYPE								
Barking	0.12	0.16	0.08	0.12	0.32	0.33	0.32	0.18
Browsing								
Overall	24.38	24.00	23.08	23.86	23.44	11.36	17.28	21.90
Stem	20.30	20.41	20.75	20.46	15.93	8.41	12.09	17.98
Budding								
Overall[b]	0.22	3.23	2.34	1.71	8.74	1.89	5.25	2.76
Stem	0.01	0.60	0.07	0.20	3.18	1.43	2.28	0.82
Clipping								
Overall	6.21	5.50	1.67	4.71	11.55	4.66	8.04	5.70
Stem	3.41	3.22	1.08	2.69	4.02	2.68	3.33	2.88
Root cutting	0.07	0.02	0.00	0.04	0.01	0.00	0.00	0.03
Pulling	0.10	0.01	0.22	0.11	0.03	0.01	0.02	0.08
Trampling	0.23	0.27	0.21	0.23	0.37	0.13	0.25	0.24
Other	0.03	0.04	0.01	0.03	0.17	0.11	0.14	0.16
All Damage	30.61	32.20	26.99	30.05	39.08	17.81	28.22	29.51
Stem Damage	23.98	24.42	22.20	23.60	23.44	12.72	17.97	21.93
AGENT								
Deer	21.82	24.26	19.31	21.32	14.38	10.62	12.46	19.04
Domestic stock	0.01	0.02	0.01	0.01	0.02	0.00	0.01	0.01
Elk	2.71	0.03	4.03	2.30	10.65	1.27	5.87	3.36
Gopher	0.10	0.03	0.01	0.06	0.01	0.00	0.00	0.04
Grouse[b]	0.22	3.25	2.39	1.72	8.78	1.97	5.30	2.79
Hare	5.40	3.90	1.31	3.80	3.70	2.64	5.61	4.33
Mountain beaver	0.82	1.18	0.37	0.80	2.88	0.59	1.71	1.07
Microtine	0.01	0.01	0.03	0.02	0.07	0.05	0.06	0.03
Porcupine	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.03	0.40	0.00	0.13	0.08	1.42	0.76	0.32

[a]Numbers in parentheses are number of plots.

[b]Frequency of overall budding and of grouse damage should be identical because grouse are the only agents. Small differences are errors.

Table 2.

DOUGLAS-FIR TREES DAMAGED BY ANIMALS, YEARS 1-5 AFTER PLANTING.[a]
(mean percent)

Damage	Year					
	0[b]	1	2	3	4	5
TYPE						
Barking	0.00	0.12	0.12	0.17	0.32	0.23
Browsing						
Overall	4.92	25.35	23.52	26.31	20.00	16.13
Stem	4.46	23.44	19.28	20.58	15.69	11.95
Budding						
Overall[c]	0.27	1.23	2.79	3.27	3.77	3.22
Stem	0.27	1.23	2.79	0.00	0.00	0.00
Clipping						
Overall	1.10	5.90	6.19	6.47	4.52	5.92
Stem	0.93	4.37	3.33	2.57	2.04	2.01
Root cutting	0.00	0.00	0.01	0.02	0.02	0.08
Pulling	0.24	0.14	0.03	0.00	0.00	0.03
Trampling	0.19	0.24	0.26	0.21	0.29	0.09
Other	0.05	0.10	0.11	0.02	0.02	0.0
All Damage	6.59	32.15	31.82	34.45	27.00	24.41
Stem Damage	5.99	29.15	25.41	23.41	18.04	14.30
AGENT						
Deer	4.15	22.05	19.84	24.12	16.68	14.14
Domestic stock	0.02	0.00	0.02	0.01	0.01	0.01
Elk	1.01	3.64	3.95	3.29	3.82	2.19
Gopher	0.01	0.01	0.03	0.05	0.05	0.06
Grouse[c]	0.28	1.23	2.86	3.30	3.77	3.27
Hare	0.75	4.39	5.17	4.83	3.23	4.53
Mountain beaver	0.38	1.01	0.72	1.47	1.03	1.09
Microtine	0.00	0.04	0.09	0.01	0.00	0.01
Porcupine	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.02	0.53	0.23	0.25	0.24	0.34

[a] Based on 165 plots.

[b] First bud burst about 4 months after planting.

[c] Frequency of bud burst and grouse damage should be identical because grouse are the only agents. Small differences are errors.

plot

The percent of plots, rather than trees, having animal damage is summarized by type and agent for each examination and for the sum of all examinations (Tables 3 and 18A). Because individual plots may not have been damaged in some years, frequency in a given examination is always lower than the combined frequency. For example, barking injuries occurred on only 5 to 9 percent of all Douglas-fir plots during annual examinations, but occurred one or more times on 25 percent of the plots for all examinations. Animal damage was recorded on all Douglas-fir plots at least once during the study, but on only two-thirds of all plots during the first examination. Animal damage occurred on more than 90 percent of all plots each year after the first, except the fifth year when only 84 percent of plots were damaged.

Damage types were browsing (99%), clipping (80%), budding (50%), trampling (35%), and barking (25%). Barking and budding occurred on proportionally more plots in Washington than in Oregon; differences were smaller for other types of damage to plots in the two states (Table 18A). In all, budding occurred on

Table 3.

DOUGLAS-FIR PLOTS DAMAGED BY ANIMALS, YEARS 1-5 AFTER PLANTING.[a]
(mean annual and aggregate percent)

Damage	Year						
	0[b]	1	2	3	4	5	1-5
TYPE							
Barking	0.00	6.67	5.45	7.27	6.67	9.09	25.45
Browsing							
Overall	55.76	86.67	91.52	88.48	78.79	72.12	99.39
Stem	51.52	85.45	88.48	85.45	76.36	63.03	98.18
Budding							
Overall[c]	4.24	13.33	20.61	26.06	29.09	23.64	49.70
Stem	4.24	13.33	20.61	0.00	0.00	0.00	25.45
Clipping							
Overall	24.85	55.76	50.30	46.06	42.42	43.64	80.00
Stem	23.03	50.30	41.21	32.12	26.06	27.27	73.94
Root cutting	0.00	0.00	0.61	1.21	0.61	2.42	3.64
Pulling	4.85	6.67	1.82	0.00	0.00	0.61	11.52
Trampling	7.27	10.30	13.94	10.30	6.67	3.64	35.15
Other	2.42	6.67	1.82	1.82	1.21	1.21	12.73
All Damage	66.67	92.73	95.15	95.76	90.30	84.24	100.00
Stem Damage	64.24	92.12	93.33	92.12	81.21	75.76	99.39
AGENT							
Deer	54.55	80.00	84.24	81.82	69.09	66.67	96.36
Domestic stock	0.61	0.00	1.21	0.61	0.61	0.61	3.64
Elk	4.85	10.91	13.33	12.12	15.15	13.33	21.21
Gopher	0.61	0.61	0.61	0.61	1.21	1.82	3.64
Grouse[c]	4.24	13.33	20.61	26.67	29.09	24.85	50.91
Hare	19.39	47.88	40.61	41.21	30.91	30.91	75.15
Mountain beaver	7.88	10.91	11.52	13.33	13.33	10.30	25.45
Microtine	0.00	1.82	3.03	1.21	0.00	0.61	6.06
Porcupine	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	1.21	4.24	3.03	1.82	1.82	4.85	10.91

[a]Based on 165 plots.

[b]First bud burst about 4 months after planting.

[c]Frequency of overall budding and of grouse damage should be identical because grouse are the only agents. Small differences are errors.

half or more of all plots in each subregion except the Oregon Coast Range.

All 165 Douglas-fir plots in both states were browsed except for one plot in the Oregon Cascade Mountains. Frequency data for that plot may have been affected by poor survival; only 25 percent of uncaged trees survived to the first year, and only 7 percent to the fifth year. Clipping occurred on 80 percent of the 165 plots, budding on 50 percent; all other types of damage occurred on less than 50 percent of the plots. Root cutting and pulling of seedlings were less frequent—on 6 plots (4%) and 19 plots (12%), respectively.

Ranked by plot frequency, damage agents were deer (96%), hares and rabbits (75%), grouse (51%), mountain beavers (25%), elk (21%), microtine rodents (6%), pocket gophers (4%), domestic stock (4%), and miscellaneous animals (11%). Damage by gophers and domestic stock was uncommon in all regions, and none was recorded on plots in the Cascade Mountains of Washington. Neither porcupines nor bears damaged any of the 165 Douglas-fir plots during the first 5 years of the study.

distribution

Distribution of damage varied considerably by subregions on both series of plots. Budding by grouse (9%) and clipping by hares and mountain beavers (11%) were greatest in the Coast Range of Washington, and browsing by deer and elk (11%) was lowest in the Cascade Mountains of Washington (Table 1).

The highest frequency of damage (39%), recorded on the 24 plots in the Coast Range of Washington, was a combination of browsing, budding, and clipping of the same trees. The lowest frequency (18%) was recorded on the 25 plots in the Cascade Mountains of Washington.

Browsing, especially stem browsing, occurred less in Washington (17%) than in Oregon (24%), but budding and clipping of laterals were more frequent on plots in Washington (5%) than in Oregon (2%). Stem clipping was comparable in both states. Deer browsed fewer trees in Washington (12%) than in Oregon (22%), although injuries by elk, grouse, hares, and mountain beavers totaled higher in Washington (18%) than in Oregon (9%).

minor types

Trampling, barking, pulling of seedlings, root cutting, and other injuries occurred on less than 1 percent of Douglas-fir trees each year. Trampling was mainly by deer, elk, and domestic livestock; barking was mainly by rodents, lagomorphs, and big game (antler rubbing). Deer and elk usually pulled seedlings only in the first and second years after planting. Root cutting by pocket gophers and mountain beavers was infrequent, and miscellaneous injury was insignificant.

survival

Mean survival of caged and uncaged trees on the 165 Douglas-fir plots in Oregon and Washington is summarized by state and subregion in Table 4. Missing and dead seedlings (damaged and undamaged by animals) were included in mortality.

Early mortality between planting and bud burst was unrelated to animal damage. Mortality from all causes peaked during the first year after planting (Fig. 2) but declined rapidly thereafter, especially on plots in Washington. After 5 years, survival on the Douglas-fir plots in Oregon and Washington averaged 71 percent of caged trees and 57 percent of uncaged trees—a highly significant ($P>0.01$) difference chiefly due to animals. Thus, about one-third (33%) of total uncaged mortality (14% divided by the 43% total) was animal related. This proportion was consistent, ranging from 32 to 35 percent for years 1 to 5.

Survival of both caged and uncaged trees (Fig. 2) was higher in Washington (77% and 66%) than in Oregon (68% and 53%). Mean survival was highest in the Washington Coast Range (85% of caged and 71% of uncaged trees after 5 years) and lowest in southwestern Oregon (59% of caged and 42% of uncaged trees).

Mortality differed between planting series. Trees planted in the first series survived better in each state than did trees planted in the second series (Figs. 2B,C). These differences were greatest in Oregon. There mean survival of caged Douglas-fir trees in the first series of 70 plots was 71 percent; it was 64 percent in the second series of 46 plots. Survival of Douglas-fir trees in Washington was 4 percent higher in the first series of 24 plots than in the second series of 25 plots. These differences are mainly attributable

Table 4

SURVIVAL[a] OF CAGED AND UNCAGED DOUGLAS-FIR TREES, YEARS 1-5 AFTER PLANTING.[b]
(mean percent)

Location	Plots	Treatment	Year: Planting	0[c]	1	2	3	4	5
OREGON									
Coast Range	49	Caged	100.00	87.30	82.59	81.16	78.10	76.90	75.47
		Uncaged	99.94	86.72	74.23	70.27	64.82	62.14	60.29
Cascade Mountains	34	Caged	100.00	81.55	72.19	71.04	69.57	68.10	67.22
		Uncaged	100.00	79.17	63.69	59.07	55.87	53.24	51.92
Southwest	33	Caged	100.00	89.10	72.16	67.31	65.19	60.98	58.88
		Uncaged	100.00	83.15	53.99	48.51	45.96	43.56	41.83
Total	116	Caged	100.00	86.12	76.58	74.26	71.93	69.79	68.33
		Uncaged	99.97	83.49	65.38	60.79	56.83	54.25	52.59
WASHINGTON									
Coast Range	24	Caged	100.00	95.83	91.25	89.17	88.33	86.67	85.00
		Uncaged	100.00	93.42	81.66	76.70	73.66	71.54	70.54
Cascade Mountains	25	Caged	100.00	89.60	75.20	71.67	70.87	70.87	70.07
		Uncaged	100.00	88.64	69.68	65.64	63.86	62.08	61.44
Total	49	Caged	100.00	92.65	83.06	80.24	79.42	78.61	77.38
		Uncaged	100.00	90.98	75.55	71.05	68.57	66.71	65.90
BOTH STATES									
Total	165	Caged	100.00	88.06	78.50	76.03	74.16	72.41	71.02
		Uncaged	99.98	85.71	68.40	63.84	60.32	57.95	56.54

[a]Missing trees are included in mortality regardless of cause.

[b]Based on 165 plots.

[c]First bud burst about 4 months after planting.

to the poor growing conditions in spring and summer of 1965 (Black et al. 1969).

On the selected sample, an average of 85 percent of caged trees and 64 percent of uncaged trees survived, a better rate due mainly to removal of all plots with poor survival.

growth

Mean height of all caged and uncaged Douglas-fir trees is shown in Figure 3A and Table 5. All trees grew more in Washington than in Oregon (Fig. 3B). On Washington plots, height averaged 58 inches (147 cm) for caged trees, and 46 inches (117 cm) for uncaged trees, a difference of 11 inches (28 cm). In Oregon height averaged 46 inches (117 cm) for caged trees and 34 inches (86 cm) for uncaged trees, a difference of 12 inches (30 cm). On all Douglas-fir plots after 5 years, mean height was 50 inches (127 cm) for caged trees and 38 inches (97 cm) for uncaged trees—a 24 percent height loss equivalent to about 1.5 years' growth.

In the Washington Coast Range, height at 5 years averaged 74 inches (188 cm) for caged trees and 58 inches (147 cm) for uncaged trees. In the Oregon Cascade Mountains, mean height at 5 years was substantially higher, 40 inches (102 cm) for caged trees and 29 inches (74 cm) for uncaged trees. Tree growth in southwestern Oregon and in the Cascade Mountains of both states was much lower than in the Coast Range of both states.

On the 30 selected plots in Oregon, caged trees were taller, 51 inches (130 cm), than in the total sample; uncaged trees were shorter, 26 inches (66 cm). Height variation between trees in both planting series was minor, as it was on the 15 selected Douglas-fir plots in Washington at 5 years. Although caged trees were taller in the first than in the second series, mean height of uncaged trees differed negligibly. Both caged and uncaged trees on the Washington plots were taller than on Oregon plots at 5 years. Uncaged trees in Washington were almost twice as tall as uncaged trees in Oregon, 51 inches (130 cm) and 26 inches (66 cm), respectively.

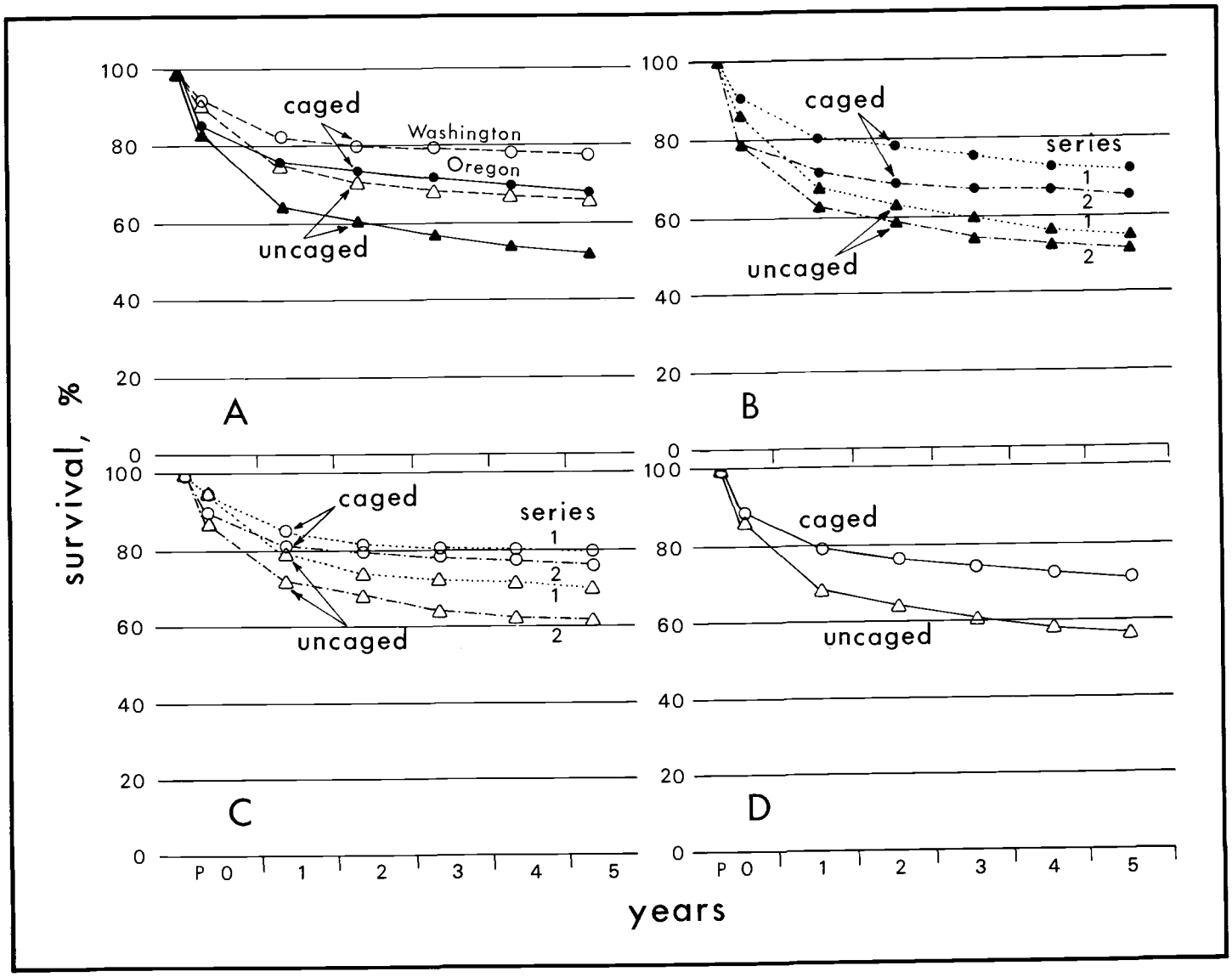

Figure 2.

Mean survival of Douglas-fir trees, years 1-5 after planting. (A) 116 plots in Oregon, 49 plots in Washington. (B) Both series in Oregon. (C) Both series in Washington. (D) 165 plots in Oregon and Washington.

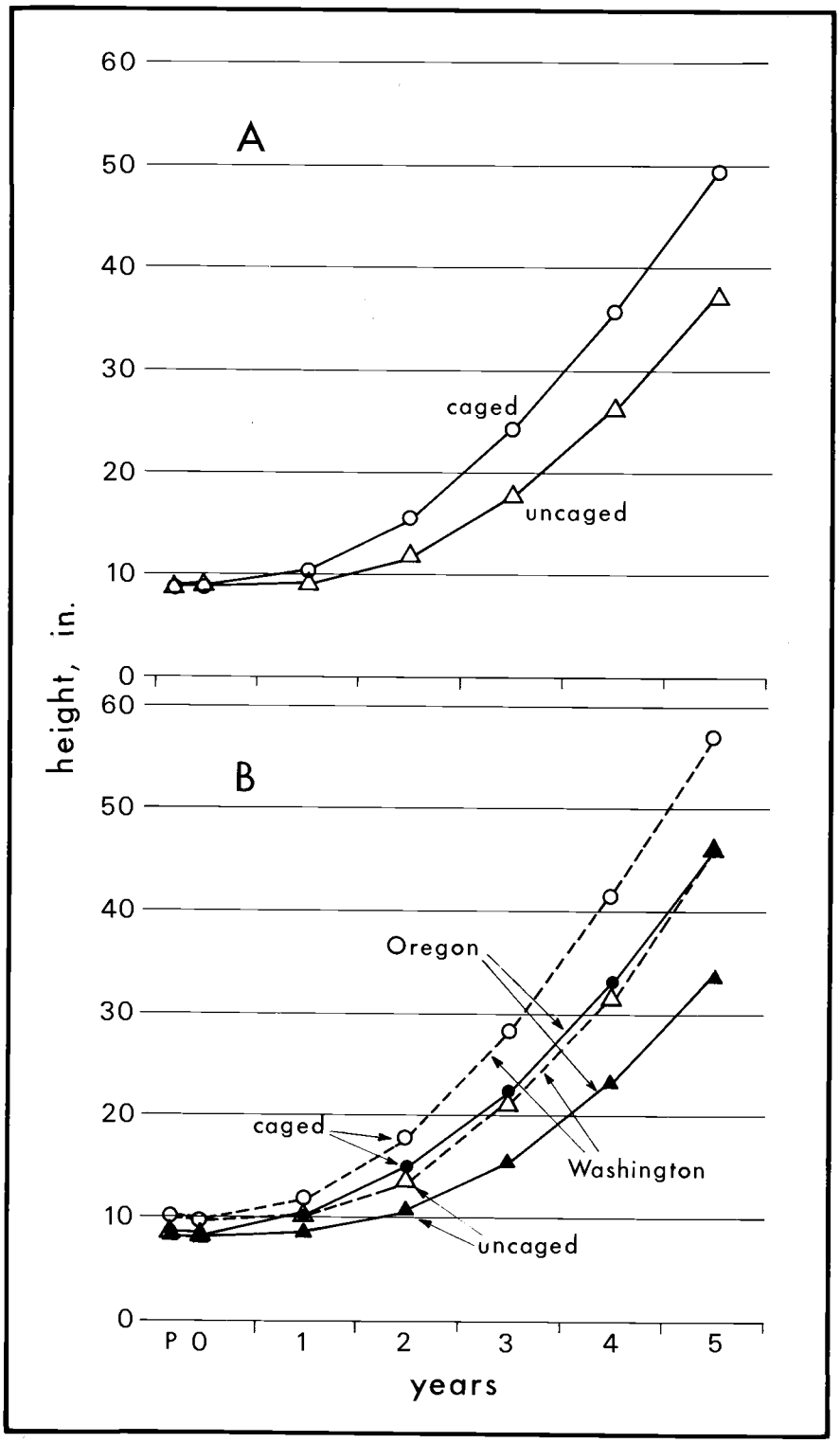

Figure 3.

Mean height of Douglas-fir trees, years 1-5 after planting. (A) 165 plots in Oregon and Washington. (B) 116 plots in Oregon, 49 plots in Washington.

Table 5.

MEAN HEIGHT OF CAGED AND UNCAGED DOUGLAS-FIR TREES, YEARS 1-5 AFTER PLANTING.[a]
(inches)

Location	Plots	Treatment	Planting	Year 0[b]	1	2	3	4	5
OREGON									
Coast Range	49	Caged	9.33	9.14	11.03	16.47	25.63	38.13	53.33
		Uncaged	9.18	8.97	9.25	12.28	18.23	27.15	39.49
Cascade Mountains	34	Caged	8.38	8.26	9.68	13.26	19.89	28.91	39.62
		Uncaged	8.23	8.19	8.38	10.39	14.31	20.73	28.77
Southwest	33	Caged	7.81	7.71	9.13	13.13	20.33	30.39	41.92
		Uncaged	7.93	7.89	8.37	10.58	14.76	21.50	30.86
Total	116	Caged	8.62	8.48	10.10	14.62	22.48	33.29	46.09
		Uncaged	8.55	8.43	8.75	11.26	16.12	23.85	33.91
WASHINGTON									
Coast Range	24	Caged	12.37	12.39	14.37	22.44	35.61	53.15	74.34
		Uncaged	12.28	12.28	13.05	17.41	26.42	39.80	57.86
Cascade Mountains	25	Caged	7.96	8.03	9.35	13.91	21.81	31.14	41.51
		Uncaged	7.79	7.71	8.31	11.20	16.88	25.15	35.25
Total	49	Caged	10.12	10.17	11.81	18.09	28.57	41.92	57.59
		Uncaged	9.99	9.95	10.63	14.24	21.55	32.33	46.32
BOTH STATES									
Total	165	Caged	9.06	8.98	10.61	15.67	24.33	35.91	49.61
		Uncaged	8.98	8.88	9.32	12.16	17.77	26.43	37.71

[a]Based on 165 plots.

[b]First bud burst about 4 months after planting.

damage and plot features

Animal damage is related to plot features such as ownership, slash treatment, aspect, slope, site quality, elevation, and stock class (Tables 1A-18A). Because none of these features is independent, occurrence of damage is similarly related to several features. For example, site quality tends to be lower as elevation or slope increases.

ownership

Browsing by deer and elk was only about half as frequent on U.S. Forest Service lands (11%) as on other ownerships (20-25%) (Table 1A). Elk frequently damaged lands managed by the Oregon State Department of Forestry, but grouse budding was least frequent there. In Oregon, private lands led in occurrence of damage by all agents except elk. Budding by grouse and clipping injuries, chiefly by hares, were most frequent on private lands in Washington. Private lands led in occurrence of damage of all types in both states (Table 2A and

3A). Damage to stems and laterals averaged 44 percent on private lands, 19 to 37 percent on public lands.

Distribution of damage related to ownerships differed most within regions. The mean for deer browsing of Douglas-fir plots in the Oregon Cascades was only about 6 percent on U.S. Forest Service plots, but 34 percent on private plots and 40 percent on Bureau of Land Management plots. Of the 49 Douglas-fir plots in Washington, only 8 percent of trees were browsed on the 24 U.S. Forest Service plots, but more than 25 percent were browsed on both the 10 plots of the Washington Department of Natural Resources and the 15 private plots. One percent of trees were budded on U.S. Forest Service plots, but 13 percent on plots on private lands. Four percent of trees were clipped on U.S. Forest Service plots, 10 percent on lands of the Department of Natural Resources, and 14 percent on private lands. These differences between private and public lands probably reflect differences in environment and management history.

slash treatment

On the average, unburned plots were damaged more often (34%) than burned plots (27%) (Table 4A). Principal differences were the higher incidence of budding and clipping, but damage by elk, hares, mountain beavers, and grouse also was more frequent.

In Oregon, occurrence of animal damage was comparable on slash-burned and unburned plots (Table 4A), but unburned plots in Washington experienced more browsing, budding, and clipping. Mean annual occurrence of deer browsing was similar on burned and unburned plots, but damage by elk, grouse, and hares was much higher on unburned plots.

aspect

Aspect influenced damage on Douglas-fir plots (Tables 5A, 6A, and 7A). Damage was greatest on plots with southerly aspects where most browsing by deer and budding by grouse occurred. Only minor differences in mean annual frequency of damage, including browsing and budding, were found among other aspects. But, on the average, more browsing by elk and clipping by hares occurred on level plots with no predominant aspect.

This overall pattern was similar to that on Douglas-fir plots in Oregon (Table 6A), although clipping by hares was more frequent on other aspects. On the Douglas-fir plots in Washington, mean occurrence of clipping by hares was greatest on level plots (Table 7A). Deer browsing and grouse budding occurred most frequently on east and south aspects; elk browsing was recorded most often on south and west aspects.

slope

Mean annual frequency of animal damage is related to slope in Tables 8A, 9A, and 10A. Damage of all types was most frequent on gentle slopes (6%-25%), although clipping damage in Oregon occurred with about the same frequency on flat, gentle, moderate, and steep slopes. In both states, damage by elk and mountain beavers was high on both level and steep terrain; hare damage was consistently highest on level and gently sloped terrain.

site quality

Of the 165 Douglas-fir plots, 88 plots were classified site 3 for Douglas-fir, 46 were site 1 or 2, and 31 were site 4 or 5 (Table 11A). All principal types of animal damage (browsing, clipping, and budding) occurred most frequently on the highest sites and least frequently on the lowest sites. Agents also followed this

pattern, except that deer damage was highest on intermediate sites (site 3). The relationship was inconsistent on Douglas-fir plots in Oregon (Table 12A), although sites 3 or better were damaged more frequently than sites 4 and 5. On Douglas-fir plots in Washington, however, damage of all types and by all agents predominated on site classes 1 and 2 (Table 13A). An average of 51 percent of trees on plots on high sites were injured each year. Only 14 percent of trees were injured on low-site plots. Notably, elk, grouse, and hares substantially damaged high-site plots.

elevation

The relation of annual frequency of damage by type, agent, and elevation is shown for all Douglas-fir plots in Oregon and Washington in Tables 14A, 15A, and 16A. Most plots (130 of 165) were located at low to medium elevations, 600 to 2,500 feet (183-762 m), where damage of all types was most frequent. Browsing was most frequent on plots at 1,100 to 1,500 feet (335-457 m), budding on plots at 2,100 to 2,500 feet (640-762 m), and clipping on plots at 0 to 500 feet (0-152 m). Deer and elk were the most frequent agents of damage at 1,100 to 1,500 feet (335-457 m), grouse at 2,100 to 2,500 feet (640-762 m), and hares at 0 to 500 feet (0-152 m). In Oregon and Washington, all types of damage were most frequent on plots at 1,100 to 1,500 feet (335-457 m).

stock class

Most Douglas-fir plots were planted with 2-0 stock (Table 17A). The three sizes of stock most commonly planted (2-0, 3-0, and 2-1) sustained comparable damage, although deer damage was highest on 2-0 stock and damage by other animals was highest on the remainder. Damage appeared more related to location than to stock size. The small number of plots of some stock classes in each subregion and the planting of older stock on sites with brush competition and high damage potential may have influenced the findings.

tree age and damage occurrence

barking

Most of the negligible amount of barking that was recorded occurred on seedlings 3 to 5 years after planting.

browsing

Browsing was most frequent in the first, second, and third years, and declined markedly in the fourth and fifth years. Douglas-fir plots in the Coast Range of Oregon were browsed most frequently (Fig. 4A). Although browsing was not systematically recorded during the dormant and growing seasons, most damage occurred on new-shoot growth in the spring.

budding

Budding by grouse (3%) was surprisingly common and widespread, especially in Washington. It ranked third among damage types, and grouse ranked fourth among damage agents (Table 1). Grouse budding occurred on 51 percent of all Douglas-fir plots (Table 18A) and remained fairly constant throughout the 5-year period; however, terminal buds generally were affected only during years 1 and 2 (Tables 2-3).

clipping

Clipping on all Douglas-fir plots (Tables 2-3) changed little from year to year, although stem clipping peaked the year after planting and declined as trees matured. Figure 4B illustrates height growth and occurrence of stem clipping, mainly by hares, on Douglas-fir plots in the Coast Range of Washington where frequency of clipping was highest.

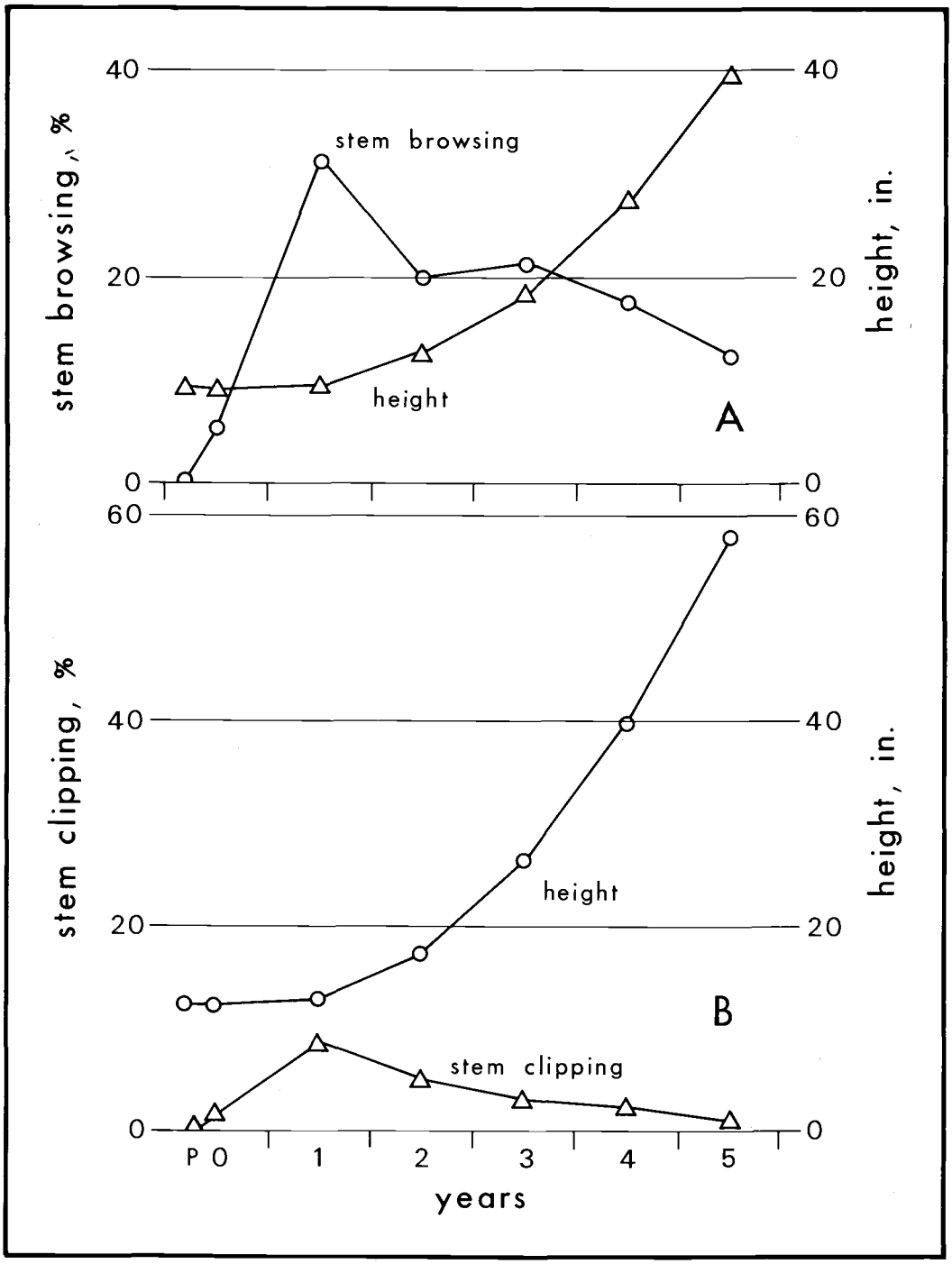

Figure 4.

Mean percent of stem damage to uncaged Douglas-fir trees in relation to mean height of trees, years 1-5 after planting. (A) Trees browsed by deer on 49 plots in the Oregon Coast Range. (B) Trees clipped, chiefly by hares, on 24 plots in the Washington Coast Range.

animal damage

Animal damage of some type occurred on all pine plots (Table 19A). Browsing occurred during the 5-year period on all but one of the plots, clipping on three-fourths of the plots, and all other damage types on less than half of the plots.

However, mean annual frequency of damage of all types was only 15 percent the pine plots (Table 6). Browsing (10%) was the most common type (as on Douglas-fir plots), followed by clipping (4%), then barking, trampling, root cutting, and pulling of seedlings (each less than 1%). Mean frequency of damage was highest in the first and second years, then stabilized at about 6 percent annually on uncaged trees (Fig. 5).

Trees were damaged by deer (7%); pocket gophers (3%); domestic stock, chiefly cattle (3%); hares or rabbits (2%); elk (<1%); and porcupines (<1%). Few trees were injured by grouse, and damage by other agents was negligible. No trees were damaged by mountain beavers or microtine rodents.

Table 6.

PINE TREES DAMAGED BY ANIMALS, YEARS 1-5 AFTER PLANTING.
(mean annual percent)

Damage	Both States[a]
TYPE	
Barking	0.60
Browsing	
Overall	9.82
Stem	8.44
Budding	
Overall	0.01
Stem	0.00
Clipping	
Overall	4.01
Stem	3.49
Root cutting	0.49
Pulling	0.16
Trampling	0.53
Other	0.01
All Damage	15.10
Stem Damage	13.20
AGENT	
Deer	7.18
Domestic stock	2.46
Elk	0.71
Gopher	2.56
Grouse	0.01
Hare	1.57
Mountain beaver	0.00
Microtine	0.00
Porcupine	0.70
Other	0.07

[a]Based on 29 plots.

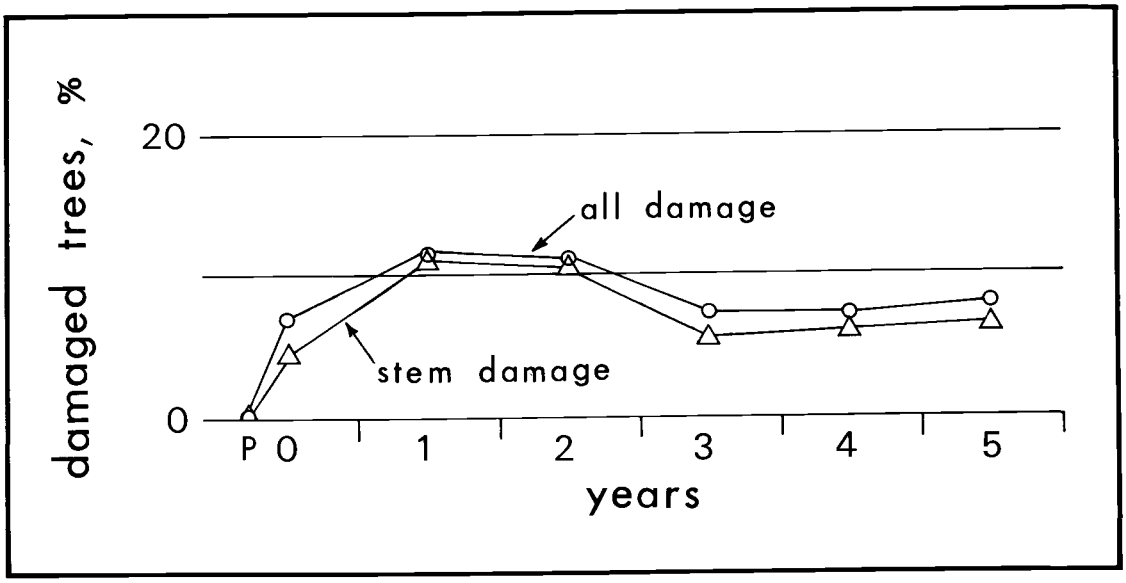

Figure 5.

Mean percent of pine trees damaged by animals on 19 plots in Oregon, years 1-5 after planting.

Deer damaged all but one plot during the 5-year period. Hares (or rabbits), domestic stock, and pocket gophers each caused damage on about half of the plots. Other agents damaged only a few plots.

survival

Mean survival of caged and uncaged seedlings on all 29 pine plots decreased rapidly in the first 2 years after planting and more gradually thereafter (Fig. 6A). After 5 years, the difference in mean survival between caged and uncaged trees (Table 7) was 22 percent (caged trees-71%, uncaged trees-49%). If this difference is attributed to animal damage, 43 percent of all mortality was animal related.

growth

Mean height of all caged and uncaged pine seedlings at 5 years was only 23 and 18 inches (58 and 46 cm), respectively (Table 7, Fig. 6B). Although the difference was only 5 inches (13 cm), the proportional height loss of 22 percent was similar to that for Douglas-fir in western Oregon and Washington.

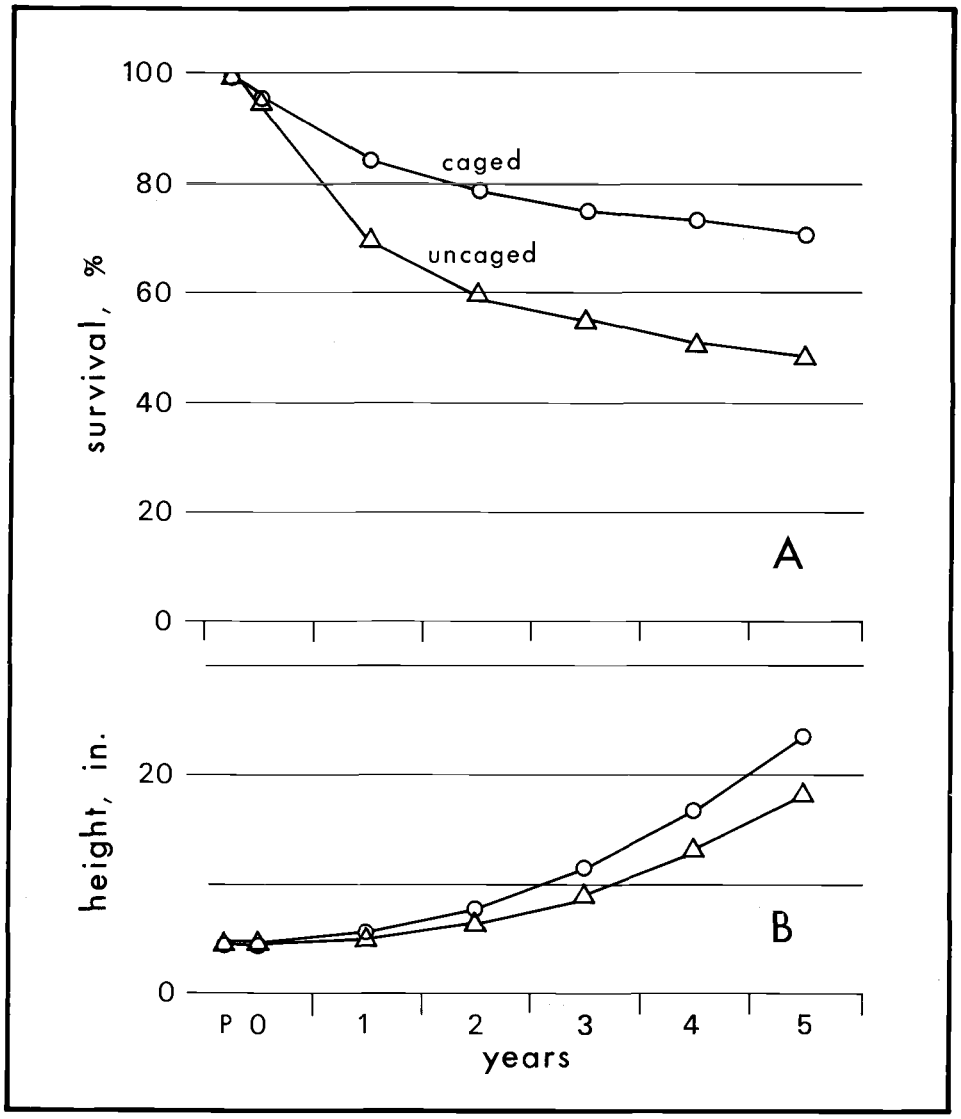

Figure 6.

Mean survival (A) and height (B) of pine trees on 29 plots in Oregon and Washington, years 1-5 after planting.

Table 7.

SURVIVAL[a] AND HEIGHT OF CAGED AND UNCAGED TREES, YEARS 1-5 AFTER PLANTING.[b]

	Year						
	Planting	0[c]	1	2	3	4	5
SURVIVAL (%)							
Caged	100.00	95.52	84.14	79.00	75.20	73.48	70.72
Uncaged	100.00	95.00	69.79	59.86	54.86	50.89	48.62
HEIGHT (in.)							
Caged	4.61	4.55	5.42	7.84	11.48	16.79	23.38
Uncaged	4.57	4.50	4.95	6.49	8.99	13.21	18.37

[a]Missing trees are included in mortality regardless of cause.

[b]Based on 29 plots.

[c]First bud burst about 4 months after planting.

animal damage

On 45 selected Douglas-fir plots, browsing was the principal type of damage, followed by clipping, budding, barking, and miscellaneous injury (Table 8, Fig. 7). Most damage on the selected plots was caused by deer, followed by hares, elk, grouse, and mountain beavers. Incidental damage was attributed to Douglas squirrels, wood rats, black bears, and band-tailed pigeons—damage agents not identified during the first 5 years of the survey.

Even on these plots, selected because of heavy damage during years 1 to 5, damage continued to decrease as stands developed. The percentage of plots damaged during the first 5 years was 52 percent, for the second 5 years 41 percent (Fig. 7). The difference between the first and second 5 years was greater on the 30 plots in Oregon (50% and 36%) than for the 15 plots in Washington (55% and 52%) (Table 6).

Table 8.

DOUGLAS-FIR TREES DAMAGED BY ANIMALS ON SELECTED PLOTS, YEARS 1-10 AFTER PLANTING.[a]
(mean annual and aggregate percent)

	Years												
Damage	0[b]	1	2	3	4	5	6	7	8	9	10	0-5	6-10
TYPE													
Barking	0.00	0.11	0.18	0.09	0.23	0.31	0.24	0.42	0.35	0.39	0.40	0.17	0.36
Browsing													
Overall	12.80	60.60	41.47	52.08	41.72	34.59	36.27	28.86	22.05	24.36	22.25	45.64	26.76
Stem	12.22	56.30	33.21	40.18	32.06	26.10	20.07	12.53	7.94	7.22	4.91	37.54	10.53
Budding	0.91	3.77	6.33	6.45	6.81	3.05	1.53	1.77	1.14	0.39	0.48	5.13	1.06
Clipping													
Overall[c]	1.47	10.04	8.08	8.44	7.05	7.15	12.41	14.19	11.42	12.02	10.46	7.93	12.24
Stem	1.37	7.32	3.61	2.93	3.22	2.45	1.81	2.37	1.36	1.76	1.36	3.94	1.73
Root cutting	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.01	0.04
Pulling	0.79	0.40	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.24	0.01
Trampling	0.48	0.25	0.27	0.32	0.37	0.07	0.06	0.07	0.03	0.10	0.03	0.33	0.06
Other	0.16	0.11	0.00	0.06	0.03	0.00	0.62	1.91	0.60	2.16	0.96	0.07	1.25
All Damage	15.99	72.93	54.45	62.87	51.42	42.77	48.05	46.14	35.58	36.17	34.89	56.37	40.17
Stem Damage	15.36	67.29	42.33	43.41	35.66	28.84	22.52	15.51	10.02	11.48	6.98	43.69	13.30
AGENT													
Deer	9.64	50.35	31.55	48.23	34.87	28.98	28.50	25.06	18.94	18.37	18.33	38.20	21.84
Domestic stock	0.07	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.53	0.50	0.00	0.02	0.21
Elk	3.79	10.67	10.19	7.10	8.32	5.96	8.42	7.13	2.93	4.40	3.88	8.64	5.35
Gopher	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.05
Grouse[c]	0.94	3.74	7.16	6.35	6.92	3.05	1.53	1.77	1.14	0.39	0.48	5.28	1.06
Hare	0.33	7.18	6.58	6.91	4.24	5.08	9.86	9.76	9.66	9.27	8.24	5.69	9.36
Mountain beaver	1.25	2.83	1.49	1.59	2.67	1.92	2.23	2.34	1.32	1.58	1.66	2.20	1.83
Other	0.02	0.05	0.15	0.09	0.03	0.07	0.80	2.87	0.93	2.85	1.62	0.08	1.81

[a]Based on 45 plots.

[b]First bud burst about 4 months after planting.

[c]Frequency of overall budding and grouse damage should be identical because grouse are the only agents. Small differences are errors.

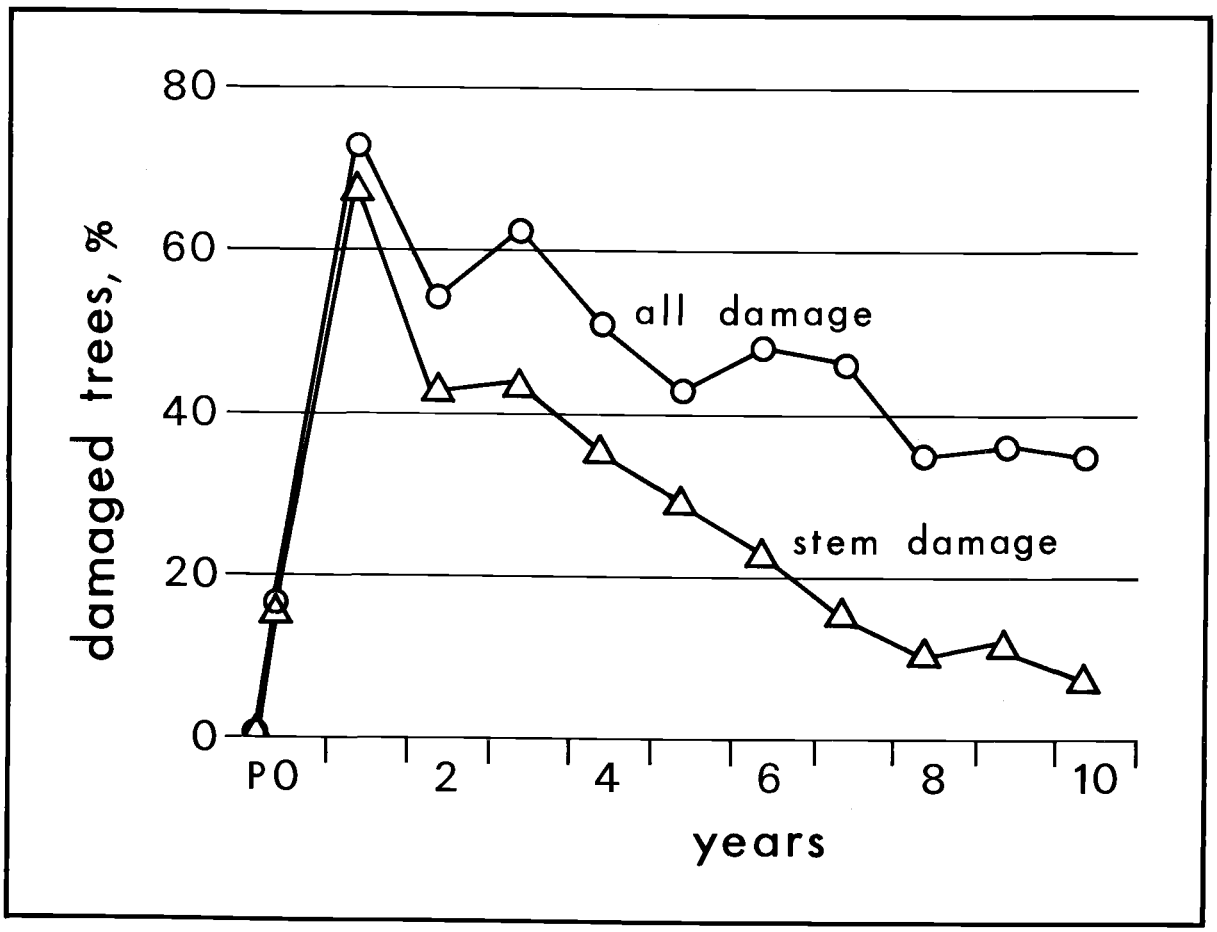

Figure 7.

Mean percent of uncaged Douglas-fir trees damaged by animals on 45 selected plots in Oregon and Washington, years 1-10 after planting.

survival

Mortality was low in years 6 to 10; hence the difference in survival between caged trees (83%) and uncaged trees (60%) was the same (23%) after 10 years as after 5 years (Table 9, Fig. 8). During the first 5 years, browsing and budding damage affected height growth but had little impact on survival, and 10-year observations further showed that established trees (5 years and older) can sustain repeated animal damage (browsing, budding, and clipping) without serious effect. Mortality that did occur (about 2% to caged and about 4% to uncaged trees in 5 years) was from stem clipping by mountain beavers and hares, mechanical damage such as windthrow (from poor planting procedures), or suppression by competing vegetation.

Mean survival was better on plots in Washington than in Oregon—90 percent of caged trees after 5 and 10 years, 74 and 69 percent of uncaged trees after 5 and 10 years, respectively. Survival for caged trees on the 30 plots in Oregon averaged about 83 percent after 5 years and 79 percent after 10 years. Survival for uncaged trees was 58 percent after 5 years and 55 percent after 10 years.

Table 9.

SURVIVAL OF CAGED AND UNCAGED DOUGLAS-FIR TREES ON SELECTED PLOTS, YEARS 1-10 AFTER PLANTING.
(mean percent)

Treatment[a]		Year 0[b]	1	2	3	4	5	6	7	8	9	10
OREGON (30)												
Caged	Mean	91.67	87.00	86.00	84.00	83.33	82.67	82.33	82.33	80.67	80.00	79.33
	S.D.	11.47	14.66	15.67	15.45	14.93	14.84	14.55	14.55	17.21	17.62	17.21
Uncaged	Mean	88.93	73.33	68.13	63.40	59.93	58.33	57.33	56.83	56.30	55.40	54.93
	S.D.	10.36	14.43	15.85	16.94	17.11	18.03	17.92	18.41	18.68	19.25	19.79
WASHINGTON (15)												
Caged	Mean	99.33	96.67	94.67	92.67	92.67	90.00	90.00	90.00	90.00	90.00	90.00
	S.D.	2.58	8.16	8.34	9.61	9.61	13.09	13.09	13.09	13.09	13.09	13.09
Uncaged	Mean	96.20	85.40	81.67	77.87	75.20	74.07	73.33	72.67	72.67	69.67	69.27
	S.D.	4.30	8.47	12.64	16.00	17.44	18.13	18.79	19.52	19.71	21.00	20.89
BOTH STATES (45)												
Caged	Mean	94.22	90.22	88.89	86.89	86.44	85.11	84.89	84.89	83.78	83.33	82.89
	S.D.	10.11	13.57	14.18	14.27	14.01	14.56	14.40	14.40	16.42	16.79	16.60
Uncaged	Mean	91.36	77.36	72.64	68.22	65.02	63.58	62.67	62.11	61.62	60.16	59.71
	S.D.	9.41	13.90	16.06	17.84	18.51	19.37	19.55	20.04	20.29	20.75	21.07

[a]Numbers in parentheses are number of plots.

[b]First bud burst about 4 months after planting.

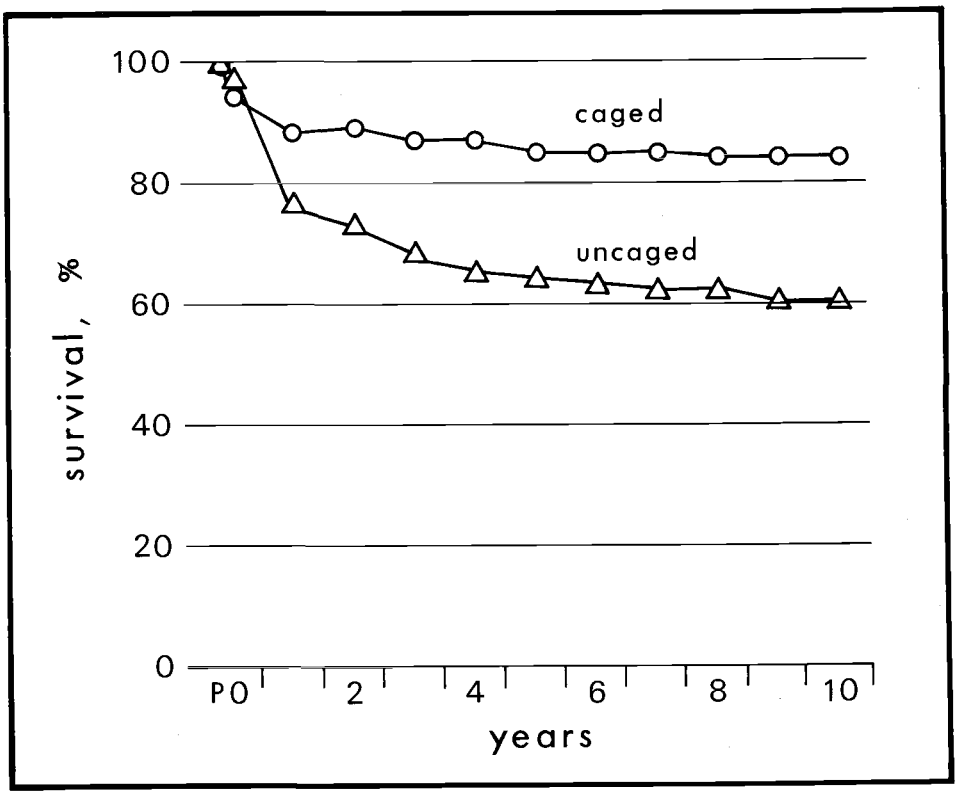

Figure 8.

Mean survival of Douglas-fir trees on 45 selected plots in Oregon and Washington, years 1-10 after planting.

growth

After 5 years, height of caged and uncaged trees in selected plots averaged 60 and 35 inches (152 and 89 cm), respectively, a difference of 26 inches (66 cm). After 10 years, heights of caged and uncaged trees (Table 10) in these plots averaged 171 and 129 inches (434 and 328 cm), respectively, a difference of 43 inches (109 cm). Although animal-related suppression of height continued and the mean difference in height between the caged and uncaged trees increased by about 18 inches (46 cm), the growth rates of caged and uncaged trees were nearly the same after 10 years (Fig. 9). Moreover, height differences between caged and uncaged trees appeared to stabilize at about 42 inches (107 cm) by the eighth year.

On the 15 selected plots in Washington, mean height of caged trees increased from 79 inches (201 cm) at 5 years to 215 inches (546 cm) at 10 years, while uncaged trees increased

Table 10.

MEAN HEIGHT OF CAGED AND UNCAGED DOUGLAS-FIR TREES ON SELECTED PLOTS, YEARS 1-10 AFTER PLANTING.
(inches)

Treatment[a]		Year											
		Planting	0[b]	1	2	3	4	5	6	7	8	9	10
OREGON (30)													
Caged	Mean	8.95	8.87	10.84	15.53	24.66	36.57	50.75	67.47	89.97	107.29	126.73	149.42
	S.D.	2.62	2.70	2.75	3.70	6.46	10.71	16.44	21.85	27.57	33.87	39.08	46.49
Uncaged	Mean	8.78	8.47	8.25	9.53	12.71	18.11	26.48	36.96	50.55	67.08	85.08	106.96
	S.D.	1.99	1.49	1.73	2.04	3.28	6.03	10.39	15.86	22.50	30.36	36.69	43.83
WASHINGTON (15)													
Caged	Mean	13.40	13.35	15.91	25.31	39.40	57.42	79.25	101.36	127.36	154.39	182.71	215.28
	S.D.	6.83	6.73	7.35	9.87	14.40	20.04	26.99	34.88	43.72	51.73	60.61	68.55
Uncaged	Mean	13.11	12.87	12.96	16.19	23.85	35.41	51.18	67.77	89.90	114.65	142.35	172.37
	S.D.	6.06	5.97	5.95	6.54	7.93	11.52	18.95	27.42	37.81	47.21	55.85	66.26
BOTH STATES (45)													
Caged	Mean	10.43	10.36	12.53	18.79	29.57	43.52	60.25	78.76	100.43	122.99	145.39	171.37
	S.D.	4.88	4.87	5.29	7.86	11.95	17.38	24.38	31.03	38.47	45.95	53.74	62.49
Uncaged	Mean	10.23	9.94	9.82	11.75	16.42	23.87	34.72	47.23	63.66	82.94	104.17	128.76
	S.D.	4.31	4.15	4.28	5.14	7.44	11.58	18.00	24.92	33.77	42.79	51.23	60.30

[a]Numbers in parentheses are number of plots.

[b]First bud burst about 4 months after planting.

from 51 to 172 inches (130-437 cm), 43 inches (109 cm) shorter than the caged trees. In the same period, mean height of caged trees on the 30 selected plots in Oregon increased from 51 to 149 inches (130-378 cm), while uncaged trees increased from 26 to 107 inches (66-272 cm), 42 inches (107 cm) shorter than the caged trees. Thus, even though trees in Washington averaged about 66 inches (168 cm) taller than those in Oregon at 10 years, differences between caged and uncaged trees were nearly identical for each state.

After 5 years, uncaged trees in Washington averaged 51 inches (130 cm) tall and were less susceptible to stem damage by browsing, budding, or clipping than were uncaged trees in Oregon with a mean height of only 26 inches (66 cm). After 5 more years' growth, however, terminal buds of shoots of most trees on all 45 selected plots were out of reach of most animals that browse, bud, and clip.

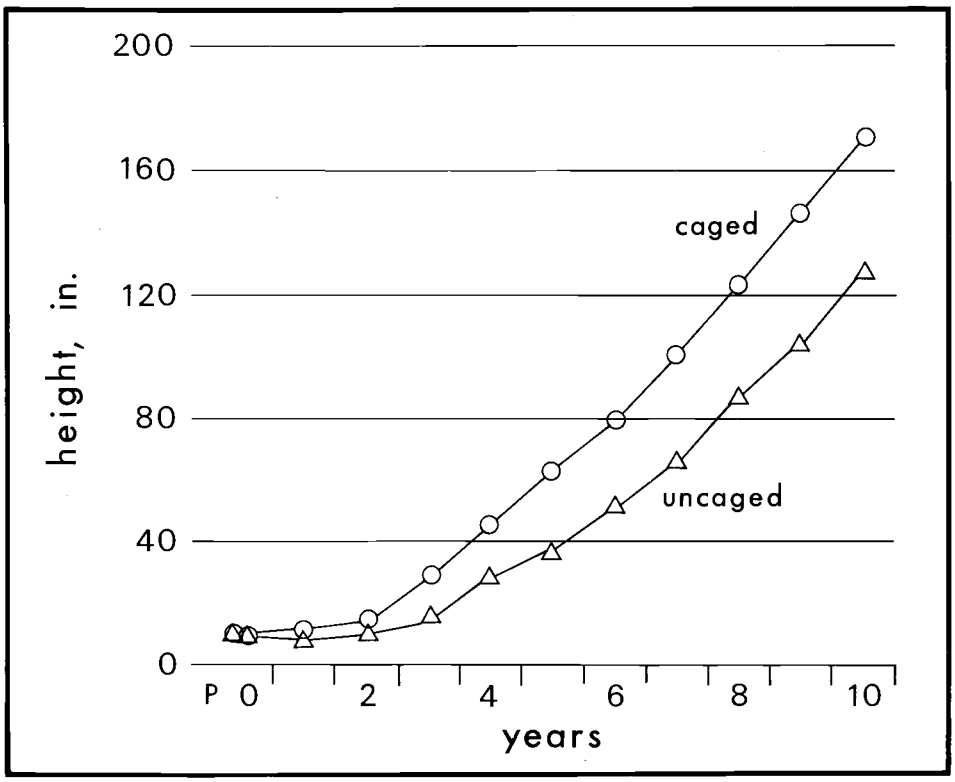

Figure 9.

Mean height of Douglas-fir trees on 45 selected plots in Oregon and Washington, years 1-10 after planting.

succession of damage agents

Douglas-fir plot 314—a high-site, low-elevation plot on Weyerhaeuser Company land in southwestern Washington—clearly illustrates the pattern of animal-damage succession (Fig. 10A). Damage by grouse, deer, and hare overlapped throughout the 10-year period. However, grouse budding in the second year was the principal damage, peaking and declining to a low level after year 4. Only laterals were budded after the third year. Deer browsing increased until the fifth year, then declined to a moderate level from years 6 to 10 (except for a sharp increase in year 8). Hare clipping, at a low level during establishment, increased to 25 to 55 percent in years 7 to 10.

Tree survival was unaffected by this continuous succession of feeding injuries mainly because laterals, not stems, were injured. After 10 years, 100 percent of the caged and 95 percent of uncaged trees survived. But height growth on this plantation—one of the fastest growing plantations in the survey—was reduced by an amount equivalent to about a year's growth; mean height was 320 inches (813 cm) for caged trees and 279 inches (709 cm) for uncaged trees.

budding by grouse

Douglas-fir plot 414 in the Coast Range of southwestern Washington illustrates suppression primarily by grouse budding. However, a small amount of browsing (10%-25%), mainly by elk, occurred each year during years 1 to 6, and lateral clipping by hares was moderate each year during years 3 to 10 (Fig. 10B).

In March 1965, 2-year-old Douglas-fir were planted at the 2,300-foot (701 m) elevation on this high-site land managed by the Crown Zellerbach Company. After 4 years, during which most damage was caused by grouse budding, height averaged 61 inches (155 cm) for caged trees and 25 inches (63 cm) for uncaged trees—a difference of 26 inches (66 cm). Stem damage by budding, browsing, or clipping was negligible after the fourth year, although hares clipped laterals on about half of all uncaged trees each year in years 5 to 10. Mean height differences increased slightly during years 5 to 7, but precommercial thinning in year 8 removed about one-third of uncaged trees, precluding further comparisons.

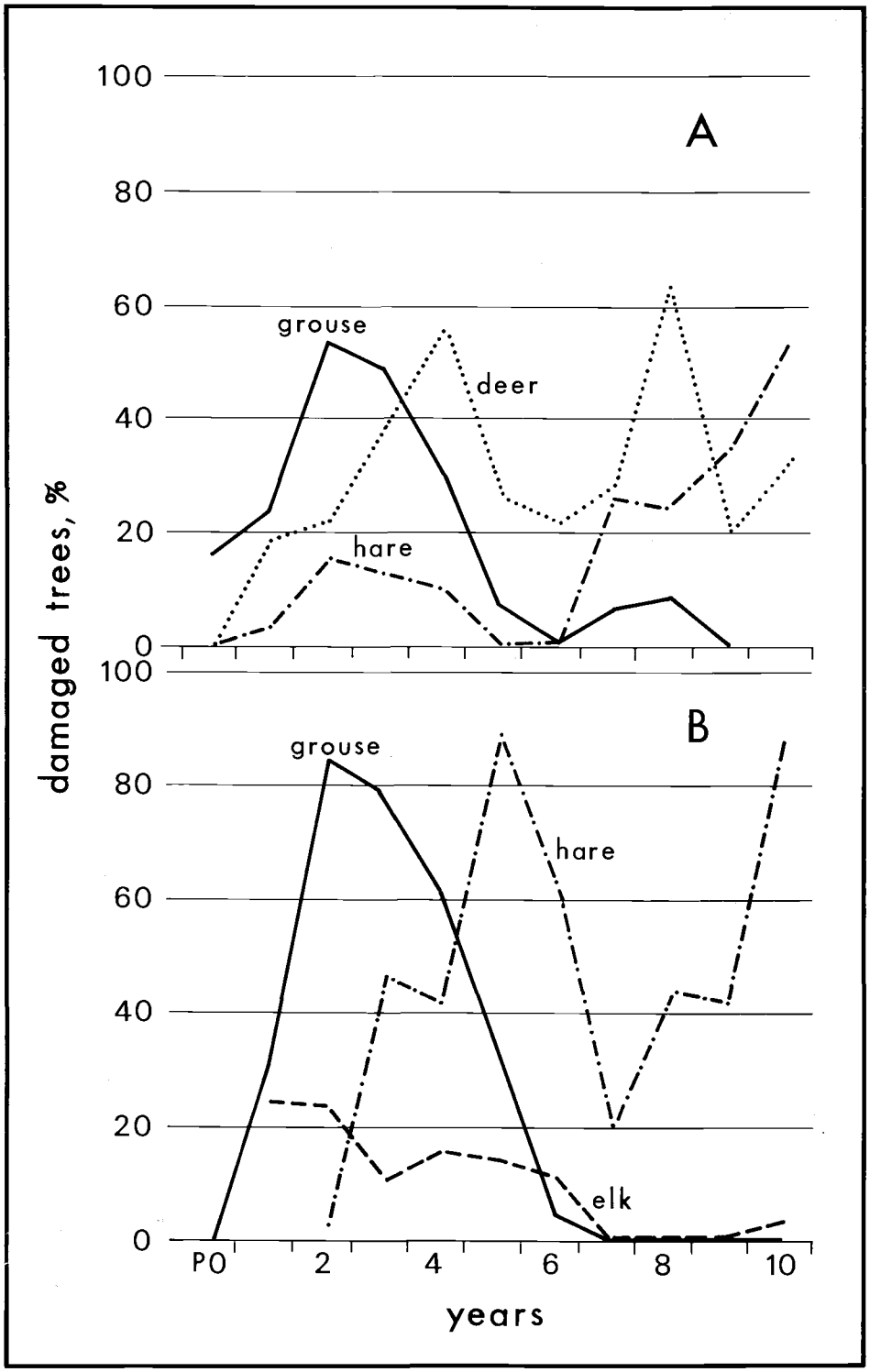

Figure 10.

Percent of Douglas-fir trees damaged by specific agents on Plot 314 (A) and Plot 414 (B) in southwestern Washington, years 1-10 after planting.

clipping by rodents

ponderosa pine

In southwestern Oregon, plot 81 experienced only a small amount of damage during early establishment (1-5 years), although pocket gophers were abundant and porcupines were in the area. Pocket gophers caused minor damage, including damage to about half of the uncaged trees in the eighth year. However, neither survival nor height growth were much affected. Porcupines damaged small numbers of pine saplings each year during years 6 to 10.

Three-year-old ponderosa pines were planted on plot 83, a site of intermediate quality at about 5,000 feet (1,525 m) on the Wallowa-Whitman National Forest in northeastern Oregon. The trees grew marginally during early establishment while browsed by deer and elk and clipped by gophers. Tree mortality, caused principally by gophers, reduced survival of uncaged trees to 43 percent after 5 years; 80 percent of caged trees survived. Gopher damage to both caged and uncaged trees increased in years 6 and 7. Because of poor tree survival, we discontinued observations in year 8.

douglas-fir

Rodent clipping caused seedling attrition on several Douglas-fir plots such as plot 120 located on the Siuslaw National Forest in western Oregon. This clearcutting had been broadcast burned, but shrubby vegetation rapidly recovered to create a favorable habitat for mountain beavers and to compound the effects of suppression caused by their clipping. Moderate clipping damage by mountain beavers reduced both height growth and survival each year. After 7 years, 52 percent of uncaged trees and 80 percent of caged trees survived.

A combination of moderate damage by deer, hare, and mountain beavers occurred on Douglas-fir plot 20 in the Cascade Mountains of western Oregon. During the first 5 years, deer browsing averaged 20 percent per examination period; clipping by mountain beaver and hare averaged 11 percent. This pattern was reversed in years 6 to 10 when the mean occurrence of mountain beaver clipping was 27 percent and deer browsing was only 7 percent each year. Similarly, on plot 19 in the same area, annual clipping by mountain beavers (mainly stem clipping) averaged 11 percent for the first 5 years and 17 percent for the second 5 years.

Browsing and clipping damage suppressed height growth. On plot 20, mean height after 10 years was 108 inches (274 cm) for caged trees and 57 inches (145 cm) for uncaged trees. Attrition of trees, mainly from mountain beaver clipping, continued and reduced survival of uncaged trees to 30 percent after 10 years. Caged trees had a survival rate of 80 percent.

browsing and trampling by domestic stock

Two-year-old, untreated ponderosa pine seedlings were planted in December 1963 on plot 49, a burned clearcutting of the Bureau of Land Management in southwestern Oregon. Dense herbaceous cover, chiefly perennial grasses that developed after planting, competed with seedlings and provided abundant forage for cattle grazing there each spring and summer throughout the study.

Initial survival was good, but nearly all uncaged seedlings were browsed by deer during the dormant season immediately after planting. Moderate browsing by cattle and minor trampling during the growing season each subsequent year drastically reduced survival of unprotected trees. After 10 years, 90 percent of caged trees survived, but only 18 percent of uncaged trees. Mean height was 84 inches (213 cm) for caged trees and 22 inches (56 cm) for uncaged trees, a difference of 62 inches (157 cm) (Fig. 11). Furthermore, two to five of the caged trees had been browsed repeatedly in years 6 to 10.

Heavy browsing damage during initial establishment, in combination with vegetative competition, adversely affects tree survival. Furthermore, suppressed seedlings remain vulnerable to browsing, and the cumulative effect of repeated moderate browsing by deer and cattle reduces both tree survival and height growth.

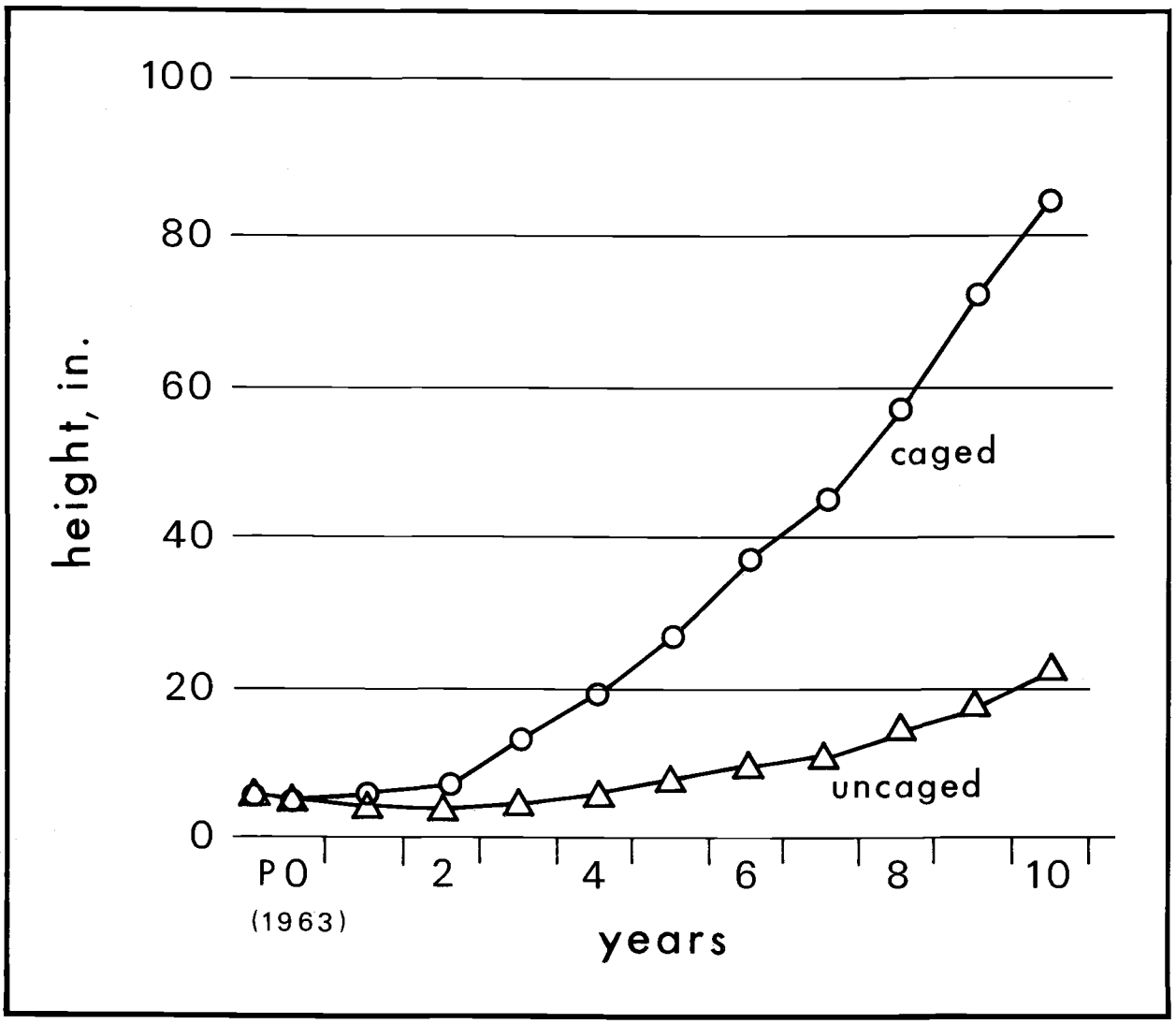

Figure 11.

Mean height of ponderosa pine trees on plot 49 in southwestern Oregon, years 1-10 after planting.

browsing by deer

Douglas-fir plot 32 illustrates that repeated heavy browsing, chiefly by deer, decreases height growth (Figs. 12, 13). In January 1964, 2-year-old Douglas-fir seedlings were planted on a site 2, unburned plot at low elevation in the Oregon Coast Range. The plantation had a high population of black-tailed deer. Roosevelt elk also occurred in the area, although their use of the plot was not noted until year 8. Seedling survival on the plot was excellent (100% of caged and 96% of uncaged trees after 10 years).

From time of planting to bud burst, browsing injury was negligible, possibly because of Thiram

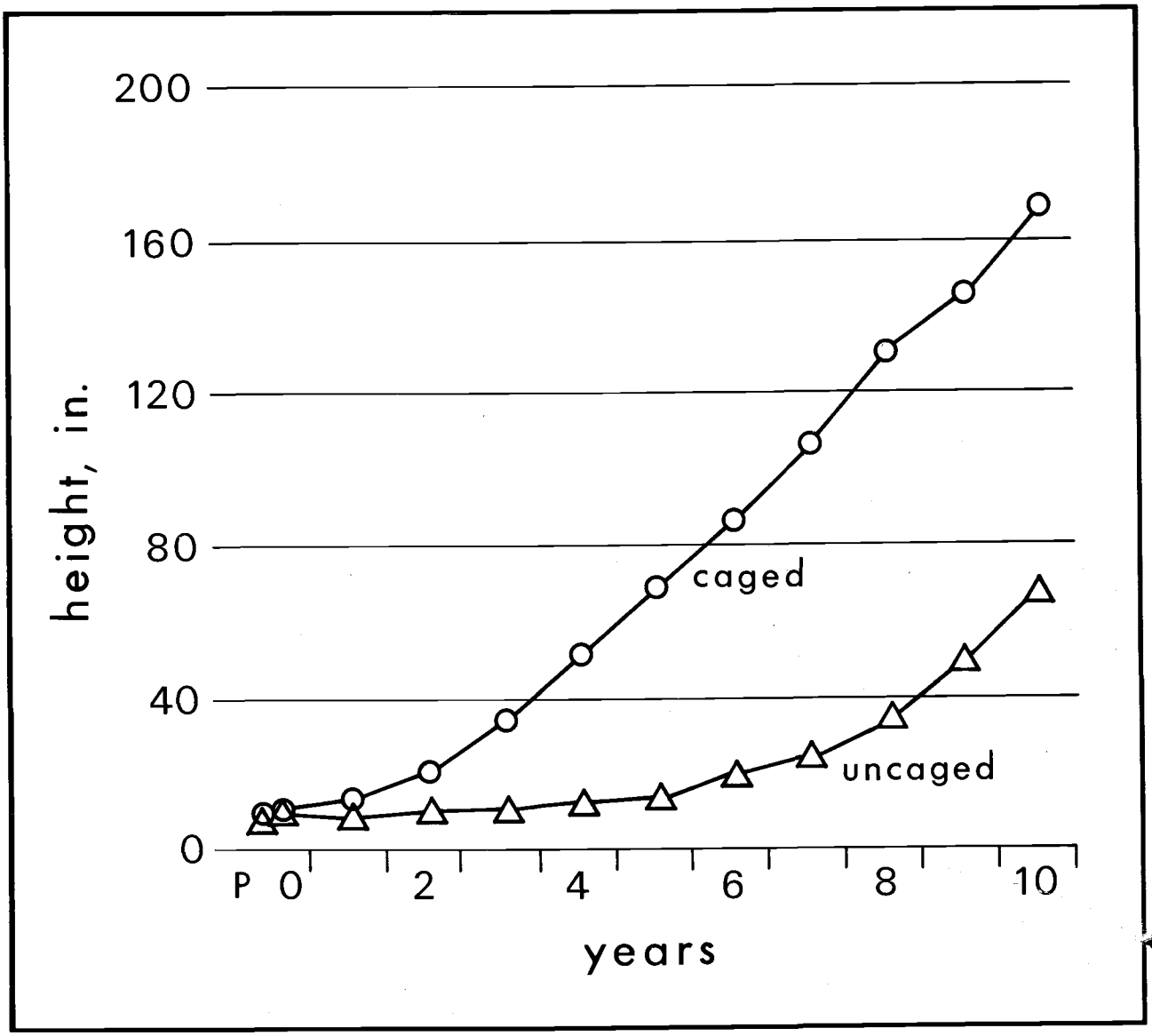

Figure 12.

Mean height of Douglas-fir trees on plot 32 in western Oregon, years 1-10 after planting.

Figure 13.

Plot 32 in western Oregon, summer 1974 after 10 years' growth. Hedged appearance, shrubby form, and multiple shoots of Douglas-fir trees illustrate the effects of repeated browsing by deer. Cages have been removed from the taller, protected trees.

animal repellent. However, deer browsed new shoots of most uncaged seedlings after bud burst in 1964. Browsing of new shoots on most seedlings, with a smaller amount of stem browsing during dormancy, was repeated through the 10th year. An exception was the dormant season of 1965 when deer browsed terminal shoots of uncaged trees. Animal damage declined from a peak of 95 percent in the fifth year to about 18 percent in the ninth year; however, browsing of terminal and lateral shoots increased to about 60 percent in the 10th year (47% stem browsing). Stem browsing by deer began decreasing when mean height of uncaged trees ranged from about 13 to 19 inches (33-48 cm). Elk browsed (about 23% of uncaged trees) for the first time in the 10th year, which probably accounted for much of the increased damage that year. Damage of other types and by other agents was negligible.

Repeated browsing did not affect survival, but it significantly suppressed growth (Fig. 12). At the end of the fifth year, height averaged only 13 inches (33 cm) for uncaged trees and 69 inches (175 cm) for caged trees. After 10 years, mean heights of caged and uncaged seedlings were 168 and 68 inches (427 and 173 cm), respectively—a difference of 100 inches (254 cm). The uncaged trees looked like shrubs with multiple shoots because of repeated browsing (Fig. 13). Growth curves of caged and uncaged trees continued to diverge for 8 years. In years 9 and 10, height growth of uncaged seedlings accelerated, approximating that of caged trees; however, the difference in height between caged and uncaged trees was equivalent to about 5 years' growth.

discussion

Apart from individual plot histories, the findings of this 10-year survey have been presented to show the average condition, mean frequency of damage, and mean response of protected and unprotected trees. Although valid, these data can be misleading because the amount of animal damage was not uniform among plantations. For the most part, damage was moderate in frequency, limited to 1 or 2 years after planting, and confined mainly to lateral shoots with only minor effects on survival, growth, or both. On some plots, such as the 45 selected plots of Douglas-fir, damage was persistent, and repeated damage to stems significantly affected growth. In other instances, clipping damage (often in combination with other mortality factors) decreased stocking below acceptable levels.

caging

Caged seedlings do not provide an unbiased sample of tree performance. Installation of cages disturbed some planting spots, and caging may have affected growth, positively or negatively. Animals frequently damaged seedlings within the cages, particularly after terminal and lateral shoots were exposed to browsing by deer and elk. After 5 years, the principal effect of caging was the greatly increased growth of competing herbaceous and woody vegetation where it was protected from all feeding by animals. In several instances, this dense vegetation suppressed growth of caged seedlings. As trees grew and became confined, cages were removed from most trees on the selected Douglas-fir plots before completion of the survey. Nonetheless, the wire netting frequently injured the foliage and stems of these caged saplings.

stand maintenance

The plantations observed for 5 years and the selected plots observed for 10 years received little maintenance except stocking surveys. Land managers on these plantations did not try to bait or trap rodent or lagomorph populations, to retreat seedlings with repellents, or to protect trees with seedling protectors or fencing. These practices would have been incompatible with survey objectives, and none were proposed. A few plantations were interplanted, treated with phenoxy herbicides or hand-grubbed to "release" conifers, or precommercially thinned.

More intensive management during stand establishment might have reduced the impact of animal damage. Stand maintenance can reduce carrying capacity of habitats for small or large mammals. By promoting conifer growth, maintenance can reduce the period of exposure to significant animal damage and increase the capacity of conifers to sustain damage. In well-stocked stands, precommercial and commercial thinning can remove trees suppressed by animals (and other agents) and thus minimize apparent adverse effects.

damage distribution

Neither the distribution nor the incidence of deer use of Douglas-fir is random (Crouch 1968, Hines 1973). Deer confined in a fenced enclosure in western Oregon in winter heavily browsed Douglas-fir trees on most sites, but browsed little at other sites within the enclosure. Deer damage to Douglas-fir plantations on Vancouver Island concentrated in areas seldom exceeding 2 acres or 0.8 ha (Smith and Walters 1965). Of Douglas-fir stem browsed by elk, 95 percent were in areas adjacent to standing timber; only 3 percent of the high-use areas were more than 300 yards (274

m) from timber (Harper 1969). Thus, even on plantations that receive only light overall use, damage may be concentrated sufficiently to cause serious loss.

Crouch (1968) and Hines (1973) concluded that the primary factor regulating deer use of Douglas-fir is the relation of deer density to the available quantity of more palatable forage. In areas of comparable deer density, conifer browsing was affected by winter weather and availability of forage. Browsing of Douglas-fir trees in winter was also related to seedling size, elevation, aspect, slope, and amount of soil disturbance. In the Tillamook Burn of western Oregon, both investigators found that deer use was greatest below elevations of 2,000 feet (610 m), on south-facing slopes with grades of less than 60 percent, and on soils disturbed by logging.

Elk transplanted by state agencies may have contributed to changes in damage patterns on some plantations. One pattern showed increased elk damage as stands developed. For example, five Douglas-fir plots in northwestern Oregon, inhabited by both deer and elk, were browsed mainly by deer during the first 5 years; elk browsing became common only as stands grew older. Harper (1969) showed that elk use was highest on clearcuttings that were 6 to 8 years old.

Browsing followed a similar pattern on a Douglas-fir plot in western Washington. Moderate to heavy deer browsing, but no elk browsing, occurred from years 1 to 5; however, from years 6 to 10, browsing was principally by elk. Although browsing decreased each year (from 54% to 4%), most was stem browsing.

On five plots in western Oregon and Washington, elk browsing was not observed during years 1 to 5, then only infrequently as plantations developed. On one plot in western Oregon, deer browsed exclusively from years 1 to 9, but in the 10th year, elk browsed stems of 23 percent of uncaged seedlings averaging 67 inches (170 cm) in height. In these instances, elk probably had extended their range to include the clearcuttings.

damage to saplings and trees

In several instances, animals damaged saplings and pole-size trees. Douglas squirrels clipped terminal leaders and upper lateral shoots of trees on seven Douglas-fir plots in Washington and six in Oregon. This type of damage, reported by Fisch and Dimock (1978), occurred mainly during years 6 to 10. Woodrats damaged 10-year-old Douglas-fir trees in a southwestern Oregon plot where a dense young stand provided a favorable habitat (Hooven 1959), although the woodrats had been absent during plantation establishment. Bear damage, which occurs most frequently on pole-size trees 10 to 30 years old (Poelker and Hartwell 1973), occurred in the 10th year on one Douglas-fir plot in western Washington. In one instance, damage to Douglas-fir saplings was attributed to band-tailed pigeons landing on and breaking the succulent leader.

damage agents

To rank damage types and animal agents in order of destructiveness to tree regeneration, both severity and amount of damage must be evaluated. Types of damage overlapped in nearly all plantations, and apportioning precise losses to each type or agent is impossible. However, we can reasonably infer that stem clipping by hares, rabbits, and mountain beavers caused most animal-related mortality in Douglas-fir. Likewise, clipping and root cutting by pocket gophers probably caused most animal-related mortality in ponderosa pine. Height losses in both Douglas-fir and ponderosa pine resulted chiefly from combinations of browsing and clipping. Because deer browsed both species almost everywhere, exceeding damage by all other agents combined, we can reasonably infer that deer browsing reduced tree height more than any other damage.

impact of damage

After 5 years, differences between protected and unprotected trees in average plantations show that animals substantially reduced height and survival of Douglas-fir (24% and 20%, respectively) and ponderosa pine (22% and 31%, respectively). Tree mortality, usually from clipped stems or roots, becomes significant when stocking is reduced below an acceptable production level and replanting is required.

Most plantations can sustain minor damage without significant impact on stocking or growth. For example, Campbell and Evans (1975a) estimated that stems of 35 percent of the trees in a plantation can be deer browsed before stands lose significant height. On many sites, regeneration from natural seedfall contributes to stocking. Although yield may be reduced when optimum stocking is not achieved promptly, natural regeneration often offsets the effects of animal damage on tree survival.

Suppressed height growth, the most common and widespread effect of animal damage, suggests extension of rotation, although thinning when stocking exceeds optimum for the site could minimize the difference between damaged and undamaged trees. Smith and Walters (1965) calculated that a height advantage of 10 inches (25 cm) for Douglas-fir at planting may, if the advantage persists, mean a difference of 2.6 years in length of the rotation. Mitchell (1964) concluded that productivity of Douglas-fir plantations on Vancouver Island would not be seriously reduced at rotation age, despite an average reduction in tree height of 6 to 24

conclusions

inches (15-61 cm) from deer browsing over 8 to 10 years.

In this survey, height of protected and unprotected trees differed by an average of 43 inches (109 cm) after 10 years on plantations heavily damaged by deer and other animals. This suggests that the growth differential will persist, measurably reducing or delaying yield. However, as Crouch (1969) noted, the relation between browsing of trees as seedlings or saplings and their condition at rotation age has not been described.

The survey of forest plantations in Oregon and Washington was designed to comprehensively evaluate the impact of animal damage. We believe that the findings represent a reasonably accurate appraisal. Moderate to heavy browsing, budding, and clipping damage—principally by deer, grouse, and hares—damaged plantations throughout both states during stand establishment. On the average, animal damage adversely affected tree survival, causing 33 percent of the mortality on Douglas-fir plots and 43 percent of the mortality on ponderosa pine plots. Animal damage suppressed tree height the equivalent of about 1.5 years' growth after 5 years. On Douglas-fir plantations experiencing heavy damage, height suppression was equivalent to about 2.5 years' growth at both 5 and 10 years after planting.

We believe that mortality factors must be evaluated carefully and damage must be identified accurately before control measures are undertaken. Minor browsing, budding, or clipping injuries—especially to established trees—can be disregarded, and control measures are not indicated. Because deer browsing is so widespread and pocket gopher and mountain beaver damage so serious, more research is justified to develop effective control measures and reforestation practices designed to alleviate damage by these animals.

Stand damage in plantations exposed to heavy animal use, especially during seedling establishment, warrants expenditure for protective measures. Areas of potentially heavy damage should be identified early (before reforestation, if possible), and the best available combination of control measures should be applied. Recognition of the distribution of damage in relation to management practices and site features will help identify high-risk areas. The findings of this survey offer the basis for developing prediction models to identify areas that will be exposed to significant animal damage. Such predictors are urgently needed.

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appendix tables

Table 1A.

ANIMAL-DAMAGED DOUGLAS-FIR TREES IN OREGON AND WASHINGTON BY OWNERSHIP, YEARS 1-5 AFTER PLANTING.
(mean annual percent)

Damage	Ownership[a] USFS (57)[b]	BLM (41)	WDNR (10)	OSDF (25)	Private (32)
TYPE					
Barking	0.29	0.13	0.18	0.01	0.19
Browsing					
Overall	12.12	25.20	25.10	27.54	29.71
Stem	10.21	22.64	18.01	22.42	22.36
Budding					
Overall[c]	2.18	1.80	3.90	0.12	6.72
Stem	0.53	0.06	2.54	0.02	2.38
Clipping					
Overall	4.57	2.47	9.84	4.66	11.38
Stem	2.49	1.43	4.82	2.46	5.19
Root cutting	0.00	0.08	0.00	0.02	0.02
Pulling	0.01	0.03	0.06	0.38	0.05
Trampling	0.26	0.08	0.29	0.44	0.22
Other	0.08	0.02	0.08	0.03	0.11
All Damage	18.85	29.10	36.80	32.52	44.36
Stem Damage	13.59	24.24	25.20	25.42	30.08
AGENT					
Deer	11.43	24.52	21.51	19.64	24.35
Domestic stock	0.01	0.02	0.06	0.01	0.01
Elk	0.95	0.80	5.24	8.35	6.44
Gopher	0.01	0.14	0.02	0.00	0.01
Grouse[c]	2.26	1.80	3.91	0.12	6.73
Hare	3.11	1.97	7.86	3.98	8.72
Mountain beaver	0.61	0.45	1.91	0.73	2.66
Microtine	0.05	0.02	0.09	0.00	0.01
Porcupine	0.00	0.00	0.00	0.00	0.00
Other	0.88	0.00	0.06	0.02	0.04

[a]USFS-U.S. Forest Service; BLM-Bureau of Land Management; WDNR-Washington Department of Natural Resources; OSDF-Oregon State Department of Forestry.

[b]Numbers in parentheses are number of plots.

[c]Frequency of overall budding and of grouse damage should be identical because grouse are the only agents. Small differences are errors.

Table 2A.

ANIMAL-DAMAGED DOUGLAS-FIR TREES IN OREGON BY OWNERSHIP, YEARS 1-5 AFTER PLANTING.
(mean annual percent)

Damage	Ownership[a] USFS (33)[b]	BLM (41)	OSDF (25)	Private (17)
TYPE				
Barking	0.23	0.13	0.01	0.07
Browsing				
Overall	15.06	25.20	27.54	32.27
Stem	13.20	22.64	22.42	26.43
Budding				
Overall[c]	3.02	1.80	0.12	1.26
Stem	0.57	0.06	0.02	0.08
Clipping				
Overall	5.09	2.47	4.66	9.48
Stem	2.40	1.43	2.46	6.67
Root cutting	0.00	0.08	0.02	0.03
Pulling	0.01	0.03	0.38	0.08
Trampling	0.37	0.08	0.44	0.04
Other	0.04	0.02	0.03	0.02
All Damage	22.93	29.10	32.52	42.52
Stem Damage	16.49	24.24	25.42	33.20
AGENT				
Deer	14.65	24.52	19.64	32.44
Domestic stock	0.01	0.02	0.01	0.02
Elk	0.71	0.80	8.35	0.11
Gopher	0.01	0.14	0.00	0.03
Grouse[c]	3.09	1.80	0.12	1.26
Hare	4.24	1.97	3.98	7.07
Mountain beaver	0.48	0.45	0.73	2.33
Microtine	0.04	0.02	0.00	0.00
Porcupine	0.00	0.00	0.00	0.00
Other	0.44	0.00	0.02	0.00

[a]USFS-U.S. Forest Service; BLM-Bureau of Land Management; WDNR-Washington Department of Natural Resources; OSDF-Oregon State Department of Forestry.

[b]Numbers in parentheses are number of plots.

[c]Frequency of overall budding and of grouse damage should be identical because grouse are the only agents. Small differences are errors.

Table 3A.

ANIMAL-DAMAGED DOUGLAS-FIR TREES IN WASHINGTON BY OWNERSHIP, YEARS 1-5 AFTER PLANTING.
(mean annual percent)

Damage	Ownership[a] USFS (24)[b]	WDNR (10)	Private (15)
TYPE			
Barking	0.38	0.18	0.33
Browsing			
Overall	8.06	25.10	26.81
Stem	6.09	18.01	17.74
Budding			
Overall[c]	1.02	3.90	12.90
Stem	0.49	2.54	4.98
Clipping			
Overall	3.85	9.84	13.54
Stem	2.61	4.82	3.50
Root cutting	0.00	0.00	0.02
Pulling	0.01	0.06	0.01
Trampling	0.12	0.29	0.43
Other	0.12	0.08	0.21
All Damage	13.26	36.80	46.45
Stem Damage	9.60	25.20	26.55
AGENT			
Deer	6.99	21.51	15.18
Domestic stock	0.00	0.06	0.00
Elk	1.28	5.24	13.62
Gopher[c]	0.00	0.02	0.00
Grouse[c]	1.12	3.91	12.93
Hare	1.55	7.86	10.59
Mountain beaver	0.80	1.91	3.03
Microtine	0.07	0.09	0.02
Porcupine	0.00	0.00	0.00
Other	1.48	0.06	0.09

[a]USFS-U.S. Forest Service; BLM-Bureau of Land Management; WDNR-Washington Department of Natural Resources; OSDF-Oregon State Department of Forestry.

[b]Numbers in parentheses are number of plots.

[c]Frequency of overall budding and grouse damage should be identical because grouse are the only agents. Small differences are errors.

Table 4A.

ANIMAL-DAMAGED DOUGLAS-FIR TREES ON SLASH TREATED PLOTS IN OREGON AND WASHINGTON, YEARS 1-5 AFTER PLANTING.
(mean annual percent)

Damage	OREGON Burned (79)[a]	OREGON Unburned (37)	WASHINGTON Burned (36)	WASHINGTON Unburned (13)	BOTH STATES Burned (115)	BOTH STATES Unburned (50)
TYPE						
Barking	0.10	0.17	0.35	0.24	0.18	0.19
Browsing						
Overall	23.86	23.85	14.83	24.05	21.03	23.90
Stem	20.94	19.43	10.67	16.03	17.73	18.55
Budding						
Overall[b]	2.20	0.64	2.54	12.72	2.31	3.78
Stem	0.28	0.02	1.32	4.94	0.61	1.30
Clipping						
Overall	3.94	6.35	6.19	13.14	4.65	8.12
Stem	2.09	3.99	3.11	3.96	2.41	3.98
Root cutting	0.01	0.08	0.00	0.02	0.01	0.07
Pulling	0.10	0.13	0.03	0.00	0.08	0.10
Trampling	0.21	0.28	0.17	0.45	0.20	0.32
Other	0.02	0.05	0.14	0.15	0.05	0.08
All Damage	29.70	30.79	22.75	43.39	27.52	34.07
Stem Damage	23.50	23.82	15.43	25.01	20.98	24.13
AGENT						
Deer	22.12	21.18	12.26	13.03	19.03	19.06
Domestic stock	0.01	0.02	0.02	0.00	0.01	0.01
Elk	1.99	2.97	3.21	13.22	2.37	5.64
Gopher[b]	0.02	0.13	0.00	0.02	0.01	0.10
Grouse[b]	2.23	0.65	2.62	12.73	2.35	3.79
Hare	3.25	4.97	3.84	10.48	3.43	6.40
Mountain beaver	0.53	1.36	1.37	2.66	0.80	1.69
Microtine	0.02	0.02	0.07	0.02	0.03	0.02
Porcupine	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.18	0.01	1.00	0.10	0.44	0.03

[a]Numbers in parentheses are number of plots.

[b]Frequency of overall budding and of grouse damage should be identical because grouse are the only agents. Small differences are errors.

Table 5A.

ANIMAL-DAMAGED DOUGLAS-FIR TREES ON DIFFERENT ASPECTS IN OREGON AND WASHINGTON, YEARS 1-5 AFTER PLANTING.
(mean annual percent)

Damage	Aspect North (37)[a]	East (12)	South (75)	West (28)	Level (13)
TYPE					
Barking	0.10	0.09	0.25	0.13	0.23
Browsing					
Overall	18.13	13.92	26.27	21.03	16.66
Stem	15.31	10.50	21.61	17.60	12.29
Budding					
Overall[b]	1.14	1.71	4.20	2.18	1.22
Stem	0.28	0.48	1.18	1.06	0.05
Clipping					
Overall	4.95	7.57	5.12	5.17	10.57
Stem	3.34	4.15	2.42	2.49	3.96
Root cutting	0.06	0.04	0.00	0.03	0.05
Pulling	0.02	0.00	0.11	0.04	0.23
Trampling	0.20	0.04	0.33	0.10	0.29
Other	0.08	0.10	0.07	0.03	0.02
All Damage	24.18	22.70	34.20	27.80	27.56
Stem Damage	19.11	15.24	25.56	21.17	16.86
AGENT					
Deer	16.63	13.98	22.36	18.77	11.99
Domestic stock	0.00	0.03	0.02	0.00	0.03
Elk	1.70	0.02	4.41	3.23	5.38
Gopher	0.13	0.00	0.01	0.03	0.03
Grouse[b]	1.16	1.73	4.25	2.18	1.24
Hare	3.30	4.63	3.75	4.78	9.42
Mountain beaver	1.43	2.78	0.88	0.31	1.13
Microtine	0.01	0.00	0.03	0.01	0.14
Porcupine	0.00	0.00	0.00	0.00	0.00
Other	0.27	0.21	0.51	0.05	0.02

[a]Numbers in parentheses are number of plots.

[b]Frequency of overall budding and of grouse damage should be identical because grouse are the only agents. Small differences are errors.

Table 6A.

ANIMAL-DAMAGED DOUGLAS-FIR TREES ON DIFFERENT ASPECTS IN OREGON, YEARS 1-5 AFTER PLANTING.
(mean annual percent)

Damage	Aspect North (29)[a]	East (8)	South (53)	West (18)	Level (8)
TYPE					
Barking	0.05	0.08	0.16	0.10	0.21
Browsing					
Overall	20.36	12.11	27.93	24.44	20.00
Stem	17.59	9.16	24.11	21.37	15.93
Budding					
Overall[b]	0.88	1.57	2.48	1.25	0.70
Stem	0.14	0.19	0.28	0.14	0.00
Clipping					
Overall	4.89	7.78	3.13	6.50	7.45
Stem	3.32	4.57	1.78	3.46	2.87
Root cutting	0.08	0.06	0.00	0.05	0.05
Pulling	0.03	0.00	0.15	0.06	0.31
Trampling	0.16	0.05	0.33	0.08	0.42
Other	0.07	0.00	0.01	0.02	0.03
All Damage	26.09	20.99	33.32	31.80	27.81
Stem Damage	21.18	14.03	26.49	25.09	19.49
AGENT					
Deer	19.24	12.17	25.29	23.87	13.23
Domestic stock	0.00	0.05	0.01	0.00	0.05
Elk	1.22	0.03	2.99	0.81	7.29
Gopher	0.15	0.00	0.01	0.05	0.05
Grouse[b]	0.90	1.57	2.51	1.25	0.74
Hare	3.70	3.71	2.58	6.00	7.38
Mountain beaver	0.97	4.10	0.44	0.40	0.09
Microtine	0.00	0.00	0.03	0.00	0.09
Porcupine	0.00	0.00	0.00	0.00	0.00
Other	0.27	0.00	0.11	0.06	0.02

[a]Numbers in parentheses are number of plots.

[b]Frequency of overall budding and of grouse damage should be identical because grouse are the only agents. Small differences are errors.

Table 7A.

ANIMAL-DAMAGED DOUGLAS-FIR TREES ON DIFFERENT ASPECTS IN WASHINGTON, YEARS 1-5 AFTER PLANTING.
(mean annual percent)

Damage	Aspect				
	North (8)[a]	East (4)	South (22)	West (10)	Level (5)
TYPE					
Barking	0.26	0.12	0.45	0.19	0.27
Browsing					
Overall	10.08	17.54	22.28	14.91	11.31
Stem	7.05	13.18	15.59	10.81	6.45
Budding					
Overall[b]	2.12	2.00	8.34	3.84	2.05
Stem	0.78	1.05	3.34	2.72	0.12
Clipping					
Overall	5.18	7.15	9.92	2.76	15.56
Stem	3.40	3.31	3.96	0.74	5.70
Root cutting	0.00	0.00	0.00	0.00	0.05
Pulling	0.00	0.00	0.02	0.00	0.11
Trampling	0.35	0.00	0.34	0.13	0.09
Other	0.10	0.29	0.20	0.04	0.00
All Damage	17.28	26.10	36.30	20.59	27.17
Stem Damage	11.59	17.65	23.31	14.11	12.65
AGENT					
Deer	7.15	17.60	15.32	9.58	10.01
Domestic stock	0.00	0.00	0.03	0.00	0.00
Elk	3.47	0.00	7.84	7.58	2.33
Gopher	0.03	0.00	0.00	0.00	0.00
Grouse[b]	2.09	2.06	8.46	3.84	2.05
Hare	1.85	6.49	6.58	2.58	12.69
Mountain beaver	3.11	0.14	1.95	0.16	2.80
Microtine	0.03	0.00	0.05	0.02	0.22
Porcupine	0.00	0.00	0.00	0.00	0.00
Other	0.28	0.62	1.46	0.04	0.00

[a]Numbers in parentheses are number of plots.

[b]Frequency of overall budding and of grouse damage should be identical because grouse are the only agents. Small differences are errors.

Table 8A.

ANIMAL-DAMAGED DOUGLAS-FIR TREES ON DIFFERENT SLOPES IN OREGON AND WASHINGTON, YEARS 1-5 AFTER PLANTING.
(mean annual percent)

Damage	Slope			
	0-5% (23)[a]	6-25% (70)	26-50% (43)	51+% (29)
TYPE				
Barking	0.27	0.15	0.18	0.18
Browsing				
Overall	18.37	25.55	18.08	21.56
Stem	14.55	20.88	15.39	17.52
Budding				
Overall[b]	0.76	4.30	2.55	0.93
Stem	0.07	1.38	0.76	0.15
Clipping				
Overall	7.84	6.37	4.66	3.93
Stem	3.56	2.72	2.78	2.89
Root cutting	0.05	0.05	0.00	0.00
Pulling	0.16	0.04	0.03	0.20
Trampling	0.22	0.17	0.17	0.51
Other	0.01	0.06	0.09	0.06
All Damage	26.54	34.40	24.98	26.76
Stem Damage	18.71	25.10	19.04	21.12
AGENT				
Deer	14.05	22.67	17.23	16.94
Domestic stock	0.03	0.01	0.01	0.01
Elk	4.94	3.53	1.02	5.16
Gopher	0.02	0.09	0.00	0.00
Grouse[b]	0.77	4.33	2.60	0.93
Hare	5.66	5.53	3.53	1.58
Mountain beaver	2.16	0.64	0.37	2.26
Microtine	0.08	0.02	0.04	0.00
Porcupine	0.00	0.00	0.00	0.00
Other	0.01	0.22	0.74	0.16

[a]Numbers in parentheses are number of plots.

[b]Frequency of overall budding and of grouse damage should be identical because grouse are the only agents. Small differences are errors.

Table 9A.

ANIMAL-DAMAGED DOUGLAS-FIR TREES ON DIFFERENT SLOPES IN OREGON, YEARS 1-5 AFTER PLANTING.
(mean annual percent)

Damage	Slope 0-5% (14)[a]	6-25% (46)	26-50% (31)	51+% (25)
TYPE				
Barking	0.14	0.11	0.07	0.20
Browsing				
Overall	21.72	27.09	20.61	23.12
Stem	18.37	23.48	18.06	19.07
Budding				
Overall[b]	0.42	2.31	2.27	0.61
Stem	0.00	0.41	0.12	0.02
Clipping				
Overall	5.41	4.88	4.59	4.16
Stem	2.40	2.71	2.51	3.06
Root cutting	0.07	0.07	0.00	0.00
Pulling	0.21	0.06	0.04	0.24
Trampling	0.27	0.12	0.18	0.49
Other	0.02	0.03	0.02	0.04
All Damage	27.42	33.85	27.07	28.22
Stem Damage	21.25	26.74	20.75	22.69
AGENT				
Deer	17.95	26.05	19.80	18.70
Domestic stock	0.05	0.01	0.01	0.01
Elk	4.17	1.19	1.00	4.92
Gopher[b]	0.03	0.13	0.00	0.00
Grouse[b]	0.44	2.35	2.27	0.61
Hare	4.60	4.44	4.07	1.83
Mountain beaver	0.77	0.14	0.51	2.37
Microtine	0.05	0.02	0.02	0.00
Porcupine	0.00	0.00	0.00	0.00
Other	0.01	0.30	0.01	0.03

[a]Numbers in parentheses are number of plots.

[b]Frequency of overall budding and of grouse damage should be identical because grouse are the only agents. Small differences are errors.

Table 10A.

ANIMAL-DAMAGED DOUGLAS-FIR TREES ON DIFFERENT SLOPES IN WASHINGTON, YEARS 1-5 AFTER PLANTING.
(mean annual percent)

Damage	Slope 0-5% (9)[a]	6-25% (24)	26-50% (12)	51+% (4)
TYPE				
Barking	0.48	0.23	0.48	0.06
Browsing				
Overall	13.16	22.60	11.54	11.82
Stem	8.60	15.91	8.48	7.84
Budding				
Overall[b]	1.28	8.10	3.27	2.92
Stem	0.17	3.24	2.40	0.93
Clipping				
Overall	11.60	9.23	4.83	2.48
Stem	5.37	2.75	3.49	1.82
Root cutting	0.03	0.00	0.00	0.00
Pulling	0.09	0.00	0.02	0.00
Trampling	0.15	0.27	0.14	0.63
Other	0.00	0.12	0.27	0.19
All Damage	25.16	35.46	19.56	17.65
Stem Damage	14.75	21.96	14.61	11.36
AGENT				
Deer	7.97	16.18	10.57	5.94
Domestic stock	0.00	0.02	0.00	0.00
Elk	6.15	8.03	1.08	6.65
Gopher[b]	0.00	0.01	0.00	0.00
Grouse[b]	1.28	8.13	3.47	2.92
Hare	7.30	7.63	2.16	0.00
Mountain beaver	4.31	1.61	0.02	1.53
Microtine	0.12	0.03	0.08	0.00
Porcupine	0.00	0.00	0.00	0.00
Other	0.00	0.09	2.61	1.00

[a]Numbers in parentheses are number of plots.

[b]Frequency of overall budding and of grouse damage should be identical because grouse are the only agent. Small differences are errors.

Table 11A.

ANIMAL-DAMAGED DOUGLAS-FIR TREES BY SITE CLASS IN OREGON AND WASHINGTON, YEARS 1-5 AFTER PLANTING.
(mean annual percent)

Damage	Site class 1&2 (46)[a]	3 (88)	4&5 (31)
TYPE			
Barking	0.16	0.14	0.33
Browsing			
Overall	24.12	24.04	12.55
Stem	19.14	20.03	10.42
Budding			
Overall[b]	4.23	2.41	1.56
Stem	1.37	0.72	0.29
Clipping			
Overall	9.68	4.38	3.56
Stem	4.33	2.50	1.83
Root cutting	0.03	0.04	0.00
Pulling	0.22	0.02	0.04
Trampling	0.25	0.21	0.30
Other	0.05	0.05	0.10
All Damage	35.96	30.34	17.56
Stem Damage	25.02	23.46	13.01
AGENT			
Deer	18.36	22.12	11.32
Domestic stock	0.00	0.02	0.02
Elk	6.68	2.28	1.50
Grouse[b]	4.24	2.42	1.67
Hare	8.07	2.84	3.03
Mountain beaver	1.65	1.06	0.22
Microtine	0.02	0.02	0.05
Porcupine	0.00	0.00	0.00
Other	0.05	0.45	0.33

[a]Numbers in parentheses are number of plots.

[b]Frequency of overall budding and of grouse damage should be identical because grouse are the only agents. Small differences are errors.

Table 12A.

ANIMAL-DAMAGED DOUGLAS-FIR TREES BY SITE CLASS IN OREGON, YEARS 1-5 AFTER PLANTING.
(mean annual percent)

Damage	Site class 1&2 (33)[a]	3 (65)	4&5 (18)
TYPE			
Barking	0.07	0.10	0.29
Browsing			
Overall	22.32	27.15	14.77
Stem	19.32	23.06	13.19
Budding			
Overall[b]	1.06	2.01	1.81
Stem	0.00	0.32	0.14
Clipping			
Overall	6.89	3.93	3.56
Stem	4.10	2.26	1.70
Root cutting	0.03	0.05	0.00
Pulling	0.28	0.03	0.07
Trampling	0.23	0.18	0.43
Other	0.02	0.03	0.04
All Damage	30.17	32.83	19.77
Stem Damage	23.61	25.85	15.47
AGENT			
Deer	19.08	25.51	13.51
Domestic stock	0.00	0.01	0.03
Elk	3.58	1.84	1.62
Gopher	0.02	0.09	0.00
Grouse[b]	1.06	2.02	1.87
Hare	5.99	2.78	3.43
Mountain beaver	0.94	0.90	0.14
Microtine	0.00	0.03	0.03
Porcupine	0.00	0.00	0.00
Other	0.03	0.22	0.00

[a]Numbers in parentheses are number of plots.

[b]Frequency of overall budding and of grouse damage should be identical because grouse are the only agents. Small differences are errors.

Table 13A.

ANIMAL-DAMAGED DOUGLAS-FIR TREES BY SITE CLASS IN WASHINGTON, YEARS 1-5 AFTER PLANTING.
(mean annual percent)

Damage	Site class 1&2 (13)[a]	3 (23)	4&5 (13)
TYPE			
Barking	0.38	0.26	0.38
Browsing			
Overall	28.68	15.24	9.47
Stem	18.68	11.48	6.59
Budding			
Overall[b]	12.28	3.55	1.22
Stem	4.84	1.84	0.50
Clipping			
Overall	16.75	5.65	3.55
Stem	4.93	3.18	2.01
Root cutting	0.02	0.00	0.00
Pulling	0.06	0.01	0.00
Trampling	0.30	0.28	0.13
Other	0.13	0.12	0.18
All Damage	50.67	23.30	14.49
Stem Damage	28.61	16.69	9.60
AGENT			
Deer	16.51	12.53	8.30
Domestic stock	0.00	0.02	0.00
Elk	14.57	3.52	1.33
Gopher	0.00	0.01	0.00
Grouse[b]	12.31	3.55	1.40
Hare	13.34	3.00	2.47
Mountain beaver	3.44	1.50	0.35
Microtine	0.09	0.02	0.09
Porcupine	0.00	0.00	0.00
Other	0.10	1.13	0.78

[a]Numbers in parentheses are number of plots.

[b]Frequency of overall budding and of grouse damage should be identical because grouse are the only agents. Small differences are errors.

Table 14A.

ANIMAL-DAMAGED DOUGLAS-FIR TREES AT DIFFERENT ELEVATIONS IN OREGON AND WASHINGTON, YEARS 1-5 AFTER PLANTING.
(mean annual percent)

Damage	Elevation, feet 0-500 (15)[a]	600-1000 (32)	1100-1500 (35)	1600-2000 (25)	2100-2500 (23)	2600-3000 (10)	3100-3500 (13)	3600+ (12)
TYPE								
Barking	0.23	0.20	0.09	0.12	0.10	0.07	0.35	0.52
Browsing								
Overall	19.79	21.43	36.20	20.44	22.19	14.71	7.24	8.46
Stem	14.32	16.69	31.09	15.75	18.64	13.07	6.48	7.64
Budding								
Overall[b]	3.92	1.27	2.26	2.05	6.38	1.70	2.50	2.41
Stem	1.41	0.48	0.39	1.02	1.73	0.15	1.38	0.00
Clipping								
Overall	12.18	7.03	3.57	4.47	6.74	2.10	6.53	2.93
Stem	5.82	3.87	1.59	3.08	2.47	0.84	3.63	1.64
Root cutting	0.02	0.00	0.12	0.00	0.00	0.00	0.00	0.00
Pulling	0.04	0.01	0.23	0.11	0.06	0.00	0.00	0.02
Trampling	0.15	0.21	0.33	0.21	0.22	0.02	0.14	0.51
Other	0.10	0.08	0.03	0.03	0.05	0.00	0.17	0.07
All Damage	33.66	29.12	41.08	26.79	33.16	18.23	16.40	13.84
Stem Damage	21.53	21.18	33.48	20.10	22.99	14.04	11.94	9.94
AGENT								
Deer	15.84	17.59	30.04	18.81	20.84	14.61	7.33	8.24
Domestic stock	0.00	0.02	0.02	0.00	0.01	0.04	0.00	0.00
Elk	5.80	4.14	6.51	1.99	2.09	0.16	0.00	0.64
Gopher	0.02	0.00	0.17	0.00	0.00	0.00	0.00	0.03
Grouse[b]	3.92	1.28	2.26	2.07	6.38	1.70	2.71	2.54
Hare	10.10	5.34	2.28	2.64	6.22	2.01	3.69	3.00
Mountain beaver	2.05	1.78	1.22	1.40	0.45	0.03	0.02	0.00
Microtine	0.07	0.02	0.00	0.02	0.02	0.03	0.02	0.00
Porcupine	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.05	0.06	0.02	0.45	0.04	0.00	2.82	0.00

[a]Numbers in parentheses are number of plots.

[b]Frequency of overall budding and of grouse damage should be identical because grouse are the only agents. Small differences are errors.

Table 15A.

ANIMAL-DAMAGED DOUGLAS-FIR TREES AT DIFFERENT ELEVATIONS IN OREGON, YEARS 1-5 AFTER PLANTING.
(mean annual percent)

Damage	Elevation, feet							
	0-500 (5)[a]	600-1000 (24)	1100-1500 (30)	1600-2000 (16)	2100-2500 (15)	2600-3000 (8)	3100-3500 (6)	3600+ (12)
TYPE								
Barking	0.05	0.14	0.08	0.04	0.07	0.05	0.00	0.52
Browsing								
Overall	16.58	20.38	37.48	23.35	25.68	17.59	11.63	8.46
Stem	13.67	16.78	33.06	18.23	22.48	15.72	10.72	7.64
Budding								
Overall[b]	2.24	0.24	1.13	1.16	3.90	2.12	3.98	2.41
Stem	0.07	0.00	0.07	0.13	0.28	0.19	1.97	0.00
Clipping								
Overall	11.19	6.98	2.40	5.91	4.04	2.52	6.75	2.93
Stem	7.56	3.83	1.40	4.05	2.37	0.95	2.21	1.64
Root cutting	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00
Pulling	0.00	0.01	0.27	0.16	0.10	0.00	0.00	0.02
Trampling	0.16	0.17	0.29	0.25	0.13	0.03	0.20	0.51
Other	0.00	0.05	0.00	0.02	0.05	0.00	0.03	0.07
All Damage	29.40	27.28	40.86	30.33	33.33	21.89	21.93	13.84
Stem Damage	21.07	20.62	34.91	22.87	25.35	16.83	15.11	9.94
AGENT								
Deer	14.80	18.19	32.82	21.08	25.98	17.47	11.73	8.24
Domestic stock	0.00	0.00	0.03	0.00	0.02	0.05	0.00	0.00
Elk	1.92	2.35	4.93	2.68	0.05	0.20	0.00	0.64
Gopher[b]	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.03
Grouse	2.24	0.24	1.13	1.16	3.90	2.12	4.09	2.54
Hare	10.89	5.88	1.57	3.62	3.24	2.48	5.89	3.00
Mountain beaver	0.28	1.16	0.75	1.89	0.70	0.00	0.00	0.00
Microtine	0.00	0.03	0.00	0.00	0.01	0.00	0.00	0.00
Porcupine	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.04	0.01	0.45	0.07	0.00	0.90	0.00

[a] Numbers in parentheses are number of plots.

[b] Frequency of overall budding and of grouse damage should be identical because grouse are the only agents. Small differences are errors.

Table 16A.

ANIMAL-DAMAGED DOUGLAS-FIR TREES AT DIFFERENT ELEVATIONS IN WASHINGTON, YEARS 1-5 AFTER PLANTING.
(mean annual percent)

Damage	Elevation, feet 0-500 (10)[a]	600-1000 (8)	1100-1500 (5)	1600-2000 (9)	2100-2500 (8)	2600-3000 (2)	3100-3500 (7)	3600+ (0)
TYPE								
Barking	0.32	0.41	0.17	0.26	0.16	0.13	0.66	0.00
Browsing								
Overall	21.39	24.59	28.52	15.27	15.66	3.17	3.47	0.00
Stem	14.65	16.42	19.28	11.34	11.43	2.44	2.84	0.00
Budding								
Overall[b]	4.76	4.35	9.02	3.64	11.02	0.00	1.23	0.00
Stem	2.08	1.92	2.31	2.49	4.46	0.00	0.88	0.00
Clipping								
Overall	12.68	7.17	10.54	1.91	11.81	0.40	6.34	0.00
Stem	4.95	4.00	2.71	1.35	2.67	0.40	4.86	0.00
Root cutting	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pulling	0.06	0.03	0.00	0.02	0.00	0.00	0.00	0.00
Trampling	0.15	0.33	0.59	0.15	0.38	0.00	0.09	0.00
Other	0.15	0.17	0.23	0.03	0.06	0.00	0.30	0.00
All Damage	35.79	34.62	42.44	20.50	32.83	3.57	11.66	0.00
Stem Damage	21.75	22.88	24.93	15.17	18.57	2.85	9.22	0.00
AGENT								
Deer	16.35	15.78	13.38	14.79	11.20	3.17	3.56	0.00
Domestic stock	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00
Elk	7.74	9.51	15.98	0.76	5.91	0.00	0.00	0.00
Gopher[b]	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grouse[b]	4.76	4.37	9.08	3.67	11.02	0.00	1.53	0.00
Hare	9.71	3.70	6.54	0.89	11.81	0.13	1.80	0.00
Mountain beaver	2.93	3.64	4.02	0.54	0.00	0.13	0.03	0.00
Microtine	0.11	0.00	0.00	0.05	0.03	0.13	0.10	0.00
Porcupine	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.08	0.10	0.10	0.44	0.00	0.00	4.47	0.00

[a]Numbers in parentheses are number of plots.

[b]Frequency of overall budding and of grouse damage should be identical because grouse are the only agents. Small differences are errors.

Table 17A.

ANIMAL-DAMAGED DOUGLAS-FIR TREES BY STOCK CLASS IN OREGON AND WASHINGTON, YEARS 1-5 AFTER PLANTING.
(mean annual percent)

Damage	Stock class 2-0 (108)[b]	3-0 (22)	2-1 (28)	Mixed and other[a] (7)
TYPE				
Barking	0.14	0.45	0.09	0.36
Browsing				
Overall	22.71	17.35	18.42	37.71
Stem	19.24	13.24	14.69	26.58
Budding				
Overall[c]	1.96	3.27	5.06	4.26
Stem	0.59	0.63	1.50	2.24
Clipping				
Overall	4.74	7.67	7.28	7.91
Stem	2.79	3.52	2.60	3.40
Root cutting	0.01	0.12	0.02	0.00
Pulling	0.09	0.01	0.14	0.03
Trampling	0.17	0.41	0.31	0.39
Other	0.05	0.08	0.05	0.16
All Damage	29.05	26.69	28.93	47.64
Stem Damage	22.80	17.89	19.06	32.70
AGENT				
Deer	20.85	13.33	15.29	24.03
Domestic stock	0.01	0.00	0.00	0.08
Elk	2.14	4.40	3.77	17.25
Gopher[c]	0.01	0.23	0.00	0.00
Grouse[c]	1.98	3.36	5.06	4.38
Hare	3.51	5.57	6.88	2.90
Mountain beaver	1.14	0.85	0.15	4.31
Microtine	0.03	0.04	0.04	0.00
Porcupine	0.00	0.00	0.00	0.00
Other	0.11	1.18	0.30	0.92

[a]Principally 2-0 and 3-0, 2-0 and 2-1, or 1-1.

[b]Numbers in parentheses are number of plots.

[c]Frequency of overall budding and of grouse damage should be identical because grouse are the only agents. Small differences are errors.

Table 18A.

ANIMAL-DAMAGED DOUGLAS-FIR PLOTS IN OREGON AND WASHINGTON, YEARS 1-5 AFTER PLANTING.
(mean annual percent)

Damage	OREGON				WASHINGTON			BOTH STATES (165)
	Coast Range (49)[a]	Cascade Mountains (34)	Southwest (33)	All (116)	Coast Range (24)	Cascade Mountains (25)	All (49)	
TYPE								
Barking	24.49	11.76	9.09	16.38	58.33	36.00	46.94	25.45
Browsing								
Overall	100.00	97.06	100.00	99.14	100.00	100.00	100.00	99.39
Stem	100.00	94.12	96.97	97.41	100.00	100.00	100.00	98.19
Budding								
Overall[b]	18.37	67.65	48.48	41.38	87.50	52.00	69.39	49.70
Stem	4.08	26.47	6.06	11.21	79.17	40.00	59.18	25.45
Clipping								
Overall	89.80	88.24	51.52	41.38	91.67	52.00	59.39	49.70
Stem	81.63	79.41	48.48	71.55	87.50	72.00	79.59	73.94
Root cutting	8.16	2.94	0.00	4.31	4.17	0.00	2.04	3.64
Pulling	12.24	5.88	24.24	13.79	8.33	4.00	6.12	11.52
Trampling	38.78	41.18	15.15	32.76	62.50	20.00	40.82	35.15
Other	10.20	11.76	3.03	8.62	33.33	12.00	22.45	12.73
All Damage	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Stem Damage	100.00	100.00	96.97	99.14	100.00	100.00	100.00	99.39
AGENT								
Deer	97.96	97.06	100.00	98.28	87.50	96.00	91.84	96.36
Domestic stock	4.08	5.88	3.03	4.31	4.17	0.00	2.04	3.64
Elk	22.45	2.94	27.27	18.10	45.83	12.00	28.57	21.21
Gopher[b]	4.08	5.88	3.03	4.31	4.17	0.00	2.04	3.64
Grouse[b]	18.37	70.59	51.52	43.10	87.50	52.00	69.39	50.91
Hare	87.76	79.41	54.55	75.86	79.17	68.00	73.47	75.15
Mountain beaver	32.65	23.53	9.09	23.28	45.83	16.00	30.61	25.45
Microtine	2.04	2.94	6.06	3.45	12.50	12.00	12.24	6.06
Porcupine	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	8.16	8.82	0.00	6.03	25.00	20.00	22.45	10.91

[a]Numbers in parentheses are number of plots.

[b]Frequency of overall budding and of grouse damage should be identical because grouse are the only agents. Small differences are errors.

Table 19A.

ANIMAL-DAMAGED PINE PLOTS IN OREGON AND WASHINGTON, YEARS 1-5 AFTER PLANTING.
(percent)

Damage	BOTH STATES (29)[a]
TYPE	
Barking	37.93
Browsing	
Overall	96.55
Stem	96.55
Budding	
Overall[b]	6.90
Stem	0.00
Clipping	
Overall	75.86
Stem	75.86
Root cutting	17.24
Pulling	31.03
Trampling	48.28
Other	3.45
All Damage	100.00
Stem Damage	100.00
AGENT	
Deer	96.55
Domestic stock	48.28
Elk	10.34
Gopher[b]	44.83
Grouse[b]	6.90
Hare	55.17
Mountain beaver	0.00
Microtine	0.00
Porcupine	20.69
Other	6.90

[a]Number in parentheses is number of plots.

[b]Frequency of overall budding and of grouse damage should be identical because grouse are the only agents. Small differences are errors.

checklist of plants and animals

plants

Douglas-fir	*Pseudotsuga menziesii* (Mirb.) Franco
Jeffrey pine	*Pinus jeffreyi*
Ponderosa pine	*Pinus ponderosa* Laws.
Western hemlock	*Tsuga heterophylla* (Raf.) Sargent

animals

Band-tailed pigeon	*Columba fasciata*
Black bear	*Ursus americanus*
Brush rabbit	*Sylvilagus bachmani*
Deer	*Odocoileus hemionus*
Douglas squirrel	*Tamiascurus douglasii*
Elk	*Cervus canadensis*
Jack-rabbit	*Lepus townsendii, L. californicus*
Mountain beaver	*Aplodontia rufa*
Pocket gopher	*Thomomys* sp.
Porcupine	*Erethizon dorsatum*
Snowshoe hare	*Lepus americanus*
Sooty grouse	*Dendragapus obscurus*
Vole	*Clethrionomys occidentalis*
Woodrat	*Neotoma fuscipes*

Black, Hugh C., Edward Dimock II, James Evans, and James Rochelle. 1979. **Animal damage to coniferous plantations in Oregon and Washington—Part I. A survey, 1963-1975.** Forest Research Laboratory, Oregon State University, Corvallis. Research Bulletin 25. 44 p.

Mammal and bird damage recorded on Douglas-fir and ponderosa pine plots—randomly established in Oregon and Washington during 1963-64, then observed for 5 to 10 years—was evaluated for impact on survival and growth. In all, 194 plots were installed, and 10 of the 110 seedlings on each plot were caged to protect them from animals. All trees were examined after planting and after bud burst each year for 5 years. A selected sample of 45 Douglas-fir plots was observed another 5 years for long-term patterns and effects of severe plantation damage. Survival and growth were compared for caged and uncaged trees. The agents, kind, amount, and distribution of animal damage were evaluated by state, by subregion, and by relation to site features. Results indicate that stand damage in plantations exposed to heavy animal use, especially during seedling establishment, warrants expenditure for protective measures.

KEYWORDS: height, survival, caging, Douglas-fir, ponderosa pine.

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