HEIGHT GROWTH LOSSES DUE TO ANIMAL FEEDING IN DOUGLAS FIR PLANTATIONS, VANCOUVER ISLAND, B.C.[1]

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ABSTRACT

Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) plantations on the east coast of Vancouver Island, British Columbia, were examined to determine the effect of animal feeding upon height growth.

Length of internodes and evidence of past leader damage were recorded and cumulative average height-age growth curves compared for undamaged trees and for trees suffering various intensities of damage.

The average reduction in tree height attributable to animal feeding in heavily browsed plantations varied from one-half to two feet over a period of 8 to 10 years. It is unlikely that either tree volume or quality at rotation age would be seriously affected.

Exposed trees were browsed more heavily than those protected by vegetation or logging slash.

INTRODUCTION

Game animals on the coast of British Columbia utilize coniferous foliage as an important source of food. Foresters expressed concern that feeding on Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) regeneration may seriously retard growth. Consequently, representatives of the forest industries requested that a study be conducted to determine if losses justify control measures. Studies were undertaken by the British Columbia Forest Service and the Department of Forestry, Canada, in the spring of 1961. The work was co-ordinated by the Tree Farm Forestry Committee[3].

W. J. Revel[4] studied the regional distribution and intensity of damage caused by deer, grouse and squirrels feeding on the young forests throughout Vancouver Island. His study was an extensive evaluation of height growth losses, recovery of browsed trees and seedling mortality.

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The study reported in this paper was undertaken by the Department of Forestry, Canada. It is an intensive evaluation of five heavily damaged Douglas-fir plantations on Vancouver Island. The primary objectives were to assess height losses of trees subjected to various intensities of leader browsing and to evaluate the effect of the injuries upon subsequent height growth. Occurrence of browsing was also studied within each plantation and related to height, age, vigour, exposure, topography, site quality and vegetation.

Plantations referred to in this report were established near Campbell River in 1958 and 1954 and on the Gordon River, three miles south-west of Cowichan Lake, in 1960, 1954 and 1951. Two-year-old seedlings were planted in the spring in all but the last plantation.

Animal feeding refers only to deer browsing although it is realized that other animals may be responsible for some of the damage.

Literature Reviews

Browsing by Columbia black-tailed deer (*Odocoileus hemionus columbianus* Richardson) caused serious damage to Douglas-fir regeneration on southern Vancouver Island (Cowan 1945). Bandy (1962) stated that hunters harvest only 10 per cent or less of the deer population on Vancouver Island whereas it is desirable to harvest one-third of the population. He advocated a longer season for antlerless deer. Sooty blue grouse (*Dendragapus obscurus fuliginosus* Ridgway) damage newly planted Douglas-fir seedlings by feeding on the buds and needles (Fowle 1960). Damage by other animals on Vancouver Island is of less importance. Elk cause serious but very local disturbance. Squirrels do not cause damage of concern (Revel 1961).

Cowan (1945) stated that forested land on Vancouver Island is very thinly populated with deer before logging or forest fires, but the number steadily increases during the subsequent 10 to 15 years. He suggested that immediate planting may allow tree leaders to grow out of the reach of deer before the animal population builds up. He also found that deer prefer areas with rolling topography and a variety of plant species in which young Douglas-fir is predominant. His study indicated that deer tend to feed in the open near mature timber or other source of shelter. Open areas with minor vegetation were preferred because food was readily available and movement was not impeded.

Deer have a varied plant diet (Cowan 1945). Stomach analyses showed feeding on the following species, listed in order of importance: Douglas-fir, salal (*Gaultheria shallon* Pursh), Old man's beard lichen (*Usnea ceratina* Ach.), alder (*Alnus rubra* Bong.), willow and mushroom species, bracken (*Pteridium aquilinum* (L.) Kuhn), thimbleberry (*Rubus parviflorus* Nutt.), horsetail (*Equisetum arvense* L.) and cedar (*Thuja plicata* Donn). Most browsing of Douglas-fir occurred between December and May when there was a shortage of other plant species.

Frontz (1930), working in Pennsylvania, found that deer do not range widely in search of food but tend to congregate in certain localities destroying all regeneration. Roy (1960) studied browsing in newly established Douglas-fir plantations in California. He reported that trees browsed once over a

period of six years were one inch shorter than undamaged trees, and those browsed 2, 3, 4 or 5 times were 5, 13, 22 or 25 inches shorter, respectively. The average height loss in the plantation was eight inches.

METHOD

Collection of Data

Five of the most heavily damaged plantations on Vancouver Island were selected for study. Lines, spaced five chains apart, were run across the contours and damage sampled at two-chain intervals along each line. The length of each distinguishable internode was measured for the eight trees nearest each sample point. All nodes were examined for evidence of past leader damage. The stub of a damaged leader, a deformed stem or an irregular bud scar was recorded as animal damage. The length of the internodes and the occurrence of damage, as measured in the field, were checked by sectioning and examining irregularities in the pith of the tree nearest each sample point (Figures 1 and 2).

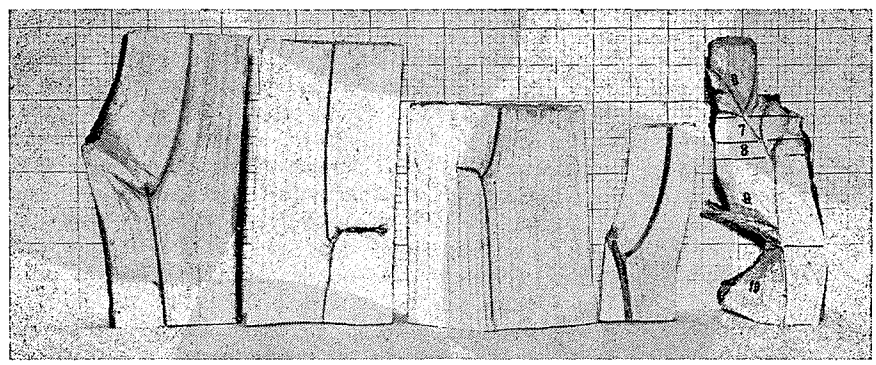


FIGURE 1. Internal evidence of past leader damage .

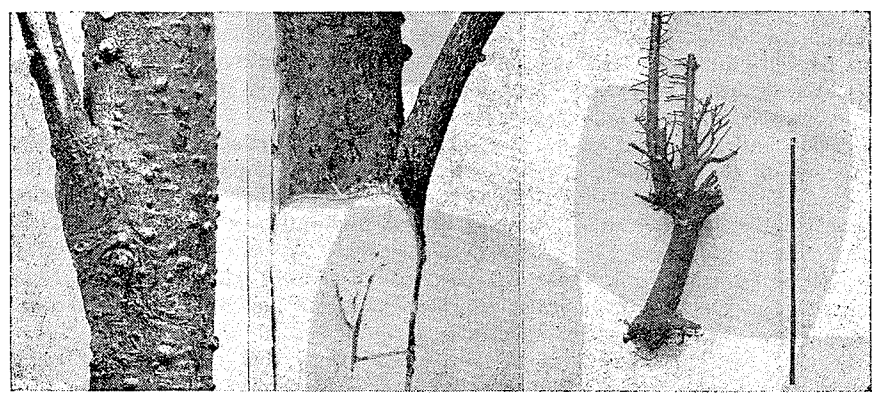


FIGURE 2. Comparison of external and internal evidence of past leader damage.

FIGURE 3. Tree browsed repeatedly since planting in the fall of 1951.

Continuous plots, ¼ by 1 chain, were established along each line. Trees in each plot were tallied as damaged or undamaged for each year between 1958 and 1961. Topography, species and abundance of vegetation, site index and exposure were recorded in each plot. Site was determined by the method described by Schmidt (1954) and exposure was assessed subjectively by classifying the trees according to the protection provided by stumps, slash, windfalls, vegetation and other factors limiting the access of deer.

Office Analysis

Height loss of individual trees was assessed by grouping the trees measured at each sample point according to the number of years in which browsing occurred prior to 1961. Browsing in 1961 was not included because further damage was expected during the winter. A cumulative average height-age curve was constructed for each group of trees. These curves were compared with a similar set of curves based on 200 sectioned trees to ensure that the former method was reliable.

The effect of leader damage on subsequent height growth was assessed by comparing the average height growth of undamaged trees to the growth of trees damaged in 1957 only and to trees further damaged in the succeeding two, three or four years.

Factors related to the distribution of damaged trees were analyzed by superimposing transparent topography, vegetation, site index and exposure rating maps over a similar map showing the proportion of browsed trees in each plot. Separate maps were drawn for damage occurring in 1958, 1959, 1960 and 1961.

RESULTS

The results show height losses and change in form attributable to animal feeding and the relationship between the occurrence of browsing and height, vigour, age, vegetation, exposure, topography and site quality. A hypothetical example is included to illustrate monetary losses anticipated at rotation age.

Effects of Animal Feeding

(a) Height

The weighted average height loss attributable to animal feeding in plantations established before 1955 varied from seven inches in the Campbell River plantation to approximately two feet in the Gordon River plantation (Table 1). These losses would be less if only dominant trees were considered. This is expected because the leaders of the fast-growing, dominant trees are within the reach of deer for a shorter period and, consequently, are browsed fewer times. However, analysis of data indicates that height loss of trees damaged the same number of times is not related to crown class.

In all plantations a direct relationship exists between height loss and the number of times the trees were browsed. Losses range from a very few inches to over three feet (Table 1.). Browsed trees were 3.0 and 0.5 inches shorter than undamaged trees in the 1958 and 1960 plantations, respectively, suggesting that browsing causes only minor height losses during the first few years after planting.

TABLE 1

HEIGHT LOSSES — 1960

Plantation	Age of Trees (years)	Number of Times Damaged	Number of Trees	Mean Total Height (inches)	Mean Height Loss (inches)
Campbell River		(1956-60)			
(1954)	10	0	161	41.0	0
		1	230	36.9	4.1
		2	265	32.3	8.7
		3	186	29.0	12.0
		4+	113	27.6	13.4
			955	33.7[1]	7.3[1]
Gordon River		(1956-60)			
(1954)	10	0	15	50.0	0
		1	45	38.6	11.4
		2	105	31.9	18.1
		3	131	24.2	25.8
		4+	148	20.7	29.3
			444	27.1[1]	22.9[1]
Gordon River		(1955-60)			
(1951)	12	0	30	59.5	0
		1	104	53.3	6.2
		2	101	46.8	12.7
		3	119	33.7	25.8
		4	91	27.7	31.8
		5+	46	21.9	37.6
			491	39.9[1]	19.6[1]
Gordon River		(1958-60)			
(1960)	3	0	36	8.5	0
		1+	60	8.0	0.5
			96	8.2[1]	0.3[1]
Campbell River		(1958-60)			
(1958)	5	0	93	12.0	0
		1+	424	9.0	3.0
			517	9.5[1]	2.5[1]

[1] Weighted average

Height growth of trees suffering various intensities of damage is shown for the 1954 Campbell River plantation (Figure 4). Similar sets of curves form the basis of Table 1. The upper curve (0) represents the average height growth of trees with no evidence of leader damage. The lower curve (8) shows the average height growth of trees that were damaged annually. The lower extremities of curves 0 and 8 are based on measurements of sectioned internodes as internodes formed during the early years could not be distinguished by external observation. Data from 1952 to 1955 were not available for curves 1, $\bar{x}$, 2, 3 or 4.

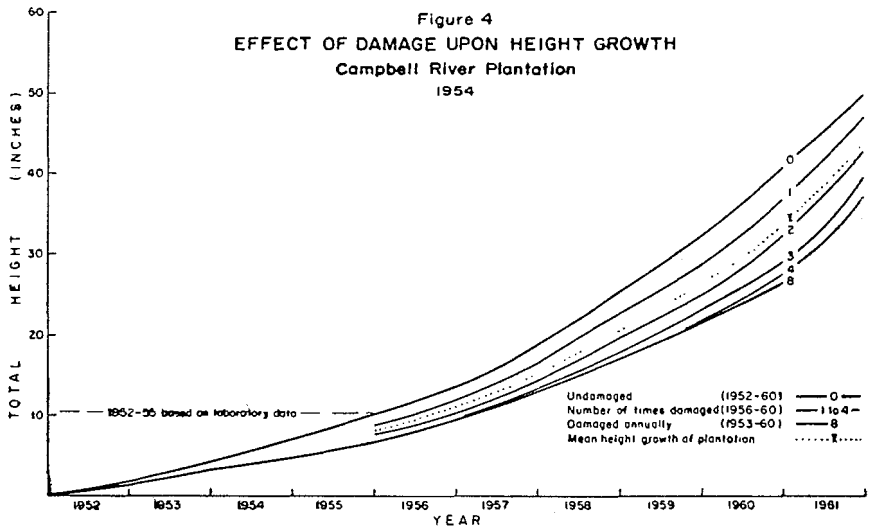
Although browsing reduces the height of trees, it has only a negligible effect upon the rate of height growth if no subsequent damage is incurred (Figure 5).

The recuperative power of Douglas-fir seedlings is sometimes underestimated. A plantation established in 1943 in the Nitinat River Valley west of Cowichan Lake was believed to be a failure because of deer browsing. Today it is adequately stocked and growing vigorously. Foliage development and diameter growth of the 12-year-old tree in Figure 3 were not seriously retarded by very severe browsing during the first five years after planting. It was 40 inches tall and showing good leader growth when removed from the plantation. An undamaged tree of the same age would be about 60 inches tall.

(b) Form

Browsing does not affect the form of trees for more than 10 years after the damage occurs. Sections through nodes show that diameter growth masks the deformation of the stem very quickly (Figure 1).

Figure 4
EFFECT OF DAMAGE UPON HEIGHT GROWTH
Campbell River Plantation
1954



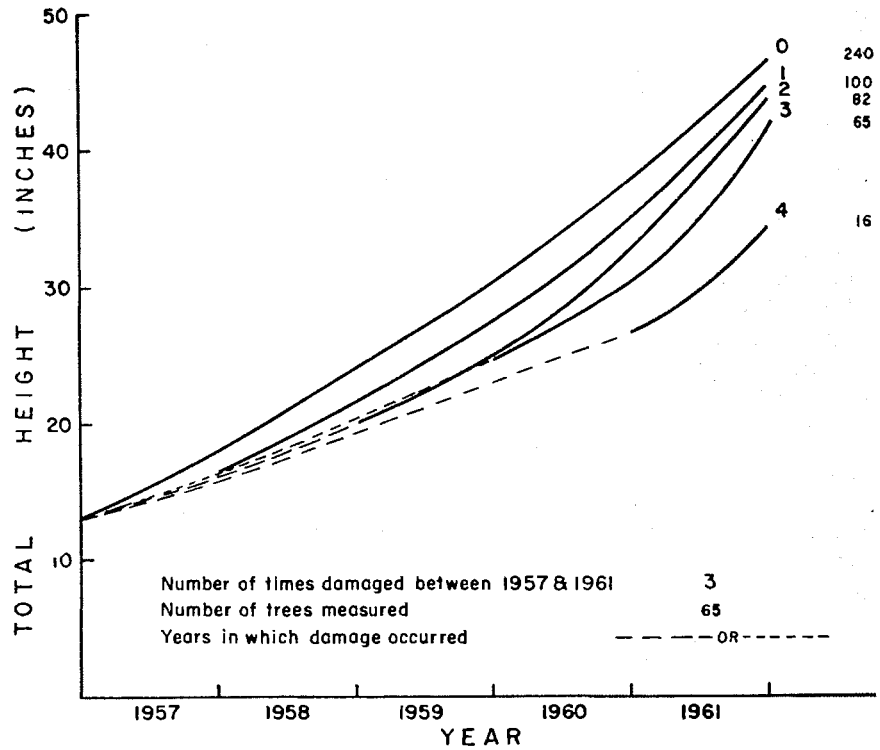


FIGURE 5. Effect of repeated damage upon height growth, Campbell River Plantation, 1954.

Factors Related to the Occurrence of Browsing

Damage was not evenly distributed throughout the plantation but was concentrated in localized areas that seldom exceeded two acres in size. Fifty to eighty per cent of the trees were browsed annually in areas where damage was centred, decreasing to 20 per cent or less in other localities.

(a) Inherent Factors

Animal feeding was heaviest on trees less than four feet in height. The proportion of leaders damaged annually decreased rapidly after trees reached a height of three feet and was negligible on trees over 4.5 feet in height. Forty, 30, 20 and 5 per cent of the trees were browsed in the 25, 35, 45 and 55 inch height classes, respectively. The maximum height of deer browsing was also evident on Arbutus (*Arbutus menziesii* Pursh) trees as leaves above breast height were rarely browsed.

There was no evidence of a relationship between tree vigour and proportion of damaged leaders. Trees with leaders beyond the reach of deer were not included in the analysis. Thirty-six per cent of the slower-growing trees and 32 per cent of the faster-growing trees were damaged during this period in the 1951 Gordon River plantation. Even less variation in the frequency of damage was apparent in the 1954 Campbell River plantation.

The average intensity of browsing was related to age, generally decreasing as the trees grew older (Table 2). Heavy damage immediately after planting in the youngest Gordon River plantation was probably caused by grouse.

TABLE 2

ANNUAL INTENSITY OF BROWSING

Plantation	Date of Planting	Leaders Damaged — % of Total Number			
		1958	1959	1960	1961
Gordon River	Fall 1951	46.2	42.1	30.0	14.9
Gordon River	Spring 1954	70.1	73.0	53.6	14.8
Campbell River	Spring 1954	46.5	42.5	21.8	22.5
Campbell River	Spring 1958	25.6	51.5	34.6	17.1
Gordon River	Spring 1960	0	48.1	19.0	3.8

(b) External Factors

The distribution of browsed trees was related to the food supply, exposure of trees, sources of shelter for deer and ease with which deer can move within the plantation. The importance of these factors can only be inferred from the distribution of damaged trees as the actual feeding of deer was not observed.

The distribution and abundance of plant species was not related to the distribution of browsed trees. Damage to trees in the 1954 Campbell River plantation was greatest in areas where Douglas-fir is associated with willow. This does not suggest a preference for these species. Cowan (1945) reported that deer prefer a variety of species which could only be obtained in the winter and spring where Douglas-fir and willow occur together. Other vegetation is usually scarce and possibly covered with snow at this time of the year.

Browsing was much heavier where stumps, logs or dense vegetation did not impede the movement or vision of deer. Exposed trees were browsed 50 per cent more times between 1956 and 1961 than protected trees. This agrees with Cowan's (1945) observation that deer dislike to force their way into thickets and Roy's (1960) findings that trees protected by hardwood sprout clumps were 40 inches in height while trees in the open were only 11 inches tall.

Heavily browsed trees were often near depressions, gullies, alder, advanced regeneration and stands of mature timber. These factors presumably offer protection to deer during unfavourable weather.

No relationship was observed between the distribution of damaged trees and site quality.

Damage caused by frost, snow, wind or leader insects before 1960 was difficult to distinguish from animal damage. However, careful examination of recently injured leaders indicated that these agents caused only negligible damage in the plantations studied.

Economic Losses Caused by Animal Feeding

Maximum height growth losses attributable to animal feeding seem unimportant when converted to monetary values. The following hypothetical example is based on data from the 1951 Gordon River plantation where heavy browsing occurred. This plantation was chosen because further damage was not expected as the leaders of most dominant trees were beyond the reach of deer. Past browsing has reduced the average height of dominants by two feet. The estimated volume loss on site index 160 at age 80 is based on the following assumptions:

(1) The tallest three trees measured at each sample point are representative of the trees which will form the future stand.
(2) Height losses will remain constant after trees reach breast height.
(3) Volume losses can be estimated by the formula

$$V = 0.005454\, D^2\, HN\, F$$

where V = volume loss per acre in cubic feet
D = diameter in inches at breast height of the average tree at rotation age
H = average height loss per tree in feet
N = number of trees per acre (7″ +) at rotation age
F = form factor

The stand is considered to have 179 trees per acre (7″ + d.b.h.) and an average diameter at breast height of 16.6 inches (McArdle and Meyer 1930). A form factor of 0.4 is used. Volume losses will be $0.005454\ (16.6)^2\ (2)\ (179)\ (0.4) = 215$ cubic feet or 1290 board feet per acre (6 board feet per cubic foot). The value of 1290 board feet discounted for 80 years at 4 per cent is approximately $0.85 if stumpage is worth $15.00 per thousand board feet or $1.70 if the stumpage is worth $30.00. These values, which decrease rapidly if the interest rate is increased, represent the total amount that should be expended per acre to ensure complete protection until trees are above breast height.

Possible losses in thinnings and reduction in timber quality have not been considered in the evaluation of economic losses, but it is realized that browsing may reduce size and number of trees that could become available from a thinning.

Discussion and Conclusions

The five Douglas-fir plantations assessed were selected to represent areas with the most severe damage that can be expected on Vancouver Island with the present deer populations.

Height losses attributable to animal feeding are generally unimportant but may be serious on very limited areas. The reduction in volume or quality at rotation age is considered to be negligible. Losses determined from this study will not be applicable in the future if logging, silvicultural or other practices create conditions favourable for deer. The effect of abnormally high deer populations is evident in game reserves where plantations may be

destroyed by animals. Consequently, periodic assessment of browsing damage is necessary if proper controls are to be initiated should heavy losses occur.

The conclusions of this study agree with those reported by Revel (1963). He emphasized that browsing by deer is widespread on Vancouver Island but it is not seriously affecting the survival or growth of young Douglas firs.

Sommaire

1. Les dégâts que le broutage cause aux sapins de Douglas de l'île Vancouver ne sont pas importants, sauf en certains endroits de faible étendue.
2. Le broutage dans des plantations de sapins de Douglas de 8 à 10 ans, qui ont subi des dégâts graves, a réduit d'un demi-pied à deux pieds la hauteur moyenne des arbres.
3. La perte moyenne de croissance en hauteur des arbres abroutis au cours de quatre ans ou plus variait de un à trois pieds.
4. Les arbres que les animaux avaient cessé d'abroutir recommençaient à croître normalement en hauteur après deux ou trois ans.
5. Le broutage ne causait que peu de dégâts une fois que les tiges principales arrivaient à hauteur de poitrine.
6. L'effet de l'abroutissement était rarement apparent 10 ans après le dernier abroutissement.
7. De 50 à 80 p. 100 des arbres étaient abroutis chaque année, aux endroits où les dégâts étaient les plus graves. La superficie de ces aires dépassait rarement deux arpents.
8. L'abroutissement avait surtout lieu dans les aires situées en bordure des peuplements surannés ou des autres endroits servant d'abri aux daims.
9. On n'a constater de corrélation entre la gravité des dégâts, le type forestier, l'essence ou la vigueur des arbres.

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