DECAY FOLLOWING SCARRING OF DOUGLAS FIR IN THE DRY-BELT REGION OF BRITISH COLUMBIA

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ABSTRACT

Decay associated with scars on Douglas fir, in the dry-belt region of British Columbia, accounted for less than 3% of the total gross cubic foot volume of scarred trees. Damage was concentrated near the base of the trees in the high-value butt logs. Tree diameter at time of logging and regional moisture regime, as well as scar characteristics, warrant consideration when attempting to predict losses from decay fungi which enter through logging injuries. Stereum sanguinolentum was responsible for 93% of the decay volume recorded.

DECAY FOLLOWING SCARRING OF DOUGLAS FIR IN THE DRY-BELT REGION OF BRITISH COLUMBIA

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The annual cut of Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco) in the Kamloops Forest District, British Columbia, exceeds 100 million cubic feet. Stands selectively cut to diameter limits, with varying degrees of logging damage, cover extensive areas. This damage, as well as that expected in managed stands in the future, concerns the forest industry because of the possibility of losses from decay.

In view of the meager information on decay development following injury to immature Douglas fir (Shea 1961, Hunt and Krueger 1962), an investigation was undertaken in cooperation with the British Columbia Forest Service in the interior dry-belt region of the Kamloops and Nelson Forest Districts. The main objectives of this study were to determine the incidence of infection, volume of decay associated with various types, sizes and ages of scars, factors responsible for infection, and the identity and relative importance of the major decay fungi.

METHODS

Scarred Douglas fir were sampled in the regions of Central Cariboo (Williams Lake, Lac La Hache) (A), South Cariboo-Okanagan (Clinton, Kamloops, Okanagan Lake) (B) and East Kootenay (Cranbrook, Canal Flats,

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including Grand Forks) (C) (Fig. 1). The fairly dry, cool areas of the Central Cariboo support primarily mixtures of Douglas fir and lodgepole pine (Pinus contorta Dougl. var. latifolia Engelm.). The warm, dry South Cariboo and lower slopes of the Okanagan drainage system support mixed stands of Douglas fir - ponderosa pine (Pinus ponderosa Laws.) and Douglas fir - lodgepole pine. The Kootenay drainage system and areas around the confluence of the Granby and Kettle Rivers, being somewhat more moist than the other two regions, support mixed stands primarily of Douglas fir - western larch (Larix occidentalis Nutt.). Eight main stands (circled numbers, Fig. 1), 100-140 years of age, at elevations of 3-4000 feet, provided young scars less than 15 years of age. Because of the relative scarcity of old scars, a number of small, randomly distributed stands (▲, Fig. 1) were sampled to obtain scars older than 15 years.

Trees were felled at one foot, and cut into 8-foot logs from stump height to the top. Ages were counted on the stumps and diameters were measured at 4.5 feet. Scars were classified according to age, size, position on the tree and depth of damage (superficial or gouged, Table 1, Figs. 2, 3); age was established by ascertaining either the year of logging or by a count of the annual rings in the callus surrounding the scar face.

Sufficient cuts were made through, above and below all scars to expose associated stains and decay. Log and decay volumes in cubic feet were computed using Smalian's formula.

A sample for cultural identification of decay fungi was taken from the top, bottom and one side of all scars, and from the gouged area of deep scars (Fig. 2). Infections extending beyond the scarred area were sampled and the pattern noted. The depth of penetration of wood-borers, found in association with the scars, was recorded.

RESULTS

A total of 234 Douglas fir, 5 to 20 inches in diameter, were felled, providing 553 scars for analysis. Young scars were found in Central Cariboo and in South Cariboo-Orkanagan stands which had undergone mechanized logging; severely scarred trees occurred most frequently adjacent to the main skid roads. Old scars were confined to horse-logged stands of the East Kootenay and to small randomly scattered stands throughout all regions; the latter were caused primarily by wind-thrown trees, axe blazes and vehicle damage along old abandoned roads.

Over 70% of the injuries were on the lower bole (Table 1). Eighty per cent of the gouged scars occurred in this position; they comprised nearly 40% of the large scars but only 12% of the small ones. Most upper bole scars were superficial, except for broken tops.

The incidence of infection varied significantly (5% level by Chi square contingency tables) among the major regions investigated for both young- and old-scar classes, and was usually lower in the warm, dry South Cariboo-Okanagan region (Table 2). Significant differences also occurred between the sample areas within each major region, except in the South Cariboo-Okanagan.

The relatively young scars of the Central and South Cariboo (Clinton) samples, which were representative of present day logging damage, were used to determine the incidence of infection in relation to scar position, size and depth (Table 3). Unlike that found by most other investigators, upper bole scars had a greater incidence of infection in all size classes than lower bole scars. Large superficial scars, both of the upper and lower bole, had consistently higher levels of infection than small and intermediate superficial scars. Gouged scars had a higher incidence of infection than superficial injuries in small scars, but the depth of the injury did not appear to influence greatly the incidence of infection in large scars. Broken tops had the highest level of infection of all scars.

Decay was found in 54% of the 68 trees having young scars with an average age of 12 years (Table 4). The average decay volume increased with increasing tree diameter, but the per cent of the gross tree volume lost remained relatively constant. Over 80% of the total decay volume occurred in the first 16-foot log in trees in the 5- and 10-inch diameter classes, and 49% in the 15-inch class.

Decay was found in only 24% of the 50 trees having scars with an average age of 32 years, and accounted for only 1.6% of the total gross volume of the scarred trees (Table 4). The difference in cause and relative position of old scars versus young scars does not allow a comparison of decay development between the two classes.

Pitch covered the surface of most scars (Fig. 3) and impregnated the wood to depths of 4 cm behind the case-hardened scar face. In all instances where decay occurred it was confined to the heartwood present at the time of logging behind this pitch-impregnated layer ; heartwood added subsequent to scarring had not been invaded by the decay fungi.

To appraise decay progression in relation to scar age, losses were recorded in 4- to 6-year-old scars and, 6 years later, 10- to 12-year-old scars in the same stands in the Central and South Cariboo (Clinton) regions. No significant volume of decay developed in the 6-year period in the dry Clinton stands (Table 5), whereas in the more moist Central Cariboo region the decay volume increased from 0 to 5.2% of the gross cubic foot volume of the injured trees.

Three of the 10 fungi isolated from decay associated with scars were responsible for 99% of the damage recorded (Table 6). Stereum sanguinolentum, the only fungus associated with scars of all types and ages, far exceeded all other fungi in incidence (92%) and as a cause of decay (93% of the decay volume). Trametes serialis and Coniophora puteana were next in importance, each causing approximately 3% of the decay. The majority of the fungi was present as secondary infections in association primarily with Stereum sanguinolentum.

Only Stereum sanguinolentum and Peniophora septentrionalis were isolated from all three regions sampled; Trametes serialis and Coniophora puteana favored the moist Central Cariboo and East Kootenay, while Fomes cajanderi was associated with Stereum sanguinolentum only in the west range of the dry belt.

Wood-borers were associated with 22% of the infected scars and 18% of the uninfected scars; penetration was approximately that of the decay, when present.

CONCLUSIONS AND SUMMARY

The study confirms the findings of Shea (1961) and Hunt and Kruger (1962) that Douglas fir possesses considerable resistance to decay development following infection through scars. Consequently, losses in this species will be of less significance than those recorded for some of the other commercial species, e. g., western hemlock (Tsuga heterophylla (Raf.) Sarg.), the true firs (Abies spp.) and the spruces (Picea spp.) (Wright and Isaac 1956, Parker and Johnson 1960).

The incidence of infection was greatest where the scars were large and the woody tissues had been gouged. Although, under the conditions of this study, the incidence of infection was highest in upper bole scars, the development of decay was most significant when associated with scars in high-value butt logs. Most logging injuries were located near the base of the stem and appeared to be the result of skidding practices.

The study underlined a need for knowledge of stand history and site conditions as well as scar characteristics when attempting to estimate present and future losses from decay following logging injury. Decay, when it occurred, was confined to the heartwood present at the time of scarring. Consequently, tree diameter at that point in time is an important factor to be considered in relation to future decay losses. Although the sample was such as to give only an indication, moisture regime of the site appeared to be correlated with decay development. The incidence of infection and increase of decay volume with time was significantly greater in the moist Central Cariboo than in the dry South Cariboo-Okanagan.

The results of this study show that where logging has occurred in trees of commercial size and skidding damage is prevalent, losses from decay, particularly in the high-value butt logs, will cause a significant economic loss in stands growing in the more moist portions of the regions.

ACKNOWLEDGMENTS

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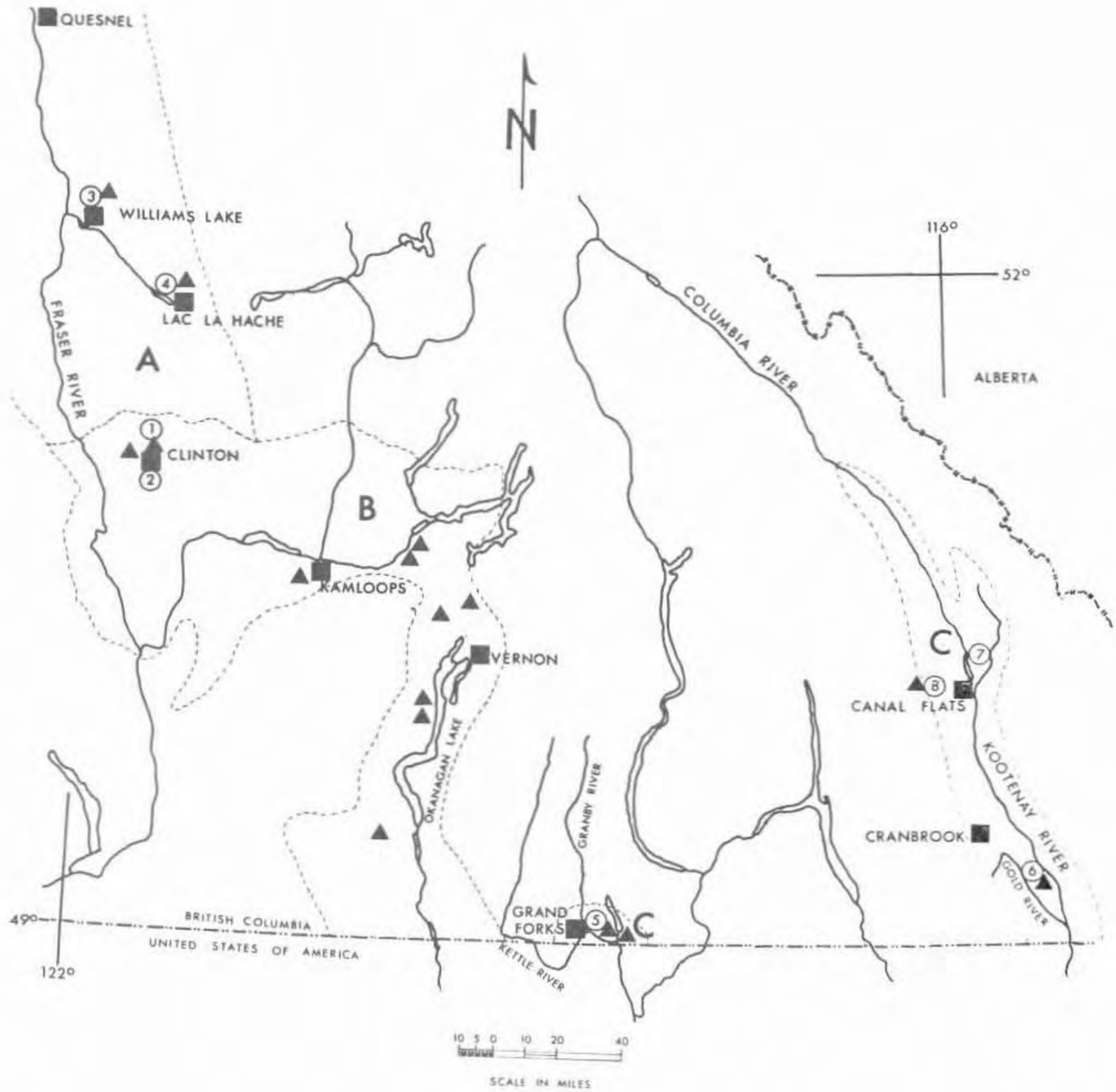
Figures

Figure 1. Map of the interior British Columbia Douglas-fir dry-belt region showing the location of the eight main stands (numbered) and the randomly distributed stands (▲) sampled.

Figure 2. Severely gouged lower bole scar caused by a caterpillar tractor blade during skidding operations.

Figure 3. Large superficial lower bole scar caused by a falling tree during logging operation. Note the heavy pitch flow over the face of the scar, typical of this type of injury.



QUESNEL
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LAC LA HACHE
FRASER RIVER
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CLINTON
B
KAMLOOPS
VERNON
OKANAGAN LAKE
COLUMBIA RIVER
116°
52°
ALBERTA
C
CANAL FLATS
KOOTENAY RIVER
CRANBROOK
GOLD RIVER
GRANBY RIVER
GRAND FORKS
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KETTLE RIVER
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BRITISH COLUMBIA
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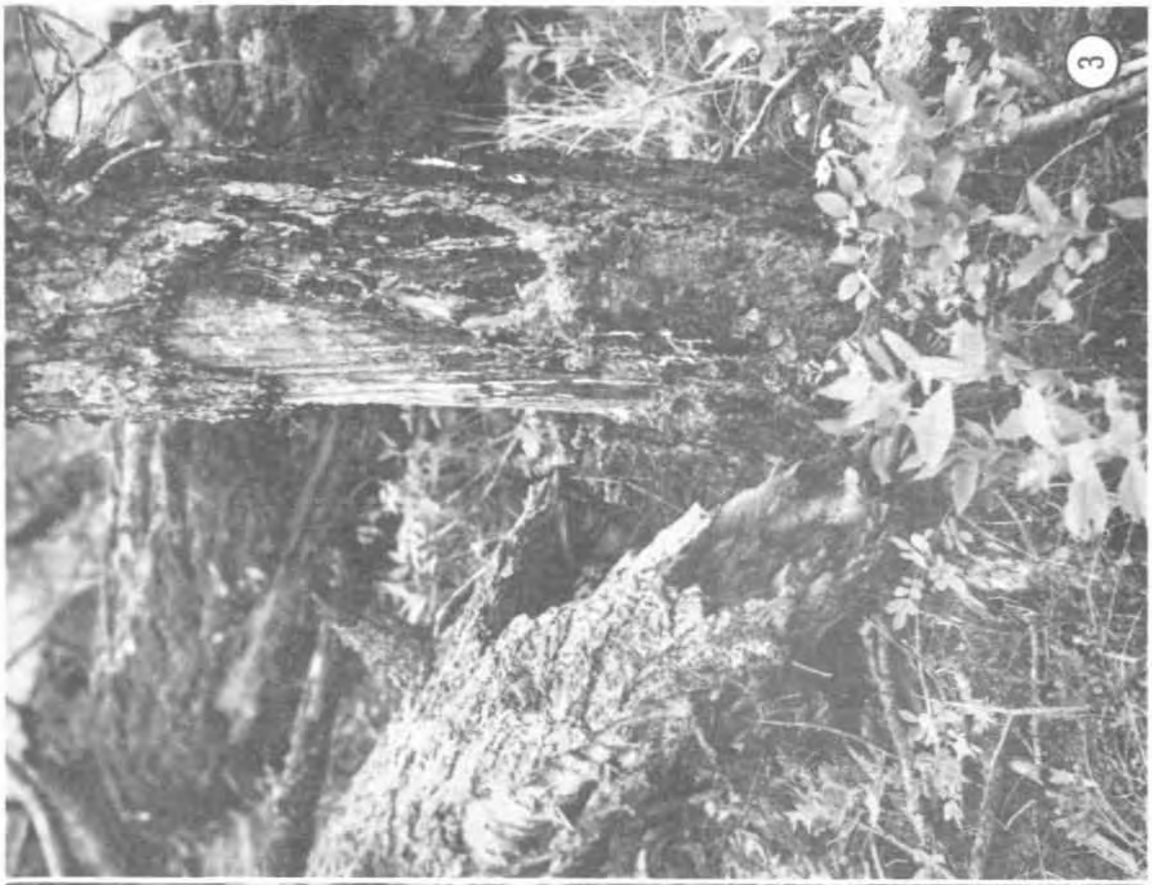
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Table 1. Frequency of occurrence of scars in relation to size, depth and position on Douglas-fir trees.

Position	Size [1] class	Depth class [2]		Total
		superficial	gouged	
lower bole	small	61	8	69
	interm.	130	30	160
	large	102	63	165
	total	293	101	394
upper bole	small	65	20 [3]	85 [3]
	interm.	45	4	49
	large	22	3	25
	total	132	27	159

[1] small = 0 to 36 sq inches; intermediate = 37 to 144 sq inches; large = 145 + sq inches

[2] superficial = bark and cambium removed; gouged = sapwood or heartwood affected.

[3] included 17 broken tops.

Table 2. Relation of scar occurrence on Douglas fir to incidence of infection by decay fungi in different regions and localities.

Scar type	Region	Locality	Avg age	No. of scars	% infec.
Young scars	S. Cariboo-Okanagan	(1) 1/	8	87	20.0
		(2)	5	88	26.0
			6	175	22.8
	Cen. Cariboo	(3)	7	142	55.6
		(4)	4	56	78.0
			6	198	62.1
	E. Kootenay	(5)	14	14	64.3
		(6)	13	17	82.4
		(7)	10	20	90.0
		(8)	10	17	41.2
			12	68	70.6
Old scars	S. Cariboo-Okanagan	(R) 2/	27	74	14.9
	Cen. Cariboo	(R)	21	25	40.0
	E. Kootenay	(R)	36	13	30.8

1/ Circled numbers, Fig. 1

2/ R = random sample areas - (▲ - Fig. 1)

Table 3. Relation of position, size and depth of scar to incidence of infection by decay fungi in Douglas fir of the Central and South Cariboo (Clinton) regions.

Position	Small and interm. scars				Large scars			
	superficial		gouged		superficial		gouged	
	no.	% inf.	no.	% inf.	no.	% inf.	no.	% inf.
lower bole	114	22.8	27	59.2	66	48.5	50	50.0
upper bole	62	54.8	14 1/	92.8	11	81.8	0	0

1/ Includes broken tops

Table 4. Frequency of infection and volume of decay associated with scarred Douglas fir of various diameter classes.

Avg scar age (yr)	Whole tree						First 16-ft log		
	diam class	no.	% inf.	avg gross volume (cu ft)	avg decay volume (cu ft)	% gross volume decayed	% inf.	% gross volume decayed	% total decay volume
	5	12	58.3	4.3	0.15	3.4	58.3	4.3	80.0
12	10	36	50.0	13.3	0.27	2.0	52.9	4.0	91.8
	15	20	55.0	25.3	0.85	3.4	55.0	3.8	49.0
		68	53.7	15.2	0.42	2.7	55.4	3.9	65.5
	5	5	20.0	4.7	0.26	5.6	0	0	0
32	10	35	22.9	11.0	0.18	1.7	21.2	2.4	70.4
	15	10	30.0	28.2	0.32	1.1	16.7	0.3	100.0
		50	24.0	13.8	0.22	1.6	18.6	1.8	62.1

Table 5. Frequency of infection and volume of decay associated with Douglas fir, 10-inch diameter class, in the Central and South Cariboo (Clinton) regions, 4-6 and 10-12 years after scarring.

Region	Scar age (yr)	No. trees	No. scars	% scars inf.	Gross tree vol (cu ft)	Gross decay vol (cu ft)	% Gross vol decayed
Central Cariboo	4	17	27	82	325	0.0	0.0
	10	18	27	79	226	10.7	5.2
South Cariboo (Clinton)	6	49	68	19	597	0.0	0.0
	12	12	13	31	144	1.3	0.9

Table 6. Frequency of occurrence and relative importance of various fungi associated with infected scars of Douglas fir.

	Lower bole		Upper bole		Broken top		Total	
	% of infec. scars	% of decay vol	% of infec. scars	% of decay vol	% of infec. scars	% of decay vol	% of infec. scars	% of decay vol
White rots								
Stereum sanguinolentum	62.8	28.0	23.9	41.3	5.1	23.6	91.8	92.9
Peniophora septentrionalis	0.8	0	1.3	0	0	0	2.1	0
Poria ferrugineo-fusca	0	0	0.4	0.4	0	0	0.4	0.4
Peniophora separans	(tr) 1/	0	0	0	0	0	(tr)	0
Stereum chailletii	(tr)	0	0	0	0	0	(tr)	0
Unknown white rots	0	0	0.4	0.6	0	0	0.4	0.6
Brown rots								
Trametes serialis	1.3	2.8	2.1	0.2	0.4	0.3	3.8	3.3
Coniophora puteana	1.3	2.8	0	0	0	0	1.3	2.8
Fomes cajanderi	(tr)	0	(tr)	0	(tr)	0	(tr)	0
Poria asiatica	(tr)	0	0	0	0	0	(tr)	0
Poria xantha	(tr)	0	0	0	0	0	(tr)	0

1/ (tr) = Secondary infection usually found associated with *Stereum sanguinolentum*