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British Columbia District

LODGEPOLE PINE LOGGING SLASH

(Project B.C. 603)

by

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ABSTRACT

Crown and slash weights from 405 lodgepole pine trees in pure, even-aged stands were sampled. Graphical analysis showed that individual crown weights are directly proportional to diameter (b.h.). Slash weight - merchantable volume ratios varied inversely as average stand diameter for stands up to 7 inches and remained constant for stands of 7 to 9 inches diameter. Surface area per pound of slash is directly proportional to the average diameter of the original stand.

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LODGEPOLE PINE LOGGING SLASH[1]

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S. J. MURARO[2]

Introduction

Of the 51.3 million acres of forest land in the Prince George-, Kamloops-, and Nelson Forest Districts, 14.2 million acres, or 28 per cent, are lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.) stands (1). Harvesting these stands for pulpwood will result in extensive areas of logging slash in the dry belt regions of this province.

The data for this study were gathered in the summer of 1960 in conjunction with an investigation of the lodgepole pine fuel complex south-east of Merritt, B. C. This report presents the analysis of these data for the purpose of predicting slash accumulations resulting from various intensities of cutting.

In this report the term "crown weight" applies to the weight of all living and dead components of the tree crown including needles, branchwood and cones, but excluding the weight of any part of the bole. The term "slash weight" applies to the weight of all components which constitute crown weight in addition to the weight of the non-merchantable bole.

It is generally conceded that a measure of the live crown weight of existing trees is the best method of assessing the quantity of slash which

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will result from a future cutting operation. In 1960 Fahnestock (5) compiled crown weight tables for dominant and co-dominant trees of seven intermountain conifers including lodgepole pine. In the same year Chandler (4) furnished slash weight tables for mixed conifer stands of the western California region.

During hazardous fire periods the living crowns of trees are an important part of the fuel complex, constituting the fuel components in which fire spread is the most rapid and the most difficult to contain. To accurately assess the total fuel complex, the spatial distribution of living and dead crowns must be considered. In 1960 Wendel (9) measured the crown weights of pond pine (*Pinus serotina* Michx.) in the southeast, and in 1963 Brown (2) measured crown weights in red pine (*Pinus resinosa* Ait.) plantations in the Lake States, both for the purpose of determining the contribution of crown fuels to the total fuel complex.

Description of Area

The study area is in the transition zone between the ponderosa pine - Douglas fir Section M.1 and the interior subalpine Section SA.2, Rowe (7), at an elevation of 4,000 to 5,000 feet M.S.L. Lodgepole pine is the major forest type. The plateau was glaciated during Pleistocene time, depositing glacial drift of variable depths over the land surface. The coarse-textured outwash to the west of Paradise Lake, and the bedrock controlled gravelly sandy loam till plain to the north of the lake are the two major land types, Spilsbury, *et al*. (8).

Plot Description

Data were collected from 405 trees on 18 plots in pure lodgepole pine stands commonly found in British Columbia (Table I).

TABLE I. Stand Parameters by Plots

Plot No.	Age	Height		Site		Crown Length	Av. Stand d.b.h.	Merch. Vol.	Density		
		Av.	Dom.	Index at 100	Product. Rating*				Plot Length	No. of Trees per Acre	Index**
	yrs.	ft.	ft.	yrs.		ft.	in.	Cc.f./ac.	ft.		
16	21	10	17	45	Poor	6	0.8	Regen.	3.3	18,100	1,450
17	21	14	18	46	Poor	9	1.4	Regen.	18.3	3,280	460
7	82	36	43	47	Poor	12	2.0	4.2	18.9	3,510	700
12	80	27	40	45	Poor	10	2.4	6.0	16.5	4,000	960
14	80	53	67	76	Fair	19	6.4	28.3	131.6	510	330
18	21	18	20	51	Fair	13	2.1	Regen.	25.7	2,300	480
5	81	43	54	60	Fair	15	3.9	22.2	26.2	2,520	980
3	80	40	58	60	Fair	18	4.6	28.1	54.3	1,210	560
13	83	45	59	72	Fair	14	4.7	21.3	67.4	990	470
8	74	41	52	62	Med.	12	3.4	19.8	16.1	4,080	1,390
11	80	55	68	70	Med.	18	5.2	44.6	46.9	1,410	730
2	70-90	54	72	70	Med.	22	5.4	31.2	93.4	710	380
1	70-90	61	82	75	Med.	26	6.7	49.2	80.0	650	430
9	200	59	80	56	Med.	18	6.8	55.1	98.0	670	460
4	110	61	70	61	Med.	30	7.7	39.8	147.0	450	580
15	82	62	75	79	Good	22	6.5	56.3	79.1	830	540
10	74	69	76	79	Good	20	8.4	56.7	136.3	480	400
61	86	65	78	81	Good	34	9.0	58.3	174.6	380	340

* Productivity capability ratings were provided by D. S. Lacate, Forest Research Officer, Canada, Dept. of Forestry, Victoria, B. C.

** Density Index = Number of trees per 1/10 acre x average d.b.h.

Procedures

Seventeen plots of variable size each containing 20 living trees, and one 1/10-acre plot containing 65 trees, were located in representative stands of lodgepole pine. The "20 tree" sampling method involves a plot width of 13.2 feet, random orientation and a length necessary to include 20 living trees within its boundaries. Each foot of plot length (Table I) is equal to 1/3300 of an acre and total plot length in feet is a relative measure of stand density.

After felling, average diameter (b.h.), height to the lower margin of the green crown, length of green crown, total height, and the weight of bridge fuels and green crown on each 5' length of bole were measured and recorded for each tree. The length and weight of the unmerchantable top from all trees 4 inches diameter (b.h.) and larger were also recorded. Spring balances, calibrated in kilograms, and fabricated slings were used to weigh the fuel components. All weights were recorded to the nearest one tenth kilogram.

Branches from each 5' section of the first and last tree felled on each plot were separated and tagged according to their origin and allowed to dry, to facilitate needle removal for the quantitative comparison of crown fuel components. At the end of the season, although drying had occurred, the removal of needles was so time consuming that data on proportion of fuel components are scanty.

The drying rates of needles and 1/10", $\frac{1}{4}$", $\frac{1}{2}$", and 1" branchwood in freshly lopped slash were measured at weekly intervals by replicated sampling and oven drying.

Analysis and Discussion

Kilograms were converted to pounds, and moisture content corrections made to express all weights in pounds of dry fuel. Green foliage was assumed to have a moisture content of 100 per cent (5), and the average moisture content of bridge fuels was approximated at 15 per cent using E.M.C. Tables and spot checks. Merchantable volumes were compiled from B. C. Forest Service cubic foot volume tables (3) using the merchantability factors for a 4 inch inside back top diameter and a 1 foot stump height.

Crown Weights

The variation of crown weight with tree diameter (b.h.) on each of the 18 plots was independently balanced on double logarithmic paper (Figure 1). A double logarithmic transformation was necessary to represent the relation between the two variables as a straight line. Data for regeneration stands are from plots 16, 17 and 18; for suppressed stands from plot 12; and for mature stands from the remaining 14 plots. The variation of crown weight with diameter, shown by the similar slope of the three lines, is nearly the same in each of the three stands. However, for a tree of the same diameter, in each of the stands a great variation in crown weight is evident, being least in mature stands and heaviest in the regeneration stands. The broken lines in Figure 1 are the limits for plus and minus 20 per cent of the estimated crown weight in a mature stand. Of the 305 values used to balance the line for the mature stand, 67 per cent of the actual values were within these limits. This apparent wide dispersion of values is partially a result of the large number of abnormally heavily crowned "school marms" and partially because of minor stand differences.

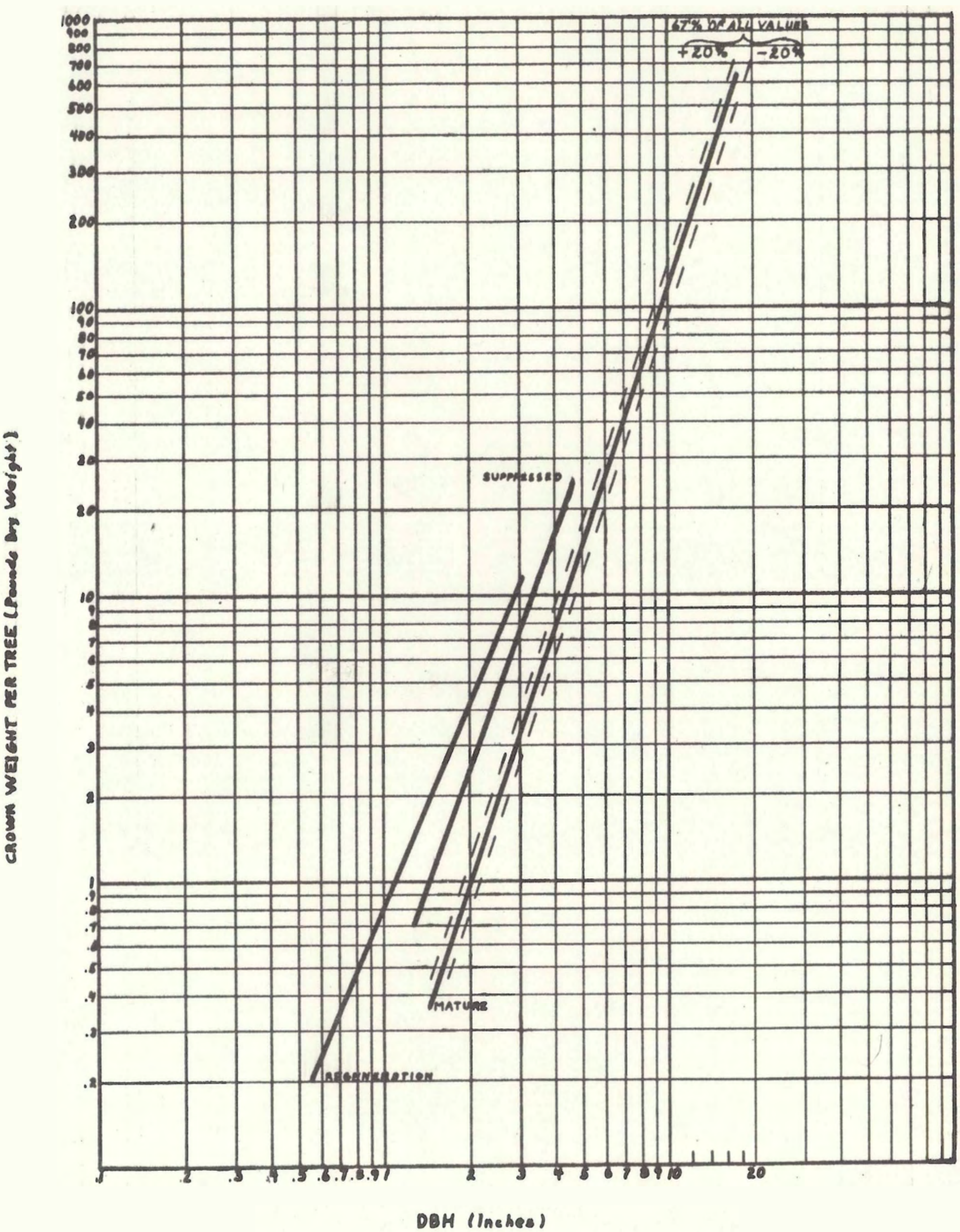

Figure I. Crown Weight As A Function Of DBH

The use of the appropriate line in Figure 1 allows an estimation of individual tree crown weights or the total crown weight per unit of land area if the number of trees in each diameter class is known. This graph does not include the weight of the unmerchantable portion of the bole. If slash weight is desired, the weight of cull material must be added to the crown weight.

Slash Weight

A slash-volume ratio for each plot was calculated by dividing the total slash weight from all trees having a diameter (b.h.) of 4 inches and larger by their merchantable volume. The variation of this ratio with average stand diameter is shown in Figure 2(a).

Slash weight per acre is easily determined by multiplying the appropriate slash-volume ratio by the merchantable volume per acre in C c.f. If the utilization standard were lowered to include only trees of 6 inches instead of 4 inches diameter (b.h.), the slope would remain essentially the same but the curve would be shifted to the right.

Because of silvicultural treatment or clearing for improvements, the stand may be clear-cut. In such cases all trees are felled but only those of merchantable size extracted. For this condition slash weights are determined in the same manner as above except that slash-volume ratios shown in Figure 2(b) are used. The difference in weight of slash resulting from the two intensities of cutting is inversely proportional to the average stand diameter. If no trees are below the utilization standard, the two curves will give the same results.

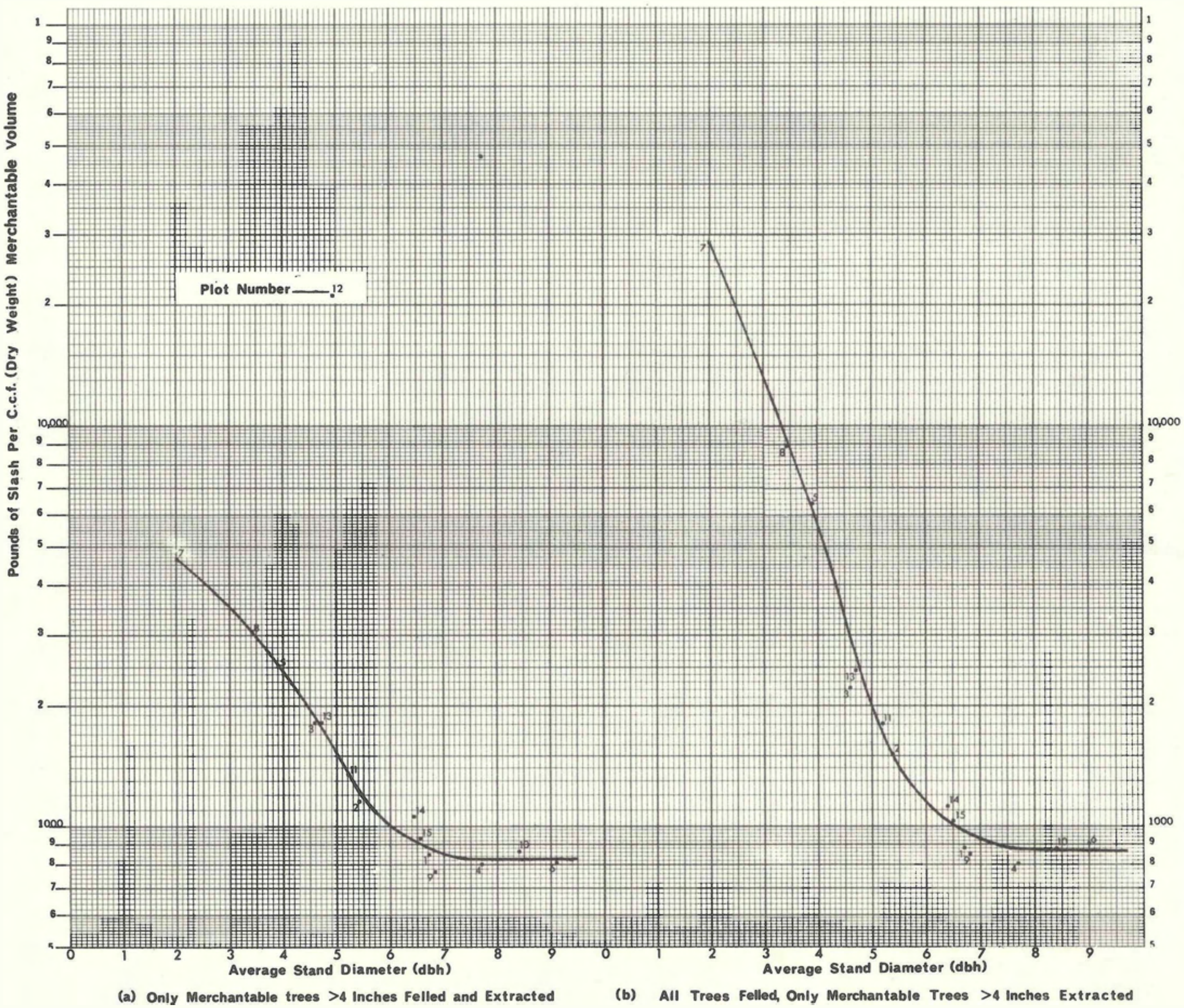

Figure 2. Pounds of Slash Per C.c.f. of Merchantable Volume As a Function of Average Stand Diameter (dbh).

Slash Fuel Components

An investigation of 18 five-foot crown sections from six trees indicated that the proportion of needle weight to branchwood weight increased towards the tip of the tree. The more vigorous trees on all sites had a greater proportion of needles than trees of poor vigour. Needle weight varied from 33 to 47 per cent of the total green crown weight, the average being 39 per cent. Approximately 2 per cent of the total green crown weight consisted of cones, while the remaining 59 per cent was branchwood. The composition of lodgepole pine slash (Figure 3) shows the variation in percentage of total slash weight of the three fuel components with average stand diameter.

To illustrate the use and importance of the data furnished in Figures 3 and 2(a), assume that two stands, A and B, are cut to the same utilization standard. The characteristics of the original stands and the resulting fuel complexes are shown in Table II. In both cases there is essentially the same total weight of slash; however, the fuel composition factors from Figure 3 reveal differences in the distribution of this weight between the three fuel components. The importance of these differences is illustrated by approximating the total fuel surface area of the two slash complexes. In the course of this study it was determined that one pound of dry needles presents approximately 37.2 square feet of surface area. Interpretation of results from a previous report by Muraro (6) showed that one pound of dry branchwood presented about 5.2 square feet of surface area. Because all tops have a large end diameter of 4 inches, the surface area, weight and volume are all directly related to their

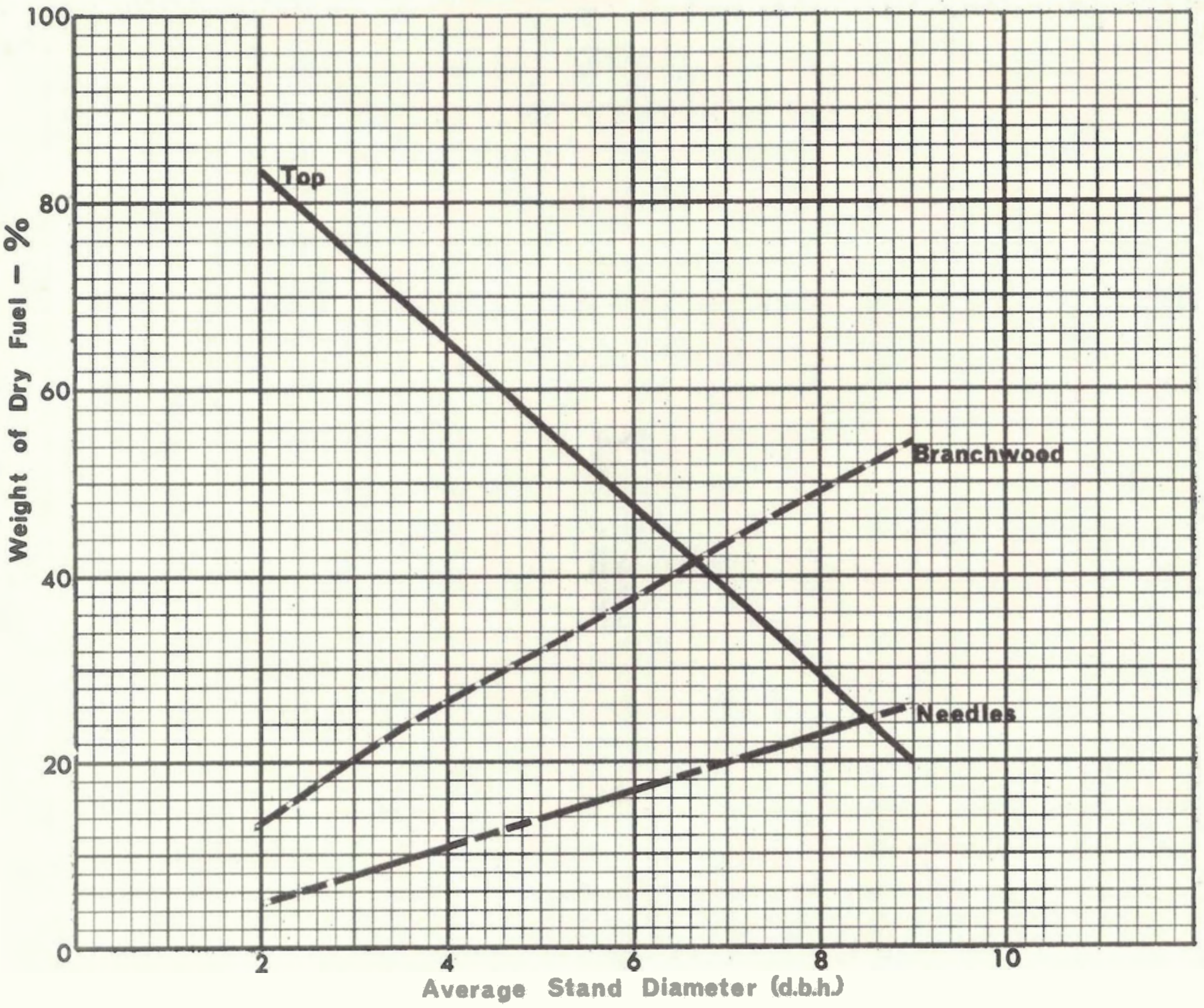

Figure 3. Composition of Lodgepole Pine Slash

TABLE II. Comparison of the Slash Fuel Complex From Two Lodgepole Pine Stands*

	Stand A	Stand B
Average stand diameter (measured)	8.0 inches	4.8 inches
Merchantable volume (measured)	56 C c.f.	28 C c.f.
Slash weight-volume ratio (Fig. 2a)	830 lbs./C c.f.	1,700 lbs./C c.f.
Slash weight per acre	830 x 56 = 46,500 lbs.	28 x 1,700 = 47,600 lbs.
Weight of needles (Fig. 3)	23% of 46,500 = 10,700 lbs.	13% of 47,600 = 6,200 lbs.
Weight of branchwood (Fig. 3)	49% of 46,500 = 22,800 lbs.	30% of 47,600 = 14,300 lbs.
Weight of tops (Fig. 3)	28% of 46,500 = 13,000 lbs.	57% of 47,600 = 27,100 lbs.
Total slash weight	46,500 lbs.	47,600 lbs.
Surface area of needles	= 10,700 lbs. x 37.2 = 398,000 sq. ft.	6,200 lbs. x 37.2 = 231,000 sq. ft.
Surface area of branchwood	= 22,800 lbs. x 5.2 = 118,500 sq. ft.	14,300 lbs. x 5.2 = 74,400 sq. ft.
Surface area of tops	$= \frac{13,600 \text{ lbs. x } 18.5}{29} =$ 8,700 sq. ft.	$\frac{27,100 \text{ lbs. x } 18.5}{29} =$ 17,300 sq. ft.
Surface area of total weight	of 46,500 lbs. = 526,200 sq. ft.	of 47,600 lbs. = 322,700 sq. ft.

*Weights and surface areas have been rounded to the nearest 100 lbs. and 100 sq. ft., respectively.

length. The surface area of a conical-shaped solid having a base diameter of 4 inches is approximated by the product of the volume of the solid in cubic feet and the constant 18.5. Because the total volume of tops may be determined from $\frac{W}{D}$ if W is the weight in pounds and D is the density of wood in pounds per cubic foot, an approximation of the equivalent surface area encompassing this volume can be determined from the expression $\frac{W}{D}$ 18.5. This expression and the conversion factors previously noted for needles and branchwood are used to illustrate the difference in fuel surface area of the two slash complexes in Table II.

The greater surface of fuel presented by slash from Stand A will result in:

(a) The ability to burn during periods of marginal burning conditions due to the larger quantity of fine fuels which dry at a faster rate than the larger fuels from Stand B.

(b) A more rapid rate of fire spread, a higher fire intensity and more uniform disposal of slash because of the greater quantity of fine fuels, the larger proportion of branchwood and the lesser proportion of the larger fuels consisting of unmerchantable tops (Figure 3 and Table II).

(c) A more pronounced change in potential fire behaviour during the third year after cutting when the greatest needle cast occurs. After needle cast has occurred, the difference in fuel surface area of the two slash complexes will be relatively small.

Drying Rates of Slash

The rate at which slash dries is dependent primarily on the type of slash, i.e., lopped or unlopped, and secondly on the macro- and micro-climatic regime of its location. Fahnestock (5) shows drying curves for both lopped and unlopped foliage and twigs in Idaho; his data for lopped slash show that differences of 10-40 per cent moisture content result from exposure to full sunlight versus heavy shade. If slash is not lopped, a lag of about 30 days occurs in full sun, and negligible drying occurs in the first 90 days under full shade. The moisture content of fine lopped slash in full sun was 10 per cent in 13 days and about 6 per cent in 18 days.

This investigation of lodgepole pine also studied the drying rate of slash. Sixty days after cutting, the moisture content of needles and larger branchwood was about 25 per cent and the moisture content of fine branchwood was about 18 per cent. The variation in these results and those of Fahnestock (5) probably reflect different climatic regimes.

Summary

The use of extensive stands of lodgepole pine in the British Columbia interior for pulpwood, will multiply a slash hazard problem that is already serious.

Analysis of crown weight data from 405 lodgepole pine trees shows that the weight of individual crowns was directly related to tree diameter at breast height. The relationship differed between stands where the trees were mature, suppressed or regeneration.

A comparison between similar slash weights from an 8 inch and a 4.8 inch average diameter stand, using a slash fuel composition graph, showed that the surface area of slash from the larger stand was about double that of slash from the smaller stand. Composition curves showed that the percentage of total slash weight consisting of needles and branchwood varied directly with average stand diameter, and the weight of unmerchantable bole varied inversely as average stand diameter.

Conclusions

Crown weights of lodgepole pine are closely related to diameter (b.h.) which is an integrator of the effects of site and density.

The slash weight - merchantable volume ratio of stands up to 7 inches diameter is inversely related to average stand diameter (b.h.) and constant between 7 to 9 inches diameter. After a further increase in diameter when decay is prevalent, a direct relation may be expected.

The weight of needles and branchwood per cubic foot of merchantable wood varied directly as the average stand diameter, while the weight of the unmerchantable bole varied inversely with average stand diameter.

The relation between weight of slash per cubic foot of merchantable wood and average stand diameter (b.h.) will furnish an accurate estimate of slash weights. When used in conjunction with the slash fuel composition graph, the fuel characteristics of size and total fuel surface area can also be determined.

The information presented in this report is useful to land managers involved in logging or land-clearing operations where disposal of slash by burning for sanitation, regeneration or hazard abatement purposes is of concern.

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MURARO, S. J.   Oxf. 431.1 and 431.2

Lodgepole Pine Logging Slash. Project B.C. 603, Canada Dept. of Forestry, Forest Research Br., Victoria, B.C. Mimeo 64-BC-5, May 1964.

Crown and slash weights from 405 lodgepole pine trees in pure, even-aged stands were sampled. Graphical analysis showed that individual crown weights are directly proportional to diameter (b.h.). Slash weight-merchantable volume ratios varied inversely as average stand diameter for stands up to 7 inches and remained constant for stands of 7 to 9 inches diameter. Surface area per pound of slash is directly proportional to the average diameter of the original stand.

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