



# LODGEPOLE PINE LOGGING SLASH

by  
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*Sommaire en français*

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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 at breast height. 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 was directly proportional to the average diameter of the original stand. This information 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 considered.

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by

S. J. Muraro<sup>1</sup>

## INTRODUCTION

Of the 51.3 million acres of forest land in the Prince George, Kamloops, and Nelson Forest Districts of British Columbia, 14.2 million acres (approximately 28 per cent) support stands of lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.) (Anon. 1957). The massive expansion of wood-using industries in these districts demands the harvest of the, until recently, relatively untouched stands of lodgepole pine. The harvesting of these stands, especially for pulpwood, will result in a vast expansion of the present slash areas.

Tables for estimating the quantity of logging slash can be prepared by establishing regressions of the measured weight of the crown and other logging residue, with various measurements of tree size. Fahnestock (1960) used the product of diameter breast height and crown length as the independent variable to calculate crown weight tables for dominant and co-dominant trees of seven intermountain conifers including lodgepole pine. Chandler (1960) used similar parameters to prepare slash weight tables for five species of the Westside mixed conifer type in California.

During periods of high fire danger the living crowns of trees are an important part of the fuel complex constituting fuel components in which fire spread is most rapid and difficult to control. To accurately assess the total fuel complex the spatial distribution of crown fuels as well as ground fuels must be considered. In studies for the purpose of determining the contribution of crown fuels to the total fuel complex Wendel (1960) used diameter breast height as the independent variable for estimating the crown weight of pond pine (*Pinus resotina* Michx.) in the southeast. Brown (1963) used the same variable to estimate crown weights in red pine (*Pinus resinosa* Ait.) plantations in the Lake States.

The data for the present study were gathered in the summer of 1960 in conjunction with an investigation of the lodgepole pine fuel complex southeast of Merritt, B.C., and analyzed for the purpose of predicting slash accumulations resulting from two intensities of logging.

In this paper 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 portion of the bole*. The term "slash weight" applies to the weight of all components constituting crown weight *in addition to the weight of the non-merchantable bole*.

## DESCRIPTION OF AREA

The study area is at an elevation of 4,000-5,000 feet MSL in the transition zone between the ponderosa pine-Douglas fir section M.1 and the interior subalpine section SA.2, (Rowe, 1959). During Pleistocene time the plateau was glaciated resulting in depositions of glacial drift over the land surface. According to Spilsbury *et al.* (1963) there are two major land types: a coarse-textured outwash in the western portion, and a bedrock controlled gravelly, sandy loam, till plain to the north. Lodgepole pine is the major forest type, resulting from extensive fires occurring at approximately 80-year intervals during the past 200 years.

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## PROCEDURES

Seventeen plots of variable size, each containing 20 living trees, and one 1/10-acre circular plot containing 65 trees were located in representative stands of lodgepole pine (Table 1). The sampling method on the 17 plots was similar to the method used by Keser<sup>2</sup> involving a plot width of 13.2 feet, random orientation and the necessary length to include 20 living trees within the plot. Each foot of plot length is then equal to 1/3300 acre and total plot length may be used as a relative measure of stand density.

After felling, diameter breast height, total length of bole and crown length of each of the twenty trees were measured. Each tree was sawn into 5 ft. lengths and the weight of dead and living crowns on each section determined. On the basis of a utilization standard of a 4 in. top diameter, the length and weight of the non-merchantable top from all trees larger than 4 inches diameter breast height were recorded.

Crown components from each 5 ft. section of the first and twentieth tree in each plot were separated and tagged according to their position on the tree and allowed to dry to facilitate needle removal for a quantitative comparison of crown components. Needle removal was so time consuming that at the end of the season only crown components on 18 sections from six trees could be compared.

To compare drying regimes of various crown fuel components, replicated samples of needles and 1/10,  $\frac{1}{4}$ ,  $\frac{1}{2}$  and 1 inch branchwood from slash lopped in June were oven-dried at weekly intervals throughout the summer.

## ANALYSIS AND DISCUSSION

### General

Corrections for moisture content were made to express all fuel weights in pounds of oven-dried fuel. Living crown components were assumed to have a moisture content of 100 per cent (Fahnestock, 1960); the average moisture content of dead crown components was approximated at 15 per cent using equilibrium moisture content tables and field checks. Merchantable volumes were compiled from B.C. Forest Service cubic foot volume tables (Browne, 1962) using the merchantability factors of a 4 inch (inside bark) top diameter and a 1 ft. stump height.

### Crown weight

A double logarithmic transformation of the crown weight and tree diameter data from each plot resulted in a straight line regression (Figure 1). Superimposing the individual plot regressions on each other showed that the 18 regressions fell into three groups.

Regressions from immature stands, plots 16, 17 and 18, had the heaviest crowns for a given diameter; 14 of the remaining regressions from plots in mature stands showed the lightest crowns for a given diameter, while the regression from plot 12, which was an extremely stagnated stand, was intermediate to the other regressions. The similar slope of the three lines shows that variation of crown weight with tree d.b.h. is nearly the same in each of the three stands. Of the 305 values used to balance the regression for the mature stand, 67 per cent of the actual values were within plus or minus 20 per cent of the estimated crown weight. This apparent wide dispersion of values is partially a result of the large number of heavily crowned "school marms" and partially because of minor stand differences. Crown weights of lodgepole pine measured during this study tend to be only slightly heavier than those measured by Fahnestock (1960) in the inter-mountain area.

<sup>2</sup> Keser, N. 1964. Paradise Lake joint project (EP 609). B.C. Forest Service, Research Division, Victoria, B.C. Unpublished report.

Table 1. Stand Parameters by Plots  
 Tableau 1. Paramètres des peuplements par place d'étude

Plot No. N° des places d'étude	Age years Âge années	Height ft. — Hauteur moyenne en pieds	Dom. ft. — Hauteur dominante en pieds	Site index at 100 years — Indice de fertilité à 100 ans	Av. Crown Length ft. — Longueur moy. de la cime en pi.	Av. Stand d.b.h. in. — D.H.P. moyen des peuplements en po.	Merch. Vol. C c.f./ac. — Vol. march. C. pi. cu. à l'acre	Plot Length ft. — Longueur de la pl. d'étude en pi.	No. of Trees per Acre — Nombre d'arbres à l'acre
1	70-80	61	82	75	26	6.7	49.2	80.0	650
2	70-90	54	72	70	22	5.4	31.2	93.4	710
3	80	40	58	60	18	4.6	28.1	54.3	1,210
4	110	61	70	61	30	7.7	39.8	147.0	450
5	81	43	54	60	15	3.9	22.2	26.2	2,520
6	86	65	78	81	34	9.0	58.3	174.6	380
7	82	36	43	47	12	3.0	4.2	18.9	3,510
8	74	41	52	62	12	3.4	19.8	16.1	4,080
9	200	59	80	56	18	6.8	55.1	98.0	670
10	74	69	76	79	20	8.4	56.7	136.3	480
11	80	55	68	70	18	5.2	44.6	46.9	1,410
12	80	27	40	45	10	2.4	6.0	16.5	4,000
13	83	45	59	72	14	4.7	21.3	67.4	990
14	80	53	67	76	19	6.4	28.3	131.6	510
15	82	62	75	79	22	6.5	56.3	79.1	830
16	21	10	17	45	6	0.8	Regen. Régénér.	3.3	18,100
17	21	14	18	46	9	1.4	Regen. Régénér.	18.3	3,280
18	21	18	20	51	13	2.1	Regen. Régénér.	25.7	2,300

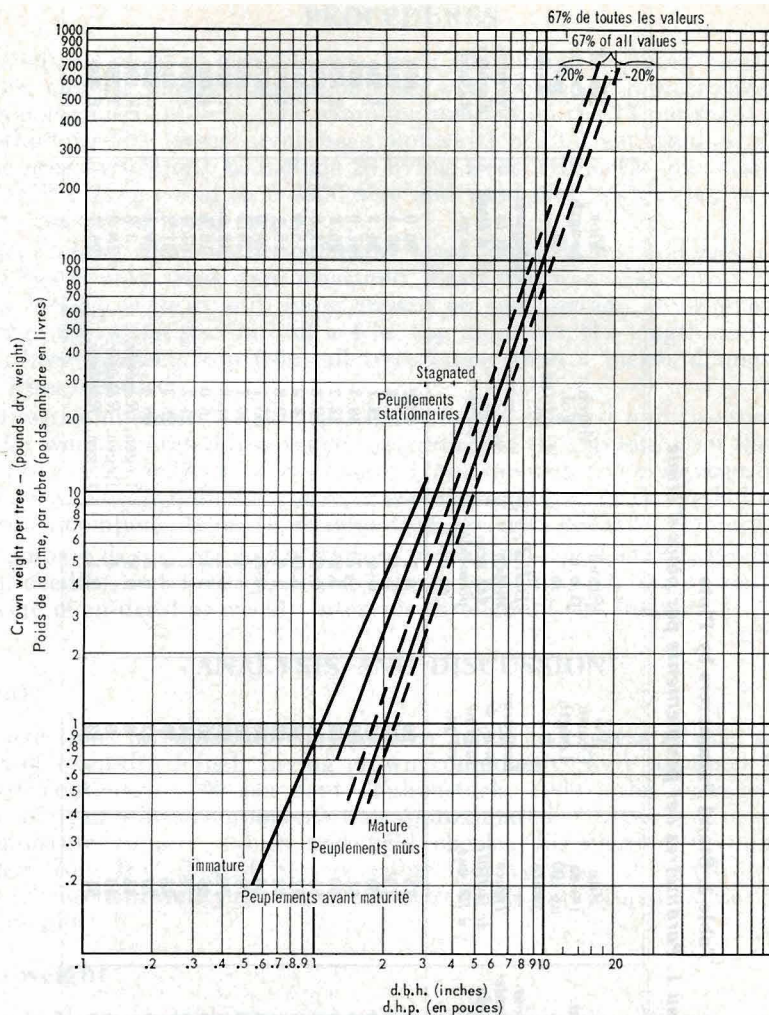


Figure 1. Crown weight as a function of d.b.h.  
Figure 1. Poids de la cime en fonction du d.b.h.

The use of the appropriate regression in Figure 1 allows an estimation of single tree crown weight or total crown weight per 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, and if slash weight is desired, the weight of unmerchantable tops and cull material must be added to the crown weight.

## Slash weight

The ratio of slash weight to merchantable volume was calculated for each plot by dividing the weight of slash from trees 4 inches and larger d.b.h. by their merchantable volume. The variation of this slash/volume ratio with average stand d.b.h. is shown in Figure 2A. A second slash/volume ratio (Figure 2B) for use in clear-cut areas was determined by dividing the weight of slash from all trees on the plot by the total merchantable volume.



Both slash weight and merchantable volume vary directly with tree diameter, but because merchantable volume in trees from 4 inches d.b.h. to 7 inches d.b.h. increases more rapidly than does slash weight, slash weight/volume ratios are inversely proportional to tree diameter for these smaller diameters. At diameters larger than 7 inches d.b.h. the increase in both slash weight and merchantable volume are apparently equal resulting in a nearly constant slash weight/volume ratio.

The hypothesis is proposed that in stands where decadence has commenced, slash weight/volume ratios for decadent trees will vary directly as diameter. The loss of merchantable volume as a result of decadence not only detracts from the merchantable volume but is added to the amount of slash and thus has a twofold effect on the slash weight/volume ratio.

Slash weight per acre is determined by multiplying the appropriate slash/volume ratio from Figure 2A by the merchantable cubic foot volume per acre. If the utilization standard were lowered to include trees of 6 inches and larger rather than 4 inches and larger, the shape of the curve in Figure 2B would remain the same but would be shifted to the right.

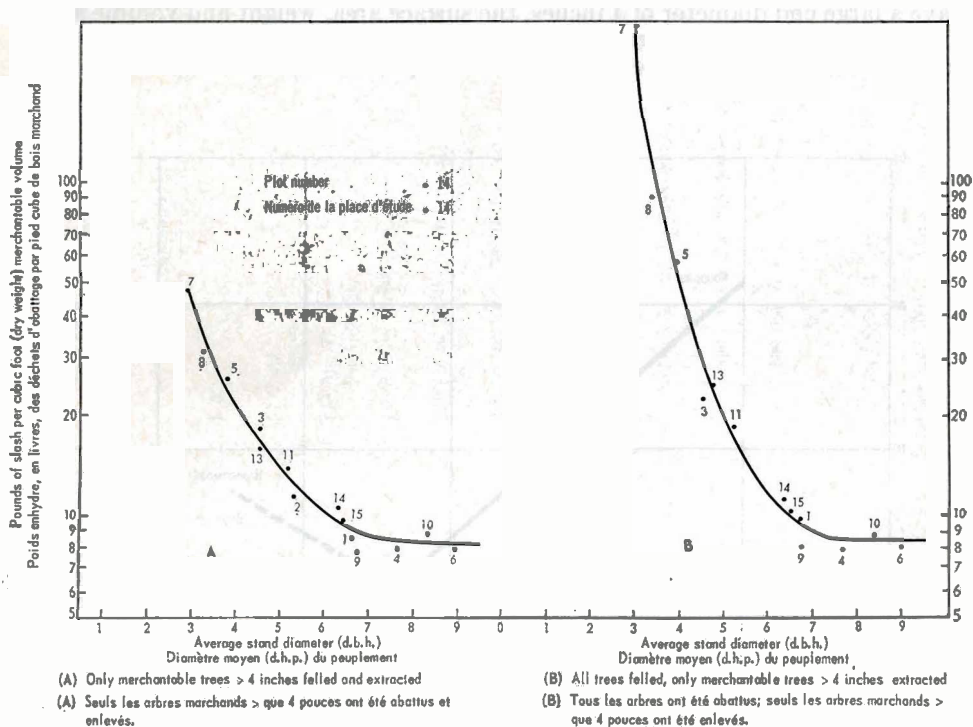


Figure 2. Pounds of slash per cubic foot of merchantable volume as a function of average stand diameter (d.b.h.)

Figure 2. Poids des déchets d'abattage, en livres, par pied cube de bois marchand en fonction du diamètre moyen (d.h.p.) du peuplement.

If a stand is to be clearcut, all trees may be felled but only those of merchantable size extracted. For this treatment, slash weights are determined in the same manner as above except that slash/volume ratios from Figure 2B 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 smaller than the utilization standard, the two curves will yield the same slash/volume ratio.

## Slash fuel components

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. 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 2A, 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 2. In both cases there is essentially the same total weight of slash; however, the fuel composition factors from Figure 3 reveal important differences in the distribution of this weight between the three fuel components. The importance of these differences is illustrated by comparing 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. Results from a previous report by Muraro (1964) showed one pound (oven-dry weight) of naturally assorted lodgepole pine branchwood having a maximum diameter of 1 inch presents 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 length. The surface area in square feet of a conical-shaped solid having a base diameter of 4 inches is approximated by the product of the

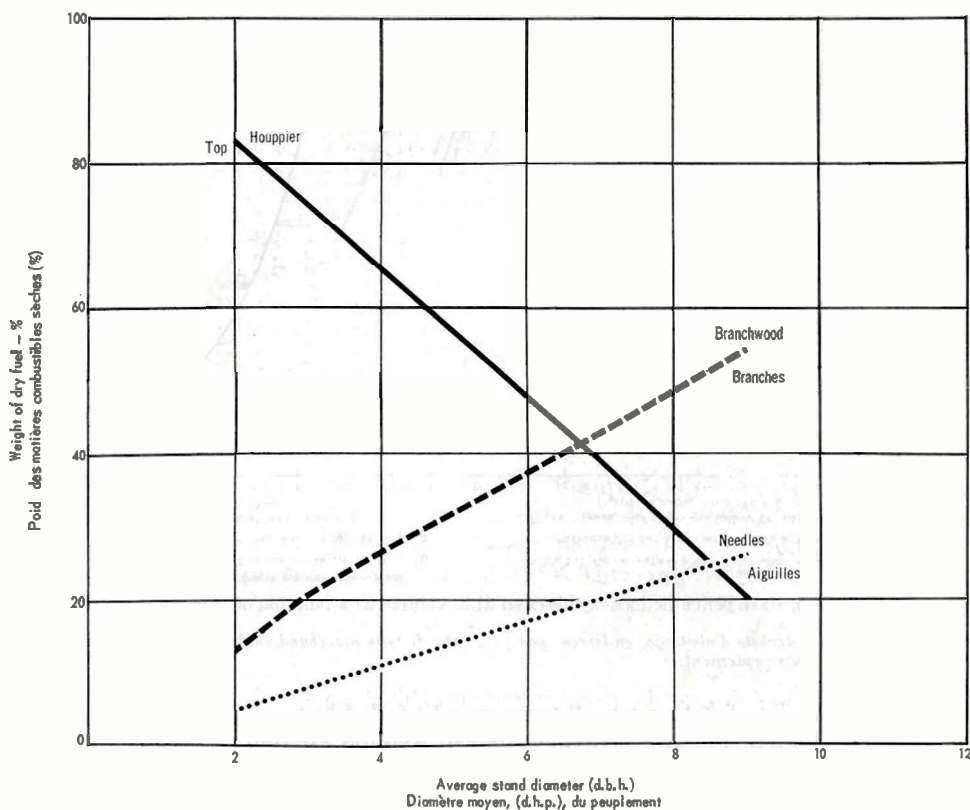


Figure 3. Composition of lodgepole pine slash.

Figure 3. Composition des déchets d'abattage du pin de Murray.

Table 2. Comparison of the Slash Fuel Complex Per Acre From Two Lodgepole Pine Stands\*

	Stand A Peuplement A	Stand B Peuplement B
Average stand diameter (measured)..... <i>Diamètre moyen des peuplements (mesuré)</i>	8.0"	4.8"
Merchantable volume (measured)..... <i>Volume de bois marchand (mesuré)</i>	56 C c.f. C. pi. cu.	28 C c.f. C. pi. cu.
Slash weight-volume ratio (Fig. 2a)..... <i>Rapport poids/volume des abattis</i>	830 lbs./C c.f. liv./C. pi. cu.	1,700 lbs./C c.f. liv./C. pi. cu.
Slash weight..... <i>Poids des abattis</i>	830 x 56 = 46,500 lbs./ac. liv./acre	28 x 1,700 = 47,600 lbs./ac. liv./acre
Weight of needles (Fig. 3)..... <i>Poids des aiguilles</i>	23% of 46,500 = 10,700 lbs./ac. liv./acre	13% of 47,600 = 6,200 lbs./ac. liv./acre
Weight of branchwood (Fig. 3)..... <i>Poids des branches</i>	49% of 46,500 = 22,800 lbs./ac. liv./acre	30% of 47,600 = 14,300 lbs./ac. liv./acre
Weight of tops (Fig. 3)..... <i>Poids des cimes</i>	28% of 46,500 = 13,000 lbs./ac. liv./acre	57% of 47,600 = 27,100 lbs./ac. liv./acre
Total slash weight..... <i>Poids global des abattis</i>	46,500 lbs./ac. liv./acre	47,600 lbs./ac. liv./acre
Surface area of needles..... <i>Superficie de l'aire ouverte d'aiguilles</i>	= 10,700 lbs. x 37.2 = 398,000 sq. ft./ac. pi. ca./acre	6,200 lbs. x 37.2 = 231,000 sq. ft./ac. pi. ca./acre
Surface area of branchwood..... <i>Superficie de l'aire couverte de branches</i>	= 22,800 lbs. x 5.2 = 118,500 sq. ft./ac. pi. ca./acre	14,300 lbs. x 5.2 = 74,400 sq. ft./ac. pi. ca./acre
Surface area of tops..... <i>Superficie de l'aire couverte de cimes</i>	= 13,000 lbs. x 18.5 = 8,700 sq. ft./ac. pi. ca./acre	27,100 lbs. x 18.5 = 17,300 sq. ft./ac. pi. ca./acre
	29	29
Surface area of total weight of 46,500 lbs..... <i>Superficie globale de l'aire des abattis de 46,500 livres</i>	= 526,200 sq. ft./ac. pi. ca./acre	322,700 sq. ft./ac. pi. ca./acre

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

\*Les poids et superficies ont été chiffrés à la plus proche centaine de livres et centaine de pieds carrés, respectivement.

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 surrounding 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 in Table 2 to illustrate the difference in fuel surface area of the two slash complexes.

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 2).
- (c) A more pronounced change in potential fire behaviour as needle cast occurs due to ageing. After needle cast has occurred, the difference in fuel surface area of the two slash complexes is small.

### Drying rates of slash

The rate at which slash dries depends primarily on the slash treatment, i.e., lopped or unlopped, and secondly on the macro- and micro-climatic regime. Fahnestock (1960) shows drying curves for both lopped and unlopped Douglas fir 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 included studies of the drying rate of lopped 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 of these results and those of Fahnestock (1960) probably reflect different climatic regimes during the test period rather than a difference due to species.

### CONCLUSIONS

Crown weights of lodgepole pine are closely related to tree diameter at breast height.

The slash weight/merchantable volume ratio of stands up to 7 inches diameter is inversely related to average stand diameter (b.h.) and is constant between 7 to 9 inches diameter. A direct relation may be expected for trees with larger d.b.h. when decay is prevalent.

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 d.b.h. will furnish an accurate estimate of slash weights. When used in conjunction with the slash fuel composition graph, characteristics of fuel size and total fuel surface area can also be determined.



## 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 that were mature, stagnated or immature.

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 stand of larger average diameter was about double that of slash from the stand of smaller average diameter. Composition curves also 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 with average stand diameter.

## SOMMAIRE

L'on a délimité, dans des peuplements de pin de Murray représentatifs, 17 places d'étude de dimensions variées contenant chacune 20 arbres vivants, ainsi qu'une place circulaire de 0.10 d'acre de surface contenant 65 arbres (tableau 1). La méthode d'échantillonnage utilisée dans les 17 places d'étude est analogue à celle qu'a employée Keser et qui prévoit une place d'étude de 13.2 pieds de largeur, de longueur suffisante pour comprendre 20 sujets vivants, et dont l'orientation est choisie au hasard. Chaque pied mesuré dans le sens de la longueur de la place d'étude correspond alors à  $1/3300^e$  d'acre et la longueur totale de la place peut servir de mesure comparative de la densité du peuplement.

Après l'abattage des arbres, on a mesuré le diamètre à hauteur de poitrine, la longueur totale du fût et la longueur de la cime de chacun des 20 arbres. Après avoir sectionné chaque arbre en longueurs de 5 pieds, on a déterminé le poids des parties mortes et des parties vivantes de chaque section. Suivant la norme d'emploi selon laquelle le diamètre de l'arbre doit être de 4 pouces à la cime, on a enregistré la longueur et le poids des cimes sans valeur marchande de tous les arbres de plus de 4 pouces de diamètre à hauteur de poitrine.

Les parties composantes de chaque section de 5 pieds de la cime du premier et du vingtième arbre de chaque place d'étude ont été séparées puis étiquetées selon leur position originale dans l'arbre, et on les a laissées sécher pour faciliter l'enlèvement des aiguilles en vue des comparaisons quantitatives à faire entre les différentes parties des cimes. L'enlèvement des aiguilles a exigé tellement de temps qu'à la fin de la saison il n'a été possible de comparer que les éléments de 18 sections de 6 arbres.

Pour fins de comparaison des régimes de séchage des matières combustibles des houppiers, des échantillons, en double, d'aiguilles et de branches de 0.10, 0.25, 0.50 et 1 pouce de diamètre, provenant d'abattages faits en juin, ont été séchés à l'étuve à des intervalles d'une semaine, au cours de l'été.

L'exploitation extensive des peuplements de pin de Murray de l'intérieur de la Colombie-Britannique, pour la production de bois à pâte, ne fera qu'aggraver le problème déjà sérieux du danger de feu que créent les déchets d'abattage.

L'étude des données obtenues après avoir pesé la cime de 405 pins de Murray démontre que le poids de chacune des cimes est directement proportionnel au diamètre de l'arbre à hauteur de poitrine. Cette proportion varie selon que le peuplement est mûr, stationnaire ou qu'il n'a pas atteint la maturité.

Une comparaison établie entre le poids d'abattis identiques provenant de deux peuplements dont les sujets ont un diamètre moyen de 4.8 pouces et 8 pouces, respectivement, comparaison faite à l'aide d'un graphique montrant

la composition des matières combustibles de l'abattis, révèle que la superficie globale des abattis provenant du peuplement à fort diamètre moyen est le double, environ, de la superficie des abattis provenant du peuplement à faible diamètre moyen. D'autres graphiques démontrent aussi que le pourcentage du poids global des abattis, c'est-à-dire le poids des aiguilles et des branches, est directement proportionnel au diamètre moyen du peuplement, et que le poids du fût sans valeur marchande est inversement proportionnel au diamètre moyen du peuplement.

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