



# FUEL WEIGHT TABLES FOR WHITE SPRUCE AND LODGEPOLE PINE CROWNS IN ALBERTA

by  
A. D. Kiil

THIS FILE COPY MUST BE RETURNED

TO: INFORMATION SECTION,  
NORTHERN FOREST RESEARCH CENTRE,  
5320-122 STREET,  
EDMONTON, ALBERTA,  
T6H 3S5

*Extrait en français*

FORESTRY BRANCH  
DEPARTMENTAL PUBLICATION NO. 1196  
1967

Published under the authority of  
The Honourable Maurice Sauvé, P.C., M.P.,  
Minister of Forestry and Rural Development,  
Ottawa, 1967

ROGER DUHAMEL, F.R.S.C.  
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY  
OTTAWA, 1967

Catalogue No. Fo 47-1196

## ABSTRACT

Tables are presented to provide estimates of oven-dry weights for live branchwood and crowns of white spruce and lodgepole pine in west-central Alberta. Other tables give the proportion of fine material less than one-half inch in diameter and the weight of the unmerchantable portion of the stem. Basic data for the tables are from 60 white spruce and 101 lodgepole pine trees in a variety of sites and stands.

## EXTRAIT

Informations sur le poids anhydre de la ramure vivante (i.e. tout le bois vivant non marchand de la ramure) et de la "cime" (tout le bois non marchand, vivant ou mort, de la ramure) d'Épinettes blanches (*Picea glauca* (Moench) Voss) et de Pins gris (*Pinus contorta* Dougl.) croissant dans le centre-ouest de l'Alberta. Autres informations sur la proportion (en poids anhydre) des rameaux à diamètre moindre qu'un demi-pouce et sur le poids de la partie non marchande de la tige. Les résultats proviennent de 60 Épinettes blanches et 101 Pins de Murray qui poussaient dans diverses Stations écologiques et plusieurs types de peuplements.

## CONTENTS

	Page
INTRODUCTION .....	1
FIELD METHODS .....	2
PREPARATION OF WEIGHT TABLES.....	3
APPLICATION .....	4
WEIGHT TABLES .....	6-12
Table 3. Live Branchwood Weight for White Spruce in West-Central Alberta .....	6
Table 4. Proportion of Fine Fuels for White Spruce in West-Central Alberta .....	7
Table 5. Crown Weight for White Spruce in West- Central Alberta .....	8
Table 6. Live Branchwood Weight for Lodgepole Pine in West-Central Alberta .....	9
Table 7. Proportion of Fine Fuels for Lodgepole Pine in West-Central Alberta .....	10
Table 8. Crown Weight for Lodgepole Pine in West- Central Alberta .....	11
Table 9. Weight of the Unmerchantable Stem for White Spruce and Lodgepole Pine in West- Central Alberta .....	12
REFERENCES .....	13

# FUEL WEIGHT TABLES FOR WHITE SPRUCE AND LODGEPOLE PINE CROWNS IN ALBERTA

by  
A. D. Kiil<sup>1</sup>

## INTRODUCTION

Quantitative and qualitative descriptions of forest fuels are prerequisites for a classification of the fuel complex in terms of fire behaviour. Fuel-weight and size distribution are two major factors influencing the intensity of combustion and are therefore included in most fuel classification schemes. Such information can be used in conjunction with an evaluation of topography and weather conditions to judge whether hazard reduction and seedbed preparation by fire are feasible. An estimate of wood fibre content would also be of considerable value to forest management when full-tree logging with chippers in the field becomes established as a practical harvesting method.

Prescribed burning is becoming important in Alberta for slash hazard reduction and seedbed preparation and forest management must be provided with means for fuel evaluation. One approach is to predict fuel weight from simple measurements of stem and crown variables. Kittredge (1944) provided a basis for this by relating foliage weight to tree diameter. A similar approach has been used by Storey *et al.* (1955), Fahnestock (1960), Chandler (1960) and Muraro (1966), to relate fuel weight expressions and one or more stem and crown factors. Kiil (1965) used the relationship between the weight of crown components and diameter breast height of white spruce and lodgepole pine in west-central Alberta to estimate slash weight in terms of timber volume.

This paper presents a set of fuel weight tables for white spruce (*Picea glauca* (Moench) Voss) and lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm) and suggests a method for their application in planning and comparing results of prescribed burns. It also provides basic data for a quantitative classification of forest fuels. Separate tables are given for the oven-dry weight expressions of live branchwood,

---

<sup>1</sup>Fire Research Officer, Department of Forestry and Rural Development, Calgary, Alberta.

crown, proportion of fine fuels and the unmerchantable portion of the stem. Live branchwood includes all live material other than the unmerchantable stem. Fine fuels are all live materials less than one-half inch in diameter. Crown weight is defined as the weight of live and dead branchwood. Oven-dry slash weight is the sum of live and dead branchwood plus the unmerchantable stem.

## FIELD METHODS

Data for the fuel weight tables were collected in 1963-64 at an elevation of approximately 4,500 feet in the Upper (B.19c) Foothills Section of Alberta (Rowe 1959). Alberta Forest Service cover type maps were used to select a range of sites and stands on the pulpwood lease area of North Western Pulp and Power Limited near Hinton. Within each stand two to five trees with full and symmetrical crowns, chosen to represent the diameter classes of greatest frequency, were felled and measured and their crowns and unmerchantable stems weighed. The total sample consisted of 60 white spruce and 101 lodgepole pine. A summary of stem and crown dimensions for each species is given in Table 1.

TABLE 1. MEAN AND RANGE OF TREE DIMENSIONS FOR WHITE SPRUCE AND LODGEPOLE PINE SAMPLE TREES

Variable	White Spruce		Lodgepole Pine	
	Mean	Range	Mean	Range
Diameter at breast height (inches)	11.1	1.8-26.7	8.3	0.9-21.1
Total height (feet)	64.0	13.1-115.3	54.1	7.9-88.8
Live crown length (feet)	39.2	7.4-89.7	21.4	4.2-64.0
Crown width (feet)	8.8	4.0-19.0	7.3	2.0-16.6
Age (years)	135	40-304	99	16-300

After felling and stem and crown measurements, each tree was divided into four equal lengths and the weight of stem and crown components obtained as follows for each section:

1. If present, a sample green branch was taken from each of the top, middle and bottom third. The sample material was segregated into three diameter classes: (1) up to 1/2 inch (2) 1/2 inch to 2 inches and (3) over 2 inches. Each size-class component was weighed by spring balance and subsampled for moisture content.

2. All remaining live branchwood was lopped flush with the stem and weighed by means of a standard weighbeam.

3. All dead branchwood was lopped flush with the stem, weighed, and subsampled for moisture content.

4. The unmerchantable stem (less than 4 inches in diameter) was weighed and subsampled for moisture content.

5. All fuel subsamples were oven-dried to constant weight in the field laboratory for 24 to 36 hours at a little more than 212°F.

## PREPARATION OF WEIGHT TABLES

Oven-dry weights were calculated for each fuel component and size-class on the basis of moisture content in percent of oven-dry weight obtained from the subsamples taken from each tree. Data were first examined graphically for straight-line relationships between the independent variables (stem and crown factors) and the dependent variables (fuel weight expressions). Combinations of independent and dependent variables exhibiting straight line relationships were subjected to regression analysis.

Results showed that a combination of the primary independent variable, diameter breast height and either crown width or crown length gave the most precise estimate of fuel weight. Crown width was judged to be a more convenient measure than crown length for fuel weight prediction purposes because it was easier to measure in the field and can be measured on aerial photographs. The general equation used for the preparation of fuel weight tables is:

$$\log W = a + b \log D + c \log CW$$

where W = oven-dry weight in pounds or in percent of live branchwood weight

D = diameter breast height in inches

CW = crown width in feet.

Tables 3, 5, 6 and 8 provide oven-dry fuel weights in pounds for specific combinations of dbh and crown width. Tables 4 and 7 present the oven-dry weights of fine fuels as percent of live branchwood. Table 9 gives oven-dry weight of the unmerchantable stem by diameter breast height classes.

## APPLICATION

There are high correlations between the logarithms of the dependent variables of fuel weight and the logarithms of the independent variables of dbh and crown width. This suggests that the prediction equations may be valid over a range of forest conditions inasmuch as they are based upon samples taken in a wide variety of site and stand density. It was expected that site and stand density would influence fuel weight of individual tree crowns to some extent, but the correlation coefficients indicate that this variation is of small significance. As the data were obtained from trees supporting full symmetrical crowns, a small overestimate of fuel weight is likely throughout the sample range.

To use these tables the following procedure is suggested. If the diameter and crown width distributions are unknown, a cruise is required to obtain a stand table and to establish the dbh - crown width relationship. Crown width should be the average of two measurements taken at right angles on 30 to 50 trees. Dbh - crown width curves are prepared, and, by using values from these curves together with the stand table, fuel weights can be determined from Tables 3 to 8.

If utilization practices specify a 4-inch top diameter, the weight of the unmerchantable stem is obtainable from Table 9. Where other minimum top diameters are used, the weight of the unmerchantable stem may be calculated from log volume and specific gravity.

Table 2 illustrates the calculations for slash weight and weight of branchwood and unmerchantable stem on one acre of a hypothetical lodgepole pine stand. No estimate is made of dead branchwood less than one-half inch in diameter. In the two species studied, this type of material is of small importance.

Slash weight totals 15.8 tons per acre, comprising 12.9 tons of live and dead branchwood and 2.9 tons of unmerchantable stem material. Live branchwood is estimated to be 10.7 tons of which 7.3 tons are fine material. These values represent medium fuel weights for lodgepole pine clearcuts in Alberta. In comparison, an open stand would produce about 10 tons of slash per acre and a dense stand would yield between 20 to 25 tons of slash per acre.



TABLE 2. CALCULATIONS FOR FUEL WEIGHT AND SIZE DISTRIBUTION ON ONE ACRE OF A HYPOTHETICAL LODGEPOLE PINE STAND.

(1) Dbh	(2) No. of Trees	(3) Crown width	(4) Crown weight (Table 8)	(5) Weight of unmerchant- able stem (Table 9)	(6) Slash weight Col. 4+ Col. 5	(7) Live branch- wood weight (Table 6)	(8) Propor- tion of fine fuels (Table 7)	(9) Weight of fine fuels Col. 7 x Col. 8 <u>100</u>
		ft.	lbs.	lbs.	lbs.	lbs.	per cent	lbs.
4	10	6	160	180	340	140	82	115
5	25	7	675	463	1,138	575	77	443
6	30	7	1,020	570	1,590	870	75	653
7	50	8	2,550	900	3,450	2,150	72	1,546
8	80	8	4,800	1,360	6,160	4,000	70	2,800
9	70	9	5,800	1,085	6,885	4,830	67	3,238
10	50	9	4,750	700	5,450	3,900	67	2,613
11	30	10	3,720	390	4,110	3,060	64	1,958
12	10	10	1,390	120	1,510	1,140	63	718
13	5	11	880	58	938	720	61	439
Total	360		25,745	5,826	31,571	21,385		14,523
Tons			12.9	2.9	15.8	10.7		7.3

## WEIGHT TABLES

TABLE 3. LIVE BRANCHWOOD WEIGHT FOR WHITE SPRUCE IN WEST-CENTRAL ALBERTA.

Dbh in.	Crown width (feet)															
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Oven-dry weight (pounds)																
2	5	6														
3	9	11	14	17												
4	12	16	20	25												
5	15	21	27	33	40											
6	20	26	34	42	50	58										
7		32	41	51	61	71										
8		38	49	60	72	84	97									
9		44	57	70	84	98	113									
10			65	80	96	112	129	147	166	185						
11			73	90	108	127	146	166	187	208						
12				101	121	142	163	186	209	233						
13				112	134	157	181	206	232	258						
14					147	173	199	226	255	284	313	344	376	408	441	474
15					161	189	217	247	278	310	342	376	410	445	481	518
16						205	236	268	302	337	372	408	445	483	522	562
17						221	255	290	326	364	402	441	481	522	564	607
18						238	274	312	351	391	432	474	518	562	607	653
19						255	294	334	376	419	463	508	555	602	651	700
20						272	314	357	401	447	495	543	593	643	695	748
21						290	334	380	427	476	527	578	631	685	740	796
22							355	403	454	506	559	613	669	727	785	845
23												649	708	769	831	894
24												685	748	812	877	944
25												722	788	855	924	994
26												759	828	899	972	1046

Log(weight) = -0.51780+1.27747 log(dbh)+1.35248 log(crown width)  
R<sup>2</sup> = 0.95  
Basis: 60 trees

TABLE 4. PROPORTION OF FINE FUELS FOR WHITE SPRUCE IN WEST-CENTRAL ALBERTA.

Dbh in.	Crown width (feet)																	
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
Oven-dry weight of fine fuels as per cent of live branchwood																		
2	100	100																
3	100	100	100	98														
4	100	99	96	93	91													
5	99	95	92	89	87													
6	96	92	89	87	84	82												
7		89	86	84	82	80												
8		87	84	82	80	78	76											
9		85	82	80	78	76	74											
10			81	79	77	75	73	72	71	70								
11			79	77	75	73	72	71	70	69								
12				76	75	72	71	70	68	67								
13				74	73	71	70	69	67	66								
14					72	70	69	68	67	66	65	64	63	62	62	61	60	
15					71	69	68	67	66	65	64	63	62	62	61	60	59	
16						68	67	66	65	64	63	62	61	61	60	59	58	
17						68	66	65	64	63	62	62	61	60	59	58	57	
18						67	66	64	63	62	62	61	60	59	58	57	56	
19						66	65	64	63	62	61	60	59	58	57	56	55	
20						66	64	63	62	61	60	60	59	58	57	56	55	
21						65	64	63	62	61	60	59	58	57	56	55	54	
22							63	62	61	60	59	59	58	57	56	55	54	
23												58	57	56	55	54	53	
24												58	57	56	55	54	53	
25												57	56	55	54	53	52	
26												57	56	55	54	53	52	

Log(per cent) = 2.23803-0.18845 log(dbh)-0.18455 log(crown width)

$R^2 = 0.83$

Basis: 60 trees

TABLE 5. CROWN WEIGHT FOR WHITE SPRUCE IN WEST-CENTRAL ALBERTA.

Dbh in.	Crown width (feet)															
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	Oven-dry weight (pounds)															
2	6	7														
3	10	13	16	19												
4	14	19	23	28												
5	19	25	31	38	44											
6	25	32	40	48	56	65										
7		40	49	59	69	80										
8		47	59	71	83	96	108									
9		56	69	83	98	112	127									
10			80	96	113	130	147	164	183	201						
11			91	109	128	147	167	188	208	229						
12				123	144	166	188	211	234	258						
13				137	161	185	210	235	261	287						
14					178	205	232	260	288	318	347	377	407	437	468	500
15					195	225	255	286	317	349	381	414	447	480	514	549
16						245	278	311	346	381	416	451	488	524	561	599
17						266	302	338	375	413	451	490	529	569	610	650
18						288	326	367	406	446	488	530	572	615	659	703
19						309	351	393	437	480	525	570	616	662	709	756
20						332	376	419	468	515	563	611	660	710	760	811
21						355	402	451	500	550	601	653	705	758	812	866
22							428	480	532	586	640	695	751	807	865	922
23												738	798	858	918	980
24												782	844	908	973	1038
25												827	893	960	1028	1097
26												872	942	1013	1084	1157

$\text{Log}(\text{weight}) = -0.384118 + 1.35610 \log(\text{dbh}) + 1.19533 \log(\text{crown width})$   
 $R^2 = 0.97$   
 Basis: 60 trees

TABLE 6. LIVE BRANCHWOOD WEIGHT FOR LODGEPOLE PINE IN WEST-CENTRAL ALBERTA.

Dbh in.	Crown width (feet)																
	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17		
	Oven-dry weight (pounds)																
1	0	1															
2	2	3	5														
3	4	6	8	10													
4	6	8	11	14	17	21											
5	8	11	15	19	23	28	33										
6		15	19	24	29	35	41										
7			23	29	35	43	50										
8				34	42	50	59	70									
9				39	48	58	69	80	91								
10				45	55	66	78	90	103								
11				51	63	75	88	102	116								
12				57	70	84	99	114	130	146							
13					78	93	109	126	144	162	180						
14						102	120	139	158	178	198	219	241	263	286		
15								152	172	194	216	239	263	287	312		
16								164	187	210	235	260	285	312	339		
17									202	227	254	281	308	337	366		
18									217	244	273	302	331	362	393		
19									232	261	292	323	355	388	421		
20									248	279	311	344	379	414	449		
21									264	297	331	366	403	440	478		

Log (weight) = -0.67346 + 1.26470 log(dbh) + 1.36575 log(crown width)

$R^2 = 0.95$

Basis: 101 trees

TABLE 7. PROPORTION OF FINE FUELS FOR LODGEPOLE PINE IN WEST-CENTRAL ALBERTA.

Dbh. in.	Crown width (feet)																
	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17		
Oven-dry weight of fine fuels as per cent of live branchwood																	
1	100	100															
2	100	98	93														
3	100	94	89	85													
4	98	91	86	82	79	76											
5	95	89	84	80	77	74	72										
6		87	82	78	75	73	71										
7			80	77	74	72	69										
8				76	73	70	68	66									
9				75	72	69	67	66	64								
10				74	71	69	67	65	63								
11				73	70	68	66	64	63								
12				72	69	67	65	63	62	61							
13					69	66	64	63	61	60	59						
14						66	64	62	61	59	58	57	56	55	55		
15								62	60	59	58	57	56	55	54		
16								61	60	59	57	56	55	54	54		
17									59	58	57	56	55	54	53		
18									59	58	57	56	55	54	53		
19									59	57	56	55	54	53	53		
20									58	57	56	55	54	53	52		
21									58	57	56	55	54	53	52		

Log(per cent) = 2.18023-0.11790 log(dbh)-0.25056 log(crown width)  
 $R^2 = 0.75$   
Basis: 101 trees

TABLE 8. CROWN WEIGHT FOR LODGEPOLE PINE IN WEST-CENTRAL ALBERTA.

Dbh in.	Crown width (feet)														
	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	Oven-dry weight (pounds)														
1	0	2													
2	2	4	5												
3	4	6	9	12											
4	6	9	13	16	20	24									
5	8	13	17	22	27	33	38								
6		16	22	28	34	41	49								
7			27	34	42	51	60								
8				41	50	60	71	83							
9				47	58	70	83	96	109						
10				54	67	81	95	110	125						
11				61	76	91	107	124	142						
12				69	85	102	120	139	159	179					
13					95	114	134	155	176	199	222				
14						125	147	170	194	219	245	271	298	325	354
15								186	212	240	268	296	326	356	387
16								203	231	261	291	322	354	387	421
17									250	282	315	349	383	419	456
18									270	304	339	376	413	452	491
19									289	326	364	403	443	485	527
20									309	349	389	431	474	518	564
21									330	372	415	460	505	552	600

Log(weight) = -0.642994+1.30603 log(dbh)+1.37732 log(crown width)

$R^2 = 0.96$

Basis: 101 trees

TABLE 9. WEIGHT OF THE UNMERCHANTABLE<sup>1</sup> STEM FOR WHITE SPRUCE  
AND LODGEPOLE PINE IN WEST-CENTRAL ALBERTA.

Dbh (inches)	White Spruce	Lodgepole Pine
Oven-dry weight (pounds)		
2	9	10
4	19	18
6	20	19
8	19	17
10	17	14
12	15	12
14	14	11
16	13	9
18	13	8
20	12	7
22	12	No data
24	12	No data
26	11	No data

<sup>1</sup>Oven-dry weight of the unmerchantable portion of the stem is based on a 4-inch minimum top diameter.

Basis: 60 white spruce trees  
101 lodgepole pine trees



## REFERENCES

- Chandler, C.C. 1960. Slash weight tables for westside mixed conifers. U.S.D.A., Forest Service, Pacific Southwest Forest and Range Expt. Stn., Technical Paper No. 48.
- Fahnestock, G.R. 1960. Logging slash flammability. U.S.D.A., Forest Service, Intermountain Forest and Range Expt. Stn., Research Paper No. 58.
- Kiil, A.D. 1965. Weight and size distribution of slash of white spruce and lodgepole pine. For. Chron. 41(4):432-437.
- Kittredge, J. 1944. Estimation of the amount of foliage of trees and stands. J. For. 42:905-912.
- Muraro, S.J. 1966. Lodgepole pine logging slash. Department of Forestry of Canada, Publ. No. 1153.
- Rowe J.S. 1959. Forest Regions of Canada. Canada, Dept. Northern Affairs and National Resources, For. Br. Bull. 123.
- Storey, T.G., W.L. Fons and F.M. Sauer. 1955. Crown characteristics of several coniferous tree species. U.S.D.A. Forest Service, Div. Fire Research, Interim Report AFSWP-K16.