Rates of Spread and Fire Damage to Timber Cover Types in British Columbia[1]

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INTRODUCTION

ALTHOUGH information about forest fire damage has been published annually since the establishment of the British Columbia Forest Service, there has been little study of rates of spread and fire damage by major species groups within timber types. An opportunity to undertake intensive analyses has existed since 1971 (Cowlard, 1972) when the first magnetic tape records were made available to University of British Columbia by the B.C. Forest Service. The B.C. Forest Service has used its data tape primarily for improving detection planning, for preparation of annual reports and for Forest District summaries. Fire damage has been described broadly by Smith (1970; 1971) and Smith and Henderson (1971,1972). The need for detailed information on probable fire damage by timber types became obvious during a review of the EDEN fire, a major slash-burn escape in the fall of 1973 (Smith,

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1974), when it appeared that there were large differences among timber types in terms of percentages of area burned annually.

Rates of spread are of much interest as indicators of the amount of suppression effort needed to control a fire. We were particularly interested in comparing rates of spread by ground cover types and timber types within Forest Districts. We also tried to determine effects of factors such as elevation, aspect, slope, and weather.

Fire damage has been reported annually for each District in terms of areas burned, numbers of fires, and resultant damage, but has seldom been compared with the physical extent of the resource or its bioclimatic nature.

We related area burned to the type areas reported by the Forest Inventory Division of the B.C. Forest Service for various groupings of existing and proposed Public Sustained Yield Units (PSYU's) and for Special Sale Areas (SSA's). It may be possible to use percentages of areas burned 1950-73 to help refine fire control objectives. We would welcome emphasis of quantitative elements in the future and expect that the B.C. Forest Service fire tapes can contribute to this as more experience is gained in using them.

It is necessary, however, to introduce the body of our paper with a warning. We have examined many factors as if they were independent of each other and their resultant effects on fire spread. This is obviously not the case and our attempts at multiple regression analysis which should deal effectively with interactions have not accounted for large proportions of the variation. We are reporting upon a complex of highly variable natural systems. As well, we must fully recognize that the data base has been subject to all the vagaries of the human input over the past 24 years. Nevertheless, our data at the very least provide the best estimates now available for describing rates of spread and percentages of area burned by ground cover, timber types, and other factors. We hope that they will prove helpful in modelling initial attack systems by helping to quantify some aspects of the real world in which decisions have to be made about how to employ scarce resources efficiently.

THE B.C. FOREST SERVICE FIRE TAPES

Fire records since 1950 have been processed to form a data bank on more than 50,000 B.C. wildfires. Data for each fire are stored on four computer card images (B.C. Forest Service, 1974b). There have been changes in the fire history forms used and in methods of coding which limit interpretation and complicate analysis. Recent fires (1967-73) are much better described than the two groups of older fires (1950-9) and 1960-7).

In our first work with the tapes we displayed fire damage by 83 timber types for merchantable (mature) and immature stands, separately. Summaries were made for each year and for four periods (1950-9, 1960-6, 1967-73, and 1950-73) for each of six Forest Districts. Then we prepared similar summaries for 95 Public Sustained Yield and other Units. For each Forest District we also tabulated the seasonal distribution of fires and prepared detailed breakdowns of the fire data by general and specific fire-cause groupings of interest to us. Copies of these outputs were filed with the Protection Division of the B.C. Forest Service and with the Pacific Forest Research Center of the Canadian Forestry Service.

The analyses of most interest here are those on rates of spread and fire damage by timber types. The data on fire losses 1950-73 can be compared with areas disturbed in 1973 by logging, wildfires, and slashfires as shown in Table 1. Progress reports have provided summaries for each of the Districts shown in Table 1 but these are too detailed for use here.

TABLE 1. Areas logged and burned by wildfires and slashfires in 1973.

Forest District	Area, acres, 1973				
	Clearcut	Partial cut	Wildfires	Slashfires[1]	All types
Vancouver	92,195	8,711	4,753	11,734	22,332,840
Prince Rupert	48,658	4,075	320	1,277	77,955,875
Prince George	95,423	85	8,190	30,255	72,726,568
Cariboo	43,473	22,050	6,734	3,940	22,198,972
Kamloops	47,740	17,548	27,171	7,156	18,210,702
Nelson	41,303	6,652	35,339	41,500	20,703,506
Province	368,792	59,121	82,507	95,862	234,128,463
	427,913				

[1]Includes total area on which hazard has been abated by fire involving either spot or broadcast burns.

RATES OF SPREAD

It is usual to talk of rates of spread and resistance to control in terms of chains of perimeter increase or line construction per hour. We were not able to provide such data directly because only areas and elapsed times were available. Therefore our results are expressed as acres per hour. An increase in fire size of one acre per hour could be the result of a fire advance of 10 chains on a front one chain wide or simply a gradual increase in size around many sides of a fire. Although shapes of fires were not recorded, future analyses could use Hornby's (1936) conclusion that the probable perimeter of fires was 1.5 times that of the circumference of a circle corresponding to the area. He found that 92 percent of all fire perimeters were less than twice such a circumference.

First we calculated rates of spread as the increase in area between the fire sizes at discovery and at attack divided by the elapsed time. Then we calculated a rate from discovery to control. The value from discovery to attack represents a naturally spreading system. The second rate includes the naturally spreading system and the effects of control activities on that. Finally we calculated some rates of spread from attack to control, and expressed spread in terms of size of fire at attack and other factors.

Although more complete studies now are feasible, the best information is that of Hornby (1936) who studied initial rates of spread of 8,789 fires in 11 Rocky Mountain timber types. Barrows (1951) recognized five fuel-based rate of spread types for the Northern Rocky Mountains which are reproduced here as Table 2.

Our data provide some basis for understanding the relative importance of the rates of spread actually observed and expressed in acres per hour. They are based on 6,652 fires for which data were complete for the variables of interest now.

Table 3 shows the influence of elevation, slope, and exposure on rates of spread from discovery to initial attack and to control. Because all of the 1950-59 data were coded as zero for elevation the lowest class has been omitted. The highest rate of spread, from discovery to initial attack, is 8.4 in the 2000-2999 foot elevation class. The highest control difficulty has been experienced in the

4000-4999 elevation class in which spread averaged 12.8 acres per hour from discovery to control. A similar relationship holds for slope in which the highest spread from discovery to attack is 5.4 in the

TABLE 2. Rates of spread in chains and corresponding areas burned in acres.

Rate of spread classification	Average initial rate of spread at BI 70[1]	Maximum rate of spread for 85% of fires At BI 70[2]	Approximate area after one hour for "maximum" spread and Min.	Ave. circumference[3]	Max.
	chains per hour				
	perimeter	increase		acres	
Low	4.5	8.0	5	2.3	1.4
Medium	6.0	10.0	8	4.5	2
High	13.0	28.0	63	28	15.5
Extreme	18.0	35.0	97	44	24
Flash	33.0	65.0	335	150	85

[1]From discovery to first attack (Barrows, 1951).
[2]15% of fires will spread faster (Barrows, 1951).
[3]Hornby (1936).

TABLE 3. Influence of elevation, slope, and exposure on rates of spread from discovery (D) to initial attack (IA) and to control (C).

Elevation feet a.s.l.	D to IA ac/hr	No. fires	D to C ac/hr	Exposure	D to IA ac/hr.	No. fires	D to C ac/hr
1000-1999	3.7	629	6.7	Flat	7.9	564	6.1
2000-2999	8.4	1078	9.3	North	1.2	500	2.2
3000-3999	5.1	1415	4.1	Northeast	4.4	360	2.8
4000-4999	5.2	858	12.8	East	3.4	567	6.3
5000-5999	3.5	396	1.6	Southeast	6.0	489	16.5
6000-6999	1.9	73	3.8	South	3.4	1001	3.7
7000-7999	1.7	5	2.2	Southwest	4.6	616	14.6
				West	3.3	695	4.3
				Northwest	4.7	268	17.1
Slope flat	5.1	1051	3.0				
under 15%	3.9	2194	3.3				
15-44%	5.4	1954	7.5				
45-74%	5.3	635	5.0				
75%+	2.6	409	10.7				

15-44 percent class and the highest from discovery to control is 10.7 acres per hour on slopes 75 percent and steeper. The worst exposures are southeast which has a spread of 6.0 acres from discovery to attack and southeast, southwest, and northwest which have rates of spread from discovery to control of 15 acres or more per hour.

Table 4 illustrates great variation from District to District in terms of effects of ground cover on rates of spread. Similarly large effects of District exist within the data summarized in Tables 3 and 5. It is obvious in Table 4 that the most serious rates of spread occur in slash fuels. Considering the data for discovery to attack, the order of spread is from bracken (1.6), duff (1.9), windfalls (3.2), brush and scrub (4.4), grass (5.6), moss (5.6) and slash (10.2 acres per hour). If firebreaks experience similar rates of spread to those in the "duff" category, we have good evidence of the advantages of reserving them. The greater resistance to control in slash fuels is evident in the average of 18.0 acres per hour from discovery to control.

Table 5 indicates the influence of timber types on rate of spread for all forest types and for slash types. Some of the most important species groups have been tabulated to give spread data on 4903 of the total number of fires which averaged 4.9 acres. Separate tabulations have been made for 515 of the slash type fires all of which averaged 10.2 acres fire spread per hour. The worst type is spruce-lodgepole pine which for 197 fires had rates of spread from discovery to attack of 25.4 acres and from discovery to control of 27.8 acres, per hour. The worst slash types are also spruce-lodgepole pine mixtures but there also are some very serious spreads from discovery to control in hemlock-cedar (151.9) and balsam-spruce (46.6).

Table 6 shows the influence of elimination of the most extreme values from averages for several groupings of data on rates of spread from initial attack to control. These data also include information on rate of increase expressed as acres per acre per hour. Suppression costs were expressed per acre and it is obvious that these are very high for some small fires which were fought vigorously to keep them small. Data from all types can be compared with those in which slash ground cover is present. A further subdivision of wild slash fires is given to show the characteristics of 62 prescribed slash fires

TABLE 4. Influence of ground cover on rate of spread by forest districts from discovery (D) to initial attack (IA) and to control (C).

Forest District	D to IA ac/hr	No. fires	D to C ac/hr	D to IA ac/hr	No. fires	D to C ac/hr
	All fuel types			Slash fuels		
Vancouver	4.7	720	3.9	11.7	186	6.1
Prince Rupert	5.8	412	9.3	5.6	47	65.6
Prince George	11.8	903	13.1	17.1	97	10.2
Cariboo	5.0	1270	3.3	10.1	117	5.4
Kamloops	3.7	1726	5.5	8.0	212	7.4
Nelson	2.0	1621	6.7	8.2	142	49.2
All	4.9	6652	4.3	10.2	801	18.0
	Grass			Bracken		
Vancouver	2.5	27	1.0	1.4	50	16.9
Prince Rupert	10.9	17	4.7	1.9	13	0.6
Prince George	23.1	105	27.0	1.9	37	18.4
Cariboo	3.7	482	2.5	2.5	20	4.5
Kamloops	4.9	451	14.1	2.7	31	3.9
Nelson	3.0	233	3.2	0.3	43	0.5
All	5.6	1315	8.5	1.6	194	9.1
	Brush, scrub			Moss		
Vancouver	3.1	75	0.8	2.6	75	4.3
Prince Rupert	2.2	25	2.2	6.6	129	3.1
Prince George	28.5	68	27.8	11.2	185	9.2
Cariboo	29.6	38	2.7	4.8	87	0.7
Kamloops	11.7	82	3.6	0.3	96	0.2
Nelson	0.5	134	0.9	1.2	80	0.4
All	4.4	422	6.0	5.6	652	3.9
	Duff			Windfalls		
Vancouver	0.7	151	1.1	8.5	53	0.6
Prince Rupert	1.1	89	0.9	5.9	36	0.7
Prince George	4.5	190	6.4	7.3	125	7.5
Cariboo	5.8	163	4.8	2.4	288	4.1
Kamloops	1.4	369	0.6	2.1	305	1.8
Nelson	0.6	489	0.7	2.2	329	7.9
All	1.9	1451	1.9	3.2	1136	4.7

TABLE 5. Influence of timber types on rate of spread from discovery (D) to initial attack (IA) and to control (C).

Species[1]	All types D to IA ac/hr	All types No. fires	All types D to C ac/hr	Slash types D to IA ac/hr	Slash types No. fires	Slash types D to C ac/hr
F	3.4	957	2.2	10.6	157	5.6
F C	2.8	254	3.0	2.5	55	3.6
F Py	4.4	339	20.0	2.8	30	1.6
C	0.2	113	0.1	0.3	7	0.3
C H	1.1	376	1.0	3.2	53	3.7
H C	1.8	167	19.7	3.7	20	151.9
S	7.5	365	8.6	8.1	27	4.7
S B	4.2	581	3.2	8.3	51	4.6
S Pl	25.4	197	27.8	18.5	24	17.1
B S	6.7	159	4.6	3.2	12	46.6
Pl	4.0	1088	3.2	20.8	62	7.0
Py	2.5	249	2.3	6.9	16	2.4
B	1.1	58	1.4	0.0	1	0.0
All	4.9	6652	4.3	10.2	801	18.0

F is Douglas-fir, C is western redcedar, Py is ponderosa (yellow) pine, H is hemlock, S is spruce, B is balsam (all true firs), Pl is lodgepole pine. The type is named for the major species present.

which escaped. Wind speed has had a large influence on the slash fire escapes. The effects of elimination of five very rapidly spreading fires in slash is dramatic in terms of reduced rates of spread from 39.2 to 8.6. Data on fires with zero or blank recorded for suppression costs have been tabulated. Since 1970 data also have been available on fire weather index and build-up index (van Wagner, 1974). Fires 1970-3 show quite low rates of spread and small initial attack size but very high suppression costs per acre. Obviously, it now costs a lot to keep fires from becoming large.

Most of the groups of data reported in Table 6 were studied also by multiple regression analyses but only small portions of the total variation could be accounted for, even using the most uniform data and appropriate transformations.

We would have liked to have reported data on rates of spread and

TABLE 6. Rates of spread from initial attack to control, effects of elimination of extreme values, and influences of slash and other factors.

Variable	Units	Averages for period studied							
		1960–1973						1970-3	
Rate-speed	Acs/hr	10.8	4.5	39.2	8.6	14.0	12.3	2.9	3.3
Rate-increase	Acs/ac/hr	19.2	5.2	18.8	10.2	15.1	0.8	6.5	7.2
Suppr. cost	$/ac	2032	1052	542	467	45	0	3399	1436
Attack size	ac	33.6	20.1	25.6	25.9	48.3	7.5	6.9	7.8
Wind speed	mph	8.50	8.68	12.0	11.9	17.7	7.9	7.9	8.3
Elevation	fasl	3118	3065	2740	2735	2477	2788	3152	2989
Slope	%	22.4	22.1	16.9	16.9	24.2	20.4	23.2	21.9
No. fires		3480	3268	441	436	62	566	858	757
Kind of fires		All	All[1]	Slash	Slash[1]	Slash[2]	Zero[3]	All	All[1]
FWI (Fire weather index)								29.3	28.8
BUI (Build-up index)								114.5	110.0

[1]With extremes eliminated
[2]Slash escape fires with slash ground cover
[3]Zero or blank suppression cost

percentages of area burned within the not-satisfactorily restocked (NSR) and non-commercial cover (NCC) components of "other cover" but these have not been separated on the tape. Although data on wildfire losses in NSR have been reported annually by the B.C. Forest Service for many years, areas logged have been reported only for the Vancouver Forest District (Smith, 1970). This has made it difficult to interpret the effects of slash burning in terms of reduction in area burned. For the decade 1963-72, annual B.C. wildfire losses in NSR averaged 12,844 acres of logged not burned, 2,174 acres of logged and burned, and 8,504 acres of old burn not logged. These areas represent large percentages of the average areas logged annually which should be quantified carefully and evaluated fully.

Although a spread index is included in the American system of rating fire danger it is just "a number expressing the relative rate of forward movement of surface fires" (Noste, 1971). The spread phase is determined by the dead and living fuel, fuel moisture, wind speed, and other significant weather or fuel elements. In the Canadian system (Van Wagner, 1974) the initial spread index is a combination of the effects of wind speed and fine fuel moisture, without the influence of variable quantities of fuel. Data on fires since 1970 may help quantify such relative spread classes. Most discussions of rate of spread still involve qualitative terms such as "very fast", "moderately" (optimum for slash burning), and "non-existent to slow" (B.C. Forest Service, 1974a). In its decision-making aid for prescribed burning the B.C. Forest Service defined rate of spread as the relative speed that a line fire will advance across a relatively uniform and continuous fuel complex. This aid gave diagrams for subjective spread class based upon three slopes 0-15, 16-35, and more than 36 percent, from which relative spread could be estimated in terms of duff moisture code and fine fuel moisture content.

Interpretation of danger ratings and aids to prescribed burning would be more helpful if there were data on effects of various factors on the basic fuel rates of spread such as shown by Stocksted and Barney (1964). Currently such work is being undertaken by the Canadian Forestry Service and the B.C. Forest Service to quantify these relationships.

Since fires must be controlled at their leading edges and sound planning requires improved knowledge of the rates at which fire lines actually can be constructed (Lindquist, 1970), much more effort should be devoted to expressing rates of spread and resistance to control in quantitative terms. Information such as that obtained in a study of fireline construction using explosives (B.C. Forest Service, 1972) should be determined for typical methods and forest types. Combination of data on line construction with rates of spread actually experienced should help develop and test mathematical models for predicting fire spread in wildland fuels (Rothermel, 1972).

AREA BURNED

Although there is much information on burned areas there have been few attempts to express them as percentages in order to determine how well fire control standards are being met over time. Beall's (1949) study should be up-dated and new fire control objectives established, and performance monitored using the B.C. Forest Service fire tapes.

Tables 7-14 are based on fire and forest inventory data for publicly managed Crown forests only.

Table 7 shows percentages of areas burned annually in Public Sustained Yield Units (PSYU's) and Special Sale Areas (SSA's). The number of these units ranges from 6 in Vancouver to 28 in Prince George. Some of the smaller and more remote units have experienced large percentage losses, which are difficult to tolerate under sustained yield management.

Table 8 provides information by timber types for each of the Forest Districts. A total of 83 possible timber types have been grouped using the "growth type" classification of the Forest Inventory Division of the B.C. Forest Service. Growth type 2 which involves Douglas-fir, cedar, cypress, and spruce has suffered severe losses, 0.893 percent of mature and .285 percent of immature types annually, 1950-73. Losses also have been high in growth type 11, spruce-lodgepole pine and spruce-deciduous, in which mature losses averaged .217 and immature losses averaged .381 percent annually.

Tables 9-13 have been prepared to show fire losses by 12 bioclimatic regions used by the Forest Inventory Division. These are likely to be related more to basic biological factors governing fire behavior than are the six Forest Districts. Table 9 gives the total areas burned, approximate area in each region, and the major forest types. Table 10 expresses areas burned annually, 1950-73, as percentages of the total area. The highest losses have occurred on the Northwest Plateau with .803 percent annually. The largest numbers of fires annually per million acres are 41.9 in the Southwest Dry Belt and 42.8 in the West Kootenay region. The low of 0.8 fires annually per million acres in the North central Plateau may have resulted from reporting only the fires which became large.

Table 11 gives numbers of fires, wood volume burned, and total damage, and these values are expressed per acre and per fire in Table 12. The estimates of damage are based upon the methods and values appropriate to each year 1950 to 1973. They would be much higher in 1974.

Table 13 records the causes of the fires which have been sum-

TABLE 7. Percentages of areas burned annually in PSYU's and SSA's by merchantable (mature), immature, and all cover types 1950-9, 1960-6, 1967-73, and 1950-73 by Forest Districts.

Forest District	No. of Units[1]		1950-59			1960-66			1967-73			1950-73		
			Mer.	Imm.	Total	Mer.	Imm.	Total	Mer.	Imm.	Total	Mer.	Imm.	Total
			Areas burned annually as percentages of total area											
Vancouver	6	Ave.	.047	.125	.152	.023	.040	.082	.052	.135	.072	.045	.133	.110
		Max.	.08	.29	.22	.05	.07	.15	.11	.36	.19	.06	.24	.18
Prince Rupert	18	Ave.	.122	.098	.067	.059	.105	.046	.070	.022	.046	.087	.073	.146
		Max.	.92	.79	1.01	.58	.73	.23	.47	.14	.18	.52	.35	.99
Prince George	28	Ave.	.043	.042	.227	.138	.074	.263	.057	.073	.120	.073	.062	.200
		Max.	.53	.30	1.76	1.44	.87	2.61	.53	.82	.95	.44	.29	.80
Cariboo	10	Ave.	.017	.089	.076	.121	.167	.143	.048	.134	.125	.055	.126	.114
		Max.	.04	.29	.19	.62	1.02	.48	.10	.85	.71	.21	.47	.24
Kamloops	19	Ave.	.055	.104	.129	.108	.047	.110	.275	.208	.269	.135	.162	.163
		Max.	.41	.48	.67	.49	.19	.41	1.73	1.35	1.20	.55	.86	.41
Nelson	14	Ave.	.071	.069	.064	.041	.043	.046	.291	.234	.201	.125	.108	.104
		Max.	.25	.17	.17	.19	.26	.18	1.72	.79	.81	.50	.26	.26

[1]Both established and proposed.

TABLE 8. Areas in timber types by Forest Districts and percentages burned annually 1950-73.

Growth No.	Species	Age	Vancouver	Prince Rupert	Prince George	Cariboo	Kamloops	Nelson	All
			Area in type (M acres) and percentage burned annually						
1	F,FPL(C)	M'	181	13	35	876	713	88	1906
	F Decid.		.045	.001	.002	.039	.216	.104	.108
	Pw(C)	I	252	10	46	509	779	216	1812
			.059	.000	.001	.176	.029	.026	.073
2	FC, FCy,	M	197	30	40	55	92	48	462
	FH, FS		.171	.030	.020	3.74	1.46	7.70	.893
		I	337	18	43	66	220	96	780
			.194	.025	.070	1.60	.172	.107	.285
3	FP1(I)	M	17	—	17	249	325	61	669
	FPy, Py		.001	—	.021	.091	.323	.082	.199
	F Decid.(I)	I	218	—	48	9	506	258	1039
			.025	—	.076	.078	.232	.271	.190
4	FL, Pw(I)	M	—	—	—	—	50	249	299
	LF, L		—	—	—	—	.004	.231	.193
		I	—	—	—	—	248	828	1076
			—	—	—	—	.009	.136	.107
5	C, CF,	M	657	2092	176	219	196	61	3401
	CH		.005	.000	.127	.047	.093	.331	.022
		I	43	40	2	3	50	13	151
			.319	.022	.683	.010	.337	.336	.246
6	H, HP1,	M	77	611	23	—	27	50	788
	H Decid.		.001	.008	.001	—	.002	.001	.088
		I	204	154	14	—	16	26	414
			.000	.042	.000	—	.035	.001	.021
7	HF, HC	M	997	2281	35	43	131	127	3614
	HB, HS		.016	.257	.037	.007	.224	.208	.179
		I	212	133	9	12	42	56	464
			.039	.086	.094	.056	.519	.280	.127
8	B, BH	M	617	2283	3067	256	482	564	7269
	BS		.000	.027	.000	.001	.061	.029	.015
		I	89	371	697	75	252	334	1818
			.230	.002	.007	.033	.023	.034	.025
9	S	M	—	606	2697	304	204	106	3917
			—	.059	.023	.097	.003	.064	.044
		I	—	157	2507	126	55	23	2868
			—	1.26	.026	.030	.003	.055	.094
10	SF, SH	M	26	753	2790	454	706	566	5295
	SC, SB		.075	.347	.120	.030	.108	.192	.150
		I	5	133	506	106	160	145	1055
			.009	.002	.141	.061	.088	.034	.092

(Continued)
TABLE 8. Areas in timber types by Forest Districts and percentages burned annually 1950-73.

Growth No.	Species	Age	Vancouver	Prince Rupert	Prince George	Cariboo	Kamloops	Nelson	All
			Area in type (M acres) and percentage burned annually						
11	S PL	M	–	491	1093	250	123	89	2046
	S Decid.		–	.076	.333	.128	.089	.012	.217
		I	–	280	2444	148	83	67	3022
			–	.075	.430	.505	.028	.023	.381
12	PL	M	20	1450	3081	3758	793	234	9336
			.000	.004	.047	.014	.009	.000	.023
		I	60	911	4654	3924	1553	1559	12661
			.010	.011	.031	.221	.066	.009	.090
13	PLF,	M	2	437	1569	473	333	95	2907
	PLS,		.304	.288	.055	.079	.085	.246	.089
	PLB	I	19	323	1185	381	390	526	2824
			.103	.232	.292	.469	.181	.118	.260
14	PL Decid	M	–	–	170	–	–	–	170
			–	–	.000	–	–	–	.000
		I	–	293	614	189	–	–	1096
			–	.000	.000	.012	–	–	.002
15	D Decid.	M	6	256	974	123	8	5	1372
	Mb, Bi		.006	.000	.000	.000	.065	.000	.001
	A Decid.	I	45	569	5290	342	224	125	6595
			.007	.000	.000	.002	.001	.000	.000

M is mature forest inventory area and merchantable timber losses. I is immature. (I) is Interior and (C) is Coastal. In addition to the species listed at the bottom of Table 5, Pw is whitepine, Cy is Cypress (yellow cedar), L is larch, Decid. is deciduous hardwoods, D is red alder, Mb is broad leaved maple, Bi is birch and A is aspen.

marized in Tables 9-12. The most important group is lightning (34.63%). The largest of the other identifiable fire causes is recreation which caused 14.14 percent of the fires. Some of the causes are concentrated in bioclimatic regions; range burning is important in the southwest interior dry belt, the Nechako-Fraser plateau, and the northeastern plains.

It should be possible to refine these estimates of percentages of inventory areas burned annually if adjustments could be made for

TABLE 9. Area burned in public sustained yield units and special sale areas by bioclimatic regions.

Bioclimatic Region	Area burned 1950-73 by cover types Merch.	Imm. M acres	Other	Total	Approx. Reg. Area MM acres	Major Forest types
North and Central Coast	2	7	48	57	26.1	C, H
Southern Coast	3	7	50	60	14.1	F, H
South Coast transition	15	22	84	121	6.1	H, F, B
Southwest Dry Belt	64	85	144	292	15.1	F, PL, S
West Kootenay	4	13	19	36	3.6	S, B, C, F
East Kootenay	22	40	55	117	6.7	S, PL, F
Central Columbia	159	85	293	538	23.1	S, C, H, F
Nechako-Fraser Plateau	61	308	210	579	20.0	PL, F, S
Central Interior	85	23	178	286	19.2	S, B, PL
Northwest Plateau	92	76	1274	1442	30.1	H, B, S
Northcentral Plateau	90	67	580	737	30.8	S, B, Decid.
Northeastern Plains	96	304	2811	3210	39.2	S, Decid.

TABLE 10. Percentage of forest cover type area burned annually by bioclimatic regions in PSYU's and SSA's.

Bioclimatic Region	Merch.	Imm.	Non-forest & residual NSR, NCC	Total	Forest Area in M acres	Annual No. of fires	No. per MM acres
	Percentage burned annually 1950-73						
North and Central Coast	.002	.074	.023	.019	12,177	25	2.1
Southern Coast	.007	.030	.074	.079	6,422	47	7.3
South Coast transition	.056	.143	.160	.128	3,927	108	27.5
Southwest Dry Belt	.069	.079	.206	.108	11,304	474	41.9
West Kootenay	.030	.029	.112	.048	3,129	134	42.8
East Kootenay	.084	.086	.084	.089	5,516	131	23.7
Central Columbia	.175	.084	.163	.155	14,455	336	23.2
Nechako-Fraser Plateau	.038	.169	.203	.129	18,674	173	9.3
Central Interior	.041	.018	.138	.071	16,891	160	9.5
Northwest Plateau	.338	.442	.994	.803	7,482	52	7.0
North central Plateau	.073	.055	.224	.146	20,973	17	0.8
North eastern Plains	.108	.126	.696	.495	27,024	79	2.9

TABLE 11. Numbers of fires, wood volume burned, and total damage in bioclimatic regions 1950-73.

	Number of fires by cover type				M M cu.ft.	M $ damage		
Bioclimatic Region	Mature	Imm.	Other	All	Mature	Mat.	Imm.	Other
North and Central Coast	54	59	503	606	10	234	155	39
Southern Coast	84	104	983	1123	11	689	315	45
South Coast transition Belt	170	267	2306	2582	21	585	1337	300
South west Interior Dry Belt	646	1682	8813	11365	32	1043	1487	231
West Kootenay	159	393	2446	3204	3	309	564	92
East Kootenay	145	551	2254	3152	18	750	812	277
Central Columbia	1110	1016	5362	8063	259	8449	1950	385
Nechako-Fraser Plateau	423	1065	2738	4159	55	1962	5404	563
Central Interior	456	342	2840	3829	91	2536	474	689
Northwest Plateau	152	131	996	1255	118	3835	2133	482
North Central Plateau	78	78	262	410	136	3566	1119	224
North East Plains	213	345	1600	1898	123	3767	7191	943

TABLE 12. Damage per acre and per fire.

	Merch. cu.ft. per Merchan-table acre	Damage per acre Dollars			Damage per	Acres per
Bioclimatic Region	burned	Mature	Imm.	Other	fire($)	fire
North and Central Coast	5391	132.	22.7	.9	706.	93.7
Southern Coast	3144	195.	48.0	.9	934.	53.2
South Coast Transition	1394	38.	60.6	3.6	861.	46.9
South west Interior Dry Belt	503	16.	17.5	1.6	243.	25.7
West Kootenay	697	74.	44.6	4.8	301.	11.3
East Kootenay	831	34.	20.4	5.0	584.	37.2
Central Columbia Wet Belt	1625	53.	23.0	1.3	1337.	66.6
Nechako-Fraser Plateau	897	32.	17.5	2.7	1906.	139.2
Central Interior	1064	30.	20.6	3.9	966.	74.8
North western Plateau	1290	42.	28.0	.4	5139.	1149.0
North central Plateau	1518	40.	16.8	.4	11974.	1796.6
North eastern Plains	1285	39.	23.7	.3	6271.	1691.3

TABLE 13. General causes of fires by bioclimatic regions, 1950-73.

Bioclimatic Region	LGH	REC	RLY	LOG	Cause of Fire RWC Number of Fires	IND	RBR	LCL	MIS	UNK	ALL
North and Central Coast	149	131	4	97	22	21	3	26	146	7	606
Southern Coast	200	281	3	190	26	18	1	68	314	22	1123
South Coast Transition	449	501	480	243	116	38	2	125	574	54	2582
Southwest Interior Dry Belt	2807	2014	1072	828	123	131	423	443	3369	155	11365
West Kootenay	1359	284	489	128	52	39	3	72	740	38	3204
East Kootenay	1268	435	432	165	34	20	3	54	692	49	3152
Central Columbia Wet Belt	5000	482	413	422	123	71	23	279	1142	108	8063
Nechako-Fraser Plateau	692	562	80	213	69	47	1166	194	1025	111	4159
Central Interior	1444	502	200	462	124	49	41	313	636	58	3829
Northwestern Plateau	342	236	66	99	46	16	55	61	315	19	1255
North central Plateau	172	112	1	29	6	11	7	9	56	7	410
Northeastern Plains	541	347	4	60	60	99	345	159	251	32	1898
All No.	14423	5887	3244	2936	801	560	2072	1803	9260	660	41646
All %	34.63	14.14	7.79	7.05	1.92	1.34	4.98	4.33	22.23	1.58	100.00

LGH is lightning, REC is recreation, RLY is railway, LOG is logging, RWC is right of way clearing, IND is industrial, RBR is range burning without permission, LCL is land clearing, MIS is miscellaneous, UNK is unknown, and the total is shown as ALL.

date of inventory, areas harvested and actual depletion by fire and other factors.

The last Table reports the four largest groups of fires from a tabulation of fires by timber cover types in each Forest District. The number of fires, average fire size, and the leading cause expressed as a fraction of the total number are given, for both mature and immature types. Out of a possible 48 cells in this Table, lightning is the leading cause in 40, logging in 4, recreation in 3, and range burning in 1 (immature lodgepole pine in the Cariboo Forest District). The timber types can be grouped for comparison with the growth type data of Table 8. There are 7 in growth type 1, 5 in 2, 5 in 3, 2 in 5, 3 in 7, 2 in 8, 4 in 10, 2 in 11, 9 in 12, and 5 in growth type 13. Again the growth types involving Douglas-fir and spruce and lodgepole pine have been found to support the most fires. Fires in the more remote portions of the Prince Rupert and Prince George Forest Districts have been very large, 1950-73.

CONCLUSIONS

Analyses of rates of spread and percentages of area burned show large and important effects of ground cover and timber types. It is obvious that fire hazard is very high in slash as a result of high rates of spread and resistance to control.

By describing variation in wildfire effects for 95 existing or proposed publicly managed units within 12 bioclimatic zones, we have illustrated the severity of fire losses. Our summary of past experience may help improve methods of fire management to be employed in the future.

There is a particular need to develop codes to distinguish among forest and non-forest elements of the "other cover" category of fire damage. Methods used for relating fire damage to timber type also should be improved and maintained on a current basis.

Fire control objectives should be defined and monitored annually for each publicly managed unit using the B.C. Forest Service fire tapes.

TABLE 14. Number, size, and leading cause of fires in the four timber types having most fires in mature and in immature stands in each Forest District, 1950-73.

Forest District	Age class	TT[1]	No. fires	Size acres	Leading Cause prop.	TT	No. fires	Size acres	Leading Cause prop.	TT	No. fires	Size acres	Leading Cause prop.	TT	No. fires	Size acres	Leading Cause prop.
		1				2				3				4			
Vancouver	M	F	45	43	.24LOG	FC	42	72	.45LOG	HB	36	29	.58LGH	FH	31	147	.41LOG
	I	F	117	30	.20REC	FC	72	111	.22LOG	FH	61	90	.21LGH	HC	23	67	.26LGH
Prince	M	SB	46	1362	.67LGH	PLS	42	717	.43LGH	PL	28	54	.43LGH	BS	26	150	.69LGH
Rupert	I	PL	79	29	.19LGH	PLS	43	418	.26LGH	S	30	1589	.43REC	SPL	29	173	.28LGH
Prince	M	SB	191	419	.76LGH	S	159	90	.50LGH	PLS	68	299	.43LGH	PL	60	587	.52LGH
George	I	PL	211	164	.31LGH	S	179	88	.31LGH	PLS	117	709	.29LGH	SPL	102	2389	.37LGH
Cariboo	M	PL	144	88	.31LGH	F	137	60	.29LGH	S	52	136	.48LGH	FPL	43	7	.35LGH
	I	PL	859	242	.47RBR	F	234	23	.21LGH	FPL	145	109	.28LGH	PLF	40	144	.30LGH
Kamloops	M	F	160	23	.59LGH	SB	152	118	.84LGH	CH	135	28	.88LGH	FPy	96	181	.28LGH
	I	F	411	13	.39LGH	PL	255	96	.44LGH	FPy	241	64	.19LGH	Py	213	12	.26REC
Nelson	M	CH	139	14	.88LGH	SB	136	150	.91LGH	HC	50	60	.80LGH	BS	37	1	.81LGH
	I	F	209	7	.42LGH	FL	174	122	.50LGH	PL	168	21	.65LGH	FS	125	11	.45LGH

[1]Symbols for species in timber types (TT) are given in Tables 5 and 8, and for fire causes in Table 13.

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