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CANADA - DEPARTMENT OF TRANSPORT - METEOROLOGICAL BRANCH

AN ANALYSIS OF THE BRITISH COLUMBIA FIRE DANGER TABLES FOR THE 1961 FIRE SEASON

by

Kenneth W. Foster

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ABSTRACT

An effort is made to demonstrate the reliability of the Federal Forest Fire Danger Tables as an index of the probability of a fire starting. The data for 1961 is the basis for the study of the Kamloops, Prince George, Prince Rupert, Nelson and Vancouver Forest Districts. In order to illustrate the reliability of the index to new fire starts, a graph of the cumulative percentage of fires in each danger class against the cumulative percentage of days in each class was used.

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1. INTRODUCTION

During the fire seasons 1957, 1958 and 1959 the Federal Department of Forestry operated a field research station near Hundred Mile House in the Cariboo and another in the Cowichan Valley near Duncan on Vancouver Island. Data on weather (humidity, wind and rainfall), fuel moisture, and test fires were empirically correlated into two separate "Cariboo" and "Coast" Forest Fire Danger Tables - "Canada, Department of Forestry, 1961" designed to indicate for their particular forest type the rate of spread, resistance to control, and new fire starts during the afternoon of calculation.

The rating system integrates past and present weather data into a coded estimate of fuel moisture content. This drying code estimate is combined with a drought index, and a seasonal factor, then corrected for wind speed and overnight humidity to produce a danger index. The index has a scale from 0 to 16 and is grouped in danger classes - Nil (0), Low (1-4), Moderate (5-8), High (9-12) and Extreme (13 - 16.

The index may serve as a criteria for fire permit issue, the staffing of secondary lookouts, aircraft disposition, fire suppression crew placement, fire analysis and forest closure decisions.

The aims of this report are, on the basis of 1961 records, to demonstrate the reliability of the Federal Fire Danger Tables as an index of the probability of a fire starting and to compare the reliability of B.C. Provincial Forestry Stations and D.C.T. Meteorological Stations.

Rate of spread and resistance to control has not been compared to the danger index because records are not adequate for this purpose. The total final acreage of fires starting on a particular day, which Williams (1959) has used to compare these factors, is too subject to single occurrences with only one year of data. Also, since control action

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Footnote: In this report the term 'index' will be taken to mean the danger index unless an obvious reference to some other type of index is implied.

is geared to fire danger, the correlation between area burned and the danger index would be lower than if the control action were constant. Beall (1950) states that "the average number of fires occurring per day in each class of fire danger is probably one of the best statistical measures of the reliability of the danger rating system". Turner (1959) in an analysis of the Model 8 Burning Index for use in the Nelson District found that the differences caused by using the maximum danger class during the life of the fire was important only in a few cases. However, on the fires of 100 acres or larger studied in the Kamloops District only in 60% of the fires was the starting day significant to the large burn of the fire. It was decided to test the index primarily as a new fire starting index, comparing the day of origin of the fire with the local index of that day. Areas studied were based on ranger districts rather than on areas of fixed radius from the station as Williams (1959) and Beall (1950) have done. It was felt that use of the climatically similar ranger districts was at least as justified as the use of an arbitrary circular area.

An attempt was made to compare the "severity" of the weather at each of the stations by using Williams' (1959) severity factors. These are based on the rate of spread (a perimeter ratio obtained from test fires) and the resistance to control of fires (a drought ratio determined from the average drought index at the mid point of each danger class at two fire weather stations, one in New Brunswick and one in Saskatchewan, over a five year period). These factors are calculated for each danger class. The "severity" is the sum of the products of the severity factor for each class and the number of days in that class divided by the total number of days in the season. The factors used were 0 for Nil, .2 for Low, 1 for Moderate, 4 for High and 12 for Extreme. Using this method different seasons can also be compared.

The reliability of the test results is influenced by "weather independent" fires, lightning, variation in risk over large areas, and the small sample of data. Though listed as a result of Forest Service action some fires for our purpose should not be considered as forest fires, e.g. Fire #826 in Vancouver District occurred on July 6 with an index of 2 at Comox and 0 at Alberni - a gravel truck fire which took 40 minutes to control. A certain percentage of these fires occur in every district independent of the weather danger. A study of low index fire occurrences at Princeton was made and the following table drawn up.

LOW INDEX FIRE OCCURRENCES AT PRINCETON
Spot lightning is excluded
Account by index of all fires starting on days with index less than 5.

Case	Size in acres	In 3 days before	2 days	1 day	start day
1	1/4 A	5	5	1	1
2	1 A. Lightning	9	12	1	0
3	15 A. Lightning	14	14	0	0
4	2 spot fires	6	8	6	2
5	1 spot fire	4	9	12	1
6	1/4 A. Lightning	13	12	12	0
7	2 A	14	10	6	4
8	1/2 A. and 2 A.	9	10	-	4

In cases 2, 3 and 6 lightning caused the fires on nil days. In each case they follow periods of a high index. This is characteristic of lightning incidence which is often connected with rain and higher humidities which lower the index. These strikes start duff smouldering and when drier days return they break out as fires. All spot lightning fires were eliminated from consideration for this reason. The larger lightning fires, which were included, may also have the effect of reducing apparent reliability as they occur either after a warm spell (on days of low index) or on high days as dry lightning strikes. Fuquay (1962) reports that in the Rocky Mountains south of the Canadian border some areas receive 1,500 flashes to the ground per thousand square miles during July and August and that lightning accounts for 70% of the fires. In the Nelson Forest District 52% (1952-61 average) of the fires were lightning caused.

Cases 5, 7 and 8 are examples of man-caused fires following a period of high index. Some may have been discovered one day late; others may be "weather independent". In cases 1 and 4 they follow a moderate index. The effect of excluding these fires in the comparison of fire occurrences to the danger index is illustrated in Figure #1 of the Kamloops District. The greater distance of the fires on days with moderate or higher rating from the random diagonal line indicates the better relationship. This effect could possibly be applied to all comparisons made. Of course not all these fires occurring on days with LOW or NIL rating can be considered 'weather independent'.

The application of any index over a fairly large area is another problem. One must note differences in fuel type from grass to wooded areas and the differences in occupation, accessibility to camping and recreation, the degree of logging off in areas, elevation, slope, forest closure, prevention control, and the awareness of the public to the danger. The public is more careful in obviously high danger periods than in moderate danger periods with the result that the apparent effectiveness of the index in the high days is reduced. There is more of a risk from the public on weekends. Adequate log supplies may make it practical for larger organizations to close down or to limit their operations during the peak of the fire season. Rain showers of limited coverage add to the difficulty of using a large area of new fire starts to compare to one index, but to obtain enough data from one year to indicate any relation requires this expedient. Further, stations not in the forested area, in a dry valley bottom or on a mountain top or along the coast can only approximate forest conditions of the large area so could not be expected to relate closely to fire behavior.

The greatest limiting factor in the testing was the small sample of fires to compare to an index in any area. One year of data was found insufficient for adequate testing. The fires, for example, could not be grouped by their cause for testing. The year 1961 may not have been a representative year for it had four months of subnormal rainfall, nine major electric storms and intense cumulative drying throughout July and August, particularly in the northern part of the Interior Plateau.

2. DISCUSSION OF THE RELATIONSHIP BETWEEN THE DANGER INDEXES AND FIRE OCCURRENCE

Discussions were grouped by Forest Districts - Kamloops, Prince George, Prince Rupert, Vancouver or Nelson, because the information varied from district to district. As a result, different techniques of analysis were applied to each district. See Appendices II to VI.

In order to illustrate the reliability of the index to new fire starts a graph of the cumulative percentage of fires in each danger class against the cumulative percentage of days in each class was used. The greater the area between the diagonal line and the line graphed the more effective is the index. The advantage of the diagram is that it is independent of the actual scale numbers used in the rating system and illustrates clearly the ability of the system to indicate the serious fire days. The danger classes are marked by the specific index at the right of the beginning of the class. The line graphed normally includes all fires except the spot lightning fires. When another grouping is used this is indicated on the graph, such as the group excluding less than 4 acre lightning fire and all spot fires, designated as (4LO).

Kamloops

Data

Station	Period of Record	Severity Index 1961 Whole Season	1961 June-Aug.	1962 June-Aug.
Princeton (YF)	May 31 to Sept. 30	3.2	2.9	3.1
Penticton (DC)	May 31 to Sept. 30	2.6	2.1	3.0
Black Knight	June 7 to Sept. 29	1.9	-	-
Kamloops (KA)	May 31 to Sept. 30	5.4		
Kamloops (Ranger Sta.)	May 1 to Sept. 29	3.6		
Ashcroft (ZA)	June 14 to Aug. 26	6.6 (approx. 4.4 when adjusted)		
Lytton (LY)	June 2 to Sept. 30	4.8	-	-
Alexis Creek	June 12 to Sept. 28	4.7*		
Williams Lake (WL)	May 31 to Sept. 30	5.1	6.2	1.8
Begbie L/O	June 5 to Sept. 20	3.8	-	-
Blue River	June 4 to Sept. 30	.8		

*Fuel in District 14 (Alexis Creek) might be better represented by a Grass Danger Index.

Princeton's Index (graph Kamloops #1) correlates positively to the new fire starts in the surrounding district, except in the extreme class. Penticton's indicates a more random relationship to fires (#2,3). Elimination of all lightning fires smaller than 4 acres and all spot fires from consideration produces a slight relationship (4LO #2,3), but still the valley station

is a poor indicator of the starting probability of a forest fire. Black Knight Forestry Station, on the other hand, is up on the plateau in the forest. The index relates very well with the surrounding areas (#4) which are of a similar elevation, but results in districts to the south (#5) are as poor as Penticton's. Fires occurring on the grassy areas of southern Kamloops District would not apply, complicating the testing of the Danger Index in this area.

To the north near Kamloops there are two stations, the airport meteorological station and the forest ranger station, approximately nine miles apart. In the area immediately surrounding Kamloops (#6) the forestry station appears better in the extreme, but both are good. To the south and southeast (#7) the forestry station relates slightly better in the high and extreme, but both are poor. To the east (#8) the airport is better in the extreme and the forestry station in the moderate, either index being quite reliable. Similarly for the area to the west (#9) the Kamloops index is very good. Slightly erratic random curves for North (#10) show that the index is beyond its range of applicability. For the total area (#11) the forestry station appears to give a slightly better indication than the airport particularly in the high and moderate danger classes.

Lytton's index relates quite well with the new fire starts in the surrounding area and to the north (#12), but south and west (#13) it is poor, random in the high and extreme. Ashcroft's index, though having a lower severity, was very similar to Lytton's so was not tested. Alexis Creek's (#14) almost random distribution of total fires (some reliability in the moderate range) and slightly positive correlation on the range burning excluded group only serves to indicate the inapplicability of the index to the area. (Turner suggests that a Grass Index would be better). The record for Kleena Kleene was too incomplete due to weekend lapses to test it.

To the west the Williams Lake station's index applies in the forested surrounding (immediately south (#15), and northeast (#16)) areas; but west in RD.14 (#17) and southeast (#18) there exists a random relationship. Begbie Lookout's index seems also to apply very well near the station, north (#19), northeast (#20), and east (#21); but south and west (#22) the relationship is poor.

At Blue River a poor positive relationship exists in the north Kamloops District (#23), however, in its own ranger district, RD.18, the limited evidence of six fires shows a possible excellent relationship. The small number of fires agrees with the low severity.

Summary by Ranger Districts of suitable stations for each area.

A - very good
B - fairly good

Southern Kamloops

R.D.17	Kamloops (airport and forestry)	B
	Princeton	B
R.D.10, 11	Princeton	B?
R.D.15	Black Knight	A
	Princeton	B

Central Kamloops

R.D.24	Begbie L/O	A
	Williams Lake	B
R.D.12	Williams Lake	A
	Kamloops	A
	Lytton	A
R.D.16	Lytton	A
	Kamloops	B
R.D.22, 8	Kamloops	A
	Lytton	A
R.D.2,3	Begbie L/O	A

Northern Kamloops

R.D.14	nothing	wrong fuel type
R.D.13,21	Williams Lake	A
	Begbie L/O	A
R.D.23,	W.G.P. Williams Lake	B
	Begbie L/O	B
	Blue River	A
R.D.18	Begbie L/O	A
	Williams Lake	B

East Kamloops

R.D.5,6	Kamloops	A
R.D.1,19,7,4	Kamloops	B
R.D.9	Black Knight	A

Except for R.D.14 and the Southern Kamloops area, Kamloops Forest district is fairly well covered with suitable stations if both meteorological and forestry stations are used, i.e., Kamloops, Lytton, Williams Lake and Princeton together with Black Knight, Blue River and Begbie Lookout. Better coverage might be achieved with forestry stations in Ranger Districts 19 and 23.

Kamloops Fire Histories

Six fire histories accompanied by the local danger and drought indexes have been selected to illustrate the relationship between the danger index and fire behavior. Their positions in relation to the stations are plotted on the Kamloops map.

#524 illustrates the principle that a fire cannot burn without fuel, a non-weather factor. On the day the fire exploded both at Williams Lake and Begbie Lookout the indexes reached the maximum of 16.

#562 is an example of a fire which lay smouldering for a long time until conditions became extreme and then broke out of control on the same day as #524, August 5.

#766 was lightning started on August 2. The high to extreme days favoured its growth. Williams Lake's index reached 15 and this fire spread. The following day, August 5, Williams Lake and Begbie reached 16 and

the fire increased to 2500 A., out of control. On the 8th a drop from 14 to 9 in the index at Begbie was accompanied by the fire being quiet. However, on August 11 Begbie's index had climbed back to 16 and the fire jumped the guards and spread to 5000 A. The indexes remained in the extreme, the fire burned furiously. A drop of the index to 8 on August 16 and the fire was quite, but by August 20 Begbie's index was back up to 14 and the fire again crowned, jumped, spotted and spread. August 21 was more of the same. Begbie's index stayed high to August 24. By this time the fire at 12,000 A. had probably created its own weather, however, on August 24 a drop to index 8 accompanied a now quite fire and by September 2 with an index of 3 at Begbie the fire was under control. Similar comparisons can be made between the Williams Lake index and #773, #911 and #1013, the fires usually jumping on the high days and more quiet on lower index days.

#1013's growth is very notable in that it created such an up draught that it affected #911 which soon joined it. The explosive day had an index of 13 at Begbie and 0 at Blue River indicating that rain was near, but none actually fell on the fire, and in any case once started the fire created its own weather. Control was only reached with Begbie's index moderate and Williams Lake's and Blue River's low.

One interesting note is that fire #954 was a hangover fire from a millsite burn. Under the extreme cumulative drying conditions on the fortieth day of 25 Drought Index at Williams Lake this fire broke out spontaneously. This supports the contention that there is a residual effect well beyond 25 days without significant rain.

SUMMARY OF FIRE HISTORIES COMPARED TO THE DANGER INDEX AT NEARBY STATIONS

(For location of fires see Kamloops Map)

Code:

B	- Burning well	R	- Rain
CR	- Crowning	O	- Spot fire
CON	- Control of blaze	SM	- Smoke
GC	- Guard completed	SP	- Spotting
H	- Hotly burning	V	- Very
JG	- Jumped guard	W	- Wind
OC	- Out of control	W+	- Very strong wind 50 - 60 mph
Q	- Fire quiet		

Date	#524 in W.G.P. disc. 5/7 Fuel: spruce, balsam El. 3,400 Feet Known Lightning fire	#562 in R.D.23 Known lightning fire - July 17-SM 18-21 no SM Fuel: Cedar, hemlock moss and debris El. 2,600 feet	#766 in R.D.23 Fuel: moss and duff, rotten windfall Known Lightning fire	#773 in R.D.23 Fuel: Deciduous, cedars, mature spruce, cedar snags, fir alder, deep duff	Wms. Lake Danger Index	Wms. Lake Drought Index	Begbie Danger Index	Begbie Drought Index	Blue River Danger Index	Blue River Drought Index
1/8	was			El.3,500 feet	13	25	12	23	6	3
2/8	B to 300 A	3 A.	0	Known lightning	12	25	11	24	9	4
3/8		GC	40 A.	fire	12	25	13	25	8	5
4/8		Q	150-300 A		15	25	13	25	7	6
5/8	W+ VH	W+ 15A, 100 A., H	350 A. W+ CR, 1500 - 2500 A.	0, 5 A	16	25	16	25	2	7
6/8	NOTE: Fire ran	2000 A., B	CR, B	SM	13	25	12	25	4	8
7/8	out of fuel	NOTE: no further	- 3000 A.	GC, JG, 5 A.	11	25	14	25	5	9
8/8	final acreage	control action	GC, Q	H. SP, B, 450 A.	13	25	9	25	7	10
9/8	2000 A.	Final acreage	B, - 3,500 A.	Q. B.	13	25	10	25	7	11
10/8		15,282 A. - e.g. of a fire which lay smouldering until conditions become extreme.	H, CR, 4,000 A. -	B.	14	25	13	25	7	12

SUMMARY OF FIRE HISTORIES (continued)

Date			#766 (continued)	#773 (continued)	Wms. Lake Danger Index	Wms. Lake Drought Index	Begbie Danger Index	Begbie Drought Index	Blue River Danger Index	Blue River Drought Index
11/8	#954 in R.D.24		H, CR, JG	JG, W+, JG	13	25	16	25	7	13
	Hangover from a		5000 A							
12/8	millsite burn		CR, JH, 5,500 A.	B	15	25	14	25	8	14
13/8	No rain since 27/5	#911 and 1013 in R.D.	OC, 6,000 A	B, JG	15	25	14	25	8	15
14/8	Fuel: spruce, pine,	23 possible	6,000 A.	JG, Q, CON	16	25	14	25	3	16
15/8	balsam, fir	lightning fire	GC, 6,000 A	Q late in day	13	25	10	25	1	17
16/8	El. 4,500 -	Fuel: fir, spruce	1/2 hr. R, VQ,	R, Q	11	25	8	25	0	11
	6,200 feet	open slash, snags	6,000 A.							
17/8		windfall	Q	Q	8	25	5	25	0	0
18/8		El. 3000-4000 feet	Q	VQ	7	25	5	24	1	1
19/8		1013 joined 911-24/8	JG, 6,500 A.	VQ	11	25	10	25	2	2
			JG,CR,SP,8,500A	VQ	13	25	14	25	6	3
		start 0, W - 75 A								
21/8		OC, CON at 500 A., CR	W + 9,000 A.	Q	14	25	15	25	9	4
22/8	1/4A, 5 or 6 Os	B	9,000 A.	Q	12	25	14	25	6	5
	75-100 A.									
23/8	H, CR, JG, VH	Q, CON	10,000 A.	Q	8	25	12	25	5	6
24/8	1000 A. W+ H,	#911 - Q,CR,2000 A.	JG,CR,12,000 A		7	25	13	25	0	7
	1/2 hr. R	#1013 - Q2,10,20								
		1500, 8000,10,000 A.								
25/8	Q, 2000-3000 A. GC	B, 25,000 A.	Q, 12,000 A.		1	19	8	25	3	0
26/8	B	Blew across lake	1/2 hr. R, JG,13,000 A.		2	20	9	25	2	1
27/8	H	CON	13,500 A		2	21	8	25	2	2
28/8	CON	Q	R, 13,500 A.		4	22	8	25	1	3
29/8	R	R	R, 13,500 A.		1	22	7	25	-	4
30/8	R		13,500 A.		3	23	7	25	-	-
31/8	R. Q.	R	Q		2	23	5	25	1	0
1/9	VQ	R	R		3	24	3	7		
2/9	Q	R	CON		5	25	3	8	Missing	
3/9	patrol	R	R		1	23	5	9	"	
4/9	"	R	End of patrol	Fire dying out	0	9	4	0		
5/9	V	R			2	9	4	1	0	0

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Prince George

Data

Station	Period of Record	1961	Severity 1961 June-Aug	1962 June-Aug
Prince George (XS)	May 3 - Sept. 30	2.2	2.9	1.0
Quesnel (QZ)	May 3 - Sept. 30	1.2		

The Prince George index gives an excellent indication of the fire weather danger in the Prince George District. In the areas near the station (Prince George #1) and areas west of the station (#2) there is a very good relationship between new fire starts and the danger index. The choice of low and extreme days is not as good in the west as in the immediate area. The graph for the west is similar to that of Smithers for the same area (Prince Rupert #4). South (#3) and east (#4) there is an accurate indication of fire occurrence. The index seems most reliable.

Quesnel's rating (#5) is very good and could be used to supplement Prince George's. Even in the surrounding area (#6) the index appears quite good.

Prince Rupert

Station	Period of Record
Sandspit (ZP)	May 31 - Aug. 13
Prince Rupert (PR)	May 31 - Aug. 13
Terrace (XT)	May 31 - Sept. 30
Smithers (YD)	May 31 - Sept. 30

Station	Ranger District	Severity 1961 June-Sept.	1961 June-Aug.	1962 June-Aug.	Area in Sq.Mi.	No. of fires per 100 days per 10,000 sq. mi.
ZP	2	.4		.2	No fires during period of record.	
PR	3	.2			13,000	1
XT	4,5	3.0			10,800	8.3
XT	7,8	3.0			3,300	22.4
YD	7,8	.9	1.0	1.3	3,300	22.4
YD	15,9,10,11	.9	1.0	1.3	6,600	1.3

There were insufficient fires to compare the indices of Sandspit (ZP) on the Queen Charlotte Islands and Prince Rupert (PR) to the local fire occurrences. Their very low severity ratings agree with this lack of fires.

Terrace's relationship (Prince Rupert #1) is very good, however, the extreme class is random indicating perhaps the inability of the index to choose the very extreme days, the increased awareness of the public to the danger, or the fact that part of RD.4 extends too far north where the index is unsuitable. East (#2) all the fires occurred on indices of 7 or above, yet the extreme class does not select the worst days.

Smithers in the surrounding area (#3) is very good and can be compared to the good graph made by Terrace, Smithers rating being a better indication of the high days. East (#4) the index is also very good. Less ability to choose the extreme days is illustrated, but the index is applied up to 120 miles from Smithers. The lower severity rating (.9) agrees with the lower incidence of fires that occurred in this area as compared to around Terrace.

Vancouver

Station	Period of Record	Severity 1961	1961 June-Aug	1962 June-Aug
Vancouver Island				
Victoria (Gonzales-City) (VI)	May 31 to July 26	1.8		
Langford	May 28 to Sept.29	3.2		
Victoria (Airport) (YJ)	May 31 to Sept.30	2.3		
Duncan	June 1 to Oct.16	3.9		
Alberni	May 28 to Aug.27	3.6		
Tofino (AZ)	May 31 to Sept.30	1.2		
Estevan (EP)	May 31 to July 26	.6		
Little Mountain	May 28 to Sept.3	2.6		
Plateau	June 8 to Sept.26	2.9		
Comox (QQ)	May 31 to Sept.30	2.9		
Menzies	May 30 to Sept.29	2.7		
Woss (R.D.15)	July 10 to Sept.28	1.4		
Port Hardy (ZT)	May 31 to Aug.13	.8		
Shelley (RD.16)	July 10 to Sept.28	.6		
Mainland				
Hope (HE)	June 2 to Sept.30	3.3		
Mission	June 7 to Sept.27	2.2		
Abbotsford (XX)	May 31 to Sept.30	1.5	1.7	.7
Vancouver (VR)	May 31 to July 26	1.1		
Sechelt	June 1 to Sept.22	1.6		
Mt. Hallowell	June 5 to Sept.24 excluding June30 to July 9	3.2		
Echo Bay (RD.14)	June 8 to July 30	2.2		

Other Meteorological Stations

Bull Harbour, Spring Island, Alert Bay Holberg, Chatham Point, Port Alberni, Nanaimo, Alta Lake and Westview. The data for Nanaimo was missing from John Armstrong's data so was not tested.

To determine the reliability of the Vancouver District stations a statistical test was used. (See Apendix). Two indicates 95% significance and three indicates 99% significance. All figures have been worked out to more decimal places, but have been rounded off to the lower figure, e.g. 2.9 becomes 2.

As a result of the relatively large number of stations it was possible to compare the indexes of the stations against each other. The difference in their means, their standard deviations and the percent of days not agreeing within two index units were calculated.

In the Vancouver district each area is discussed individually, comparing the danger classes and new fire starts and the different stations.

Vancouver Island

Southern Vancouver Island

Significance Test*

	District	Ext/LN	High/LN	11+/LN
Victoria Airport	23	2	4	5
Langford	23	2	4	3

Station Comparisons

	Severity	Difference of Class Mean	Standard Deviation	% not within 2	Days in Comparison
Langford/Victoria Airport	3.2/2.3	+ 1	2.0	20%	118
Langford/Victoria Ciry	3.2/1.8	+ 1	1.9	25%	56
Victoria (City)/Victoria (Airport)	1.8/2.3	0	1.7	11%	55

Langford's index agrees with the index at Victoria Airport (YJ), but, as it reached high before the Airport's, it might be a better indicator of the more extreme conditions away from the coast. The early start of the fire season in this area supports this view. For a broader coverage the Airport's index, moderated slightly by the forest, fog, and sea and not too influenced by the extreme local conditions near Langford, corresponds more adequately to conditions along the west coast and in the Central and Southern Vancouver Island areas. Victoria's City office index agrees closely with the Airport's except, in very few instances, but the Airport's is probably better since it is not so affected by the sea breezes and Juan de Fuca Strait winds. One year's data is insufficient to prove this.

/Ext/LN indicates that the test for significance was applied to comparison between fire probability on days in the EXTREME danger class and that on days in the LOW and NIL danger classes.

South-East Coast

Significant Test

	Ranger District	Ext/LN	High/LN	11+/LN
Victoria Airport (YJ)	21,22	1	3	1
Duncan	20,21,22	3	3	

	Severity	D C M*	SD*	% not	Days
Duncan/Victoria Airport (YJ)	3.9/2.3	+1	2.9	41	118

Duncan's index chooses the extreme days very well. The index was developed very near there so the fuel type and compensation for the diurnal pattern of wind was probably correct. Not influenced by fogs from the west coast the index is reliable only for the east coast and interior where it is better than Victoria's latter index. The Airport's however, is fairly good, and quite comparable. Comparison of indexes indicates a poor relationship, so although Victoria's is good for the general weather changes, Duncan's index is more effective for its more local changes.

North and East Coast

Significance Test

	Ranger Districts	Ext/LN	High/Ln	11+/LN
Victoria (YJ)	20,19,24	1	4	3
Plateau	17,18,19,20	1	1	
Comox (QQ)	17,18,19,20	2	2	
Little Mountain	18,19,20,21	1	2	
Menzies	17,18,19	0	0	

Station Comparisons

	Severity	D.C.M.	SD	% not	Days
Little Mt./Comox	2.6/2.9	0	2.9	28	94
Menzies/Comox	2.7/2.9	-1	2.3	24	112
Alberni/Comox	3.6/2.9	0	2.4	26	87
Plateau/Comox	2.9/2.9	-1	2.1	31	102
Comox/Victoria Airport (YJ)	2.9/2.3	0	2.3	19	116
day change - Comox/Victoria Airport (YJ)		0	2.4	19	116

* refer to previous table for meaning of abbreviations.

Victoria Airport's index applies very well to the interior area, but Comox's would probably be the better index. The Forestry Station at Alberni appears to be representative of RDS. 17, 18, 19, but insufficient data prevents accurate comparison. The Alberni (Met) station might easily be used. Nanaimo's data was missing so was not tested. The indexes at meteorological stations appear to be better than those at forestry stations, probably because of the stations' lower elevations and nearness to the forests. Comox's index compares quite closely with Victoria's, indicating the same general weather conditions for most of the island.

West Coast

Significance Test

	Ranger District	EXT/LN	High/LN	11+/LN
Victoria Airport (YJ)	25, 26	-	4	3
Tofino	24, 25, 26	-	1	
Alberni	25, 26	-	3	4
Comox	25, 26	1	5	

	Severity	D.C.M.	SD.	% not	Days
Estevan/Tofino	.6/1.2	-1	1.5	16	56
Tofino/Alberni	1.2/3.6	-2	2.7	33	84
Alberni/Comox	3.6/2.9	0	2.4	26	87

Tofino's index is too moderated by the sea to be an effective index for the inland area where most fires occur. Estevan's index parallels Tofino's. Alberni's in the interior corresponds very well to incidence of coastal fires, as does Comox's and Victoria's.

North Vancouver Island

As a result of low weather hazard the Port Hardy area had too few fires to make comparisons. The severities of the forestry stations of Woss Lake (1.4) and Shelley (.6) agree with Port Hardy's (.8) and support the evidence of few fires.

Total of Vancouver Island

Significance Test

	Ranger District	Ext/In	High/LN	11+/Ln
Victoria (YJ)	19 - 26	3	8	8
Comox	17-20,25,26	2	5	

The meteorological stations seem to adequately cover the island. Comox and especially Victoria Airport appear to be excellent. A network of Port Hardy, Alberni, Comox, and Victoria, supplemented by Langford and Duncan Forestry stations, should be very good in practice.

Mainland Vancouver District

Area: Lower Fraser Valley

Significance Test

	Ranger District	EXT/LN	High/LN	11+LN
Abbotsford	1	1	3	2
Hope	1	1	2	
Mission	1,4	2	2	

Station Comparisons

	Severity	D.C.M.	SD.	% not	Days
Abbotsford/Hope	1.5/3.3	-2	2.3	46	114
Mission/Abbotsford	2.2/1.5	0	1.8	16	83
Vancouver/Abbotsford	1.1/1.5	0	2.1	13	54
day change - Mission/Abbotsford		0	1.6	12.5	64

Abbotsford parallels Mission, the forestry station, and is a good reliable indicator of fire occurrence. Hope is in a more continental location and its index is not representative of the lower valley.

South Eastern Vancouver District

Significance Test

	Ranger District	EXT/LN	High/LN
Abbotsford	2,3		3
Hope	2	3	1
Hope	2,3,4	3	1

Station Comparisons

	Severity	D.C.M.	SD.	% not	Days
Abbotsford/Hope	1.5/3.3	-2	2.3	46	114

The index at Hope, the best station for this area, indicates the extreme days very well.

Railway Fires in R.D. 6 — Significance Test

	Ranger District	EXT/LN	High/LN	11+/LN
Sechelt	6 Rly.	0	3	0
Abbotsford	6 Rly.	0	0	0
Hope	6 Rly.	10	12	11

Station Comparisons

	Severity	D.C.M.	SD.	% not	Days
Sechelt/Abbotsford	1.6/1.5	0	3.4	39	99
Sechelt/Hope	1.6/3.3	-2	3.0	51	97
Abbotsford/Hope	1.5/3.3	-2	2.3	46	114

Hope's index indicates the dangerous conditions in the interior, while Sechelt's, though having little correspondence with Hope's, also indicates some correlation to the railway fires.

Mainland Coast and Northern Interior

Significance Test

	Ranger District	EXT/LN	High/LN
Sechelt	5,6,7,8		2
Abbotsford	4,5,6,7		
Hope	2,3,4,5,6	3	1

Station Comparisons

	Severity	D.C.M.	SD.	% not	Days
Sechelt/Abbotsford	1.6/1.5	0	3.4	39	99
Sechelt/Hope	1.6/3.3	-2	3.0	51	97
Abbotsford/Hope	1.5/3.3	-2	2.3	46	114
Mt. Hallowell/Abbotsford	3.2/1.5	+1	3.7	46	97

Hope's relates with these areas, but Sechelt's severity index is much closer to the actual fire occurrence of the area. There were insufficient fires and extreme and high days to draw conclusions on this wet coast area.

Total for Mainland

	Districts	Ext/LN	High/LN
Abbotsford	1-7		5
Mission	1-7	4	3

The indexes at Abbotsford and Hope together give a good indication of forest fire danger in southern mainland Vancouver District. Mission, the forestry station, parallels Abbotsford, so that duplication would be unnecessary. The Northern Vancouver District is perhaps indicated by Port Hardy's and in the Interior an index computed at Alta Lake (AE) might be of value.

Nelson

Data	Federal Index Meteorological Stations	Period of Record		Severity 1961	Severity 1962
	Old Glory (CG)	June 21 to July 26	.9		
	Carmi (XO)	May 31 to Aug. 13	2.5		
	Crescent Valley (QS)	May 31 to Sept. 30	.7	.7	.6
	Kimberley (QE)	May 31 to Sept. 30	1.3	1.6	3.6
	Revelstoke (RV)	May 31 to Aug. 13	2.0	2.2	1.3

Forestry stations using Model 8 Index.

Beaverdell	May 31 to Sept. 28
Cranbrook	May 31 to Aug. 13
Revelstoke	May 31 to Aug. 13

A comparison of the Federal Danger Table and the Model 8 Danger Index was made using Revelstoke (RV) and Revelstoke Forestry station, Carmi (XO) and Beaverdell, and Kimberley (QE) and Cranbrook. The results indicated a correspondence between the indexes.

There was not enough data to compare each pair of stations though this would give a better correlation.

Model 8	Total Distribution of Three Pairs of Stations						
61-70	0	0	0	2	1	1	3
51-60	1	1	0	0	7	6	0
41-50	1	4	4	11	7	4	1
31-50	8	14	9	12	16	12	0
21-30	33	21	16	9	2	3	0
11-20	24	9	2	4	1	0	0
0-10	8	0	0	0	0	0	0
Federal Index	0-2	3-4	5-6	7-8	9-11	12-14	15-16

The results indicate a conversion of:

Federal Index	Model 8
0-1	Low (0 - 20)
2-7	Moderate (21 - 35)
8-11	Average (36 to 50)
12+	High (50 - 75)

It was noted that on the Revelstoke (RV) - Revelstoke comparison, 60% of the time they were in the same class and 40% of the time they were different by one class.

Old Glory's (Nelson #1) graph of new fires starting in each danger class is random. The station (7,700 feet) is above the forest, so the results are not too surprising.

Carmi's relationship (#2) although positive does not pick out the extreme days. Unfortunately for test purposes, only 3 fires occurred in R.D.20 so the whole area was considered and the ability of a station to pick out extreme and low days decreases with distance.

Crescent Valley in the immediate area (#3) using the less than 4 acre lightning and all spot excluded group (4LO) indicates a good relationship, however, there were 80 spot lightning fires, 15, 1/4 to less than 4 acre lightning fires, 19 spot non-lightning fires, and only 15 4LO fires. In districts further away (#4) the relationship is again quite random except for the 4LO class of fires. Spot lightning fires in all areas have a negative relationship to the index, more fires start on low days.

Kimberley relates well in the surrounding area (#5) and is a good index in districts further away (#6).

Revelstoke in the close surrounding districts (#7) indicates a poor positive relationship and further afield (#8) a random relationship, but there were not many fires to judge from. The three non-spot man caused fires all occurred on high and extreme days, so possibly the relationship is good.

Number of fires more than 1/4 acre
per 100 days per 10,000 sq.mi. *

Station	Districts	Man or Lightning caused	Danger Class: Nil	Low	Mod.	High	Ext.	No.of fires
Carmi	20,13,16,12	Man	-	-	-	47	-	4
		Light	60	17	-	12	-	4
Crescent Valley	11,8,21,9,6	Man	-	19	19	49	-	10
		Light	112	16	83	49	-	25
Kimberley	19,4,14,1	Man	-	-	4	25	31	5
		Light	-	9	16	50	-	14
Revelstoke	22,15,7,10	Man	-	-	-	30	22	3
		Light	44	55	60	45	22	27

* Note that each figure is relative within the station, but is not comparable to other stations as the length of record is different for each station.

The results are fairly good for the Federal Forestry Fire Danger Tables in the Nelson District when applied to man caused fires. The relationship is positive in spite of the difference in fuel type between the Nelson area and the area the tables were designed for. Good results were obtained particularly in the Kimberley area. However, about 75% of the fires were lightning caused and lightning presents a different problem than man caused fires.

2.6. Lightning Occurrences

Lightning accounted for 34.1% of the fires in B.C. and 51.9% of the fires in the Nelson District in the years from 1952 to 1961. Lightning occurrence not relating to the danger index classes is shown in the summary table for the Nelson District. However, the table of the proportion of fires reaching a given size to all reported lightning fires gives a result supporting the effectiveness of the index.

Lightning Occurrence Tables

(Prince George Index used on R.D.'s 16,2,8,4,3,14,9,11,5,17, 13,6,15)

Danger Class	Days in each Class	Fires in each Class	Fires per day	% of Fires Reaching 1/4 acre	% of Fires Reaching 4 acres	% of Fires Reaching 20 acres	% of Fires Reaching 100 acres.
Ext.	13	38	2.92	68%	34%	24%	13%
High	21	56	2.67	36%	14%	9%	5%
Mod.	27	36	1.33	36%	17%	8%	6%
Low	42	15	.36	20%	7%	-	-
Nil	12	4	.33	-	-	-	-
Total Fires	149			62	28	17	10

Lightning Fires - Nelson District

Kimberly Index (R.D.19,4,5,6,14,17) and Crescent Valley (R.D.8,11,21)

Class	Total Fires in each Class	% Fires Reaching 1/4 acre	% Fires Reaching 4 acres	% Fires Reaching 20 acres
Ext.	1	-	-	-
High	40	33	10	5
Mod.	83	24	7	4
Low	98	19	5	3
Nil	93	12	0	0
Total Fires	315	63 fires	15 fires	8 fires

In the Prince George area in the Extreme Class 34% of the fires reached 4 acres, in the High Class 14%, in the Moderate 7%, and Low 1%, while in the Nelson district in the High Class 10% reached 4 acres, Moderate 7%, and Low 5%. Similar results were obtained by Turner with the Model 8 index in the Nelson District. The use of the Federal Index for lightning fires then would be justified if used to indicate the expected growth of lightning fires in each danger class.

Of particular interest is the timing of lightning occurrence in relation to the index. There seems to be a fairly persistent occurrence of lightning on the downward trend of the index, following a hot spell with maximum index.

TABLE OF INDEX AND LIGHTNING FIRE OCCURRENCE

Kimberley and Cranbrook

July	12	13	14	15	16	17	18	19	20	21	22	23
Danger Index	7	7	8	10	7	0	1	3	4	5	0	0
Model 8	34	40	63	61	24	28	28	28	37	31	15	8
L Fires	0	0	5	16	25	7	0	0	0	5	6	1
Fires 1/4 A. L	0	0	3	2	5	0	0	0	0	1	1	0

Aug.	22	23	24	25	26	27	28	29	30
Danger Index	6	7	10	0	3	6	5	6	7
Model 8	45	61	56	40	45	45	40	12	39
L Fires	0	5	13	1	2	0	0	7	0
1/4 L	0	2	3	1	0	0	0	0	0

Terrace

July	24	25	26	Aug.	1	2	3	4	19	20	21	22
Danger Index	11	12	12		15	13	11	11	16	16	10	11
L Fires	0	3	9		0	0	0	7	0	3	17	4
1/4 L.	0	3	2		0	0	0	5	0	0	8	1

On July 14-15 the Danger Index at Kimberley and the Model 8 index at Cranbrook had maximum values for the period. Heavy lightning activity accompanied the high indexes and the days following of much lower indexes. Later on July 21-22 there was moderate lightning activity accompanying the drop of the indexes. Again Aug.23-24 and Aug.29 maximums for the periods were reached and lightning similarly accompanied the drops in index. On the other hand, at Terrace moderate lightning occurred with the index remaining high on July 25-26 and on Aug.4, however, on Aug.19-22 the heavy lightning activity coincided with a drop in index. These examples illustrate that often lightning coincides with cloudiness, showers, high relative humidities, and increased wind, all of which, except for the wind, lower the index. The higher the index before the lightning the more the preparation the ranger should make when he hears a lightning forecast and the longer he should remain prepared after the index drops. It also emphasizes the difficulty of relating lightning starts on any basis of danger rating.

Comparison of Kamloops Airport and Ranger Station

The two stations are about 9 miles apart, Kamloops Airport at 1133 feet and the Ranger Station at about 1600 feet. The danger indexes were roughly comparable in predicting fire starting probability as observed in the Kamloops District discussion. Only specific differences between the stations will be discussed here, fire severities, winds, humidities, and rainfall differences.

From the valley location of the airport one would expect the additional severity of 5.4 as compared to 3.6 for the Ranger Station.

The wind at the Airport was greater than at the Ranger Station by a factor of about 1.7 (median of 22 winds) for winds of 14 mph. or more at either station and about 1.2(average) for the other lower winds, certainly not near the factor of 3 which has been suggested by Williams for the Prairie Provinces. On three days the wind was three times as strong at the Airport as it was at the Ranger Station.

The noon and overnight relative humidities are generally lower at the Airport than at the Ranger Station.

Rainfall amounts were much lower at the Airport.

The combined effect on the airport's index of a higher wind, lower noon and overnight relative humidities, and less rain was a mean of 2 units above the Ranger Station's, a root mean square difference of 2.4 index units and 39% of the time the danger indices were not within 2 units of each other.

COMPARISON OF KAMLOOPS AIRPORT AND KAMLOOPS RANGER STATION

Danger Index: Mean of Kamloops Airport is 2 indexes above the Ranger Station's. Standard deviation is 2.4 indexes.
Percentage of time not within two indices is 39%.

	Wind (mph) average				Noon Relative Humidity			
	J	J	A	S	J	J	A	S
Ranger Station	8.0	5.1	4.8	6.3	36.9	35.9	38.2	52.5
Airport	9.9	7.4	5.8	8.9	30.1	34.6	35.8	44.5

	Rain (inches)				Overnight Relative Humidity			
	J	J	A	S	J	J	A	S
Ranger Station	.80	1.42	1.52	1.31	66.9	82.2	79.9	93.0
Airport	.63	1.06	.96	1.03	71.4	71.2	70.9	76.5

3. DISCUSSION OF DANGER INDEX PROBLEMS

Some difficulties arise from the use of any index to indicate fire weather danger in an area and other problems seem particular to this Federal Fire Danger Index. The upper or near limit of the Drought Code and Drying Code is very often reached when one or the other is low resulting in a danger index which sometimes would appear to be lower than it should be. Because tables were derived from empirical correlation this factor could have been over corrected and compressed into the near and upper limits to fit the available data. It seems that the index is not sufficiently sensitive in the extreme danger class to indicate day to day variations near the upper end of the scale. The Intermountain Model 8 Index incorporates the principle that the limits should rarely or never be reached. The same principle probably should be applied to the Drought Code, and Danger Index. When very quick drying occurs because of extremely low night and day relative humidities and strong wind, extreme conditions can result in a few days, yet because of the lag of the Drought Index, the Danger Index appears to be too low to indicate the real danger. The fact that Lytton had 25 consecutive days of high and extreme of which 19 were extreme, 17 in a row, 12 of which were 15 or 16, indicates the possibility that at or near the end of this hot weather spell the conditions were worse than when the extreme class was first reached. Similarly, when the Drought Index has reached its limit of 25, after 25 more days without significant rainfall the danger is undoubtedly worse, so that a given danger rating with the drought index just reaching 25 is not comparable to the same danger rating 25 days later. Turner found in some of his unpublished studies that there was a definite residual effect of rainless periods in excess of 50 such days. The graphs of the men employed to fight fires in the Prince George

and Kamloops Districts, Figs. I and II, compared to the Drought and Danger Indexes of Prince George (XS) and Begbie Lookout illustrates this point. The number of tractors used was also related, but was found to give similar results to the men employed so was omitted. The extended drought index was obtained by continuing to add one point for each rainless day beyond 25. In this extended period the effect of rainfall was increased by a factor of two in comparison to the tabulated reductions. The curve derived, though only a rough prediction, seems to give a good indication of conditions. It must be observed here that the Drought Index is not affected at all by the extremely low or high relative humidities, by wind, or the amount of solar radiation, it just increases one unit per day. Trying to average out these effects in the correlation probably reduces the reliability of the danger rating. On the other hand, the index may recover too quickly as seems to be the case at Hope and Williams Lake. The graphs of noon relative humidity and index show their rough coincidence and the incorporated lag of the index, Figs. III and IV after the humidities have dropped. It is part of the same problem. At Williams Lake an index of 13 on Sept. 14 is not the same as an index of 13 on Aug. 15. At Williams Lake the Drought Index had been 25 since July 13 while on Sept. 14 the index was starting up to 18. The record of fire starts seems to confirm this opinion. At Hope after the series of fires on August 15 there were only small fires until August 29, but the index had reached 8 on August 23. The fact that Armstrong (1962) found a lower drought ratio when computing Williams Severity Index, (Williams, 1959) 2.10 as compared to 2.52 and 2.32 for Saskatchewan and New Brunswick is more evidence of the fact that the drying code reaches extreme at a lower Drought Index more often than is usual for other parts of Canada. An improved Drought Index without a limit and a drying code with increased sensitivity near the top of its range, plus more years of research to determine the effects of drought on lag and recoveries is needed.

Armstrong (1962) reported the influence of the Drought Index being too extreme on the Danger Index. Possibly the extension as suggested would compensate for the compression of all the more extreme conditions on the higher indexes.

Wind Anomalies - 1961

	Kamloops Ranger Station	Kamloops Airport	Adjusted Ranger Station*
4/6	10	26	30
9/6	7	20	21
26/6	14	26	42
21/7	6	18	18
5/8	4	20	12
2/9	6	14	18
7/9	6	14	18
10/7	8	16	24

* According to Mr. Williams, on the basis of studies made in the Prairie Provinces Airport winds may be greater than forest station winds by a factor of 3.

The wind anomalies between the two Kamloops stations 9 miles apart indicates the difficulty in suggesting that one index is representative of a large area. The graph of wind and danger index at Prince George at high and extreme indexes indicates the influence of this specific station wind. The possibility that this wind is not representative of the whole day exists. The compensations for the diurnal variations of the field station in the development of the tables may not apply to the station used. In addition, differences in the prevailing pressure pattern may change the diurnal wind pattern. In Australia, Douglas (1957) reports that surface barometric chart features and frontal analysis are incorporated into their studies. Certainly a one minute mean taken once a day is not completely reliable.

Rain (inches)

Date	Ranger Station	Airport	Date	Ranger Station	Airport
6-7/6	.40	.35	23-24/7	.02	.01
9/6	.06	.05	28-29/7	.61	.24
12/6	.01	.00	16/8	.84	.83
18-19/6	.10	.00	30/8-3/9	.98	.48
27/6	.05	.08	5/9	.03	.00
30/6	.18	.15	7/9	.12	.03
2/7	.10	.00	19-26/9	.13	.12
6-8/7	.41	.53	23/9	.07	.06
16-17/7	.23	.28	25/9	.16	.18
21/7	.05	.00	27-29/9	.50	.34

The rain records of Kamloops Airport and Ranger station illustrate the difference between two close stations. Magnified over the areas which must be taken into consideration, the values of the index must be most carefully weighed when rain has occurred in part of the district. On June 18-19, July 2, July 21, July 28-29, Aug. 30 - Sept. 4 and Sept. 27-29 anomalies exist. This shower difference is not peculiar to 1961.

Rainfall within a 4 1/2 mi. radius near Kamloops (inches)

Date	Kamloops Airport 50 43'N, 120 25'W 1133 feet	Experimental Station 50 43'N, 120 25'W 1150 feet	Mission Flats 50 41'N, 120 21'W 1264 feet	Tranquille 50 45'N, 120 31'W 1180 feet
July 5-6, 1951	.55	.45	.47	.13
Aug. 24-25, 1956	.00	.00	.15	.00
July 4-6, 1952	.03	.23	.95	.10
June 22-23, 1951	.31	.34	.03	.20
July 16-18, 1953	.38	.47	.69	.19
Aug. 16-17, 1953	.08	.20	.00	.00
June 2, 1955	.50	.19	.29	.00

From the Monthly Weather Records the rainfall was selected for 4 stations near Kamloops. Mission Flats is most comparable to the Ranger Station in position. The examples were chosen to show the difference between stations and, to avoid error due to rainfall collection time, were all of short periods of rainfall activity.

A lot can be said for the index in spite of its limitations and difficulties. One impressive feature is the correlation of danger index and men employed as observed in the Prince George District (Fig. 1) who incidently did not have the Danger Index available to them. The lag of employment lay-off after conditions improved is, as would be expected, caused by the necessary clean up.

Practical Use of The Index

The danger rating requires careful interpretation by the field user. In its present form at least it appears to be best suited as a guide to administration headquarters. Differences of fuel, slopes, exposure, logging, elevation, and limited rain coverage must be taken into account. The flashy fuels are affected by a small amount of rain, but are dried by a small amount of sunshine. Heavy fuels require continuous rain to lower danger. Inch for inch an intermittent rain is more effective than a shorter period continuous rainfall. Showers are often local, leaving some areas dry. The greater the steepness of a slope the more drying that occurs. According to Gayle (1952) area spread of a fire is thirteen times as great in logged off areas as in forested areas. Wind varies in the forest from e.g. 6 mph. in virgin timber, 8 mph. in a partial cut to 27 mph. in a clear area. Wind varies markedly throughout the day and local knowledge of different wind patterns needs to be applied. Relative humidity varies similarly 50% in virgin timber, 40% in a partial cut, and 37% in clear cut area. The ranger must consider elevation, the amount of logging operations, public occupation of the land, accessibility of areas and the value of timber stands. The index should be carefully interpreted.

Useful information might be obtained from a consideration of the Drought Index alone. For example, during the period Aug. 16-20 in the Kamloops District there was a reduction in Danger Index but no significant drop in the Drought Index, thus indicating a quick return to former levels of the Danger Index on the first dry day. It might be possible to take advantage of such a period by increasing control measures at a time when they would be most effective. The decrease in men employed seems to indicate that this was not done. (See Kamloops District graph of Index and men employed.)

4. CONCLUSION

The Federal Fire Danger Index seems fairly reliable as an indicator of the fire weather danger throughout most of B. C. on the basis of 1961 data. Certain modifications such as revision of the Drought Index and the overcoming of the unrepresentative wind problem, have been suggested as a possible improvement. The location of a station seems the basis of reliability. The meteorological stations and forestry stations are good as long as they are not in dry river valleys, on mountain tops or near the sea coast. The best coverage is achieved by a network of Forestry and Meteorological stations, the more representative the stations the more accurate the picture.

There seems to be a need for the meteorological service to establish a station somewhere in the area between Prince Rupert, Port Hardy and Kleena Kleene.

It would probably be useful to continue and expand the use of the index from meteorological stations as an aid to the B. C. Forest Service.

In addition, some suggestions for the future might be made. The fact that records have been kept for many years at some meteorological stations suggests the possibility of detailed investigations of diurnal wind patterns and other variables affecting the danger index. Records of the Forest Service could be used to make comparisons of weather records (not just in the form of a Danger Index) to weather caused fire occurrences of different past fire seasons. Excellent stations like Victoria Airport, Hope, Prince George, Williams Lake, Kamloops could be studied in detail with perhaps valuable results.

In view of the importance attached to the new British Columbia Fire Danger Tables, an exploratory study such as this was thought to be necessary at the earliest possible date. Many of the findings, as a result of small samples, can only be tentative and these should subsequently be checked against the data for several fire seasons.

APPROVED,

D. P. McTaggart-Cowan,
for Director.

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APPENDIX I

TEST FOR SIGNIFICANCE OF THE DIFFERENCE BETWEEN FIRE OCCURRENCE VALUES.

APPENDIX I

Test for Significance of the Difference Between Fire Occurrence Values.

The daily fire occurrence in any given area can take any of the values 0, 1, 2, -----n. Averaging over a sufficiently large sample of days, the mean value of fire occurrence (m) can be obtained.

Since the probability of occurrence is small, it would be expected that the distribution of days having any given number of fires (r) would be fitted by a Poisson series.

$$P(r) = \frac{m^r e^{-m}}{r!}$$

The following table gives the observed and theoretical frequencies of daily fire occurrence (excluding "spot" lightning fires) over the Vancouver Forest District for the 1961 fire season.

TABLE I

Fires/day	0	1	2	3	4	5	6	7	8	9 +
Observed frequency	15	14	23	20	15	9	7	5	7	7
Calculated "	3.6	12.7	22.4	26.2	23.1	16.3	7.7	3.9	1.8	4.3

N = 122 days mean fire occurrence m = 3.52 fires/day. Combining values for which the calculated frequency is less than 5 and obtaining a value of chi squared of 25.66 with 6 degrees of freedom, we get a probability of less than .001 that such deviations can occur by chance - confirming that such a distribution is not fitted by a Poisson series.

This failure to fit a Poisson series to the above data would appear to arise from the fact that the probability of occurrence is not constant, but varies from day to day.

This variation in probability of occurrence may be reduced appreciably by considering days of nearly uniform fire danger (danger classes). The following table gives the comparison of observed and calculated frequencies of fire occurrence in Ranger District 23, for days in the HIGH danger class as indicated at Victoria Airport during the 1961 season.

TABLE II

Fires/day	0	1	2	3	4	5 or more
Observed frequency	5	8	12	11	6	11
Calculated "	3.1	9.0	10.1	9.6	6.8	14.3

N = 53 days m = 2.85

Chi squared = 1.48 with 4 degrees of freedom giving a probability of 0.8 that such deviations could arise by chance.

This confirms that a Poisson series can be used to fit the distribution of daily fire occurrence for classes of more or less homogeneous fire danger.

This then permits the use of $\sqrt{m}$ as an estimate of the standard deviation of fire occurrence in any sample meeting the above requirements.

Now comparing two samples, of N1 and N2 days, having mean daily fire occurrences of m1 and m2 respectively, the standard error of the difference between the two values (of m1 and m2) is given by

$$\epsilon^2 = \frac{m1}{N1} + \frac{m2}{N2}$$

(Yule and Kendall - Int. to Theory of Statistics, 1937
Chas Griffin, London - p. 387)

If (m1 - m2) exceeds 3ϵ the difference between the two values of fire occurrence is significant at the 99% level; if it exceeds 2ϵ the difference is significant at the 95% level.

This makes it possible to test the significance of observed differences between the mean daily fire occurrence for various danger classes; from the mean daily fire occurrence in each class and the number of days in each sample.

PRINCE GEORGE

DROUGHT AND DANGER INDEXES FROM PRINCE GEORGE

MEN EMPLOYED TOTAL FOR DISTRICT

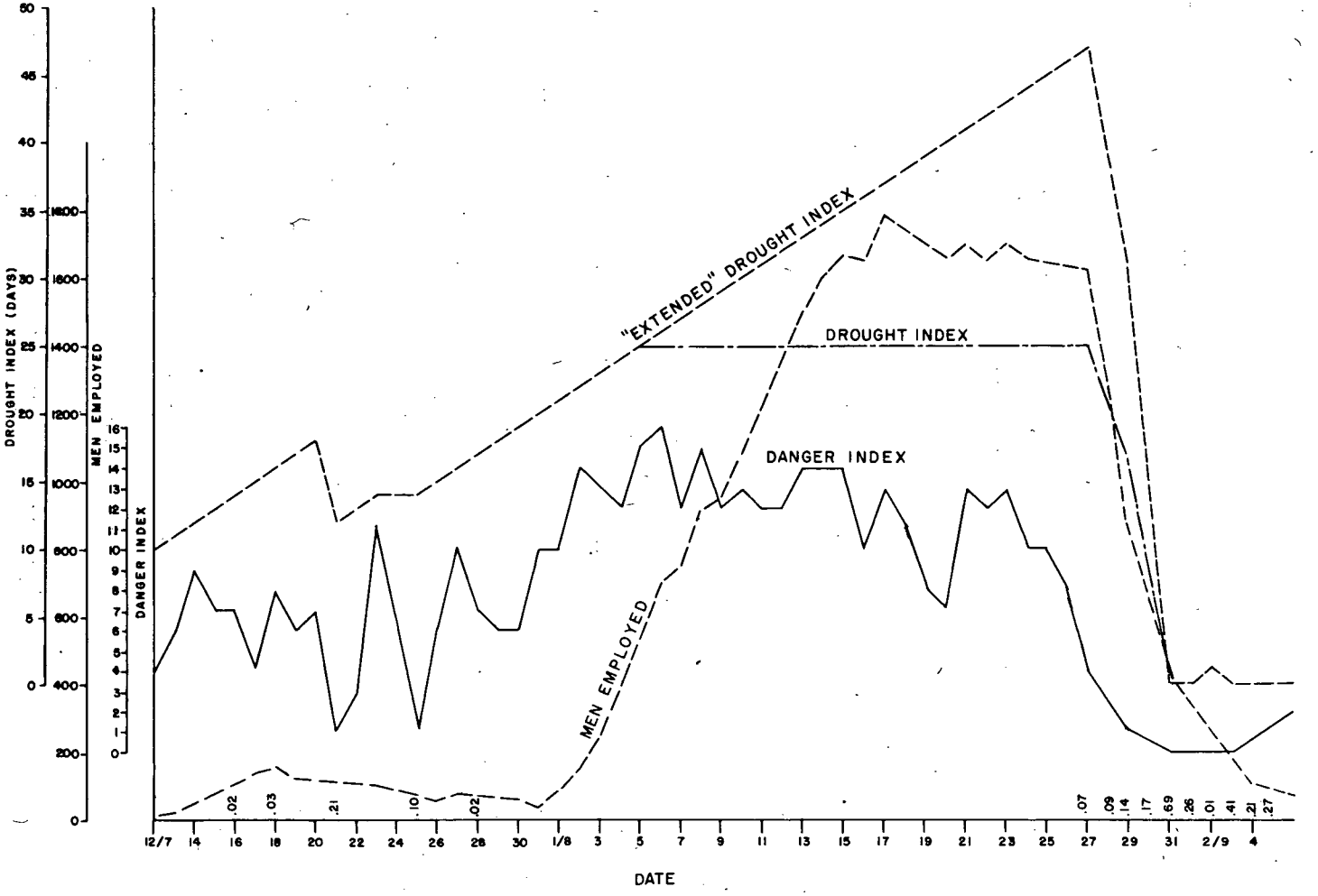


Figure 1

CIR-3827
TEC-464
10 Apr. 63.

KAMLOOPS FOREST DISTRICT

DROUGHT AND DANGER INDEXES FROM BEGBIE LOOKOUT

MEN EMPLOYED TOTAL FOR DISTRICT

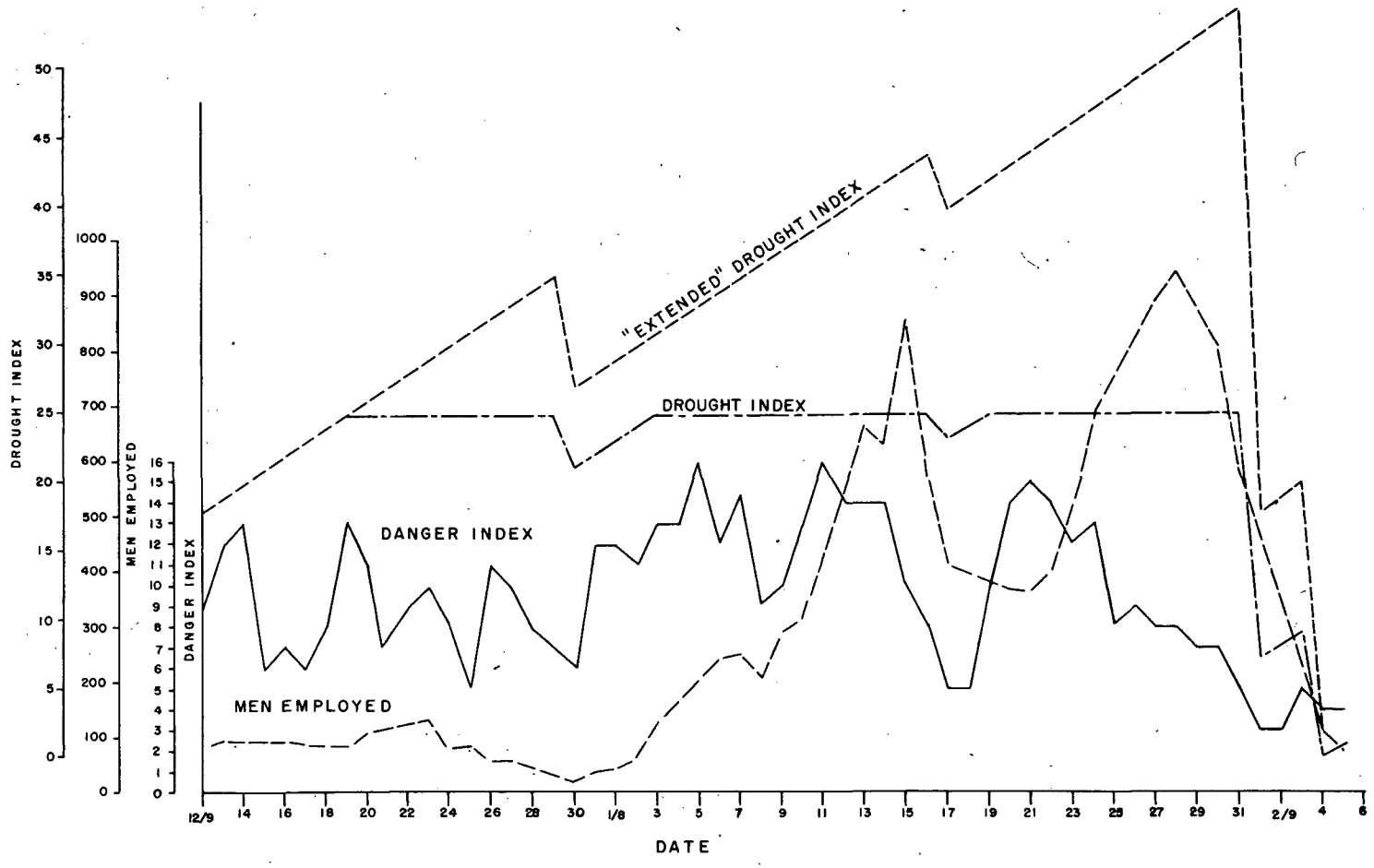


Figure 2

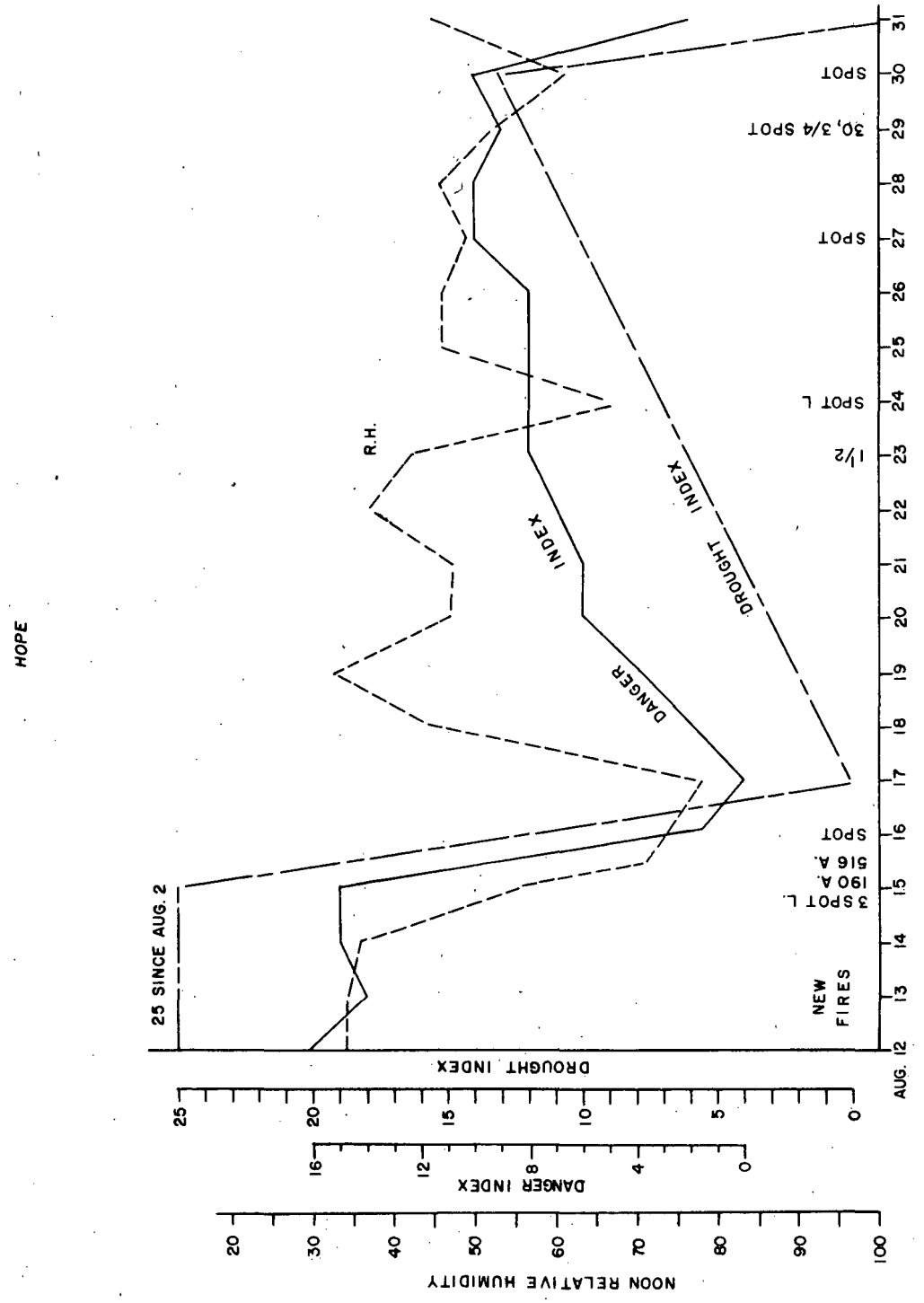

NOON RELATIVE HUMIDITY
DANGER INDEX
DROUGHT INDEX
AUG. 12
NEW FIRES
3 SPOT L.
190 A.
516 A.
SPOT
1/2
SPOT L
SPOT
30, 3/4 SPOT
SPOT
25 SINCE AUG. 2
HOPE
R.H.
DANGER INDEX
DROUGHT INDEX

Figure 3

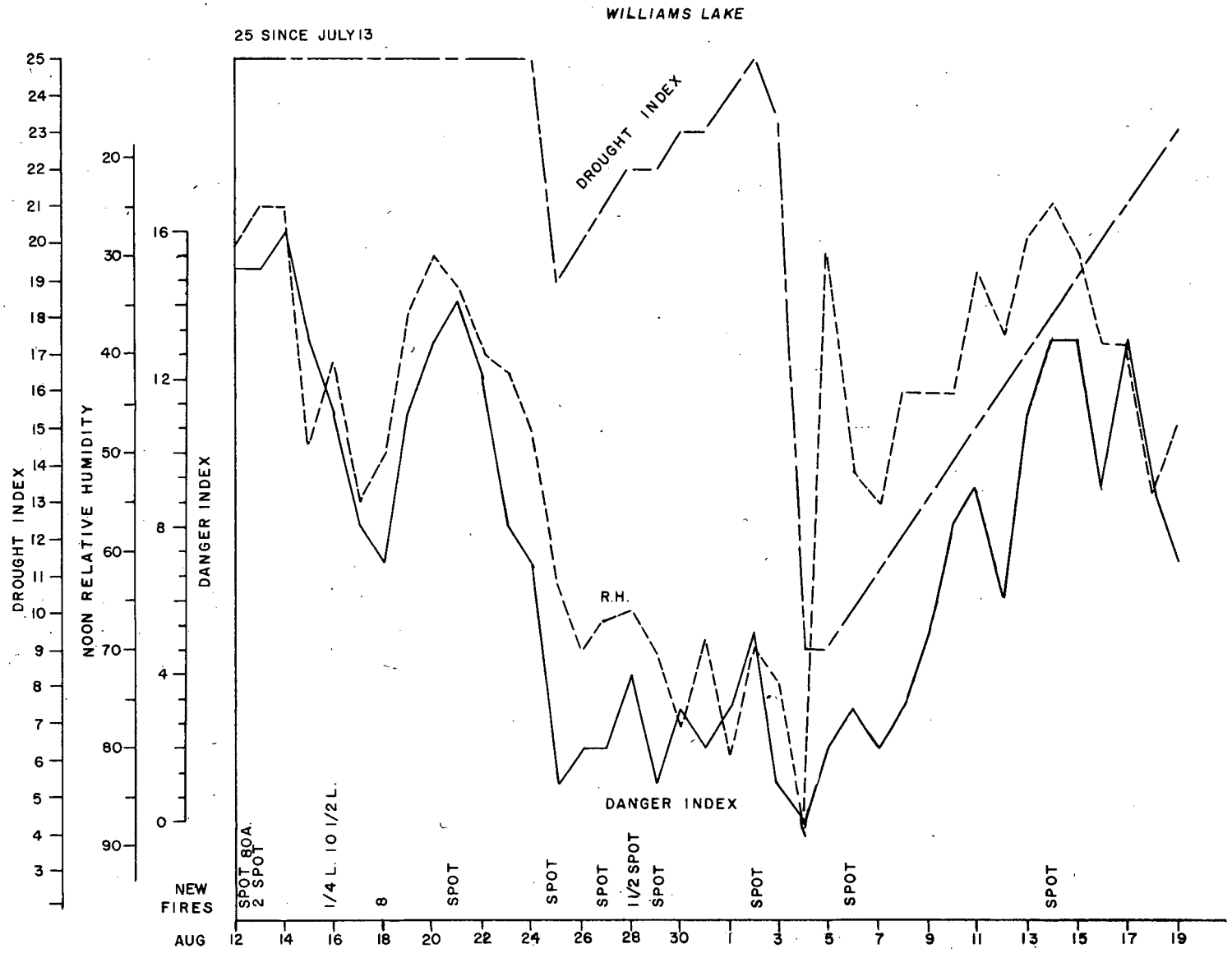

WILLIAMS LAKE
25 SINCE JULY 13
DROUGHT INDEX
R.H.
DANGER INDEX
DROUGHT INDEX
NOON RELATIVE HUMIDITY
DANGER INDEX
NEW FIRES
SPOT 80A.
2 SPOT
1/4 L. 10 1/2 L.
8
SPOT
SPOT
SPOT
1 1/2 SPOT
SPOT
SPOT
SPOT
SPOT
AUG
12 14 16 18 20 22 24 26 28 30 1 3 5 7 9 11 13 15 17 19

Figure 4

WIND AND DANGER INDEX

PRINCE GEORGE

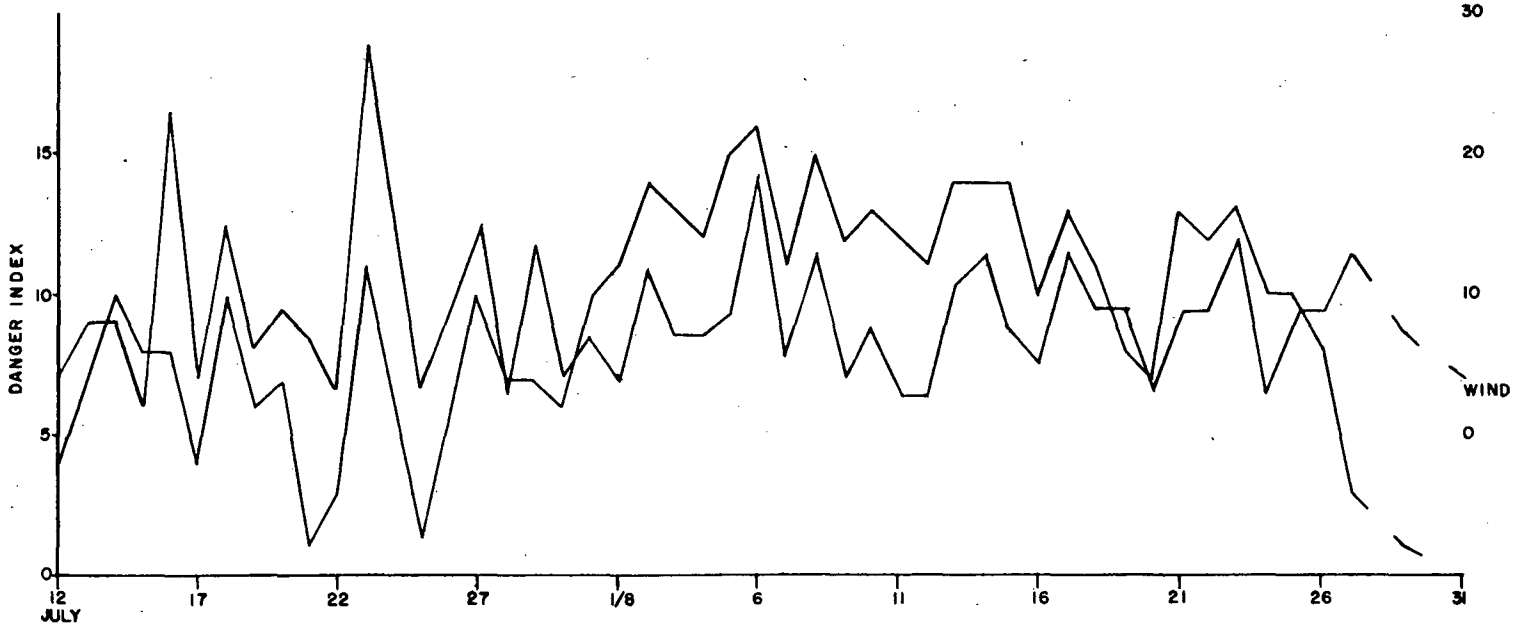


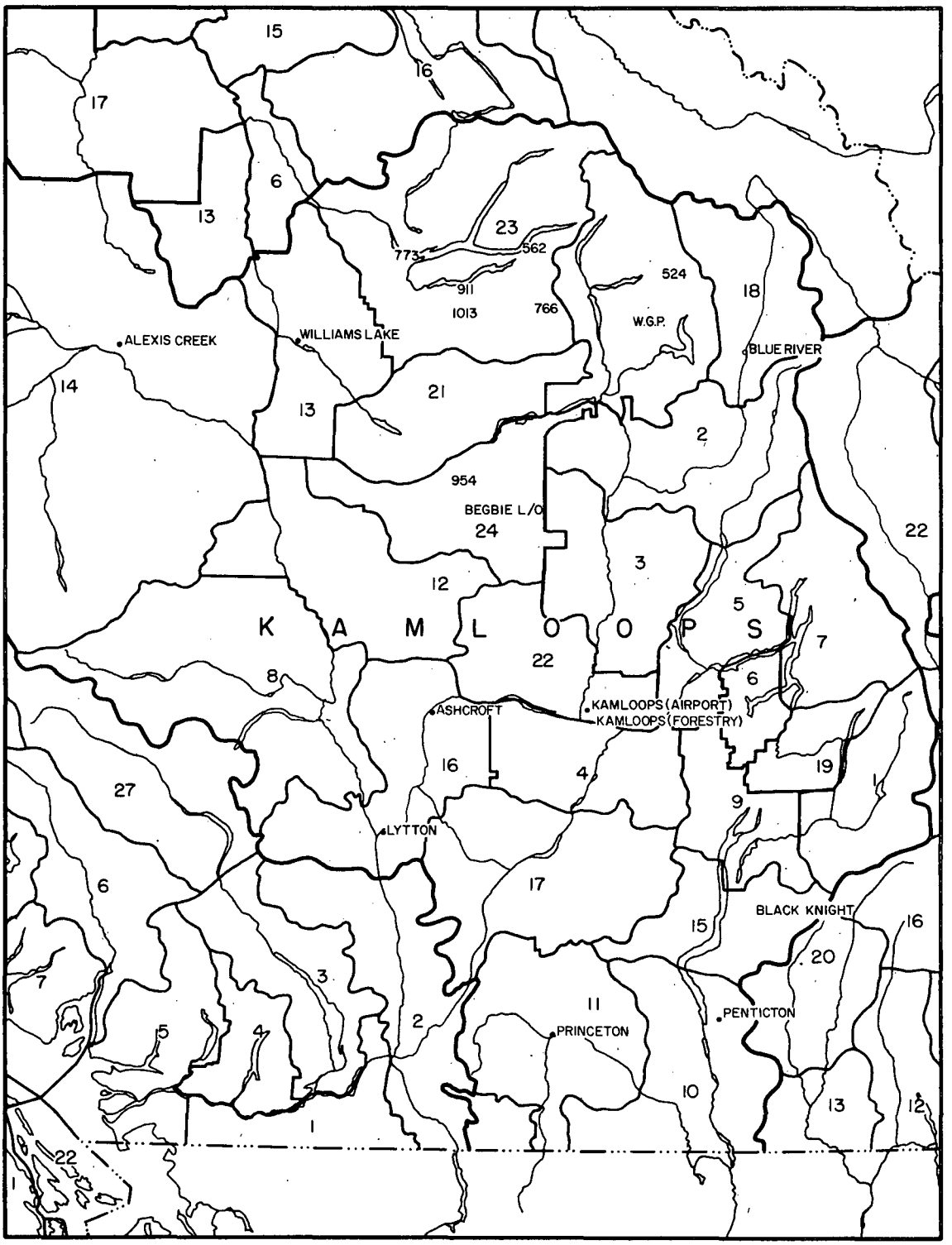
Figure 5

CIR-3827
TEC-464
10 Apr. 63.

APPENDIX II

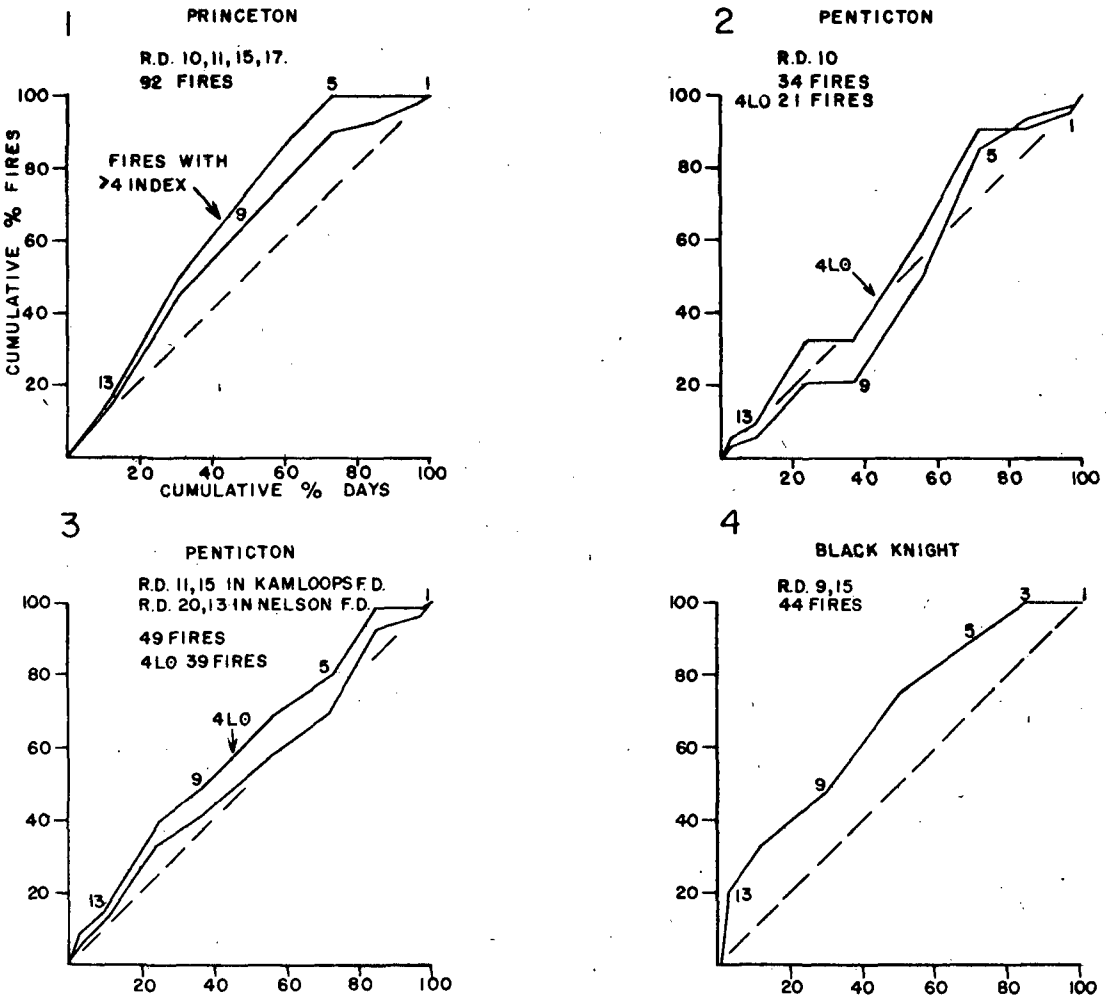
KAMLOOPS FOREST DISTRICT

CIR-3827
TEC-464
10 Apr. 63.



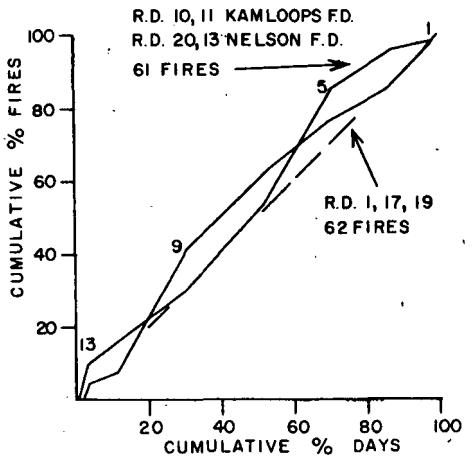
CIR-3827
TEC-464
10 Apr. 63.

Cumulative Percentage Of Fires
Related To Cumulative Percentage Of Days
In Fire Danger Classes



KAMLOOPS
F.D.

5



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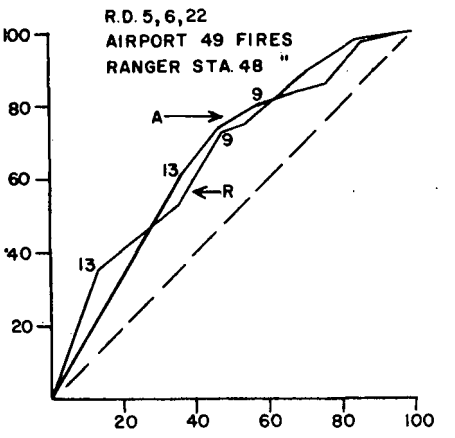

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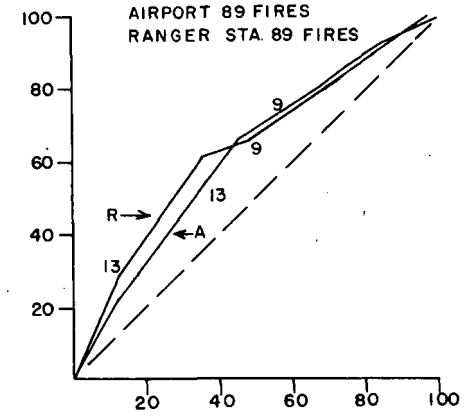

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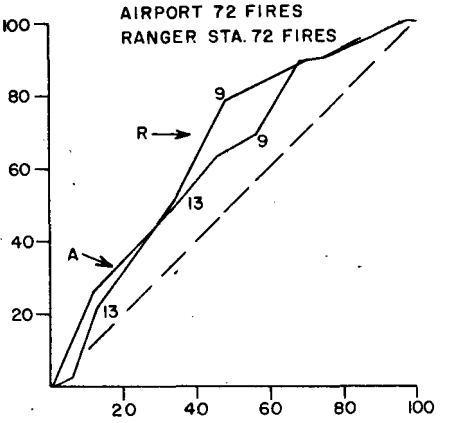
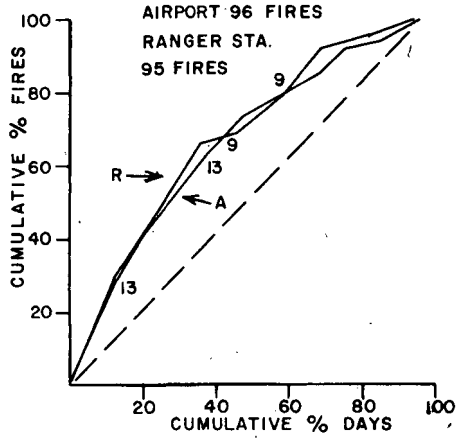


CIR-3827
TEC-464
10 Apr. 63.

KAMLOOPS
F.D.

9



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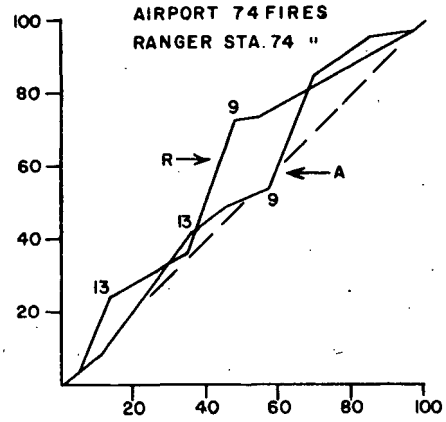

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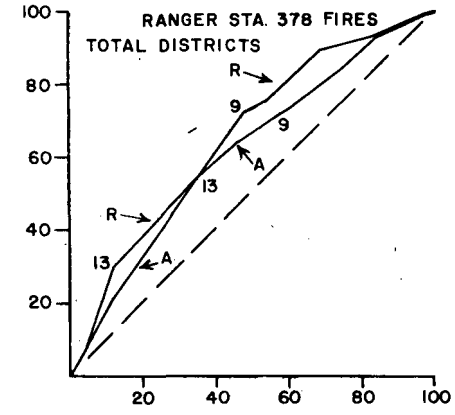

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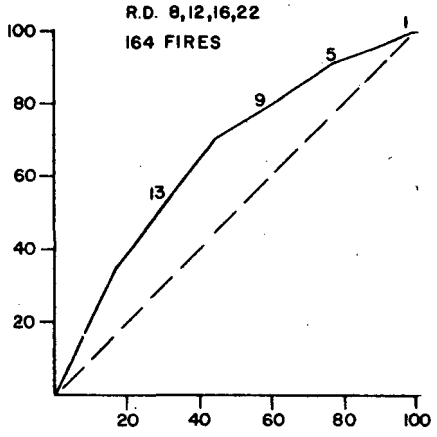
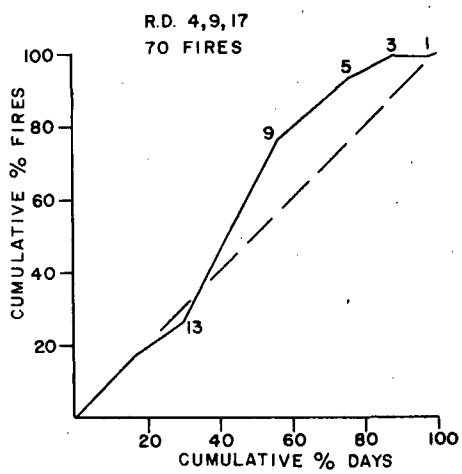
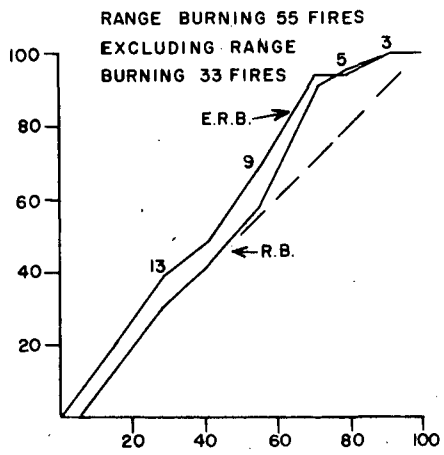


KAMLOOPS
F.D.

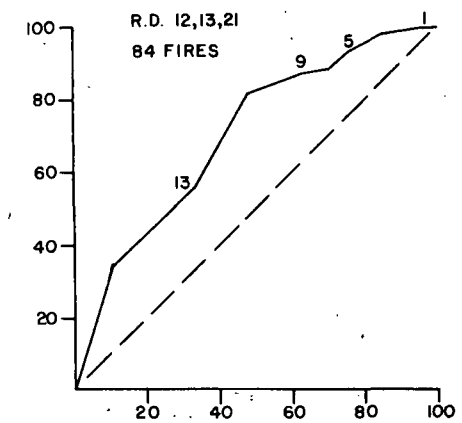
13 LYTTON



14 ALEXIS CREEK



15 WILLIAMS LAKE



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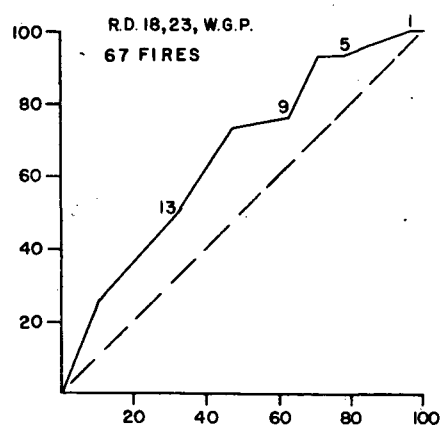

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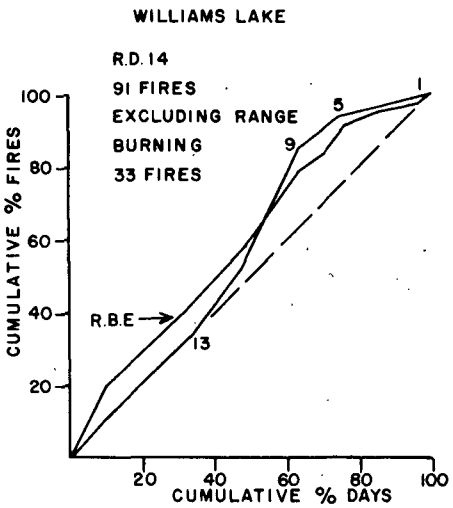
KAMLOOPS
F.D.

17



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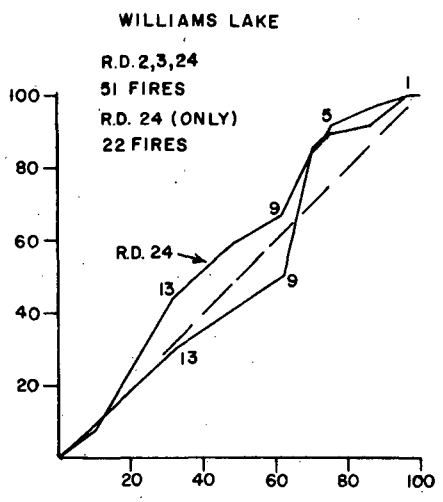

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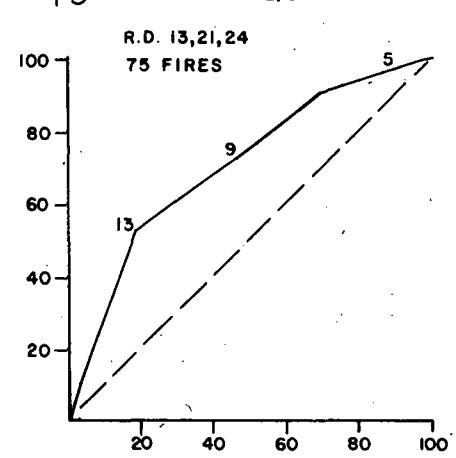

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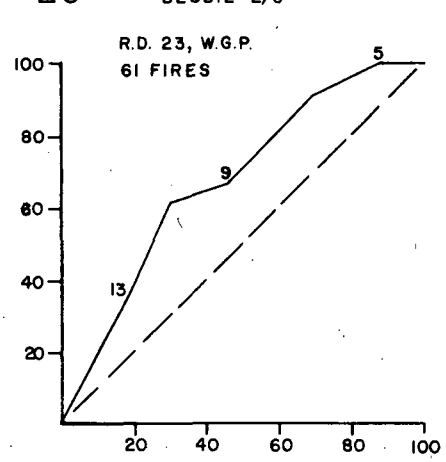
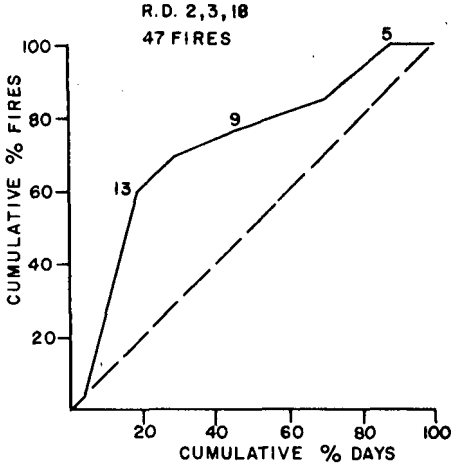


KAMLOOPS
F.D.

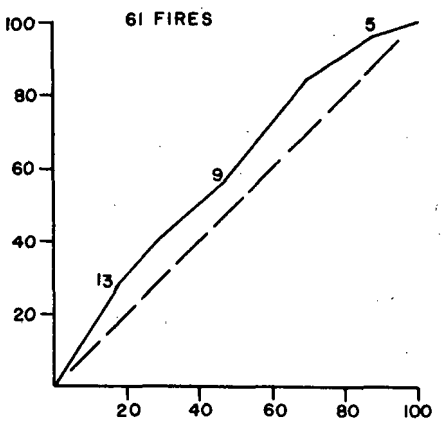
21 BEGBIE L/O

R.D. 2,3,18
47 FIRES



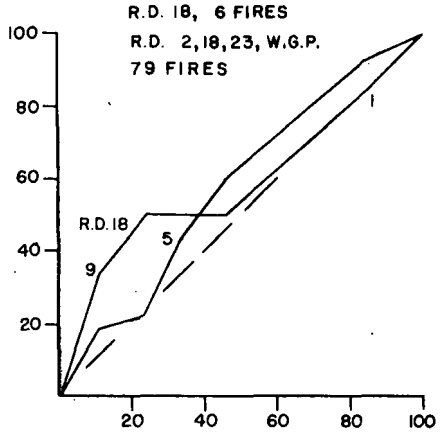
22 BEGBIE L/O

R.D. 12,14
61 FIRES



23 BLUE RIVER

R.D. 18, 6 FIRES
R.D. 2,18,23, W.G.P.
79 FIRES

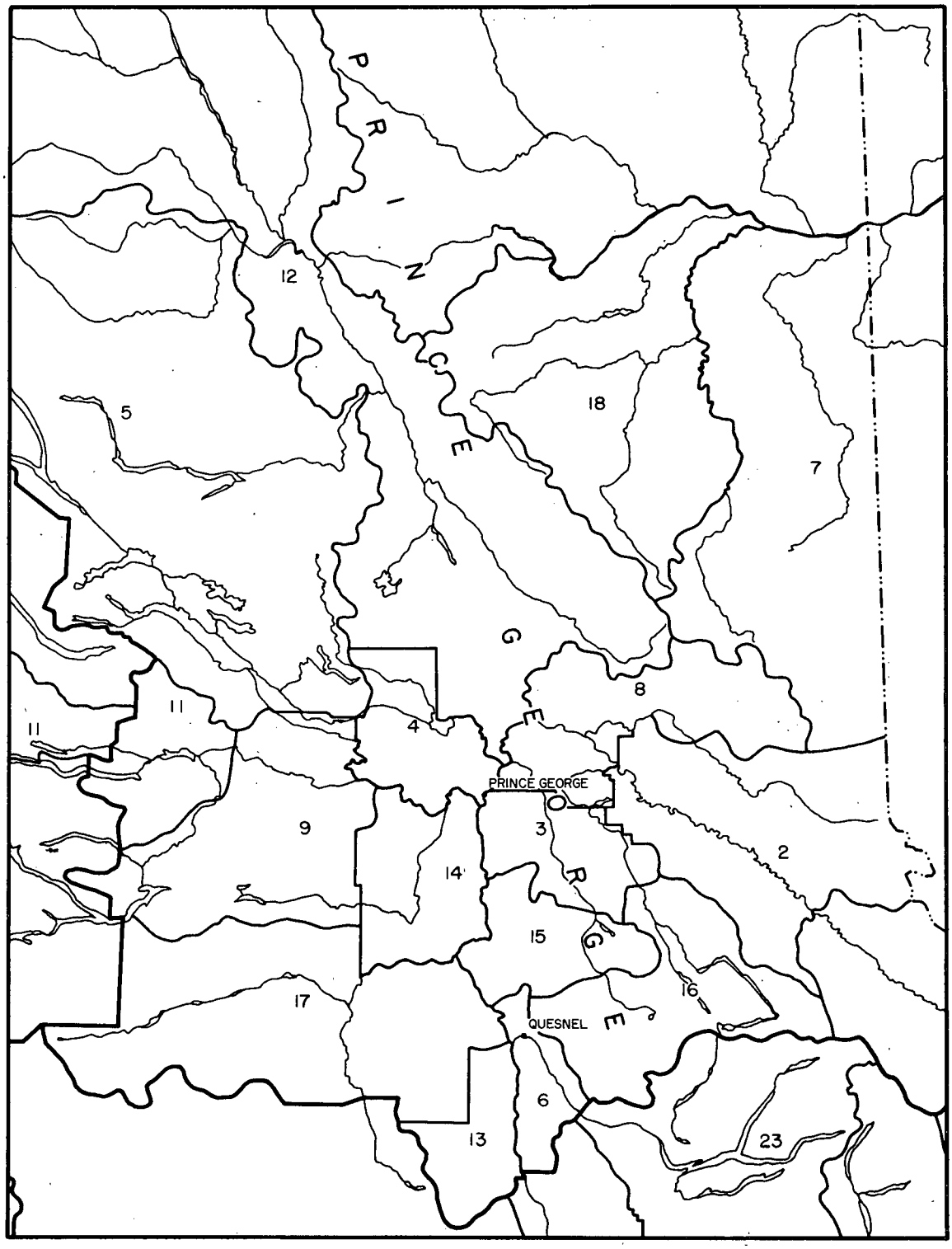


CIR-3827
TEC-464
10 Apr. 63.

APPENDIX III

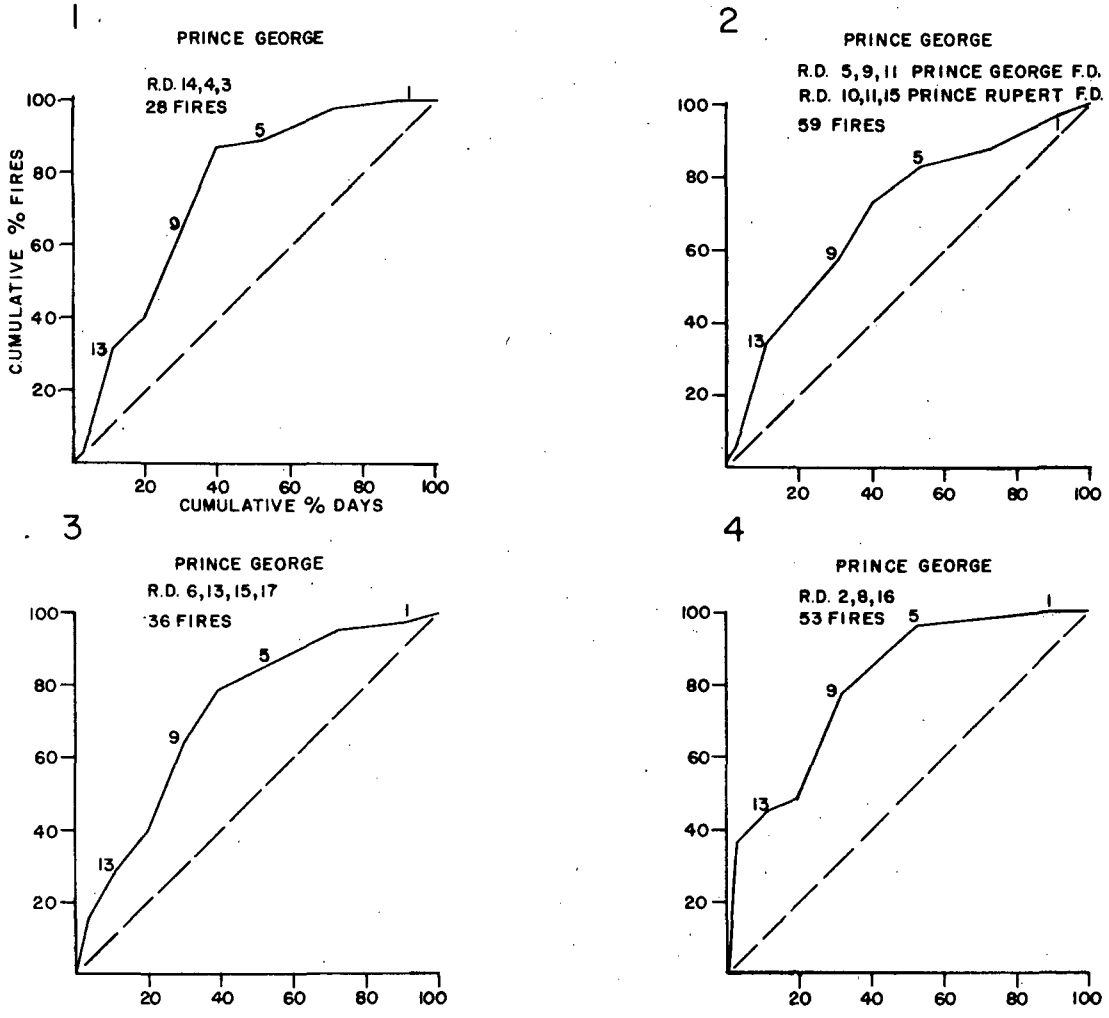
PRINCE GEORGE FOREST DISTRICT

CIR-3827
TEC-464
10 Apr. 63.



CIR-3827
TEC-464
10 Apr. 63.

Cumulative Percentage Of Fires
Related To Cumulative Percentage Of Days
In Fire Danger Classes

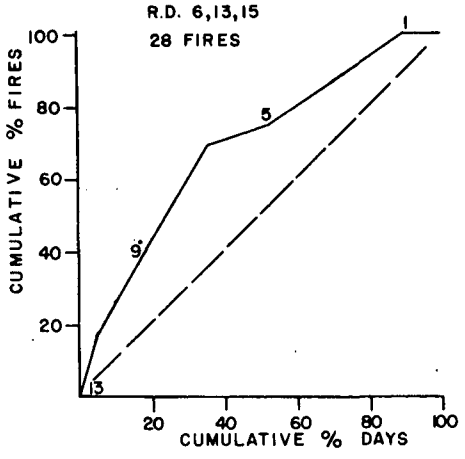


PRINCE GEORGE
F.D.

5

QUESNEL

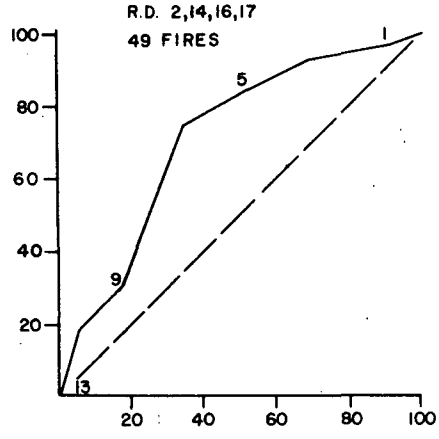
R.D. 6,13,15
28 FIRES



6

QUESNEL

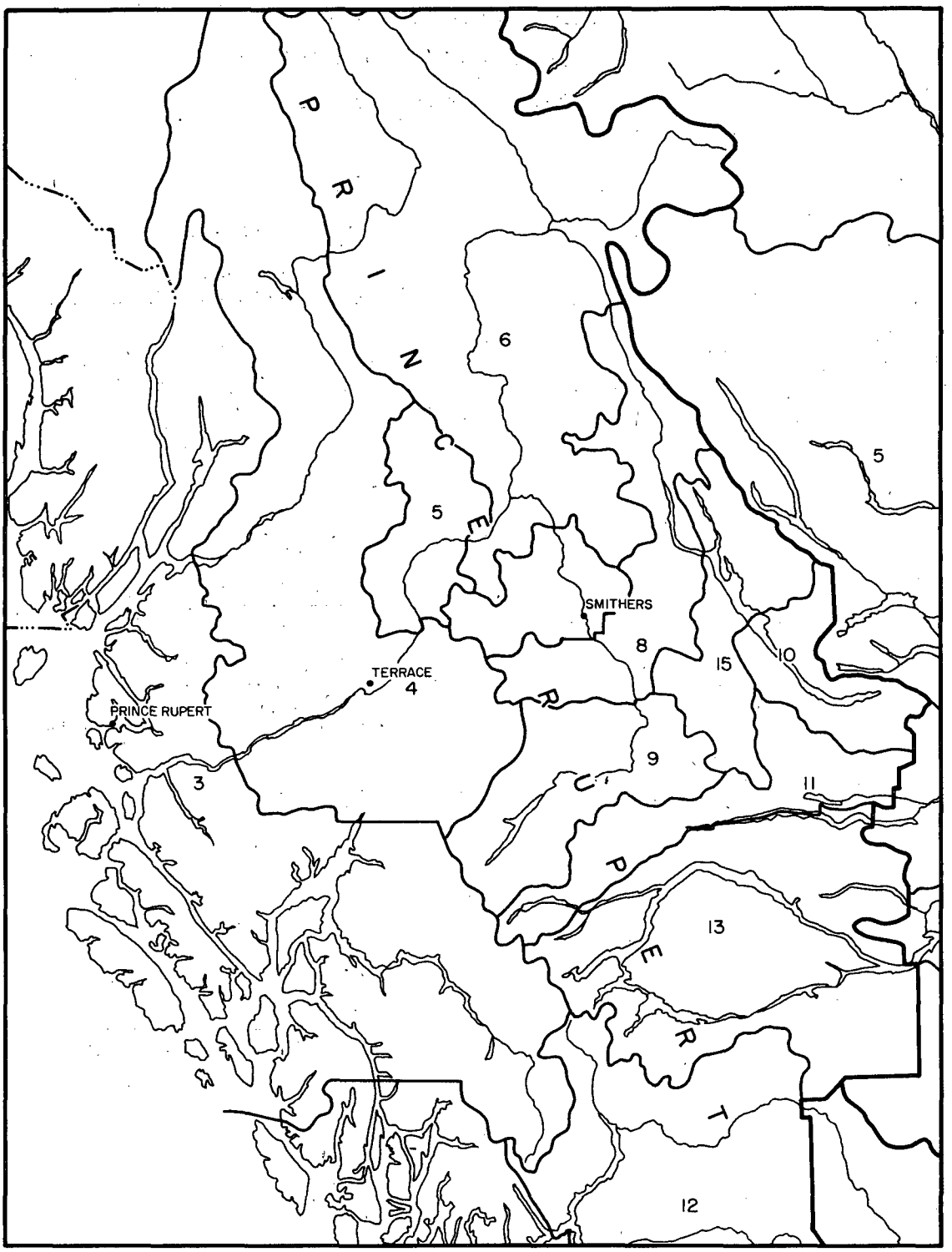
R.D. 2,14,16,17
49 FIRES



APPENDIX IV

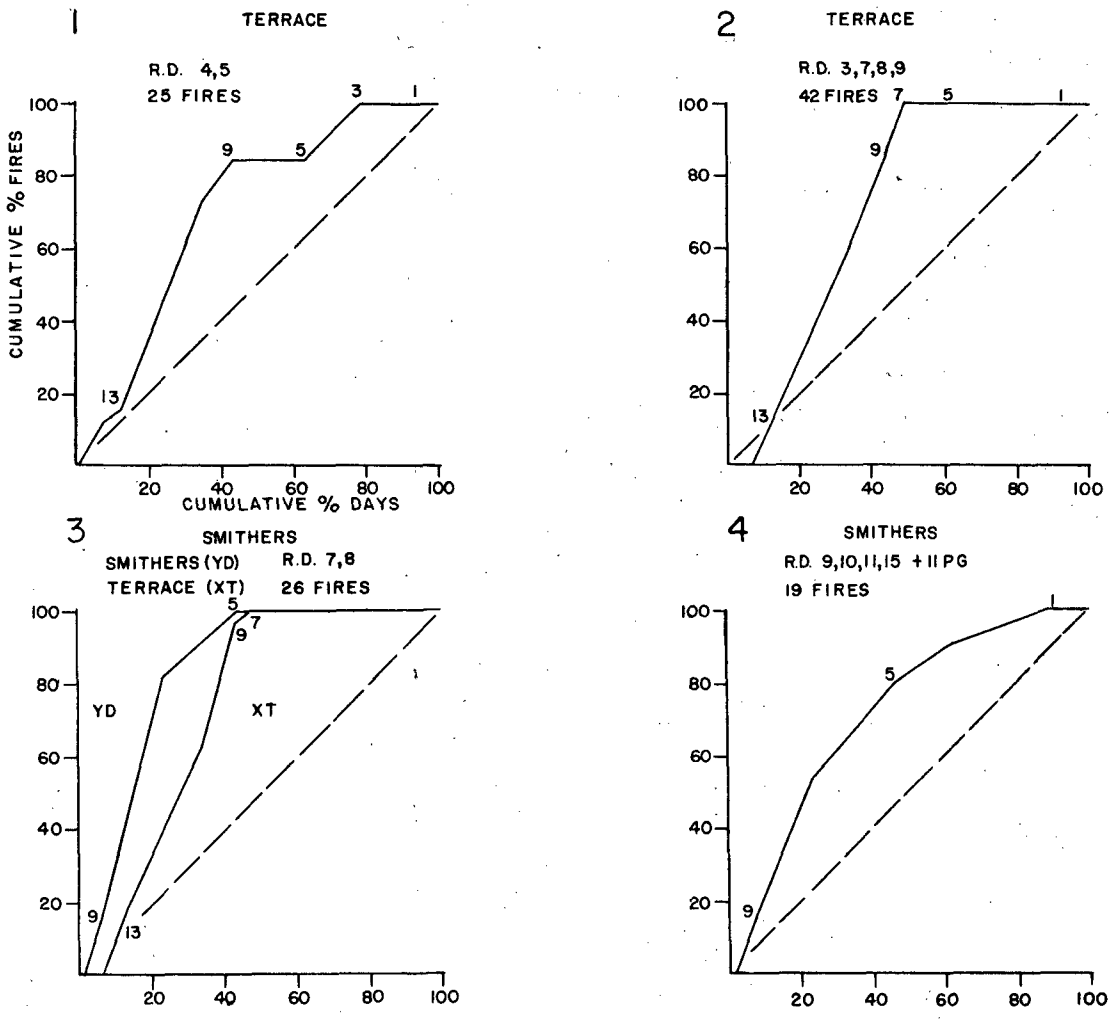
PRINCE RUPERT FOREST DISTRICT

CIR-3827
TEC-464
10 Apr. 63.



CIR-3827
TEC-464
10 Apr. 63.

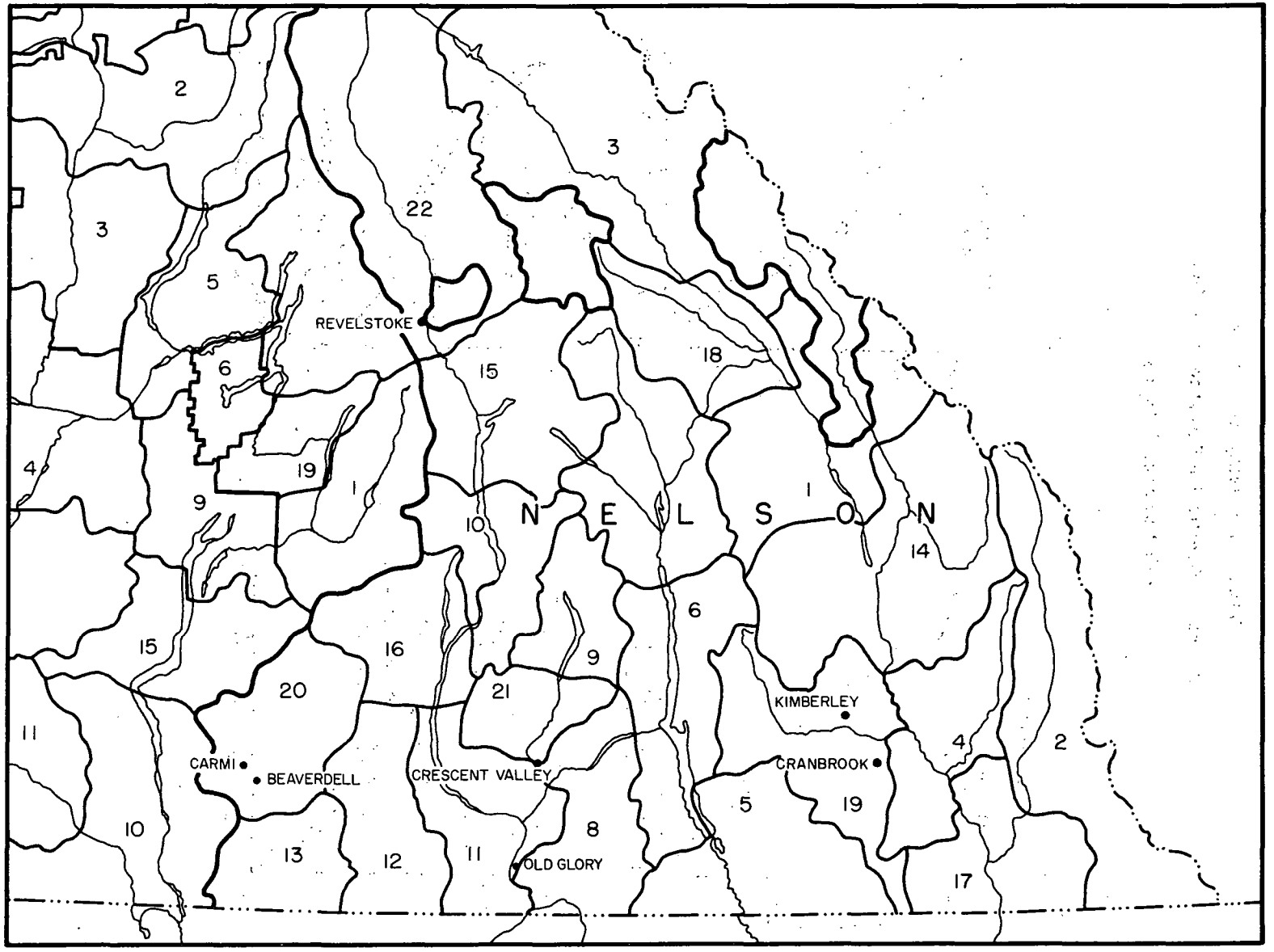
Cumulative Percentage Of Fires
Related To Cumulative Percentage Of Days
In Fire Danger Classes



CIR-3827
TEC-464
10 Apr. 63.

APPENDIX V

NELSON FOREST DISTRICT



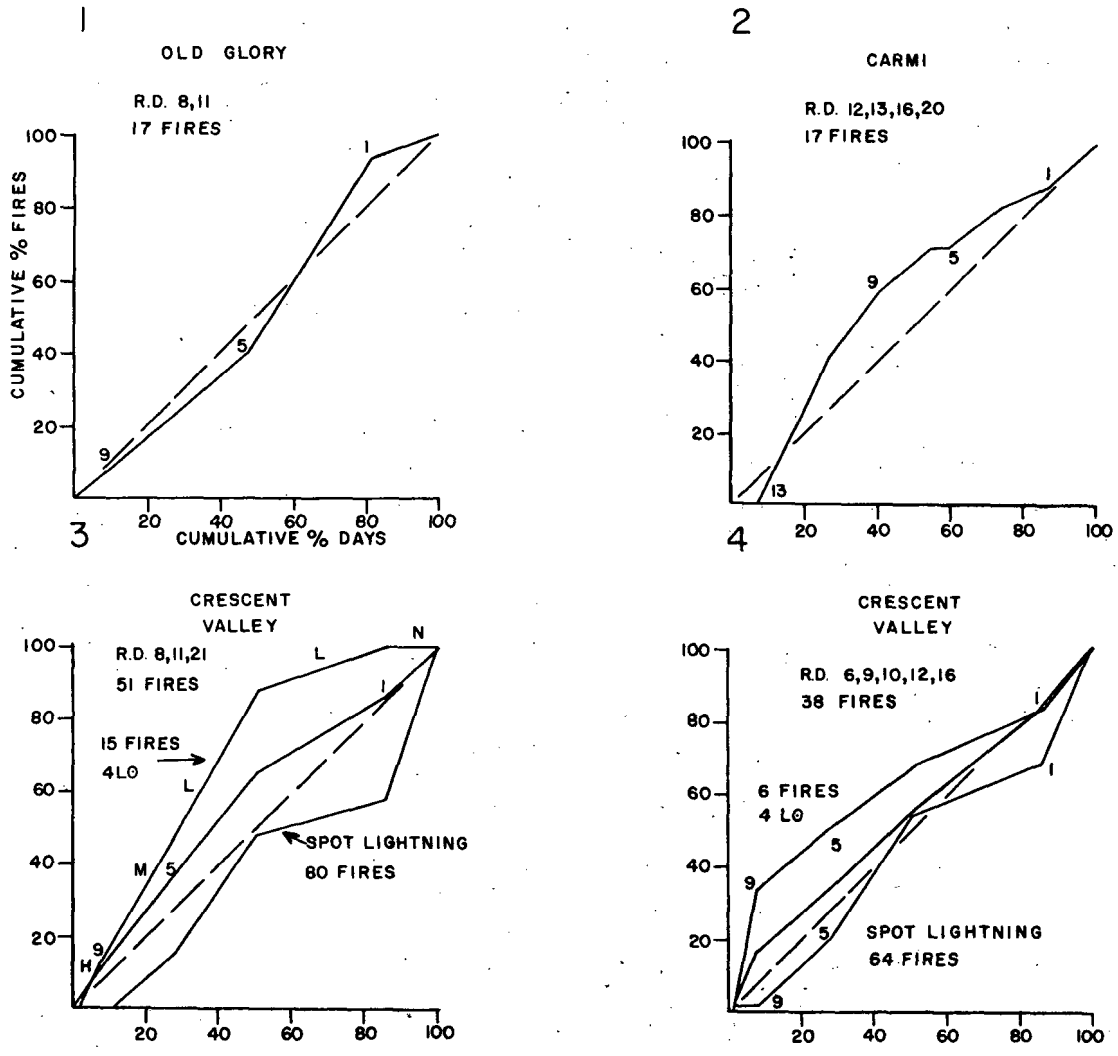
CIR-3827
TEC-464
10 Apr. 63.

CIR-3827
TEC-464
10 Apr. 63.

Cumulative Percentage Of Fires

Related To Cumulative Percentage Of Days

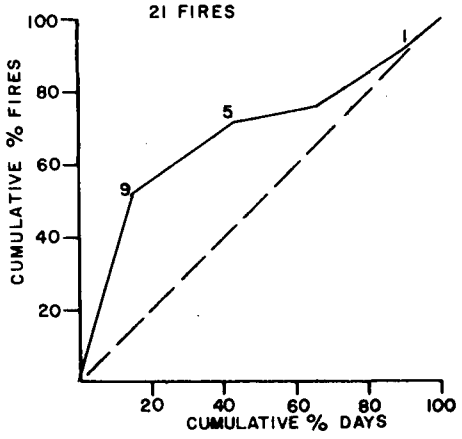
In Fire Danger Classes



NELSON
F.D.

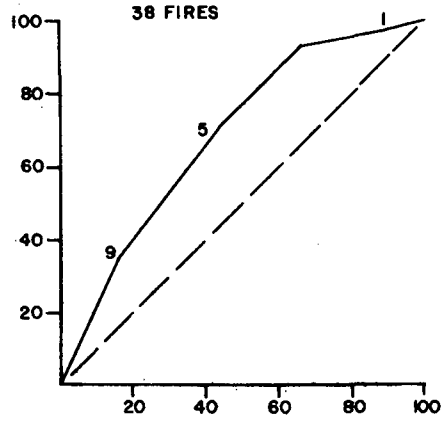
5 KIMBERLEY

R.D. 4, 19
21 FIRES



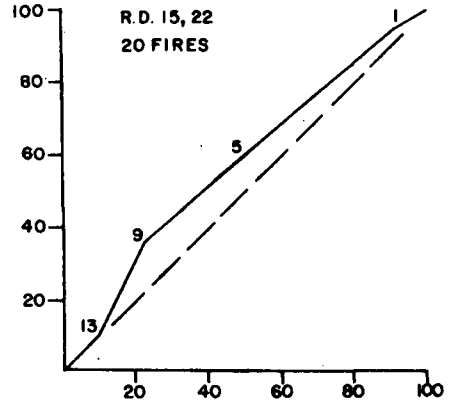
6 KIMBERLEY

R.D. 5, 6, 14, 17
38 FIRES



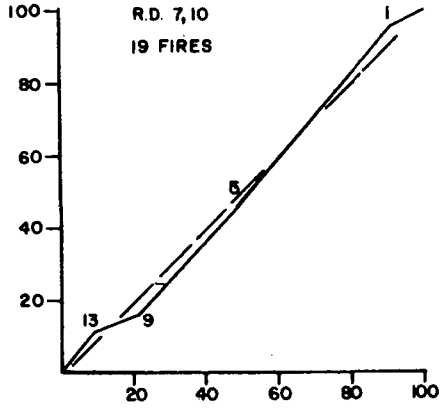
7 REVELSTOKE

R.D. 15, 22
20 FIRES



8 REVELSTOKE

R.D. 7, 10
19 FIRES



APPENDIX VI

VANCOUVER FOREST DISTRICT

CIR-3827
TEC-464
10 Apr. 63.