CONVERSION OF WILLIAMS' SEVERITY RATING FOR USE WITH THE FIRE WEATHER INDEX

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INFORMATION REPORT PS-X-21

CANADIAN FORESTRY SERVICE
DEPARTMENT OF FISHERIES AND FORESTRY
NOVEMBER, 1970

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In 1959, D.E. Williams published a method of calculating the fire season severity rating[1], an integrated measure of fire weather over the whole season. Being based solely on the daily fire danger index (1956 type), it could be used as an objective yardstick for comparing fire weather from year to year or from site to site within any region using the same danger tables.

The seasonal severity rating (SSR) is essentially a weighted average of the daily danger indexes in the old 16-point scale. The weighting factors were developed from 2-minute test fires in jack pine, using a combination of fire perimeter and drought index to represent severity. Thus each day can be assumed to have its individual daily severity rating (DSR), and a severity rating can be calculated for any desired period such as a week or a month. To simplify the calculation, Williams assigned each danger class a weighting factor relative to 1 for Moderate. His procedure for calculating the SSR is:

1) Multiply the number of days in each class by the required weighting factor.

2) Sum the products of step 1.

3) Divide by the total number of days.

The weighting factors are listed in Table 1 along with the scale ranges and mid-points.

Table 1. Scale ranges, mid-points and severity factors.

Danger Class	1956 Danger Index		Equivalent	Williams'
	Scale range	Midpoint	FWI	Severity Factor
Nil	0	0	0	0
Low	1-4	2.5	3.1	0.2
Moderate	5-8	6.5	7.8	1
High	9-12	10.5	16.5	4
Extreme	13-16	14.5	31.7	12

[1] Williams, D.E. 1959. Fire season severity rating. Can. Dept. N.A. and N.R., Forest. Res. Div. Tech. Note 73.

In converting this system for use with the Forest Fire Weather Index (FWI), it would be desirable to make the new SSR's similar to the old ones and at the same time uniform throughout Canada. However, it is not possible to attain both objectives, since the previous danger system had nine different regional versions, each with its own reaction to fire weather. Furthermore, it is not possible to produce new SSR's identical to the old ones in any region, because the old and new danger indexes react differently to weather both day-to-day and throughout the season. It seems better, therefore, to suggest a single severity rating procedure based on the FWI to give comparable results throughout Canada.

The first step was to convert the class mid-points of the old danger index (FDI) to their corresponding FWI values (see Table 1), using the scale equation[2]:

$$\log (\text{FWI} = 0.266\ (\text{FDI})^{0.647}$$

(This equation forms a somewhat artificial link between the two indexes, since it is based on a single set of weather factors that give 16 in the B.C. Coast Danger Index and 40 in the FWI. It is not valid as a general conversion.) Williams' severity factors for the class mid-points were then plotted on double-log paper against the FWI equivalents, resulting in a good straight line with equation:

$$\text{DSR} = 0.0272\ (\text{FWI})^{1.77}$$

At this point it was decided to issue a conversion based on DSR's for every value of the FWI, rather than on weighting factors for danger classes only. This approach has three advantages:

1) It is more accurate, especially for short periods such as a week or month.

2) It gives more realistic weight to very high values of FWI.

3) The danger class structure, which varies from region to region, can be ignored.

The equation can be used directly in a computer for calculation of the SSR, or, for manual work, the DSR's can be taken from Table 2 which gives the values for FWI's up to 50. (This table can be readily extended.) The SSR is simply the mean of the DSR's. As examples, the monthly and seasonal severity ratings for 1966 and 1968 at Petawawa were worked out for both danger systems, and appear in Tables 3 and 4.

To make a regional severity rating as comparable as possible with the old one, it would first be necessary to prepare from experience a curve of FWI versus FDI to replace the scale equation used in this present work. Poor correlation would be expected owing to the different mechanics of the

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[2] Van Wagner, C.E. 1970. Fourth progress report on fire danger development work at Petawawa. Dept. Fish. Forest. Int. Rep. PS-17.

two systems. In any event, severity rating may eventually be done within each region from curves of fire business against the FWI (or one of its components) based on actual experience. The need for the conversion given here would then disappear. Meanwhile, if anyone should desire to work out seasonal severity ratings, this method preserves a link with Williams' original system, and should give roughly similar results.

Table 2. Daily severity rating (DSR) tabulated for the first 50 values of the FWI.

FWI	DSR	FWI	DSR	FWI	DSR
0	0	17	4.10	34	13.97
1	0.03	18	4.53	35	14.71
2	0.09	19	4.99	36	15.46
3	0.19	20	5.46	37	16.23
4	0.32	21	5.96	38	17.01
5	0.47	22	6.47	39	17.81
6	0.65	23	7.00	40	18.63
7	0.85	24	7.54	41	19.46
8	1.08	25	8.11	42	20.31
9	1.33	26	8.69	43	21.17
10	1.60	27	9.29	44	22.05
11	1.90	28	9.91	45	22.95
12	2.21	29	10.54	46	23.86
13	2.55	30	11.20	47	24.78
14	2.91	31	11.87	48	25.73
15	3.28	32	12.55	49	26.68
16	3.68	33	13.25	50	27.65

Note: The seasonal severity rating (SSR) is obtained by summing the individual values of the DSR and then dividing by the number of days.

Table 3. Severity ratings based on two fire danger systems for 1966 at Petawawa.

Period	Severity rating, 1956 Ontario tables	Severity rating, FWI
May	3.67	1.34
June	2.89	2.60
July	5.96	7.27
August	1.65	1.41
September	0.94	1.31
October	1.76	0.58
All season	2.83	2.42

(Note: Values for May and October are higher in the old system, which has no temperature or day-length effect. The drop from August to September in the old system is caused by the sudden switch to the fall danger table on September 1. The new system probably gives a truer, smoother picture.)

Table 4. Severity ratings based on two fire danger systems for 1968 at Petawawa.

Period	Severity rating, 1956 Ontario tables	Severity rating, FWI
May	6.95	2.50
June	0.77	0.36
July	1.11	0.86
August	0.99	0.56
September	0.82	0.55
October	0.69	0.34
All season	1.89	0.86

(Note: The difference here is mainly due to some dry but cool weather in May that produced extreme indexes in the old system, but relatively lower values in the FWI.)