forest management note

Note No. 12 Northern Forest Research Centre Edmonton, Alberta

CALCULATING SPRING DROUGHT CODE STARTING VALUES IN THE PRAIRIE PROVINCES AND NORTHWEST TERRITORIES

The Drought Code (DC) component of the Canadian Forest Fire Danger Rating System (CFFDRS) assesses the influence of summer drought conditions on the fire potential of very slow-drying forest fuels. These are fuels that have a time lag or rate of moisture change of 52 days (Van Wagner 1974). The exact forest fuels considered by the DC were not rigidly specified during the development of the CFFDRS, nor was the DC intended to indicate the exact moisture content of any particular type of material. In its original form the DC was designed to model moisture content changes in the upper layers of mineral soil, just below the upland duff (Turner 1972). The DC in its present form monitors the moisture content of organic matter about 10-25 cm in depth, which weighs approximately 25-50 kg/m^2 when dry and is capable of holding up to 20 cm of water when saturated. The two other standard fuel moisture codes of the CFFDRS rate the moisture contents of fine surface litter and duff.

The DC integrates the effects of temperature, rainfall, and changing day length as the fire season progresses and provides a rating between 0 and 800 (and occasionally higher) to indicate the moisture content of these very slow-drying forest fuels. For example, a DC value of 400 implies that there is a 10-cm moisture deficit in the deep, compact, organic layers and a moisture content of around 125% (Lawson 1977).

The DC serves as a guide to long-range preparedness requirements for large protection areas. It responds very slowly to changes in fire weather conditions and is therefore a useful indicator of seasonal drought effects on forest fuels, because by design it integrates past weather over a longer period than other components of the CFFDRS. As a result, the DC can signal when the lower layers of deep duff may be drier than the upper, a situation that could lead to subsurface fire problems such as those documented by Henderson and Muraro (1968). Thus the DC is the logical yardstick by which to gauge the extent of mop-up problems and suppression difficulties associated with persistent smouldering in deep duff layers and/or concentrations of large, dead and downed woody fuels. Such phenomena can be expected at DC values of around 400 or greater. The DC may also reflect the water available for fire suppression, the moisture content of coniferous tree foliage, and the possibility of fire spread through normally immune fuel types.

Spring Starting Values

In forested areas where snow cover is a normal feature during the winter, fire danger rating calculations should begin in the spring, on the third day after an area is essentially free of snow. Assuming saturation and three days of moderate drying, the spring DC starting value is normally 15 (Anonymous 1978). Overwinter precipitation greater than 200 cm of snow generally recharges moisture reserves; however, a high DC value in the fall and/or below-normal winter precipitation generally necessitates overwinter adjustment of spring DC starting values to correct for this moisture deficiency. In the case of the latter, spring starting dates may be several weeks earlier than normal. Depending on the magnitude, an error in the DC starting value will only be corrected after substantial rain, otherwise it will be carried through a good portion of the fire season. Several days of heavy rain or equivalent snowmelt are generally necessary to reduce the DC to near 0.

Overwinter Adjustment

The standard CFFDRS procedure for overwinter adjustment of spring DC starting values (Turner and Lawson

1978) requires four input values: (1) the DC value on the last day of Fire Weather Index (FWI) calculations the previous fall; (2) the total precipitation (in mm water equivalent) between the date of the last calculation and the spring start-up date; (3) the carry-over fraction of last fall's moisture (1.00, 0.75, or 0.50); and (4) the fraction of winter precipitation effective in recharging depleted moisture reserves in the spring (0.50, 0.75, or 0.90). Turner and Lawson (1978) provide guidelines for selection of appropriate fractional values, which vary according to climate and site characteristics. For fire danger rating purposes the proportion of winter precipitation that actually percolates into the ground is generally estimated to be 50% in west-central Canada. The remainder is lost through interception by tree canopies, direct evaporation or sublimation of the snowpack, evapotranspiration, and runoff before the ground thaws in the spring.

Starting values can be derived from a graph or equations (Turner and Lawson 1978); a program for the Texas Instruments Model TI-59 hand-held calculator is available on request from the author[1]. A spring DC starting value calculated to be less than 15 is set equal to 15. In addition, a table look-up approach for spring DC starting values has been developed by Stocks *et al.* (1977).

1981 Fire Season

Because of the subnormal precipitation during the winter of 1980-81, overwinter adjustment of spring DC starting values was necessary. In March 1981, spring DC starting value look-up tables were issued by the Northern Forest Research Centre (NoFRC) to fire management agencies in the prairie provinces, Northwest Territories, Prairie and Western Region national parks and the Yukon. The tables covered 194 selected fire weather stations and were based on the 1980 fall DC values submitted to NoFRC. A value of 0.75 was used for the carry-over fraction of fall moisture, and 0.50 was used for the precipitation effectiveness fraction. Participating agencies estimated total overwinter precipitation based on data obtained from the nearest or most representative Atmospheric Environment Service (AES) station or other year-round observing station. In the example (Fig. 1), a DC value of 290 was reached on the last day of FWI calculations (October 27, 1980) at Chisholm Lookout in the Slave Lake Forest of Alberta. A total of 111 mm of precipitation fell from then until the starting date of April 7, based on information obtained from the Smith Ranger Station (20 km away), a cooperating AES climatological observing station. By interpolation of the table values the corresponding spring DC starting value was found to be 180.

A summary of the computed spring DC starting values appears in Table 1. Thirteen percent of the stations started at the suggested standard value of 15. The highest starting values were at Turner Valley RS (200), Keane LO (200), and Yates LO (200) in Alberta, at Uranium City (233) in Saskatchewan, at Whitemouth (188) in Manitoba, at Norman Wells (272) in the Northwest Territories, and at Pelly Farm (278) in the Yukon. If a dry spring fire season is anticipated, DC starting values of 200+ are generally considered cause for concern.

Recommendations for Managers

The service provided to user agencies also presented an opportunity for NoFRC to review the general operating practices at fire weather stations. It appears that daily calculations of the FWI and associated components are being curtailed far too early in the fall. There is a natural tendency to stop monitoring fire danger conditions once cool, wet autumn weather sets in. Overwinter adjustment of spring DC starting values is made with a greater degree of confidence knowing that fuel drying and wetting have stopped or are nearly stopped. Index calculations or at least temperature and precipitation measurements should be continued until November 1 or the date of continuous snow cover or ground freeze-up, whichever comes first (Turner and Lawson 1978). If this is not possible for financial or logistical reasons, then the DC wetting and drying

AREA: ALBERTA, SLAVE LAKE FOREST
STATION: CHISHOLM LOOKOUT
THE LAST DROUGHT CODE RECORDED WAS 290 ON 27/10/80.
CARRY-OVER FRACTION OF FALL MOISTURE IS 0.75, AND PRECIPITATION EFFECTIVENESS FRACTION IS 0.50.

WINTER PRECIPITATION (MM)	SPRING DROUGHT CODE
0	405
10	379
20	354
30	331
40	309
50	288
60	269
70	250
80	232
90	215
100	198
110	182
111 →	← 180
120	167
130	152
140	138
150	125
160	111
170	99
180	86
190	74
200	62
210	51
220	40
230	29
240	19
250	15
260	15
270	15
280	15
290	15
300	15
310	15
320	15
330	15
340	15
350	15
360	15
370	15
380	15
390	15
400	15

AES OR OTHER STATION USED FOR PRECIPITATION TOTAL Smith Ranger Station.
TOTAL PRECIPITATION BETWEEN 27/10/80 AND 07/04/81 IS 111 (MM).
SPRING START-UP DATE April 7.
SPRING DROUGHT CODE 180.

Figure 1. Sample spring Drought Code starting value look-up table.

[1] The exclusion of certain manufactured products does not imply rejection nor does the mention of other products imply endorsement by the Canadian Forestry Service.

Table 1. **Distribution of spring Drought Code starting values for 194 selected fire weather stations in the prairie provinces and far north at the beginning of the 1981 fire season**

DC classes	Number of fire weather stations[1]				
	Alberta	Saskatchewan	Manitoba	Northwest Territories	Yukon Territory
15	9	2	13	-	-
16-65	31	10	13	-	1
66-115	36	15	4	1	3
116-165	20	11	1	2	4
166-215	8	2	1	2	-
216-265	-	1	-	1	1
266-315	-	-	-	1	1

[1] Includes national parks within each province or territory.

factors (Anonymous 1978) should be estimated from values recorded at the nearest agency fire weather station or AES station. The temperature and precipitation data collected at AES synoptic stations are in a form that is usable for DC calculations. Sherlock (1981) continued DC calculations at a fire weather station up to the suggested closing date utilizing weather data collected at a nearby AES synoptic station. Noon local standard time temperatures can be approximated by subtracting 3°C from maximum recorded temperatures at AES climate stations. Observers at climate stations generally do note the time(s) precipitation began and ended, and this information can be used in deriving the 24-h accumulated rainfall. Worth noting is the fact that the 24-h rainfall total must reach at least 2.9 mm in order to have any effect in reducing a DC value. Similarly, the wetting and drying phases could be approximated in the spring for late starting stations.

Overwinter monitoring of the DC has been recommended by Kiil (1977). In this way, early-season fire problems can be anticipated and adjustments in operational preparedness can be made accordingly. The spring DC starting value look-up table can be a convenient aid in this regard. Potential starting values can be compared against cumulative precipitation. Winter precipitation data recorded at the principal AES stations are available in the monthly *Canadian Weather Review* and a weekly publication entitled *Climatic Perspectives.* Both series are published by the AES Canadian Climate Centre, 4905 Dufferin Street, Downsview, Ontario M3H 5T4. Finally, a storage-type snow gauge (e.g., Sacramento) to measure overwinter precipitation could be placed at fire weather stations that are isolated from a year-round meteorological observing station.

There remains an unanswered question regarding overwinter adjustment of DC starting values: What cumulative carry-over effects might be introduced to the DC as a result of overwinter adjustments year after year, particularly in climatically arid forest environments? In most cases the effect of a very high spring starting value will have largely dissipated by the end of a normal fire season, so that precipitation deficits accumulated through more than one year will not likely be reflected in the DC. Further research is needed on this aspect of fire danger rating climatology in conjunction with localized studies of fuel moisture conditions. It should be noted that the DC has a relatively minor effect on the Buildup Index and in turn on the FWI. Its main value is as a subsidiary indicator of the dryness of deep organic material wherever a substantial duff or muskeg layer exists.

It is worth emphasizing that even though a station may receive sufficient overwinter precipitation to reduce the DC to the normal or a low starting value, organic layers below 25 cm may still be dry and present problems as the overriding fuel layers dry out. In other words, a low spring value may not fully represent the condition of fuel layers deeper than those now assessed by the DC. Conversely, high spring starting values will likely overrate the potential for smouldering combustion on shallow duff/soil sites.

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