A CALCULATOR PROGRAM

FOR THE

CANADIAN FIRE WEATHER INDEX

(MAGNETIC CARD VERSION)

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Addenda:
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p.10 -- "23. Read edge 1 ... "
          "26. Press ... DMC 33.4 ... "

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Overview

The Canadian Fire Weather Index (FWI) is designed to assist fire control specialists with their estimates of the rate of fire occurrence, spread, and energy output. At each forestry weather station, six current and six forecasted indices are determined each day by the use of a set of interrelated tables. Temperature, relative humidity, wind, rain, and three index values from the previous day (called "yesterday's index values") are required for each FWI determination.

Although the tables are based on a series of fairly involved mathematical equations (far too cumbersome to solve with pencil and paper or by conventional calculator), their use presents some problems, and a new calculator program for this system has now been written. The very nature of tables and their associated classes guarantees that there will be discrepancies between the table and the equation values. These differences appear when computer programs based on equations are used to check field calculations based on tables. Another difficulty associated with the tables is their vulnerability to error. Because today's index values depend on yesterday's values, errors created one day are carried forward for many subsequent days.

Recently, hand-held calculators have been developed that have capabilities approaching those of older computers. We programmed one such calculator, the Texas Instruments TI-59, with the equation version of the FWI and present that program here. Unfortunately, although these calculators are capable of amazing feats, they still have limitations

when it comes to a program of this magnitude. Storage limitations make extra work for the user, and their slowness is still a problem. We can expect these shortcomings to be overcome in the next few years.

The initial portion of the FWI is entered into the calculator on two magnetic cards. This has to be repeated with every new FWI calculation. Once the user enters the input data, program execution proceeds in three phases. First, the fine fuel moisture code (FFMC) is determined and stored internally. Second, because of program space limitations, a third magnetic card must be read in order to calculate the duff moisture code (DMC) and drought code (DC). As soon as the card is read, calculations proceed automatically. The last phase involves reading a fourth magnetic card containing the program code necessary to calculate the initial spread index (ISI), the buildup index (BUI), and the fire weather index (FWI). The six calculated indices can be viewed by repeatedly pressing the /R/S/ button.

Operating Instructions

Starting

Turn the calculator on (sliding switch above the display). All letters or functions written on the keys are activated by pushing the keys. Those functions written directly above the keys are activated by pressing /2nd/ and then the key of interest.

To begin, enter 3/2nd/ /OP/ 17. This partitions the memory, preparing it to receive the information stored on four magnetic cards labelled A, B, C, and D. The number 719.29 should be displayed. One cannot read the cards until this number is obtained.

Entering the Program

Read in magnetic cards A and B. Before each read operation, press /CLR/. Insert the card into the slot below the display on the right side, always with the black side down. Pull the card from the left side after it emerges. For each card, the top and bottom edge must be read. The first time that a card is read, position it so that the writing is normal. The second time, the writing should be upside down but still facing you. Between each read operation, erase the display by pressing /CLR/.

After the first edge of card A is read, a 1 should appear. Clear the 1 and read the second edge of card A. A 2 should appear. A 3 and 4 should appear after reading the first and second edges of card B. If, after any read operation, a digit (0 or otherwise) flashes, the process must be repeated once the display has been cleared with the /CLR/ key. If repeated attempts to read the card fail, turn the calculator off and then on and repeat the whole process.

Weather and Index Input

Once card B has been entered, proceed to enter the weather and yesterday's index values. All weather entries are expressed in metric symbols. First, using the white numerical keys, enter the value of interest. Decimal points and decimal fractions are acceptable. Next, tell the machine what you intend the numbers to represent. This is done with the five keys labelled A through E at the top of the calculator. The written guide just above these keys will assist you (Appendix I). For example, temperature is key A, wet bulb is B, wind is C, rain is D, and month is E. Here, month is any number from 5 to 10 where 5 is May, 6 is June, and so on. In some cases, such as the predicting of indices by

calculator, wet bulb temperature will not be known but relative humidity will; at such times, enter relative humidity on key E (the program assumes that any number below 11 is a month and any number 11 or above is a relative humidity). It is not necessary to enter a wet bulb temperature if a relative humidity entry is made.

To enter yesterday's FFMC, press $\overline{/2nd/}$A; yesterday's DMC, press $\overline{/2nd/}$B; and yesterday's drought code, press $\overline{/2nd/}$C. The items can be entered in any order, with one exception: If a wet bulb temperature is to be entered, there first must be a temperature previously entered; otherwise, the automatic calculation of relative humidity, which is made immediately after the entry of a wet bulb temperature, will be wrong. Note that after a wet bulb temperature is entered, a C flashes on the left side of the display for about 10 seconds; it indicates that the machine is calculating the relative humidity, and it disappears when the relative humidity has been displayed.

In an effort to ensure that reasonable numbers have been entered, a few checks on the data have been devised. If errors are detected, either a 3.1 or a 3.141592654 (π) is displayed, in which case the correct data must be substituted. Some of the checks are as follows:

(a) Dry bulb temperature must be below 36.

(b) Wet bulb temperature must be below dry bulb temperature.

(c) FFMC cannot be below 36.

(d) DC must be above 50.

Should more storage space become available, many more data checks will be possible.

Changing the Input Data

If you wish to change any input value, merely re-enter the number and entry letter. If you are uncertain as to the values already entered,

you may recall them from memory by pressing the /RCL/XX key sequence,

where XX is the storage location given in the following table:

Item	Storage Location
Temperature	00
Relative Humidity	01
Wind	02
Rain	03
Yesterday's FFMC	04
Yesterday's DMC	05
Yesterday's DC	06
Month	07

When you press /RCL/ and then 02, the current value for wind will be

displayed. If you wish to change it, re-enter it using key C.

Executing the Program

The program will start to process the data after /2nd/E is pressed. You

will see the letter C flickering in the left portion of the display.

After about 20 seconds, it will stop flickering and the number 2 will

flash on the display for about half a second. At this time, read in the

first edge of card C. A 3 will flash on the display for half a second.

Read in the second edge of card C. If this is successful, the machine

will automatically continue calculating for about 10 seconds. The

flashing C will again stop, and a 2 will flash briefly on the display.

Read in edge 1 of card D. If this is successful, a 3 will appear

briefly, and at that time, read in the second edge of card D. The

program will then continue automatically and complete the calculations

of the 6 indices in about 10 seconds.

Viewing the Output

Upon completion, the computed FFMC value will be displayed. The remaining

5 indices can be viewed sequentially by repeated pressing of the /R/S/

key. The order is FFMC, DMC, DC, ISI, BUI, and FWI. The sequence will

be repeated if $\overline{/R/S/}$ is pushed again, and $\overline{/2nd/}$E will also initiate the sequence review at any time after the calculations are completed. The program can be stopped at any time by shutting off the calculator. An example describing the necessary steps is presented in Appendix II.

Trouble

If something goes wrong (indicated by a flashing display or an obviously incorrect answer), the simplest solution is to shut the calculator off and begin again. The more sophisticated users can clear the memories according to the calculator manual procedures and attempt to overcome the problem by repeating the last few steps. However, this may be more troublesome than is restarting.

Repeated Calculations

If another FWI calculation is to be made, the best way for the inexperienced user to do it is to shut the calculator off and repeat the process. The more experienced user will probably not find it necessary to repeat reading of edge 1 of card A. To guarantee that edge 2 of card A and the two edges of card B can be read, press $\overline{/INV/}$ $\overline{/2nd/}$ $\overline{/FIX/}$, then $\overline{/CLR/}$. Read the three edges, pressing $\overline{/CLR/}$ between reads. The program is now ready to accept the new input data.

Program Structure

Thirty data registers are used along with 720 program locations. The total program requires about 1400 program locations. The data necessary for the calculations of relative humidity, DMC, and DC are on edge 2 of card B, entered into partition 4 (data locations 0-29). The main program is contained in partition 1 (locations 0-239); it calls the FFMC, DMC-DC, and ISI-BUI-FWI subroutines, which are in partitions 2 and 3 (locations 240-719). The FFMC subroutine is stored on edge 2 of card A and edge 1

of card B and is loaded into the 2nd and 3rd partitions during the initial card reading sequence. The program halts when the FFMC has been calculated and stored. At this time, the DMC-DC program commands are read into partitions 2 and 3 from edges 1 and 2 of card C, thus destroying the FFMC subroutine. The ISI-BUI-FWI subroutines are also read when the DC has been calculated and stored.

Obtaining a Copy of the Program

The program can be obtained from the Canadian Forestry Service by sending four blank TI-59 magnetic cards to

> Peter Kourtz
> Petawawa National Forestry Institute
> Canadian Forestry Service
> 240 Bank Street, P.O. Box 9702
> Ottawa, Ontario, Canada
> K1G 3Z6

The cost of a magnetic card is about 50¢, and they can easily be duplicated by following the TI-59 instructions for card reading. Listings of the program contents and data registers are available on request.

Future Developments

It is recognized that the use of magnetic cards is a nuisance. Texas Instruments offers the possibility of putting the program on a solid state "chip" that can be installed easily by a user in the back of the calculator. The cost of a batch of 250 chips is about $14,000. Three points to be considered when deciding whether this step is desirable are the rapid changes in this technology, the inconvenience of the cards, and the flexibility that we now have in reprogramming the cards.

It is not too difficult to visualize the complete replacement of the tables by such a system in the near future. Researchers will be able to incorporate refinements to the FWI that are known now but cannot be added yet simply because of the complex table lookup scheme that would result.

APPENDIX I

DATA ENTRY GUIDE

TEXAS INSTRUMENTS				
FWI				
YFFMC	YDMC	YDC	EXQ.	OUTPUT
TEMP.	WET BULB	WIND	RAIN	RH/MON.

APPENDIX II

Following is an example of how the Texas Instruments TI-59 is used to calculate the FWI indices for one station.

The input values:

Temperature	27°C
Wind	22 km/hr
Rain	0.00 mm
Relative Humidity	49
Month	7
Yesterday's FFMC	88
Yesterday's DMC	30
Yesterday's DC	210

STEPS:

1. Turn the calculator on
2. Press 3/2nd//OP/17
3. Press /CLR/ when 719.29 appears
4. Read edge 1 of card A
5. Press /CLR/ if a 1 appears, repeat card read if a flashing number appears
6. Read edge 2 of card A
7. Press /CLR/ if a 2 appears, repeat card read if a flashing number appears
8. Read edge 1 of card B
9. Press /CLR/ if a 3 appears, repeat card read if a flashing number appears
10. Read edge 2 of card B
11. Press /CLR/ if a 4 appears, repeat card read if a flashing number appears
12. Enter 27, press A
13. Enter 22, press C
14. Enter 0.0, press D
15. Enter 49, press E
16. Enter 7, press E
17. Enter 88, press /2nd/A
18. Enter 30, press /2nd/B
19. Enter 210, press /2nd/C
20. Press /2nd/D to start execution
21. Read edge 1 of card C after a 2 appears
22. Read edge 1 of card C

23. Read edge 2 of card D after a 2 appears

24. Read edge 2 of card D

25. In 10 seconds the number that is displayed is the FFMC value--88.6

26. Press $\overline{/R/S/}$ to display the FWI indices: DMC 23.4

    DC 218.6

    ISI 10.6

    BUI 48.3

    FWI 22.3