# FORECASTING FOREST FIRE DANGER BY COMPUTER

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Daily forest fire weather forecasts and special fire weather forecasts for "going" fires have been prepared in the Maritime Provinces, by the Department of Forestry and Rural Development, since 1964. During the summer of 1967, this service will be provided to the Province of Quebec, and in the not too distant future may be extended to other Canadian provinces.

The work involved in providing this service can be classified as routine and non-routine. The routine work involves the daily calculation of current and predicted fire danger indexes based on fire danger index tables and current and predicted fire-weather elements. Once the predicted indexes have been calculated they are immediately sent to interested agencies by means of a teletype network.

The non-routine work involves the preparation, on request, of special fire weather and fire danger index forecasts for areas in which there are going fires or for specific fires.

The routine part of this service appeared to be ideally suited for a computer operation. Consequently, in early 1967 a project was set up by the Forest Fire Research Institute to examine the role that a computer might play in the expanding fire-weather forecasting program. To this end a computer program was written to handle the routine work for the Maritime Provinces. Also, an experiment was designed to test the feasibility of using this program to give fire danger index forecasts on a daily basis for the Maritimes.

To visualize where and how the computer fits into this program it is necessary to know the structure of the Canadian danger rating system and the current procedures used to give a fire danger forecast.

## THE CANADIAN FIRE DANGER RATING SYSTEM

The Canadian fire danger rating system is composed of a drought and danger index. The drought index accounts for the long-term effect of dry weather on heavy fuels. The danger index is obtained by combining the drought index and an estimate of fine fuel moisture content. It is the

expression of the ease with which a fire could start and spread in specific forest types of the area that afternoon. Both indexes are found by adding to yesterday's indexes values dictated by the current day's noon weather. The current day's noon weather factors that are required are relative humidity, wind speed, and precipitation.

The initial danger index calculation assumes that the previous night's relative humidity approached 100 per cent. If this is not the case, a correction factor may be applied to the current day's danger index.

A fast drying and a slash index may also be calculated. Both indexes are based on the current day's drought and danger indexes. The fast drying index is used to indicate inflammability in open, well-exposed fuel types such as roadsides, old cut-overs, or burned-over areas. The slash index is used for relatively recent coniferous cut-over where the slash has not been burned or otherwise removed.

To obtain a predicted danger index for the following day, the current day's danger index must first be calculated. This is done by combining in the fire danger tables yesterday's values of the drought and danger indexes with the current day's noon weather. The current day's drought and danger indexes are then used as yesterday's indexes and are combined with tomorrow's predicted weather in the tables to give tomorrow's predicted drought and danger indexes.

## CURRENT FIRE DANGER FORECASTING PROCEDURE

The details of the Maritimes' current fire danger forecasting procedures are described in "Steps in Forecasting Forest Fire Danger in the Maritime Provinces". * In brief, the three Maritime Provinces are divided into 12 forecast regions. Each region is further subdivided into either 3 or 4 forecast areas. The approximate sizes of a region and an area are 4,500 and 1,200 square miles respectively. With the aid of the Meteorological Service personnel and facilities, 24-hour fire-weather forecasts are prepared for the regions or areas, depending on how accurately the forecasters feel the breakdown can be made.

While the following day's forecast is being prepared the current day's weather, drought and danger index data from the forestry and synoptic stations are collected at Fredericton, New Brunswick. These data are sent to Fredericton by way of teletype and telephone and usually arrive before 2:30 p.m. The average current day's drought and danger indexes are calculated for each forecast area. These data are then combined with the 24-hour forecasted weather for each forecast area to find a corresponding danger and drought index forecast.

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* Paul, P. M.: 1966, Steps in forecasting forest fire danger in the Maritime Provinces. Background paper for the Canadian Institute of Forestry, Session on Forest Fire Control, Banff, Alta., Oct. 1966. Canada Dept. of Forestry, Forest Research Laboratory, Fredericton, New Brunswick.

Special forecasts are prepared at the same time for the press, radio and television. These forecasts are based on averages of the forecast areas and in some cases are expressed in the broad danger classes rather than on a numeric rating. By 4:30 p.m. the forecasts are completed and sent out to the requesting agencies by way of teletype. The forecasts are revised, if necessary, the following morning using updated weather forecast data.

## THE FIRE DANGER COMPUTER PROGRAM

Early in 1967, a computer program was written to handle the routine daily fire danger forecasting work of the Maritimes. Some of the more important features of this program are listed below.

(a) Current and predicted drought, danger, slash and fast drying indexes are calculated for each station. The current and predicted danger indexes are corrected for low night relative humidities if enough information is presented to make this correction.

(b) The data from up to 440 weather stations can be handled by the program.

(c) Any existing numeric identification coding system for weather stations, forecast regions and forecast areas may be used. The program redefines any external coding system to a form suitable for the computer.

(d) Current relative humidity for each station is calculated based on dry and wet bulb or dry bulb and dew point temperatures.

(e) Weather may be forecasted for regions or areas or combinations of regions and areas or combinations of regions.

(f) The weather forecast input data required for each forecast area or region are:

1) forecast area or region code number

2) forecasted noon relative humidity

3) forecasted 24-hour precipitation

4) forecasted noon wind speed

5) forecasted maximum night relative humidity (optional).

(g) The current weather input data required for each station are:

1) weather station code number

2) noon wet and dry bulb temperatures

3) noon precipitation

4) noon wind speed

5) previous night's maximum relative humidity (optional).

(h) The forecast and weather station data can be presented in any order. Missing stations are allowed, but their missing data must be assembled before the following day's run.

(i) The current day's drought, danger and relative humidity for each station are automatically punched on cards. These are used the following day as yesterday's drought, danger, and noon relative humidity.

(j) For each station, a record is prepared on cards and printed paper of the station code number, date, previous day's drought and danger, current weather, current indexes, predicted weather and predicted indexes.

A more detailed description of the steps taken in the program may be seen in Appendix I. A sample of the current and predicted indexes as they come from the computer may be seen in Appendix II.

The computer program occupies approximately 85,000 core memory locations in the computer. Loading time (with binary decks) and execution time for a program having 135 stations providing input data are approximately 1.3 minutes and 1.4 minutes respectively. The approximate cost per run is 15 dollars. The computer used is an IBM 360/65. A copy of the program may be obtained from the Forest Fire Research Institute.

## USE OF THE PROGRAM

For the 1967 fire season an experiment has been set up to test the feasibility of using this program in Ottawa to predict the daily fire danger for the Maritimes. There are several reasons why the program will be used in Ottawa (a distance of 700 miles from Fredericton). First, there is no computer available in the Maritimes that is capable of efficiently executing this relatively large program. Secondly, it is of interest to know if one central computer might be able to handle all the fire danger forecasting for most of Canada. It is obvious that a central computer is capable of doing all the necessary work, but the telecommunications equipment required to perform this task in the time required might not be feasible from the technical and economic aspects.

During this summer's trial, the manual method of computing the fire danger indexes will be used similar to the previous summer's operation. This will be carried out in Fredericton. However, immediately after all the current weather data from the reporting stations and the predicted weather data are received, they will be forwarded to Ottawa by teletype. This operation should be completed by about 2:30 p.m. (A.D.T.).

In Ottawa these data will output from the teletype in the form of punched paper tape. This tape will be converted to punched cards and placed in the computer program. The program will then be executed and the output

will be in the form of printed paper. Unfortunately, there are no facilities in Ottawa to convert the computer output to paper tape suitable for teletype transmission. The only alternative available will be to manually type the computer output (current and forecasted weather station indexes) into the teletype. These data will be transmitted to Fredericton as quickly as possible. It is hoped that the Fredericton fire danger office will have this information by 4:30 p.m. each day. In Fredericton the computer-calculated answers will be compared to the manually-calculated answers.

No plans have been made to use the computer to update the forecast each morning. However, this summer a computer program will be written for this purpose. It will be a simplification of the present program and should entail no technical problems.

Each day, it will be the duty of the technician in charge at Fredericton to supply the current day's drought and danger indexes for any of the missing stations to Ottawa. These will be used as yesterday's indexes the following day. This will insure that the missing stations will not be skipped if they report the following day.

Should the answers produced by the computer be accurate and arrive before the manual calculations can be completed, the Fredericton office may rely on the computer answers entirely.

## FUTURE PLANS

If, at the end of this summer's trials, it is found that a computerized forecasting system is desirable and a centralized operation is feasible, a more elaborate telecommunications system will be devised. This system will consist of a group of high-speed data transmission sets, located at central points such as Fredericton, that would send the previously collected weather data directly to the central computer. These data would be held in the computer memory and processed by the computer program at specified times throughout each day. The computer output will be channelled immediately to the correct location by means of the same telecommunication equipment.

This procedure is feasible even today in Ottawa. The Post Office Department is currently operating a very similar system. Very likely the same equipment that they use would be available for the fire danger forecasting.

## BENEFITS OF A COMPUTER ORIENTATED FORECAST SYSTEM

1) Human errors made during the calculation of the relative humidity and indexes are eliminated.

2) More information can be provided than ordinarily would be calculated in the field. This program calculates the current and predicted drought, danger, slash and fast drying indexes for each station. The manual forecast procedure provided only the predicted drought and danger indexes for forecast areas.

3) Record keeping by field personnel can be significantly reduced or eliminated.

4) Daily weather records can automatically be punched on cards or printed on magnetic tape. Monthly weather summaries for each station can be made on the last day of each month.

5) Forecast reliability can easily be checked throughout the fire season. Punched records are kept of forecasted fire danger and actual fire danger.

6) More complex and accurate danger rating systems may be used. No longer will the rating system have to be simplified in the number of variables considered or the ease in making the calculations. Complex equations involving many variables can easily be handled by a computer.

7) The ultimate computerized fire danger forecast system will be much faster than a manual system.

8) Updates of the forecast can be made at any time throughtout the day as new forecast information becomes available. Long-term forecasts may also be made.

9) A computerized system frees the fire weather forecaster from the routine tasks so that he can spend more time improving forecasts and making special forecasts for going fires.

## APPENDIX I

### GENERAL DESCRIPTION OF THE STEPS TAKEN IN THE COMPUTER PROGRAM

1) The appropriate fire danger tables are read into the computer's memory.

2) The relationship between the two different station coding methods is defined. The computer coding system for the stations and forecasting areas permits the computer to interpret in which forecast area each weather station is located simply by the station code number.

3) The current day's date, station names and corresponding code numbers are read.

4) Yesterday's drought and danger indexes and noon relative humidity for each station are read.

5) The predicted weather data for each forecast region or area are read. These data include the relative humidity, wind speed, rain and maximum night relative humidity - they are printed for later verification and for the permanent weather records.

6) If the weather is forecast for larger areas than the finest possible breakdown, the forecast weather data are allocated to the finest breakdown. For example, the weather may be forecast for a region that contains 3 forecast areas; the program will allocate this one set of predicted weather data to all 3 areas. From this point on, the computer program only deals with the smallest possible weather forecast breakdown. In the process of allocating these data a new forecast area coding system is developed.

From step 7 to step 23 the program deals with data from individual stations. It repeats these steps until all stations have been dealt with.

7) The current day's noon weather for a particular station is read. These data include the field code station number, dry, wet and dew point temperatures, wind, rain and night maximum relative humidity; all these are printed as part of the permanent weather record.

8) The field code number for the station is changed to the revised, or computer, code number.

9) If a value for the dew point is given, a sub-routine is called that calculates the relative humidity based on dry bulb and dew point temperature.

10) If no dew point temperature is present, a sub-routine is called that calculates the relative humidity based on the dry- and wet-bulb temperatures.

11) The current day's weather for the station is checked. These checks are:

a) The rain must be less than 2 inches (24-hour rainfall).

b) The relative humidity must be less than 100, but greater than 10 per cent.

c) The wind speed must be less than 30 miles per hour.

d) The maximum night relative humidity must be less than 100 but greater than 10 per cent.

e) The wet and dry bulb temperatures must be less than 100°F but greater than 35°F.

f) The wet bulb temperature must be less than the dry bulb temperature.

If these conditions are not met, the program prints out a message listing the current weather values and bypasses all further calculations with the data from that station. Another station's data are then read.

12) If the data pass these checks, the forecast area in which the station occurs is determined. This is done by knowing the relationship between the revised station coding system and the revised forecast area numbering system.

13) The values of the predicted weather variables taken from the appropriate forecast area are defined for this particular station.

14) A validity check is made of these values, similar to that of step 11.

15) The current day's drought and danger indexes are calculated based on yesterday's drought and danger indexes for that station and the current day's weather.

16) If there has been no rain for the past 24 hours and if enough information is available (yesterday's noon relative humidity and last night's maximum relative humidity), a sub-routine is called that will correct the danger index for maximum night relative humidity. If it rained, or if the appropriate humidity values are not available, the program skips the calling of this sub-routine.

17) The current day's slash and fast drying indexes are then calculated for the station.

18) The four current day's indexes for the station are held in memory.

19) The current day's danger and drought indexes and the current day's relative humidity are redefined as yesterday's drought, danger and relative humidity.

20) The predicted weather variables are redefined as today's weather variables.

21) These redefined values are put through the same steps as used to calculate the current day's four indexes. In this manner the same set of tables is used twice and the necessity of having two duplicate sets of tables is avoided.

22) The resulting indexes are redefined as tomorrow's predicted indexes and are stored in memory.

23) The current weather from another weather station is read (step 8) and the preceding steps are repeated.

24) When the index calculations for all stations have been completed, a printout is made of each station's code number, name and the four current and four predicted indexes. The stations are listed according to a pre-arranged order. An example of this may be seen in Appendix 2.

25) The current day's drought and danger indexes and noon relative humidity for each station are punched on cards. These are used the following day as yesterday's drought, danger and noon relative humidity. Also, the complete weather and index data for each station are punched on cards.

26) For each forecast area, the number of stations and their predicted drought and danger indexes are used to calculate the average predicted drought and danger. These values are then printed.

27) The program automatically switches from the spring and summer index tables to the fall index tables, depending on the current day's date.

## APPENDIX II

NOVA SCOTIA 24 HOUR FORECAST FOR AUGUST 23 1967.

| ID | NAME | CURRENT INDEXES | | | | PREDICTED INDEXES | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | DRT | DAN | SLH | FST | DRT | DAN | SLH | FST |
| 654 | BRIDGEWATE | 10 | 13 | 16 | 16 | 11 | 12 | 16 | 15 |
| 661 | SHERWOOD | 11 | 14 | 16 | 16 | 12 | 12 | 16 | 15 |
| 662 | WESTCALEDO | 11 | 8 | 15 | 11 | 0 | 5 | 13 | 7 |
| 691 | MILTON | 14 | 12 | 16 | 15 | 0 | 5 | 13 | 7 |
| 663 | MIDDLEOHIO | 12 | 14 | 16 | 16 | 12 | 9 | 15 | 12 |
| 650 | YARMOUTH | 6 | 4 | 12 | 8 | 0 | 4 | 12 | 6 |
| 651 | EASTKEMPVL | 10 | 13 | 16 | 16 | 0 | 4 | 12 | 6 |
| 698 | YARMOUTH | 8 | 11 | 15 | 14 | 0 | 4 | 12 | 6 |
| 664 | LAKEJOLLY | 12 | 10 | 16 | 13 | 12 | 4 | 9 | 5 |
| 652 | LAWRENCETN | 8 | 9 | 15 | 12 | 8 | 7 | 14 | 10 |
| 653 | KENTVILLE | 9 | 11 | 15 | 14 | 3 | 4 | 12 | 8 |
| 665 | LAKEGEORGE | 13 | 12 | 16 | 15 | 7 | 6 | 14 | 9 |
| 699 | GREENWOOD | 8 | 12 | 16 | 15 | 2 | 4 | 12 | 8 |
| 753 | STANLEY | 18 | 14 | 16 | 15 | 19 | 16 | 16 | 16 |
| 762 | WILLOWHILL | 5 | 10 | 15 | 14 | 6 | 12 | 16 | 15 |
| 751 | CHIGNECTO | 16 | 8 | 15 | 11 | 17 | 13 | 16 | 15 |
| 752 | WENTWORTH | 17 | 9 | 15 | 11 | 18 | 14 | 16 | 15 |
| 791 | WILLIAMSDA | 0 | 1 | 6 | 0 | 1 | 6 | 13 | 9 |
| 792 | FTLAWRENCE | 25 | 16 | 16 | 16 | 25 | 16 | 16 | 16 |
| 750 | TRURO | 15 | 12 | 16 | 15 | 16 | 13 | 16 | 16 |
| 757 | SHUBENACAD | 21 | 16 | 16 | 16 | 22 | 15 | 16 | 16 |
| 761 | NUTTBY | 22 | 16 | 16 | 16 | 23 | 15 | 16 | 16 |
| 797 | TRURO | 7 | 12 | 16 | 15 | 8 | 12 | 16 | 15 |
| 851 | BLUEMT | 1 | 4 | 12 | 7 | 2 | 7 | 14 | 11 |
| 861 | GREENHILL | 4 | 7 | 14 | 11 | 5 | 10 | 15 | 14 |
| 863 | GARCADEDE | 5 | 11 | 15 | 14 | 6 | 11 | 15 | 14 |
| 850 | ANTIGONISH | 19 | 8 | 15 | 10 | 20 | 13 | 16 | 15 |
| 862 | FAIRMONT | 5 | 10 | 15 | 14 | 6 | 11 | 15 | 14 |
| 899 | COPPER L | 4 | 10 | 15 | 14 | 5 | 11 | 15 | 14 |
| 764 | HAMMONDPLA | 17 | 4 | 1 | 4 | 18 | 10 | 16 | 12 |
| 798 | HALIFAX | 5 | 11 | 15 | 14 | 6 | 13 | 16 | 16 |
| 799 | SHEARWATER | 5 | 10 | 15 | 14 | 6 | 11 | 15 | 14 |