

SHORTER CONTRIBUTIONS

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AN ADAPTATION OF THE LUKE FIRE DANGER INDEX

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1. INTRODUCTION

The Luke fire danger index is in common use throughout Australia by meteorological and fire control personnel. (See form F.C. 22 of the N.S.W. Forestry Commission).

In its application to synoptic meteorology the index suffers from the drawback that it is defined in terms of the relative humidity, whereas the hygrometrical parameter reported on the synoptic network is the dew point. Time is lost in converting dew points to humidity readings before the Luke index can be applied and, on the other hand, since temperature and dew point forecasts have to be combined to produce a forecast of relative humidity, a further unnecessary step is introduced whenever predictions of fire danger are made.

It is therefore desirable to devise a scheme for defining the Luke index in terms of the dew point. If, in the process, the index could be expressed as a continuous function of the fire weather elements, it would be an advantage.

2. LUKE'S TABLE B

In Fig. 1 dew point is plotted as abscissa and temperature as ordinate. The temperature class boundaries of Luke's Table B are drawn in as horizontal lines, viz. 59.5, 67.5, 75.5, 83.5, 91.5 and 99.5 degrees. It is necessary to close the unbounded top and bottom categories of Luke's table, which has been done by drawing in lines at 51.5 and 107.5, thereby maintaining the class interval of 8F.

The other cell boundaries in Luke's Table B are formed by the relative humidities of 0, 15.5, 29.5, 49.5, 79.5 and 100 per cent. It is therefore necessary to locate these lines on Fig. 1.

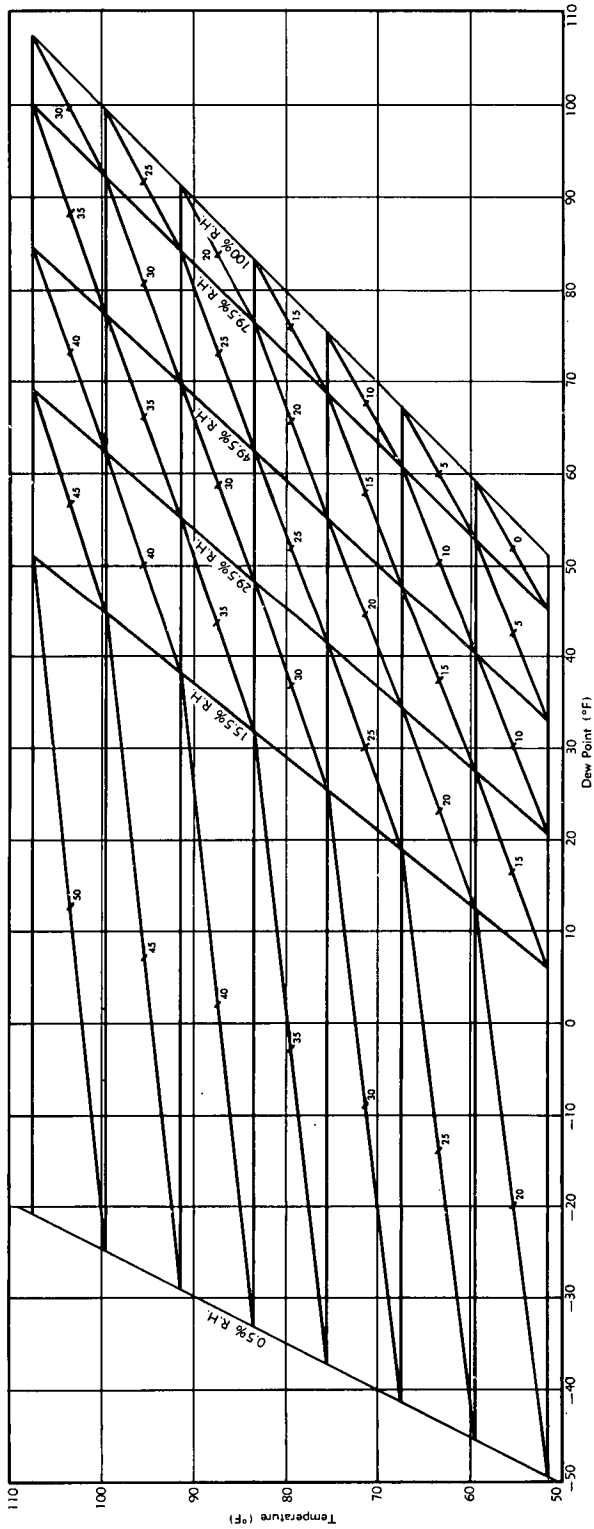


Fig. 1. Partial Fire Danger Rating as given in Lakes Table B.

From the vapour pressure definition of the dew point, and using values of the saturation vapour pressure given in the Meteorological Observer's Handbook (1925), the equations to the above humidity lines are found to be:-

100%:-	$y = x,$
79.5%:-	$y = 1.029 x + 4.817,$
49.5%:-	$y = 1.088 x + 15.448,$
29.5%:-	$y = 1.158 x + 27.645,$
15.5%:-	$y = 1.244 x + 44.196.$

The 0% relative humidity boundary presents a difficulty. From the definition of relative humidity, 0% R.H. requires a vapour pressure of zero. For every value of the dew point there exists a measurable vapour pressure; for instance, at -40°F there is a vapour pressure of 0.0039 inches Hg. It is obvious that 0% R.H. is unattainable. The difficulty can be resolved if we re-define the index in terms of, say, 0.5% R.H., which is virtually synonymous with 0%. The equation to this line is found, by means of Marvin's Tables (1937), to be:-

$$0.5\%:- \quad y = 1.942 x + 147.912.$$

The above relative humidity boundaries have been drawn in as sloping straight lines in Fig. 1. To each rhomboid-shaped cell there exists a partial fire danger rating as given in Luke's Table B. These partial danger ratings have been inserted in Fig. 1.

A weakness in the existing system is apparent if we consider diagonal lines from top left to bottom right. The values of the fire danger rating are seen to increase by discrete steps of 10. We may overcome this weakness in the following manner:-

To the centroid of each cell (the intersection of the diagonals) we ascribe the cell value. The smooth curve joining points of equal rating thus becomes an isoline of partial fire danger rating. The virtual equivalent of this procedure is to draw in the diagonals from bottom left to top right of each cell. The resulting polygons are an approximation to the smooth curves above. We have adopted the latter procedure.

As a final step we may remove the temperature and relative humidity lines from the diagram, and the result is Fig. 2 in which the partial fire danger appears as a continuous function of the temperature and the dew point.

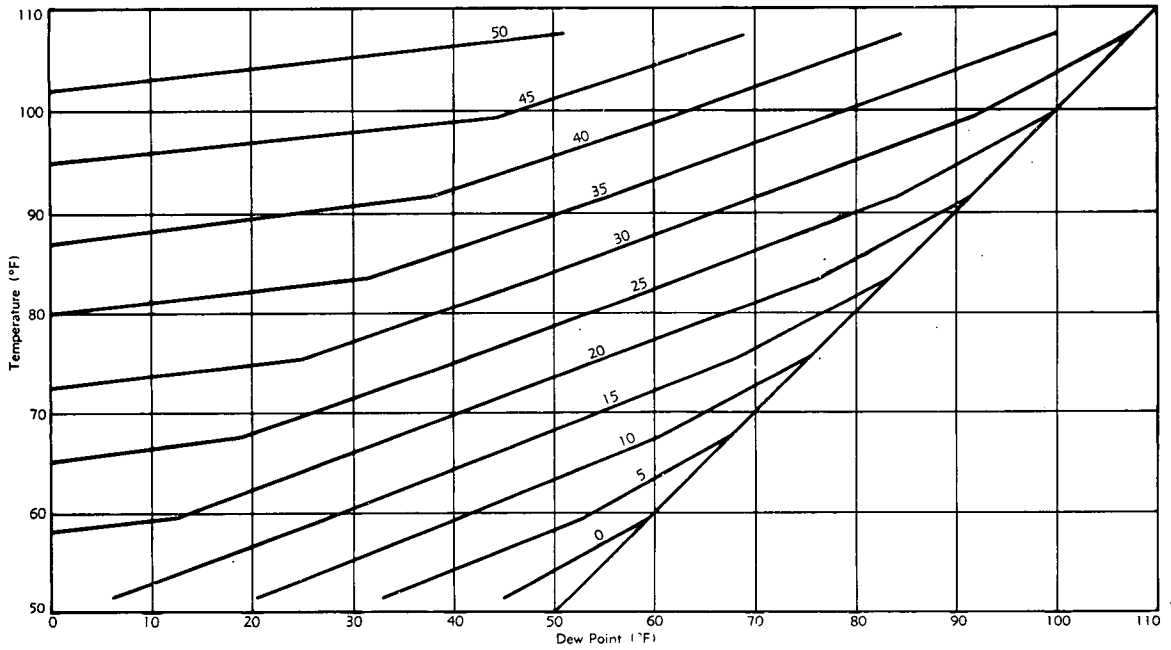


Fig. 2. Partial Fire Danger Rating as a Continuous Function of Temperature and Dew Point.

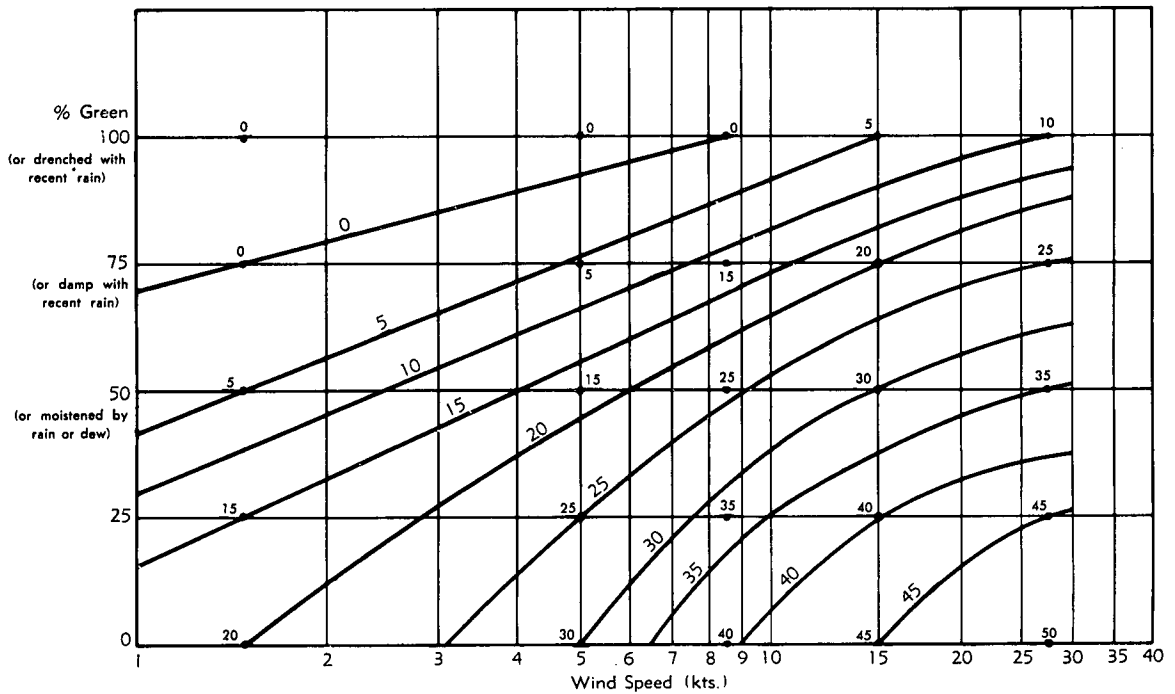


Fig. 3. Partial Fire Danger Rating as a Continuous Function of Wind Speed and Fuel State.

3. LUKE'S TABLE A

Luke's Table A, involving the wind speed and the fuel state, does not lend itself to a similar treatment. However, it may be reduced to a continuous function in the following manner.

Firstly the open, unbounded right-hand category must be closed. This is done by assuming that the category contains Beaufort forces 6-7, i.e. is bounded by 33 kt. No inconvenience would result in practice. Now, on Fig. 3, with Wind Speed as bascissa and Fuel State (expressed from 0 to 100% green), we plot the values of Luke's Table A against the given fuel state and the mean wind speed in the class interval. We then proceed to draw smooth curves through the points.

The resulting curves presented had a hyperbolic appearance when plotted on ordinary graph paper, suggesting that some degree of linearisation might be achieved by the use of semi-logarithmic paper. This has been done in Fig. 3, which displays the partial fire danger rating as a continuous function of wind speed and fuel state.

4. THE FIRE DANGER RATING

As with Luke's tables, the final fire danger rating is obtained by summing the contributions from Figs. 2 and 3. It is only necessary now to modify Luke's Table C to accommodate all the possible integral values of the rating from 0-100. (With Luke's tables some values were not possible). This is done in the following table:-

Fire Danger Index	
Figures	Words
0-19	Nil
20-39	Low
40-59	Moderate
60-74	High
75-89	Very High
90-100	Serious

REFERENCES

- Australian Meteorological Observer's Handbook, 1925, C'wealth Bur. of Met.
 Marvin, C.F. 1937 Psychrometric Tables.
 The Measurement of Fire Danger - Form F.C.22, Forestry Commission of N.S.W.