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A TABLE OF DIURNAL VARIATION IN THE FINE FUEL MOISTURE CODE

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Introduction

The Canadian Forest Fire Weather Index[1/] contains a subsidiary index, called the Fine Fuel Moisture Code, that keeps track of the moisture content of fine dead forest fuel from day to day. The Fine Fuel Moisture Code (FFMC) is computed from daily weather readings taken at noon and yields in code form the moisture content of the fine fuel as it is expected to be during the afternoon peak fire danger period. The FFMC, because of its design, will not give valid answers if entered with weather readings taken at times other than noon. Anyone wishing to determine the Fire Weather Index (FWI) for times other than the afternoon peak period therefore requires a means of estimating the FFMC as it varies throughout the diurnal cycle. A table for that purpose is presented here, and its use to find the FWI throughout the day is described.

In 1969, Muraro, Russell, and Lawson[2/] developed a table showing the 24-hour cycle of FFMC for any starting value, and also showing the effect of varying night humidity. This table was basically sound and satisfactory except for the difficulty in matching real fuel moisture data with the supposed values according to the FFMC scale. The present report should be considered merely a sequel to the work of Muraro, Russell and Lawson, in which the scale problem is ironed out and their data partly reworked.

Development

The prediction of diurnal variation in the FFMC is based on the

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1/ ANON. 1970. Canadian Forest Fire Weather Index. Can. Dep. Fish. Forest., Can. Forest. Serv.

2/ MURARO, S.J., RUSSELL, R.N., and LAWSON, B.D. 1969. Development of diurnal adjustments table for the Fine Fuel Moisture Code. Can. Forest. Serv., Pacific Forest Res. Centre, Inform. Rep. BC-X-35.

assumption that temperature and relative humidity follow more or less normal diurnal cycles in periods of fine settled weather. (Unsettled or changeable weather is often accompanied by rain and need for such information is then at a low level.) The object was, then, to predict the trend in fine fuel moisture for 24 rainless hours following a starting point known at noon. High starting moisture contents were assumed to represent the residual effect of previous rain.

Muraro, Russell, and Lawson based their table on fuel moisture data from a dry lodgepole pine site near Prince George, B.C. They sampled the forest litter up to eight times a day during three field seasons, and drew up a series of curves of the diurnal fuel moisture trend for various starting points. They first stratified the data by classes of initial actual 1600-hr fuel moisture, and later converted to classes of FFMC as determined at noon. The reader is referred to their Information Report BC-X-35 for a detailed account of the problems and procedures involved.

The first step in continuing this work was to design a new scale linking actual fine fuel moisture content with the FFMC value. The scale presently embodied in the FFMC is simply

$$F = 101 - M$$

where F is FFMC, and M is actual moisture content. This scale is adequate for relative day-to-day prediction but has too short a working length for good correlation with real fuel moisture. Thus, the maximum fine fuel moisture according to this scale is 101%, whereas values as high as 300% may be encountered in nature. Accordingly, two sets of fuel moisture data and their corresponding FFMC values were graphed: one set from lodgepole pine (Figure 3 in Information Report BC-X-35), and another set from jack pine forest at Petawawa. These seemed fairly compatible (see Figure 1) and a partly arbitrary curve was drawn through them. The new curve (called the F-scale) shows as before a value of 101 for F when M equals zero, but the maximum possible M is 250 rather than 101. This maximum limit is obviously poorly defined, but is not of great consequence. The dry end of the scale is more important and here the data follow a fairly smooth trend. The following pair of equations match this curve quite well and express the new F-scale:

$$M = \frac{205.20\ (101-F)}{82.90 + F}$$

$$F = \frac{82.90\ (250-M)}{205.20 + M}$$

The second step was to reharmonize the basic fuel moisture data in order to utilize the greater range of actual moisture content allowed by the new scale. In this procedure the data were regraphed in two ways:

1) as curves of fuel moisture content over time of day for different initial moisture values, and 2) as curves of fuel moisture at a particular hour over varying initial moisture content at 1600 hr. The second set of curves was used to readjust the first set, after which the second set was drawn again. Figure 2 shows a partial set of final harmonized curves in terms of real moisture content over time for different starting points. The same pattern used by the previous workers was followed in constructing the table. That is, for times from 1200 to 2000 hr a single humidity trend was assumed; for the hours 0600, 0800, and 1000, however, three classes of humidity are shown to allow for variation in overnight weather. In Figure 2 only the highest overnight humidity class appears.

The third step was to convert the desired column headings of initial FFMC to actual fuel moisture content according to the F-scale. Finally, values of fuel moisture for each starting value and hour were read from the curves, converted to FFMC and entered in the new table (Figure 3).

Description of Table

a) As mentioned earlier, the FFMC, although determined from noon weather readings, actually refers to fuel moisture at the peak afternoon period, say 1600 hr. Accordingly, the 1600-hr FFMC given in the new Diurnal FFMC Table has the same value as the column heading for the initial FFMC determined at noon; the real noon FFMC given in the 1200-hr row is somewhat lower.

b) For times during afternoon and evening (up to 2000 hr), a single humidity trend is assumed, and only one value of FFMC is given for each initial value and time of day. For the morning hours, the Table allows for three classes of prevailing relative humidity, which must be measured or estimated. The effect of low morning humidity is assumed to have disappeared by mid-afternoon; this follows Péch's[3/] earlier conclusion.

c) The Table gives diurnal trends of FFMC for initial FFMC's of 50 and above only. Below this - starting point, the fuel moisture is so high that no one is likely to be interested in its diurnal variation.

d) The Table presumes a reasonably normal cycle of temperature and relative humidity during the 24 hours following each standard noon determination of FFMC. No allowance is made for rain.

[3/] Péch, Gy. 1968. Comments on revising the night humidity correction table. Unpublished report, Can. Forest. Serv., Forest Fire Res. Inst.

e) The new Table was produced purely by graphical methods, the moisture content values being read from empirical curves. If it should ever be necessary to compute the diurnal trends of FFMC, these curves will have to be reduced to algebra, not an easy task because of their complex form. Probably informal direct use of the Table will suffice.

Finding FFMC and FWI Throughout the Day

To find FFMC at times other than noon:

1) For morning hours only, measure or estimate current relative humidity.

2) Referring to Diurnal Table, find column heading closest to FFMC last computed at noon.

3) Find row heading for desired time of day and relative humidity (if required).

4) Where column and row intersect read desired current FFMC.

5) For times of day not listed, interpolate between adjacent rows.

To find the Fire Weather Index (FWI) at times other than noon:

1) Measure or estimate current wind speed.

2) Find current FFMC as described above.

3) Assume no change in DMC, DC, or ADMC since last noon.

4) Determine Initial Spread Index (ISI) from Table 4 in the Canadian Forest Fire Weather Index, using current wind speed and current FFMC.

5) Determine FWI from Table 6, using current ISI as just found and ADMC as last determined at noon.

To illustrate the above procedures, imagine that FFMC and FWI are desired for 0600 hr on June 9 in the example Monthly Record on Page 18 of the Canadian Forest Fire Weather Index. The current humidity and wind at 0600 hr are, say 75% and 5 mph. The following tabulation shows how the 0600 June 9 values follow from the starting values at noon on June 8.

Item	Starting values June 8, noon	Current values June 9, 0600 hr
Relative Humidity	28%	75%
Wind speed	14 mph	5 mph
FFMC	87	72
DMC	24	24 (no change)
DC	196	196 (no change)
ISI	9	1.0
ADMC	36	36 (no change)
FWI	18	2

In case of appreciable rain since noon, the whole procedure is of course invalid. If the amount of rain is small, the resulting FFMC and FWI may be of use as maximum limits.

DIURNAL FFMC TABLE

Time "T"	Relative Humidity (percent)	50	55	60	65	70	75	78	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99
		FFMC Determined at Noon																										
		FFMC at Time "T"																										
1200		42	46	50	53	56	63	66	69	70	72	74	76	79	81	83	85	87	88	89	90	91	92	93	94	95	96	97
1400		46	50	54	59	64	70	74	76	77	79	81	82	83	84	85	86	88	89	90	91	92	93	94	95	96	97	98
1600		50	55	60	65	70	75	78	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99
1800		52	58	63	67	71	75	78	80	81	82	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98
2000		54	59	63	67	70	74	76	78	79	80	81	82	82	83	84	85	86	87	88	89	90	91	92	92	93	94	95
0600	<68	58	59	60	61	62	65	67	69	70	71	72	72	73	74	75	76	78	80	81	82	83	84	85	87	88	90	92
	68-87	51	52	54	56	59	63	64	66	67	68	69	70	70	71	72	73	75	76	77	79	80	81	82	83	84	85	87
	>87	45	47	49	52	55	59	61	63	64	65	66	67	68	69	70	71	72	74	75	76	77	79	80	81	82	83	85
0800	<48	63	64	65	66	68	71	72	74	74	75	76	76	77	78	79	80	82	83	84	85	86	87	88	89	90	92	93
	48-67	53	55	57	59	62	66	68	70	71	72	73	74	75	76	77	78	79	80	82	83	84	85	86	87	88	89	91
	>67	47	48	50	53	56	60	63	66	67	68	69	70	71	72	73	74	76	77	79	80	81	82	83	84	85	87	89
1000	<38	73	74	74	75	76	79	80	82	82	82	83	84	84	85	85	86	87	88	89	90	91	92	92	93	94	95	96
	38-57	65	67	69	71	73	75	76	78	79	80	80	81	82	82	83	84	85	86	87	88	89	90	91	92	92	93	94
	>57	60	62	64	66	68	70	72	74	74	75	76	77	77	78	79	80	81	82	83	84	84	85	86	87	88	89	90

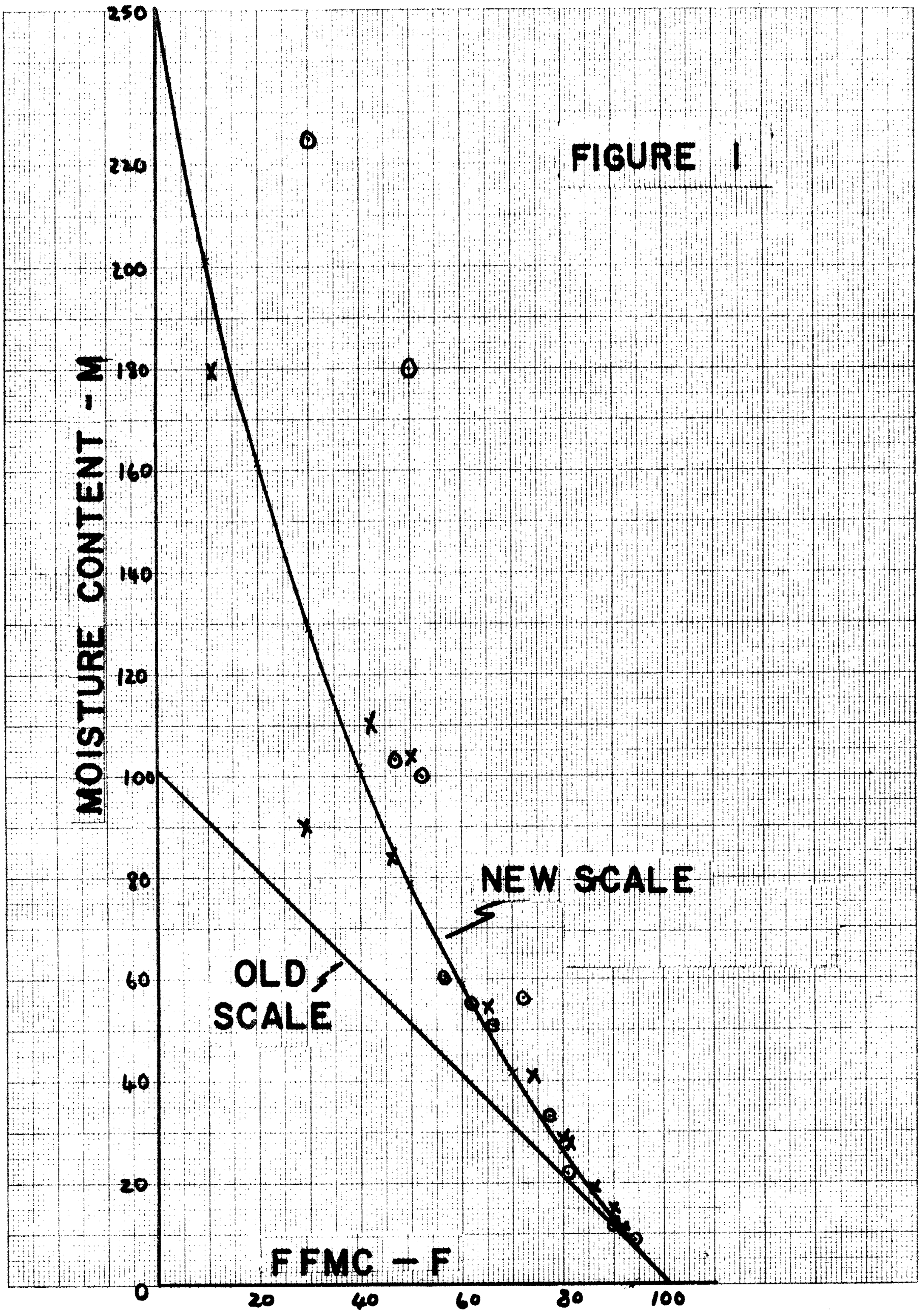
MOISTURE CONTENT - M
250
220
200
180
160
140
120
100
80
60
40
20
0
FFMC - F
20
40
60
80
100
NEW SCALE
OLD SCALE

FIGURE I

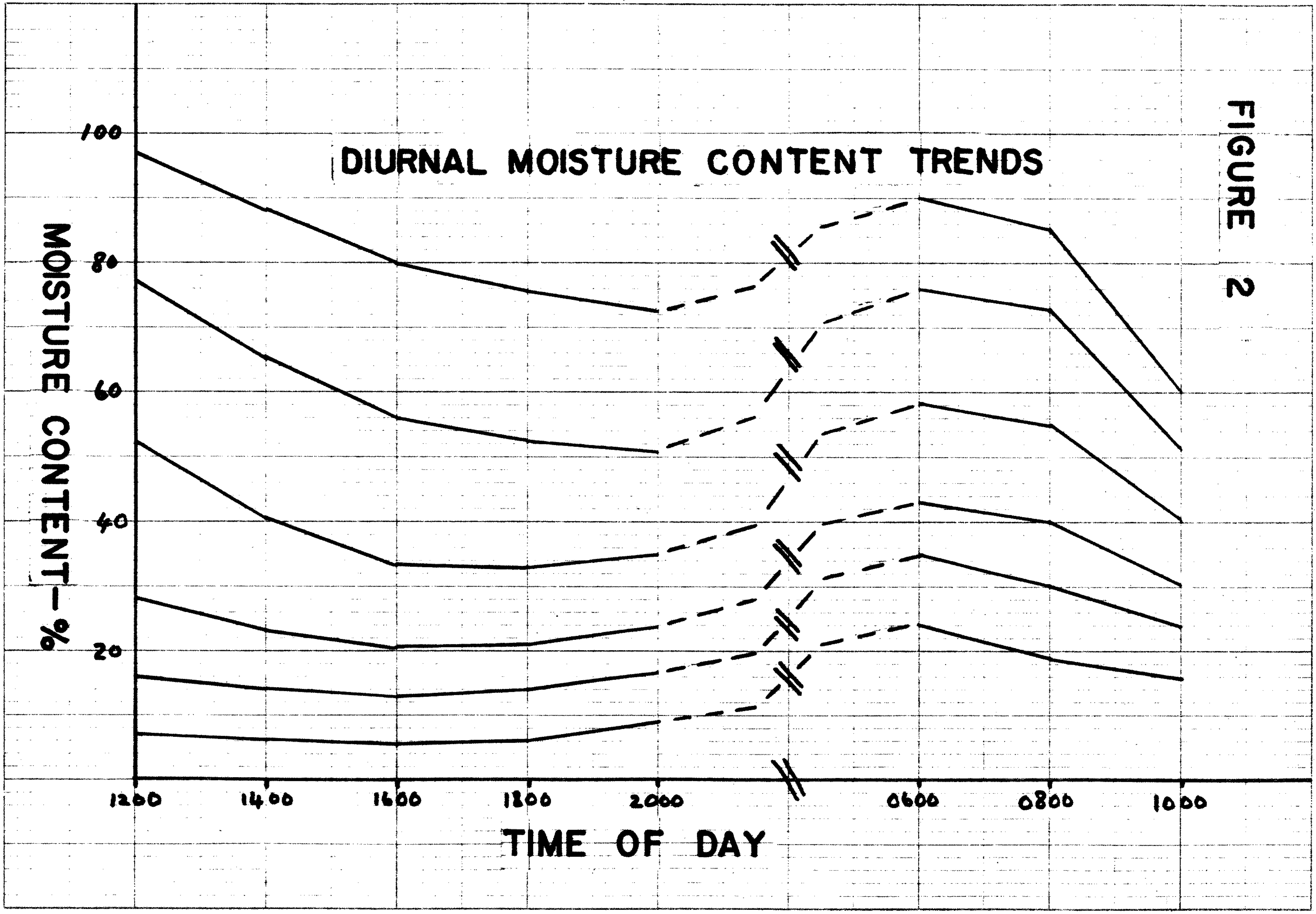
DIURNAL MOISTURE CONTENT TRENDS
MOISTURE CONTENT—%
100
80
60
40
20
1200
1400
1600
1800
2000
0600
0800
1000
TIME OF DAY

FIGURE 2