CALIBRATION OF SURFACE WIND SPEED OBSERVATIONS IN CANADA

by

A. J. Simard

FOREST FIRE RESEARCH INSTITUTE
OTTAWA, ONTARIO
INFORMATION REPORT FF-X-30

CANADIAN FORESTRY SERVICE
DEPARTMENT OF FISHERIES AND FORESTRY
APRIL, 1971

CALIBRATION OF

SURFACE WIND SPEED OBSERVATIONS IN CANADA

by

A. J. Simard

Forest Fire Research Institute
Department of Fisheries and Forestry
Majestic Building
396 Cooper St.
Ottawa 4, Canada

Information Report FF-X-30
April 1971

CONTENTS

USERS NOTE FOR THE FIRE WEATHER INDEX COMPUTER PROGRAM

1. If both DC and DMC equal zero, the equations at line 322 of subroutine FINDEX may yield a divide check. While this is unlikely to occur, the following modification to the subroutine will provide an additional margin of safety:

```
     C.  ADJUSTED DUFF MOISTURE CODE                         321
*        IF (DC.LE.0.0.AND.DMC.LE.0.0)  GO TO 4
         ADMC=(0.8*DC*DMC)/(DMC+0.4*DC)+0.5                  322
         IF (ADMC.GE.DMC)  GO TO 5                           323
         P=(DMC-ADMC)/DMC                                    324
         C=0.92+(.0114*DMC)**1.7                             325
         ADMC=DMC-(C*P)+0.5                                  326
*        GO TO 5
*    4   ADMC=0.0
     5   IF (ADMC.LT.0.0)  ADMC=0.0                          327
```

* = Additional cards

2. It has been ascertained that the range of acceptable input values can be expanded somewhat without adversely affecting the program. The effect of such an expansion is an increase in the disparity between the computer calculated results and those obtained through table look-up. The difference between the two approaches may be doubled particularly in the F.F.M.C., where it could be as much as ten to twenty points. For those who are not concerned with comparisons with table values, the following limits might be considered for all subroutines:

Relative Humidity:	2% and 98%
Temperature:	32^{O}F and 105^{O}F
Wind:	0 m.p.h. and ~~60~~ 50 m.p.h.
Rainfall:	0 in. and 5 in.

3. In addition the intermediate upper limits on PO, DO and ADMC may be removed without adversely affecting the program. These are at lines 272, 297 and 331 respectively. The limit on the FFMC must be retained.

4. The rounding off procedures were inserted mainly to increase the compatability of the computer and tabular results. They are not necessary if only the computer results are being used. Rounding off is done by adding 0.5 at the end of an equation, converting to integer and reconverting to real. The first column in the following table indicates equations where (+0.5) at the end of an equation could be removed, and the second column indicates the program lines with the associated conversion sequence.

(Addendum FF-12)

1.	2.
250	251, 2
280	281, 2
302	307, 8
322	328, 9
335, 337	339, 40
341	---

If the 0.5 is removed, the conversions sequence must also be removed.

5. It was found that a slightly more accurate starting date for eastern Canada could be obtained by using a temperature of 48° instead of 50° in line 37. Whether or not this would be true for western Canada is not known.

ABSTRACT

Implementation of Forest Fire Weather Forecasting requires the development of a procedure for obtaining representative wind speed observations for large areas. In this paper, a procedure is outlined whereby surface observations can be used to obtain area averages. The procedure involves the calibration of each station with respect to a standard value, and then relating the calibrated value to a wind speed distribution which is applicable to the Forest Fire Weather Index. A map showing wind speeds across Canada which can be used to calibrate any station is also presented.

ACKNOWLEDGEMENTS

The author wishes to express his gratitude to L. B. MacHattie of the Forest Fire Research Institute for the considerable assistance which he provided during the course of the analysis. Thanks are also due to A. G. Copeman who performed much of the data compilation, and P. M. Paul who assisted in the preparation of the final report.

CALIBRATION OF SURFACE WIND SPEED OBSERVATIONS IN CANADA

INTRODUCTION

Wind speed is one of the most important meteorological parameters affecting the recently developed Canadian Forest Fire Weather Index (Canadian Forestry Service, 1970). The difficulties involved in obtaining a reliable estimate of the average wind speed over a large area using a point observation have been discussed in a previous report (Simard, 1969a). A second report (Simard, 1969b) described a computer program which had been developed to compare forestry and nearby airport wind speed observations for the purpose of calibrating the forestry stations.

In the latter report, brief mention was made of the possibility of calibrating individual airports as well as forestry stations. Further work with data from a large number of D.O.T.* stations across the country has indicated that calibration of wind speed measurements at individual airports is essential if any comparison of fire behaviour data between stations is to be made. The purpose of this report is to describe the procedures used to calibrate individual airport observations. In addition, a quantitative definition of a standard wind speed distribution with respect to the Fire Weather Index is also presented.

CALIBRATION OF SURFACE OBSERVATIONS

The main purpose of station calibration is to remove bias caused by local topography, the site, or instrument location which would result in an individual station not being representative of the general area within which it is located. On the other hand calibration should

* The Meteorological Branch of the Department of Transport is now the Canadian Meteorological Service of the Department of Fisheries and Forestry.

not affect large scale differences which represent real differences in surface or geostrophic wind speed distributions. Since all surface wind speed observations are influenced by local conditions to some degree, upper air measurements should be analyzed to determine true wind speed.

In North America upper air observations are taken twice daily (at 0000 GMT* and 1200 GMT) by a network of radiosonde stations which are located 300 to 500 miles apart. On each ascent, data on wind speed as well as several other parameters are recorded for a series of standard pressure levels. The daily observations for each pressure level have been summarized and averaged by month and time of day by the Met. Branch, D.O.T. For this analysis, monthly summary data from the 0000 GMT observation for all months within the period 1962 to 1966 were obtained for all stations within or near the forested areas of Canada. Thirty-three stations in Canada and the United States were used. These stations are listed in Table 1**.

Wind speed profiles from the surface to the 700 mb level (approximately 9,000 feet) were plotted for each station using the average wind speed at each pressure level for April through October only. Station elevations for the Canadian stations were plotted by using the average pressures for April through October which are listed by Titus (1965). For the U.S. stations, elevation in feet was converted to surface pressure using the relationship 1 mb = 28 ft. and a sea-level

---

* Greenwich Mean Time.

** Data for the Canadian stations were obtained from the Meteorological Branch, Department of Transport, Toronto, Ontario. Data for the U.S. stations were obtained from the National Weather Records Centre, U.S. Department of Commerce, Asheville, N.C.

Table 1. LIST OF RADIOSONDE STATIONS AND SUMMARY OF DATA

			Observed Surface Wind Speed	Wind Speed 100 mb Above Surface	Hypothetical Projected Wind Speed at Surface
1.	ARGENTIA	NFLD.	6.6	23.5	23.3
2.	STEPHENVILLE	NFLD.	3.5	23.5	18.8
3.	SABLE ISLAND	N.S.	5.9	22.4	21.7
4.	GOOSE	LAB.	5.1	21.1	18.1
5.	SEPT ISLES	QUE.	5.2	19.9	17.5
6.	CARIBOU	ME.	4.9	22.1	19.9
7.	PORTLAND	ME.	4.2	20.8	18.6
8.	NITCHEQUON	QUE.	5.1	21.5	20.6
9.	MANIWAKI	QUE.	3.1	18.1	15.5
10.	BUFFALO	N.Y.	3.8	20.7	17.5
11.	MOOSONEE	ONT.	4.5	20.4	18.4
12.	SAULT STE. MARIE	MICH.	5.3	21.7	20.2
13.	TROUT LAKE	ONT.	5.2	20.2	17.0
14.	INTERNATIONAL FALLS	MINN.	4.7	20.2	17.5
15.	CHURCHILL	MAN.	7.6	21.1	19.9
16.	BAKER LAKE	N.W.T.	6.7	19.0	18.1
17.	THE PAS	MAN.	5.6	17.5	15.2
18.	BISMARK	N.D.	6.0	20.2	19.3
19.	GLASGOW	MONT.	6.3	18.4	17.9
20.	GREAT FALLS	MONT.	6.3	17.5	17.2
21.	FT. SMITH	N.W.T.	5.1	15.2	13.0
22.	COPPER MINE	N.W.T.	4.9	14.3	13.0
23.	EDMONTON	ALTA.	5.3	16.6	13.7
24.	SPOKANE	WASH.	4.7	13.9	13.2
25.	TOTOOSH ISLAND	WASH.	6.0	14.2	13.9
26.	PRINCE GEORGE	B.C.	4.8	14.1	10.8
27.	FORT NELSON	B.C.	3.7	12.5	8.7
28.	PORT HARDY	B.C.	4.5	14.1	10.5
29.	ANNETTE ISLAND	ALA.	4.8	17.9	16.8
30.	NORMAN WELLS	N.W.T.	4.8	14.1	13.0
31.	INUVIK	N.W.T.	4.2	12.5	10.1
32.	WHITEHORSE	Y.T.	5.3	14.3	13.4
33.	FAIRBANKS	ALA.	3.6	12.9	9.2

pressure of 1,013 mb. Four typical profiles are shown in Figure 1.

The individual wind speed profiles obtained through the above process are of dubious reliability close to the surface. There are several reasons for this:

1. The surface winds are affected by local factors at each site.
2. Since all flights are made at 0000 GMT, the local flight time varies from 2030 LST in Newfoundland to 1400 LST in Alaska. The diurnal variation of wind speed during this period is considerable. Any country-wide comparison of surface winds would therefore require an adjustment for time of day.
3. Radiosonde stations are quite often not at the same airport location as the hourly reporting synoptic stations, as the requirements for releasing balloons at set times would pose a hazard to air traffic. Therefore, surface wind speeds measured at radiosonde stations may be significantly different from those measured at synoptic stations.
4. Observations at pressure levels close to the average surface pressure can be made only if the surface pressure is greater than the pressure level under consideration. Therefore, a sample of wind speed observations close to the ground would be biased in favour of high pressure days.
5. In most cases, there are only one or two points with which the rapidly changing profile is defined. Such limited data makes precise definition of the curve exceedingly difficult.

Geostrophic wind is, by definition, that wind which blows above the level of ground influence. The level of ground influence is generally considered to be 1,000 to 3,000 ft. above the surface, depending on several factors.

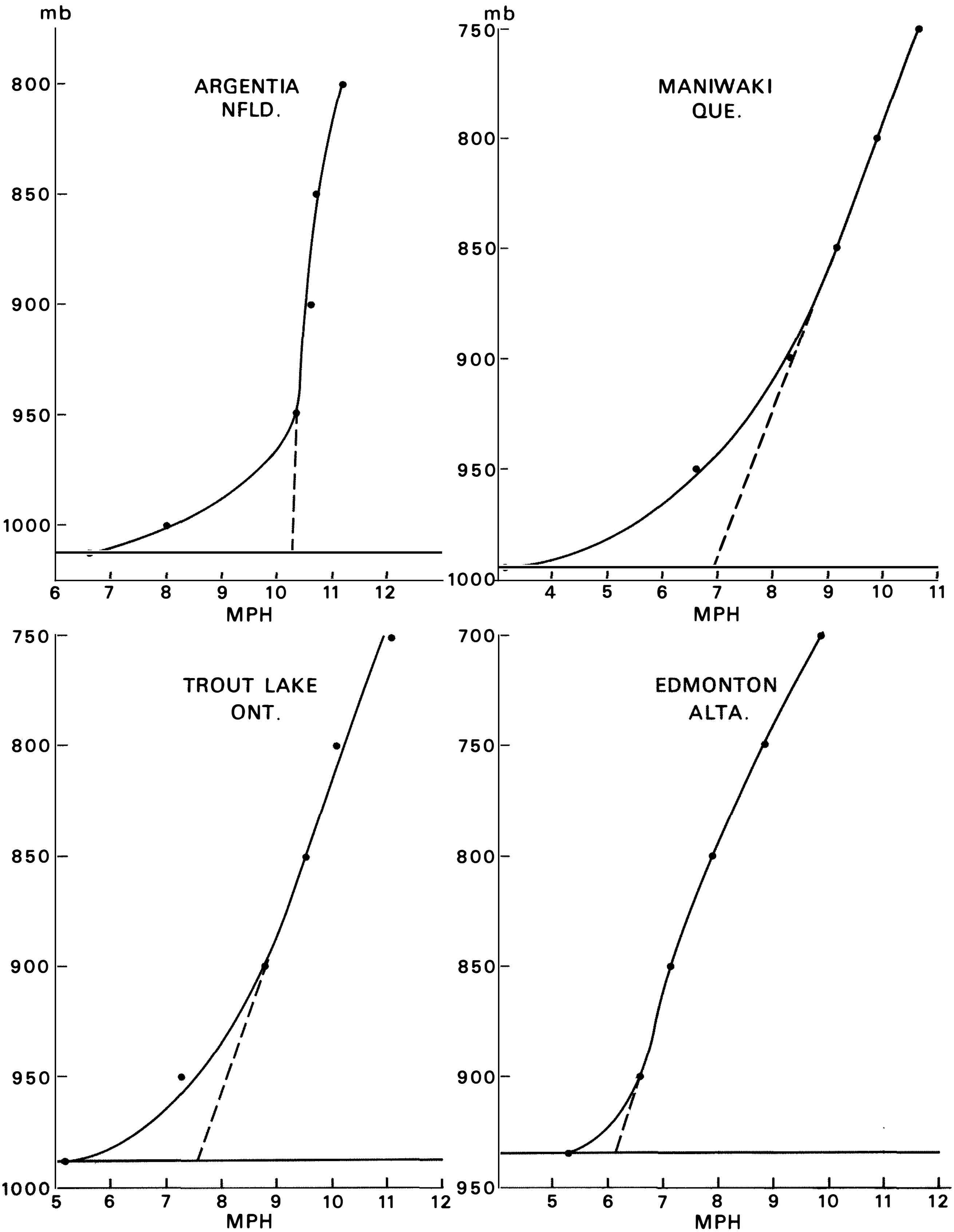

FIGURE 1 FOUR TYPICAL WIND SPEED PROFILES

Individual station profiles used in this study were in agreement with this general observation in that ground influence did not extend beyond 100 mb (about 3,000 ft.) for any station. In many cases ground influence terminated considerably below this level. Therefore, the average wind speed at 100 mb above the surface at each station was initially chosen as the standard for all radiosonde stations. These values are listed in Table 1.

When attempting to relate the upper air observations to actual surface measurements, some significant discrepancies were noted between the patterns exhibited by the two. At the same time it was noted that the slopes of the individual wind speed profiles above the 100 mb level varied considerably. This variability in slope above the level of ground influence was assumed to be a characteristic of the geostrophic wind pattern. Most of the profiles were very nearly linear for some distance above the point at which ground influence was no longer manifested. Because of this, it was a fairly straightforward matter to project this profile to the surface to obtain a hypothetical estimate of the average surface wind speed in the absence of friction. The patterns of the average hypothetical frictionless surface wind speeds agreed with actual surface measurement patterns much more closely than did the values 100 mb above the surface. For this reason the projected surface wind speeds were used as the final standard values for all radiosonde stations. These values are also listed in Table 1.

An attempt was made to draw an isotack* pattern for Canada using the hypothetical surface winds. With only 33 radiosonde stations, however,

---

* Lines of equal wind speed.

it was possible to differentiate only general patterns on a Continental scale. There were many areas where stations were several hundred miles apart where the pattern could not be depicted with any degree of certainty.

In an effort to improve the resolution, average surface wind speed data (24 hours per day) for 67 airports (D.O.T., 1959) were added to the radiosonde data. All airport averages were adjusted to a uniform height of 10 meters above the ground by using the relationship given by Sellers (1965). The airport data was adjusted to make it comparable with the hypothetical data by dividing each airport average by the ratio between the averages of two sets of data.

For example, the average zero friction surface wind speed was 16.1 m.p.h. and the average observed surface wind speed at the same airports was 8.86*. The ratio of the two averages is 0.55. The average for each airport was divided by 0.55 and the result plotted with the radiosonde data. With the additional data it became possible to plot isotack patterns with a minimum resolution of about 100 miles, and in some areas considerably less. This resolution was felt to be quite adequate for the purposes of this calibration, as wind speed variations which affect areas much less than 100 miles across would be more closely related to local influences rather than general geostrophic wind speed patterns. It is these local effects that this calibration is attempting to remove.

The isotacks plotted in Figure 2 are hypothetical "zero friction" surface wind speeds. The contour interval is 2 m.p.h. While the patterns are in general agreement with the surface wind speed patterns plotted by

---

* Only those locations where both radiosonde and airport observations were obtainable at the same location were used to determine these averages.

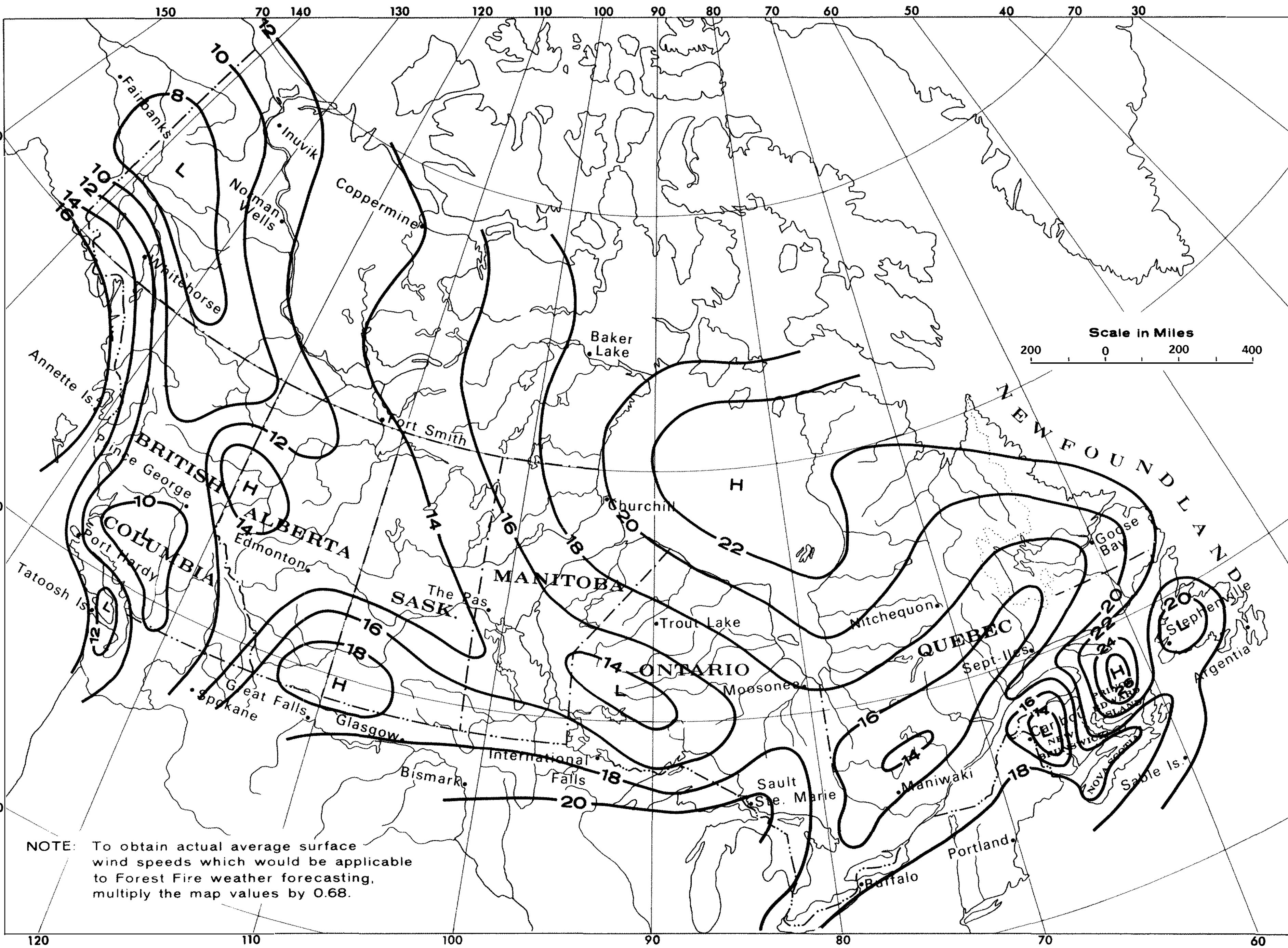

FIGURE 2. AVERAGE HYPOTHETICAL ZERO FRICTION SURFACE WIND SPEEDS

Thomas (1953) an objective comparison is not possible due to the lack of resolution in Thomas' work. In general however, the patterns are not unexpected. There is a trough of low wind speeds between the Pacific Coast and Rocky Mountains. Part of this trough also extends eastward across the forested regions of the entire country to Labrador although the average wind speed gradually increases in the eastern part of the country. There are zones of high winds in the Prairies, Hudson Bay, along both coasts and particularly in the Gulf of St. Lawrence.

While the absolute values which are shown are naturally greater than what would actually be observed on the ground it is possible to use relative values from Figure 2 to calibrate any set of actual surface observations. In other words, it would be possible to calibrate observations at a number of stations regardless of whether they were made in the afternoon or in the early morning, in flat prairie land or in rolling wooded terrain. The next section discusses the procedures used to calibrate observations which would be applicable to the Forest Fire Weather Index. Similar procedures could be applied to any other set of observations.

RELATING HYPOTHETICAL SURFACE OBSERVATIONS TO THE FIRE WEATHER INDEX

In the Canadian Forest Fire Weather Index the following statement can be found: ". . . wind speeds used in the Forest Fire Weather Index apply to measurements made in forest clearings. The use of wind speeds measured in open areas (such as airports and lookout towers) may give speed values which are too high". This cautionary note merely reminds users of the existence of a potentially serious problem. More specific recommendations were not given simply because, even though some research has been done, the state of practical knowledge in this field leaves much to be desired.

The work of Dalgliesh and Boyd (1962) indicates that the general surface roughness (prairie vs. forest) will have a considerable large scale effect on surface wind speed. Much investigation of this effect has been undertaken. The work of Jenson (1954) is typical of the results which can be found in the literature. He examined wind speeds over two west to east transects across Jutland. Over a relatively smooth transect, the surface wind speed was reduced to 80% of its value at the western shore at a distance of 10 km inland. At 25 km inland it was further reduced to 65% of its original value. After passing over the eastern shore, it had regained 75% of its original speed at a distance of 10 km from the shore. Over a rough transect, the value was reduced to 50-55% of its original after 20-30 km and remained at this level until reaching the eastern shore. It is logical to assume therefore that surface wind speeds measured in the prairies and on sea coasts would tend to be higher than those measured in forested or hilly areas even though they resulted from the same pressure gradient. It is unlikely that a significant increase would be noticed in wooded or rolling areas even in a level clearing which was sufficiently large to accommodate a major airport.

The above conclusions are supported by a comparison of data from a large number of airport stations. Average wind speeds tend to be lower at airport exposures in forested areas than at comparable exposures on the prairies or on sea coasts. They are sufficiently lower in fact, that the limit of 30 m.p.h. in the ISI table of the FWI is more applicable to an average airport in a forest environment than an average forestry station in the same environment as it would have considerably less exposure.

More specifically, the wind speed distribution which was observed at Vancouver Airport is plotted in Figure 3. This distribution is similar to distributions obtained at most airports which have a completely unobstructed exposure.

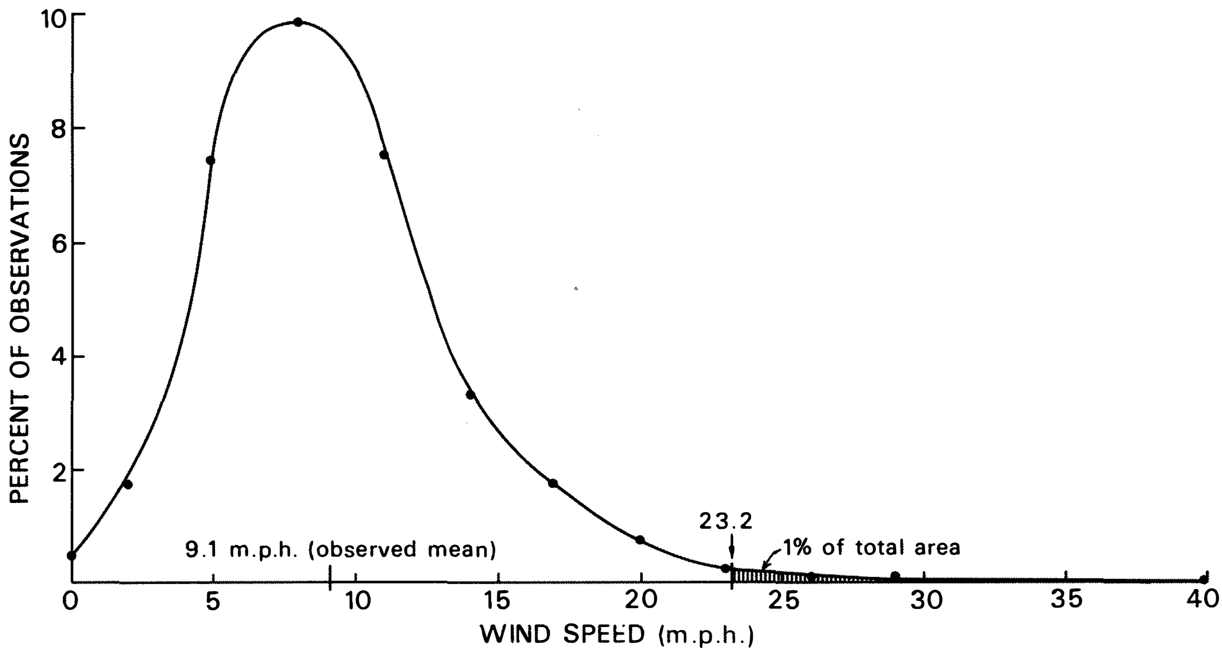

FIGURE 3. OBSERVED SURFACE WIND SPEED DISTRIBUTION AT VANCOUVER INT. AIRPORT (1200 L.S.T. Observations April through October)

There are two points of interest: (1) the mean, and (2) the asymptotic tail on the right hand side of the distribution. A wind speed scale should have a sufficiently high limit so that the scale is exceeded only very infrequently, yet it should not be so high that almost all of the observations fall on the lowest part of the scale. Either situation would limit the table's usefulness. To resolve this problem, a standard wind speed distribution for the FWI was defined for this analysis as one having 99% of all observations between 0 and 25 m.p.h. In a 200 day fire season an average of two days each year would be above 25 m.p.h., but the 30 m.p.h. limit should not be exceeded more than once in 3 to 5 years.

Since the hypothetical surface values are in terms of average wind speed, it was necessary to determine the expected average of the standard distribution as defined above. To do this, data from 90 stations (listed in Table 2) were analyzed in the same manner as Vancouver International Airport as will be described below.

1. The observed distribution of wind speeds is plotted (Figure 3).
2. The wind speed which is greater than or equal to 99% of all observations is determined graphically (23.2 m.p.h.).
3. This value is divided by 25.5 (which yields an adjustment factor (col. 2, Table 2) of 1.10).
4. This ratio is multiplied by the observed average wind speed (9.1 m.p.h., col. 1, Table 2). This yields an average for a distribution which would have 1% of its winds above 25 m.p.h. (10.0, col. 3, Table 2).

The averages for the 90 stations were normally distributed about a mean of 10.2 m.p.h. This contrasts with an average observed mean of 10.8 m.p.h.* for the stations which were analyzed.

The above procedure applies specifically to wind measurements which will be used in conjunction with the Fire Weather Index. In analyzing observations where there is no requirement for fitting a predetermined scale, the observed average (in this case 10.8 m.p.h.) can be

*Noon LST wind observations for the period April through October.

used directly. The remaining procedures apply to the calibration of any set of observations where either the desired or observed average is known.

The first requirement is an average hypothetical surface wind speed which applies to the set of stations being analyzed. The hypothetical surface wind speed (col. 4, Table 2) at each of the stations was determined from the map (Figure 2). The average of all of these values (15.0 m.p.h.) was then determined.

The second step is the calculation of the ratio of the desired average surface wind speed (10.2) to the hypothetical average surface wind speed (15.0) which is 0.68. Next, the hypothetical surface wind speed at the location of each station under consideration was multiplied by 0.68 to determine the average wind speed which should have been observed at the specific point if the station were truly representative of the area within which it lies and had its wind speed distribution fitted the Fire Weather Index tables. These values are listed in Table 2 (col. 5). The last step was the determination of the ratio of the hypothetical to the observed average. This ratio is the station correction factor, which when multiplied by the observed winds at the particular station, corrects the wind speed to the desired average for the area. This procedure makes it possible to compare wind speed observations and factors related to them at any number of stations. The correction factors for each station are listed in Table 2 (col. 6).

It should be pointed out that this calibration is useful only for forecasting and other presuppression planning purposes. When planning for a specific fire in a specific location all of the local topographical influences should be considered as they will affect the winds in the immediate vicinity of the fire which will in turn affect the rate of spread of the particular fire in question.

In summary, this paper presents a procedure whereby surface wind speed observations at a large number of stations can be standardized. There are two basic steps: the first is the calibration of each station which was accomplished by drawing the isotack patterns across the country. These patterns were based on the projection of upper air observations to the surface with supplemental surface observations for improved resolution. The second step involved relating these hypothetical surface observations to a wind speed distribution which was appropriate to the Fire Weather Index. The final result of this step was a correction factor for each station which, when multiplied by the observed wind speed at that station would yield a corrected and standardized observation which would be directly comparable with any other station.

TABLE 2. DATA SUMMARY FOR SELECTED CANADIAN STATIONS.

				All Wind Speeds are Station Averages			
Place	Province	Observed Wind Speed *1*	Adjustment Factor *2*	Adjusted Observed Wind Speed *3*	Hypothetical Zero Friction Wind Speed *4*	Hypothetical Surface Wind Speed *5*	Station Adjustment Factor *6*
Gander	Nfld.	15.0	0.71	10.6	22.0	15.0	1.00
Goose Bay	"	11.7	0.88	10.3	18.1	12.3	1.05
Knob Lake	"	13.9	0.78	10.8	18.4	12.5	0.90
Stephenville	"	9.3	1.11	10.3	19.9	13.5	1.45
St. John Torbay	"	15.7	0.72	11.3	22.9	15.6	0.99
Greenwood	N.S.	12.6	0.77	9.7	15.5	10.5	0.83
Halifax-Dartmouth	"	13.0	0.85	11.0	18.6	12.6	0.97
Sydney	"	15.9	0.85	13.5	19.5	13.3	0.84
Yarmouth	"	11.2	1.00	11.2	18.0	12.2	1.09
Campbellton	N.B.	9.6	0.96	9.2	15.0	10.2	1.06
Chatham	"	11.8	0.91	10.7	16.7	11.4	0.97
Fredericton	"	11.0	0.89	9.8	14.0	9.5	0.86
Moncton	"	13.7	0.86	11.8	20.0	13.6	0.99
St. John	"	13.9	0.85	11.8	16.9	11.5	0.83

...cont.

Column *1.* Noon LST observations only from April through October.
2. The adjustment factor which changes the wind speed distribution so that 1% of the winds are greater than 25 m.p.h.
3. The average wind speed resulting from the adjustment factor (column 2).
4. From the map (Figure 2).
5. The zero friction wind speed (column 4) multiplied by 0.68.
6. The adjustment factor which, when multiplied by the observed wind speed yields the surface wind speed for the general area. It was calculated by dividing column 5 by column 1.

TABLE 2. cont.

Place	Province	Observed Wind Speed 1	Adjustment Factor 2	Adjusted Observed Wind Speed 3	Hypothetical Zero Friction Wind Speed 4	Hypothetical Surface Wind Speed 5	Station Adjustment Factor 6
		All Wind Speeds are Station Averages					
Bagotville	Que.	12.3	0.91	11.2	15.8	10.7	0.87
Mont Joli	"	13.5	0.84	11.3	18.3	12.4	0.92
Montreal-Dorval	"	11.5	0.95	10.9	17.0	11.6	1.01
Quebec	"	13.7	0.95	13.1	16.5	11.2	0.82
Sept-Iles	"	13.7	0.76	10.4	17.5	11.9	0.87
Val D'Or	"	9.7	1.25	12.1	15.0	10.2	1.05
Armstrong	Ont.	10.5	1.06	11.1	13.5	9.2	0.88
Earlton	"	9.6	1.01	9.7	16.4	11.2	1.17
Ft. William	"	11.2	0.86	9.6	15.7	10.7	0.96
Gore Bay	"	12.0	0.92	11.0	19.0	12.9	1.08
Graham	"	11.6	0.97	11.2	15.0	10.2	0.88
Kapuskasing	"	10.8	1.00	10.8	17.1	11.6	1.07
Kenora	"	11.2	1.07	12.0	16.0	10.9	0.97
Killaloe	"	9.8	1.12	11.0	15.5	10.5	1.07
London	"	12.2	0.88	10.7	16.7	11.4	0.93
Muskoka	"	9.2	1.30	12.0	15.9	10.8	1.17
Nakina	"	9.8	1.17	11.5	15.0	10.2	1.04
North Bay	"	11.0	1.08	11.9	16.5	11.2	1.02
Ottawa	"	10.9	1.01	11.0	16.4	11.2	1.03
Sioux Lookout	"	10.8	1.07	11.6	14.6	9.9	0.92
Stirling	"	8.9	1.15	10.2	16.5	11.2	1.26
Sudbury	"	16.0	0.71	11.4	18.0	12.2	0.76
Timmins	"	11.7	0.96	11.2	17.4	11.8	1.01
Toronto-Malton	"	11.9	0.92	10.9	17.0	11.6	0.98
White River	"	7.7	1.47	11.3	16.7	11.4	1.48
Wiarton	"	12.2	0.91	11.1	17.8	12.1	0.99
Windsor	"	12.6	0.85	10.7	17.0	11.6	0.92

...cont.

TABLE 2. cont.

Place	Province	Observed Wind Speed	Adjustment Factor	Adjusted Observed Wind Speed	Hypothetical Zero Friction Wind Speed	Hypothetical Surface Wind Speed	Station Adjustment Factor
		All Wind Speeds are Station Averages					
		1	*2*	*3*	*4*	*5*	*6*
Churchill	Man.	15.1	0.74	11.2	19.9	13.5	0.89
Dauphin	"	13.0	0.66	8.6	15.4	10.5	0.81
Gimli	"	14.2	0.75	10.6	15.8	10.7	0.75
Portage La Prairie	"	13.1	0.86	11.3	16.8	11.4	0.87
Rivers	"	14.9	0.73	10.9	16.8	11.4	0.77
The Pas	"	11.8	0.88	10.4	15.2	10.3	0.87
Hudson Bay	Sask.	9.9	1.03	10.2	13.8	9.4	0.95
North Battleford	"	11.6	0.86	10.0	14.6	9.9	0.85
Prince Albert	"	13.0	0.89	11.6	13.8	9.4	0.72
Calgary	Alta.	12.3	0.87	10.7	14.5	9.9	0.80
Cold Lake	"	12.7	0.83	10.5	13.5	9.2	0.72
Edmonton	"	14.2	0.73	10.4	13.7	9.3	0.66
Ft. McMurray	"	8.0	1.30	10.4	13.0	8.8	1.10
Grand Prairie	"	11.7	0.72	8.4	15.1	10.3	0.88
Lac LaBiche	"	9.2	1.0	9.2	13.1	8.9	0.97
Lethbridge	"	13.8	0.78	11.1	18.0	12.2	0.88
Penhold	"	12.6	0.93	11.7	14.2	9.7	0.92
Rocky Mountain House	"	7.4	1.15	8.5	13.5	9.2	1.24
Vermilion	"	11.2	1.00	11.2	13.8	9.4	0.84
Wagner	"	10.1	1.12	11.3	13.8	9.4	0.93
Whitecourt	"	8.4	1.18	9.9	13.8	9.4	1.12

...cont.

TABLE 2. cont.

Place	Province	Observed Wind Speed 1	Adjustment Factor 2	Adjusted Observed Wind Speed 3	Hypothetical Zero Friction Wind Speed 4	Hypothetical Surface Wind Speed 5	Station Adjustment Factor 6
		All Wind Speeds are Station Averages					
Abbotsford	B.C.	7.8	1.08	8.4	12.0	8.2	1.05
Cape St. James	"	16.8	0.65	10.9	16.0	10.9	0.65
Comox	"	9.9	0.97	9.6	13.1	8.9	0.90
Ft. Nelson	"	6.8	1.26	8.6	9.5	6.5	0.96
Ft. St. John	"	12.6	0.79	10.0	14.5	9.9	0.79
Kimberly	"	8.7	0.93	8.1	13.5	9.2	1.00
Lytton	"	7.7	0.89	6.9	9.5	6.5	0.79
Nanaimo	"	6.9	1.60	11.0	12.0	8.2	1.19
Penticton	"	10.0	0.87	8.7	10.5	7.1	0.71
Port Hardy	"	8.5	1.07	9.1	11.6	7.8	0.92
Princeton	"	4.7	1.39	6.5	10.0	6.8	1.45
Prince George	"	9.1	0.97	8.9	10.5	7.1	0.78
Quesnel	"	6.2	1.33	8.2	9.5	6.5	1.05
Sandspit	"	10.8	0.77	8.3	16.5	11.2	1.04
Smithers	"	5.8	1.34	7.8	11.5	7.8	1.34
Smith River	"	7.9	1.30	10.3	8.7	5.9	0.75
Spring Island	"	9.7	0.73	7.1	13.5	9.2	0.95
Terrace	"	8.5	0.86	7.3	13.0	8.8	1.04
Vancouver Int.	"	9.1	1.10	10.0	13.0	8.8	0.98
Victoria-Gonzales	"	10.5	0.85	8.9	12.0	8.2	0.78
Ft. Simpson	N.W.T.	7.6	0.92	9.0	12.2	8.3	1.09
Ft. Smith	"	9.8	1.11	10.9	13.5	9.2	0.94
Norman Wells	"	9.9	0.91	9.0	11.5	7.8	0.79
Yellowknife	"	12.0	0.86	10.3	14.3	9.7	0.81
Teslin	Y.T.	7.9	1.13	8.9	11.5	7.8	0.99
Watson Lake	"	9.5	1.03	9.8	8.0	5.4	0.57
Whitehorse	"	10.8	0.83	9.0	12.8	8.7	0.81

REFERENCES

1. Canadian Forestry Service, 1970. Canadian Forest Fire Weather Index, Dept. of Fisheries and Forestry, Ottawa.

2. Dalgliesh, W. A. and D. W. Boyd, 1962. Wind on buildings, Canadian Building Digest, Division of Building Research, National Research Council CBD 28.

3. Jenson, M., 1954. Shelter effect, Danish Technical Press, Copenhagen.

4. Met. Br. D.O.T., 1959. Climatic summaries for selected meteorological stations in Canada, Vol. 2, Humidity and wind, Meteorological Branch, Department of Transport, Toronto, Ontario.

5. Sellers, W. D., 1965. Physical climatology, the Univ. of Chicago Press, Chicago, Ill., pp. 141-155.

6. Simard, A. J. and J. M. Valenzuela, 1969. A computer program to analyze differences in simultaneous wind speed and direction measurements at several stations, Forest Fire Research Institute, Information Report FF-X-18.

7. Simard, A. J., 1969. Variability in wind speed measurement and its effect on fire danger rating, Forest Fire Research Institute, Information Report FF-X-19.

8. Thomas, M. K., 1953. Climatological atlas of Canada, Meteorological Division, Department of Transport.

9. Titus, R. L., 1965. Upper air climate of Canada, Meteorological Branch, Department of Transport, Toronto, Ontario.