

ANNUAL SNOWFALL IN EASTERN CANADA

by

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Normal Snowfall

The Canadian Meteorological Service has been accumulating data on snowfall since the first observations were made in Toronto in 1844. Other long-term records exist mainly in a narrow band along our southern border. It was only recently, with the establishment of the Joint Arctic Weather Stations, that data from all parts of Canada has become available. This explains in part the lack of official charts of the Normal Annual Snowfall covering all of Canada. Connor in 1936 and Thomas in 1953 published mean annual snowfall maps. Connor was able to cover about one half the total area of Canada with the data available at that time. Thomas was able to draw a map for all of Canada, but the mean values used were based on records varying from over 100 years to very short records in the Arctic Archipelago. Recently new normals based on the period 1921-50, have been computed. A map of the normal snowfall of Canada based on these new normals will be published in a proposed Atlas of Canada next year. In the meantime, because of the lack of easy reference to published maps showing the normal snowfall, and since the data have now been compiled in a standard form, I thought that it might be useful to discuss various features of snowfall in Eastern Canada.

Figure 1 shows the complex pattern of this normal annual snowfall. The main controls of the amount of the annual snowfall are (1) the length of the season when the temperature is low enough that the precipitation falls as snow instead of rain, and, (2) the precipitation which is likely to fall during this period of low temperature. In mid-winter mean monthly precipitation is heaviest on the Atlantic coast and decreases to the northwest — it is about 5 inches per month along the coast of Nova Scotia and eastern Newfoundland, 2-1/2 inches per month on a line along the north shore of the Gulf of St. Lawrence to the Lower Lakes, and 1 inch per month in the northwestern portion of the map. In winter the mean temperature also decreases with distance from the Atlantic. These two controls reach an optimum balance for the greatest mean annual snowfall in an area which extends from southern Labrador, through central Quebec, to the James Bay Watershed in Ontario. Normal snowfall throughout this snow belt varies from 120-200 inches per winter. To the north of this area the colder temperatures give a longer snowfall season, but the much lower precipitation throughout this longer season does not produce as great a mean yearly snowfall. Snowfall actually de-

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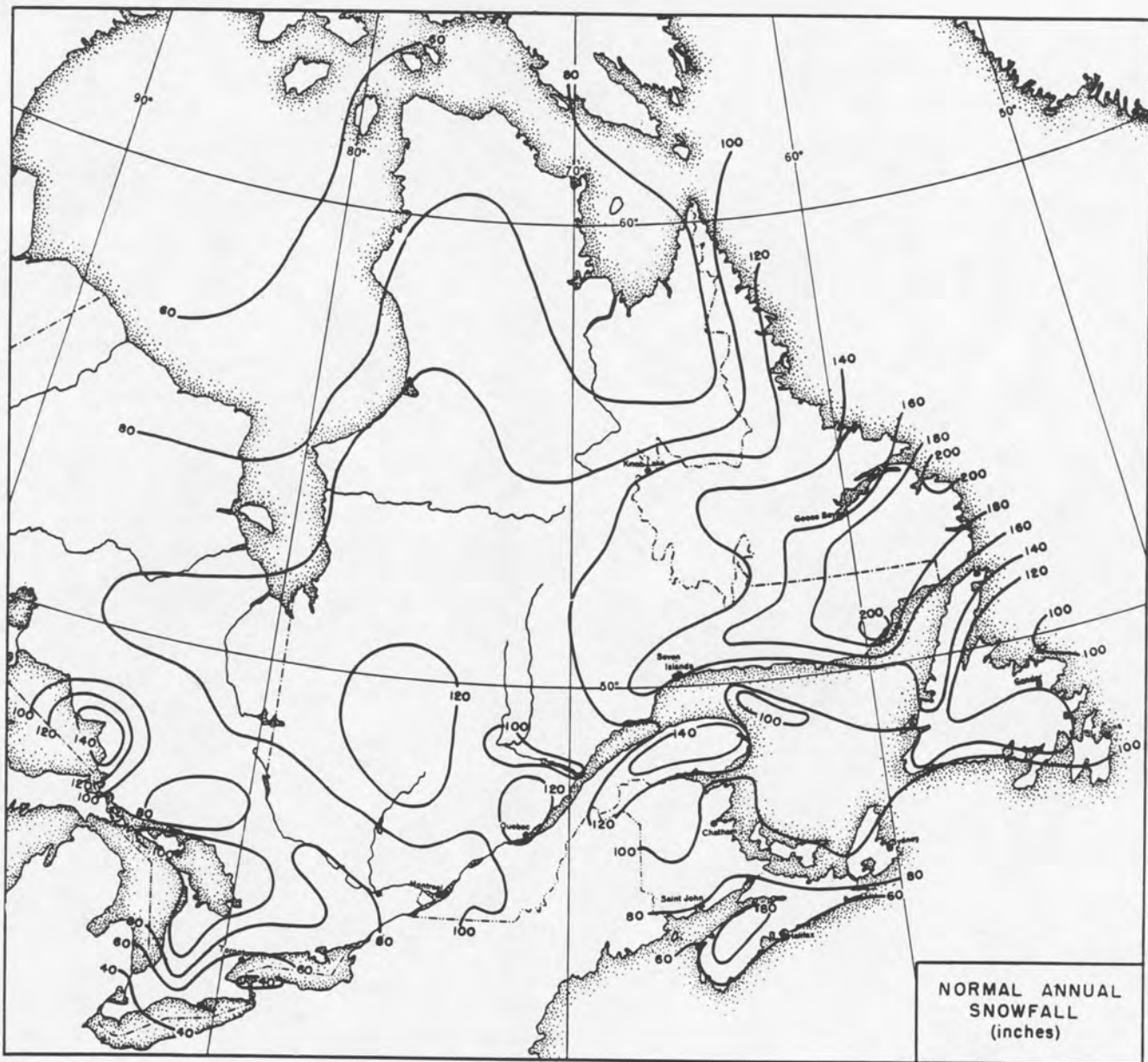


FIG. 1

creases to a mean of 60 inches per year in the northwest section of this map. To the south of the area of greatest snowfall, the higher temperatures shorten the snowfall season, and cause some of the precipitation even in mid-winter to fall as rain, so the yearly snowfall total decreases southeastward and ranges from 60 to 80 inches in the southeastern coastal sections.

Superimposed on this simplified pattern of the normal annual snowfall are other variations due to the irregular nature of the east coast which bring the warming influence of the water far inland, the presence of the Great Lakes, and the differences in elevation which may both influence the amount and the form of the precipitation due to the decrease in temperature at higher elevations. In Ontario there are three major snow belts, one near each of Lake Superior, Georgian Bay and Lake Huron. It is interesting that each snow belt lies east of the body of water which causes it, and extends inland as far as the elevation of the land continues to increase. In the snow belts east of Lake Huron and Georgian Bay the normal snowfall is between 100 and 120 inches. On the bleak east shore of Lake Superior few observations are available but what we have indicate a normal annual snowfall near 160 inches. Farther east near Lake St. John, the observations from stations along the Saguenay River or on the shores of Lake St. John show much less snow (<100 inches) than that which falls on the surrounding higher ground. At Quebec City the normal annual snowfall of 124 inches is greater than that for any other major Canadian city. In areas bordering the Gulf of St. Lawrence or the Atlantic, normal snowfall is least in the coastal regions and reaches a maximum in the interior where the increased distance from the water and higher elevations combine to give an area of maximum snowfall. There are 5 such areas shown in Figure 1. There is first the region of very heavy snowfall north of the Gulf of St. Lawrence, then the interior of the Gaspe Peninsula, central and northwestern New Brunswick, southwestern Nova Scotia, and the interior of Newfoundland. These are all thinly populated areas and in all, except that in Nova Scotia, there is still doubt of the extent of this snowfall due to the few data available. It should also be pointed out that in large areas in the central and northern part of this map, where the pattern of the snowfall seems more regular than in the south, the regularity is likely due in part to the fewer number of observations available north of the more densely settled areas of Eastern Canada.

Variation of Seasonal Snowfall

No description of the normal snowfall would be complete without some reference to its variability on a seasonal or monthly basis. Many of the records of snowfall in Canada for the 50 years, 1901-1950, have been analyzed and some of the results of the analysis for Eastern Canada will serve to illustrate the greater variability of the snowfall in the Maritime climate of the eastern part of Canada when compared to that in the more continental climate of the interior.

TABLE I
PERCENTAGE PROBABILITIES OF SEASONAL SNOWFALL LIMITS (inches)

	19.9	39.9	59.9	79.9	99.9	119.9	139.9	159.9	179.9	199.9	over	Normal	Extremes	
	-	-	-	-	-	-	-	-	-	-	&		Greatest	Least
	0	20.0	40.0	60.0	80.0	100.0	120.0	140.0	160.0	180.0	200.0			
Windsor	6	52	38	6	0	0	0	0	0	0	0	43.9	78.0	12.9
London	0	4	16	28	32	20	0	0	0	0	0	77.0	115.8	28.2
Toronto	0	18	40	38	4	0	0	0	0	0	0	54.6	82.6	25.7
Southampton	0	0	0	10	26	20	30	6	4	2	2	116.4	210.7	65.0
Parry Sound	0	0	0	6	14	26	26	16	8	2	2	118.2	204.8	67.9
Ottawa	0	0	4	36	30	22	8	0	0	0	0	80.5	135.7	49.5
Montreal	0	0	2	6	28	38	22	4	0	0	0	100.8	150.5	48.7
Quebec	0	0	0	8	6	42	22	14	6	2	0	123.7	199.8	70.8

In Table I are listed the probabilities for seasonal snowfalls for locations in southern Ontario and the St. Lawrence Valley falling within certain limits. At Toronto where the normal winter snowfall is 54.5 inches, the range between the extremes is less than the normal snowfall. The probabilities themselves indicate a fairly normal distribution to the seasonal snowfalls. At Montreal, where the normal snowfall is 100.8 inches, the range is greater than at Toronto but still about equal to the normal snowfall. Southampton and Parry Sound are located in the snow belts east of Lake Huron and Georgian Bay, respectively. Both have had winters with more than 200 inches of snow. The probabilities for seasonal snowfall amounts extend over more intervals and the distribution is skewed to the higher values. This probability of the occurrence of winters with snowfall so far above the normal does not exist for nearby locations out of the snow belts such as Windsor, Toronto, Ottawa or Montreal, and is more characteristic of that found in the Atlantic provinces. Quebec City is apparently close enough to the Atlantic that some of the characteristics of the Maritime climate show up in the snowfall. The interval in which the seasonal snowfall for Quebec City is most probable is the one below that which contains the normal snowfall — the result again of some seasons with unusually heavy snowfall.

TABLE II

PERCENTAGE PROBABILITIES OF SEASONAL SNOWFALL LIMITS (Inches)

	0 - 19.9	20.0 - 39.9	40.0 - 59.9	60.0 - 79.9	80.0 - 99.9	100.0 - 119.9	120.0 - 139.9	140.0 - 159.9	160.0 - 179.9	180.0 - 199.9	200.0 - over	Normal	Extremes	
													Greatest	Least
Halifax	0	10	36	26	18	6	4	0	0	0	0	64.1	130.2	28.8
Sydney	0	0	4	34	22	14	20	6	0	0	0	96.9	155.6	40.0
Yarmouth	0	8	24	26	22	14	4	0	2	0	0	83.1	174.6	33.2
Charlottetown	0	0	4	18	38	26	6	6	2	0	0	112.7	164.1	60.0
Chatham	0	0	6	16	34	34	8	0	2	0	0	88.1	163.2	53.0
Saint John	0	4	24	32	22	10	6	2	0	0	0	82.7	145.9	36.4
St. John's	2	6	12	28	8	20	10	6	6	0	2	102.0	226.1	13.8
Gander	0	0	0	7	43	22	0	21	0	0	7	119.2	236.3	63.1
Goose Bay	0	0	0	0	0	18	18	27	27	10	0	140.9	182.6	104.5

Table II contains similar data for places in the Atlantic provinces. In general, if these places are near the Atlantic, there is a probability of some unduly heavy seasonal snowfalls, and the interval containing the mean snowfall is not the most probable. St. John's, Newfoundland, has the most striking distribution of seasonal snowfall amounts when these probability amounts are spread across the table from a probability of a winter's snowfall of less than 20 inches to one over 200 inches. Data for Goose Bay and Gander, unlike that for 50 years for other places listed in these tables, are only for the period since the airports were established. Snowfall at Goose Bay is heavy but with a regular distribution. Normal snowfall at Gander is 20 inches less than at Goose Bay, but its irregular distribution makes the planning for efficient snow clearance more difficult due to the chance of a winter with very heavy snowfall. In Table I, at places outside the snowbelts, the difference between the extremes was nearly equal to the normal snowfall. In Table II, with the more variable snowfall, this difference is greater than the normal with the exception of Goose Bay, and varies up to twice the normal snowfall at St. John's.

The remainder of the tabular data (Tables III-IX) have been prepared to answer requests for expectancies of monthly snowfall amounts. The usual request is for the probability of the snowfall falling below or exceeding certain limits. The probabilities for the total snowfall for each month falling below certain limits have been listed in the tables. The probabilities for it to equal or exceed the same limits will be found by subtracting the values listed from 100. These tables are also based on the 50 years 1901-1950.

TABLE III

TORONTO

PERCENTAGE PROBABILITIES OF MONTHLY SNOWFALL AMOUNTS

Limits (ins.)	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
Less than 2-1/2	100	96	48	6	2	0	14	54	100	100
" " 5		100	68	16	16	8	24	78		
" " 10			92	52	26	34	52	100		
" " 20			98	94	70	88	96			
" " 30			100	98	98	96	100			
" " 40				100	100	100				

MONTHLY SNOWFALL (in inches)

Normal	0	0.2	4.3	9.8	14.1	13.6	9.4	3.0	0.1	0
Extreme	*	4.2	22.5	36.4	30.2	32.4	20.8	8.7	1.6	0

Table III for Toronto indicates a fair scattering of the probabilities throughout the winter. Thus in November, 48 per cent of these months will have less than 2-1/2 inches of snow. In 8 per cent the snowfall will be \geq 10 inches. The total precipitation for November is fairly reliable and this variation is mainly due to the critical role of temperature. Throughout the winter there exist probabilities for fairly light snowfalls in months with well above normal temperature. The monthly snowfall during February is most consistent when there is a 52 per cent probability that the snowfall will be \geq 10 inches but $<$ 20 inches. Toronto is fortunate in that the total of the snowfall in the extremely snowy months, as listed in the last line, are less than will be found at other places nearer the Atlantic.

TABLE IV

MONTREAL

PERCENTAGE PROBABILITIES OF MONTHLY SNOWFALL AMOUNTS

<u>Limits (ins.)</u>	<u>Sept.</u>	<u>Oct.</u>	<u>Nov.</u>	<u>Dec.</u>	<u>Jan.</u>	<u>Feb.</u>	<u>Mar.</u>	<u>Apr.</u>	<u>May</u>	<u>June</u>
Less than 2-1/2	100	92	18	0	0	0	2	30	100	100
" " 5		98	30	0	0	0	8	52		
" " 10		100	50	4	0	4	30	80		
" " 20			86	46	28	40	60	100		
" " 30			100	74	72	74	86			
" " 40				96	92	96	96			
" " 50				98	100	100	100			

MONTHLY SNOWFALL (in inches)

Normal	*	0.7	9.2	21.1	23.8	21.5	18.0	6.5	*	0
Extreme	1.0	8.6	29.2	53.2	45.3	43.9	45.4	17.8	1.3	0

At Montreal (Table IV) the monthly snowfall at the beginning and the end of winter is quite as variable as at Toronto. In December, January and February, the probability that the total monthly snowfall for that particular month will be between 10 and 30 inches is about 70 per cent. While the month with the greatest snowfall at Toronto had a total nearly 4 times the normal snowfall, the extreme monthly total for Montreal is just about 2-1/2 times normal. In these two largest cities in Canada, Montreal's normal annual snowfall of 101 inches is much greater than the 55 inches for Toronto, but the more consistent nature of the monthly snowfalls permits a more efficient planning for street clearing and snow removal for Montreal.

TABLE V

QUEBEC

PERCENTAGE PROBABILITIES OF MONTHLY SNOWFALL AMOUNTS

<u>Limits (ins.)</u>	<u>Sept.</u>	<u>Oct.</u>	<u>Nov.</u>	<u>Dec.</u>	<u>Jan.</u>	<u>Feb.</u>	<u>Mar.</u>	<u>Apr.</u>	<u>May</u>	<u>June</u>
Less than 2-1/2	100	86	4	0	0	0	2	24	92	100
" " 5		96	8	0	0	0	6	42	94	
" " 10		100	52	2	0	2	20	66	100	
" " 20			82	32	14	24	52	86		
" " 30			98	82	58	76	86	98		
" " 40			100	96	90	96	100	100		
" " 50				100	96	98				

MONTHLY SNOWFALL (in inches)

Normal	0	1.2	13.0	23.2	28.9	25.7	20.4	11.0	0.3	*
Extreme	*	6.7	33.9	40.8	61.8	82.4	39.6	30.5	6.0	*

As mentioned previously, Quebec (Table V) has the greatest normal snowfall of any city in Canada. The distribution of this snowfall by months indicates that it is quite consistent in mid-winter. Considering the normal monthly snowfalls, it is remarkable to find that in mid-winter half of the months can be expected to have a snowfall in the interval ≥ 20 but < 30 inches. The extreme months have much greater snowfalls than at Montreal — January had a snowfall of 61.8 inches and in one extreme February, 82.4 inches fell.

TABLE VI
CLARKE CITY (SEVEN ISLANDS)
PERCENTAGE PROBABILITIES OF MONTHLY SNOWFALL AMOUNTS

<u>Limits</u> (ins.)	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
Less than 2-1/2	100	67	0	0	0	0	0	13	75	100
" " 5		74	0	0	0	0	0	22	83	
" " 10		96	12	0	4	4	0	43	100	
" " 20		96	58	14	21	24	29	83		
" " 30		96	96	38	50	48	58	100		
" " 40		100	100	76	67	72	87			
" " 50				81	88	80	96			

MONTHLY SNOWFALL (in inches)

Normal	*	2.9	19.3	33.0	41.3	42.1	25.1	8.1	0.6	
Extreme		0.3	33.0	30.9	61.4	60.8	63.8	51.9	26.8	8.0

Clarke City-Seven Islands (Table VI) have been included as it is the terminus of the Ungava-Labrador Railroad which has been built to bring out the iron ore from the interior, and it was felt that it would be interesting to see the conditions under which this development must operate. This is a combined record of the present observing station at Seven Islands and an older station which was situated nearby at Clarke City. The combined record varies from 21 to 25 years due to missing data for some months. The normal snowfall at Seven Islands is heavy for five months of the year, reaching a peak in January and February where the combined total for these two months is close to 7 feet. The snowfall of October and April tend to be quite variable but the months in between are again fairly consistent in regards to snowfall.

TABLE VII

CHATHAM

PERCENTAGE PROBABILITIES OF MONTHLY SNOWFALL AMOUNTS

<u>Limits (ins.)</u>	<u>Sept.</u>	<u>Oct.</u>	<u>Nov.</u>	<u>Dec.</u>	<u>Jan.</u>	<u>Feb.</u>	<u>Mar.</u>	<u>Apr.</u>	<u>May</u>	<u>June</u>
Less than 2-1/2	100	92	18	0	0	0	2	16	94	100
" " 5		100	34	2	0	4	6	24	96	
" " 10			68	20	12	12	24	58	100	
" " 20			90	60	48	62	76	84		
" " 30			98	92	88	92	96	100		
" " 40			100	96	98	100	100			
" " 50				100	98					

MONTHLY SNOWFALL (in inches)

Normal	*	1.0	8.2	16.6	20.9	17.6	14.9	8.7	0.2	0	
Extreme		1.2	18.3	35.2	44.4	57.8	35.1	31.6	27.4	7.5	2.0

Few attend this conference from the Maritime provinces but three tables are listed from these to complete the study of the variability of monthly snowfall amounts in Eastern Canada. At Chatham (Table VII) in northern New Brunswick, a wide range exists for the probable monthly snowfall for December and January as well as in the months of spring and fall. February is the month of most consistent snowfall with 80 per cent of the Februaries having a snowfall ≥ 10 but < 30 inches. At Halifax (Table VIII) the snowfall season is about one month shorter than at Chatham. The extremes in mid-winter are comparable to those for Montreal, although the normal snowfall for these months is much less. Table IX for St. John's, Newfoundland, has been included to show the most variable snowfall on record for Canada. For four winter months the snowfall may be greater than 50 inches or less than 2-1/2 inches. With the extreme of 109 inches for February, we have a month where the average daily fall was almost four inches, while there has been another February where the total fall was less than 2-1/2 inches. The normal annual snowfall for St. John's is just one inch above that of Montreal. As indicated by the lack of zeros in the body of the table, anything is probable.

TABLE VIII

HALIFAX

PERCENTAGE PROBABILITIES OF MONTHLY SNOWFALL AMOUNTS

Limits (ins.)	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
Less than 2-1/2	100	94	64	6	0	0	8	38	100	100
" " 5		100	90	12	8	0	30	58		
" " 10			98	40	22	24	62	86		
" " 20			100	80	64	64	86	96		
" " 30				94	94	88	96	100		
" " 40				100	96	98	100			
" " 50					100	100				

MONTHLY SNOWFALL (in inches)

Normal	0	0.2	2.5	12.6	17.1	16.0	11.0	4.6	0.1
Extreme	0	3.5	17.4	38.3	46.7	42.8	31.2	24.1	1.0

TABLE IX

ST. JOHN'S

PERCENTAGE PROBABILITIES OF MONTHLY SNOWFALL AMOUNTS

Limits (ins.)	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
Less than 2-1/2	100	98	54	2	4	2	14	42	84	100
" " 5		98	74	12	12	8	20	58	94	
" " 10		100	90	30	24	12	40	76	100	
" " 20			100	56	50	40	76	96		
" " 30				82	72	76	86	100		
" " 40				88	84	86	92			
" " 50				90	92	92	96			

MONTHLY SNOWFALL (in inches)

Normal	0	0.4	4.8	25.0	29.1	27.4	19.2	6.3	1.9	*
Extreme	0	7.8	19.6	71.4	74.0	109.0	60.0	24.1	7.9	*

The tabular data presented are from only a small portion of the whole area covered by Figure 1. They illustrate that nearness to the Atlantic cause a variation in both the seasonal and monthly snowfall which varies inversely with distance from the coast. Inland along the St. Lawrence at Seven Islands and Quebec City, the monthly snowfall amounts are not liable to wide variations, but a few seasonal snowfall totals will be much greater than normal. Montreal has a snowfall remarkably consistent with regards both monthly and seasonal amounts, and in the interior of Quebec and northern Ontario for which no tables have been presented, it is expected that the snowfall will follow this pattern closely. This is based partly on analysis of some of the records which have not been presented here, and partly from the similarity of the continental climate prevailing over this region in winter. In southern Ontario the snowfall, both seasonal and monthly, in the snowbelts have characteristics which are similar to that of the Atlantic Coast. In areas away from the lakes the monthly snowfall totals may be quite variable, yet there is not the corresponding irregularity in the seasonal amounts.