

**A PRELIMINARY IDENTIFICATION OF SNOW COVER PATTERNS
AND RISK IMPLICATIONS FOR CANADIAN WINTER RESORT OPERATORS**

R.B. Crowe

Atmospheric Environment Service Downsview, Ontario

W.M. Baker

Private Recreation Tourism and Park Consultant
Toronto, Ontario

ABSTRACT

Using data for selected meteorological stations considered representative of conditions in major physiographic regions of Canada having extensive commercial winter resort development, the natural snow cover patterns are identified in terms of total suitable days and variations in their occurrence for the major market periods, including early season, Christmas, mid-winter and spring.

The patterns are then discussed in terms of their major risk implications for investment and operational decision-making by private enterprise and government.

INTENT OF THE PRESENTATION

Skiing and snowmobiling enthusiasts in most parts of Canada have suffered through a number of poor winters in recent years with inadequate and poor quality of snow cover. In fact, out of the last four winters practically all Canadian winter recreation areas have reported two bad seasons, and in many cases three sub-normal seasons out of the four.

The objective of the presentation is modest, being primarily to alert commercial ski resort operators and lending agencies to the nature and variation in the length and reliability of the natural snow cover conditions in major geographic regions of Canada where winter resort facilities are presently concentrated and where market forces for expansion appear to be strongest. No attention is given to snow quality, total snow depth or snow-making requirements and limitations. In the evaluation of the quality of total climate supply foundations of the industry, several additional parameters affecting participant comfort and ease of access to the resort facilities are important. Moreover, climate conditions in the local and immediate urban regional market areas are of major consequence. No attention is given to these aspects.

In spite of the aforementioned limitations, natural snow cover conditions as defined in this report provide some indication of the opportunities and constraints confronting the industry. They are indicative of the need for snow-making equipment to extend or guarantee an operating season of sufficient length to maintain business viability. They represent a caution or alert to investors with respect to reasonable debt limits and the need for financial reserves to face a succession of adverse natural snow conditions.

THE APPROACH

Natural snow cover conditions for 23 stations in 6 major geographic regional locations in Canada including the Cordillera, Prairies, Shield, Southern Ontario, Appalachians and Maritime Atlantic were analyzed (Figure 1). For 21 of the stations records

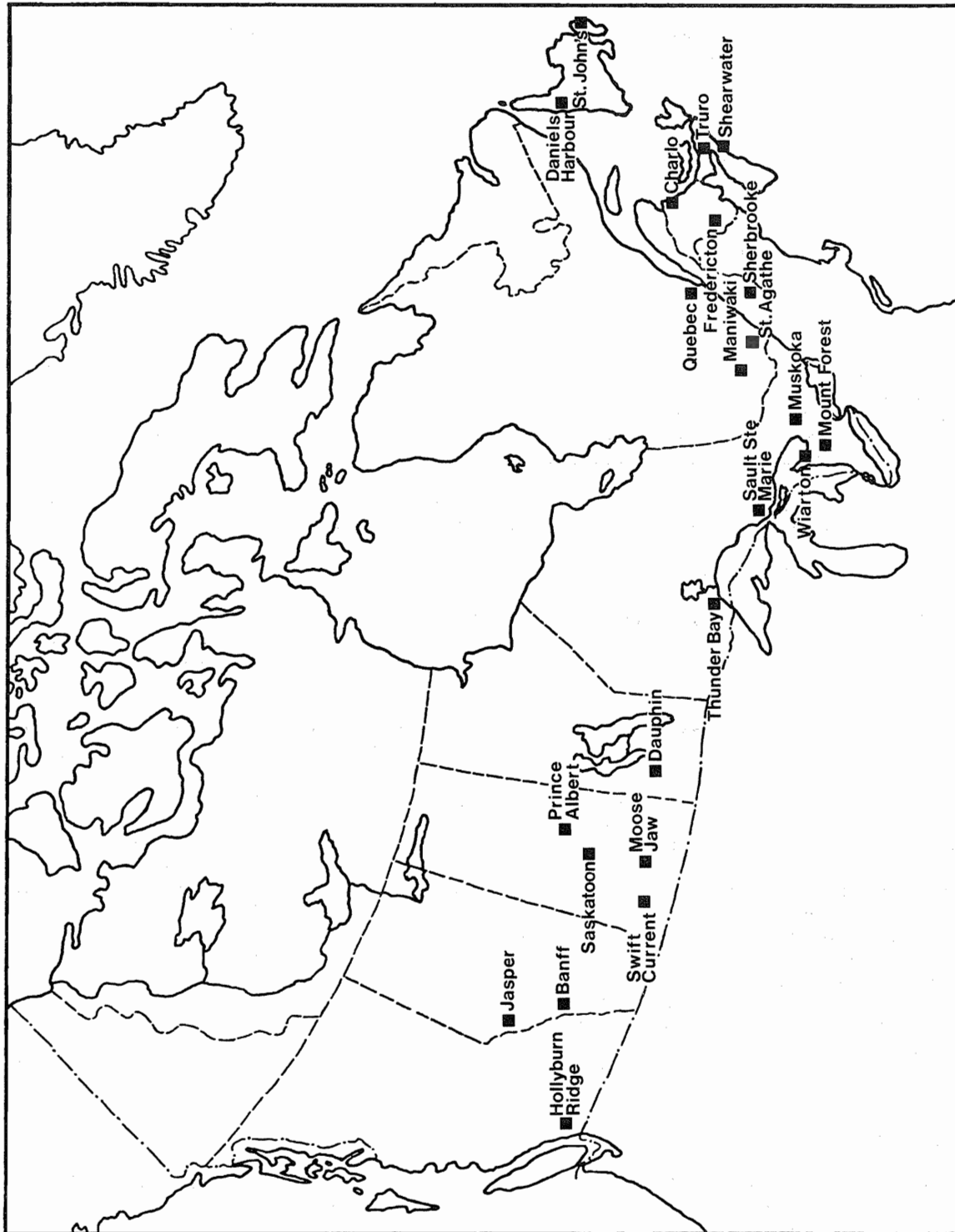


FIGURE 1. LOCATIONS OF STATIONS

from 21 to 42 years are available (Table 1), a time space considered sufficient for the determination of realistic mean and median values. While only 17 years of records are available for St. Agathe de Monts in Québec and Charlo in New Brunswick, the data presented for these stations appears reasonably reliable.

Initially the natural snow cover seasonal length is discussed in terms of the whole winter and major market period segments: Fall, Christmas-New Years, Mid-Winter and Spring. This is followed by a presentation of measures of reliability, an extremely important parameter of the natural snow cover for commercial downhill ski operators and especially for cross country skiing enterprises where artificial snow making is not practical at least at the present time. In both cases, some salient implications of the pattern of commercial operations are noted.

DEFINITION OF NATURAL SNOW COVER SEASON

A suitable day for skiing and snowmobiling activities from the standpoint of natural snow cover conditions was defined as one in which there was 5 cm or more of snow on the ground and liquid or freezing precipitation was not greater than 2.4 mm in a 24-hour period. It is repeated that conditions are defined solely on the basis of natural snow cover, with no reference to participant comfort factors such as temperature, wind speeds and sunshine. The assessment does not extend to the broader concept of a suitable winter outdoor activity day as defined in studies of the tourist and recreation climate of various provinces and regions of Canada, including Newfoundland, the Maritime Provinces, Ontario and the Prairie Provinces completed by the Atmospheric Environment Service in recent years. It was felt that 5 cm of snow at a wind-swept airport observing site would be equivalent to a considerably deeper cover in the woods or at a north-facing ski slope.

There may be 5 cm of snow on the ground for a number of days early and late in the winter when this condition is interspersed with a varying number of days with no or lesser amounts of snow cover (Figure 2). From a ski resort operational perspective it was arbitrarily considered that the season at any station begins when at least half of the years have a suitable 5-cm snow cover and likewise ends when less than half of the years have a suitable snow base.

Within the season as previously defined several divisions were made on the basis of the natural seasonal pattern and market relationships (Table 2). The Fall segment was defined as extending from the first day when at least half of the years have a suitable snow cover to December 20th. The length of this division varied from station to station. The Christmas-New Years market segment was considered to extend over 15 days from December 20 to January 4th. This period is constant for most stations, being defined on market rather than natural conditions. It is recognized that this market segment frequently is stated to run from December 26th to the day after New Year day covering only 8 days when perhaps 16 per cent or more of the total seasonal revenues are earned. The segment as defined in this discussion probably coincides fairly well with the general holiday setting. The Main or Mid-Winter segment extends over 57 (or 58 days in a leap year) from January 4 to March 1. This is the central natural heart of the operating season. The Spring segment beginning on March 2 and extending until the date when less than half of the years have a normal snow cover, varies in length from station to station. It includes the "winter-break" of the school season and in some cases, the Easter holiday weekend. The former is of major importance in the marketing pattern of many Canadian winter resorts.

NATURAL SNOW COVER SEASONAL LENGTH

Total Season Length

From a Canada-wide perspective, the natural snow cover season ranges from a high of 180 days on the Pacific Ocean slopes of the western Cordilleran Region to a

TABLE 1
ELEVATION AND LENGTH OF RECORD OF STATIONS

	Elevation (metres)	Length of Record (Yrs.)
<u>Cordillera</u>		
Hollyburn Ridge, B.C.	951	25
Banff, Alta.	1397	33
Jasper, Alta.	1061	36
<u>Prairies</u>		
Swift Current, Sask.	817	29
Moose Jaw, Sask.	577	30
Saskatoon, Sask.	501	33
<u>Shield</u>		
Prince Albert, Sask.	428	32
Dauphin, Man.	304	34
Thunder Bay, Ont.	199	42
Sault. Ste. Marie, Ont.	192	22
Muskoka, Ont.	280	35
Maniwaki, Qué.	170	30
Ste. Agathe, Qué.	399	17
Québec, Qué.	73	38
<u>Southern Ontario</u>		
Wiaraton, Ont.	222	32
Mount Forest, Ont.	415	21
<u>Appalachians</u>		
Sherbrooke, Qué.	241	21
Charlo, N.B.	37	17
Daniels Harbour, Nfld.	20	31
<u>Maritime Atlantic</u>		
Fredericton, N.B.	20	29
Truro, N.S.	40	23
Shearwater, N.S.	51	30
St. John's, Nfld.	140	31

low of 73 days in the Atlantic Maritime region in the vicinity of Truro, Nova Scotia (Table 3). In effect, the east coast maritime season is only about 41 to 46 per cent as long as that of the Pacific slopes of the western mountains. Shearwater, Nova Scotia, has been included in the table simply to indicate that there is virtually no natural snow cover season as defined in this paper in parts of the Atlantic Provinces.

Four distinct station groupings are discernible. At the upper end of the range are three stations (Holyburn Ridge, British Columbia; Charlo, New Brunswick; and Ste. Agathe des Monts, Québec) with natural snow cover seasons between 144 and 180 days. A second grouping of six stations with seasons varying from 128 to 135 days includes Banff, Alberta; Prince Albert, Saskatchewan; Dauphin, Manitoba; Thunder Bay, Ontario; Maniwaki, Québec and Québec City. A third grouping of 10 stations display seasonal lengths ranging from 109 to 125 days. Included in the group are Jasper, Alberta; Swift Current, Saskatchewan; Saskatoon, Saskatchewan; Sault Ste. Marie, Ontario; Muskoka, Ontario; Wiaraton, Ontario; Mount Forest Ontario; Sherbrooke, Québec; Daniels Harbour, Newfoundland and Fredericton, New Brunswick. These stations with a natural snow cover season between 73 and 52 days from the fourth and decidedly lower grouping. Included are Moose Jaw, Saskatchewan; Truro, Nova Scotia and St. John's Newfoundland.

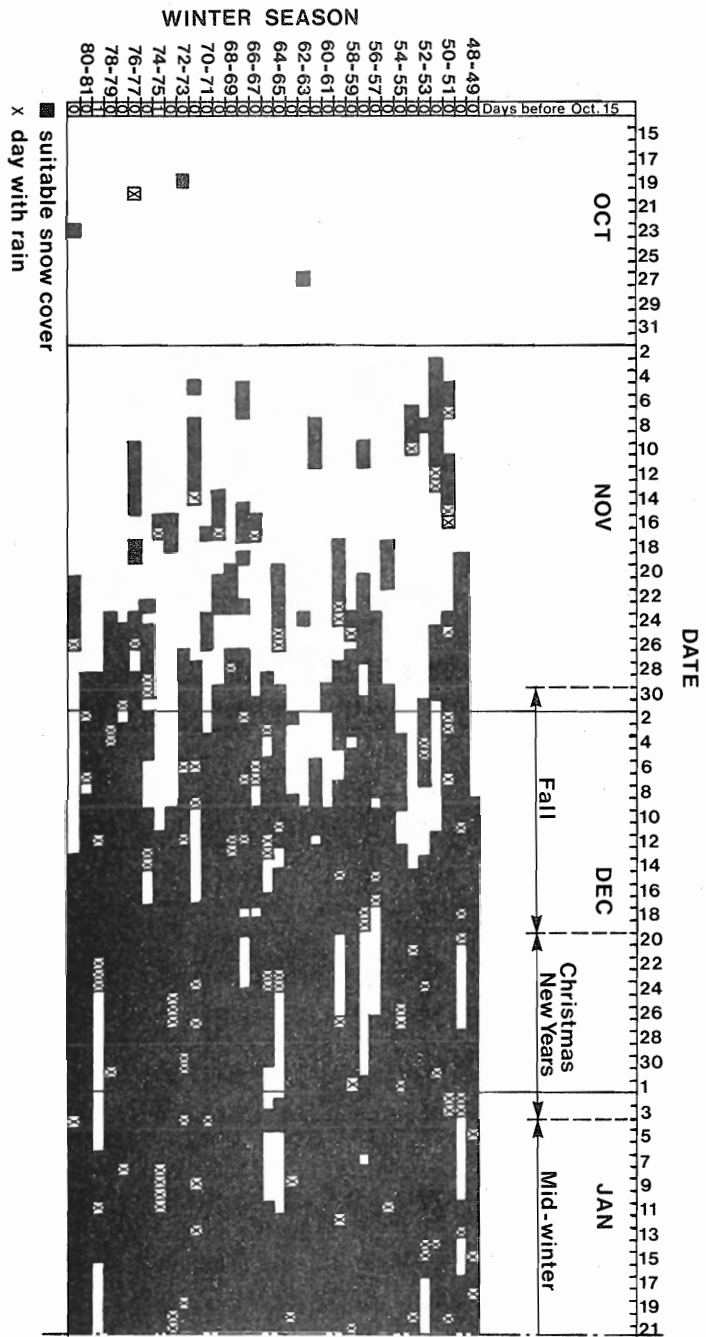


FIGURE 2. SNOW COVER PATTERN AT MUSKOKA, ONTARIO

TABLE 2

SEASONAL COMPONENTS OF NATURAL SNOW COVER
FOR WINTER RESORT OPERATIONS

<u>Seasonal Component</u>	<u>Definition</u>	<u>Length</u>
Fall Segment	Begins when at least half of the years have a suitable snow cover	Variable
Christmas-New Years Segment	Begins December 20 Ends January 3	15 days*
Mid-Winter Segment	Begins January 4 Ends March 1	57 days* (58 leap year)
Spring Segment	Begins March 2 Ends when less than half of the years have a suitable snow cover	Variable

* In some marginal areas, the lengths of the Christmas-New years and Mid-Winter segments are shortened because not all days have at least half the years with a suitable snow cover.

TABLE 3

NATURAL SNOW COVER SEASONAL LENGTH (DAYS)

	<u>Beginning Date</u>	<u>Ending Date</u>	<u>Fall Segment</u>	<u>Christ.-N. Years Segment</u>	<u>Mid-Winter Segment</u>	<u>Spring Segment</u>	<u>WINTER</u>
<u>Cordillera</u>							
HOTTYburn Ridge, B.C.	Nov. 25	May 23	25	15	57	83	180
Banff, Alta.	Nov. 21	Apr. 3	29	15	57	33	134
Jasper, Alta.	Nov. 27	Mar. 30	23	15	57	29	124
<u>Prairies</u>							
SWIFT Current, Sask.	Nov. 29	Mar. 19	21	15	57	18	111
Moose Jaw, Sask.	Dec. 9	Mar. 11	11	15	57	10	93
Saskatoon, Sask.	Nov. 27	Mar. 27	23	15	57	26	121
<u>Shield</u>							
Prince Albert, Sask.	Nov. 25	Apr. 8	25	15	57	38	135
Dauphin, Man.	Nov. 25	Apr. 8	25	15	57	38	135
Thunder Bay, Ont.	Nov. 27	Apr. 6	23	15	57	36	131
Sault. Ste. Marie, Ont.	Dec. 2	Apr. 5	18	15	57	35	125
Muskoka, Ont.	Nov. 30	Mar. 30	20	15	57	29	121
Maniwaki, Qué.	Nov. 30	Apr. 6	20	15	57	36	128
Ste. Agathe, Qué.	Nov. 25	Apr. 17	25	15	57	47	144
Québec, Qué.	Nov. 28	Apr. 12	22	15	57	42	136
<u>Southern Ontario</u>							
Warton, Ont.	Dec. 9	Mar. 28	11	15	57	27	110
Mount Forest, Ont.	Dec. 10	Mar. 27	10	15	57	26	108
<u>Appalachians</u>							
Sherbrooke, Qué.	Dec. 2	Apr. 1	18	15	57	26	108
Charlo, N.B.	Nov. 29	Apr. 29	21	15	57	31	121
Daniels Harbour, Nfld.	Dec. 12	Apr. 12	8	15	57	59	152
						42	122
<u>Maritime Atlantic</u>							
Fredericton, N.B.	Dec. 13	Mar. 31	7	15	57	30	109
Truro, N.S.	Dec. 30	Mar. 12	0	5	57	11	73
Shearwater, N.S.	Feb. 16	Feb. 21	0	0	6	0	6
St. John's, Nfld.	Jan. 6	Mar. 29	0	0	55	28	83

It is clear from an examination of the individual natural snow cover seasonal length measures presented in Table 3 and the foregoing description of the grouping tendencies that widely ranging physical geographic settings across Canada display roughly comparable conditions. The three stations having the higher values include Hollyburn Ridge in the western Cordillera in British Columbia (180 days), Charlo in the Appalachian Region in New Brunswick (152 days) and Ste Agathe des Monts on the southern margins of the Canadian Shield in Québec (144 days). Natural snow cover seasonal lengths for Jasper in the western Cordillera (124), Saskatoon in the parkland section of the Prairies (121 days), Sault Ste. Marie in the Canadian Shield (125 days) and Daniels Harbour in the Appalachian Mountain structures that penetrate the western extremities of Newfoundland (122 days) are comparable.

From the standpoint of the commercial winter resort industry the pattern clearly indicates that opportunities for viable operations are present in widely varying locations across Canada. Conditions in the lower elevations of Atlantic Maritime areas, however, are marginal to unsatisfactory. In the strong local and immediate regional market areas of southern Ontario, values are weak from a comparative national perspective, indicating the importance of snow making equipment to resorts in this area.

Seasonal Segment Lengths

The main difference between stations are associated with variations in the lengths of the Fall and Spring segments. In the Atlantic Maritime locations at low coastal elevations, there is no Fall segment, sometimes no Christmas-New Years segment, and a weak to non-existent Spring. Skiing from the standpoint of natural snow cover essentially is restricted to the 55 to 57 day Mid-Winter segment.

To some extent the value of snow-making equipment is associated with lengthening of the Fall and Spring shoulder segments, particularly the former. This is especially true in the case of resorts in the general vicinity of stations in the lower end of the range of values observed in Table 3. It is noted that the length of the Fall segment is particularly important. If skiers are "on the boards" well before the Christmas-New Years holiday segment the market situation is generally good for the remainder of the year. An exceptionally long Spring does not appear to be so critical, at least under present market patterns. In many, if not all locations in Canada, the market sags markedly, and in some cases virtually closes off about the beginning of April, regardless of snow conditions at the resorts. The traditional rhythm of the outdoor recreation activity patterns of the urban market that have evolved largely in response to climate conditions govern demand patterns. In this spring season it is the snow cover conditions in the early weeks of March that coincide with the school winter holiday break that are critical.

MEASURES OF RELIABILITY

Within the seasonal length patterns previously noted, not all days have suitable snow cover conditions due to thaws and liquid precipitation that occurs from time to time. Attention now is focused upon measures that provide some indication of the reliability of satisfactory natural snow cover within the season and its four major segments, namely Fall, Christmas-Winter Holiday, Mid-Winter and Spring.

Mean Percentage of Suitable Days

In Table 4 the mean percentage of days with suitable natural snow cover conditions during the entire season and its various segments are shown. On an all season basis, three distinct groupings of percentage values can be discerned. Thirteen or 56 per cent of the stations display a high degree of reliability with mean percentage values for suitable days ranging from 81 to 93. In the second grouping that is composed of 7 stations, the comparable percentage values are between 70 and 77, indicating reasonably strong reliability. Three stations in the lower grouping displaying values between 56 and 61 per cent are located in the east coast Maritime-Atlantic region. Measures of this order are unsatisfactory from the standpoint of viable commercial winter resort operations.

Percentage values for the critical Christmas-New Years market segment are very encouraging from a Canada-wide perspective as is the case for the main Mid-Winter segment. The weakness of the Maritime Atlantic area is strongly in evidence. The percentage values of 73 and 78 for southern Ontario stations, where market conditions are strong, are somewhat less than desirable when compared with many locations across Canada, where they range between the high 80's to mid 90's. Conditions are somewhat less favourable in southern Prairie locations, as indicated by the mean percentage statistics for Swift Current (71) and Moose Jaw (68). Here snow-making equipment provides a critical element of operating reliability in this important market period.

In every case percentage values for suitable days in the Fall segment of the season are noticeably lower than in the Christmas-New Years and the Mid-Winter divisions. In the lower elevations of Atlantic Maritime region as exemplified by Truro, Shearwater and St. John's, there is no Fall natural snow-cover segment. In the southern portions of the Prairie region reliability is weak as indicated by the percentage values for Swift Current (54) and Moose Jaw (55). Conditions at the resorts serving the powerful southern Ontario market are only slightly better as indicated by the percentage values for Wiarton (64) and Mount Forest (61). Here snow-making equipment functions primarily to increase the reliability of the opening segment of the season. In another sense it can be said to lengthen the viable Fall operating season for commercial downhill ski resorts.

It is of interest to note that 10 of the stations or 43 per cent display encouraging mean percentage values for the Fall segment of the natural snow cover season ranging from 69 to 82. These stations are associated primarily with the Cordilleran and Shield regions.

Mean percentage values for the Spring segment tend to be noticeably stronger than those of the Fall segment. Seven or 30 per cent of the station display mean percentage values between 79 and 87, suggesting good reliability. In this regard, locations in the Canadian Shield are particularly strong, five of the seven stations being situated here. Another 9 stations or 39 per cent, have mean values for the spring segment between 71 and 78, indicative of a high degree of reliability, particularly in the early weeks of March. Conditions in southern Ontario and the southern parts of the Prairie provinces are less satisfactory as shown by values ranging from 60 to 67 per cent. The situation is virtually hopeless in the Atlantic-Maritime locations.

As previously noted, good skiing conditions are present at many Canadian commercial ski resort centres for a considerable time after interest in winter activities in the local and regional urban market centres has passed. In effect, the psychological market outlined is out of synchronization with natural snow cover and often ideal temperature and sunlight conditions at the resorts.

Median Number of Days

In Table 5, the median values for the number of days with suitable natural cover on an annual and a seasonal segment basis are indicated. This measure of reliability both reinforces and enhances the appreciation of conditions revealed in the examination of mean values.

The pattern of median values for the entire season displays an interesting set of five groupings or concentrations. At the upper extremity of the range of values extending from 99 to 126 days, excluding the high value of 136 days for Charlo, New Brunswick, three groupings, about evenly divided in numbers, are readily observable. Together they account for 14 stations or 61 per cent of the total included in the table. All are situated in the Cordilleran Shield and Appalachian regions. A group of 5 stations that includes such dispersed locations as Hollyburn Ridge, British Columbia; Banff, Alberta; Prince Albert, Saskatchewan; Dauphin, Manitoba, and Québec City display median values between 121 and 126 days. In a broad regional sense, the strongest natural snow conditions in Canada are encountered here. A second group of five stations including Jasper, Alberta; Thunder Bay, Ontario; Sault Ste. Marie, Ontario, Maniwaki, Québec, and Ste.

TABLE 4

MEAN PERCENTAGE OF SUITABLE DAYS

	Fall Segment	Christ.-N. Segment	Years Mid-Winter Segment	Spring Segment	WINTER
<u>Cordillera</u>					
Hollyburn Ridge, B.C.	60	76	71	73	71
Banff, Alta.	76	96	98	79	88
Jasper, Alta.	81	89	93	77	87
<u>Prairies</u>					
Swift Current, Sask.	54	71	82	67	73
Moose Jaw, Sask.	55	68	74	63	70
Saskatoon, Sask.	61	87	94	77	83
<u>Shield</u>					
Prince Albert, Sask.	82	100	100	87	93
Dauphin, Man.	77	95	97	80	89
Thunder Bay, Ont.	72	90	99	77	87
Sault. Ste. Marie, Ont.	67	90	96	77	86
Muskoka, Ont.	70	84	91	78	84
Maniwaki, Qué.	73	89	94	80	86
Ste. Agathe, Qué.	76	89	95	83	87
Québec, Qué.	69	94	96	84	88
<u>Southern Ontario</u>					
Warton, Ont.	64	73	86	66	77
Mount Forest, Ont.	61	78	84	60	75
<u>Appalachians</u>					
Sherbrooke, Qué.	65	83	90	72	81
Charlo, N.B.	70	94	96	83	87
Daniels Harbour, Nfld.	62	70	82	74	77
<u>Maritime Atlantic</u>					
Fredericton, N.B.	59	72	81	71	75
Truro, N.S.	--	55	60	52	58
Shearwater, N.S.	--	--	56	--	56
St. John's, Nfld.	--	--	62	58	61

Agathe des Monts, Québec, have median values between 112 to 119 days. Apart from Jasper, Alberta, all stations in this group are located in the southern margins of the Canadian Shield. The third set of 4 stations with median values between 99 and 103 days includes Saskatoon, Saskatchewan; Muskoka, Ontario; Sherbrooke, Québec and Daniels Harbour, Newfoundland. In this case the geographic distribution of the stations is widely dispersed between major regions.

At the lower end of the distribution, two groupings are noticeable. Four stations including Swift Current, Saskatchewan; Warton, Ontario; Mount Forest Ontario, and Fredericton, New Brunswick, show median values between 83 and 88 days. From the standpoint of natural snow cover seasonal length, conditions here are only about 70 per cent as strong as those in the aforementioned group of higher value stations having median days ranging between 121 and 126. Of interest, the resorts serving the strong local and regional southern Ontario markets are associated with this grouping. At the extreme lower end of the distribution are the stations of the lower elevations of the Maritime Atlantic region where median days range from 43 to 52, indicating poor or unsatisfactory conditions for viable commercial resort operations.

TABLE 5

MEDIAN NUMBER OF DAYS WITH SUITABLE NATURAL SNOW COVER

	Fall Segment	Christ.-N. Years Segment	Mid-Winter Segment	Spring Segment	WINTER
<u>Cordillera</u>					
Hollyburn Ridge, B.C.	16	12	42	62	126
Banff, Alta.	26	15	57	30	121
Jasper, Alta.	22	15	57	28	116
<u>Prairies</u>					
Swift Current, Sask.	13	13	53	16	83
Moose Jaw, Sask.	7	13	50	9	66
Saskatoon, Sask.	16	15	57	24	103
<u>Shield</u>					
Prince Albert, Sask.	25	15	57	38	126
Dauphin, Man.	24	15	57	35	125
Thunder Bay, Ont.	17	15	57	32	118
Sault. Ste. Marie, Ont.	13	15	56	28	111
Muskoka, Ont.	14	14	54	25	103
Maniwaki, Qué.	16	15	56	33	112
Ste. Agathe, Qué.	22	15	54	40	129
Québec, Qué.	18	15	55	37	122
<u>Southern Ontario</u>					
Warton, Ont.	7	13	53	21	88
Mount Forest, Ont.	6	13	51	17	86
<u>Appalachians</u>					
Sherbrooke, Qué.	14	14	54	23	104
Charlo, N.B.	15	15	55	52	135
Daniels Harbour, Nfld.	5	12	53	35	99
<u>Maritime Atlantic</u>					
Fredericton, N.B.	4	13	50	25	88
Truro, N.S.	0	3	34	5	43
Shearwater' N.S.	0	0	4	0	4
St. John's' Nfld.	0	0	35	19	52

It is noteworthy that the median values are high for the critical Christmas-New Years and Mid-Winter season for all regions with the exception of the Maritime Atlantic. As was the case with mean values, the median number of days in the Spring is much greater than the Fall segment. At Daniels Harbour in Newfoundland the spring median value is 7.2 time as long as that of the Fall.

SOME CONCLUDING COMMENTS

The complexity of the natural snow cover pattern across Canada as revealed by this relatively simple analysis of total, mean and median values on a total and segment basis is one of the most important features. While there is a degree of correspondence between conditions in major physical geographic regions in Canada, variations and anomalies are characteristic. For example, Hollyburn Ridge in British Columbia has the longest natural snow cover season (180 days) but the value for its Fall segment (25 days) is exceeded by that of Banff (29 days) and equalled by Prince Albert, Saskatchewan, (25) days or Ste. Agathe des Monts, Québec (25 days). The median value for the Spring season length of Hollyburn Ridge is 62 days, while the corresponding measures for Banff (31 days) and

Jasper (28 days) on the eastern slopes of the Cordillaran region are akin to those stations on the Canadian Shield and far below a value of 52 days for Charlo, New Brunswick. Charlo, largely by virtue of its long Spring season is the second most favourable location in Canada from the standpoint of natural snow cover to total seasonal length.

Several important implications for investment in winter resort facilities ensue from this complex pattern. Opportunities for viable operations exist over a wide range of locations across Canada. Special site and aspect factors may provide sufficient snow conditions for viable commercial operations in areas where regional patterns appear limiting. In effect, attention to site detail is an absolute essential. It is clear, however, that opportunities on a broad regional scale are strongest in the Cordillaran region, especially its eastern slopes, the Canadian Shield on its southern margins and the higher elevations of the Appalachian Mountains and its uplifted flanks. They are least favourable in southern Ontario and the portions of the Prairie provinces. In the former case the local and regional market is the strongest in Canada.

Winters with unsatisfactory snowfall conditions occur at all locations, but are most frequent in those areas where the seasonal patterns are weakest. In regions such as southern Ontario, operators must be prepared to face two poor natural snowfall years in succession with three on exceptional occasion.

In the case of downhill skiing facilities artificial snow-making equipment can lengthen and guarantee an operating season sufficient to maintain business viability, the latter aspect being very important. For the cross-country skiing market that appears to have the greatest potential for growth in many parts of Canada at the present time, the natural snow cover conditions are the final determinant for viable commercial operations. The data supplied in this paper therefore are critical for investment decision-making for these facilities.