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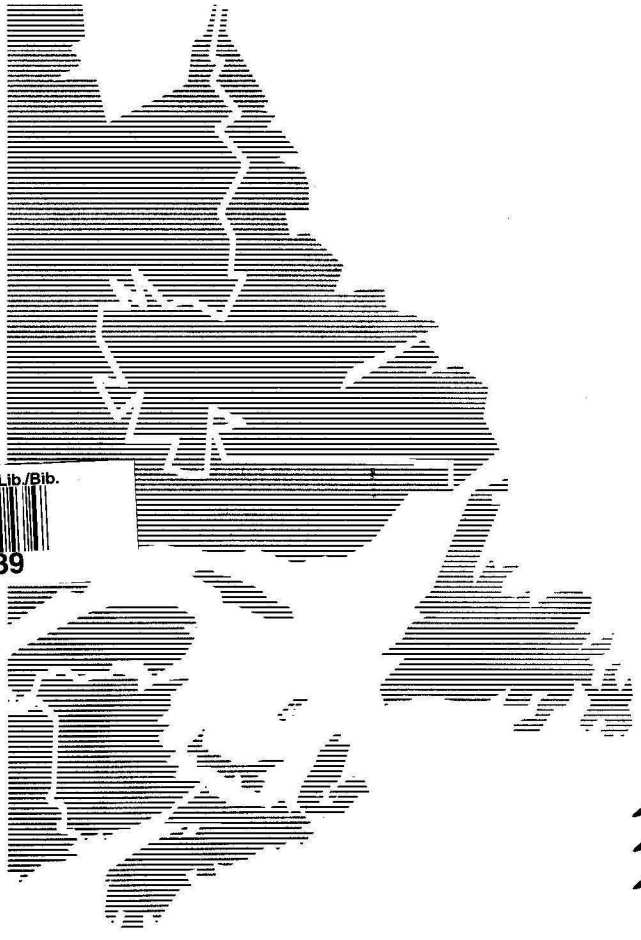

1994 Summer Severe Weather Season For New Brunswick

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NBWSO 95 - 002

INTRODUCTION

1994 marks the first year in which the summer severe weather watch and warning program for New Brunswick was carried out by the new Weather Services Office (WSO) in Fredericton. It was the eighth year for which a summer severe weather forecast program has been in place for New Brunswick. Before 1994 severe weather forecasting was carried out by the Maritimes Weather Centre.

The summer of 1994 was characterized by below average temperatures and above average rainfall at the beginning of the season in May. Temperatures were above average in June as were rainfall amounts. July, August and September were very dry, with temperatures near or slightly above normal.

As compared to the last few years, 1994 was a relatively active severe weather season, with a total of 9 confirmed severe weather events. This is compared to 8 in 1993, 5 in 1992 and 7 in 1991. The season began on June 17th and ended on September 17th when the last severe weather event occurred for the season.

The criteria for severe weather have remained unchanged over the last several years and are as follows:

Damaging Winds	>= 90 km/h
Hail	>= 15 mm diameter
Rain	>= 25 mm/h or 50 mm/3h
Tornado or Tornadic Water Spout	

PROGRAM STRUCTURE

WSO OPERATIONS

The WSO began issuing forecasts in the fall of 1993. As compared to a Weather Centre, the WSO has fewer staff and of course a correspondingly smaller area of responsibility. Currently the WSO provides Public, Aviation, Agricultural and Smog Advisory forecasts for the province of New Brunswick. During the first year of operation many commercial products were added to the production cycle. These include:

-Flood Forecast support for the Saint John River Basin. (year round)
-Five day forecast for New Brunswick Power. (year round)
-New Brunswick Power Thermal Plant Forecast support. (year round)
-Department of Natural Resources and Energy Forestry Forecast support. (seasonal)
-Department of Transportation Road Forecast. (seasonal)

During the day, 3 staff are on shift. One supervisor (MT6), one

forecaster (EG6) and one media position (EG6 6am-1pm). At night one supervisor and one forecaster run the shift. Unlike many other forecast offices, there is no dedicated severe weather forecaster. The assessment of severe weather potential is made by the available staff on shift and if necessary duties are redistributed to allow for a comprehensive assessment.

The method for assessing severe weather potential is based on the Kansas City techniques as outlined in Training Branch's Summer Severe Weather Correspondence Course. Some use is also made of the CMC Summer Severe Weather Package.

SEVERE WEATHER DETECTION

The Weather Watcher Network continues to expand and now stands at 160. These watchers comprise one of our main sources of severe weather detection. There continues to be a requirement for additional watchers especially in the northern and southwestern parts of the province. This network is now operational throughout the year but during the winter months watchers do not contact the office but are contacted by office staff and used as sources of additional weather information during a storm.

A CANWARN (Canadian Weather Amateur Radio Network) was established in the winter of 1994 and also runs all year around. CANWARN New Brunswick has been modeled after similar HAM Radio weather networks in southern Ontario. When severe weather is anticipated, staff on shift call one of the CANWARN Net Controllers (there are nine) to come to the office to operate the network. On a HAM Radio, which has been set up in the operational area, the Net Controller stands by to receive reports of severe weather from close to one hundred volunteer HAM Radio operators across the southern half of the province. All participants have received training through seminars in recognizing both summer and winter severe weather. The network has proved to be very useful both last winter and over the summer.

Some of the advantages of this system include:

1) Once the network is up and running the participants become proactive in detecting severe weather.

2) Several reports can be passed on very quickly to the forecast staff by the Net Controller and no time is lost by staff having to extract and note down information because all the necessary information is recorded by the Net Controller.

3) The network is expected to grow quite rapidly as operators not on the net are curious and want to get involved after hearing the net in operation.

4) Many of the operators are mobile and so can cover a greater area.

5) The Net Controller can be proactive in seeking out information from a large number observers all at the same time.

The only draw back at this time is that the net operates on VHF so communication is limited to line of site transmission utilizing repeater towers. As a result, northern parts of the province are not covered by the network because of a sparse repeater network. In the future it may be possible to go to a UHF network which does not require the use of repeaters.

Mechanic Settlement Radar located in southern New Brunswick and the Halifax radar in Nova Scotia were used extensively to aid in severe thunderstorm detection. Both have CAPPI capability and are equipped with severe storm map displays. In long range PPI mode the Mechanic Settlement radar provides nearly complete coverage of the province.

SOFTWARE SUPPORT

The main software support during the season were two interactive upper air display systems. Both the Weather Analysis and Display System (WADS) developed by Willi Purcell and YXY Tephi-Hodo Display developed by George Trojan were used to modify soundings and calculate several severe weather indices. SSI values of 95 or greater have in the past been strongly correlated with severe weather in New Brunswick. We were unable to calculate the index this year due to software problems. SWEAT values of 250 or greater seem to have a good correlation with severe weather in the province based on results from several cases over the last couple of years. An effort will be made to fine tune this threshold for New Brunswick as we gain more experience with this index in the coming year.

HIGHLIGHTS OF EVENTS.

The 1994 season was quite active when compared to the last few years. Between May and September 1994 Saint-Leonard reported 23 days with thunder. Between 1985 and 1990 the average number was 19. Nine events of severe weather were confirmed during the 1994 season, just above the average of 7 for the previous 3 years. Climatology shows that tornadoes are relatively rare in New Brunswick with one on average every 2 to 5 years. In 1994 there were two probable and one possible tornado.

Here is a brief summary of the severe weather events in 1994:

Damaging winds	5 events
Hail	0 events
Rain	2 events
Tornado	2 events

The second occurrence of severe weather for the 1994 season was a probable tornado in the Mactaquac in mid June 1994. Some trees were blown and a few buildings were damaged. There were several occurrences of severe thunderstorms causing intense lightning, hail, heavy rain and strong winds.

One incident, which at first was thought to be a tornado, was investigated by WSO staff in the Acadian Peninsula. During the afternoon of July 13th, a series of thunderstorms developed across northern New Brunswick. Radar indicated two distinct lines of convection, oriented northeast-southwest and about 160 km apart. These lines were associated with a cold front moving southeast through the province. Around 3:00 pm, very strong winds, heavy rain and walnut size hail occurred on the north end of Lameque Island. The main damage was caused by strong winds, estimated to be in excess of 100 mph by a local fisherman. A 6 ton metal shed under construction was lifted from its foundation several times then rotated by 30 degrees and set back down. There was also some spotty damage to small diameter trees. In all likelihood the damage was caused by a micro burst but the possibility of a small F0 tornado could not be ruled out.

The last severe weather event of the season occurred on September 17th in northern New Brunswick. A tornado touched down in the Dundee area around 2:00 pm. Eight people witnessed the event in which a three bedroom mobile home was lifted 40 to 60 feet in the air and torn apart. Debris from the trailer was strewn 11/2 miles. Fortunately the trailer was unoccupied at the time and no injuries were reported.

A detailed chronological summary of the 1994 events can be found in Appendix A.

VERIFICATION

STATISTICS COMPUTED

Three main statistical values were computed for verification of watches and warnings. Their definitions follow:

POD (Probability of Detection) -a measure of the ability to successfully predict the occurrence of an event. This is simply the number of events successfully predicted divided by the total number of events.

FAR (False Alarm Ratio) -proportion of false predictions of an event. This is the total number of predictions which did not verify divided by the total number made.

NPFD (Normalized POD-FAR Difference) -combines the POD and FAR by subtraction to give an overall measure of accuracy of prediction. This statistic has long been recognized as a good overall measure of forecasting skill. NPFD = [(POD-FAR)+1]/2

1994 VERIFICATION OF WATCHES AND WARNINGS

Statistics for the 1994 season are presented below. It is apparent from the statistics in table 3 and 4 that there is more skill in watches than warnings. The primary reason for this can be attributed to the fact that warnings are issued for much smaller areas than watches. Watches are typically issued for a half dozen or so counties where warnings are issued typically for 2 or 3 counties at a time. The result is a greater chance of having severe weather event detected in the larger area. It is believed that in many cases warnings for areas were not counted as successes simply because the associated severe weather was not detected. In a few of these cases very strong radar echoes were detected in the warning areas but no ground reports of severe weather were received likely due to sparse population. Despite the low skill scores for warnings the view is held that they did have value.

The results from this year indicate for watches there was a 33 % chance of severe weather being detected (POD) after a watch was issued. After the first occurrence of severe weather a warning is normally issued if it is believed the severe weather will continue. In these cases no severe weather was detected after the issue of a warning. The false alarm ratio (FAR) for both watches and warnings was quite high indicating that there is a tendency to over forecast severe weather.

The NPFD has been used for a number of years now to indicate overall skill with watches and warnings. Since 1992 individual verifications have been computed for each province in the Maritimes. Given the short time period of comparison, the relative scarcity of severe weather and the small number of watches and warnings issued each year, it is difficult to infer any trends in forecast skill. Despite this, the statistics show that the combined skill score (NPFD) for watches and warnings showed a decline in 1994 as compared to the previous 2 years. This is not too surprising given that the WSO is a new forecast office and many staff are new to forecasting in this area. In addition, this was the first year in which there was no dedicated severe weather forecaster available with specialized training.

Table 1. Events and Forecasts.

OBSERVED EVENTS	9
BULLETINS ISSUED	21
WATCHES ISSUED	14
HITS (WATCHES)	3
FALSE ALARM (WATCHES)	11
WARNINGS ISSUED	7
HITS (WARNINGS)	0
FALSE ALARM (WARNINGS)	7
MISSED EVENTS	6

Table 2. Overall Verification (watches and warnings).

POD	33%
FAR	86%
NPFD	24%

Table 3. Verification of watches.

POD	33%
FAR	79%
NPFD	27%

Table 4. Verification of warnings.

POD	0%
FAR	100%
NPFD	0%

Table 5. Yearly Verification Summary.

YEAR	1992	1993	1994
# OF EVENTS	5	8	9
# WATCHES AND WARNINGS ISSUED	11	5	21
OVERALL VERIFICATION	POD 60 FAR 73 NPFD 44	43 40 52	33 86 24
# WATCHES ISSUED	9	5	14
WATCH VERIFICATION	POD 60 FAR 67 NPFD 46	43 40 52	33 79 27
# WARNINGS ISSUED	2	0	7
WARNING VERIFICATION	POD 0 FAR 100 NPFD 0	NA NA NA	0 100 0

SEVERE WEATHER CLIMATOLOGY

In an attempt to establish a better climatology for severe weather in New Brunswick, tables 6 through 9 have been generated for the last 4 years data. While it is a bit premature to draw significant conclusions from this small database, it is a start and will become more representative as additional data is collected in future years.

Table 6 shows the number of severe weather days each month as well as the length of each season. From the data it is apparent that the most active months are June through August. Both June and August show a peak in activity. This can likely be attributed to greater north to south temperature contrasts over the region in June and August as compared to July. Most severe weather in New Brunswick is associated with the passage of baroclinic systems so it is logical that June and August would show peaks in activity.

Over the last 4 years the average date of the first severe weather event was June 13th with the last event most likely at the beginning of September. Severe weather can be expected on average 6 days each year.

Table 6. Severe Weather Days

YEAR	APRIL	MAY	JUNE	JULY	AUGUST	SEPT	OCT	TOTAL	FIRST	LAST	LENGTH
1991	0	0	2	0	2	0	0	4	JUNE 26	AUGUST 18	54
1992	0	1	1	1	1	0	0	4	MAY 21	AUGUST 31	113
1993	0	0	3	1	3	0	0	8	JUNE 16	AUGUST 28	74
1994	0	0	3	3	2	1	0	9	JUNE 17	SEPT 17	93
AVG	0	.25	2.25	1.25	2.0	.25	0	6.25	JUNE 13	SEPT 1	83.5

Table 7 shows the occurrence of severe weather by 3 hour time period. Severe Weather is quite unlikely before noon and after midnight. Peak hours for severe weather are between 3:00 pm and 9:00 pm. Over the last 4 years 83 percent of the severe weather events took place during this time period.

Table 7. Severe Weather By Time Period

ADT	1991	1992	1993	1994	AVG	TOTAL	% OF TOTAL
9 AM TO NOON	0	0	0	0	0	0	0
NOON TO 3PM	0	1	0	2	.75	3	10
3PM TO 6PM	4	3	2	3	3.0	12	41.5
6PM TO 9PM	1	1	6	4	3.0	12	41.5
9PM TO 12AM	2	0	0	0	.75	3	7
12 AM TO 9 AM	0	0	0	0	0	0	0
TOTAL	7	5	8	9		29	100

Table 8 shows the frequency of severe weather in each public forecast region. Based on a rather small number of events since 1991, it suggests that the occurrence of severe weather is spread relatively evenly across the province with the exception of a few regions. Regions 5, 15 and 18 show a higher percentage than average. Region 15 is the most active at 24%, almost twice as much as region 5 which has the second highest frequency. The

higher frequencies over the most northwestern regions can likely be attributed to a more continental climate with higher temperatures as well as increased surface convergence and upslope effects resulting from the more hilly terrain. The frequency peak in region 5 is not readily explained and may not be statistically significant as this is a small sample.

A public forecast region map can be found in Appendix B.

Table 8. Distribution Frequency of Severe Weather by Forecast Region (1991-1994)

Saint John and County (1)	1 3%	Kouchibouguac National Park (11)	0 0%
Sussex Kennebecasis Valley and Kings County (2)	1 3%	Stanley Doaktown Blackville Area (12)	1 3%
St. Stephen and Northern Charlotte County (3)	1 3%	Woodstock and Carleton County (13)	2 7%
Grand Manan and Coastal Charlotte County (4)	0 0%	Miramichi and Area (14)	2 7%
Fredericton and Southern York County (5)	4 14%	Grandfalls and Victoria County (15)	7 24%
Oromocto and Sunbury County (6)	1 3%	Mt. Carlton Renous Highway (16)	0 2%
Grand Lake and Queens County (7)	0 0%	Edmundston and Madawaska County (17)	2 7%
Moncton and Southeast New Brunswick (8)	1 3%	Cambelton and Restigouche County (18)	3 10%
Fundy National Park (9)	0 0%	Bathurst and Chaleur Region (19)	1 3%
Kent County (10)	1 3%	Acadian Peninsula (20)	1 3%

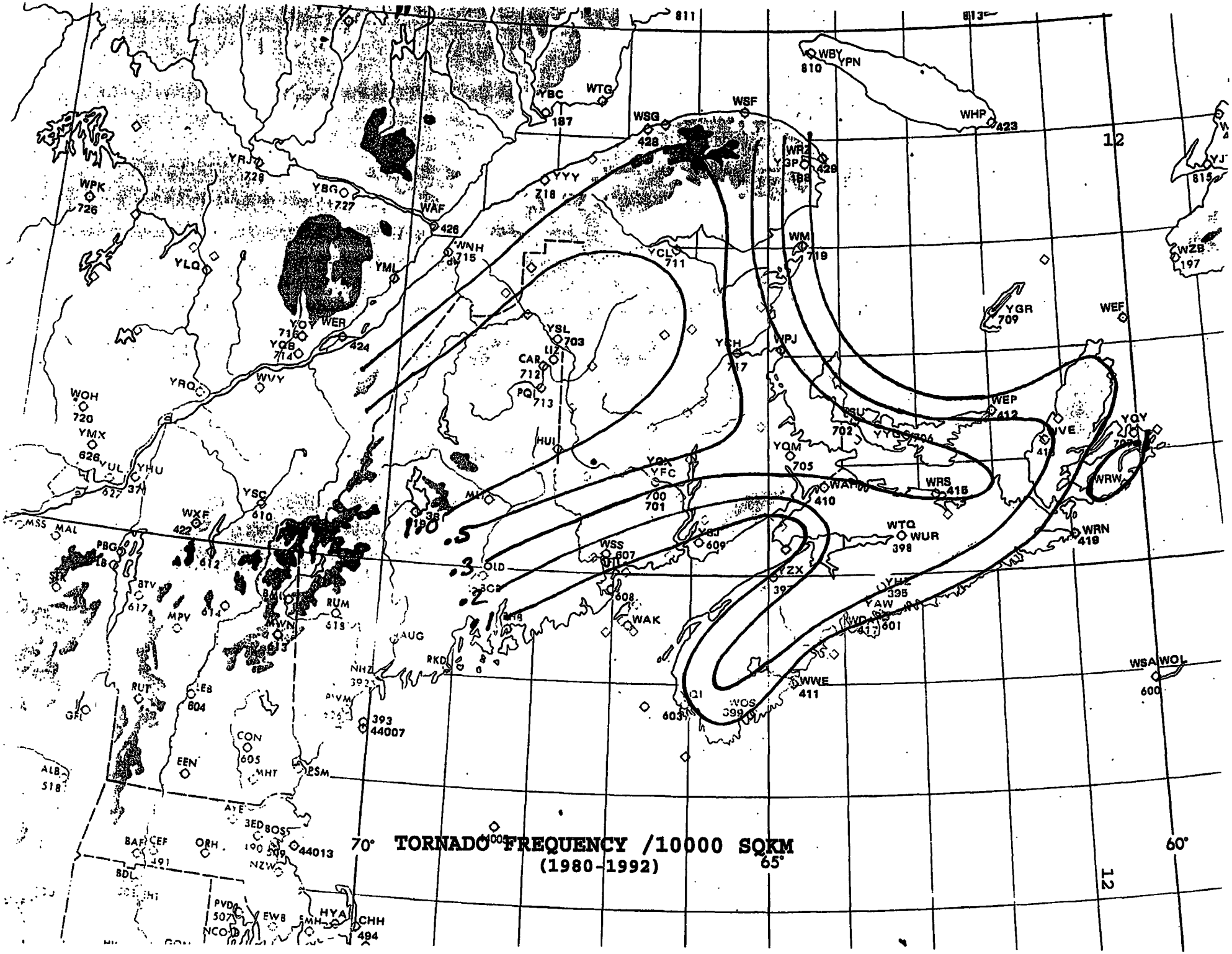
Table 9 shows the frequency of severe weather by type. The most common type of severe weather is damaging winds and heavy rain with an average of near 3 events per year for each. One surprising statistics is the relatively high frequency of tornadoes over the last four years. More than one tornado on average per year has been reported. This is significantly higher than the long term climatological average of one tornado every 2 to 5 years. This increase may not be representative of long term averages for the future, rather just a short term increase in frequency. It is also possible that this increase is due to a better detection network. Over the last several years the severe weather watcher network has expanded significantly and in general

it is likely that there is a greater awareness among the public of severe weather than there was a decade ago. Based on these assumptions it is possible that tornadoes may be more frequent than we previously thought because we are better able to detect them. As we add to this database in the coming years it will become more representative of long term averages.

Table 9. Severe Weather Frequency by Type (1991-1994)

TYPE	1991	1992	1993	1994	AVERAGE
WIND	2	3	1	5	2.75
HAIL	4	0	0	0	1.25
RAIN	1	1	6	2	2.5
TORNADO	0	1	2	2	1.25
TOTAL	7	5	8	9	7.25

An updated yearly tornado frequency map has been generated for the Maritimes based on this new data and other confirmed tornado events since 1980. This map is a portion of a national map which was produced during the Summer Severe Weather Workshop held in Edmonton in March 1995. The map can be found on the following page. It shows that the highest frequency of tornadoes for the Maritimes is in the northwest corner of New Brunswick where on average one tornado can be expected every year.


TORNADO FREQUENCY /10000 SQKM
(1980-1992)
.5
.3
.2
.1
70°
65°
60°
12
12

FUTURE WORK

In the coming year several new projects are planned to enhance the severe weather program.

1) The Alberta Weather Centre's Severe Weather Automated Message Preparation System (SWAMP), which is currently undergoing upgrading, should be installed in the WSO this spring.

2) Installation of the new RDP software for the Mechanic Settlement Radar is planned for this year.

3) The National Weather Service (NWS) is planning to install a Doppler Radar near Houlton Maine this summer. Negotiations are underway with NWS to allow for direct access to radar images from this site via modem. It is expected that this radar will provide good coverage of central and western New Brunswick much of which is currently not covered by the Mechanic Settlement Radar.

4) Quebec Hydro operates a very large lightening detection network throughout Quebec. It provides good coverage of New Brunswick and is expected to be available on the Image Manager this year.

5) It is recognized that very few of the staff have extensive experience and specialized training in severe weather prediction. This is an area where a great deal of improvement can be made. A training package and severe weather checklist may be implemented this year to begin addressing this weakness.

6) Gradual expansion of CANWARN and the Severe Weather Watcher Network will continue.

7) Implementation of the All Channel Alert (ACA) system is planned for the near future.

SUMMARY

1994 was the first summer severe weather season for the New Brunswick WSO. It was a relatively active season with 9 severe weather events. These events included two tornadoes, one early and one late in the season. A CANWARN network which utilizes HAM Radio operators was established in the southern part of the province to augment the volunteer Severe Weather Watcher Network. It proved to be very successful for both summer and winter severe weather days. Overall verification of watches and warnings showed a decline in skill score over the previous 2 years. This was a result of a slight increase in the False Alarm Ratio and a slight decrease in the Probability of Detection. It is recognised that

more severe weather forecast training is required for all staff to address this weakness. Some work has been done to establish a climatology for severe weather in New Brunswick. It is expected that the climatological statistics generated in tables 6 through 9 and the new yearly tornado frequency map will be of assistance to forecasters. Many improvements to the severe weather program are expected to take place over the next year. The addition of a NEXRAD Doppler Radar near Houlton Maine and access to Hydro Quebec's lightening detection network will provide a considerable improvement in severe weather detection.

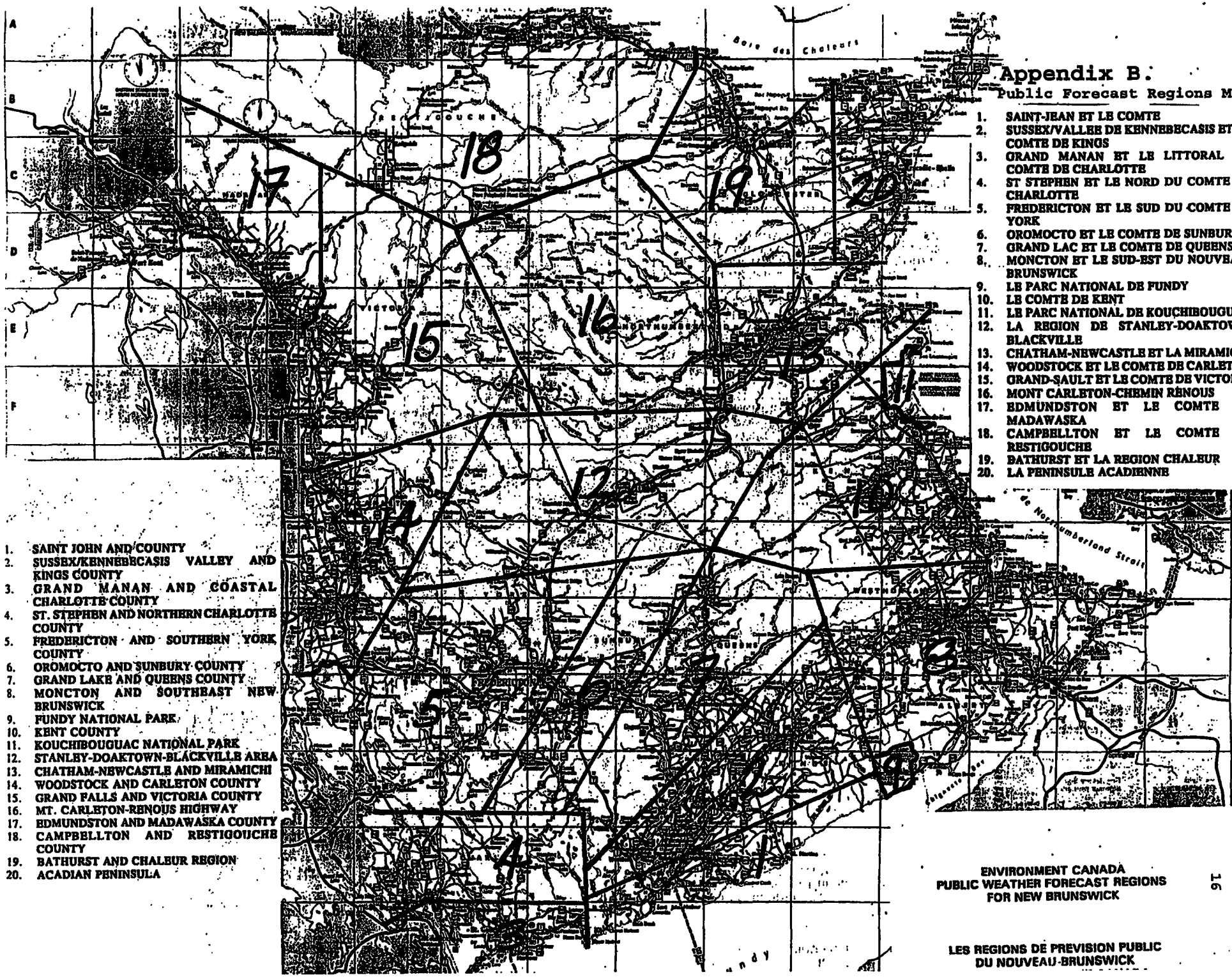
Appendix A.

Detailed Summary of Severe Weather Events.

DATE	LOCATION	CAUSE	DAMAGE REPORTED
June 17 3-6 pm	Rogersville	wind	-incomplete damage report
June 18 4 pm	Mactaquac area	tornado	-steel roofing torn off a barn -100 pounds cow mats moved -trees uprooted
June 30 9 pm	Edmunston area	rain	-very heavy rain caused dangerous driving conditions
July 2 7 pm	Grand Falls	rain	-localised flooding
July 13 3 pm	Petite-Riviere de l'Ile	micro-burst or small tornado	-heavy trailers moved -pea to walnut size hail with heavy rain -few trees uprooted -6 ton steel shed lifted and rotated 30 degrees
July 26 evening	Dalhousie	wind	-50 kt wind gusts near the shore -no damage reported
Aug 2 7 pm	Hoyt	wind pea size hail	-few trees uprooted -localized damage to trees and plants from hail -half the roof of a two car garage blown off
Aug 5 1:30 pm	Beersville	micro-burst	-sheet metal garage demolished
Sept 17 2 pm	Dundee	tornado	-mobile home destroyed when lifted 40 to 60 feet in the air -debris strewn 1 1/2 miles away -garage moved about 25 feet

Appendix B.

Public Forecast Regions Map



1. SAINT JOHN AND COUNTY
2. SUSSEX/KENNEBECASIS VALLEY AND KINGS COUNTY
3. GRAND MANAN AND COASTAL CHARLOTTE COUNTY
4. ST. STEPHEN AND NORTHERN CHARLOTTE COUNTY
5. FREDERICTON AND SOUTHERN YORK COUNTY
6. OROMOCTO AND SUNBURY COUNTY
7. GRAND LAKE AND QUEENS COUNTY
8. MONCTON AND SOUTHEAST NEW BRUNSWICK
9. FUNDY NATIONAL PARK
10. KENT COUNTY
11. KOUCHIBOUGUAC NATIONAL PARK
12. STANLEY-DOAKTOWN-BLACKVILLE AREA
13. CHATHAM-NEWCASTLE AND MIRAMICHI
14. WOODSTOCK AND CARLETON COUNTY
15. GRAND FALLS AND VICTORIA COUNTY
16. MT. CARLETON-RENOUS HIGHWAY
17. EDMUNDSTON AND MADAWASKA COUNTY
18. CAMPBELLTON AND RESTIGOUCHE COUNTY
19. BATHURST AND CHALEUR REGION
20. ACADIAN PENINSULA

1. SAINT-JEAN ET LE COMTE
2. SUSSEX/VALLEE DE KENNEBECASIS ET LE COMTE DE KINGS
3. GRAND MANAN ET LE LITTORAL DU COMTE DE CHARLOTTE
4. ST STEPHEN ET LE NORD DU COMTE DE CHARLOTTE
5. FREDERICTON ET LE SUD DU COMTE DE YORK
6. OROMOCTO ET LE COMTE DE SUNBURY
7. GRAND LAC ET LE COMTE DE QUEENS
8. MONCTON ET LE SUD-EST DU NOUVEAU-BRUNSWICK
9. LE PARC NATIONAL DE FUNDY
10. LE COMTE DE KENT
11. LE PARC NATIONAL DE KOUCHIBOUGUAC
12. LA REGION DE STANLEY-DOAKTOWN-BLACKVILLE
13. CHATHAM-NEWCASTLE ET LA MIRAMICHI
14. WOODSTOCK ET LE COMTE DE CARLETON
15. GRAND-SAULT ET LE COMTE DE VICTORIA
16. MONT CARLETON-CHEMIN RENOUS
17. EDMUNDSTON ET LE COMTE DE MADAWASKA
18. CAMPBELLTON ET LE COMTE DE RESTIGOUCHE
19. BATHURST ET LA REGION CHALEUR
20. LA PENINSULE ACADIENNE

ENVIRONMENT CANADA
PUBLIC WEATHER FORECAST REGIONS
FOR NEW BRUNSWICK

LES REGIONS DE PREVISION PUBLIC
DU NOUVEAU-BRUNSWICK

1994 summer severe weather season for New Bru
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FLEETWOOD, RICK .