Confirmed Tornado
Cumberland - Glenburn, Ontario
June 27, 1978

Date- Local: Tuesday, June 27th, 1978
UTC: Tuesday, June 27th, 1978
Time- Local: 1700
UTC: 2100
Location: Cumberland – Glenburn (Ontario portion of the Lac Carmen - Masson - Glenburn, ON F3 tornado)
Region: City of Ottawa
Classification: Confirmed Tornado
Category: A
Casualties: None
Track Length: 24250
Width: None available
Motion: 285 degrees
Damage Estimate: None available
F-Scale Rating: F0
Code: BS
Damage Survey: Yes
Spotter Reports: None
Other Documents:

Paper titled "The Interaction of a Tornado with Rough Terrain" by James B. Harrington and Micheal J. Newark. The paper provides a detailed track map and shows the 3 tornadoes that occurred near Lac-Du-Loups, this one here, and the St. Bernadin, ON.

Report on the tornadoes of June 27, 1978 by M. J. Newark and P. J. Elms

Report titled "Tornado Damage in Masson, Quebec" by J. T. Templin and K. R. Cooper.

Tornado F-Scale Assessment

Brad L. Rousseau
Tornado Data Production Assistant, Environment Canada
February 23rd, 2011

Classification: Confirmed Tornado
Date: Tuesday, June 27th, 1978
Location: Cumberland – Glenburn (Ontario portion of the Lac Carmen - Masson - Glenburn, ON F3 tornado), City of Ottawa Region

Assessment: F0
F-Code: BS
Explanation of Assessment: Only reports of barn damaged, but no description about the damage. This is the Ontario portion of the Lac Carmen - Masson - Glenburn, ON F3 tornado. The damage within ON itself is only rated at F0. The true start point is:45.603168, -75.922981, with a full path length of 65680 m and motion (line of best fit) of 280 degrees.

SJS

REPORT ON THE TORNADOES OF TUESDAY JUNE 27TH, 1978

Prepared by

M.J. Newark and P.J. Elms

July 10, 1978

INTRODUCTION

At least two tornadoes (and possibly 3) occurred in Ontario and Quebec on Tuesday June 27, 1978. This conclusion is the result of personal visits to storm damaged areas, interviews with the provincial police of Quebec and Ontario, Ontario Hydro and discussions with news reporters and private individuals. The storm tracks are shown in figures 1a and 1b.

1. Unconfirmed tornado at Dillon, Ontario (vicinity of Parry Sound)

A storm at 0730 EDT near Dillon, Ontario, displayed tornado characteristics but confirmation of a funnel sighting could not be obtained. Damage was confined to a path about 400 m in width and several kilometres in length. Trees, some up to 60 cm in diameter, were uprooted or broken off and minor damage to rooftops and TV masts was reported. Secondary damage was caused by trees falling onto houses and hydro wires. Hail of about 2 cm diameter accompanied the storm, while in Huntsville, hail as large as golf balls was reported. Windows along the storm path were broken and cars and trucks dented.

A total damage estimate is not available and there were no injuries or deaths. In response to questioning, there was no indication that anyone had heard the severe thunderstorm warning issued by the Ontario Weather Centre at 0500 EDT that morning.

2. Confirmed tornado Bob Lake - Lac des Loups - vicinity Duclos, Quebec

Personal examination revealed a continuous damage path about 300 m in width and at least 13 kilometres in length which slashed through this sparsely populated area on the fringes of the rugged Parc de la Gatineau (figure 2). The tornado funnel was seen by many people at about 1630 EDT and was at first mistaken for the smoke of a fire. It was accompanied by a terrible roar, but no rain or hail fell at the time.

It commenced somewhere between Bob Lake and Thorne Lake (police confirm that no damage was reported by residents around Thorne Lake), and travelled along a sinusoidal but generally west to east path through the village of Lac-des-Loups to the vicinity of Duclos.

Trees along the storm track were completely flattened. A cottage at Bob Lake was pushed off its foundation. In Lac-des-Loups, several houses and cottages suffered extensive damage; one house was lifted into the air with its occupants, a mother and three children, and thrown a metre or two off its foundation. Other buildings sustained considerable roof damage and two small cottages were demolished. There were no personal injuries or deaths.

Several residents had heard a weather warning but had not taken any particular action as a result. Very few of the dwellings had a basement or any other suitable place of refuge. A total damage estimate is not available, but must run into many thousands of dollars.

2.1 Confirmed tornado, Cascade - Mont Cascade - Masson, P.Q., - Rockland, Ontario.

A black tornado funnel was seen by many eyewitnesses. As it crossed the Gatineau River it lashed the river surface into a fury of waves and

turned a foggy grey colour as it drew water up about 10 or 12 metres. No rain or hail accompanied the tornado at this point. Only that portion of the track in the vicinity of Cascade was visited by the authors (figure 3).

The large uninhabited Parc de la Gatineau lies to the west of Cascade and the origin point of this tornado is unknown. Its total damage length is estimated to be about 50 kilometres at least, and in the area inspected was about 300 m wide. Trees, some as large as 1 m through the butt, were levelled in profusion and some had been snapped or twisted off. No primary property damage was seen in the vicinity and very little secondary damage. The description of the very bad damage and injuries in Masson is left to others, while considerable pictorial evidence of it has been published by the Ottawa daily papers.

The tornado reached Cascade around 1700 EDT and passed Masson at about 1730 EDT. This gives an average speed of about 70 km hr^{-1}.

Estimates of damage due to this tornado run as high as $3 million, more than 30 people were injured and 50 or more families were left homeless.

2.2 Continuation of the tornado in the vicinity of Clarence Creek to St. Bernadin

The Ontario Hydro Commission has conducted a detailed study of the damage in the vicinity of St. Bernadin because a number of their large high-voltage transmission towers were felled by the storm at approximately 1800 EDT. Nobody reported a funnel cloud, but many barns

and silos were badly damaged along a narrow path. Hail the size of chicken egges fell for a short time preceding the wind damage.

A damage estimate is unavailable. No injuries or deaths were reported.

3 THE STORMS AS SEEN BY WEATHER SATELLITE

GOES photographs received by the Satellite Data Lab., AES, indicate that the Quebec - eastern Ontario tornadoes were produced by the same parent thunderstorm complex which originated near Huntsville, Ontario at about noon EDT. Small at first, this complex moved across Algonquin Park, then growing in size curved east-southeastwards across Calumet Island. It crossed the Ottawa River near Rockland carried on across the western end of Montreal Island, finally moving into New Brunswick (figure 4). At the time that the tornadoes were occurring, the photographs show a multiple towered CB complex with a huge anvil cloud streaming downwind. This complex in turn was one of several others aligned northeast-southwest along a cold front. Calculations show that the motion of the particular complex was from 290^{o} at 70 km hr^{-1}.

4 CONCLUSION (and possibly 3)

(a) At least 2 tornadoes struck Ontario and Quebec on Tuesday, June 27, 1978.

(b) The most severe damage was at Masson, Quebec, where 30 or more people were injured, 50 or more families rendered homeless, and at least $2 million worth of property damage was sustained.

(c) Some people heard weather warning messages, but either could not or did not take precautionary measures.

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5-6 TORNADO DAMAGE IN MASSON, QUEBEC

by J.T. Templin
Division of Building Research
National Research Council

K.R. Cooper
National Aeronautical Establishment
National Research Council

Although tornadoes are relatively infrequent in Canada compared to other parts of the world, they are not unheard of. The area of Ontario and Quebec has experienced many small tornadoes over the years. On 27 June 1978 about supper time, several isolated houses and a five square block area of Masson, Quebec, were demolished by high winds. Although damage was estimated at more than $3 million, there were no deaths and only minor injuries. Because the damaged areas were so near to Ottawa (about 50 km) and easily accessible, a study was made to examine characteristics of the tornado and the structural damage it caused.

The damage site was visited the day after the tornado to observe structural damage and size of affected areas. A helicopter was used to fly over all affected areas several weeks later to plot the course of the tornado and to map the full extent of damage.

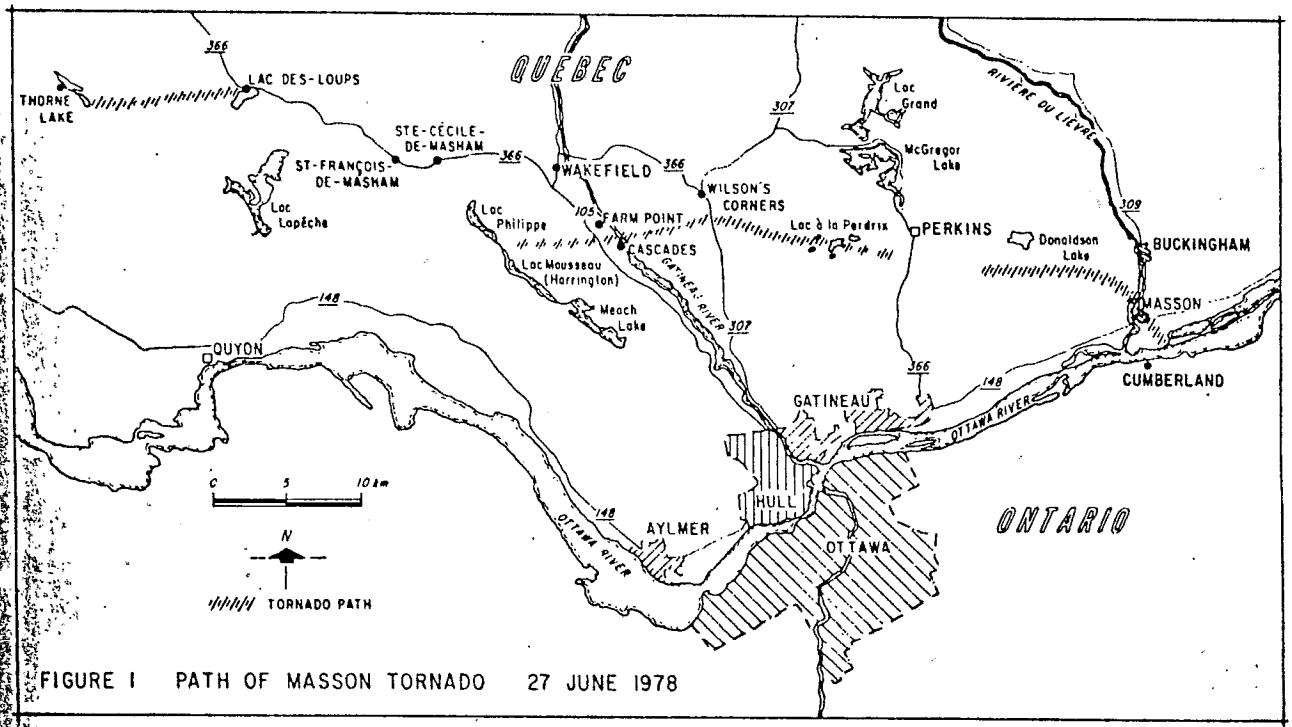


FIGURE 1 PATH OF MASSON TORNADO 27 JUNE 1978

Figure 1 shows the path of the tornado determined by damage observed from the helicopter. The storm moved from west to east. It is possible that the damage near Lac-des-Loups may have been a separate tornado spawned by the same storm. However, there seems little doubt that the remaining damage was due to a single tornado that lifted off the ground and touched down several times over a distance of 45 km. At some points along its path it seemed to skip along touching down only briefly at each instance. Most of the path was determined by observing regions of felled trees. Although it was usually difficult to observe an orderly pattern in the felled trees from the helicopter, a definite swirl pattern was apparent in the damage in a few locations, especially at points where the tornado had just touched down (Figure 2). However, in some locations the trees were all down in the direction of motion of the tornado. Occasionally the trees fell at right angles to the path. The width of the path varied from 500 m or more to less than 100 m. The path through Masson was less than 200 m across. The evidence indicates a small tornado but typical of those that occur in Eastern Canada.

It is difficult to determine wind speeds from damage to non-engineered structures. However, there were at least two cars that were rolled by the tornado (Figure 3). It was estimated from aerodynamic data on cars that a wind speed of 56 m/sec (125 mph) would be required to roll a medium size car sitting at right angles to the direction of wind.

Damage in Masson was restricted to the path of the tornado (Figure 4). Along the path there were four types of damage: roofing and cladding damage at the windward side, entire roof removed, roof and leeward wall removed, entire house removed above foundation. Figure 5 shows the damage caused by debris. Figure 6 shows the sharp definition of the damage path. The house on the left (background) sustained no damage while the other lost its roof and parts of two walls. This roof had been held to the walls by only two nails at each end of each truss.

The tornado also passed across several high voltage power lines (Figure 7). It does not appear that any damage was done

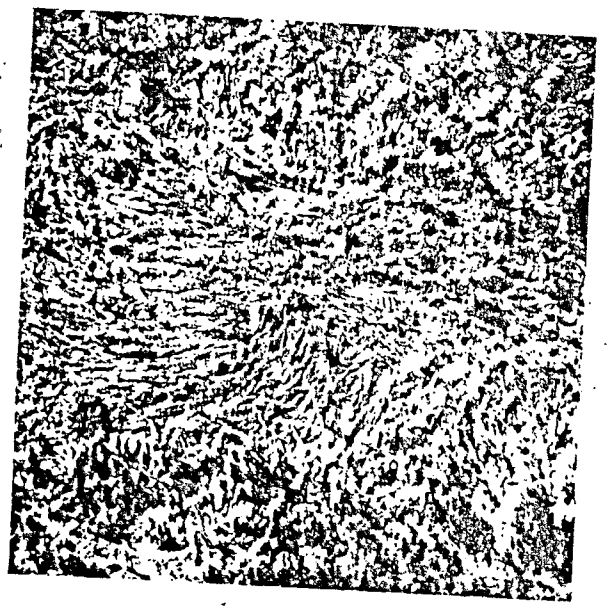


Figure 2 - Swirl pattern of felled trees



Figure 3 - Overturned car

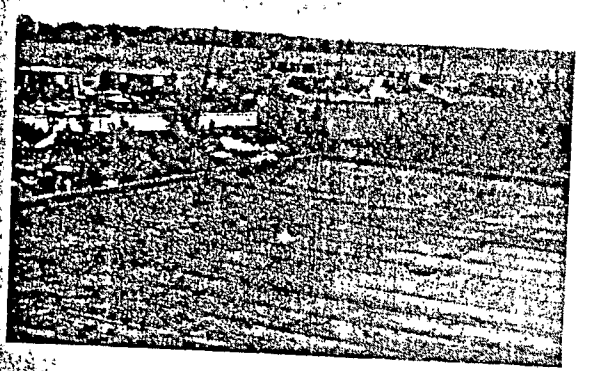


Figure 4 - General damage in Masson

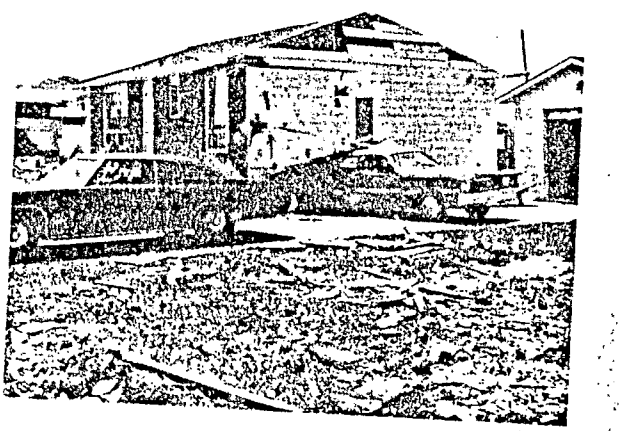


Figure 5 - Damage due to debris (tornado moved from right to left)

even though some towers were right on the centreline of the tornado path.

It can be seen from the evidence that the Masson storm was a weak tornado but produced winds that are high for the Eastern Canada region. Other than hydro towers, no engineered structures were in the path of the tornado. Some of the damage to housing indicated inadequate tie-downs of roofs to walls and walls to foundations.

The lack of injuries can be partly explained by the type of damage. When roofs only are removed, there is not much danger to occupants of the houses. Some occupants were saved by going into their basements when the tornado was approaching. If the tornado had hit mobile homes that were not anchored to the ground, damage and injuries would have been much more serious.



Figure 6 - House with roof removed (tornado moved from left to right)

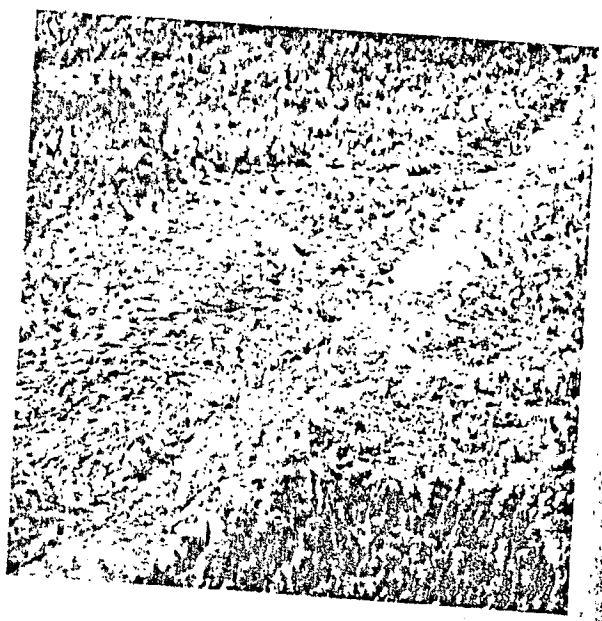


Figure 7 - Tornado path across power line

WIND EFFECTS I

RESUME OF DISCUSSION

In the question period following this session, Vickery noted that only the force normal to the plane of his open frames was measured, other force components being small. The Reynolds number corrections could, he thought, be estimated from measurements of individual sections at appropriate wind speeds. Estimates of the angle of attack for highest force might be made for low solidity by noting when rear columns are not shielded by fron columns. At higher solidity, Vickery noted, the maximum force is obtained at higher angles ($40^{\circ} - 60^{\circ}$) because of the greater blockages of each frame. Individual frame loads were not measured in Vickery's tests, since frames are usually tied together by longitudinal braces during construction.

The studies of window glass design described by Beason led to an appeal from an industrial representative that a group like CWEA act as a focus for the formulation of requirements for glass design which could be used without wind tunnel studies in complicated situations. The load-duration properties of glass were briefly described—higher strength under short peak loads than under sustained loads. Stournaras of the Ontario Research Foundation showed slides of a recently-built apparatus which can investigate the effect of rate of loading and cyclic loads as well as frame conditions on large (5 foot by 8 foot) panels of glass. Linear loading rates of up to 14 psi per second have been measured in a small pilot version of the device which uses a piston and air pressure to load the test panel. Beason reiterated, in answer to a question, that age, through chemical action of water vapour on surface flaws on the glass, can lower overall glass strength.

Mehta, in answer to a question on design of buildings against tornadoes, suggested that critical facilities such as nuclear plants are designed for very high (360 mph) wind speeds (300 mph in Western North America), that essential buildings (hospitals, police stations, school cores, etc.) should have design speeds of 150 – 250 mph, and that other buildings could be designed to withstand wind speeds of only 120 mph. J. T. Templin, questioned about the Masson tornado, noted that there was little correlation of the high wind speeds in the tornado with nearby wind speeds and that the tornado path did not appear to follow topographical contours.

THE INTERACTION OF A TORNADO WITH ROUGH TERRAIN

By JAMES B. HARRINGTON and MICHAEL J. NEWARK

Petawawa National Forestry Institute
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ON the 27 June 1978 the first of three tornadoes touched down near Thorne Lake, Quebec (45°41′N, 76°22′W) and proceeded eastward along a sinusoidal path over Lac-des-Loups. Another skirted north of Gatineau Park, through the village of Masson, crossing the Ottawa River into Ontario; the third occurred near St. Bernardin, Ontario. The tornadoes in Quebec exhibited considerable interaction with the rough terrain of the region. They tended to seek out valleys and avoid hills, they intensified on downslopes, and created their greatest destruction in the hollows between large ridges.

INTRODUCTION

Tornado damage to Canadian forests is more common than generally believed. Various estimates place the frequency of occurrence at approximately 0.4 to 0.8 per $10^4 km^2$ annually in the forests of Ontario and Quebec (Newark 1983; East *et al.* 1974). The probability of tornado damage is about 0.02 per cent annually (Newark 1983), which, in Ontario, represents about one tenth of the area burned by forest fires each year (Harrington and Donnelly 1978).

The path taken by a tornado over rough topography, if known, could influence the design and location of structures and power lines. It could also influence the ecology of a region. This paper describes the damage patterns created by tornadoes which traversed the rough forested terrain of the Laurentian Highlands near Ottawa, Canada.

OBSERVATIONS

Satellite photographs on 27 June 1978 indicate that the Quebec–eastern Ontario tornadoes were produced by the same parent thunderstorm complex which originated near Huntsville, Ontario at about 1100 Eastern Standard Time. Small at first, this complex moved across Algonquin Park, then grew in size as it curved east-south-eastward across Calumet Island. It crossed the Ottawa River near Rockland and carried on across the western end of Montreal Island, finally moving into New Brunswick. At the time that the tornadoes were occurring, photographs show a multiple towered cumulonimbus complex with a huge anvil cloud streaming downwind. This complex in turn was one of several others aligned along a cold front oriented from the north-east to the south-west. Calculations show that the average motion of the particular complex was from 290° at $70 km h^{-1}$.

The McGill weather radar in Montreal observed a large isolated storm-cell echo which came within range near Pembroke, Ontario at approximately 1415 EST. The cell motion was from 280° at an almost constant speed of $63 km h^{-1}$. A hook echo appeared in the vicinity of St. Bernardin and persisted until about 1800 EST when the complex passed about 20 km south of Montreal with a hook still visible on the radar but no severe weather.

Eyewitness descriptions of the tornadoes

In the vicinity of Lac-des-Loups, the tornado so closely resembled a column of smoke that the volunteer fire chief dispatched a truck to put out the fire. To their dismay, the firemen could not catch up with the 'smoke'. To Roland Davis, 2.5 km south of Wilson's Corners, the funnel at first appeared to be about 15 m across and "looked like the Ajax tornado on television". It lifted, then came down again as a rope-like vortex. Oakley Carey, about 14 km to the east on the Perkins road, also saw something like the

Ajax advertisement tornado. He said that it was full of tin, leaves and debris and was narrow, about 6m across, and white at the bottom but very wide and dark at the top. Raymond Trudel, located 0.5km north of the tornado track and 1.5km east of Oakley Carey, also had an excellent view. He reported that "the funnel was full of debris and pumping up and down" which was possibly a consequence of the stretching and shrinking of the vortex as it passed over the hills and valleys. No report of more than a single vortex has come to light, although (as described later) ground surveys revealed evidence of multiple damage paths.

Surveys and data collection

On 4 July 1978, after a preliminary survey by aircraft, two photographic missions were flown from the point where a tornado crossed the Gatineau River to Masson, Quebec. Black and white photographs were taken by personnel of the Forest Management Institute (FMI) of the Canadian Forestry Service at a scale of approximately 1:5000 along the length of this track, and at a scale of 1:2000 over the damage patches. On 25 July 1978, after the foliage on the felled trees had died, the damage area from Thorne Lake to Masson was photographed by the National Aeronautical Establishment of the National Research Council (NRC) from an altitude of approximately 1830m at an average scale of 1:15600. Maps made from the NRC photographs have since been published (Newark 1983). The FMI photographs were analysed stereoscopically at a resolution of 50m and the orientation of downed trees and the fraction of the forest blown down was determined.

Details of the damage pattern were examined during fifteen expeditions on foot to various portions of the tornado track. These observations supplemented and checked the photographic analysis. Of particular interest were the effects of minor topographic features such as knolls and gullies which were unresolved in the photographs. Wind-thrown trees obscured by the foliage of undamaged trees, and trees whose tops has been severed were also more readily observed from the ground. In addition a ground survey was made in Masson by the National Research Council (Templin and Cooper 1978). No aerial photographs were made of the tracks through Ontario, but a telephone survey was conducted and damage report was plotted on a 1:15000 topographic map. In the St. Bernadin area, a ground survey was made by Ontario Hydro (personal communication). Fig. 1 uses the data from all sources, and summarises the tornado tracks, the damage visible in aerial photographs, and the times reported by eye-witnesses.

TORNADO DAMAGE

Fig. 2 shows the location of the storm echoes at various times and the associated rainfall rates as observed by the McGill weather radar at Ste-Anne-de-Bellevue. The areas of tornado damage and times of tornado passage indicate that the tornadoes followed a path related to the south-western corner of the radar echo.

The damage visible from the air gave the appearance of frequent skipping, however, a close examination on the ground revealed a more or less continuous path varying in severity and marked by twisted, snapped or uprooted trees and damaged homes. Areas apparently undamaged when surveyed from the air actually contained fallen trees shielded from view by the foliage. In the open agricultural area of eastern Ontario traversed by the tornadoes, property damage and fallen hydro-electric transmission towers were the results.

In the community of Masson, estimates of property damage ran as high as $3 million, 36 were injured, and 50 or more families were left homeless. In Lac-des-Loups, one house was lifted into the air with its occupants (a mother and three children) and thrown a metre or two off its foundation. Well constructed homes even under the centre of the vortex suffered little damage.

Houses and trailers in dense woods appeared to have been protected from the wind even where the entire forest was flattened.

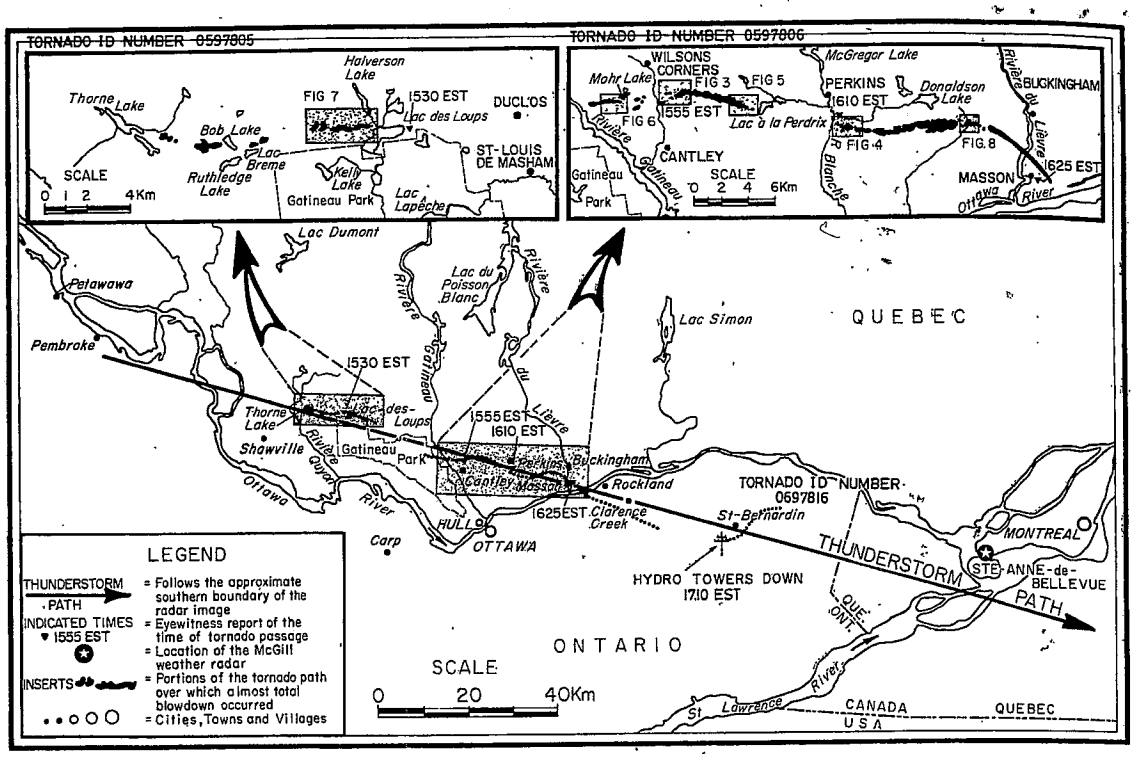


Fig. 1 The tornado damage tracks of 28 June 1978 superimposed on the general path followed by the parent thunderstorm. The inset maps show portions of tornado tracks in greater detail obtained from aerial photographs. Areas for which detail is available at a yet larger scale are indicated by their appropriate Fig. numbers

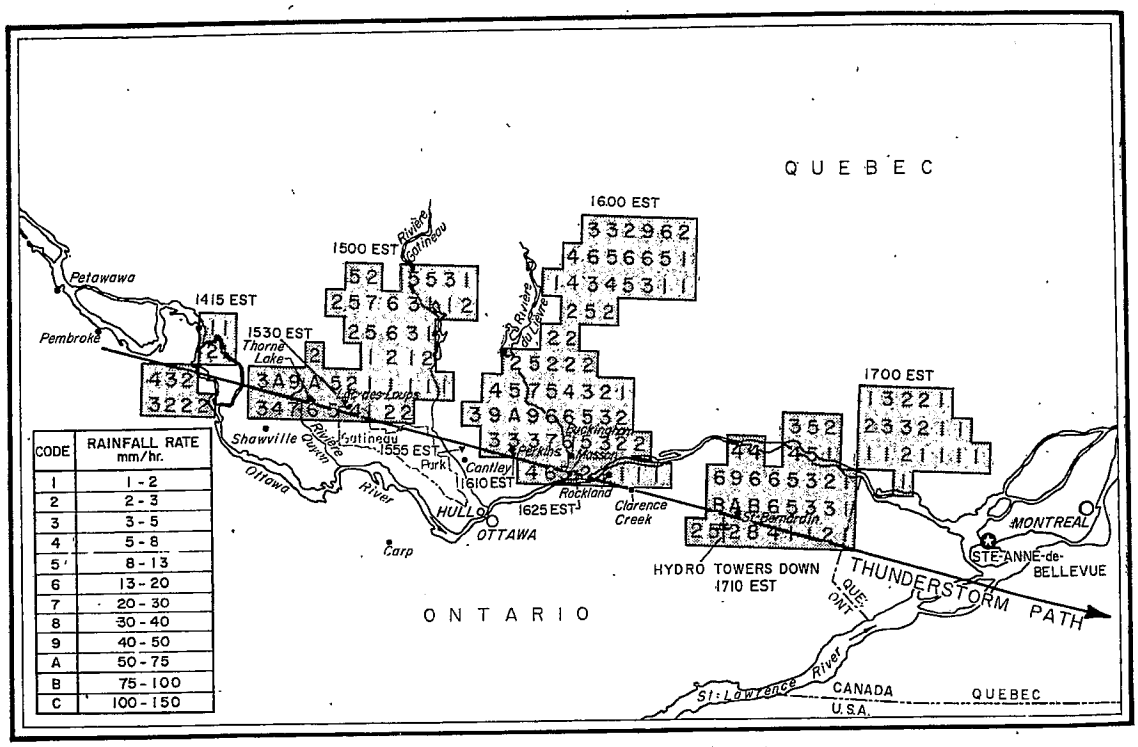


Fig. 2 The McGill weather radar (Ste-Anne-de-Bellevue) 2.5 km Constant Altitude Plan Position Indicator (CAPPI) rainfall rates for the period 1415 EST to 1700 EST, 28 June 1978. The times of tornado passage are indicated along the thunderstorm path. Scale as Fig. 1

Damage to the forest

The susceptibility of a tree to wind-throw is a function of its height relative to surrounding trees, drag coefficient, area exposed, and rooting (Grace 1977; Fraser and Gardiner 1967). In general, tall shallow-rooted trees with dense foliage and inflexible branches are most susceptible.

June 1978 was a wet month in the tornado area. The soil on the hills is shallow and the forest is generally mature, ranging in height from 15 to 22 m. Fraser and Gardiner estimate that, depending on rooting and soil moisture conditions, trees 15 m in height will suffer wind-throw with critical wind speeds of 60 to 80 km h^{-1}. For trees 22 m in height, the range is 50 to 72 km h^{-1}. Fraser and Gardiner's estimates concerned trees in sustained high winds where gusting could progressively weaken the grip of the roots. The speed requirements during a tornado may be higher because of the brevity of the strong winds. The trees along the tornado path were generally poorly rooted in shallow, nearly saturated soil. Wherever the larger trees were windthrown and smaller trees left standing, the minimum wind speed can be estimated as 50 to 60 km h^{-1}, based on Fraser and Gardiner's critical speeds. It should be noted that size and rooting are not the only significant factors. Species is also important, with balsam fir, because of its solid profile, and poplar, because of its concentration of branches near the top of the tree, being particularly vulnerable.

Damage tracks

The damage was resolved into three tornado tracks (Newark 1983) located as shown in Fig. 1 and whose physical characteristics are summarised in Table 1.

TOPOGRAPHY

The Laurentian Highlands, over which the tornadoes passed, are composed of rugged forested hills extending 90 to 120 m above the level of interspersed lakes and valleys. Along major rivers such as the Gatineau, the rise of the hills is greater by about 60 m. A gently sloping plain of variable width lies between the Ottawa River and the rough topography of the Laurentian Highlands. The proximity and length of the tornado damage paths afforded an unusual opportunity to study in detail the interaction between a tornado and rough terrain. Of particular interest are the effects of topographic features such as knolls and gullies.

Relationship of damage to topography

Figs 3 to 8 inclusive show maps of tree-fall on detailed topographical charts, and reveal several traits of the tornado's behaviour. First, the tornado appears to have systematically avoided passing over high terrain if a path through valleys or gullies was available (this can be seen in Figs 3, 5, and 6). Second, where the tornado did in fact pass over hills (south-east of Perkins in Fig. 4, and near Donaldson Lake in Fig. 8), it appeared

TABLE 1 Physical characteristics of the Ottawa Valley area tornadoes of 27 June 1978. The Universal Transverse Mercator (U.T.M.) grid is printed on National Topographic System maps. Number 0597805 refers to the Thorne Lake to Lac-des-Loups tornado; 0597806 refers to the Cascades, Quebec to Pendleton, Ontario, tornado; 0597816 refers to the St. Bernardin, Ontario tornado. All dimensions and times are approximations. For the meaning of F-number see Newark (1983), pages 82–83.

TORNADO IDENTITY NUMBER	TOUCHDOWN TIME (EST)	U.T.M. TOUCHDOWN COORDINATES	DAMAGE WIDTH AVERAGE (m)	DAMAGE WIDTH AVERAGE (m)	DAMAGE LENGTH (km)	DAMAGE AREA (km^2)	F-NUMBER
0597805	1520	395660,5059270	95	510	11	1	1
0577806	1545	428160,5050190	135	1000	60	8	3
06978126	1710	513400,5030600	Unknown	Unknown	14	Unknown	2

to undergo a cycle of weakening part way up the windward slope and strengthening part way down the lee slope. Generally it appears to have been weaker over ridge tops and strongest in the valleys (see Fig. 4a). This would be expected in theory because of the conservative nature of potential vorticity (the ratio of absolute vortex vorticity to the effective depth of the vortex) which implies that the absolute vorticity of the tornado increases as its vortex is stretched by moving downslope. Vorticity may be regarded as a measure of circulation; therefore, the orientation of tree-fall can be used as a rough indication of the degree of vorticity in the tornado.

Along the damage track most trees were felled either in a parallel direction (i.e. from west to east) or in the directions up to about 90° to the left of the track, with little evidence of circulation. However, on the windward side of the ridges there was a tendency for increased convergence with trees on the north side of the damage track falling in directions 180° opposite to those on the south side. This is particularly clear in Fig. 4. There is evidence of cyclonic rotation in the vicinity of the location labelled 'A' in Fig. 8. This pattern was typical of that occurring around small knolls. Trees atop the knoll were frequently undamaged as though a Taylor Column had settled over the knoll (Lamb and Janowitz 1985).

It was noticed during the ground survey that damage seemed to be accentuated in gullies, even those too small to be identified at a 7.6 m contour interval. The long fingers of damage shown in Fig. 4, which consitute multiple damage paths joining the main track at a large angle, are such a case. Each was associated with a sharp gully. The channelling, or funnelling, effect of gullies was observed as far as several hundred metres from the main damage path. Fig. 5 also shows fingers of damage, but in this case the orientation of tree-fall indicates counter-clockwise looping around the two prominent knolls. It is possible that the tornado was making an independent cycloidal damage track in this area, but the chance of the cycloidal loops being so neatly located around the knolls is a remarkable coincidence and it is more likely that the knolls and gullies themselves were responsible for this damage pattern. As a conjecture, these fingers of damage may have

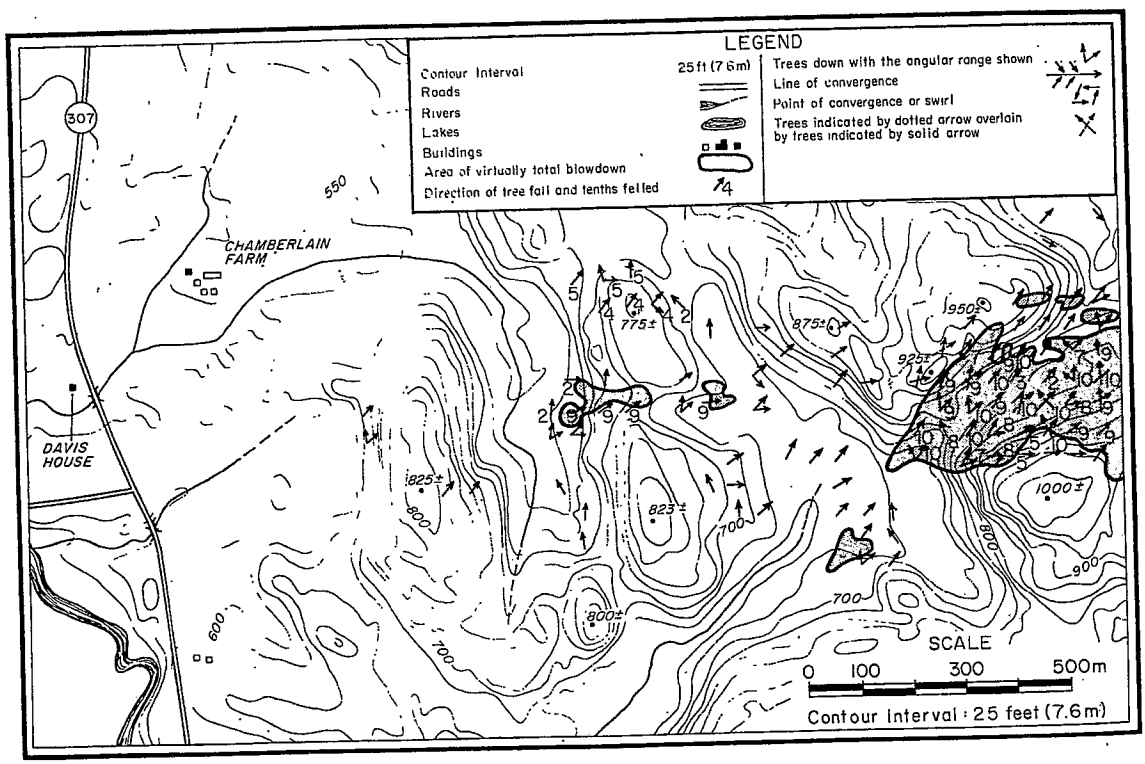


Fig. 3 Tornado damage patterns north-east of Cantley, Quebec

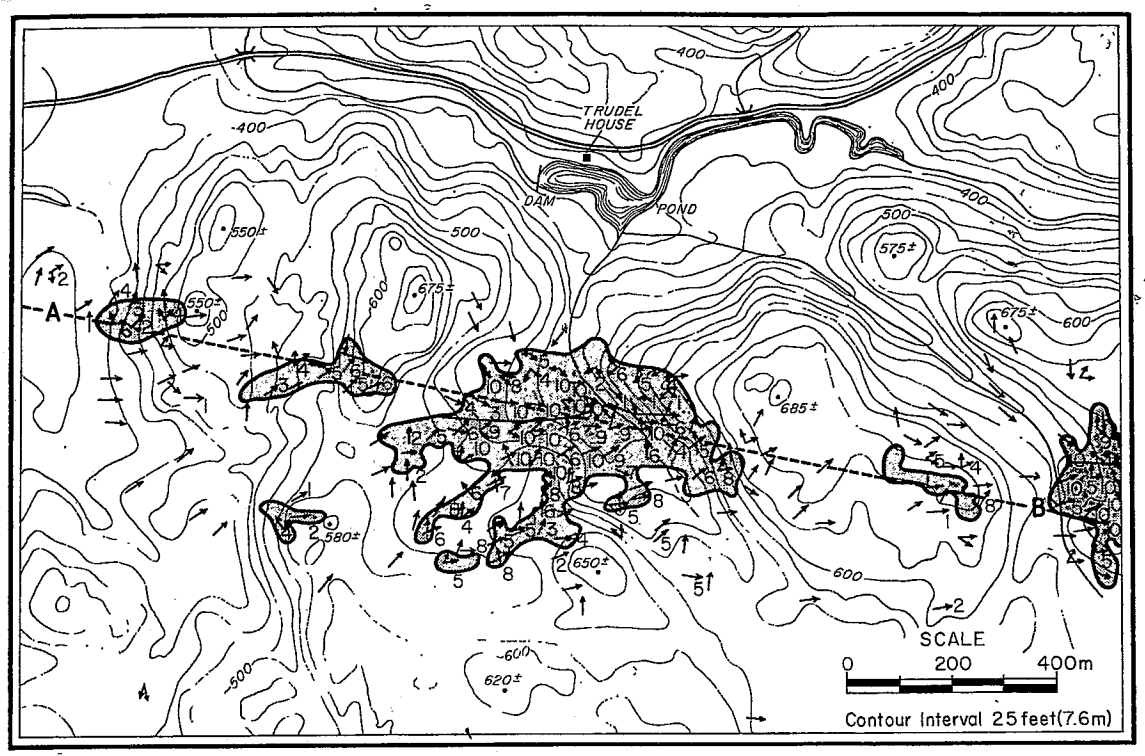


Fig. 4 Tornado damage south-east of Perkins, Quebec. (See Fig. 3 for the legend). A cross section of damage and elevation between A and B is shown in Fig. 4(a)

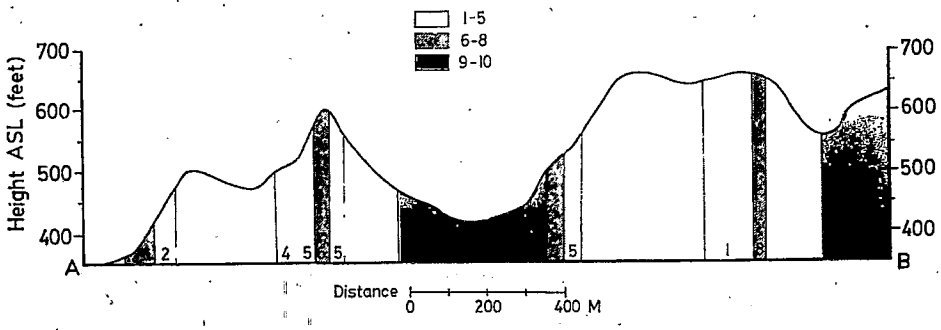


Fig. 4(a) A cross section showing the relationship between damage location, damage amount, and topographic elevation between points A and B in Fig. 4. Shaded areas show damage location with numbers showing tenths of felled trees

been caused by secondary vortices, induced by the increased absolute vorticity in the lee of the prominent knolls, and were then guided by the terrain.

The damage west of Lac-des-Loups (shown in Fig. 7) is a clear exception to the tendency of the tornado to avoid passing over high terrain if an easier alternative route was available (as has been noted in other parts of the track). In this case the damage trail led directly over some of the highest hills encountered, even though a parallel valley was conveniently located about 500 m to the north of the 320 m crest, and lower elevations were even closer alongside the 245 m hill to the east. The orientation of the two damage patches on the western side of the figure appear to indicate that the tornado was describing a cycloidal path independent of the terrain at that location, and with strength sufficient to

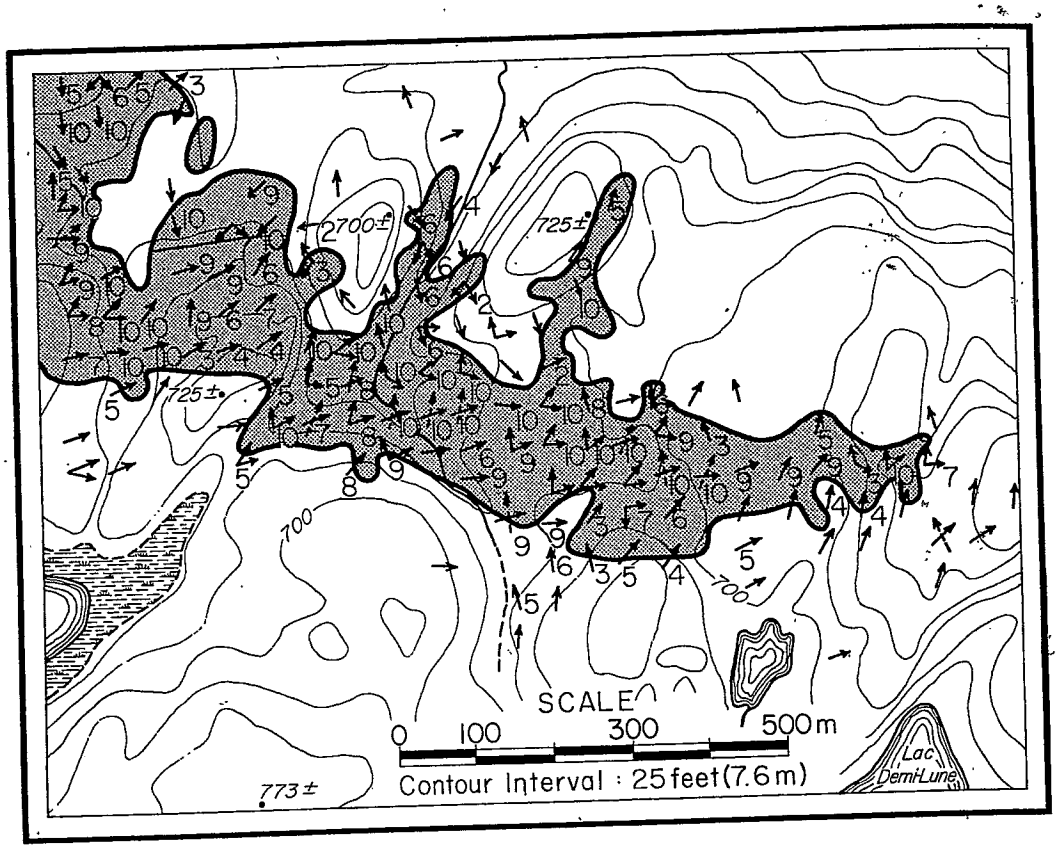


Fig. 5 Tornado damage path west of Lac-à-la-Perdrix, Quebec. (See Fig. 3 for the legend)

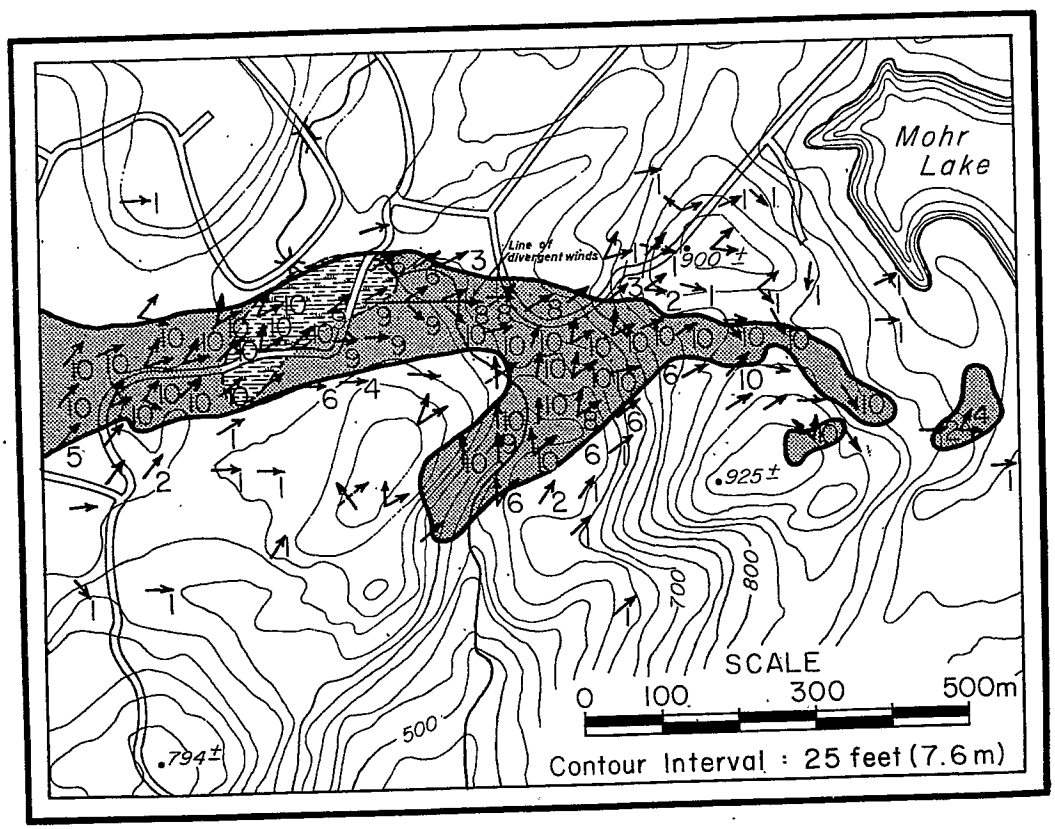


Fig. 6 Tornado damage path west of Mohr Lake, Quebec. (See Fig. 3 for the legend)

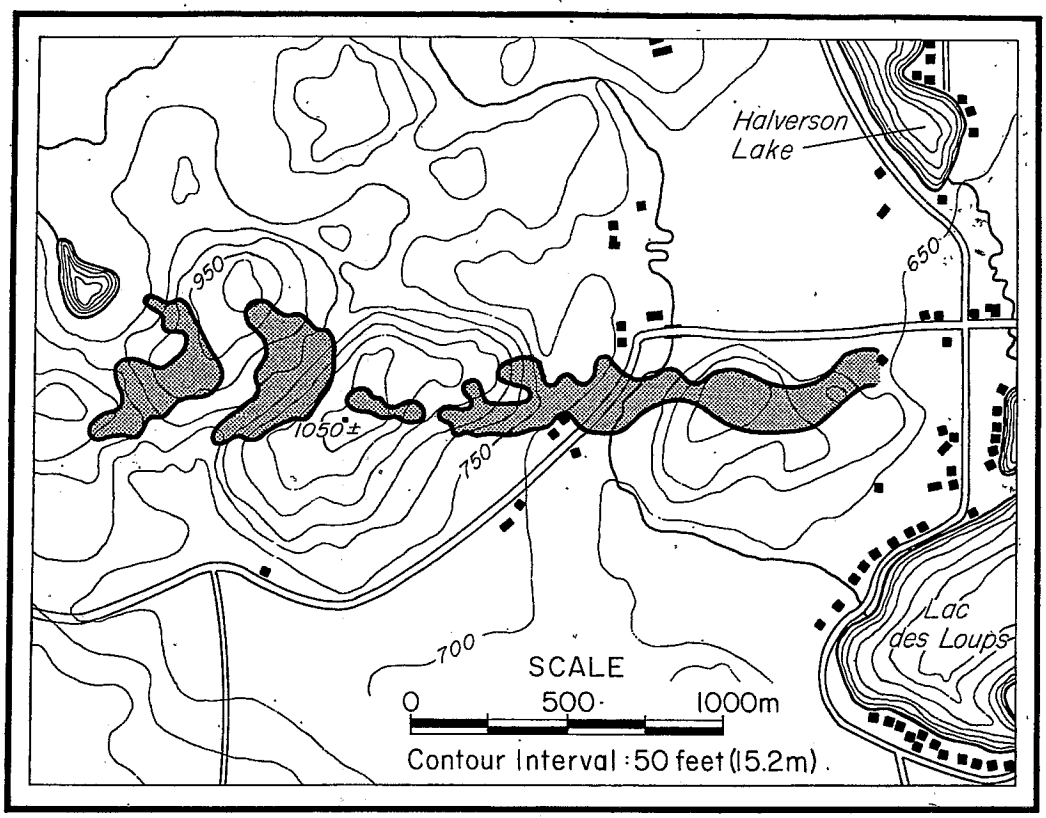


Fig. 7 Tornado damage path west of Lac-des-Loups, Quebec. (See Fig. 3 for the legend)

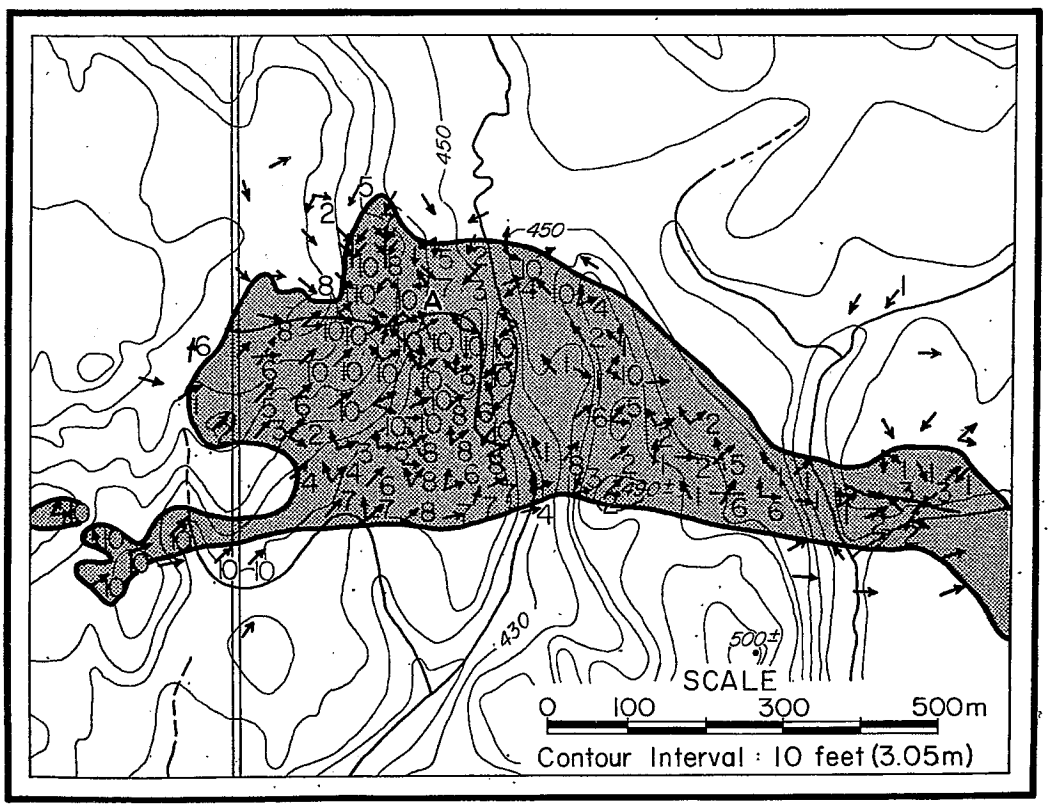


Fig. 8 Tornado damage path near Donaldson Lake, Quebec. (See Fig. 3 for the legend)

cause damage only during the south-to-north segments of the path. Subsequent to passing over the high hill it began following a straight line path. It may be that the considerable increase in surface roughness represented by this hill was responsible for the change in nature of the tornado's behaviour as has been noted by Blechman (1975) in the case of tornadoes moving over the Niagara Escarpment in Wisconsin.

SUMMARY

From a study of the tornadoes in Masson and area, which appear to be typical (with respect to their formation, lifetime, direction of travel, and type of damage etc.) of those which commonly occur in Ontario and Quebec, it can be inferred that there is a strong interaction between tornadoes and the terrain. The tornadoes of 27 June 1978 appeared to strengthen on downslopes, reaching their greatest intensity in valleys, and then weaken as they crossed hills or ridges. They exhibited a tendency to avoid high terrain if there were a convenient route across lower ground, although a significant exception to this was noted to the west of Lac-des-Loups. It is believed that valleys and gullies (some too small to appear at a contour interval of 7.6 m) funnelled damaging winds through distances of hundreds of metres, and channelled them into the primary path. Two forms of cycloidal motion are conjectured, one apparently independent of the terrain, and the other apparently caused by the particular topography of hills and valleys at a certain location.

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ADDRESS WANTED

Attempts have been made to return a colour transparency to Mr Ian Somerton, who lived in Moseley, Birmingham, in 1980. It is returned by the Post Office marked 'Gone away'. Anyone able to provide his new address is asked to let the *Weather* office have details.