CYCLONE IN BYRON BAY REGION, NEW SOUTH WALES,
29th DECEMBER 1964

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ABSTRACT

A small but intense cyclone developed between Broadwater (29°00'S, 153°26'E) and Ballina (28°51'S, 153°32'E) on the north coast of New South Wales on the afternoon of 29 December 1964, and moved northeastwards along the coast bringing hurricane force southwest to southeast winds to a strip of country five to six miles wide and about fifteen miles long. Winds which are estimated to have approximated or exceeded 100 miles per hour, brought about the total destruction of many buildings, services, trees and crops in the area, and left others badly damaged.

1. INTRODUCTION

During the afternoon of the 29 December 1964, hurricane force winds accompanied by thunderstorms with heavy rain and hail, devastated many localities in the Ballina - Brunswick Heads section of the north coast (New South Wales). While hail appears to have been a major factor in causing damage in southern parts of the region, in and around the area between Bangalow - Byron Bay and Brunswick Heads, widespread and severe damage resulted from the effects of strong winds on buildings, crops, trees, and power and telephone lines.

About twenty buildings, mainly private residences, were completely destroyed and fifty or more badly damaged. Countless trees were uprooted, snapped off, or completely defoliated and debranched, causing extensive areas to have the appearance of having been subject to a bomb attack.

2. THE AREAS AND LOCALITIES DEVASTATED

The region of severe damage or total destruction appears to have been along a strip five to six miles wide and twelve to fifteen miles long, extending from the vicinity of Bangalow to Brunswick Heads, as shown in the accompanying map, Fig. 1.

Strong to gale force winds were apparently experienced beyond these limits, from reports received from local residents, but as these sections are in most cases only sparsely settled, it is not possible to give details.

(a) Brunswick Heads

This is a closely settled section and at the time of the storm had an influx of five to six hundred holiday makers who were crowded into reserves along the river front.
In this town, the most serious damage was confined to a few buildings and structures, together with trees in the camping area (Plate 1) and along the water front. Campers were the main sufferers here, and it is surprising that although many trees fell in the camping reserves and most tents were blown away, only a few people were seriously injured. The main damage to permanent structures appears to have been the collapse of a shelter shed in the waterfront reserve (Plate 2), the wrecking of roofs by the transport of the top of a Norfolk Island pine tree from this reserve across the terrace (Plate 3), the smashing of a merry-go-round and the bursting of fibro-cement walls of the surf shed on the ocean foreshore. However, prompt action by the local council within a few hours of the storm, resulted in most evidence of damage being obliterated before photographs could be taken.

(b) Tyagarah

This is a sparsely settled centre with residences spaced from a few hundred yards to several miles apart. This centre probably suffered more than any other from the destructive force of the wind, partly because of the open nature of the country and the lack of trees to break the force of the wind, but mainly due to the exposed positions at or near the top of windward slopes favoured by residents when building their homes. Damage here was extensive, and many houses (see Plate 4) and out-buildings were totally destroyed over a strip about five miles wide.

(c) Ewingsdale

This is another sparsely settled centre, most of which lies in a broad open valley on the northern side of a range of hills about 500 feet in height. Although no homes were completely destroyed here, many lost their roofs and a number of out-houses were completely demolished. However, many trees were completely defoliated and debranched, and the local telephone exchange weighing over 4 tons rolled 23 yards uphill (Plate 5).

(d) Bangalow Environs

Apart from the collapse of the grandstand at Bangalow sports ground, damage was very minor in the town itself. However, in higher sections to the north many trees were destroyed and a number of buildings completely demolished, notably at the Methodist Youth Centre (see Plates 6 and 7). In places road traffic was halted for some hours while council employees cut through trees fallen across the roadway (Plate 8).

3. STRUCTURAL TYPES OF DAMAGE

Damage to houses and similar structures could be divided into several types:

(a) Bodily lifting of the structure off its foundations and transport downwind for distances varying from \( \frac{1}{3} \) to \( l \) times the width of the structure. This type of damage appears to have been confined to relatively new buildings and older buildings well away from the coast.

(b) Complete removal of the roof appears to have occurred in cases of the older type of galvanised iron structure, particularly where the roof projected well beyond the walls. Newer types of building with little or no eave section or tiled roofs, usually withstood the full force of the wind. However, in several cases tiles were removed singly or in groups, apparently due to lack of wiring to the bearers underneath.
Heavy black lines indicate boundary of region of extreme winds.
Arrows show mean direction of wind, from the fall of live trees.
Numbered circles show positions at which photographs were taken.

Fig. 1  Locality map showing path of cyclone.


Plate 3. Brunswick Heads. Position 2. Facing West. Decapitated Norfolk Island Pine in the foreshore reserve. The top of this tree caused damage to roof of building on the other side of the street in the background. The tree was approximately 20 inches in diameter where failure occurred.
Plate 4. Tyagarah. Position 3. Facing North-east. Wreckage of house. Standing walls are being supported by water tanks. Note refrigerator [on the left] which was carried about ten yards.


Plate 6. Bangalow. Position 5. Facing South. Wreckage from the main building at the Methodist Youth Centre. The grand piano has been moved about 40 yards from its original position.
Plate 7. Bangalow. Position 5. Facing Northwest. Wreckage from the main building of the Methodist Youth Centre. Note the inverted floor which was carried about 60 yards downwind. The intact building in the background was carried approximately 1.5 times its own length downwind.

Plate 8. Possum Creek. Position 6. Facing Northwest. Fallen trees along the road with tops removed. Note folded failure of trees on the right. The house in the background has been moved about ten feet off its foundations.
(c) Complete destruction of the building. A number of descriptions of the destruction of homes from people inside at the time and inspection of ruins, indicate the following sequence:-

(i) Lifting of linoleum by wind pressure under doors etc.
(ii) Lifting of the building off its foundations with an undulatory movement of the floor. In some cases a violent bumping of the floor against the foundations also was noted. At this stage loosening or breaking of fastenings apparently occurred.
(iii) Removal of the roof, usually bodily. Complete destruction often occurring well downwind, with sheets of galvanised iron being carried several hundred yards or more.
(iv) Collapse of the windward wall inwards.
(v) Collapse of the remaining walls outwards.
(vi) In some cases the removal of all walls downwind, with total destruction.
(vii) Stripping of linoleum from the floor, and sometimes inversion of the floor and its carriage downwind.
(viii) Dispersal of furniture, etc. In some cases even heavy items, such as refrigerators and pianos, were moved many yards, but these may have been carried some distance by the floor before being tipped off (Plate 6).

(d) Small buildings, which were usually of relatively flimsy construction, were often completely disintegrated and the debris carried hundreds of yards. However, in at least one case the structure (a garage) was sufficiently strongly built to be lifted and transported bodily downwind, leaving the car undamaged except for one small dent.
In general, debris from wrecked houses and other buildings was carried in a straight line downwind. In some instances sheets of roofing iron were located distances of a mile or more downwind. In one case, a 6 ft by 3 ft galvanised iron sheet was wrapped around the cross arm of a telegraph post, 30 feet above ground level, at a distance of about half a mile. Linoleum and curtains, for some undetermined reason, were usually shredded into small pieces which in some instances were noted at distances well in excess of a mile downwind. Galvanised iron water tanks which were more than half full of water, usually resisted the wind and were often the only structures left standing. In other cases the walls of collapsing houses pushed water tanks over and these then rolled or were carried considerable distances downwind.

4. DAMAGE TO TREES

Many thousands of trees were destroyed throughout the region during the passage of the hurricane force winds, but live trees showed only a limited number of characteristic destruction patterns, which appeared to be related to such factors as species, height and shape.

Tall trees (say 30 feet in height or taller) if in soft ground were blown over. However, in firm ground tall trees of the native species usually lost most of their branches, while pine trees were often snapped off, usually some distance above the ground (Plate 3).

The influence of the root system in determining the direction of fall of individual trees appears to have been small, as in many areas fallen trees lay parallel to each other with few exceptions, thus indicating the wind direction at the time of fall with some accuracy.
Smaller saplings, up to about 30 feet in height, with most of the foliage at the top of the tree (e.g. eucalypts) were almost invariably broken off at the roots and lay in the direction of the wind at the time.

Among the smaller trees (20 to 30 feet in height), several species common in the region have a single trunk with branches and foliage so disposed as to give an overall spherical, cylindrical or conical appearance, with the lowest branches relatively close to the ground. When trees of these shapes were subject to very strong winds, the branches were parted vertically on the windward side, and folded back to the leaside. In some species the wood is brittle, having a low tensile strength, and in these cases branches were broken off near the trunk leaving a stump perhaps 6 to 12 feet in height. In other species, such as the cypress, breakage of branches rarely occurred, but the trunk of the tree frequently split to ground level and opened out on the windward side. In cases where splitting of the trunk was resisted, branches did not tend to spring back to their original position, suggesting the wood had failed due to shear stresses. While small-leafed trees tended to retain their leaves after passage of the strong wind, large-leafed trees were practically denuded of foliage.

For trees of the same species, it would appear that failure would occur at about the same wind speed independently of size, provided the shape is the same, thus some estimate of the distribution of very strong winds during the storm can be made.

In addition, the fact that similar tree damage due to past storms exists in this and other regions, suggests that this type of damage could be used as an index to the spatial pattern of strong winds.

5. DAMAGE TO POWER AND TELEPHONE LINES

Spans between telegraph and power line poles were completely denuded of wires over considerable distances in most sections. There is little doubt that many breakages of wires were due to flying debris of various sorts, but in some instances failure can only be explained on the basis of wind pressure.

Although in firm soil, many power and telephone poles were left at angles of up to $30^\circ$ to the vertical. It must be assumed, however, that the lean of the poles resulted from the effect of wind both on the wires before failure and the poles.

It is understood that several poles were snapped off near the surface, but it appears that in these particular cases the poles were old and partly rotted away.

6. THE GENERAL WIND PATTERN AND TYPE OF STORM

Several newspapers report, and many local residents stoutly maintain, that the damage was caused by one or more tornadoes which passed over the region. However, the evidence available, apart from one rumour of a cloud like an elephant's trunk being seen out to sea off Brunswick Heads, does not support this theory. While the possibility of waterspouts out to sea is not excluded, the following evidence does not suggest tornadoes over the land.

(a) Appearance of the Storm

The first suggestion of the likelihood of storms in the affected region was the appearance of a line of thunderclouds (Cumulonimbus), lying from east to west, to the south soon after midday. As these moved northwards towards the region, frequent and intense lightning flashes were observed and thunder became audible.

Many people took cover as these storms approached while others ignored them until they struck, consequently many descriptions of the storms tend to be sketchy. However, a number of good eyewitness reports were received. In general, as the storms approached, they were seen to be enormous thunderstorms showing black underneath and "boiling" above.
Edges of the clouds, and in some cases the bottom parts, showed a vivid green colouration. Intense lightning accompanied by thunder was noticed by most people, and as the cloud passed overhead bursts of hail or heavy rain were received. These varied considerably in amount and intensity over short distances, but hailstones appear to have been up to 1 ½ to 2 inches in diameter. With the passing of the leading edge of the cloud, a loud noise like a train or a number of semi-trailers was heard and most people realised a strong wind was arriving and attempted rather belatedly to take precautionary measures or reach cover. At least one resident in trying to reach his house had to crawl on hands and knees. Of the many descriptions received, none described the characteristic appearance of a tornado, although several described line squalls adequately.

(b) Wind Changes

Depending on the distance from the coast and thus the presence or absence of the sea breeze, the wind changes noted with the arrival of the storm were from northeast to northwest, changing to southwest to southeast as the storm passed over. Winds with a northerly component, became fresh to strong just prior to the change to hurricane force, southwest to southeast.

(c) Orientation of Debris

Debris from buildings in all cases was carried in straight narrow paths downwind and compass bearings taken on these indicate a southwesterly wind direction. These directions are included among the wind arrows shown in Fig. 1.

(d) Orientation of Fallen Dead Trees

Attention to the orientation of fallen dead trees is probably responsible, in part at least, for reports of tornadoes. Firstly, it appears that many trees which were victims of earlier storms and long dead, had been assumed to have been blown over in this storm. Secondly, many trees which had died following earlier storms, remained standing although the roots had rotted away; these needed only the moderate to strong northerlies in advance of the storm to cause them to fall over. In addition, some observers no doubt tended to orientate themselves by the road which changes direction frequently. Consequently, many claims are made that trees fell from the south in one section and the north in another, indicating a tornado. This could not be substantiated by personal observations taken using a compass to obtain the direction of fall of live trees. Although a search was made for indications of torsional failure of trees which might be expected with the occurrence of a tornado, no indication of this type of damage could be found.

(e) Wind Direction and Force from Live Trees

In the discussion in Section 4 it was suggested that damage to trees could give an indication of wind direction and the extent of destructive winds over the region.

A considerable number of field observations using a compass to obtain directions, were made on fallen live or dying trees, and further data of the same nature were obtained from aerial photographs. These were plotted on a map of the region, giving the resultant wind direction distribution shown in Fig. 1.

It was found that trees destroyed by folding of branches to the leaside were also conspicuous on aerial photographs, where they showed a typical star or asterisk shaped detail. These were probably the more conspicuous since the aerial photographs were taken more than three weeks after the storm and damaged trees were dying and dying out.

The full black lines on Fig. 1, indicate the limits of this type of damage.
(f) Previous Storms

Aerial photographs taken at 1500 feet and 6000 feet along a strip between Brunswick Heads and Tyagarah, showed a wealth of detail from which the path of debris could be traced and the destructive influence of strong winds in the more remote forest areas clearly seen. However, close examination showed that all the forest damage was not due to this particular storm. From the records of a local resident it was found that the last visitation occurred on 11 February 1962 and an earlier one was experienced in June 1948.

Surface observations also led to this view, as a number of long-dead trees showing both the folding and falling in the wind direction characteristics while alive, were noted. Consideration of the weathering of these, however, suggested a date prior to 1962.

From the above and consideration of Fig. 1, it is seen that very strong winds from a direction between southeast and southwest, caused damage over a path about six miles wide between Bangalow and a position east of Brunswick Heads (about 15 miles).

7. ESTIMATES OF WIND SPEED

Estimates of wind speed could be made in several cases by analysis of the effect of wind on damaged buildings and the behaviour of certain pieces of debris. Three cases were noted at rather widely separated places as follows.

(a) Tyagarah

Two sheets of galvanised roofing iron, each originally 6 ft by 3 ft, were found in the vicinity of this centre. In one case the sheet had been wrapped around the cross arm of a power line pole and in the other around the branch of a tree. A comparable case to these occurred in the Smithtown Tornado in August 1964 (Carr 1965) and the Aeronautical Laboratory, Fishermens Bend, Melbourne, estimated that a minimum wind speed of 102 miles per hour would be required to produce the observed deformation of the iron. It appears reasonable to assume that in the present cases a wind speed of the order of 100 miles per hour was also attained.

(b) Ewingsdale

Although the Country Telephone Exchange at Ewingsdale with its contents weighed over four tons, it was lifted off its foundations and rolled 23 yards uphill, coming to rest in the inverted position shown in Plate 5.

Details of the dimensions and weight of this building, together with details of the distribution and weight of items of equipment in the building, were obtained from the Country Exchange Section of the Postmaster General's Department. Given these details the Aeronautical Laboratory of the Department of Supply was able to derive an estimate of the minimum windspeed necessary to overturn the building.

At the time of overturning of the building, the sum of the moments of the wind pressures on various parts of the building (e.g. roof and walls) about its rear lower edge would equal the sum of the moments of the weights of the building and its contents about the same axis.

The wind pressures on various parts of the building, assuming the direction of the wind is at right angles to the building, can be computed from the equation,

\[ P = \frac{1}{2} C_p \rho v^2 \]
where \( P \) = wind pressure in lbs/square foot
\( C_p \) = pressure coefficient
\( \rho \) = standard air density (0.002378 slugs/cubic foot)
\( v \) = wind velocity in feet/second.

Appropriate values of \( C_p \) are

- Windward wall +0.9
- leeward wall -0.5
- windward roof -0.6
- leeward roof -0.5

The dead load moment of the building and its contents about the lower rear corner was found to be 20 ton feet.

From these data and allowing for wind pressure variations over the windward side of the building, the wind speed was found to be between 190 and 200 feet/second, i.e. about 130 miles per hour.

(c) Bangalow

Windows on the rear of a building at the Methodist Youth Centre which faced into the wind, were found to have burst inwards under wind pressure. These windows were made up of four sheets of glass, 22 inches long and 13 inches wide. From the thickness of samples of this glass, the glazing size was identified as the trade size 16/18 ounce.

Glazing sizes adopted by the Standards Association of Australia indicate that a sheet of glass of this size and thickness would safely stand the pressure due to a wind speed of 90 m.p.h. but would fail before the wind speed reached 110 m.p.h. This suggests an average windspeed of the order of 100 m.p.h. over a short period.

However, as it was impossible to determine whether the roof was damaged before or after breakage of the windows, it is not certain that reduction of pressure in the building was not a factor in failure of the glass. Under these circumstances it can only be said that the windspeed could have reached a maximum value in excess of 100 m.p.h., allowing for the position of windows on the windward side.

8. COMMENT ON THE COMPUTED WIND SPEEDS

In view of differences of exposure, and changes in wind speed with space and time, the values derived in the previous section can be taken to be in good agreement. However, it should be noted that the computed speeds are averages over perhaps 15 to 30 seconds, consequently the highest gusts could exceed the computed speeds by a substantial margin.

This suggests that most of the area between the full black lines shown in Fig. 1 experienced extreme gusts of the order of 100 miles per hour, and damage to trees by folding of branches back to the lea side occurs with gusts approaching this speed.
9. RAINFALL

As no pluviographs exist in the affected region, it is not possible to obtain definite information regarding the temporal pattern of rainfall. From accounts given by residents it appears that most of the rain fell at the time of the storm, but light rain or drizzle of a showery type persisted during most of the night at many places with southerly winds.

Totals to 9 a.m. on the following day (30 December) ranged from 20 points to 150 points over the region, most of which fell in about 20 minutes at the time of the storm. However, since hail was also received in most cases, an increase of up to 25 per cent on these figures would probably be a reasonable estimate. In many cases rain thoroughly saturated damaged buildings and their exposed contents, ruining many household items which could otherwise have been reclaimed.

10. SYNOPTIC SITUATION

At 9 a.m. on 29 December 1964, several small closed depressions were in evidence in a trough orientated NW/SE across the north coast of New South Wales (see Fig. 2). Central pressures of a pair of them appear to have been somewhat less than 1010 millibars at 9 a.m.

During the day the small depression just inland of the north coast intensified and moved northeasterwards, crossing the coast between Broadwater and Ballina between 2.30 and 3 p.m. Here the low pressure rapidly intensified and developed into a small cyclone with a central pressure below 998 millibars, and continued to move in a northeasterly direction along the coast. (The position of this system at 3 p.m. is shown on Fig. 3.)

The 200 millibar analysis for 9 a.m. on 29 December is shown in Fig. 4. Here it is noticed that an upper troposphere trough existed over the north coast of New South Wales and an isotach maximum was located over southeastern Australia. In the following 24 hours a closed low pressure developed in the upper trough as it moved eastward and at the same time the isotach maximum moved northeast over the north coast of New South Wales to a location to the north of this low pressure centre.

Under these circumstances it appears that the diffuent flow pattern at high levels, with decreasing speed downstream from the jet maximum shown in Fig. 4, was substantially divergent at the time it moved over the north coast of New South Wales.

The development of the small cyclone thus appears to have been associated with high level divergence on the right exit of the jet maximum as it approached and crossed the coast. Under these circumstances southwest to southeast gradient winds of over 100 miles per hour appear quite possible. In the thunderstorm conditions experienced, mixing and accelerating downdrafts could then produce surface winds of the magnitude indicated by the damage.

11. CONCLUSIONS

(i) A small closed depression, originating southwest of Coff's Harbour and moving northeasterwards, intensified into a small cyclone as it crossed the coast between Broadwater and Ballina during the afternoon of 28 December 1964.

(ii) As the cyclone moved northeast along the coast, neighbouring coastal land sections were subject to the southwest to southeast winds associated with the cyclone. These approached or exceeded 100 miles per hour over an area between Bangalow and Brunswick Heads.

(iii) The widespread nature of the damage caused by the disturbance and the absence of evidence of circulatory winds over small areas, eliminates the possibility of one or more tornadoes.
Fig. 2  Surface analysis for 0900 EST 29 December 1964.

Fig. 3  Surface analysis for 1500 EST 29 December 1964.

Fig. 4  200 millibar analysis for 0900 EST 29 December 1964.
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REFERENCE