Fire Management Branch
Department of Conservation & Environment

A FIRE TORNADO IN THE SUNSET COUNTRY JANUARY 1981

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Ackowledgements: The photograph shown in Figure 3 was taken by I. Brilliant. The contributions of P Novotny and C Reisinger are also acknowledged.

SUMMARY

A fire tornado which occurred in a major fire in the Sunset Country during the 1980/81 fire season is described. The tornado travelled a distance of one kilometre and caused damage to vegetation on a swathe up to 50 m wide. The meteorological conditions present at the time of formation are discussed.

INTRODUCTION

Whirlwinds often occur during fires, both as fire whirls originating in or near the flame front or as dust whirls over the burnt area after the fire has passed. Occasionally, under severe conditions, a fire whirl will develop sufficient intensity to warrant the term fire tornado. In these instances the hot gases rising above the fire form a vortex which may develop wind speeds in excess of 140 km/hr (Morton, 1970). Therefore although they are usually short-lived, some fire tornadoes can be quite destructive, pose a threat to the safety of suppression crews and cause additional control problems because of increased spotting activity.

During fires in the Sunset Country and Big Desert in December 1980 and January 1981, several fire tornadoes were observed by suppression crews. This report discusses the circumstances under which one such tornado occurred during the Sunset Country fire.

DESCRIPTION

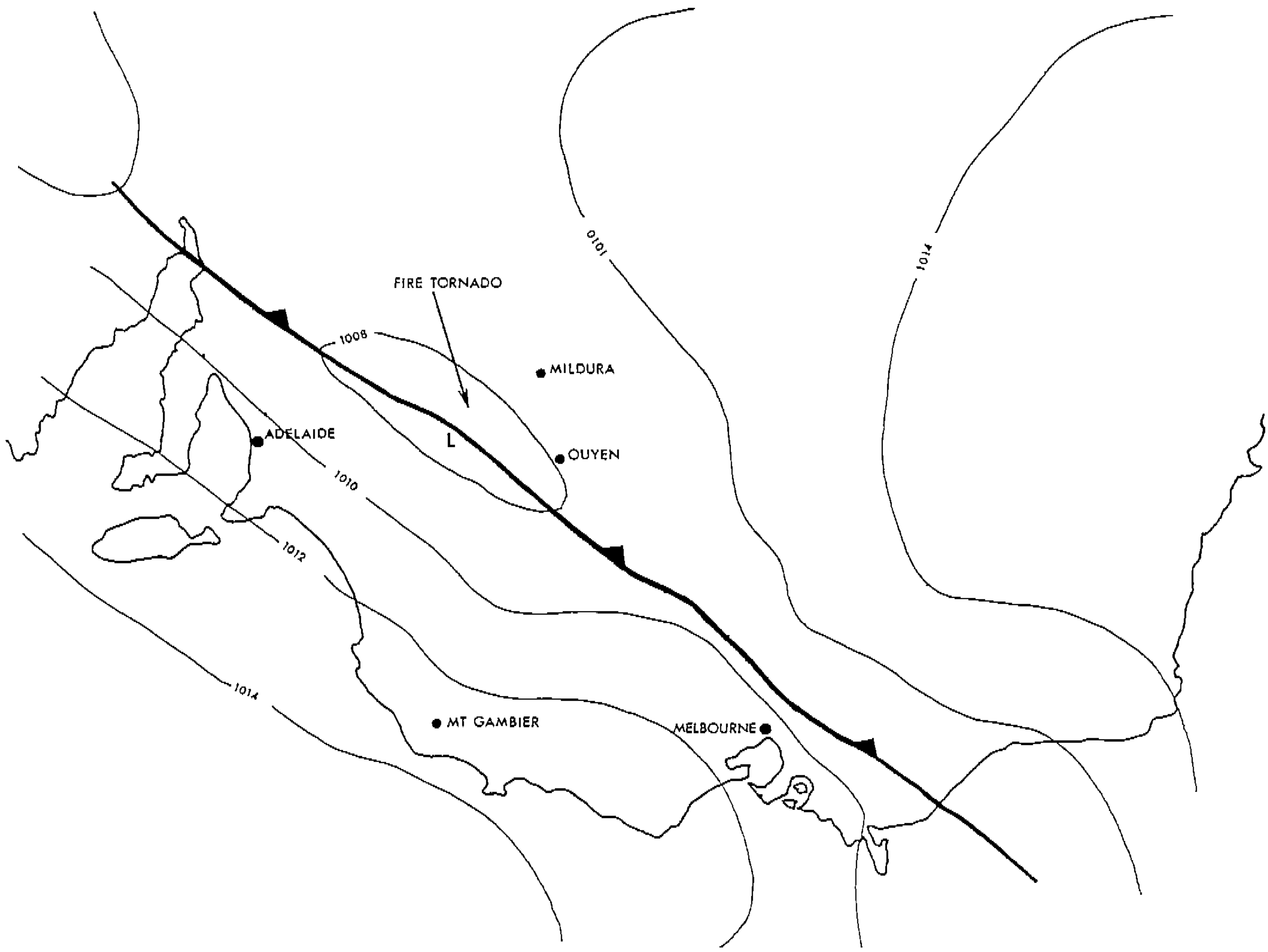
The fire started from a lightning strike on 28 December and eventually burnt 119 000 hectares in a period of 9 days. On 1 January the fire area was 16 000 hectares and about midday a number of spot fires started outside the southern control line. The Fire Danger Index (FDI) (McArthur, 1967) was close to 45 and the spot fires quickly consolidated and spread on a broad front to the south-east. A strong convection column developed and the fire spread 8 km and burnt more than 2 500 hectares in the 3 to 4 hours before the wind changed to the south between 1500 and 1600 hours. The fire spread 8 km back to the control line before 2000 hours.

The vegetation in this area was dominated by mallee eucalypts up to 6 m tall on sand ridges and 7-8 m tall on the interdune flats. The

TABLE 1: WEATHER CONDITIONS - WALPEUP - 1/1/1981

	TIME	AIR TEMP (°C)	RH (%)	WIND SPEED AT 10 m (km/hr)	WIND DIRECTION	FDI
	1500	43	12	16	NW	44
	1600	41	14	17	W	38
Pre-frontal	1700	39	16	18	NW	34
	1800	40	15	12	NNW	32
	1900	40	15	14	N	34
Frontal Passage	2000	36	20	8	S	23
	2100	35	22	24	S	29
	2200	31	30	28	SSE	21
Post-frontal	2300	28	35	24	SE	15

FIGURE 1 SYNOPTIC CHART — 1500 HOURS 1-1-81



major species were green mallee *(Eucalyptus viridis)*, yellow mallee *(E. incrassata)* and oil mallee *(E. oleosa)*. Porcupine grass *(Triodia irritans)* was abundant throughout the area and, together with litter accumulations of 10-12 t/ha occurring under clumps of mallee, was the major fuel component.

An indication of the conditions in the fire area is given by the data shown in Table 1 and obtained from the Department of Agriculture's Mallee Research Station at Walpeup, 70 km east of the fire and 30 km west of Ouyen. Because the front was lying on a NW/SE line (Fig. 1) and slow moving, there was a phase difference in weather conditions of approximately four hours between Walpeup and the fire area.

The fire tornado is thought to have originated near the head of the fire at about the time the cold front passed through the area and it is possible the additional turbulence caused by the passage of the front was responsible for triggering its formation. The wind direction changed from the north-west to the south and as the tornado moved in a northerly direction its strength gradually increased. Near the control line it cut a swathe 50-60 m wide (Fig. 2 and 3) in which trees were torn from the ground or snapped off and the smaller shrubs and leaf litter removed from the site. Its strength quickly diminished after crossing the control line and it finished approximately 1 km from the origin.

DISCUSSION

King (1964) describes a fire tornado in the Dandenongs which had a horizontal air speed of 140 km/hr approximately 20 m from the axis and 60-150 m above ground, and a vertical air speed in the core up to 330 km/hr. Despite these characteristics the wind conditions near ground were not severe enough to cause damage to trees.

FIGURE 2 TORNADO PATH—AERIAL VIEW

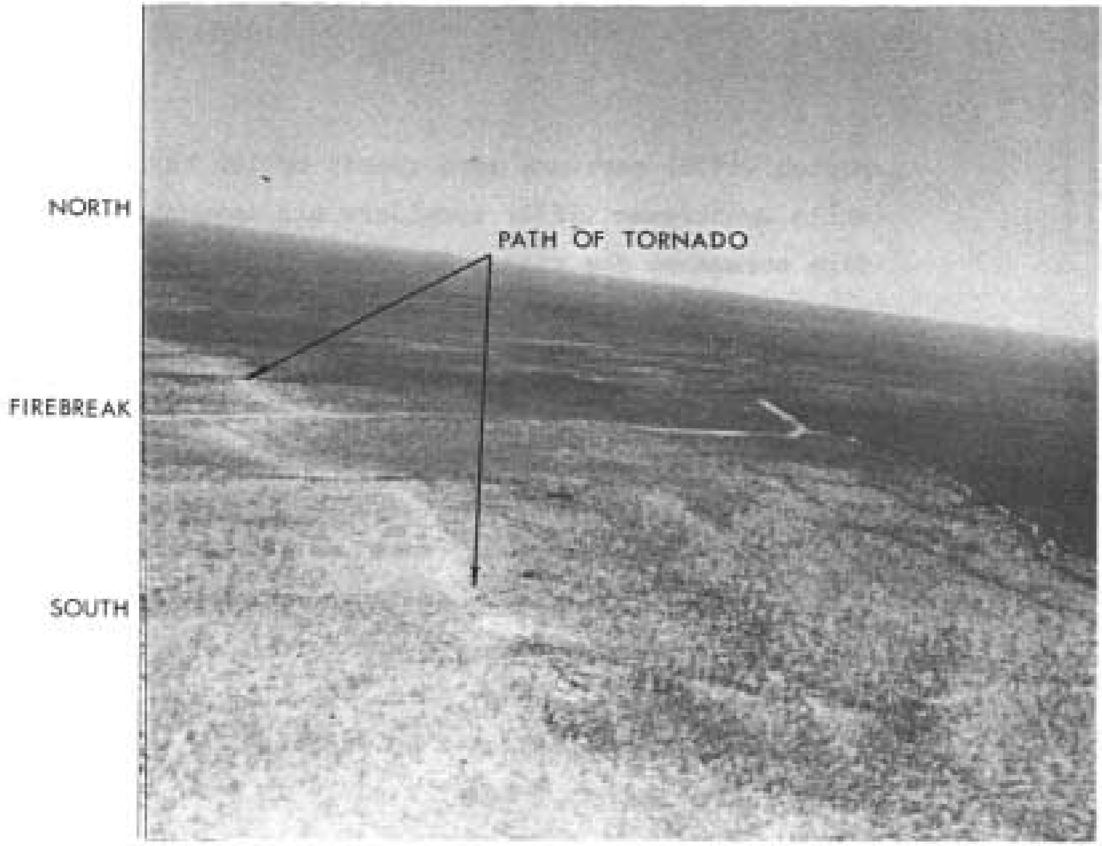


FIGURE 3 TORNADO PATH—LOOKING NORTH FROM FIREBREAK

Morton (1970) mentions wind speeds of 180 km/hr at ground level while Countryman (1971) considers air speeds in large and intense fire tornadoes may exceed 480 km/hr. Considering the damage caused by this tornado, air speeds much greater than described by King are likely to have occurred. In addition, it was much more persistent than the transient and relatively stationary phenomenon described by King. I Brilliant (pers. comm.) observed from a very long distance a second fire tornado in the Sunset Country on the same day and considers it lasted for at least 5-10 minutes. Graham (1955) indicates that large tornadoes of this type can in fact exist for more than one hour.

The fire intensity adjacent to the path of the tornado was much higher than in nearby burnt areas. In laboratory studies Byram and Martin (1970) found burning rates in woody fuels to be 2 to 5 times the normal rate and Countryman (1971) mentions that the burning rates of liquid fuels in artificially created fire whirls in the laboratory can be 5-6 times the rate in still air, and that the increased burning rate in woody fuels is also likely to be substantial. In fact, the increased burning rate and higher fire intensity may in turn mean more favourable conditions for further whirlwind development.

Morton (1970) considers that large fire tornadoes form only under conditions of strong insolation when ground temperatures are unusually high and the lower atmosphere is unstable. Haines and Updike (1971) discussed optimal conditions for fire whirl development on level terrain, and considered the following factors to be important.

1 A fire of sufficient area and size to produce the heat source necessary to form vortices.

2 A neutral to unstable atmosphere with either:-

FIGURE 4 TEMPERATURE PROFILES LAVERTON 0900 HOURS 1-1-81

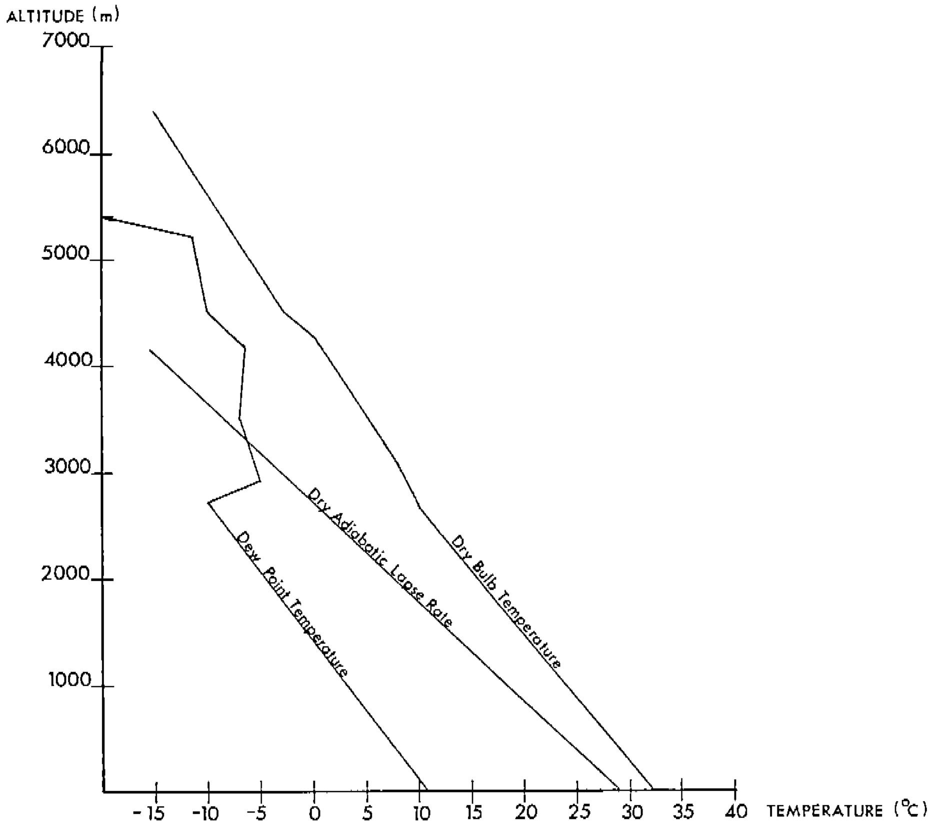
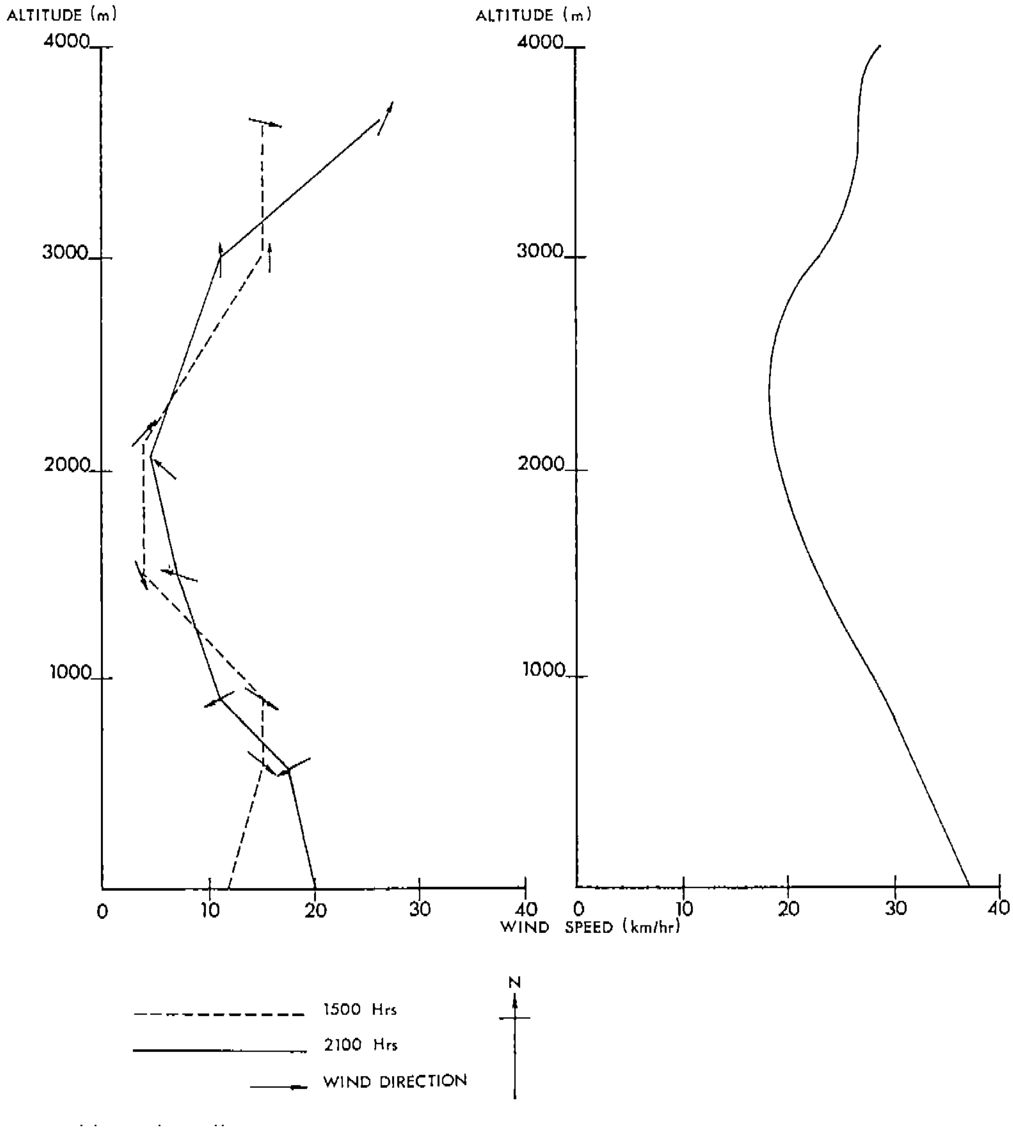


FIGURE 5(A) WIND PROFILES MILDURA 1-1-81

FIGURE 5(B) TYPE 1(A) PROFILE



(i) a superadiabatic lapse rate in the atmospheric layer extending from the surface to a height of 90-120 m, with a lapse rate near the dry adiabatic for 600 m - 1500 m above, or

(ii) a deeper lower layer with a superadiabatic or a dry adiabatic lapse rate.

3 Little or no wind.

4 Clear skies and therefore the potential for strong surface heating.

Even though there are no data indicating the minimum fire intensity and area required to produce vortices the behaviour described earlier indicates this would not have been a limiting factor here. Assuming a mean rate of forward spread of 3 km/hr and a fuel load of 10 t/ha the intensity would have been of the order of 15 000 kw/m of flame front.

The only data available to determine atmospheric stability come from Laverton and a simplified representation of the 0900 hours information is given in Figure 4. The separation of the plots of T (dry bulb temperature) and T_D (dew point temperature) indicates the atmosphere was dry with an environmental lapse rate of approximately 8^{o}C per 1000 m up to 2700 m. Comparison with the dry adiabatic lapse rate (DALR) of 10^{o}C per 1000 m shows this layer to be stable although close to the DALR as required earlier. In the fire region a superadiabatic lapse rate existed near the surface later in the day, as a result of the high temperatures shown in Table 1 and the capacity for intense surface heating caused by sparse vegetation cover and extensive areas of exposed ground.

The data available from Walpeup (Table 1) indicate that wind speeds were probably quite low at the time of tornado formation. However, a factor not discussed by Haines and Updike, but previously considered by Byram (1954) to have an important influence on fire behaviour is the atmospheric wind profile. The profiles obtained from Mildura for 1500 and 2100 hours are shown in Figure 5 (a) and the Type 1 (a) described by Byram in Figure 5 (b). Byram considered the Type 1 (a) profile to be associated with fires where a massive convection column can form and fire behaviour become very erratic on level terrain. Although the absolute wind speeds in both the 1500 and 2100 hour profiles are less than in the Type 1 (a), both exhibit the same decrease in wind speed with increasing altitude for a part of their profile. This is likely to have been important in allowing convection and the subsequent erratic fire behaviour.

CONCLUSION

Large fire tornadoes of the type described occur infrequently. When they do occur they can cause extensive damage and dramatic changes to fire behaviour, including very intense spot fire development, and therefore constitute a significant threat to the safety of fire crews.

Fire tornadoes are most likely to occur when there is a very high intensity fire burning in atmosphere which is unstable, particularly close to the ground. Light winds which cause little atmospheric mixing and clear skies leading to strong surface heating are factors which can help create this instability near ground level. Tornado formation may be triggered by a sudden increase in turbulence created by for example the passage of a cold front or some abrupt change in topography.

ACKNOWLEDGEMENTS

The photograph shown in Figure 3 was taken by I Brilliant. The contributions of P Novotny and C Reisinger are also acknowledged.

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