

SOME ASPECTS OF THE BEHAVIOUR  
OF THE CAROLINE FIRE OF  
FEBRUARY 1979

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## INTRODUCTION

On Friday 2 February 1979, under conditions of extreme fire danger, three fires started in the Mt Gambier region of South Australia. Two fires were controlled while still in grassland and at relatively small areas. However, the third fire, which originated near Caroline (see Map 1) spread quickly into softwood plantation east of the origin, and before it was controlled early the following day burnt over a distance of 27 km and an area of 7 668 hectares. This area included approximately 3 334 hectares of softwood plantation, most of which was in South Australia, and 4 170 hectares of native forest, most of which was in the Lower Glenelg National Park, Victoria.

This report describes the progress of the fire and discusses the behaviour of the fire in relation to the existing fuel and weather conditions. The emphasis is on fire behaviour in the softwood plantations.

Much of the meteorological information presented was obtained from the Mt Gambier station of the Commonwealth Bureau of Meteorology situated approximately 22 km north/north-west of the fire origin. Other details were provided by people involved in the suppression operation, from photographs taken during and after the fire, and from personal observations in the fire area both during and after the fire.

## DESCRIPTION OF FIRE AREA

The Glenelg River gorge divides the area of the fire into two land systems. In South Australia the topography is dominated by low parallel sand ridges, running mainly north-west to south-east, overlying a limestone base. Extensive softwood plantations of radiata pine (*Pinus radiata*) and maritime pine (*P. pinaster*) have been established in this region, with some large blocks of native eucalypts forest retained within the plantation areas.

On the Victorian side the topography lacks any distinct pattern of sand ridges and is generally flatter than in South Australia. The native vegetation is dominated by brown stringybark (*Eucalyptus baxteri*) forest with a heath understorey.

## DEFINITION OF TERMS

Van Wagner (1976) recognised three types of crown fire in conifer forests. A clear understanding of the term crown fire is relevant to the description of fire behaviour in this report, and the types recognised by Van Wagner are defined below.

- 1 Passive crown fire - the crown phase of the fire is dependent on the surface phase, the spread rate of which will control the spread of the whole fire.
- 2 Active crown fire - the crown phase and the surface phase will travel together with both contributing significantly to the spread rate.
- 3 Independent crown fire - the crown phase is able to spread independently of the surface fire, although the factors which support an independent crown fire are such that it is unlikely to be sustained over long periods.

## FIRE WEATHER CONDITIONS

The weather conditions at Mt Gambier (see Appendix 1) at 1200 hours included a temperature of 38°C, relative humidity of 16 per cent and a wind velocity averaging 46 km per hour, with gusts to 69 km per hour, from the west/north-west.

The Fire Danger Index (FDI) (McArthur, 1967) remained in the extreme range from 1100 hours until just after 1630 hours.

At 0830 hours the lower atmosphere was conditionally unstable with an overnight surface inversion expected to disappear by mid-morning.

A direct measure of the moisture content of fine fuels within the fire area during the afternoon is not available. However, as for most of the day the temperature was above 35°C and the relative humidity less than 16 per cent, the moisture content (as a percentage of oven-dried weight) of the fine fuels was probably less than 5 per cent. Samples taken under radiata pine

indicated a moisture content close to 10 per cent at 2100 hours and 12 per cent at 2200 hours.

## FIRE BEHAVIOUR - NARRATIVE

The following narrative describes the fire development by time periods and concentrates on the spread of the head fire. All times given in this report are Central Standard Time (CST).

### 1208-1350 hours

The fire was detected at 1208 hours. It originated near an old windrow of pine slash in grassland 200-300 metres north-west of compartment 164 in the Caroline Forest (see Map 1).

During this period the fire covered a distance of approximately 8 km with an average rate of forward spread of 4.8 km per hour. Most of the stands burnt were aged sixteen years or less, and were unpruned and unthinned. The high spread rate occurred despite the presence of significant fire breaks, some up to 100 metres wide, in the path of the head fire.

A report of smoke independent of the main fire indicated a spot fire approximately one kilometre ahead of the main front.

### 1350-1430 hours

The weather conditions remained similar to those shown previously. Another spot fire started approximately 500 metres ahead although it was quickly joined by the main fire which during this period had a rate of forward spread of approximately 3.0 km per hour. Stands burnt were aged ten years. At 1430 hours the fire had reached the edge of a block of native forest included within the plantation.

1430-1500 hours

The FDI remained in the low 60's and the spread rate in the eucalypt forest averaged 3.0 km per hour.

Extensive short distance spotting from the eucalypt forest allowed the fire to cross the wide firebreak bordering the eastern edge and commence burning in the eight-year-old pine stands east of the break.

1500-1540 hours

During this period the head fire burnt through predominantly eight-year-old stands with an average rate of forward spread of 2.9 km per hour, which was a significant reduction in spread rate from the first period even though the FDI remained at much the same level.

1540-1555 hours

At 1540 hours the head fire reached the eastern edge of the South Australian plantation area and moved into grassland with scattered eucalypts. The spread rate increased in this open country to average approximately 5.3 km per hour. By 1555 hours the fire had spread into a belt of open brown stringybark forest adjoining compartments 059 and 060 of the Rennick Plantation in Victoria.

1555-1610 hours

Short distance spotting from the eucalypt forest soon established the fire in the thirteen year old radiata and maritime pine stands in compartments 059 and 060. A heavy concentration of fuel in a recently thinned section of compartment 060 caused very severe fire behaviour. In this short period the apparent spread rate was 5.0 km per hour, due mainly to a mass fire effect generated by spotting from the fire in eucalypt forest close to the border.

At 1610 hours the fire had reached the Glenelg River and spot fires were reported across the river in the Lower Glenelg National Park.

1610-0230 hours

When the wind changed sometime after 1630 hours the fire south of the Glenelg River in the National Park moved away to the east/south-east on a broad front. The strong gusty winds that had persisted all afternoon began to die away and by 1830 hours the wind had changed to a light breeze from the north-west pushing the fire in the Park towards the town of Nelson. Although the FDI now indicated moderate fire danger, heavy fuel accumulations in the open brown stringybark forest permitted the fire to continue burning with a high intensity. The rate of forward spread for much of this period was between 1.0 and 1.5 km per hour.

0230-0430 hours

Around 0230 hours the wind strength increased as a cold front moved through the fire area, and the spread rate increased to average 2.7 km per hour over the period 0230-0330 hours with significant short distance spotting occurring.

By 0330 hours the fire front had moved back onto the Glenelg River but light rain associated with the change prevented spot fires from starting across the river. Steady rain at 0430 hours checked the fire spread on all edges.

## FIRE BEHAVIOUR - DISCUSSION

This section discusses in more detail the fire behaviour experienced in the softwood plantation areas.

### 1 Fuel properties and fire behaviour

In the fire area, 9-10 year old stands of radiata and maritime pine were at the stage of canopy closure. In unthinned stands aged 9 years and older there was therefore a relatively continuous fuel distribution within the tree crown level. Unthinned intermediate aged stands (9-18 years) formed

the majority of the plantation area burnt, and the behaviour of the main head fire in these areas was characterised by a high spread rate (up to 5 km per hour) in conjunction with an active crown fire with flame heights on occasion estimated to exceed 40 metres. In younger stands incomplete canopy closure appeared to contribute to the lower spread rate of 3 km per hour as the FDI remained at similar levels.

The importance of changed fuel distribution associated with increased stand age is well illustrated by a comparison of fire behaviour in compartments 314 and 57b in the Caroline forest. Fire in the 1968 radiata pine of compartment 314 was very intense, with full crown fire development. Despite this, when the fire crossed into compartment 57b, 1954 radiata pine, it became much lower in intensity and in many places there were unburnt branches within one metre of the ground.

A recently thinned section of intermediate age radiata pine, in compartment 060 Rennick Plantation, was burnt during the passage of the main head fire at about 1600 hours. A fire storm with flame heights greater than 50 metres was reported. Slash fuels within the 20 hectare area, which was thinned in late 1970, obviously contributed significantly to the increased fire intensity. Similarly, thinned stands of 1960 radiata pine south of Carba (Map 1) burnt by the northern flank fire were more severely damaged than neighbouring unthinned stands. In general it seems that thinned stands, which retain heavy ground fuel accumulations, constitute at least as great a hazard as unthinned stands of the same age despite the gaps in crown fuel distribution caused by thinning.

The benefit of pruning, at least under moderate fire danger conditions, was also illustrated during this fire. At 2200 hours the fire in pruned radiata pine (compartment 059, Rennick Plantation) was burning with a flame height of 20-30 cm and a spread rate of approximately 25 metres per hour. In unpruned sections passive crown fire was occurring with spread rates up to 150 metres per hour. Similarly, at 2230 hours the fire burning in unthinned/unpruned radiata pine south of Carba was fluctuating between a relatively slow moving ground fire with flame heights of 5-8 metres, and a crown fire of 15-20 metres.

## 2 Spotting characteristics

At least two spot fires are thought to have started a significant distance ahead of the main fire in the softwood plantation. The first occurred in compartment 377 approximately one kilometre ahead of the main front then burning in compartment 111. This spot fire spread less than 500 metres before being enveloped by the main fire. The second spot fire occurred in compartment 355, approximately 500 metres ahead of the main fire and spread approximately 100 metres before being overrun by the main fire. Other evidence of spotting from the plantation area was found in the fuel reduced eucalypt forest north of Honeysuckle Flat, where one spot fire was started 600 metres from the main fire.

Very short distance spotting is likely to have been a major factor contributing to the fire crossing the many substantial firebreaks throughout the plantation area. In the Rennick plantation, spotting from the firestorm in compartment 060 was probably responsible for establishing the fire across the Glenelg River in many places.

## 3 The pattern of fire spread

Throughout most of its spread within the plantation area, the behaviour of the fire was characterised by periodic changes in the level of fire intensity. These changes showed up as wide bands burnt by very intense crown fire, with all foliage being removed, and much narrower bands where the foliage was only scorched.

Such behaviour appears to be particularly noticeable in very high intensity fires occurring in relatively uniform fuel distributions, and where topography does not have a great influence on fire spread.

Cheney N P (pers. comm.) considers that this behaviour is probably associated with changes in the strength of convective activity over the fire and that the following sequence of events may be responsible for the observed behaviour :

- (a) Convective activity increases as the fire spreads more rapidly



- (b) The convection column eventually dominates the wind field near the fire and air movement becomes inwards to the base of the column from all directions.
- (c) Without any strong directional wind influence the fire becomes relatively slow spreading, although a very rapid and intense burn out of fuels continues over most of the fire area.
- (d) After burn out the convective activity lessens and the external wind field again exerts an influence on fire spread.

In the Caroline fire this complete cycle must have been occurring over fairly short intervals. For example, in some areas the length of the intensively burnt sections were up to 400 metres. At a spread rate of 5 km per hour the cycle would therefore be occurring, on average, at approximately 5 minute intervals.

#### 4 A comparison with two other plantation fires

The Wandilo fire of 1958 (McArthur, et al, 1966) and the Longford fire of 1962 (McArthur, 1965) burnt in topography very similar to that described earlier. At Wandilo, 23 and 24 year old radiata and maritime pine stands were burnt, while at Longford, intermediate aged unthinned stands of both radiata and maritime pine were burnt.

As would be expected from a comparison of FDIs, Table 1 shows the average spread rates experienced during the Caroline fire were generally much higher than during the other two fires.

Table 1 - Fire behaviour comparisons

	Caroline	Wandilo	Longford
Maximum FDI	64	33	29
Rates of spread (m/hr)	3000-5000	1200-1600	600-800
Spotting distance (m)	Up to 1000	400-600 (2000 after fire storm)	Up to 300

## REFERENCES

- McArthur A G (1965) Fire behaviour characteristics of the Longford fire.  
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- Van Wagner C E (1976) Conditions for the start and spread of crown fire.  
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Appendix 1.

METEOROLOGICAL STATISTICS - MOUNT GAMBIER, FEBRUARY 2, 3, 1979

TIME (CST)	TEMP (°C)	RH (%)	WIND SPEED (Kph)		DIRECTION (Deg)	FIRE DANGER	
			Mean	Max.		INDEX	CLASS <sup>N</sup> .
0900	35	15	33	46	340	44	VH
1000	38	15	30	57	300	46	VH
1100	39	14	39	70	300	59	X
1200	38	16	46	69	280	64	X
1300	38	16	43	72	290	60	X
1400	38	16	44	69	290	61	X
1500	37	17	46	69	270	60	X
1600	37	17	43	67	290	57	X
1700	36	17	35	50	270	46	VH
1800	35	20	19	33	290	27	VH
Trough							
1900	32	24	6	17	320	15	H
2000	27	39	Calm			7	M
2100	25	47	Calm			5	L/M
2200	26	42	6	9	320	7	M
2300	25	47	Calm			5	L/M
First front							
2400	23	61	19	35	270	5	L/M
0100	20	83	9	35	270	2	L
0200	19	83	9	17	250	2	L
Second front							
0300	18	88	33	52	270	3	L
0400	18	88	28	43	270	2	L
0500	16	94	28	54	270	1	L

