

Jim Gould
Bushfire Research



72

THE CAROLINE FOREST FIRE
2nd FEBRUARY 1979

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THE CAROLINE FOREST FIRE

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WOODS AND FORESTS DEPARTMENT

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Minister of Forests

FOREWORD

With *Pinus radiata* plantations now a major feature of Australian forestry, dissemination of information relevant to its protection and management is a matter of continuing importance.

In February 1979, South Australia experienced its largest *Pinus radiata* plantation fire so far, under conditions of extreme fire danger.

The suppression of that fire put established tactics and practices to a severe test; the results of which must be of both interest and value to all major plantation forest owners in Australia.

The Department is pleased to pass on those results in this Bulletin, the latest in its technical bulletin series.

Ted Chapman
MINISTER OF FORESTS

PREFACE

Despite protection measures and precautions, it is inevitable that wild fires will continue to break out under climatic conditions normal to rural South Australia.

Equally inevitably, some of those fires will break out on days of extreme fire danger, under conditions which may well defy suppression for the period preceding a change of weather favourable to suppression activities.

The Caroline fire of 2nd February, 1979, put under severe test many aspects of the forest fire protection measures then current practice in the South-east Region by both the Woods and Forests Department and the other major forest owners.

This Bulletin, by the present Regional Forester for the South-east Region, E.R. Pfeiffer, and District Forester D.J. Geddes, who was fire boss for the Caroline fire, examines the more relevant of those measures in relation to that fire.

One outstanding feature merits particular mention in view of the recurrent discussions in this State with respect to use of prescribed burning to protect native forest. This is that a head fire of the magnitude of the Caroline pine fire actually stopped at the edge of low (stringybark) eucalypt forest under which fuel had been reduced by preceding prescribed burns.

P.M. South
DIRECTOR

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Crown fire emerging from 16 year old unthinned *Pinus radiata* plantation at 1400 hours, 2nd February, 1979, showing flame height to be 3-4 times that of the 22 metre high standing trees. Still-photograph taken from Super-8 movie filmed by G. Laidlaw.



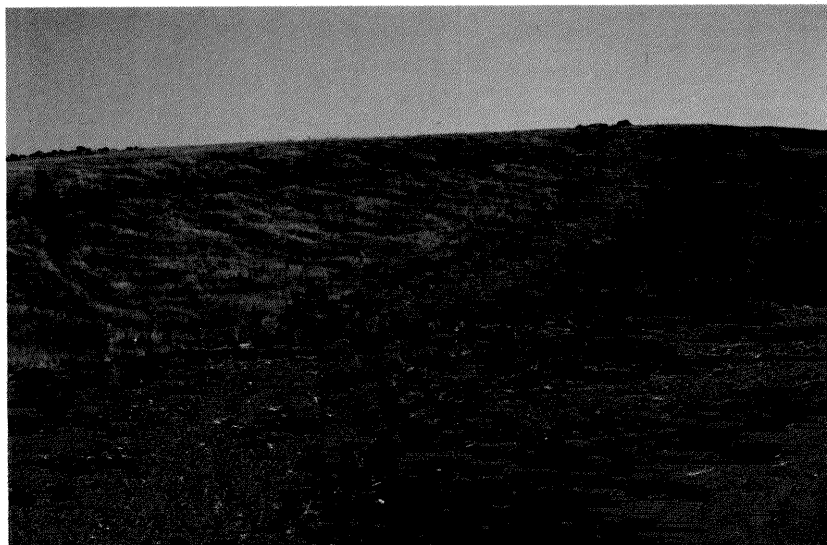
Shelterbelt and well-grazed pasture typical of Glenburnie and Yahl fires. Photograph taken 2 months after the fire. Photograph: J. Pratt.

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Aerial photograph of origin of fire. The old burnt-out wind-rows can be clearly seen.
Photograph: R.V. Woods.



Close up of wind-row heap where fire is suspected to have started.
Photograph: D.J. Geddes.

I. SUMMARY

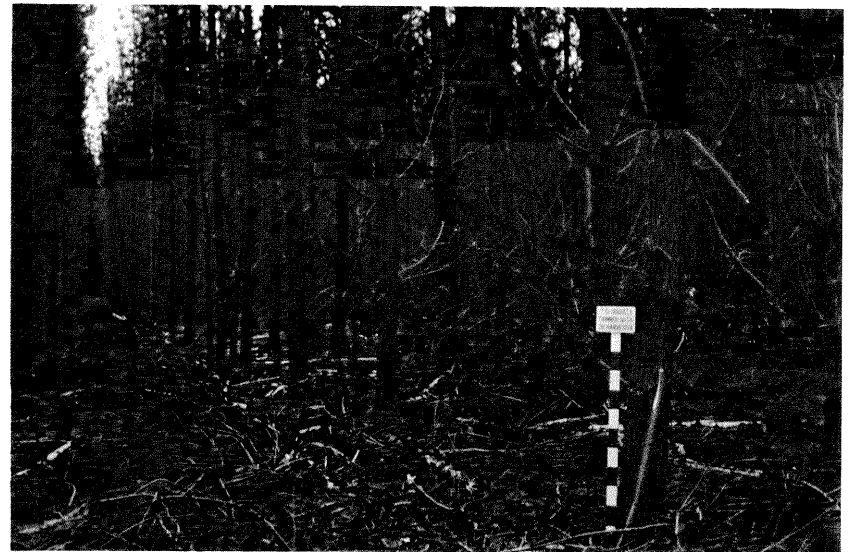
The largest pine plantation fire in Australia occurred on a day of extreme forest fire danger on Caroline Forest in the South-east of South Australia on 2nd February, 1979.

The origin of the fire was in grassland but it quickly spread to a nearby 16-year old unthinned *Pinus radiata* (D. Don) stand developing into a crown fire almost immediately. In the next 4 hours, it burnt 15 kilometres through 3 500 hectares of mainly State-owned unthinned pine plantations before crossing the State border into plantations owned by the Forests Commission, Victoria, and Victorian National Park dry sclerophyll eucalypt forest. When controlled, the fire had burnt a total of 7 400 hectares and for a distance of 30 kilometres.

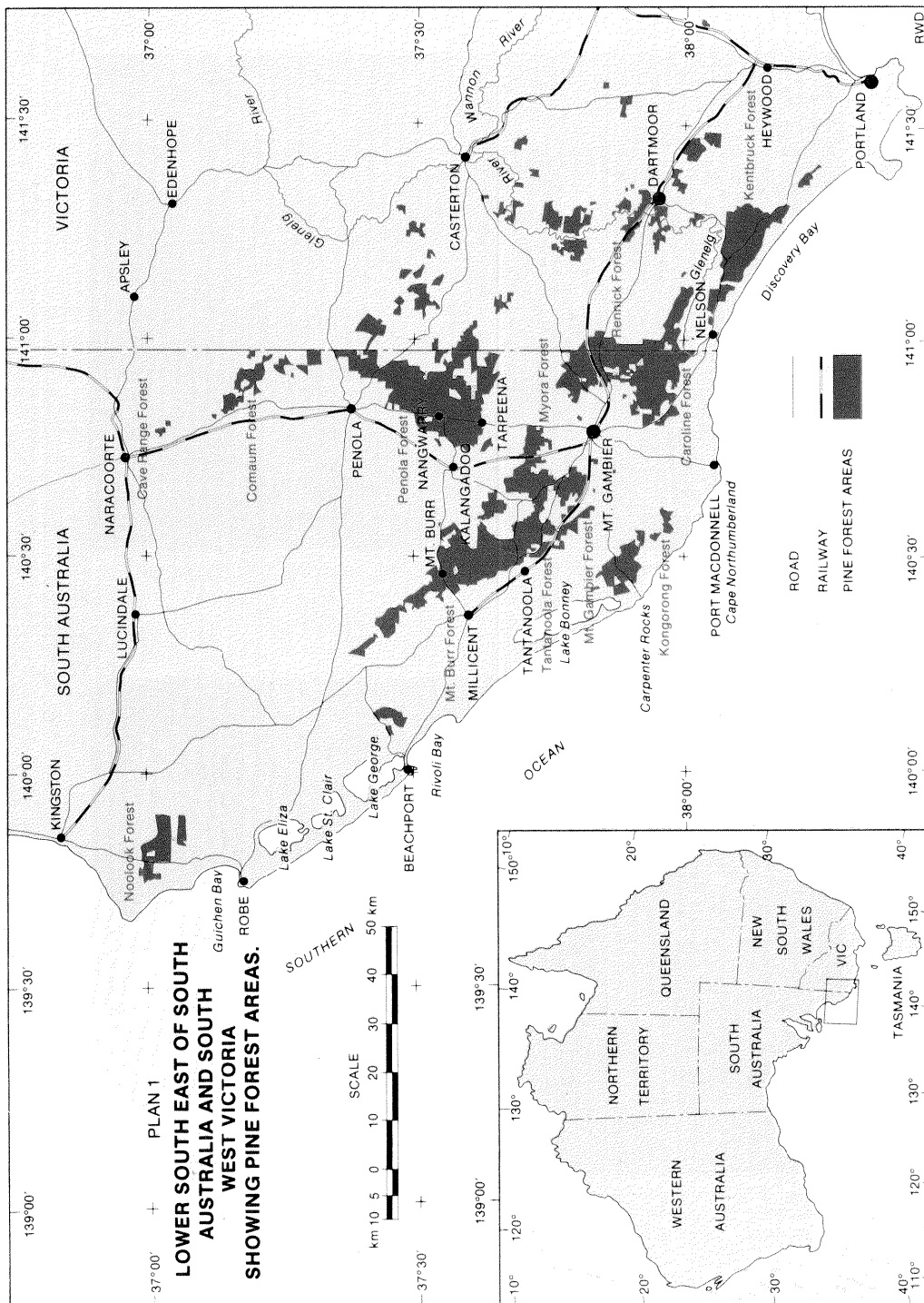
The fire fighting techniques employed and some aspects of fire behaviour, particularly in the plantation area, are discussed.



10 year old unthinned *Pinus radiata* plantation, showing fuel distribution.
Photograph: D.J. Geddes.



19 year old *Pinus radiata* plantation thinned with mechanical tree harvester, six months prior to Caroline fire.
Photograph: D.J. Geddes.



II. INTRODUCTION

(i) The Region

The forested region of the South-east of South Australia is relatively flat sandy country with over 90 per cent of the land under 60 metres altitude. In general, access for fire fighting is good, with very few steep slopes. The major rural land uses in the South-east of South Australia and South-west Victoria are farming, grazing and forestry. Approximately 124 000 hectares of conifer plantations have been established since planting commenced in 1907.

The summer weather pattern is influenced by a recurrence of anticyclones centred approximately along latitude 35° south. The weather sequence is one of warm to hot days followed by several mild to warm days with normally little rain. If the eastward movement of the anticyclone is slow, then the northerly air stream moving over South Australia persists for several days with temperatures increasing. These weather conditions constitute a most serious fire hazard and all major bushfires have occurred on such days (Mason, 1957).

Caroline Forest is one of the South Australian Woods and Forest Department Reserves in the South-eastern Region of the State. It is located to the south-east of the city of Mount Gambier adjoining the South Australian - Victorian border, where, in conjunction with Myora Forest Reserve, it forms the Myora Forest District.

At the time of the fire, Caroline Forest had 8 200 hectares of standing plantations, the main species being *Pinus radiata* (D. Don) interspersed with 1 600 hectares of native dry sclerophyll forest.

The Caroline fire occurred in an area where there were continuous even-aged unthinned plantations, some of which were areas replanted following the Kongorong fire of 1959 which burnt along a similar path (Hancock, 1977).

The topography of this area is undulating sand dunes with some limestone knolls and interspersed flats, bounded on the south-eastern side by the Glenelg River, which briefly enters South Australia at this point.

(ii) South Australian Woods and Forests Department Fire Control Organization

(a) Equipment

Fire units in South Australia have been developed by the Woods and Forests Department specifically for use in plantation fires, although they are also suitable for fighting all types of wild fire. A similar design has been adopted by the private forest companies in this region.

Special safety features are high steel sides, a protective water-spray system, cabin to house the 5-6 man crew, and back-up electric petrol pump to overcome vaporization in petrol lines.

These units carry between 2 500 and 3 000 litres of water, which is sufficient to last for 30 minutes of normal suppression action. Back-up water supplies are provided by supply tankers of 5 000 litre capacity on the basis of at least one supply tanker to two front line units. Currently there are 12 such fire units and 6 back-up tankers in the region.

Each fire unit has 360 metres (1,200') of 38 millimetre (1½") "rubber"-lined percolating canvas hose in 30 metre lengths fitted with hermaphrodite couplings of the "Minsup" type, as well as two live reels, each with 30 metres of 19 millimetre (¾") rubber hose. The canvas hose is packed in figure-of-eight rolls which enables them to be unrolled by pulling from one end without getting tangles. See Appendix 1 for technique used.

Woods and Forests Department policy is to use the canvas hose to make a direct attack on the fire flank with water. This allows the crews to work in comparative safety by leaving behind them a wetted and extinguished edge without having to work in front of the fire.

The edge is consolidated by using small John Deere 350 bulldozers, fitted with front-mounted snow-plough-type blades which follow the hose lays and construct a fire line to mineral soil.

A command van, fitted with radio communication, mapping, and clerical facilities, has been designed for use as a field base for the fire boss and support staff.

(b) Regional Organization

The South-east Region of the Forest Operations Division of the Woods and Forests Department is under the control of a Regional Forester. The Region is further divided into 5 Forest Districts, each having a District Forester in charge with requisite staff under them. In addition, there are 3 Senior Foresters responsible to the Regional Forester, one of whom is in charge of co-ordinating Protection.

Staff from other Divisions are also available for fire duties when required.

A readiness plan has been drawn up for expected fire danger ratings using the McArthur Forest Fire Danger Index (Appendix 2). In this plan the McArthur ratings have been changed so that Extreme fire danger commences at a scale of 45.

The private forest companies, Softwood Holdings Limited and Southern Australia Perpetual Forests Limited (SAPFOR) always respond immediately to fires in forest areas and the forecast is passed on to them and the border forests of the Forests Commission, Victoria.

Rural fire fighting organizations are not included in any readiness plans for forest fires.

(c) Automatic Despatch

The Woods and Forests Department has adopted a policy of all-out suppression effort in the initial attack in an endeavour to achieve quick control of the fire before it can build up.

The South-east Region is divided into Automatic Despatch Zones and for any particular zone for a given fire danger rating, a designated number of fire units will automatically leave for any fire in that area for which automatic despatch is called by the fire boss. If it is established that they are not all required, the surplus units are recalled by radio. See Appendix 3 for more detail.

(d) Detection

A system of fire look-out towers provides coverage over the whole region; the number of towers manned depending on the fire danger for the day as rates on the McArthur scale. On occasions when visibility is limited during a day of Extreme forest fire danger, air spotting patrols may be used to supplement the towers, on the authority of the Regional Forester.

III. METEOROLOGICAL CONDITIONS

(i) Forecast

The early morning forecast, received at 0730 hours on 2nd February, 1979, was -

"Hot at first with a southerly change during the afternoon. Maximum temperature 35°C, Dew Point 12, Relative Humidity 25%, winds N 25-35 kph at first, changing to S 35-45 kph later."

Forest fire danger rating on the McArthur scale was Very High (36).

Once the fires started, the Bureau of Meteorology, Adelaide, supplied special up-to-date forecasts when and as required.

(ii) Actual Weather

By 1000 hours, it was obvious that the weather was going to be worse than forecast. The temperature had already reached 35°C and relative humidity had dropped to 16% which, with wind speed of 45 kph, rated a fire danger of Very High (46) on the McArthur scale, and consequently rated as Extreme on the readiness plan.

The state of readiness for the South-east Region was changed accordingly by the Regional Forester and all Districts advised to react as for Extreme fire danger.

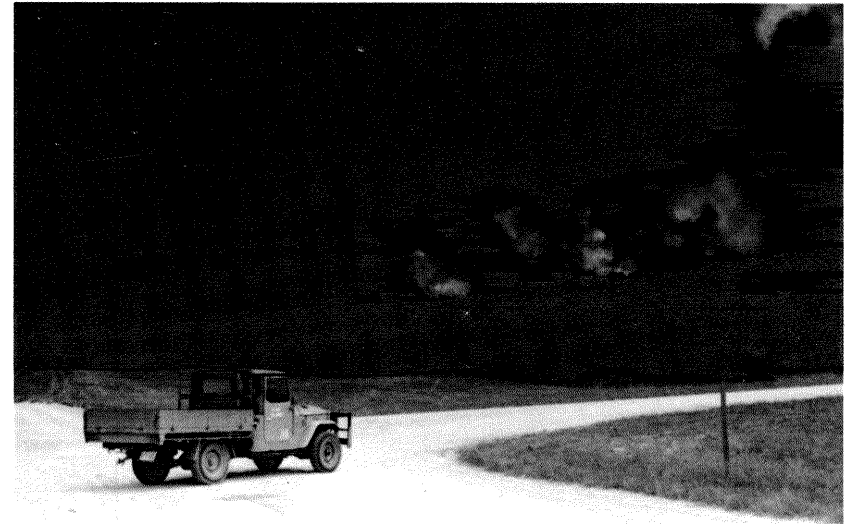
As the day progressed, the temperature rose to 39°C at 1200 hours and the wind swung from north to west-north-west and remained constant in direction from then on.

Meteorological statistics for 2nd and 3rd February, 1979, as supplied by the Bureau of Meteorology, Meteorological Office, Mount Gambier Airport, are contained in Table 1.

(iii) Atmospheric Stability

The aerological diagram (Figure 1) from readings taken at the Meteorological Office, Mount Gambier Airport, at 0900 hours shows that the air mass at that time was stable to a height of 1 900 metres (6,000 feet), then neutral to unstable with a definite inversion at 3 400 metres (11,000 feet).

This relative stability appeared to remain throughout the day.



Head fire in 9 year old *Pinus radiata* plantation, 2 hours after fire started.

Photograph: R. Borschman.



Head fire in *Pinus radiata* after crossing the border at 1700 hours.

Photograph: R. Borschman.



Flank fire surge emerging from pines at prescribed burnt native forest edge at 2000 hours.
Photograph: R. Borschman.



1963 Plantation near where the fire entered the pines, showing slope of crown fire lift into crowns.
Photograph: J. Pratt.

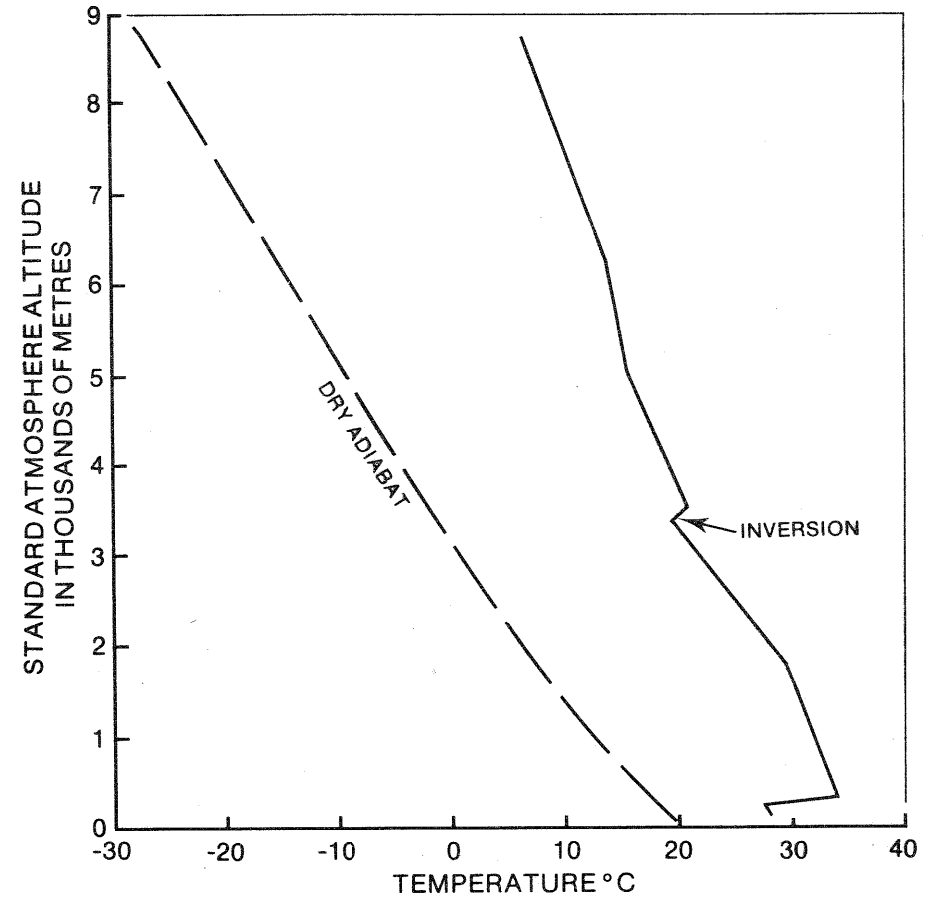


Figure 1. Radiosonde Sounding at 0900 hours, 2nd February 1979, taken at Mt. Gambier Aerodrome.

Table 1.

Meteorological Statistics - 2nd February, 1979

Meteorological Office, Mount Gambier Airport

Time	Temp. °C	Dew Point °C	RH %	Wind -			Fire Danger -	
				Speed kph Av.	Gusts	Direction	Index	Classification McArthur Scale
<u>Friday, 2nd February</u>								
0900	30	5	21	28	(40)	010	30	Very High
1000	35	5	16	31	(45)	340	46	Extreme
1100	38	7	15	30	(60)	300	51	Extreme
1200	39	7	14	39	(70)	300	67	Extreme
1300	38	8	16	45	(69)	280	72	Extreme
1400	38	8	16	42	(72)	290	66	Extreme
1500	38	8	16	43	(69)	290	67	Extreme
1600	37	8	17	45	(69)	270	66	Extreme
1700	37	8	17	42	(67)	290	62	Extreme
1800	36	7	17	34	(50)	270	50	Extreme
1900	35	9	20	18	(31)	290	29	Very High
Trough								
2000	32	9	24	2	(6)	320	16	High
2100	27	12	39	Cal'm			8	Moderate
2200	25	13	47	Cal'm			6	Moderate
2300	26	12	42	Cal'm			7	Moderate
2359	25	13	47	Cal'm			6	Moderate
1st Front								
<u>Saturday, 3rd February</u>								
0100	23	15	61	18	(34)	270	5	Low
0200	20	17	83	8	(34)	270	1	Low
0300	19	16	83	8	(15)	250	1	Low
2nd Front								
0400	18	16	88	31	(51)	270	2	Low
0500	18	16	88	28	(42)	270	2	Low
0600	16	15	94	28	(54)	270	1	Low
0700	15	12	82	37	(60)	260	3	Low
0800	13	12	94	23	(48)	280	1	Low
0900	13	13	100	Cal'm				

Note: 3.8 millimetres of rainfall was recorded for the period 0600 hours - 0900 hours Saturday, 3rd February, 1979.

(iv) Synoptic Situation

A high pressure system moved slowly across the State during Friday, 2nd February. It was preceded by a trough ahead of a succession of two cold fronts. The arrival of the trough at 2000 hours caused winds to drop from around 30 kph to calm.

The first front arrived just after mid-night of 2nd February. Wind speeds increased again to over 30 kph but wind direction did not change significantly.

The second front at about 0400 hours on Saturday, 3rd February, caused a sudden increase in wind strength to 50 kph but again there was no significant change of direction.

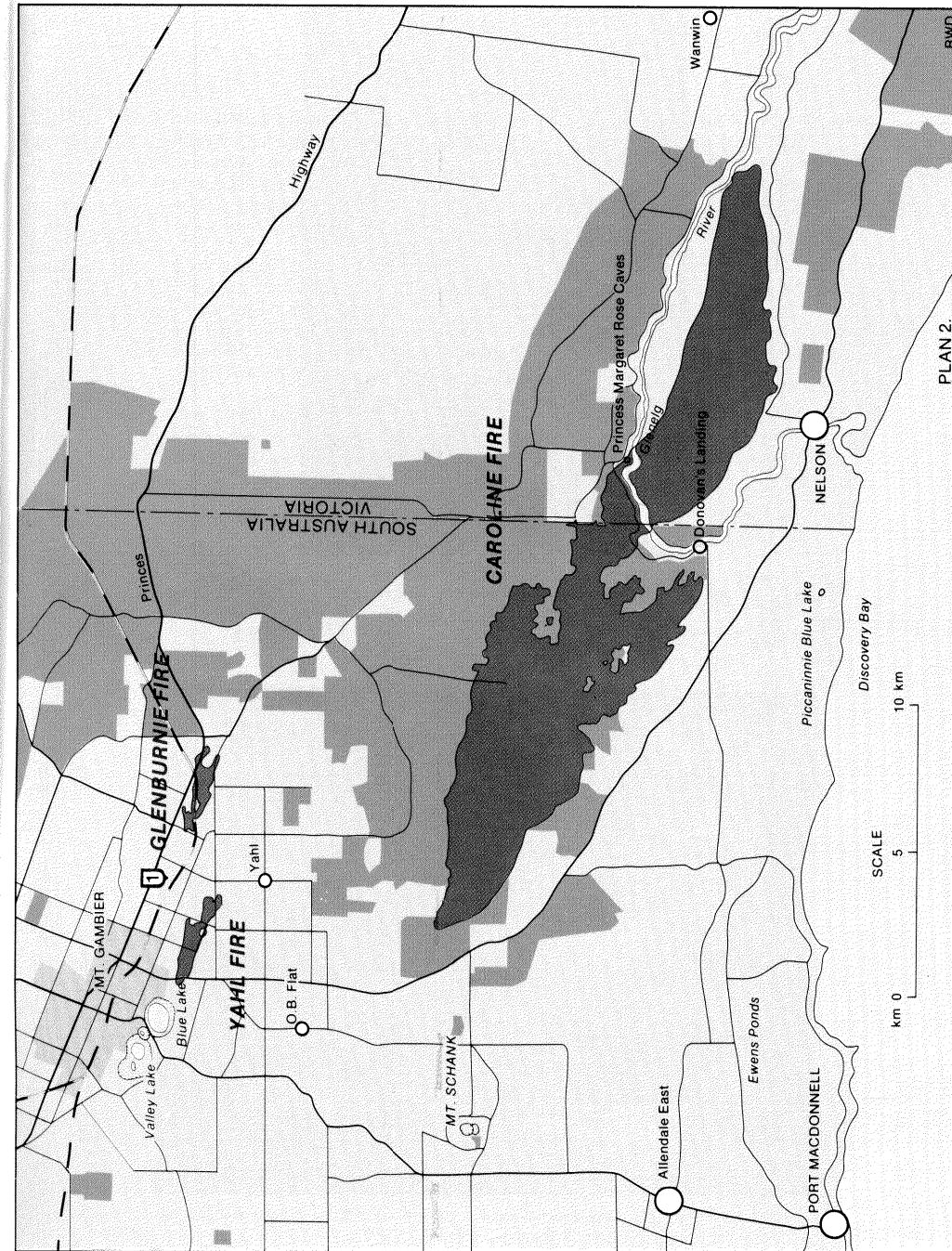
IV. FIRE LOCATIONS

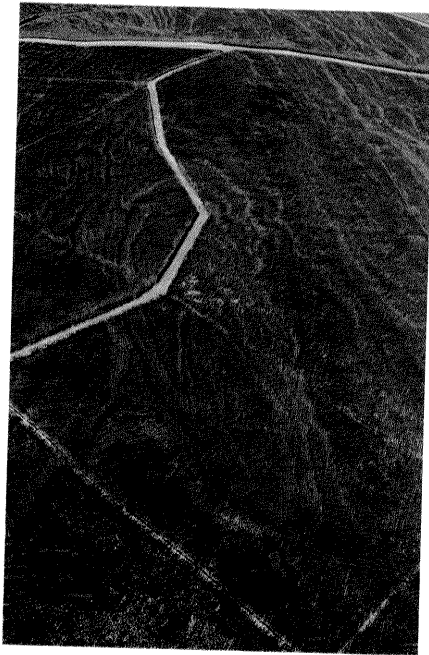
In the 80 minutes prior to the starting of the Caroline fire, two other potentially dangerous grass fires occurred, both of which threatened large areas of pine plantation at Myora Forest. These fires heavily committed fire fighting forces, causing a delay in initial attack on the Caroline fire.

The origins of the three fires were less than ten kilometres apart. The first fire, the Yahl fire, started at 1150 hours, 300 metres south of the Mount Gambier City boundary and travelled four kilometres before being controlled. The second fire, the Glenburnie fire, commenced at 1300 hours near the Mount Gambier Racecourse and burnt 3.5 kilometres before being controlled only 100 metres from an unthinned 14-year old *Pinus radiata* plantation.

The Caroline fire started at 1308 hours, 9.5 kilometres south of the Yahl fire and approximately one kilometre east of the Mount Gambier-Nelson Road. It covered almost 30 kilometres before being controlled at the Glenelg River 15 kilometres into Victoria.

The locations of the three fires in relation to each other are shown on Plan 2.





Spot fire of 1402 hours, origin at the bottom of the picture. A line of white sand shows where fire intensity increased at join with head fire.

Photograph: J. Pratt.



Aerial photograph showing effects of crown fire flank surges with strips of unburnt tree crowns between, giving typical plantation fire pattern.
Photograph: Lands Department.

V. YABL AND GLENBURNIE FIRES

These two grass fires had fast rates of spread of the order of 6 to 8 kph and were of great concern due to the likelihood of them becoming established in Myora Forest plantations. Most of the fuel was well-grazed improved pasture, with pine shelterbelt rows, a small orchard and a number of hay stacks. Rural dwellings were also located in the path of the fire.

Control of these fires was vested in local District Council-appointed Fire Control Officers, but both fires received maximum suppression efforts from fire units of the Woods and Forests Department, the Forests Commission, Victoria, Southern Australia Perpetual Forests Limited, Softwood Holdings Limited, the South Australian Country Fire Services and the Victorian Country Fire Authority.

The Yabl fire was caused by a short circuit in a power transmission pole igniting surrounding dry grass. The Glenburnie fire started when a tree branch, broken off in the strong winds, knocked a power line to the ground.

Areas burnt were -

Yabl fire	145 hectares
Glenburnie fire	113 hectares

VI. CAROLINE FIRE(i) Fuel Types and Areas Burnt

(a) Burnt area summary -

Grass	628 hectares
Native forest	3 250 "
Plantation	3 517 "
Total area burnt	<u>7 395 hectares</u>

(b) Grassland - well grazed improved pasture

Areas burnt -

South Australia	551 hectares
Victoria	<u>77 "</u>
Total grassland burnt	<u>628 hectares</u>

(c) Native Forest - mostly low stringybark (*Eucalyptus baxteri*) forest with a shrub and bracken understory.

Some areas had a recent history of fuel reduction burning. Most of the Victorian National Park had not been burnt since the Kongorong fire in 1959; fuel quantities were in the order of 50 tonnes per hectare.

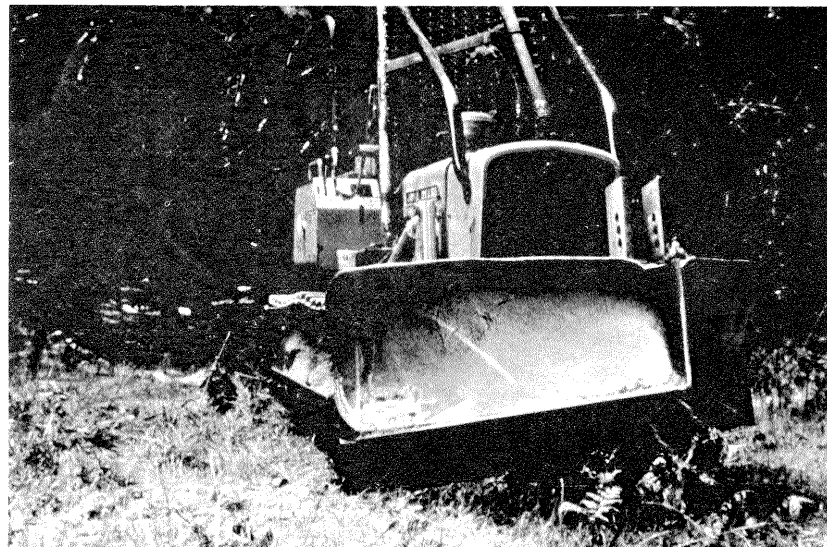
Areas burnt -

South Australia	480 hectares
Victoria	<u>2 770 "</u>
Total native forest burnt	<u>3 250 hectares</u>

(d) Pine Plantation -

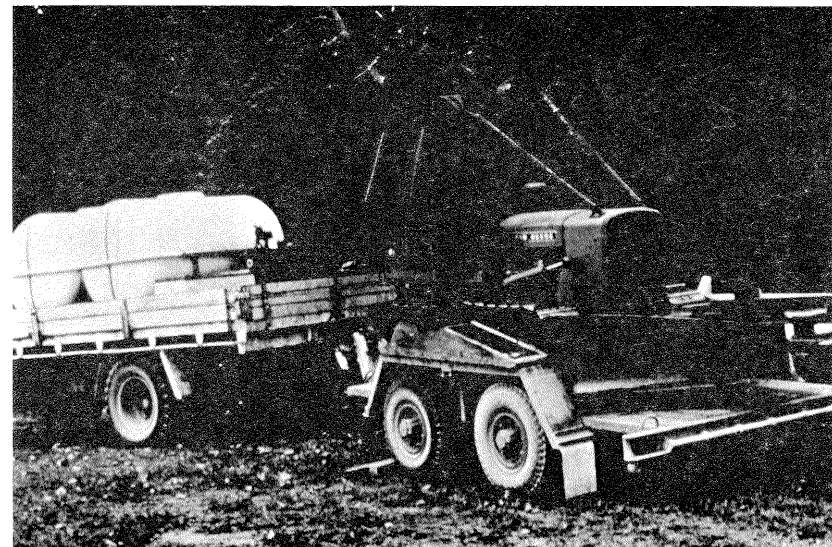
The plantations formed a more or less continuous belt from the fire origin to the Glenelg River on the South Australian side of the border and continued on north of the river in Victoria. In South Australia their age varied from 2 to 25 years with two main age groups of unthinned *Pinus radiata* stands.

The largest group was 8 to 11 years old and accounted for almost 40% of pines burnt. Trees ranged in size from approximately 15 to 18 metres in height and were unpruned except for some strips along the edges of main access routes. Canopy had closed in most of this area with the 10 and 11 year old pines building up a compact pine needle litter layer. However, green branches in general persisted from 1 to 3 metres above ground level to tree top.



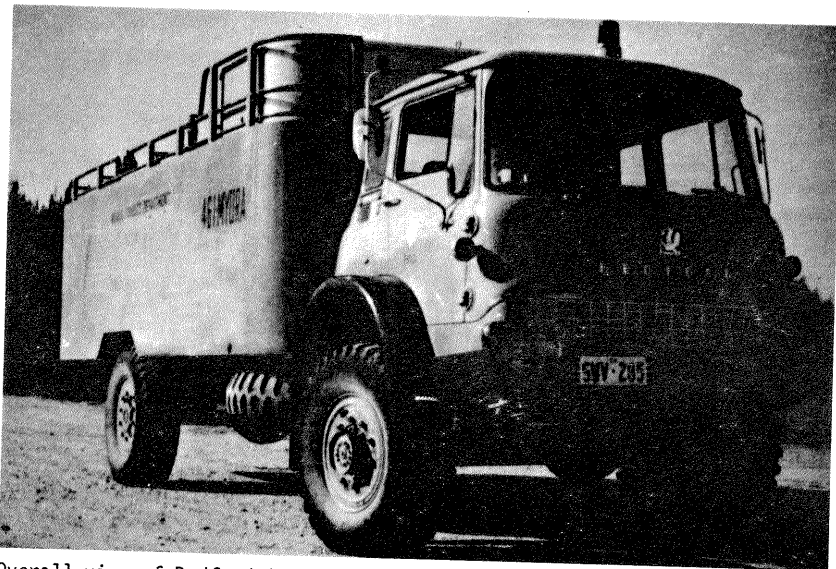
John Deere 350 with V-blade plough for constructing mineral earth fire line.

Photograph: D.J. Geddes.

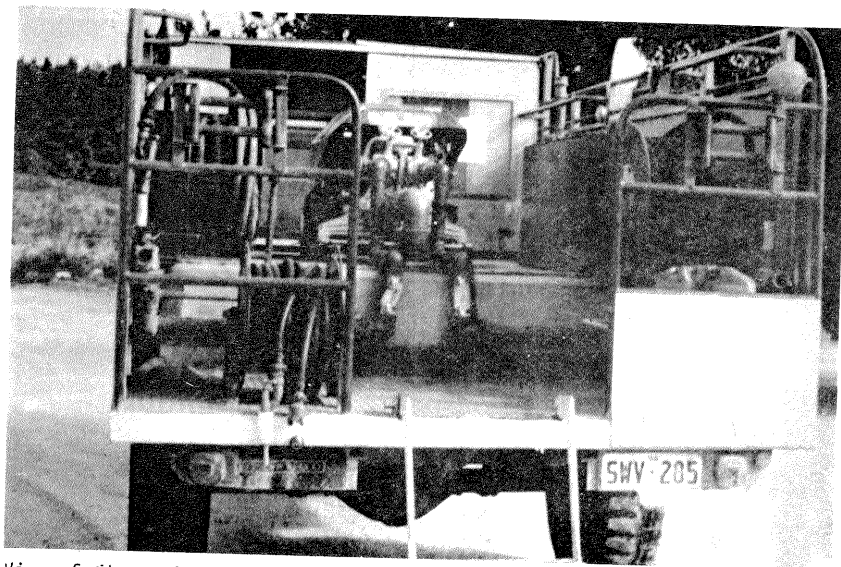


5 000 litre supply tanker with twin fibre-glass tanks, towing John Deere on trailer.

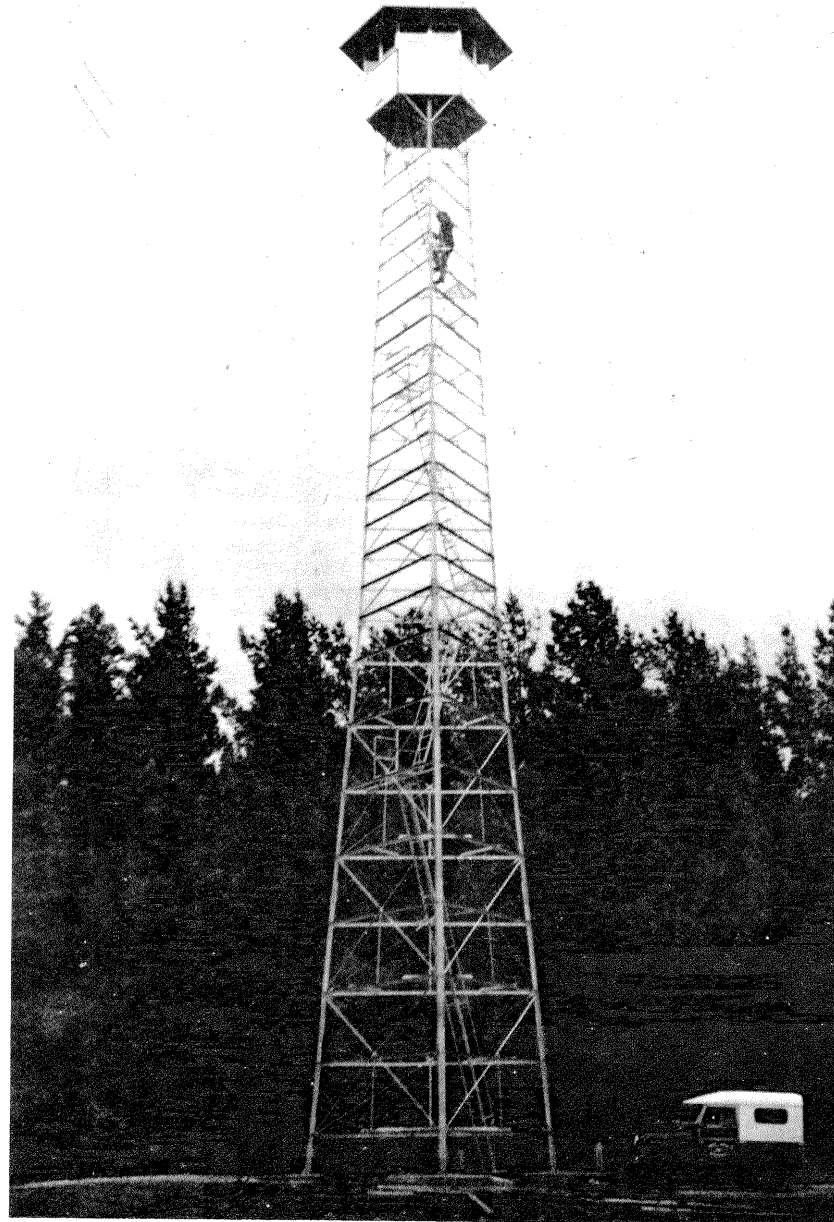
Photograph: D.J. Geddes.



Overall view of Bedford 2 500 litre fire unit.
Photograph: D.J. Geddes.



View of fire unit deck layout.
Photograph: D.J. Geddes.



Mount Edward fire lookout tower.



Canvas hoses - open and connected.



Canvas hose clamped shut.

Dead litter on the ground was estimated to represent a fuel weight of 8 to 17 tonnes per hectare. Green needles, dead branches and dead litter hanging in the trees accounted for a further 6 to 9 tonnes per hectare (Dr. D.B. Boomsma, 1980).

The next largest age class was 14 to 19 years old and accounted for almost 30% of burnt plantation. Most of this area was unthinned, unpruned and had closed canopy. Large amounts of dry pine needle litter had accumulated and heavy clusters of needles occurred in branch axils. Ground vegetation had been suppressed. Surface needle litter is estimated to have varied from 20 to 30 tonnes per hectare. Green needles, dead branches and dead litter hanging in the trees represented 12 to 18 tonnes per hectare.

The remainder of the stands had been thinned. Approximately 30 hectares of a 19-year old *Pinus radiata* plantation had been manually first-thinned to 850 trees per hectare five years prior to the fire. Tenth row extraction rows were used and most of the thinning debris had decomposed. 90 hectares of another 19-year old *Pinus radiata* stand was mechanically thinned to 650 trees per hectare in the six months prior to the fire with a John Deere 743 Tree Harvester. Fifth row extraction rows were used and most of the debris was accumulated in the extraction rows and had been well compacted. Very few dead pine needles remained in the branch axils of the residual trees. Ground fuel weights including litter and logging debris were approximately 40 tonnes per hectare between the extraction rows, and the compacted fuel in the outrows was about 200 tonnes per hectare.

Areas burnt -

Woods and Forests Department (South Australia)	
<i>Pinus radiata</i> thinned	122 hectares
<i>Pinus radiata</i> unthinned	2 367 "
Other <i>Pinus</i> species unthinned	422 "
Laslett (South Australia) - privately owned	
<i>Pinus radiata</i> unthinned	170 "
Forests Commission, Victoria	
<i>Pinus radiata</i> unthinned	163 "
Net Plantation Area Burnt	3 244 hectares
Gross Plantation Area Burnt	3 517 hectares

(ii) Origin and Cause

The most likely point of origin of the Caroline fire was some 250 metres west-north-west of the north-west corner of the 1963 plantation, on privately-owned forest land (see Plan 3).

Centenary Tower, the fire look-out tower situated in Mount Gambier, reported white smoke initially and then 9 minutes later black smoke. This indicated that the fire started in grassland and then burnt into pines producing the black smoke. The rate of spread in the grass was consistent with the rates of spread of the two other grass fires at that time.

The area in which the fire started was an ex-1939 *Pinus radiata* plantation which had been clear felled in 1971. After lying for several years, the slash was bulldozed into wind-rows which contained large amounts of soil mixed in with the debris. These wind-rows were burnt in May 1978. Prior to the Caroline fire, there was continuous standing by grass between the wind-rows.

Three possible causes were put forward to explain the fire ignition. These were arson, ignition from a bottle, or rekindling of debris in a burnt wind-row. Arson is unlikely because of the general inaccessibility of the area although trail bikes were reported in the area earlier in the day. A bottle was found approximately 100 metres inside the fire edge. If the fire had started at that point, it would need to have burnt back 100 metres against the 70 kph winds prevailing at that time. Unlikely as it may seem, rekindling in an old slash wind-row, perhaps containing a hardwood log, appears to be the most probable cause. Early crews mopping up the westernmost wind-row stated that it was very hot and required a large amount of water to extinguish.

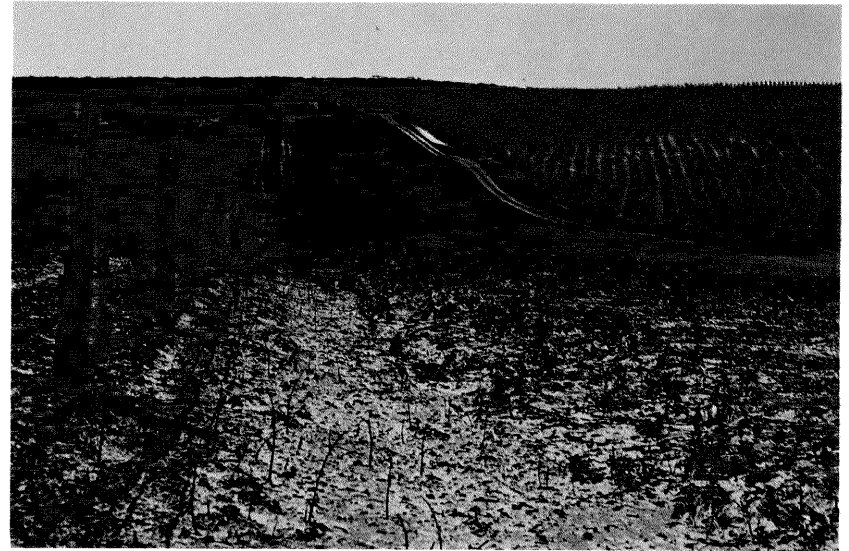
(iii) Fire Fighting Organizations

The Country Fires Act 1976 gives foresters employed by the Woods and Forests Department sole authority to control fires within forest reserves so in this case the District Forester, Myora, became the fire boss and took charge of the fire. Liaison with all other organizations was through the Field Command Van and the Woods and Forests Department Regional Office in Mount Gambier.

The fire suppression forces from the various organizations concerned with fighting fires concentrated on the Caroline fire, once the other two fires were controlled, with units from the Woods and Forests Department and the private forest companies employed in a direct attack on the northern flank.

The South Australian Country Fire Services, which did not have units suitable for fighting pine fires, maintained a watch on the southern flank and were able to control it once the fire entered into grassland.

Forests Commission, Victoria, and Victorian Country Fire Authorities and National Parks concentrated their efforts on trying to prevent the fire crossing the border and then on suppression action in Victoria.



Edge extinguished by mown break and graded track on south-east section of fire.

Photograph: J. Pratt.

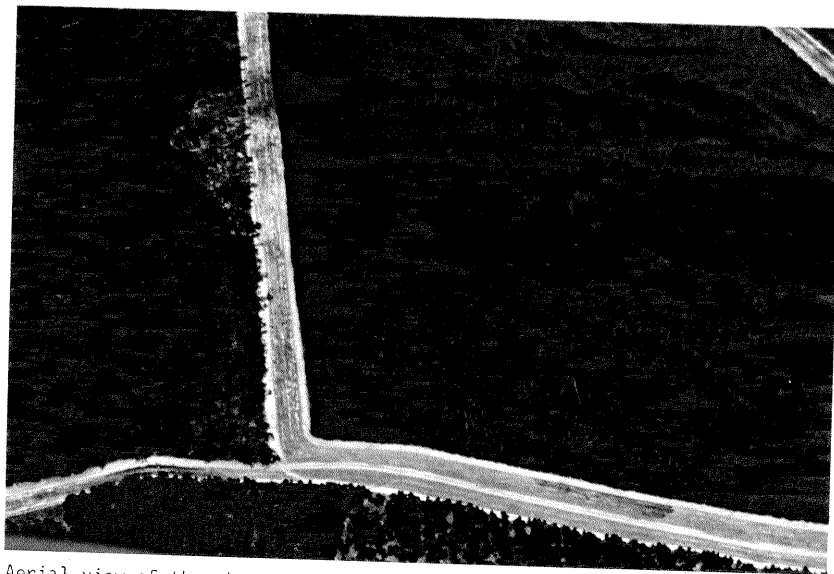


The severity of the fire in these pines is shown by the way in which all laterals have been burnt.

Photograph: R.V. Woods.



Severely burnt native forest with previously prescribed burnt area showing in the background.
Photograph: D.J. Geddes.



Aerial view of the above showing how the fire was stopped by the prescribed burn.
Photograph: R.V. Woods

(iv) Tactics

The Caroline fire broke out while the Yahl and Glenburnie fires were still being fought. It was decided that due to the potential danger of either of these grass fires getting into the large plantation areas of Myora Forest, it was necessary to keep all available units at these fires until their forward progress was stopped and the forests were no longer in danger in this area. The plantations at Myora menaced by these fires are high quality and hence some of the most valuable the Woods and Forests Department owns. The possibility of another pine fire north of the Caroline fire that could have created a situation in which two major pine fires were burning at once, was a major consideration in the decision taken.

The wind direction at the time of initial attack was west to north-west, with an expected change from the south. Therefore, control of the northern flank became the first priority before the anticipated change occurred and caused rapid spread of flank fire. Most of the suppression efforts were concentrated on this flank.

The Caroline fire was so well developed when first attacked, a crown fire having taken hold almost immediately it entered the pines, that an attack on the head was out of the question. Spot fires were also developing up to two kilometres in advance of the head fire. Crews could not and were not allowed to work too far ahead of unsecured edges to reduce the risk of being trapped by fire coming around them from behind and all canvas hose lays were followed up by mineral earth fire lines in order to secure them as quickly as possible. This is in line with Woods and Forests Departmental plantation fire fighting policy of direct attack with water, followed up by a physical separation of burnt from unburnt material. Burnt area is to be kept to a minimum. The constancy of the wind direction and the prevailing atmospheric stability helped to ensure the safety of crews in this situation.

(v) Fire Suppression Narrative

(a) 1400-1700 Hours

The initial attack by the major forest fire units was delayed by almost 90 minutes due to suppression action at the Yahl and Glenburnie fires. Four small private fire units were the first to arrive and started to put out the grass fire at the origin. This was not finally accomplished until Woods and Forests Department units arrived. The section was then consolidated with a graded edge. See Figure 2, Feast's Section.

Pine fire edge suppression with canvas hose lays commenced at 1430 hours from the western side of compartment 106 of 1960 plantation.

Thirteen major forest tankers were assigned to the northern pine edge as they arrived from the Glenburnie fire. One tanker was assigned to hold the southern edge and Country Fire Services crews were also used here to extinguish the fire as it came out into grassland.

The first 1.5 kilometres of northern pine fire edge was controlled by direct attack with water, at a rate of 0.5 kilometres per hour, and was completed at 1715 hours. Rate of water usage was approximately 14 000 litres per kilometre. Hose lays were followed up by the John Deere 350 crawler tractors fitted with V-blade "snow ploughs" to form mineral earth fire lines. These tractors were despatched to Caroline before the fire units left the other two fires. Consequently they were immediately available for line construction, but their rate of working was restricted to the canvas hose lay suppression rate of 0.5 kph. Fuel types in this first 1.5 kilometres were three compartments of 19-year old unthinned *Pinus radiata* with a small portion of one compartment having received a first thinning five years previously.

In Victoria, the Forests Commission and Country Fire Authority forces made preparation to prevent the fire crossing the South Australian-Victorian border by grading the border fire break and back-burning, using information relayed from a spotter plane to gauge where the fire was likely to cross.

Soon after 1530 hours, the head fire reached the western boundary of a 265 hectare area of native forest known as Honeysuckle Flat at the junction of its northern and southern portions. The northern 110 hectare portion of this natural eucalypt forest had been prescribed burnt in October 1977, some 15 months prior to the Caroline fire; the southern part was due to receive a prescribed burn, having been unburnt since 1966 (see Figure 7 detailing prescribed burning plan). This produced an outstanding demonstration of the effect of prescribed burning on the progress of a wild fire. The head did not burn into the northern area any more than 300 metres before going out. Several spot fires started about 800-900 metres in but those fires also went out of their own accord. That part of the hardwood area through which the fire could not burn acted as a buffer to the eight-year old *Pinus radiata* plantations to the east. The fire in the southern previously unburnt part of Honeysuckle Flat native forest was devastating, burning all the green foliage and fine branches to a small-end diameter of about 20 millimetres.

This buffering effect of the prescribed burnt part of Honeysuckle Flat was further enhanced by the 420 hectare area of native forest to the east known as Wild Dog Flat,

which had also been regularly burnt. The fire passed the south-west corner of this block at about 1630 hours and although flank fires then continued to hit the western boundary until 2000 hours, only 15 hectares were burnt. If it had not been for the prescribed burning in Wild Dog Flat, the Caroline fire would almost certainly have swept across the border at a point further north and into more Victorian *Pinus radiata* plantations. These pines continue for 15 kilometres in an east-south-east direction and are mostly unthinned, ranging from 5 to 15 years old.

The unit which was sent to the southern edge started a hose lay at 1545 hours in 1962 compartment 140 but it took until 2030 hours to control this edge as far as the open grassland south of the forest.

Although the section of the southern flank in open grassland was controlled by local Country Fire Services units, the fire in the plantation west of the grassland burnt unchecked until after the passage of the trough at 2000 hours.

(b) 1700-1900 Hours

At 1700 hours, the fire crossed the border and then the Glenelg River, and Victorian forces were split north and south of the river. North of the river, initial work involved rounding up several potentially dangerous spot fires in the grass, north of the Rennick airstrip, protecting the buildings at the Princess Margaret Rose Caves and containing the fire to the hardwood area along the northern bank of the river to prevent it spreading into the pines.

South of the river, where the fire was in the Lower Glenelg National Park, bulldozer trails were commenced almost immediately along the northern and southern fire flanks in the predominantly *Eucalyptus baxteri* native forest. Forests Commission forces at Heywood had anticipated the fire burning into the National Park and had moved two bulldozers to the area.

In South Australia, the northern pine edge suppression had reached the private 10-12 year old, 1.8 metre spaced, unthinned *Pinus radiata* plantation of Laslett's (see Figure 3, Laslett's Section). This next 2 kilometres of edge slowed the suppression rate because of time spent in locating unpruned access tracks to get units into the end of and beyond the initial hose lays. Another problem arose because the small tractors with V-blades could not manoeuvre within this tightly spaced plantation. This lack of ability to consolidate the wetted edge became critical because a further problem in this area was a layer, from 10 to 60 centi-

metres deep, of sawdust which had been dumped in places amongst the pines as a mulch a number of years earlier. This burning sawdust was extremely difficult to extinguish, and frequently rekindled, so without a back-up fire line, the canvas hose suppression rate was slowed such that fire trucks began to bunch up.

Eight units were therefore sent around on the wide fire breaks to the eastern side of this plantation, where three of them were deployed securing a line back into it and the rest continued eastwards along the northern fire edge. This decision was taken because at that time, on advice from the Bureau of Meteorology in Adelaide, the wind was not expected to change from the west-north-west for another six hours and it was felt that the private plantation bottleneck could be most quickly dealt with by tackling it from both sides. In addition, heavy bulldozers were brought in to clear a mineral earth fire break along the northern fire edge, in Laslett's; but work was slow because the pines had to be pushed over and moved aside.

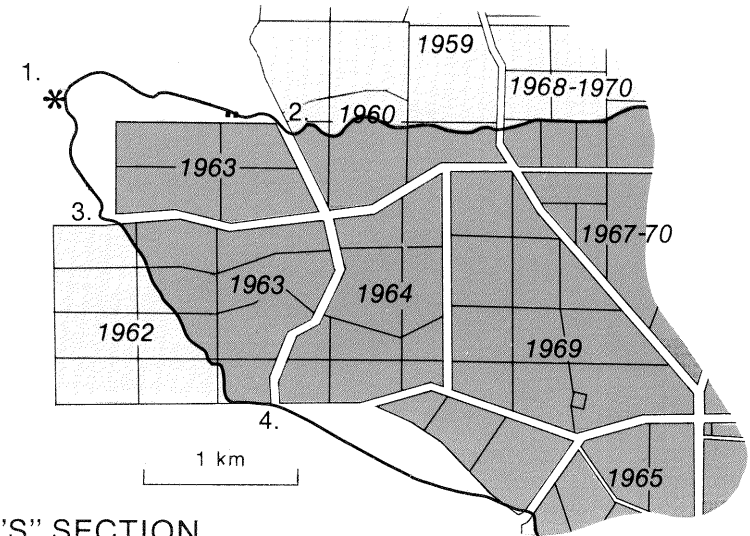
(c) 1900-2400 Hours

By 1900 hours, it looked as though the fire could be going for more than one day before being controlled and the Woods and Forests Department fire crews had been fire fighting continuously since mid-day; relief crews were brought in so that the experienced fire fighters would be fresh for the next day.

The relief crews continued work along the northern flank and an additional crew was deployed to the southern flank, making two major forest tanker crews there, supported by a large number of private farmer units and Country Fire Services trucks. These support units provided water to the forest tankers and controlled the grass fire south of the forest.

Under the milder night-time conditions, the rate of fire suppression improved to about 0.7 kilometres per hour on the northern edge over a distance of about 3.5 kilometres in 16 to 19 year old unthinned *Pinus radiata* plantation (see Figure 4, Piccaninny Section).

In Victoria, the partially burnt compartments of 1966 *Pinus radiata* plantations were burnt out to the fire breaks to make them safe. South of the river, the fire in the National Park was now being contained by bulldozing tracks along the edges with two tractors on each flank and a follow up of four tankers. Direct attack on the head was not possible due to the extreme heat. Spread of the southern flank was slowed for a short time at 2300 hours whilst burning in a fuel-reduced area near the town of Nelson.

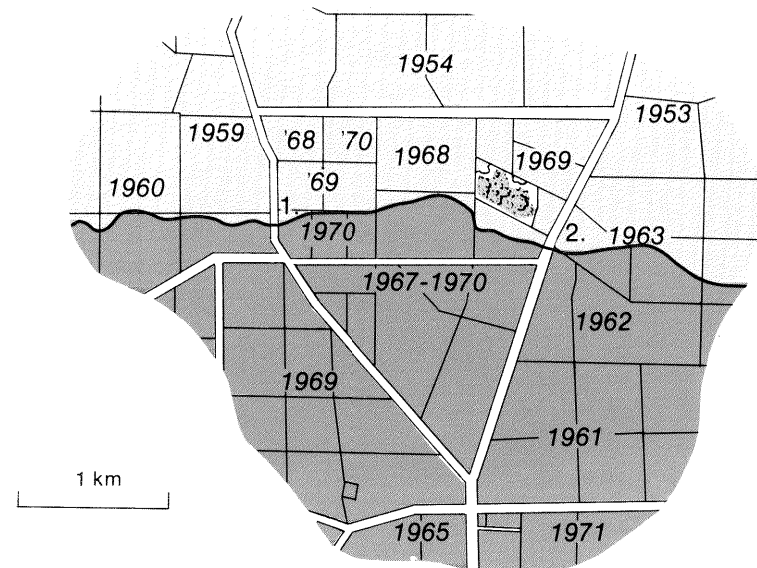


“FEAST’S” SECTION

1. * is the origin.
2. Hose lay commenced at 1430 hours.
3. One unit assigned to this edge at 1545 hours.
4. Edge in grassland controlled by Country Fire Service Units.

Figure 2.

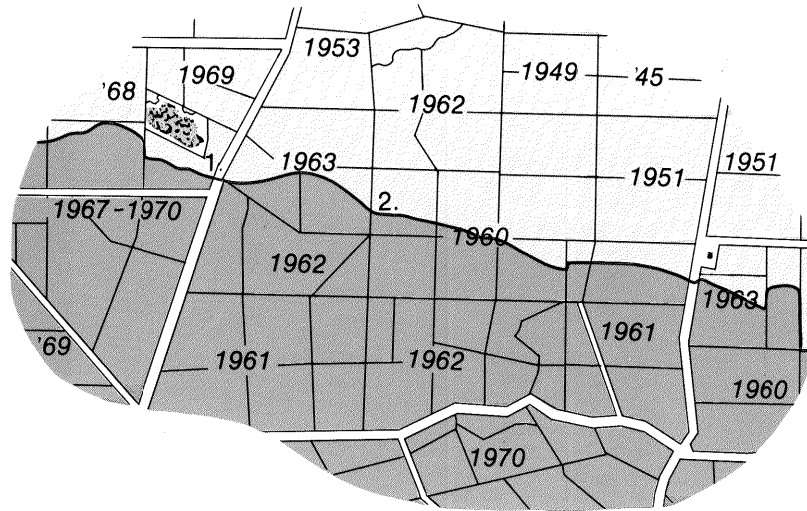
rd



“LASLETT’S PINES” SECTION

1. Hose lay commenced 1700 hours and continued by two units.
2. Two units commenced line westwards and three units continued eastwards.

Figure 3.

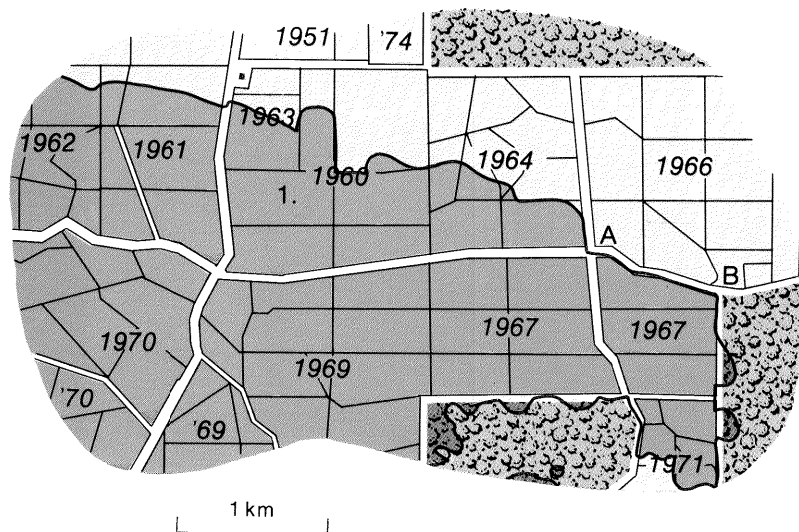


"PICCANINNY" SECTION

1. Hose lay commenced.
2. Relief crews change-over point.

Figure 4.

rd



"GRUB ROAD" SECTION

1. 1960 plantation first thinned prior to fire.
2. Fire edge self-extinguishing along fire-break A-B and by prescribed burnt native forest.

Figure 5.

(d) 0000-0900 Hours (Saturday, 3rd February, 1979)

Soon after mid-night the relief crews in South Australia started work on a 19-year old *Pinus radiata* plantation which had been thinned with a Tree Harvester six months previously (see - Fuel Types and Areas Burnt). Although extinguishing the fire edge presented no great problems, some difficulties were experienced in creating a bare earth fire line because of the mat of logging debris along the extraction rows. A heavier bulldozer with a straight blade had to be used instead of the V-blade on the John Deere. Suppression rates continued at about 0.7 kilometres per hour for another three kilometres through this 19-year old thinned *Pinus radiata* and some 15-year old unthinned *Pinus pinaster* plantations to a point where the flank had been contained by fire breaks adjacent to a 12-year old plantation and the forward run stopped by prescribed burnt native forest. At this particular point, the fire break was 60 metres wide. The vegetation had been mown and a 1.5 metre wide strip ploughed along each edge. This was sufficient to stop the flank fire and the head fire surges were stopped by the prescribed burnt Wild Dog Flat native forest.

In Victoria, following an increase in wind speed at 0330 hours, mass spotting occurred in the National Park and the fire burnt to the Glenelg River throwing embers over the river to the Wanwin pine plantations (see Plan 2). However, the cool change had taken effect and no spot fires developed across the river.

The forward rate of fire spread was stopped in Victoria at 0500 hours and bulldozer trails around the perimeter were completed by 1100 hours. Mopping up then commenced and continued until the afternoon of Sunday, 4th February.

Fire line construction along the northern fire edge in Laslett's private plantation was completed by 0300 hours on Saturday, but the area was not made safe for several days because of the difficulty extinguishing the sawdust.

Water usage along the northern 12 kilometres of pine edge averaged approximately 13 000 litres per kilometre.

On the southern flank, the fire was burning in the eastern end of the Bottlebrush Native Forest Reserve and a heavy bulldozer was called in at 0200 hours to cut a fire line through the area.

The rest of the southern edge in pines was controlled following some rain at 0400 hours.

No reliable information has been obtained on the final suppression action taken in the fire in the grassland on the south-eastern part of the southern edge in South Australia. This was open grassland and bracken and was under the control of the local rural fire authorities. It was contained sometime in the early hours of Saturday morning.

No fire fighting activity was required in any of the 2-7 year old pines on the southern flank. Fire danger had dropped at this stage, and in general the mown fire breaks with 1.5 metre cultivated edge strips were sufficient to stop the fire (see Figure 6, South-east Section).

Four millimetres of rain fell at about 0700 hours on Saturday, 3rd February, by which time most of the fire had been contained and mopping up commenced.

VII. DISCUSSION

(i) Fire Behaviour

(a) Burning Patterns

The fire burnt under uniform conditions throughout on the South Australian side of the border. The wind remained constant in direction and speed in stable atmospheric conditions which, coupled with the relatively flat topography and uniform fuel distribution, led to a classic fire shape and flow pattern, and predictable fire behaviour.

The main fire front burnt almost continuously as crown fire on a narrow front, at a fairly constant rate of forward spread, and more or less in a straight line. This was followed by a succession of narrow crown fires travelling along the flanks at varying distances behind the main front to produce the typical pattern commonly seen in plantation fires. In this case, the intensity of the fire can be gauged from the fact that nearly 80% of the area burnt was by crown fire.

The rate of spread in the pine plantation can be broken down into hourly segments -

	RATE OF SPREAD in kph	COMMENTS
1300-1400	3.5	This included 400 metres of grassland at the origin, where the rate of spread was 6 kph.
1400-1500	4.0	The slightly higher rate of spread resulted from a spot fire extending the head fire.
1500-1600	3.2	Totally in pine plantation.
1600-1700	3.0	Slowed by the effects of prescribed burning, and of suppression action taken at the border.
1700-	1.5-2.5	Mainly in native forest east of the Glenelg River in Victoria.

(b) Flame Height

From eyewitness observation and from films taken of the crown fires, it is possible to state that flame heights exceeded 70 metres at peak intensities at these points of the fire. This could be expected for a fire with a forward rate of spread of more than 3 kilometres per hour (50 metres per

minute), a fuel loading in excess of 25 tonnes per hectare and a vertical distribution of fuel such as is found in an unthinned unpruned pine plantation.

The flank fire behind the crown fire surges burnt at heights of 1 to 1½ metres except when unpruned trees "torched" up, in which case the flames went to the green level or higher. This was verified by fire crews taking suppression action on the flank fire.

No evidence of measured flame depth is available. However, some observers report seeing a fireball effect as flames of crown fire surges crossed open fire breaks and also as the head fire crossed the Glenelg River.

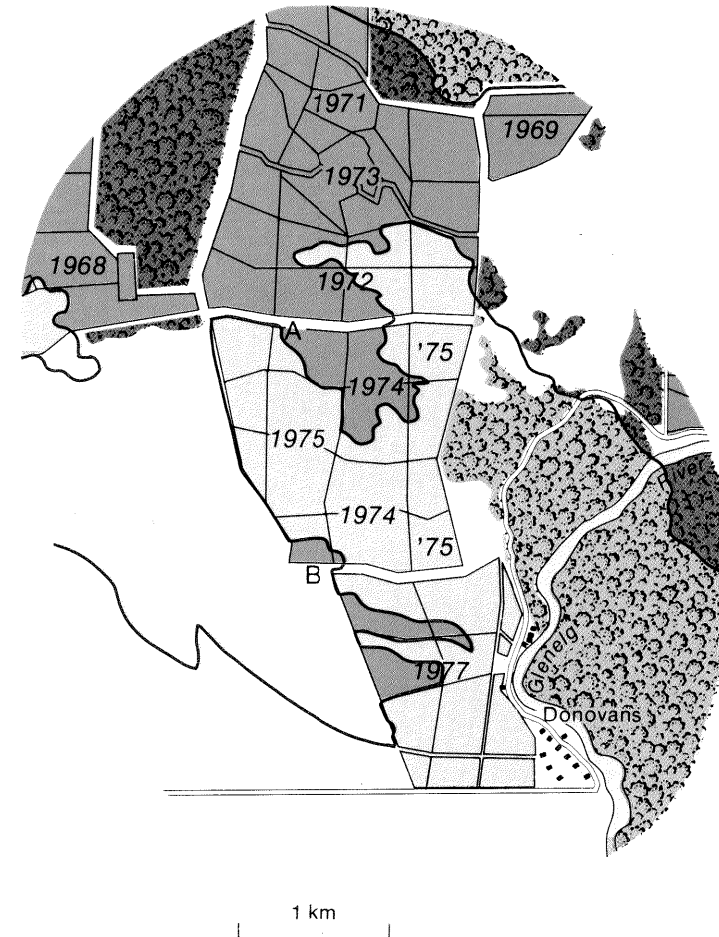
Other factors which had some influence on fire behaviour in the pines were -

- (i) Low-pruned 20-metre wide strips along the edges of some fire breaks had the effect of reducing the crown fire to a ground fire on the downwind side of the break but did not have a material effect on the overall rate of spread.
 - (ii) Thinned areas were not in the main thrust of the head fire but had an effect on the northern edge flank fire where, because the fuel was on the ground and not aerially distributed, fire intensity was reduced.
- (c) Crowning
- Several places where crowning started were clearly visible after the fire and showed that the fire did not lift into the crowns in a single vertical lift but did so gradually leaving a sloping edge between burnt and unburnt crown rising from ground level to the upper crown. In other words, the fire climbed progressively into the crown with its forward spread.
- (d) Spotting

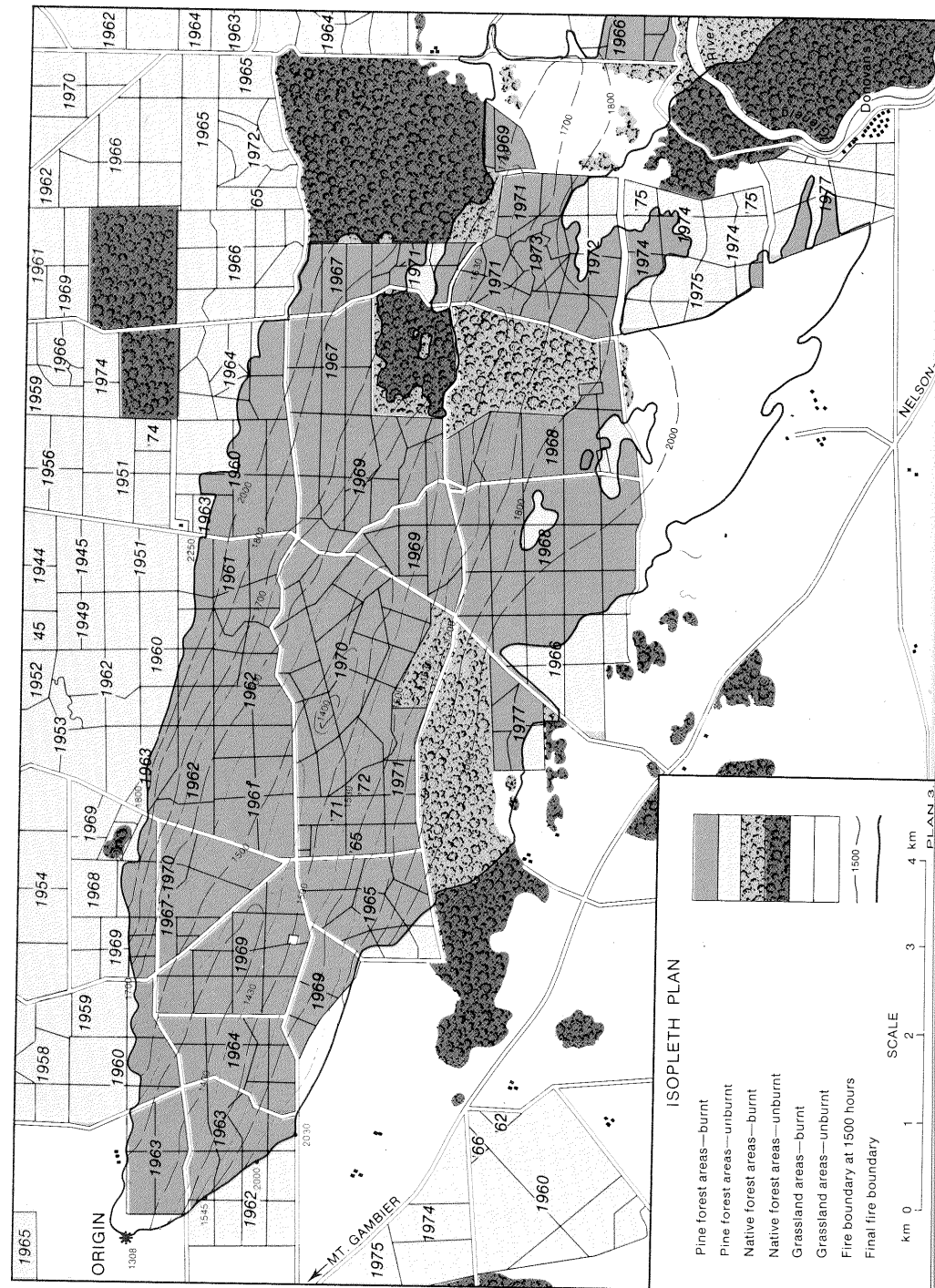
Multiple short-distance spotting was prevalent, as could be expected, but only two definite cases of any long-distance spotting were noted.

The first was reported by fire look-out towers at 1402 hours, just 54 minutes after the start of the fire and it is likely that this spot resulted, not from the head fire, but from burning eucalypts and casuarinas on a fire break, some 1 500 metres from the fire origin, during a surge of the flank fire. Thus the spot could have travelled 4 to 5 kilometres, although the actual point of ignition was only 2.5 kilometres ahead of the main fire, which overtook and joined with it 30 minutes later.

Figure 6.
"SOUTH EAST" SECTION



All edges were self-extinguishing in this area. The fire was contained on the break A-B by a one metre ploughed strip against the pine edge on a mown fire-break.



At the junction of these two fires, the effect of increased intensity resulting from the mass fire effect was clearly visible both from the air and on the ground where everything was burnt to ash exposing mineral soil and completely burning lateral limbs and all needles from the trees.

The second occurrence of long-distance spotting occurred at the State border where the fire entered open grassland with some banksia and eucalypt trees on the South Australian side. Spots were thrown across a back-burn set to try to control the head fire, and ignited in grassland adjacent to and threatening the Forests Commission, Victoria, pine plantations. Spotting distance was about 1.5 kilometres and seems likely to have come from the eucalypts and banksia

The fire also crossed the border by medium of mass spotting from natural hardwood forest into pine plantation at 1700 hours.

The fact that there was a relatively stable atmosphere as previously shown by the aerological diagram recorded at Mount Gambier Meteorological Office (Figure 1) probably accounts for the lack of further long-distance spotting; the convection column build-up being minimal.

(e) Radio Transmission

Although distance for reception of radio signals was normal along the flank of the fire, transmission across the fire was interrupted and possible only for short distances. This signal attenuation across a fire is more common in the low-band frequencies such as used by the Woods and Forests Department (74.09 MHz).

(ii) Fire Suppression Activity

There are several points arising from the fire which are worth emphasizing as being relevant to pine plantation fires -

(a) Canvas Hose Lay

That more than 12 kilometres of fire edge was controlled by direct attack using water from 38 millimetre canvas hose lays at a suppression rate of 0.5 to 0.7 kph, shows the effectiveness of this method. It has the advantages of reducing the fire perimeter and is quicker in the long run than side burning from existing breaks since crews can work ahead of still burning sections; something which would be dangerous in extreme conditions if a burn out technique was being used. The fact that no one was injured demonstrates that the crews were able to work safely.

With this technique, however, it is necessary to have immediate follow-up of the hose lay with a fire line to mineral earth. The adaptation of John Deere 350 bulldozers

fitted with snow-plough type blades has proved itself in this field and taken over the role previously filled by a hand tool crew using McLeod tools (Rakho). Where access is limiting or logging debris is a problem, heavier machines may be required.

Current planning is to include fire retardants on the fire units for use in this direct attack technique. This should give more efficient suppression per volume of water used, as well as reducing rekindling; thus giving greater flexibility and less dependence on machinery for immediate fire line construction.

(b) Back Burning

Attempts made to back burn at the State border by crews from the Forests Commission, Victoria, were not successful because of spotting. This was the only place where there was any chance of being successful in an attempt to stop the head fire by back burning and was fully justified.

(c) Detection

The efficiency of fire look-out towers was demonstrated by these fires.

The first fire, the Yahl fire, was only 3 kilometres from the Centenary Tower fire look-out in Mount Gambier but the first report was from a person in the vicinity of the fire and it was not until a further 10 minutes that the fire was seen and reported by the tower man. In this case, the fire was screened by the Blue Lake crater and the strong wind kept the initial smoke volume from rising.

Similarly the Glenburnie fire was going for 5 minutes before being reported by the tower.

However, the base of the Caroline fire was visible to the tower in Mount Gambier and it is reasonable to assume that it was detected very soon after it started.

Centenary and Rennick (Forests Commission, Victoria) towers reported the fire within two minutes of each other and two other towers in the network reported it within another 10 minutes.

While this 10 minute delay in reporting could be regarded as unacceptably high, the tower system is, in general, efficient and reliable.

(d) Self-extinguishing Edges

As far as can be ascertained from available information, a large section of the fire edge extinguished itself on ploughed strips, 1.5 metres wide, on breaks where all grass and bracken had been mown with slashers. This occurred mainly in the south-east sector near the border when the wind dropped after 1900 hours (see Figure 6, South-east Section).

In the same area, the fire that did enter the young plantations also went out of its own accord, probably because the area had been grazed; so ground vegetation was sparse and the trees had not yet closed canopy.

Similarly in two other areas where bare rocky ground predominated, the fire went out of its own accord.

Where the prescribed burnt Wild Dog Flat native forest stopped the forward flank surges, the east-west 60-metre wide break contained the northern flank fire between 2000 and 2030 hours. Again there was a 1-2 metre wide strip cleared to mineral earth (see Figure 5, Grub Road Section).

The necessity of the strip cleared to mineral earth on breaks, and the advantages of grazing in young plantations, as fire protection measures were demonstrated.

(e) Wind-row Burning

As the fire may have started from a rekindle of a wind-row burnt some 9 months previously, it then becomes a good forest management practice to ensure that where such burning has taken place, there are adequate precautions taken against such an unlikely happening. Routine inspections and a break cleared to mineral earth, of a width commensurate with the fuel loading, are essential.

(iii) Fire Management

(a) Fuel Reduction Burning

The effectiveness of prescribed burning as a management tool was demonstrated in the native forest areas as previously mentioned. Figure 7 details prescribed burning operations dates in the Honeysuckle Flat and Wild Dog Flat native forest areas. All burns were done in spring, resulting in only mild to moderate crown scorch of the overstorey trees. The aim was to reduce the fuel quantity and leave a mosaic of burnt and unburnt understorey. Approximately 80% of this understorey was burnt.

It seems logical to extend this tactic to pine plantations in the future to create barriers in strategic areas of plantation once thinning has occurred and although it would seem probable that complete control of a pine fire could not be achieved in this way, it would help to reduce fire intensity and rate of spread and to increase rate of suppression.

(b) Plantation Design

From this fire, it became obvious that row direction and spacing are all important. Access along the rows for machinery is most important and therefore they need to be aligned parallel to the wind direction of severe fire weather. This is already general Departmental practice for first rotation areas in this Region; since it is important for stand stability also.

The experience of close spacing in the privately owned plantation indicated the need for row widths wide enough to allow machinery access.

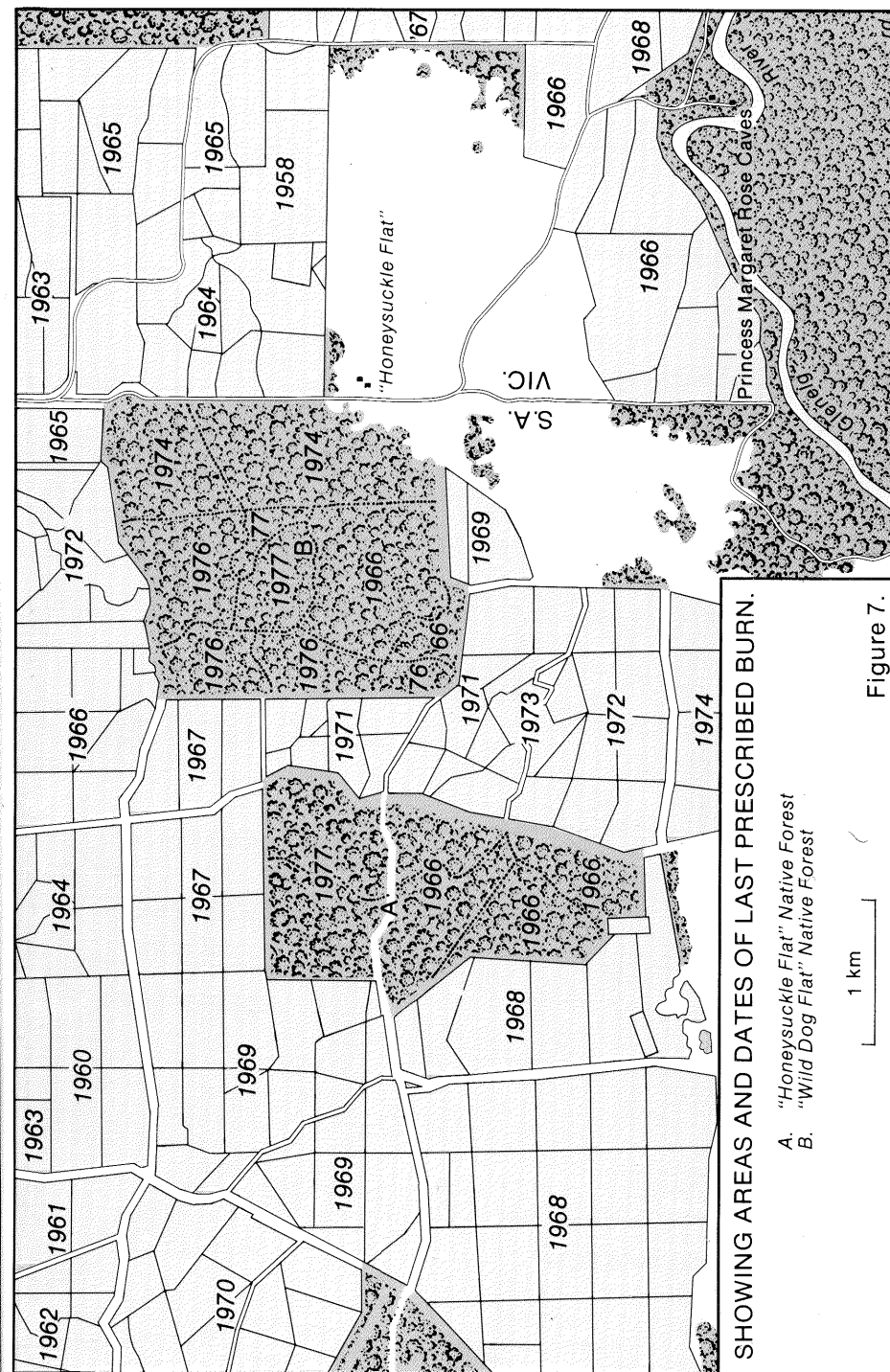
The width of breaks did not appear significant for a fire such as this, since it crossed over 60-metre wide breaks as easily as it did those 20 metres wide. This substantiates the findings of Douglas (1964) who said: "Reliance on fire breaks as such should be confined to locations close to the sources of likely ignition or against grass country. Within large areas of plantation, 'fire breaks' can be limited in width to 10 metres or less, their main function being to provide access and to delineate compartments." It was also demonstrated that a strip as narrow as one metre, to mineral earth, is all that is necessary on a break to stop any creeping ground fire, as the fire did extinguish itself on such breaks when the wind dropped.

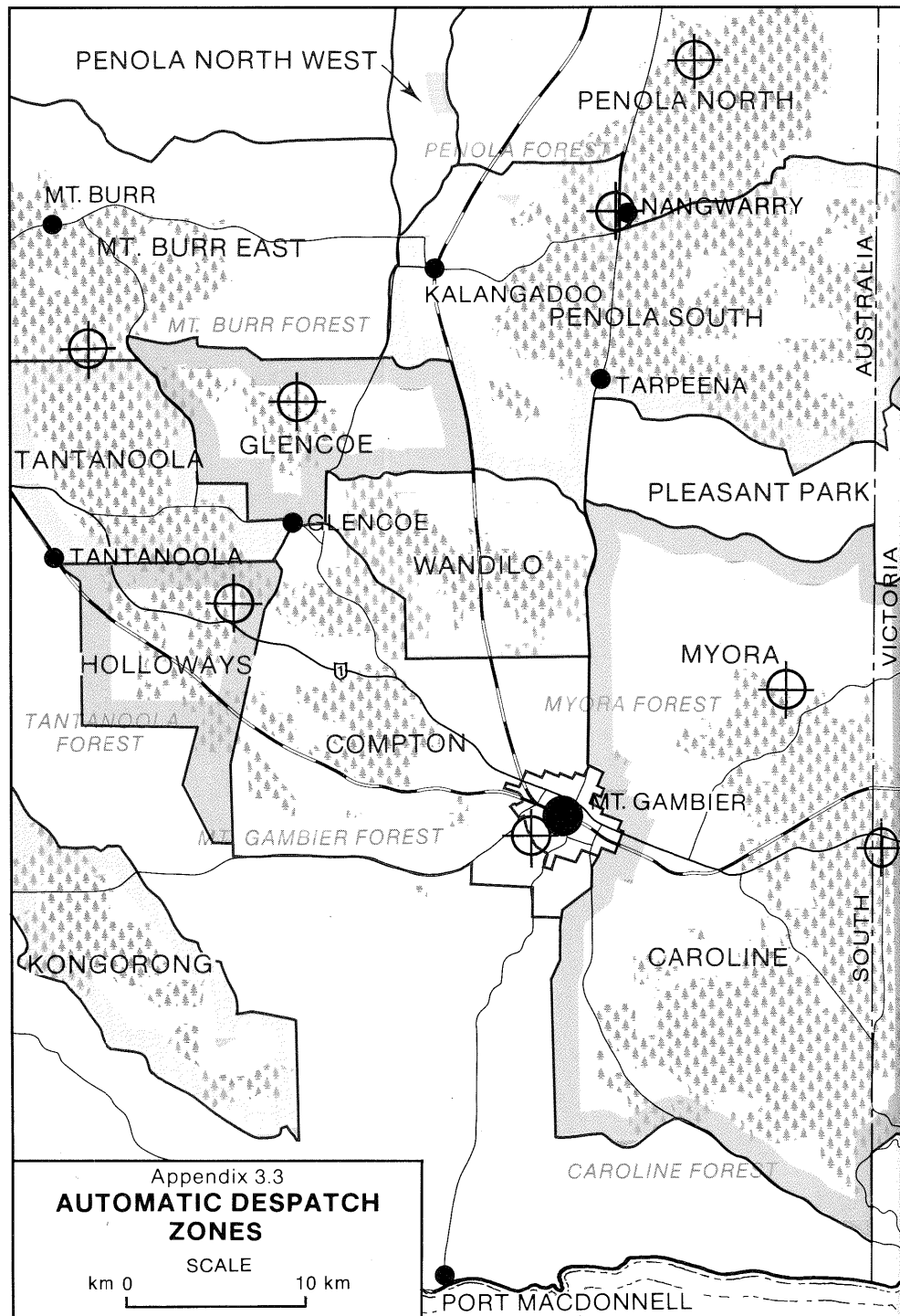
The direct attack with canvas hose requires good access for fire units.

In this area, the breaks had been well graded and maintained for access and as a result, there was no vehicle damage reported.

(iv) Conclusions

This fire is to date the largest pine plantation fire in Australia, and has provided us with information on fire behaviour and suppression tactics. It showed that under conditions of Extreme fire danger, it is not possible to halt the forward progress of a large pine plantation fire but the spread of such fires can be controlled by a direct flank attack with water.





In this fire, the only long-distance spotting recorded originated from native forest trees within the plantation area although multiple short-distance spotting was common.

The effects of prescribed burning, used as a hazard reduction measure in the native forest, were outstanding and greatly reduced the area burnt.

Despite the classic form and unusually constant wind conditions, this fire attained great size and caused massive devastation.

This review of tactics and practices confirms the soundness of present methods of suppression used in South Australian pine plantation fires and in turn, suggests that even under more unstable weather conditions they could be applied with confidence.

VIII. REFERENCES

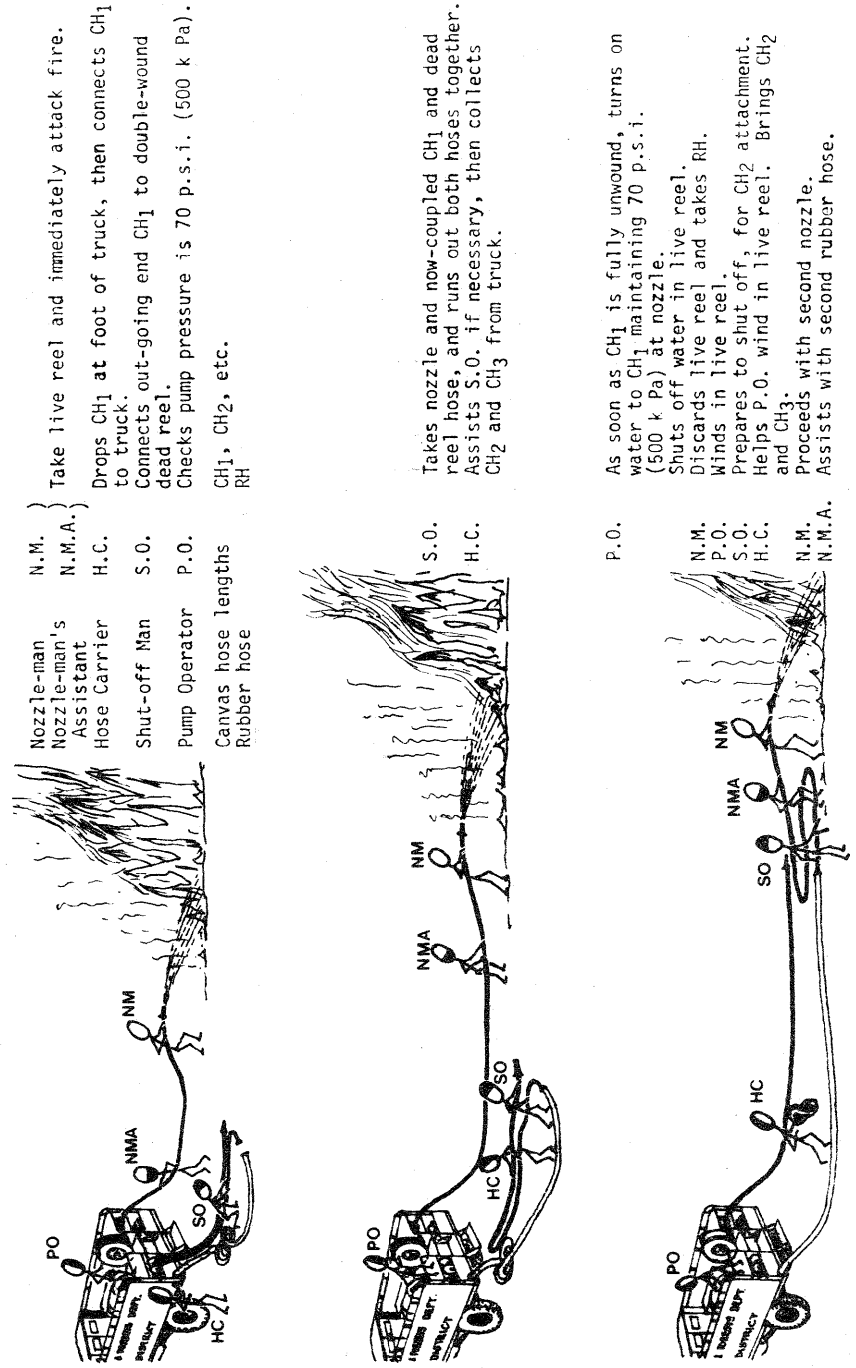
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Nozzle-man
Nozzle-man's Assistant
Hose Carrier
Shut-off Man
Pump Operator
Canvas hose lengths
Rubber hose

N.M.
N.M.A.
H.C.
S.O.
P.O.

Take live reel and immediately attack fire.
Drops CH1 at foot of truck, then connects CH1 to truck.
Connects out-going end CH1 to double-wound dead reel.
Checks pump pressure is 70 p.s.i. (500 k Pa).
CH1, CH2, etc.
RH

Takes nozzle and now-coupled CH1 and dead reel hose, and runs out both hoses together. Assists S.O. if necessary, then collects CH2 and CH3 from truck.

P.O.
N.M.
P.O.
S.O.
H.C.
N.M.
N.M.A.

As soon as CH1 is fully unrolled, turns on water to CH1 maintaining 70 p.s.i. (500 k Pa) at nozzle.
Shuts off water in live reel.
Discards live reel and takes RH.
Winds in live reel.
Prepares to shut off, for CH2 attachment. Helps P.O. wind in live reel. Brings CH2 and CH3.
Proceeds with second nozzle.
Assists with second rubber hose.

WOODS AND FORESTS DEPARTMENT

SOUTH-EAST FOREST RESERVES

The Automatic Despatch System

The purpose of this system is -

1. To vary the state of readiness for fire suppression in conformity with the daily variations in forest fire danger; and
2. To ensure that an adequate first attack force is directed to each fire as quickly as possible.

The main steps in the system are -

1. The establishment of a "readiness" schedule in the form of an "Organization Guide" and in which the numbers and locations of crews allocated for standby duties are laid down for each level of forest fire danger, for both working and non-working days.

Detection and other aspects are also covered -

2. The separation of the South-east Region as a whole into areas to which Forest Reserve fire crews will, or will not, be despatched automatically when fires occur;
3. The sub-division of the overall "automatic despatch area" into fifteen zones, five of which are designated "peripheral", and the remaining ten designated "central";
4. The establishment of a schedule which dictates for each particular automatic zone, which standby crews are to assemble automatically there when required.

It is recognized that on many occasions too large a force will commence to assemble at a fire than eventually proves to be needed, but this is accepted as being a reasonable cost in order to avoid, as much as possible, having too little equipment arrive too late.

Essential Basis for Automatic Despatch of First Attack Forces (South-east Forests only)

Forest Fire Danger	For 10 Central Auto Despatch Zones	For 5 Peripheral Auto Despatch Zones	Remarks
Low and Moderate	First attack by local action.	Additional help provided upon request.	<p>Note: (1) "Major unit" comprises 2 800 litre capacity fire appliance with high performance pump and ancillary fittings. (2) The 20 000 litre tanker will automatically attend all fires in central zone on days High and above. For peripheral zone areas, this tanker attends only by permission of Regional Forester. (3) In certain instances when fires occur in both central and peripheral zones, some uncommitted fire units will move to new standby locations away from their home base.</p>
High	4 major units, plus 3 x 5 000 litre water tankers.	1, 2, 3 or 4 major units depending on zone. One 5 000 litre water tanker and 1 or 2 small 600 litre units.	
Very High	6 major units, plus 6 x 5 000 litre water tankers.	1, 2, 4 or 5 major units depending on zone. One 5 000 litre water tanker and 1 or 2 small 600 litre units.	
Extreme	8 major units, plus 6 x 5 000 litre water tankers.	2, 4 or 6 major units depending on zone. One or two 5 000 litre water tankers and one or two small 600 litre units.	

Abbreviated Automatic Despatch of First Attack Forces
for
Central Forest Areas
1979-80

	PENOLA NORTH	MYORA CAROLINE NORTH	MOUNT BURR WEST FURNER	TANTANOOLA GLENCOE	COMPTON
HIGH (4 + 3) Week-days	2 Penola Mount Burr Conaum Supply Tankers Penola Conaum Mount Gambier	2 Myora Mount Gambier Supply Tankers Myora Mount Gambier Penola	2 Mount Burr Tantanoola Penola Supply Tankers Mount Burr Penola Tantanoola	1 Mount Burr Mount Gambier Tantanoola Supply Tankers Tantanoola Mount Burr Mount Gambier	1 Tantanoola Myora Mount Gambier Supply Tankers Mount Gambier Tantanoola Myora
VERY HIGH (6 + 6) Week-days	2 Penola Mount Burr Conaum Tantanoola	2 Myora Mount Gambier Tantanoola Penola	2 Mount Burr Mount Gambier Penola Tantanoola	1 Mount Burr Tantanoola Mount Gambier Penola	2 Mount Gambier Tantanoola Myora
Week-ends	2 Penola Mount Burr Conaum Tantanoola	2 Myora Mount Gambier Tantanoola Penola	2 Mount Burr Mount Gambier Penola Tantanoola	2 Mount Burr Tantanoola Mount Gambier Penola Myora	2 Mount Gambier Tantanoola Myora
EXTREME (8 + 6)	3 Penola Tantanoola Mount Gambier Conaum Mount Burr Myora S/by at M.G.F.R.	2 Myora Mount Gambier Tantanoola Penola Mount Burr S/by at M.G.F.R.	2 Mount Burr Mount Gambier Penola Tantanoola	2 Mount Burr Tantanoola Mount Gambier Penola Myora	2 Mount Gambier Tantanoola Myora Penola Mount Burr S/by at M.G.F.R.

NOTE:

Supply tankers (S.T.'s) to attend all zones in VERY HIGH and EXTREME conditions.
Command vehicle will normally be despatched to all fires VERY HIGH and above.
Specific standby locations of major fire units on EXTREME days are to be approved by the Regional Freester.
Trailer pump will attend all fires being attended by mechanic from Motor Vehicle Repair Section.
22 500-litre tanker to attend fires when specifically requested.

See map on page 44