BOX 9

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STIRLING RANGE FIRE BEHAVIOUR STUDY,

CURRENT DEVELOPMENT. NOVEMBER 1974

INTRODUCTION

This report gives the current state of knowledge on the fire behaviour study on the Stirling Range National Park.

It will be divided under the following headings:

(1) Vegetation

(2) Fuel assessment

(3) Fire behaviour
- (i) Wind effect
- (ii) Moisture effect
- (iii) Fuel effect
- (iv) Slope effect

(4) Predicting fire behaviour

(5) Recommendations

REPORT

(1) Vegetation

For burning purposes there are three basic fuel types occurring in the Park,

(a) Heath

(b) Woodland

(c) Moist Gully

(a) The heath type fuel covers the vast majority of the park and consists of proteaceous vegetation to between two and three metres. There is very little fuel on the ground apart from scattered sedges. Consequently the important fuel layer is the dead foliage characteristically retained on the bush for several years and building up to form an aerial fuel.

The quantity of fuel present is determined by the vegetation age, its stocking density and to a lesser extent the predominant species. For example, the Dryandra sp. have very heavy concentrations of fuel compared to Lambertia sp.

(b) The woodland fuel is a typical forest fuel type consisting of a litter bed of Eucalypt leaves plus a low understorey shrub layer. The species in the park forming the woodlands are Wandoo, yate and marri. This type covers significant areas of the park and is particularly noticeable along the Chester Pass Road.

(c) The Moist Gully type is found in the foothills of the ranges on the South facing slope in gullies with a permanent watercourse. It consists of a low jarrah canopy with a dense understorey of shrubs. It is a minor fuel type but quite complex requiring special care in burning.

Test fires were conducted mainly in the heath with a few in the Moist Gullies. No fires were conducted in the Woodland type.

(2) Fuel Assessment

A simple method of measuring quantity of heath type both live and dead has been devised. The technique consists of taking a line of twenty point samples with a thing steel rod marked off in one foot intervals. The rod is inserted through the vegetation and contacts either live or dead on each one foot intercept are recorded on a yes, no basis.

The total number of live and dead contacts for the line are summed and the amount of fuel read off against the tables -

Total No. of contacts	Total O.D.W. of all material. t/ha	Total O.D.W. of dead material. t/ha
5	3.6	1.0
10	4.3	1.2
15	5.1	1.4
20	6.0	1.7
25	7.2	2.0
30	8.5	2.4
35	10.0	2.9
40	11.9	3.4
45	14.1	4.1
50	16.7	4.8
55	19.8	5.7
60	21.9	6.8

(3) Fire Behaviour

The heath type fuel was the only one where sufficient information is available for discussion. General comments on the other two fuel types are made later.

(i) Wind effect

Because of the absence of an overstorey, wind ~~velocities~~ attain high speeds in this fuel and consequently have a major effect on fire behaviour. Results from fires on the North aspect slopes and the South aspect flats has shown that all other things being equal headfire rate of spread is linearly related to wind velocity measured at 1.5 metres.

These relationships are:

North aspect slopes MC $\approx$ 6% fuel quantity $\approx$ 12t/ha

$$\text{HFROS (m/hr)} = \frac{\text{Wind vel (km/hr)} - 2.1}{0.038}$$

South aspect flats MC $\approx$ 14%, fuel quantity $\approx$ 18t/ha

$$\text{HFROS (m/hr)} = \frac{\text{Wind vel.(km/hr)} - 1.76}{0.032}$$

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(b)
(i) Drying rate is very rapid coming from saturation to burning point in one to two days provided no rain falls in that period.

(ii) Drying days of only max temp. 14 and min RH 70% are enough to produce the above drying rates.

(iii) The continual presence of strong winds appears to be a large contributing factor to the above.

(c) There is a marked rain shadow effect caused by the East West orientation of the ranges. In the 47 day space of the trial 174 mm of rain fell on the Southerly ~~Northerly~~ aspect.* This is reflected in fuel moisture content where the southerly aspect is generally wetter, consequently having only 15 burning days for the period compared to 21 for the north slopes.

* whilst only 151 mm fell on the north slopes.

(iii) Fuel effect

No actual fuel quantity on type effect was demonstrated. Rates of spread for the Southern flat plots were on a par with and sometimes greater than the Northern slope plots. As the fuel quantities on the Southern plots was greater than the northern ones it is possible the two effects, i.e. slope and fuel, cancelled each other out. This however is only surmise and consequently cannot be of any use. More fires in different fuel types are needed to determine this.

(iv) Slope effect

As for fuel quantity no effect was demonstrated. The slopes are large, mostly in excess of 20° hence an effect would be expected in the form of increased rate of spread. Fuel distribution could be a reason for this lack of slope effect. Because the fuel is not continuous some force is required to push the flames from one bush to another. It may be that slope on its own is not a strong enough force to bend the flames into the next bit of fuel. This also explains why wind is such a dominating influence in fire spread in heath fuel.

Moist Gully Fuel type

These areas were found to be particularly heavy with fuel and the reason became obvious after repeated attempts to conduct test fires, that in Spring they just do not dry out enough to carry a fire. The fires, when they do burn, are likely to be slower moving but more intense than heath fires due to inhibition of wind movement by the thick scrub.

Woodland type

This type can suffer severely by high intensity fires through defoliation ~~on~~ leaf scorch. Although no test fires were conducted, it appears similar to Eastern jarrah wandoo country, and would best be suited by low intensity fires which should be fairly predictable by using the jarrah tables.

(4) Predicting fire behaviour

As wind velocity and moisture content have been shown to be the dominating factors affecting fire behaviour, it is logical that a prediction table utilizing these would be adequate.

From the information at hand a suitable table was drawn up and found to predict quite within the accuracy limits desirable hence -

Because of the strong influence of wind velocity on HFROS fire shape is also markedly affected. (See section 4).

This fuel requires wind to drive the fire through the suspended particles as they are not continuous. In the absence of wind, fire behaviour drops and the fire peters out.

(ii) Moisture Content

Moisture Content samples of suspended dead fuel were taken at each fire. Ignition moisture content was found to be at approximately 30% of oven dry weight.

When moisture content was plotted against headfire rate of spread whilst wind velocity was held constant, a typical exponential form was realized of the general equation $y = ab^x$.

The shortage of fires prevented analysis of all sites, however enough data was present for the Northern aspect slopes to develop these relationships.

0-6 km/hr wind velocity

$$HFROS = 160(0.8874)^x$$

6.1-10 km/hr wind velocity

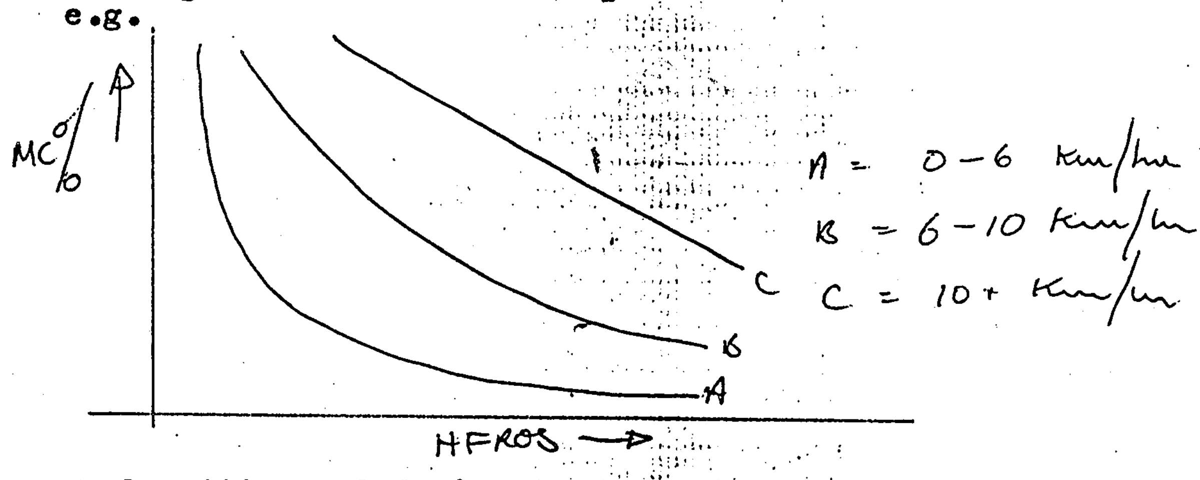
$$HFROS = 492(0.8521)^x$$

x = MC% O.D.W.

The shapes of these curves mean that for every drop of 5% in moisture content the headfire rate of spread doubles. Hence if the rate of spread is

20	metres/hr	at	20%	MC the progression is
40	"	"	15%	"
80	"	"	10%	"
160	"	"	5%	"

Indications are that when wind speed rises over 10 km/hr it tends to override the dramatic moisture content effect, forcing the curve from an exponential one into almost linear, e.g.



Fuel wetting and drying

The Autumn 1974 drying trial highlighted a number of points:

(a) Saturation of the dead material is very rapid requiring only 2 mm of rainfall to bring the moisture content from 20% to 160%.
Any excess rainfall has no effect in the subsequent time for drying as it runs off the foliage and is lost through infiltration or surface flow.

Jarrah rate of spread index	Headfire rate of spread Stirlings. m/hr
0 - 10	20
11 - 20	75
21 - 30	110
31 - 40	125
41 - 50	150
51 - 60	180
61 - 70	200
71 - 80	240
81 - 90	320

The values for the flats and slopes corresponded markedly well highlighting the apparent lack of a slope effect on headfire rate of spread.

An important effect of slope on fire behaviour is however in fire shape.

Fire shape is described by the ratio $\frac{\text{Long Axis}}{\text{Short Axis}}$ and indicators were found to be Headfire Rate of Spread and topography, hence:

Fire Shape $\frac{\text{Long Axis}}{\text{Short Axis}}$

HFROS metres/hr	Slopes	Flats
0 - 100	2.5	2.0
100 - 200	5.0	2.5
200 +	8.0	3.0

The lateral spread of a fire has great importance in planning the type of burn required.

(5) Recommendations

(1) To predict fire behaviour allow two rainless days following fuel saturation, thus allowing free moisture to dry from the fuel.

(2) Use the jarrah fire danger tables 1 and 3 on a 1:1 wind ratio to calculate a jarrah rate of spread index.

(3) Correlate this index with reported Stirling Range data to gain a rate of spread of headfire in heath type fuel.

(4) With estimated headfire rate of spread and topographical situation refer to reported table for fire shape.

Knowing headfire rate of spread and fire shape it is possible to produce a calculated fire effect. For example if a hill is to be burnt and a mosaic of burnt and unburnt patches are required, first select a jarrah rate of spread index of 70 - 80.

HEADFIRE RATE OF SPREAD M/HR NORTH ASPECT

Wind vel. km/hr	Aerial MC% 0-5	7	10	12	15	17	20	25
0-2	20	15	10	7	5	3	2	-
3	25	17	12	9	6	4	3	-
4	50	37	25	18	12	9	6	3
5	75	55	35	25	17	12	8	4
6	100	75	50	37	25	18	12	6
7	125	95	65	50	33	25	17	8
8	150	110	75	57	38	29	19	10
9	180	135	90	67	45	35	22	11
10	200	175	100	75	50	40	25	12

Unfortunately there was not enough data to draw up a similar table for the Southern aspect site.

The usefulness of the above table depends entirely on the users knowledge of the fuel moisture content prior to lighting. As there is no way of knowing this at present, the table is valueless. A trial to evaluate the use of fuel moisture indicators (in this case 12 mm _Pinus radiata_ dowels) was planned for this year, but was abandoned when the project was suspended.

A second approach to predicting fire behaviour, that is correlating the Stirling Range data with an already established fire behaviour table, was made.

The table chosen was the Jarrah Forest Fire Danger Tables which basically contain three steps:

(1) Basic Fire Danger. An estimation of fuel moisture content subject to relative humidity and temperature fluctuations.

(2) Head Fire Rate of Spread - a combination of moisture content and wind velocity to give an estimated headfire rate of spread.

(3) Rainfall Correction Factor. An estimation of available fuel due to free moisture.

Table 2 is of no value to Stirling Range fuel because unlike a forest fuel, it does not form a layer which dries sequentially from the top.

Consequently when attempting the correlation with the Stirling Range fires, any fires that were obviously affected by free moisture were excluded so that Table 2 was omitted from calculations of Jarrah rate of spread.

A Jarrah rate of spread index was calculated for the Stirling Range fires using a 1:1 wind ratio. The Jarrah rate of spread index was averaged for fires in the following classes, 0-50 metres/hr, 51-100, 101-150, 151-200, 201-250, 251-300, 301-350, and plotted against the class mid point. A smooth curve resulted giving the following information.

This will give a headfire rate of spread in excess of 200 metres/hr and as burning is on a slope a fire shape of 8.

If the extent of the slope is 1000 metres the spots at the bottom must be no closer than 125 metres if flank fire close up is to be avoided. The actual distance apart of the spots will be determined by the width of unburnt vegetation required between the burnt strips.

If a total burn is desired the spot fires should be placed so as flank fires overlap before the headfire has completed its course, and the burn timed to finish before 6 p.m.

Test fires have indicated that in Spring for which these instructions apply, fires will not sustain overnight due to high moisture pick-up with a rising relative humidity.

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