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WILDFIRE MIS-BEHAVIOUR & THE JARRAH FOREST

BY

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SUMMARY

The observed headfire rates of spread in a jarrah (E. marginata) forest summer wildfire in the South West of Western Australia were in excess of those predicted by the Forest Fire Behaviour Tables for Western Australia (Sneeuwjagt & Peet 1976).

Early indications are that this wildfire caused a minor and temporary re-structuring of the jarrah population but degraded its commercial value by up to 24%. Understorey root-stock species are re-establishing and the Acacia species component has increased significantly, the degree of increase being proportional to fire intensity and fuel age.

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INTRODUCTION

Under extreme fire weather conditions in January 1977, a wildfire near Lake Muir in the South West of Western Australia burnt through 7,100 hectares of State Forest, Flora and Fauna Reserve, Vacant Crown Land and private property.

The timbered land burnt by the wildfire was mixed jarrah-marri (E. calophylla) forest ranging from 15 - 25 metres crown top height and containing 5 and 15 year old fuels. State Forests Department personnel were engaged in suppressing the wildfire and detailed surveillance by the Department's air and ground crews gave an unequalled opportunity to examine severe fire behaviour and its effects.

Fire behaviour observed during the wildfire is compared to predictions calculated from the Forest Behaviour Tables for Western Australia (Sneeuwjagt & Peet 1976). This paper highlights and discusses a suspected weakness in the model in the higher intensity range of summer fires.

To determine the response of jarrah and understorey species to the various wildfire intensities, permanent plots were established in both wildfire and control spring burnt forest in June 1977. Results of the initial assessment of jarrah fire damage and vegetation response to fire are presented and discussed in relation to fire intensity, burn season, site and other possible contributary factors.

METHODS

(1) Fire Behaviour - Actual vs Predicted

Wildfire behaviour data ~~was~~ recorded at regular intervals throughout the duration of the wildfire and comparisons were made

of the observed fire rates of spread and the predicted rates of spread for periods of the wildfire run. Fire intensity was calculated using Byram's (1959) formula for both the 5 year old fuels in State Forest and the 15 year old fuels in Vacant Crown Land and using observed rates of spread. Surface fuel moisture contents for the northern jarrah type fuels were calculated from the Forest Fire Behaviour Tables (Sneeuwjagt & Peet 1976) using adjusted Bridgetown weather readings. Fuel and weather conditions for the wildfire periods studied are presented in Table 1. * Wind ratios of 4:1 and 2:1 were used to calculate the fire rates of spread in table 2 to account for variations in forest structure and to emphasize the strong influence of wind on summer fire behaviour.

TABLE 1 HERE

(2) Jarrah Wildfire Damage

A system of stratified random sampling was employed to determine the impact of various fire intensities on jarrah. Although assessed, the impact on marri is not discussed in this paper because of the species poor representation. It is felt that comments made in this paper are pertinent to both jarrah and marri.

Three fire intensity classes presented in table 2 were identified by the observed fire behaviour in the 5 and 15 year old fuels. These classes were further identified in the field by degrees of crown damage. Within each intensity class, three site types were identified. On each gully, midslope and ridge site, 4 belt quadrats each 4m x 100m were randomly located. Forest

* wind speed at canopy level is to wind at 1m above ground level within the forest.

containing 15 year old fuels occurred on uplands surrounded by swamps and flats so were considered midslope sites, there being no further stratification in this fuel age. A spring burnt control containing less than 1 year old fuels at the time of the wildfire was located in adjacent forest.

All jarrah trees within the sample plots were measured and placed into one of the five stem diameter over bark classes shown in figures 1-6. Trees killed by the wildfire were classified by measuring the dead stag and noting that it was dead and whether it had coppiced. Fire scaring on each tree was placed into one of 3 severity categories. Damage serverity was measured by the total area of killed cambium which was estimated from bark decorticication and exposed wood (see figs. 1-6). Damage caused by the recent wildfire as distinct from previous fires, was identified readily. Basal area and volume loss as a result of the three wildfire intensities was calculated. Fire scaring is expressed as a ratio of the basal area/ha and the total area of damage per hectare to enable damage-intensity comparisons.

(3) Vegetation Response

Vegetation response to wildfire was examined at two levels - rootstock species and non-rootstock legumes. A lack of pre-burn vegetation information precludes all but an examination of the rootstock species fire succession. This is being studied by the annual vegetation assessment of a 200 hectare study area. The study is designed to detect major vegetation composition changes by allocating an abundance code to all species occurring within a 10m radius of sample points. The belt transects used to study fire damage in jarrah were used as sample plots for counting the individual occurrences of non-rootstock legumes, particularly Acacia

species. These species have been selected for study because of speculation that their promotion by fire may improve the health of the forest (Shea, McCormick & Portlock 1979). Acacia sp. response was gauged against an adjacent spring burnt control.

RESULTS & DISCUSSION

(1) Fire Behaviour

TABLE 2 HERE

Assuming that fuel and wind estimates were not erroneous, the predicted fire rate of spread (2:1 wind ratio) for the 24th January (Table 2) is acceptable although the observed maximum rate of spread far exceeds the prediction. On the 25th of January and up to 1400 hours, the rate of spread prediction for 5 year old jarrah fuels (2:1 wind ratio) is low by a factor of 3 for the mean observed rate of spread and by a factor of 8 for the maximum observed rate of spread. The large differences may be partly explained by the likelihood that fuels in the gullies in the main run of the headfire were older than 5 years (Sneeuwjagt, 1977). For the period 1400 - 1900 hours on the 25th, the predicted and observed values differ by about 30%, which, considering the complex nature of fire behaviour, is not unreasonable. However, maximum observed rates of spread are far in excess of the predicted rates of spread. This may be a combination of spotting and crowning which is not accounted for by the prediction model (Sneeuwjagt, 1979). A lack of experimental data of the type experienced in this wildfire may also explain the discrepancies between predicted and observed fire behaviour.

The prediction model was developed using data gathered from much lower intensity spring and autumn experimental fires. The inaccuracies incurred by extrapolating the spring - autumn based model would suggest that there is a shift in the influence of certain pyro-components under summer conditions. Wind is one such component which is a controlling influence on summer fire behaviour. Under the cooler spring conditions, fire behaviour is controlled by fuel moisture content and to a lesser degree, wind speed. This is borne out in the prediction model, resulting in under predictions when fuels are very dry (Table 2). Under these dry conditions, pre-heating and oxygenation are limiting factors to rate of spread and fire intensity, both of which are influenced by wind speed. For this reason, it is most important that wind speed profiles through varying forest structures are more identifiable with forest structure than the wind ratios used by the existing model. A limiting factor to predicting summer fire behaviour is accurate forecasts of wind speed which will vary considerable on a local basis.

(2) Jarrah Fire Damage

FIGS. 1-6 HERE

Initially, wildfire impact on the jarrah population was to cause a minor re-structuring of the population distribution. Regeneration from rootstock and epicormic crown replacement should ensure that this re-structuring is temporary. All fire intensities experienced during this wildfire (Table 2) killed back to ground level a high proportion of stems less than 120mm diameter breast height over bark (d.b.h.o.b.). From Table 3 this represents

between 9% and 12% basal area loss resulting from fire intensities in excess of 500 kwm^{-1} and for intensities of less than 200 kwm^{-1}.

TABLE 3 HERE

FIG. 7 HERE

Stems >120mm D.B.H.O.B. were not killed by intensities <500 kwm^{-1}, but a small proportion of these stems were killed by higher intensity fire. There is no significant difference ($p = 0.05$) in mortality level between the defoliated and full scorch categories both within and between fuel ages. The obvious conclusion is that jarrah fire resistance increases with stem size, with trees in excess of 150mm D.B.H.O.B. being extremely resistent to the fire intensities experienced. Immunity is afforded by the thicker bark of larger trees (Beadle 1946). Large diameter trees have the added advantage of a greater cambial area, minimizing the risk of girdling by fire. In all situations where the fire intensity exceeded 500 kwm^{-1}, bark up to and often beyond the crown break of overstorey trees was completely blackened, having ignited under the very dry conditions. Fig. 7 describes an increase in charcoal depth and a decrease in bark thickness with increased fire intensity and burn season. The flaking off of burning bark is yet another mechanism to protect the sensitive cambial tissue from heat damage, but not all burnt bark flakes off as evidenced by charcoaled stems. Reduced bark thickness and blackened stems must combine to detract from the bark's properties of insulating cambial tissue from damaging

radiation. Stand dynamics may be affected by the increased solar energy absorption of the blackened stems which may persist up to 10 years.

As this is a preliminary report, no conclusions on the long term effect of wildfire on jarrah growth rates can be made. The small stem component of the population (<150mm d.b.h.o.b.) has suffered a setback of 5-15 years, being the approximate age spread of most stems killed by fire. This setback was consistent in all intensity classes sampled as indicated by the percentage basal area loss figures (Table 3) which, considering the range of intensities, are consistently low.

Ecologically, jarrah appears little affected by wildfires. Commercially however, the jarrah stand has been degraded by wildfire. It is apparent that the incidence of dry siding increases with burn intensity and fuel age. As with mortality, fire damage (dry siding) incidence decreases with stem size. The extent of secondary and tertiary damage is very much dependent on the quantity of large woody fuels available for burning. The availability of such fuels is regulated by past logging history and the fuel dryness, which is highest in summer. The reduced incidence of secondary and tertiary damage in gully sites is probably a result of lower tonnages of <u>woody</u> fuels. The ridge sites displayed a higher degree of logging activity as evidenced by the ground debris (4t/ha) and coppice on stumps. Summer wildfires ignite stumps and heavy woody fuels which burn for many days. This long slow heating of nearby stems is far more effective at inducing dry siding than the fast burning nature of leaf litter fuels (Beadle 1940). Under spring conditions woody fuels are damp and are often extinguished by the cool, moist spring evenings. Tertiary dry-

siding imparted as a result of the rapid combustion of fine litter fuels was most severe on the leeward side of stems. This is as a result of the "chimneying" effect which leaves a narrow fire scar running vertically up the stem. Injury of this type will occlude much faster than the broad, radial scars imposed by burning logs. (Hare, 1961)

A reduced availability of heavy woody fuels for burning and the cool, moist edaphic and climatic spring conditions combine to minimise fire damage to jarrah (Table 3).

(3) Vegetation Response

Rootstock species killed by fire have regenerated from rootstock and appear to be occupying the same spaces as they were prior to the wildfire. It is too early to comment on the fire succession in any more detail.

Legumes such as <u>Acacia alata</u>, <u>Acacia pulchella</u>, <u>Acacia myrtifolia</u> and <u>Kennedia coccinea</u> are strongly represented following the summer wildfire.

FIG. 8 HERE

Dry soils and heavy fuels encourage the successful germination of the soil stored seeds (Christensen & Kimber 1975). From Fig. 7, the successful establishment of Acacia sp. has increased with fire intensity until defoliant conditions are reached in the 5 year old fuels. This is inconsistent with the Acacia response to defoliant fire conditions in 15 year old fuels. It is assumed there was a lack of soil stored seed in the 5 year old fuel type. There is a highly significant difference ($p = 0.05$) in the

successful germination of Acacia sp. between the two fuel ages examined. This is in keeping with Christensen & Kimber (1975) who found that fire intensity, per se, was not as important in stimulating seed germination by temperature treatment as fuel available for burning and seasonal dryness of both fuels and soils. This is further supported by the poor response following spring burning (fig. 7) even though fire intensities were similar to the 30% scorch category of the wildfire. Factors contributing to the poor spring burn Acacia and Kennedia response probably include (a) poor degree of heat penetration into the soil (b) less energy available for heating Soil as energy is used in overcoming latent heat of vapourization (c) poor reduction in phytoxic allelopathy (d) poorer mineralization of organic matter.

CONCLUSIONS

The Forest Fire Behaviour Tables for Western Australia (Sneeuwjagt & Peet, 1976) grossly under-predicted the fire rates of spread experienced during the Lake Muir Wildfire. Further research is required to improve the spring fire data based model for summer use.

Following assessment some 2½ years after the summer wildfire it can be concluded that the jarrah population is resilient to the fire intensities experienced but is commercially degraded and suffers temporary reduction in fire immunity. Immunity will increase with time as bark is replaced and fire scars occlude. Sequential fires before healing is complete will further degrade the timber value of the jarrah forest.

A lack of pre-burn vegetation data prevents the drawing of a detailed vegetation response conclusion. Rootstock species such as Bossiaea linophylla and Hakea lissocarpa readily regenerated

from rootstock. Non-rootstock species requiring seed heating for optimum germination were favoured by the summer wildfire and high fuel quantities.

ACKNOWLEDGEMENTS

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TABLE 1

Surface Fuel Moisture Content (S.M.C.) and weather conditions for the duration of the Lake Muir Wildfire.

PERIOD	* Min. S.M.C. (%)	Wind Speed (K.P.H.)	Min. R.H. (%)	Max. Temp (°C)	* Fire Danger Rating
24 January					
1315 - 1830 hrs	7	20	20	37	Extreme
24/25 January					
1830 - 1100 hrs	13	6	O/NIGHT	O/NIGHT	Moderate
25 January					
1100 - 1400 hrs	5	15 - 30	25	40	Extreme
1400 - 1900 hrs	4	10 - 30	25	40	Extreme
25/26 January					
1900 - 0900 hrs	12	10	O/NIGHT	O/NIGHT	Moderate
0900 - 1700 hrs	4	5 - 20	20	30	Extreme

* Calculated from Forest Fire Behaviour Tables for Western Australia (Sneeuwjagt & Peet, 1976).

TABLE 3

Commercial impact of fire intensity and season of fire on jarrah.

1	2	3	4	5	6	*7
Summer Fire						
100 - 2,00	5	20.3	19.6	3.4	8.0	8.0
500 - 2,000	5	19.2	17.2	10.0	7.0	12
500 - 2,000	15	22.2	20.2	9.0	6.5	15
5,000 - 9,000	5	15.0	14.0	7.0	5.4	22
5,000 - 10,000	15	16.0	14.0	12.5	5.0	24
Spring Control						
100 - 200	5	20.6	20.0	2.9	12.1	5

* Calculated assuming a reduction of 1m in commercial log length as a result of secondary and tertiary damage.

1 - Fire intensity class (Kwm^{-1})

2 - Fuel Age (Years)

3 - Pre-burn Basal Area (M^2/ha)

4 - Post-burn Basal Area (M^2/ha)

5 - Basal Area Loss (%)

6 - $\frac{\text{Post-burn Basal Area}}{\text{Area Cambial Kill}}$

7 - Commercial Vol. Loss (%)

TABLE 2

Observed & predicted rates of spread for periods of the Lake Muir Wildfire Using 2:1 & 4:1 wind ratios

Period	(Years) Fuel Age/Type	*Predicted R.O.S. m/hr		Observed R.O.S. m/hr		+Intensity Kwm^{-1}	Canopy Damage
		2:1	4:1	Mean	Max.		
24 January							
1315 - 1830 hrs	15 - Jarrah + Flats	834	216	1 000	3,500	6,192	Defoliation
24/25 January							
1830 - 1100 hrs	15 - Jarrah uplands	72	57	80	200	500	Full Scorch
25 January							
1100 - 1400 hrs	5 - Jarrah uplands	700	146	2,300	6,000	9,400	Defoliation
1400 - 1900 hrs	5 - Jarrah uplands	1,000	207	1,400	2,000	5,780	Full Scorch & Defol.
1400 - 1900 hrs	15 - Jarrah + Flats	3,000	621	2,500	6,000	15,480	Defoliation
25/26 January							
1900 - 0900	5 - Jarrah + Flats	36	23	50	-	200	Half Scorch
1900 - 0900	15 - Jarrah + Flats	108	69	80	150	500	Full Scorch
0900 - 1700	5 - Jarrah uplands	610	148	500	-	2 000	Full Scorch

* Predictions calculated from Forest Fire Behaviour Tables for Western Australia (Sneeuwjagt & Peet 1976)

+ Byram Intensity (Kwm^{-1}) = H.W.R.

WHERE: H = Heat yeild 18,600 ($Kj\ kg^{-1}$)

W = Weight of burnt fuel ($kg\ m^{-2}$)

R = Fire rate of spread (ms^{-1})

Figs. 1-6: Impact of different fire intensities & fuel ages on jarrah.

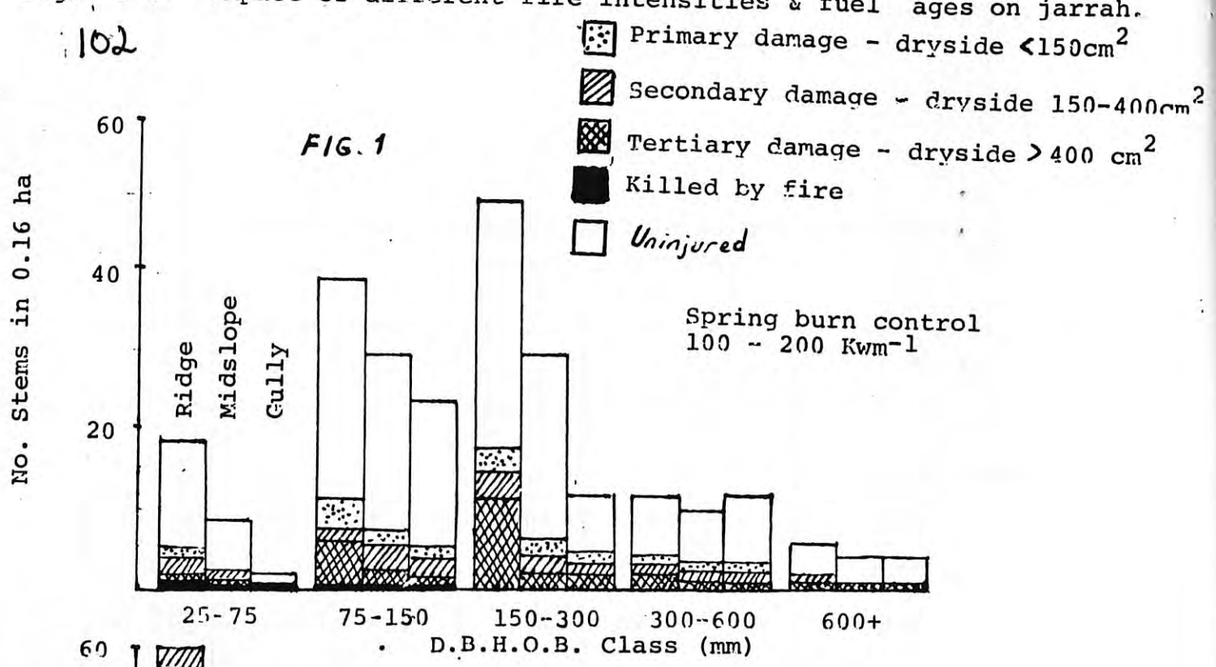


FIG. 2

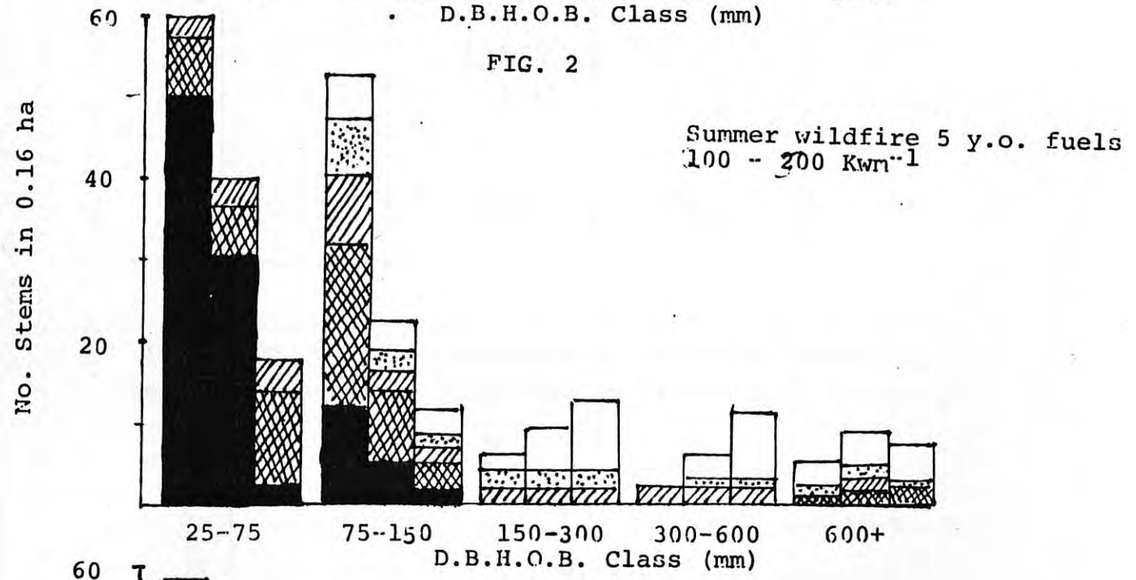


FIG. 3

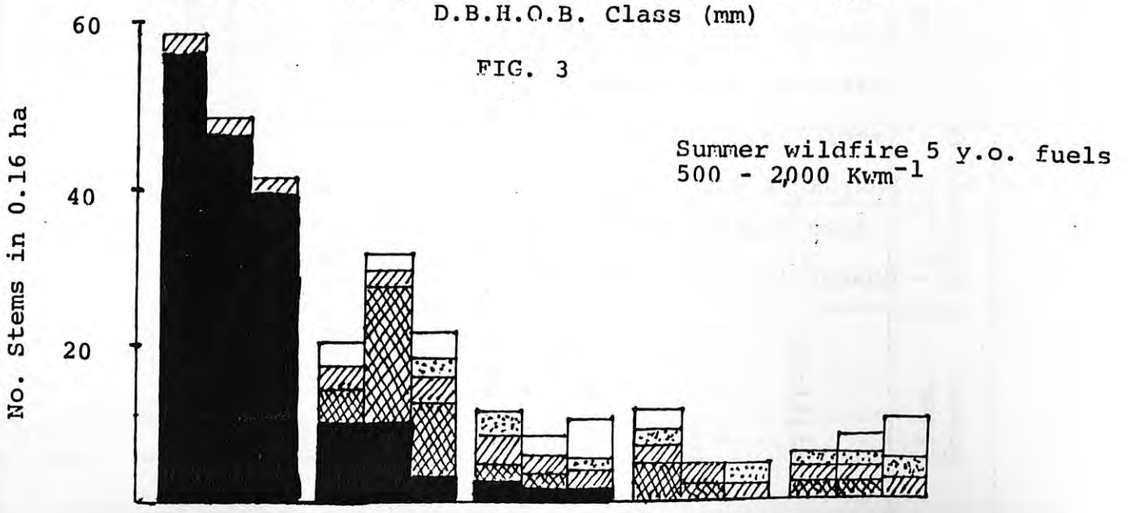


FIG. 4

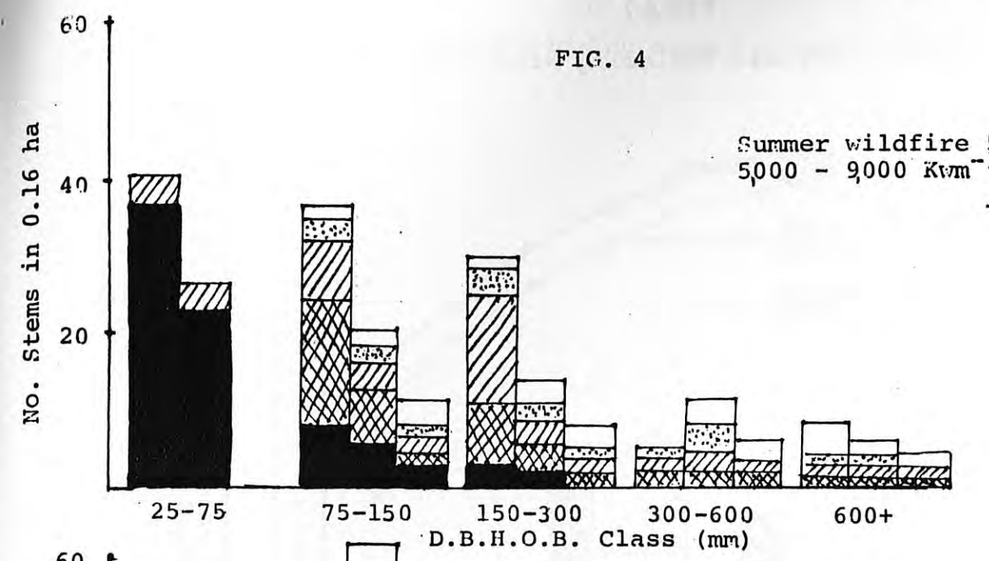


FIG. 5

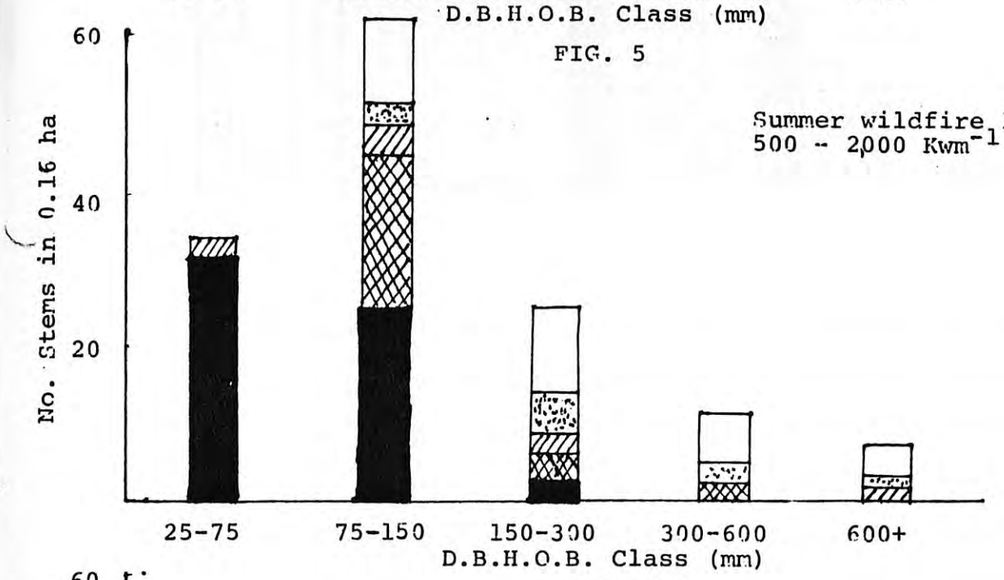


FIG. 6

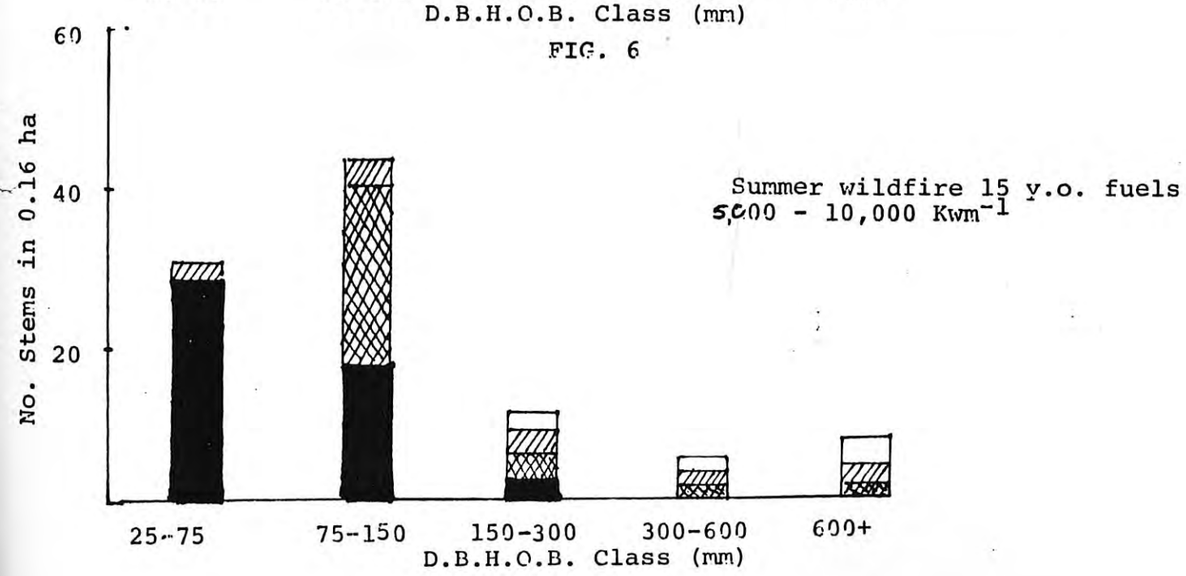
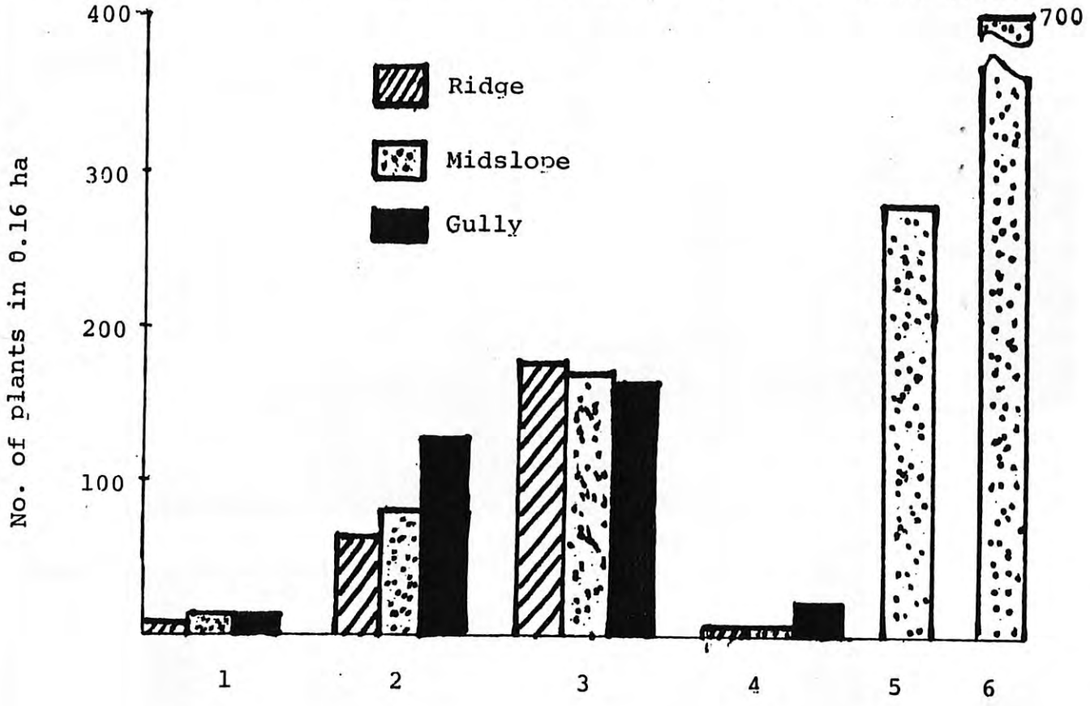


FIG. 7

Acacia sp. response following wildfire & control burn.



1 - Spring control fire, 5 y.o. fuels (100-200 Kwm^{-1})

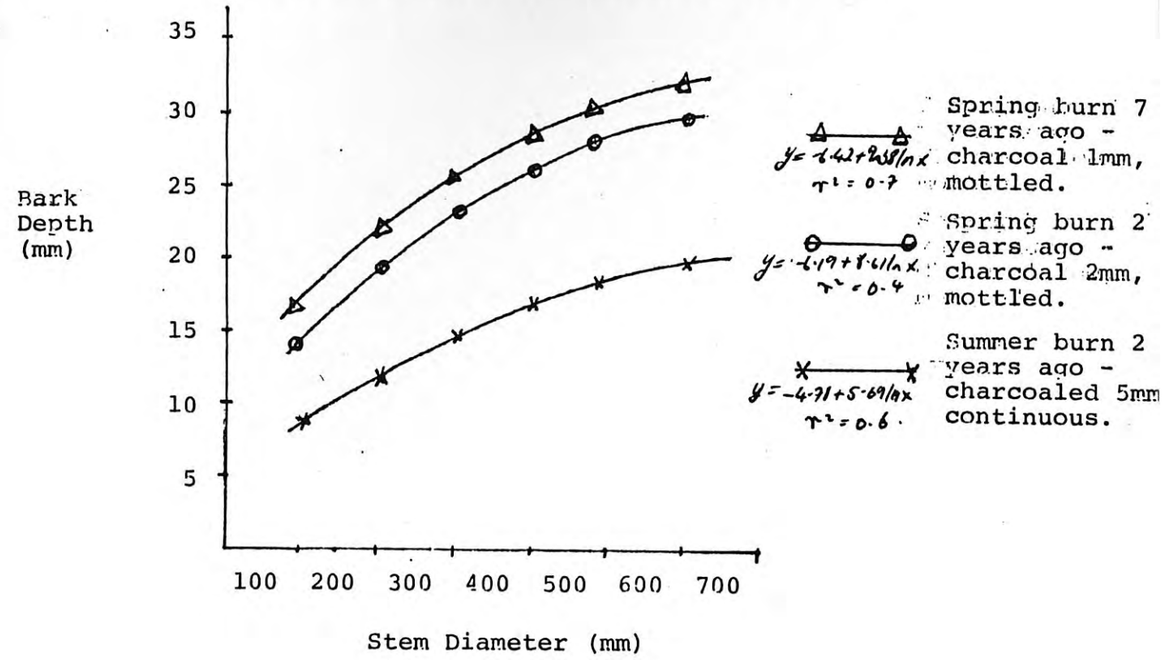
2 - Summer wildfire 5 y.o. fuels (100-200 Kwm^{-1})

3 - Summer wildfire 5 y.o. fuels (500-2,000 Kwm^{-1})

4 - Summer wildfire 5 y.o. fuels (5,000-9,000 Kwm^{-1})

5 - Summer wildfire 15 y.o. fuels (500-2,000 Kwm^{-1})

6 - Summer wildfire 15 y.o. fuels (5,000-10,000 Kwm^{-1})

FIG. 8

Jarrah bark & charcoal depth following summer & spring fires.