Landnote

Department of Conservation & Land Management

3/88

INTENSE FIRE BEHAVIOUR IN A 16 YEAR OLD STAND OF KARRI (Eucalyptus diversicolor) AND YELLOW STRINGYBARK (Eucalyptus muellerana)

By L. McCaw, R. Smith, J. Neal
Dept. of Conservation and Land Management
Research Centre Manjimup W.A. 6258

SUMMARY

This report describes the behaviour of a small but intense fire which burnt a 16 year old stand of karri (*Eucalyptus diversicolor*) and yellow stringybark (*Eucalyptus muellerana*). The fire developed rapidly from burning embers blown across a track and within 30 minutes of ignition had travelled 350 m and burnt out 12 ha of forest, much of it completely defoliated. The estimated rate of forward spread of the fire was considerably greater than that predicted for mature karri forest by the Forest Fire Behaviour Tables.

INTRODUCTION

Young regenerated stands of karri (*Eucalyptus diversicolor)* are now an important component of the southern forests of Western Australia. Fire is excluded from regenerated stands until the co-dominant trees have attained sufficient height and bark thickness to tolerate the use of low intensity fire for fuel reduction. To date, the fire management strategies adopted in the Southern Forest Region have successfully restricted the area of young stands burnt by wildfires to only a few hectares each year.

Despite this, there remains the potential for large, high intensity fires to develop in regenerated forest on a number of days during each summer. Such fires can be extremely destructive and may eliminate several decades of growth during a single afternoon; the 1980 fire at Eden is ample testimony to this fact (Sneeuwjagt 1981, Bridges 1983).

Opportunities to study the behaviour of moderate and high intensity fires in regenerated forest are limited. There is an understandable reluctance to sacrifice good stands for experimental purposes, as well as practical problems associated with safe implementation of intense fires. Any information about fire behaviour that can be gathered opportunistically during wildfires is therefore valuable.

The purpose of this note is to describe and discuss the behaviour of a small but intense fire which burnt a 16 year old stand in the Manjimup District on January 4th 1988.

METHODS

Stand description

The fire burnt 12 ha of a 16 ha patch located on Schell Rd, Andrew block about 25 km NW of Manjimup. At the time of the fire the stand was approaching 16 years old. The site had been cleared and debris windrowed prior to planting in 1972 with a mixture of karri and yellow stringybark in approximately equal proportions. The stand was located on gravelly soils in a mid-lower slope position with a generally westerly aspect and slope of 5^{o}.

Dominant trees in the stand were 20-22 m in height but there were many smaller stems and canopy closure was incomplete. For this reason, the 3-5 m tall understorey of netic (*Bossiaea laidlawiana*) had not been suppressed to any significant degree and generally remained standing.

Fuel assessment

The amount of fuel consumed by the fire was estimated from samples collected in an adjacent unburnt area of the stand; this area had remained unburnt because of action by suppression crews. At each of 4 points we collected 5 quadrats (each 0.04 m^2) of litter from the forest floor and a 2.5 m^2 quadrat of elevated fuel that included trash (suspended dead twigs and bark < 25 mm diameter) and scrub foliage. Fuel samples were oven dried and then weighed. We also determined the diameter to which live scrub stems had been consumed by the fire in areas subject to complete crown scorch and to defoliation; in each case 30 stem diameters were measured with calipers.

Weather data

Weather data were obtained from records at the Manjimup District Office, except in the case of wind speed and direction which were estimated by an experienced officer (A. Hordacre) at the fire.

RESULTS AND DISCUSSION

Weather situation

During the month of December 1987 dry conditions were experienced up until the 24th when there was widespread rainfall across the Manjimup district; 25 mm were recorded at Manjimup on this day. Light falls continued over the following days until 1st January 1988. Drying rates of fine fuels would have been slow due to heavy cloud cover and high relative humidity. The Soil Dryness Index (Mount 1972, Burrows 1987) was approximately 1120 on the day of the fire.

January 4th was a hot, dry day with light to moderate south westerly winds at Andrew block (Table 1). For karri with a type 4 + 5 understorey, the predicted surface and profile moisture contents were 7% and 46% respectively. On the basis of the wind speeds experienced at Andrew block, the predicted rate of forward spread for mature karri forest with standard fuel conditions (15-19 t/ha of available fuel) was 30 m/h (Table 1).

Table 1 Weather conditions, predicted fuel moisture and predicted rate of forward spread for mature karri forest on January 4th 1988.

Weather variable	
Maximum temperature (°C)	37
Minimum relative humitity (%)	17
Dew Point (°C)	8
Cloud cover	five eighths
Wind speed and direction (*a*)	8-10 km/h from SW
Fuel moisture	
Karri (4+5) Surface Moisture Content (%)	7
Karri (4+5) Profile Moisture Content (%)	46
Soil Dryness Index	1120
Predicted rate of forward spread	
Karri (4+5) (m/h)	30

(*a*) Estimated tower wind conditions at Andrew block (in the open at 30 m above ground level).

Description of the fire

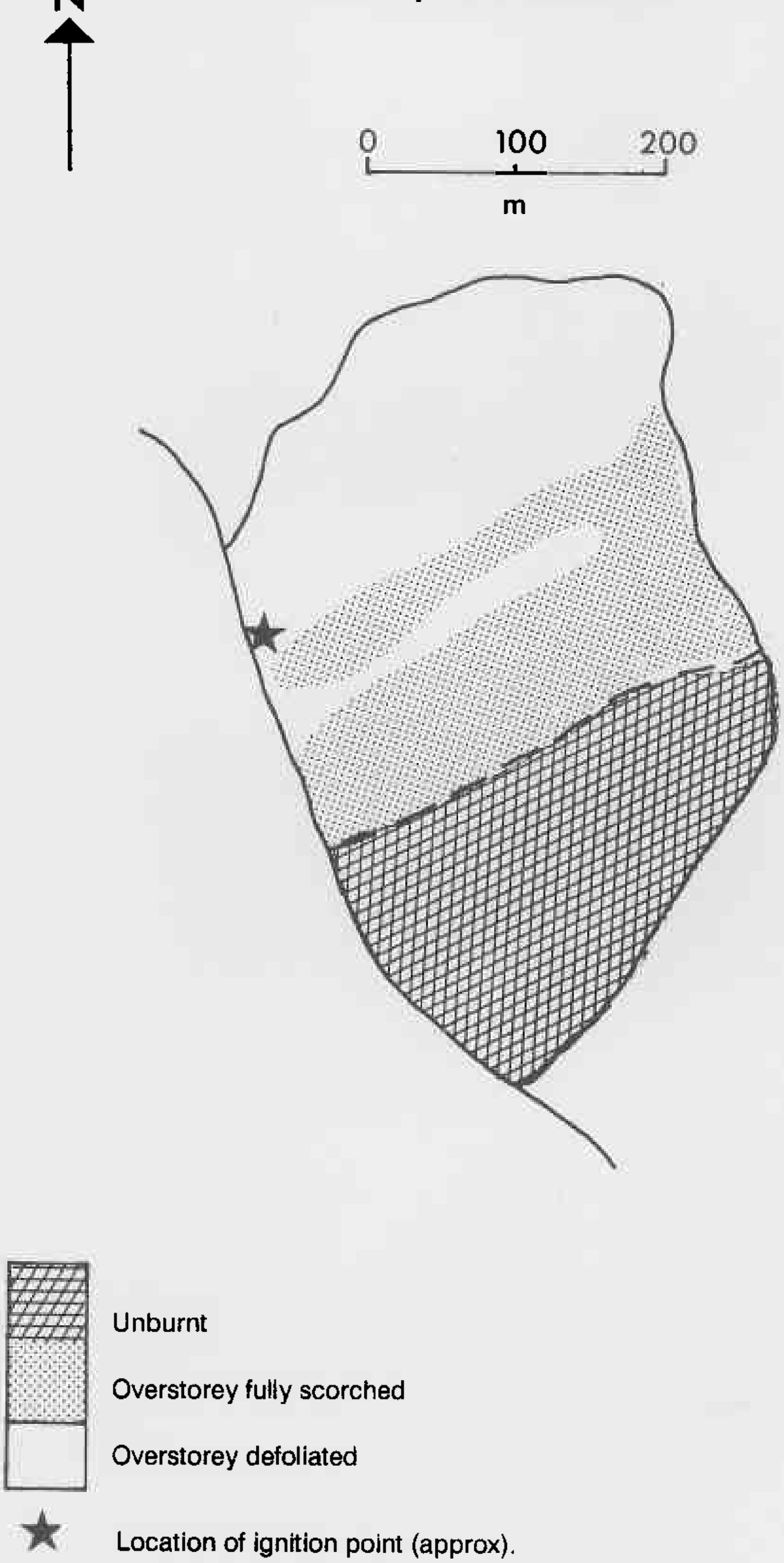
The 16 year old stand was surrounded by mature forest which had been burnt during the previous month as part of a routine aerial prescribed burning operation. At 1535 hours the pilot of a spotter aircraft reported that a hopover from the mature forest had burnt about 10 m into the regenerated stand. Flame heights at this time were estimated to be about 1 m. Embers blown across the track from a burning tree were probably responsible for ignition.

Fire crews arrived on site at about 1605 hours to find that the fire had burnt upslope to the northern and eastern edges of the stand; crews reported that mature trees for a distance of up to 50 m into the adjacent burnt forest had been ignited by spotting activity. During the 30 minutes since the aircraft report the fire had travelled 350 m, so that the average rate of forward spread during this period would have been 700 m/h.

The southern flank of the fire was only of low intensity and suppression crews were able to construct and hold a fireline with hand tools along an old track alignment. Edge fires lit along this track burnt quietly with an average flame height of 0.5 m.

Most trees in the northern half of the burnt area were completely defoliated except for a band along the western edge (Fig. 1). In the southern section most tree crowns were fully scorched, but only scattered patches had been defoliated. Given the completeness of defoliation in the main path of the fire and the high rate of forward spread it is likely that trash, understorey and tree crowns were consumed simultaneously by an active crown fire front. The southern flank of the fire was burning across the slope and across the direction of the prevailing wind and was therefore substantially less intense.

Fig. 1. Pattern of crown damage in regenerated forest caused by the fire of 4/1/1988



Fuel consumption

Litter and trash fuels were completely consumed throughout the defoliated section, but patches of partly consumed litter remained along the southern flank. In defoliated sections of the stand live understorey stems up to an average of 5 mm had been consumed whereas in the scorched section only live material less than 2 mm diameter had been consumed. Despite this difference the estimated quantity of litter, trash and understorey fuel consumed in the defoliated section (21.8 t/ha) was only slightly greater than that consumed in the fully scorched section (20.7 t/ha Table 2). Additional fuel from tree crowns was also consumed in the defoliated areas; although not assessed during the fuel sampling this probably comprised a further 8-10 t/ha (unpublished data).

Table 2. Fuel characteristics of 16 year old regrowth at Schell Rd determined from field sampling.

Fuel component	Quantity (t/ha)	
	Mean	SEM
Litter	10.2	0.6
Trash	4.8	2.2
Scrub foliage		
- dead	4.0	1.9
- live <2 mm diameter	1.7	0.4
- live 2-5mm diameter	1.1	0.3

Fire intensity

Fire intensity (Byram 1959) is calculated from the product of the amount of fuel consumed, the rate of fire spread and the heat yield of the fuel; the latter quantity is relatively constant for eucalypt forest fuels.

The intensity of the main headfire would have been of the order of 10-11000 kw/m, based on an average rate of forward spread of 700 m/h and 30 t/ha of fuel consumed in defoliated parts of the stand. Estimation of the intensity of flank fires is more difficult because flankfire spread rates could not be reliably determined. Trees in flankfire zones were scorched to full height, with occasional defoliated patches, so that fire intensities were probably in the range 1000-1500 kw/m. Calculated values for fire intensity would be slight over-estimates because not all of the fuel would have been consumed in the active combustion zone, in particular the larger diameter components of the trash fuel.

Fire intensities in the range 3000-7000 kw/m are defined as high, while those above 7000 kw/m are defined as very high (Cheney 1981). Attempts to suppress fires above 3000 kw/m in intensity are rarely successful in forest fuels, even with heavy machinery and aerial retardant drops (Loane and Gould 1985). Under these conditions, control can only be achieved when the fire encounters a low fuel buffer of sufficient width to contain the massive spotting activity associated with the headfire.

Comparison of observed rate of forward spread with predicted rate of forward spread for mature forest

To provide a comparison with the regenerated stand, the rate of forward spread expected in mature forest under equivalent weather conditions was calculated from the Forest Fire Behaviour Tables (Sneeuwjagt and Peet 1985) for three ranges of wind speed.

Inputs used in the calculation were as follows:

1.	Fuel quantity (t/ha)		
	- litter	=	10.1
	- trash	=	4.8
	- scrub foliage (6.8 t/ha) x flammability factor (3.0)	=	20.4
	- estimate of eucalypt crown foliage consumed	=	10.0
	- Total	=	45.3
2.	Fuel quantity correction factor	=	2.8
3.	M^c^Arthur slope correction	=	1.4
4.	Karri (4 + 5) Surface Moisture Content (%)	=	7
5.	Predicted rate of forward spread (m/h)		
	- fortower wind 6-10 km/h	=	118
	- " " 11-16 "	=	149
	- " " 17-22 "	=	227

The estimated rate of forward spread in the regenerated stand (700 m/h) greatly exceeded the spread rates predicted for mature forest even with tower wind speeds of up to 22 km/h.

However previous studies have found that low intensity surface fires which consume only the litter and trash fuels in regenerated stands do have similar rates of spread to those predicted for mature forest provided that the fire is not advancing upslope, and that wind speeds at flame height remain below 2.5 km/h (McCaw 1986). The current Forest Fire Behaviour Tables were developed for mature forest where crown fires are rarely experienced because of the distinct separation between the understorey and overstorey crown strata. Van Wagner (1977) proposed that there was a critical surface fire intensity required for the initiation of a crown fire. The critical intensity level appears to be quite low in young regenerated stands, no doubt because of the presence of elevated trash and understorey foliage; in this particular stand the rough fibrous bark characteristic of *E. muellerana* may have also contributed to the initiation of crown fire.

Recovery of the stand

Current knowledge of the post-fire response of young karri indicates that karri trees < 15 cm diameter which have been defoliated are unlikely to recover to any significant degree. Larger trees which have been defoliated may resprout from epicormic shoots on the stem but will have suffered extensive damage to the upper stem which will render them incapable of any future productive growth.

Fully scorched karri should resprout from epicormic shoots on the stem and larger branches, and eventually revert to a relatively normal crown. This may take 3-5 years during which diameter and height growth will be significantly retarded. Serious scarring of the lower stem may also have occurred, although the fact that woody debris had been windrowed prior to planting will tend to reduce the incidence of stem damage.

The tolerance of *E. muellerana* to fire has not been investigated in detail in Western Australia. However the species has thick rough bark and appears to resprout vigorously and may therefore at least equal karri in fire tolerance.

A small experiment to compare the recovery of karri with that of *E. muellerana*, and to evaluate the cost effectiveness of several rehabilitation techniques has been established at the site.

CONCLUSION

The potential for intense fires to develop rapidly in young regenerated forest is clearly illustrated by the events at Schell Rd. Fire behaviour could be expected to be considerably more severe during hotter and drier conditions, and in the event of a major headfire entering young regeneration. Fire protection measures for regenerated forest areas should therefore continue to receive top priority.

The advent of commercial thinning in young stands will have a major impact on fire protection measures. Thinning has the effect of flattening the understorey and disrupting the vertical continuity of the fuel complex which should reduce the potential for crown fire development. Prescribed burning should be possible during mild spring conditions in thinned stands. However the implications for wildfire behaviour of the drier fuel conditions and greater wind penetration in thinned stands should not be overlooked.

Other types of regenerated forest may have a similar fuel and vegetation structure to young stands of karri; for example rehabilitated bauxite mine pits. This study may provide a guide to the fire behaviour potential of these stands.

ACKNOWLEDGEMENTS

We would like to acknowledge the assistance of Alan Hordacre, Manjimup District with the preparation of this report.

REFERENCES

Bridges, R. (1983). Integrated logging and regeneration in the silvertop ash-stringybark forests of the Eden region. Forestry Commission N.S.W. Research Paper 2.

Burrows, N.D. (1987). The Soil Dryness Index for use in fire control in the south-west of Western Australia. Department of Conservation and Land Management Technical Report No . 17.

Byram, G.M. (1959). Combustion of forest fuels. *In* Forest fire: control and use. Ed. by K.P. Davis McGraw Hill, New York.

Cheney, N.P. (1981). Fire behaviour. In "Fire and the Australian biota". Ed. by A.M. Gill, R.H. Grove and I.R. Noble. Aust. Acad. Sci. Canberra. pp 151 -176.

Loane, I.T. and Gould, J.S. (1985). Aerial suppression of bushfires - cost benefit study for Victoria. CSIRO Division of Forest Research, Canberra.

McCaw, W.L. (1986). Behaviour and short term effects of two fires in regenerated karri (*Eucalyptus diversicolor*). Forest Department. Conservation and Land Management Technical Paper. No. 9.

Mount, A.B. (1972). The derivation and testing of a soil dryness index using run-off data. Forestry Commission Tasmania Bulletin 4.

Sneeuwjagt, R.J. (1981). The Eden fire and its implications for fire protection. IFA Newsletter 22(3).

Sneeuwjagt, R.J. and Peet, G.B. (1985). Forest fire behaviour tables for Western Australia. Department of Conservation and Land Management.

Van Wagner, C.E. (1987). Conditions for the start and spread of crown fires. Canadian Journal of Forest Research 7:23-34.