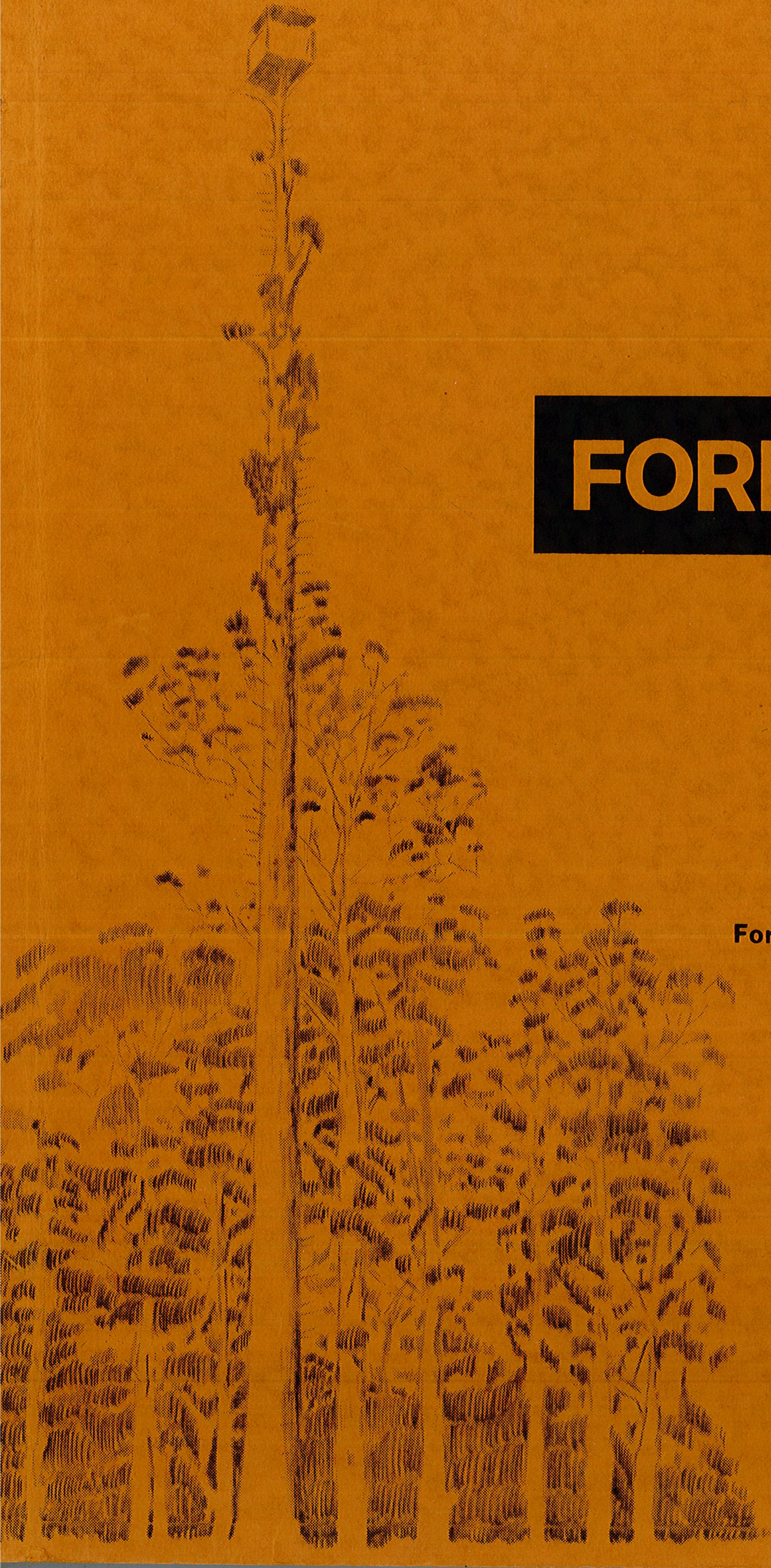
& supplement
Special issue
Fire control 1971

MR. WHITE



FOREST NOTES

Forests Department Perth Western Australia

VOL 9 NUMBER 5

FOREST NOTES

SPECIAL ISSUE ON FOREST FIRE CONTROL IN W.A.

March, 1971.

Editors: R.J. Underwood and G.B. Peet.

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EDITORS' NOTES

This is the second "Special Issue" of Forest Notes and is devoted to aspects of forest fire control in Western Australia. The Editors' objective was to publish a series of papers covering the broad spectrum of forest fire control activities in the south-west: policy, operations, research and ecology.

Naturally all aspects of this wide field could not be covered and the result may be deemed by some to be lopsided in one direction or another. For instance, little attention is given to the vital, and at the moment controversial subject of fire weather and forecasting, while on the other hand the number of papers submitted dealing with aspects of pine burning is out of proportion to the significance of this operation within the overall context of current departmental fire activities.

Nevertheless, it is felt that the major requirements of the publication of a "Special Issue" are met. These are, firstly to inform staff by what is perhaps a more stimulating medium than the official circular; and secondly to set down a record of the accomplishments, problems and philosophies of our fire control organisation at this stage in the history of the department.

The hard work and enthusiasm of all contributors is gratefully acknowledged.

R.J. Underwood and G.B. Peet.

FOREST FIRE CONTROL POLICY IN W.A.

by

F.J. Campbell.

Western Australian Fire Control Policy is based on prevention by hazard reduction and classical techniques of pre-suppression and suppression.

Many of these policies have stood the test of time but there have been modification and developments from increased knowledge, new technology and sociological changes.

In this paper, comments are made on some of the more recent policy changes and on future changes which can be anticipated.

PREVENTION – by risk reduction.

Public education has largely developed as the province of the Bush Fires Board and Fire Brigade Board. However, there is a need for local education of school children and neighbouring private owners, by divisional staff. Consideration of fire causes and locations each season indicates where education is needed.

Bush Fire Brigade organisation in the South-west has shown marked improvement during the last decade but can benefit from guidance and encouragement from local foresters.

Law enforcement has become a stronger deterrent as Shires have accepted their responsibilities under the Bush Fires Act. Regular reporting to the Shires of fires adjacent to State Forest, has played an important part in obtaining Shire involvement.

PREVENTION – by hazard reduction.

Control burning has undoubtedly proved in W.A. to be one of the major tools of fire prevention. Rotational burning in hardwood areas has probably been the key to reduced fire losses evidenced over the past several years (see Table I).

The justification for and selection of burning frequency, intensity and season must still be based on the following criteria in order to balance cost against potential loss:

(i) isolation of high risk and high value areas;
(ii) reduction of forest crop damage by wildfire with broadcast rotational burning;
(iii) minimising fire risk in trade operation areas by advanced burning;
(iv) removal of dangerous fuel concentrations by top disposal burning, regeneration of cut over forest, and minimising possible plantation fire losses by subdividing large blocks with control burned buffers.

The balancing of cost against potential loss has been a subjective process which is in need of economic study but on the whole there have been few problems in selecting management objectives aligned primarily at protection of the tree crop and community assets. There is and will be increasing demands for management to be directed specifically at flora and fauna protection, water production and recreational values. Eventually this will lead to precise area definition of management aims and hazard reduction techniques can then be directed accordingly. Until further knowledge indicates the need for reconsideration, present control burning practice will continue.

The major extension of areas control burned in recent years has been a direct result of greater understanding of fire behaviour, the factors influencing it and their use in predicting suitable weather. This understanding, which has come from research done by G.B. Peet and his co-workers, has placed Western Australia as world leaders in the use of controlled fire for forest fuel reduction as a fire prevention measure.

The application of this technique must always be preceded by careful planning and weighing of management aims, side effects, economic and aesthetic costs against fire preventions benefits to the multiple uses and users of State Forests.

The development of aerial ignition of control burns has reduced the cost and manpower component of control burning thus resulting in its extension to almost all State Forest – a most important aspect with the decline in available funds and men. The application of control burning under pine canopy is still in its infancy but holds considerable promise in reducing potential wildfire losses and minimising expensive mechanical and chemical fire break establishment.

In both of these recent developments, policy has been declared, which of necessity must be conservative till research produces techniques which are proven reliable in practice. Unquestionably present practice and policy will be modified with the completion of Karri and Pine fire behaviour tables in the near future.

Fire weather forecasting which provides the data for fire behaviour prediction has this season been handed over to the Bureau of Meteorology.

In the past forecasts were prepared by a Departmental officer in a scheme initially developed and carried out by our present Conservator, Mr. Wallace, and followed for the last 20 years by Mr. Allan Hatch. The standard of internal forecasts was very high and certain changes in forecasting procedure have been made in an attempt to replace the local knowledge and experience of Mr. Hatch.

Forecasting Regions have been modified, local forecasts provided and 10.00 hours forecast confirmation introduced. The success or need for change in this scheme will be appraised at the end of this season.

It is intended that both Hazard and Fire Danger should be assessed from the forecast as the former is a better indicator of ignition potential and the latter a better indicator of fire behaviour after ignition.

PRE-SUPPRESSION

Man power-Training;
Equipment and Transport;
Detection;
Communications;
Water Supplies;
Road tracks and breaks.

Generally policies and procedures laid down in this section have seen little change recently and with the following exceptions are unlikely to change, as they result from many years of tried and proven experience.

Fire Suppression training has received greater emphasis under mock conditions. This has been necessary due to high employee turnover and reduced involvement of all staff and employees in suppression and hazard reduction. Principles have to be imparted rapidly often under class room conditions. Such teaching has its place but must be supported with "on the job" tests under capable supervision. Manpower and fund limitations are likely to demand the involvement of all personnel in fire control at some time and each person's value increases as his field of skills is widened.

Detection needs vary rapidly with time and Man's activities. Towers remain our key means of detection but whether coverage should be increased or decreased is best known locally and deserves local attention. It is likely with rising wages and capital costs that aircraft will displace at least in part, the fixed detection system. Daily awareness of tower detection effectiveness is essential with annual manning expenses in the vicinity of $60,000.

Communications have improved immensely with the introduction of V.H.F. equipment. The general aim towards a "complete" system envisages separate communication means for the four links of

(i) Lookout to Lookout or Headquarters:– telephone or radio telephone;
(ii) Headquarters or Lookout to gang:– V.H.F. channel 1, 2 or 3;
(iii) Fire to Headquarters:– V.H.F. channel 4, telephone or H.F.
(iv) Point to point round the fire:– V.H.F. channel 1, 2 or 3.

To this can be added the use of a fourth V.H.F. channel, for aerial burning. Two mobile V.H.F. repeaters should be in service by the 1971/72 season. H.F. radio and P.M.G. telephone will continue as the means of interdivisional communications.

Water supplies, roads, tracks and breaks have each received recent policy consideration and the current directives are unlikely to change for some time.

SUPPRESSION

Major changes have occurred in organisation procedures for large wildfires. The need for an adequate support organisation to fire fighters has been recognised for some time but only recently has its structure been defined and the duties of participants spelt out. The value of this has already been demonstrated and the defined limits of fire behaviour and size of suppression force at which it is introduced ensures that staff will be practiced in its application from year to year. A major test of fire organisation simulation was recently undertaken in conjunction with Civil Defence authorities and its success has highlighted a field in which further development can be expected. It can be applied to most aspects of fire control training. As control burning has been extended, so large fire frequency has dropped but this should in no way lead to complacency. Multiple fires under extreme weather conditions will continue as a threat which could at least briefly prove beyond the capacity of our suppression organisation.

Fire fighting equipment is becoming more sophisticated and use of fire retardant chemicals is increasing but successful fire suppression still depends on the skill and fire behaviour understanding of crews and officers.

It can be expected that cost plus loss calculations will be used to determine policy modifications in such areas as plantation expenditure on fire protection and hardwood control burning distribution and frequency.

In W.A. where successful forest management depends on fire protection all foresters must involve themselves in the application of defined policies.

TABLE 1

Year	Area of State Forest	Area of State Forest under Protection	Area Burnt by Wildfire on Protected State Forest	No. of Wildfires	Area Control Burnt
1951–52	3,441,951	1,954,550	52,468	324	228,000
1952–53	3,460,092	2,111,310	8,692	289	164,000
1953–54	3,462,239	2,312,000	12,500	324	416,921
1954–55	3,834,207	2,318,550	11,618	278	317,243
1955–56	3,891,687	2,411,870	18,685	313	344,596
1956–57	3,990,295	3,348,045	11,522	359	456,000
1957–58	4,169,090	3,402,352	33,617	530	316,800
1958–59	4,323,902	3,518,325	22,503	434	398,186
1959–60	4,329,514	4,102,616	2,640	232	503,472
1960–61	4,343,153	4,105,296	475,979	398	573,203
1961–62	4,347,956	4,107,710	66,689	463	1,199,820
1962–63	4,459,309	4,109,932	9,960	231	582,336
1963–64	4,459,038	4,112,279	21,455	281	890,552
1964–65	4,461,266	4,261,187	3,588	214	885,492
1965–66	4,448,827	4,448,827	6,158	251	735,179
1966–67	4,448,682	4,448,682	5,901	365	894,154
1967–68	4,451,351	4,451,351	4,774	248	1,096,142
1968–69	4,456,326	4,534,953	*32,432	252	1,013,448
1969–70	4,460,584	4,460,584	13,838	294	1,118,223

*17,500 acres occurred in one fire in an area not at the time subject to rotational Control Burning.

SOME ASPECTS OF FIRE RATE OF SPREAD IN KARRI LITTER

by

David Ward

Part I – Measuring R.O.S.

1. Linear and Area R.O.S.

It is normal at present to describe fire R.O.S. in linear terms, i.e. feet per minute, or chains per hour. An alternative however, would be to describe R.O.S. in terms of area burnt in any period of time, and this may offer some practical advantages for controlled burning or wildfire suppression operations.

2. Relationship of Area to Time since Ignition

Data obtained from experimental fires in Karri has shown that for low intensity fires burning under constant weather conditions, area is in constant proportion to the square of the time since ignition, i.e. where A = Area, and T = Time

$$\frac{A}{T^2} = K$$

3. Use of $\frac{A}{T^2}$ in Fire Area Prediction

If we designate the area of a fire as "A" at time "T", and "a" at another time "t", then

$$\frac{A}{T^2} = \frac{a}{t^2}$$

$$\therefore \quad a = \frac{At^2}{T^2}$$

Therefore, if we know "A", "T", and "t", we can calculate "a".

Example

A fire has burnt an area of 6,400 sq. ft. in 40 minutes since ignition. What will be its area one hour later (i.e. at 100 minutes from ignition)?

Using above formula:–

$$a = \frac{6{,}400 \times (100)^2}{1{,}600}$$

$$= 4\,(100)^2$$

$$= \underline{40{,}000 \text{ sq. ft.}}$$

It must be emphasized that this formula is only proven for small, low-intensity fires. Its application to high-intensity wildfires needs investigation.

For those interested in things mathematical, it can be shown that $\frac{2A}{T^2}$ is the rate of area acceleration in terms of unit area per $(\text{unit time})^2$ (van Wagner, 1969).

4. Prediction of Perimeter from Area

It is possible, given area and shape of a fire, to calculate the length of perimeter. A.R. Pirsko of the U.S. Forest Service produced a chart for this purpose in 1961. This could be useful for logistic purposes in fire suppression.

Part II – Factors Controlling R.O.S. in Karri litter

1. Source of Data

During the season 1969/70 a total of 166 experimental fires was burnt in Karri scrub at Strickland Road near Manjimup.

2. R.O.S. and Flame Height

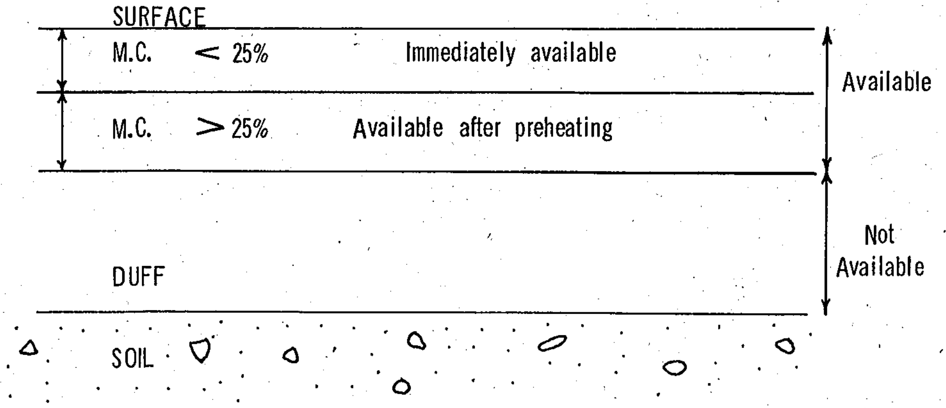
Amongst the Strickland Fires, a correlation was noted between Flame Height at any point of the perimeter and linear R.O.S. in that direction. It would seem to be axiomatic that the height or length of a flame is mainly dependent upon the fuel supply. One source of fuel is the oxygen brought by the wind: the other is organic matter available in the litter. Disregarding wind for the moment, let us examine litter fuel quantity.

3. R.O.S. and Fuel Quantity

In attempting to predict R.O.S. in leaf litter, some attention has been given in the past to fuel quantity. The system used up to the present has been to describe two different fuel quantities, the first being T.P.A. present before burning; the second T.P.A. consumed during the burn (termed "available" fuel).

Neither of these quantities, however, has shown much correlation with R.O.S. and this leads to the suspicion that some other measure of fuel quantity is needed.

Fig. I

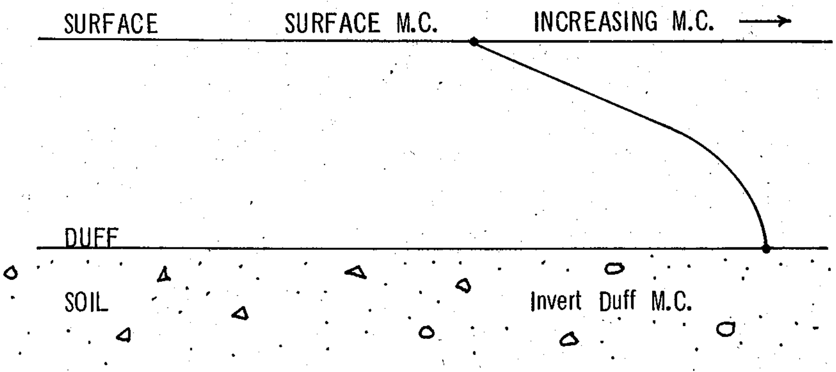


4. Immediately Available Fuel

From Strickland data it seems that Karri litter will not immediately burn at M.C.$>$ 25%. Fuels at initial M.C.$>$25% have eventually burnt, when they have been subject to preheating by already burning fuel, presumably because the preheating has reduced the M.C. to 25% or less.

Could it then be that our "available" or consumed fuel should be divided into two horizons – one at M.C. $\leq$ 25%, which will burn immediately, and another at M.C. $\geq$ 25%, which will burn after some predrying? The depth of the second horizon will depend, of course on its initial moisture content, and the amount of heat energy released by the initial horizon. Fig. 1 illustrates the idea.

Fig. II



With this in mind I have made tentative investigations into the M.C. gradient through the litter bed, with a view to predicting what fraction of that fuel-bed is immediately available for combustion, i.e. at what level a M.C. of 25% occurs.

Observations of electrical resistance at various levels in litter lead me to believe that the M.C. curve in leaf litter is of the logarithmic form shown in Fig. 11.

A more intensive study is needed to establish the shape of this curve, but since drying rate decreases with depth, it would seem rational to expect a curve of approximately the above shape.

5. Prediction of Fuel Quantity $\leq$ 25% M.C.

Once the shape of this curve is established, we can construct a chart from which, given surface M.C., Duff M.C., and Fuel Quantity before burning (Depth or Weight), we can predict Fuel Quantity $\leq$ 25%.

In Fig. IV I show such a chart, in which, for present purposes, I have drawn the moisture curve as an arc of a circle of radius equal to the fuel depth. I have accepted fuel depth and weight as synonymous, and graduated the chart in T.P.A. (tons per acre), since this is the measurement available from Strickland Road.

6. Relationship of Fuel Quantity $\leq$ 25% M.C. to R.O.S.

From Strickland data I have selected fires to give the greatest possible range of R.O.S., and by using the chart have established the T.P.A. $\leq$ 25% M.C., and, in Fig. 111, plotted this against R.O.S. $(\frac{A}{T^2})$.

This graph shows, I believe, a function of the form $f(x) = x^2$.

Conclusion

(i) For low-intensity fires under constant conditions in Karri litter, area burnt is in constant relationship to the square of the time since ignition. $\frac{A}{T^2}$ is, therefore, a useful parameter for experimental fires, since area progresses geometrically, and so is a more sensitive measurement than the arithmetic linear R.O.S.

Also, $\frac{A}{T^2}$ could be a useful prediction factor for controlled burning, and (with perimeter), in wildfire suppression. Its application to high-intensity fires needs investigation.

(ii) Present measures of fuel quantity do not appear to relate to fire R.O.S. in Karri fuels. The fuel horizon at a M.C. of less than 25% does appear to relate closely to R.O.S., and, together with wind, may be of prime importance in predicting R.O.S.

The shape and progress of the moisture curve through the litter profile under the influence of various rainfall and drying regimes needs investigation.

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1. Wagner van, C.E. (1969) – A Simple Fire Growth Model.
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2. Pirsko, A.R. (1961) – Alignment Chart for Perimeter Increase of Fires.
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Fig. III

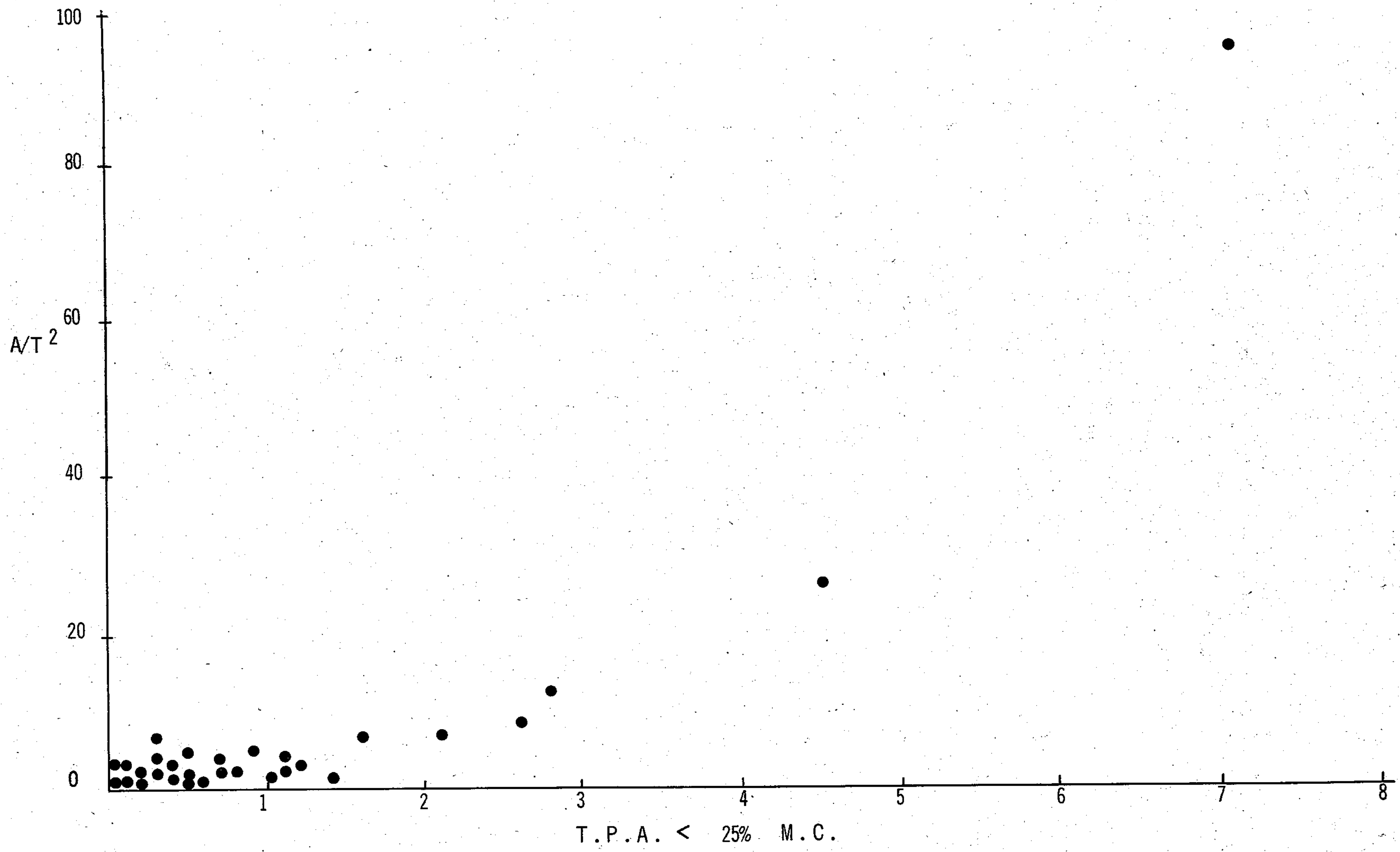
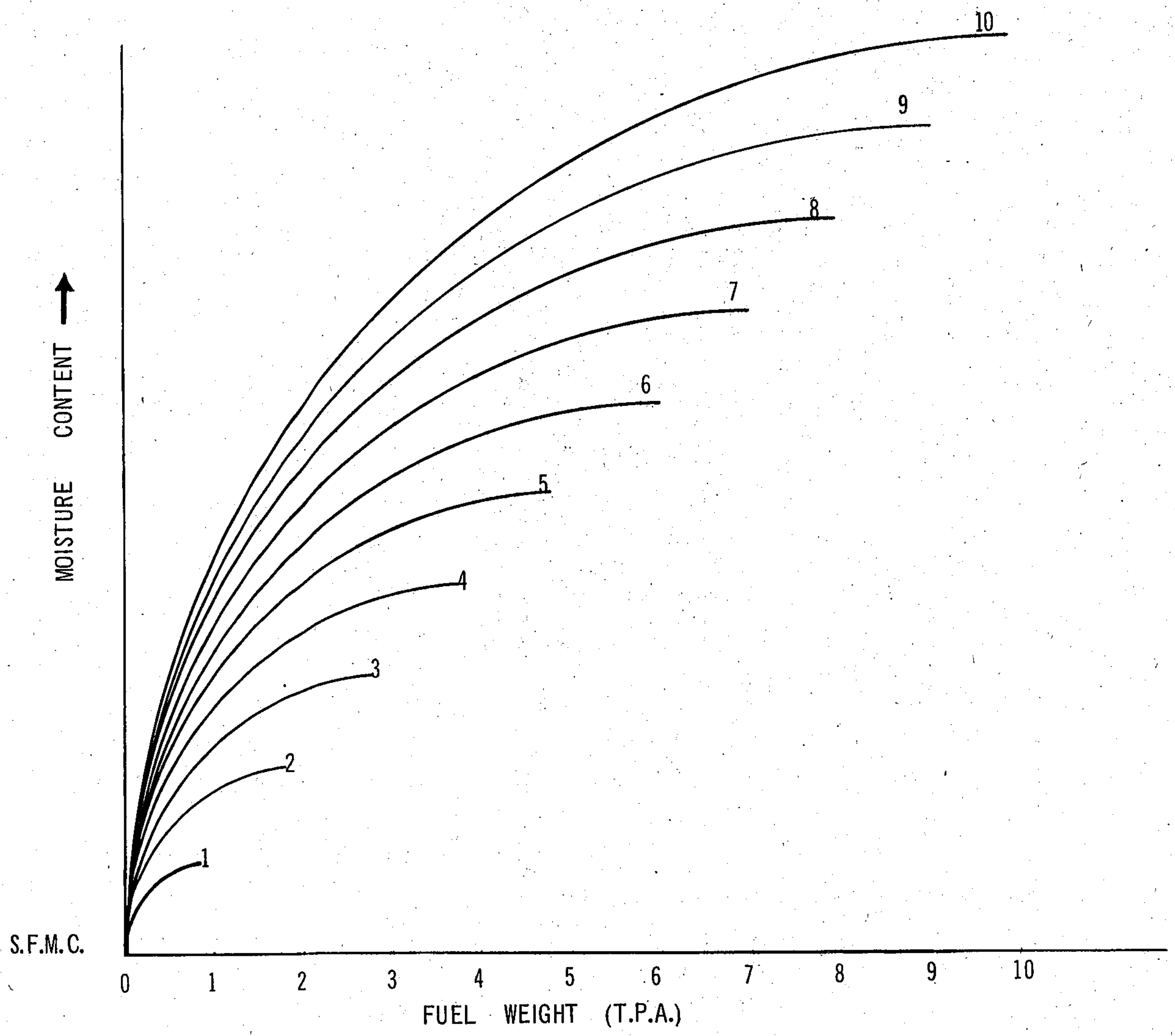


Fig. IV

INSTRUCTIONS

1. Select curve appropriate to fuel T.P.A. present.
2. The y-intercept of the top of this curve represents Duff M.C., the y-intercept of bottom of curve (i.e. origin of axes) represents surface M.C.
3. Interpolate position of 25% M.C. on y-axis by using ruler.
4. From 25% M.C. position, find T.P.A. < 25% M.C. on x-axis.



A CONTROLLED BURNING GUIDE FOR MARITIME PINE PLANTATIONS

by

G.B. Peet, J. McCormick and R. Sneeuwjagt.

INTRODUCTION

This fire behaviour guide is for planning controlled burning in plantations of Maritime pine (P. pinaster). It is a preliminary effort, has not been presented as a Departmental report, and therefore has no official sanction.

Our purpose in publishing it here is to invite you, the users, to suggest such modifications or changes you think are necessary for field operations. These can be incorporated before putting it forward for approval and general testing.

We intend making a few changes in the figures, e.g. moisture contents in Tables I, II and III will be re-calculated before next winter. It is unnecessary to deal with the details of these figures unless you observe a glaring mistake. More value to us will be gained by concentrating on presentation, ease of understanding and use.

We used five tables where information flows from one to the next culminating in an expression of fire intensity. The principles of this flow are similar to the Jarrah tables, but the way moisture content and fire intensity are calculated varies somewhat.

We would like to know if the flow from one table to the next is easy to follow. If not, where do the hitches lie?

Are the fuel and weather factors used in the tables readily understood? Is information in Tables IV and V sufficient to stop or start a burn? Do you think an extension to cover lighting technique should be added? Is the explanation adequate, and if not where are the confusing parts?

An alternative presentation you may prefer is the slide rule type such as McArthur used for his forest fire danger tables.

BACKGROUND INFORMATION

The controlled burning guide (attached) deals with winter conditions and refers best to unthinned stands.

Separate papers have been written by McCormick in this issue, showing methods of assessing fuel tonnages and allowing for edge effects in drying.

It is assumed fuels have been mapped and sufficient winter rain has fallen to thoroughly wet the duff and ground-wood. (Between 3 and 5 inches in the past 4 to 6 weeks seems necessary.).

Since the prerequisites are a wet duff and wood, these fuels play no further part in this calculation of fire behaviour. The guide refers to fires burning in the top ½ to 1½ inches of a litter bed. The quantity of fuel and its moisture content are worked out first, then wind is added for rate of forward spread and, finally, rate of spread combines with available fuel to predict fire intensity.

WEATHER

Certain weather information is necessary for these tables.

(a) Forecast of minimum relative humidity and wind strength to-day.

(b) Measurements of wind strength at 4 feet above the ground within the compartment (roughly one-fifth of velocity at 30 feet in the open).

(c) A record of rainfall read at 8 or 9 a.m. each morning, also number of dry days since rain. A drying day is one when no rain fell (ignore the temperature control used for jarrah). Combine rain which fell on successive days.

(d) A chart of overnight relative humidity. Moisture uptake in litter depends on time of exposure as well as on increases in humidity. An easy way of integrating the two was to count the rectangles on a hygrograph chart. The instrument used here was a Casella thermohygrograph fitted with a 7-day chart. One rectangle represents a count of 1, also 2 per cent humidity for 2 hours (refer Fig. 1). The chart should be marked at the 70 per cent humidity line. Each morning count the rectangles between the trace and 70 per cent line. This is the overnight relative humidity count for Table II. If charts vary in calibration adjustment is easily calculated on the basis of what one rectangle represents.

(e) List the weather information and table calculations in the sequence shown in Table VI. This will minimize errors and keep the day to day calculations in order.

DISCUSSION

This method of estimating moisture content should be a closer approximation to natural conditions than the jarrah tables.

After rain, no account is taken of daily fluctuations until the 3 p.m. moisture content reaches 36 to 40 per cent. Thereafter, the fuel is inflammable and day and night changes become important.

The rate of moisture change depends on initial moisture content as well as the drying force. This was the reason for using 3 p.m. percentages, to work out overnight gains, and 9 a.m. for daily drops.

Some testing was done with the spread phase (Table IV).

For 100 fires predicted rates from Table 4 were compared with actuals. For 70 fires actual spreads were slower than predicted, indicating the tables tend to overestimate. The error was not large, for 93 fires actual rates were within 0.6 feet per minute of predicted rates. Fifty fires were within 0.2 feet per minute. This is ample accuracy for the field since fairly tight safety limits were imposed in both Tables IV and V.

In Table V, fires exceeding 20 B.T.U. per second per foot were considered risky for controlled burning. These limits were set from growth plots all of which were burnt quite mildly. It may be possible to slacken the controls once results of more intense fires last winter are known, and some measure of the risk point is fixed. On the other hand, it is unnecessary to burn at intensities of more than 20 B.T.U. to fill the objectives of controlled burning.

The guide assumes normal tree sizes are maintained in planning. Burning under trees less than 6'' diameter, with a 1/3 to ½'' thickness of bark, and pruned, is considered risky. Scorch to tree crowns should be negligible.

A CONTROLLED BURNING GUIDE FOR MARITIME PINE (P. PINASTER) PLANTATIONS

CONTENTS AND EXPLANATION

Table I. Uses amount of last rain and number of dry days since rain to predict when an initial 3 p.m. moisture content of 36 to 40 per cent is reached, and thereafter tons per acre of needle fuel available for burning. When 3 p.m. M.C. reaches 36 to 40 per cent move to Table II.

N.B. Field check fuel availability before lighting, i.e.
½" of dry surface needles = 3 tons per acre.
1" of dry surface needles = 5 tons per acre.
1½" of dry surface needles = 7 tons per acre.

Note "too damp" and "unsafe" dry limits. At 36 to 40 per cent litter will ignite but burning will not sustain.

Table II. Predicts Moisture Content of surface needles at 9 a.m. to-day from their M.C. at 3 p.m. yesterday, and overnight count of relative humidity. (A count of 1 represents an increase of 2 per cent (above 70) for 2 hours. Note "too damp" limit.

Table III. Predicts M.C. at 3 p.m. to-day from to-day's 9 a.m. M.C. (Table II) and minimum relative humidity. Note "too damp" and "too dry" limits.

Table IV. Predicts rate of Forward Spread of Headfire from 3 p.m. M.C. (Table III) and wind velocity at 4 feet in the compartment. Note safe limits.

Table V. Combines R.O.F.S. (Table IV) with available fuel (Table I) to predict fire intensity for the burn in B.T.U./sec./ft. Note boundaries of safety.

Table VI. Provides an example of the weather record necessary to work the table. A forecast of minimum relative humidity to-day and wind strength is needed as well. The table shows the sequence of "feeding in" and "extracting" information and finally whether conditions are safe or otherwise.

Table I. Effects of Past Rain showing time to reach a M.C. of 36 to 40 per cent and Increasing Fuel availability thereafter.

Number of Days Since Rain	Amount of Rain (points)				
	10	30	50	100	150+
1	3				
2	5	3			
3	7	5	3		
4		7	5	3	
5			7	5	3
6				7	5
7					7

36 to 40 per cent.

Table II. Moisture Content at 9 a.m. (%)

	3 p.m. M.C. (yesterday)	Overnight Count of Relative Humidity								
		10	20	30	40	50	60	70	80	90
	6 to 10	12	14	16	18	19	21	23	24	26
	11 to 15	13	16	18	20	23	25	27	30	32
	16 to 20	14	17	20	23	26	29	32	35	
	21 to 25	15	19	23	26	30	34	38		
	26 to 30	16	20	25	29	33	38		Too	Damp
	31 to 35	17	22	27	32	37				
Start point from Table I.	36 to 40	18	23	30	36					

Table III. Moisture Content at 3 p.m. (%)

9 a.m. M.C. (Table II)	To-day's Minimum Relative Humidity							
	11 to 20	21 to 30	31 to 40	41 to 50	51 to 60	61 to 70	71 to 80	81 to 90
6 to 10	3	5	7	8	9	10	15	19
11 to 15	4	7	9	12	14	17	20	23
16 to 20	5	8	11	14	17	21	24	28
21 to 25	6	10	13	17	21	24	28	32
26 to 30	7	12	15	20	24	28	32	37
31 to 35	8	13	17	22	27	32	38	40
36 to 40	9	15	19	25	30	36	40+	40+

Too Dry Too Damp

Table IV. Rate of Forward Spread of Headfire (ft./min.)

3 p.m. M.C. To-day	Wind Velocity at 4 feet in m.p.h.									Flame Ht. and R.O.S.	
	0 to 0.5	0.6 to 1.0	1.1 to 1.5	1.6 to 2.0	2.1 to 2.5	2.6 to 3.0	3.1 to 3.5	3.6 to 4.0		R.O.S.	F.H. feet
11 to 15	0.8	1.0	1.4	1.7	2.0	2.3	2.6	2.9		0.5	1.0
16 to 20	0.6	0.9	1.2	1.5	1.7	2.0	2.3	2.6		1.0	1.5
21 to 25	0.5	0.7	1.0	1.2	1.5	1.7	1.9	2.2		1.5	2.0
26 to 30	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8		2.0	2.5
31 to 35	0.3	0.4	0.6	0.7	0.9	1.0	1.2	1.3			

Patchy Risky

Table V. Acceptable Fire Intensity

R.O.F.S. ft./min.	Av. Fuel Tons/acre		
	3	5	7
0.5	Safe		
1.0			
1.5		Risky	
2.0			
2.5		Unsafe	

Table VI. Example of Weather Record

1	2	3	4	5	6	7	8	9	10	11		
Date	Rain to 9 a.m. (points)	Number of dry days	Fuel Average (T.1.)	Count of RH	M.C. at 9 a.m. (T.2.)	Min. RH To-day	M.C. at 3 p.m. (T.3.)	Wind Vel. at 4 feet	R O F S ft/min (T.4.)	Fire Intensity Class (T.5.)	Column refers to	Table No.
1	170	1	Too Damp								2	1
2		2	,,								3	1
3		3	,,								5	2
4		4	3	30	30	40	15	0.8	1.0	Safe	7	3
5		5	5	40	20	28	8			Too Dry	9	4
6		6	7	90	26	80	32	1.7	0.7	Safe	10 & 4	5
7		7	Too Dry									
8	10	1	5	20	23	44	17	2.3	1.7	Risky		

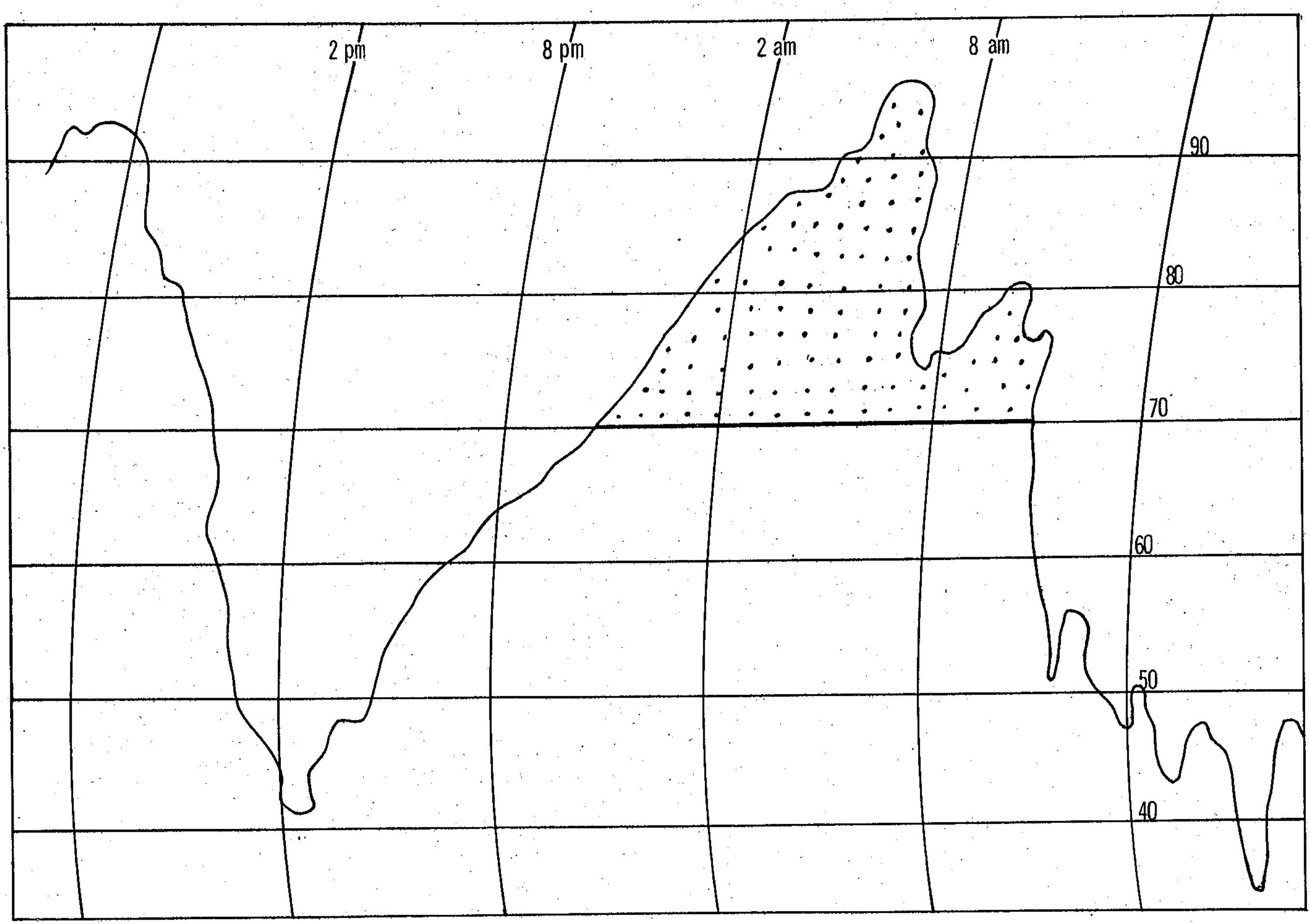
Fig. I

COUNT OF OVERNIGHT

RELATIVE HUMIDITY

Number of rectangles exceeding 70% = 39

One rectangle = 2% RH x 2 hours.



REVIEW OF CURRENT PROBLEMS ASSOCIATED WITH AERIAL BURNING IN SOUTHERN FORESTS

by

L. Nicol

INTRODUCTION

Since the advent of prescribed control burning by the aerial ignition system in 1965, major achievements have resulted in our burning techniques and forest fire protection measures, over the dense mixed forest areas of the lower South West.

The initial control burning from aircraft tests were carried out during spring 1965 over large areas of low quality Jarrah forest and coastal plains with a high degree of success.

This type of operation was extended to areas carrying high quality Jarrah forest in 1966, after successfully refining the techniques for dropping incendiaries and improving the ground marking system. Once again this method proved highly successful.

In 1967 it was clearly evident from the early success that this method of burning would play a very important role in achieving the reduction of the heavy fuels in the large areas of mixed forest, over which because of the wide variety of fuel types and poor access it was almost impracticable to apply a rotational burning system by the hand burning method.

MASTER PLAN

Aim:

It was decided to divide all of the State Forest and some areas of V.C.L. into annual burning strips running east-west or north-south in direction to provide for a 5 year burning rotation. Areas containing young Karri regeneration and recently cut-over forest were excluded from this planning, as complete protection must be maintained over these areas until the saplings and advanced growth are able to withstand the application of fire.

The annual burning strips were divided into daily job areas representing a day's operation for one aircraft and suppression crews. The desirable area for a daily operation is considered to be about 12/15,000 acres.

Having accepted the practical application of a master plan covering the three Southern Divisions, large scale control burning commenced in 1967 in accordance with this plan.

Results:

The progress of the programme over the past five seasons is illustrated in Table I.

Table I	Year	Acreage
Area burnt by Aircraft	1965/66	27,200
	1966/67	68,000
	1967/68	242,866
	1968/69	181,910
	1969/70	250,166
	TOTAL	770,142

With the completion of the 1970/71 programme it is fairly certain that the total area burnt by the aircraft method in the three Southern Divisions will exceed the 1,000,000 acre mark. This is a notable achievement considering the problems encountered.

Rotational Burning of Karri:

The Karri forest is a much less inflammable fuel complex than Jarrah. For this reason it is unlikely that a five year rotation will be feasible, especially after two cyclic burns when the heavy litter accumulations are removed and scrub density may be reduced.

From observations it is generally considered that after the second burn on the five year rotation basis the likely rotation for subsequent burns may have to be extended to seven years. If this does apply it will tend to increase the problems of burning in mixed forest areas.

PROBLEMS EMERGING FROM PAST BURNING

1. Edging

Early edge burning of dense Karri scrub has proved a problem. Two alternatives seem possible, rolling scrub with a bulldozer and chemical spraying. The former has been the accepted practice, and has been generally successful, but is an expensive operation. The wet gullies and boggy areas cannot be rolled, so consequently weak points occur where these conditions prevail on job perimeters.

Limited use has been made of chemical sprays for scrub control in the Jarrah-Marri scrub type with a great deal of success. This type of scrub control has been extended to the dense Karri scrub types with only minor success, largely because of scrub density and height. These factors prevented the deep penetration of sprays. It is considered that further trials are necessary in this field with a view to reducing the costly operation of bulldozers.

2. Roading

In the past, lack of roading in some areas has prevented regular control burning. In the most highly developed areas the intensity of roading is now a disadvantage in aerial burning. Unfortunately these road networks do not seperate forest types where they would be useful; instead they form buffers against a grid pattern of spot fires. Many of these tracks are unnecessary for current forest management and could be abandoned. Aircraft burning has illustrated the need for good quality perimeter roading as distinct from internal roading.

3. Karri Scrub Types

There are several scrub types in the Karri forest which affect controlled burning, each has a different performance. At one extreme is the grassy forest floor which burns similarly to Marri surrounds; at the other are the Trymalium gullies which rarely burn at a drought index below 600*. These differences introduce major problems when designing a burning prescription.

Karri scrub differences increase the problem when several lightings may already be necessary to burn flats, Jarrah and Karri in that order in one particular job.

4. Heavy Duff Layers

In order to achieve an acceptable fire intensity only part of the heavy Karri litter can be burnt in one lighting. The damp duff remaining after the initial burning dries late in the summer and

* See paper by Van Didden on Byram Drought Index in this issue.

can relight from smouldering logs etc. This burning under uncontrolled conditions poses a problem since the duff layer can weigh as much as 3 to 4 tons per acre. In addition, scrub and understorey species (e.g. casuarina) killed by the first burn cures and adds to the fuel. Where this occurs on a perimeter, suppression problems can develop. Until rotational burning has reduced the duff layer, perhaps after the second cycle, perimeters should be located in Jarrah forest surrounds whenever possible.

5. Incendiaries

It is a well-known fact that a lot of heat is necessary to start a fire in Karri forest under control burning conditions. The present incendiaries seem inadequate and poor ignition may in some instances be due to incendiary limitations. Research should investigate the matter with the object of developing an incendiary that will produce a more intense fire for use on Karri stands.

6. Beacons

Despite modification to the beacons there is still insufficient range for a smooth operation. There seems no doubt some fault lies in the A.D.F. instrument in the aircraft. Research is needed to provide matched equipment which will give the necessary 10-15 miles range.

7. Forecasts and Fire Danger

Since the whole burning operation, including planning before and during the burn, hinges on the weather forecasts, accuracy is essential. There are day to day weaknesses in the present system which will have to be overcome for the long term development of large scale aerial burning.

The existing Karri Fire Danger Tables have obvious errors which are largely due to the variable scrub types, density and the different drying rates of the deep fuels and scrubs. Fire Research Officers are at present investigating this aspect of the problem.

CONCLUSION

The introduction of aerial burning to the southern forest region has greatly improved fire control in this area. However, there are still a number of important problems, and until these are overcome, trouble-free and high quality burns will not always be achieved.

THE PLACE OF FIRE IN THE SILVICULTURE AND MANAGEMENT OF SOUTHERN FORESTS

by

B.J. White

Every year the South West of Western Australia undergoes a prolonged summer drought, in which periods of extreme fire danger occur with absolute certainty. Add to this the further absolute certainty that ignition will take place, with or without the agency of man, then a situation must exist in which fire can be ignored or belittled only at the peril of the operation and personnel involved.

The Forests Department of Western Australia bases its fire protection on a policy of fuel reduction by controlled burning. Experience has shown that any policy of fire exclusion is doomed to failure. Ignition cannot be eliminated, and progressive fuel accumulation makes a mockery of suppression under these circumstances.

The use of fire to provide protection from fire – inoculation by a minor dosage, as it were – is only one aspect of fire usage in today's forest activity. Present knowledge and skill allows us to use fire to achieve any or all of the following three objectives:–

(1) Promotion of regeneration
(2) Protection
(3) Waste disposal

The action of all fires in forest is the same: – ground fuel in the form of dead leaves, bark, twigs and larger dead slash is consumed. Depending upon meteorological conditions and fuel quantity, fuel can also include the living parts of trees and scrub. Controlled fires are seldom designed to include the latter as fuel. Though the action of all fires is similar, the objectives sought by their deliberate use differ.

Regeneration burning of Karri is perhaps the simplest example of use of fire to promote regeneration. Logging slash is burnt to create overall ashbed free of scrub competition, and to promote seedfall thereupon from seed trees left for this purpose. Disposal of waste, in the form of slash, is desirable also, but it is subsidiary to the principal aim of regeneration. Likewise, the fire affords protection to the young regeneration for the following 4-5 years. A Karri regeneration burn is one of the few in which crown scorch is unimportant. Jarrah and Marri, being lignotuberous with the capacity to exist in shrub form beneath full canopy, require a different approach. A regeneration burn as such is unnecessary because advance growth exists ready for release. However, advance growth should be replenished between cutting cycles, and judicious burning coincident with seed supply is perhaps one way of encouraging its formation. The benefit of ashbed to all forms of regeneration is well known and worth seeking.

Widespread fuel reduction burns, aerial and otherwise, are familiar protection measures which are discussed at greater length in other articles. Their place in Silviculture and Management is vital in that they secure the investment. All cultural measures – regeneration, thinning, etc., assume that the stand will reach financial maturity, and their justification depends upon this premise. Without protection, measures to improve stand growth and value become risky. Unless the expected gain is spectacular they are not worth attempting. Regular controlled burning in mid-cycle justifies a more sophisticated approach to Silviculture and Management. Pinus radiata plantations must be considered as calculated risks, wherein the spectacular growth rates justify the risk of destruction by fire. Silvicultural measures such as thinning, which reduce rotation length, must also reduce the risk of loss by fire by reducing time of exposure to risk. Should controlled burning of P. radiata become effective and feasible, the position changes.

The simplest waste disposal burn done is the removal of bulldozed windrows prior to planting with exotics. The whole objective is waste disposal with perhaps ashbed effects the only other benefit to be gained. Top disposal burns in Jarrah forest aim to dispose of heavy logging slash. Primarily this is a protection measure, to avoid the massive accumulation of fuel within a young regenerated stand. Its removal also has practical advantages for later access, and hence waste disposal is also involved. No doubt the burn has also a stimulating effect on the development of advance growth into dynamic saplings. It has been suggested (ref. 1) that in eucalypt forests, fire is an essential agent in the disposal of plant wastes in the form of bark, twigs, leaves and plant exudates,, and that waste disposal is essential to the health and vigour of the growing tree. Be that as it may, it is difficult to conceive how else other than by fire, durable heartwoods such as Jarrah and Marri could be disposed of. The rate of decomposition by biological activity alone would appear to be below the production rate. All burns, whatever their primary objective, can be considered waste disposal burns.

It becomes obvious that fire is one of our most important Silvicultural tools. Perhaps the best way to appreciate its use is to consider alternatives, should we be debarred from using it. It would not be impossible to regenerate Karri naturally without fire. One can visualize scrub control by sprays, plowing to expose the mineral soil, and fertilizing to promote growth. Costs however, would be much greater, and the hundreds of tons of slash per acre would be a continual nightmare. Less would be required for advance growth to become dynamic in Jarrah forest, but the nightmare of heavy slash accumulation would remain. Having established a crop, its protection then becomes the problem. History has shown that fire exclusion does not work. Any Silvicultural improvement measures would be unjustified. One could know with practical certainty that one day a wildfire will remove this slash accumulation, and the existing crop would suffer commensurately. Failure is guaranteed.

The policy of fire use rather than fire avoidance has entailed 10 years' research into its behaviour. One can visualize that the need to investigate further will be continual. Use of aircraft in fuel reduction would not have been feasible without a solid background of fire behaviour studies. In future its use as a Silvicultural and management tool will undoubtedly increase with greater knowledge of its behaviour. By selecting different times and intensities it is possible that the scrub composition can be manipulated. A host of possibilities of use arise:– from promoting wildflower displays, to increasing scrub density to keep soil temperatures down. Such a measure may create an effective barrier to the spread of phytophthora. It appears that crown scorch in Jarrah has minor injurious effect provided that it is done in spring and the leaves have been scorched, not defoliated. If techniques can be refined to a degree where the precise amount of scorch is achieved, interesting possibilities arise. Leaf growth can perhaps be stimulated following thinning. A heavy bud crop could be removed if not required, so that growth can go into wood production rather than seed production, (ref. 2). Control of leaf eating insects such as leaf miner may be a possibility by this means. The conception of new hypotheses for fire use, their test by experiment, and perhaps eventual adoption in practice, make an exciting field of endeavour.

Of course, as conservationists, care must be taken not to "go overboard" on controlled burning (ref. 3). The long term ecological significance of regular burning should be studied along with the possibilities for its positive use. The effect on smaller mammals, and the provision of refuge areas should not be forgotten.

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BURNING UNDER *P. pinaster*

by

A. Ashcroft.

In undertaking a controlled burning operation under *P. pinaster*, it is recommended that the following procedures should be observed:—

Check out the written prescription and ascertain the fire danger rating required together with any other conditions stipulated for the burn.

Because fuel moisture is a major controlling factor of burning under pine canopy, it is of utmost importance that all variables dealing with this aspect are identified.

In compiling the prescription all known factors should be considered, and therefore the prescription should contain such information as:

Year of planting to indicate the stage to which heavy plated bark exists on the lower bole of the tree, and if not previously burnt, the percentage of red needles likely to make up the fuel bed. (This percentage appears to be highest in the 13 to 18 year group.)

Trees per acre. Wind velocity in the forest varies considerably with stocking. Therefore this information is important in assessing the windbreak effect at ground level within the stand.

Co-dominant height and green crown level. The type of stand to be burnt described by these figures will indicate what fire intensity can be tolerated without crown scorch.

Pruning and thinning will provide information on fuel quantity, type and distribution, as well as the effects on wind velocity and drying rates. In unpruned stands some "torching" of trees could be expected.

Fuel. It should be known whether the fuel bed consists of needlebed only, needlebed with new slash or needlebed with old slash.

A fuelbed of needles only, is by far the simplest fuel to handle, being more even in distribution and compaction, thus giving a reasonably even "available fuel" quantity and will therefore give a consistent quality burn.

The age of the fuel is important to predicting fire behaviour.. The red (new) needles normally burn during periods of high relative humidity, whereas the grey (old) needles, having weathered and lost some of their "water proofing" properties, quickly absorb moisture and become unavailable for burning.

Slope, elevation and aspect. Slopes with a southerly aspect dry more slowly than similar areas with northerly or westerly aspects, due to effects of solar radiation.

During the winter burning season, drainage of soil moisture from elevated areas, such as the dune or hill top will exhibit greater fuel drying potential than more low lying areas.

Soil Type. Moisture retentative properties of various soils affects fuel drying rates. Personal experience suggests that gravel dries first, followed by sand, loam, and clay.

Crown Density. Low crown density will increase fuel drying rates by reason of reduced shading effects and more wind movement. This together with openings in the crown cover, will tend to increase vertical development of any burning, often creating a "chimney effect" around such openings.

Scrub (quantity, type and species). The presence of certain scrub types will often indicate the likely flame fronts produced from flaring of flammable species, as well as providing aeration of pine and other fuels suspended above the surface.

Location and perimeter of areas. The location of the area to be burnt in relation to the remainder of the plantation, can often suggest increased drying of the fuel in the area, particularly on the coastal plains where western edges are relatively exposed to high wind velocities from the westerly winds of the winter low pressure systems.

Almost all perimeters show greater fuel drying rates than internal areas, usually in the order of western, northern, eastern and southern edges.

By the means of field checks ascertain whether sufficient past rain has saturated the fuel bed. Then having checked the prescription for burning, calculate the day's predicted fire danger index, using the Fire Danger Tables. Remember that unlike hardwood forests, drying can take place in pine fuel on days below 60° temperature.

Weather readings should be taken at a nearby local recording point or in the field at the site of the burn.

If the above conditions check out, the next step is to light a "test fire," selecting a point where fuel drying rate is likely to be at a maximum for the area.

Observe the fire behaviour of the test fire for sufficient time to allow fire development to stabilise and if the result confirms the predicted fire danger range, calculate a grid lighting pattern to give a 2 hour close (as per pine burning instructions). This would normally give strip distances of up to 3 chains.

On the initial lighting, spot distances should be doubled to allow an observation to be made of the fire behaviour intensity increase, due to the multiple fire effect.

Remember that further fire can easily be added if performance is below expectation. In this way greater control is exercised.

When selecting a lighting pattern for a 2 hour close other than in minimum conditions, where line of fire and close spots are used, the ideal result is to produce an elongated fire shape with spots spaced far enough apart whereby the head fire has travelled sufficiently deep to remove its influence on a flank fire close.

In conditions where junction zones occur between the headfire, flank fires and tail fire a very marked increase in fire intensity can be produced usually resulting in a hot burn.

During the burning, weather readings should be taken and fire danger ratings calculated at not more than two hourly intervals, remembering that fire behaviour can vary sharply over short periods due to changes in fuel moisture content and weather.

APPLICATION OF THE BYRAM DROUGHT INDEX IN THE MANJIMUP FOREST REGION.

by

G.W. van Didden.

INTRODUCTION:

The following article is a report on the work carried out in relation to the Byram Drought Index. It is also part of an investigation into the variables involved in the litter drying studies in Karri forest.

At the present moment, techniques used for burning northern Jarrah forest are applied to the southern Karri forests, using modified rain correction tables to predict fuel availability. These tables in their present form have on occasions proved incorrect when compared with actual conditions in the field.

One of the reasons for this, may be that rainfall over the previous month or months, has not been taken into account in the rainfall correction factor now used. The Byram Drought Index overcomes this problem and has been defined as a number representing the net effect of evapotranspiration and precipitation in producing cumulative moisture deficiency in deep duff or upper soil layers.

EXPLANATION OF DROUGHT INDEX.

The drought index is a numerical value ranging from 0 to 800 given to a state of fuel dryness in forest areas and is based on past weather conditions. The system was devised by Byram and Keetch (1963) and has been reviewed with an eye on Australian conditions by McArthur (1966).

The following points are parts of the work by Byram and Keetch.

The moisture content of the upper soil, as well as that of the covering layer of duff has an important effect on the fire suppression effort. Also it is noted that extremely difficult fire suppression is associated with cumulative dryness or drought. During these extreme drought conditions, moisture contents of living scrub and tree crowns may be lowered, so that fires may crown more readily.

The concept of drought can be expressed in numerical terms. Values would range from zero (saturation point) up to some maximum value which corresponds to the absence of available moisture in the soil and duff. Drought index thus is a quantity that relates to the flammability of organic material on or in the ground. A prolonged drought influences fire intensity largely because more fuel is available for combustion.

The drought index does not replace the Fire Danger Rating, because it represents an entirely different moisture regime in which the response to weather changes is much slower than with the Buildup Index.

Although the drought index number has a definite meaning in terms of moisture deficiency, the significance of a particular stage of drought for fire control must be determined locally.

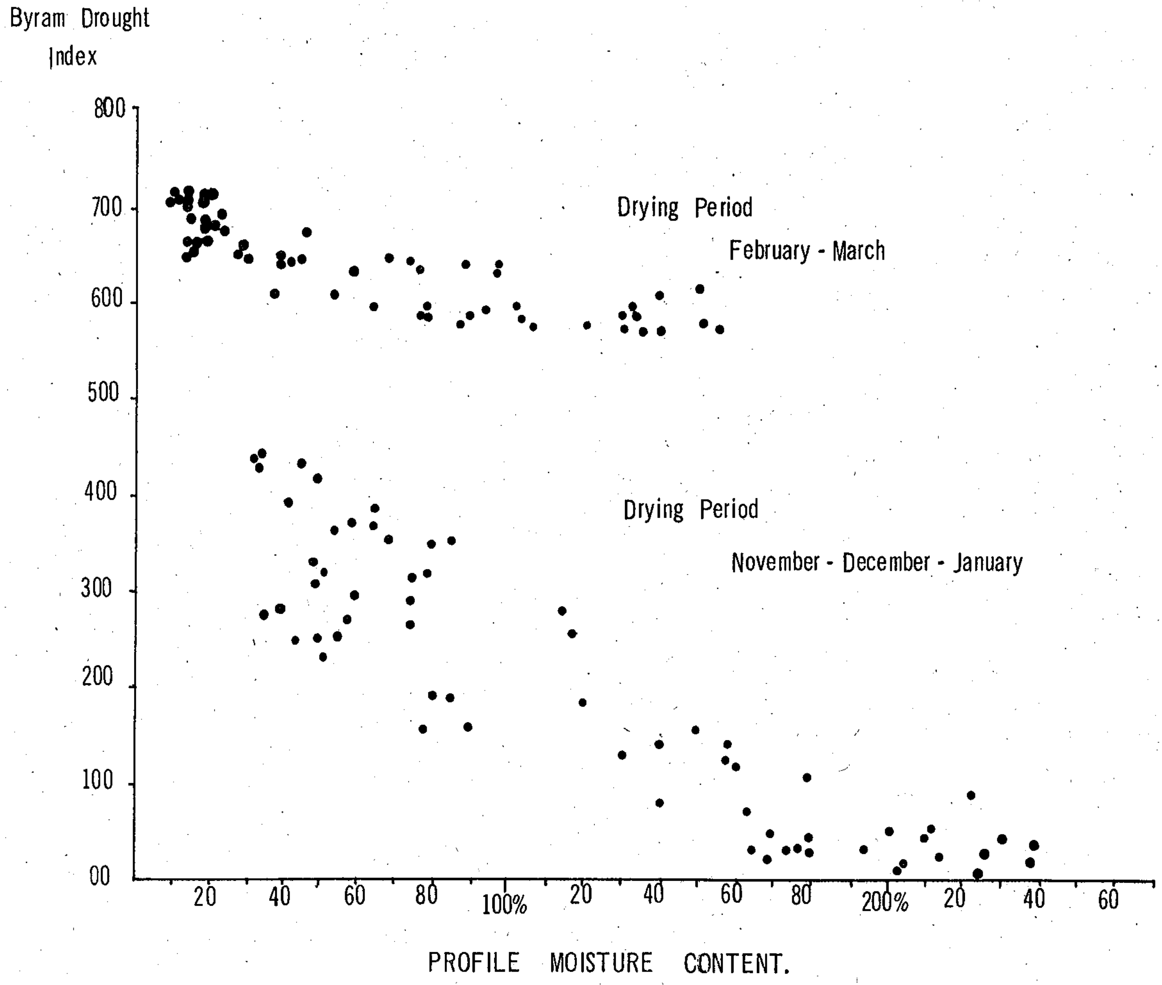

Fig. I Relationship between the profile fuel moisture content of karri fuel and the Byram drought index. Each dot represents a fuel moisture sample in karri, at Channybearup during '65 to '69.

EXPERIMENTAL RESULTS

(A) Profile Moisture Content. To check if there is any relationship between the drought index and profile moisture content the following procedure was adopted. Samples of profile moisture content taken in heavy Karri fuels of eight to ten tons per acre were plotted as points against the Byram drought index figures. The results showed some correlation between profile moisture content and the Byram drought index in both autumn and spring. (See Fig. I).

(i) During the drying period between November, December and January the profile moisture content ranged from 250% MC when fully saturated at a zero index; to 40% MC at the driest point when the index reached 440.

(ii) During the drying period of February through to March, the profile moisture content ranged from 160% MC occurring at an index level of 550; down to 9% MC occurring at an index level of 720.

(B) Rainfall correction factor. To provide a rainfall fuel correction table for Karri, 147 individual moisture content figures were fed into a computer. A multiple regression analysis using actual profile moisture contents, with twenty-seven independent variables, which included the Byram index gave some good results.

The following seven combinations were used to explain the difference in moisture content and gave a correlation coefficient of 0.87.

(1) Byram drought index
(2) Accumulated rainfall over 30 days.
(3) Number of days since rain.
(4) Mean temperature today.
(5) Average of max, and min. temp.
(6) Mean R.H. past two days.
(7) Mean Dew point past two days.

Even so some of the variables will have to be changed or substituted to make them more manageable.

(C) Forest type. Data obtained from experimental fires carried out in the Manjimup district, provided information on different forest types. Plotting of points to compare the drought index to forest types or when they were burnt; appears to give some indication of when different forest fuel types reach a stage of inflammability at certain points on the Drought Index.

(i) Indications suggest that pure Jarrah and Jarrah-Marri forest fuel types are burnt during an index of 40 to 400.

(ii) Mixed forest types such as Jarrah-Karri-Marri, Karri-Marri and Marri-Karri etc., all have fuel types which are burnt when the index rises above 150. The upper limit under which burning was carried out was 720.

(iii) Pure Karri without any admixture of tree types required a relatively high drought index, with several fires just above 450; while the majority of fires occurred when the index rises above 600.

(D) Scrub Types. Later information from experimental fires in the Strickland Road plots, seemed to indicate that scrub cover may be a better indication for selecting burning conditions than tree types.

(i) Acacia pulchella could be burnt when the index rose above 100, an upper limit of 400 was set, to prevent an excessive amount of scrub flare which occurred above this figure.

(ii) Acacia strigosa burnt satisfactorily when the index rises above 180 with an upper limit of 400.

(iii) Bossiae aquafolium or netic burnt mainly when the index rose above 400 although some very light intensity fires were achieved at 200. No upper limit seems to exist for this scrub.

(iv) Trymalium spathulatum or Karri hazel required a relatively high drought index, with several fires above 400, but the majority of fires occurred when the index rose above 600. No upper limit seems to exist.

The following table shows approximate dates when it is considered three of the scrub species would have become available for burning in the past burning seasons.

Pulchella	Netic	Trymalium	End of Season
14.11.64	12. 1.65	24. 2.65	25.3.65
14.12.65	21. 1.66	24. 3.66	11.4.66
6.11.66	17.12.66	2. 2.67	14.3.67
29. 9.67	18.12.67	15. 2.68	25.3.68
14.11.68	28.12.68	28. 1.69	6.4.69
5.10.69	16.12.69	22.12.69	9.4.70

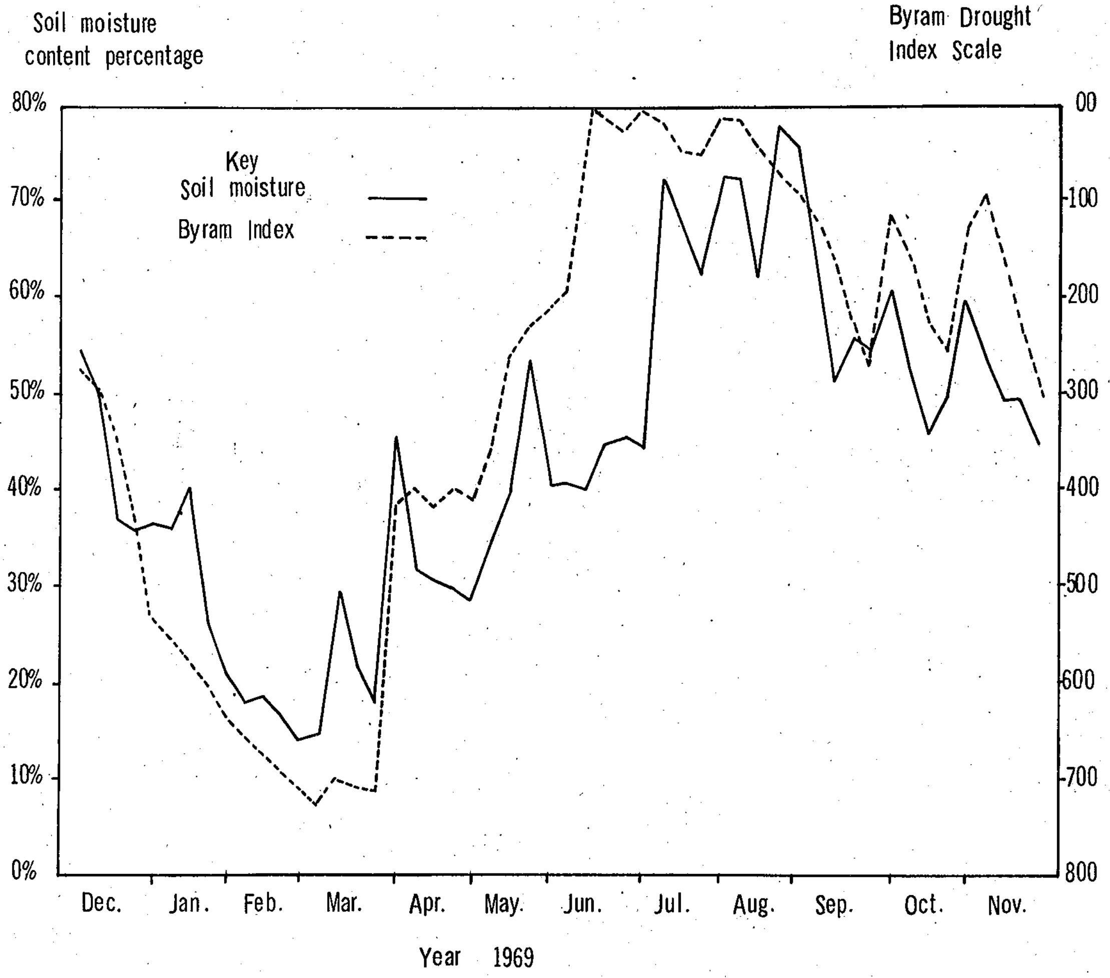

Fig. II Comparison between the Byram drought index and soil moisture content in the upper six inches.

From this type of information it would seem desirable to lift or suspend the present burning restrictions in pure Karri, where the scrub cover is predominantly Trymalium spathulatum, that is, if we are completely serious about carrying out a policy of control burning in Karri to reduce the fuel build up.

(E) Soil Moisture. To test one of the basic assumptions:– that the soil-duff layer gains moisture from rainfall and loses moisture by evapotranspiration are demonstrated by two graphs, superimposed on one another. (See Fig. II).

One graph representing the Byram drought index, the other the actual moisture content of the soil in the upper six inches are compared for a complete year. Results here, are favourable enough to warrant further investigation for other research purposes.

Data supplied by P. Christensen of the Silviculture research section. Details of actual sampling site are: from a poorly drained section in cutover Jarrah forest.

(F) Fire Suppression. In fire control, the effect of suppression problems were observed to occur above a drought index of 550; it was noted at this stage that dry stags and dead limbs caught alight. It must be noted that these observations are only based on one season, and would need to be confirmed in subsequent years to be of any value.

However, a study of large uncontrolled fires in the Manjimup district between '65 and '69 showed that large fires occurred between an index range of 224 up to 703. (A fire was considered large if it reached over 50 acres before being suppressed).

The following percentage of fires occurred at different stages on the index.

30 per cent of all large fires occurred between 500 to 600.
40 per cent of all large fires occurred between 600 to 700.

Discussion. Other possibilities to use as drought or moisture deficiency indicators were investigated, but proved unsuitable due to method and duration of sampling. They were: the moisture content of outer bark,, limbs, groundwood, duff and surface leaves.

Although the drought index has been shown to have a definite meaning in terms of fuel availability in forest types, the reason is probably the type of scrub cover rather than tree types, in the Karri forest around Manjimup.

The index has shortcomings which must be realized, that is:– The index is only of value on a rising hazard or scale, Recent rainfall must still be taken into account to describe the fuel moisture content of the fine fuels.

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FIRE IN THE JARRAH FOREST – A SILVICULTURAL APPRAISAL

by

P.C. Kimber.

INTRODUCTION

Controlled burning in the Jarrah forest is regarded primarily as a fuel reduction measure aimed at decreasing the possibility of uncontrollable wildfires occurring. Although this aspect of burning is necessary for the survival of the forest, there are other aspects of fire worth taking into consideration and which may, in the long run, prove of great importance in forest management.

FIRE AND THE FOREST COMMUNITY

The association of the Jarrah forest with fire has been discussed in an article on fauna surveys in this issue. The plant community comprising the Jarrah forest exhibits all the classical adaptations which botanists quote as indicating resistance to fire for ground vegetation species, these include:–

1. The perennial life form. Probably 95% of the plant species in the Jarrah forest are perennials.

2. The presence of a caudex or lignotuber. This is a large subterranean rootstock, well endowed with dormant buds which shoot after a fire and replace the shoots destroyed by the fire. Very many of the dicotyledon plants in the Jarrah forest have this structure. The monocots (grass-like plants) although lacking a lignotuber are nevertheless protected from permanent fire damage by having their main shoots, and sometimes rhizomes, two or three inches below ground level. These, in turn, also reshoot when the surface parts of the plant are destroyed by fire.

3. Fruits that can only be opened by heat – for example, many Hakeas and Grevilleas.

4. Seeds that will only germinate after heat treatment; the acacias are well known in this category.

Jarrah itself has a number of characteristics which make it very resistant and hard to kill by fire. The main ones are:

1. The lignotuber.
2. Dormant buds on the stem or trunk. These form epicormic shoots when the crown is destroyed by fire.
3. A thick bark. McArthur (1968), describes Eucalyptus macrorhynca in the ACT, as having a thick bark and being very fire resistant. The bark of Jarrah is 30% to 50% thicker than that of E. macrorhynca and is a correspondingly better insulator against heat.

EFFECTS AND SILVICULTURAL USES OF FIRE.

1. Forest Composition.

Marri is generally estimated at comprising between 5% and 10% of the northern Jarrah forest. I suggest that this relatively low proportion of Marri is being maintained by burning. Peet (1965), in assessing the effects of the 1961 Dwellingup fire, found Marri to be far more susceptible than Jarrah. In severely damaged areas a very high proportion of the Marri component had been killed. My own work on regeneration suggests that Marri seedlings establish themselves more easily and they are more vigorous than Jarrah seedlings. In some areas Marri seedlings outnumber Jarrah. When the area is burnt, however, the situation is reversed due to the relatively high susceptibility of Marri to fire.

2. Growth Rates

Studies have been made by Loneragan (1961) comparing the growth rates of Jarrah poles in regularly burnt forest with those in unburnt forest. Those in burnt forest were found to grow slightly faster than the unburnt trees. The difference in growth rates was small but nevertheless detectable.

3. Soil Properties

No changes in the major nutritional values and properties were found by Hatch (1959) in the soils under regularly burnt forest stands.

4. Seedfall and Regeneration

Van Noort (1959) has determined that a mild controlled burn, involving no crown scorch, will open the capsules on Jarrah crowns, and bring the seed to the ground within two or three weeks. In another study on regeneration the same author (1960) attributed a massive increase in Jarrah seedlings on one of his study areas to the coincidence of a fire with a seed year. The application of controlled burning to regeneration is obvious. Not only does burning bring a lot of seed to the ground at one time, but it also reduces competition from the ground vegetation favouring survival of Jarrah seedlings.

A lack of fire appears to inhibit the development of advance growth. In a survey made in Amphion compartment 6, which has been protected from fire for 35 years, large Jarrah advance growth was found to be weak with very woody almost leafless shoots and rotting lignotubers. Similar sized plants in an adjacent regularly burnt compartment were found to be healthy and vigorous.

5. Crown Scorch

The effect of total crown scorch on growth rates depends on the season of scorching. Jarrah has an inherent growth cycle; new leaves are formed in summer, while wood increment (or increase in the size of the stem) is accrued in the two separate periods of spring, and late autumn/winter. Spring growth commences in September and accounts for approximately one third the total annual stem increment. The autumn/winter wood growth period lasts from late March to August and accounts for the other two thirds.

Trees which are scorched in autumn stop growing until a new crown is formed the following summer. Virtually one whole year's growth is lost. A scorch in spring, however, leaves the trees leafless only until the new flush occurs in the following January and February; wood growth recommences the following autumn. Assuming that the scorch takes place in October or November, when half the spring wood growth has taken place, a loss of roughly one sixth the annual growth is realised. I suspect that this small loss of wood increment due to a spring scorch is likely to be more than compensated for by the extra vigorous growth resulting from the new, young crown which forms when the tree recovers. Experiments are in progress to determine this point.

Podger (1963), of the Forest Research Institute, has shown that greatly increased growth rates follow defoliation by more severe fires, so it seems a reasonable hypothesis that increased growth rates, perhaps to a lesser degree should follow crown scorching. If this proves to be so, we may well be burning to purposely achieve crown scorch in the future. Another aspect of this factor is discussed in the following section.

6. The Control of Flowering and Seeding

Research into the flowering and seeding habits of Jarrah poles has shown that the energy the tree expends on producing seed results in a 30% loss of wood increment. Jarrah seeds every five to seven years and during a rotation seed is produced far in excess of the quantity required to regenerate the forest under careful management. Thus if we can prevent the tree from seeding we have the prospect of increasing timber production quite significantly. The simplest way of achieving this appears to be by scorching the crowns when they are carrying flower buds in the spring. Again this is purely a suggestion at present, but research is being done on the subject and results should be forthcoming in a year or two.

It should be mentioned at this point that it has been established by local fire researchers that a fire intense enough to cause crown scorch does not damage the bole of the tree.

CONCLUSIONS

I have attempted to show that controlled burning as well as being a hazard reduction method, is unlikely to harm the Jarrah forest environment and may even be essential to its continued vigour and good health. It also seems very likely that fire can be adapted for use as a management tool, to ensure adequate regeneration and possibly to even give a marked increase in the productivity of the Jarrah forest.

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FIRE RESEARCH IN WESTERN AUSTRALIA

by

G.B. Peet.

The past decade has introduced a number of changes in fire control techniques for West Australian forests. Two of the most obvious were aerial burning and burning under pines. Some impetus for these changes came from an expanding fire research programme after the 1961 fires, and a change in the attitude of foresters towards large-scale controlled burning.

By Australian standards, the W.A. fire research group is a big one, also an increasing volume of work on fire ecology and operations is coming forth from other research and administrative personnel. This represents a considerable effort on fire research. What is it likely to produce, and will it be enough for future demands?

The first priority for the fire research group still remains problems in operations. Most of these problems stem from an inability to forecast fire behaviour. There is a decade of experience to show that these forecasts must be based on measurements; personal judgment is too often unreliable and inaccurate.

The fire research programme falls into two broad categories: relatively short-term fire behaviour studies which take 60 to 70 per cent of time, and longer term studies of fire effects on the forest.

Problems in operations still abound despite the progress which followed aerial burning. The quality of controlled burning in Karri forests is quite unreliable because there's no fire behaviour tables for this complex fuel. The quality of burning under pines is generally good, but the costs and production rates vary considerably from place to place. The techniques need considerable upgrading if the future protection demands of an expanding plantation area are to be met. Is there any chance at all the buffer system will continue to work? It seems to inherit all the problems of the old 5-chain breaks. The quality of some Jarrah burning is suspect, indicating that weaknesses still exist in planning. Problems in aerial burning technique, evident in 1967, have yet to be worked on properly.

There's no doubt at all one of the main problems for future operations will be upgrading the quality of controlled burning. The issues of conservation and studies on fire ecology will demand it. After all, what hope is there of implementing a valid plan for management of forest fauna and flora, until a real control over fire is achieved? In this harsh fire enviornment this means fires occur by prescription and not by chance, since exclusion is impractical and not necessarily desirable anyway.

The longer term studies of fire effects on the forest will help in drawing up fire management plans. The fire group's contribution in fire ecology relates to studies of girth growth and bole damage, and structural changes in scrub understorey.

SHORT-TERM PROJECTS

The forecasting of research results and how they can be woven into operations has definite pitfalls. However, there is some merit in setting objectives in the hope of filling them.

No new fire behaviour tables have been produced since 1965, except some modifications to the Jarrah tables to provide temporary information on pines and Karri. There are a number of reasons for this, apart from the section's early involvement with aerial burning.

Firstly, fire behaviour tables are fairly useless unless they form part of a fire management plan. The compiling of aids for these plans, e.g. controlled burning, required a number of offshoot studies such as litter accumulation, hours of burning time etc., most of which were summarized in Forest Fire Danger Tables. These requirements became evident over several years as the Jarrah tables were put into practice.

For Karri and pines it was immediately obvious that a lot of work was necessary on fuel classification before any sort of fire management plan could be envisaged.

At present a system for classifying litter and tops fuel has been developed for Maritime pine plantations, (McCormick, 1970), and should be fairly easily adapted for Monterey pine.

Substantial progress has been made with classifying the complex scrub and litter fuels in Karri forest (Sneeuwjagt, 1970).

In both forests it seems much more detailed fuel-type mapping will be necessary to ensure fires occur by prescription and not by chance. The broad descriptions used in present prescriptions are not adequate, particularly for Karri.

One of the major problems in compiling any fire behaviour table is defining rates of drying and day to day fluctuations in the moisture content of litter. Problems with rainfall correction factors in the Jarrah tables are well known. The reasons are quite simple, litter beds are never even in depth, disposition, composition, or exposure. This introduces a considerable variation into any average drying rate used for prediction purposes.

For Karri forest, and to a much lesser extent pines, the variations are so large during the controlled burning season, that average values are fairly meaningless unless adequate adjustments are provided.

Measurements have been made of "edge drying" effects in pine compartments and adjustments made for within compartment rates.

Four different sites were measured in Karri types last summer differing in topography and scrub cover (van Didden, 1970). A formula for predicting moisture changes in one of these types has been worked on, and seems more reliable than the analyses used for the Jarrah table.

Sufficient fires have been measured in unthinned Maritime pine for rate of spread tables to be drawn up. Worked started last year on unthinned stands. It has been necessary to confine this data to controlled burning conditions.

An excellent range of fire information was collected in Karri last summer, ranging from very mild creeping fires to extremely intense ones which consumed the whole mass of dense 12 feet-high scrub. Unfortunately the data was confined to one fuel age, although six scrub types were covered. It will be necessary to extend the information into very heavy and very light litter before comprehensive prediction tables can be compiled. The heavy litter will be this season's programme.

Providing fuel mapping and planning is upgraded, and reliable prediction tables are produced, there seems no fire behaviour reason why Maritime pine cannot be burnt on a much broader scale, at much less cost than is done at present. This does require the slow and careful development of lighting technique, the same as was done for Jarrah forest; (this is an important prerequisite.) This species seems much more resistant to fire in winter than was thought a few years ago, and trials are underway to find out what intensities pole sizes can stand.

Unlike pine, the grid pattern of lighting for controlled burning will never be very successful for Karri. The influence of fuel change dominates too much to produce anything like even fire behaviour. Future lighting should be in a sequence where distinct fuel and topographic types are burnt out separately. Defining these types and the sequence is one of the main problems at present.

New concepts for basic fire hazard have been developed (Table A) using overnight changes in relative humidity, as well as daily trends (Sneeuwjagt, 1970). These analyses were guided by the work of Hatch (1969) who showed fire hazard predictions were improved by including a measure of overnight conditions. The experimental methods for these experiments were modelled on Canadian work for their forest fire weather index (McCormick, 1969).

LONG-TERM STUDIES

Since 1963 a number of trials have been established measuring girth growth responses to fire. About 700 trees are measured each month. So far there has been little or no significant response to mild controlled burning.

It is unfortunate that all the early treatments were mild. This showed properly burnt-under trees were unaffected, but did not indicate the upper limit of acceptable risk. It was shown that pines scorched to less than 10 feet of green tip, lost girth growth.

This year a range of fire intensities were used on two large trials in Maritime pine at Ludlow. Monterey pine at Grimwade was burnt under more intensely than had been tried previously. Intensities of more than 30 B.T.U. per sec. per ft. created some butt damage in Monterey pines of pole-size.

Heavy fuels made burning under 20 feet high Karri quite risky. Thirty per cent were killed by 30 B.T.U. per sec. per ft. while smaller ones were nearly all killed. On the other hand, Jarrah under 20 feet high has been burnt under without apparent damage.

These trials are providing a basis for prescribing fire intensities that protect timber values during controlled burning. In the future, it is likely other values such as regeneration of understorey scrub and the fate of fauna will assume an increasing importance in fire management plans. The first small trials on scrub structure started in Dwellingup during 1965, and at Manjimup in 1967. Recently this work has been considerably expanded by Per Christensen in the southern forest and plans are afoot for a large trial near Dwellingup.

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THE EFFECT OF FIRE INTENSITY ON KARRI SAPLING STANDS.

by

G.W. van Didden.

INTRODUCTION

One of the problems associated with controlled burning, is to know to what height the young regrowth has to grow before burning can be carried out without undue detrimental effect.

An experiment has been made to determine at what stage in the growth of Karri saplings a mild control burn can be carried out.

STAND DESCRIPTION

The area contains mainly overmature, defective Karri trees mixed with vigorous young saplings. Canopy cover in the area is 50%.

Scrub coverage on the site consists mainly of Hovea elliptica, Hibertia montana, Bracken and Pimelia, which cover approximately 50% of the site. Scrub height ranges from 6 to 12 feet.

The area was burnt by a wildfire in 1950. Trade cutting took place during Sept.-Dec. 1962.

EXPERIMENTAL TECHNIQUE

The first control burn of a light intensity (14 to 23 B.T.U. per sec. per foot) was carried out in 1966. Forty dominant or co-dominant saplings were observed. The average sapling height at this stage was 12.5 ft with a range of 9 ft to 18 ft.

Headfire flame height ranged from 1 ft to 3 ft while rates of spread varied from 0.6 ft to 2.4 ft per minute.

Out of the 40 saplings only two survived. These had individual heights of 15 ft and 18 ft. The remaining saplings would have most certainly been killed by full crown scorch, although they subsequently coppiced at the butt. From this information it should be evident that saplings 12.5 ft high should be protected for several more years.

The second control burn of a slightly higher intensity than the first burn (19 to 44 B.T.U. per sec. per foot) was carried out in 1969. The average sapling height at this stage was 19.5 ft with a range of 14 to 29 ft.

Headfire flame height ranged from 1 ft to 6 ft while rates of spread varied from 0.5 to 5 ft per minute.

Out of the 40 saplings measured 26 survived, and had a completely normal crown, 4 developed bole epicormics, while the remainder of the saplings died, but then coppiced at the butt. Average scorch height on the measured trees was 15 ft.

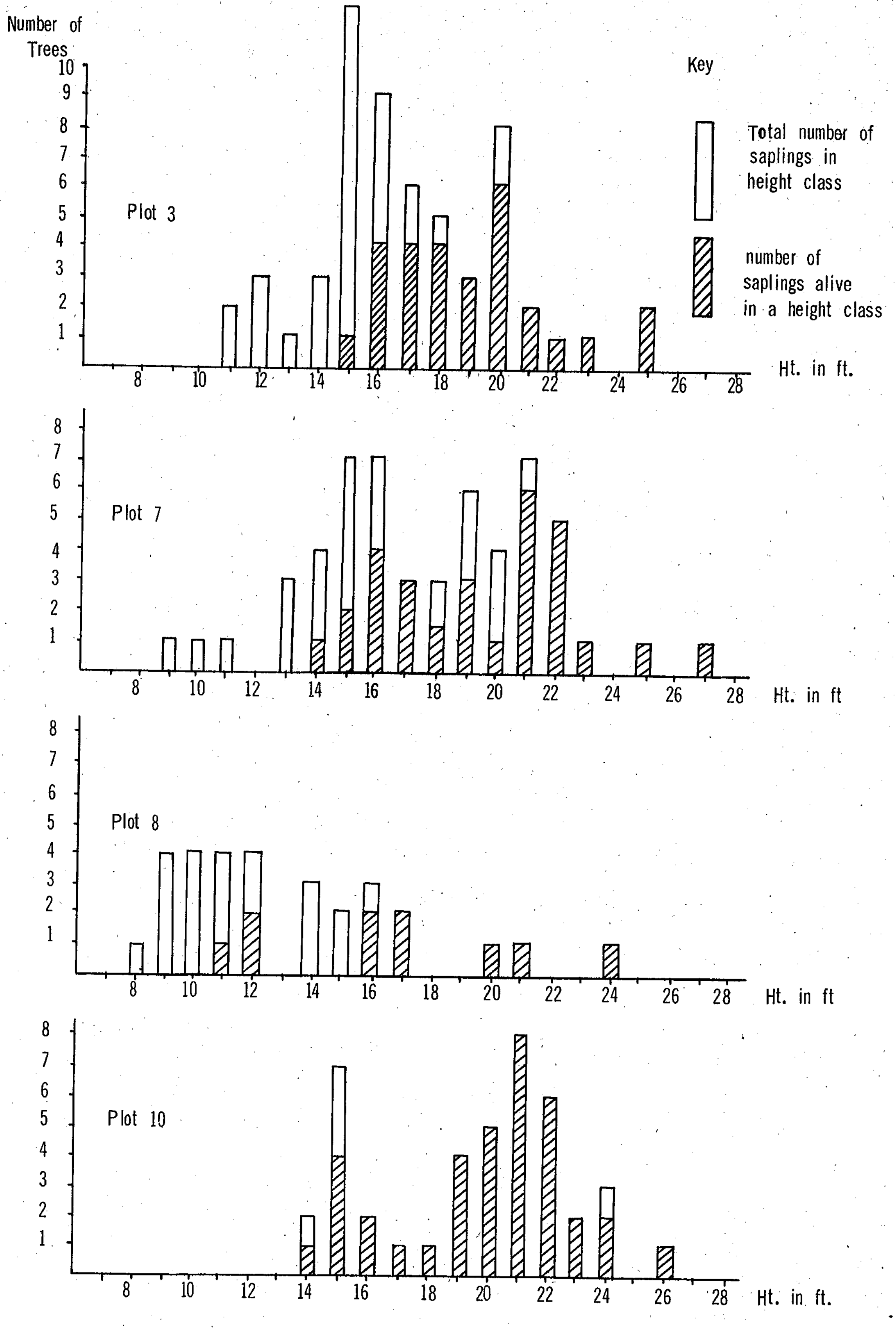
Additional information on survival was obtained by measuring the scorch height and total height of all remaining saplings in each plot that were over 6 ft. in height. A histogram with survival details in each different height class is attached. For details see the Appendix. Maximum scorch height ranged from 16 to 21 ft. for the plots. Survival rate was of course greatly increased with trees above 16 ft in height. Average scorch height was 14.5 ft.

CONCLUSION

Depending on site quality, Karri regeneration will have to be protected from fire for at least 7 to 8 years from the time of the regeneration burn or the date of planting.

This period of time would seem to be sufficient for a large majority of the stems to reach a height of 20 ft and so be able to survive mild control burns.

APPENDIX - LEWIN SCORCH PLOT



FUEL QUANTITY ASSESSMENT IN PINUS PINASTER

by

J. McCormick.

The Jarrah burning guide contains a table of fuel weights, the compilation of which involved the simple task of relating fuel weight to canopy cover and fuel age; however, fuel quantity values for Pinus pinaster cannot be obtained so readily since ground fuel weights depend largely on crown area and density. These are two parameters subject to a great extent by numerous factors, including site, strain, ground slope, thinning intensity, geographical location etc. In effect, ground fuel weights vary markedly within and between plantations containing the same conifer species. The position is further aggravated by the introduction of thinning slash.

Since a fuel quantity table appears to be out of the question for the time being at least, the alternative presented is a method of rapid fuel quantity assessment which can be applied by an inexperienced operator armed simply with a girth tape and a fuel depth gauge. The proposed system, its derivation and application will be explained in two sections; firstly, that in which the unthinned stand is considered and secondly, the thinned stand.

THE UNTHINNED STAND

Early investigations indicated a marked relationship between Pinus pinaster fuel depth and fuel weight which resulted in a 100 quadrat sampling trial being carried out in a fourteen year old unthinned stand. Where Y represented fuel quantity in tons per acre O.D.W. and X represented fuel depth in inches the resultant curve was $Y = 1.737 + 3.2468X$ which was significant at the 99% level with a coefficient of determination of .89 (Fig. I limits set at 95%).

The regression was tested against FQ/FD data taken from experimental spot fires run in sixteen year old fuel which had a maximum depth of three inches. The resultant curve, $Y = 2.12 + 2.91X$, significant at the 99% level with a C. of D. of .60 showed a remarkably good comparison.

A field test was carried out in McLarty plantation in which a twenty eight acre compartment (1A) was gridded at approximately 2 x 1 chains and 108 depth measurements taken which gave an average depth of 2.23 ± .1" with an average fuel quantity of 8.98 tons per acre. and a 95% significance range of 8.33 to 9.63 tons per acre. With a minimum of four depth measurements per acre, a thirty acre compartment can be sampled comfortably by one operator within half an hour. Precise gridding of the area is unnecessary but depth measurements should be taken at intervals of twenty two paces in lines roughly parallel to each other at approximately two chain intervals. A fuel depth-fuel quantity table has been drawn up (Table 1) which relates T.P.A. to half inch depth classes.

THE FUEL CONTOUR

It is obvious from what has gone before that the drawing up of a fuel contour plan for any compartment is a simple matter and this has been done for the compartment in question (fig. II). Contour strata can be set as desired. The plan illustrated has three strata – white represents area with less than eight tons per acre; hatching represents area with eight to fourteen tons per acre and the black area represents fourteen to twenty tons per acre. The latter would indicate pockets of heavy fuel which in the event of controlled burning would require careful attention, particularly in the unthinned stand.

THE THINNED STAND

The system devised for thinning-slash utilises the weight of flash fuel per tree top times thinning intensity, thus giving available flash fuel in tons per acre.

The task of finding the amount of needles and twigs per thinning crown by total crown sampling appeared cumbersome, therefore the parameter – O.D.W. of fuel per foot length of leading branch was devised for both needles and twigs less than half inch thick. Sampling was carried out until a variance ratio of less than 5% was reached for both needles and twigs. There was no relationship between the amount of fuel per foot branch length and the butt girth of the crowns sampled, therefore the parameters were considered acceptable.

The total leading branch length per thinning crown was related to crown butt girth for 100 measured crowns and gave the curve (fig. III) $Y = 18.11X - 79.6$ (sig.) 99%; C of D = .77 where the independent variable represented crown butt girth in inches. The table drawn up (Table II) represents oven dry weights for needles and twigs in tons per cent: therefore knowing the number of thinning tops per acre and their mean butt girth, the amount of available slash fuel is arrived at from the table in tons per acre O.D.W.

To arrive at the mean butt girth of tops in a thirty acre compartment it is suggested that a random sample of fifty girth measurements be taken. However, the operator with the statistical niceties at his finger tips will be able to arrive at a suitable sample number and thus relieve himself of unnecessary toil and trouble. Girth sampling is taken in conjunction with depth sampling. Where thinning intensity is unknown, the sample lines may be used in a line intersect method for assessing the number of tops per acre.

It is intended that information concerning the type of fuel depth gauge best suited for sampling P. pinaster fuel and instructions for its use will be included in a future issue of Forest Notes.

Table I. P. pinaster fuel depth (ins.) – Tons per acre (ODW)

Depth	T.P.A.	Depth	T.P.A.	Depth	T.P.A.
0.5	3.36	3.0	11.48	5.5	19.59
1.0	4.98	3.5	13.10	6.0	21.21
1.5	6.61	4.0	14.72	6.5	22.84
2.0	8.23	4.5	16.35	7.0	24.46
2.5	9.85	5.0	17.97	7.5	26.09

Table II. P. pinaster Crown butt girth (ins.) – Foliage and Twigs – Tons per acre (ODW).

Girth	Foliage	Twigs	Girth	Foliage	Twigs
6.0	.17	.04	13.5	.95	.23
6.5	.22	.05	14.0	1.00	.24
7.0	.27	.07	14.5	1.07	.26
7.5	.32	.08	15.0	1.11	.27
8.0	.38	.09	15.5	1.16	.28
8.5	.43	.10	16.0	1.21	.29
9.0	.48	.11	16.5	1.27	.30
9.5	.53	.13	17.0	1.31	.31
10.0	.59	.14	17.5	1.37	.33
10.5	.63	.15	18.0	1.42	.34
11.0	.69	.17	18.5	1.47	.36
11.5	.74	.18	19.0	1.53	.37
12.0	.79	.19	19.5	1.58	.38
12.5	.85	.20	20.0	1.63	.39
13.0	.90	.21			

Fig. I

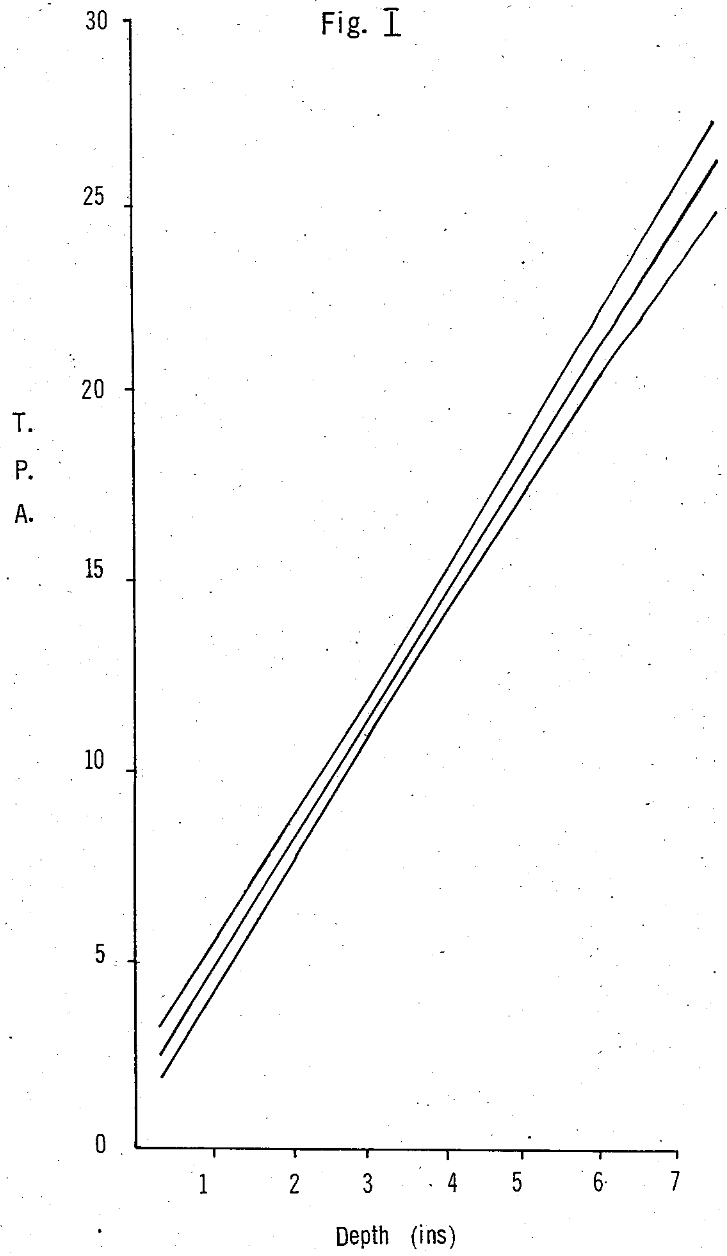
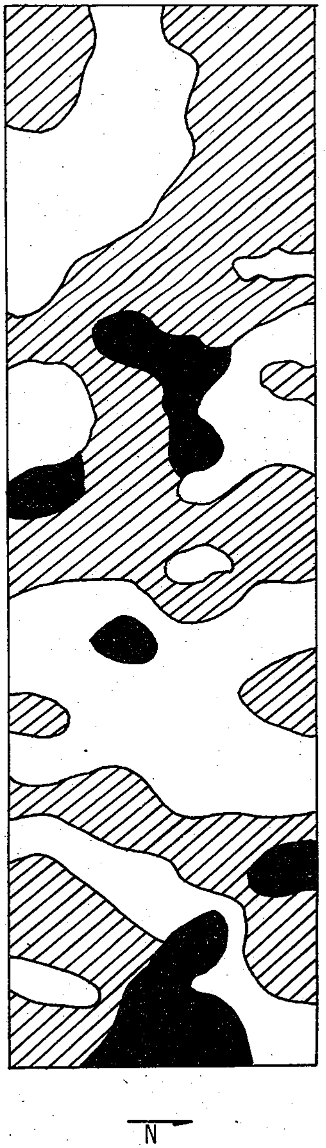
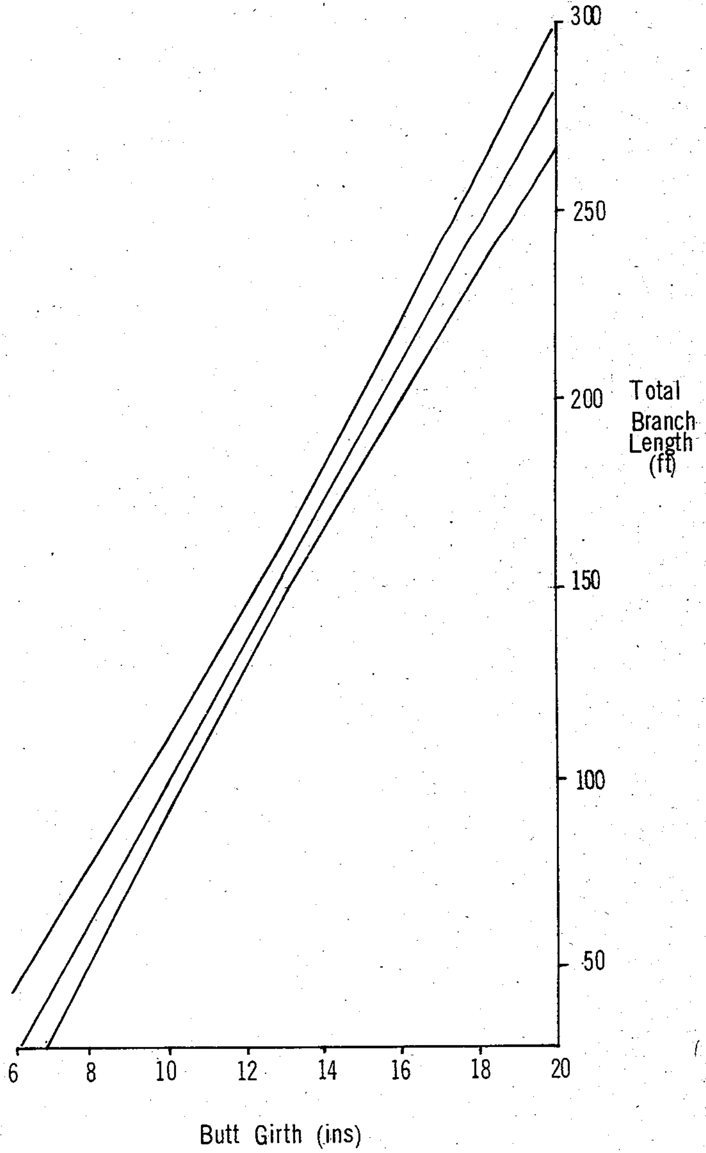


Fig. II



Mc Lartys 1A 28 acres
Planted 1956
Assessed Sept. 1970

Fig. III



THE EFFECT OF CROWN SCORCH ON GROWTH IN P. PINASTER

by

R.J. Kitt

The area of land under pine plantations is rapidly increasing and consequently so too are the areas required to be controlled burnt annually. Controlled burning in pine is, of course, now a necessity if fire risk is to be reduced to a minimum. The worry to the responsible officer in this field is great, as under most site and weather conditions the danger of crown scorch is always present. The problem of scorch is a difficult one as so few facets have been investigated. For example – what degree of scorch is necessary before girth and height increments are affected? How does this effect vary in relation to scorch severity? What period of time elapses before scorch trees return to normal? There are many unanswered questions.

In an attempt to answer some of these questions a field experiment in the form of a dendrometer trial was established in Somerville (P. pinaster) plantation following a top disposal burn in September 1966 in which a number of trees received varying degrees of scorch. The average height and G.B.H.O.B. of the trees at the commencement of the trial were 50' and 2' 5" respectively. 60 trees were selected and fitted with dendrometer bands. The tree heights, crown heights, and the height of green crown remaining were recorded for each tree. The 60 trees selected consisted of 30 scorch and 30 controls. The controls were matched individually by G.B.H.O.B. with scorch trees. The 30 scorch trees were divided into 3 classes (10 per class) as follows:–

A scorch – mean height of green tip – 1'6" (severe scorch)

B scorch – mean height of green tip – 5'0"

C scorch – mean height of green tip – 10'6" (light scorch)

Dendrometer readings were recorded monthly and total tree and crown heights annually. A variance test has been applied to each scorch class, the results of which are shown below. The trial has now been maintained for over 3 years.

MEAN GROWTH PER TREE FOR FIRST 3 YEARS AFTER BURNING.

Scorch Class	Year	Scorch	Control	Diff.	V.R.	Sig.
A	1	.125	.701	.576	31.14	.01
	2	.513	1.367	.854	24.63	.01
	3	.640	1.005	.365	9.21	.01
B	1	.383	.735	.352	6.16	.05
	2	.923	1.374	.451	5.99	.05
	3	.735	1.022	.287	5.72	.05
C	1	.750	1.004	.254	1.96	NS
	2	1.451	1.488	.037	0.04	NS
	3	1.059	1.055	+ .004	0.001	NS

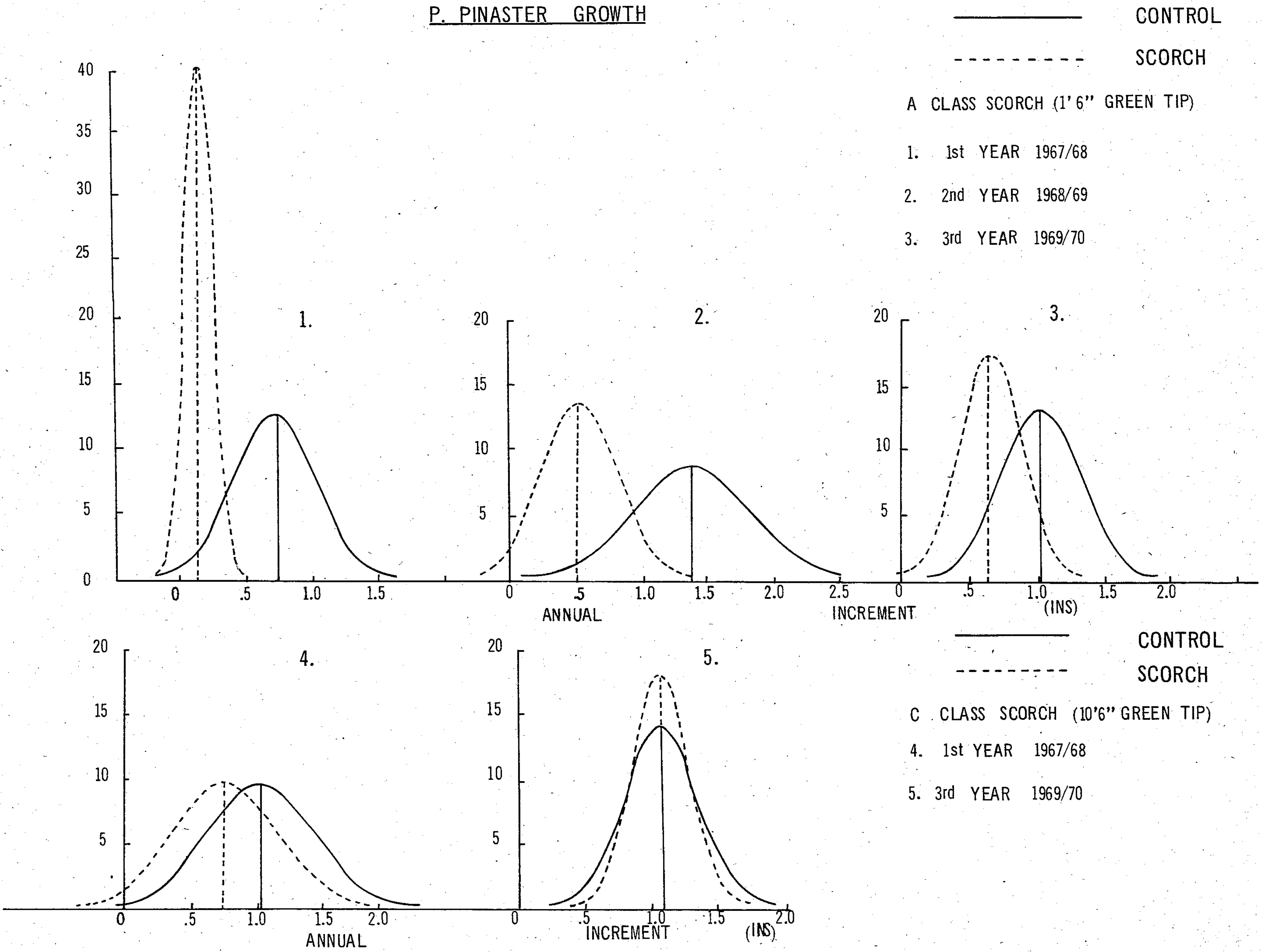
The growth pattern of trees in each scorch class in relation to control trees is perhaps best illustrated in the form of normal curves as shown in the following graphs. B class scorch has been omitted as its growth rate lies between that of A scorch and C scorch.

Height readings have been taken annually and the latest readings taken in September 1970 revealed the following mean crown heights which are compared with crown heights taken at the commencement of the trial.

SEPT. '70 READINGS	FEB. '67 READINGS
A scorch – 16.2' (61% of mean control crown ht.)	1.5'
B scorch – 17.7' (62% of mean control crown ht.)	5.0'
C scorch – 22.3' (78% of mean control crown ht.)	10.5'

Even from initial readings there were indications of a marked detrimental effect on growth rate which from the A scorch and to a lesser extent the B scorch trees has persisted up to the present time, while growth rate for C scorch trees has returned to normal after 3 years. As the effect of severe scorch (A class) is still highly significant 3 years following scorching it seems reasonable to assume that this effect may be prolonged a further 3 or even more years. From these results evidence may be such to confirm the theory that degree of increment loss is directly related to the severity of crown scorch.

P. PINASTER GROWTH



CAMBIUM DAMAGE IN P. PINASTER BURNS

by

L.M. Harmon

The result of crown scorch in P. pinaster is known to be detrimental. However, before this study, no attempt had been made to assess likely cambium damage to this species as a result of controlled burning.

In August 1969, a number of experimental fires were run in twelve year old P. pinaster at McLarty's plantation. During burning, flame heights averaged 2.5 ft. and fire intensity ranged from 40 to 45 B.T.U.'s.

Six months later a number of the smallest trees were examined in the experimental fire areas. The G.B.H.O.B. ranged from 8 ins. to 1 ft. 4 ins. and the bark thickness ranged from 0.15 to 0.4 of an inch.

These trees were cut down, peeled and examined for cambium damage. None was found.

One year later experimental fires in thinned areas with intensities up to 260 B.T.U.'s resulted in serious crown scorch.

G.B.H.O.B. for these trees ranged from 10 ins. to 1 ft. 9 ins. and bark thickness ranged from 0.32 to 0.84 of an inch.

Two months later twenty trees were examined. All had gum extrusion from pruning scars but only three indicated gum extrusion from damaged cambium bark.

It would seem from these observations that P. pinaster cambium can withstand considerable fire intensity with little detrimental effect, so that crown scorch could well be the limiting factor in determining the ceiling height of controlled burn intensity.

Observation of the twenty hot burned trees is continuing.

EDGE BURNING IN PINUS PINASTER

by

J. McCormick.

The area most susceptible to severe crown scorch in a P. pinaster burn is of course the exposed outer compartment edge and this for several reasons such as:–

(a) the rapid drying of edge fuel.

(b) strong wind turbulence and

(c) heavy 'edge effect' fuels which are greatly increased by the current, costly and laborious practice of pulling in thinning tops and pruning slash. The abolition of this practice and its replacement by the cheaper practice of edge burning would at the same time cut costs and eliminate edge scorching; it would, furthermore, allow the O.I.C. of a burn to take his mind off the edges and concentrate his attention on the bit that really matters i.e. the actual burn itself.

An edge effect study carried out in 14 years old, unthinned P. pinaster in McLarty's plantation provided the edge drying pattern and a typical edge drying trend commencing one day after rain which saturated the fuel bed completely is illustrated.

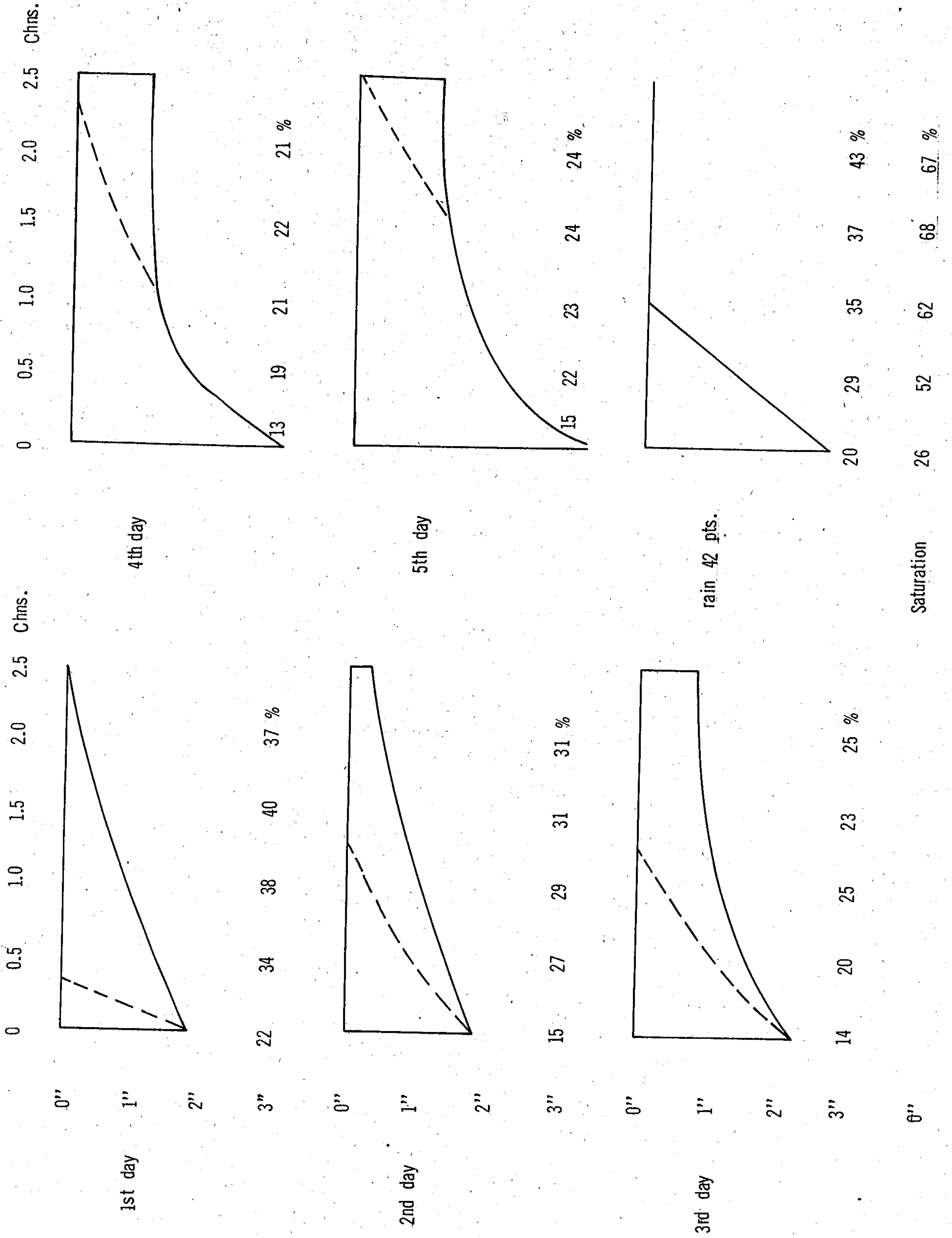
Fuel moisture content and dry duel depths were measured at 3 p.m. daily after rain until rain commenced on the sixth day (re illus). These measurements taken at half chain intervals inward from the compartment edge to a distance of two and a half chains indicated that several days occurred in which edge burning could have been carried out safely to a distance of approximately one chain inward since ignition of the surface litter can only be obtained at the 25-30% moisture content level.

The fuel contour areas illustrated represent that part of the total fuel profile free from surplus moisture, the actual fuel bed being five to six inches deep. The areas above the broken lines indicate the amount of fuel available at ignition moisture content.

Owing to intermittent rainfall periods experienced throughout the winter season there is often occasion when edge burning can take place but when complete burning cannot be carried out; in fact, a considerable percentage of experimental spot fires run in unthinned P. pinaster over the past six years by fire research staff have been run along compartment edges to a depth of one to two chains since dry fuel was unobtainable within the compartments.

The drying trend illustrated occurred in mid-May 1969. Further testing showed that the drying pattern held good throughout the winter months with slightly less penetration around late June and July.

PINUS PINASTER FUEL - EDGE DRYING PROFILES.



ESTIMATION OF KARRI UNDERSTOREY FUEL WEIGHTS FROM SELECTED STRUCTURAL PARAMETERS

by

R.J. Sneeuwjagt

INTRODUCTION

Fire behaviour in Karri understorey scrub can alter rapidly from low intensity flames burning in litter, to flaring of foliage, to conflagrations consuming whole scrub.

The present Karri forest fire danger tables (Harris, 1968), which is an extrapolation of the successful Jarrah fire danger tables, contain subjectively selected fuel loadings chosen to account for the scrub fuel differences.

However, these corrections, which are incorporated in the drought index, do not take into consideration differences in scrub type, density, height and disposition. Consequently, these adjustments have not met with a great deal of success.

It was with the aim of remedying this situation that a detailed study of Karri scrub fuel was initiated in 1961 prior to an intensive experimental fire behaviour study, (Ward, 1970).

The scrub study was designed to develop a simple, rapid sampling technique for evaluating fuel characteristics of high dense scrub, so that relationships between the structural parameters and fuel weights could be used to obtain scrub fuel loadings for more reliable predictions of Karri fire danger.

EXPERIMENTAL METHOD

The Study Area

The experimental area located at Strickland Road, twenty miles west of Manjimup, consists of a cover of mature and over mature Karri and Marri. The scrub understorey is representative tive of a major portion of the southern Karri forests. The major understorey species include Netic (Bossiaea aquifolium Benth), Hazel (Trymalium spathulatum Labill), and various Acacia species such as A. pulchella and A. strigosa. The area was divided into 180 three-chain square plots, which were sufficiently large to contain an experimental fire.

Assessment Method

The major considerations in choosing a suitable sampling method for measuring scrub composition and structure are the procedure be objective, reproducible, efficient and adaptable to tall and dense vegetation.

The line transect and random quadrat sampling techniques were judged unsuitable in the tall and dense vegetation.

The method chosen was based on a system of point sampling developed by Levy and Madden (1933). In this point sampling method the observer records the number of contacts at separate height intervals made by the plant species on a long vertically placed rod. The rod used was ¼ inch in thickness, and thirteen feet in length marked at one foot intervals.

Errors introduced by observer interpretation and by the finite rod diameter are only slight, so long as the diameter is kept small and all observations are made objectively (Goodall 1952).

The two major expressions derived by the Levy point sampling method which are of value to the present study are:

(i) Total Cover Density (T.C.D.)

$$\text{T.C.D.} = \frac{\text{total number of hits recorded on vegetation}}{\text{number of rods with at least one contact}}$$

(ii) Percentage cover contribution (P.C.C.)

$$\text{P.C.C.} = \frac{\text{total number of contacts recorded on the species}}{\text{total number of hits on all species.}}$$

T.C.D. is an expression of overall scrub structural density, and P.C.C. is an expression of the contribution of a particular species to the total population.

Because of the large number of plots to be assessed it was necessary to sample at minimum acceptable intensity. A sampling trial of four plots with up to 100 systematically chosen sites in each, indicated that 30 to 40 sites per plot gave reliable estimates of plot cover density and cover contribution by the main species. On the basis of these results the remaining plots were assessed using 36 sites per plot (40 per acre).

Each of the 180 plots was divided by three equally spaced lines. Six sites were spaced per line and sampling was conducted one yard either side of the 18 sites to give a total of 36 observations. Depending on topography of the area, the time taken for two men to assess each plot varied from 30 to 60 minutes.

Once, each of the percentage cover contribution values were determined it was possible to classify each plot in terms of major scrub species contribution.

A graphical method using an equilateral triangle was used to seperate the plots into distinct scrub types. In this convenient method of plotting, the triangle apices represented 100 per cent contribution by Hazel, Netic and 'other species'. Figure I shows that plots lying, say, on base line BC contain only Hazel and Netic, but no 'other species'. Similarly, those lying on line DF contain equal percentage of Hazel.

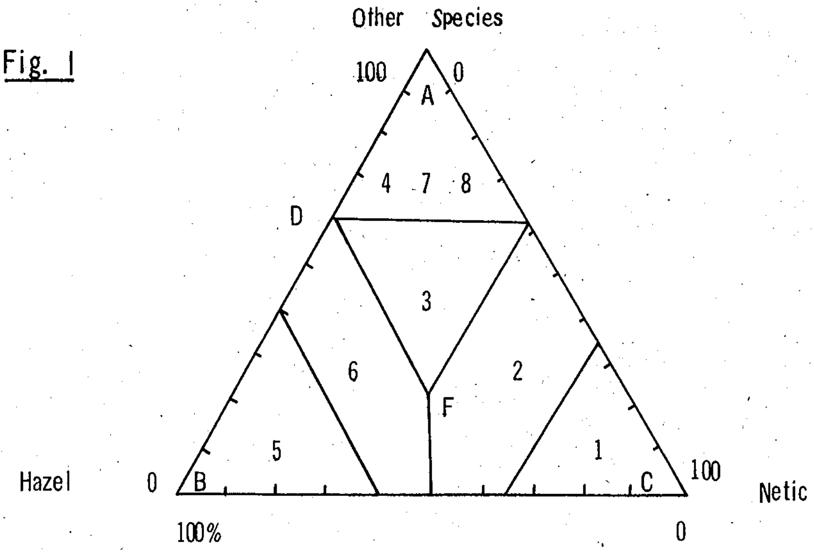
Eight distinct scrub classes were located within the triangle.

These are:–

(1) Netic only (> 65%)
(2) Netic dominant (> 40%) plus Other Species (O.S.)
(3) Mixture of Netic, Hazel and O.S.
(4) A. pulchella dominate ± Netic and O.S.

(5) Hazel only (> 60%)
(6) Hazel Dominant(> 40%) + Netic, O.S.
(7) Swamp type (A. divergens, swordgrass mainly)
(8) A. strigosa dominant + Netic.

Fig. 1



Scrub Weight Assessment

In order to determine what the expressions of cover density and height meant in terms of scrub weight, a weight sampling was conducted on each of the scrub types. Sampling was limited to those plots exhibiting extremes in both height and cover density within each of the scrub types. Six plots were sampled within each scrub type, each of which belonged to one of the following six categories.

A.	Tallest plots	(i) Densest	(ii) Least dense
B.	Intermediate height plots.	(i) Densest	(ii) Least dense
C.	Shortest plots	(i) Densest	(ii) Least dense

Sampling within each plot was conducted on a systematic basis, using every fourth of the original 36 points as the new weight sampling site. The sampling number of nine per plot was derived at from tests conducted on four trial plots in three scrub types.

The sampling method involved the weighing of all live and dead scrub material within a vertical cylinder of 1.66 feet radius, and described by a sliding wire arm attached to a twelve foot vertical pole. The radius of assessment was calculated to give simple conversion to tons per acre.

All material within two foot height intervals was removed by cutting, and seperated into live and dead. These were further broken up into four diameter classes of less than 1/8 inch (flash), 1/8 to 1/2 inch, 1/2 to 1 inch, and greater than 1 inch. Moisture samples were collected of all scrub components for each height interval. These were oven dried at 105°C and the calculated moisture contents used to express the data in terms of equivalent oven dry weight.

RESULTS

Scrub Weight Relationships

A preliminary examination of live scrub weight data indicated the existence of constant relationships between scrub component and total live weights for all scrub classes.

Weights of material less than 1/8 inch were plotted against total live weight and two linear regressions were evident (Fig. II).

The Netic and Acacious species dominant plots could be combined into one close regression. The Hazel dominant types separated out in a regression above the first. Those plots containing a mixture of these species, fell in between the two regressions.

The weights of material of 1/8 to 1/2 inch diameter and greater than 1/8 inch also separated out into two distinct linear regressions (Figs III & IV). Similar treatment on the dead material data, however, failed to show relationships existing between the total dead weight and the weights of the various size components. It was noticed that the weights of dead material do not vary much between samples of a scrub type, so that it was possible to use mean values for all plots within a scrub type irrespective of scrub height and density.

Scrub Weight and Scrub Height-density Relationships

The possible presence of relationships between live material weights and the derived quantitative expressions of scrub height and density were investigated. It was shown that both height and density parameters were directly related to scrub weight, although individually these parameters do not give sufficiently accurate estimates of scrub weight.

By combining cover density and height as a product a much better relationship was obtained. It was found possible to combine the Netic and Acacia species dominant types in a single linear regression (Fig. V). The Hazel dominant types formed a slightly concave regression above the first. (See Fig. VI).

The presence of these relationships make possible the determination of total live weight values of scrub types of known average top height and cover density. Thus, a direct estimation of scrub weight may be obtained by using the simple "Levy" point sampling technique to determine top height and cover density.

Scrub Weight Profile Histograms

It is of interest to both fire managers and research workers to learn how the weights of the various scrub components are distributed throughout the understorey profile.

From the scrub weight field data, the weights of the three live scrub components within 2 foot height intervals were plotted against the top height x cover density value of each sample plot within scrub types. A line of best fit for each size class gave three consistent and logical trends for each height interval.

These graphs were combined into a series of weight profile histograms for each scrub group, with each histogram spanning 20 units of the height-density product range.

Figure VII shows an example of two ranges of product values (80-100 and 100-120) for the Netic dominant scrub group.

DISCUSSION AND CONCLUSIONS

The present study successfully identified relationships existing between live scrub fuel weight, and the product of the structural parameters of scrub cover density and top height for all scrub fuels encountered.

The weights of live scrub structural components were demonstrated to be directly related to total live weight.

Thus, the values of average cover density and top height, determined by the point sampling method, are the only parameters required in order to estimate the weights of the total live material and the scrub components.

The weights of the dead scrub material did not vary greatly with change in scrub height and density, so that it was possible to adopt mean weight values for the entire range of parameters within each scrub type.

It is planned to investigate further the various weight-parameter relationships of several other common Karri understorey scrub types, and to expand the present data into both older and younger age groups.

At the completion of this work, it will then be possible to estimate scrub fuel weights of all common Karri scrub types within a proposed control burn area, by employing the simple point sampling technique and making use of the pertinent relationships obtained.

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Fig. II

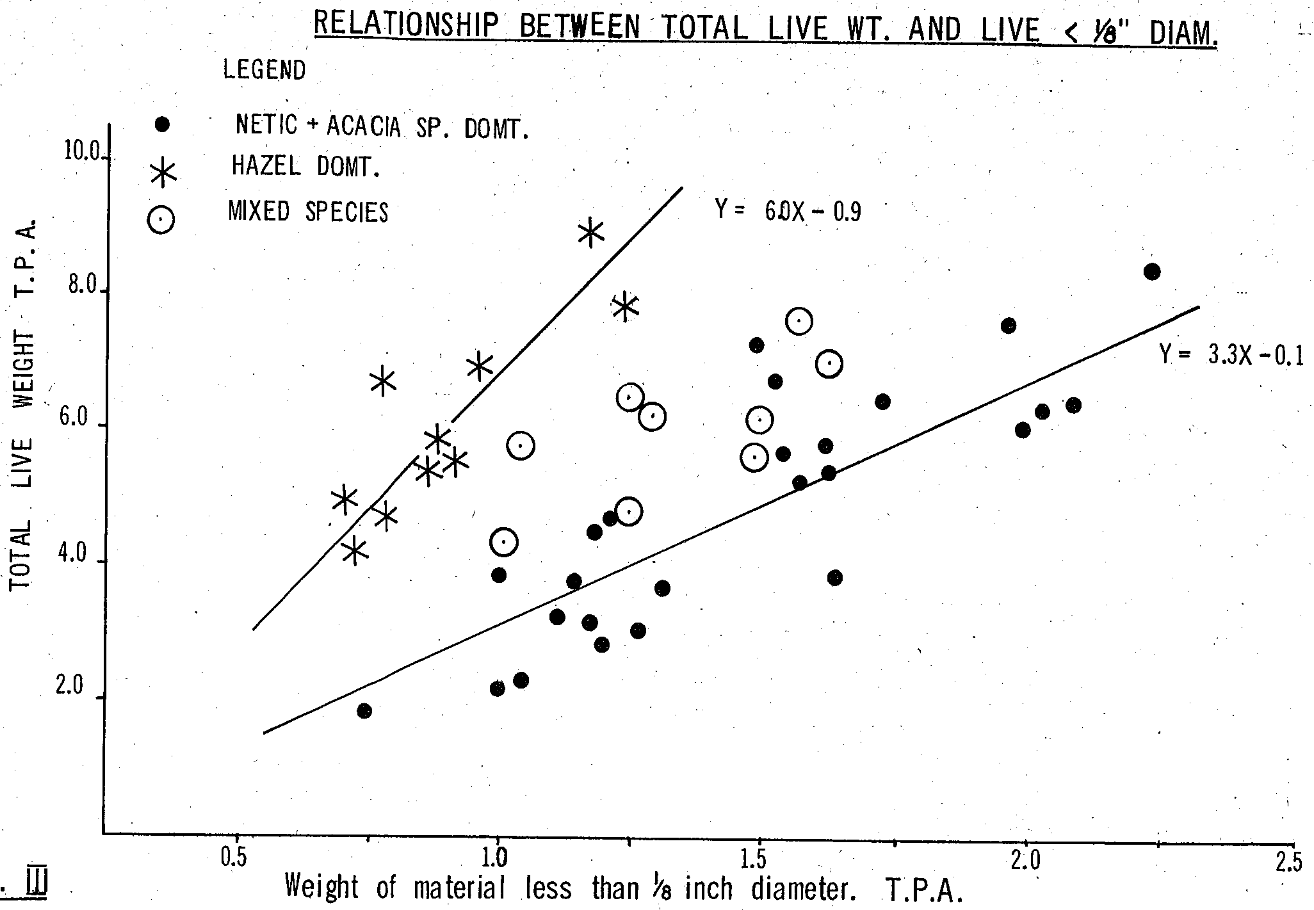
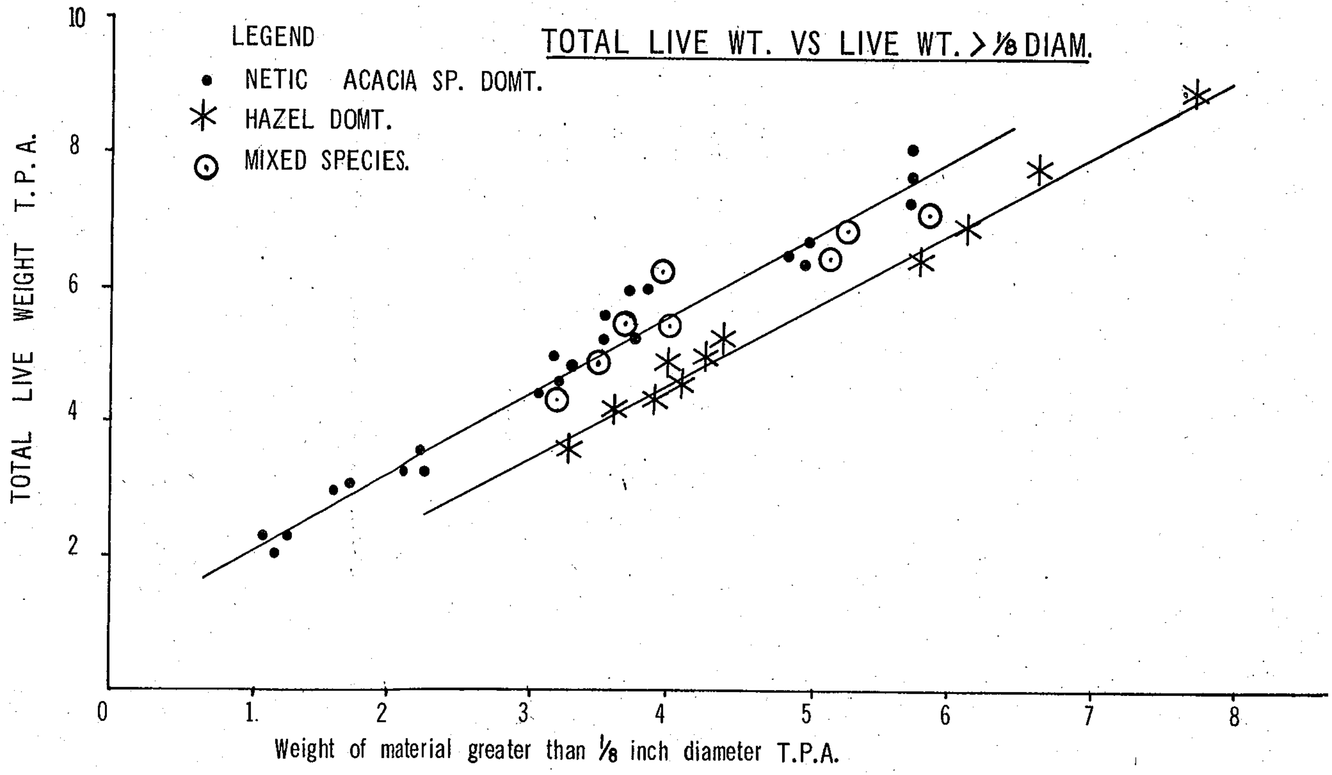


Fig. III



RELATIONSHIPS BETWEEN TOTAL LIVE WT. AND WEIGHTS OF VARIOUS LIVE FUEL SIZE COMPONENTS.

Netic domt. and Acacia sp. domt. only.

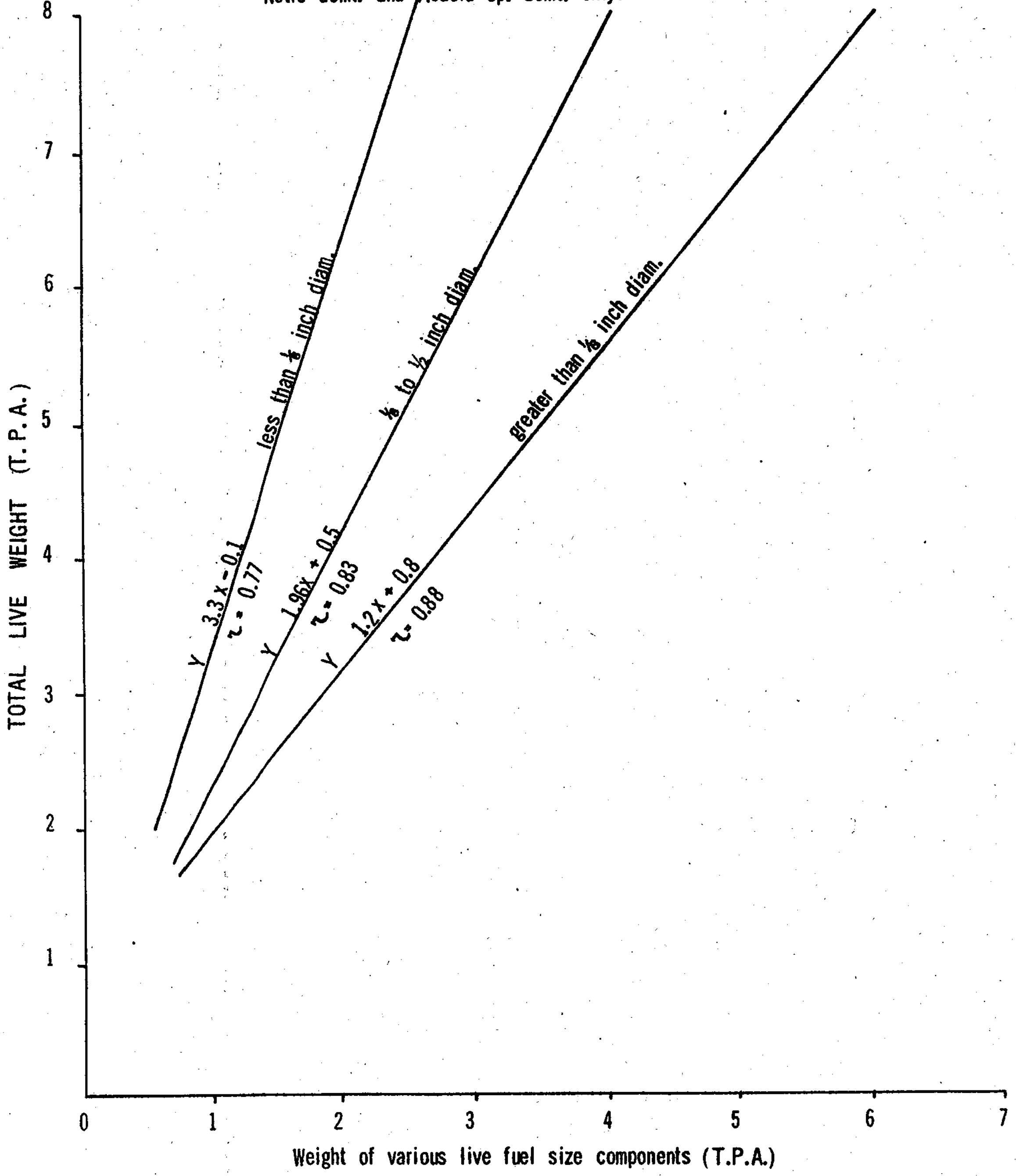
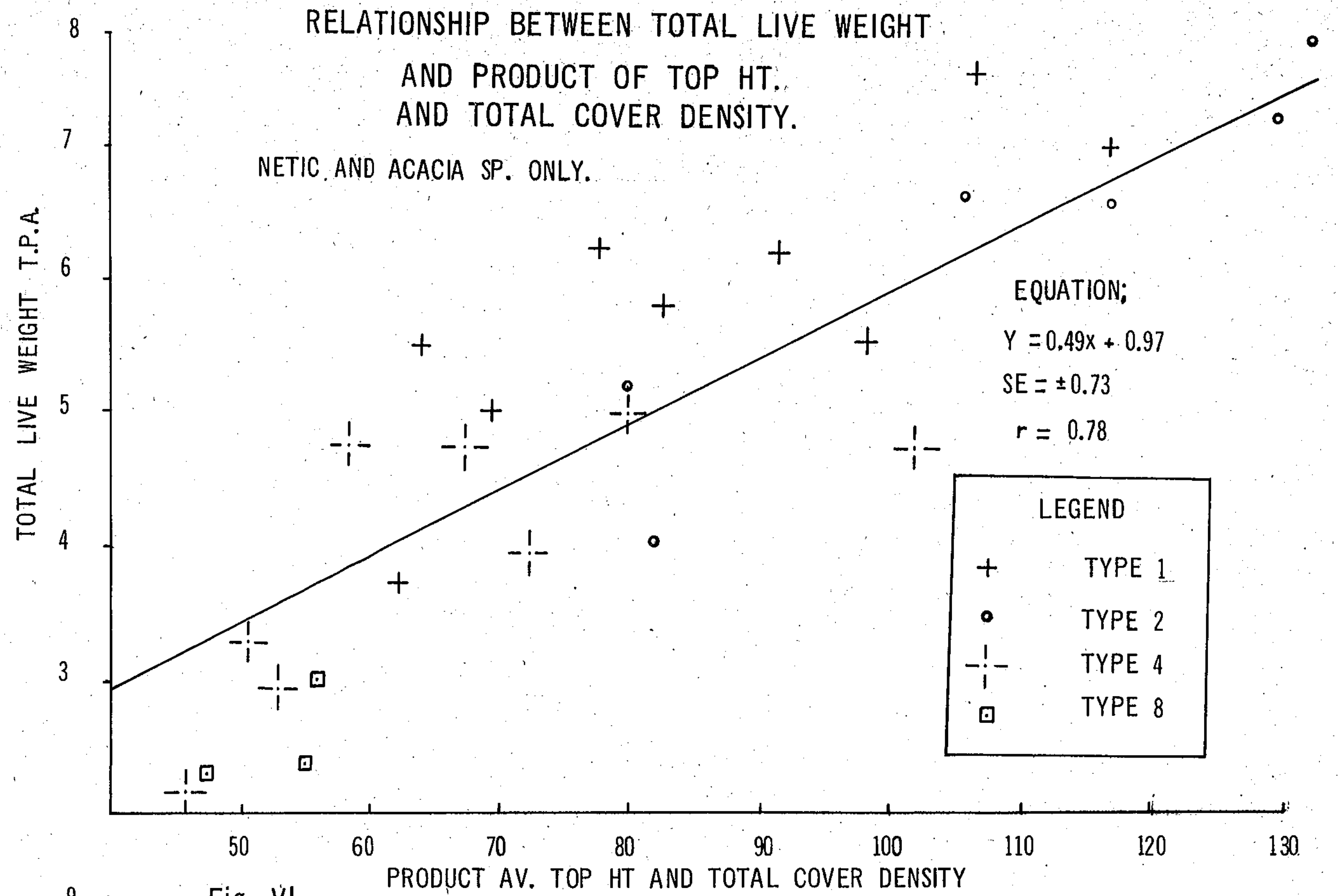


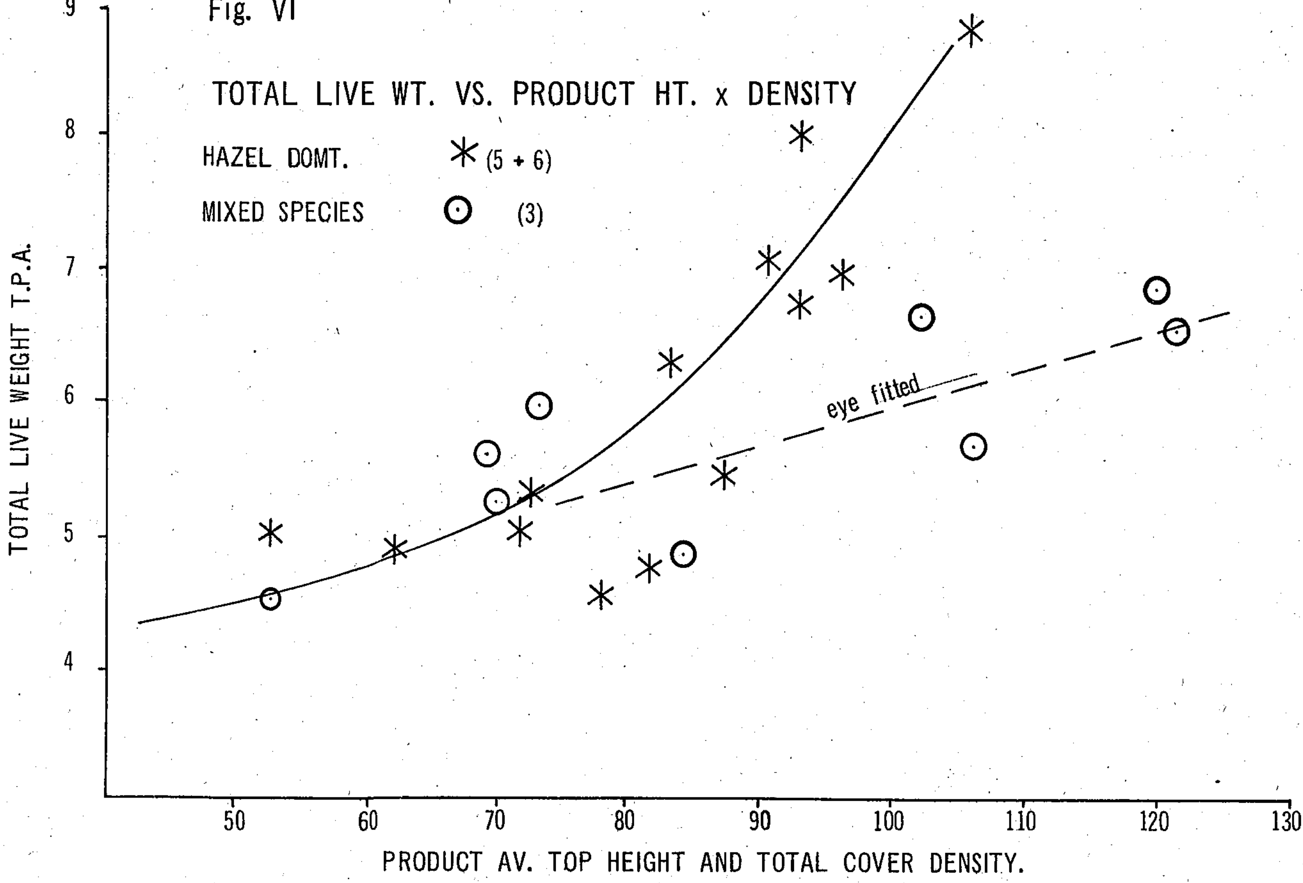
Fig. V



RELATIONSHIP BETWEEN TOTAL LIVE WEIGHT AND PRODUCT OF TOP HT. AND TOTAL COVER DENSITY.

NETIC AND ACACIA SP. ONLY.

Fig. VI

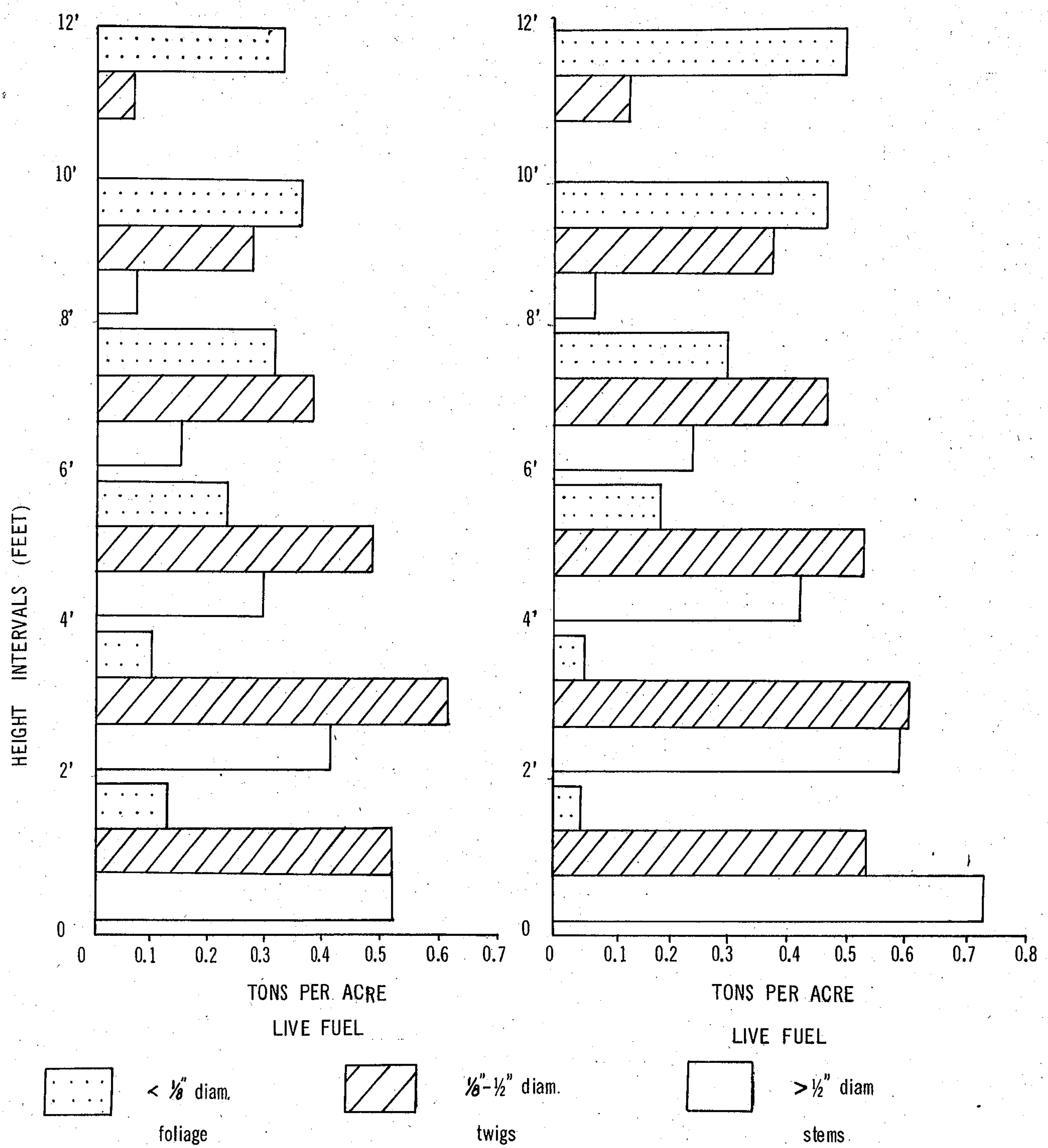


TOTAL LIVE WT. VS. PRODUCT HT. x DENSITY

Fig. VII LIVE SCRUB WEIGHT PROFILE HISTOGRAMS

TWO EXAMPLES WITHIN ONE MAJOR SCRUB TYPE.

BOSSIAE AQUIFOLIUM DOMT.



HT. x C.D. PRODUCT 80 - 100

HT. x C.D. PRODUCT 100 - 120

THE STUDY OF THE EFFECT OF FIRE ON FOREST FAUNA IN W.A.

by

P.C. Kimber.

INTRODUCTION

Views on the deliberate burning of vegetation for fire hazard reduction are sharply divided in Western Australia. On the one hand we have those people, primarily foresters and agriculturists, who recognise fire as a management tool in their day to day working. By far the greatest numerically are those that have little to do with land-use management – we can call them the city dwellers if you like – and I believe that this large segment of the community has a general fear of fire; a fear born of ignorance.

We live in a climatic region of the world, in common with the Mediterranean countries and South-Western United States, where fire has been a natural and regular phenomenon for millenia. Mild, wet winters produce a vigorous flush of vegetation which dries out in the severe, long dry summers. Fires due to lightning are inevitable under these conditions. Indeed, early explorer's first impressions of W.A. frequently mention a thick smoke haze as part of their first view ot the country. That W.A., and the South West forested areas in particular, have been subjected to fire for a long period has been well documented. The reader is referred to Wallace's (1966) excellent recent historical account of fire in the Jarrah forest. Churchill (1968), writing in the Australian Journal of Botany, produces evidence of the association of fire with the south west forests for at least 7,000 years and he finds that some of the fires were severe ones.

The detractors of fire as a land management tool will say that we are destroying the ecological balance by its use. However, if the forest has been burnt over a period of 7,000 years or more this seems unlikely. No doubt, were burning stopped the fauna and flora would change. But the existing ecological balance has in all probability developed together with fire, in other words the plants and animals of the forest have adapted themselves to a habitat that is burnt periodically. In fact the fauna and flora that exists at present are the natural ones. There is a considerable weight of evidence that the rabbit (by competing for food) and the domestic cat (by predation) between them have altered W.A.'s fauna more than any other factor.

We are now in the day of conservation, and we have to prove our theories. The Forests Department is undertaking a massive exercise in what can be partly described as apologetics. We know that hazard reduction burning is essential to the very existence of our forests and we now are setting out to find what effects our controlled burning practices have on the flora and fauna. This, then, is the background to a comprehensive programme of studies now being undertaken by the Department to determine what happens to plants and animals when we burn. This article deals only with the animal side of the studies.

Probably the greatest difference between the natural fires of centuries past and controlled burns today is exemplified by the aerial controlled burn where a very large area is lit up over a relatively short period. It is this type of burning on which our investigations will be concentrated as it has, on the face of it, the greatest potential for animal destruction.

AIMS OF THE STUDY

The broad aim is to determine the relationship between forest fauna and fire, particularly at the frequency and intensity of the controlled burning as it is now practised. The aims can be put in more detail as follows:–

(1) To find the effects of controlled burning on the larger animals with wide habitat ranges (Kangaroos and Brush for example).

(2) To find the effects of burning on those species with narrow or specialised habitat requirements where the burning of a small area of a particular vegetation type could have a profound effect on the numbers of that particular species (examples are certain types of swamps inhabited by Quokkas and, in some cases Tammars).

(3) From the findings of the first two aims, any vegetation types that require protection from fire or special burning techniques can be defined and recommendations made for their application.

(4) The preparation of a comprehensive check-list of the forest fauna. The range of animals to be covered will have to be limited of necessity. It is likely to be confined to mammals, birds and some reptiles.

THE STUDY PROGRAMME

The study will be conducted in a number of stages which we can classify under two main headings. Firstly extensive surveys of animal distribution in the forest will be made. Secondly a far more intensive investigation will be made into the effects of fire on these animals.

(a) Extensive Studies.

(1) A forest-wide survey of the large, easily recognised animals (particularly Kangaroos, Brush, and Emu) was started on 13th October and most staff members of the Department took part in it. The object was to gain some knowledge of the distribution, density, and habitat preferences of these three species. The survey was remarkably successful, due in no small part to the keen interest of all staff in the project. The results are still being summarised but one outstanding fact has already emerged – both Kangaroos and brush show a stong preference for young scrub. There is a strong correlation between the number of kangaroos and brush observed and the period since the area was last burnt; the longer this period the less of the two species were seen.

A repeat of the original survey will take place at a later date. The two surveys together will complete this part of the project.

(2) Stage two of the extensive studies involves the collection and collation of existing knowledge of forest animals. Most members of the Department will by now have been asked for any information they have on forest fauna. The data collected in this way will give us a broad, but probably still incomplete picture of what species live in the forest.

(3) To complete the picture an intensive search will be made in selected areas for species which are suspected (from literature on the subject) to be present but which so far have not been located.

Thus the stage of extensive studies is expected to enable us to prepare the check-list, mentioned in the section on aims of the survey; also it will yield detailed information on the habits and numbers of the larger, more obvious animals.

(b) Intensive Studies

Closer, more intensive studies will then be made in three or four carefully selected areas. These areas will, as far as possible, be chosen to coincide with an aerial burning block. Each area will be surveyed and mapped by vegetation types. The fauna associated with each type will be determined, both qualitatively and numerically at various intervals before, and after controlled burning. Similar study areas will be selected outside the aerially burnt block to compare animal numbers with those inside the block.

Separate additional studies may be necessary for animals with narrow, specialised habitats which are not represented in the three or four main areas.

These intensive studies are expected to yield the important information we are seeking. In particular any habitats and species which may be endangered by fire will be recognised and measures can be taken to prevent their being harmed.

CONCLUSION

I would like to finish with a word of explanation. It is quite certain that we are killing young birds and some smaller animals in our controlled burning operations. This much we realise and it is not the object of this study to prove or disprove this point. Our objective is to determine whether these inevitable mortalities are having an overall effect of reducing animal populations or not.

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THE ROLE OF FIRE ECOLOGY IN WEST AUSTRALIAN FORESTS

by

P. Christensen.

Ecology is a new name for a very old subject. It is simply scientific natural history. The name is derived from two Greek words, oikos – meaning house, and logos – discourse. It is then, the 'discourse', discussion or study of plants and animals in their 'house', habitat or immediate environment. Fire ecology is the study of the effects of fire on plants and animals in their natural environment.

The discoveries of Charles Darwin in the middle nineteenth century gave tremendous impetus to the studies of species and their classification. Since it is a great deal easier to study the taxonomy and morphology of individual species, and this incidentally needed to be done, it tended to drive botanists and zoologists into Herbaria, Museums and Laboratories from whence they have only recently emerged. Currently it is being realized that species cannot be dealt with individually but have to be studied in relation to their physical and biotic environment. The study, protection and preservation of the environment has recently received so much impetus that word ecology might be said to enjoy the rather doubtful status of being one of the 'in' words of this decade.

How does all this concern us as foresters? In the past we could doze contentedly behind the shielding maxim "multiple use", deluding ourselves that because of the all embracing nature of the term, its mere utterance absolved us of all further responsibility. Then it was sufficient if we could demonstrate that the nation's timber resources and water catchments were adequately managed and protected. Now it is no longer sufficient that the trees are growing and the scrub looks green. People want to know whether everything is being adequately protected and preserved. Are all the species of plants still there? Where is the fauna that roamed the bush? How are our activities, logging, burning, etc. affecting the environment?

In the past only those species of plant or animal that provided food, shelter or tools etc. were considered of importance to man. With our increasing knowledge we are becoming more aware that we are part of the scheme of things, and that our wellbeing is dependent on how we treat all the living things around us. Also, modern advances in technology enable the utilization of an ever increasing range of plants and animals. A host of so called uncommercial species play vital roles in many of the newer branches of science. Cytology – the study of cells, Biochemistry – the study of enzymes, vitamins, fermentation, hormones etc. Biophysics – the study of nerve signals, muscle contraction etc. Photochemistry – the kinetics of reactions influenced by light. Genetics – the study of the mechanism of inheritance and of course, Ecology – the study of the physical and biotic environment of plants and animals.

A small fruit fly for instance, Drosophila melanogaster has contributed immeasurably to our knowledge of genetics. Live animals are used for a variety of purposes ranging from that of pets to studies in sociological problems, psychological problems and the Moon project. Early advances in the field of pharmacology were dependent on plant and animal products. Take Quinine the anti malarial drug derived from the bark of a South American oak. Penicillin the product of a fungus, and a host of other products. Plants and animals of all kinds have contributed and are contributing to just about every field of human knowledge ranging from such obvious fields as agriculture to psychology and space exploration. Let us not delude ourselves, the more advanced our technology becomes the more dependent we ourselves become on the plant and animal kingdom.

Thus perhaps the most important value of any single species, apart from its own role in the scheme of things, is its possible latent scientific or economic potential. It is impossible to state this in terms of hard currency. Take the two examples given earlier, Penicillin and Quinine; how does one evaluate the countless thousands of lives these two drugs alone have saved? Who is to say what fantastic secrets may lie hidden awaiting discovery in even the most insignificant species? Each species of plant or animal is unique, it possesses its own genetic make-up which sets it apart from all other life forms. Once lost, no species of plant or animal can ever be recovered, it is irreplacable.

We may turn now to our own particular case. I quote from Royce, R.D. and Aplin, T.E.H. of the W.A. Herbarium – "The flora of W.A. comprises over 6,500 Angiosperms (flowering plants), some fifty ferns and over 400 marine algae, as well as many mosses, lichens and liverworts which have never been completely listed.

It is one of the most interesting floras of the world, due to its high degree of endemism, i.e. the large number of species which are entirely restricted to the region. This is especially noticeable in the South Western Vegetation Province, which extends from Shark Bay at its northern extremity to Israelite Bay on the south coast, and has an eastern boundary approximating closely to the 10 inch isohyet.

"It has been estimated that the endemism of the South West is as high as 75%. When compared with island floras, this may not of course, appear to be a very impressive total. The Hawaiian Islands for instance, record an endemism of 90% and more, but the number of species and actual area of land involved are not very great. When considered as a portion of a continent, however, the figure for the South-West flora is a particularly high one and is possibly only exceeded by the Cape Province of South Africa and some areas of the South American Continent".

Climatic and soil factors have resulted in the distribution of vegetation types into general provinces and within these are different vegetation formations, e.g. Jarrah forest, Karri forest, etc. Each of those formations provide food and shelter for a rich and varied fauna. This fauna also has many species endemic to W.A. e.g. the Quokka,, the Western Brush Wallaby, Honey Possum or Noolbenger and the Dibbler to name but a few of the better known species.

The State forest area is situated more or less in the centre of the South-West where many of the endemic species occur. We have an obligation to the community who entrusted this part of our State to our care to see that these species are protected and preserved for future generations.

Besides the reasons for preservation already outlined above, there are a number of others, nonetheless vital, but perhaps more tangible reasons for protecting and preserving the natural state of our forests. Places for recreation are assuming an increasing role as population expands. State forest areas are one of the largest potential recreational areas in this State close to major population centres. Here people can come for a short respite from the rush of city life and enjoy a day or longer in the peace and quiet of the country. We are the wildflower State and not only do our forest areas attract "local" tourists but they come from the other States as well as from abroad to see the wildflower display in Spring.

If we should prove incapable of protecting both the flora and the fauna entrusted to our care, we stand a good chance of this responsibility being taken out of our hands and thereby losing one of the more rewarding aspects of forestry. In 1969, the editor of "The New Zealand Journal of Forestry" in reviewing the report of a wildlife inquiry foresaw their foresters becoming relegated to manage purely exotic plantations, unless they could prove their ability and intention of safeguarding wildlife interests.

Our operations affect both flora and fauna. Logging operations result in opening up the forest canopy which may have a profound influence on the vegetation. However, the main single ecological factor in W.A. State forests is undoubtedly fire. We have demonstrated beyond reasonable doubt that fire is a part of the environment, and that its use is in the best interests of both the public and their timber resources. However, we have not shown what effect the present system of controlled burning has on the flora and fauna, and only the foolish or ignorant would argue that it has no effect.

At the present time there is only a limited amount of knowledge available on this subject. However, it appears that fire can be both harmful and beneficial. Karri requires fire to stimulate opening of the capsules, and to provide suitable conditions for germination and early establishment. Such species of wildflowers as Boronia megastigma may also need fire to release them from the competition of other species and allow the seed to germinate. Leadbeater's Possum in Victoria is only found in areas where Mountain Ash has been killed by fire and new growth has sprung up. The Tammar finds shelter in thickets formed from the early regeneration stages of Casuarina sp. until it becomes too tall. There is evidence from the recent fauna survey carried out by the Department, that the Western Grey Kangaroo is attracted to recently burned areas of forest. A study in the forests of Daylesford and Trentham, Victoria, revealed that controlled burning had little apparent effect on the population of the Bush Rat (Rattus fuscipes) and the Brown Phascogale (Antechinus stuartis), whereas wildfires seriously depleted microfauna and small mammals.

It is also known that too frequent burning will eliminate Acacia sp., and low intensity fires can markedly change the habitat by changing the species composition of the understorey as has been described by Dr. Ashton.

Thus the effects of controlled burning on flora and fauna is a relatively untouched field and little is yet known. The Department has already established itself as one of the leaders in the use of fire for protection purposes. Not only do we possess the necessary resources, but it is clearly also our duty to investigate the results of our own policies. With the necessary basic knowledge fire can be used not only for protection purposes but also for the safeguarding of the flora and fauna species entrusted to our care.

The concept of fire as a fauna management tool is not new. The Kenai National Moose Range in the U.S.A. is burnt at regular intervals to extend the browse production by reducing the growth of spruce and allowing a higher population of moose. Too frequent burning favours grass and herbs, eliminates browse and greatly reduces the moose population. The National Parks in Africa use fire extensively. The Kruger National Park authorities burn the grassland every two or three years.

To adequately protect and preserve the infinite variety of flora and fauna within State forests a thorough knowledge of the special requirements of each species is necessary. This means a programme of investigations into the fire ecology of both flora and fauna species. The Department already has such a programme under way and a start is being made on investigations of the fire ecology of some wildflower species and also certain major scrub types. Fauna studies are not a major part of the programme at this stage, but it is hoped that there will be expansion in this field as flora and fauna are not easily studied separately.

For instance very hot fires encourage Acacias. Very cool or very frequent fires may eliminate them altogether. The Bronzewing Pigeon feeds on Acacia seed and is thus also affected by any change in the abundance of this species.

This knowledge is required so that the requirements of each species is realized and steps can be taken so that it is preserved. Once the necessary knowledge is available it will be possible to burn specific areas at predetermined frequency and intensity so as to maintain a wide range of habitat type.

The tremendous problem facing us is that we should preserve and encourage everything that lives and grows in the forest. The proper use of fire allows us to maintain the large variety of habitats necessary to achieve this.

THE EFFECTS OF FIRE ON LITTER DECOMPOSITION AND ON THE SOIL FAUNA IN A PINUS PINASTER PLANTATION.

by

J.A. Springett.

ABSTRACT.

Controlled fires are used in forest management programmes. Their effects on decomposition in Pinus pinaster litter has been estimated by using 10 cm x 30 cm strips of unbleached calico buried in the soil to measure the relative decomposition rates in burnt and unburnt areas. The soil microarthropods in the two areas were compared. Detailed taxonomic information was not available for most groups and so attributes such as feeding habits and the presence of food in the gut were used to classify individuals.

The results showed that although the population densities and the proportion of mites to collemboles did not differ on the two areas the decomposition rate was reduced on the burnt area. The proportion of fungal feeders was less as was the proportion of animals with visible gut contents. This may indicate a lower rate of fungal decomposition in the burnt area. The lower numbers of animals with visible gut contents on the burnt area could be an indication of reduced feeding activity or it could reflect a change in the type of food eaten as bacterial food is not easily visible in the gut.

It is possible that fire has produced a change in the physical or chemical properties of the soil litter which favours bacterial rather than fungal decomposition. If this is so and is reproducible in other forest types, it can be seen that controlled burning may be capable of making a fundamental change in the energy pathways in the forest ecosystem.

Reprinted from Proceedings of the Fourth International Colloquium on Soil Zoology.
Dijon September 1970 Annales de Zoologie 1970.

(Editors' Note: This work was carried out in Western Australia where Dr. Springett is under contract to the Forests Department to carry out Soil Zoological Studies of litter decomposition, mainly in Pinus pinaster. She is also helping the study of the ecology of the Noisy Scrub Bird by carrying out special litter studies pertinent to the bird's habitat and feeding habits.)

AN EFFECT OF BURNING ON JARRAH SCRUB REGENERATION

by

J. McCormick.

It is one thing to control-burn large forest areas but quite another to predict the long term effect that prolonged cyclic burning will have on the native flora. In recent years pronounced changes in the plant population occurred in Dwellingup division when the aftermath of the 1961 wildfire produced large areas of dense fireweed species which in turn have been almost completely removed by controlled burning.

To study the effect of controlled burning on these fireweeds, a small trial was established in Wilson block in 1968. The three major scrub species tested were Acacia pulchella, Acacia strigosa and Bossiaea aquifolium which grew to a height of 4'6" and had a cover density of 80%. In each species-area a one square chain plot was established in which 25 fixed 2 x 2 ft. quadrats were assessed for genera and species numerical dominance before and after controlled burning and areal dominance after burning (re tables). The plots were treated with a controlled burn of 20 B.T.U.'s intensity in mid November 1968. All major scrub plants were either scorched or defoliated in the burn. The effect of burning on major plot species numbers was

	Before burning	(18 months) After burning
Acacia pulchella	95	4
Acacia strigosa	252	11
Bossiaea aquifolium	220	12

Most of the major species after burn plants were of new seedling growth. The total plant population was reduced by 40%, whereas the number of lower strata species was reduced by 9%, only.

The effect of controlled burning on some individual genera and species is recorded:–

Leguminoseae	The most pronounced effect of burning was on leguminous plants which showed a marked loss in numerical and areal dominance over all other genera (re tables).
Proteaceae	Achieved areal dominance after burning.
Papilionaceae	Upper strata species Bossiaea aquifolium was replaced in dominance by lower strata papilionates.
Rhamnaceae	Trymalium ledifolium appeared to germinate profusely and establish itself readily, whereas T.spathulatum, a plant generally found in more moist areas was eliminated by the burning.

Myrtaceae	Eucalypt seedlings were reduced in number by 50% by burning but removal of upper strata plants led to good areal dominance.
Orchidaceae	Orchids appear to grow profusely in the burnt plots...
Rubiaceae	Opercularias indicate good seedling regeneration.
Epacridaceae	Good regeneration of Leucopogon capitillatus was observed.
Steruliaceae	Lasiopetalum floribundum introduced since burning and now has considerable areal importance.

Species common to the general area among the families – Goodeniaceae, Dilleniaceae, Apiaceae, Amaryllidaceae etc. show little dynamic variation as a result of the burning treatment.

It is evident from the trial that perennial plants with rhizomous or more pronounced root systems will better withstand controlled burning than tall perennial plants with sparse root systems grown rapidly from seed, e.g. the three major species considered in the trial. It is therefore reasonable to surmise that in the event of cyclic four to five year controlled burning the perennial plants more likely to become dominant will be those which can best establish a pronounced root system within the given time, thus species dominance will be governed to a large extent by periodicity of burning and fire intensity.

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Plant Families in Order of Numerical Importance

B		A	
Leguminosae	347	Apiaceae	179
Papilionaceae	293	Goodeniaceae	109
Apiaceae	203	Rhamnaceae	80
Goodeniaceae	143	Orchidaceae	69
Rhamnaceae	108	Papilionaceae	67
Proteaceae	82	Proteaceae	57
Myrtaceae	54	Rubiaceae	50
Dilleniaceae	43	Dilleniaceae	35
Ranunculaceae	34	Ranunculaceae	35
Rutaceae	30	Epacridaceae	29
Tremendraceae	29	Myrtaceae	26
Stylidiaceae	28	Tremandaceae	22
Orchidaceae	19	Stylidiaceae	20
Amaryllidaceae	13	Steruliaceae	20
Liliaceae	12	Liliaceae	19
Pittosporaceae	11	Rutaceae	17

Restionaceae	9
Droseraceae	4
Epacridaceae	4
Iridaceae	2
Rubiaceae	2
Cycadaceae	1
Steruliaceae	0

Leguminoseae	15
Amaryllidaceae	12
Restionaceae	12
Droseraceae	8
Cycadaceae	2
Iridaceae	1
Pittospermaceae	0

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Plant Families in Order of Areal Importance

A	Sq.ft.
Proteaceae	13.99
Liliaceae	10.10
Myrtaceae	10.05
Steruliaceae	4.17
Papilionaceae	3.77
Grass type sp.	3.48
Dilleniaceae	2.76
Rutaceae	0.98
Cycadaceae	0.94
Apiaceae	0.94
Epacridaceae	0.79
Goodeniaceae	0.77
Restionaceae	0.60
Ranunculaceae	0.47
Rhamnaceae	0.37
Amaryllidaceae	0.23
Rubiaceae	0.21
Orchidaceae	0.19
Stylidaceae	0.15
Tremandraceae	0.14
Iridaceae	0.14
Leguminosae	0.08
Droseraceae	0.05
Pittospermaceae	0.00