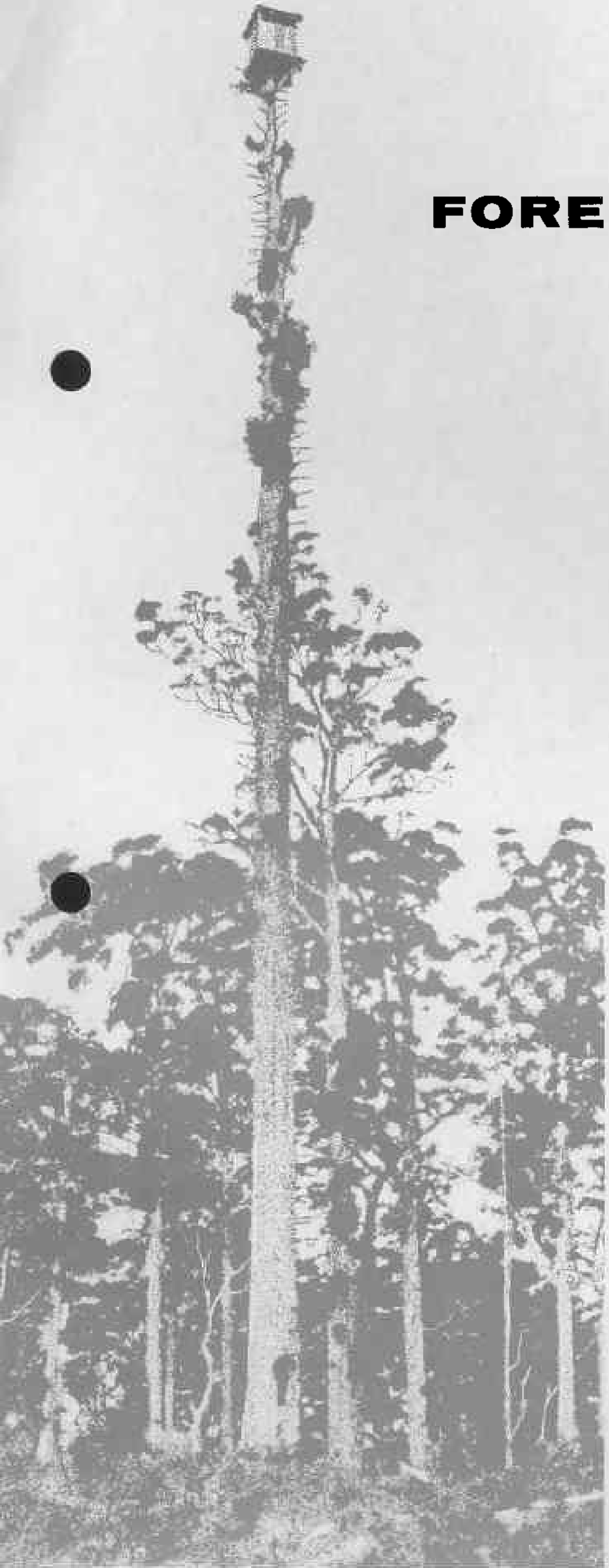
Research Paper No. 4
1974



FORESTS DEPARTMENT
OF WESTERN AUSTRALIA
54 BARRACK ST., PERTH

REGENERATION METHODS IN MIXED MARRI – KARRI STANDS

by

B. J. WHITE

SUMMARY

A typical mixed marri-karri stand is described. Due to the predominance of marri in the smaller size classes, utilization of only the karri component of such stands results in discrimination against this, the more valuable species, in future crops. The development of a large scale chipwood market utilizing marri could offer an economical means to manipulate species composition of the regenerated crop.

This study attempts, by retaining an appropriate seed source, to achieve the following aims:

(1) Favour karri.

(2) Favour marri.

(3) Maintain the mixture.

Results indicate that the composition of the regeneration could be strongly influenced by the retention of a karri seed source. In this trial marri seed was lacking; hence the influence of marri seed trees was insignificant. Marri advance growth and stump sprouts, however, provided an adequate overall, but somewhat uneven, stocking of this species.

INTRODUCTION

Approximately half the area-occurrence of karri (*Eucalyptus diversicolor*, F. Muell.) is in pure stands. The balance comprises mixed stands, in which marri (*Eucalyptus calophylla*, R.Br.) is the most common, and usually numerically dominant, other species.

Where karri only is saleable, and is selectively logged from such mixtures, the regeneration of marri, the less valuable species, is favoured— a tendency which can be altered only by the concurrent and massive removal of marri by one means or another. Assuming that little, if any, of the marri would be saleable, favouring karri regeneration would involve the expensive removal of marri to waste. Recently however, the possibility of sale of marri in quantity as chipwood has not only offered the means of removing marri economically, but has raised the question whether or not it should be maintained, even encouraged, as a future pulpwood resource. Accordingly this trial was established to demonstrate alternative silvicultural treatments to achieve the following four broad aims:

(1) Favour karri

(2) Favour marri,

(3) Maintain the mixture,

(4) Convert to exotics.

All alternatives envisaged the complete utilization of the virgin stand and the establishment of a replacement even-aged crop. In treatments 1, 2 or 3, natural regeneration would be used through the retention of an appropriate seed source. Alternative 4 is not included in this discussion.

This note details the establishment phase of the project and reports some preliminary results of regeneration treatments.

PLATE 1: *Typical mixed marri-karri forest showing karri emergent above the marri canopy.*

THE STUDY AREA

The study area is a rectangular block (40 chains x 25 chains) 100 acres in extent, located near March Road, Quinninup, in the Pemberton Division.

Topography is undulating with rounded slopes. Average slope is about 5°, rising to a maximum of 10° over short distances. All aspects except south and southeast are included.

The original forest type was a typical virgin marri/karri (MK) stand. Mean stand composition (Fig. 1) was derived from 10 acres of assessment lines run along the treatment plot boundaries.

In vertical cross section, karri stood out as isolated emergents above a general lower layer of marri (Plate 1). Whereas the karri consisted mainly of large mature stems, the marri was represented in all size classes in a distribution similar to that of a balanced mixed aged stand.

The obvious preponderance of marri in the smaller size classes (Fig. 1) demonstrates its marked tolerance, compared with karri, to overhead canopy. It also indicates the difficulty of obtaining karri regeneration from any form of partial or selective cutting. With small lignotuberous marri advance growth added to that already shown in Figure 1, it can be seen that optimum conditions must be given to seedling karri regeneration for it to compete successfully.

Lignotuberous advance growth was not sampled prior to plot establishment. However, 100 mil-acre quadrats along a randomly selected line surrounding the trial area indicated that, on the average, there were 770 stems per acre of which 620 were marri and 150 were jarrah.

Standing volume per acre was approximately 90 loads (4,500 cu. ft. true measure). Of this, only 35 loads per acre were of marketable karri. However, it is clear that mixed MK stands have the capacity to produce large volumes of wood material. Other descriptive data collected included a soil survey and a scrub understorey survey.

Both karri and marri occupied the whole trial area. The relative proportion of one to the other varied from place to place, with karri appearing to dominate in the better drained gullies and basic soil types. However, assessment line figures, when superimposed on soil types, failed to confirm any strong difference. Jarrah was confined to the lateritic soil types, occurring on or near the ridge tops, and was a minor component in the study area.

THE TREATMENTS

Plots (Fig. 2) were allocated for treatment as follows:

Plot 1 retain karri seed source—favour karri,

Plot 2 retain marri seed source—favour marri,

Plot 3 retain marri and karri seed source—maintain mixture.

Treemarking

Karri seed tree requirements for adequate seed supply have been investigated previously. Three dominants or co-dominants per two acres is considered a safe conservative level, and was specified for Plot 1.

Nothing was known about seed supply or requirements of marri. An arbitrary figure of three seed trees per acre was specified for Plot 2. Similarly in Plot 3, one karri and 2-3 karri seed trees per acre were specified.

Guidelines for the selection of seed trees were:—

Karri: Seed trees must be dominants or co-dominants with a healthy spreading crown. Preferably they should be sound healthy trees of good form.

Marri: Seed trees must be dominants or co-dominants above pole size; must have a healthy spreading crown, and have a bole of good form free of excessive lean, kinks, bends.

Seed trees were marked with paint crosses, and numbered consecutively. Difficulty was experienced in maintaining the specification for marri, as insufficient trees of good form and good crown were available. Location of seed trees is shown in Figure 2. Actual seed trees retained are shown in Table 1.

TABLE 1

SEED TREES RETAINED

Plot	Desired Species	Number	Number per acre	
1	Karri	37	1.48	
2	Marri	70	2.80	
3	Karri & Marri	29 58	1.2 2.3	3.5

Utilization

It was assumed that marri could be removed for chipping, and that virtual total removal would result.

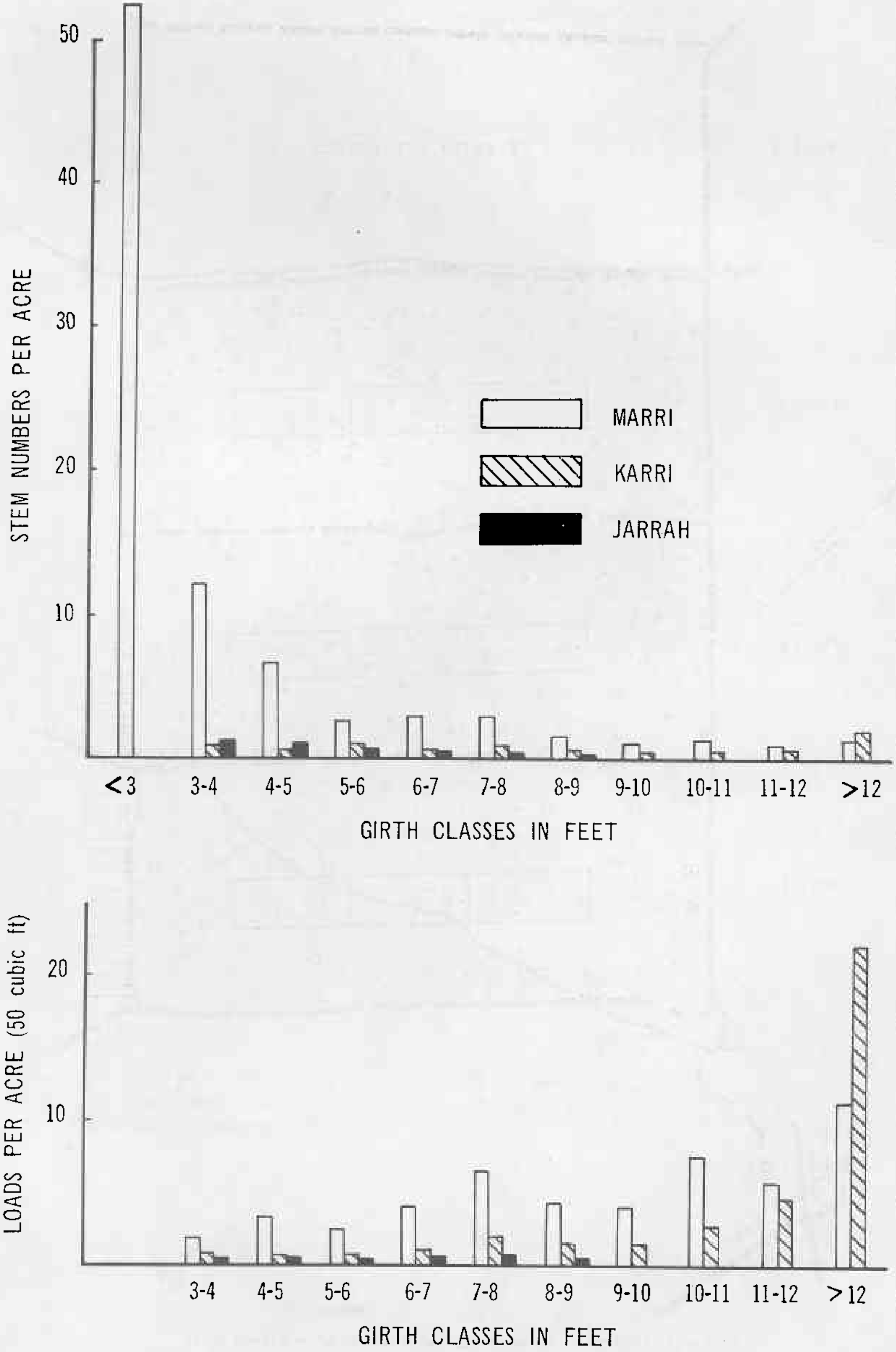


FIGURE 1: *Stand composition of the study area showing original distribution of stems and volumes.*

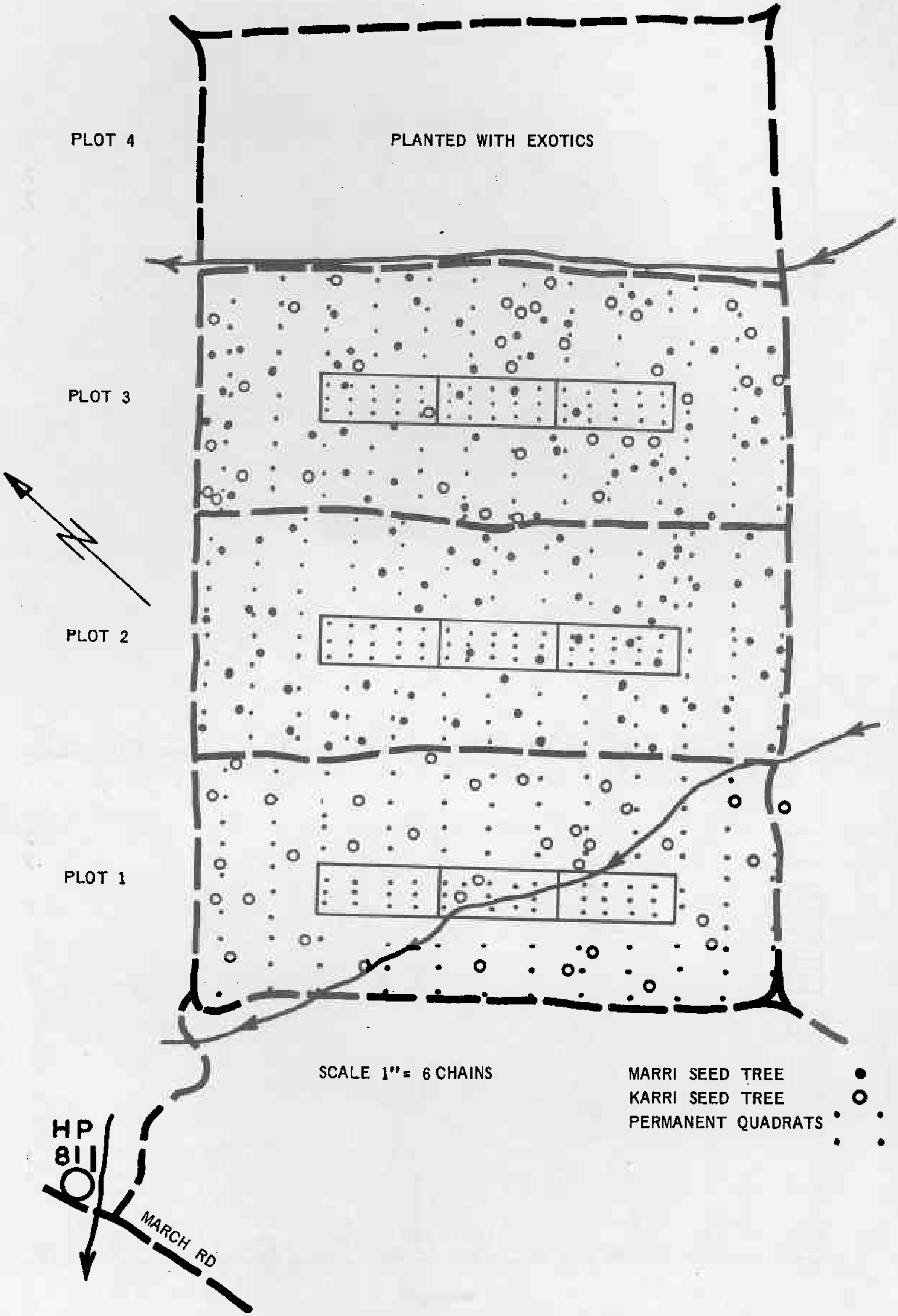


FIGURE 2: *Treatment and sampling layout for the March Road Trial.*

Whether marri was removed before or after karri, was considered immaterial, provided that removal of both species was complete before regeneration burning.

Karri logging took place in February-April 1968. Marri removal was achieved by bulldozing most stems, with chain-saw falling of the larger or more difficult trees. This method probably discriminates against marri regeneration more than straight chain-saw falling, which would probably be used in an actual chipwood operation. Whereas marri stumps sucker vigorously, the bulldozed stem has no such regenerative powers.

The marri on Plot 1 was removed prior to karri logging; in Plots 2 and 3 marri was removed afterwards. All marri operations were completed by November 1968. The approximate cost of marri removal was $22.00 per acre, of which $12.00 was for bulldozing, and $10.00 was for chain-saw falling.

Seed Supplies

Sampling had indicated that adequate karri seed supplies would be available in the summer 1968-69, and that the quantity available would diminish the following summer. The estimated supply was 318,000 seeds per acre, which was 2-3 times the minimum amount necessary. Binocular scanning of marri crowns revealed an almost complete dearth of marri seed. If advantage was to be taken of the current karri seed crop for regeneration burning, then it was almost certain that no marri seedling regeneration could be expected. As karri regeneration depended solely upon seedlings produced from seed crops at 4-5 year intervals, whereas lignotuberous advance growth could regenerate marri independent of seed supply, the decision was made to burn for regeneration promptly in the spring of 1968-69.

Regeneration Burn

The regeneration burn was required to produce a clean overall ashbed, remove all scrub competition, and consume as much logging slash as possible. Quantity of slash fuel would have exceeded 100 tons per acre. With regards to seedling karri regeneration the mistake to avoid is too low a fire intensity. Requirements of safety and control were the only constraint on the severity of the burn.

Fire Hazard and Fire Danger of the day were slightly higher than forecast.

The burn obtained was intense and satisfactory for karri. All seed trees except the tallest karri were scorched to total heights. No green scrub remained on the area. A higher than expected proportion of the slash was consumed. Karri seed trees still had green crowns immediately after the burn, but all showed typical scorch symptoms a day or so later.

Marri seed trees suffered greater damage from the burn than did the taller karri. Six per cent of the karri seed trees were incapacitated as such, i.e. either the whole tree or the whole crown was burnt down, compared with 11 per cent of the marri. Most damage occurred either during or shortly after the burn. Seedfall would have been materially affected because most seed fell after this time. The seed from fallen crowns would be concentrated *in situ*, not dispersed.

PRELIMINARY RESULTS

Seedfall

Seedfall was measured on three centrally located acres per plot, making a total of nine acres sampled (Fig. 2).

TABLE 2

PRESCRIBED FORECAST AND ACTUAL WEATHER CONDITIONS FOR THE REGENERATION BURN 8/1/69

	Max. temp.	Min. R.H.	Winds	Fire Hazard*	Local** Fire Danger	Time of Lighting
Prescribed	Not specified		E. (7-12 m.p.h.)	Not spec.	Purple	R.H. 60% for 1 hour prior to lighting (evening or night burn)
Forecast 8/1/69	68°	45%	SE. (4-7 m.p.h.) veering SW (8-12 m.p.h.)	Approaching moderate	Purple	
Actual 8/1/69	71°	51%	SE veering SW (10-16 m.p.h.)	4.8 moderate	Purple-green	Slash lit in late afternoon

* Wallace (1946); F.D.W.A. (1964). ** Harris (1968).

One stationary and two roving seed trays were employed on each acre. At each collection the two roving seed trays were shifted to another randomly located position on the acre. Technique and analysis followed that described by Wilm (1946). Results are given in Table 3.

The results from Plot 1 show consistency over the three acres sampled. Predicted seedfall (Christensen, P. S., 1969, F.D.W.A., unpublished report) was within six per cent of that measured by seed trays. On Plot 3, results were more varied.

One tray per sample acre was installed in an open patch prior to the burn, the intention being to determine if massive immediate seedfall may be triggered by a fire and be consumed by it. Inspection the following morning showed no seeds in the trays. As it was possible at this stage to walk between the burning tops, any seedfall from this stage onwards would, apart from the tops themselves, be on to cool ground. As this was a high intensity fire, and as seed was ripe, ready to fall, it is concluded that the risk of consuming the seed crop in the regeneration burn is negligible.

Trays were collected and shifted frequently within the first few weeks, after which collections were wider spaced. Most seed was expected to fall within the first few weeks. Progressive seedfall with time is shown in Figure 3. Apart from an increase in the second week, seedfall was fairly even for 8-9 weeks, after which the rate fell away markedly. Hence seedfall could be considered complete by two months from the regeneration burn.

Regeneration

Karri germinates appeared in profusion following the opening autumn rains in April 1969, by which time marri and jarrah sprouts from advance growth and stumps had already appeared.

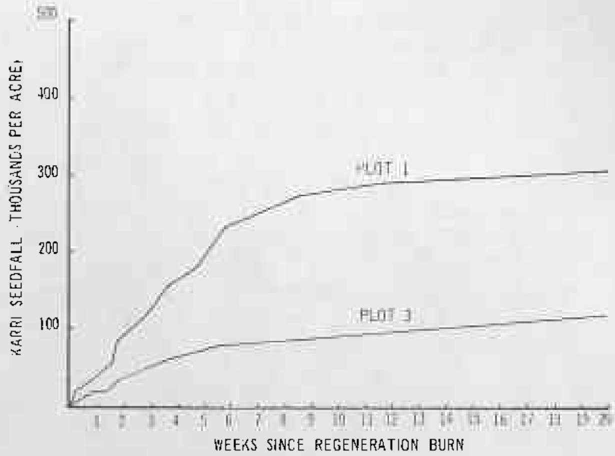


FIGURE 3: *Karri seedfall following regeneration. Plot 1 has karri seed trees and Plot 2 has both karri and marri seed trees.*

P. S. Christensen used this area for a study on germination and survival of karri. The graph in Figure 4, derived from his data, shows that germination was 95 per cent complete by the end of June. Mortality was greatest in the winter months, June-July-August, after which the mortality rate fell till December, when deaths from moisture stress began to occur.

A regeneration survey of the whole area was carried out in September. On each 25-acre plot a systematic grid of points, in lines two chains apart and one chain along the line, was established and permanently marked with 2 inch x 2 inch pegs. The start of the grid in each plot was randomly selected within the first chain along the centre line (Fig. 2). Within each central three acre plot the grid was intensified to a one chain line with points 0.5 chain along each line. At each point a circular mil-acre was

TABLE 3

SEEDFALL

Plot	Seed Source*	Karri Seedfall (thousands per acre)	Average	Predicted
1	Karri (1.48 trees/ac.)	Acre 1. 320 (± 109)** Acre 2. 315 (± 63) Acre 3. 345 (± 77)	327	318
2	Marri (2.8 trees/ac.)	Nil		
3	Karri (1.2 trees/ac.) Marri (2.3 trees/ac.)	Acre 1. 265 (± 117) Acre 2. 45 (± 25) Acre 3. 50 (± 17)	120	Not forecast

* No marri seedfall was recorded in seed trays. ** Standard errors in brackets.

described, using the peg as centre. The following information was recorded:

Germinates:

Number of each species (K, M or J).
Height of tallest of each species.

Lignotuberous advance growth:

Number of each species (K, M or J).
Height of tallest of each species.

Sprouts from stumps:

Number of each species (K, M or J).
Height of tallest of each species.

The intention of the permanent grid was to study the growth and development of the regenerated stand by periodic measurements over an indefinite period.

The average results for each of the central three acre plots are given in Table 4. Stocking is expressed as stems per acre, and as percent stocking by mil-acres (in brackets). Stems per acre can indicate how successful seedfall and germination has been, yet gives no clue to spatial distribution, and hence effective stocking. Percent stocking by mil-acres expresses how well the existing stems occupy the area.

The vast difference made by the retention of the karri seed source is obvious.

As expected no marri seedfall was recorded in trays, and only 10 marri germinates were recorded in the total of 500-odd mil-acres observed. All marri regeneration can therefore be considered to arise from established root systems, either from lignotuberous advance growth or from stumps. If any carry-over of marri seed from earlier crops existed, either as dormant shed seed, or within shed capsules, none apparently survived the regeneration burn.

Marked differences in numbers of marri per acre can be noted between the three plots. As marri lignotuberous advance growth was not sampled prior to commencement of operations, it is uncertain whether this is a reflection of the distribution of advance growth on the original stand, of varying fire intensity in the regeneration burn, of varying logging damage, or of other factors.

An attempt was made to relate the occurrence of marri advance growth to factors which were observable at this stage, viz. soil type, aspect, density of karri regeneration. Sampling was done in the adjacent uncut stand to check for obvious relationships between marri advance growth and forest type. No convincing pattern was found. It appeared that some patches of typical karri loam carried few marri, but other similar patches were found to carry many. Perhaps the chance occurrence of past fire in relation to seed supply could be the main factor determining the occurrence of marri advance growth.

It was decided not to pursue this aspect further at this stage, but rather to accept the fact that whilst marri advance growth is plentiful it is clumped in distribution and areas of light stocking occur.

The high percentage stocking by mil-acres of karri in Plot 1 (95%) and Plot 3 (90%), indicates that an excellent overall stocking of this species was obtained where it was sought.

Considering marri lignotuberous advance growth alone, the lowest stocking was 146 stems per acre on Plot 1. At 12 per cent stocking by mil-acres this would be understocked by any standard, and the aim of ensuring karri dominance was achieved. Plot 3 at 773 stems per acre and 39 percent stocking by mil-acres would satisfy most conditions. Plot 2 at 500 stems per acre and 29 percent stocking by mil-acres could approach the borderline of effective stocking, but would not warrant expenditure of funds to improve it. The average figure for the whole 75 acres was 483 stems per acre and 28% stocking by mil-acres. Three hundred stems per acre, reasonably spaced, is considered adequate stocking for jarrah. Though the 483 stems exceeds this 300 minimum, the 28 percent stocking suggests clumping, with open patches. Total removal of all standing timber, with no seed source retained, followed by a regeneration burn, would, it is considered, produce such a stand. Leaving a seed source and timing the regeneration burn to coincide with seed years will ensure full stocking and can change the species composition of the regenerated crop.

In Plot 2, where a marri seed source only was left, 162 germinates per acre of karri were recorded. These were probably from seed windthrown for some distance from adjacent plots or the surround. If a

TABLE 4

REGENERATION STOCKING

Plot	Seed Source Species	Seed Source No./ac.	Stocking at Oct. 1969—Stems per acre. (% stocking by Mil-acre) Karri (seedlings)	Marri (advance growth)	Jarrah (advance growth)	All Species
1	Karri	1.48	18,160 (95%)	146 (12%)	—	18,306 (95%)
2	Marri	2.8	162 (12.5%)	500 (29%)	125 (11%)	787 (46%)
3	Karri Marri	1.2 2.3 } 3.5	6,475 (90%)	773 (39%)	13 (2.5%)	7,261 (94%)

larger area were so treated, such that long distance seed throw became impossible, it seems likely that karri would virtually disappear from the stand.

It is conceivable that an intense slash burn such as this would destroy a proportion of the lignotuberous advance growth. Though failure to sample advance growth before burning precluded obtaining any direct results, the adjacent burnt but uncut surround was sampled as a comparison with the plots subject to the intense slash burn. By repeatedly selecting mil-acre plots at random from within the 2 chain x 1 chain grid it was found that 100 mil-acres so selected would estimate advance growth stocking in stems per acre with a precision of ± 4 per cent at the 95 per cent level of probability. Thus a sample of 100 mil-acres, at 1-chain intervals along a randomly selected line, comprised the sample from the surround.

Results given in Table 5, suggest that approximately 20 percent of the lignotuberous advance growth was destroyed in the fire.

Plot 1, which carried least marri regeneration (146 stems per acre) had its marri bulldozed and fallen a year earlier than Plots 2 and 3. With heavy slash being drier, it is conceivable that fire intensity could have been higher on Plot 1 than on Plots 2 and 3, and that greater damage to advance growth may have resulted.

Early Survival and Growth

Stand age was 13 months at time of last measurement. Most deaths of karri germinates occurred in the early months June-July (Fig. 4). Logging of seed trees was expected to cause further deaths, as was summer drought. The first regeneration survey was done in spring (Sept. 1969) following winter deaths, when the germinants had attained visible size. A re-survey was done on Plot 1 following the removal of seed trees in November 1969. A further survey was carried out in May 1970, following the opening winter rains. By so doing it was hoped to gauge the effect of seed tree removal and summer drought on regeneration mortality. Heights of the dominant seedlings and sprouts were measured to assess early growth.

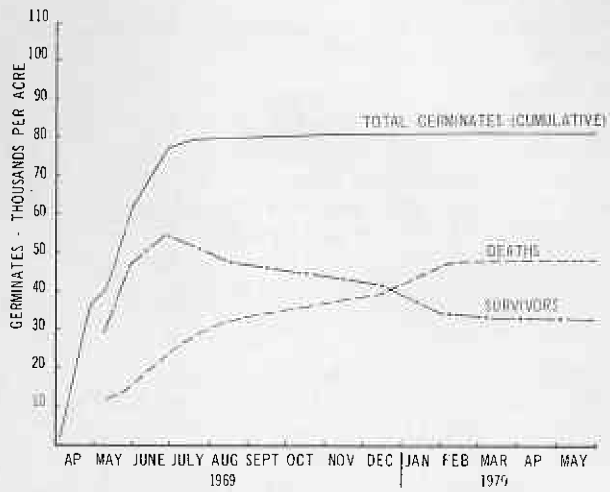


FIGURE 4: *Progression of germination and survival of karri at March Road.*

Where seed trees were logged in Plot 1 the loss of karri seedlings in numbers per acre attributable to the operation was 9 per cent. In the assessment following logging only those mil-acres disturbed by logging were assessed. Where no disturbance occurred, no loss was recorded and the previous count was accepted. There was no loss in percent stocking by mil-acres. It was concluded therefore that the damage caused by seed tree logging was negligible.

Considerable variation was found in successive counts of mil-acres. Some increased, some decreased. Where large numbers of small karri germinates occurred the possibility of an error in counting was high. Increases in karri could have been due also to germination of dormant seed or seed blown in from the surround. Later developing sprouts could account for increases in marri advance growth. Decreases were assumed to be caused by deaths by various means. It is noticeable that per cent stocking by mil-acres has changed little compared with stems per acre, indicating that effective stocking has been little affected by change in stem numbers to date.

So far growth of marri sprouts has outstripped that of seedling karri (Table 6).

TABLE 5

EFFECT OF REGENERATION BURN ON LIGNOTUBEROUS ADVANCE GROWTH STOCKING

	Stocking:— Lignotuberous Marri Advance Growth		
	*Burnt, uncut surround	Cut, Burnt for Regeneration (whole plot)	Loss
Stems per acre	620	483	22.1% of stems
Percent stocking by mil-acres	38%	28%	10% (26.3% of stocked quadrats)

* From 100 mil-acre samples.

TABLE 6
HEIGHT OF DOMINANTS IN INCHES

	Sept. 1969	May 1970	Increment
Karri	3.5	23.6	20.1
Marri	47.5	72.8	25.3

At the time of the last measurement the marri was continuing to increase in height faster than karri. Having an established root system this is not surprising. This situation is expected to reverse at a fairly young age as karri has been observed to have a height increment of 3-5 ft. per annum from age 2-10 years.

Future Development of the Project

By utilizing natural regeneration processes it has been possible to favour the regeneration of either species of this mixed marri-karri stand.

Future objectives include:

(a) By periodic observation and measurement to follow the natural development of the stands so formed.

(b) Sufficient area is available to experiment with thinning regimes which will further manipulate the stand towards a variety of objectives: maximum volume or maximum value production; to favour either species or to maintain a balance; to manage for pulpwood, pole or sawlog production.

(c) To observe the long-term ecological significance of the changes brought about.

REFERENCES

1. Wilm, H. G. (1946)—The Design and Analysis of Methods for Sampling Microclimatic Factors. Journ. Amer. Stat. Assn. 41: 221-32.

2. Harris, A. C. (1968)—Conservator of Forests Dept. W. Aust.—Forest Fire Danger Tables.

3. Wallace, W. R. (1936)—Forest Fire Research in Western Australia. Aust. For. Vol. 10.

4. Forests Dept. Western Australia (1964)—Foresters Manual (Fire Control). Bull. 58. Pamphlet No. 7.

First published in 1971

Reprinted December 1974

27108/12/74—500 SETS—C510