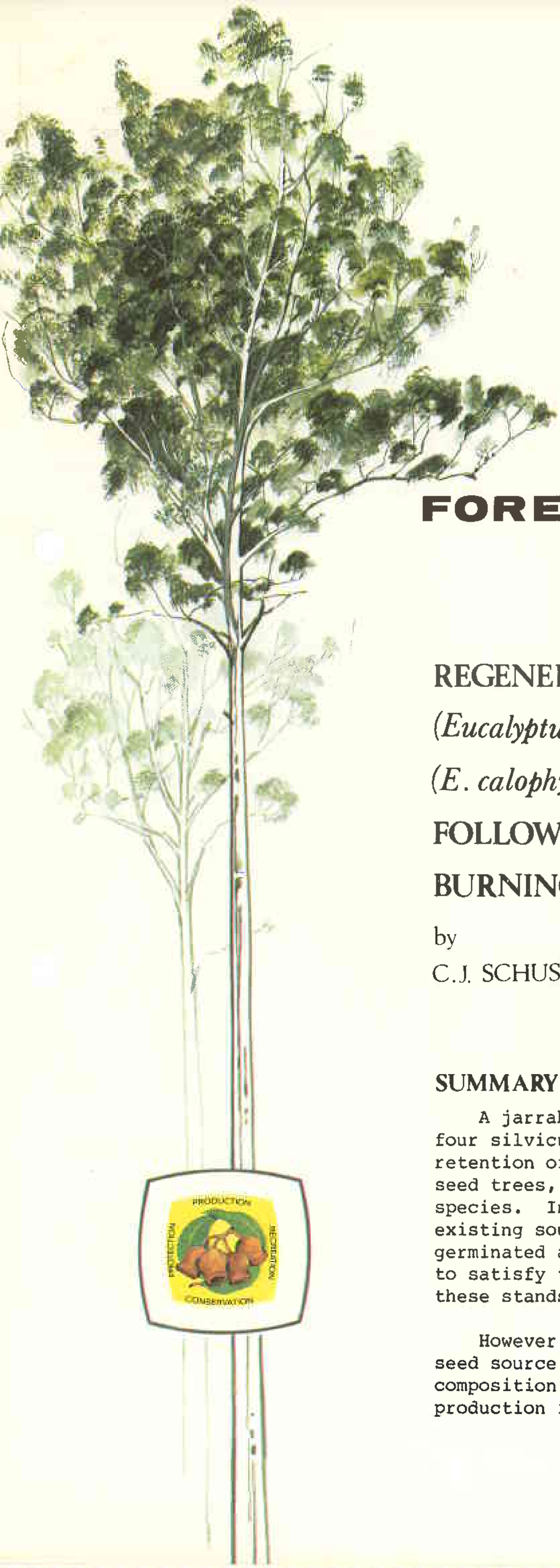

ODC 231:178.6

Research Paper 64
1980

FORESTS DEPARTMENT
OF WESTERN AUSTRALIA

REGENERATION IN A JARRAH (*Eucalyptus marginata* Sm.) AND MARRI (*E. calophylla* R.Br.) FOREST FOLLOWING LOGGING AND BURNING

by
C.J. SCHUSTER

SUMMARY

A jarrah and marri forest stand was logged using four silvicultural variations: clearfelling, the retention of jarrah seed trees, the retention of marri seed trees, and the retention of seed trees of both species. In all cases, regeneration from both the existing source of lignotuberous stems and seedlings germinated after the top disposal burn was sufficient to satisfy the minimum level of stocking required in these stands.

However, it is unlikely that the retention of a seed source for regeneration will alter the species composition of the next crop available for timber production in the forest.

INTRODUCTION

In the forest of the extreme south-west of Western Australia, jarrah (*Eucalyptus marginata* Sm.) often grows in association with marri (*E. calophylla* R.Br.).

Both species can regenerate through lignotuberous advance growth. These stems can survive in a repressed condition for many years under the mature tree canopy until vigorous growth into the sapling stage is stimulated by the death or removal of the canopy cover.

This pool of lignotuberous advance growth is the major regeneration medium for these forests. With logging the majority of the large over-mature stems were removed from the forest, thus creating gaps in the canopy. These gaps regenerate from the lignotuberous advance growth and coppice from the stumps of felled trees (Jacobs, 1955).

In the past, in these mixed stands, jarrah stems alone were removed by logging, as this species was favoured over marri for sawn timber production. However, with the advent of a woodchip market, a large proportion of the marri component of these stands can now also be harvested.

In anticipation of the sale of marri as woodchip, the trial described in this paper was established to determine the adequacy of regeneration in these mixed stands, and to establish whether the species composition of the regrowth could be manipulated by the cutting system employed. The utilization of both the marri and jarrah components of these stands favours one or other seed source, and creates much larger gaps in the tree canopy. The probability of a greater degree of mechanical damage to the advance growth stems, due to a higher intensity of logging activity, also warranted study.

There were three reasons for the various seed tree treatments in this trial: firstly, to determine the efficiency of seed-tree retention for regeneration should the existing lignotuberous sources fail; secondly, to determine whether any of these seedlings would develop into saplings; and thirdly, to determine whether one species could be favoured over the other by different regeneration treatments.

METHOD

Design

The trial was established in a mature jarrah-marri stand in Lewin Block, 24 km west of Manjimup. The area was logged in 1969 and 1970, and five plots each of 5 ha were established using a five-treatment unreplicated design. This simple design was chosen so that the plots could easily be compared with each other.

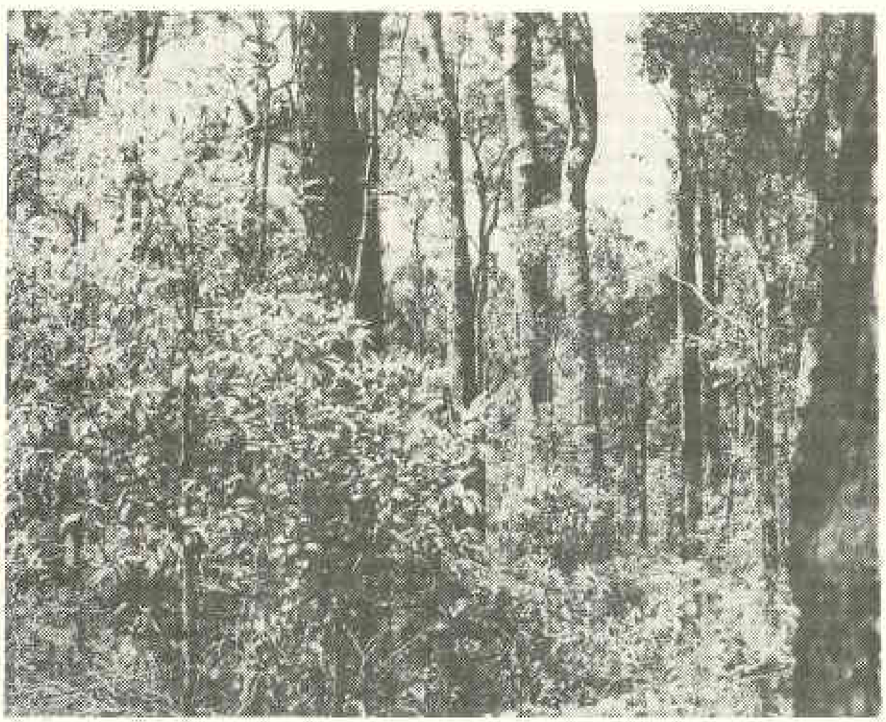

FIGURE 1: Virgin jarrah-marri forest before logging.

Treatments

The five treatments were: the retention of a virgin (untreated control) stand (Fig. 1); clear felling retaining jarrah seed trees only; clear felling retaining marri seed trees only; clear felling retaining seed trees of both species; and clear felling all growing stock.

Jarrah sawlogs were removed from the site but potential marri chipwood was felled and left at the stump, as the chipwood project had not commenced at the time of this trial.

Owing to variable stand conditions, the seed tree spacings were not constant. The seed tree stockings were 5.4 per ha (marri only); 6.4 per ha (jarrah only); and 12 per ha (jarrah (7.6) and marri (4.4)). After felling was completed, slash was burnt in a normal operational top disposal burn. The fire was also allowed to run through the litter in the untreated plot, resulting in virtually complete litter removal.

Assessment

Stocking of regeneration. No fire behaviour or fuel mass data are available for the top disposal burn. However, a mild fire was prescribed, which was lit in the late afternoon and early evening.

The burn was conducted in mid-December 1970, on a day with a maximum temperature of 25°C, and with relative humidity ranging from 49% at the start of lighting to 55% at the finish of lighting in the early evening. The fire danger rate of spread index was approximately 23 $m \cdot h^{-1}$, and the fire hazard was moderate (Sneeuwjagt and Peet, 1979). There had been 6 mm of rain in the week preceding the burn.

None of the seed crops in any of the treatments was assessed. However, seed crops in each plot appeared comparable for the two species.

Prior to logging, two 500 m lines were located in each plot. Along these lines a total of 500 quadrats 4 m^2 in area, at spacings of 2 m, were assessed for the numbers of jarrah and marri advance growth they contained.

After logging but before burning, a central line 500 m long was randomly selected in each plot. Along this line 50 quadrats 4 m^2 in area were permanently established at 10 m spacings. The numbers of seedlings, coppice stems (Fig. 2), saplings, and lignotuberous advance growth (Fig. 3) were counted in each quadrat.

Further assessments were completed during autumn, four months after burning, and seven years later. Unfortunately, some of the data for the immediate pre-fire assessment have been misplaced, and the only results available are those for the percentage of 4 m^2 plots which were stocked with either jarrah or marri.

Effect of coppice on other forms of regeneration. A separate assessment of coppice regeneration in this trial was completed eight years after burning.

Because of the rapid growth, vigour and numbers of coppice stems, it was thought they might suppress seedling and advance growth regeneration, resulting in mortalities.

Six 150 m^2 (15 x 10 m) sub-plots were established in the clear-felled plot, and all regeneration was assessed to establish stocking levels and height growth. Then the five closest stems (not including coppice) to each coppicing stump were assessed for height growth and proximity to the coppicing stump.

In addition, ten circular sub-plots, each 5 m in radius (area 78.5 m^2) were established around coppicing stumps in the jarrah and marri seed tree plot, and within them the numbers and height of each regeneration form present were assessed.

These additional plots were located in the jarrah-marri seed tree plot because the coppice stems here exhibited more vigorous growth than in the clear-felled plot. It was thought that this fact would emphasise more clearly any adverse effect of competition from coppice on the other forms of regeneration.

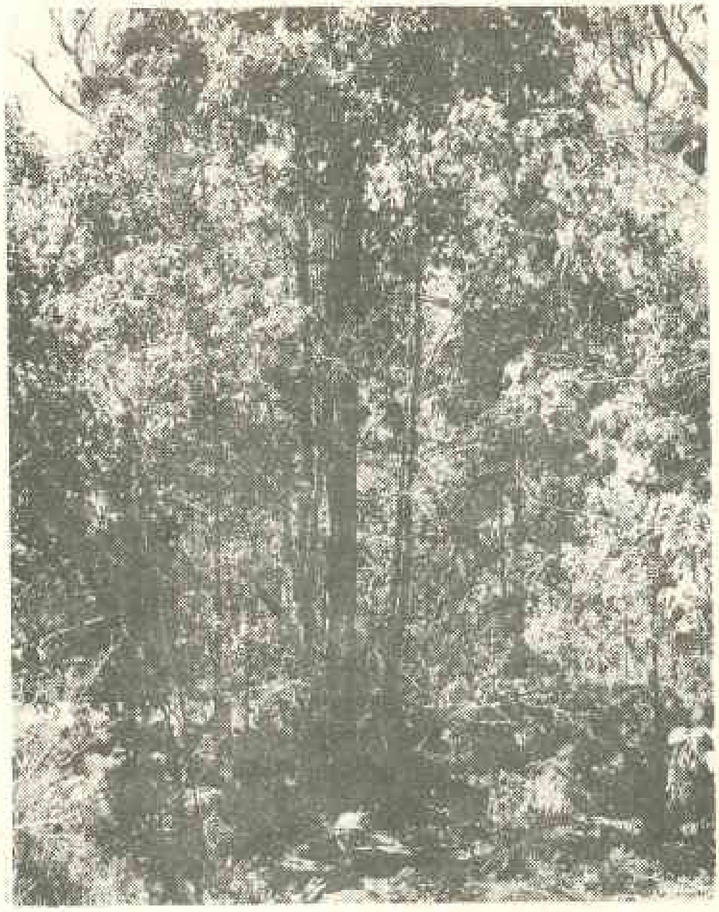

FIGURE 2: Jarrah coppice eight years after a regeneration burn.

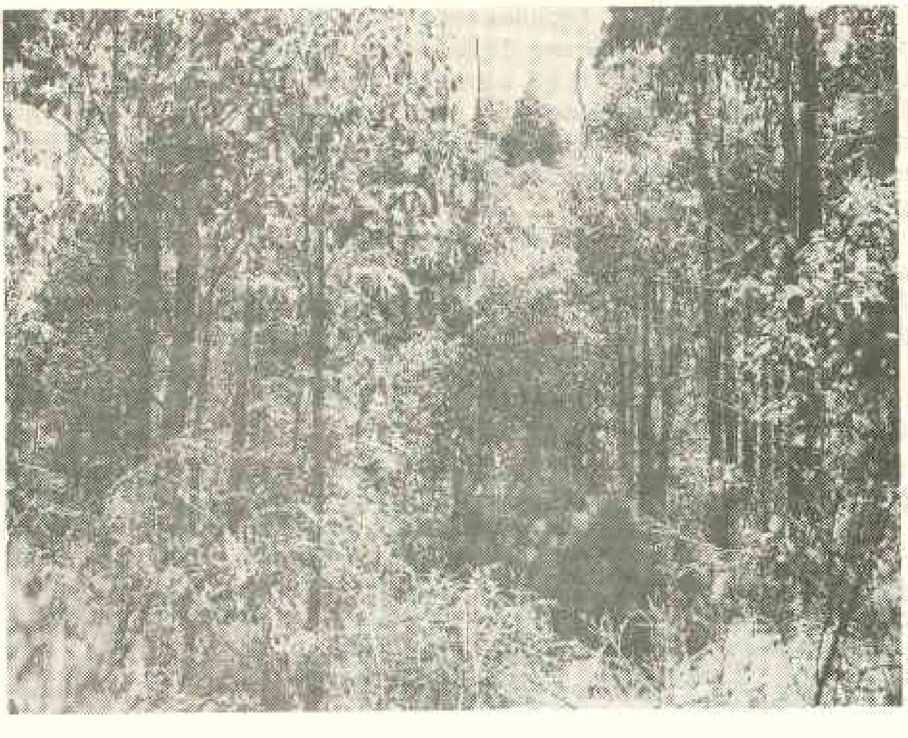

FIGURE 3: Vigorous eight-year-old jarrah and marri advance growth.

TABLE 1

Seedling regeneration of jarrah and marri following logging and burning

Treatment	Species	7 years post burn[1]	
		Nos sampled[2]	Stems per ha
Virgin stand	J	0	0
	M	4	200
Marri seed trees	J	2	100
	M	23	1150
Jarrah seed trees	J	60	3000
	M	19	950
Mixed seed trees	J	27	1350
	M	42	2100
Clear felled	J	2	100
	M	3	150

[1]No seedlings observed in any of the treatments before 7 years post burn

[2]Nos sampled = total number of stems of each type assessed in the fifty 4 m^2 plots per treatment

TABLE 2

Advance growth regeneration of jarrah and marri following logging and burning

Treatment	Species	Pre logging[1]		4 months post burn		7 years post burn	
		Nos sampled[2]	Stems per ha	Nos sampled	Stems per ha	Nos sampled	Stems per ha
Virgin stand	J	88	4777	45	2250	36	1800
	M	63	3408	54	2700	116	5800
Marri seed trees	J	74	3636	29	1450	10	500
	M	77	3779	30	1500	11	550
Jarrah seed trees	J	52	2729	50	2500	25	1250
	M	133	6967	38	1400	31	1550
Mixed seed trees	J	111	5483	33	1650	15	750
	M	70	3458	31	1550	22	1100
Clear felled	J	97	5012	37	1850	36	1800
	M	98	5084	38	1900	75	3750

[1]The results of the pre-logging assessment have been adjusted to correlate with post-burn assessments, as the pre-logging assessment involved 500 plots each of 4 m^2 instead of 50 plots as for later assessments

[2]Nos sampled = total stem numbers counted in each treatment

TABLE 3

Sapling[1] regeneration of jarrah and marri following logging and burning

Treatment	Species	7 years post burn[2]	
		Nos sampled[3]	Stems per ha
Virgin stand	J	4	200
	M	17	850
Marri seed trees	J	2	100
	M	5	250
Jarrah seed trees	J	2	100
	M	0	0
Mixed seed trees	J	4	200
	M	0	0
Clear felled	J	0	0
	M	0	0

[1]Saplings are those stems which have an overbark stem diameter greater than 5 cm at 1.3 m above the soil surface

[2]No sapling regeneration was observed in the 4 month post-burn assessment

[3]Nos sampled = total stem numbers counted in each treatment

TABLE 4

Coppice regeneration[1] of jarrah and marri following logging and burning

Treatment	Species	4 months post burn		7 years post burn	
		Nos sampled[2]	Stems per ha	Nos sampled	Stems per ha
Virgin stand	J	0	0	0	0
	M	0	0	0	0
Marri seed trees	J	0	0	31	1500
	M	0	0	18	900
Jarrah seed trees	J	0	0	34	1700
	M	2	100	12	600
Mixed seed trees	J	1	50	30	1500
	M	1	50	18	900
Clear felled	J	1	50	72	3600
	M	3	150	19	950

[1]In this table, each coppicing stump is recorded as one stem (many stumps have multiple stems)

[2]Nos sampled = the total number of stems counted in the assessment of each treatment

RESULTS

Stocking levels

The results of the assessments of stem numbers before logging, four months after the burn and seven years after the burn are shown in Table 1 (seedlings), Table 2 (advance growth), Table 3 (saplings), and Table 4 (coppice growth). The pre-burn assessment is not included because it can be based on stocking by 4 m^2 quadrats only.

In the tables, only those assessments where the particular form of regeneration under consideration was present have been included. For example, as there was no coppice growth before logging and burning, the two assessments before burning have been excluded from Table 4.

The successful establishment of seedlings from the retained seed trees is indicated in Table 1. Seedling regeneration was greatest in the plots cut to seed trees and least in the clear-felled and uncut plots. Where seedlings are present in the absence of seed trees of that species, they may result either from seed from the original stands, some of which may have survived the mild burn, or from seed blown in from adjacent plots.

Jarrah advance growth had decreased in all plots at the 7-year post-burn assessment (Table 2). This could be attributed to mechanical damage during logging, to the growth of some stems into the sapling class (Table 3), or to the destruction of some stems in the top disposal burn.

After logging and burning, marri advance growth tended to decrease in numbers in the treated plots. In the virgin plot, however, marri advance growth numbers increased substantially. This indicates that marri seedlings are able to successfully germinate and establish under full forest canopy.

In the clear-felled and virgin plots, a large increase in the numbers of marri advance growth was evident between four months and seven years after the burn. However, in the other three treatments the numbers fell or remained virtually constant during this period.

The large increase in marri advance growth after the immediate post-burn assessment in the clear-felled plot may be attributable to the timing of the assessment. It is possible that not all lignotubers had re-sprouted within four months of the burn.

Sapling stocking at 7 years is low in all treatments (Table 3), largely because the trial is not yet of an age which would allow for full development of the existing advance growth. None of the newly regenerated seedlings has yet developed to the sapling stage. The saplings assessed in the virgin plot are possibly the result of mortalities or defoliation through fire in the mature overstorey, which would allow the existing advance growth to develop.

Coppice growth is most numerous in the completely clear-felled plot (Table 4), although all treated plots exhibit some degree of coppice formation. The coppice stocking includes not only stems on the stumps of felled mature trees, but also stems from sapling and larger advance growth, broken or damaged in the logging and burning operation, and which subsequently produced coppice shoots.

The total stocking by 4 m^2 quadrats and by total stem numbers for each assessment are presented in Tables 5 and 6.

In terms of both total stem numbers and quadrat stocking percentages, the situation 7 years after regeneration differs little from that existing before logging (Tables 5 and 6). However, all treated plots showed a decrease in quadrat stocking following the logging and burning operations. This could be due to the destruction of growing stock during logging and burning or to the failure of some lignotuberous and coppice stems to develop new shoots prior to the assessment four months after the burn.

All treated plots showed an increase in stem numbers after the regeneration burn. The size of the increase varied from 73% (marri seed trees) to 162% (completely clear felled). In the latter most of the increase was due to coppice growth. In comparison, stem numbers in the untreated virgin stand increased by only 58% over the same period. This increase was due mainly to marri advance growth.

TABLE 5

Stocking percentage by 4 m^2 plots of all jarrah and marri regeneration

Treatment	Species	Stocking percentage by species: Pre logging	Pre burning	4 months post burn	7 years post burn
Virgin stand	J	70	66	68	44
	M	62	56	64	86
	Total	87	86	90	90
Marri seed trees	J	49	42	32	48
	M	62	32	40	56
	Total	78	62	60	80
Jarrah seed trees	J	47	60	50	76
	M	66	44	38	66
	Total	89	74	68	98
Mixed seed trees	J	65	40	34	66
	M	64	40	36	68
	Total	86	60	56	88
Clear felled	J	64	58	40	82
	M	65	42	40	80
	Total	91	72	60	94

The total stocking percentages are not equal to the sum of the jarrah and marri stockings, as some plots are stocked by both species

TABLE 6

Total stem numbers of all jarrah and marri regeneration

Treatment	Species	Pre logging[1]: Nos sampled[2]	Stems	4 months post burn: Nos Sampled	Stems	7 years post burn: Nos Sampled	Stems
Virgin stand	J	88	4777	46	2300	40	2000
	M	63	3408	66	3300	137	6850
	Total	151	8185	112	5600	177	8850
Marri seed trees	J	74	3636	29	1450	45	2250
	M	77	3779	30	1500	57	2850
	Total	151	7415	59	2950	102	5100
Jarrah seed trees	J	52	2729	50	2500	121	6050
	M	133	6967	30	1500	62	3100
	Total	185	9696	80	4000	183	9150
Mixed seed trees	J	111	5483	34	1700	76	3800
	M	70	3458	32	1600	82	4100
	Total	181	8941	66	3300	158	7900
Clear felled	J	97	5012	38	1900	110	5500
	M	98	5084	41	2050	97	4850
	Total	195	10096	79	3950	207	10350

[1]The pre-logging assessment results have been adjusted to the same sampling intensity as the other assessments

[2]Nos sampled = total number of stems assessed in each treatment

The results of assessment of the effect of coppice regeneration on the other forms of regeneration are presented in Tables 7 and 8.

The results of the assessment of regeneration in ten circular plots (each of 78.5 m^2 in area) in the jarrah-marri seed tree area are contained in Table 7. The results of the assessment of six 150 m^2 plots in the clear-felled area are contained in Table 8. In both tables, the seedling and advance growth regeneration have been summed for comparison with the overall plot mean. This was done because of difficulty in distinguishing between seedlings and advance growth.

Coppice does not influence the stocking levels of the other forms of regeneration.

TABLE 7

The effect of jarrah and marri coppice growth on other forms of regeneration eight years after slash burn: jarrah-marri seed tree treatment

Regeneration type	Mean no. of stems assessed per 78.5 m^2 sub-plot (around coppice)	Equivalent stocking of sub-plot (stems/ha)	Overall plot stocking (stems/ha
Marri seedling and advance growth	23.2	2950	3200
Jarrah seedling and advance growth	20.6	2618	2100
Total seedling and advance growth	43.8	5568	5300

TABLE 8

The effect of jarrah and marri coppice on other forms of regeneration eight years after slash burn: clear-felled treatment

Number of coppice stems		Sub-plot		Stocking of total plot[2] (stems/ha)	Mean height (m) of all regeneration	
Number assessed	Equivalent stocking (stems/ha)	Mean area (m^2)[1]	Equivalent stocking (stems/ha)		Sub-plot around coppice	Total plot
45	495	9.57	5224 ± 1404[3]	5800	2.54 ± 1.16[3]	3.83 ± 1.50[3]

[1] Area quoted here is the ground area inside the circle containing the 5 regeneration stems closest to the target coppice stem.

[2] The stocking level for the total clear-felled plot accounts only for seedling, advance growth and sapling regeneration.

[3] 95% confidence intervals about the mean.

However, the results from the clear-felled treatment (Table 8) indicate some reduction in the mean height growth of seedlings, advance growth and sapling stems in close proximity to a coppice stem. This may increase in importance as the stand ages.

CONCLUSIONS

The pool of advance growth present was sufficient to regenerate the cut-over areas in this trial. However, not all stands logged will have adequate quantities of advance growth and in some it may be necessary to supplement the regeneration with seedlings from retained seed trees. This trial shows that both jarrah and marri will regenerate successfully from seedlings, provided that sufficient seed trees are retained.

However, it appears that the species composition of the second rotation overstorey will be determined by the advance growth and saplings present in the forest before logging. These are able to take advantage of the reduced competition from overstorey species following logging and burning, and assume vigorous growth immediately after the regeneration burn. Only through supplementary planting or thinning will it be possible to alter the composition of the second rotation crop in the absence of a further severe disturbance such as logging or fire.

This suggests that retained seed trees can influence the second rotation crop only where the resulting seedlings develop in the absence of competition from both the overstorey, vigorous advance growth, and coppice from stems present before logging and burning. These conditions could exist in sections of clear-felled coupes and all coupes should be examined before logging to ascertain whether the advance growth stocking is adequate.

Coppice from the stumps of felled trees did not affect the regeneration of seedlings and advance growth. However, in areas where stocking levels of the other forms of regeneration are marginal, some coppice control may be necessary to ensure optimum growth.

ACKNOWLEDGEMENTS

I wish to thank Mr B.J. White and Mr A.R. Annels, who planned and initiated this trial.

REFERENCES

JACOBS, M.R. (1955). Growth Habits of the Eucalypts. Forestry and Timber Bureau, Canberra, Australia.

SNEEUWJAGT, R.J. and PEET, G.B. (1979). Forest Fire Behaviour Tables for Western Australia. Forests Department of Western Australia.