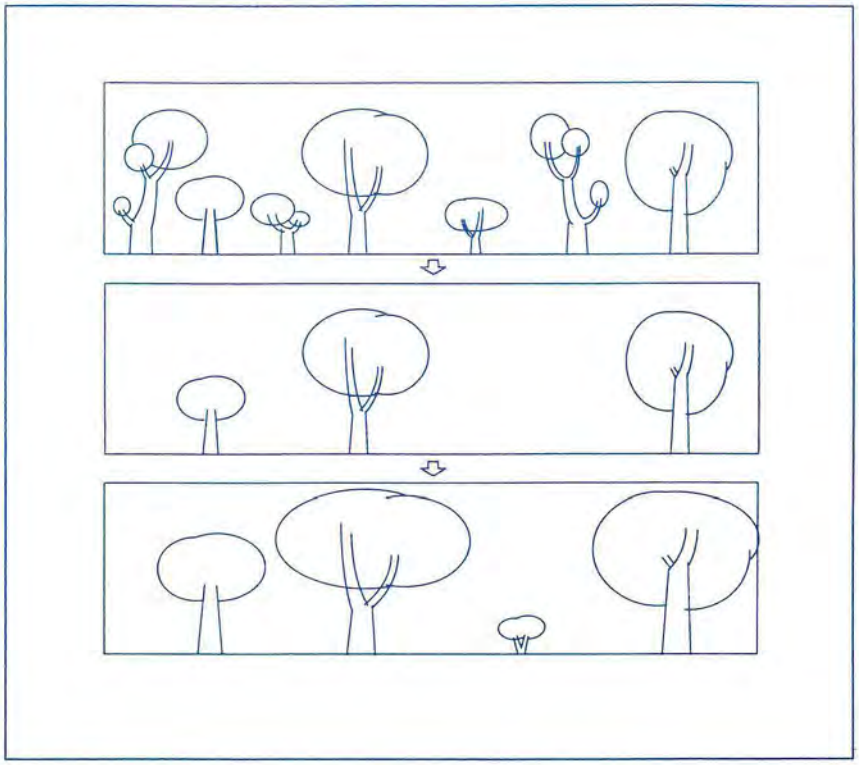
CHANGES IN RESPONSE TO FOREST THINNING ON HANSEN, HIGGENS AND JONES CATCHMENTS



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CHANGES IN FOREST COVER IN RESPONSE TO FOREST THINNING ON, HANSEN, HIGGENS AND JONES CATCHMENTS

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Contents

Summary

Basal area (BA) and percentage crown cover on the Hansen, Higgens and Jones research catchments in the Northern Jarrah Forest of south-west Western Australia were assessed in June 1996 for comparison with previous assessments

On Hansen Catchment a heavy uniform thinning in 1985/86 reduced average BA from 35 m^2/ha pre-treatment to 7 m^2/ha (assessed in 1989). Over the 7 years (1989-96) BA increased to 14 m^2/ha and crown cover increased from 14% to 26%.

There was a similar clear increase in BA and crown cover on Higgens Catchment. This catchment was subject to a less intense uniform thinning in 1988/89, average BA being reduced from 37 m^2/ha pre-treatment to 14 m^2/ha (assessed in 1991). Over the 5 years (1991-96) BA increased to 18 m^2/ha and crown cover had increased from 29% to 39%.

However, there was apparently little increase in BA or crown cover on Jones Catchment. This catchment was subject to an operational style treatment with thinning (1988/89) concentrated in areas judged to at least risk of dieback due to the fungal pathogen *Phytophthora cinnamomi*. Average BA was reduced from 43 m^2/ha pre-treatment to 17 m^2/ha (assessed in 1991). Average BA in 1996 was estimated to have remained constant at around 17 m^2/ha and crown cover showed little increase (estimated 39% in 1991, 40% in 1996). Reasons for the apparent lack of a significant increase in BA and crown cover on Jones Catchment were not established. One possibility is that there were really small increases but the sampling intensity was not sufficient to accurately assess small changes. Another possibility is that escalation of dieback (due to *Phytophthora cinnamomi*) reduced forest cover in parts of the catchment negating increases in the remainder of the catchment.

It was not possible to assess reductions in crown cover achieved by thinning as different methods for assessing crown cover were used in the pre-treatment and first post-treatment assessments. The different methods used are discussed in the report and recommendations made for standardising methods in future assessments.

1. Introduction

The Hansen, Higgens and Jones Catchments are amongst a group of small (~ 100 ha) experimental catchments in the high (>1100 mm/yr) rainfall zone of the Northern Jarrah Forest. They are being studied to evaluate the effect of forest management practices on water quality and yield and dieback caused by the fungal pathogen *Phytophthora cinnamomi* (SCRLUWS, 1987). Hansen, Higgens and Jones Catchments have each had a forest thinning treatment applied. The nearby Lewis Catchment serves as a control while treatments in other catchments in the group (Warren and Bennet) are designed to test rehabilitation of dieback degraded forest, open-cut mining for bauxite and rehabilitation after mining.

The hypothesis being tested by the thinning experiments is that thinning can increase both water yield and timber production from high rainfall Jarrah forest catchments without detriment to water quality (Shea *et al.*, 1975, Stoneman and Schofield, 1989). Timber production may be increased by removing ('thinning out') poor form trees. This allows the remaining better form (crop) trees to grow more quickly. Water yield may also be increased as reducing forest cover reduces transpiration rates.

The purpose of this study was to quantify the effect of forest thinning in the Hansen, Higgens and Jones Catchments on forest cover. Specific objectives were:

- assess average basal area of forest cover on each catchment;
- measure crown cover on the catchments; and
- summarise the results of previous assessments of forest cover.

2. Methods

Two assessments of forest cover on the catchments had been completed, a pre-treatment assessment and one post-treatment assessment. The assessments were made by staff of the Department of Conservation and Land Management (CALM), Dwellingup Research Station and results made available for summarising in this report.

The following describes methods used in the second post-treatment (June 1996). Similar methods were used for the first two assessments.

2.1 Crown cover

Crown cover was assessed at each point of a 50 x 50 m grid established on each catchment. A compass and hip chain were used to locate the points, picking up as many of the grid pegs (established for the first post-treatment assessment) as possible. The compass often gave erroneous readings (up to 10 m error over 100 m) due random magnetic influences, presumably mostly from ironstone. Therefore, it was necessary to constantly correct the position on the catchment as pegs or other definable features (tracks, bores) were noted.

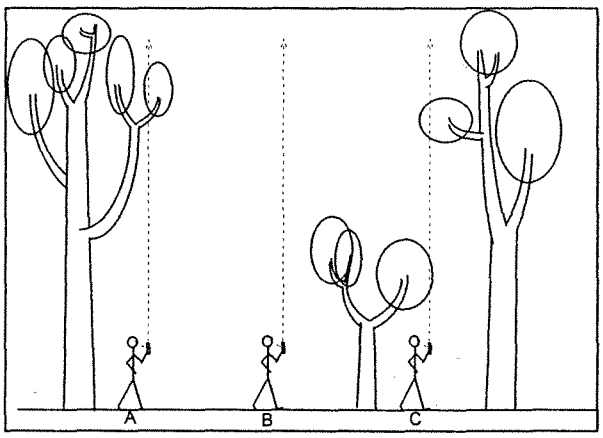

Fig. 1. Crownometer observations. A="hit" on overstorey species; B="miss"; C="hit" on both overstory and understorey species. Note that in calculating total crown cover "double hits", as in C, are only counted once, i.e. 2 "hits" from 3 observations in the above example.

The instrument used for crown assessment (crownometer) gives the observer a vertical line of sight. Cross-hairs indicate a precise point above the instrument. The percentage of observations where the cross-hairs intersect crown cover ("hits") gives the estimate of crown cover (Fig. 1).

While crown cover may seem to be a simple concept there are, however, many definitions in use. It was found necessary to define and assess two measures of "crown cover", depending on whether or not gaps in any branch outline are recorded as "cover".

The first measure was *foliage cover*. In this case "gaps" within a branch outline are not recorded. A "hit" is only recorded if the cross-hairs of the crownometer intersect green leaves. Thus *foliage cover* is defined as the percentage of ground covered by (the vertical projection of) foliage. It corresponds to early use of the measure in Australia by Carnahan (1977), Specht, 1970 and Specht, *et al.* 1974 (who also used the term *projective foliage cover* to mean the same thing). *Foliage cover*, as just defined, was the measure used in the pre-treatment assessments made on the experimental catchments.

The second measure, used in the assessments made in the first post-treatment assessment, was *crown cover*. This was defined as the percentage of ground area covered by crown, the crowns being treated as opaque. Thus, if the cross-hairs of the crownometer intersect a gap in the crown this would be a "hit' if *crown cover* is being assessed but not if *foliage cover* is being assessed. In this study gaps of up to 250 mm within a branch outline were assessed as *crown cover* but not *foliage cover*.

In the second post-treatment assessment (June 1996) both *foliage cover* and *crown cover* were recorded.

The term *crown cover*, as defined for this study, appears to be slightly different from that promoted by Walker and Hopkins (1990). They define *crown cover* as the percentage of the sample site within the vertical projection of the periphery of crowns. Thus they treat

whole crowns, not just branch outlines, as being opaque.

2.2 Basal area

Basal area of all tree and shrub species on the catchments was assessed at every tenth sample point in the 50 x 50 m grid used for the crown cover assessments.

Basal area of a tree stem is the cross-sectional area measured at the standard breast height (1.3 m). It can be calculated for an individual tree (m^2) or for a stand of trees (m^2/ha). In this study it was assessed by the angle-count method. This is a long established procedure described in many texts, e.g. Carron (1968). A simple angle gauge similar to that described by Wood (1990) was used.

3. Results

3.1 Observation points

The number of crownometer observation points (50 x 50 m grid) in the second post-treatment assessment were Hansen Catchment (308 points), Higgens Catchment (231 points) and Jones Catchment (242 points). Since basal area was assessed at every 10th point the number of basal area counts were Hansen (31), Higgens (23) and Jones (24). A similar number of observations were made for the first post-treatment assessment (same grid used). For the pre-treatment assessment observations were made on a 200 x 10 m grid pattern, giving approximately 400 crownometer observations and 40 basal area counts per catchment.

On Hansen and Higgens Catchments more than half the grid pegs were still in place and, for the second post-treatment assessment, it was relatively easy to locate grid points using the pegs that were in place and the compass and hip chain to locate the other points. However, for Jones Catchment, no map showing the grid layout was obtained. A 50 x 50 m grid was established using compass and hip chain. Constant adjustment of position was necessary by reference to tracks and bores as they were passed.

3.2 Forest cover

Basal Estimates of foliage cover and/or crown cover and basal area for the three assessments on the three catchment are given in Appendices A, B and C. Scientific names for species recorded are given in Table 1.

Table 1. Species recorded in the assessments

Common name	Scientific name
Jarrah	*Eucalyptus marginata*
Marri	*Eucalyptus calophylla*
Blackbutt	*Eucalyptus patens*
Bullich	*Eucalyptus megacarpa*
Sheoak	*Allocasuarina fraseriana*
Bull Banksia	*Banksia grandis*
Swamp Banksia	*Banksia littoralis*
Snoddy Gobble	*Persoonia longifolia*
Round-leaf Persoonia	*Persoonia elliptica*
Tea Tree	*Leptospernum* sp
Blackboy	*Xanthorrhoea preissii*
Water Bush	*Bossia aquifolium*

4. Discussion

4.1 Introduction

The objectives set for this study (see Introduction) were all met. Further comment relates to the growth response and methodology for assessing crown cover.

4.2 Growth response

There was a clear increase in basal area on Hansen and Higgens Catchments in the period between the first and second post-thinning assessments (Fig. 2). However, even if basal area continues to increase at a steady rate, Fig. 2 indicates it will be a long (~ 30 years) period before basal area returns to pre-treatment levels. In practice the rate of basal area increase is likely to decline as competition between retained crop trees increases. Basal area could, of course, be kept below a defined limit by future harvesting of crop trees (future thinning).

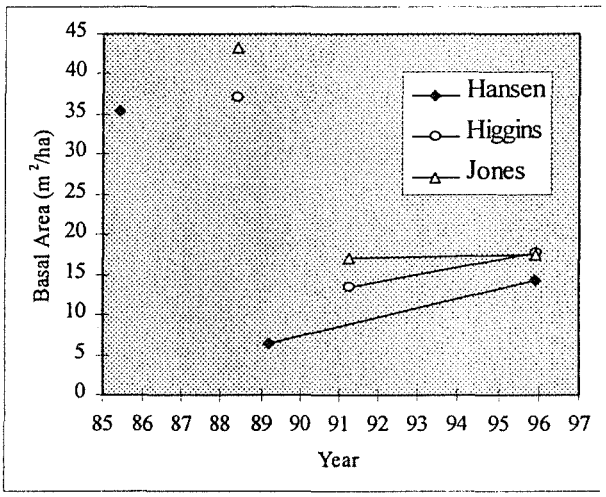

Fig. 2. Basal Area response to thinning treatments. Graph shows *basal area* on each catchment just prior to thinning and (connected points) at the time of the first and second post-treatment assessments.

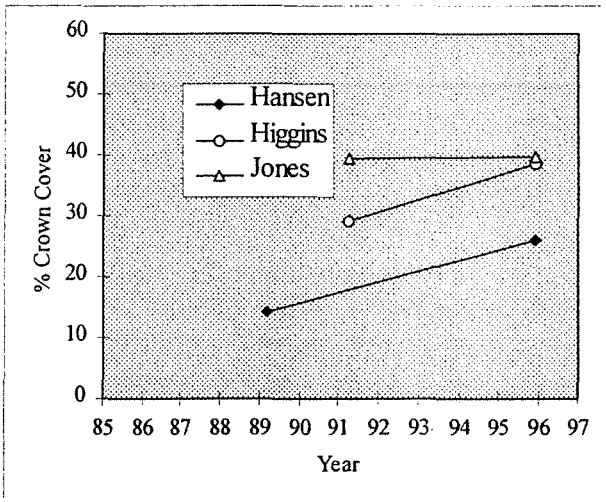

Fig. 3. Crown Cover response to thinning treatments. Graph shows increase on each catchment in *% crown cover* from the first to the second post-treatment assessments. There were no pre-treatment assessments of *% crown cover*.

Fig. 3 shows there was a similar clear increase in *crown cover* on Hansen and Higgens Catchment in the period between the first and second post-thinning assessments.

The rate of basal area and crown cover increase on Jones Catchment appeared to be negligible (Figs 2 & 3). This may be because only parts of Jones catchment was thinned leaving it with the highest retained average basal area (Appendices A, B and C). However, caution is necessary in comparing results from assessments made just 5 years apart. The estimates may not have sufficient precision to accurately evaluate small changes. For example, catchment average basal area estimated for Jones Catchment in the second post-treatment assessment was 17.4 m^2/ha. But variability of the 24 point estimates of basal area was such that the 90% confidence limits for the estimate were 15.1-19.7 m^2/ha.

Another possibility is that, since the 1991 assessments, escalation of dieback due to *Phytophthora cinnamomi* has caused a reduction in forest cover (BA and crown cover) in parts of the catchment. This could have offset increases in forest cover in healthy forest on the catchment so that the average level of forest cover

changed little. This effect could not be evaluated as sample points differed between all three assessments.

4.3 Method for assessing crown cover.

Some thought should be given to standardising methods for assessing "crown cover". Interpretation of results in this study was hampered by the use of different methods in pre- and post-treatment assessments.

Calculation of *foliage cover* may seem to be best as it should give a better indication of transpiration potential. However, there are difficulties with recording it in the field. This is because the observer must decide whether or not sights within a branch outline pass through a gap between leaves or not. Even a slight breeze causing the branch to move in the field of view makes this task difficult. (It helps if the optics of the crownometer are such that the view of the cross-hairs has a focus at infinity rather than at some level below the crowns, but the task is still difficult in any breeze.) I noted from studies on the Yarragil 4L catchment in 1980 that there were statistically significant ($p < 0.05$) differences between observers in their estimates of *foliage cover* using a crownometer in the same area. Thus, the method is subject to observer bias, some observers tending to record a "hit" if green leaves pass across the cross-hairs at some time while making an observation, others tend the opposite way.

Crown cover, either as defined for this study or as defined by Walker and Hopkins (1990), does not have the same practical problems for field assessment with crownometer. This is because it is only necessary to judge if the observation is with a branch outline (whole crown outline if following Walker and Hopkins definition), not in a small gap in the crown.

Walker and Hopkins suggest what seems a convenient method for estimating *foliage cover* from field estimates of *crown cover*. They present a series of photographs showing degree of openness (*crown type*). The range is from 40%-70% which they say covers most Australian woody plants. By matching the photographs (range of leaf sizes also given) with the "openness" of the crowns in the field it is possible to estimate *crown type*, then

% foliage cover = % crown cover x *crown type.*

It is recommended that, in future studies, *crown cover* is more practical to assess in the field than *foliage cover* and should therefore be the standard for direct assessment. If desired the estimates of crown cover can be converted to estimates of foliage cover using Walker and Hopkins (1990) technique. However, for ongoing assessments on the Hansen, Higgens and Jones Catchments it will be necessary to persist with the same methods as already used to facilitate study of trends in forest cover.

Walker and Hopkins also cite practical difficulties with use of a crownometer and suggest an alternative method (to use of crownometer) for field assessment of crown cover. This method relies on establishing a transect and measuring crown widths and crown gaps of trees alongside the transect Although the Walker and Hopkins method was not tested in the field it seems likely that it would be less efficient than use of the crownometer, especially to estimate crown cover over a large area such as the experimental catchments (~ 100 ha). The practical difficulties suggested by Walker and Hopkins with crownometer use were not generally found in the Jarrah forest assessed in this study.

5. Conclusion

- Hansen Catchment was subjected to a heavy uniform thinning in 1985/86, average BA being reduced from 35 m^2/ha pre-treatment to 7 m^2/ha (assessed in 1989). Over the 7 years (1989-96) BA increased to 14 m^2/ha and crown cover had increased from 14% to 26%.

- There was a similar clear increase in BA and crown cover on Higgens Catchment. This catchment was subject to a less intense uniform thinning in 1988/89, average BA being reduced from 37 m^2/ha pre-treatment to 14 m^2/ha (assessed in 1991). Over the 5 years (1991-96) BA increased to 18 m^2/ha and crown cover had increased from 29% to 39%.

- However, there was apparently little increase in BA or crown cover on Jones catchment. This catchment was subject to an operational style treatment with thinning (1988/89) concentrated in areas judged to at least risk of dieback disease due to the fungal pathogen *Phytophthora cinnamomi*. Average BA was reduced from 43 m^2/ha pre-treatment to 17 m^2/ha (assessed in 1991). Average BA in 1996 was estimated to have remained constant at around 17 m^2/ha and crown cover showed little increase (estimated 39% in 1991, 40% in 1996).

- It was not possible to assess reductions in crown cover due to thinning as different methods for assessing crown cover were used in the pre-treatment and first post-treatment assessments.

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Appendix A

Table 1. Forest cover on Hansen Catchment

Table1 (a) Pre-treatment assessment - 1981

Species	% Foliage Cover			Basal Area (m^2/ha)		
	O/S	U/S	All	O/S	U/S	All
Jarrah			32.3			26
Marri			9.0			5
Blackbutt			1.6			0.3
Sheoak			4.4			2
Snoddy						0.3
Gobble						
Bull			3.3			2
Banksia						
Tea Tree			1.1			0.2
Blackboy			.			0.1
Total	47.7	1.3	**49.0**	33.3	2.1	**35.4**

Table1 (b) Post-treatment - 1989 assessment

Species	% Crown Cover			Basal Area (m^2/ha)		
	D	S	All	D	S	All
Jarrah			10.8	3.7	1.0	4.7
Marri			2.2	0.9	0.2	1.1
Blackbutt			0.7	0.1		0.1
Sheoak			0.7	0.1	0.1	0.2
Total	N/A	N/A	**14.4**	5.0	1.5	**6.5**

Table1 (c) Post-treatment - 1996 assessment

Species	% Foliage Cover			% Crown Cover			Basal Area (m^2/ha)		
	O/S	U/S	All	O/S	U/S	All	O/S	U/S	All
Jarrah	6.8	3.6	12.3	10.7	4.2	14.9	5.6	4.3	9.9
Marri	2.3	1.9	4.2	3.9	1.9	5.8	2.1	0.5	2.6
Blackbutt	1.0	0.6	1.6	1.3	0.6	1.9	0.8		0.8
Sheoak	1.0	0.3	1.3	1.0	0.6	1.6	0.4	0.2	0.6
Snoddy Gobble		0.3	0.3		0.3	0.3		0.1	0.1
Bull Banksia		1.3	1.3		1.3	1.3		0.3	0.3
Tea Tree								0.1	0.1
Blackboy								0.1	0.1
Total	13.0	8.1	**21.1**	16.9	9.1	**26.0**	8.9	5.4	**14.3**

Catchment treated: 1985-86

Treatment: Uniform thinning excluding swamp and 50 m buffer surrounding the swamp.

Notes:

(i) O/S = overstory; U/S = understorey; D = dominants/co-dominants; S= sub-dominants/suppressed; N/A = not available

(ii) For definitions of *foliage cover* and *crown cover* refer main text.

(iii) In the pre-treatment assessment more than one species was occasionally recorded at an observation point. Hence "sum of specie's cover " > "total cover". In post-treatment assessments only one species (the highest crown stratum) was recorded where more than one species had crown above the observation point.

(iv) Estimates of foliage cover (crown cover) recorded pre-treatment differ from that given in SCRLUWS (1987) and Ruprecht *et al.* (1991).

Appendix B

Table 2. Forest cover on Higgens Catchment

Table2 (a) Pre-treatment assessment - 1981

Species	% Foliage Cover			Basal Area (m^2/ha)		
	O/S	U/S	All	O/S	U/S	All
Jarrah			30.7			28.1
Marri			5.6			3.9
Blackbutt			0.3			0.5
Bullich			3.1			0.6
Sheoak			2.3			1.4
Snoddy			0.3			0.3
Gobble						
Bull			8.7			2.1
Banksia						
Tea Tree			0.3			
Blackboy						0.2
Total	42.0	6.5	**48.5**	34.5	2.6	**37.1**

Table2 (b) Post-treatment - 1991 assessment

Species	% Crown Cover			Basal Area (m^2/ha)		
	D	S	All	D	S	All
Jarrah			20.1	8.4	1.0	9.4
Marri			2.5	0.7	0.5	1.2
Blackbutt			0.4	0.3	0.1	0.4
Bullich			2.1	0.8		0.8
Sheoak			2.5	0.6	0.5	1.1
Bull Banksia			0.4		0.1	0.1
Swamp			1.2		0.1	0.1
Banksia						
Other					0.2	0.2
Total	N/A	N/A	**29.1**	10.7	2.6	**13.5**

Table2 (c) Post-treatment - 1996 assessment

Species	% Foliage Cover			% Crown Cover			Basal Area (m^2/ha)		
	O/S	U/S	All	O/S	U/S	All	O/S	U/S	All
Jarrah	15.6	3.9	19.5	22.5	5.2	27.7	11.0	2.0	13.0
Marri	1.7		1.7	2.2		2.2	1.5	0.6	2.1
Blackbutt	0.9		0.9	0.9	0.4	1.3	0.3	0.3	0.6
Bullich	0.9		0.9	2.2		2.2	0.7		0.7
Sheoak	1.7		1.7	2.2		2.2	1.0	0.1	1.1
Snoddy Gobble					0.4	0.4		0.2	0.2
Bull Banksia		0.9	0.9		1.3	1.3		0.3	0.3
Swamp Banksia		0.4	0.4		0.9	0.9		0.2	0.2
Water Bush		0.4	0.4		0.4	0.4			
	20.8	5.6	**26.4**	29.9	8.7	**38.5**	13.9	3.7	**17.6**

O/S = overstory; U/S = understorey; D = dominant; S = sub-dominant; N/A = not available

Catchment treated: 1988-89
Treatment: Uniform thinning

Appendix C

Table 3. Forest cover on Jones Catchment

Table 3 (a) Pre-treatment assessment - 1981

Species	% Foliage Cover			Basal Area (m^2/ha)		
	O/S	U/S	All	O/S	U/S	All
Jarrah			33.9			30.9
Marri			10.4			5.8
Blackbutt			0.5			0.8
Sheoak			1.9			1.5
Snoddy			0.9			0.7
Gobble						
Round-leaf			0.7			0.1
Persoonia						
Bull			7.1			3.0
Banksia						
Swamp			1.6			0.3
Banksia						
Total	46.7	7.7	**54.4**	39.0	4.3	**43.3**

Table 3 (b) Post-treatment-1991 assessment

Species	% Crown Cover			Basal Area (m^2/ha)		
	D	S	All	D	S	All
Jarrah			30.7	9.3	3.4	12.7
Marri			2.6	1.9	0.4	2.3
Blackbutt			0.9	0.1	0.2	0.4
Bullich						
Sheoak			3.9	0.8	0.4	1.2
Snoddy						
Gobble						
Bull			1.3		0.2	0.2
Banksia						
Other						0.2
Water						
Bush						
Total	N/A	N/A	**39.4**	12.1	4.8	**17.0**

(c) Post-treatment - 1996 assessment

Species	% Foliage Cover			% Crown Cover			Basal Area (m^2/ha)		
	O/S	U/S	All	O/S	U/S	All	O/S	U/S	All
Jarrah	19	2.1	21.1	22.7	2.9	25.6	11.0	1.8	12.8
Marri	4.1	0.8	5.0	5.4	1.7	7.0	1.8	0.3	2.1
Blackbutt	1.2		1.2	2.1		2.1	0.1	0.2	0.3
Bullich									
Sheoak	1.2		1.2	1.7		1.7	1.6	0.5	2.1
Snoddy Gobble		0.4	0.4		0.4	0.4		0.3	0.3
Bull Banksia		2.1	2.1						
Swamp Banksia									
Water Bush					2.9	2.9		0.1	0.1
Total	25.6	5.4	**31.0**	31.8	7.9	**39.7**	14.3	3.1	**17.4**

O/S = overstory; U/S = understorey; D = dominant; S = sub-dominant; N/A = not available

Catchment treated: 1988-89

Treatment: Operational style treatment with thinning concentrated in areas with least risk of being affected by dieback disease.