Water Authority
of Western Australia

WATER RESOURCES DIRECTORATE

A Quantitative Description Of Jarrah Forest Vegetation On A Hillslope In The Del Park Catchment, Western Australia

Report No. WS 1

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A Quantitative Description Of Jarrah Forest Vegetation On A Hillslope In The Del Park Catchment, Western Australia

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Del Park Hydrology Study Series
Volume 1

Report No. WS 1

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SUMMARY

This report presents a quantitative physical description of the vegetation on a 20 m x 340 m hillslope transect in the Del Park research catchment. The description includes species identification and distribution, measures of forest density (stocking, basal area, canopy cover and leaf area), site type classification and dieback hazard rating.

The overstorey vegetation on the hillslope transect was predominantly jarrah (Eucalyptus marginata) and marri (E. calophylla) on the middle and upper slopes and bullich (E. megacarpa) on the lower slope. Throughout the hillslope, the middlestorey was dominated by bull banksia (Banksia grandis) and sheoak (Allocasuarina fraseriana). Sheoak comprised 17% of the total number of trees.

The total number of trees on the hillslope was 436 (height > 1.4 m), which corresponds to a tree stocking of 641 trees per hectare. The total stocking, which includes jarrah coppice, was 856 stems per hectare. The total basal area on the hillslope was 29.1 m^2 ha^{-1} with the jarrah-marri component comprising 15.4 m^2 ha^{-1} (53%). The total projected canopy cover for the overstorey and middlestorey was calculated at 45%, the leaf area at 9500 m^2 and the leaf area index at 1.4. These figures indicate that the hillslope at Del Park was medium density jarrah forest.

The tree stocking and basal area were greater on the lower slope due to salvage logging on the middle and upper slopes in 1977 and an unusually dense stand of bullich on the lower slope. Overall the hillslope stocking was moderate.

In comparison to other areas in the northern jarrah forest, the hillslope transect had an average basal area. When compared to measurement of other Havel S site types, the hillslope had below average basal area. The hillslope projected leaf cover and leaf area index were also slightly below average compared to other measurements in the northern jarrah forest.

The overstorey comprised 78% and the middlestorey 9% of the leaf area of the hillslope. Together they would most likely account for most of the interception and transpiration on the slope. Understorey species present on the hillslope included blackboy (Xanthorrhoea preissii), waterbush (Bossiaea aquifolium), zamia palm (Macrozamia riedlei), bracken fern (Pteridium aquilinum), Lasiopetalum floribundum, Leucopogon verticillatus, and Acacia pulchella. The groundflora species on the hillslope included Adenanthos barbigera, Hovea chorizemifolia, Xanthorrhoea gracilis, Trymalium ledifolium, Phyllanthus calycinus, and Hibbertia montana major. The understorey and groundflora respectively comprised 9% and 4.5% of the leaf area on the hillslope. Understorey plants had a higher frequency on the middle and upper slopes.

The dieback hazard analysis, based on the presence or absence of understorey indicator species, gave a high hazard classification to the hillslope. The most significant indicator species were Adenanthos barbigera, Drosera Spp, Hibbertia montana major, Lasiopetalum floribundum and Scaevola striata. Currently there is no expression of dieback at this site.

ACKNOWLEDGEMENTS

The authors express their gratitude to the forestry cadets of CALM for carrying out overstorey measurements on the Del Park hillslope. Thanks also go to Dr B. Shearer, Mr M. Dillon and the other members of the dieback mapping team for their assistance in identifying indicator species and calculating the dieback hazard rating. Mr R. Pickett is also acknowledged for his processing on the Intergraph System. The authors are grateful to Dr I.J. Colquhoun, Dr E.A.N. Greenwood, Mr G.L. Stoneman, Dr H. Borg, Mr J.R. Bartle and Mr I.C. Loh for their helpful comments on the text.

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1. INTRODUCTION

In 1983 the Hillslope Processes Group (HPG) was formed as one of four research groups to undertake research into water resource problems relating to the mining of bauxite in the northern jarrah forest. The purpose of the HPG is to carry out detailed research on water and salt movement in the undisturbed forest and to determine the impact of bauxite mining and rehabilitation on these processes. Where possible, contributions are also made to the understanding of the interaction of mining with dieback disease.

To date one hillslope has been established and is located in the Del Park catchment. Hydrological components on the hillslope have been monitored since 1984 and will continue until mid-1987, when mining is planned to commence. The hillslope under study is shown as area 'C' in Fig. 1, which contains the ore body to be mined. Within area 'C' a transect through the ore body has been monitored more intensively. It is the vegetation on this transect which is the subject of this report. A botanical survey of the Del Park research catchment has previously been carried out by Mattiske and Associates (1985).

The purpose of this report is to describe the forest vegetation on the hillslope transect in a quantitative manner. This will:

(i) be used directly in the calculation of some hydrological components;

(ii) enable a better interpretation of patterns of soil water use;

(iii) form a part of the total site description necessary for extrapolation of results, assessment of site variability and future site selection;

(iv) contribute to an understanding of the dieback status of the hillsope;

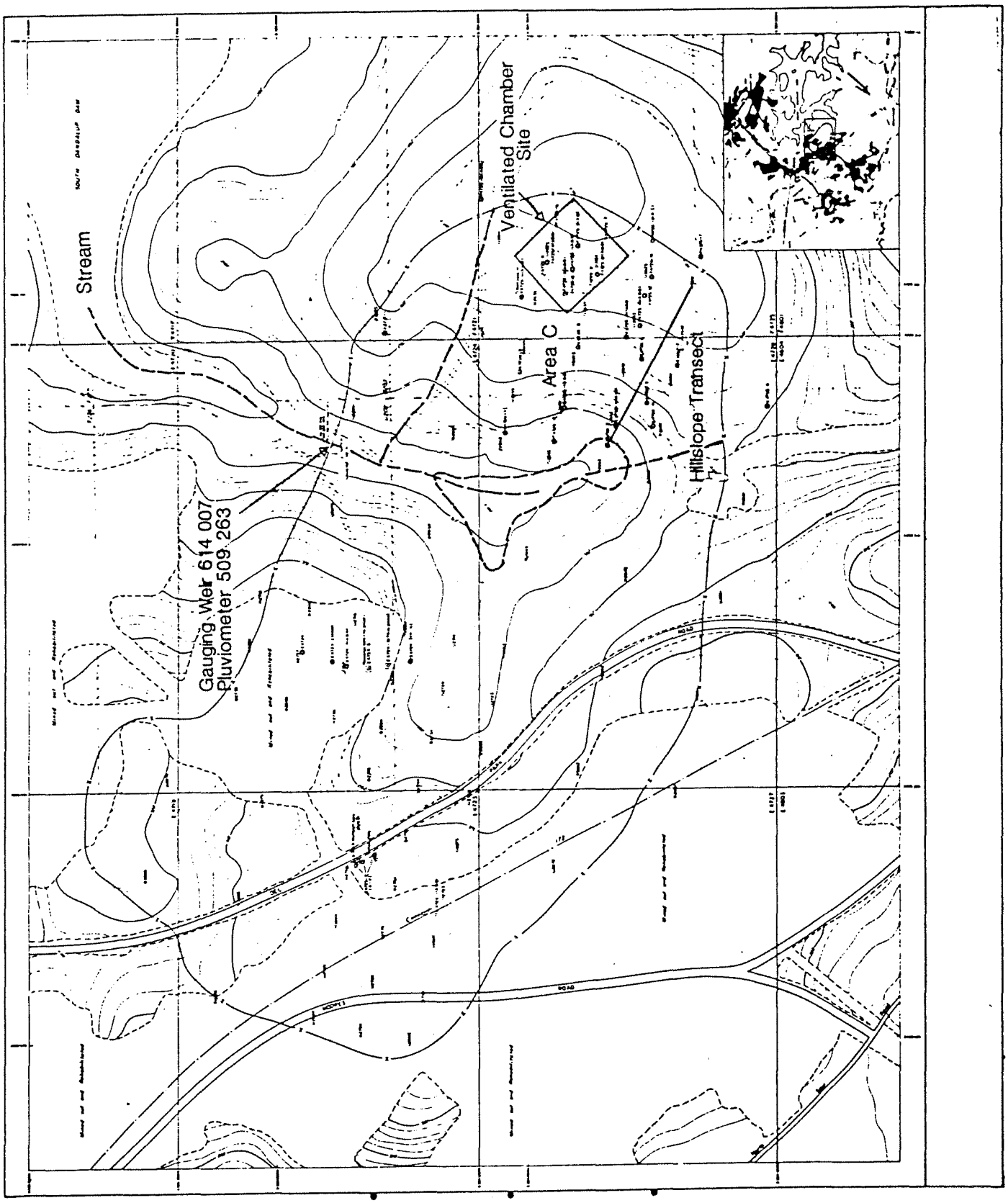


FIGURE 1 - DEL PARK HILLSLOPE LOCATION MAP

(v) aid the interpretation of the performance of specific instruments.

In this report, Section 2 describes the study area. The methods used are given in Section 3 and the results in Section 4.

A discussion on the comparison between this study and other studies carried out in the northern jarrah forest is detailed in Section 5.

All common and scientific names of vegetation species encountered in this report are summarised in Appendix A. Their general characteristics are described in Appendix B. Also, to simplify presentation, all vegetation terms are defined in Appendix C, rather than in the text. Abbreviations used in the text are summarised in Appendix D. Appendix E describes the Havel site types.

2. STUDY AREA

2.1 Location and climate

The Del Park catchment is located approximately 100 km south of Perth and 5 km NNW of Dwellingup. The catchment is 130 ha in area, and the hillslope transect is 340 m by 20 m giving an area of 0.68 ha (see Fig. 1). The region has a Mediterranean climate (high winter rainfall and a dry, hot summer). The average annual rainfall is 1300 mm, 80% of which falls during the 6 months from May to October. The average annual pan evaporation is 1700 mm.

2.2 Topography and geology

The Del Park catchment has an approximate elevation of 300 m above sea level, with the hillslope varying from 277 m to 307 m. Valley side slopes are generally moderate with an average inclination of 10%. The hillslope transect slope is approximately 9%.

The catchment is located within the south western province of the Archean Yilgarn Block. The rocks are generally granitic with a large number of dykes comprised mainly of quartz dolerite. In situ weathering of the basement rocks has led to the development of a deep lateritic profile.

The catchment comprises 55% Dwellingup formation and 45% Yarragil formation (Public Works Department, 1984). The Dwellingup formation is a laterite plateau consisting of uplands of duricrust, gravels and sands generally overlying mottled clay soils. The Yarragil formation consists of upland valleys with sandy gravels on slopes and orange earths on the swamp floors. (Landform types were derived by Department of Conservation and Environment, 1980).

3. METHODS

3.1 Vegetation survey and data capture

An initial vegetation survey covering the overstorey and middlestorey was undertaken by CALM during April, 1985. The measurements took 12 people approximately four days to complete. A minimum height of 1.4 m was determined as the lower limit of measurement. For each tree the species position in x and y co-ordinates, stem diameter, height, canopy width, canopy depth and the number of coppices were recorded. The stem diameter was measured at breast height over bark (dbhob). The tree height and canopy depth were measured using a clinometer, while 'average' canopy width was measured by sighting a plumbob at two points on opposite sides of the canopy.

The second survey was undertaken to quantify the understorey and groundflora. This was completed in October 1986. The number of plants of a particular species were recorded in 20 m x 20 m quadrats up the hillslope. For recording purposes the understorey was defined as having height within the range 1.4 m to 0.25 m and the groundflora was defined as having height less than 0.25 m.

3.2 Mathematical definitions of stand density terms

Stand density and forest cover terms in the literature are often not clearly defined and frequently relate more to the method of measurement than a strict definition. This section attempts to overcome the potential confusion in this area by providing mathematical definitions of terms used in this report. The terms and formulae are listed in Table 1, and Fig. 2 gives a diagrammatic explanation of stand density terms. In the formulae 'i' refers to an individual, and summations of i = 1, n refers to a stand of n members. Also U refers to union and Σ to summation.

Table 1 Terms, formulae and units of stand density

Term	Formulae	Units
stand area	S	m^2
tree basal area	d_i	m^2
projected leaf cover	a_i	m^2
projected branch cover	b_i	m^2
projected crown cover	c_i	m^2
stand projected leaf cover	$A = \bigcup_{i=1}^{n} a_i$	m^2
	$A' = \bigcup_{i=1}^{n} a_i / S$	%
stand projected branch cover	$B = \bigcup_{i=1}^{n} b_i$	m^2
	$B' = \bigcup_{i=1}^{n} b_i / S$	%
stand projected crown cover	$C = \bigcup_{i=1}^{n} c_i$	m^2
(projected canopy cover)	$C' = \bigcup_{i=1}^{n} c_i / S$	%
stand basal area	$D = \bigcup_{i=1}^{n} d_i$ or $\sum_{i=1}^{n} d_i$	m^2
	$D' = \sum_{i=1}^{n} d_i / S$	$m^2\ m^{-2}$
stand wood and leaf cover	A U B U D	m^2
overstorey leaf area	l_{oi}	m^2
middlestorey leaf area	l_{mi}	m^2
understorey leaf area	l_{ui}	m^2
groundflora leaf area	l_{gi}	m^2
overstorey stand leaf area	$L_o = \sum_{i=1}^{n} l_{oi}$	m^2
middlestorey stand leaf area	$L_m = \sum_{i=1}^{n} l_{mi}$	m^2

understorey stand leaf area	$L_u = \sum_{i=1}^{n} l_{ui}$	m^2
groundflora stand leaf area	$L_g = \sum_{i=1}^{n} l_{gi}$	m^2
total stand leaf area	$L = L_o + L_m + L_u + L_g$	m^2
overstorey stand leaf area index	$LAI_o = L_o/S$	$m^2\ m^{-2}$
middlestorey stand leaf area index	$LAI_m = L_m/S$	$m^2\ m^{-2}$
understorey stand leaf area index	$LAI_u = L_u/S$	$m^2\ m^{-2}$
groundflora stand leaf area index	$LAI_g = L_g/S$	$m^2\ m^{-2}$
total stand leaf area index	$LAI = LAI_o + LAI_m + LAI_u + LAI_g$	$m^2\ m^{-2}$

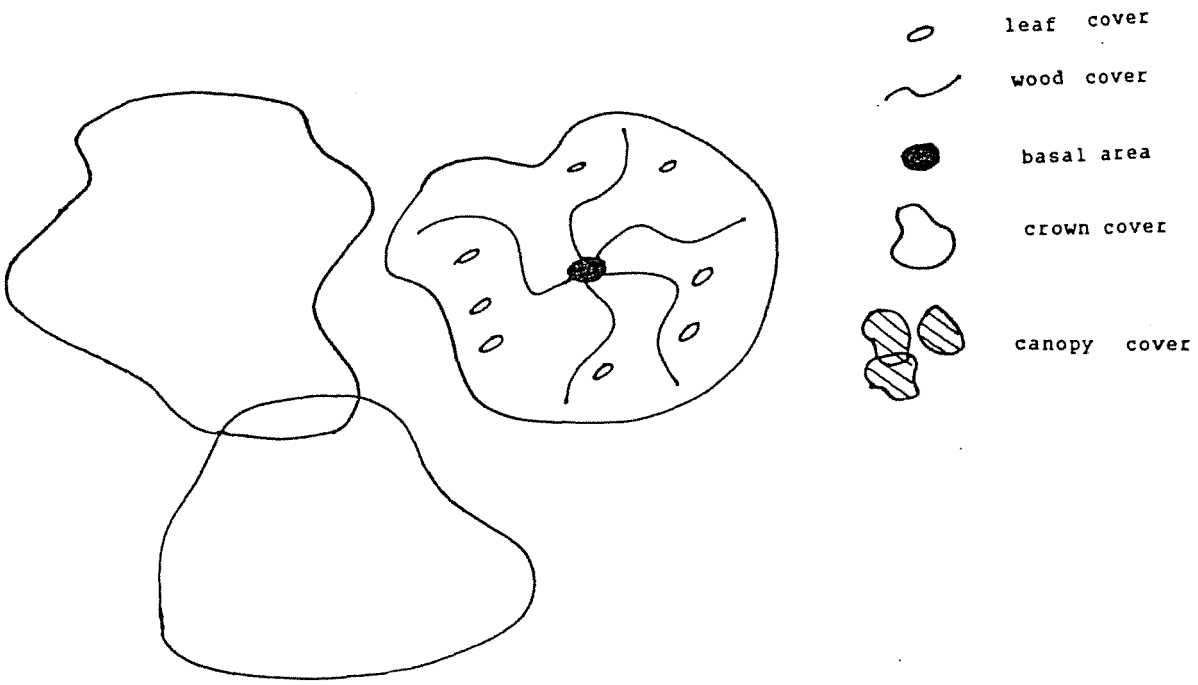


Figure 2 Diagrammatic explanation of stand density terms

3.3 Basal area

The basal area was calculated by using the diameter measurement for the trees surveyed, including the coppices, from the initial survey.

3.4 Cover

3.4.1 Intergraph interpretation

Using canopy width data, stem location and assuming circular canopies and vertical stems, a measurement of the stand projected canopy cover was estimated. The intergraph system was used to interpret the union of all the canopies on the hillslope transect.

3.4.2 Visual sighting of cover

A 'crownometer', developed by CALM, was used to estimate stand projected leaf cover. The procedure followed was to sample the vegetation cover on a 4 m by 2 m grid. When a leaf intersected the cross hairs, cover was said to be present, but when open sky or wood intersected the cross hairs, cover was said to be absent. Therefore, with a large sample, an estimate of the stand projected leaf cover can be attained.

Projected leaf cover was estimated for tree species by comparing the leaf cover to photographs which were 10, 30, 50, 70, 90% black (randomly located) on a clear background.

3.5 Leaf area

Leaf area and leaf area index measurements were estimated by applying regression equations for a number of tree species.

Carbon et al. (1979) produced a relationship between leaf area and tree parameters for jarrah-marri forests:

$$LA = 287 * DBH - 33 \quad 3.1$$

where LA is leaf area in m^2
DBH is diameter at breast height in m

K. Whitford (pers. comm.) has made an extensive study of leaf area measures in jarrah and recommended the use of the following regression equation to predict leaf area:

$$LA = 0.019(DBH)^{2.18} + 0.501(CD)(CW) - 6.43 \quad 3.2$$

where LA is leaf area in m^2
DBH is diameter at breast height in cm
CD is canopy depth in m
CW is canopy width in m

This equation was derived from data at two sites and 52 trees and covers the diameter range of 6 to 48 cm. This information, although derived for jarrah, has been also used on marri and bullich. As these trees adopt a similar form to jarrah, it is likely that the regression produces reasonable values for leaf area. It must also be noted that the leaf area undergoes a seasonal variation which can be as large as 40% of the median leaf area. Dimensional relationships such as equations 3.1 and 3.2 should define the mid-point in the seasonal variations of leaf area.

For jarrah trees with a diameter less than 6 cm, the leaf area calculated by equation 3.1 or 3.2 was negative and it was necessary to develop another leaf area equation which took the form:

$$LA = 0.18 * DBH + 0.7 \quad 3.3$$

This equation was determined by comparing the relationship between leaf area and diameter for jarrah saplings and the leaf area calculated by equation 3.2 for jarrah trees with a diameter between 6 to 8 cm.

This approach was considered adequate because there were only five jarrah trees less than 6 cm in diameter.

Sheoak has a form and leaf shape that is different to the eucalypts. Its leaf area was derived separately. This was done by sampling a number of needles to obtain a leaf area per needle, then a leaf area for a small branch and a larger branch. These data were then used to calculate a leaf area for 14 sheoaks on the hillslope, from which a regression equation was derived:

$$LA = 0.54 * D + 10.68 \qquad 3.3$$
$$R^2 = 0.74 \quad sig = 0.001$$

where D is diameter at breast height in cm
LA is leaf area in m^2

The calculations and estimates of leaf area were undertaken in October, 1986 and would be close to the minimum seasonal value.

The procedure used for bull banksia was similar to that used for sheoak and is consistent with the technique described by Carbon et al. (1979). Photographs depicting various leaf sizes of banksia branches and trees of known leaf area were used to estimate the tree leaf area. The regression equation derived was:

$$LA = 1.022 * D - 2.35 \qquad 3.4$$
$$R^2 = 0.86 \quad sig = 0.0027$$

These values were again taken in October, 1986 and should be considered as a minimum estimate of leaf area over the year.

The understorey leaf area was calculated by estimating the average number of leaves on a plant for each species and then measuring the mean leaf area for each species. Then, by multiplying the average number of leaves by the mean leaf area, an estimate of the mean leaf area per plant per species was derived. This method gives a crude estimate for leaf area for the understorey.

An estimate of the groundflora leaf area was derived by comparing the leaf area of the groundflora to that of the understorey in percentage terms. The percent leaf area of the groundflora was multiplied by the leaf area of the understorey to give the groundflora leaf area.

3.6 Havel site type classification

In order to detect and define different vegetation characteristics of the northern jarrah forest, Havel (1975) developed nineteen biologically meaningful site vegetation types (see Appendix E for definitions of each site type). The vegetation site types are defined primarily by the presence or absence of indicator species.

3.7 Phytophthora cinnamomi hazard rating

A dieback hazard analysis of the hillslope, based on the presence or absence of indicator plant species was undertaken by CALM. The plant species studied were:

(i) Acacia drummondii
(ii) Acacia pulchella
(iii) Adenanthos barbigera
(iv) Casuarina fraseriana
(v) Clematis pubescens
(vi) Conostylis pathyrantha
(vii) Conostylis setigera

(viii) Drosera sp.
(ix) Grevillea wilsonii
(x) Hibbertia hypericoides
(xi) Hibbertia montana major
(xii) Hibbertia perfoliata
(xiii) Lasiopetalum floribundum
(xiv) Marianthus drummondianus
(xv) Opercularia echinocephala
(xvi) Patersonia occidentalis
(xvii) Scaevola striata
(xviii) Sollya heterophylla
(xix) Sphaerolobium medium
(xx) Trymalium ledifolium
(xxi) Xanthosia silvatica

The analysis of the data (B. Shearer pers. comm.) involved applying a weighting for the plant species present to a set of five equations, each representing a different hazard rating. After all weightings have been applied for the 21 species studied, the equation with the highest value corresponds to the hazard rating.

4. RESULTS

4.1 Species present

4.1.1 Middlestorey and overstorey

A total of 436 trees were located on the hillslope, comprising six species. These species were jarrah (Eucalyptus marginata), marri (E. calophylla), bullich (E. megacarpa), banksia (Banksia grandis), sheoak (Allocasuarina fraseriana) and Persoonia elliptica. The frequency of each of these tree species is shown in Fig. 3(A). This diagram shows the dominance of jarrah on the hillslope. However, at approximately 60%, the jarrah/marri proportion is low for the jarrah forest as a whole (J. Bartle pers. comm.). On the other hand, the proportion of sheoak is unusually high.

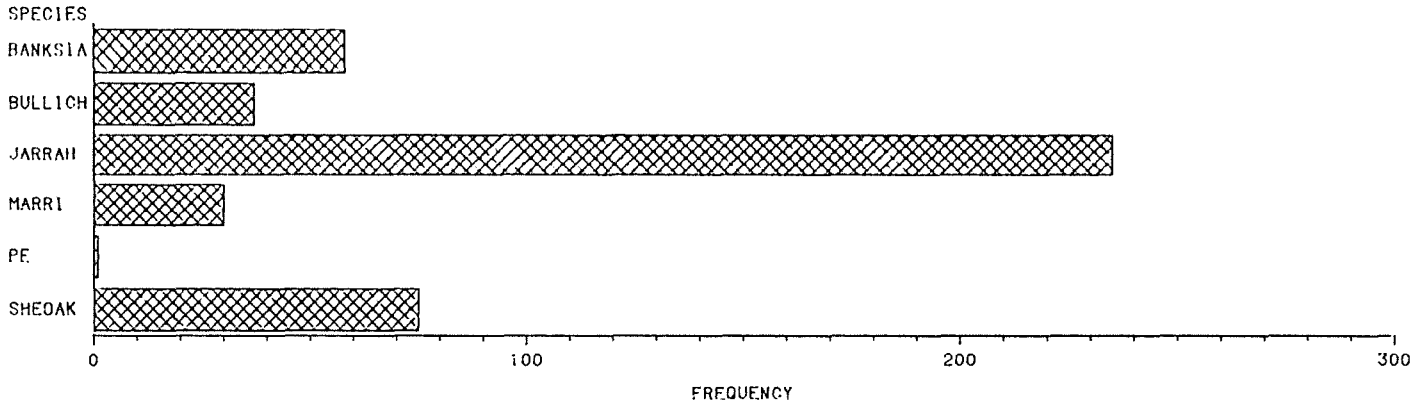
4.1.2 Understorey and groundflora

The major understorey species located on the hillslope were blackboy (Xanthorrhoea pressii), water bush (Bossiaea aquifolium), zamia palm (Macrozamia riedlei), bracken fern (Pteridium esculentum), free flowering lasiopetalum (Lasiopetalum floribundum) and prickly moses (Acacia pulchella). Also included in the understorey were jarrah and banksia saplings and Persoonia longifolia saplings. The number and percentage of each species is shown in Fig. 3(B).

The groundflora species present included, Adenanthos barbigera, Clematis pubescens, Leucopogon verticillatus, L. capitellatus, L. propinquus, Mirbelia dilatata, Phyllanthus calycinus, Trymalium ledifolium, Xanthorrhoea gracilis and Kennedia coccinea.

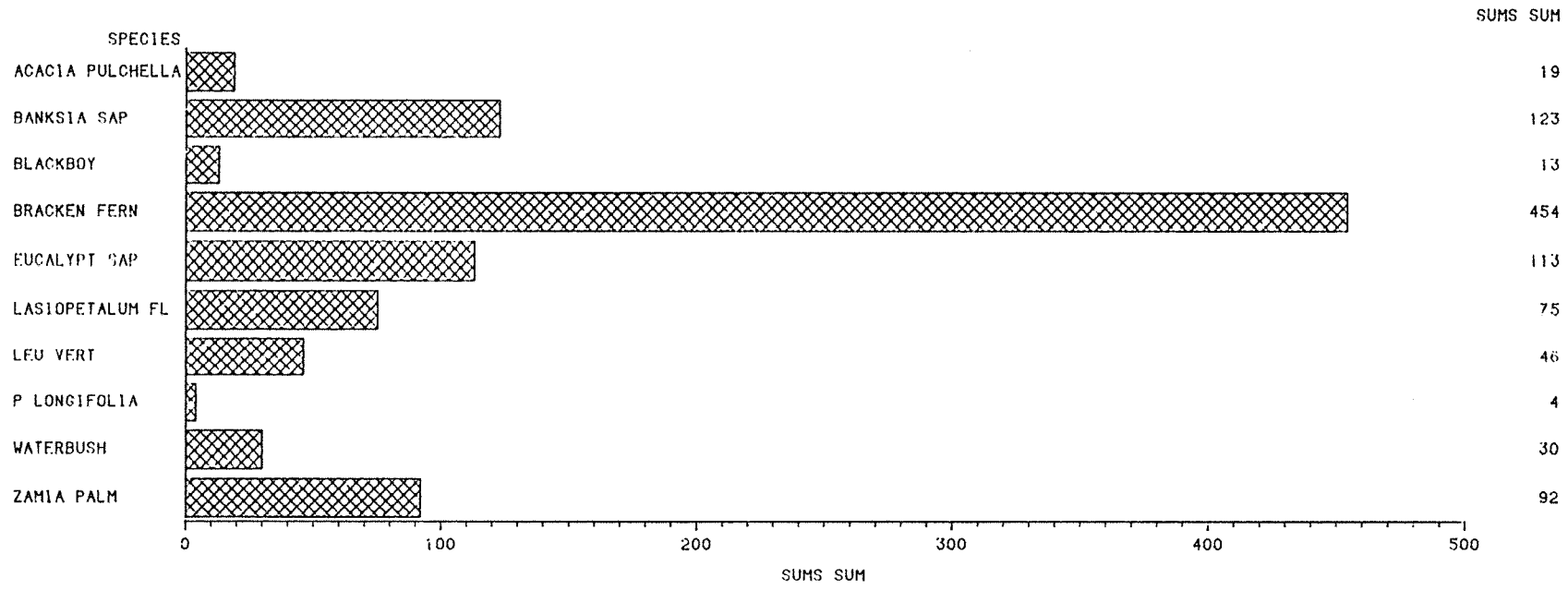
FIGURE 3(A) - SPECIES IN OVERSTOREY AND MIDDLESTOREY

VEGETATION ANALYSIS – DEL PARK HILLSLOPE



SPECIES	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
BANKSIA	58	58	13.30	13.30
BULLICH	37	95	8.49	21.79
JARRAH	235	330	53.90	75.69
MARRI	30	360	6.88	82.57
PE	1	361	0.23	82.80
SHEOAK	75	436	17.20	100.00

FIGURE 3(B) - SPECIES IN UNDERSTOREY



4.2 Distribution of vegetation over the hillslope

The vegetation distribution on the hillslope transect is shown on Fig. 4(A). The hillslope transect is approximately just right of centre running up the photograph. Items of note on Fig. 4(A) include the change in vegetation from the hillslope transect to the vegetation on the left of the photograph, and the vegetation change at and adjacent to the swamp area in the bottom right hand area.

Figs. 4(B) and 4(C) depict the typical vegetation on the lower region of the hillslope. Note the overstorey species of bullich, jarrah and marri, while the understorey is predominantly waterbush. The region from 70 m to the top of the hillslope at 340 m is shown in Figs. 4(D), 4(E) and 4(F). The overstorey is comprised of jarrah and marri, the middlestorey of bull banksia and sheoak, and the understorey of zamia palm and bracken fern.

4.2.1 Overstorey

The distribution of the total number of trees on the hillslope is shown in Fig. 5. There are three vehicle tracks traversing the hillslope. These are at the 53-57 m, 110-115 m, and 169-173 m distance intervals upslope. This would explain partly the smaller number of trees occurring in the 40-60 m grid. There is a greater number of trees on the lower half of the transect than the upper half, but there is no apparent statistical trend with distance upslope. However, there has been salvage logging on the hillslope in the mid-1970s which would distort any natural trend.

Figs. 6(A)-(F) show the distribution of specific tree species up the hillslope. The statistics generally reinforce species characteristics, with bullich only occurring in the first 80 m,

adjacent to the valley floor (see Appendix B for more details on bullich and the other major tree species). Jarrah was rare in the first 60 m, however from 60 to 340 m, jarrah was the dominant species apart from the section 220 to 260 m. Marri was evenly distributed, ranging from 0 to 4 trees over the 20 m grids up the hillslope as can be seen in Fig. 6. Bull banksia was present from 0 to 240 m and from 300 to 320 m. Sheoak was present over the hillslope with the exception of 100-120 m. The one Persoonia elliptica was located at 169 m.

4.2.2 Understorey

Fig. 7 shows the total number of understorey plants in the range 0.25 m to 1.4 m. There is consistently greater frequency of understorey plants in the upper half of the hillslope. This is due to the influence of bracken fern in the region from 160 m to 300 m. Also vehicles and people traversing may have had some impact downslope of 60 m.

Diagrams of the individual species located in the understorey are shown in Figs. 8(A)-(J). The waterbush is predominantly found in the region 0 to 40 m with a few plants found in the region 220 m to 260 m. The zamia palm is similar to the waterbush and found more commonly on the lower slope. The bracken fern is generally found on the midslope, but is common to all the hillslope. L. floribundum is found throughout the hillslope, banksia and jarrah saplings are found throughout the hillslope but predominantly midslope. L. verticillatus is found on the mid to upper slope. At midslope four P. longifolia saplings were found and A. pulchella was found predominantly on the upper slope.

4 (A) AERIAL VIEW OF SWAMP AND LOWER HILLSLOPE

FIGURE 4 - PHOTOGRAPHS OF HILLSLOPE TRANSECT

4(B) LOOKING DOWNSLOPE AT 20 M

4(C) LOOKING DOWNSLOPE AT 40 M

FIGURE 4 - PHOTOGRAPHS OF HILLSLOPE TRANSECT

4(D) LOOKING UPSLOPE AT 60 M

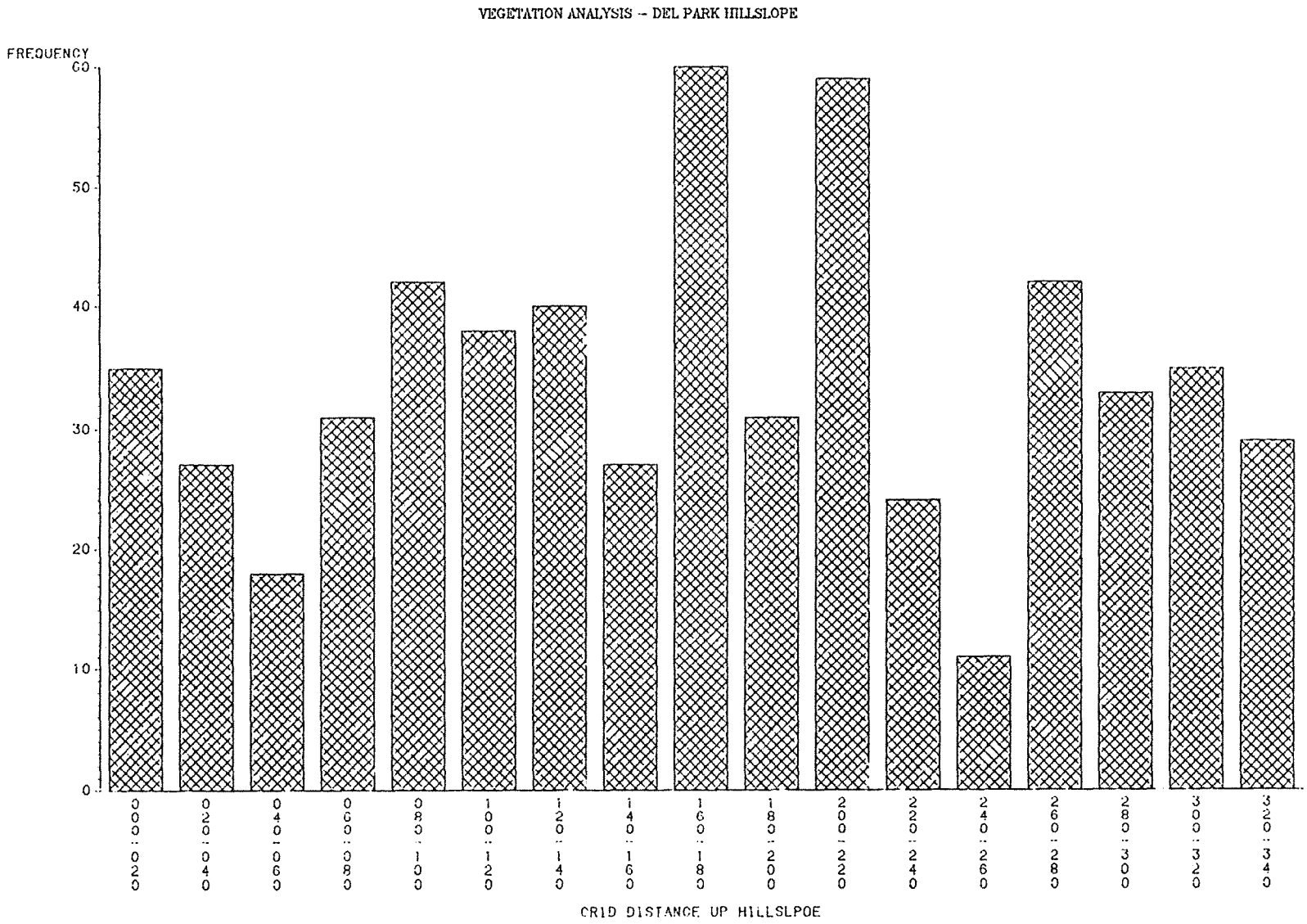
4(E) LOOKING UPSLOPE AT 100 M

FIGURE 4 - PHOTOGRAPHS OF HILLSLOPE TRANSECT

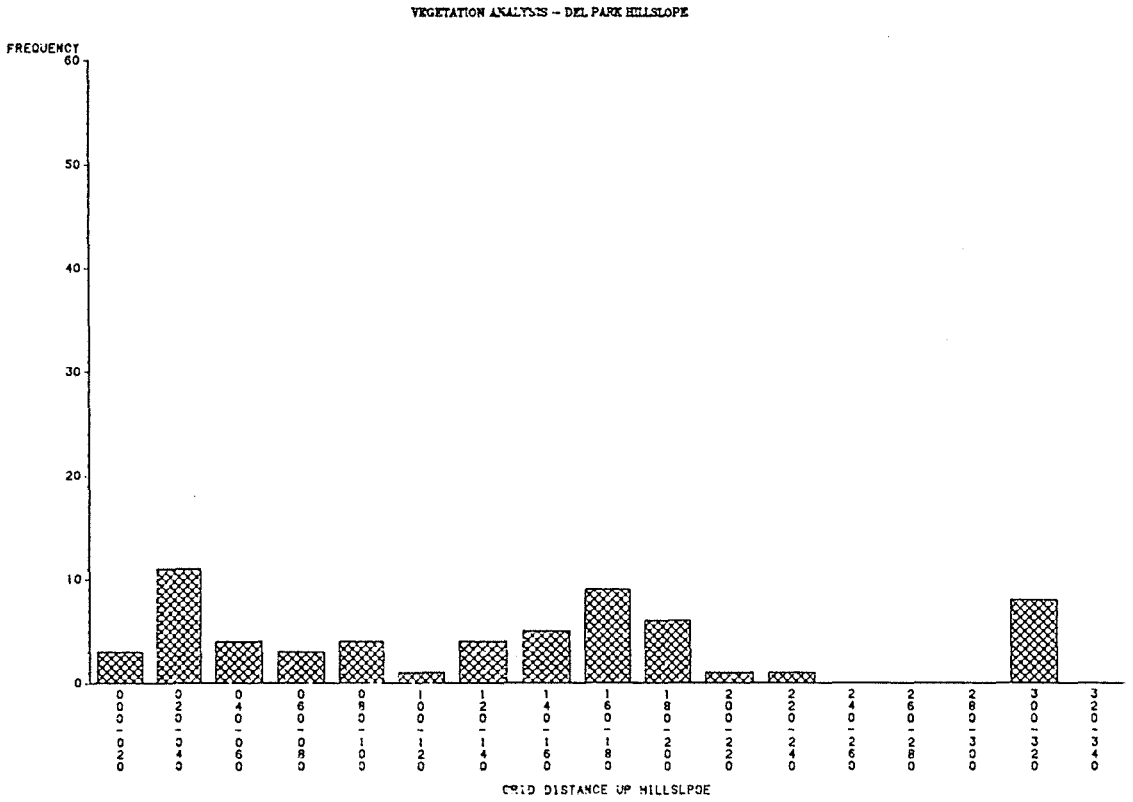
4(F) LOOKING UPSLOPE AT 240 M

FIGURE 4 - PHOTOGRAPHS OF **HILLSLOPE** TRANSECT

FIGURE 5 - TREE DISTRIBUTION



(A) BANSKIA



(B) BULLICH

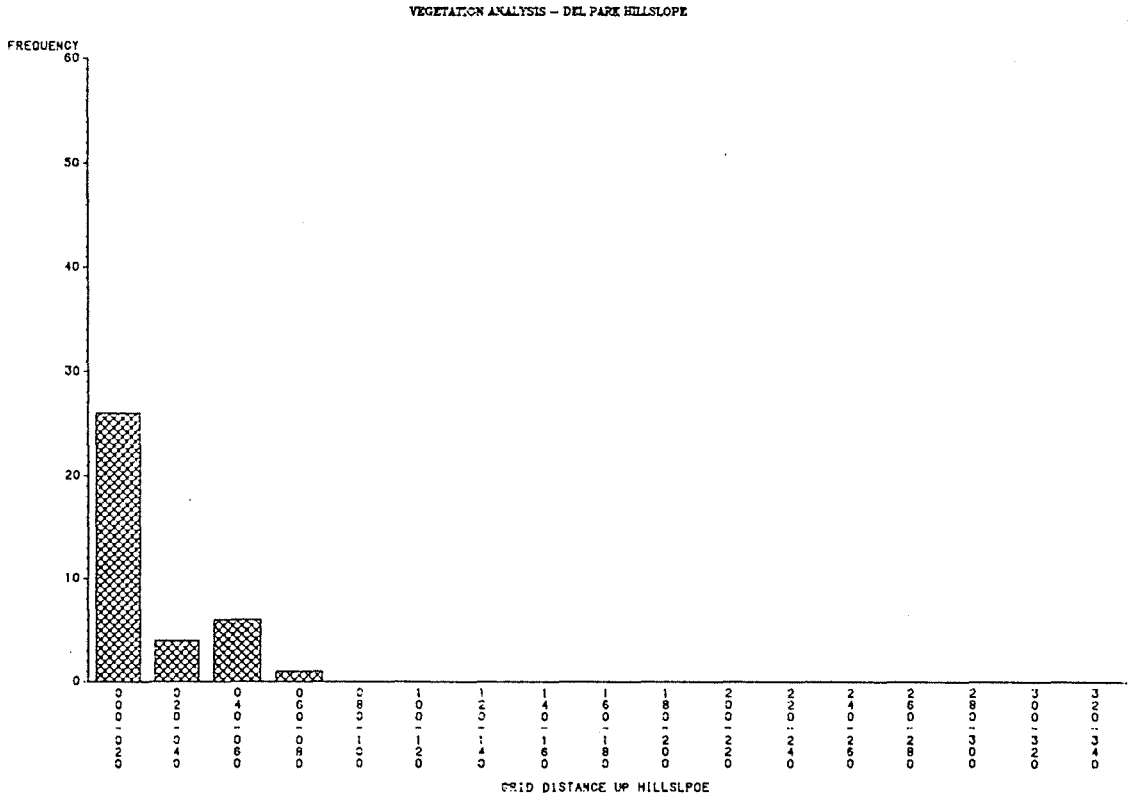
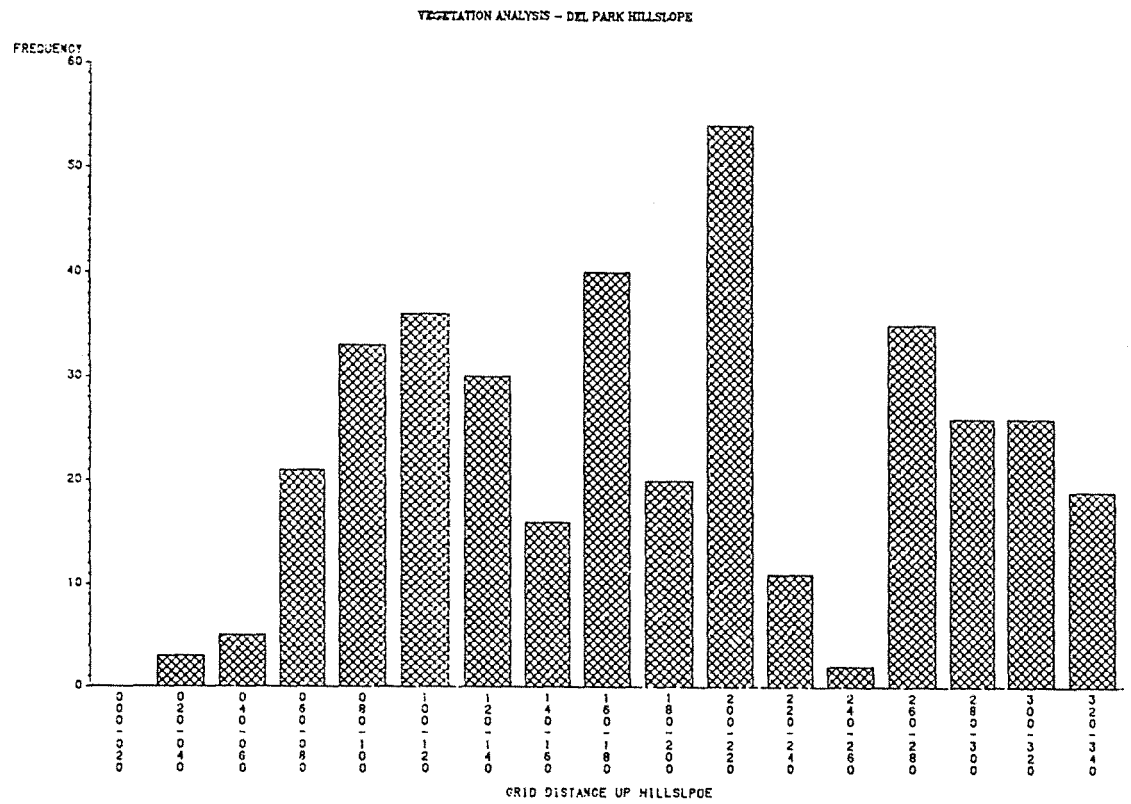


FIGURE 6 - TREE DISTRIBUTION BY SPECIES

JARRAH (C)



(D) MARRI

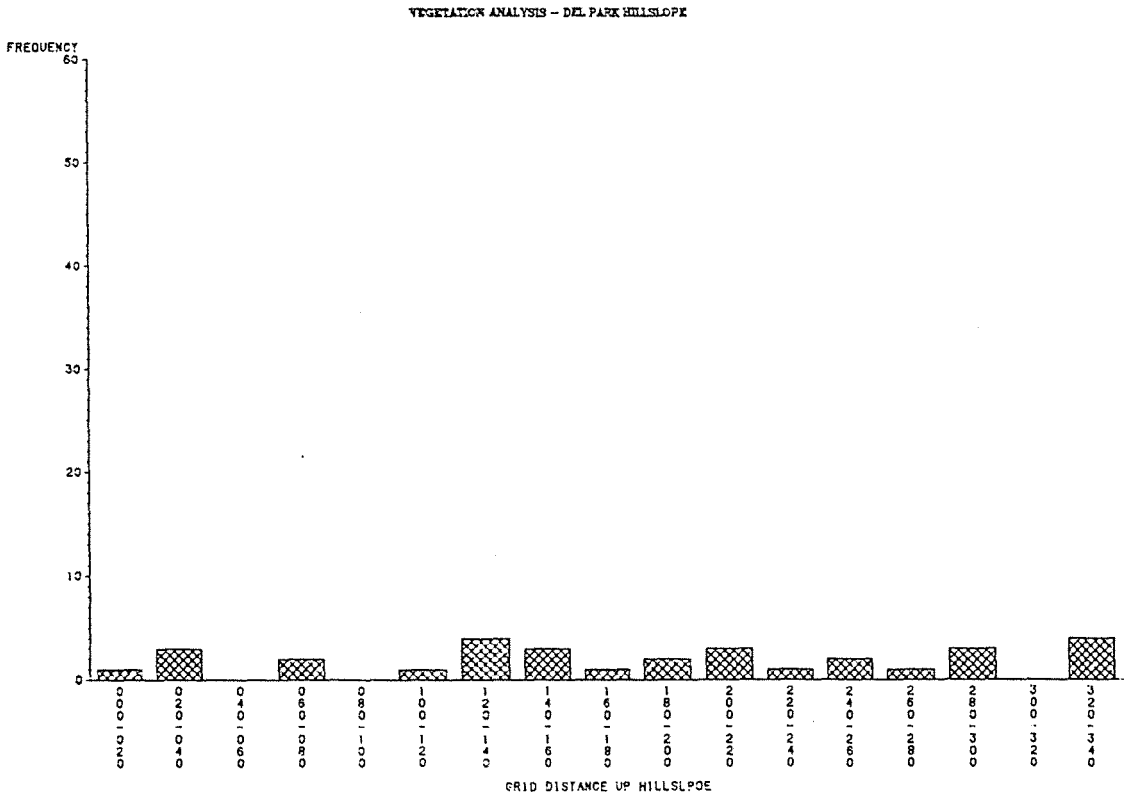
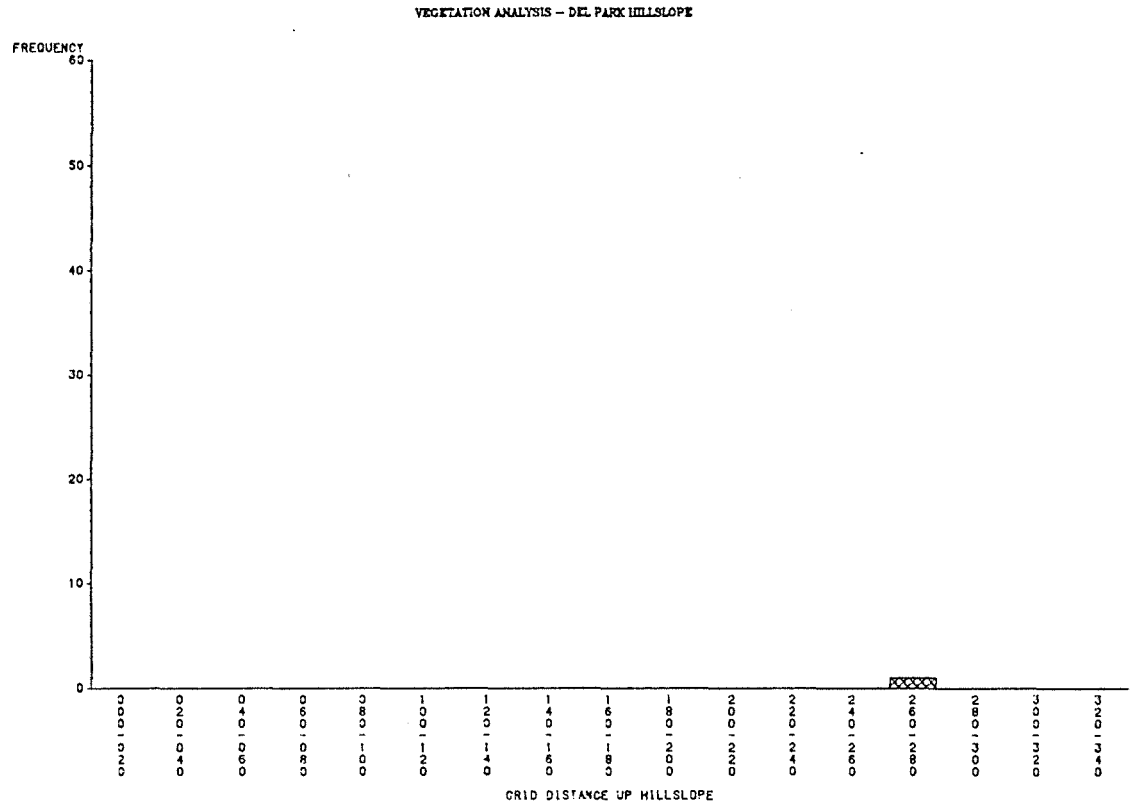


FIGURE 6 - TREE DISTRIBUTION BY SPECIES

P. ELLIPTICA (E)



(F) SHEOAK

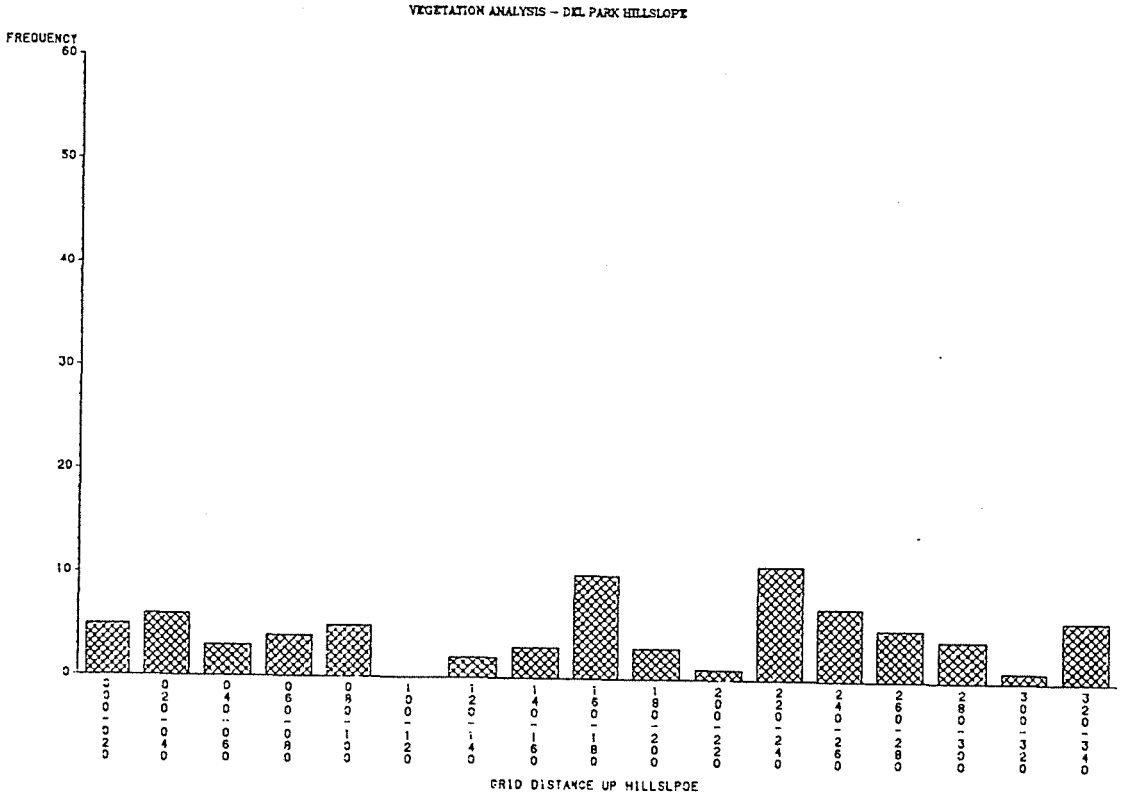
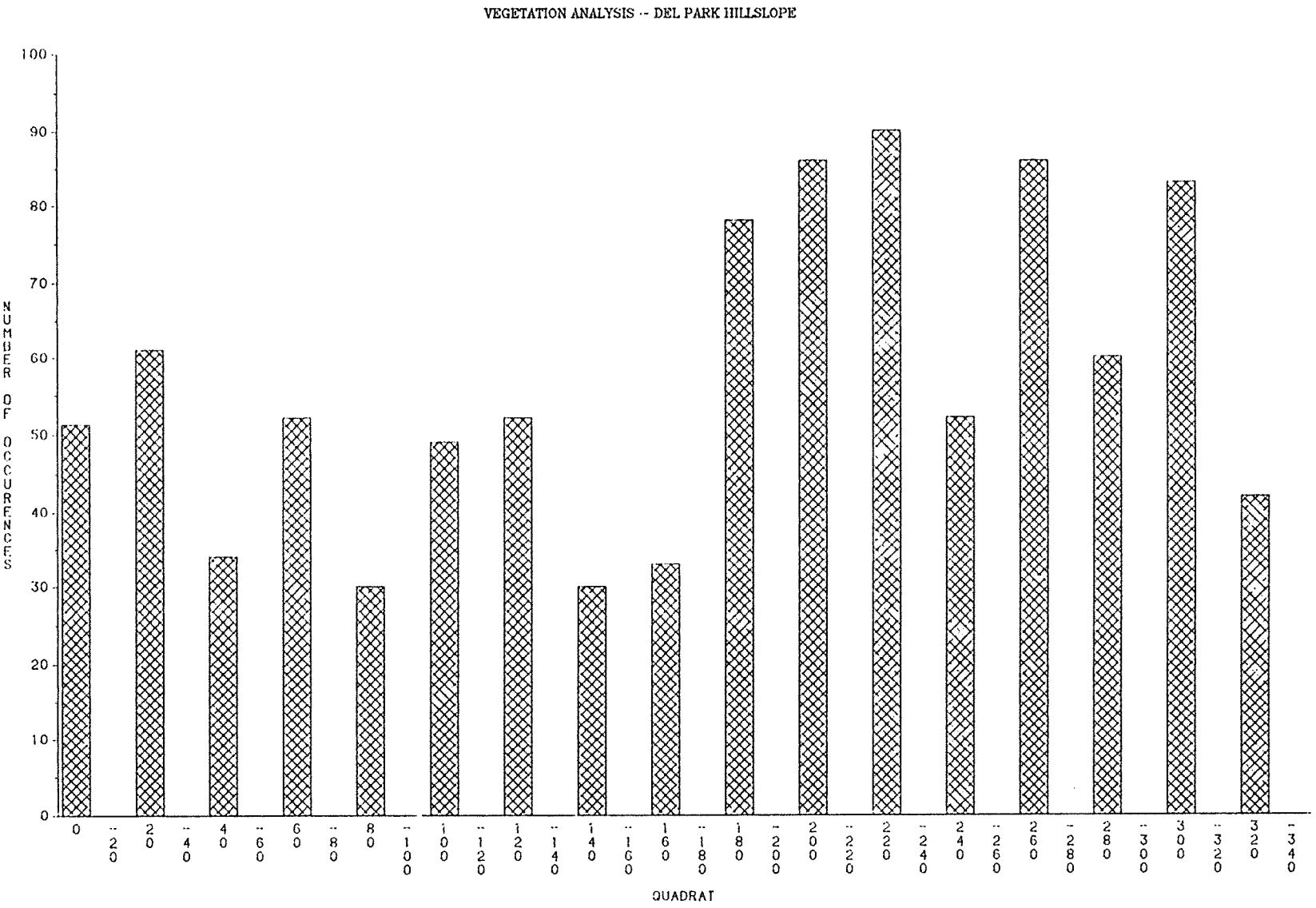
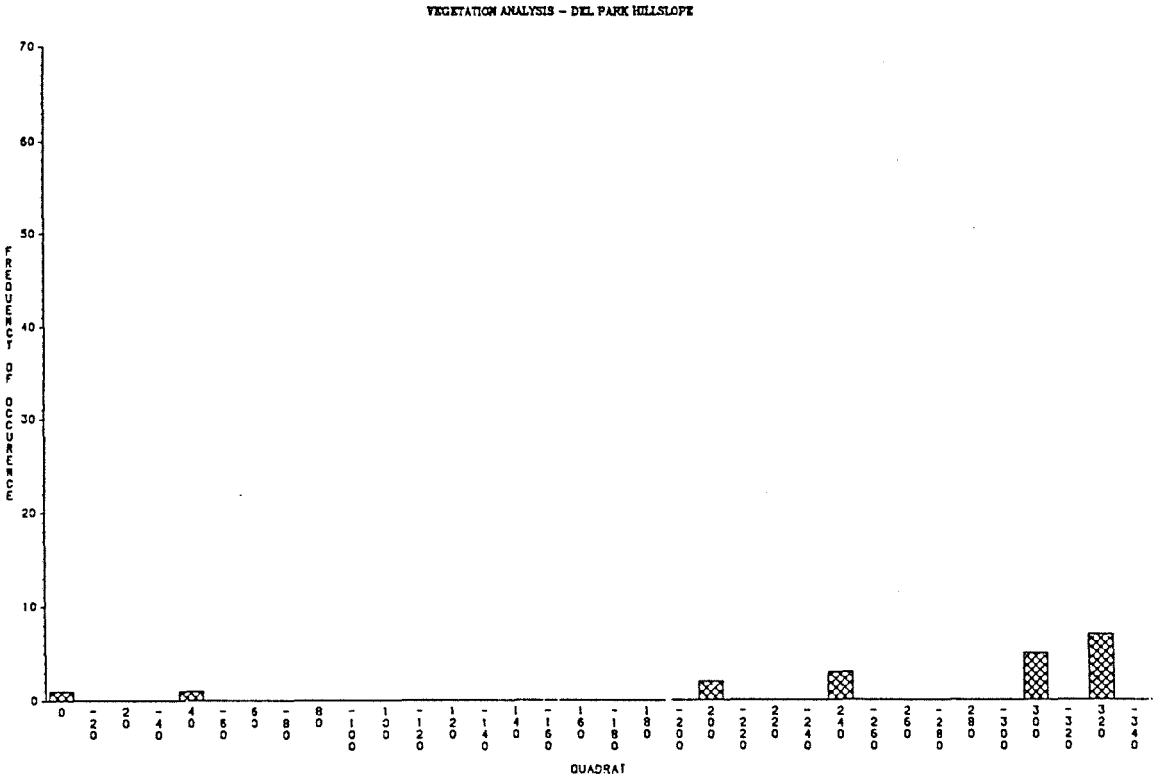


FIGURE 6 - TREE DISTRIBUTION BY SPECIES

FIGURE 7 - DISTRIBUTION OF UNDERSTOREY



(A) ACACIA PULCHELLA



(B) BLACKBOY

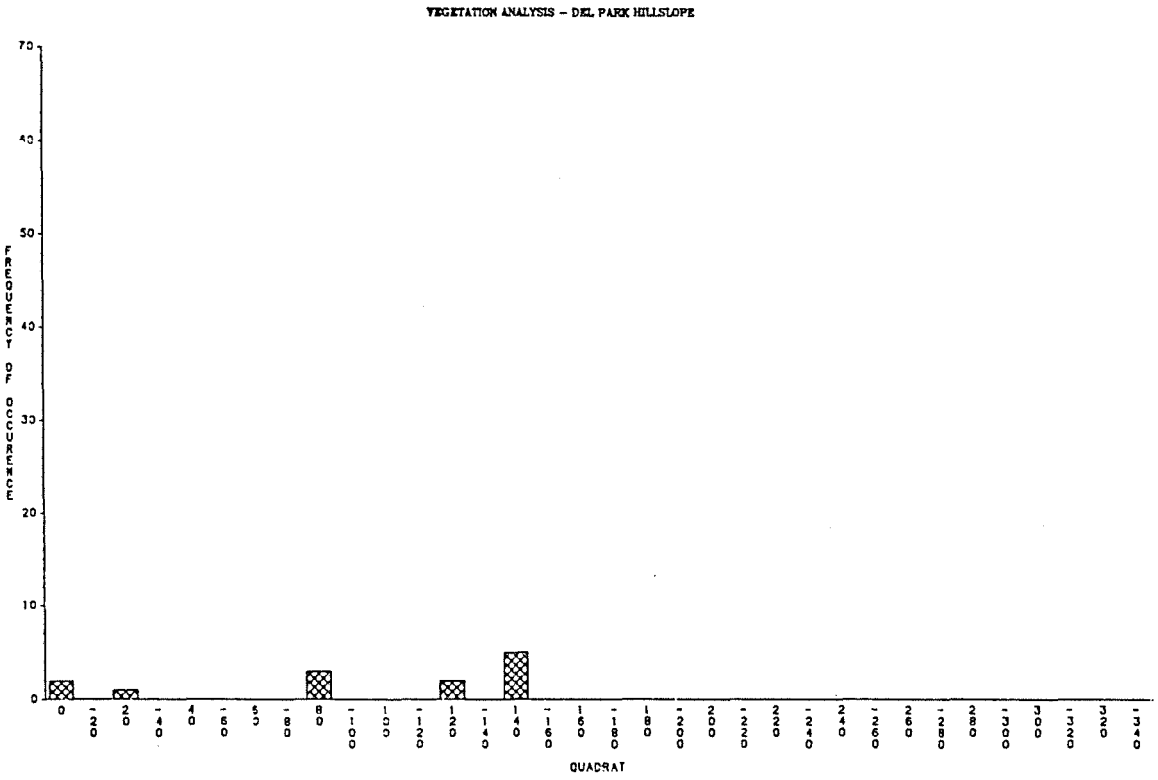
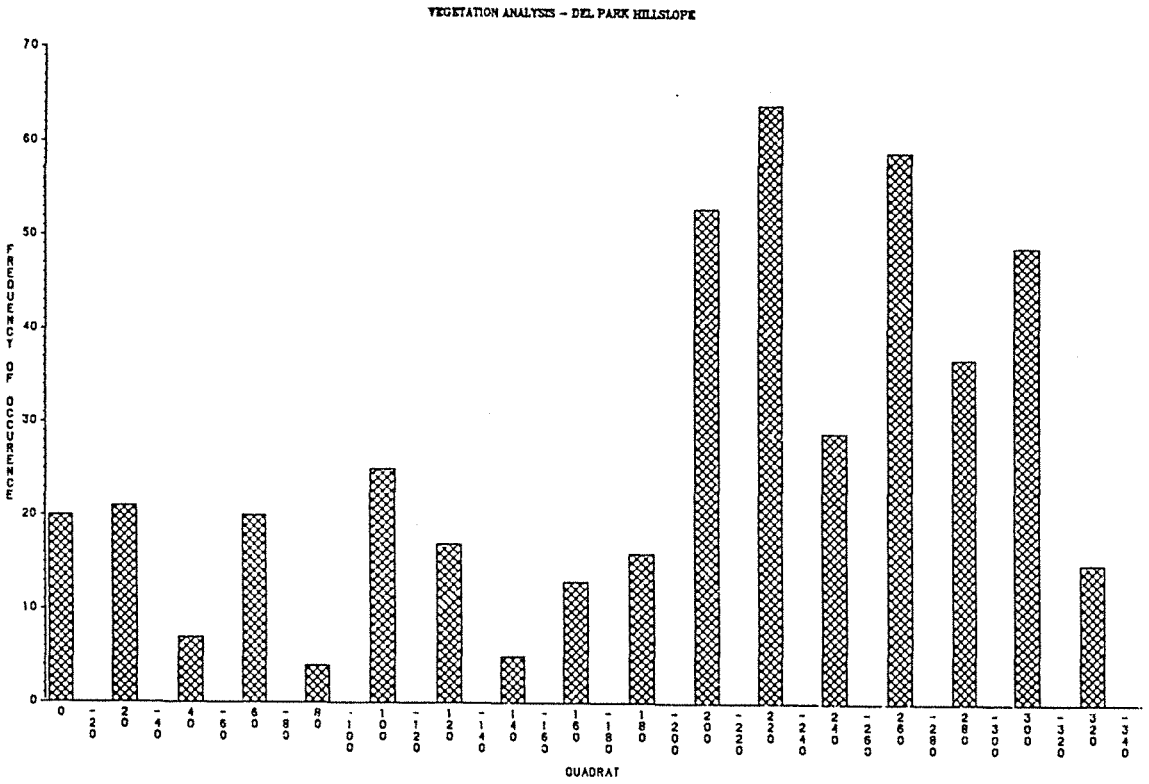


FIGURE 8 - UNDERSTOREY DISTRIBUTION BY SPECIES

(C) BRACKEN FERN



(D) LASIOPETALUM FLORIBUNDUM

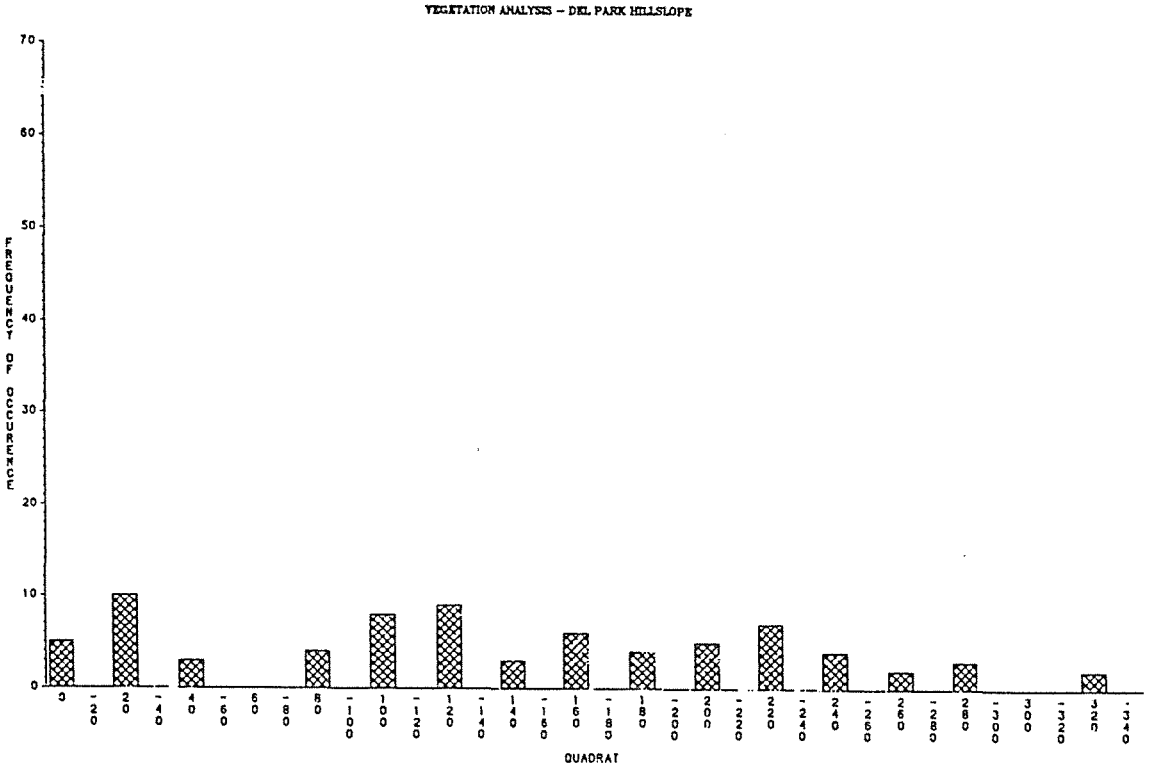
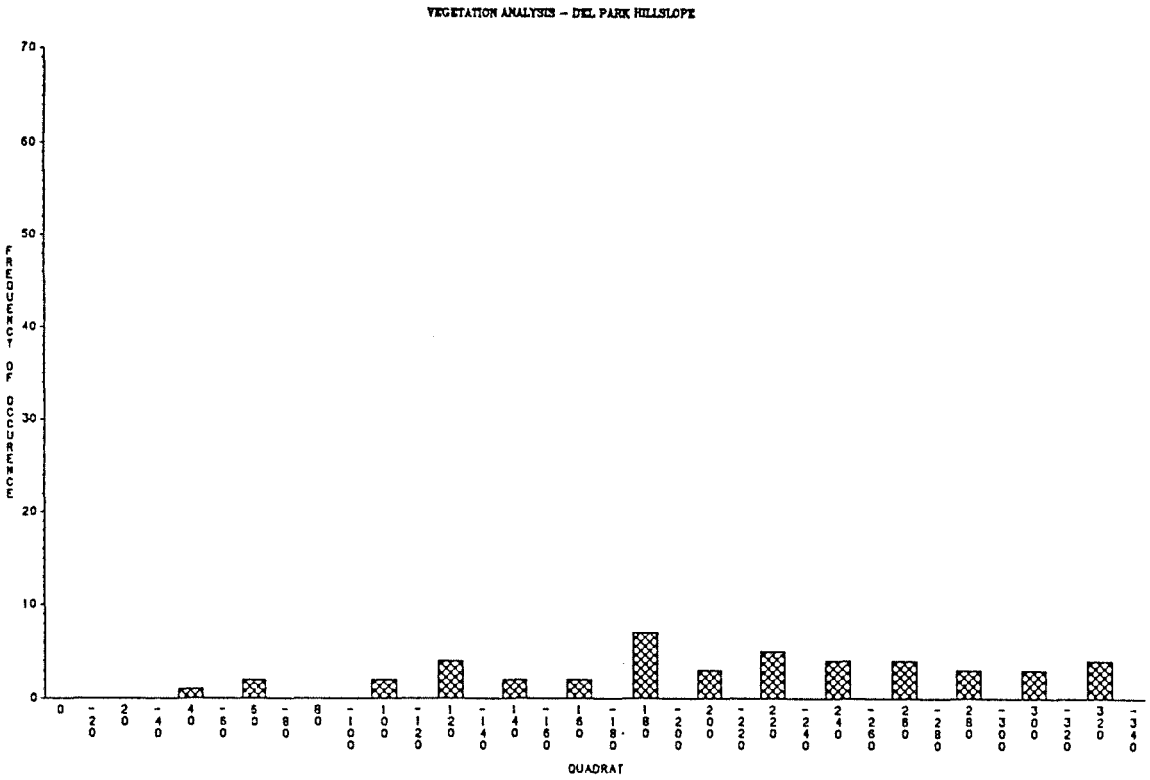


FIGURE 8 - UNDERSTOREY DISTRIBUTION BY SPECIES

(E) LEUCOPOGON VERTICILLATUS



(F) WATER BUSH

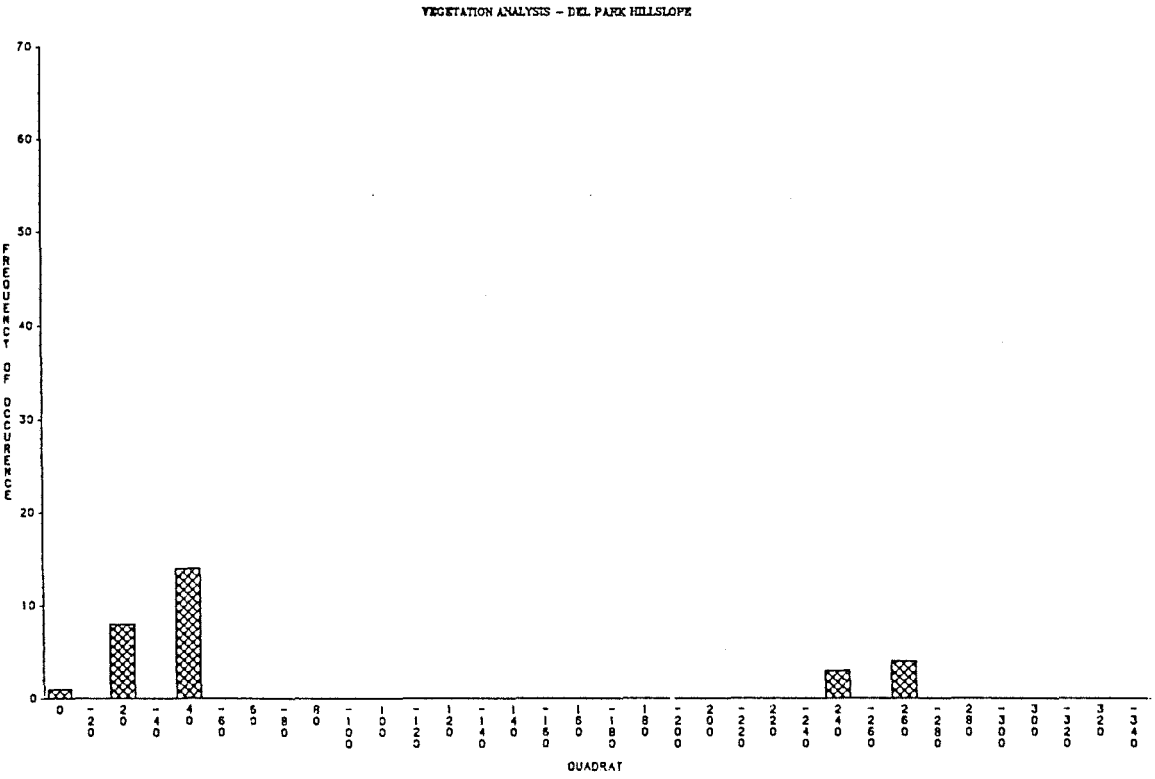
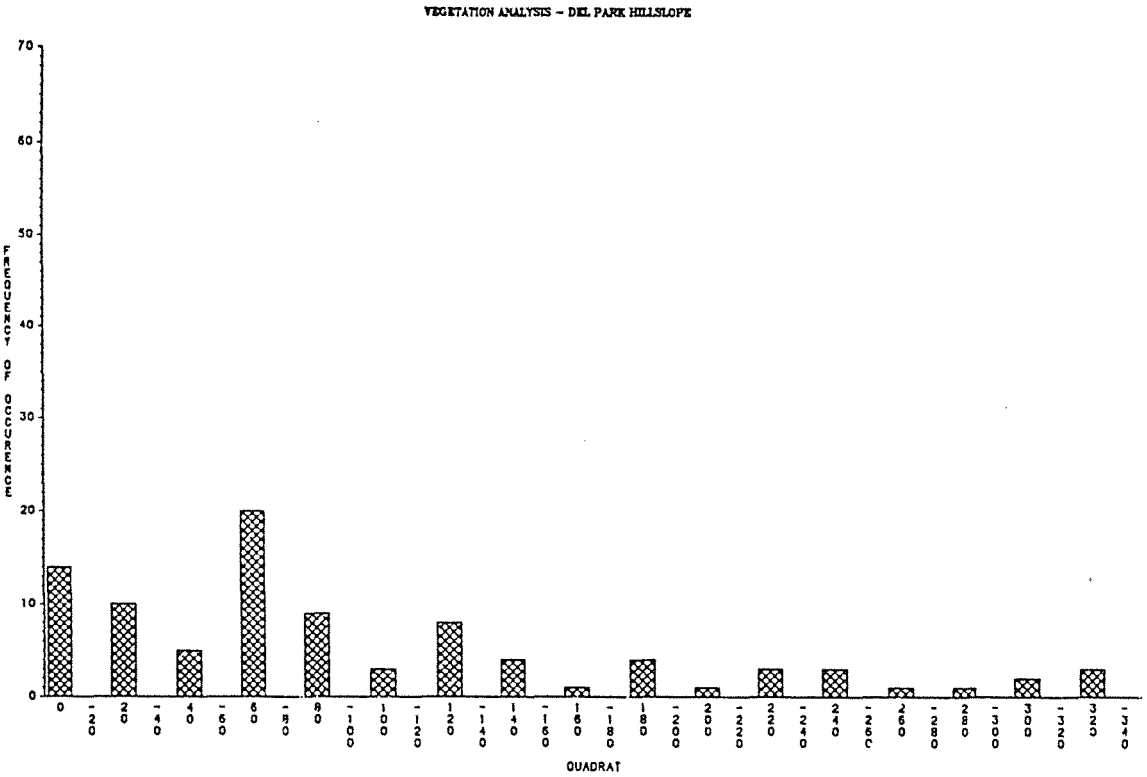


FIGURE 8 - UNDERSTOREY DISTRIBUTION BY SPECIES

(G) ZAMIA PALM



(H) BANKSIA SAPLING

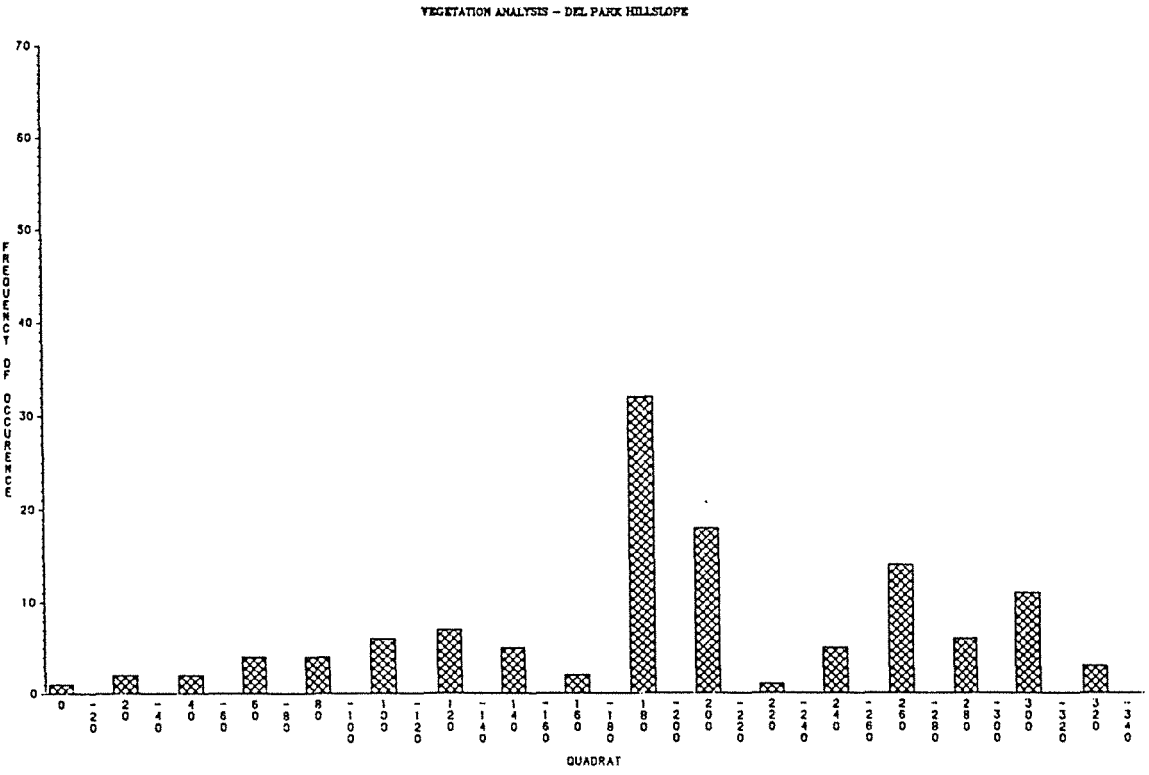
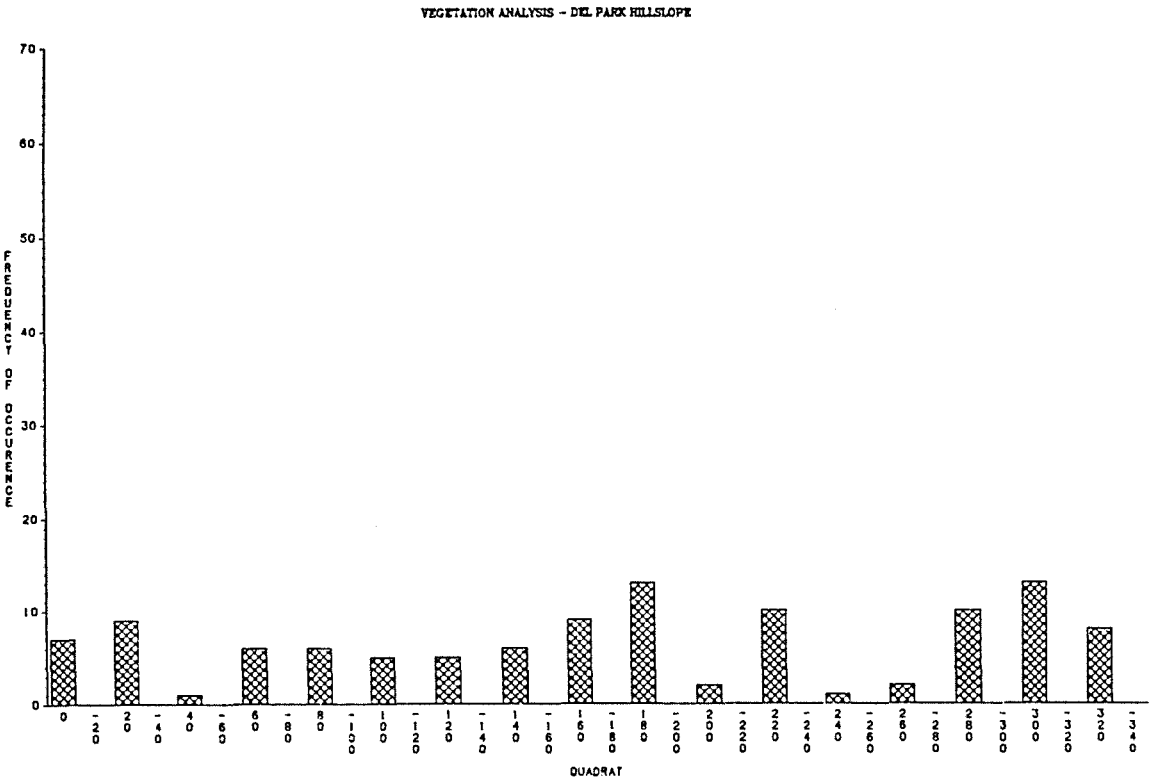


FIGURE 8 - UNDERSTOREY DISTRIBUTION BY SPECIES

(I) JARRAH SAPLING



(J) PERSOONIA LONGIFOLIA

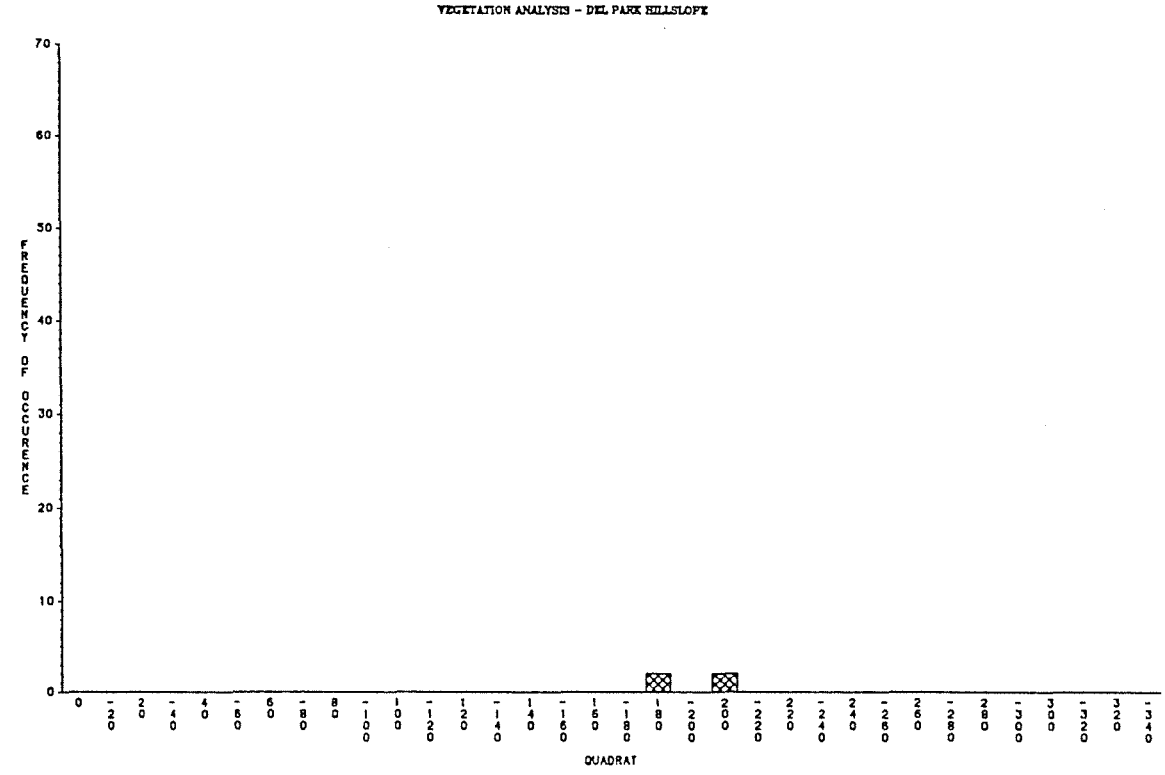


FIGURE 8 - UNDERSTOREY DISTRIBUTION BY SPECIES

4.2.3 Groundflora

The groundflora was difficult to quantify but was considered to range from 5-15% of ground area over the hillslope, with a mean of 12%. Estimates of groundflora were influenced considerably by the effect of people and vehicles. In particular the region from 20 m to 60 m has been affected a great amount by use of vehicles in the initial installation of instrumentation.

4.3 Distribution of overstorey tree parameters

A number of overstorey tree parameters were identified for a more detailed analysis. These were diameter, height and crown cover.

4.3.1 Diameter

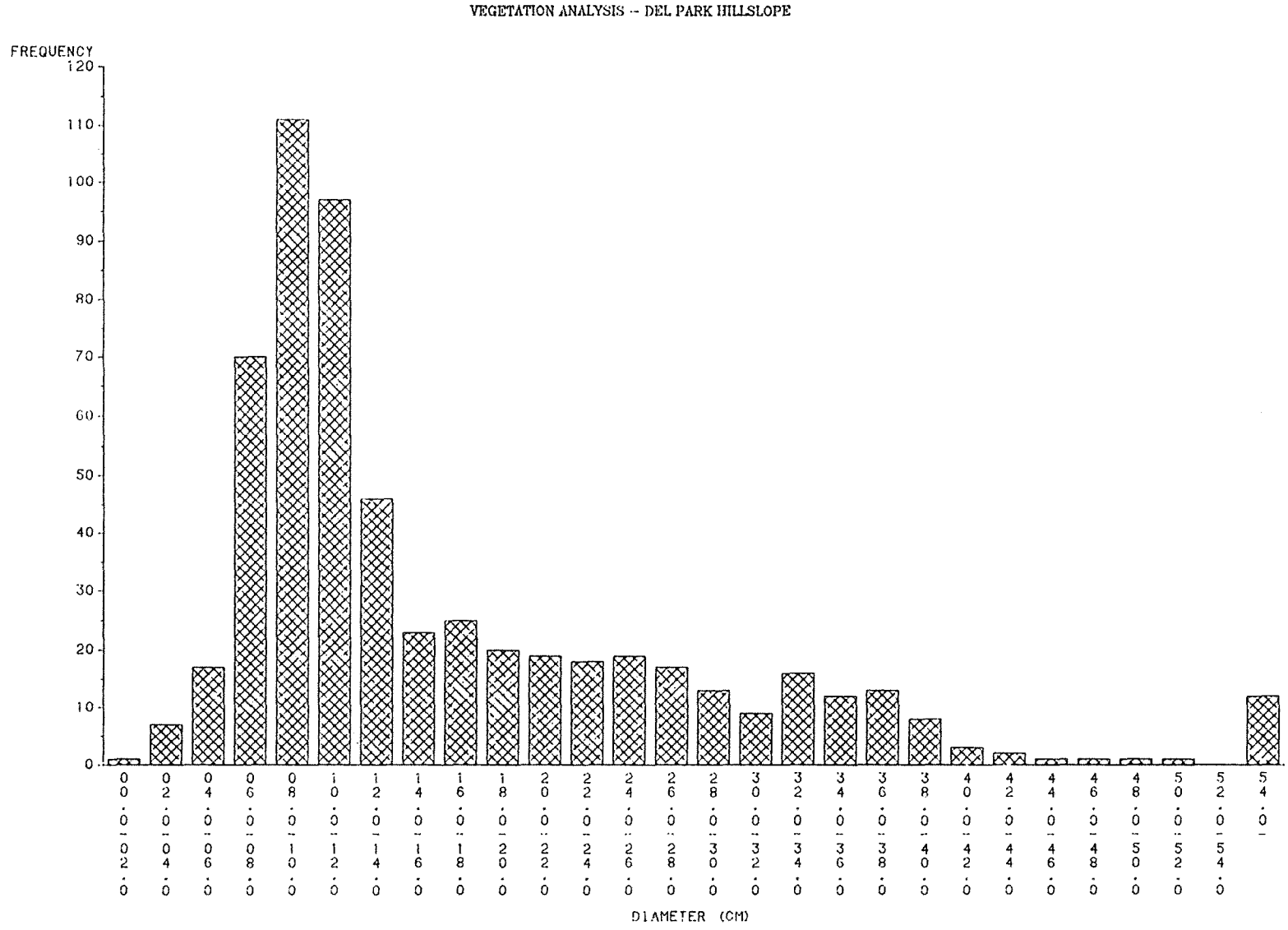
The distribution of tree diameters is shown in Fig. 9. This diagram shows a positive skewness which is due to the logging of the jarrah, primarily that which was done in 1977. Table 2 describes the diameter statistics for individual species and their total. For jarrah, the median diameter was 12 cm. Data from Abbott and Loneragan (1982) found that for a jarrah coppice, the first 10 cm is reached in 10 years but each subsequent 10 cm is added in around 30 years. This is consistent with the observation that this section of the Del Park experimental catchment was salvage logged of jarrah in 1977.

TABLE 2 DIAMETER STATISTICS BY SPECIES

SPECIES (cm)	MEAN (cm)	MEDIAN (cm)	ST.D (cm)	MAX (cm)	MIN
Banksia	10.8	10.0	4.8	27.5	4.8
Bullich	23.2	20.1	19.3	69.3	1.8
Jarrah	16.7	12.0	11.5	88.9	4.0
Marri	22.9	22.6	13.9	71.9	6.0
P elliptica	17.0	-	-	-	-
Sheoak	27.5	25.0	15.8	96.5	7.9
	18.8	14.5	13.7	96.5	1.8

The bullich, sheoak and marri diameters are relatively evenly distributed from 0.02 m to 0.56 m which indicates that there has been no disturbance of bullich, marri or sheoak. The banksia tree diameter is evenly distributed up to 0.2 m.

FIGURE 9 – DISTRIBUTION OF DIAMETER



4.3.2 Height

The height distribution of the trees above 1.4 m on the hillslope had a positive skewness (Fig. 10). The maximum height was 28.6 m, the median tree height was approximately 8.6 m, with the highest frequency class being 6-8 m. The basic statistics of the height parameter are shown for each species and for their total in Table 3.

TABLE 3 HEIGHT STATISTICS BY SPECIES

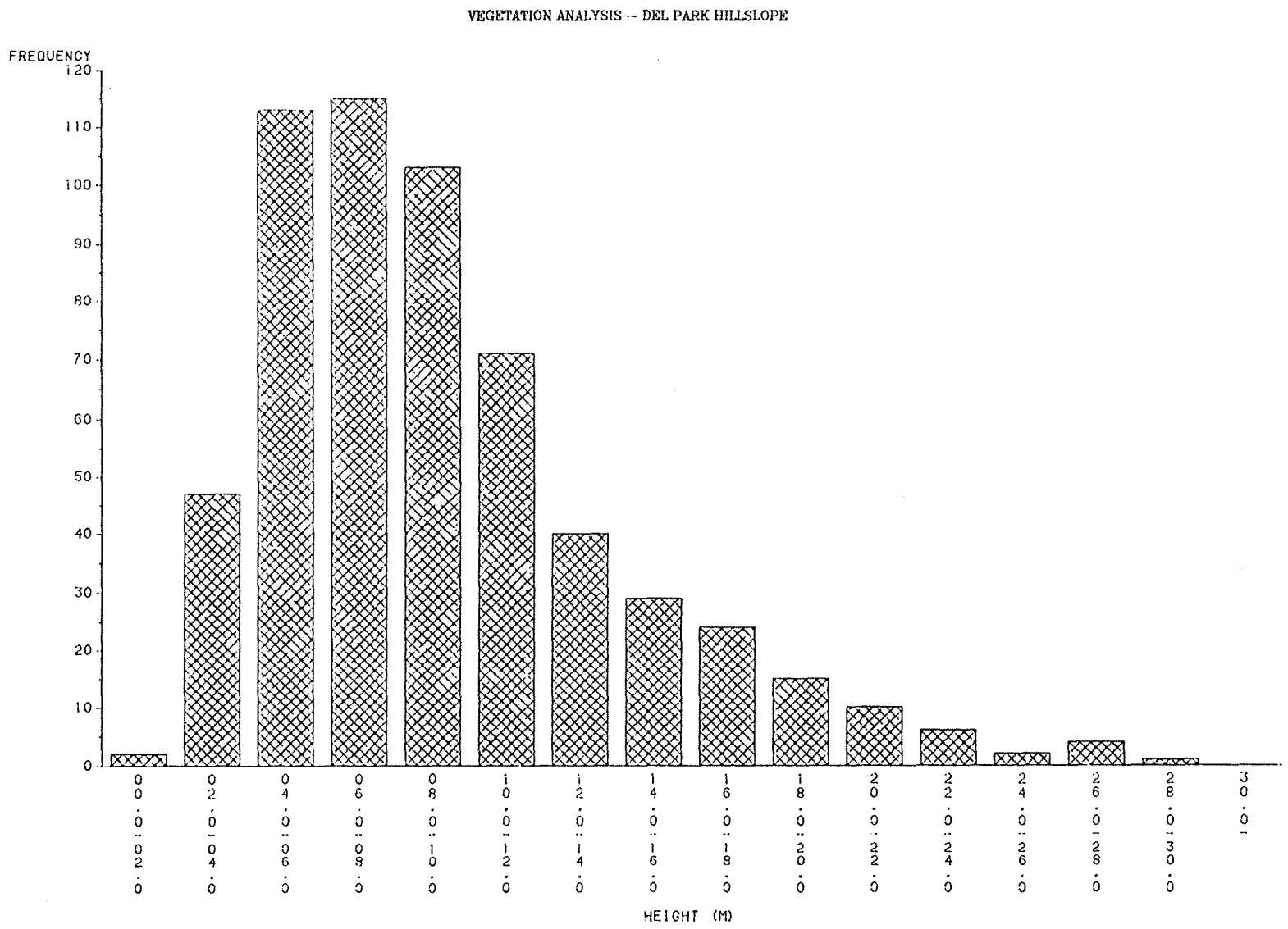
SPECIES	MEAN (m)	MEDIAN (m)	ST.D (m)	MAX (m)	MIN (m)
Banksia	5.7	4.8	4.9	10.9	1.4
Bullich	11.5	12.0	6.5	26.0	2.4
Jarrah	10.7	9.4	6.6	28.6	1.4
Marri	12.3	11.6	6.8	26.8	2.8
P elliptica	5.0	-	-	-	-
Sheoak	8.6	8.3	3.4	17.1	2.6
	9.9	8.6	6.2	28.6	1.4

From Table 3, the maximum height for banksia is around 11 m while for sheoak this is closer to 17 m. The median height of jarrah is less than both marri and bullich due to past jarrah logging.

4.3.3 Crown width

The range of crown widths is from 0.5 m to 9.9 m, with the mean crown width of 3.4 m, and median of 3.0 m. Fig. 11 describes the distribution of crown diameter and Table 4 details the crown width statistics by species and overall.

FIGURE 10 - DISTRIBUTION OF HEIGHT



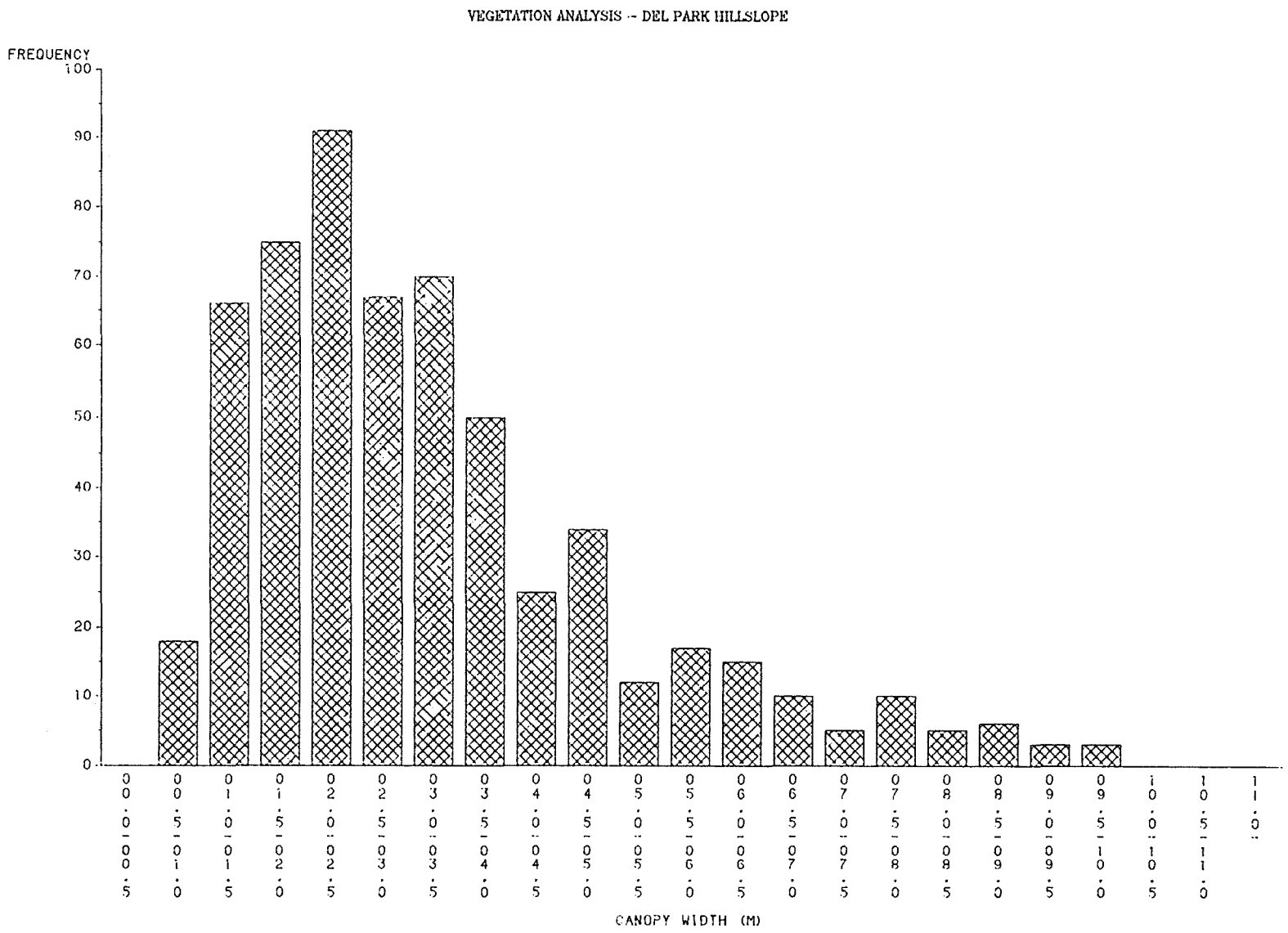


FIGURE 11 - DISTRIBUTION OF CROWN WIDTH

TABLE 4 CROWN WIDTH STATISTICS BY SPECIES

SPECIES	MEAN (m)	MEDIAN (m)	ST.D (m)	MAX (m)	MIN (m)
Banksia	2.5	2.3	1.3	6.0	0.5
Bullich	3.9	3.0	2.7	9.7	0.5
Jarrah	3.0	2.6	1.8	9.4	0.5
Marri	4.6	4.2	2.4	8.8	1.3
P elliptica	2.0	-	-	-	-
Sheoak	4.5	4.3	2.0	9.8	1.3
	3.4	3.0	2.0	9.8	0.5

4.4 Stocking and basal area

4.4.1 Stocking

The total number of stems (> 1.4 m height) on the hillslope was 582, giving a stocking of 856 stems per hectare. Of the total number of stems, 146 were jarrah coppice stems. The distribution of stocking on the hillslope is given in Fig. 12.

4.4.2 Basal area

The basal area for each overstorey and middlestorey species is shown on Fig. 13. The stand basal area on the hillslope was 29.1 m^2 ha^{-1}. The eucalypt component comprised 19.2 m^2 ha^{-1} which was approximately 66% of the stand basal area, while the jarrah component comprised 12.9 m^2 ha^{-1} (44%). For stocking, 69% was the proportion of eucalypt species, and 54% was the proportion of jarrah.

FIGURE 12 - STOCKING

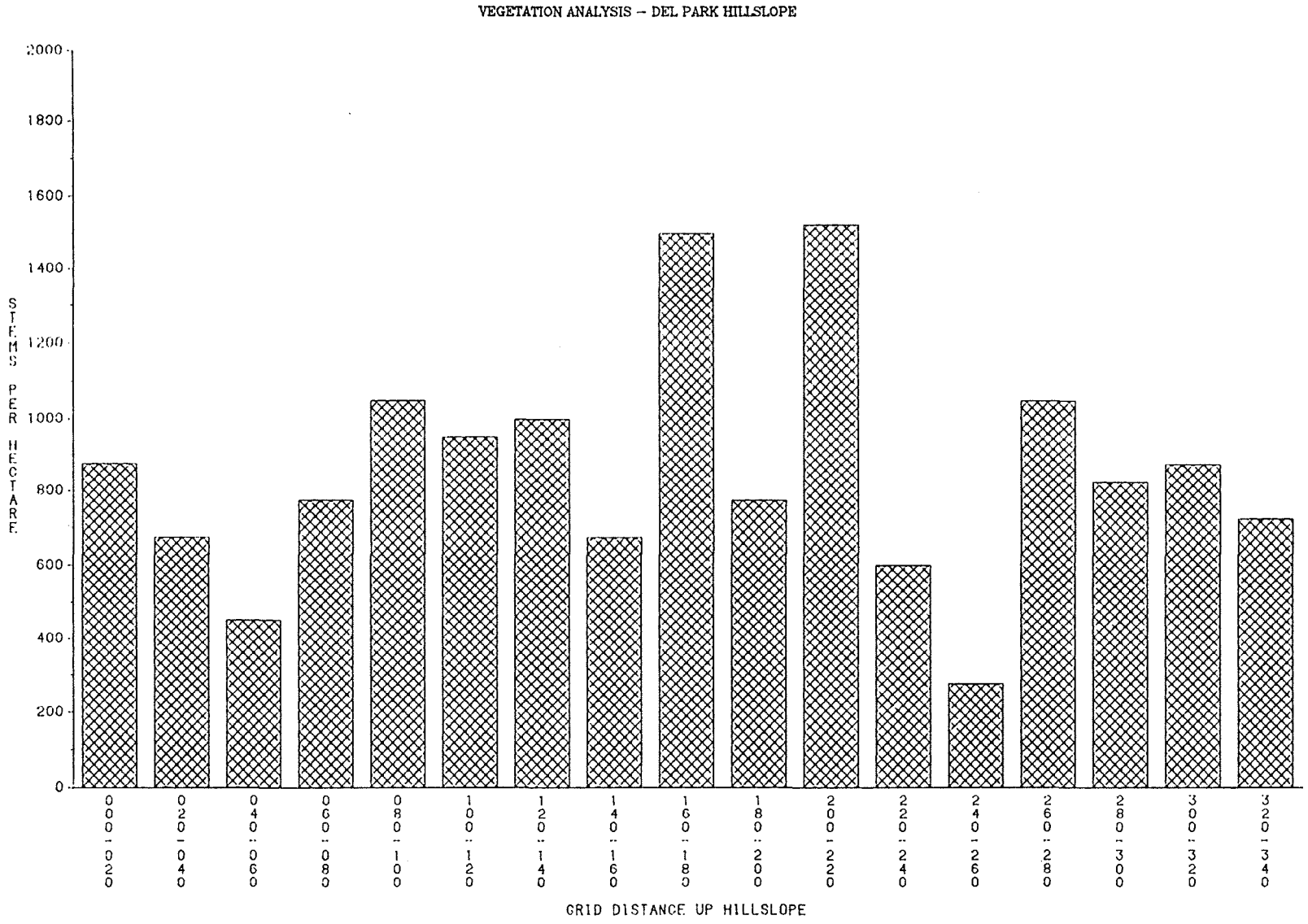
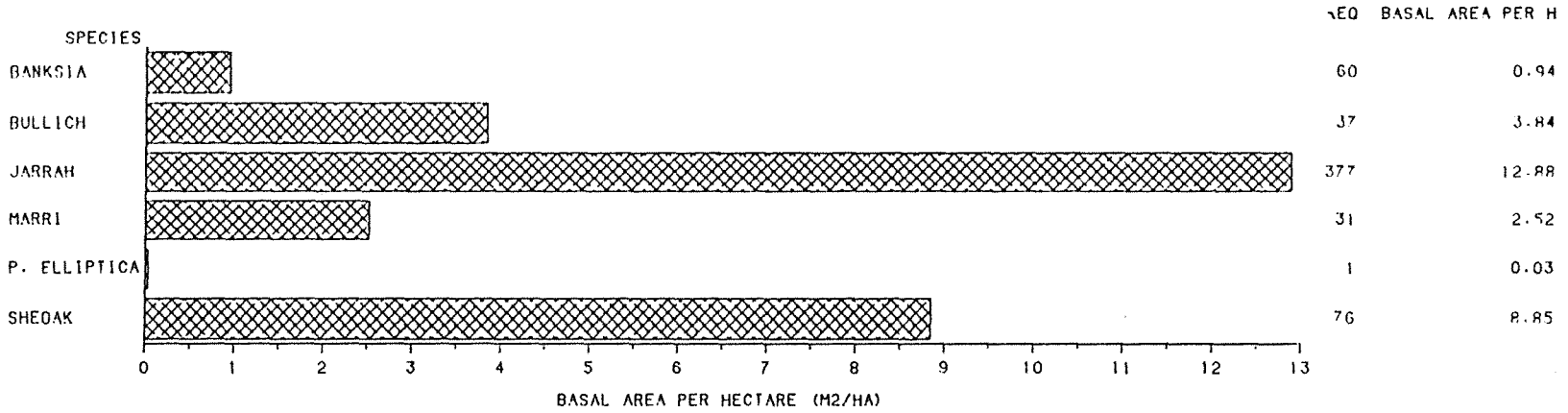


FIGURE 13 – BASAL AREA BY SPECIES

VEGETATION ANALYSIS – DEL PARK HILLSLOPE



SPECIES	NEQ	BASAL AREA PER H
BANKSIA	60	0.94
BULLICH	37	3.84
JARRAH	377	12.88
MARRI	31	2.52
P. ELLIPTICA	1	0.03
SHEOAK	76	8.85

From a survey of the tree stumps present on the hillslope transect, an estimate of the stand basal area prior to the salvage logging in 1977 was 34 m^2 ha^{-1}. This estimate of basal area gives a basal area of 17.8 m^2 ha^{-1} for the jarrah component, which is 52% of the stand basal area estimated at 1977. This represents a decrease in jarrah basal area of 5 m^2 ha^{-1} due to the salvage logging.

The distribution of basal area on the hillslope transect is depicted in Fig. 14. The basal area is higher below the 100 m mark (mean = 40 m^2 ha^{-1}) than above 100 m (mean = 21.7 m^2 ha^{-1}). This reflects the logging primarily taking place on the upper slope and the dense bullich stand on the lower slope. However, there is no statistically significant basal area - distance relationship as the linear regression applied to the data in equation 4.1 shows:

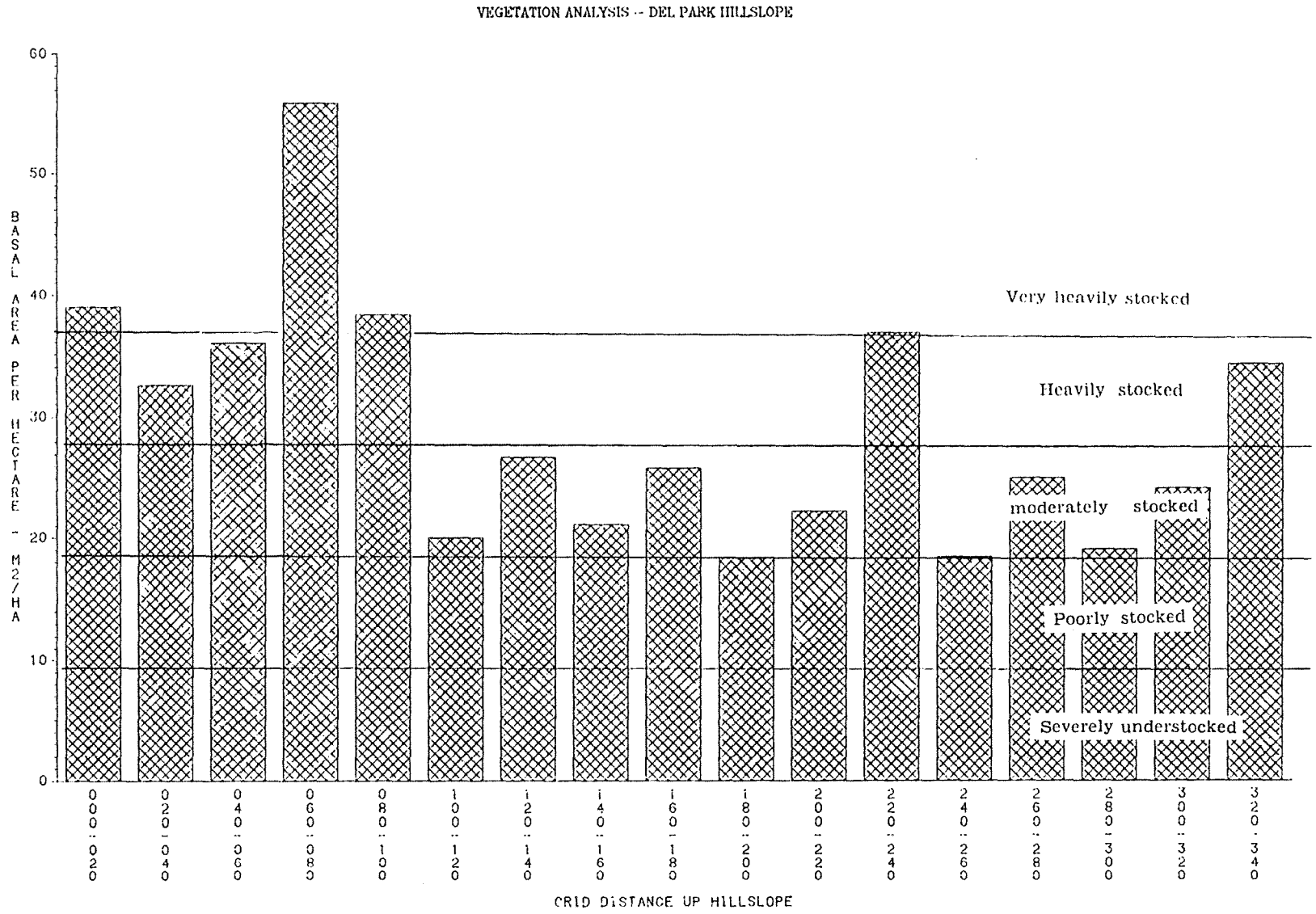
$$BA = 37.1 - 0.06 * y \qquad 4.1$$
$$R^2 = 0.3$$

where BA is basal area (m^2 ha^{-1})
y is distance upslope (m)

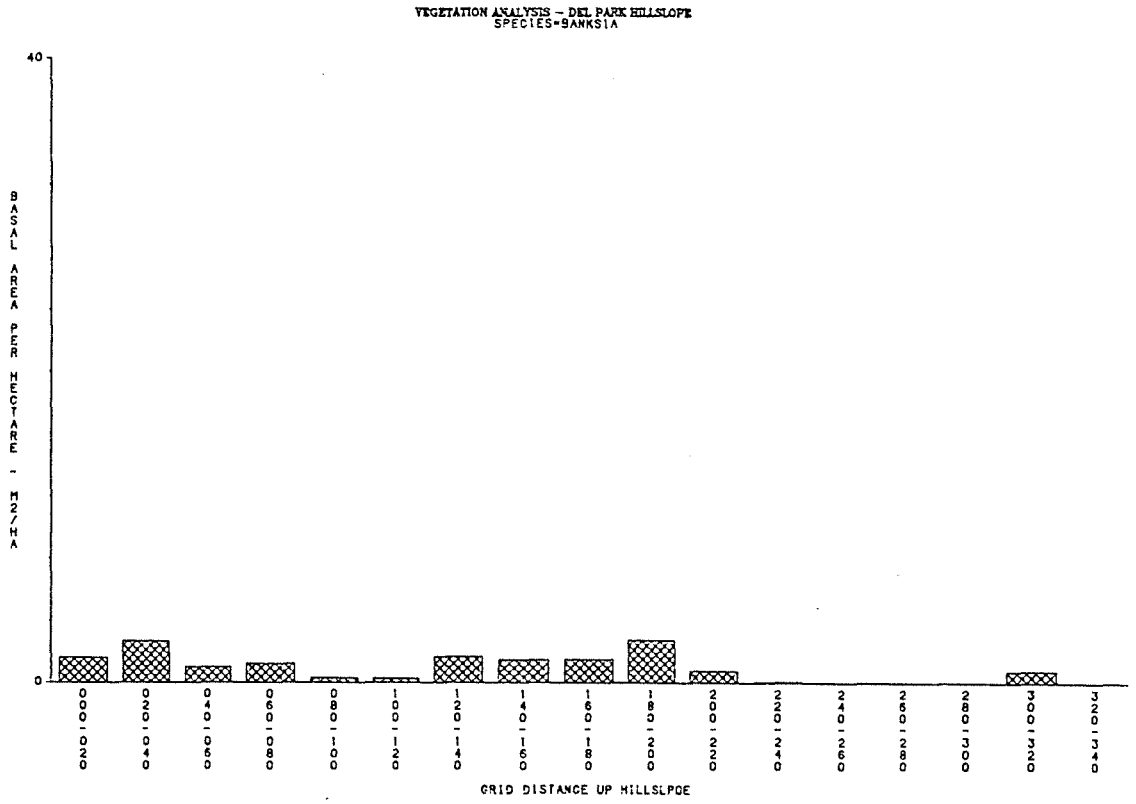
For individual species only bullich has any significant trend with distance upslope due to its typically occurring in narrow belts along the edges of stream and swamp areas. The basal areas for each species up the hillslope are shown on Figs. 15(A)-(F).

Applying basal area groupings, as used by Havel (1975b), defines the hillslope transect as moderately to heavily stocked. However, if only the 100-340 m section was included the definition would be a moderately stocked stand.

FIGURE 14 – BASAL AREA DISTRIBUTION



(A) BANKSIA



(B) BULLICH

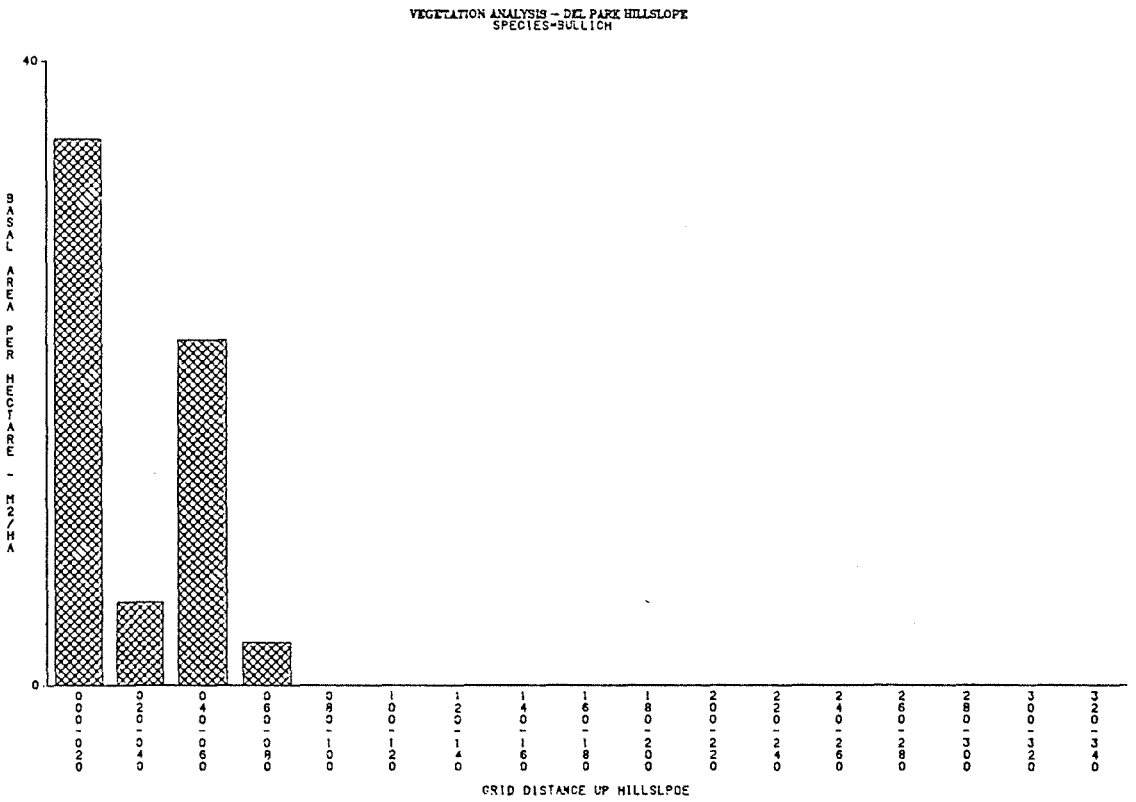
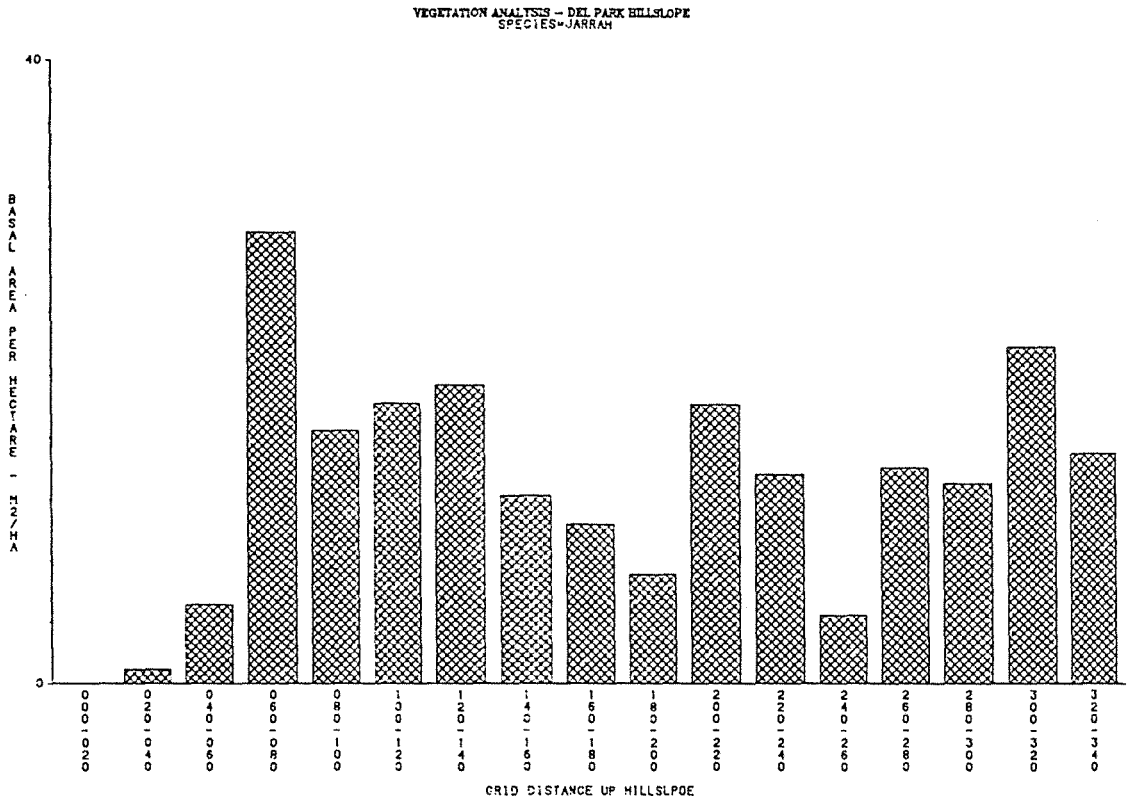


FIGURE 15 - BASAL AREA DISTRIBUTION BY SPECIES

(C) JARRAH



(D) MARRI

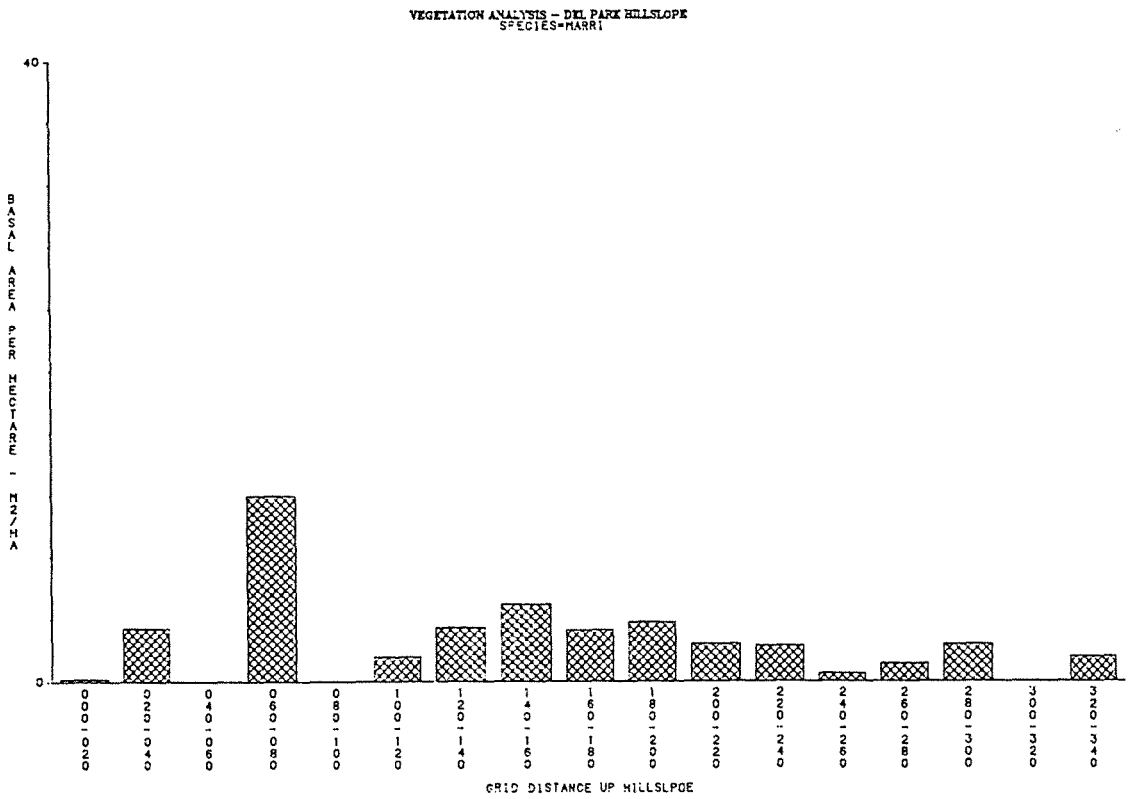
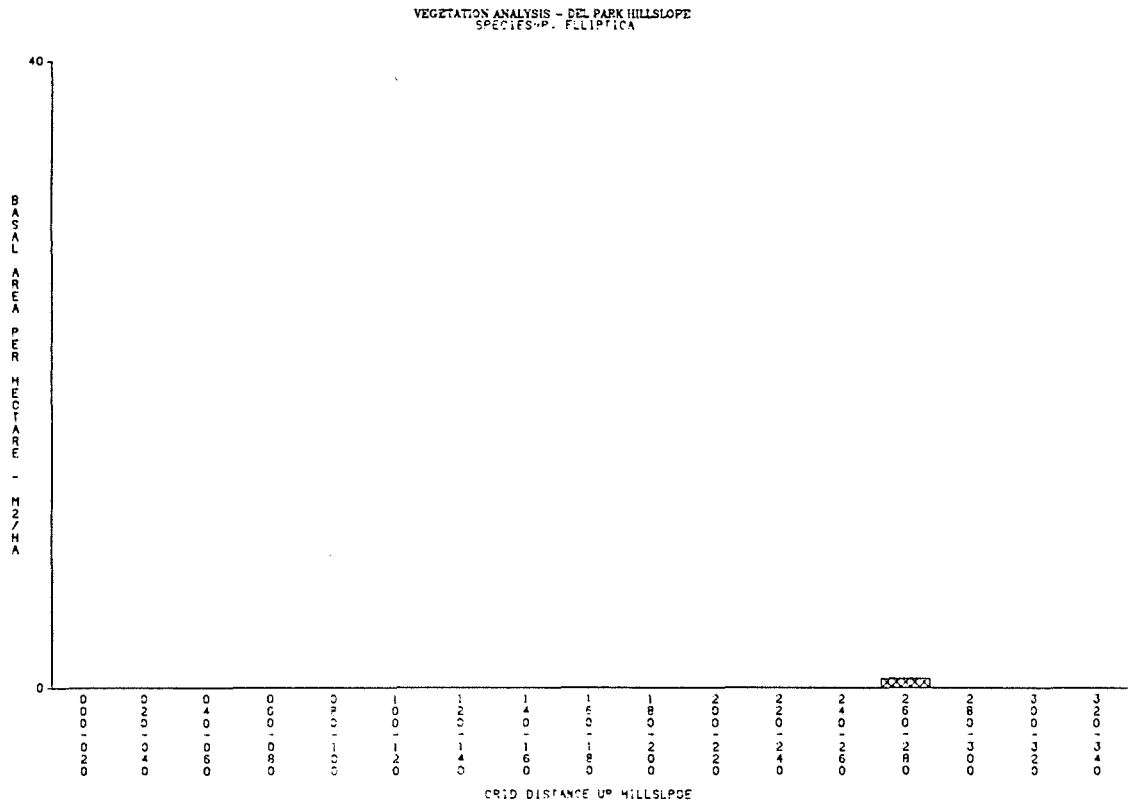


FIGURE 15 - BASAL AREA DISTRIBUTION BY SPECIES

(E) P. ELLIPTICA



(F) SHEOAK

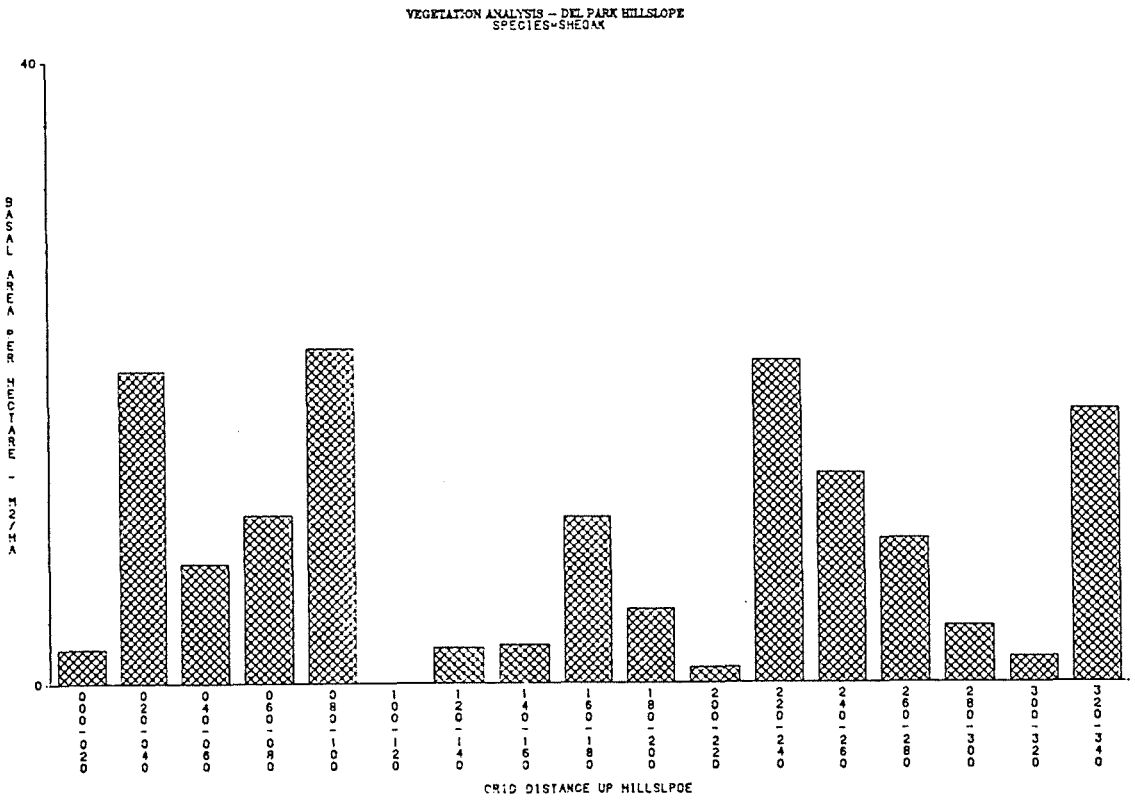


FIGURE 15 - BASAL AREA DISTRIBUTION BY SPECIES

4.5 Canopy cover

Measurement of the stand projected leaf cover by the crownometer gave a value of 47% cover over the hillslope transect. The crownometer calculation was statistically analysed to give confidence limits, assuming a normal probability distribution. The 95% confidence limits for the cover were calculated at:

$$P_{0.95} = (0.44; 0.50) \qquad 4.2$$

The stand projected canopy cover was calculated from intergraph interpretation. This method calculated the stand projected canopy cover at 47%. The stand projected leaf cover was calculated at 43% after applying a factor for projected leaf cover to the non-intersected canopy cover. This was derived from the total projected canopy cover, multiplied by projected leaf cover. The projected leaf cover for the various species is shown in Table 5.

TABLE 5 PROJECTED LEAF COVER FOR INDIVIDUAL TREES BY SPECIES

SPECIES	ESTIMATED AVERAGE PROJECTED LEAF COVER - OCT. 1986
Banksia	0.85
Bullich	0.60
Jarrah	0.75
Marri	0.75
Sheoak	0.65

Fig. 16 depicts the estimated canopy cover of the hillslope transect from Intergraph interpretation. The canopy cover as shown in Fig. 16 highlights the frequent gaps in the canopy which are evident from traversing the hillslope.

FIGURE 16 - PROJECTED CANOPY COVER

The differences in the stand projected leaf cover between the crownometer and the Intergraph interpretation was small and can be attributed to:

(i) the time difference of 18 months in the dates of the surveys, therefore variations due to growth and the season are factors;

(ii) the Intergraph interpretations assumed the canopy was centred on the stem;

(iii) the variation in projected leaf cover and crown cover of individual trees was significant over the hillslope transect.

4.6 Leaf area and leaf area index

The total leaf area for the hillslope transect was estimated at 11 000 m^2 (see Table 6) and the leaf area index at 1.6.

TABLE 6 LEAF AREA BY STRATA

Stratum	Leaf area m^2	(%)	Height definition (m)
Overstorey	8540	77.6	HT > 7 m
Middlestorey	960	8.7	1.4 < HT < 7
Understorey	990	9.0	0.3 < HT < 1.4
Ground flora	500	4.5	HT < 0.3
TOTAL	11000		

The leaf area for the overstorey and middlestorey was estimated at 9500 m^2 and the leaf area index at 1.4. Leaf areas for each tree species are shown on Fig. 17 while the distribution of the understorey and middlestorey leaf area index on the hillslope is shown in Fig. 18. The proportion of eucalypt leaf area on the hillslope was approximately equivalent to the proportion of basal area on the hillslope. (This may be partly because the regression used to predict leaf area was a function of basal area.) The range of leaf area indices was from 2.4 to 0.8 with a mean of 1.4 as shown in Fig. 18. The leaf area index from 0 m to 100 m was 1.7 and from 100 m to 340 m was 1.1. The upperstorey and middlestorey comprised 86% of the leaf area and are therefore likely to account for most of the interception and transpiration on the hillslope.

4.7 Havel site type classification

A Havel (1975a, b) site type classification of the hillslope transect was carried out. The initial 40 m was given a type C-S and from 40 m to 340 m was type S. The first 40 m was given a type C-S due to the presence of bullich and the relative absence of jarrah. From 40 m to 340 m was considered type S due to the presence of jarrah along with banksia, Adenanthos barbigera, zamia palm, Bossiaea aquifolium, Lasiopetalum floribundum, sheoak and Persoonia longifolia.

4.8 Phytophthora cinnamomi hazard rating

The hillslope transect was investigated and considered to have no expression of Phytophthora cinnamomi. The hazard rating for the hillslope transect was calculated as a high impact or type 4 (using method of B. Shearer, pers. comm.), apart from the initial 40 m of the transect where the proximity to the swamp community affected the results.

The most significant indicator plant species were Adenanthos barbigera, Drosera, Hibertia montana major, Lasiopetalum floribundum and Scaevola striata. Other species present were Allocasuarina fraseriana, Conostylis setigera, Operculavia echinocephala, Trymalium ledifolium and Acacia pulchella.

VEGETATION ANALYSIS – DEL PARK HILLSLOPE

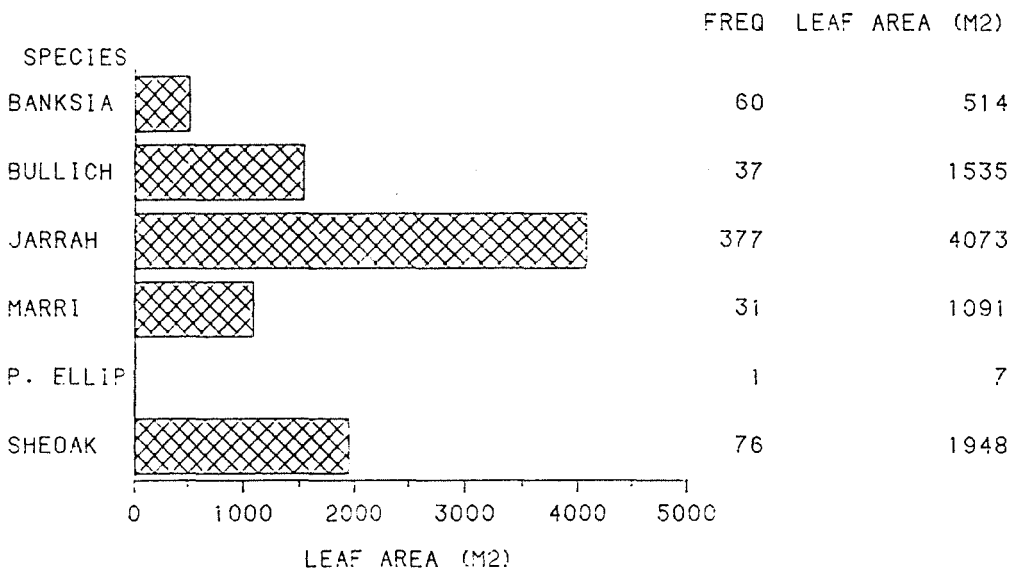


FIGURE 17 - LEAF AREA BY SPECIES

FIGURE 18 - LEAF AREA INDEX DISTRIBUTION

5. DISCUSSION

5.1 Comparison of the hillslope transect vegetation to other sites in the northern jarrah forest

The overstorey species of jarrah, marri, bullich and sheoak encountered on the hillslope transect are characteristic of many areas in the northern jarrah forest, particularly the HRZ. The understorey species found on the hillslope transect are also found throughout the HRZ of the northern jarrah forest.

The stand basal area for the hillslope transect was calculated at 29.1 m^2 ha^{-1}. In comparison to other measurements in the jarrah forest (see Table 7) the hillslope transect has an average forest density for the HRZ.

The range of basal area measurements on the hillslope were not significantly different from other sites in the northern jarrah forest. However, the eucalypt species basal area of 19 m^2 ha^{-1} was low compared to the results from Abbott and Loneragan (1983). The main reason for the low eucalypt percentage on the hillslope transect was considered to be salvage logging which occurred in 1977, which reduced the jarrah basal area by 5 m^2 ha^{-1}.

The projected leaf cover of the hillslope transect is compared to other projected leaf cover data in the northern jarrah forest in Table 8.

TABLE 7 COMPARISONS OF BASAL AREA FOR THE NORTHERN JARRAH FOREST (HRZ)

REFERENCE	LOCATION /TYPE	TECHNIQUE	PLOT SIZE (mxm)	NO. OF PLOTS	BASAL AREA (m^2 ha^{-1}) mean	range
Stoate and + Helms (1938)	Good quality	-	-	-	42.6	
Kimber + (n.d.)	Northern Jarrah Forest	-	-	112	~32	?-49
Abbott and Loneragan (1986)	Virgin forest	-	-	3	35.7	32-37.8
Bettenay et al. (1980)	Collie (West)	Prism	-	-	-	20-40
Worsley (1985)	Collie	Tape	40x40	4	29	18-43
Abbott and Loneragan (1983)	Northern Jarrah Forest	Tape*	50x50	26	24	13-38
Havel (1975a)	Jarrah Forest S site type	Prism	40x40	9	39	27-64
This report	Del Park Hillslope	Tape	20x20	17	29	18-55

* Measurements taken for eucalypt species only and underbark measurement.

+ Cited in Abbott and Loneragan (1986)

TABLE 8 COMPARISONS OF STAND PROJECTED LEAF COVER FOR THE NORTHERN JARRAH FOREST

LOCATION	STAND PROJECTED LEAF COVER (%)
Hansen catchment	42
Higgins catchment	45
Lewis catchment	40
Jones catchment	50
Yarragil 4L catchment	60
Yarragil 4X catchment	56
Dwellingup - Virgin	62
- Stand pole	59
Del Park Hillslope	43

Note : The catchment data were obtained from Steering Committee for Research on Land Use and Water Supply (in press).
: Dwellingup data from Abbott and Loneragan (1986).

The comparisons indicate that the hillslope transect had a slightly reduced leaf cover than comparable catchments in the northern jarrah forest.

A comparison of the hillslope transect leaf area index to other measurements in the jarrah forest is made in Table 9. The leaf area indices measured at other sites were, on average, slightly higher than for the hillslope transect. The variability of LAI is generally less than that of the hillslope as shown by the standard deviations in Table 9.

The presence of Adenonthos barbigera, Lasiopetalum floribundum, Macrozamia riedlei, Phyllanthus calycinus and the chief indicators of Banksia grandis, Persoonia longifolia and Casuarina fraseriana confirm that the hillslope transect was the Havel site type S. This site type (S) is common to the lateritic uplands of the northern jarrah forest.

TABLE 9 A COMPARISON OF LEAF AREA INDICES IN THE NORTHERN JARRAH FOREST

LOCATION OF SITES	FOREST TYPE	MEAN LAI	STANDARD DEVIATION
Jarrahdale	Jarrah-Marri	2.1	0.5
Collie	Jarrah-Marri	1.8	0.4
Bingham River	Jarrah-Marri	1.4	0.4
Manjimup	Jarrah-Marri		
	Virgin	1.5	0.2
	1 year regrowth	0.3	0.2
	5 year regrowth	1.7	0.3
	40 year regrowth	1.3	0.3
Del Park hillslope	Jarrah-Marri	1.4	0.5
Dwellingup	Jarrah-Marri	1.05	0.1
	Jarrah-Marri	2.0	

(Note : Jarrahdale, Collie, Bingham R. and Manjimup data reproduced from Carbon et al. 1979b, and Dwellingup data from G. Stoneman, K. Whitford and J. Sommer pers. comm.)

5.2 Comparison of hillslope to the Mattiske report

In August, 1985, Mattiske and Associates (1985) prepared a report entitled 'Botanical Studies: Del Park Experimental Catchment' for Alcoa of Australia Ltd. The main objective of this study was to prepare baseline botanical data for the Del Park experimental catchment. This information has also been represented on a vegetation map.

For the Del Park hillslope transect the following site vegetation classification was obtained:

DISTANCE UP HILLSLOPE	SITE VEGETATION TYPE
0 - 10 m	W1
10 - 40 m	W2
40 - 60 m	T1
60 - 310 m	P - S1
310 - 430 m	S1

Site Vegetation Type

W1 Open forest of E. patens, - E. megacarpa. Understorey species include Lasiopetalum floribundum and Xanthorrhoea preissii. Indicator groups: WETAL, FERMO, GRAHIR.

W2 Open forest of E. megacarpa, E calophylla and E. marginata. Understorey species dominated by Xanthorrhoea preissii, Lasiopetalum floribundum and Bossiaea aquifolium. Indicator groups: WETAL, GRAHIR, HIGRA FREGRA.

T1 Open forest of E. calophylla, E. marginata. Understorey species dominated by Bossiaea aquifolium, Lasiopetalum floribundum, Macrozamia riedlei, Pteridium aquilinum, and Xanthorrhoea preissii. Indicator groups: GRAHIR, HIGRA, FREGRA.

P-S1 Open forest of E. marginata - E. calophylla with admixtures of Allocasuarina fraseriana, Banksia grandis and Persoonia longifolia. Understorey species dominated by Hovea chorizemifolia, Adenanthos barbigera, Phyllanthus calycinus, Leucopogon verticillatus and Lasiopetalum floribundum. Indicator groups: largely SANGRA, FREGRA, GRAMED to a lesser extent HIGRA, and GRAHIR.

S1 Open forest of E. marginata - E. calophylla with admixtures of Banksia grandis and Persoonia longifolia. Understorey species dominated by Adenanthos barbigera, Leucopogon capitellatus, Hovea chorizemifolia, and Phyllanthus calycinus. Indicator groups: FREGRA, GRAMED.

The major differences between the detailed hillslope study and the broadscale mapping was that the present study found sheoak in large numbers on the hillslope, and only bullich on the lower slope (blackbutt not present).

The Mattiske study only sampled at 50 m intervals and recorded vegetation within a 10 m radius in detail (a 20 m radius was used to define rating of trees). Within the hillslope transect there were 6 sampling points of 300 m^2 each (4.4% of the total hillslope transect area). Therefore, a comparison between the hillslope transect and the large scale mapping shows that although there is general agreement on the site classification there are differences in the quantitative values for tree numbers and stem size. The Mattiske report found the average stem size over the Del Park catchment to be 23 cm and the hillslope transect to be 17 cm. This study calculated the mean diameter as 18.8 cm. These values indicate that there is reasonable correlation between this study and the Mattiske report. The Mattiske data does highlight the smaller diameter caused by the more intense logging which has occurred on the hillslope compared to the Del Park catchment as a whole.

6. CONCLUSIONS

The vegetation on the hillslope transect in the Del Park research catchment has been quantitatively described with the following conclusions:

i) Species distribution

The predominant species were jarrah, sheoak, bullich and marri. The jarrah-marri proportion was low as compared to other jarrah forest sites. Sheoak, in particular, had a relatively high proportion.

Bullich dominated the lower slope and jarrah the middle and upper slopes. Marri and sheoak were relatively evenly distributed on the hillslope.

The predominant middlestorey species was Banksia grandis. Banksia was fairly evenly distributed on the lower and middle slopes, but largely absent on the upper slope.

The survey of understorey found that bracken fern was mainly located on the middle to upper slopes, Lasiopetalum floribundum was evenly distributed, zamia palm was predominantly found on the lower slope, and the jarrah and banksia seedlings were relatively evenly distributed.

ii) Overstorey and middlestorey tree dimensions

Diameter, crown width and height, for the overstorey and middlestorey, were found to have distributions with positive skewness, which were approximately log normal.

The median height of jarrah (9.4 m) indicated that there was a mixture of rapid growing coppice, approximately 10 years old and trees older than 30-40 years.

iii) Measures of stand density, canopy cover and leaf area

Terms covering stand density and forest cover were defined mathematically to avoid confusion often encountered in the literature.

The mean basal area of the hillslope transect was 29 m^2 ha^{-1} which may be regarded as medium density for the high rainfall zone. The basal area components were jarrah (12.9 m^2 ha^{-1}), marri (2.5), bullich (3.8), and sheoak (8.9). Again sheoak represented a high contribution. The basal area of banksia was small (0.9 m^2 ha^{-1}).

The basal area distribution on the hillslope showed a discontinuity at about 100 m, below which the average basal area was 40 m^2 ha^{-1} and above was 22 m^2 ha^{-1}. This was attributed to the absence of logging and a relatively dense stand of bullich on the lower slope.

The Intergraph method determined canopy cover at 47% and leaf cover at 43%. This agreed well with the crownometer method which gave a leaf cover of 47%.

Leaf area index for all the hillslope vegetation was calculated by regression techniques at 1.6. This is considered a medium value for the HRZ. The leaf area indices by vertical strata were : overstorey (1.26), middlestorey (0.14), understorey (0.15) and groundflora (0.07).

Clearly the bulk of the leaf area at this site was overstorey and middlestorey which would thus be expected to dominate interception and transpiration. Leaf area index was dominated by jarrah (0.60), sheoak (0.29), bullich (0.23) and marri (0.16). The leaf area proportion of sheoak was smaller relative to its proportion of basal area.

iv) Dieback hazard

The phytophthora cinnamomi hazard rating was determined as medium to high. However the method of hazard rating is still being evaluated. At present there is no expression of disease on the hillslope transect.

v) Comparison with the vegetation survey of Mattiske (1985)

Comparison between this hillslope study and the catchment study of Mattiske (1985) indicated a reasonable correlation between stocking densities and diameters, but a poor comparison of species distribution.

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APPENDIX A

Common and scientific names of plants mentioned in this report

PLANTS - Overstorey

COMMON NAME	SCIENTIFIC NAME
banksia	Banksia grandis
blackbutt/yarri	Eucalyptus patens
bullich	Eucalyptus megacarpa
jarrah	Eucalyptus marginata
marri	Eucalyptus calophylla
sheoak	Allocasuarina fraseriana
wandoo	Eucalyptus wandoo

- Understorey

acacia	Acacia pulchella
blackboy	Xanthorrhoea preissii
bracken fern	Pteridium aquilinum
waterbush	Bossiaea aquifolium
zamia palm	Macrozamia riedlei

APPENDIX B

Description of major tree species

from Boland et al. (1985)

Bull Banksia

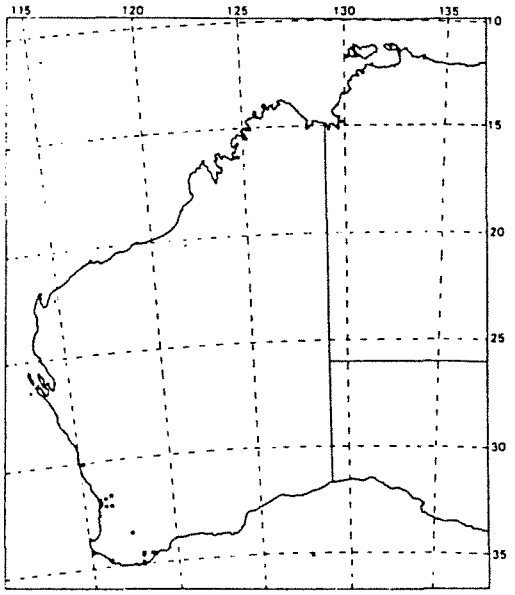
Giant banksia — *Banksia grandis* Willd.
family Proteaceae

Banksia grandis is probably the most conspicuous banksia in Western Australia. It is usually about 5–10 m in height with a trunk 0·25–0·5 m in diameter but can attain heights of up to 15 m. Trees usually have short, stout, often crooked boles and wide, open, spreading crowns but where trees occur in dense stands they are rather spindly with narrow, erect crowns. They also occur as very stunted trees among granite rocks and on windswept hills overlooking the southern ocean. New foliage is conspicuously reddish brown and the species is capable of epicormic growth. The species is lignotuberous.

Bull banksia occurs in Western Australia from south of Toodyay and Wanneroo down the west coast and the plains and plateaux around to Albany and Cape Riche. Small isolated populations occur to the north beside Mt Lesueur and to the east near Woodanilling about 150 km from the coast. The range of latitude is 30–35°S and that of altitude is from near sea level to 300 m. The distribution is mostly in the warm humid climatic zone with some extension into the warm sub-humid zone. The mean maximum temperature of the hottest month is in the range 23–29°C and the mean minimum of the coldest month is 4–9°C. There are no frosts near the coast but inland sites would receive about 10–20 per year. Mean annual rainfall is 650–1300 mm with a winter maximum.

Banksia grandis commonly occurs on lateritic podsolic soils of the Darling Range. The species also occurs on wet sandy soils in the karri (*Eucalyptus diversicolor*) forests and on the coastal sandy plains with their yellow siliceous and also pale-coloured calcareous sands.

Bull banksia forms a conspicuous understorey tree in eucalypt forests especially under open-forests of jarrah (*E. marginata*) and also under the tall open-forests of karri. It is commonly the only banksia present in the marri (*E. calophylla*) and jarrah forests. On the coastal plains giant banksia is associated frequently with she-oak (*Casuarina fraserana*) but also with tuart (*E. gomphocephala*) and other banksia species. The Woodanilling population is unusual in that it occurs farther east than the main *B. grandis* occurrence and, because the species occurs in a low open-woodland on sandy soils, its associates include Western Australian Christmas tree (*Nuytsia floribunda*) and coast banksia (*B. attenuata*).



Related species: *B. grandis* is closely related to *B. solandri*. The latter species is a slender-stemmed shrub up to 5–6 m tall; leaves have fewer and more rounded lobes; flowers are hirsute, purplish brown in colour and the perianth parts are more persistent than for *B. grandis*.

Type: From a cultivated specimen in Berlin, Germany, probably from seed collected by Archibald Menzies.

Published: *Spec. Pl.*, edn 4, 535 (1798).

Names: Botanical—Latin *grandis* (great, large, tall), alluding to the large size of this banksia; common—indicates the gross size of this species compared with most other banksias.

Bark: Young bark on saplings is soft and rubs off with a talc-like feel. Older bark is hard, granular and rather knobbly.

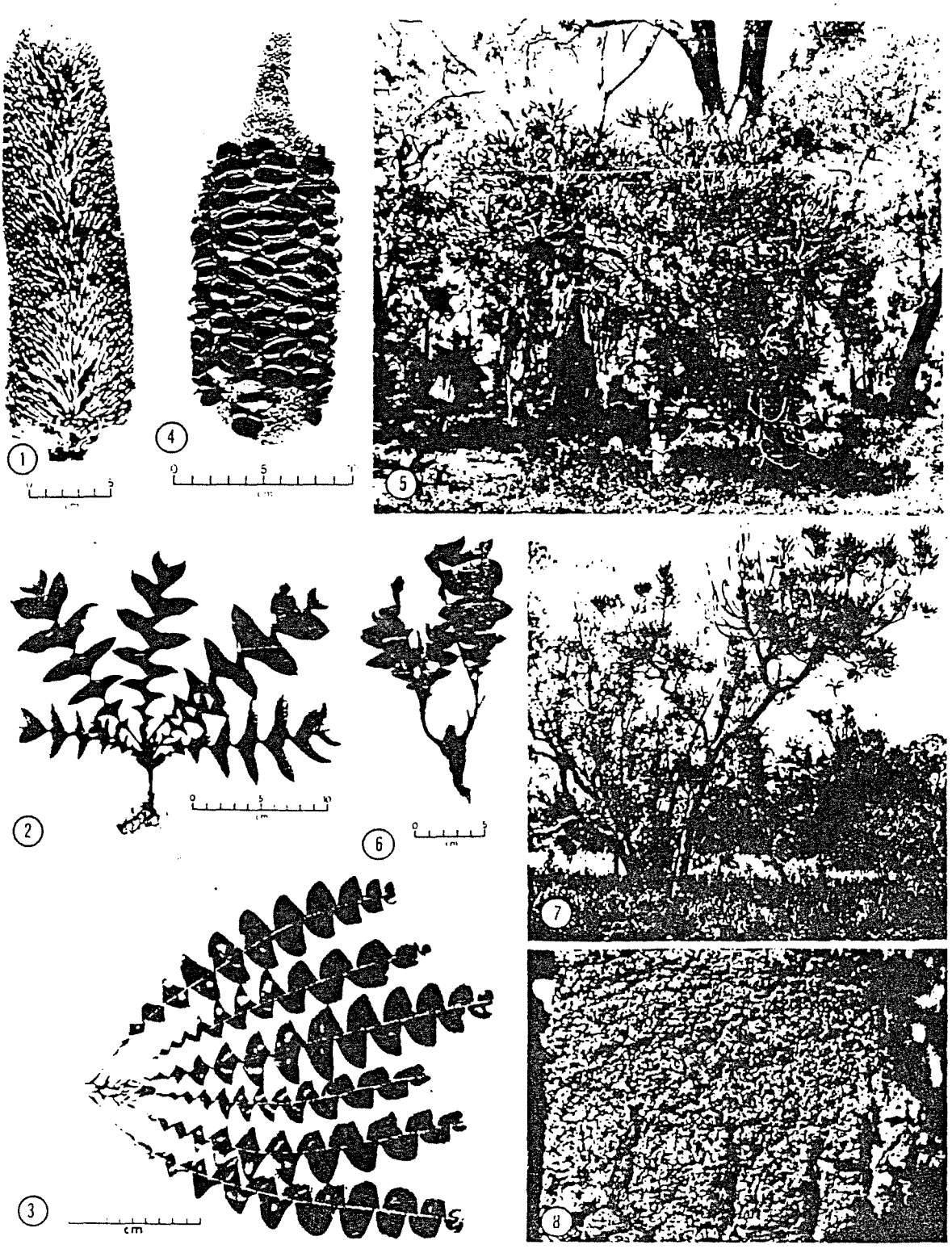
Leaves: Seedling—alternate, petiolate (about 1–1·5 cm) and slightly winged, obovate, 5–15 × 2–7 cm, 5–7 triangular segments each side of the leaf each ending in an abrupt point, green above and lighter green below, softly hairy; secondary veins parallel with fine rectangular veins between. Adult—alternate, petiolate, obovate, 20–50 × 4–8 cm, shiny dark green, deeply divided almost to the midrib into large triangular pieces with the wide base of each lobe overlapping the preceding one near the leaf midrib. The under surface of the leaf is covered with a soft white tomentum.

Inflorescences: Floral spikes, upright, cylindrical, 25–40 × 10–15 cm. The unopened flowers are metallic green while the open flower is golden yellow. Styles long and slightly curved at the end but not hooked, released from the base upwards. Flowers Sept.–Nov. and on the south coast between Augusta and Albany Sept.–Jan.

Fruits: Spikes oblong, cylindrical, about 7 × 18 cm and often with a narrow dome at the apex where the seed follicles have failed to develop. Follicles relatively thin-walled about 2 cm wide and dehisce spontaneously. A high percentage of the seeds in the follicles are destroyed by insects.

Wood: No information available.

Distinctive features: An understorey species occurring in jarrah forests, with large deeply divided leaves and large erect fruits.



Banksia grandis 1. Inflorescence at bud stage 2. Seedling 3. Adult leaves 4. Fruit after dehiscence 5. Stand, Darling Range, near Perth, W.A. 6. Field seedling indicating lignotuber-like structure 7. Tree, Kings Park, Perth, W.A. 8. Bark

Bullich

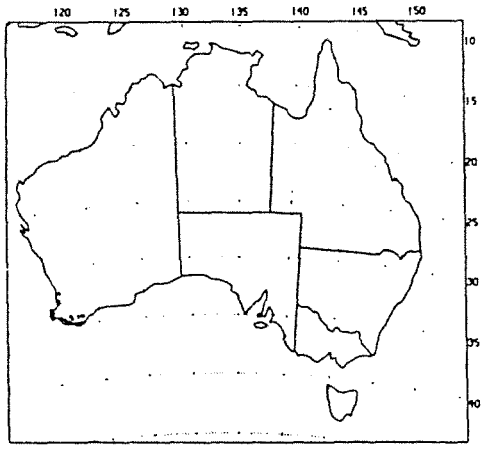
MAA:A *Eucalyptus megacarpa* F. Muell.
family Myrtaceae

Eucalyptus megacarpa has two forms. One is a tree up to 30 m in height, with a straight trunk and usually a dense crown. The other is a depauperate tree, shrub or mallee only 2–5 m high.

Bullich is found in a coastal belt, mainly less than 80 km wide, which extends from near Perth southwards to Cape Leeuwin and then eastwards to the Albany district in Western Australia. The latitudinal range is 32½–35°S and the altitude is mainly from 100 to 400 m, but it extends to 1000 m in the Stirling Range. The climate is warm humid to warm sub-humid, with the mean maximum temperature of the hottest month varying from 25 to 30°C. The winters are mild, with the mean minimum temperature of the coldest month about 6–9°C, or somewhat less in the Stirling Range. The area is frost-free on the coast while there may be up to 10 frosts a year elsewhere. The mean annual rainfall is around 750–1250 mm with most of it falling from May to September and variability is moderately low.

The tree form mainly grows in moist situations on silty to sandy loam alluvium edging swamps and on gentle topography along streams and other drainage channels. The smaller form is also found on gentle slopes but these may include the upper slopes of low ranges. The soils include coastal sands, lateritic podsols, and others derived from granite, shales, gneiss and quartzite.

Bullich, as a tree, typically occurs in open-forest as almost pure stands in narrow belts along the edges of damp areas, sometimes with Western Australian blackbutt (*Eucalyptus patens*) and with several tree-form eucalypts such as jarrah (*E. marginata*) growing in adjacent forest. Nearer the coast this form grows with karri (*E. diversicolor*) and yate (*E. cornuta*). As a small shrub or mallee it may be associated with shrubby marri (*E. calophylla*), Swan River peppermint (*Agonis flexuosa*) and blackboy (*Xanthorrhoea* species).



Published: *Fragm.* 2, 70 (1860–61).

Names: Botanical—Greek *megas* (large), plus *carpos* (fruit); common—of Aboriginal origin.

Bark: A gum decorticating nearly to ground level, leaving a smooth, alabaster-white or yellowish white surface. Towards the base of the tree there may be small, somewhat thin, elongated plates of outer bark which are retained for a time.

Leaves: Seedling—opposite, sessile, slightly amplexicaul, broadly ovate, 5–16 × 3–9 cm, green, discolorous. Juvenile—alternate, petiolate, ovate, 13–18 × 4·5–9 cm, green, discolorous. Intermediate—alternate, petiolate, broad-lanceolate, 10–17 × 3–4·5 cm, green, nearly concolorous. Adult—alternate, petiolate, broad-lanceolate, often falcate, 8·5–14 × 2–3 cm, dull green, concolorous.

Inflorescences: Simple, axillary, 3-flowered; peduncles strongly flattened, 1–2·6 cm long and up to 0·7 cm wide; buds sessile or very shortly pedicellate, truncate-ovoid to subglobular, 1·8–2·1 × 1·2–1·5 cm; opercula low hemispherical–apiculate or often prominently beaked. Flowers Oct.–Nov.

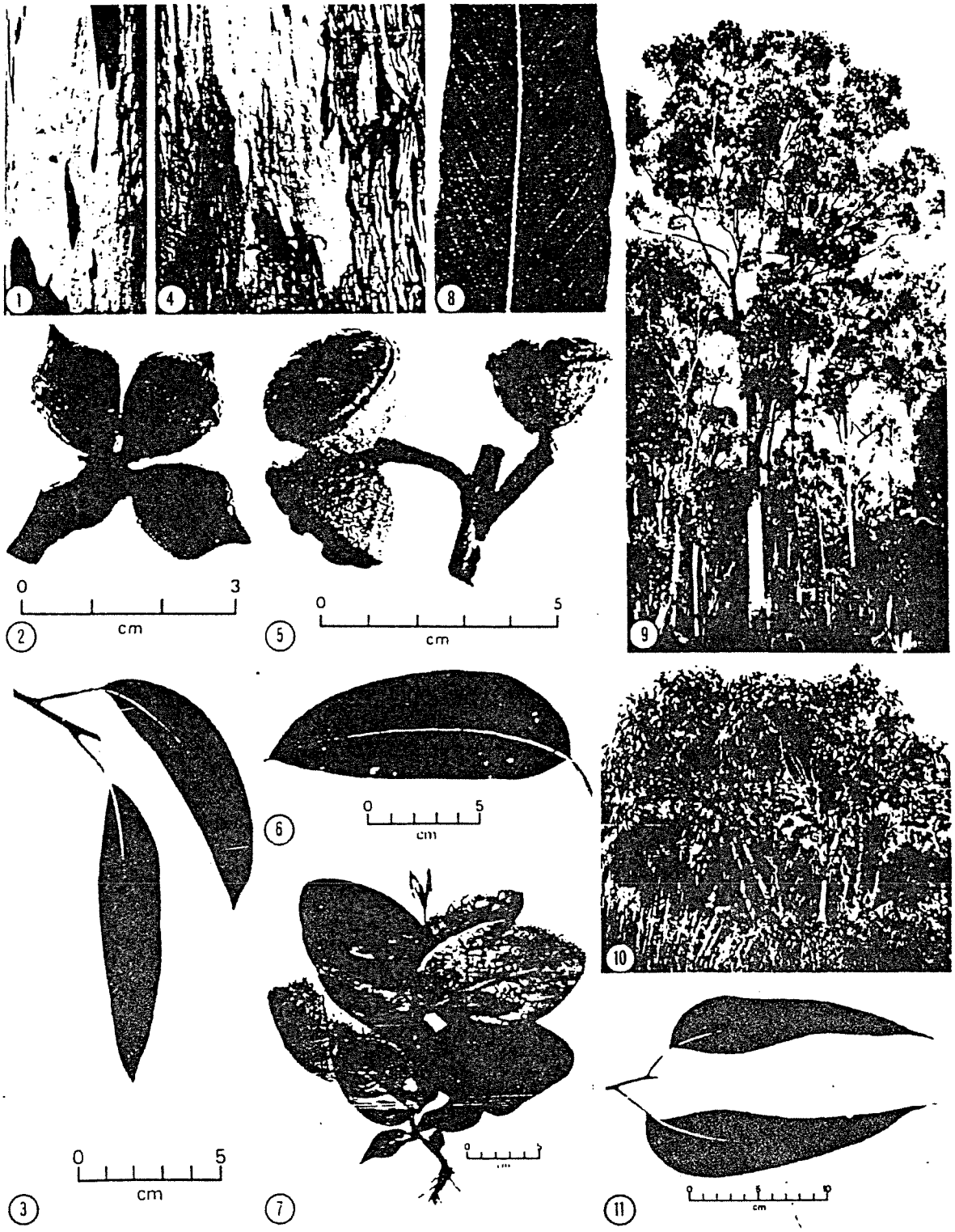
Fruits: Sessile or very shortly pedicellate, truncate-globular to hemispherical, 1·6–2·5 × 1·8–2·8 cm; disc very broad with conspicuous, slightly raised lobes almost obscuring the 3–5 valves. The hypanthia may be nearly smooth or marked with faint striations.

Wood: Heartwood strong, moderately fissile but subject to gum veins; of limited availability and use.

Distinctive features: A smooth, white-barked tree or a mallee, always with conspicuously large, often curved, firm-textured leaves; large buds and fruits; broad, lobed disc almost obscuring the 3–5 valves.

Related species: *E. megacarpa* clearly belongs with several other western, large-fruited *Monocalyptus* species which make up subseries *Preissianae* (Pryor and Johnson 1971). It is closest to *E. aquilina* which is always a mallee, has larger buds and fruits, a very conspicuous lobed disc and is known only from the Cape le Grand area.

Types: A cultivated specimen in Sydney and non-cultivated specimens from near King George Sound, Western Australia.



Eucalyptus megacarpa 1, 4. Bark 2. Buds 3. Adult leaves 5. Fruits 6. Juvenile leaf 7. Seedling 8. Adult leaf venation 9. Tree, W.A. 10. Mallee form, W.A. 11. Intermediate leaves

Jarrah

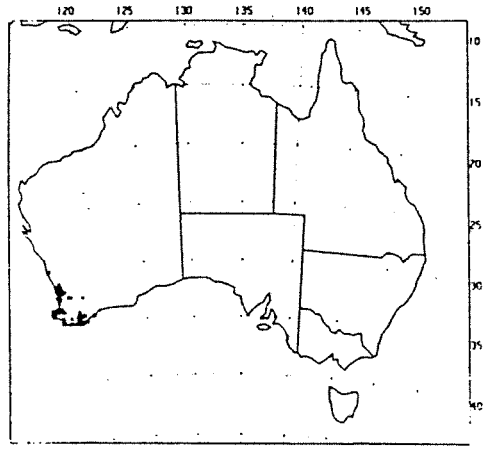
MADCA *Eucalyptus marginata* Donn ex Smith
family Myrtaceae

Eucalyptus marginata is one of the most important hardwoods of Australia. In Western Australia it represents about two-thirds of the annual production of sawn timber. Under optimum conditions it is a tall tree attaining 30–40 m in height with dbh up to 2 m. The commercial bole length rarely exceeds one-half of the total height. On poor sites the species is reduced to a mallee form.

Jarrah grows in the southwest of the State and the production area (about 1–2 million hectares) coincides closely with that for Western Australian blackbutt (*E. patens*). The prime jarrah area is a belt 30–50 km wide, which extends along the Darling Range from Chidlows Well some 50 km east of Perth, southwards to the vicinity of Albany. This belt is bounded by the Darling escarpment on the western side and approximately by the 630 mm isohyet on the eastern. Most of this area is now State forest. There are a few eastern outliers such as Tutanning Reserve southeast of Pingelly and Jilakin Rock east of Kulin. The latitudinal range is 30–35°S and the altitude for the best forests is from 100 to about 300 m at the far north of its distribution. The climate is warm humid to warm sub-humid, with mean maximum temperatures for the hottest month around 25–31°C and mean minimum temperatures for the coldest month around 5–9°C. Up to 12 frosts a year may be experienced in some areas away from the coast. Mean annual rainfall is about 700–1250 mm with a winter maximum.

Jarrah has its best development and greatest size on red loams of deeply dissected river valleys between the Murray and Warren Rivers. Clay forms the subsoil and where this is exposed by erosion the species gives way to other eucalypts. Abundant but poorer quality jarrah, producing smaller logs of easy extraction, occurs on the Donnybrook Sunkland, a low plateau south of Busselton. On the better soils of the south it is replaced by karri (*Eucalyptus diversicolor*) or marri (*E. calophylla*) while on limestone ridges it is replaced by tuart (*E. gomphocephala*). On poor, deep sands height is reduced and it is only of mallee form near Mt Lesueur.

A feature of jarrah is its occurrence in pure or almost pure stands and the jarrah forests of the northern Darling Range provide invaluable watershed protection. On the drier, eastern side of the occurrence where jarrah becomes progressively smaller, there is limited association with wandoo (*E. wandoo*), powder bark wandoo



(*E. accedens*) and York gum (*E. loxophleba*) before it is entirely replaced by them.

The species has suffered badly from jarrah dieback caused by the fungus *Phytophthora cinnamomi* and forest quarantine measures have had to be implemented to restrict the spread of this disease.

Related species: Pryor and Johnson (1971) placed *E. marginata* with *E. staeri* in subseries *Marginatinae*. The two species are clearly allied but *E. staeri* is a small tree with shaggy bark, concolorous leaves and larger buds and fruits and has a restricted occurrence in southern southwest Western Australia.

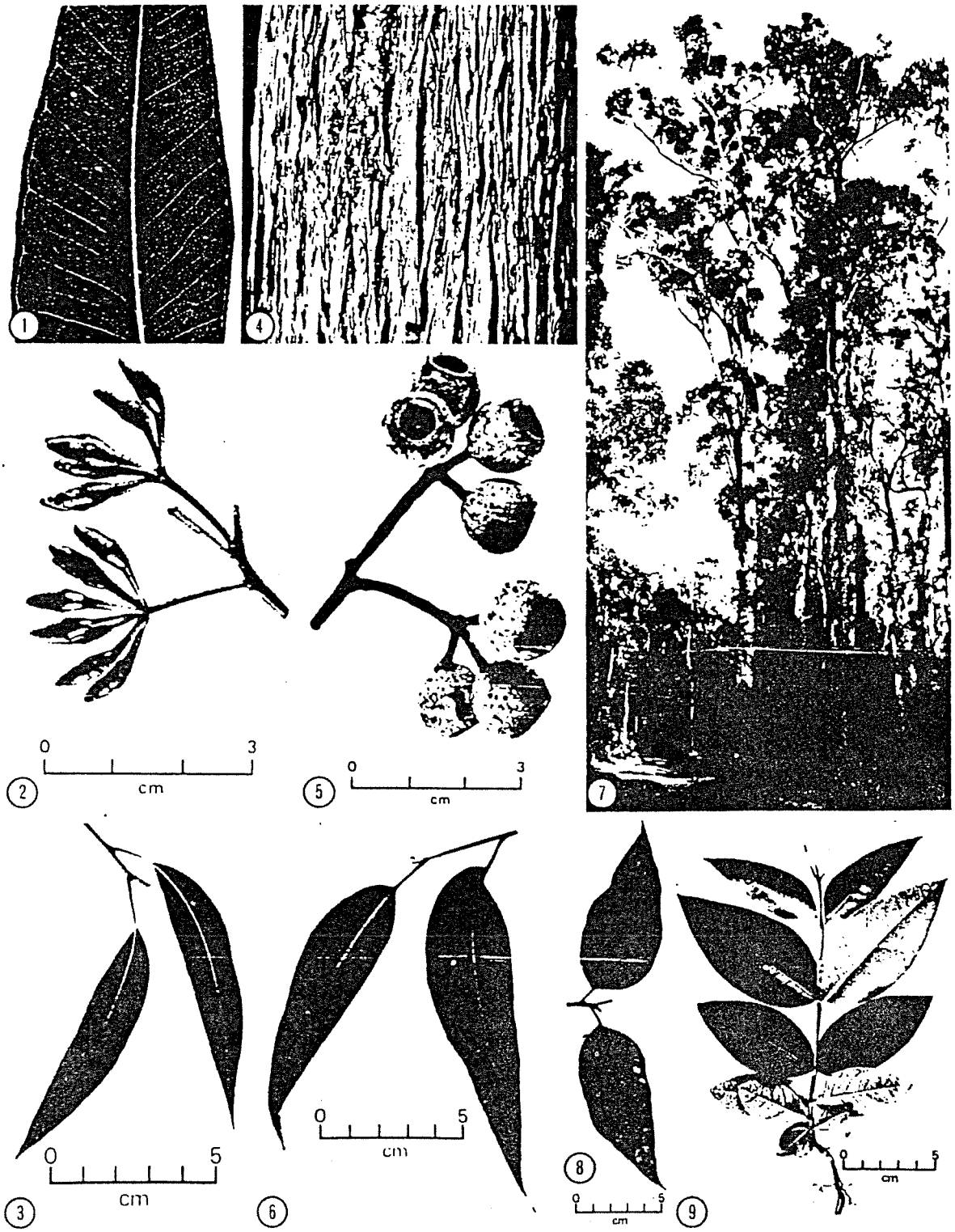
Type: Cultivated specimen at Kew, United Kingdom, from seed collected by A. Menzies in 1794.

Published: *Trans. Linn. Soc. London* 6, 302 (1802).

Names: Botanical—Latin *marginatus* (edged, bordered), refers to prominent margins of leaves; common—of Aboriginal origin.

Bark: Rough and persistent to the small branches, of somewhat stringy appearance but held in long flat straps of brown fibrous bark, red-brown when fresh, weathering to grey.

Leaves: Seedling—opposite and sessile for 3–6 pairs, then becoming alternate and petiolate, ovate, 7–13 × 3·5–6 cm, dark green, discolorous. Juvenile—alternate, petiolate, ovate, 9–13 × 4–6 cm, dark green, discolorous. Intermediate—alternate, petiolate, broad-lanceolate, often falcate, 12–17 × 3–4 cm, tapering to a fine point, dark green, discolorous. Adult—alternate, petiolate, broad-lanceolate to lanceolate or falcate, 8–13 × 1·5–3 cm, tapering to a fine point, dark green, glossy, discolorous. In the northern part of its range, e.g. Baker's Hill and environs, the leaves may be somewhat bluish.



Eucalyptus marginata 1. Adult leaf venation 2. Buds 3. Adult leaves 4. Bark 5. Fruits 6. Intermediate leaves 7. Stand, near Manjimup, W.A. 8. Juvenile leaves 9. Seedling

Inflorescences: Simple, axillary, 7- to 11-flowered; peduncles slender, terete to slightly angled, 1–2 cm long; pedicels 0·5–1·3 cm long; buds 0·8–1·7 × 0·3–0·5 cm; hypanthia obconical; opercula narrowly conical or horn-shaped, 2–3 times as long as the hypanthia. Flowers Sept.–Dec.

Fruits: Distinctly pedicellate, globular or ovoid, 0·9–1·6 × 0·9–1·5 cm, thick and woody; disc mostly descending at an angle of around 45°, but occasionally vertically depressed or at other times level; valves 3, to rim level or slightly enclosed.

Wood: Heartwood dark red to reddish brown, hard, coarse-textured, strong, durable and termite resistant, with relatively poor burning qualities; density about 830 kg m^{-3}; used for heavy construction, either in the round or sawn, piling, sleepers, ship building and bridge and wharf construction, as well as for all purposes in house construction, including beams, rafters and flooring. The wood finishes well and is used for the manufacture of high quality furniture.

Distinctive features: Bark fibrous, held in flat straps, persistent to the small branches; leaves discolorous at all stages; opercula narrowly conical to horn-shaped; fruits globular to ovoid, relatively large, woody. Cotyledons of jarrah and *E. staeri* are unique in that the hypocotyl is reduced and the cotyledonary petioles emerge from below ground level.

A photograph of a specimen of jarrah (*Eucalyptus marginata*) collected by Robert Brown (1773–1858) in December 1801 near Albany, Western Australia. Brown was the naturalist aboard Matthew Flinders' ship the '*Investigator*' which undertook the first circumnavigation of Australia.

A virgin stand of jarrah (*Eucalyptus marginata*) near Collie, Western Australia. This species produces a valuable dark durable timber. In recent years, natural stands of jarrah have suffered serious damage from a soil fungus (*Phytophthora cinnamomi*) which attacks and destroys the fine feeding roots.

Marri

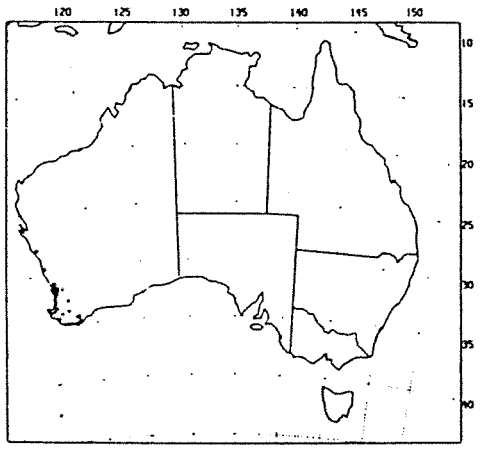
Red gum CAFUA *Eucalyptus calophylla* R. Br.
family Myrtaceae

Eucalyptus calophylla is usually a medium-sized to tall tree up to 40 m in height and 1·5 m dbh, while exceptional specimens have been found to 60 m. The crown development varies with site, but under favourable conditions it is usually dense and heavily branched. The bole is commonly around one-half of the tree height. On poor soils it is sometimes of mallee form.

Marri is widely distributed in the southwest of Western Australia and the major occurrence coincides with the principal range of jarrah (*E. marginata*) and karri (*E. diversicolor*). It is abundant in the Darling Range and its overall distribution extends from north of Geraldton southwards to Cape Riche and eastwards to beyond Narrogin in the wheatlands. The latitudinal range is around 29–35°S while the altitudinal range is from just above sea level to over 300 m. The climate is warm humid to subhumid, with dry and warm to hot summers, the mean maximum temperature of the hottest month being in the range 24–30°C. The winters have mild days and usually cool nights with the mean minimum temperature of the coldest month around 4–8°C. Areas near the coast may be frost free; elsewhere there may be 1–15 frosts a year. The mean annual rainfall is 650–1500 m, with a distinct winter maximum.

Marri occurs on lateritic sandy gravels of the plateau of the Darling Range and also on the slopes and plains from the Range to near sea level. While it will grow on comparatively poor soils its best development is generally found on the better sandy loam alluvium in the valleys between laterite-capped ridges. Soils where marri grows are considered better for agriculture than those of typical jarrah sites.

This species occurs in tall open-forest and open-forest formation and is commonly associated with jarrah and to a lesser extent with karri. Small pure stands occur south of Blackwood where it reaches its best development. On the drier side of its range, e.g. on the eastern remnants and slopes of the Darling plateau it may occur with other eucalypts such as wandoo (*E. wandoo*), powderbark wandoo (*E. accedens*) and above Western Australian flooded gum (*E. rudis*) in the gullies.



Type: Near Princess Royal Harbour, Western Australia, 29 Dec. 1801, R. Brown.

Published: *J. Geogr. Soc.* 1, 20 (1831–32).

Names: Botanical—Greek *calos* (beautiful), plus *phyllon* (leaf); common—of Aboriginal origin.

Bark: Typical bloodwood-type, persistent to the small branches, short-fibred, tessellated. In young trees the bark is grey in colour but with age it becomes brownish to dark grey, and is frequently stained in patches to a reddish hue by the kino which exudes from the tree.

Leaves: Seedling—opposite for several pairs, then alternate, petiolate, peltate, ovate, 7–12 × 4–6 cm, green, strongly discolorous. Juvenile—alternate, petiolate, peltate, ovate, 12–20 × 6–8·5 cm. Adult—alternate, petiolate, ovate to broad-lanceolate, 9–14 × 2·5–4 cm, green, strongly discolorous.

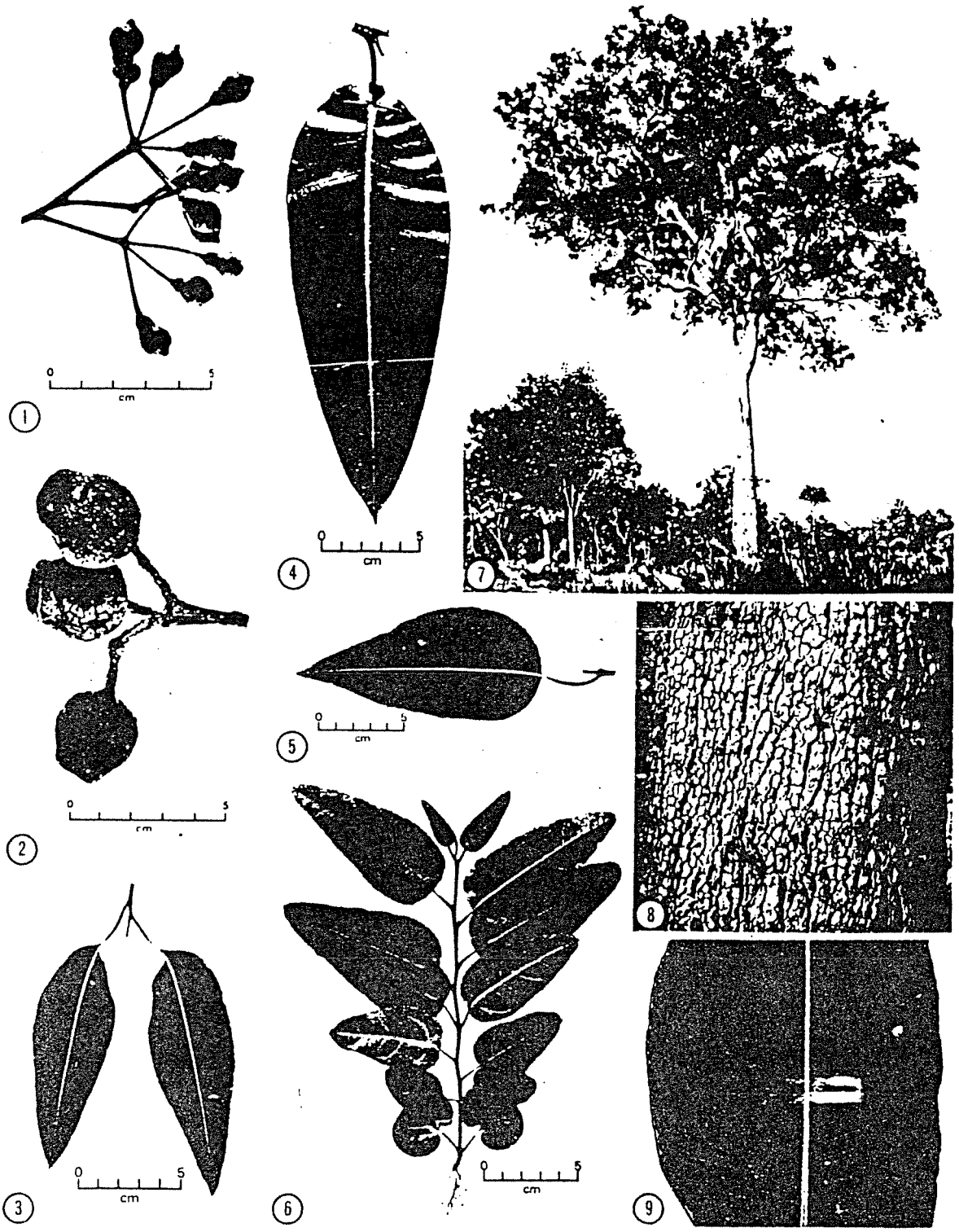
Inflorescences: Large, terminal, corymbose panicles of 3- or 7-flowered umbels; peduncles terete to angular, 2·5–4·5 cm long; pedicels 2–4 cm long; buds clavate to occasionally globular, 0·8–1·5 × 0·5–0·9 cm; opercula hemispherical; filaments generally cream but occasionally pink. Flowers Feb.–Mar.

Fruits: On long, stout pedicels, ovoid or more often urceolate with constriction below opening, 3–5 × 2·8–4 cm, thick and woody; disc broad, descending; valves 4, deeply enclosed.

Wood: Sapwood susceptible to *Lyctus* borer attack; heartwood pale yellow to light brown, hard, strong, durable, non-fissile, moderately resistant to termites, easily worked but marred by gum veins; density about 850 kg m^{-3}; used for weatherboards, scantlings, case manufacture, tool handles, sporting goods, fence posts and piles. Once a relatively non-commercial competitor in jarrah and karri forests, it is now the principal species used for woodchips in Western Australia.

Distinctive features: Bloodwood-type bark, tessellated, thick; juvenile leaves setose, peltate; adult leaves broad, strongly discolorous; inflorescences of large, terminal, corymbose panicles, 3- or 7-flowered; pedicels to 4 cm long; flowers cream or rarely pink; fruits very large, woody, urceolate; the largest seed in the genus being up to 2 cm long, black, wingless, boat-shaped; very large cotyledons, up to 3 × 4·5 cm.

Related species: *E. calophylla* is somewhat isolated taxonomically and was placed in the diverse subseries *Gummiferinae* by Pryor and Johnson (1971). Marri is clearly distinguished among all bloodwoods by its very large buds and fruits. As a small tree it may be mistaken for *E. ficifolia* which has generally smaller fruits that are less urceolate, winged seed and pink, orange or red flowers.



Eucalyptus calophylla 1. Buds 2. Fruits 3. Adult leaves 4. Juvenile leaf
5. Intermediate leaf 6. Seedling 7. Tree, between Pinjarra and Mandurah, W.A.
8. Bark 9. Adult leaf venation

She-oak

Casuarina fraserana Miq.
family Casuarinaceae

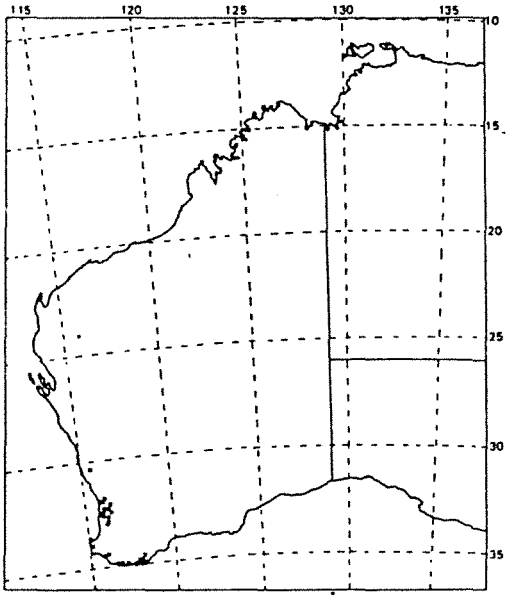
Western Australian she-oak

Casuarina fraserana is typically a medium-sized tree up to 15 m tall and 0·5–1 m in diameter. Good specimens have straight boles for two-thirds of the tree height and small crowns. More commonly, however, the bole is only one-half or less of the total tree height with the crown being moderately large and containing large branches. The species is noted for the copious fall of branchlets throughout the year.

She-oak occurs in the southwestern corner of Western Australia in the coastal and hinterland region from Perth in the north to near Albany in the east. There is a small isolated population between Moora and Jurien Bay. The species occurs typically on the coastal lowlands and in the Darling Ranges. The range of latitude is 31–35°S and that of altitude from near sea level to about 300 m. The climate is in the warm humid climatic zone with pronounced dry summers. The mean maximum temperature of the hottest month is 20–30°C and the mean minimum of the coldest month varies from 4·5 to 10°C. The area receives some frosts each year and the mean annual rainfall is 750–1000 mm with most rain falling during winter.

C. fraserana occurs principally on impoverished lateritic gravels which may be deep or quite shallow with massive subsurface concretions. The species may also occur on heavily leached yellow siliceous sands along the coast. The topography is mostly one of rather gentle relief.

She-oak usually occurs as an understorey to open-forests of jarrah (*Eucalyptus marginata*) in the Darling Ranges where other associates include giant banksia (*B. grandis*), *Persoonia longifolia* and *Dryandra sessilis*. On sandy coastal soils the species occurs in woodland to open-forest formations in association with poor-formed jarrah (*Eucalyptus marginata*), and several banksias such as firewood banksia (*B. menziesii*), coast banksia (*B. attenuata*) and holly-leaved banksia (*B. ilicifolia*).



Bark: Outer surface is smoothish with a fine-textured surface, grey, soft and slightly flaky when rubbed. The newer bark beneath the older bark is light-yellow and noticeably granular.

Leaves: Seedling—permanent and deciduous branches similar in morphology, whorls of 4–5 triangular leaf-teeth, about 0·1–0·15 cm long, internodes (articles) 0·7–0·8 cm long, glabrous, dull-green. Adult—deciduous and permanent branches different in morphology; deciduous branches 16–32 cm long, shed after 2–3 seasons, thick (0·1 cm diameter), leaf-teeth in whorls of 6–8, erect or spreading with ciliate margins, internodes (articles) 0·5–1 cm long, dull green.

Inflorescences: Male and female on separate trees. Male—on long cylindrical spikes, 5–10 × 0·3–0·5 cm, containing up to 50 whorls of male flowers per spike, at the end of deciduous branches; male trees are golden brown when in flower in July–Sept. Female—consisting of alternating whorls of 6–8, eventually forming a large subglobose to cylindrical 'cone', 2–4 × 2–3 cm, on a stalk 0·5–3 cm long, bracteoles very thick, shortly exserted, ferruginously pubescent, dorsal surface rugose with multiple protuberances, cone slits about 0·4 cm.

Fruits: Samaras, to 1 cm long, dark brown, with hyaline wing.

Wood: Sapwood pale; heartwood dark red, density 830 kg m^{-3}. The wood is used for turnery, but was formerly used widely for roof shingles, barrel staves and fuel. This species is perhaps the only casuarina from Western Australia that has been utilized to any extent.

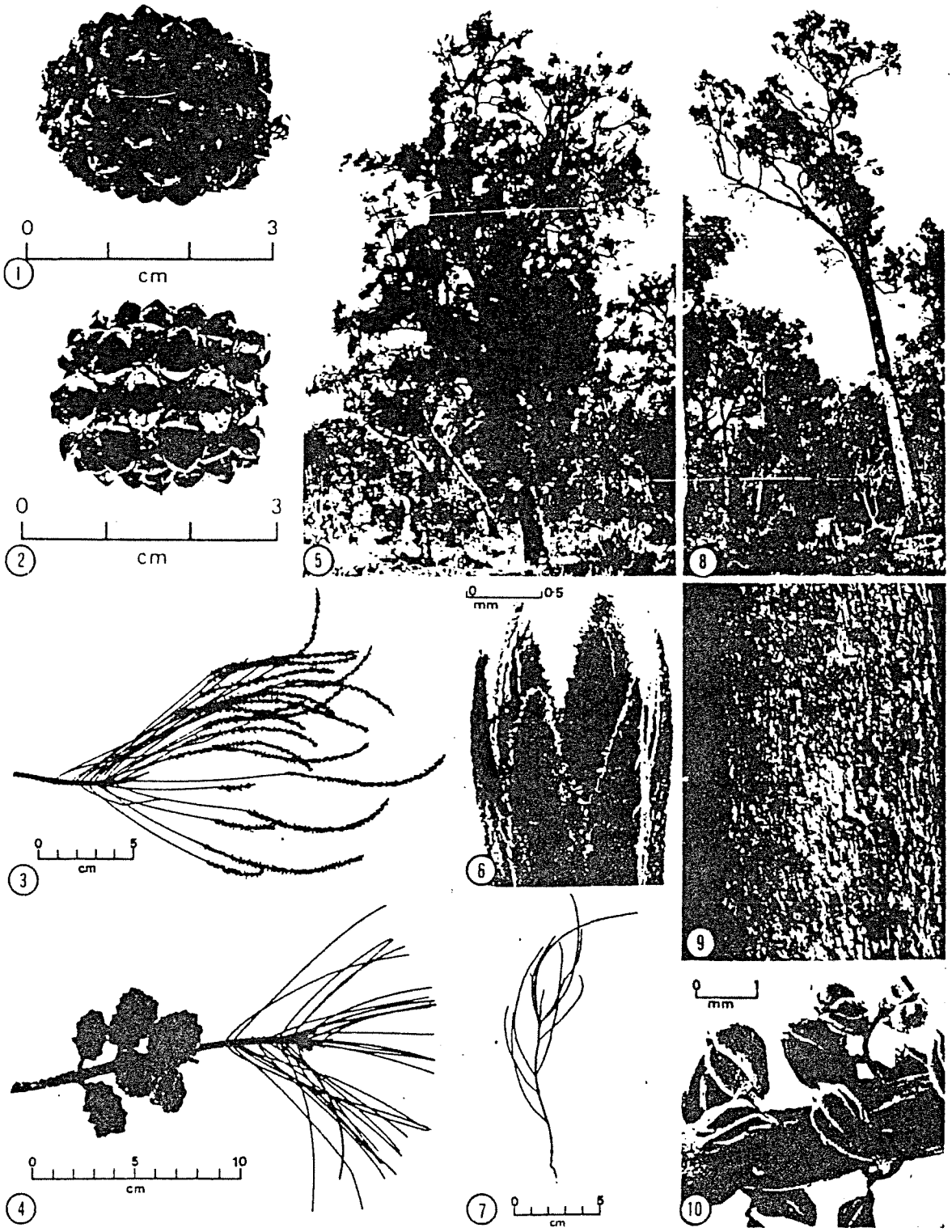
Distinctive features: A tall *Casuarina*, occurring frequently in association with *Eucalyptus marginata* and *Banksia grandis*. The fruits are large, woody and often appear misshapen. The backs of bracteoles of the 'cone' are covered with tessellations and a mass of fine hairs. Slender brown hairs are found in the cavities formed after the bracteoles have released the fruit.

Related species: No very closely related species.

Type: Near Perth, W.A., 1840, J. A. L. Preiss (No. 2000).

Published: *Rev. Crit. Casuar.* 59, t. 6 (1848).

Names: Botanical—honours C. Fraser (? 1788–1831), first superintendent of the Sydney Botanic Gardens and Colonial botanist; common—she-oak is commonly applied to casuarinas and 'she' may refer to the sex of female trees or may be a corruption of the word for the sound made as wind blows the branchlets of a casuarina tree. However, it is most likely that the prefix 'she' means inferior, i.e. with oak-like timber but not as good as in true English Oak. The name 'oak' is explained under *Casuarina cunninghamiana*.



Casuarina fraserana 1. 'Cone' before dehiscence 2. 'Cone' after dehiscence 3. Male inflorescences at ends of deciduous branchlets 4. Fruiting branch 5. Tree between Kelmscott and Roleystone, W.A. 6. Leaf 'teeth' at joint (S.E.M.) 7. Seedling 8. Tree between Kelmscott and Roleystone, W.A. 9. Bark 10. Male flowers showing anthers (S.E.M.)

APPENDIX C

Definition of terms

basal area	The area of the cross-section of a stem, usually of a tree at breast height (1.3 m above ground on the upslope side of the tree) over bark. When applied to a crop, the sum of the basal areas of all stems or the total basal area per unit of ground area.
canopy	The cover of branches and foliage formed by tree crowns.
canopy cover	The cover of branches and foliage formed by tree crowns, sometimes expressed as a percentage of the ground area covered.
canopy depth	The depth of the canopy from the top of the canopy to the bottom of the leaf foliage.
canopy width	The average diameter of the canopy.
coppice	A shoot (or shoots) arising from adventitious buds at the base of a woody plant that has been cut near the ground or burnt back.
projected crown cover	The vertical projection of crown cover onto the ground.

diameter, breast height	The diameter of a tree measured at the standard reference point, nominally 1.3 m above ground on the uphill side of the tree, or at the nearest representative point (Abbr. DBH). DBH is usually expressed as overbark (OB) or underbark (UB).
dieback disease	In Western Australia, particularly applied to the effect of the root rot fungus Phytophthora cinnamomi.
dieback disease hazard	The degree to which site factors combine to favour infection by the fungus and intensification of the disease.
dieback disease intensification	The buildup of fungal activity in a locality by either natural or artificial spread.
dieback disease susceptibility	The ease and rapidity with which the pathogen Phytophthora cinnamomi is able to bring about the decline and death of a species.
forest	An ecosystem characterized by a more or less dense and extensive tree cover.
groundflora	Herbaceous plants and low growing shrubs in a forest.
leaf angle	The angle of inclination with respect to the horizontal.

leaf area	The area of foliage (one side) of vegetation.
leaf area index	The area of foliage (one side) per unit area of ground surface.
projected leaf cover	The cover of foliage formed by tree crowns, sometimes expressed as a percentage of the ground area covered.
logging	To fell, haul and deliver the utilizable part of a tree stem
middlestorey	The middle stratum of a multi-storeyed high forest.
overstorey	The upper stratum of a multi-storeyed high forest.
projected canopy cover	The completeness of tree canopies within a stand or area.
rehabilitation	The process of planning, earthworks and re-establishment of vegetation necessary to reinstate pre-defined land uses following disturbance.
salvage logging	A cutting made to remove trees killed or injured by fire, insects, fungi or other harmful agencies, for the purpose of fully utilizing merchantable material before it becomes worthless.
stem	The trunk of a tree. There may be more than one trunk per tree due to coppices caused by logging on the natural environment.

stocking	The total number of stems per unit area.
tree	A woody perennial plant having one well-defined stem and a more or less definitely formed crown, usually greater than 2.4 m high.
tree density	The total number of trees per unit area.
understorey	The lower stratum of a multi-storeyed high forest.

APPENDIX D

Abbreviations used in report

CALM	Department of Conservation and Land Management
D	Diameter
DBH	Diameter at Breast Height
DBHOB	Diameter at Breast Height Over Bark
HPG	Hillslope Processes Group
HRZ	High Rainfall Zone
IRZ	Intermediate Rainfall Zone
LA	Leaf Area
LAI	Leaf Area Index
PC	Phytophthora cinnamomi
R^2	Coefficient of determination
Sig	Significance of regression equation with respect to probability of R values having no correlation (e.g. if sig = 0.001 it means that there is a .1% chance that the correlation is zero)
STD	Standard Deviation
X	Traverse distance on hillslope
Y	Longitudinal distance on hillslope

APPENDIX E

Description of Havel site types from Havel (1975a)

APPENDIX 4

Enumeration of continuum segments (site-vegetation types) in terms of composition, structure and environmental features.

SEGMENT A CO-ORDINATES high — F1, low — F2, high — F3, low ± F4.

PLOTS (147) (81, 85, 71, 93)

(a) INDICATOR SPECIES

GROUPS		INDIVIDUAL SPECIES
VERWET	....	*Melaleuca preissiana, Banksia littoralis, Hakea ceratophylla, Hakea varia.*
BROWET	....	*Leptocarpus scariosus, Leptospermum ellipticum.*
BROMO	....	*Mesomelaena tetragona, Synaphea petiolaris, Lepidosperma angustatum.*

Less consistently :

SAMORG	....	*Adenanthos obovata, Dasypogon bromeliaefolius.*
FERMO	....	*Hypocalymma angustifolium, Eucalyptus patens, Acacia extensa*
SANLEA	....	*Lyginia tenax*

(b) TREE STRATUM

			RANGE	MEAN
GENERAL: Sparse, low stand	BASAL AREA (m²/ha)	....	7–20	13
	HEIGHT (m)	....	16–23	19

COMPOSITION: *Melaleuca preissiana, Banksia littoralis, Eucalyptus calophylla, Eucalyptus patens.*

(c) TOPOGRAPHICAL AND GEOGRAPHICAL POSITION

			RANGE	MEAN
CURVATURE: Concave	SLOPE (degrees)	....	0–3	2
GENERAL: Broad heads of valleys in eastern zone	ROCK OUTCROPS: Nil			

(d) SOIL

GENERAL: Grey sand over pale yellow or pale brown sand, often clay or organic-iron hardpan at depth. Plot 147 differs markedly in having much heavier texture and is not included in following figures.

PHYSICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN		RANGE	MEAN
GRAVEL %	Nil		FIELD CAPACITY (%)	3–7	5
SILT + CLAY (%)	2–13	7	WILTING POINT (%)	1–3	2
DEPTH TO WATER TABLE (cm)	0–15	....	AVAIL. MOISTURE (%)	2–4	3

CHEMICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN		RANGE	MEAN
pH	5·1–5·5	5·4	EXCH. Ca(me%)	0·7–3·7	1·5
N%	0·02–0·11	0·05	EXCH. Mg(me%)	0·4–2·1	0·9
P (ppm)	8–30	15	C.E.C. (me%)	6·5–10·3	8·2
K (me%)	0·02–0·53	0·16	SATURATION (%)	22–68	37

(e) BROAD DESCRIPTION

Wet, leached acid sands, waterlogged in winter, underlain by impermeable horizon.
Plot 147 differs from the remainder both in soils and in vegetation, and is included solely to

SEGMENT B CO-ORDINATES low ± F1, medium to high + F2, high — F3, low ± F4.

PLOTS (144, 88, 86, 91, 92) (69) (83, 48, 84)

(a) INDICATOR SPECIES

GROUPS		INDIVIDUAL SPECIES
BROWET	....	*Leptocarpus scariosus*, less *Leptospermum ellipticum.*
BROMO	....	*Mesomelaena tetragona, Synaphea petiolaris, Lepidosperma angustatum.*
SAMORG	....	*Adenanthos obovata, Dasypogon bromeliaefolius, Petrophile linearis.*
SANLEA	....	*Conospermum stoechadis, Patersonia occidentalis, Hibbertia polystachya, Lyginia tenax*

Less consistently :

FERMO	....	*Hypocalymma angustifolium, Acacia extensa*
EAGSAN	....	*Sphaerolobium medium, Isopogon dubius*
BROFEM	....	*Baeckea camphorosmae, Dampiera alata*

(b) TREE STRATUM

			RANGE	MEAN
GENERAL: Very open forest to wood land	BASAL AREA (m²/ha)	....	14–41	24
	HEIGHT (m)	....	13–28	21

COMPOSITION: *Eucalyptus marginata, Eucaluptys calophylla*, scattered understorey of *Banksia grandis*

(c) TOPOGRAPHICAL AND GEOGRAPHICAL POSITION

			RANGE	MEAN
CURVATURE: Concave	SLOPE (degrees)	....	1–3	2
GENERAL: Upland depressions and broad valley heads, mainly in eastern zone	ROCK OUTCROPS: Nil			

(d) SOIL

GENERAL: Light grey sand over grey to pale yellow sand, somewhat heavier texture and compaction in subsoil. Plots 83, 48 and 84 approach loamy sand.

PHYSICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN		RANGE	MEAN
GRAVEL %	0–26	3	FIELD CAPACITY (%)	2–12	5
SILT + CLAY (%)	3–22	7	WILTING POINT (%)	1–6	2
DEPTH TO WATER TABLE (cm)	2–90	....	AVAIL. MOISTURE (%)	2–5	3

CHEMICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN		RANGE	MEAN
pH	5·4–5·9	5·8	EXCH. Ca(me%)	0·1–2·0	1·0
N%	0·01–0·06	0·03	EXCH. Mg(me%)	0·1–1·4	0·6
P (ppm)	10–26	16	C.E.C. (me%)	1·7–9·5	6·2
K (me%)	0·05–0·22	0·10	SATURATION (%)	13–65	35

(e) BROAD DESCRIPTION

Leached infertile acid grey sands, moist to wet in winter, rapidly drying out in summer.
Plot 69, with group WETAL, forms transition to segment D. Plots 83, 84, 48, with groups DRYGRA, SANGRA and GRAMED, form transition to segment E, and have slightly heavier

SEGMENT D CO-ORDINATES high — F1, low ± F2, F3, F4.

PLOTS 80, 57, 50, 76, 72, 63, 73, 158, 82, 77, 66, 102.

(a) INDICATOR SPECIES

GROUPS		INDIVIDUAL SPECIES
BROWET	....	*Leptocarpus scariosus, Leptospermum ellipticum.*
BROMO	....	*Mesomelaena tetragona, Synaphea petiolaris, Lepidosperma angustatum, Kingia australis.*
BROFEM	....	*Dampiera alata,* to lesser degree *Baeckea camphorosmae.*
FERMO	....	*Hypocalymma angustifolium, Acacia extensa,* some *Eucalyptus patens.*

Less consistently :

BROFER	....	*Hakea lissocarpha.*
DRYSAG	....	*Daviesia pectinata*
WETAL	....	*Agonis linearifolia*

(b) TREE STRATUM

			RANGE	MEAN
GENERAL: Variable, frequently affected by dieback	BASAL AREA (m²/ha)	....	11–38	21
	HEIGHT (m)	....	16–33	24

COMPOSITION: *Eucalyptus marginata, Eucalyptus calophylla,* slight admixture of *Eucalyptus patens*

(c) TOPOGRAPHICAL AND GEOGRAPHICAL POSITION

			RANGE	MEAN
CURVATURE: Concave	SLOPE (degrees)	....	1–3	2
GENERAL: Lower slopes and floors of valleys	ROCK OUTCROPS: Isolated outcrops of secondary lateritic ironstone			

(d) SOIL

GENERAL: Orange-brown loamy sands and sandy loams over sandy clay or secondary lateritic ironstone.

PHYSICAL PROPERTIES (TOPSOIL)

		RANGE	MEAN		RANGE	MEAN
GRAVEL %	....	0–26	11	FIELD CAPACITY (%)	2–33	15
SILT + CLAY (%)	....	4–23	14	WILTING POINT (%)	1–12	6
DEPTH TO WATER TABLE (cm)		2–90	....	AVAIL. MOISTURE (%)	2–23	9

CHEMICAL PROPERTIES (TOPSOIL)

		RANGE	MEAN			RANGE	MEAN
pH	....	5·4–6·4	6·0	EXCH. Ca(me%)	....	0·4–3·4	1·3
N%	....	0·03–0·16	0·09	EXCH. Mg(me%)	....	0·1–3·1	0·9
P (ppm)	....	5–97	24	C.E.C. (me%)	....	0·1–1·4	0·7
K (me%)	....	0·01–0·40	0·18	SATURATION (%)	....	10–68	36

(e) BROAD DESCRIPTION

Orange-brown loamy sands or sandy loams, over impermeable horizon, on lower slopes and valley floors, seas. ally waterlogged.

SEGMENT E. CO-ORDINATES low — F1, high + F2, low ± F3, low ± F4.

PLOTS 79, 67, 96, 101, 61, 39, 59, 120, 74, 75, 78, 52, 55.

(a) INDICATOR SPECIES

GROUPS		INDIVIDUAL SPECIES
BROMO	....	*Mesomelaena tetragona, Synaphea petiolaris, Lepidosperma angustatum.*
BROFEM	....	*Baeckea camphorosmae, Dampiera alata, Kingia australis*
FERMO	....	*Hypocalymma angustifolium.*

Less consistently :

EAGSAN	....	*Sphaerolobium medium, Hakea cyclocarpa.*
DRYSAG	....	*Daviesia pectinata.*
BROWET	....	*Leptocarpus scariosus, Leptospermum ellipticum.*
GRAMED	....	*Adenanthos barbigera, Banksia grandis.*
SANLEA	....	*Patersonia occidentalis, Hibbertia polystachya.*

(b) TREE STRATUM

			RANGE	MEAN
GENERAL: Variable	BASAL AREA (m²/ha)	....	0·5–43	20
	HEIGHT (m)	....	14–30	23

COMPOSITION: Chiefly *Eucalyptus marginata,* light admixture of *Eucalyptus calophylla,* few *Banksia grandis*

(c) TOPOGRAPHICAL AND GEOGRAPHICAL POSITION

			RANGE	MEAN
CURVATURE: Concave	SLOPE (degrees)	....	1–5	3
GENERAL: Lower slopes and depressions	ROCK OUTCROPS: Mostly nil.			

(d) SOIL

GENERAL: Grey, yellow or brown sands and loamy sands with admixture of lateritic gravel which tends to increase with depth; orange mottling in subsoil.

PHYSICAL PROPERTIES (TOPSOIL)

		RANGE	MEAN		RANGE	MEAN
GRAVEL %	....	0–65	21	FIELD CAPACITY (%)	7–14	8
SILT + CLAY (%)	....	5–15	10	WILTING POINT (%)	1–5	3
DEPTH TO WATER TABLE (cm)		27–90+	....	AVAIL. MOISTURE (%)	3–9	5

CHEMICAL PROPERTIES (TOPSOIL)

		RANGE	MEAN			RANGE	MEAN
pH	....	5·3–6·1	5·8	EXCH. Ca(me%)	....	0·3–3·1	1·7
N%	....	0·03–0·23	0·07	EXCH. Mg(me%)	....	0·2–1·1	0·6
P (ppm)	....	5–26	17	C.E.C. (me%)	....	4·4–11·1	7·4
K (me%)	....	0·02–0·47	0·18	SATURATION (%)	....	13–67	36

(e) BROAD DESCRIPTION

Gravelly sands, moist to wet in winter, dry in summer, of medium fertility. This is a broad transitional segment between swamps and gravelly slopes, held together by species groups BROMO, BROFEM, FERMO.

SEGMENT W CO-ORDINATES low — F1, low — F2, low ± F3, low — F4.

PLOTS 65, 45, 36, 118, 170, 149, 90.

(a) INDICATOR SPECIES

GROUPS	INDIVIDUAL SPECIES
BROMO	.... *Lepidosperma angustatum, Mesomelaena tetragona, Synaphea petiolaris.*
BROFER	.... *Hakea lissocarpha.*
FERMO	.... *Hypocalymma angustifolium, Eucalyptus patens, Acacia extensa.*

Less consistently :

BROWET	.... *Leptocarpus scariosus, Leptospermum ellipticum.*
BROFEM	.... *Dampiera alata.*

(b) TREE STRATUM

		RANGE	MEAN
GENERAL: Moderately dense, of medium height	BASAL AREA (m^2/ha)	24–54	33
	HEIGHT (m)	18–32	27

COMPOSITION: Equal admixture of *Eucalyptus marginata, Eucalyptus calophylla* and *Eucalyptus patens.*

(c) TOPOGRAPHICAL AND GEOGRAPHICAL POSITION

		RANGE	MEAN
CURVATURE: Concave	SLOPE (degrees)	1–4	3
GENERAL: Lower slopes and valley floors	ROCK OUTCROPS: Rare, occasionally granite		

(d) SOIL

GENERAL: Yellow-brown or orange-brown sandy loams to loams occasionally with lateritic gravel, especially in the subsoil.

PHYSICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN		RANGE	MEAN
GRAVEL %	0–26	14	FIELD CAPACITY (%)	3–35	16
SILT + CLAY (%)	13–20	12	WILTING POINT (%)	1–12	6
DEPTH TO WATER TABLE (cm)	27–90	....	AVAIL. MOISTURE (%)	1–22	9

CHEMICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN			RANGE	MEAN
pH	5·5–6·3	6·0	EXCH. Ca(me%)	....	1·0–6·4	3·5
N%	0·05–0·34	0·14	EXCH. Mg(me%)	....	0·7–5·4	1·9
P (ppm)	12–66	36	C.E.C. (me%)	....	7·0–23·0	10·6
K (me%)	0·25–0·86	0·58	SATURATION (%)	....	33–67	55

(e) BROAD DESCRIPTION

Moist sandy loams on lower slopes and valley floors, with tendency to excessive wetness in winter.

SEGMENT C. CO-ORDINATES low — F1, med to high + F2, low ± F3, low to med ± F4

PLOTS 40, 49, 159, 171.

(a) INDICATOR SPECIES

GROUPS	INDIVIDUAL SPECIES
BROWET	.... *Leptocarpus scariosus.*
BROMO	.... *Mesomelaena tetragona, Lepidosperma angustatum.*
WETAL	.... *Agonis linearifolia, Eucalyptus megacarpa.*
FERMO	.... *Hypocalymma angustifolium, Eucalyptus patens.*

Less consistently :

BROFEM	.... *Dampiera alata, Baeckea camphorosmae.*

(b) TREE STRATUM

		RANGE	MEAN
GENERAL: Low to medium density and height	BASAL AREA (m^2/ha)	15–24	19
	HEIGHT (m)	20–27	24

COMPOSITION: Chiefly *Eucalyptus patens* with admixture of *Eucalyptus megacarpa, Eucalyptus calophylla, Eucalyptus marginata.* Occasionally also *Eucalyptus rudis, Banksia littoralis.*

(c) TOPOGRAPHICAL AND GEOGRAPHICAL POSITION

		RANGE	MEAN
CURVATURE: Concave	SLOPE (degrees)	1–2	1
GENERAL: Valley floor	ROCK OUTCROPS: Occasional outcropping of secondary (valley) laterite in form of sills.		

(d) SOIL

GENERAL: Sandy loam to sandy clay topsoil, sandy clay subsoil, colour yellow-grey to brown.

PHYSICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN		RANGE	MEAN
GRAVEL %	0–78	23	FIELD CAPACITY (%)	6–13	9
SILT + CLAY (%)	7–33	18	WILTING POINT (%)	3–7	5
DEPTH TO WATER TABLE (cm)	10–70	....	AVAIL. MOISTURE(%)	3–6	5

CHEMICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN			RANGE	MEAN
pH	4·5–6·0	5·6	EXCH. Ca(me%)	....	0·9–3·3	2·3
N%	0·04–0·39	0·15	EXCH. Mg(me%)	....	0·3–4·2	1·8
P (ppm)	19–101	46	C.E.C. (me%)	....	6·1–28·3	12·1
K (me%)	0·05–0·64	0·33	SATURATION (%)	....	25–69	44

(e) BROAD DESCRIPTION

Moist to wet sandy loams along creeks and on margins of swamps.
Plot 40 differs from the rest in several aspects, such as heavier occurrence of group BROFEM and heavier soil texture. It shares with them the occurrence of key group WETAL and shallow depth to ground-water table.

SEGMENT F CO-ORDINATES low ± F1, low + F2, low ± F3, low ± F4.

PLOTS 4, 5, 8, 25, 127, 129.

(a) INDICATOR SPECIES

GROUPS	INDIVIDUAL SPECIES
EAGSAN	.... *Stirlingia latifolia.*
BROWET	.... *Leptocarpus scariosus.*
SANLEA	.... *Nuytsia floribunda, Caustis dioica,*

Less consistently :

BROMO	.... *Mesomelaena tetragona.*
DRYSAG	.... *Daviesia pectinata.*

(b) TREE STRATUM

		RANGE	MEAN
GENERAL: Low, medium density	BASAL AREA (m²/ha)	7–18	21
	HEIGHT (m)	15–27	20

COMPOSITION: *Eucalyptus marginata* almost without admixture or second storey.

(c) TOPOGRAPHICAL AND GEOGRAPHICAL POSITION

		RANGE	MEAN
CURVATURE: Uniform to concave	SLOPE (degrees)	1-2	1
GENERAL: Lower slopes and broad upland depressions	ROCK OUTCROPS: Nil		

(d) SOIL

GENERAL: Coarse grey sand over yellow sand.

PHYSICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN		RANGE	MEAN
GRAVEL %	Nil		FIELD CAPACITY (%)	2–5	3
SILT + CLAY (%)	2–6	3	WILTING POINT (%)	1	1
DEPTH TO WATER TABLE (cm)	>150	....	AVAIL. MOISTURE (%)	1–3	2

CHEMICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN		RANGE	MEAN
pH	4·5–6·1	5·5	EXCH. Ca(me%)	0·4–2·7	1·5
N%	0·01–0·04	0·02	EXCH. Mg(me%)	0·1–0·7	0·4
P (ppm)	6–46	19	C.E.C. (me%)	0·6–15·5	5·2
K (me%)	0·07–0·24	0·15	SATURATION (%)	22–65	40

(e) BROAD DESCRIPTION

Mildly sloping sand plains, generally on lower slopes of broad eastern valleys.
Additional indicators not fully tested, but found quite consistently are *Lysinema ciliatum, Gompholobium tomentosum, Bossiaea eriocarpa, Calytrix flavescens.*

SEGMENT J. CO-ORDINATES low—F1, high + F2, low ⊥ F3, low ⊥ F4.

PLOTS 126, 128, 43, 45, 97, 68, 89, 107.

(a) INDICATOR SPECIES

GROUPS	INDIVIDUAL SPECIES
SANLEA	.... *Conospermum stoechadis, Hibbertia polystachya, Nuytsia floribunda, Lyginia tenax.*
BROMO	.... *Mesomelaena tetragona, Lepidosperma angustatum.*
BROWET	.... *Leptocarpus scariosus.*
DRYGRA	.... *Patersonia rudis, Styphelia tenuiflora.*

Less consistently :

EAGSAN	.... *Stirlingia latifolia, Isopogon dubius, Sphaerolobium medium.*
BROFEM	.... *Baeckea camphorosmae, Dampiera alata.*

(b) TREE STRATUM

		RANGE	MEAN
GENERAL: Medium density and height	BASAL AREA (m²/ha)	5–28	14
	HEIGHT (m)	10–28	21

COMPOSITION: *Eucalyptus marginata, Eucalyptus calophylla, Eucalyptus patens* at the moist and *Banksia attenuata* at the dry end of the range.

(c) TOPOGRAPHICAL AND GEOGRAPHICAL POSITION

		RANGE	MEAN
CURVATURE: Uniform to concave	SLOPE (degrees)	1-3	2
GENERAL: Lower slopes and broad upland depressions	ROCK OUTCROPS: Nil		

(d) SOIL

GENERAL: Deep, pale yellow-grey sand, frequently underlain by lateritic gravel in sandy clay matrix at depth.

PHYSICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN		RANGE	MEAN
GRAVEL %	2–18	4	FIELD CAPACITY (%)	2–8	4
SILT + CLAY (%)	1–8	5	WILTING POINT (%)	1–3	2
DEPTH TO WATER TABLE (cm)	>90	....	AVAIL. MOISTURE (%)	2–4	3

CHEMICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN		RANGE	MEAN
pH	5·6–6·1	6·0	EXCH. Ca(me%)	0·5–1·9	1·2
N%	0·02–0·04	0·03	EXCH. Mg(me%)	0·2–1·4	0·5
P (ppm)	7–14	10	C.E.C. (me%)	4·7–8·0	6·2
K (me%)	0·03–0·15	0·10	SATURATION (%)	18–57	31

(e) BROAD DESCRIPTION

Leached sands in medium to low-rainfall zone.

SEGMENT H. CO-ORDINATES low -|- F1, high -|- F2, low -|- F3, low -|- F4.

PLOTS (124, 99, 108, 153) (123, 70, 62, 94, 44, 117, 100, 87) (105, 14, 6, 135, 106, 41, 56, 58, 98)

(a) INDICATOR SPECIES

GROUPS	INDIVIDUAL SPECIES
BROMO	.... *Mesomelaena tetragona, Synaphea petiolaris, Lepidosperma angustatum.*
EAGSAN	.... *Stirlingia latifolia, Sphaerolobium medium, Hakea cyclocarpa, Isopogon dubius*
DRYSAG	.... *Dariesia pectinata, Hakea ruscifolia.*
DRYGRA	.... *Styphelia tenuiflora, Patersonia rudis, Acacia strigosa.*

Less consistently :

BROFER	.... *Hakea lissocarpha*
BROFEM	.... *Baeckea camphorosmae.*
SANGRA	.... *Casuarina fraseriana.*

(b) TREE STRATUM

		RANGE	MEAN
GENERAL: Variable	BASAL AREA (m^2/ha)	2-57	26
	HEIGHT (m)	19-33	25

COMPOSITION: Overwhelmingly *Eucalyptus marginata*, little *Eucalyptus calophylla*, some second storey of *Casuarina fraseriana* and *Banksia grandis*.

(c) TOPOGRAPHICAL AND GEOGRAPHICAL POSITION

		RANGE	MEAN
CURVATURE: Uniform to concave	SLOPE (degrees)	1-16	3
GENERAL: Lower and middle slope in mildly undulating landscape, eastern zone	ROCK OUTCROPS: Occasional low outcropping of lateritic ironstone.		

(d) SOIL

GENERAL: Yellow-grey sand or loamy sand merging into lateritic gravel at depth.

PHYSICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN		RANGE	MEAN
GRAVEL %	0-71	24	FIELD CAPACITY (%)	2-15	12
SILT + CLAY (%)	2-15	9	WILTING POINT (%)	1-9	8
DEPTH TO WATER TABLE (cm)	>90	....	AVAIL. MOISTURE (%)	1-6	4

CHEMICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN		RANGE	MEAN
pH	4·9-6·4	6·0	EXCH. Ca(me%)	0·4-6·3	2·1
N%	0·02-0·10	0·05	EXCH. Mg(me%)	0·1-4·4	0·9
P (ppm)	3-100	28	C.E.C. (me%)	3·2-29·3	8·2
K (me%)	0·05-1·20	0·27	SATURATION (%)	11-94	41

(e) BROAD DESCRIPTION

Gravelly sands in low-rainfall zone.

This large group of plots could be further subdivided into three subgroups, as indicated by brackets above. The first of these, characterized by *Stirlingia latifolia*, tends toward segment F; the second, characterized by *Mesomelaena tetragona*, tends toward segment E. The third has no definite trend.

SEGMENT P CO-ORDINATES low -|- F1, mod. to high -|- F2, high -|- F3, high -|- F4.

PLOTS 154, 61, 2, 143, 130, 47, 114, 51, 54, 116, 141, 60, 113, 156.

(a) INDICATOR SPECIES

GROUPS	INDIVIDUAL SPECIES
BROMO	.... *Lepidosperma angustatum, Lechenaultia biloba.*
SANGRA	.... *Casuarina fraseriana, Grevillea wilsonii*
DRYGRA	.... *Styphelia tenuiflora, Patersonia rudis, Acacia strigosa.*
GRAMED	.... *Banksia grandis, Adenanthos barbigera, Hovea chorizemifolia, Persoonia longifolia.*

Less consistently :

DRYSAG	.... *Dariesia pectinata, Hakea ruscifolia.*
GRAHIR	.... *Lasiopetalum floribundum.*
FREGRA	.... *Phyllanthus calycinus, Trymalium ledifolium.*

(b) TREE STRATUM

		RANGE	MEAN
GENERAL: Moderately tall, dense stand	BASAL AREA (m^2/ha)	18-78	40
	HEIGHT (m)	24-35	29

COMPOSITION: Overwhelmingly *Eucalyptus marginata* with occasional *Eucalyptus calophylla*; strong development of second storey of *Casuarina fraseriana* and *Banksia grandis*.

(c) TOPOGRAPHICAL AND GEOGRAPHICAL POSITION

		RANGE	MEAN
CURVATURE: Mostly uniform	SLOPE (degrees)	0-12	4
GENERAL: Mild, lower and middle slopes	ROCK OUTCROPS: Moderately frequent occurrence of isolated lateritic ironstone outcrops.		

(d) SOIL

GENERAL: Lateritic gravel with sand or loamy sand matrix, or sand with heavy gravel.

PHYSICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN		RANGE	MEAN
GRAVEL %	15-73	55	FIELD CAPACITY (%)	5-11	7
SILT + CLAY (%)	4-18	8	WILTING POINT (%)	2-6	3
DEPTH TO WATER TABLE (cm)	Not detected		AVAIL. MOISTURE (%)	2-5	3
	Much greater than 90				

CHEMICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN		RANGE	MEAN
pH	5·4-7·1	6·1	EXCH. Ca(me%)	0·5-8·9	3·5
N%	0·01-0·14	0·06	EXCH. Mg(me%)	0·4-3·4	1·0
P(ppm)	12-100	35	C.E.C. (me%)	2·2-21·7	8·4
K (me%)	0·05-0·99	0·30	SATURATION (%)	11-78	54

(e) BROAD DESCRIPTION

Gravelly sands and sandy gravels, occurring on mid and lower slopes in medium and high-rainfall zone.

SEGMENT Z CO-ORDINATES low + F1, low + F2, low + F3, low + F4.

PLOTS (151) (37, 19, 11, 46, 13, 9, 23, 18).

(a) INDICATOR SPECIES

GROUPS	INDIVIDUAL SPECIES
FREGRA	*Phyllanthus calycinus, Macrozamia riedlei, Leocopogon capitellatus, Leucopogon propinquus.*
BROFER	*Hakea lissocarpha.*
DRYGRA	*Stypheliа tenuiflora, Patersonia rudis, Acacia strigosa.*

Less consistently :

BROMO	*Lepidosperma angustatum, Lechenaultia biloba, Synaphea petiolaris*

(b) TREE STRATUM

		RANGE	MEAN
GENERAL: Open forest	BASAL AREA (m^2/ha)	11–62	29
	HEIGHT (m)	20–32	24

COMPOSITION: Chiefly *Eucalyptus marginata* with admixture of *Eucalyptus calophylla*. Second storey largely missing.

(c) TOPOGRAPHICAL AND GEOGRAPHICAL POSITION

		RANGE	MEAN
CURVATURE: Mainly uniform	SLOPE (degrees)	2–8	5

GENERAL: Mainly valley slopes

ROCK OUTCROPS: Variable with none to heavy ironstone and occasional granite.

(d) SOIL

GENERAL: Grey-brown loamy sands to sandy loams with moderate to heavy admixture of lateritic gravel, frequently over base of gravel in clay matrix.

PHYSICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN		RANGE	MEAN
GRAVEL %	30–75	50	FIELD CAPACITY (%)	6–18	12
SILT + CLAY (%)	7–13	10	WILTING POINT (%)	2–7	4
DEPTH TO WATER TABLE (cm)	>90	....	AVAIL. MOISTURE (%)	4–10	6

CHEMICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN		RANGE	MEAN
pH	5·6–6·1	5·9	EXCH. Ca(me%)	0·7–8·4	4·9
N%	0·03–0·18	0·10	EXCH. Mg(me%)	0·2–2·7	1·4
P (ppm)	3–143	58	C.E.C. (me%)	4·3–17·1	11·9
K (me%)	0·05–0·99	0·24	SATURATION (%)	15–87	56

(e) BROAD DESCRIPTION

This segment is representative of upper slopes and uplands in medium to low-rainfall zone. The composition of the soil and the combination of the indicator groups indicates that it is a drier equivalent of segment S.

Plot 151, which virtually doubles the basal area range for this segment, has been placed here although it has a very poor development of the key group, DRYGRA, simply because it would be too small a group on its own or even in combination with plot 150 from segment S, which resembles it in many respects.

SEGMENT S CO-ORDINATES low to med. + F1, medium — F2, high + F3, high + F4.

PLOTS 150, 109, 112, 152, 115, 155, 133, 137, 38.

(a) INDICATOR SPECIES

GROUPS	INDIVIDUAL SPECIES
GRAMED	*Banksia grandis, Persoonia longifolia, Hovea chorizemifolia, Adenanthos barbigera.*
FREGRA	*Macrozamia riedlei, Phyllanthus calycinus, Leucopogon capitellatus, Leucopogon propinquus.*
DRYGRA	*Acacia strigosa, Stypheliа tenuiflora, Patersonia rudis.*

Less consistently :

BROMO	*Lepidosperma angustatum, Lechenaultia biloba.*
SANGRA	*Casuarina fraseriana.*
GRAHIR	*Bossiaea aquifolium. Lasiopetalum floribundum, Acacia urophylla.*
HIGRA	*Leucopogon verticillatus.*
DRYSAG	*Daviesia pectinata.*

(b) TREE STRATUM

		RANGE	MEAN
GENERAL: Moderately tall, dense stand	BASAL AREA (m^2/ha)	27–64	39
	HEIGHT (m)	23 35	30

COMPOSITION: Predominantly *Eucalyptus marginata* with some *Eucalyptus calophylla* and second storey of *Banksia grandis, Persoonia longifolia* and *Casuarina fraseriana*

(c) TOPOGRAPHICAL AND GEOGRAPHICAL POSITION

		RANGE	MEAN
CURVATURE: Uniform or convex.	SLOPE (degrees)	2–9	5

GENERAL: Mid and upper slopes, plateaus and ridges in medium to high-rainfall zone.

ROCK OUTCROPS: Frequent massive lateritic ironstone.

(d) SOIL

GENERAL: Yellow to orange heavy lateritic gravel with loamy sand matrix.

PHYSICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN		RANGE	MEAN
GRAVEL %	21–76	51	FIELD CAPACITY (%)	8–15	10
SILT + CLAY (%)	8–12	10	WILTING POINT (%)	3–6	4
DEPTH TO WATER TABLE (cm)	Mostly greater than 90	....	AVAIL. MOISTURE (%)	4–8	6

CHEMICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN		RANGE	MEAN
pH	5·5–6·6	6·1	EXCH. Ca(me%)	1·3–4·0	2·9
N%	0·08–0·43	0·25	EXCH. Mg(me%)	0·4–1·1	0·8
p (ppm)	8–43	25	C.E.C. (me%)	3·9–12·2	6·9
K (me%)	0·08–0·74	0·35	SATURATION (%)	36–87	59

(e) BROAD DESCRIPTION

Heavy gravels with sandy loam matrix, occurring on slopes, ridges and plateaus in medium to high-rainfall zones.

SEGMENT T CO-ORDINATES high | F1, high | F2, high | F3, medium to high | F4.

PLOTS (172, 168, 162, 167) (157, 140, 142, 132, 111).

(a) INDICATOR SPECIES

GROUPS	INDIVIDUAL SPECIES
HIGRA	.... *Leucopogon verticillatus, Pteridium esculentum, Clematis pubescens.*
FREGRA	.... *Macrozamia riedlei, Leucopogon capitellatus, Leucopogon propinquus, Phyllanthus calycinus*
GRAHIR	.... *Acacia urophylla, Lasiopetalum floribundum, Bossiaea aquifolium.*

Less consistently :

FEHIRA	.... *Chorizema ilicifolium.*
GRAMED	.... *Banksia grandis, Adenanthos barbigera.*
FERMO	.... *Eucalyptus patens.*
DRYGRA	.... *Styphelia tenuiflora, Acacia strigosa, Patersonia rudis.*
BROFER	.... *Hakea lissocarpha.*

(b) TREE STRATUM

		RANGE	MEAN
GENERAL: Tall, dense stand	BASAL AREA (m^2/ha)	26-44	35
	HEIGHT (m)	29-39	33

COMPOSITION: *Eucalyptus marginata* with moderate admixture of *Eucalyptus calophylla*, in few plots also *Eucalyptus patens*, second storey of *Banksia grandis, Persoonia longifolia.*

(c) TOPOGRAPHICAL AND GEOGRAPHICAL POSITION

		RANGE	MEAN
CURVATURE: Mainly convex	SLOPE (degrees)	2-15	7
GENERAL: Upper slopes and ridges in strongly dissected, high-rainfall western zone.	ROCK OUTCROPS: Heavy massive lateritic ironstone, occasional granite and epidiorite.		

(d) SOIL

GENERAL: Orange to brown gravel with sandy loam to loam matrix, in a few marginal cases loam with medium gravel.

PHYSICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN		RANGE	MEAN
GRAVEL %	3-84	44	FIELD CAPACITY (%)	11-23	16
SILT + CLAY (%)	9-46	25	WILTING POINT (%)	5-14	8
DEPTH TO WATER TABLE (cm)	Much greater than 90	....	AVAIL. MOISTURE (%)	5-11	8

CHEMICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN		RANGE	MEAN
pH	5·8-6·9	6·1	EXCH. Ca(me%)	2·3-14·7	7·3
N%	0·06-0·30	0·14	EXCH. Mg(me%)	1·2-5·8	2·5
P (ppm)	10-188	89	C.E.C. (me%)	6·5-25·9	14·8
K (me%)	0·20-1·04	0·60	SATURATION (%)	45-80	70

(e) BROAD DESCRIPTION

In the northern portion of the jarrah forest, this segment is very much restricted to the slopes of the strongly dissected high-rainfall western zone. By contrast, it is more broadly distributed in the southern portion.

The segment can be subdivided into two groups, one characterized by the presence of *Adenanthos barbigera* and *Leptomeria cunninghamii*, having a lower silt and clay fraction.

The other is characterized by the absence of *Adenanthos* and some occurence of *Eucalyptus patens*, and *Chorizema ilicifolium* having a markedly higher silt and clay fraction and higher fertility. It has a strong affinity to Segment U.

SEGMENT U CO ORDINATES high | F1, high | F2, low | F3, low | F4.

PLOTS, 138, 139, 35.

(a) INDICATOR SPECIES

GROUPS	INDIVIDUAL SPECIES
FERMO	.... *Eucalyptus patens.*
FREGRA	.... *Macrozamia riedlei*, some *Leucopogon capitellatus, Phyllanthus calycinus.*
HIGRA	.... *Pteridium esculentum, Clematis pubescens*, some *Leucopogon verticillatus.*

(b) TREE STRATUM

		RANGE	MEAN
GENERAL: Moderately tall, dense stand	BASAL AREA (m^2/ha)	34-59	49
	HEIGHT (m)	26-31	29

COMPOSITION: Mixture of *Eucalyptus patens* and *Eucalyptus calophylla.*

(c) TOPOGRAPHICAL AND GEOGRAPHICAL POSITION

		RANGE	MEAN
CURVATURE: Uniform	SLOPE (degrees)	1-5	3
GENERAL: Uniform slope in dissected high-rainfall western zone	ROCK OUTCROPS: Nil		

(d) SOIL

GENERAL: Brown sandy loam over clay loam at 40 cm.

PHYSICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN		RANGE	MEAN
GRAVEL %	0-36	14	FIELD CAPACITY (%)	33-40	36
SILT + CLAY (%)	15-23	20	WILTING POINT (%)	13-15	14
DEPTH TO WATER TABLE (cm)	30 for plot only 35		AVAIL. MOISTURE (%)	20-24	22

CHEMICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN		RANGE	MEAN
pH	6·1-6·3	6·2	EXCH. Ca(me%)	6·0-18·1	13·1
N%	0·22-0·41	0·32	EXCH. Mg(me%)	5·8-7·1	6·5
P (ppm)	105-277	201	C.E.C. (me%)	16·1-30·7	25·6
K (me%)	0·32-1·54	1·11	SATURATION (%)	78-84	82

(e) BROAD DESCRIPTION

Fertile loams on slopes of main river valleys in high rainfall zone.

The members of this group all occur on the peripheries of former agricultural clearings, and although heavily wooded, may have been subject to considerable disturbance in the past. If this is so, plots 138 and 139 should be combined with the fertile subgroup of segment T, and plot 35 with segment Q, with which they have much in common. The former group would be retained as Segment U. This would result in a narrower, clearer definition of Segment T.

SEGMENT R CO-ORDINATES medium + F1, low — F2, high + F3, low — F4.

PLOTS 17, 95, 131, 110, 10, 53, 16.

(a) INDICATOR SPECIES

GROUPS	INDIVIDUAL SPECIES
FREGRA	*Trymalium ledifolium, Phyllanthus calycinus, Macrozamia riedlei, Leucopogon capitellatus, Leucopogon propinquus*
BROFER	*Hakea lissocarpha*
Common species of broad distribution patterns :	*Hibbertia hypericoides, Hibbertia montana, Dryandra nivea, Grevillea synapheae.*
Less consistently :	
BROMO	*Lepidosperma angustatum, Lechenaultia biloba.*
DRYGRA	*Styphelia tenuiflora, Patersonia rudis, Acacia strigosa.*
GRAMED	*Adenanthos barbigera, Leptomeria cunninghamii.*

(b) TREE STRATUM

		RANGE	MEAN
GENERAL: Open forest, irregular stocking	BASAL AREA (m²/ha)	10–38	21
	HEIGHT (m)	16–30	26

COMPOSITION: Mainly *Eucalyptus marginata* with admixture of *Eucalyptus calophylla.*

(c) TOPOGRAPHICAL AND GEOGRAPHICAL POSITION

		RANGE	MEAN
CURVATURE: Uniform or concave	SLOPE: (degrees)	1–9	5
GENERAL: Valley slopes, frequently in proximity to granite outcrops	ROCK OUTCROPS: Variable, from none to heavy.		

(d) SOIL

GENERAL: Grey to brown sandy loam to sandy clay with admixture of lateritic gravel.

PHYSICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN		RANGE	MEAN
GRAVEL %	32–66	58	FIELD CAPACITY (%)	20–37	28
SILT + CLAY (%)	9–20	15	WILTING POINT (%)	8–21	15
DEPTH TO WATER TABLE (cm)	90	....	AVAIL. MOISTURE (%)	11–15	13

CHEMICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN			RANGE	MEAN
pH	5·2–6·3	5·9	EXCH. Ca(me%)	....	1·3–16·8	7·3
N%	0·03–0·54	0·19	EXCH. Mg(me%)	....	0·6–6·9	2·8
P (ppm)	12–209	80	C.E.C. (me%)	....	6·3–39·0	18·5
K (me%)	0·08–0·82	0·40	SATURATION(%)	....	33–79	60

(e) BROAD DESCRIPTION

Gravels with loamy to clayey matrix, occurring chiefly on lower and middle slopes of valleys, probably representing admixture of the ironstone gravel and kaolinitic clay from the old lateritic

SEGMENT Q. CO-ORDINATES + low F1, + high F2, + medium F3, — high F4.

PLOTS 148, 163, 161, 164, 166, 169, 22, 160, 165.

(a) INDICATOR SPECIES

GROUPS	INDIVIDUAL SPECIES
FERMO	*Hypocalymma angustifolium, Eucalyptus patens, Acacia extensa.*
FEHIRA	*Trymalium spathulatum, Chorizema ilicifolium.*
FREGRA	*Macrozamia riedlei, Phyllanthus calycinus, Trymalium ledifolium, Leucopogon capitellatus, Leucopogon propinquus.*
DRYFER	*Hakea lissocarpha.*
Less consistently :	
DRYFER	*Hibbertia lineata.*
HIGRA	*Pteridium esculentum.*
BROMO	*Lepidosperma angustatum*
GRAHIR	*Lasiopetalum floribundum.*

(b) TREE STRATUM

		RANGE	MEAN
GENERAL: Moderately tall and dense stand	BASAL AREA (m²/ha)	17–46	29
	HEIGHT (m)	24–38	31

COMPOSITION: Mainly *Eucalyptus patens* with admixture of *Eucalyptus calophylla* and some *Eucalyptus marginata.*

(c) TOPOGRAPHICAL AND GEOGRAPHICAL POSITION

		RANGE	MEAN
CURVATURE: Uniform or Convex	SLOPE (degrees)	2–6	4
GENERAL: Lower and middle slopes, high-rainfall zone	ROCK OUTCROPS: Occasional lateritic or epidioritic boulders.		

(d) SOIL

GENERAL: Dark brown sandy or silty loam over red-brown clay loam.

PHYSICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN		RANGE	MEAN
GRAVEL %	0–44	18	FIELD CAPACITY (%)	14–30	20
SILT + CLAY (%)	15–34	18	WILTING POINT (%)	4–11	9
DEPTH TO WATER TABLE (cm)	120 and above	....	AVAIL. MOISTURE (%)	8–16	11

CHEMICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN			RANGE	MEAN
pH	5·8–7·2	6·3	EXCH. Ca (me%)	....	1·0–9·8	4·7
N%	0·08–0·24	0·14	EXCH. Mg(me%)	....	0·8–5·1	2·2
P (ppm)	56–211	114	C.E.C. (me%)	....	5·8–17·0	10·4
K (me%)	0·44–1·14	0·82	SATURATION (%)	....	34–92	67

(e) BROAD DESCRIPTION

One of the best sites from the point of view of fertility and moisture, occurring chiefly on slopes of major valleys in western high rainfall zone.

SEGMENT M CO-ORDINATES low + F1, low + F2, low + F3, medium + F4.

PLOTS (30, 24, 42) (1, 29, 12) (33, 121, 32) (15, 136, 34, 21)

(a) INDICATOR SPECIES

GROUPS	INDIVIDUAL SPECIES
	Eucalyptus wandoo.
BROFER	*Hakea lissocarpha.*
FREGRA	*Macrozamia riedlei.*

Other common species, not tested fully by CORD program, include :

Acacia pulchella, Loxocarya flexuosa, Kennedia prostrata, Ptilotus manglesii.

Less consistently :

DRYFER	*Gastrolobium calycinum.*
FERMO	*Hypocalymma angustifolium, Eucalyptus patens.*
BROFEM	*Baeckea camphorosmae, Dampiera alata.*
DRYGRA	*Patersonia rudis.*

(b) TREE STRATUM

		RANGE	MEAN
GENERAL: Open stand of medium height	BASAL AREA (m^2/ha)	5–19	12
	HEIGHT (m)	21–37	27

COMPOSITION: Largely *Eucalyptus wandoo* with occasional *Eucalyptus patens* at lower and *Eucalyptus marginata* at upper range of occurrence. Second storey missing.

(c) TOPOGRAPHICAL AND GEOGRAPHICAL POSITION

		RANGE	MEAN
CURVATURE: Uniform to concave.	SLOPE (degrees)	2–9	4
GENERAL: Valley slopes in middle and upper reaches of valley in dry eastern zone.	ROCK OUTCROPS: Either none or scattered ironstone floaters.		

(d) SOIL

GENERAL: Brown sandy loam to loam over yellow or red-brown clay loam.

PHYSICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN		RANGE	MEAN
GRAVEL %	6–73	41	FIELD CAPACITY (%)	7–27	19
SILT + CLAY (%)	12–27	18	WILTING POINT (%)	2–11	7
DEPTH TO WATER TABLE (cm)	With one exception >90		AVAIL. MOISTURE(%)	4–16	11

CHEMICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN		RANGE	MEAN
pH	5·5–6·6	6·3	EXCH. Ca(me%)	2·9–11·1	7·4
N%	0·01–0·29	0·16	EXCH. Mg(me%)	0·8–3·0	1·8
P (ppm)	43–262	126	C.E.C. (me%)	7·5–18·8	12·8
K (me%)	0·22–1·24	0·75	SATURATION (%)	48–95	75

(e) BROAD DESCRIPTION

Loams with medium to heavy admixture of lateritic gravel, occurring chiefly on valley slopes in dry eastern zone.

On both edaphic and topographic characteristics and in terms of vegetation it represents a drier equivalent of R. This large segment could be subdivided on the occurrence of *Macrozamia riedlei* and *Hypocalymma angustifolium* but the advantage of this is difficult ...

SEGMENT L CO-ORDINATES low F1, low F2, low + F3, high + F4.

PLOTS 26, 27, 28, 134

(a) INDICATOR SPECIES

GROUPS	INDIVIDUAL SPECIES
	Eucalyptus wandoo.
BROFER	*Hakea lissocarpha.*
FERMO	*Eucalyptus patens, Hypocalymma angustifolium.*
DRYFER	*Diplolaena drummondii, Hibbertia lineata.*

The following species, not otherwise used as indicators, also occur consistently :

Acacia pulchella.
Hibbertia montana.

(b) TREE STRATUM

		RANGE	MEAN
GENERAL: Open stand of medium height	BASAL AREA (m^2/ha)	2–19	14
	HEIGHT (m)	24–31	28

COMPOSITION: Mainly *Eucalyptus wandoo* with admixture of *Eucalyptus patens.* On one occasion, away from the plots, *Acacia acuminata* has been observed in this type.

(c) TOPOGRAPHICAL AND GEOGRAPHICAL POSITION

		RANGE	MEAN
CURVATURE: Concave	SLOPE (degrees)	2–5	4
GENERAL: Lower slopes, dry eastern zone.	ROCK OUTCROPS: Few ironstone floaters		

(d) SOIL

GENERAL: Brown silty loam over red-brown clay loam.

PHYSICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN		RANGE	MEAN
GRAVEL %	0–50	12	FIELD CAPACITY (%)	23–33	28
SILT + CLAY (%)	14–31	24	WILTING POINT (%)	7–11	9
DEPTH TO WATER TABLE (cm)	30 in one plot >90 in others		AVAIL. MOISTURE(%)	15–21	18

CHEMICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN		RANGE	MEAN
pH	5·5–6·5	6·1	EXCH. Ca(me%)	7·0–18·5	13·4
N%	0·27–0·34	0·31	EXCH. Mg(me%)	2·7–4·7	3·8
P (ppm)	64–306	199	C.E.C. (me%)	20·9–26·4	23·1
K (me%)	0·79–0·98	0·93	SATURATION (%)	49–96	79

(e) BROAD DESCRIPTION

Fertile loams on lower slopes in low-rainfall zone. The paucity of perennial species in three of the plots may reflect grazing disturbance in the area half-a-century ago. In both edaphic topographic features and in some species-groups, this segment is a drier equivalent of segment Q. This is particularly true of plot 134.

SEGMENT Y CO-ORDINATES low — F1, low ± F2, low ± F3, low — F4.

PLOTS 103, 104, 119. 31, 20, 122.

(a) INDICATOR SPECIES

GROUPS	INDIVIDUAL SPECIES
	Eucalyptus wandoo.
BROFER	*Hakea lissocarpha.*
FERMO	*Hypocalymma angustifolium.*
BROFEM	*Baeckea camphorosmae, Dampiera alata.*
DRYFER	*Hibbertia lineata, Gastrolobium calycinum.*
BROMO	*Mesomelaena tetragona, Lepidosperma angustatum.*
Occasionally	
SANLEA	*Hibbertia polystachya.*

(b) TREE STRATUM

		RANGE	MEAN
GENERAL: Open stand of medium height	BASAL AREA (m^2/ha)	7–20	13
	HEIGHT (m)	20–31	27

COMPOSITION: *Eucalyptus wandoo* virtually without any associates or second storey.

(c) TOPOGRAPHICAL AND GEOGRAPHICAL POSITION

		RANGE	MEAN
CURVATURE: Concave	SLOPE (degrees)	1–5	3
GENERAL: Valley floors and lower slopes	ROCK OUTCROPS: Nil		

(d) SOIL

GENERAL: Yellow-grey sandy loam to sandy clay over pale yellow or grey sandy clay at varying depth.

PHYSICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN		RANGE	MEAN
GRAVEL %	0–27	10	FIELD CAPACITY (%)	7–33	14
SILT + CLAY (%)	12–25	19	WILTING POINT (%)	2–9	4
DEPTH TO WATER TABLE (cm)	15 and above		AVAIL. MOISTURE (%)	4–23	9

CHEMICAL PROPERTIES (TOPSOIL)

	RANGE	MEAN			RANGE	MEAN
pH	5·8–6·3	6·1	EXCH. Ca(me%)	....	2·3–5·7	3·9
N%	0·06–0·34	0·12	EXCH. Mg(me%)	....	1·0–2·7	1·7
P (ppm)	14–85	56	C.E.C. (me%)	....	7·2–14·7	10·7
K (me%)	0·17–1·36	0·60	SATURATION (%)	....	44–82	60

(e) BROAD DESCRIPTION

Pale loamy soils which become hard and crusted in summer and waterlogged in winter, occurring in broad valleys in eastern dry zone.

APPENDIX 5

List of plant species referred to in Bulletins 86 and 87.

Acacia acuminata Benth.
Acacia aneura F. Muell. ex Benth.
Acacia alata R.Br.
Acacia cyanophylla Lindl.
Acacia drummondii Lindl.
Acacia extensa Lindl.
Acacia microbotrya Benth.
Acacia nigricans R.Br.
Acacia pulchella R.Br.
Acacia sibirica S.Moore
Acacia strigosa Link. *
Acacia urophylla Benth.
Actinostrobus pyramidalis Miq.
Adenanthos barbigera Lindl.
Adenanthos cygnorum Diels.
Adenanthos meissneri Lehm.
Adenanthos obovata Labill.
Adiantum aethiopicum L.
Agonis flexuosa (Spreng.) Schau.
Agonis juniperina Schau.
Agonis linearifolia (DC.) Schau.
Agonis parviceps Schau.
Albizzia lophantha (Willd.) Benth.
Astartea fascicularis (Labill.) DC.
Astroloma ciliatum (Lindl.) Druce
Astroloma pallidum R.Br.
Baeckea camphorosmae Endl.
Banksia attenuata R.Br.
Banksia grandis Willd.
Banksia ilicifolia R.Br.
Banksia littoralis R.Br.
Banksia littoralis R.Br.var. *seminuda* A. S. George
Banksia menziesii R.Br.
Banksia prionotes Lindl.
Boronia spathulata Lindl.
Borya nitida Labill.
Bossiaea aquifolium Benth.
Bossiaea linophylla R.Br.
Bossiaea ornata (Lindl.) Benth.
Bossiaea pulchella Meissn.
Brachychiton gregorii F. Muell.
Callitris preissii Miq.
Calytrix flavescens A. Cunn.
Casuarina decussata Benth.
Casuarina fraseriana Miq. **
Casuarina huegeliana Miq.
Casuarina humilis Otto & Dietr.
Casuarina obesa Miq.
Caustis dioica R.Br.
Chorilaena quercifolia Endl.
Chorizema ilicifolium Labill.
Clematis pubescens Hueg.
Codonocarpus cotinifolius (Desf.) F.Muell.
Conospermum stoechadis Endl.
Conospermum triplinervium R.Br.
Conostylis aculeata R.Br.
Conostylis setigera R.Br.
Cyathochaete clandestina R.Br.
Dampiera alata Lindl.
Dampiera linearis R.Br.
Dasypogon bromeliaefolius R.Br.
Daviesia longifolia Benth.
Daviesia pectinata Lindl.
Daviesia polyphylla Benth. ex Lindl.
Daviesia preissii Meissn.
Daviesia rhombifolia Meissn.
Dillwynia cinerascens R.Br.
Diplolaena microcephala Bartl. var. *drummondii* Benth.
Dryandra bipinnatifida R.Br.
Dryandra nivea R.Br.
Dryandra sessilis (Knight) Domin
Eucalyptus accedens W.V.Fitzg.
Eucalyptus astringens Maiden

* Since the completion of the field work, taxonomic revision has resulted in the subdivision of *Acacia strigosa* Link. into *Acacia preissiana* (Meissn.) B. R. Maslin and *Acacia lateriticola* B. R. Maslin. Where uncertainty exists as to which of the two new species is involved, the old name has been retained.

** The rectification of an old spelling error has resulted in the recent changing of *Casuarina fraseriana* to *Casuarina fraserana.* This announcement came too late for the amendment to be made in this Bulletin, and the incorrect spelling therefore remains.

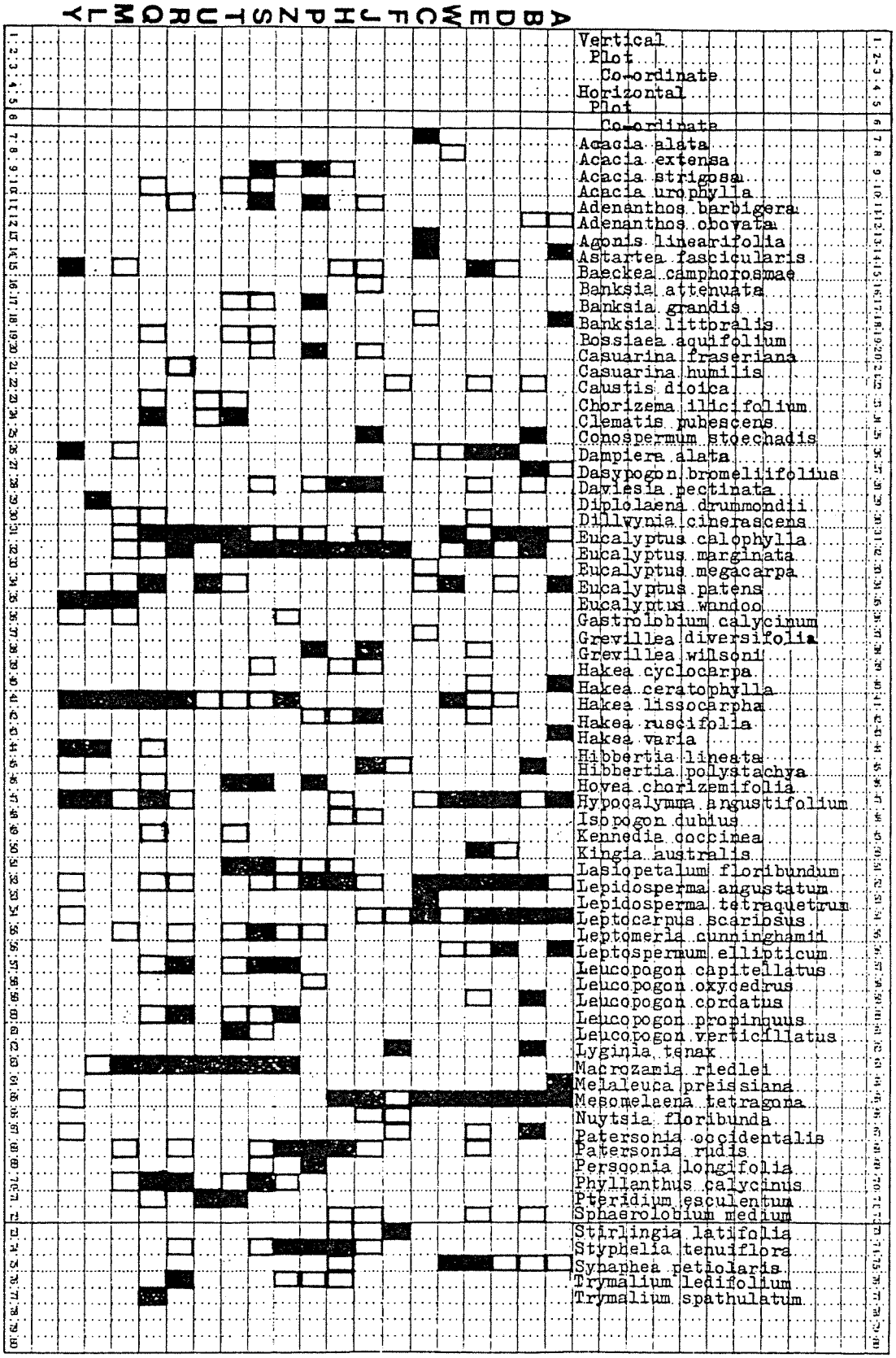


Figure 20

Table of indicator species used in allocation of new field observations to appropriate site-vegetation types by matching. Three levels of occurrence are used as follows:

a) completely blank—species should be absent;

b) outline only—species should be present, but absence not critical;

c) outline filled—species should be present.