PROGRESS REPORT TO DIEBACK-RESEARCH FUND
1980

The Effect of Improving the Nutrition of the Jarrah Forest on "Jarrah Dieback"

F.J. HINGSTON (Project Leader)

CSIRO, Division of Land Resources Management

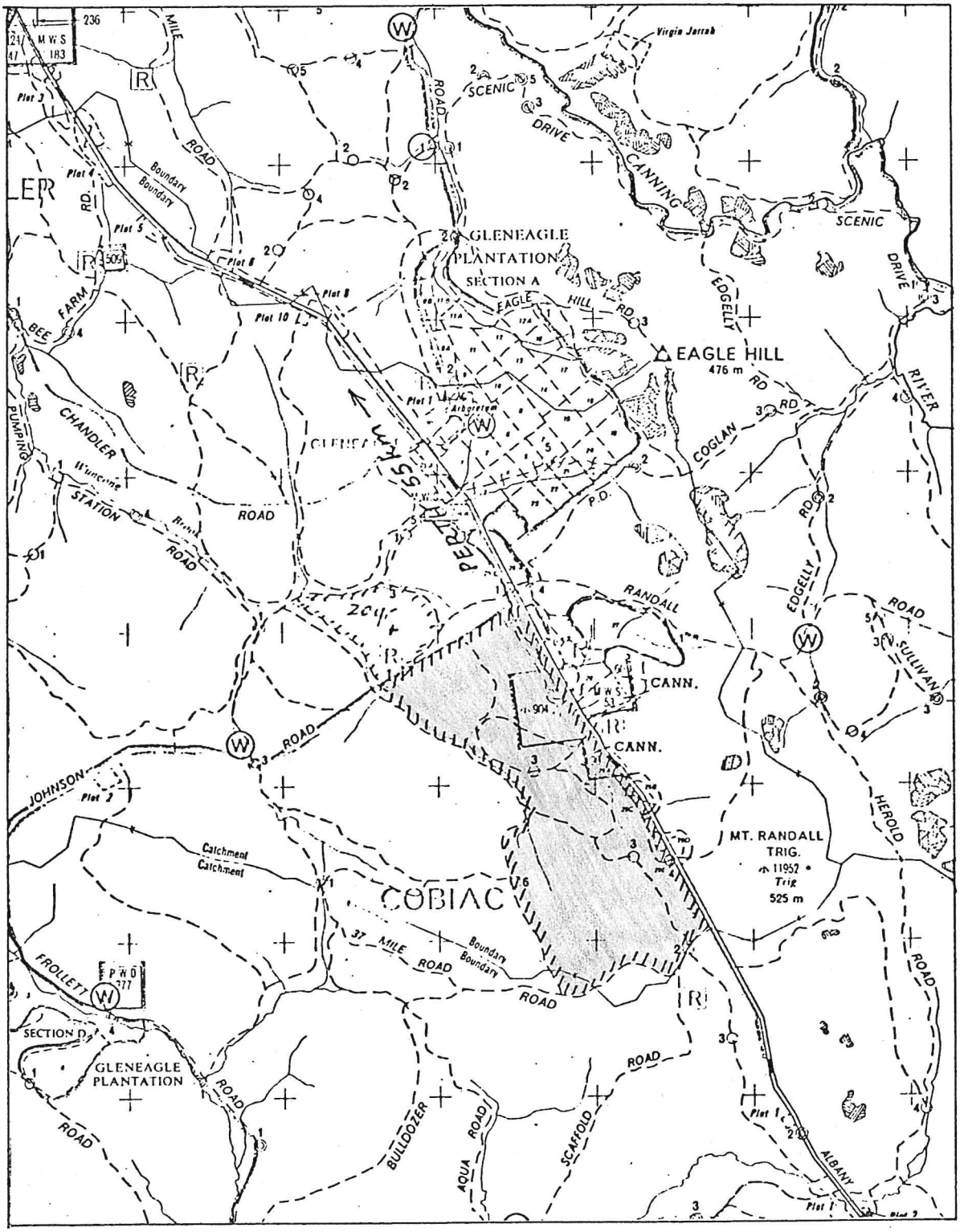

Figure 1. Location of experimental area

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1. MAIN THRUST OF RESEARCH

To determine the effect of lifting the nutrient levels in the jarrah forest ecosystem by fertilization on its susceptibility to attack by Phytophthora cinnamomi.

1.1 Approach:

(a) To determine the effect of fertilizers on the forest plant community (e.g. banksias, legumes, eucalypts), growth responses and proportions of species in the community.

(b) To determine the effects of responses of vegetation to fertilizer on the forest environment, e.g. shading and mulching due to increased litter-fall (soil temperature and moisture), increased microbial activity in the forest floor due to nutrients and litter accumulation, drier forest site due to increase in water uptake by fertilized vegetation.

(c) To study the effects of changes in the litter-soil environment on survival and pathogenicity of P. cinnamomi.

1.2 Phasing of the Study

(1) Selection and characterisation of the forest site.

(2) Application of treatments, burning and fertilizer application.

(3) Measurement of response.

(4) Studies of pathogenicity of P. cinnamomi on treated plots.

2. PROGRESS

2.1 Phase 1: The selected area of forest (Figure 1) has been surveyed for soils and vegetation.

A selection of maps showing the distribution and density of the major plant species, and a map of soil distribution are included as Appendices (Appendix 1 to 8).

Soils: The soils on the 600 hectare site were examined at two positions near each peg on the 200 x 200 m grid. Six major soil units and their proportions in the area are listed below:

TABLE 1

Shrub species (< 1.4m high) identified in the experimental plots, Cobiac Forest Block

	BLOCK A ($2000m^2$) PLOTS 1-20		BLOCK B ($2000m^2$) PLOTS 21-40		BLOCK C ($2000m^2$) PLOTS 41-60		($6000m^2$) PLOTS 1-60	
SPECIES	NUMBER OF TIMES FOUND	COVER* AREA (m^2)	NUMBER OF TIMES FOUND	COVER* AREA (m^2)	NUMBER OF TIMES FOUND	COVER* AREA (m^2)	NUMBER OF TIMES FOUND	COVER* AREA (m^2)
Acacia alata	15	16.25	0	0.00	2	0.17	17	16.42
Adenanthos barbigerus	20	25.65	19	29.10	20	36.70	59	91.45
Banksia grandis	19	21.30	20	30.70	20	24.58	59	76.58
Boronia spathulata	20	10.02	15	7.00	20	5.81	55	22.83
Bossiaea ornata	20	96.30	20	93.60	20	117.30	60	307.20
Casuarina fraserana	10	5.90	17	11.33	12	11.30	39	28.53
Eucalyptus calophylla	15	16.60	13	3.96	15	10.41	43	30.97
Eucalyptus marginata	20	20.88	20	8.03	17	10.86	57	39.77
Hibbertia montana	20	3.81	20	4.50	20	5.95	60	14.26
Hibbertia perfoliata	15	2.15	13	0.97	16	5.30	44	8.42
Hovea chorizemifolia	20	0.55	13	0.19	17	0.24	50	0.98
Lasiopetalum floribundum	20	51.00	17	38.15	7	21.05	44	110.20
Lepidosperma tenue	20	52.25	20	36.80	20	34.30	60	123.35
Lomandra sonderi	19	32.60	16	9.80	19	21.35	54	63.75
Lomandra collina	3	0.16	11	2.76	16	5.55	30	8.47
Lomandra ? rigida	20	13.35	19	7.83	15	4.62	54	25.80
Persoonia longifolia	12	3.86	14	7.52	15	3.57	41	14.95
Tetratheca viminea	15	0.24	13	0.18	11	0.14	39	0.56
Xanthorrhoea gracilis	20	88.80	7	21.80	9	23.60	36	134.20
Xanthorrhoea preissii	8	104.50	19	416.00	16	116.30	43	636.80
Xanthosia atkinsoniana	20	0.40	13	0.15	10	0.12	43	0.67
Xanthosia peltigera	11	0.26	5	0.09	15	0.27	31	0.62
Cyathocaete clandestina	20	79.65	9	8.25	12	35.60	41	123.50
Sedge	15	0.47	15	0.66	18	1.40	48	2.53
Grasses	16	0.83	18	1.47	17	1.15	51	3.45
Conostylis setosa	14	1.42	9	1.80	13	1.61	36	4.83
Loxocarya flexuosa	12	65.40	10	25.00	13	39.60	35	130.00
Macrozamia riedlei	14	22.50	14	26.40	8	7.40	36	56.30
Mean No. sp. per plot	31.3		27.8		30.9		30.0	
Mean % cover per plot	38.5		41.2		30.3		36.6	

\+ 89 species recorded
25 species occurred > 15 times in one block

* Based on % cover estimation

TABLE 2

Distribution and basal area at breast height (ABH) of trees in the exerimental plots, Cobiac Forest Block

BLOCK	PLOT	*Eucalyptus marginata* No. of Stems	*Eucalyptus marginata* Mean ABH (cm^2)	*Eucalyptus calophylla* No. of Stems	*Eucalyptus calophylla* Mean ABH (cm^2)	*Casuarina fraserana* No. of Stems	*Casuarina fraserana* Mean ABH (cm^2)	*Banksia grandis* No. of Stems	*Banksia grandis* Mean ABH (cm^2)	*Persoonia longifolia* No. of Stems	*Persoonia longifolia* Mean ABH (cm^2)	*Persoonia elliptica* No. of Stems	*Persoonia elliptica* Mean ABH (cm^2)
A	1	170	336	16	329	54	353	308	29	12	26	2	58
	2	93	658	33	307	14	569	342	23	23	15	1	104
	3	71	775	30	253			160	26	18	23	3	115
	4	174	424	41	188	1	266	89	31	4	25	8	104
	5	37	3600	7	789	66	319	124	30	8	64	2	64
	6	128	385	45	223	22	830	141	43	17	27		
	7	134	394	7	217	14	590	88	47	12	28		
	8	47	726	8	415	56	436	122	62	31	29		
	9	73	515	7	197	54	565	78	54	15	25	1	108
	10	288	290	20	154	31	441	85	23	2	18		
Total stems and mean ABH for Block		1215	525	214	260	312	460	1537	33	142	27	17	96
B	11	52	947	17	591	32	970	61	77	7	39	2	227
	12	141	308	23	280	25	710	79	31	33	27	1	152
	13	67	647	25	154	31	713	114	50	16	30		
	14	52	1183	4	214	40	638	43	78	3	48	3	81
	15	30	1120	19	164	66	853	78	59	20	28		
	16	40	1243	5	342	63	495	68	48	4	22	3	73
	17	52	1171	14	574	21	507	106	59	50	37		
	18	33	578	6	692	87	463	100	65	2	90	2	20
	19	150	394	6	330	48	294	111	71	5	46	1	249
	20	60	609	13	214	26	1355	116	48	19	29		
Total stems and mean ABH for Block		673	675	132	325	439	647	876	57	159	33	12	113
C	21	88	849	25	167	31	723	138	38	3	14	3	163
	22	77	1005	14	142	37	576	62	44	12	41		
	23	120	402	16	294	43	784	41	43	12	31	1	93
	24	60	1065	2	2523	14	766	52	46	7	42	5	92
	25	52	878	8	1703	33	648	88	46	10	47		
	26	48	1438	9	2744	15	452	81	31	5	34	2	164
	27	90	560	20	850	1	165	129	43	32	31	1	243
	28	60	816	27	430	12	276	175	58	15	46	2	59
	29	59	904	2	1562	62	632	55	53	8	842	8	92
	30	50	1366	9	686	5	2008	86	65	26	49	2	112
Total stems and mean ABH for Block		704	852	132	698	253	668	907	65	130	89	24	112

(a) Laterite outcrops (8% of the area) - mainly on ridge summits and upper slopes.

(b) Yellow gravels (48% of the area) - upper and mid slopes.

(c) Yellow fine gravels (13% of the area) - lower slopes and gently sloping heads of valleys.

(d) Yellow sands (9% of the area) - lower slope and valley head situations, usually immediately downslope of the yellow fine gravels if these are present. The yellow sands grade into yellow fine gravels.

(e) Grey sands and gravels (2% of the area) - broad low rises, limited in extent.

(f) Orange earths (20% of the area) - all major swampy valley floors.

A toposequence of soils representing upper, mid and lower slope situations was sampled from each of the three areas (blocks) selected for experimental plots. Samples were taken from pits to a depth of 100 cm for chemical and physical analysis and morphological descriptions of the profiles have been recorded. The litter accumulated in the previous five years was sampled from five 0.25m^2 quadrats at each of the pits.

These toposequences were remarkably similar; the gentle upper slopes were occupied by soils with yellow gravelly surface horizons overlying mottled red and yellowish brown clay at about 60 cm depth and were apparently in situ; the steeper mid-slopes and gentler lower slopes carried deep fine gravels, showing some evidence of stratification and are possibly colluvial.

Vegetation: In a survey of the whole area on a 200 x 200 m grid, over 200 species were identified and an estimate made of their percentage cover.

On the 30 plots selected for the fertilizer experiment, two sub-plots 10 x 10 m were marked for subsequent re-measurement. Eighty-nine species of plants were identified and their percentage cover was recorded. The results for the most prominent species are summarized in Table 1.

A total of 7,878 trees were tagged for identification and the basal areas at breast height were measured for each plot (Table 2).

The litter-fall collected monthly over a 12 month period has been recorded at each of the 30 experimental plots.

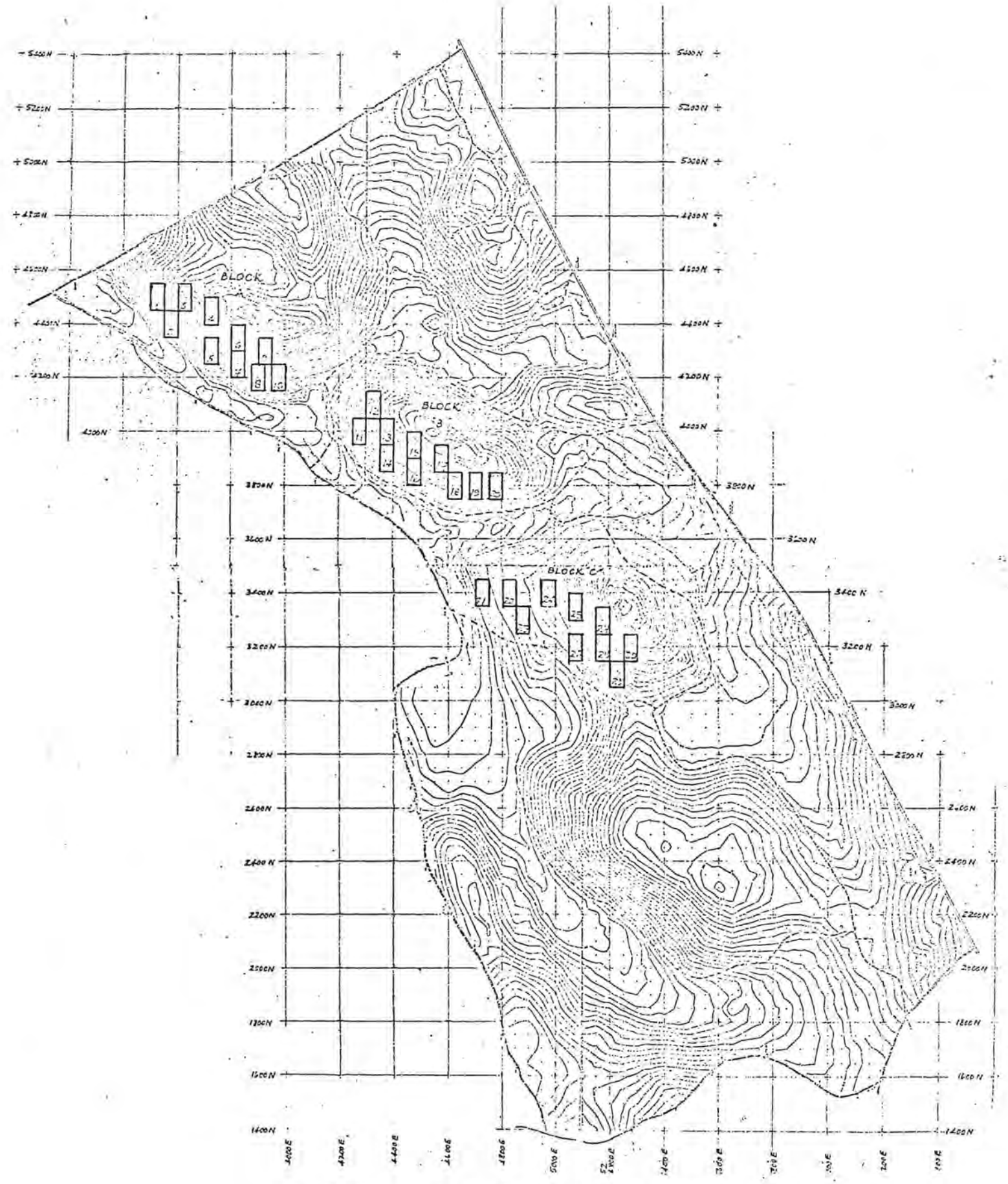


Figure 2. Location of experimental plots

TABLE 3

Elemental composition of jarrah leaves,
Cobiac Forest Block

Leaf (-petiole)	Ca	K	Cl	S	P	Si	Al	Mg	Na	N
Mean Conc.	.750	.465	.405	.114	.044	.091	.017	.468	.195	1.50
S^2	.042	.004	.039	<.001	<.001	<.001	<.001	.004	.004	.003
Source of Variation										
Between Trees: P	<.001	<.002	<.001	<.001	NS	<.01	<.01	.05	<.001	NS
Range Between Trees	.427-1.169	.322-.554	.073-.779	.102-.141	.038-.049	.043-.160	.011-.024	.379-.575	.095-.299	1.44-1.60
Leaf (+petiole)										
Mean Conc.	.807	.459	.404	.111	.043	.103	.018	.463	.201	1.45
S^2	.052	.004	.038	<.001	<.001	<.001	<.001	.004	.004	.003
Source of Variation										
Between Trees: P	<.001	<.001	<.001	<.001	NS	NS	NS	NS	<.001	<.05
Range Between Trees	.517-1.208	.317-.547	.078-.769	.009-.137	.037-.048	.051-.119	.011-.023	.374-.572	.097-.298	1.38-1.55

NS Not significant (P<.05)

TABLE 4

Soil characteristics relating to nitrogen availability, Cobiac Forest Block

Soil Type	Depth (cm)	N (%)	C (%)	Ratio C/N	1. Potentially Mineralizable N ($\mu g\ g^{-1}$)	2. Biomass C ($\mu g\ g^{-1}$)	Flush 3. N-Mineralization (Anaerobic Incubation) ($\mu g\ g^{-1}$)	4. Lipid Phosphate ($\mu g\ g^{-1}$)
Yellow Sand (<2mm fraction)	0-10	.062	2.12	34	57	262	5.8	.80
	10-20	.042	1.26	30	45	106	7.8	.52
	20-30	.032	0.90	28	41	84	7.2	.32
Fine Yellow	0-10	.070	2.94	42	73	128	9.3	.92
	10-20	.030	1.00	33	37	60	3.5	.32
	20-30	.025	0.82	33	36	50	5.0	.27
Yellow Gravel (<2mm fraction)	0-10	.131	5.95	45	216	368	33.8	1.91
	10-20	.055	2.25	41	75	150	15.5	.52
	20-30	.040	1.65	41	64	102	9.4	.32
Orange Earth (<2mm fraction)	0-10	.263	5.77	22	165	266	26.2	1.89
	10-20	.163	2.33	14	68	188	11.0	1.02
	20-30	.132	1.85	14	38	118	8.3	.84

Notes

1. Incubation procedure (Stanford et al. 1974)
2. Method of Jenkinson and Powlson (1976)
3. Method of Waring and Bremner (1964)
4. Method of White et al. (1979)

TABLE 4 (continued)

Relationship between Properties

Linear Regression $Y = b + mX$

Y	X	b	m	r*	Significance
Potentially Mineralizable N ($\mu g\ g^{-1}$)	N-Flush Anaerobic Incubation N ($\mu g\ g^{-1}$)	4.60	6.02	0.98	P<.001
	Biomass-C ($\mu g\ g^{-1}$)	-2.36	0.50	0.86	P<.001
	Total N (%)	32.5	503	0.64	P<.05
	Organic C (%)	1.25	31.21	0.96	P<.001
	Lipid-P ($\mu g\ g^{-1}$)	4.99	88.6	0.90	P<.001
Biomass-C ($\mu g\ g^{-1}$)	Lipid-P ($\mu g\ g^{-1}$)	37.6	148	0.88	P<.001

*r is the correlation coefficient

The vegetation and litter data were analysed statistically for height and aspect effects to determine whether the plots could be arranged to provide more uniformity within blocks than could be obtained by grouping the plots as shown in Figure 2.

The results showed that this blocking could not be significantly improved upon.

Foliar analysis: An exploratory sampling of jarrah foliage has been made to determine the usefulness of foliar analysis for study of response of this species to N and P fertilization (Table 3).

For many elements the results show significant variation between trees. Phosphorus concentrations did not differ significantly between the trees sampled and nitrogen differed only for leaf plus petiole ($P < .05$).

Sampling is to be continued on a seasonal basis as part of the program to measure response.

Glasshouse studies: Glasshouse experiments to determine the response of jarrah seedlings to N and P have shown significant responses and interaction between these nutrients.

Experiments have also been conducted to examine the effect of N, P and other nutrients on the roots of plants infected with P. cinnamomi.

Soil studies: As part of the program to examine the response of the ecosystem to nitrogen and the fate of fertilizer nitrogen, the soils have been studied to determine the characteristics which may determine N mineralization and N immobilization rates. A summary of some of the relationships obtained to date is given in Table 4.

Studies have also been made of the effects of moisture and temperature on the rates of mineralization in representative jarrah forest soils.

2.2 Phase 2 (1981-83 Program): Application of fertilizer and measurement of response.

The site was burnt on 1st December 1980 using a fire of moderate intensity. In April-May 1981, fertilizer treatments are to be applied to selected plots.

Rates of fertilizer application: No fertilizer is to be applied on 3 plots (one in each block) which are to be used as controls. All remaining plots (27) will receive a basal dressing of 4.2 kg K, 0.8 kg Cu, 0.8 kg Zn, 0.1 kg Mo, 4 kg Mn and 19 kg S per hectare.

Superimposed on this basal application will be a factorial experiment with the following rates of N and P:

3 rates of P (0, 50, 200 kg P ha^{-1})

3 rates of N (0, 50, 200 (1st year) + 200 (2nd year) kg N ha^{-1})

Replication 3 x in three blocks

Measurements: It is intended that the following measurements will be made:

(a) Soil moisture and temperature

(b) Litter fall

(c) Litter decomposition

(d) Nutrient uptake, foliar analysis and growth response of selected species.

(e) Botanical composition of shrub community (first measurement in Spring 1981).

(f) N mineralization, immobilization, leaching and denitrification.

(g) Nodulation of legume (Bossiaea ornata).

(h) Studies of ectomycorrhizae (seasonality and responses to nutrients)

(i) Response of roots to fertilizer.

2.3 Phase 3 (1983-84 Program): Studies of pathogenicity of P. cinnamomi on treated plots.

3. STAFF

Professional Staff:

† F.J. Hingston (Project Leader)
N. Malajczuk
† A.M. O'Connell
T.S. Grove
† G.M. Dimmock
† J.H. Galbraith

Technical Staff:

† M.S. Jones
† P.M.A. Menage
*†J.M. Dumaresq
H. Anderson

† Contributors to Phase 1

* Supported by Jarrah Dieback Fund

LIST OF APPENDICES

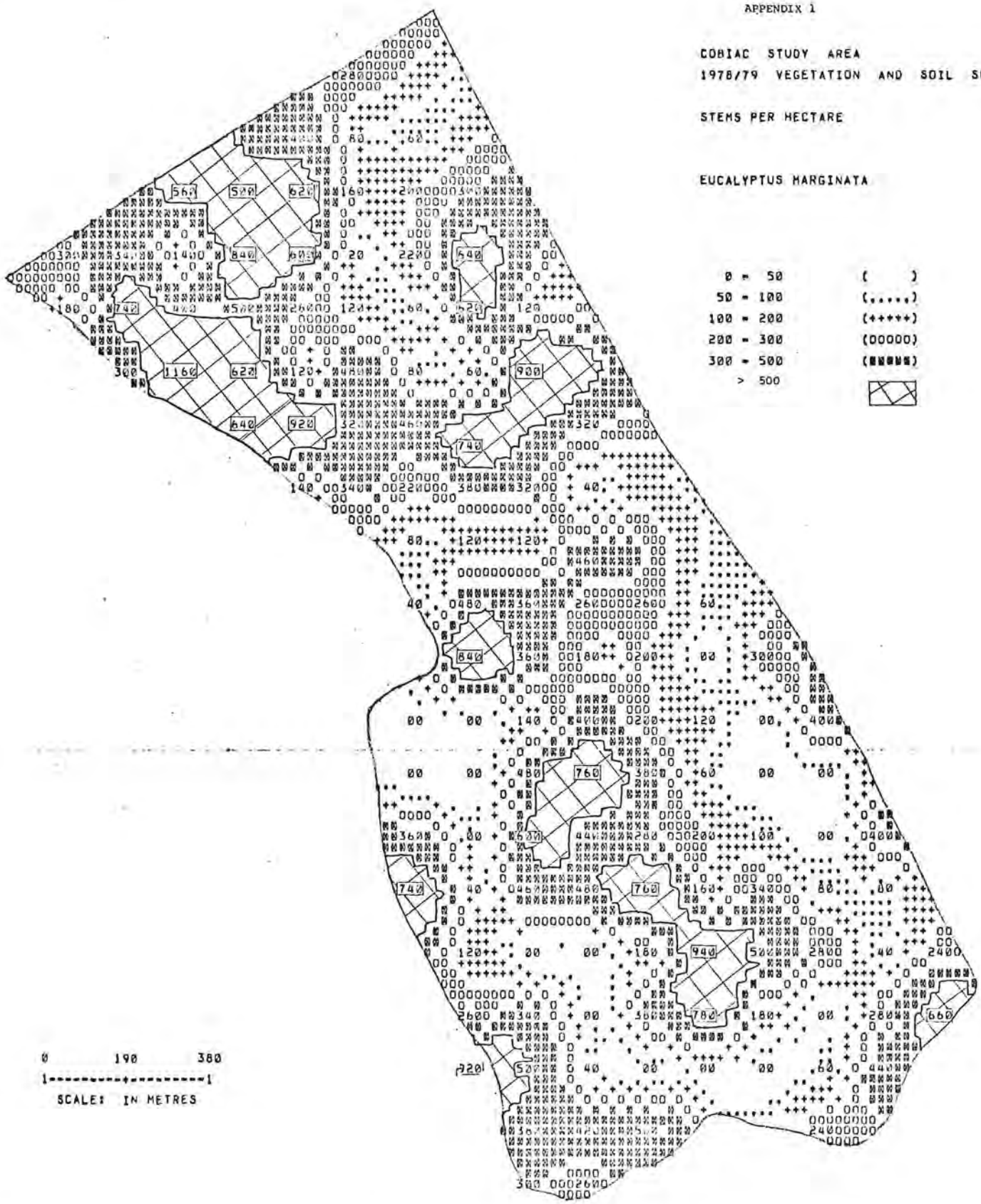
APPENDIX 1

COBIAC STUDY AREA
1978/79 VEGETATION AND SOIL SURVEY

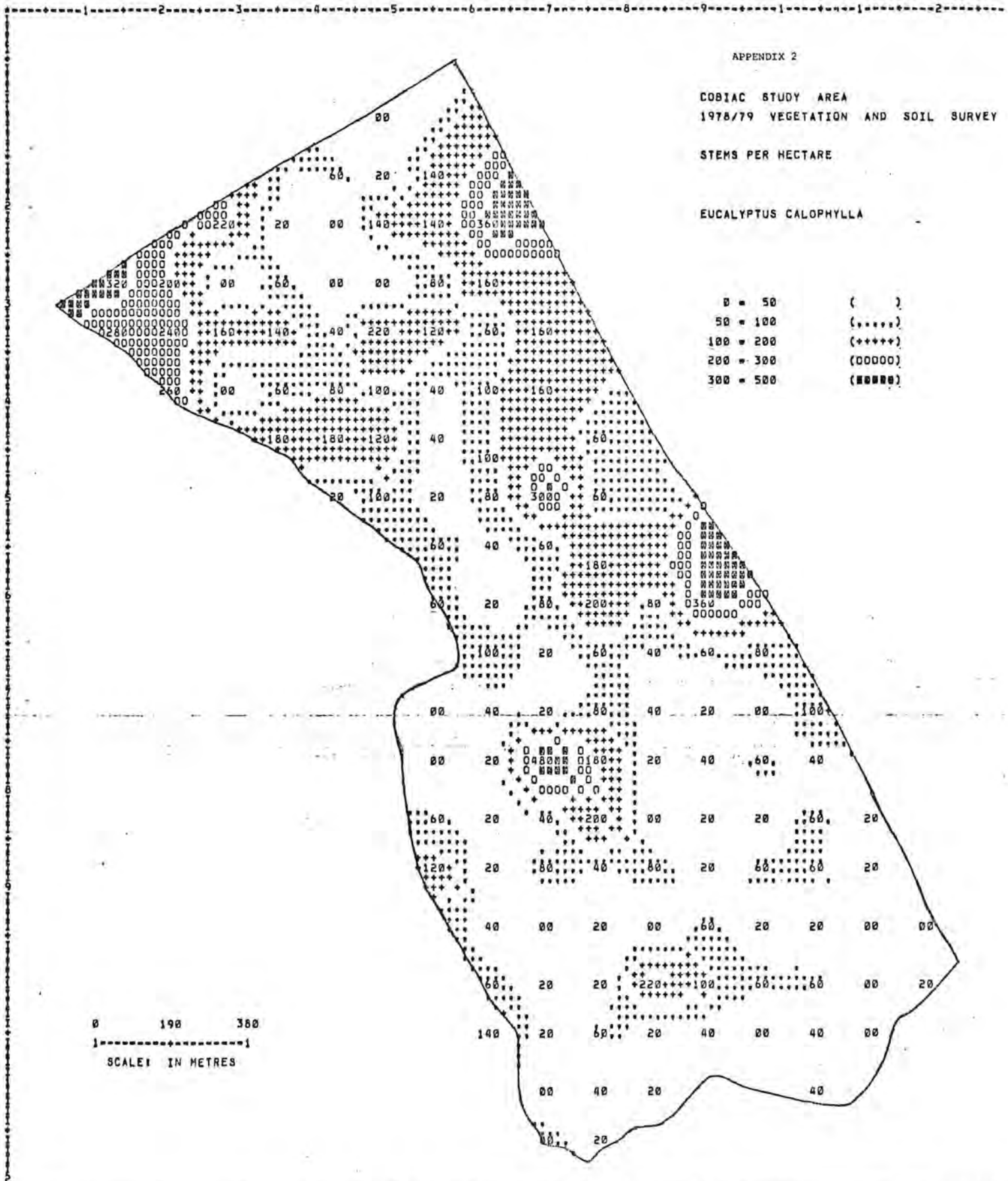
STEMS PER HECTARE

EUCALYPTUS MARGINATA

0 - 50	( )
50 - 100	(.....)
100 - 200	(+++++)
200 - 300	(OOOOO)
300 - 500	(MMMMM)
> 500	



SYMAP


APPENDIX 2
COBIAC STUDY AREA
1978/79 VEGETATION AND SOIL SURVEY
STEMS PER HECTARE
EUCALYPTUS CALOPHYLLA
0 - 50 ( )
50 - 100 (.....)
100 - 200 (+++++)
200 - 300 (OOOOO)
300 - 500 (■■■■■)
0 190 380
SCALE: IN METRES

SYMAP

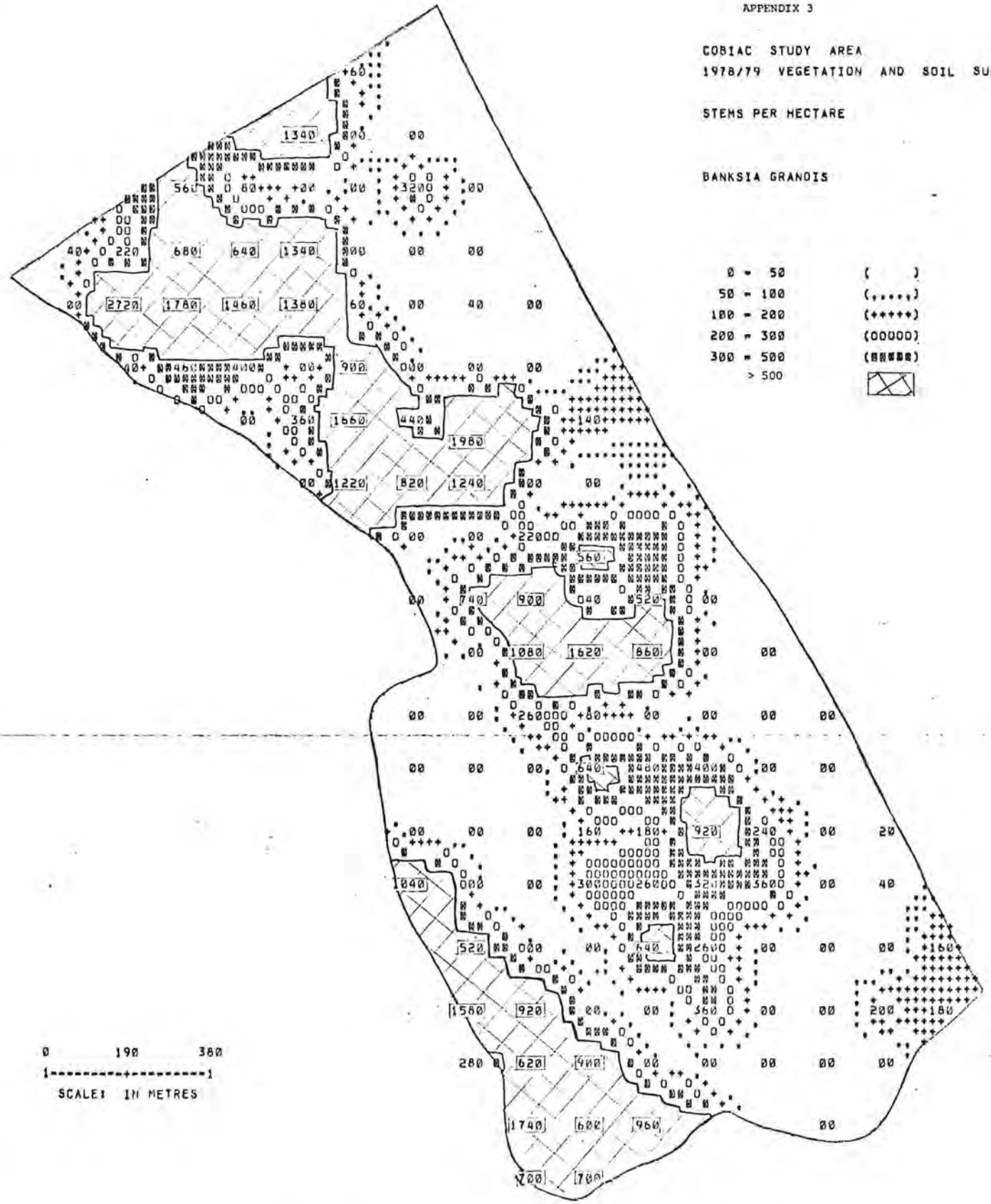
APPENDIX 3

COBIAC STUDY AREA
1978/79 VEGETATION AND SOIL SURVEY

STEMS PER HECTARE

BANKSIA GRANDIS

0 - 50	( )
50 - 100	(,,,,,)
100 - 200	(+++++)
200 - 300	(00000)
300 - 500	(#####)
> 500	



0 190 380
SCALE: IN METRES

SYMAP

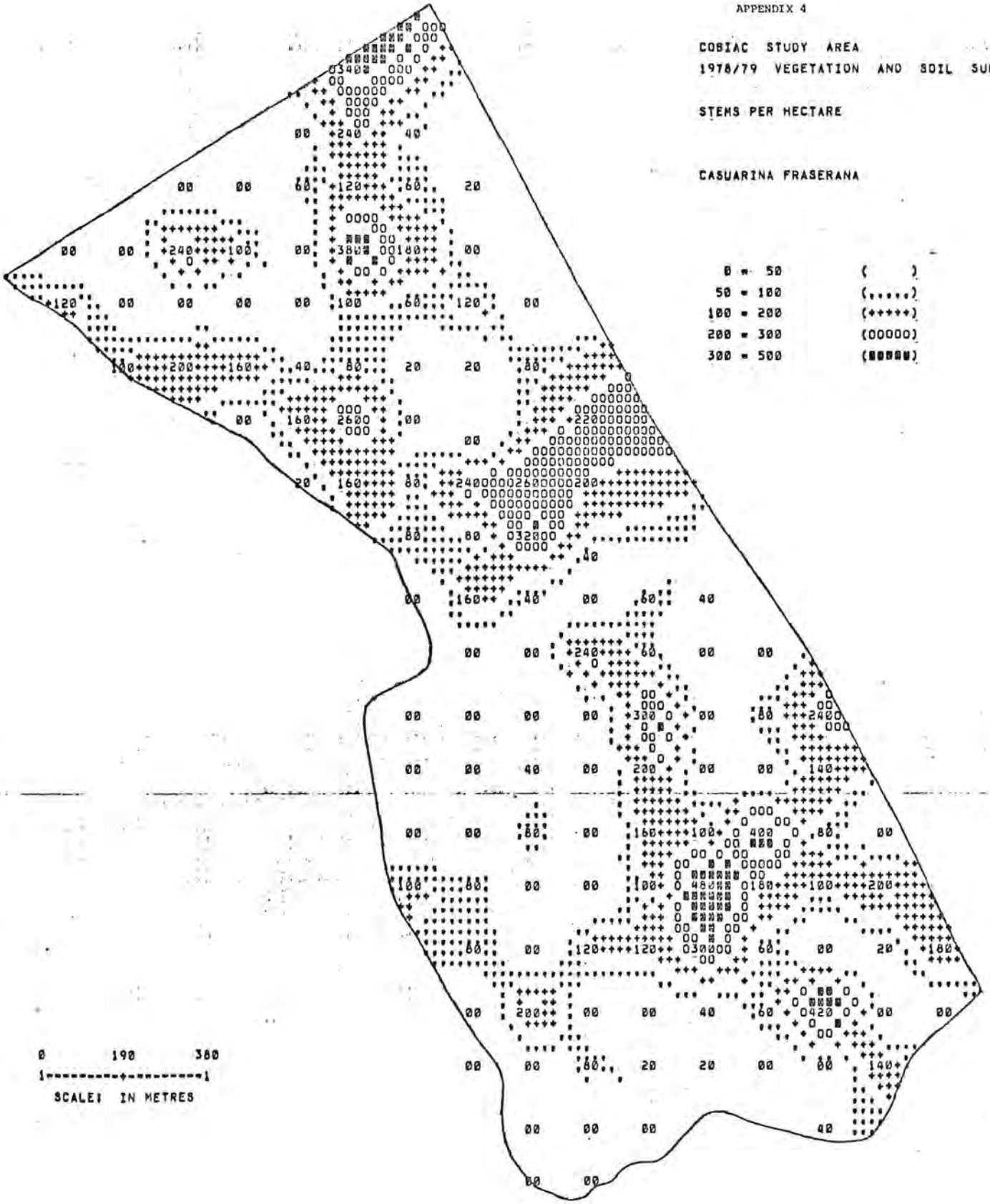
APPENDIX 4

COBIAC STUDY AREA
1978/79 VEGETATION AND SOIL SURVEY

STEMS PER HECTARE

CASUARINA FRASERANA

0 - 50	( )
50 - 100	(.....)
100 - 200	(+++++)
200 - 300	(00000)
300 - 500	(■■■■■)



SYMAP

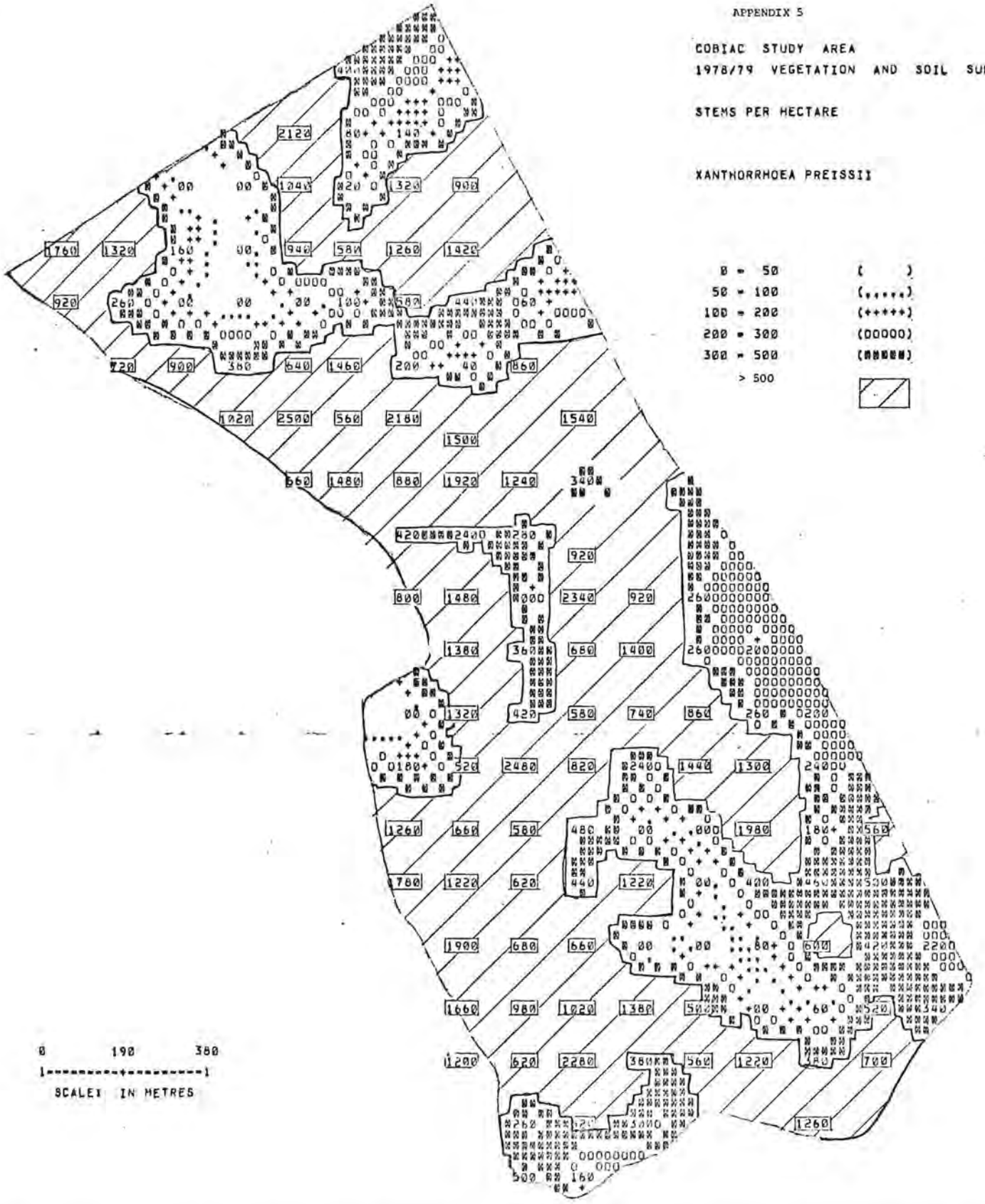
APPENDIX 5

COBIAC STUDY AREA
1978/79 VEGETATION AND SOIL SURVEY

STEMS PER HECTARE

XANTHORRHOEA PREISSII

0 - 50	( )
50 - 100	(.....)
100 - 200	(+++++)
200 - 300	(00000)
300 - 500	(#####)
> 500	



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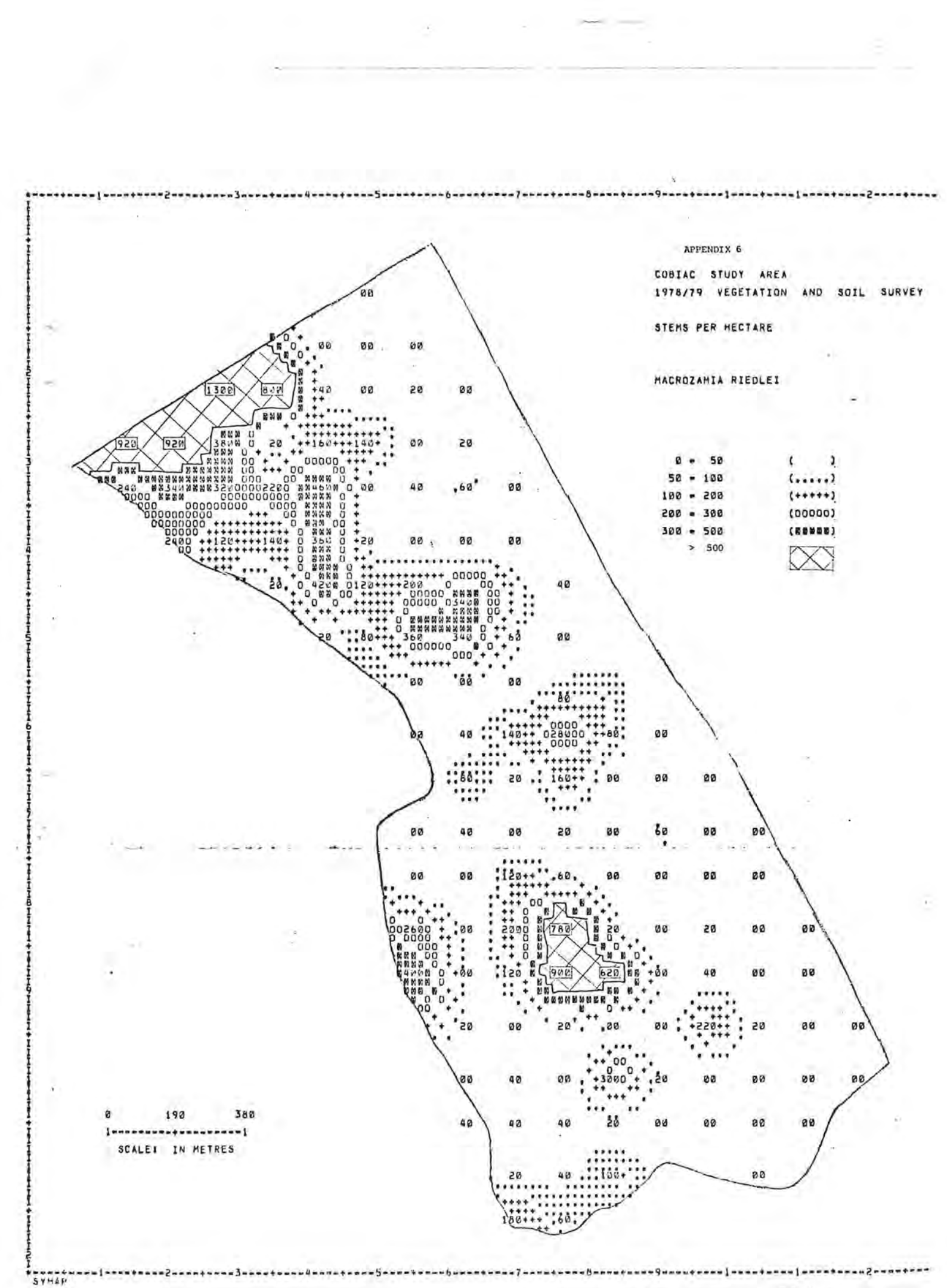
APPENDIX 6
COBIAC STUDY AREA
1978/79 VEGETATION AND SOIL SURVEY
STEMS PER HECTARE
MACROZAMIA RIEDLEI
0 - 50
50 - 100
100 - 200
200 - 300
300 - 500
> 500
0 190 380
SCALE: IN METRES

APPENDIX 7

COBIAC STUDY AREA
1978/79 VEGETATION AND SOIL SURVEY

PERCENT COVER VALUES

BOSSIAEA ORNATA

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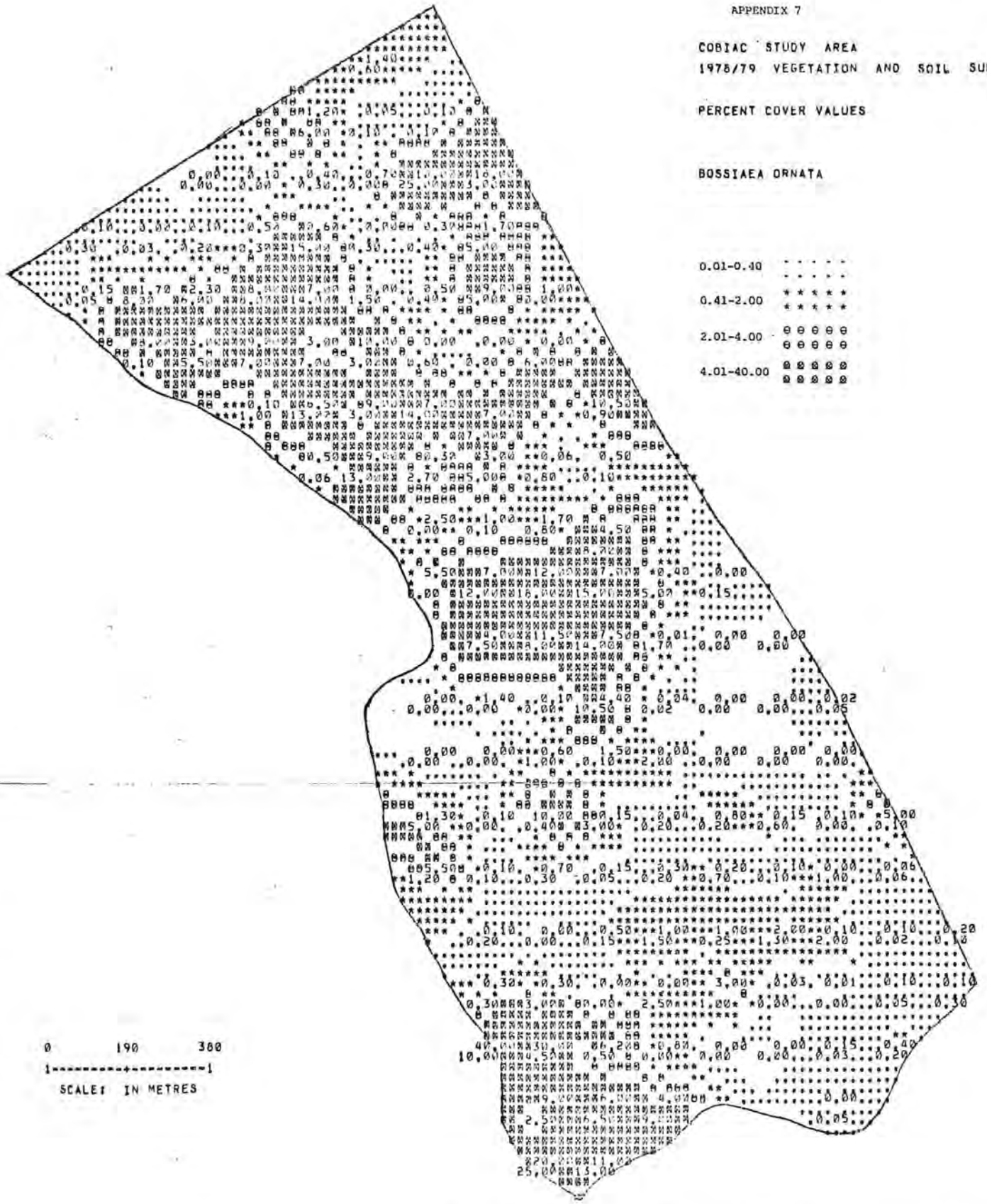
0.41-2.00
2.01-4.00
4.01-40.00



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APPENDIX 8

COBIAC STUDY AREA
1978/79 VEGETATION AND SOIL SURVEY

SOIL MAP