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APPENDIX 1

Changes in nomenclature

The following list provides updated nomenclature for plant species described in this text, including those detailed on old surveys. Nomenclature follows the National Herbarium of New South Wales.

Previous nomenclature	Current nomenclature
Callitirs robusta	*Callitris glaucophylla*
Casuarina lepidophloia	*Allocasuarina cristata*
Casuarina cristata	*Allocasuarina cristata*
Casuarina Leuhmanni	*Allocasuarina leuhmannii*

Scientific names for vegetation described on maps and surveys presented in this thesis.

Common name	Scientific name
Ironbark	*Eucalyptus crebra*
Pine	*Callitris glaucophylla*
Oak	*Allocasuarina leuhmannii*
Apple	*Angophora floribunda*

APPENDIX 2

Soil Profile Descriptions

Soil profiles observed in the field are described and presented here (see also Hart 1992). The location of each profile can be found in Figure 3-2.

For each soil profile the following information is given: location, sampling method (i.e. auger hole, soil pit), general slope and aspect, landform element, vegetation structure, corresponding vegetation site number, substrate, principle profile form (PPF) (after Northcote 1979), drainage, corresponding soil moisture site number or equivalent and other comments such as disturbance and fire.

Profile descriptions are made using the terminology as suggested in the Australian Soil and Land Survey Field Handbook (McDonald et al 1984) and in Northcote (1979). A Japanese colour book (Oyama & Takehara 1970) was used to determine colour, and a CSIRO pH test kit (Inoculo Laboratories, Victoria) was used to determine field pH. Each profile has been classified according to Northcote (1979) Principal Profile Form (PPF).

Soil and vegetation sites were located during several field trips in October 1987 and March and May 1988. The topographic map is Cubbo 8736-N first edition 1:50,000 series (Central Mapping Authority 1974). Sites are located along Dunwerian Road and Pine Road. They are listed here in east to west order from the Junction Road intersection (711 500 mE 6605 800 mN) west to Greens Road intersection with Pine Road (704 200 mE 6605 800 mN) (Fig. 3-5). Soil profile site numbers are prefixed

'SP'. Site locations are in metres west from Junction Road. The vegetation is described in detail elsewhere (Chapter 6), and the dominant land use within the study area is logged native forest (sleeper cutting), occasional broom cutting and some honey production.

Where relevant, other comments are listed after individual profile descriptions.

Site No.: SP1

Location: 350m **Sampling:** auger hole

Slope/Aspect: level **Landform:** flat adjacent to ephemeral watercourse

Vegetation structure: open-woodland **Vegetation Site:** 1

Substrate: alluvium, sandstone at depth **PPF:** Dy4.52 **Drainage:** well drained

Other comments: burnt 1951, site destroyed by bulldozing 1988

Horizon	(mm)	Description
O1	surface	Leaf litter 10% cover, single grain quartz sand, no crust, many ant mounds, cracks 1-5mm wide
A1	0 - 150	dark brown (7.5YR 3/4m ,4/3d) sandy loam, earthy fabric, organic, many roots binding together, some large chambers, ants and termites, cracks from surface 1-5mm wide. pH 5.5, clear and even to
A12	150 - 250	greyish brown (7.5YR brown (7.5YR 5/6m, 7/4d) bleached clayey sand, some charcoal & fine quartz pebbles, pH 5.5, clear & even to
B2	300 - 500	yellowish brown (10YR 5/6) mottled dark reddish brown (5YR 3/6m more than 10%) sandy clay, ± coarsely pedal, harsh, coarse qtz pebbles, pH 6.5, gradual to
B3	500 - 1000	yellowish brown (10YR 5/6) mottles brownish grey (6/1), dark reddish brown (5YR 3/6), sandy clay, harsh, pH 7.0, gradual to
C	1000 +	weathered sandstone

Site No.: SP3

Location:	1,100m	**Sampling:**	auger hole
Slope/Aspect:	upper slope, gently inclined/west	**Landform:**	ridge
Vegetation structure:	open-forest	**Vegetation site:**	3
Substrate:	iron-rich sandstone/conglomerate	**PPF:**	Uc5.21
Drainage:	impeded at top of B	**Comments:**	burnt 1951

Horizon	(mm)	Description
O1	surface	single grain sand, leaf and twig litter, many surface cracks
A1	0 - 50	brown (7.5YR 4/3m, 5/4d) organic coarse loamy sand, some rounded quartz gravel, fine charcoal, earthy fabric, bound by roots, many ant and termite galleries, pH 5.5, gradual to
A12	50 - 200	as above but more compacted fabric, gradual to
B2	200 - 400	brown (7.5YR 4/4m, 5/3d) coarse clayey sand, contains coarser gravel and some charcoal, pH 5.5, gradual to
C	400 - 600 +	weathered sandstone with some quartz pebbles

* when soil is moist (after rains) mosses and lichens are abundant. The cracks visible in dry conditions are not obvious when soil surface is wet (May 1987).

Site No.: SP2

Location: 700m **Sampling:** auger hole

Slope/Aspect: gently inclined/east **Landform:** hillslope

Vegetation structure: shrubland **Vegetation site:** 2

Substrate: Pilliga Sandstone **PPF:** Uc4.21

Drainage: impeded at top of B **Comments:** burnt 1951 and some broom cutting ironbark removal

Horizon	(mm)	Description
01	surface	sparse single grain sand, litter of *Melaleuca uncinata* leaves, often bound together by lichen into a mat, soil surface moist
A1	0 - 200	brownish-black (10YR 2/3m, 4/4d) loamy sand, damp, organic earthy fabric, much fine quartz gravel throughout, some charcoal, many ant chambers, pH 5.5 clear to
A2	200 - 300	dark brown (10YR 3/4m) loamy sand, no gravel, some charcoal, pH 5.5, clear to
A3	300 - 500	yellowish brown (10YR 5/8) loamy sand, pH 6.5, gradual to
B2	500 - 800	yellowish brown (10YR 5/8) clayey sand, pH 6.5, gradual to
B3	800 - 1000	mottled clayey sand, no charcoal, pH 7.0, gradual to
C	1000 +	weathered sandstone

Site No.: SP4

Location: 1,400m **Sampling:** auger hole

Slope/Aspect: gently inclined/west **Landform:** mid-slope

Vegetation structure: open forest **Vegetation site:** 4

Substrate: Pilliga Sandstone **PPF:** Dy5.42

Drainage: impeded at top of B **Comments:** burnt 1951

Horizon	(mm)	Description
O1	surface	moist surface, thick litter, polygonal cracks 1-20mm liverworts and lichens common amongst litter
A1	0 - 20	dark brown (10YR 3/3m, 5/2d), fine powdery sandy loam organic, many ant and termite galleries, bioturbated, cracks from surface, pH 5.5, clear and even to
A12	20 - 50	dark brown (10YR 3/3m, 5/2d) sandy loam, few small quartz pebbles, charcoal bound with roots, bioturbated earthy fabric, sharp irregular boundary to
A2cb	50 - 300	greyish yellow-brown (10YR 5/2m, 7/2d) sandy loam, quartz pebbles, charcoal, bioturbated, pebble layer with quartz 2-10mm diameter imbedded in upper surface forms domes over clay layer beneath, hard, massive, fills cracks which extend down into the B horizon at spacing of 50cm, pH 5.5, tongued boundary to
B2	300 - 500	mottled brown (10YR 4/4 main colour) dull yellowish brown (5/3), yellowish brown (5/8) and brownish grey (4/1) harsh sandy clay, resists shearing, columnar structure, heavily bioturbated, pH 6.0, gradual to
C	500 +	weathered sandstone

* Site No. 4 exhibits the typical morphology of a solodised solonetz profile.
* bedrock is exposed 14 metres west of this site along the road.

Site No.: SP5

Location: 2,100m

Sampling: auger hole and pit

Slope/Aspect: gently inclined/west

Landform: lower slope

Vegetation structure: shrubland

Vegetation site: 5

Substrate: clayey sandstone

PPF: Dy5.42

Drainage: impeded at top of B

Comments: burnt 1967-1968; minor broom cutting

Horizon	(mm)	Description
01	surface	surface moist, thick litter of *Melaleuca uncinata, Acacia triptera, Hibbertia* species bound together by lichens, no surface cracking
A1	0 - 100	brown (7.5YR 4/6m) loamy sand, some organic material, few roots, quart gravel, charcoal, some bioturbation some ants, pH 5.5, clear even to
A12	100 - 200	brown (7.5YR 4/4m) loamy sand as above, pH 5.5, clear even to
A13	200 - 500	bright brown (7.5YR 6/3m) loamy sand with charcoal and quartz gravel, pH 5.5, clear to
A2cb	500 - 600	dull brown (7.5YR 6/3, 7/1d) bleached moist clayey sand covering domes, charcoal, pH 6.0, irregular to
B2	600 - 700	mottled brown (10YR 4/6 main), bright yellowish brown (6/8), bright reddish brown (5Yr 5/8) harsh sandy clay, columnar structure, pH 6.0, gradual to
C	700 +	weathered sandstone

Site No.: SP6

Location: 3,093m **Sampling:** auger hole

Slope/Aspect: gently inclined/east **Landform:** lower slope

Vegetation structure: shrubland **Vegetation site:** 6

Substrate: clayey sandstone **PPF:** Dy5.42

Drainage: impeded at top of B **Comments:** burnt 1966/1967

Horizon	(mm)	Description
01	surface	*Melaleuca uncinata, Calytrix tetragona* litter and lichens forming mat (70% cover), moist surface, some bare earth
A1	0 - 50	dark brown (7.5YR 3/3m) organic sandy loam, earthy fabric, contains charcoal & fine quartz gravel, pH 5.5, clear and even to
A12	50 - 200	brown (7.5YR 4/4m, 6/4d) sandy loam, earthy fabric, charcoal & some fine quartz gravel, faunal channels, pH 5.5, clear and even to
A2cb	200 - 300	moist bright brown (7.5YR 5/6m, 7/4d) bleached clayey sand, some charcoal & fine quartz pebbles, pH 5.5, clear and even to
B2	300 - 500	yellowish brown (10YR 5/6) mottled dark reddish brown (5YR 3/6m more than 10%), sandy clay, ± coarsely pedal, harsh, coarse quartz pebbles, pH 6.5, gradual to
B3	500 - 1000	yellowish brown (10YR 5/6) mottles brownish grey (6/1) dark reddish brown (5YR 3/6), sandy clay, harsh, pH 7.0, gradual to

C	1000 +	weathered sandstone

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* this profile deeper than No. 7

* soil profile moist throughout (October 1986).

Site No.: SP7a

Location:	3,300m	**Sampling:**	auger hole
Slope/Aspect:	gently inclined, east	**Landform:**	low ridge
Vegetation structure:	low shrubland	**Vegetation site:**	7
Substrate:	clayey sandstone	**PPF:**	Dg4.42
Drainage:	impeded at top of B	**Soil moisture site:**	1
Comments:	burnt 1951		

Horizon	(mm)	Description
01	surface	thick litter from *Melaleuca* sp. lichen bound, crust, *Drosera peltata* common, surface moist
A1	0 - 50	brown (10YR 4/4m) sandy loam containing a little charcoal, earthy fabric, no gravel, organic, pH 6.5, clear and even to
A12	50 - 200	brown (7.5YR 4/4m) clayey sand, very moist, charcoal, pH 6.5, gradual to
A13	200 - 300	brown (7.5YR 4/6m) clayey sand as above but more moisture, clear and even to
A2cb	300 - 400	dull yellow orange (10YR 7/2m), with reddish brown 5YR 4/8) mottles, clayey sand, bleached layer, ironstone common, pH7.0, clear and even to
B1	400 - 500	Light reddish grey (2.5YR 7/1m) with dark reddish brown (2.5YR 3/6m) mottles, sandy clay, harsh, pH 7.0, gradual to
B2	500 - 600	dark reddish brown (2.5YR 3/6m) with light reddish brown (2.5YR 7/1m) mottles, very sandy clay, harsh, pH 7.0, gradual to

C	600 +	coarse weathered iron-rich sandstone

SITE No.: SP7b

Location: 3,400m **Sampling:** auger hole

Slope/aspect: gently inclined/west **Landform:** mid-slope

Vegetation structure: shrubland **Vegetation site:** -

Substrate: clayey sandstone **PPF:** Dy5.42

Drainage: impeded at top of B **Soil moisture site:** 2

Comments: burnt 1951

Horizon	(mm)	Description
01	surface	litter with lichen and moss crusts
A1	1 - 150	brown (7.5YR 4/4m) sandy loam, some charcoal
A2	150 - 400	brown (7.5YR 7/2) sandy loam
B	400 - 800	yellow brown harsh sandy clay, red mottles present at about 500 mm, charcoal
C	800 +	weathered sandstone

* mottled red and yellow sandstone is exposed on the edge of the broom plain and is also visible in the road. Also present are scattered conglomerate pebbles.

Site No.: SP8a

Location:	3,653m	**Sampling:**	auger hole & pit
Slope/Aspect:	gently inclined/west	**Landform:**	upper slope
Vegetation structure:	woodland	**Vegetation site:**	8
Substrate:	Pilliga Sandstone	**PPF:**	Db4.42
Drainage:	Impeded at top of B	**Soil moisture site:**	4a
Comments:	burnt 1951		

Horizon	(mm)	Description
O1	surface	variable thickness of litter of leaves and wood, top 5mm comes off in a layer. Many termite and ant workings, many small surface cracks, soil mounded against fallen logs
A1	0 - 100	dull brown (7.5YR 5/4m) organic loamy sand, very bioturbated, porous earthy fabric, pH 6.5, clear and wavy to
A2cb	100 - 150	dull brown (7.5YR 6/3m, 7/1d) loamy sand, cement like, on top of and down cracks to form columns, quartz stones of varying sizes as layer within, bleached layer, pH 7.0, clear and wavy to
B2	150 - 500	brown (7.5YR 4/6m) harsh sandy clay, columnar, with mottles of A1 material, mainly found as faunal channels, gradual to
C/R	500 +	weathered sandstone, yellow/white stains

* after heavy rainfall the A2 becomes saturated and there is subsurface water flow along the top of the B horizon

* polygonal crack pattern, associated with domes in top of B horizon, obvious in road adjacent to this site.

* classic biourbation/rainwash duplex soil model as described by Humphreys & Mitchell (1983).

Site No.: SP8b

Location: 3,696m **Sampling:** auger hole

Slope/Aspect: gently inclined **Landform:** upper slope

Vegetation structure: shrubland **Vegetation site:** -

Substrate: Pilliga Sandstone **PPF:** Db3.42

Drainage: impeded at top of B **Soil moisture site:** 5

Comments: burnt 1951

Horizon	(mm)	Description
01	surface	surface litter of *Acacia* sp. & *Eucalyptus viridis*
A1	0 - 30	brownish black (7.5YR 3/2m) organic sandy loam, earthy fabric, quartz pebbles on top of domes, some ironstone throughout, bioturbated, pH 6.5, wavy to
A2cb	30 - 200	light yellowish grey (7.5YR 6/3m, 7/2d) dome top material with quartz pebbles, domes 120 - 150mm across, pH 7.0, abrupt to
B2	200 - 300	brown (7.5YR 4/4m) bioturbated harsh sandy clay, pH 7.0, columnar structure, roots common, gradual to
C/R	300 +	dry weathered sandstone, mealy

* soil extremely difficult to auger when dry

Site No.: SP9a

Location: 3,746m **Sampling:** auger hole

Slope/Aspect: gently inclined/west **Landform:** mid-slope

Vegetation structure: shrubland **Vegetation site:** -

Substrate: Pilliga Sandstone **PPF:** Dy4.42

Drainage: impeded at top of B **Soil moisture site:** 5a

Comments: burnt 1951

Horizon	(mm)	Description
O1	surface	Litter of *Melaleuca uncinata, Acacia* sp., & *Calytrix tetragona.* Ants & termites evident, single grain quartz sand on surface
A1	0 - 100	dark brown (7.5YR 3/4m) sandy loam, some bioturbation - not as common as in site 8, pH 6.0, clear to
A2cb	100 - 200	yellowish brown (10YR 5/3m, 7/2d) sandy loam, pH 7.0, clear to
B2	200 - 700	yellow (10YR 5/8) harsh sandy clay, pH 7.0, gradual to
C/R	700 - 1000+	white mealy sandstone

Site No.: SP9b

Location: 3,803m **Sampling:** auger hole

Slope/Aspect: gently inclined/west **Landform:** mid-slope

Vegetation structure: shrubland **Vegetation site:** -

Substrate: ?alluvium **PPF:** Dy5.42

Drainage: impeded at top of B **Soil moisture site:** 6

Comments: Burnt 1951

Horizon	(mm)	Description
01	surface	*Melaleuca uncinata* litter
A1	0 - 50	dark brown (7.5YR 3/4m) organic fine sandy loam, pellety fabric (ant & termite casts), fine charcoal, roots, pH 5.5, clear to
A12	50 - 200	brown (7.5YR 4/6m) sandy clay loam, earthy fabric, some 2-5mm diam. qtz gravel, charcoal, pH 6.0, clear & wavy to
A2cb	200 - 300	yellowish brown (10YR 5/6, 7/4d) clayey wet sand, some red mottles, large diameter ironstone gravel, pH 6.0, clear and wavy to
B1	300 - 400	bright brown (7.5 YR 5/8m) harsh sandy clay, some dark reddish brown mottles (5YR 3/6m), ironstone gravel & some quartz pebbles, pH 7.0, gradual to
B2	400 - 700	yellowish brown (10YR 5/8m) harsh sandy clay with dull yellow orange (10YR 7/3m) mottles, ironstone gravel, pH 7.0, gradual to
B3	700 - 1000	bright yellowish brown (10YR 6/6m), with dull yellow orange (10YR 7/2m) & dark reddish brown (5YR 3/6m)

mottles, pH 8.0, gradual to

C 1000 + ?alluvium

Site No.: SP9c

Location: 3,846m **Sampling:** auger hole

Slope/Aspect: gently inclined/west **Landform:** mid-slope

Vegetation structure: shrubland **Vegetation site:** -

Substrate: ?alluvium **PPF:** Dy5.22

Drainage: impeded at top of B **Soil moisture site:** 6a

Comments: burnt 1951

Horizon	(mm)	Description
01	surface	litter and single grain sand
A1	0 - 100	brownish black (7.5YR 3/2m) organic sandy loam, earthy fabric, highly bioturbated, contains charcoal, pH 6.0, clear to
A2	100 - 200	brown (10YR 4/4m) sandy loam, bioturbated, earthy fabric, charcoal, pH 6.5, clear to
B2	200 - 600	yellowish brown (10YR 5/8m) harsh sandy clay, pH 6.5 gradual to
B3	600 - 800 +	yellow (10YR 5/8m) sandy clay, with dark reddish brown mottles (5YR 3/6m) difficult to auger, pH 7.0

Site No.: SP9d

Location:	4,021m	**Sampling:**	auger hole
Slope/Aspect:	gently inclined/west	**Landform:**	lower slope
Vegetation structure:	closed shrubland	**Vegetation site:**	9
Substrate:	alluvium/Pilliga Sandst.	**PPF:**	Db3.12
Drainage:	impeded at top of B	**Soil moisture site equiv:**	8a
Comments:	disturbance by broom cutters		

Horizon	(mm)	Description
O1	surface	Surface litter uncommon. Surface ridged with A1 material in piles
A1	0 - 200	brown (7.5YR 4/4d, 3/2m) sandy loam, bioturabated, contains charcoal, earthy fabric, few roots, pH 5.5, clear to
A2cb	200 - 400	sandy loam, bleached
B2	400 - 500	brown (10YR 4/4m) sandy clay, pH 6.5, gradual to
C/R	500 +	mottled sandy clay - alluvium ?

Site No.: SP10

Location:	4,469m	**Sampling:**	pit
Slope/Aspect:	level	**Landform:**	flat
Vegetation structure:	open-woodland	**Vegetation Site:**	10
Substrate:	alluvial sands	**PPF:**	Uc5.11
Drainage:	free draining	**Comments:**	burnt 1951, sand extraction

Horizon	(mm)	Description
01	surface	litter layer mainly of *Callitris* sp., sandy gravelly lag with lichen and moss crusts, areas of bare earth common with rounded quartz fragments
A1	0 - 50	thin layer of coarse sand, single grain, over a thin crust which breaks up easily, vesicular underneath in some areas, in others a more clay crust bound with lichen which forms pillars on erosion, over brown (7.5YR 4/6m, 6/6d) coarse sand containing minor organic material, pH 6.0. clear to
B2	50 - 1000	bright brown (7.5YR 5/8m) coarse sand, some faunal channels back filled with A1 material, sandy fabric, single grain, charcoal, pH 5.0, gradual to
B/C	1000 +	bright brown (7.5YR 5/8m) slightly finer sand, contains some clay, more coherent and compacted, contains charcoal, pH 6.0

* yellow earth

Site No.: SP11

Location: 6,702m **Sampling:** auger

Slope/Aspect: gently inclined/west **Landform:** lower slope

Vegetation structure: closed-forest **Vegetation Site:** 11

Substrate: ?alluvium **PPF:** Ug6.1

Drainage: not well drained **Comments:** burnt 1951

Horizon	(mm)	Desrciption
01	surface	10mm deep with *Allo Casuarina* litter, becomes finer with depth, many surface cracks,
A1	0 - 20	brownish black (10YR 3.2m, 5/4d) fine sandy clay loam, porous, fine pedal fabric, 5mm quartz pebbles throughout, fine roots, pH 6.5, clear to
A11	20 - 200	black (10YR 2/1m, 2/2d) fine sandy light clay, highly pedal, porous polyhedral 5mm peds, many roots, bioturbated, Ph 7.0, clear o
B2	200 - 400	brownish-black (5YR 2/2m, 3/2d) fine sandy light clay, similar pedality to above, pH 7.0, clear to
C	400 - 1000+	dull yellow brown (10YR 5/3m) fine sandy light clay, pedality as above, litle ironstone gravel, pH 7.0.

---

* gilgai depressions up to 1.2 metres deep and about 3 metres across on average
* surface is grey/brown and self-mulching
* after rains the depressions adjacent fill with water which remains for some time

Site No.: SP12

Location: 4,103mm **Sampling:** pit & auger hole

Slope/Aspect: gently inclined/west **Landform:** lower slope

Vegetation structure: woodland **Vegetation site:** 12

Substrate: alluvium/Pilliga Sandst. **PPF:** Dy5.42

Drainage: impeded at top of B **Soil moisture site:** 9

Horizon	(mm)	Description
O1	surface	Litter from *Eucalyptus crebra, Callitris glaucophylla* Surface layer of whole leaves, twigs, branches, large faecal pellets, some lichens and mosses
A1	0 - 200	dark brown (10YR 3/3m, 5/2d) organic loamy sand, bioturbated, charcoal, some fine to coarse quartz gravel, earthy fabric, pH 5.5, clear even to
A2	200 - 300	yellowish brown (10YR 5/6m, 6/4d) sandy loam, quartz gravel contains fine charcoal, pH 6.0, clear, even to
B2	300 +	dull yellowish brown (10YR 4/3m) hard, compacted coarse sandy clay, massive, harsh. Some orange mottles, pH 7.0

Site No.: SP13

Location:	5,458m	**Sampling:**	pit
Slope/Aspect:	level	**Landform:**	flat adjacent to creek
Vegetation structure:	open-woodland	**Vegetation site:**	13
Substrate:	alluvial sands	**PPF:**	Uc4.21
Drainage:	impeded at top of B		

Horizon (mm)		Description
01	surface	covered with litter
A1	0 - 50	brownish black (10YR 3/2m, 5/2d) organic coarse sandy loam, bioturbated, pellety appearance, charcoal. pH 5.5, gradual to
A12	50 - 300	dark brown (10YR 3/4m, 5/4d) coarse loamy sand, less bioturbated and organic, more clay. Very fine charcoal. pH 6.0, gradual to
A2	300 - 450	brown (10YR 4/4m, 6/4d) moist, loamy sand favoured by Kurrajong roots. pH6.0. Gradual to
B2	450 - 800	yellowish brown (10YR 5/6m) coarse loamy sand, yellow and brown rounded pebbles. pH 6.5. Abrupt to
D	800 +	concreted sand, open textured. pH 7.0

Site No.: SP14

Location: 5,800m **Sampling:** no profile description

Slope/Aspect: level **Landform:** flat

Vegetation structure: tall woodland **Vegetation site:** 14

Substrate: ?alluvium **PPF:** Dy5

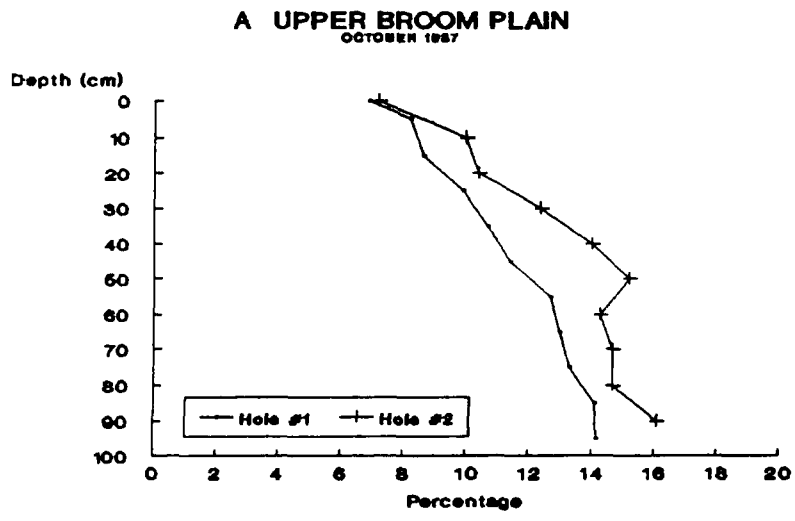
Drainage: *** **Comments:** Burnt 1951, some *Opuntia stricta*

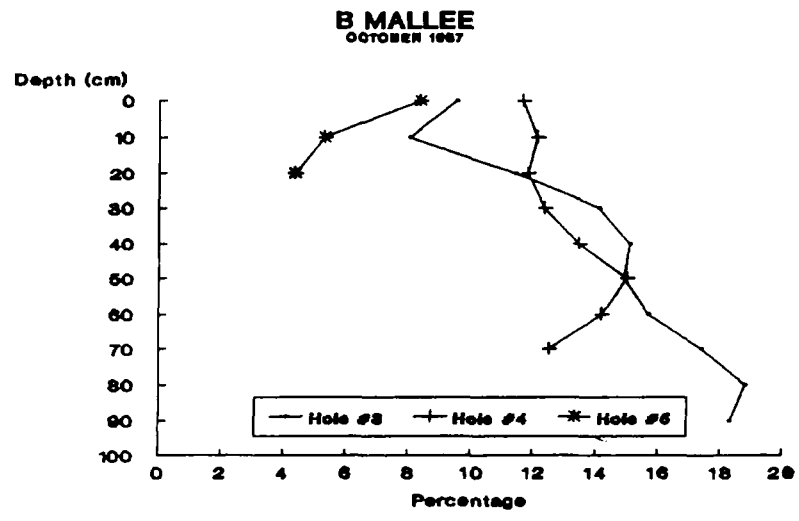
Horizon	(mm)	Description
01	surface	litter of leaves, bark & twigs of *Eucalyptus* and *Callitris*, cracks common over a wide area, some ants
A1	0 - 30	dark brown sandy clay loam
A2	30 - 40	light brown sandy clay loam, bleached
B	40+	yellow brown sandy clay

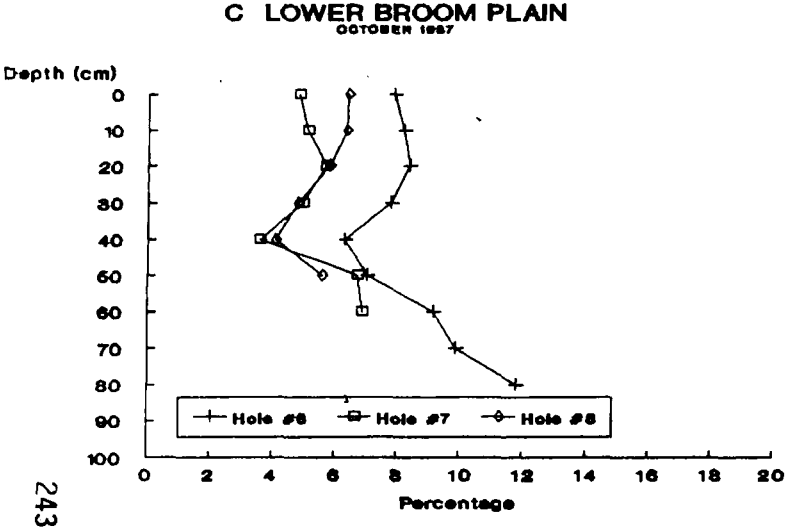
APPENDIX 3

Soil moisture - graphed results.

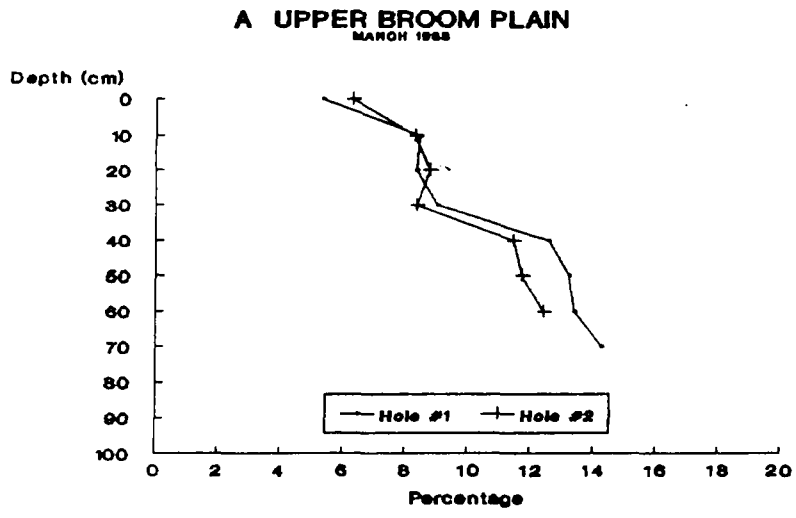
The following graphs present the results of gravimetric soil water measurement. The graphs give the results for each sampling period (c.f. Table 5-1 in Chapter 5), and were used for the production of Figures 5-6, 5-7 and 5-8.

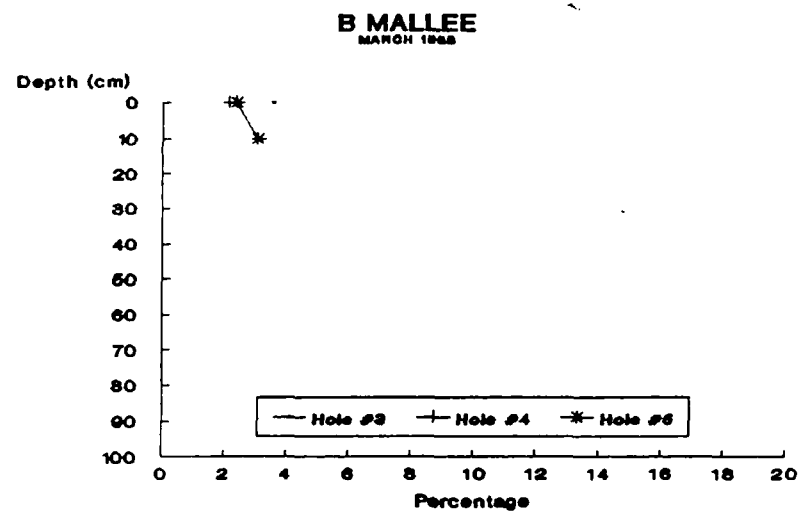


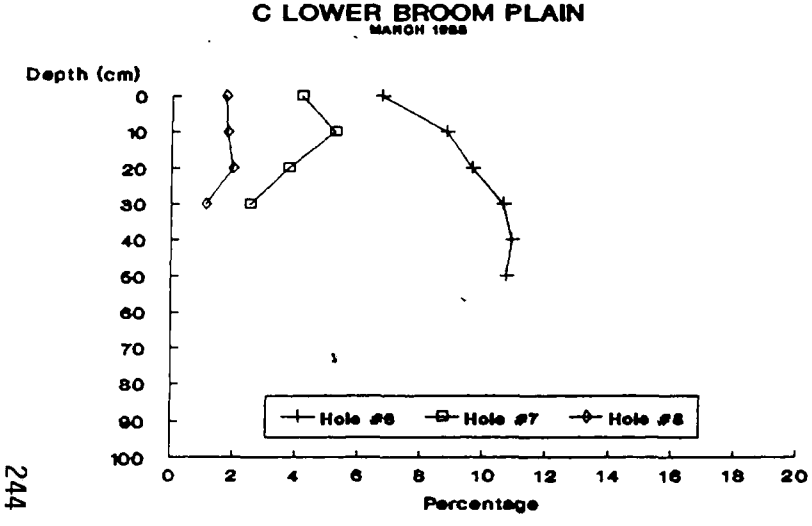


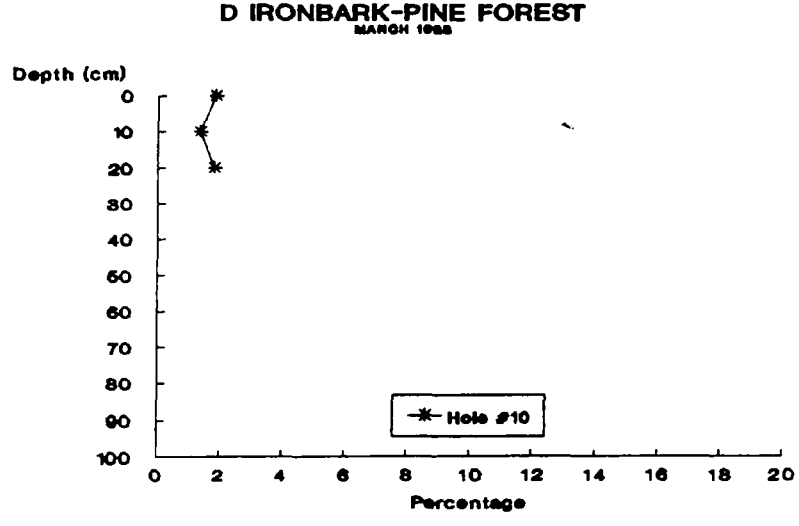


OCTOBER 1987

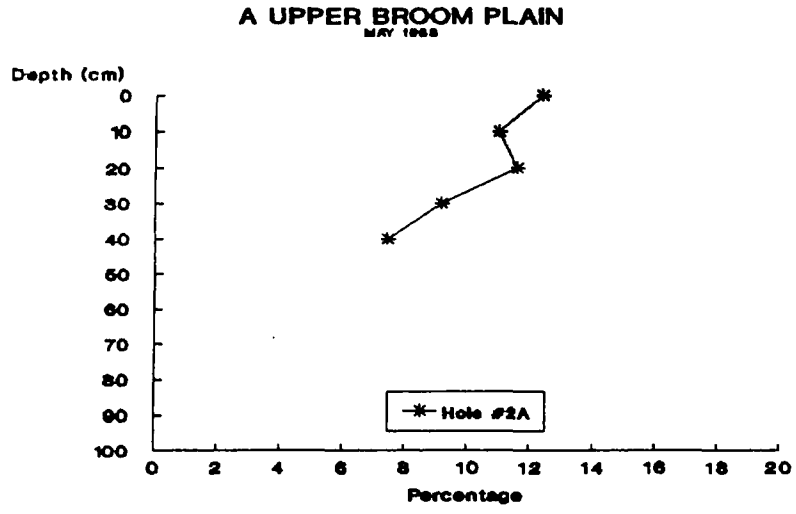

A UPPER BROOM PLAIN
MARCH 1988
Depth (cm)
0
10
20
30
40
50
60
70
80
90
100
0
2
4
6
8
10
12
14
16
18
20
Percentage
Hole #1
Hole #2

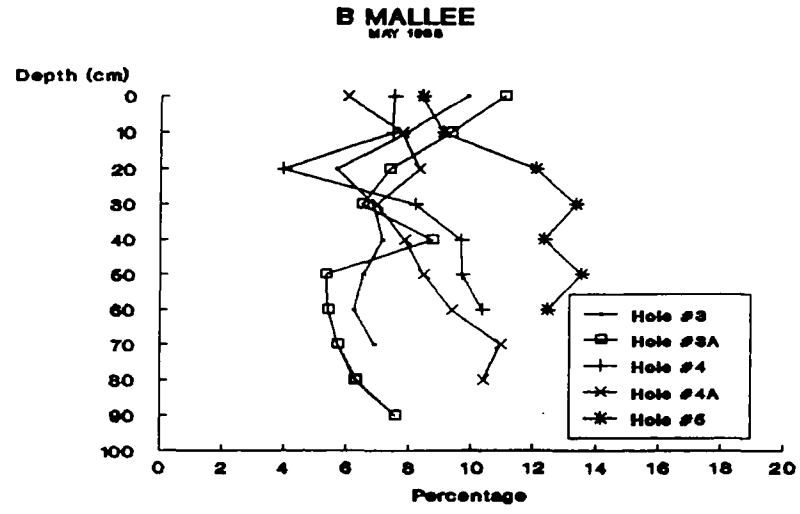

B MALLEE
MARCH 1988
Depth (cm)
0
10
20
30
40
50
60
70
80
90
100
0
2
4
6
8
10
12
14
16
18
20
Percentage
Hole #3
Hole #4
Hole #5

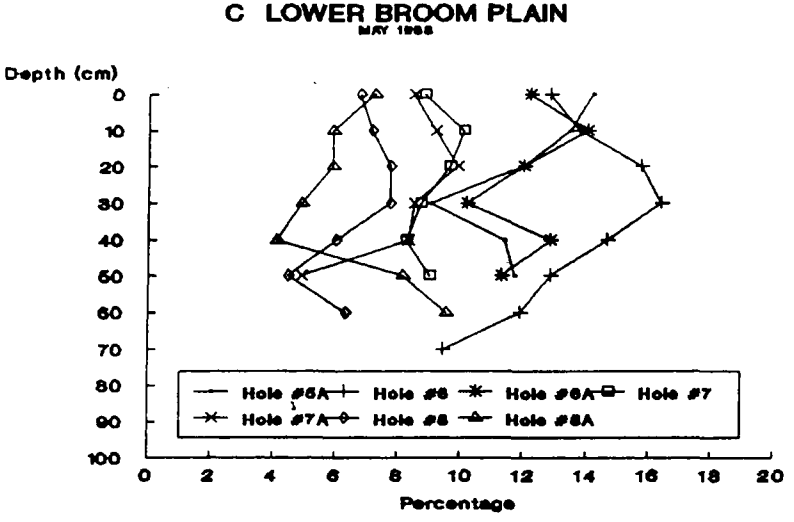

C LOWER BROOM PLAIN
MARCH 1988
Depth (cm)
0
10
20
30
40
50
60
70
80
90
100
0
2
4
6
8
10
12
14
16
18
20
Percentage
Hole #6
Hole #7
Hole #8

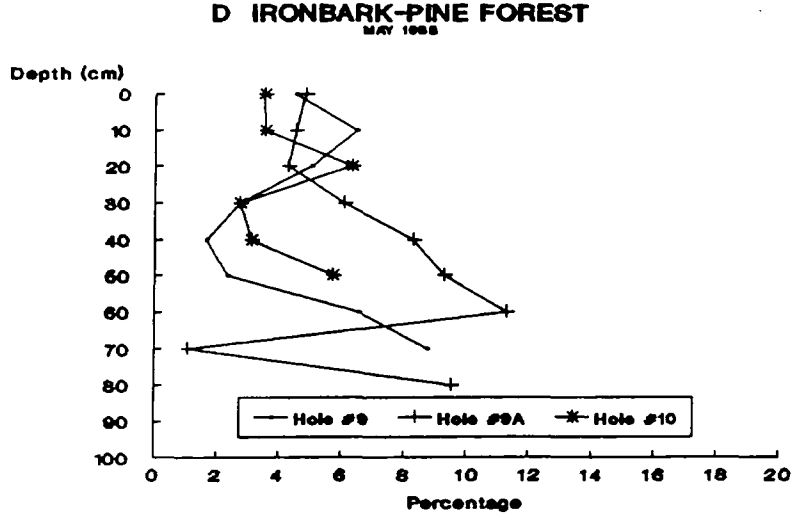

D IRONBARK-PINE FOREST
MARCH 1988
Depth (cm)
0
10
20
30
40
50
60
70
80
90
100
0
2
4
6
8
10
12
14
16
18
20
Percentage
Hole #10

MARCH 1988

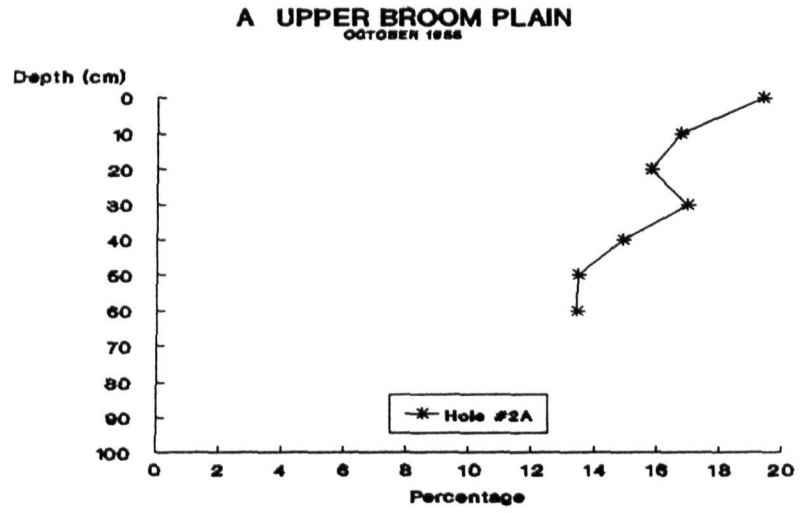

A UPPER BROOM PLAIN
MAY 1988
Depth (cm)
0
10
20
30
40
50
60
70
80
90
100
0 2 4 6 8 10 12 14 16 18 20
Percentage
Hole #2A

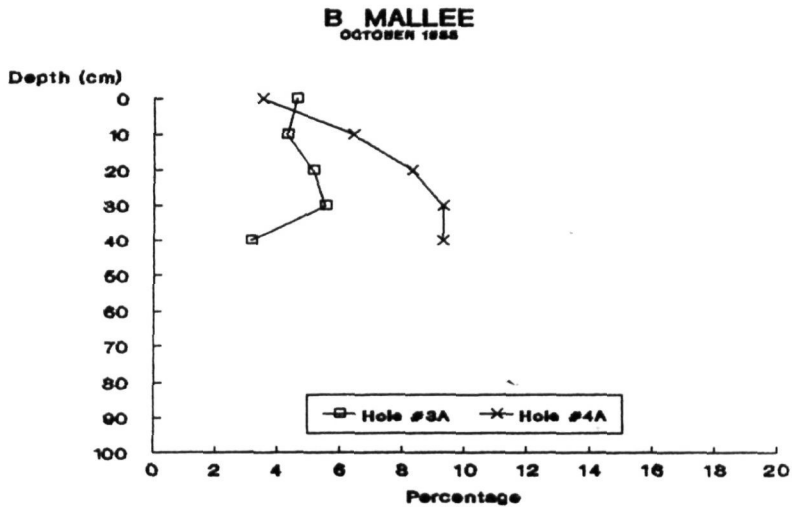

B MALLEE
MAY 1988
Depth (cm)
0
10
20
30
40
50
60
70
80
90
100
0 2 4 6 8 10 12 14 16 18 20
Percentage
Hole #3
Hole #3A
Hole #4
Hole #4A
Hole #6

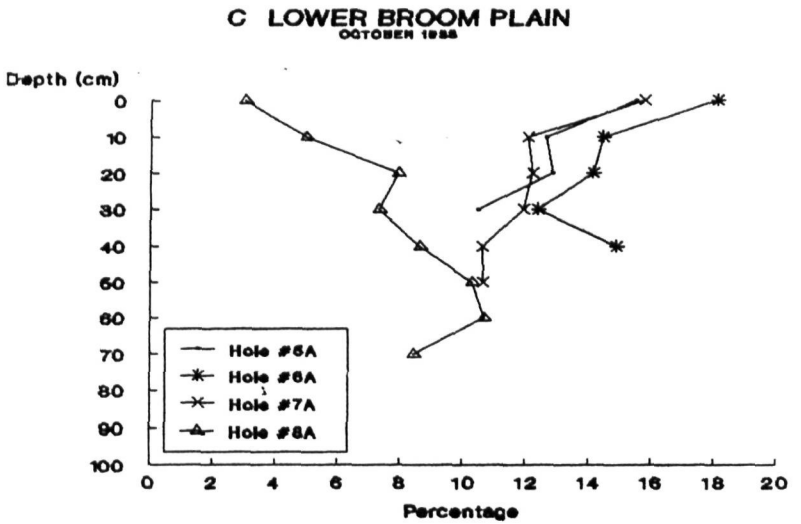

C LOWER BROOM PLAIN
MAY 1988
Depth (cm)
0
10
20
30
40
50
60
70
80
90
100
0 2 4 6 8 10 12 14 16 18 20
Percentage
Hole #5A
Hole #6
Hole #6A
Hole #7
Hole #7A
Hole #8
Hole #8A

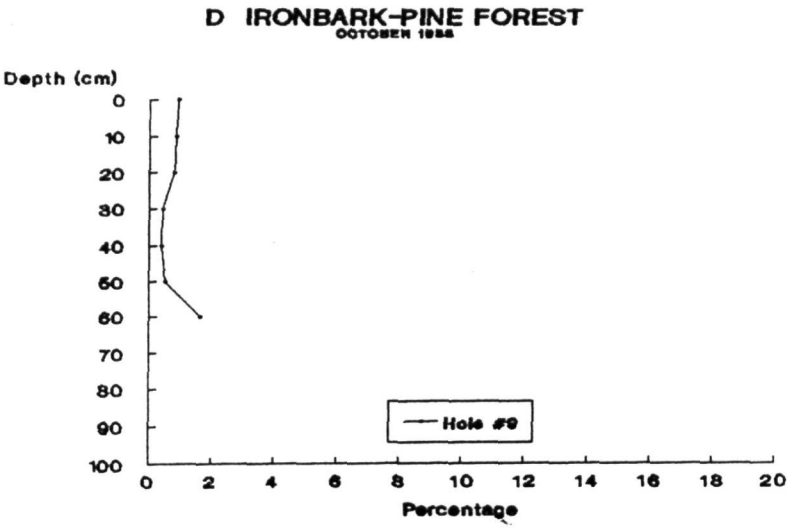

D IRONBARK-PINE FOREST
MAY 1988
Depth (cm)
0
10
20
30
40
50
60
70
80
90
100
0 2 4 6 8 10 12 14 16 18 20
Percentage
Hole #9
Hole #9A
Hole #10

MAY 1988

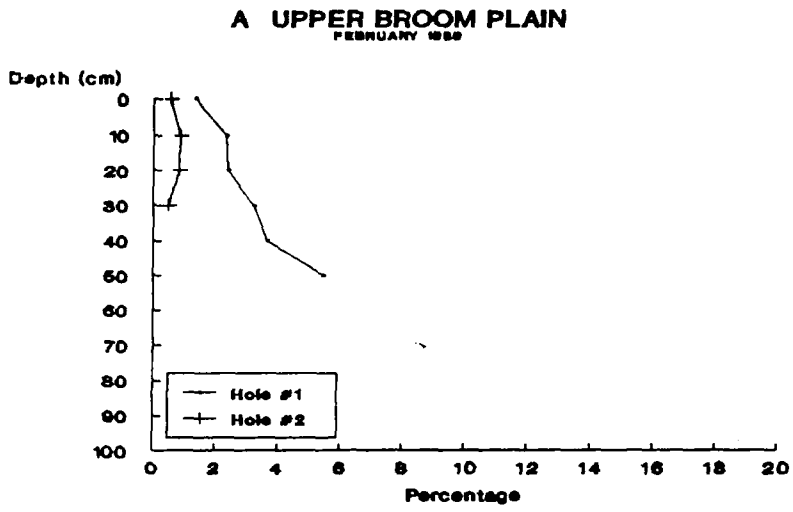


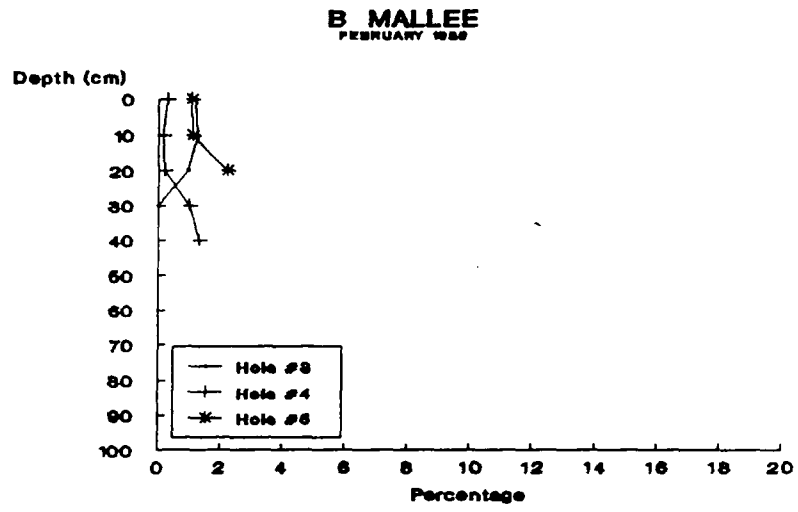


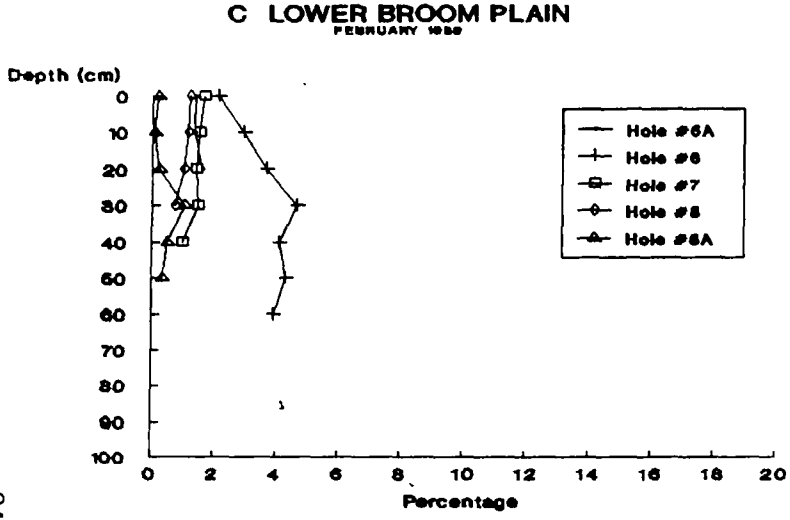


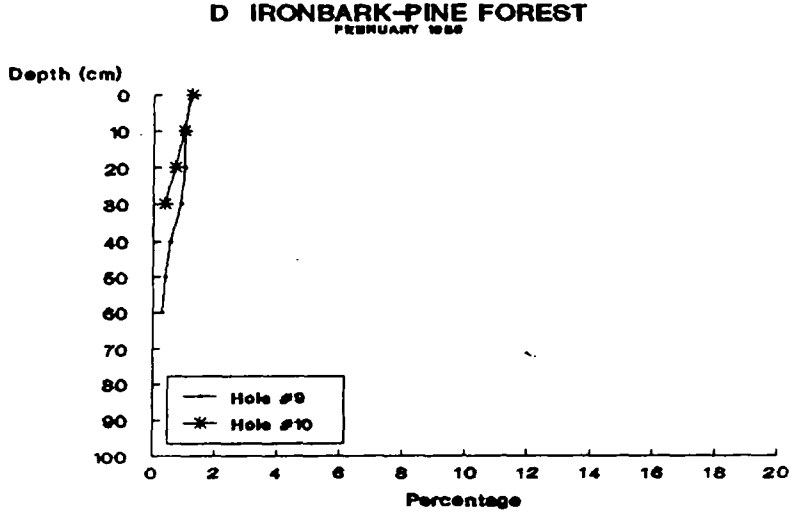


OCTOBER 1988

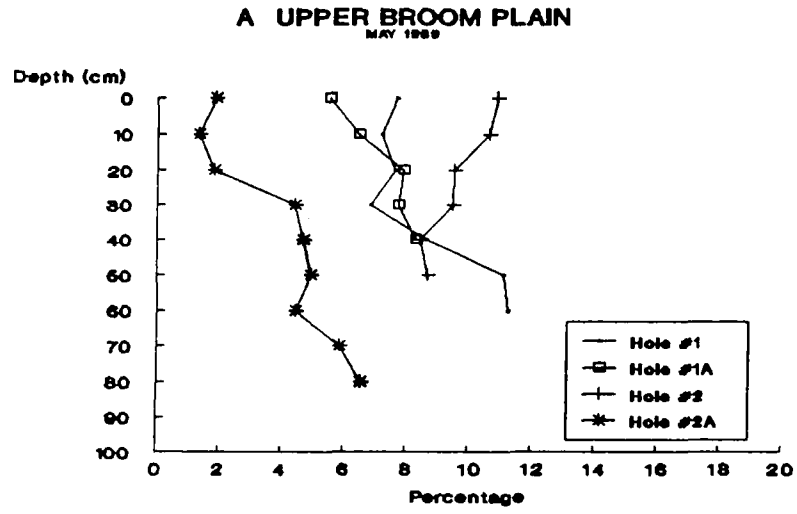


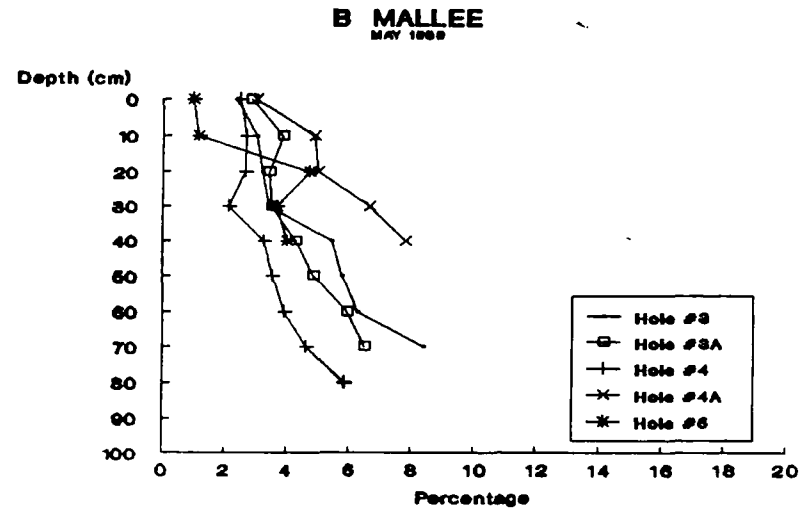


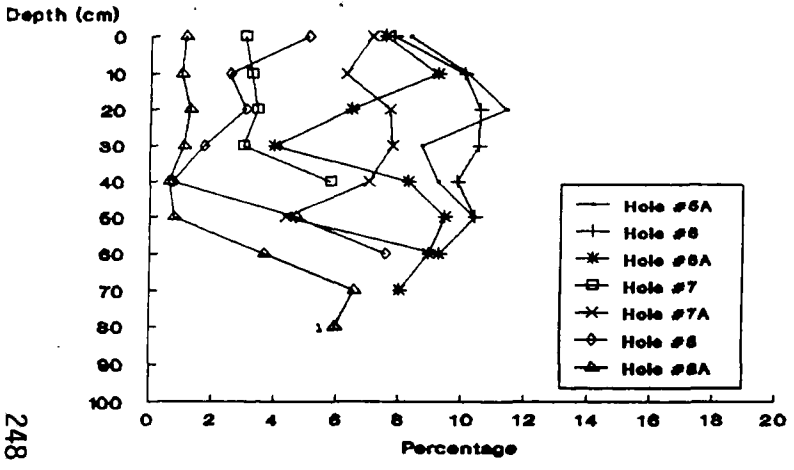


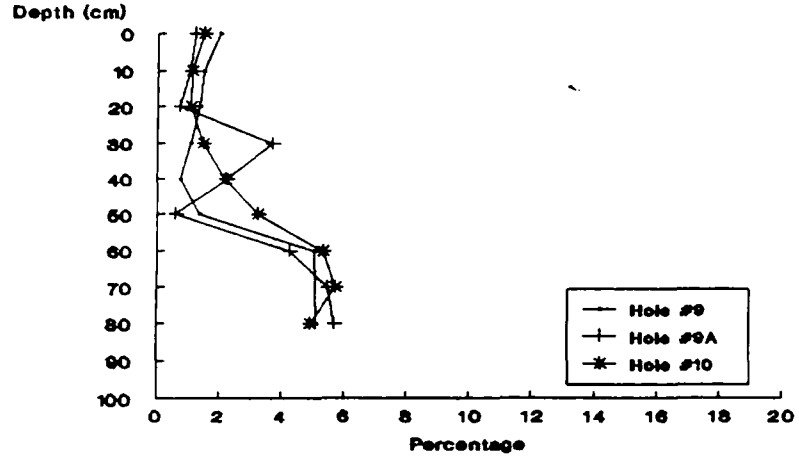


FEBRUARY 1989

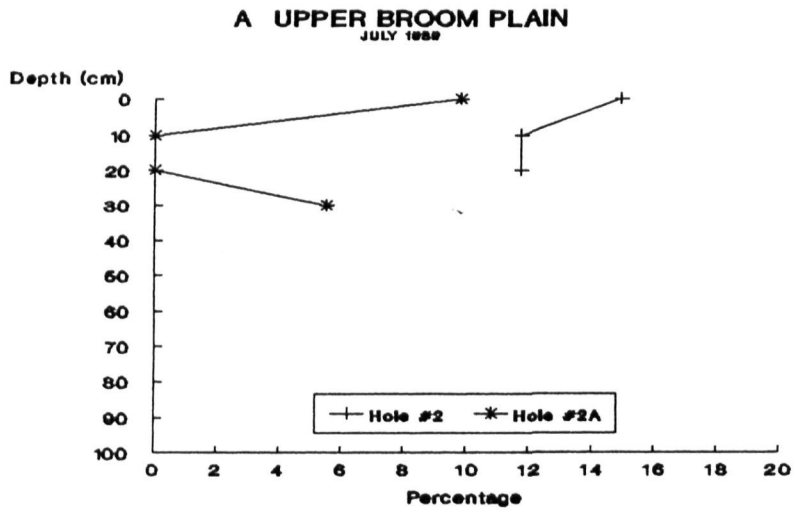

A UPPER BROOM PLAIN
MAY 1989
Depth (cm)
0
10
20
30
40
50
60
70
80
90
100
0
2
4
6
8
10
12
14
16
18
20
Percentage
Hole #1
Hole #1A
Hole #2
Hole #2A

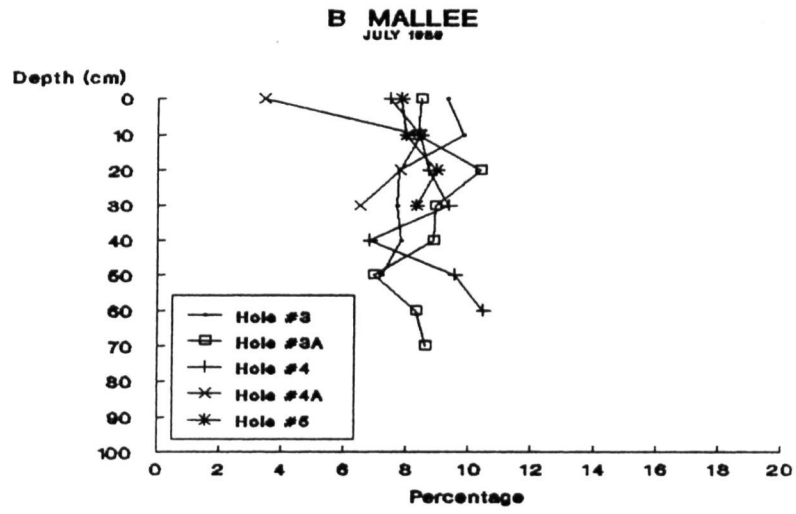

B MALLEE
MAY 1989
Depth (cm)
0
10
20
30
40
50
60
70
80
90
100
0
2
4
6
8
10
12
14
16
18
20
Percentage
Hole #3
Hole #3A
Hole #4
Hole #4A
Hole #5

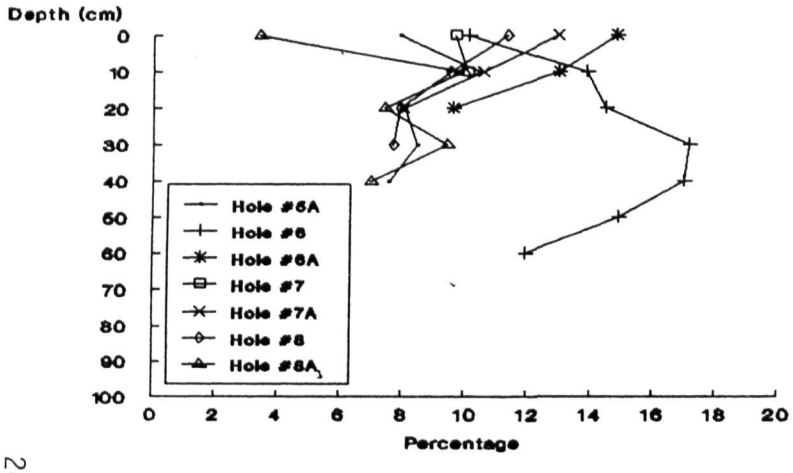

C LOWER BROOM PLAIN
MAY 1989
Depth (cm)
0
10
20
30
40
50
60
70
80
90
100
0
2
4
6
8
10
12
14
16
18
20
Percentage
Hole #5A
Hole #6
Hole #6A
Hole #7
Hole #7A
Hole #8
Hole #8A

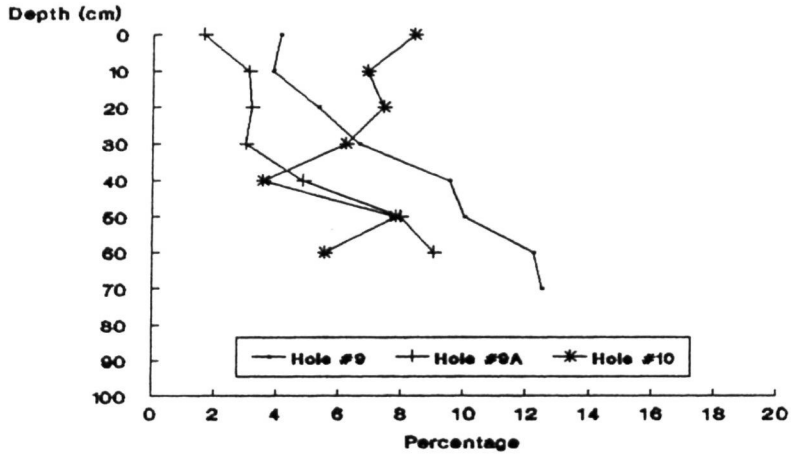

D IRONBARK-PINE FOREST
MAY 1989
Depth (cm)
0
10
20
30
40
50
60
70
80
90
100
0
2
4
6
8
10
12
14
16
18
20
Percentage
Hole #9
Hole #9A
Hole #10

MAY 1989


A UPPER BROOM PLAIN
JULY 1989
Depth (cm)
0
10
20
30
40
50
60
70
80
90
100
0 2 4 6 8 10 12 14 16 18 20
Percentage
Hole #2
Hole #2A


B MALLEE
JULY 1989
Depth (cm)
0
10
20
30
40
50
60
70
80
90
100
0 2 4 6 8 10 12 14 16 18 20
Percentage
Hole #3
Hole #3A
Hole #4
Hole #4A
Hole #5


C LOWER BROOM
JULY 1989
Depth (cm)
0
10
20
30
40
50
60
70
80
90
100
0 2 4 6 8 10 12 14 16 18 20
Percentage
Hole #6A
Hole #6
Hole #6A
Hole #7
Hole #7A
Hole #8
Hole #8A

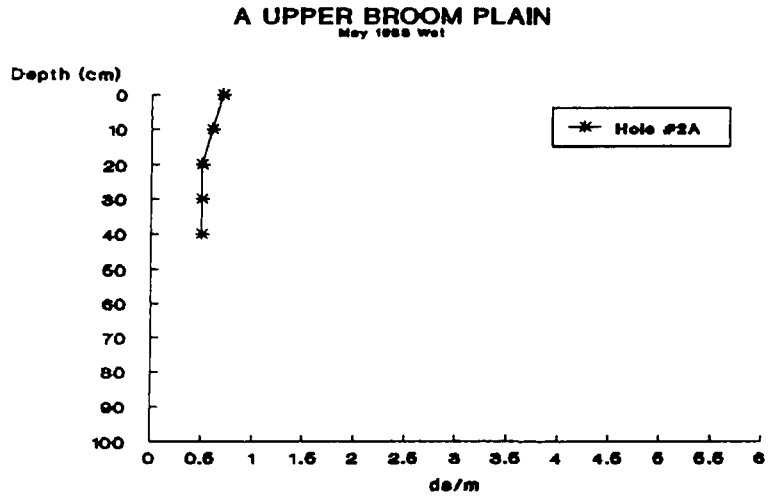

D IRONBARK-PINE FOREST
JULY 1989
Depth (cm)
0
10
20
30
40
50
60
70
80
90
100
0 2 4 6 8 10 12 14 16 18 20
Percentage
Hole #9
Hole #9A
Hole #10

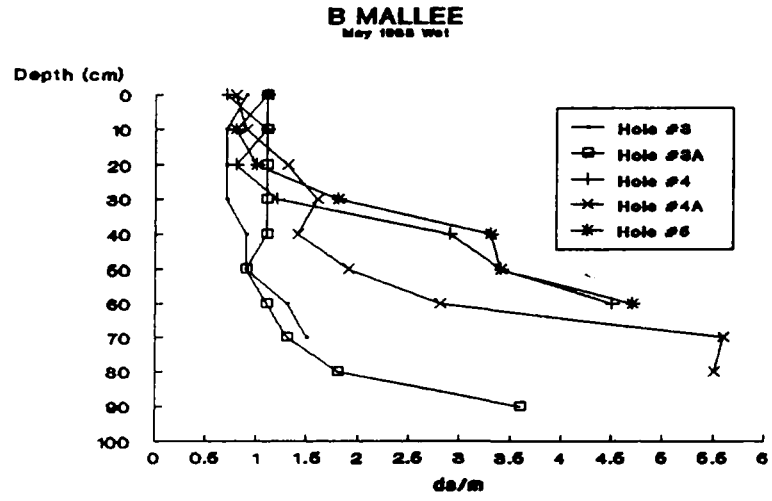
JULY 1989

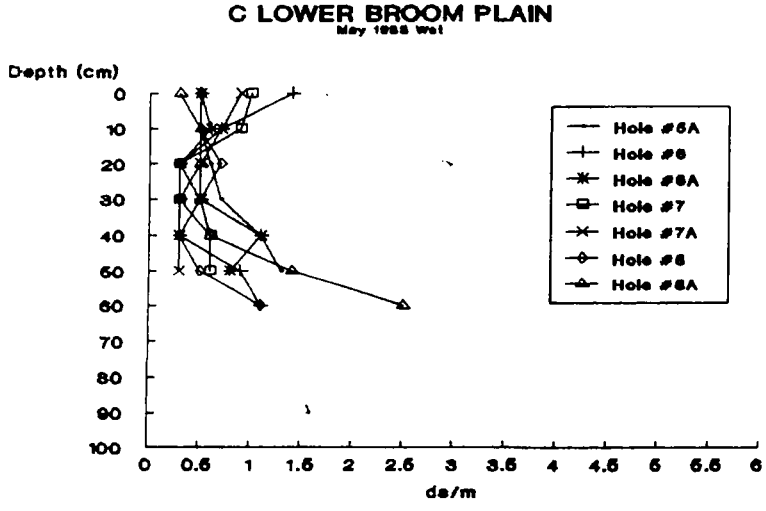
APPENDIX 4

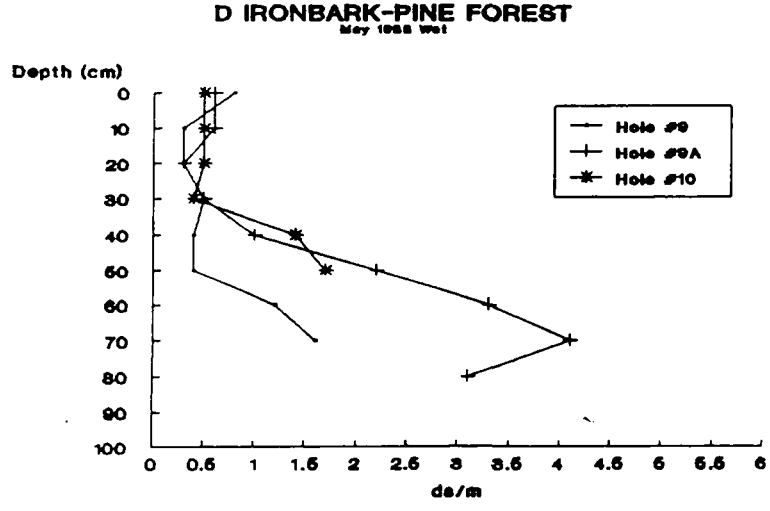
Soil Conductivity (Salinity)

Soil conductivity (salinity) was measured both in the field (July 1991) and on the soil samples collected for gravimetric determination (March 1988 and May 1988). These results are presented here in graph form. A Hanna Instruments Conductivity and Total Dissolve Solids Tester was used to measure conductivity on the March and May 1988 samples. For the July 1991 in field measurements a conducivity meter was used.

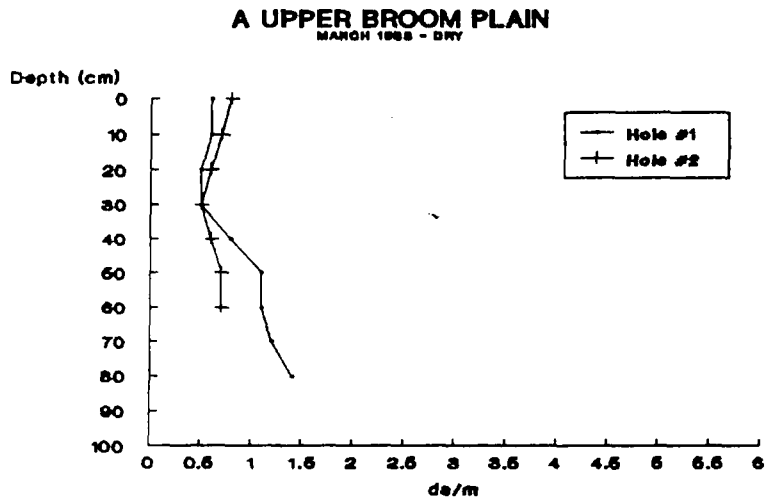

A UPPER BROOM PLAIN
May 1988 Wet
Depth (cm)
0
10
20
30
40
50
60
70
80
90
100
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
ds/m
Hole #2A

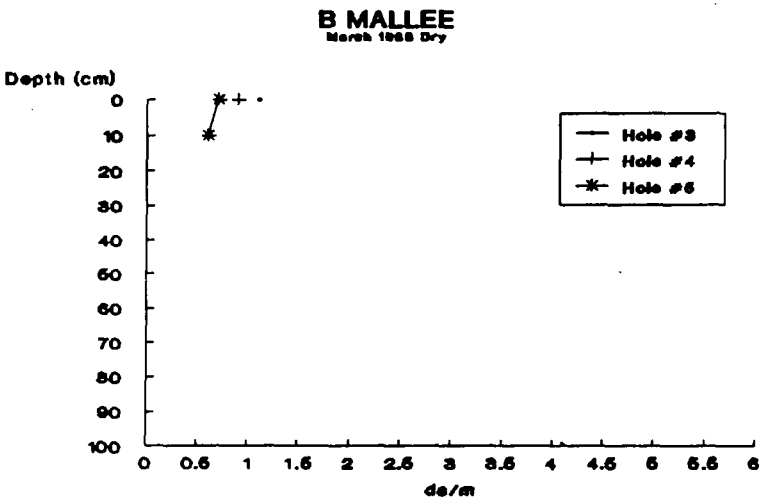

B MALLEE
May 1988 Wet
Depth (cm)
0
10
20
30
40
50
60
70
80
90
100
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
ds/m
Hole #3
Hole #3A
Hole #4
Hole #4A
Hole #5

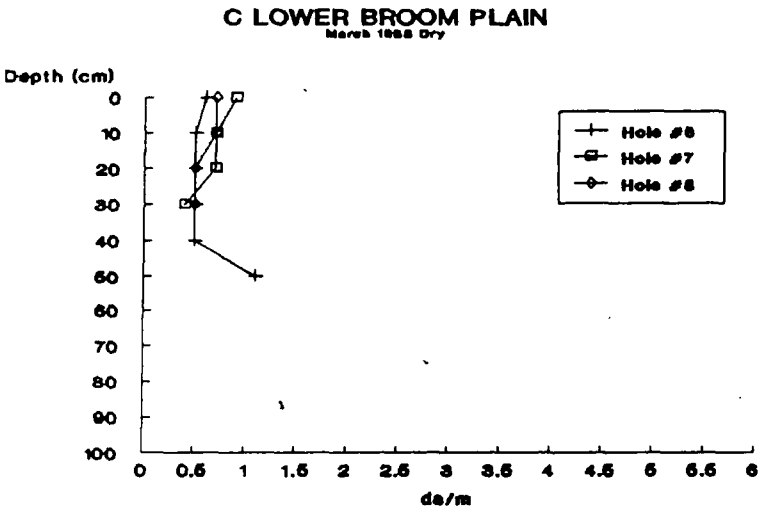

C LOWER BROOM PLAIN
May 1988 Wet
Depth (cm)
0
10
20
30
40
50
60
70
80
90
100
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
ds/m
Hole #6A
Hole #6
Hole #6A
Hole #7
Hole #7A
Hole #8
Hole #8A

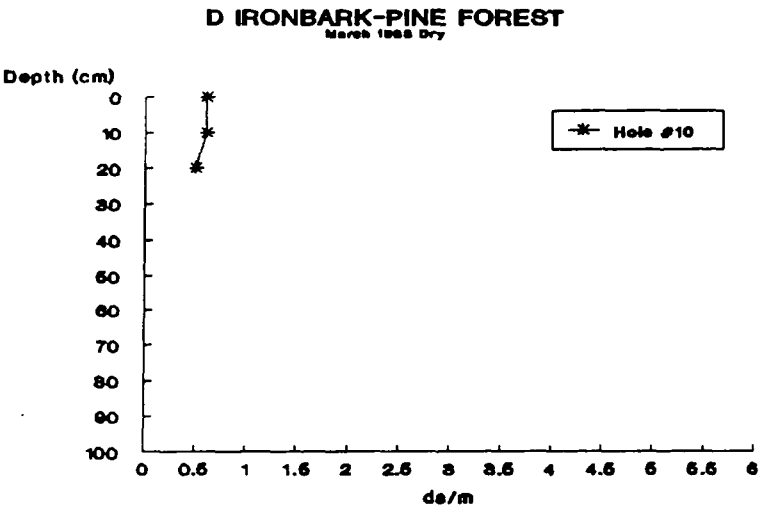

D IRONBARK-PINE FOREST
May 1988 Wet
Depth (cm)
0
10
20
30
40
50
60
70
80
90
100
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
ds/m
Hole #9
Hole #9A
Hole #10

MAY 1988 - WET





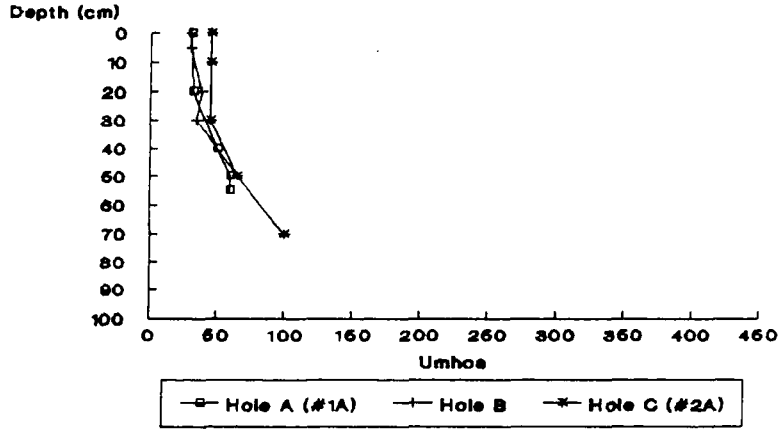




MARCH 1988 - DRY

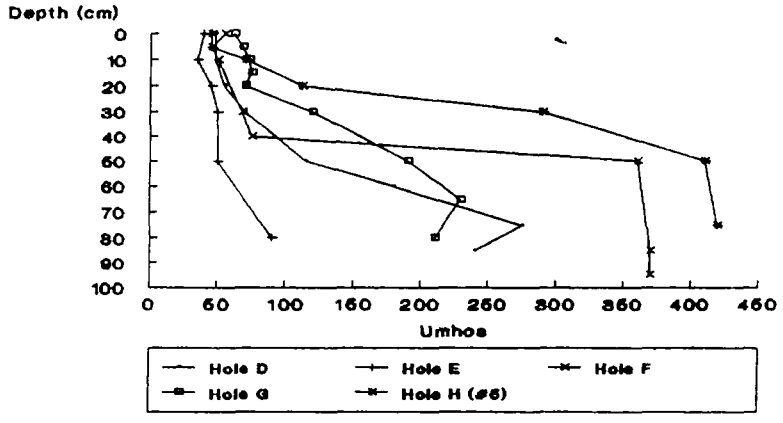
A UPPER BROOM PLAIN

July 1991



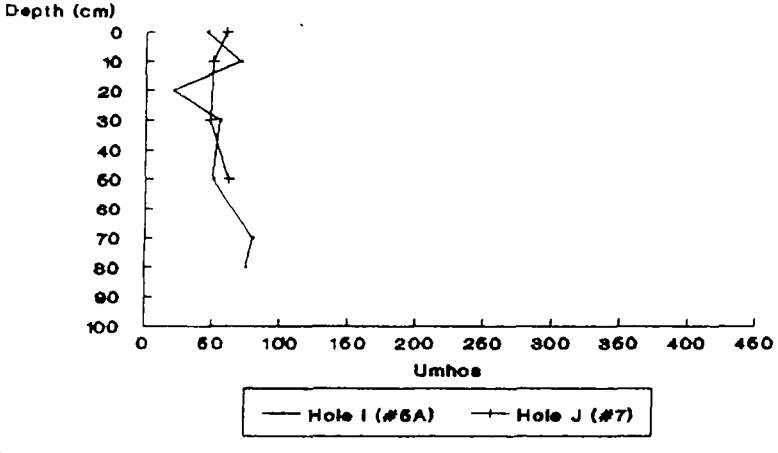
B MALLEE

July 1991



C LOWER BROOM PLAIN

July 1991

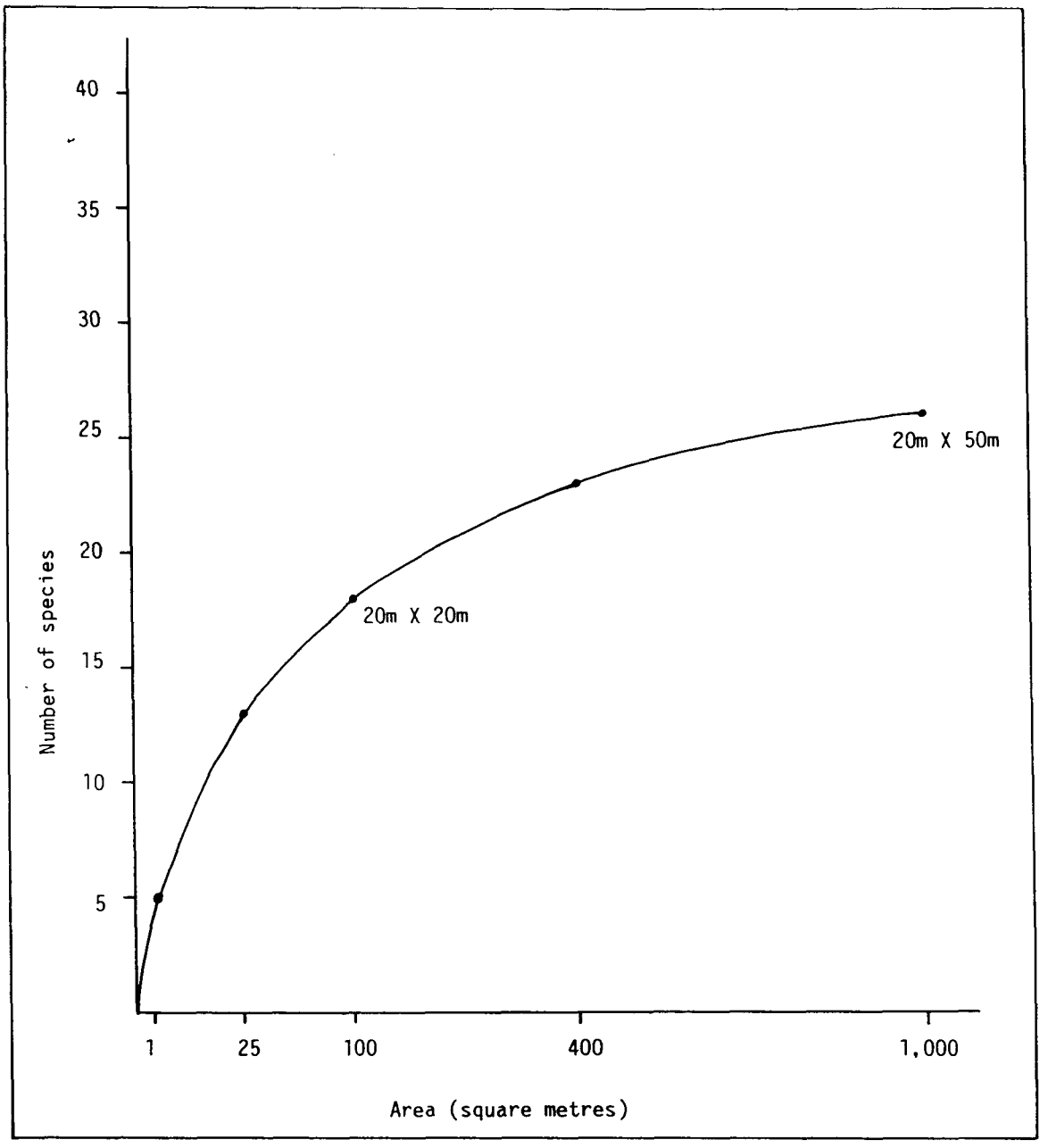


JULY 1991

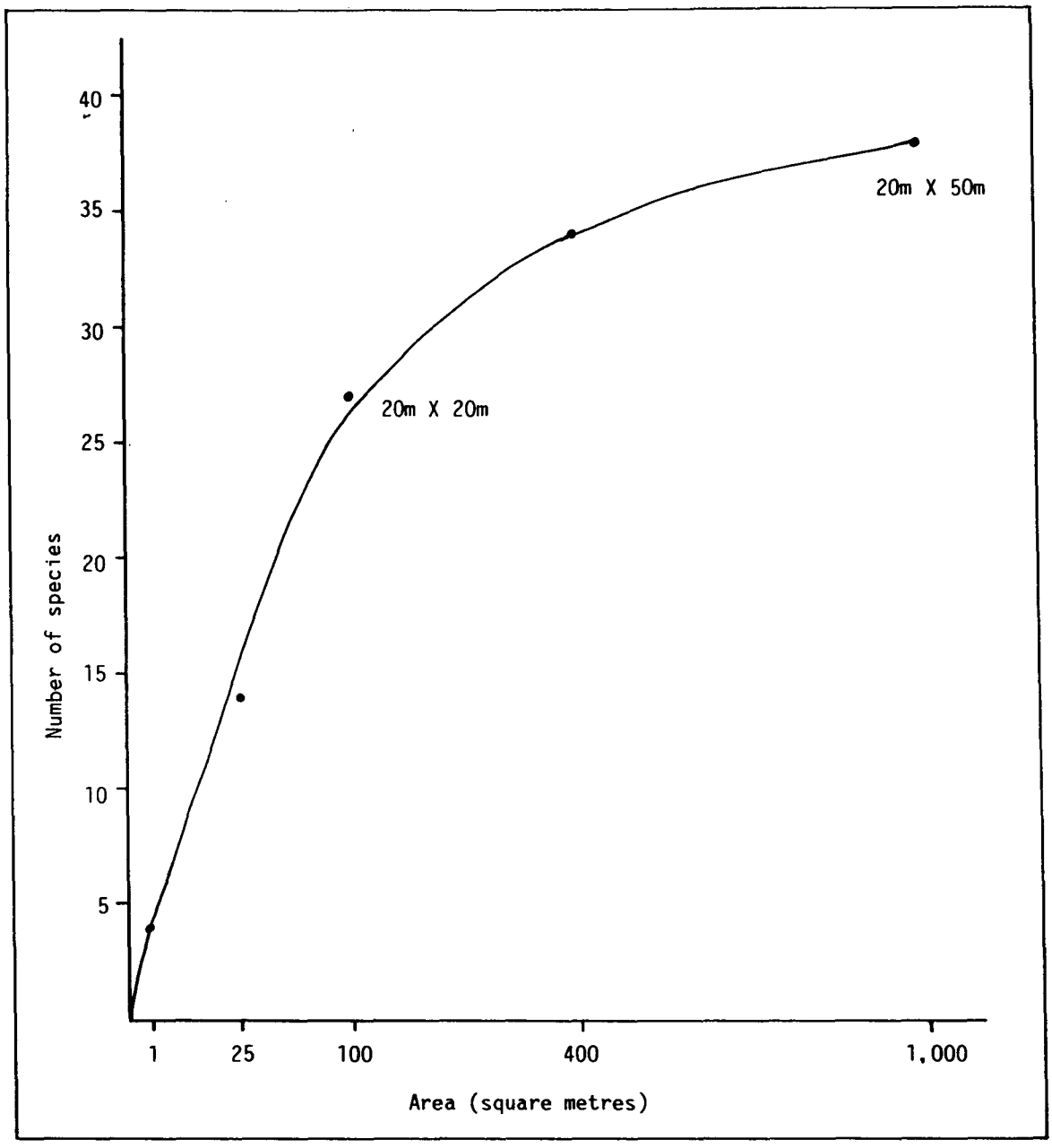
APPENDIX 5

Species-area curves

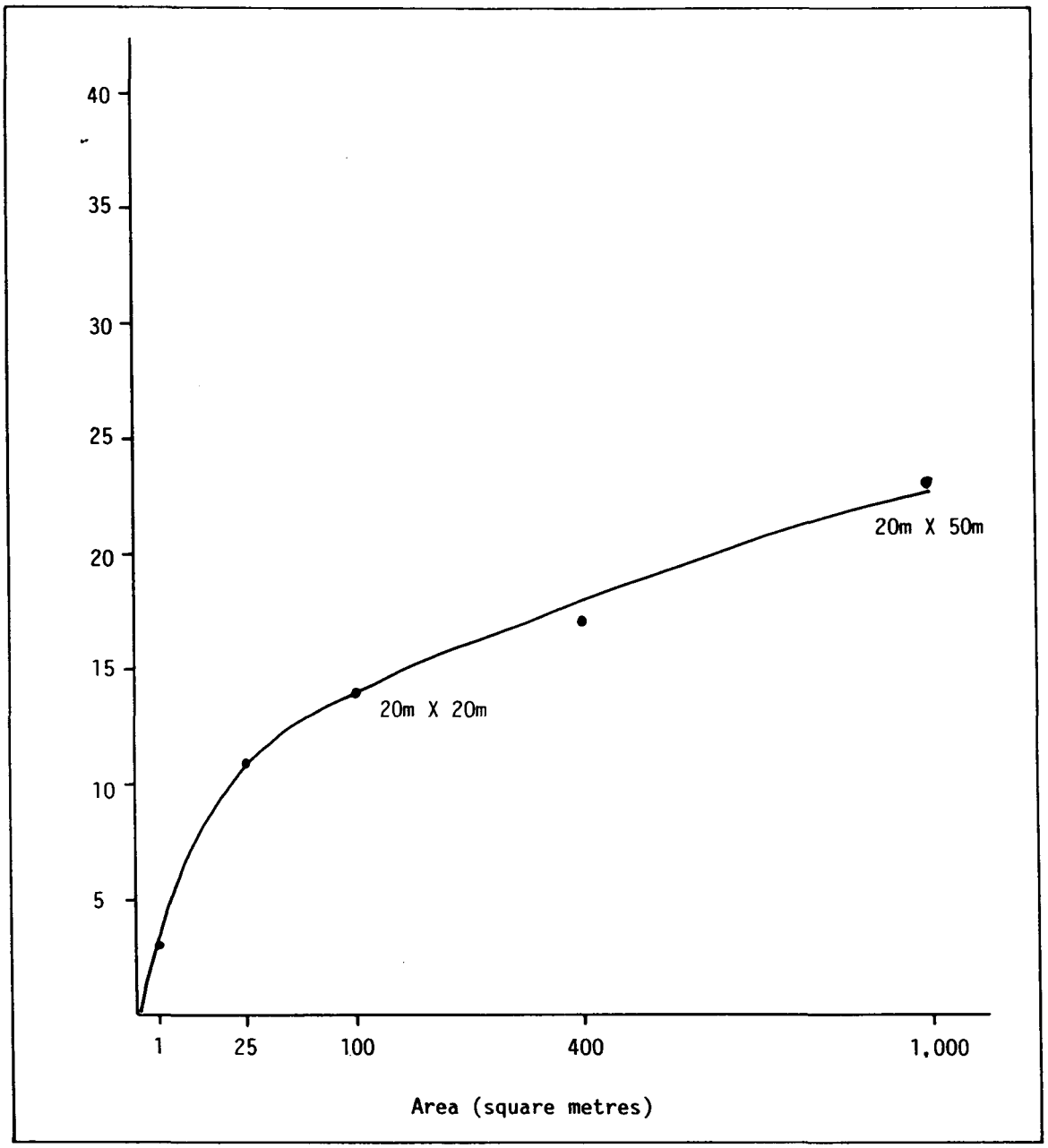
The following species area curves were completed to confirm that the quadrat size of 20 metres x 50 metres was adequate to sample the vegetation in the different communities as regognised from air photos and field survey.



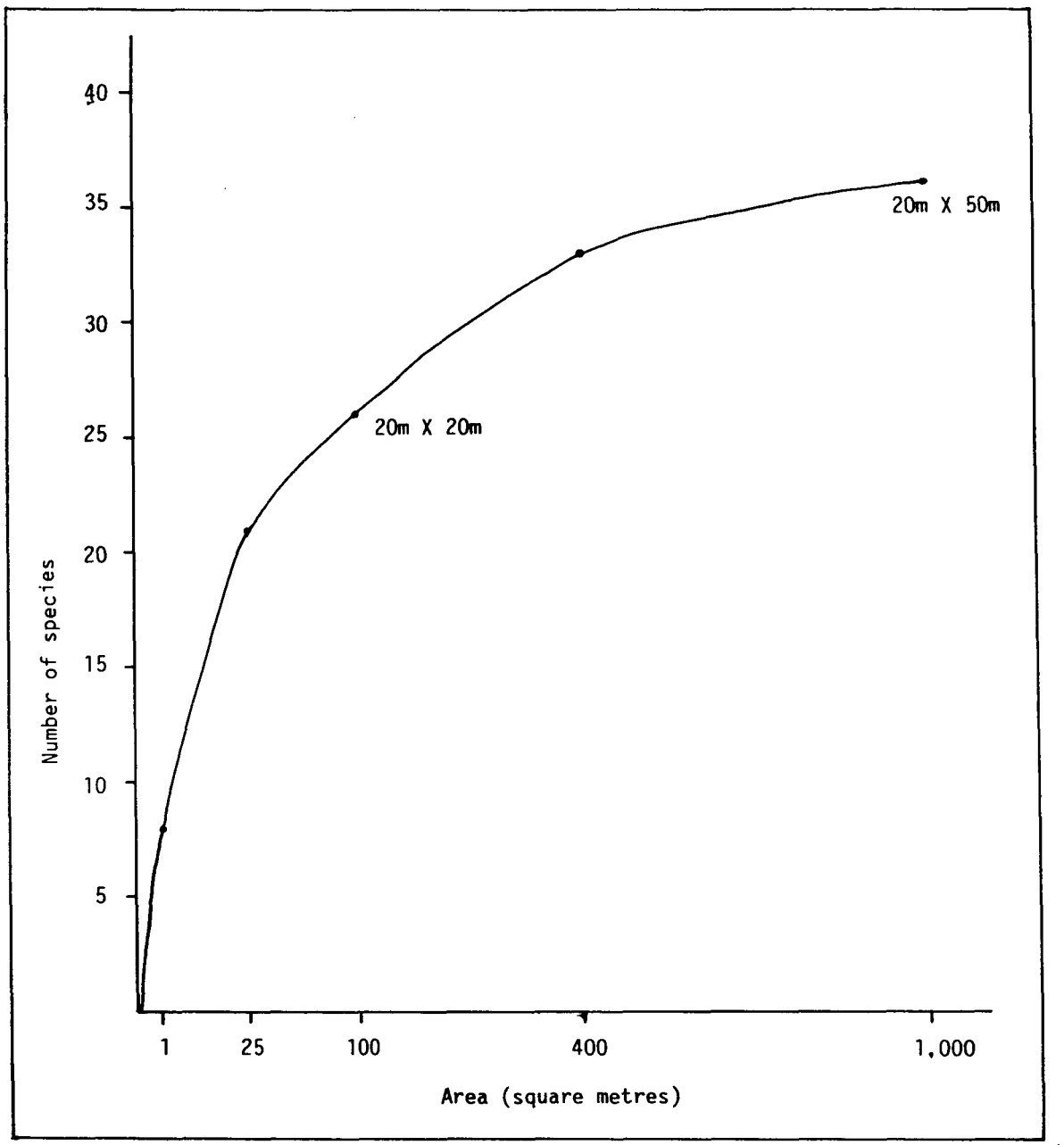
Upper Broom Plain (Site V7)



Mallee (Site V8)



Lower Broom Plain (Site V9)



Sand Monkey (Site V10)

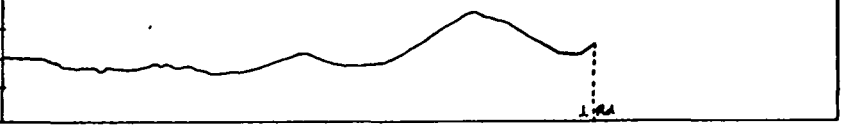
APPENDIX 6

Data Sheets

The following data sheets were used for sampling vegetation.

LOCATION - SITE NAME :

Map	Lat.	Long.
date :		
recorder		
Aerial photo name		run #

SITE FACTORS		W Dunwerian Road E
elevation m		
slope deg		
aspect deg		

GEOLOGY

SOILS

skeletal		sandy		well-drained		Northcote :	
shallow		loamy		damp		Comments :	
deep		clayey		water logged			

HABITAT f - frequent c - common o - occasional r - rare n - nil

logs	> 30cm		earth bank		Water	standing	
	< 30cm		termite mound			running	
	stags					fresh	
hollows	large		outcrop			brackish	
	small		rockshelf			saline	
tree holes	base					swamp	
	branches				dry watercourse		
	trunk						

Comments

FIRE	litter cover %		date last fire
intensity : low		if recent : crown combustion	estimate : confirmed record
medium		crown scorch	word of mouth
high		understorey only	air photo
			field estimate

DISTURBANCE	h - heavy	m - medium	l - light
grazing	clearing	feral animal damage	pollution
logging	erosion	soil disturbance	exotic plants

Comments

PHOTOGRAPHS

VEGETATION

Stratum #	height	% cover	dominant growth form	dominant species in stratum

Height

V. tall	> 30m
tall	20 - 30m
mid-height	10 - 20m
low	6 - 10m
V. low	2 - 5m

GROWTH FORM

T Tree
M Mallee
S Shrub

I Tiller grass
H Hummock grass
G Tussock grass
V sedge
R Rush
O Stolon grass

F Forb
E Fern
X Moss
N Lichen

W Liverwort
L Vine
U Rosette

Species	Stratum	Growth Form	Cover + <5% uncommon 1 <5% common 2 5-20% 3 21-50% 4 51-75% 5 76-100%	Pop. numbers A 1-5 B 5-10 C 10-20 D 20-50 E 50-100 F 100+	Coll #

APPENDIX 7

Species List

A species list for all species recorded within quadrats is presented together with the site in which each plant was collected. Species collected in duplicate quadrats are combined under the same site number. Other collections were made throughout the course of field work but as these were independant of the permanent quadrats, they have not been recorded here.

Nomenclature follows the National Herbarium of New South Wales. Where identification to species level was difficult to determine, the genus name is followed by the letters 'sp.'

Key to symbols:

IB/P	- Ironbark/Pine forests	Bx/P	- Box/Pine forests/woodlands
M	- Mallee woodland	B	- Broom shrublands
SM	- Sand monkey woodlands	G	- Gilgai forests
IB/Ac	- Ironbark/Acacia forests		

* - denotes an introduced species.

Species	Site	IB/P			IB/Ac		Bx/P	M			B			SM	G
		1	12	13	3	4	14	8	2	5	6	7	9	10	11
FERNS															
ADIANTACEAE															
Cheilanthes austrotenuifoila		1	12	13	3	4	14	8	2	5	6		9		
C. sieberi			12		3					5					
GYMNOSPERMS															
CUPRESSACEAE															
Callitris glaucophylla		1	12	13			14	8	2					10	
ANGIOSPERMS - MONOCOTYLEDONS															
ANTHERIACEAE															
Laxmania gracilis		1				4				5					
ASPHODELIACEAE															
Bulbine semibarbata		1				4		8							
CENTROLEPIDIACEAE															
Centrolepis strigosa						4				5		7	9		
CYPERACEAE															
Carex inversa															11
Cyperus fulvus			12												
Gahnia aspera		1						8			6		9		
Schoenus ericetorum													9		
S. ?moorei										5					
S. subaphyllus														10	
JUNCACEAE															
Juncus subsecundus				13											
J. sp.									2						
LOMANDRACEAE															
Lomandra filiformis		1	12								6	7			

Species	Site	IB/P			IB/Ac		Bx/P	M	B				SM	G
		1	12	13	3	4	14	8	2	5	6	7	9	10	11
LOMANDRACEAE (continued)															
L. leucocephala subsp. leucocephala														10	
L. longifolia														10	
L. multiflora subsp. multiflora			12				14	8						10	
L sp.					3					5	6				
ORCHIDACEAE															
Pterostylis sp.								8							
PHORMIACEAE															
Dianella revoluta			12					8	2	5	6		9	10	
POACEAE															
Aristida benthamii var. benthamii		1		13			14	8				7	9	10	
A. caput-medusae					3										
A. jerichoensis var. subspinulifera							14		2			7	9		
A. leichhardtiana		1	12		3	4	14	8	2			7			
A. ramosa var. ramosa		1	12	13	3	4	14	8				7	9	10	
var. scaberula						4									
A. sp. 1											6		9		
Chloris ventricosa									2						
Cymbopogon refractus			12					8							
Danthonia caespitosa								8							
D. linkii var. linkii		1	12			4	14	8					9		11
D. richardsonii								8							
D. setacea															11
D. sp.			12					8					9		
Digitaria breviglumis					3								9		
D. diffusa			12											10	
D. ramularis					3										
D. varians							14								
Enteropogon acicularis		1						8							11
Eragrostis brownii			12			4									
E. lacunaria		1	12	13		4	14	8					9		11
Microlaena stipoides			12		3								9		
Panicum effusum			12			4		8							
P. subxerophilum		1	12			4		8							
Paspalidium caespitosum					3	4							9?		11
P. constrictum			12			4		8							

Vegetatio **91**: 209–218, 1991.
A. Henderson-Sellers and A. J. Pitman (eds).
Vegetation and climate interactions in semi-arid regions.

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Vegetation changes in the Pilliga forests: a preliminary evaluation of the evidence

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Abstract

Changes in the vegetation of Australia since white settlement have been much discussed in recent times. In particular, the changes that have been reported to have occurred in the Pilliga forests in northern New South Wales have been used as a reference for other areas of the State. Two periods of pine regeneration are believed to have occurred in the Pilliga, but preliminary research concerning the history of these forests has uncovered various sources of information indicating that the story is a more complex. Climatic data, archival records and the biology and ecology of various flora and fauna are examined in this paper in a preliminary attempt to gain a more accurate picture of change or stability in the vegetation of this region.

Introduction

The Pilliga Forests of northern New South Wales are often referred to as the 'Pilliga Scrub' and these two terms, 'forest' and 'scrub', reflect long held conflicting perceptions about the nature of this environment.

The most widely accepted view of the origin of the forest country is presented by E. Rolls (1981) in: *A Million Wild Acres*. This book, hailed as an Australian classic by Murray (1984), offers the opinion that prior to European settlement the present forest country comprised a mosaic of open woodland and grassy plains that was maintained by regular Aboriginal fires. The initial exclusion of fire by early graziers, heavy stocking, above average rainfalls between 1879 and 1887, reduced stocking and the reintroduction of fire, encouraged extensive pine regeneration and the eventual abandonment of many grazing runs. No similar pine regeneration event is believed to have occurred until after the wet year of 1950, the fire of 1951 and the reduction of rabbit numbers by *Myxomatosis*. This paper will question the details of this sequence of events because there is a scattered body of evidence which is in conflict with the general model. For example:

1. Although all of the forest area seems to have been claimed by pastoralists by the 1880s, there is little evidence that the core of the forest east of Baradine Creek was ever heavily grazed, of even entirely occupied.
2. Survey maps from the 1870s to the 1930s depict vegetation boundaries in this core area which are remarkably similar to those of today.
3. A number of primary sources describe thick

scrub and pine regeneration events at other times.

4. Although the Forestry Commission management plan (Forestry Commission 1986) generally accepts this model (but with a significant anomaly in the timing of the nineteenth century regeneration event), archival data and past management objectives indicate that earlier foresters had a different appreciation of the environment.

Resolution of these conflicts requires a detailed examination of all the evidence for change or stability in the vegetation and it is the purpose of this paper to begin this process.

Location

The State Forests of the Pilliga, (Figure 1), situated north of Coonabarabran in northern New

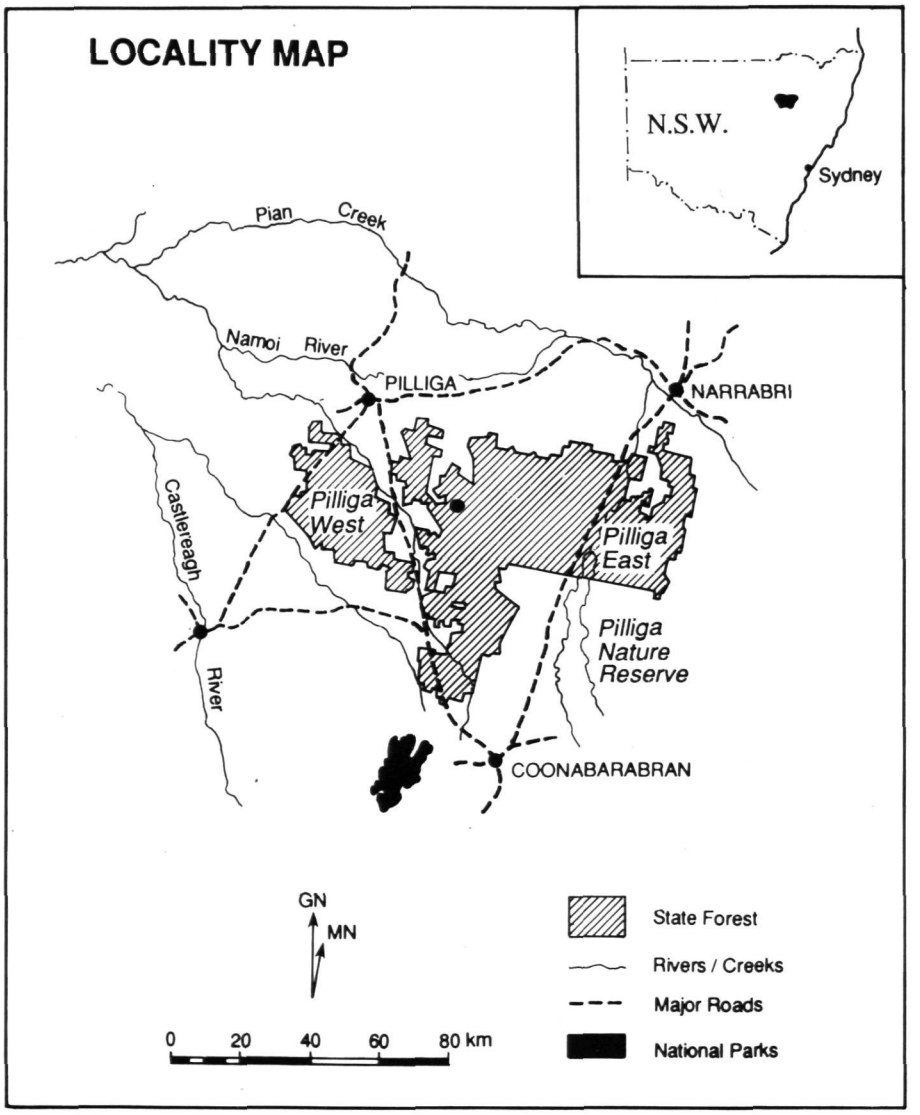

Fig. 1. Location of the Pilliga State Forests, New South Wales, Australia.

South Wales, cover an area of 400,000 ha and constitute the biggest single mass of dedicated native forest in the State.

The geology of this area is of non-marine, Jurassic, Pilliga sandstone which dips to the north-west and flanks part of the Great Artesian Basin (Brown *et al.* 1977). Outcropping sandstone is common in the southern sections of the forests whilst to the north it is covered by extensive sediments deposited by dendritic streams draining north and west. These sediments become finer towards the Namoi River (Mitchell *et al.* 1982). The climate is warm sub-humid with variable rainfall averaging 450–700 mm per annum and showing a slight summer maximum.

There are two parts to the forest; an area covering the main river valleys and Pilliga west which has been settled at various times, and an inner core which is predominantly covered in cypress pine and ironbark forests and woodlands and broom plain scrubs (mainly *Melaleuca uncinata*).

As part of an ongoing series of projects including detailed examination of the soil stratigraphy and vegetation, the history of pre-European and European settlement in the Pilliga Forests is being examined. In particular, we are looking at historical documents for evidence of changes in the vegetation over the past 172 years in an effort to distinguish between those changes which may have been driven by climate and those which may have been initiated by changes in land use.

The accepted view

As noted earlier, Rolls (1981) presents the most widely accepted view of the sequence of events which is assumed to have taken place in the forests of the Pilliga and which has been repeated by others including Austin and Williams (1988). Two periods of pine regeneration are recognised; between 1879 and 1887 and in 1950/51. Of the first period Rolls (1981) claims that by the 1870s settlement in the Pilliga area was more or less complete and at that time there had been no regular burning for about 25 years and that domestic stock had displaced native herbivores (rufous rat-kangoroos). As a consequence of this, pine spread from the ridge country and invaded clear valley floors, and wire and spear grass replaced better species. The graziers began to burn in an effort to control unfavourable grasses and pine scrub encroachment. Weather patterns also had an important influence. Rolls claims that the period 1875–1878 was droughty and that 1879 was very wet, the cattle market was depressed and additional sheep were put on the grass which was burnt to clear seed and give the stock green pick with the consequence that '... where the fires ran years of pine seed came to life.' (Rolls 1981, p 183–184). Similar factors of a reduction in grazing pressure (from rabbits), wet seasons and a major fire are used to explain the second regeneration event in 1950/51. A quotation summarises his argument;

'The four or five good years between 1879 and 1887 were the only years in which it was possible for the new forest to come away. By the next good rains in the 1890s there were sufficient rabbits, as enthusiastic eaters of seedlings as the disappearing rat-kangoroos, to stop most new tree growth. The extent of the country to be abandoned was determined by the 1890s. Except for a thickening of the undergrowth in places in the several wet years following the breaking of the 1902 drought, there was little more growth of pine or scrub until 1951, when a huge fire germinated seedlings (sic) on land soaked by heavy rain in 1950. At the same time myxomatosis destroyed the rabbits. And the lovely tangle which is the modern forest came to life.' (Rolls 1981, p 205).

Evaluation of the model

The validity of this general model needs to be questioned on five important points:

1. The reality and significance of the stated climatic events.
2. The evidence for pre-existing pine scrubs, other periods of regeneration and the actual timing of the main events.
3. The significance of stored seed.

4. The significance of rat-kangoroos in reducing pine regrowth.
5. The significance of fire in relation to pine regeneration.

The weather patterns

Rolls argued that '... the four or five good years between 1879 and 1887...' (Rolls 1981, p 205) were the important years for pine regrowth in the Pilliga. This climatic pattern and the drought between 1875 and 1878 are difficult to confirm because the only official records starting that early are from Narrabri on the north eastern edge of the region. At this station the record shows that rainfall was 24% below average in 1875, average in 1876, and 26% below average in 1877; droughty perhaps but not extreme, although Nicholls (pers. comm.) has confirmed that 1877 was an El Niño year and that a large part of western New South Wales was in severe drought. Rainfall was 44% and 36% above average in 1878 and 1879 respectively and there were only three good years (above average rainfall), rather than 'four or five' within his critical period, these being 1879, 1885 and 1886 (Bureau of Meteorology 1989).

From 1881 rainfall records are also available for Baradine and Coonabarabran. All three stations show similar patterns and can be accepted as representing the Pilliga. At each station 1886 and 1887 were wet years, 1888 was dry, and the early 90s were very wet. This period finished in 1892 at Baradine, and 1894 at Coonabarabran and Narrabri. The years 1886, 1889 and 1890 rank in the ten highest rainfall records at all stations and at Narrabri 1890 is the wettest year on record with the total rainfall being 103% above average (Bureau of Meteorology 1989). If several consecutive wet years are significant in setting pine seed and allowing germination and establishment as Lacey (1973) indicates, then the period 1889 to 1892/94 seems likely to be more important climatically than the late 1870s as the actual regeneration period. This suggestion is supported by the acceptance of the 1890s as the period of regeneration by the Pilliga Management Plan (Forestry Commission 1986).

The circumstances of the 1950/51 regeneration event also supports this conclusion because the rainfall at all three stations was well above average between 1947 and 1950 (with the exception of 1948 at Coonabarabran) and 1950 was the wettest year on record at Coonabarabran and Baradine and the second wettest at Narrabri. Between 1892 and 1947 there were no other such extreme consecutive wet years.

These five decades of lower rainfall follow the patterns identified by Pittock (1975) and appear to have been generally unfavourable to cypress pine regeneration. There were some other periods of pine regeneration however, for example; at Gilgandra in 1917/18 when rabbits were recorded as attacking seedlings and destroying that crop (Forestry Commission 1918) and in 1932/34 in the east Pilliga forests where there had been no sheep grazing and very few cattle (Lindsay 1948).

The 1950/51 regeneration event first became apparent throughout most of the natural range of the white cypress pine in 1953/54 when the seedlings from the 1952 seed year (Forestry Commission 1953/54) were overtopping the grasses. This observation is consistent with the normal two year flowering and cone formation cycle (Lacey 1973) but also indicates that weather conditions for some years after 1953 must have been favourable for seedling survival. Soil moisture levels for a couple of years after the record wet of 1950 were probably high despite average or below average rainfall and the years 1954, 1955 and 1956 were again much wetter than average. We suspect that this coincidence of a subsequent wet period was important in consolidating the regeneration and that this also has a parallel in the 1890s rainfall sequence but not in the 1880s.

So far our review of weather patterns has only examined rainfall, but it is also believed that temperature is important in that mild summers are necessary for seedling establishment (Forestry Commission 1986).

Pre-existing scrubs and other regeneration events

No research has been done on the occupation of the forest area by the Kamilaroi aborigines but the few sites that have been recorded are only short distances from main creeks and it seems likely that they rarely visited the forest core.

The journals of Oxley (1820), Sturt (1833) and Mitchell (1839, 1848) describe journeys down the Lachlan, Bogan and Macquarie rivers and all specifically mention on many occasions that the lighter red soils away from the rivers often supported dense scrubs including *Callitris* sp. It is notable that there are more references to the difficulties of traversing such 'dreadful scrub' country when the explorers made side trips away from the river, or were using pack animals rather than wheeled vehicles which confined them to clearer country.

It is apparent that at the time of first exploration pine scrubs did exist in parts of northern and mid-western New South Wales and southern Queensland but unfortunately there are few records which relate directly to the Pilliga. Oxley crossed the area of the present Pilliga Nature Reserve in 1818 and commented on the density of ironbark saplings but apparently had no trouble in the open valleys and it was along these main valleys that settlement started in the 1840s. All of the forest areas seems to have been claimed by pastoralists by the 1880s but there is little evidence that the core of the forest east of Baradine was ever heavily grazed or even entirely occupied.

Our examination of records shows the majority of runs held were along the main watercourses; the Namoi River and Baradine and Bohena Creeks, as well as in the foothills of the Warrumbungles. These runs were maintained as cattle stations until the cattle market low of 1875 when sheep were introduced. As reported in Rolls, various runholders had access to other runs further into the core of the forest, but it is unknown at present how often they ventured in there and how many stock they ran. Rolls reports that one manager of a combined property never ventured into this area for fear of being lost (Rolls 1981 p 190).

As earlier settlers departed, runs were divided and/or combined and occupation licenses were issued, some of which cover our area of study. Stocking rates are as yet unknown.

It is reported that the Crown did not receive any rental from the Pilliga later than the year 1888 (Forestry Commission n.d.), a fairly good indication that its use was very little indeed. The settlement was along the rivers and on the flats – it was known that the country in the core was both poor and scrubby.

Other evidence of what the core area was like can be gained from reports and survey maps of the 1870s to the 1930s. In 1878 railway surveyors working on the eastern side of the Pilliga commented on 'the marvellously dense scrubs' of the poor sandy soils as if they had long been there (Carver 1878). In 1880 the Surveyor General called for reports from all his Land Commissioners and surveyors on the extent, age and significance of the pine scrub on leased lands all over the west and the response concerning the Pilliga region was that the country contained very extensive indigenous scrubs on poor sandy soils which were of no value for grazing or agriculture. The scrubs were not then believed to be recent but had been present since before first settlement (Anon 1881).

Survey maps depicting vegetation boundaries in the core of the forest show remarkable similarities to the present vegetation patterns.

Figures 2 (a) and 3 (a) are tracings from topographical surveys conducted in 1914 (Lands Dept. 1914a & b). Figures 2 (b & c) and 3 (b & c) are tracings from air photographs taken in 1938 and 1970. Figure 2 shows an area adjacent to Etoo and Rocky creeks (Central Mapping Authority 1974, Cubbo 1 : 50,000, grid ref. 603703). The area west of the creeks has been settled; the remainder has been little touched. Allowing for the nature of the 1914 survey it seems that the boundaries of the deep sands and the broom plains have not changed, at least in this century. In the 1914 survey, the surveyor recognised areas of thick forest ('thick forest of Pine, Ironbark, Oak, Box and Budda' [Lands Dept. 1914a]) to the north and south of the sands and

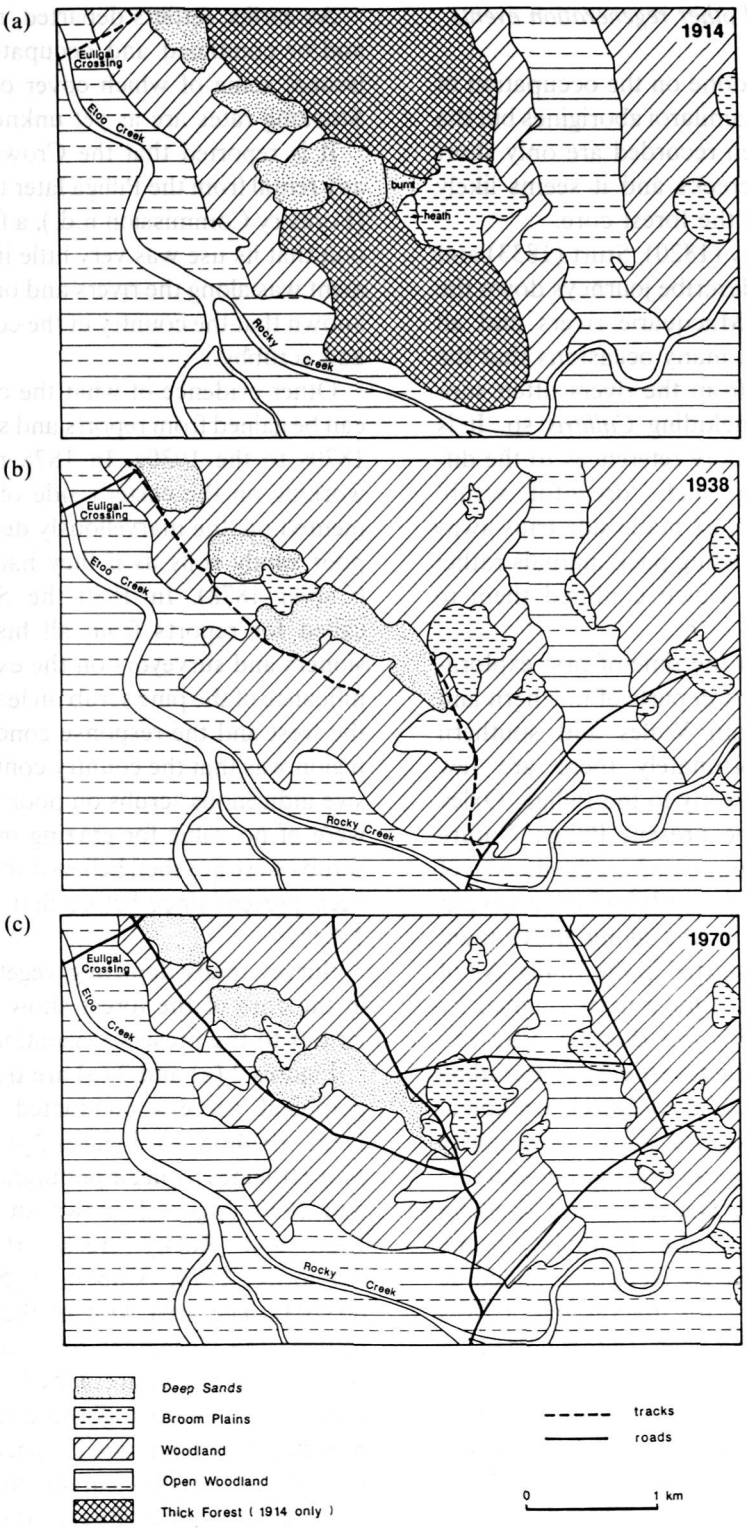

Fig. 2. Tracings from a 1914 survey (a) and airphotographs taken in 1938 (b) and 1970 (c), of the Etoo and Rocky Creek area in the central western portion of the Pilliga State Forests (Fig. 1).

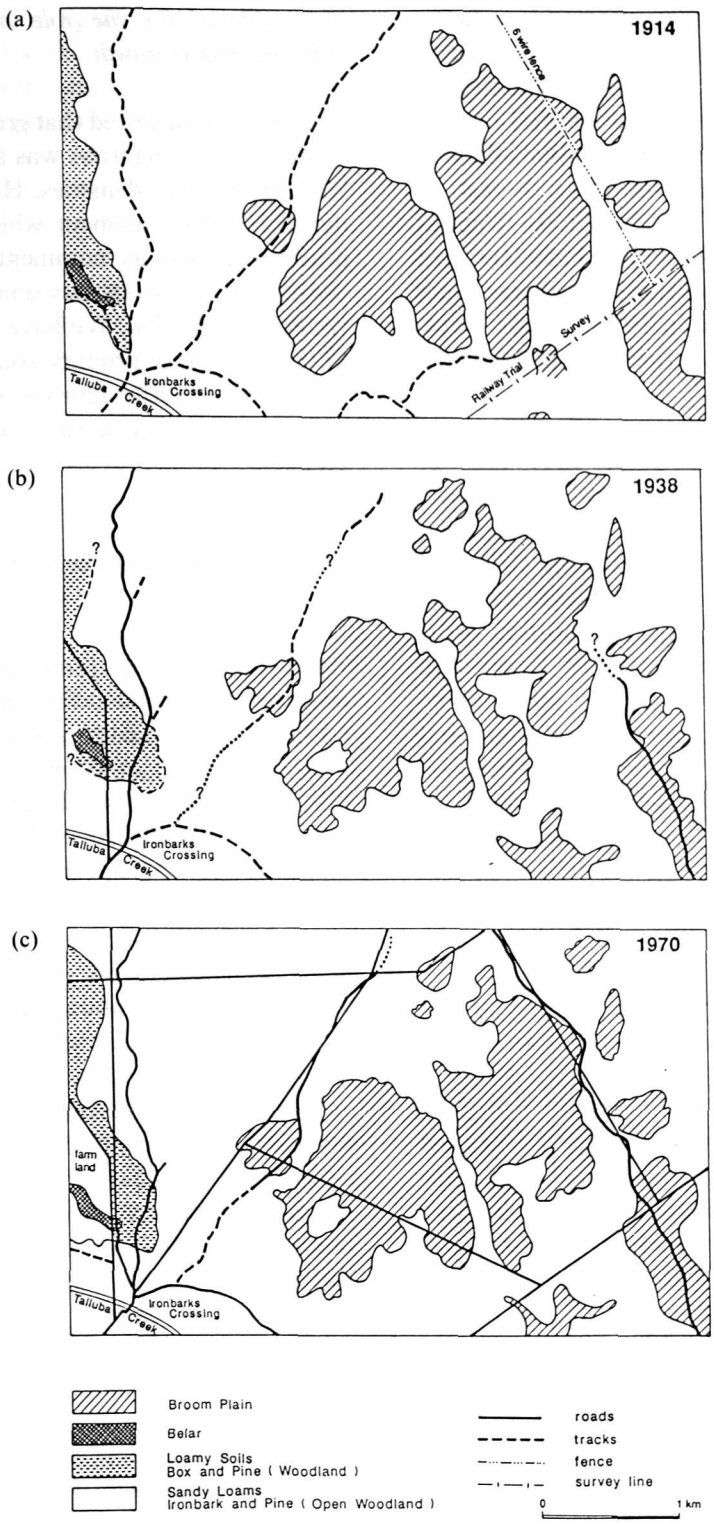

Fig. 3. Tracings from a 1914 survey (a) and airphotographs taken in 1938 (b) and 1970 (c), of the area north and east of Ironbarks Crossing slightly north east of the area in Figure 2.

the central broom plain. While problems arise here with the exact meaning of a 'thick forest', these denser areas are not obvious on the air photographs of later years; a reversal of the expected trend if the forest was becoming denser.

Figure 3 is of an area north and east of Ironbarks Crossing on Talluba Creek (Central Mapping Authority 1974, Cubbo 1 : 50,000, grid ref. 615714). Again, the vegetation patterns seem not to have changed since 1914 (Lands Dept. 1914b), and indications are that the density is also similar.

Nineteenth century maps covering the core of the forest are rare. McClean's 1847 map of squatting districts on the Liverpool Plains shows settlement along the Macquarie, Castlereagh and Namoi Rivers. Other maps include the 1874 map of the Coghill run which gives some information regarding the vegetation, and two portion plans dating from 1878 in the Parish of Dunwerian (Lands Dept. 1878) give similar information. Chatfield was the surveyor for these portions, and although his fieldbook numbers are noted on these plans, we have not yet been able to locate them. Portion plans only cover a small part of the forest, but the notes regarding vegetation detail in 1878 closely match the vegetation on 1970 air photographs and on the ground at the present time.

The importance of stored seed

Rolls (1981) suggests that large stores of pine seed were available on mature trees or in the soil prior to the regeneration years and he implies that this was another important factor in the successful events. This idea was widely held by early observers including Fosbery (1913), but is not supported by the studies of Lacey (1972, 1973) which showed that seed was normally shed in a period of about four weeks in summer and that viability under field conditions was as low as 1% several months after seedfall.

The evidence for the role of rat-kangoroos in reducing pine regrowth

Rolls (1981) suggested that grazing of young pine by rufous rat-kangoroos was an important factor limiting regrowth densities. He presented no evidence for this statement which was apparently drawn from a single comment on the prevalence of rat-kangoroos (species unidentified) made by Oxley (1820 p 270). We have so far been unable to find any other primary source confirming the identity of the rat-kangoroos in the Pilliga and no evidence that they were at all partial to young pine.

The significance of fire in relation to pine regeneration

Rolls (1981) and most nineteenth century observers believed that fire was an important factor in successful pine regeneration. There is, however, no clear relationship between the extensive fires in the Pilliga in November 1951 and the germination of 1952 seed. Many mature cypress pines survived these fires even after being defoliated (Forestry Commission 1951/52), pine regeneration was apparently just as successful in areas which were not burnt elsewhere in the Pilliga, and it was abundant over most of their natural range in the absence of fires elsewhere in the State.

Fire is known to be an important thinning mechanism in young pine stands (Lacey 1973) because seedlings have a high mortality (Wilson & Mulham 1979), but whether it is significant in other ways is not clear and this topic also requires further study.

Conclusions

We have no argument with the observation that increasing densities of woody shrubs are a very serious management problem in many parts of the rangelands in New South Wales as described by Booth (n.d.) and that white cypress pine is one of

the problem species in lighter soils on the higher rainfall margin. What this paper takes issue with is the general belief that there were only two main periods of pine regeneration in the Pilliga area and dense shrub cover was virtually unknown at the time of first settlement when open woodlands and grassy plains were believed to be the norm.

Climatic records suggest that there were two main opportunities for extensive pine regeneration and that Rolls (1981) may have incorrectly identified the first of these by about a decade. We also have evidence that pine did regerate at other times in the twentieth century but may not have survived well because of rabbits or subsequent unfavourable weather.

To judge from the land settlement patterns around the Pilliga it seems to be important that we differentiate the central core of the forests where our evidence indicates that there has been little change in the vegetation, from areas to the west of Baradine Creek, especially Pilliga West State Forest where pine regeneration did close over former grazing lands in the 1890s. Even as recently as 1912 a soils map by Jensen (1912) labelled the central region 'almost unknown'. It is only since good road access was provided by the Forestry Commission after the 1930s that it has became accessible.

Most of the fieldwork that we have been doing in the past few years has centred on the Dunwerian area in the core of the forest. Here we are gathering evidence which seems to point to a remarkably stable vegetation pattern over the past century. The pattern is governed by a factoral complex dominated by soil characteristics, in particular moisture.

Work thus far has been of a preliminary nature only, but has opened up several interesting lines of evidence which we plan to follow up. These include:

1. Tree-ring studies which will help us to establish the pattern of pine regeneration over the past 100 or so years. Preliminary tree-ring counting from pine in the core area indicates a wide scatter of tree ages which would tend to support the hypothesis that regeneration is fairly well spread and not confined to two main events.
2. A closer examination of the available climatic records including temperature and the ENSO phenomenon.
3. A closer examination of the historical records which might exist in obscure places or in the memories of settlers descendants. We need to sort out what stock was in the forest, where, how many and when.

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