CHAPTER 5

RESULTS AND ANALYSIS - PART 1

SOILS

INTRODUCTION

This chapter presents and discusses the results of fieldwork for all of the soil studies.

Investigation of the soils was an essential part of this research. Firstly, the study area has, for some time, been considered poor and scrubby country unsuitable for agriculture. However, these poor soils carry a high diversity of plant species and a range of different communities having sharp boundaries between them. Secondly, as discussed in Chapter 1, it was suggested that a number of edaphic conditions may be influencing vegetation distribution, that is; vegetation patterns are closely linked to variations in soil moisture which in turn will be controlled by subtle topographic and soil differences. Other factors to be considered include soil erosion, possible effects of soil salinity, the abundance, distribution and activity of soil fauna, and the effects of fire.

SOIL MATERIAL DESCRIPTION AND DISTRIBUTION

A description of the soil profiles under each plant community is given in Appendix 2. By combining this information with other data collected by Mitchell (pers. comm. 1995) and Hart (1992) a stratigraphic cross-section of all the field recognizable soil layers can be drawn through the plant communities and topographic units in the study area. This is presented in Figures 5-1, 5-2 and 5-3. Figure 5-1 is a transect from Junction Road to Ironbarks Crossing Road (section A-B on Figure 3-5), Figure 5-2 extends from Ironbarks Crossing Road west to the Ironbark-Pine community of Site 12 (section C-D on Figure 3-5) and Figure 5-3 extends from Site 12 to the Belah community located on Pine Road between Dunwerian Road and Greens Road (section E-F on Figure 3-5). Figure 5-2 includes more details of the stratigraphy because this is the section where soil-moisture and conductivity studies were also undertaken.

For the study area, two primary profile forms (in the sense of Northcote 1979) are found, these being uniform soils and duplex or texture contrast soils. The general trend in the duplex soils is for the light-textured topsoils to be acid whilst the clay subsoils are neutral or slightly alkaline. When moist, the pedal clay subsoils tend to be very sticky but when dry they become extremely hard, and hand augering is impossible (this condition is at its most extreme in the mallee community). These characteristics classify these soils as harsh texture contrast soils in the sense of Paton (1978). On the upper hillslopes in the mallee community the harsh clay subsoils are clearly derived from the sandstone by *in situ* weathering processes, but the origin of the clay subsoils further downslope are not so clear and it was often difficult to differentiate weathered sandstone from alluvial materials in the deeper auger holes in this section.

A notable characteristic of the texture contrast soils is the development of columns and domes in the harsh clay subsoils. Plates 5-1 and 5-2 illustrate this columnar structure. Topsoil material can be found up to 40 cm depth between the domes (Fig. 5-4 and Plate 5-1).

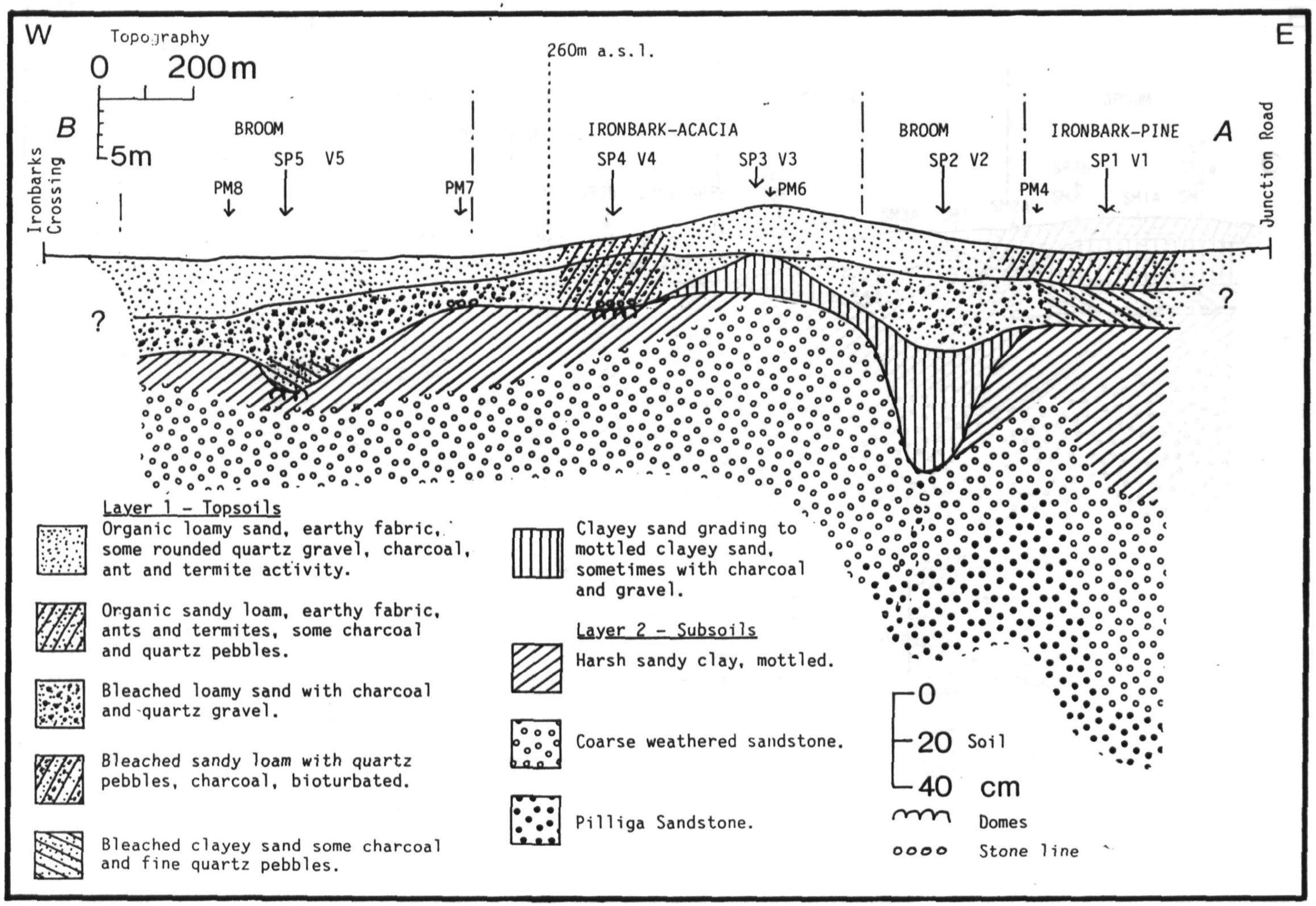

Figure 5-1 Soil stratigraphic section *A-B* (refer Fig. 3-2) along Dunwerian Road, between Junction Road and Ironbarks Crossing Road showing relationships between soil materials. Soil profile sites (SP) and vegetation sites (V) annotated. Sites prefixed by 'PM' are from Mitchell (pers. comm. 1995).

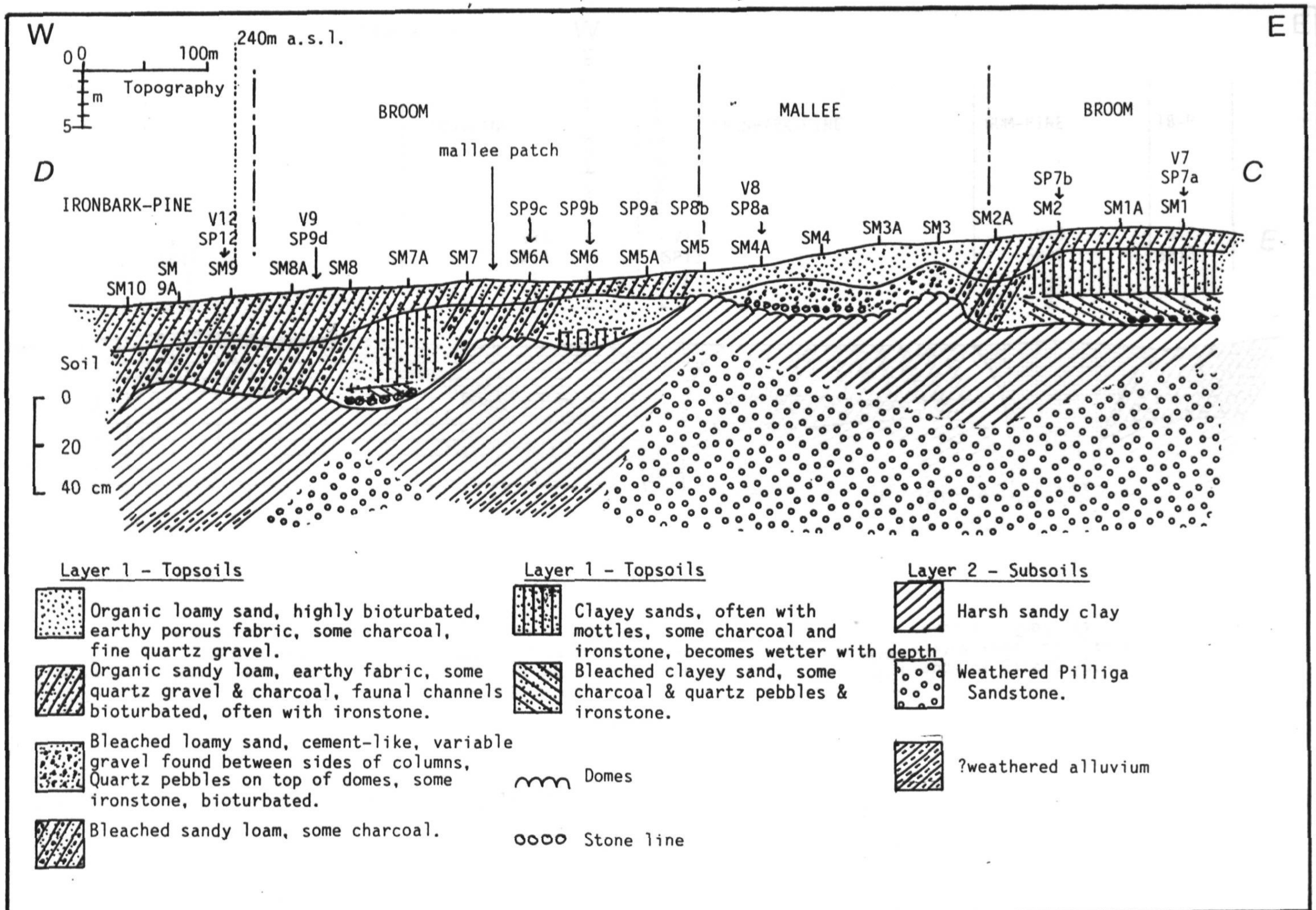

Figure 5-2. Soil stratigraphic section *C-D* (refer Fig. 3-2) along Dunwerian Road from Ironbarks Crossing Road to Site V12, showing relationships between soil materials. Soil profile sites (SP) and vegetation sites (V) annotated.

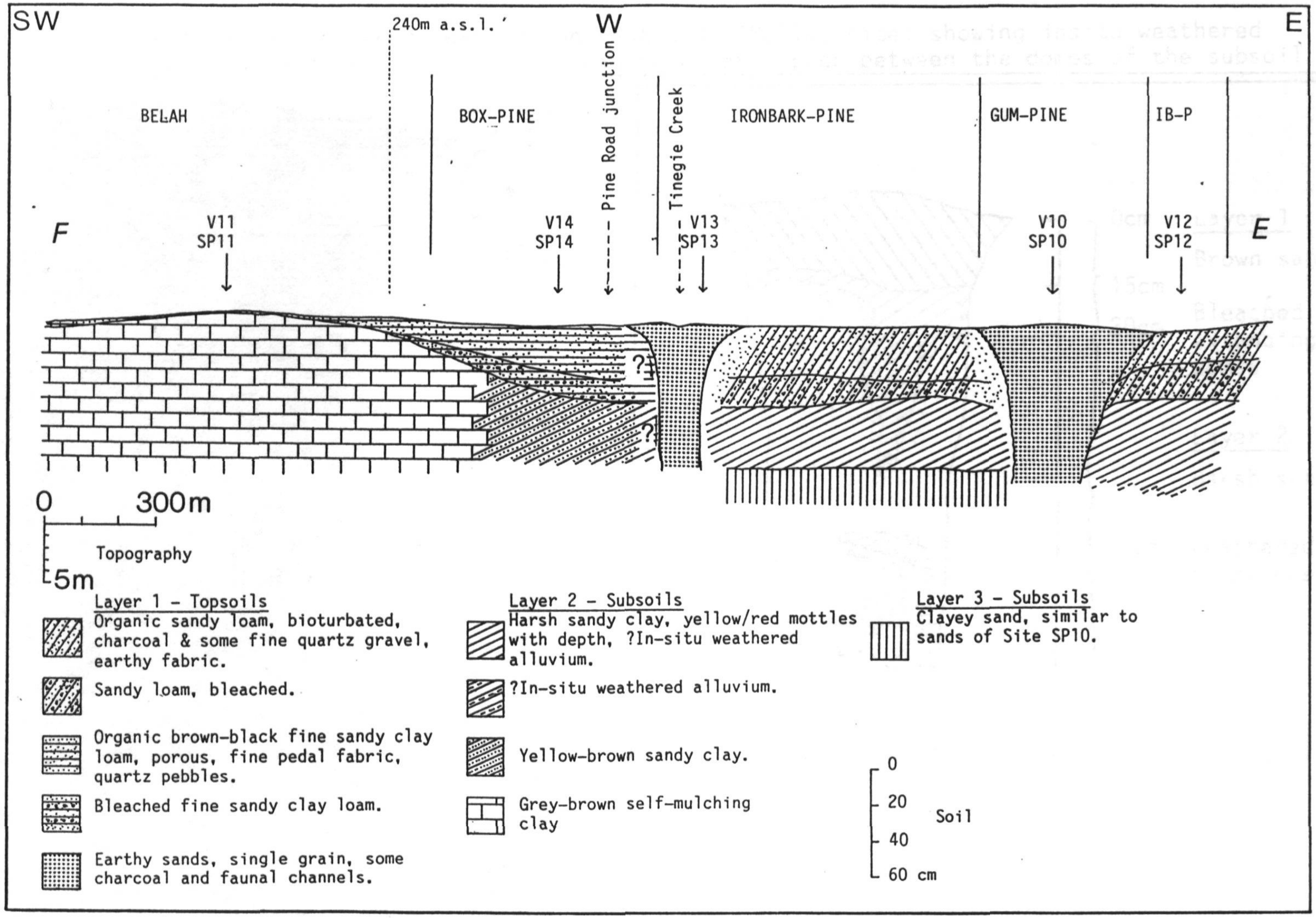

Figure 5-3 Soil stratigraphic section *E-F* (refer Fig. 3-2) along Dunwerian and Pine Roads showing relationships between soil materials. Soil profile sites (SP) and vegetation sites (V) annotated.

Plate 5-1 Pit profile in the harsh texture contrast soil (Mallee site) showing insitu weathered Pilliga Sandstone. Topsoil material can be clearly seen between the domes of the subsoil.

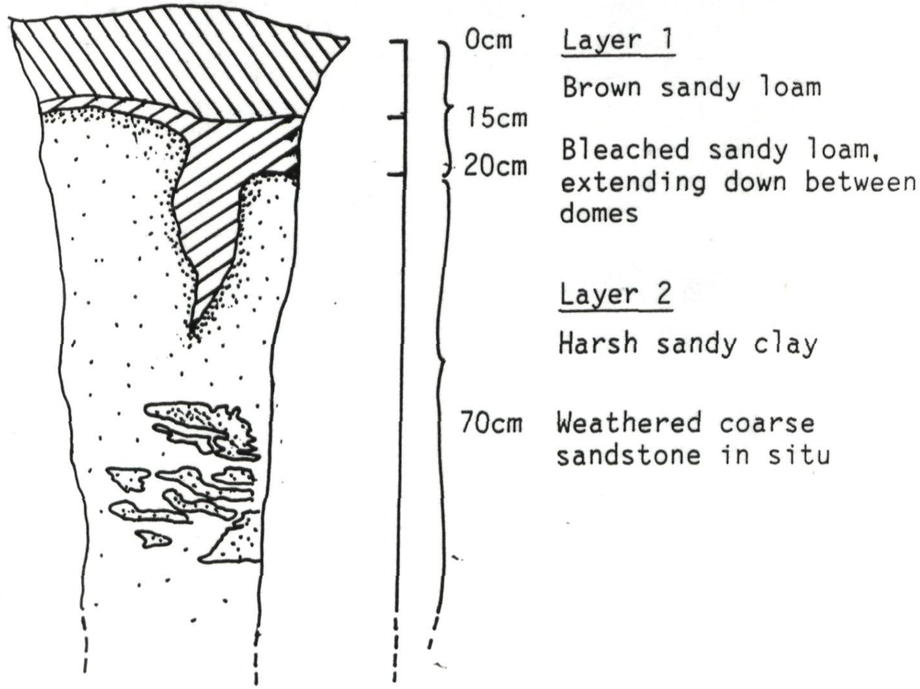

Plate 5-2 Morphology of the dome tops in the texture contrast soil under the mallee community after topsoil removal.

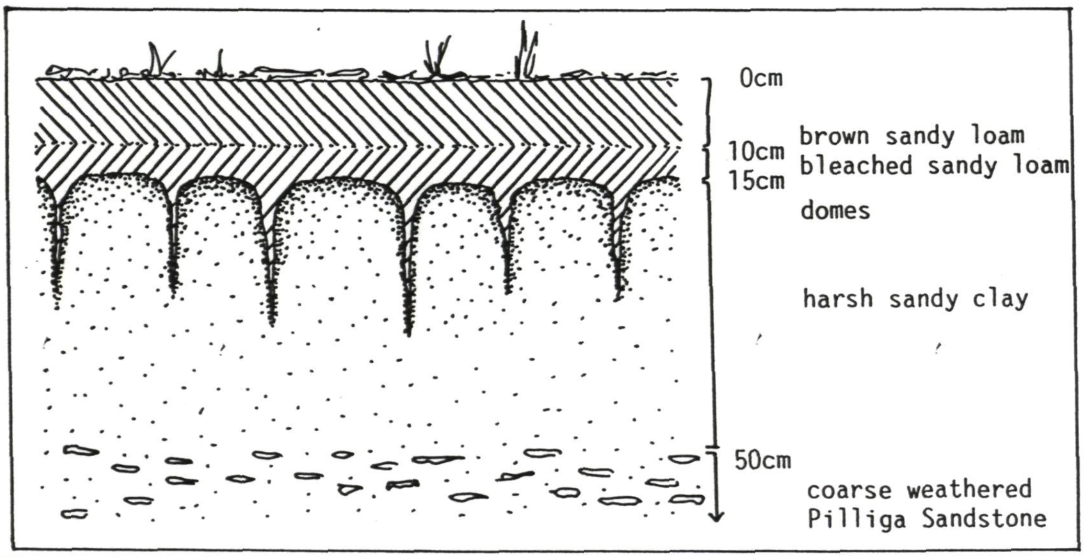

Figure 5-4 Diagrammatic cross-section of the texture contrast soil found under the Mallee community

These profiles are classified as either columnar soloths if the subsoils display a columnar structure or soloths if the columns are absent (Hart 1992). The columnar soloths appear to be present whenever bedrock is within approximately 1 metre of the surface. They are particularly evident in the soils of the mallee community and parts of the adjoining broom plain communities. Under wet conditions the domes act as a barrier to water penetration thus producing a perched water table in the lower topsoils. Any attempt at augering renders the sample contaminated as subsurface water flows into the auger hole. Further, as will be discussed later in this chapter, the soils of the mallee community appear to to be the driest; any water which has infiltrated is transported along the top of the subsoil domes further downslope.

These harsh texture contrast soils equate with the solodic soils of Stace *et al* (1968), belong to the ultisol soil order in *Soil Taxonomy* (Soil Survey Staff 1975) and although their morphology is comparable to that of the solodised solonetz, the theory of formation as described by Stace *et al* (1968) does not seem applicable. Paton (1978) and more recently Paton *et al* (1995) have grouped soils of this nature with other fabric and texture contrast profiles and have criticised the traditional theory concerning the development of solodised solonetz which relies on vertical leaching of all free salts (solonisation) producing a solonetz. This is followed by further leaching of exchangable sodium and magnesium (solodisation) producing a solodised solonetz. This is considered to be an intermediate stage before the final soloth stage is reached (Paton 1978). This view relies on pedogenic processes (leaching) operating vertically downward within the soil profile, and excludes consideration of any of the effects of surface erosion, sediment deposition and the role of soil fauna in mounding and mixing soil materials on or near the surface. All of these are contemporary processes which have been shown to be an essential part of texture contrast soil formation in similar sandstone environments of the Sydney Basin (Humphreys and Mitchell 1983) and the full significance of which has been emphasized by Paton *et al* (1995).

In the sandstone areas of the Sydney Basin, texture contrast soils are formed on hillslopes where a sandy topsoil moves over in situ weathered bedrock. The mobile sandy topsoil is formed by the physical mixing of soil particles (bioturbation) by ants, termites and other soil fauna which bring the soil material to the surface where rainwash erosion removes the finer size fraction. Where this sandy topsoil overlies a clay subsoil, texture contrast soils are formed; where it moves over rock or sandy subsoils, uniform soils are formed.

This model of duplex soil formation can be directly applied to the study area as similar stratigraphic relationships have been observed within soil mantles. For example, shallow uniform coarse sandy soils are found on the sandstone ridges (Appendix 2, Soil Profile SP4). Downslope from the ridges where sandstone is not near-surface the soil becomes deeper and is characterised by a sandy loam topsoil overlying a harsh clay subsoil, this subsoil being derived directly from weathered Pilliga Sandstone or from the Quaternary alluvial sediments overlying this sandstone (Fig. 5-1 and 5-2; Appendix 2, Soil Profile SP2, SP6, SP7, SP8). These soils support a range of plant communities as described in Chapter 6.

Generally, the soils under the Mallee, broom and Ironbark-Pine communities are the harsh texture contrast soils. Site SP1, an ironbark-pine community, is an exception in having uniform soils probably due to its proximity to a watercourse resulting in deeper sandier profiles. At this site, as with other Ironbark-Pine sites the soils are characterised by deeper sandy loam topsoils, in the order of 30-50cm in depth.

For the study area some differences between the texture contrast soils under the different plant communities have been observed and these are presented in the following discussion.

1. Bedrock and domes

Bedrock is within 1 m of the surface under the Mallee community, whereas under the broom, Ironbark-Pine and Pine-Box communities bedrock is not found near surface. The domes and columns strongly developed within the subsoil of the Mallee community are not as common elsewhere, although they do occur. Domed morphology in the top of the subsoils is also found in the western end of the broom plain adjacent to Site SM8A (refer Fig. 3-6). At this location, Mitchell (pers. comm. 1995) found coarse weathered sandstone at 4 metres depth. Strongly developed domes were also found in the middle of the western broom plain where a small patch of Mallee can be found (Fig. 3-6 and Fig. 5-2 between Sites 6A and 7. Here, depth to weathered sandstone is 65 cm.

The presence of polygonal crack patterns in the road surface along Dunwerian Road would seem to indicate that domes and columns are quite widespread. The observed relationship between Mallee communities and areas where the texture contrast soils typically display shallow topsoils over strongly developed domes in the subsoils needs to be tested elsewhere.

2. Topsoils

The topsoils in the Mallee are much shallower (10-20 cm) when compared to the broom plain, Ironbark-Pine and Pilliga Box-Pine sites. In these latter communities the topsoils average 30-40 cm in depth resulting in less subsurface water flow allowing for greater penetration of water after rainfall. For the broom plain communities this means that the soils are often much wetter than the up-slope mallee community soils. This aspect will be discussed further in this chapter.

The topsoils in the Mallee community have abundant cracks and signs of termite activity compared to other communities. The soil of the Ironbark-Acacia forests also displayed many cracks with ant/termite activity. Hart (1995) found that the turnover rate for the surface 10 cm of soil by termite activity was 261 years in the Mallee community, 306 years for the broom and 1,014 years for the Ironbark-Pine forests. Given this rate of turnover in the mallee soils and their topographic position in the landscape, the activity of soil fauna such as the termites has probably enhanced the development of soils here, and the soil genesis model of Humphreys & Mitchell (1983) is applicable.

There is a difference in the colour of the topsoils in different plant communities. For example, the Mallee soils are darker than the adjacent broom plain soils, reflecting the amount of organic material incorporated by termite activity (Hart 1995). Topsoils are also dark in the Pilliga Box-Pine community (Site V14). This may be related to the proximity of this site to the Gilgai site (Site V11) where the soils are brown self-mulching clays (Fig. 3-5). Further, the gilgai soils are slightly more elevated topographically so following rainfall events, surface water flow is downslope into the Pilliga Box-Pine community where the topsoils are fine sandy clay loams.

3. Boundaries between plant communities

The boundaries between some of the plant communities are abrupt, occuring within 3 to 5 metres. In some cases these boundaries appear to be coincident with a change in slope, and in other cases, to the proximity of bedrock to the soil surface. Examples include the boundaries between the Mallee and broom plain communities (see Plate 1-1 and 5-3); the broom plain and Ironbark-Pine communities; the Ironbark-Acacia communities; and the Pilliga Box-Pine and Belah communities.

The boundary between the Ironbark-Pine community (Site V12) and the Gum-Pine community (Site V10) is more gradual; i.e. extending over 30 metres, probably reflecting similar topsoils and drainage conditions, or a gradual change in these conditions.

4. Topsoil structure and texture

There appears to be a difference in the structure and pore size between the Mallee and broom plain topsoils (Hart pers. comm. 1995). Most significantly, the soils of the Mallee are slightly lighter textured as a result of the turnover rates of the soil fauna and rainwash removing the finer clay-size particles downslope. Further, the Mallee soils are the lightest texture of all soils investigated and the shallowest.

Topsoils of the Pilliga Box-Pine community are slightly heavier in texture being a fine sandy clay loam compared to other areas (excludng the Belah site). This is most likely due to its proximity downslope of the Belah site and receiving run-off from this grey clay

Plate 5-3 View east along Dunwerian Road overlooking the broom plain. The Mallee community is in the background, showing the abrupt boundary between these two communities.

area.

5. Sand monkeys

Other soils found within the study area include the deep, yellow, well drained earthy sands, found on the sand monkeys (Jensen 1907) which appear from air photos to be of fluvial origin (Plate 5-4; Appendix 2, Soil Profile SP10). These features sit slightly higher in the surrounding landscape and extend to at least 6 metres depth. At depth they are composed of raw sands and fine gravels (Mitchell pers. comm. 1995).

The geomorphic origin of the sand monkeys is unclear. On the air photos most of them appear as sinuous bodies of variable width with the general appearance of stream channels and their general trend is adjacent and parallel to the present stream system. Four different origins are indicated but there has been insufficient research to categorise all sand monkeys.

i) In some cases the sand monkeys are clearly crevasse splay deposits of sand from the present streams (see Figure 3 in Mitchell *et al* 1982) but in many other cases; for example the study area, the relationship to adjacent creeks is less distinct (Fig. 2-1).

ii) Limited deep drilling in the sand monkey between E-F on Fig. 5-3 confirmed the presence of occasional fine gravels within the sand and revealed a lenticular channel cross section shape to the sand body. This sand monkey (and many others) is a sand choked drainage line (comparable to prior streams in the Riverina (Butler 1950)). The fact that sand monkeys are slightly higher topographic features, in the order of 1 to 2 m, may be explained by the fact that sands are less susceptible to compaction and settling than the surrounding finer

Plate 5-4 Soil profile typical of the sand monkey (Site SP10). These are deep earthy sands.

alluvium.

iii) In yet other cases some sand monkeys may be levees along the present streams and in several instances the possibilty exists that some sand deposits are small, low source bordering dunes.

iv) The surface soil materials on all sand monkeys are very bioturbated and generally finer grained sand than the body of the sand deposit which is clearly of fluvial origin. The possibility of some aeolian reworking of the surfaces of many sand monkeys cannot be excluded.

All of the stratigraphic relationships and the possibility of aeolian reworking indicate that most sand monkeys are relict features associated with different runoff conditions and vegetation in the past. Initial thermoluminescence dates at 220-240 cm depth indicate 61.5$\pm$6.8 Ka (Hart *et al* 1996), however, without further work and an extensive dating programme little more can be said about these features.

6. Gilgai

The gilgai soils are composed of grey-brown and brown self-mulching clays and exhibit gilgai microrelief (Appendix 2, Soil Profile SP11). After heavy rainfall events the gilgai depressions become filled with water which may remain for several (Plate 5-5). When dry conditions prevail these soils exhibit a loose surface structure and have a number of major deep cracks and the surface is covered with minor cracks. This is especially noticeable within the depressions.

The geomorphic origin of the gilgai clays and the gilgai microrelief is also unclear. Their distribution is limited and they do not have a clear relationship with the present drainage patterns.

Plate 5-5 Gilgai (Site SP11) filled with water after 25mm of rain, May 1987.

Like the sand monkeys they are generally slighter higher in the landscape than surrounding soils. There are two possible explanations; i) they may be relics of a former level of clay deposition on stream floodplains or outwash areas or, ii) they may be parts of an extensive clay sheet which underlies the modern surface materials and which has been domed up and cracked by pressure of the overlying sediments. Whatever the case may be, the original conditions of clay deposition no longer apply and gilgai sites have some potential to contribute to an improved understanding of the landscape history of the Pilliga if their stratigraphy and age can be determined by further research.

SOIL MOISTURE STUDIES

a. Gravimetric soil water measurement

Soil sampling was carried out over a period of 21 months, from October 1987 to July 1989. During this time a range of soil moisture regimes were experienced and as a result, some interesting features of the soils under different moisture regimes became apparent. Table 5-1 presents the sampling dates for each soil site, the maximum depth to which soil could be collected and a general description of soil surface moisture condition at the time of collecting. These soil surface conditions can be cross-referenced to the study area rainfall records presented in Table 3-1.

b. In-field soil moisture measurement.

In-field soil moisture measurement (plaster of paris blocks) was carried out over a period of 27 months (9 visits). During the course of this work equipment failure was discovered and in reviewing the earlier test results it became clear that it was impossible to

Table 5-1 Soil sampling for gravimetric determinations

Hole #	Oct 87	Mar 88	May 88	Oct 88	Feb 89	May 89	July 89
	Maximum depth of collection (cm)						
Upper Broom Plain							
SM1	-	80	-	-	60	70	-
SM1A	-	-	-	-	-	50	-
SM2	-	70	-	-	40	60	30
SM2A	-	-	50	70	-	90	40
Mallee							
SM3	-	10	80	-	40	80	60
SM3A	-	_	100	40	-	80	80
SM4	-	10	70	-	50	90	70
SM4A	100	-	90	50	-	50	40
SM5	100	20	70	-	30	50	40
Lower Broom Plain							
SM5A	100	-	60	40	30	60	50
SM6	80	60	80	-	70	70	70
SM6A	-	-	60	50	-	80	30
SM7	-	40	60	-	50	50	20
SM7A	90	-	50	60	-	70	30
SM8	70	40	70	-	40	70	40
SM8A	-	-	70	80	60	90	50
Ironbark - Pine Forest							
SM9	60	_	80	70	70	90	80
SM9A	-	-	90	-	-	90	70
SM10	-	30	60	-	40	90	70
General conditions	dry	dry	wet	very wet	very dry	wet	very wet

distinguish the valid results. As a consequence, all the data had to be rejected and only the results from the less frequent gravimetric moisture measurements and general field obervations about soil moisture condition could be used to assess soil moisture variation and distribution.

This was unfortunate because these results were of direct interest for their use as an in-field method of measurement, for providing a comparison with the gravimetric determination, and would have given a much longer period of measurement; i.e. 32 months (Table 5-2).

Table 5-2 Soil moisture sampling: in-field recording and gravimetric sampling.

Date	In-field recording	Gravimetric sampling	months
10/1987		*	0
3/1988	Block installation[a]	*	5
5/1988	Block installation[b]	*	7
8/1988	*		10
10/1988	*	*	12
2/1989	*	*	16
5/1989	*	*	19
7/1989	*	*	21
10/1989	*		24
3/1990	*		29
6/1990	*		32

a: installation of block numbers SM1 to SM10

b: installation of block numbers SM1A to SM9A

Sampling difficulties and data limitations

Attempts were made to sample all soils at 10cm intervals but when the soils of the broom plain and Mallee communities have experienced dry conditions for some months the top of the harsh clay subsoil is cement-like and extremely difficult to auger. This is expressed in the extreme case in the Mallee where the topsoils are not ony shallow but are usually the driest. A soil in this state means that augering for soil samples is impossible, unless by chance the auger penetrates between individual domes and a greater depth can be achieved. Conversely, after prolonged rainfall or heavy rainfall events, the water percolates through the topsoil and saturates the top of the clay subsoil resulting in a perched water table and sub-surface flow in the A2 (Plate 5-6). The topsoil becomes structureless, and is 'porridge-like' in its consistency. Auger holes are completely filled by the sub-surface flowing water. In this case, the topsoil is saturated and samples from other depths are contaminated by water in the hole. Where domes are not present in the subsoil, the auger can be simply pushed into the ground to a depth of 30-40 cm with little effort. Water may still flow into the auger holes, preventing efficient sampling.

At any one time, the soils under the mixed open forests appeared to be the driest of all sites sampled, although problems with soil collection also resulted from both dry and wet conditions here. This is reflected in the depth to which soils were collected (Table 5-1).

SOIL MOISTURE

The spatial variation in soil moisture along the transect, recorded from field observations and gravimetric sampling, is presented

Plate 5-6 Subsurface flow in the A2 horizon, Mallee community, (Site SP8).

in Figures 5-5, 5-6, 5-7 and 5-8. Rainfall for the preceding months is noted on these figures. Figure 5-5 presents the results of field observations of the soil surface condition and these are graphed as either 'wet', 'damp' or 'dry'. Presenting the results in this subjective manner is open to question but they do give a guide to moisture conditions at the time of observation.

Figures 5-6, 5-7 and 5-8 are based on the graphs presented in Appendix 3, and allow for direct interpretation of the soil moisture results. Within these three figures the graphed results are grouped into 0-2% (= dry), 2-6%, 6-10%, 10-14%, 14-18% and 18% and greater (= very wet). These graphs are presented by separating the soil layers into their components; i.e. topsoils and subsoils, to more easily see the pattern of moisture distribution in the soil profile.

Throughout the course of the study a number of soil moisture conditions prevailed as a result of local precipitation, ranging from extremely dry (October 1988) to extremely wet (July 1989). However, under these variable conditions a pattern emerges of a wetting regime over the extent of the transect. This is most obvious from observed soil surface conditions (Figure 5-5) and from the A horizon/topsoil (Figure 5-6).

The pattern becomes less clear with depth, partly due to the lack of data as a result of problems with field collection as discussed above.

From Figure 5-5 the topsoil in the broom plain communities seems to be 'wetter' than the mallee and ironbark-pine forest communities. Further, the upslope section of the western broom plain is generally wetter than the downslope section.

Figure 5-6 presents the gravimetric results for the topsoil/layer

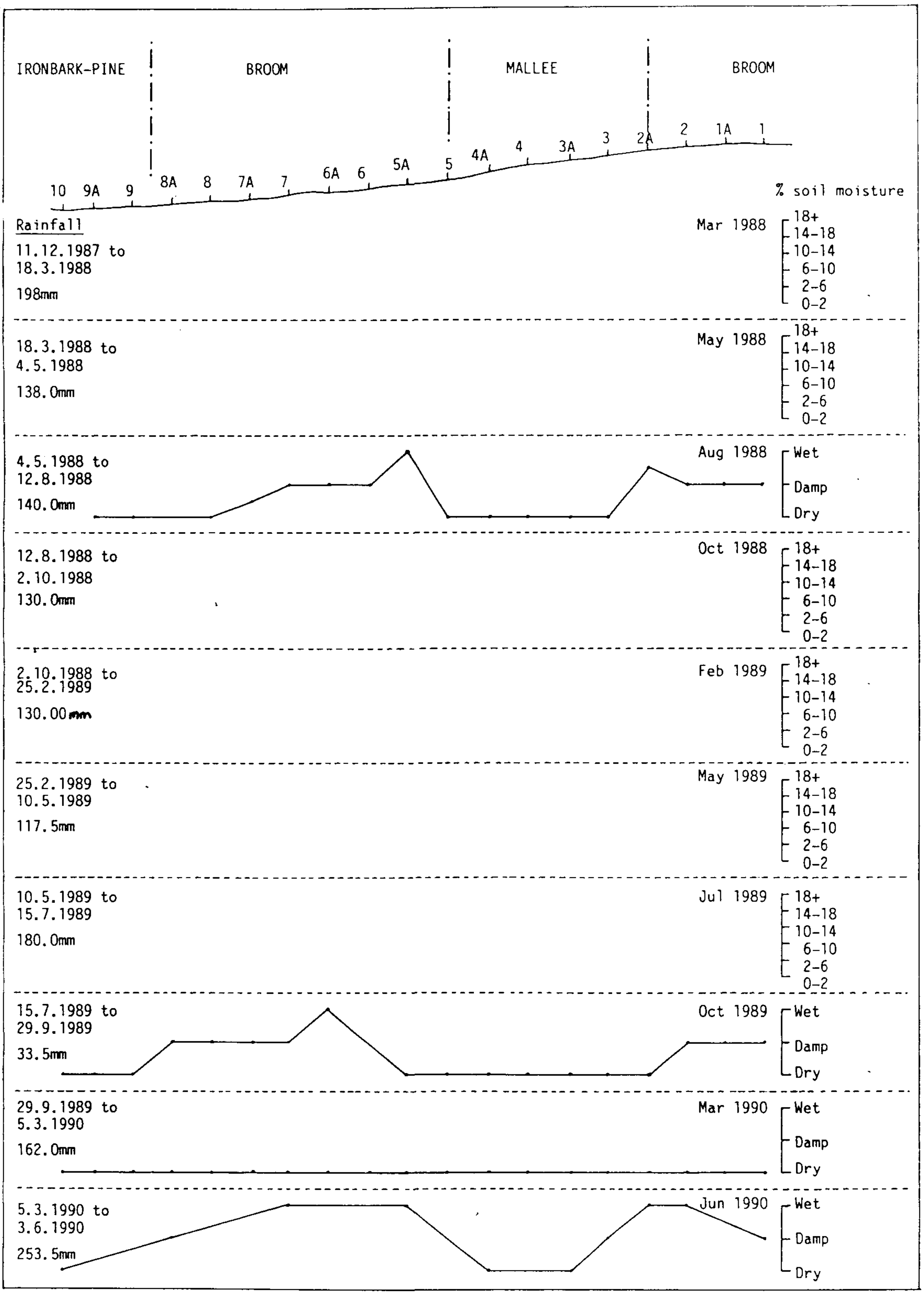

Figure 5-5 Soil moisture of the soil surface recorded as either wet damp or dry at the time of observation.

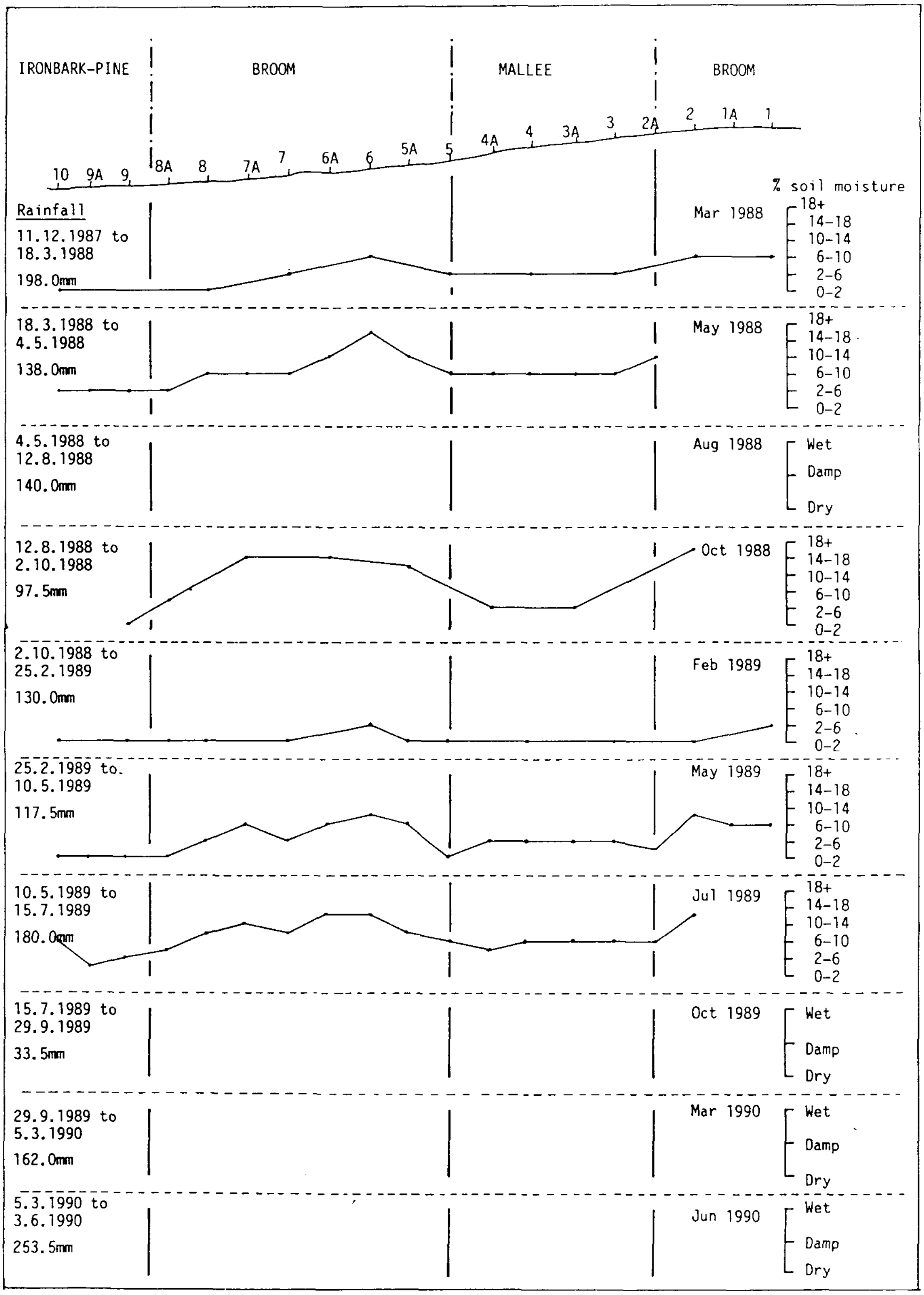

Figure 5-6 Soil moisture of the topsoils/A horizons from gravimetric determination. Moisture is presented as a percentage of total weight of the sample collected.

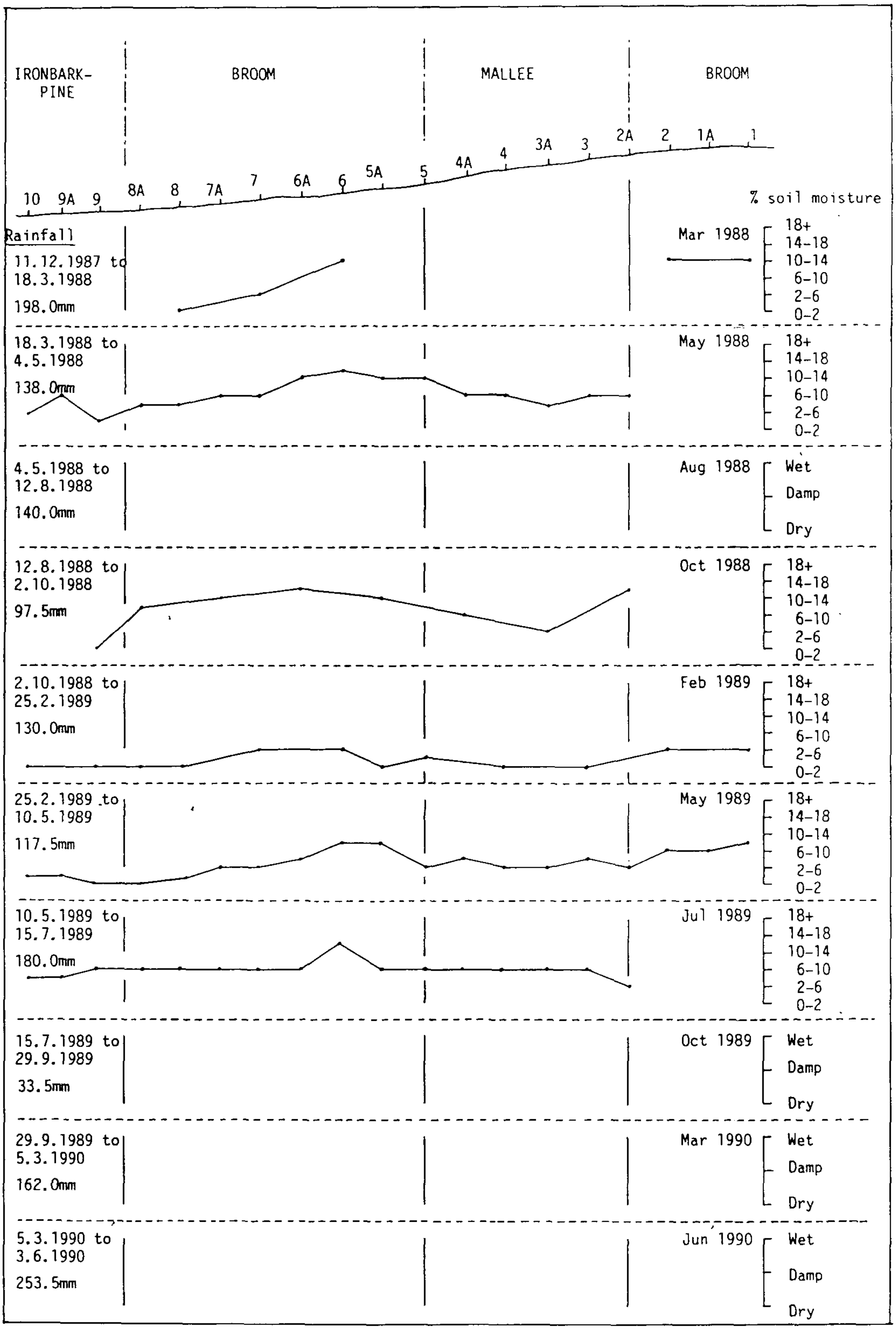

Figure 5-7 Soil moisture of the subsoils/B horizons from gravimetric determination. Moisture is presented as a percentage of the total wieght of the sample collected.

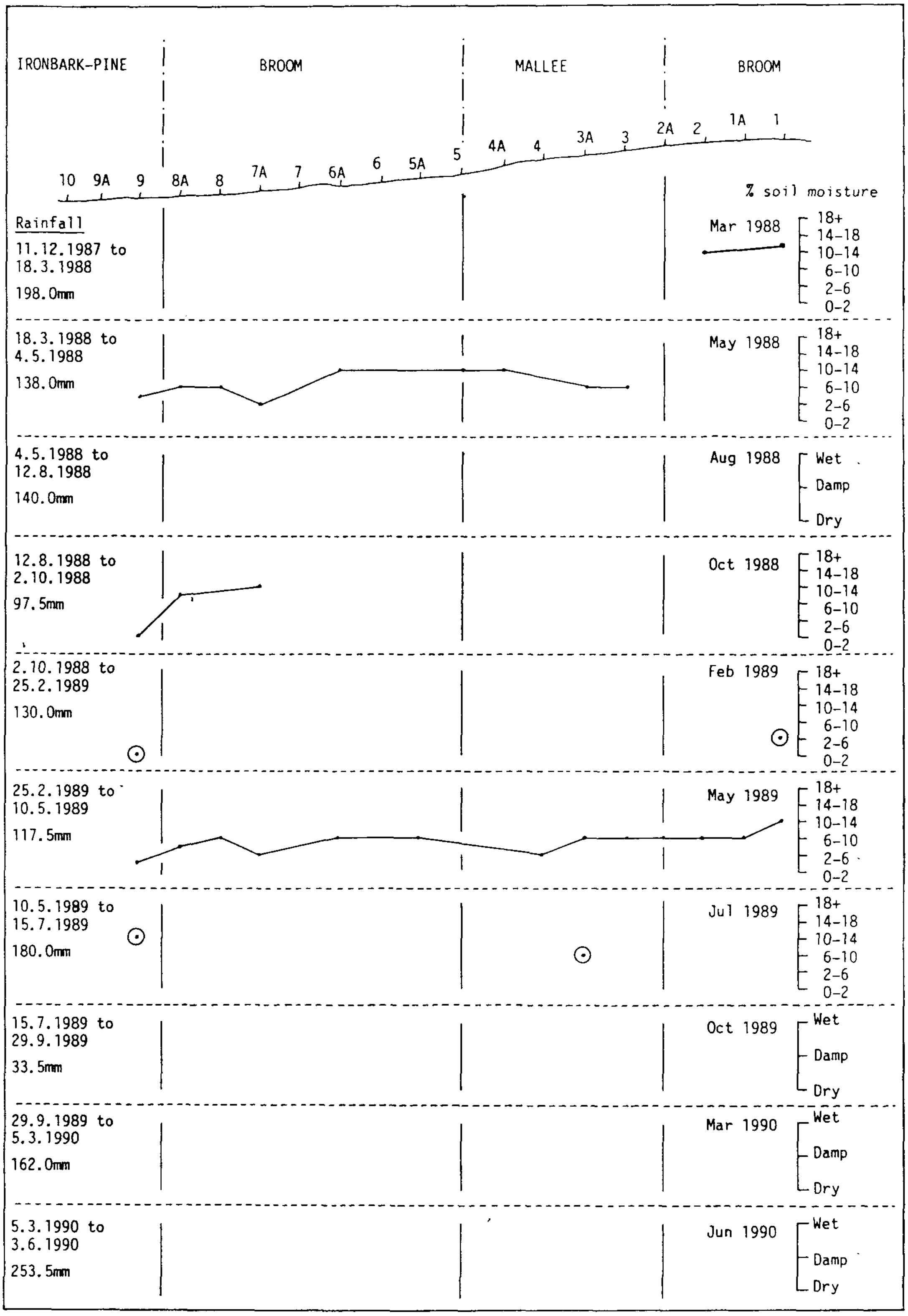

Figure 5-8 Soil moisture of the subsoils/C horizons from gravimetric determination.

1/A horizon and a similar pattern emerges, whether the soils were dry at the time of collecting (February 1989) or very wet (July 1989). The broom plains are 'wetter' in the same way as for Figure 5-5. More obvious is the difference between the mallee and ironbark-pine soils. From Figure 5-6 and the graphs in Appendix 3 the topsoil in the ironbark-pine community appears to be the driest, but these soils are also the deepest.

Figure 5-7 presents the subsoil/layer 2/B horizon data. As can be seen from this figure, some of the results are incomplete due to sampling difficulties. However, May 1988, May 1989 and July 1989 display a similar pattern to that above although moisture is increasing with depth in the ironbark-pine forest. Further, in February 1989 (dry) the broom and mallee were similar.

Figure 5-8 presents the results from the subsoils/layer 2/C horizon. Much data are missing from this figure, again due to sampling difficulties encountered, (refer Table 5-2 and Appendix 3) and, as with Figure 5-7 only May 1988, May 1989 and possibly July 1989 allow for some comparison, and the general trend appears to be the same.

As discussed previously in this chapter, short of removing large amounts of topsoil, it is often difficult to establish whether the domes characteristic of the top of the subsoils or B Horizon are confined only to the mallee community or whether they are more widespread. It appears from this study that they are widespread, being present under the mallee, under the western end of the lower broom plain, in the middle of the lower broom plain where a small patch of mallee is growing, and on the fringes of the gilgai soils. This may reflect the nature of the clays in the parent material (Pilliga Sandstone and alluvium derived from Pilliga Sandstone) from which most of these soils are derived.

Results from particle size analysis studies currently in progress indicate that the *in situ* subsoils derived from Pilliga Sandstone are higher in clay (Hart pers. comm. 1995). This means that the subsoils under the mallee community are more clayey than adjacent areas, and may be an important contributing factor to the production of a perched water table in the A2 after rainfall. Further, the ant and termite activity prevalent in the Mallee brings subsoil material to the surface where rainwash removes the fines downslope into the higher sections of the adjacent broom plains. Here, the topsoils are generally wetter compared to the Mallee and the lower sections of the broom plains, probably due to the amount of subsurface flowing water from the mallee community and the increase in clay particles in the topsoils. This aspect requires further investigation.

SALINITY

Appendix 4 presents the results of electrical conductivity measurements made in the March 1988 and May 1988 soil samples. As with some of the soil moisture results, collecting in dry times meant that few samples were obtained, especially for the Mallee and Ironbark-Pine soils.

The general trend is that conductivity increases with depth especially in the harsh clay subsoils. This is more pronounced in the May 1988 figures when the soils were wetter. Further, the subsoils in the Mallee and Ironbark-Pine communities demonstrate higher conductivity levels compared to broom plain subsoils.

In early July 1991, conductivity was measured directly in the field, being measured in Umhos. Rainfall (Baradine Station 52002) for the preceding two months was high, May 1991 with 147.7 mm, June having 82.2 mm resulting in high soil moisture levels. The results from these measurements was similar to those discussed above, that is, increasing conductivity levels with depth, and highest subsoils levels in the mallee community (Ironbark-Pine community not sampled). Results for these measurements are also given in Appendix 4.

RELATIONSHIP BETWEEN SOIL MOISTURE AND SALINITY

March 1988 - dry

There does not seem to be any clear relationship with soil moisture and salinity levels although this was a dry period as indicated by the lack of data especially for the subsoils of the Mallee and Ironbark-Pine communities where conductivity levels seem to be greater. No comparison can be made.

May 1988 - wet

High soil moisture levels were recorded for the collection time (Fig. 5-6, 5-7 and 5-8; Appendix 3). Conductivity results indicate similar results for the light-textured topsoils across all the communities sampled. However, increases in conductivity with depth especially for the Mallee and Ironbark-Pine communities were recorded. Further, the western and lower end of the broom plain (Site SM8A) also demonstrates an increase in conductitivy with depth.

July 1991 - wet

Although the Ironbark-Pine community was not sampled, a similar pattern emerges. That is, conductivity levels in the subsoils, or clays, in the Mallee community are higher than those of the broom plains.

CONCLUSIONS

From this study it is suggested that the physical soil properties such as soil texture and depth and its effect on drainage are important factors in determining the distribution of plant communities within the study area.

A number of different soil profiles are present. The most extensive are the texture contrast soils and their development can be explained by the model of genesis presented by Paton (1978), Paton *et al* (1995) and Humphreys & Mitchell (1983) within the Sydney Basin and other areas. Although the relief within the study area is slight compared to sandstone areas of the Sydney Basin, the same processes occur here.

The sandy topsoil is formed by the physical mixing of soil particles (bioturbation) by the activity of ants and termites. These fauna bring soil material to the surface where rainwash removes the finer particles downslope through the catchment. *In situ* weathering of Pilliga Sandstone and/or alluvium derived from this sandstone forms a clayey subsoil resulting in the texture contrast morphology. The pedal clay subsoils are very sticky when moist but very hard when dry. According to Paton (1978) and Paton *et al* (1995) these are harsh clay subsoils and by their very nature can have a marked effect on the topsoils as well. Following rainfall events, water percolates through the topsoils with relative ease. On contact with water the clay constituents of the subsoil become rapidly deflocculated, preventing further water movement. An almost watertight seal is formed near the upper surface of the B horizon, or the domes in this case, resulting in waterlogging of the lower topsoils and subsurface lateral flow. An intense bleached zone in the lower topsoils is formed over a very sharp boundary with the B horizon. This is what is found within the texture contrast soils of the study area, and helps to explain the soil sampling difficulties encountered.

Conductivity varies appreciably within the clay subsoils along the transect where distinct vegetation boundaries are present. This increase in conductivity with depth is not necessarily associated with the presence of bedrock near surface (Fig. 5-2), but there may be some relationship with conductivity and the distribution of soil moisture within the profile. For example, the conductivity values are highest in the deeper subsoils for both the mallee and ironbark-pine communities. The soil moisture levels in the subsoils of these two communities is relatively higher that the topsoils. Without further investigation, this comment can only be speculative. Further, it is unclear at present whether the distribution of any conductivity pattern is vertical or horizontal or both.

Soil moisture was measured along a transect from a low crest to a drainage depression and results demonstrated a relationship with the morphology of the texture contrast soils as indicated in Figures 5-5, 5-6 and 5-7. The Mallee and Ironbark-Pine communities are usually the driest in terms of the amount of soil moisture but for different reasons. The Mallee community is characterised by shallow topsoils over a domed clay subsoils. Generally, when water percolates through to the top of the clay subsoils, it cannot penetrate any further and quickly moves laterally downslope into the broom plain community where the topsoils are much deeper and water can penetrate further. The Ironbark-Pine community is further downslope and is probably exposed more to water infiltration from rainfall rather than sub-surface water moving downslope. Further, the uptake of water by the Ironbarks, Pines and Oak trees may also have a great influence here.

In between these Mallee and Ironbark-Pine communities is the broom plain where wetter conditions prevail. This community may act as a 'sink' collecting sub-surface flowing water from the upslope Mallee community. This is supported from Figures 5-5, 5-6 and 5-7 where the general trend is for the broom plain to be wetter up-slope and drying out downslope towards the Ironbark-pine community. Soil moisture is greatest at depth within the mallee and ironbark-pine communities whereas the broom plain communities have most of the soil moisture in the topsoils where most root growth is found.

As previously discussed, other soil profiles present are those of the sand monkey and gilgai which are stratigraphically distinct from the texture contrast soils. These may also be features independent of each other, and warrant further detailed investigation because of the interesting soils and the vegetation they carry.

From the above study, the physical soil factors such as topography, soil texture and depth and its influence on drainage appear to be major determinants of the distribution of plant communities along the transect.

FUTURE DIRECTIONS

Sampling difficulties occurred during the course of fieldwork which need to be overcome in future work. Measuring points need to be established throughout the soil profile. This requires suitable moisture levels in the soil to allow for efficient augering. The pattern of soil moisture could be measured more efficiently on a daily basis by using an automatic field-based recording apparatus such as a data logger. Further, a matrix of measuring points could be established in order to measure moisture spatially down and across slopes. This would give a more accurate picture of the pattern and distribution of water flow.

CHAPTER 6

RESULTS AND ANALYSIS - PART 2

VEGETATION

VEGETATION

Within the study area seven plant communities based on the perennial species are recognised and described. The main structural formations are;

1. *Eucalyptus crebra - Callitris glaucophylla* open forest/woodland.
2. *Eucalyptus crebra - Acacia neriifolia* open forest.
3. *Callitris glaucophylla - Eucalyptus pilligaensis* open forest/ woodland.
4. *Eucalyptus viridis* woodland.
5. *Callitris glaucophylla - Eucalyptus chloroclada* open woodland.
6. *Allocasuarina cristata* open forest.
7. *Melaleuca uncinata, Calytrix tetragona* and *Micromyrtus sessilis* closed to open shrublands.

These seven subjectively recognised plant communities are described below. Soil profile descriptions, presented in Appendix 2, are cross-referenced here. Principle Profile Forms, (PPF [Northcote 1979]) are also given. Site numbers are given and are prefixed by 'V' for vegetation site, and 'SP' for soil profile site (usually the same number as vegetation sites). Structural forms of the vegetation follow Specht 1970).

1. ***Eucalyptus crebra* - *Callitris glaucophylla* open forest/woodland**

(Narrow-leaved Ironbark - White Cypress Pine) Plate 6-1.

Distribution: This is a widespread community throughout the study area, and over the greater Pilliga Scrub. It is found at Sites V1, V12 and V13.

Soils: Several different soil types are found. At Site V1, which is on a flat adjacent to an emphemeral water course, the soils are well drained uniform sandy loams, PPF Uc4.42, over alluvium. Site V12 has a harsh texture contrast soil, PPF Dy4.12, and bedrock is not near surface. Site V13 is on a flat adjacent to Tinigie Creek and has uniform sandy loams to loamy sands, PPF Uc4.21 (Appendix 2, Soil Profiles SP1, SP12, SP13).

Structure: These communities usually attain a height of 15-20 m. Where *Callitis glaucophylla* forms dense stands, (usually but not always indicating even-aged regrowth), it supresses the herbaceous ground cover due to the production of fine leaf litter. This is particularly evident in the area of Site V13 where there is a substantial amount of young pine regeneration. Here, in parts, the stand density of young pine can be 2 to 3 stems per square metre with stem diameters ranging from 2-5 cm.

Canopy species: The dominant canopy species are *Eucalyptus crebra* and *Callitris glaucophylla*.

Other species: The understorey is commonly shrubby and may include *Dodonaea viscosa* subsp. *cuneata, Melaleuca uncinata* and *Phebalium squamulosum* subsp. *gracile*. The herbaceous layer is dominated by various grass species including *Stipa setacea*. *Laxmannia gracilis* is also present.

Plate 6-1 *Eucalyptus crebra-Callitris glaucophylla* open woodland (site V12).

2. ***Eucalyptus crebra* - *Acacia neriifolia* open forest** (Narrow-leaved Ironbark - Silver Wattle) Plate 6-2.

Distribution: This community is not common within the study area mainly due to the absence of other sandstone ridge sites which are more common in other areas to the south further into the Cubbo and possibly Bugaldie land unit. For the study area it is represented by Sites V3 and V4.

Soils: Site V3 is located on a ridge, which is the highest point along the transect of Dunwerian and Pine Roads. It displays a uniform coarse loamy sand, PPF Uc5.21, over sandstone and conglomerate. Site V4 is located 300 m downslope from Site V3, and has a shallow harsh texture contrast soil, PPF Dy5.42, over sandstone (Appendix 2, soil profiles SP3, SP4).

Structure: *Eucalyptus crebra* is tallest species attaining an average height of 16 metres. Co-dominant with the *E. crebra*, although not as tall (10-12m) is *Acacia neriifolia*. The understorey comprises mainly shrubs and herbaceous ground covers. *Callitris glaucophylla* is absent from this site.

Canopy species: *Eucalyptus crebra* and *Acacia neriifolia*.

Other species: Shrubs include *Prostanthera ringens, Phebalium squamulosum* subsp. *gracile, Philotheca* species A, *Melaleuca uncinata* and *Dodonaea viscosa* subsp. *cuneata*. Grasses and herbs include *Thyridolepis mitchelliana, Stipa scabra* subsp. *scabra* and *Calotis cuneifolia*.

Plate 6-2 *Eucalyptus crebra-Acacia neriifolia* open forest (site V3).

3. ***Eucalyptus pilligaensis* - *Callitris glaucophylla* open forest/woodland** (Pilliga Box - White Cypress Pine) Plate 6-3.

Distribution: Within the study area, this community is not as widespread as the *Eucalyptus crebra - Callitris glaucophylla* community. It can be found on gently inclined midslope areas such as at Site V14.

Soils: Soils display a texture contrast, usually being a shallow sandy loam over grey clay. (Appendix 2, soil profile SP14).

Structure: At Site V14 the structure is open forest, 20-25 m high. The understorey is open and shrubby.

Canopy species: The dominant species is *Eucalyptus pilligaensis*.

Other species: Shrubs and small trees include *Dodonaea viscosa* subsp. *cuneata*, *Atalaya hemiglauca* and various grass species and other herbaceous annuals. Young *Callitris glaucophylla* regeneration is present, and is approximately 2-3 metres in height.

4. ***Eucalyptus viridis* woodland** (Green Mallee) Plate 6-4. Mallee.

Distribution: Several communities are present within the study area, and are represented by Site V8. From field observations and air photos these mallee communities appear to be found on the margins of broomplains.

Soils: Soils under *Eucalyptus viridis* are classified as harsh texture contrast soils, PPF Db4.42. These are usually a sandy loam overlying a harsh sandy clay which displays domes and columns (Appendix 2, Soil Profile SP8). Pilliga Sandstone bedrock is within 1 m of the surface.

Structure: Mid-height closed to open woodland 7-8 m high.

Canopy species: *Eucalyptus viridis*

Other species: Understorey species include *Dodonaea viscosa* subsp.

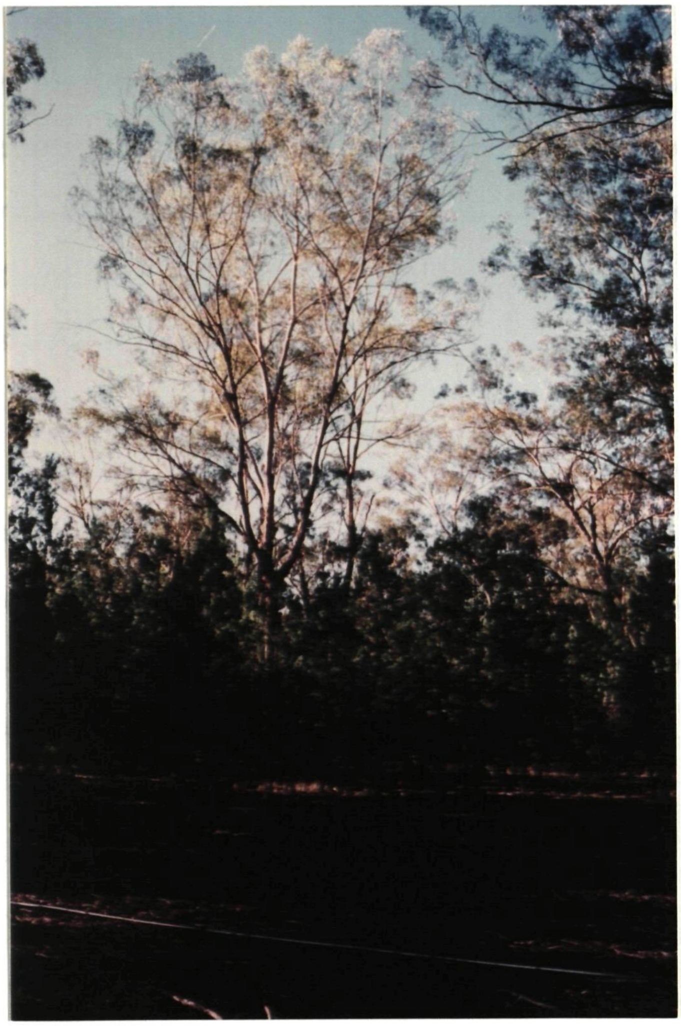

Plate 6-3.
Eucalyptus pilligaensis
- *Callitris glaucophylla*
open forest (Site V14).

Plate 6-4. *Eucalyptus viridis* woodland (Site V8).

cuneata, Acacia lineata, Olearia decurrens and occasional *Santalum acuminatum.* The herbaceous layer is relatively sparse and includes various grass species including *Stipa scabra* subsp. *scabra, Stipa setacea* and *Paspalidium constrictum.* Other species include *Einadia hastata, E. nutans* and *Oxalis corniculata* sens. lat.

5. ***Callitris glaucophylla - Eucalyptus chloroclada* open woodland** (White Cypress Pine - Dirty Gum) Plate 6-5.

Distribution: This community is not common within the study area although is much more common elsewhere in the forest. It is represented by Site V10.

Soils: Soils are deep yellow earthy sand on the sand monkeys, PPF: Uc5.11 (Appendix 2, Soil Profile SP10).

Structure: The structure is an open woodland to 15 m in height, with a low shrubby understorey.

Canopy Species: The main canopy species are *Eucalyptus clorocIada* and *Callitris glaucophylla.*

Other species: The shrubby understorey is dominated by *Brachyloma daphnoides. Allocasuarina diminuta* subsp. *diminuta, Pimelea linifolia* subsp. *linifolia* and *Xanthorrhoea glauca* subsp. *angustifolia* are also common. There are a number of grass species including *Triodia mitchellii* var. *breviloba* and *Stipa benthamii*, and *Dampiera lanceolata* and *Actinotus helianthi* are common herbaceous components.

6. ***Allocasuarina cristata* open forest** (Belah) Plate 6-6a and 6-6b.

Distribution: This community is also not common within the study area, nor is it common elsewhere in the Pilliga. It is represented here as Site V11. Several other patches of this community occur in comparable

Plate 6–5 *Callitris glaucophylla - Eucalyptus chloroclada* open woodland (Site V10).

Plate 6-6a *Allocasuarina cristata* forest (Site V11) with gilgai microrelief.

Plate 6-6b *Allocasuarina cristata* forest.

geomorphic and pedologic locations elsewhere as observed on air photos and confirmed by ground observation.

Soils: The soils are grey self-mulching clay, PPF: Ug6.1, overlying a substrate of alluvium. Gilgai microrelief is present (Appendix 2, Soil Profile SP11).

Structure: The structure is an open forest up to 24 m high. The understorey is open and sparse due to the fine leaf litter produced by *Allocasuarina cristata* forming dense mats up to 3 cm in thickness.

Canopy species: *Allocasuarina cristata*

Other species: Some small trees and shrubs are present and include *Eremophila mitchellii, Dodonaea viscosa* subsp. *mucronata* and *Senna artemisioides* subsp. *filifolia.* The sparse herbaceous layer is dominated by various chenopods including *Maireana enchylaenoides, Sclerolaena diacantha, S. birchii* and *Einadia nutans. Ptilotus semilanatus, Zygophyllum glaucum* and *Stipa scabra* subsp. *scabra* are also common.

7. ***Melaleuca uncinata - Calytrix tetragona - Micromyrtus sessilis* closed heath to tall shrubland** (Broom - Fringe Myrtle - Heath Myrtle) Plate 6-7a and 6-7b.

Distribution: These communities are the broom plains and are widespread throughout the study area. They are commonly found on sloping topography with variable aspect. Sometimes they can be found spreading off low ridges where sandstone may be near surface. For the study area the sites are V2, V5, V6, V7, V9.

Soils: Soils of these communities are usually harsh texture contrast soils, although uniform soils can be found. Generally, the subsoil does not display the domes and column morphology but at some sites

Plate 6-7a Upper broom plain, east of the Mallee community (Site V7)

Plate 6-7b Lower broom plain, west of the Mallee community. Note the band of Mallee in the right background.

this can be found, for example Site V9. Site V2 has loamy sands to clayey sands, PPF: Uc4.21. Sites V5, V6, V7 and V9 have harsh texture contrast soils (loamy sands over harsh sandy clays), PPF Dy5.42, Dy5.42 and Db4.42 and Dy5.42 respectively (Appendix 2, Soil Profiles SP2, SP5, SP6, SP7, SP9).

Structure: The structure within the broom plains varies considerably, ranging from closed heath to tall shrubland. Heights are variable, ranging from 2-5 m, depending on the dominant species.

Canopy species: The canopy species vary in dominance within and between the different broom plains. *Melaleuca uncinata, Calytrix tetagona* and *Micromyrtus sessilis* may be either individually dominant or share dominance.

Other species: Shrubs found within the broom plains include *Hibbertia covenyi, Cryptandra amara, Acacia lineata, A. triptera* and *Allocasuarina diminuta* subsp. *diminuta.* The herbaceous layer can include *Drosera pelata, D. glanduligera* especially after wet conditions, and various grass species. Leaf litter from the canopy species can form a distinct litter layer together with lichen crusts. *Cassytha melantha* is a common vine within these communities.

VEGETATION MAPPING

Figure 6-1 presents a vegetation map for the study area compiled from air photo interpretation and ground survey, displaying these seven communities and other associations. This can be compared to Lindsay's (1967) survey work presented in Figure 3-5. There are a number of differences between both figures most likely reflecting sampling methods used. This is particularly noticeable in the region of the broom plains where more detail is included on Figure 6-1. Generally,

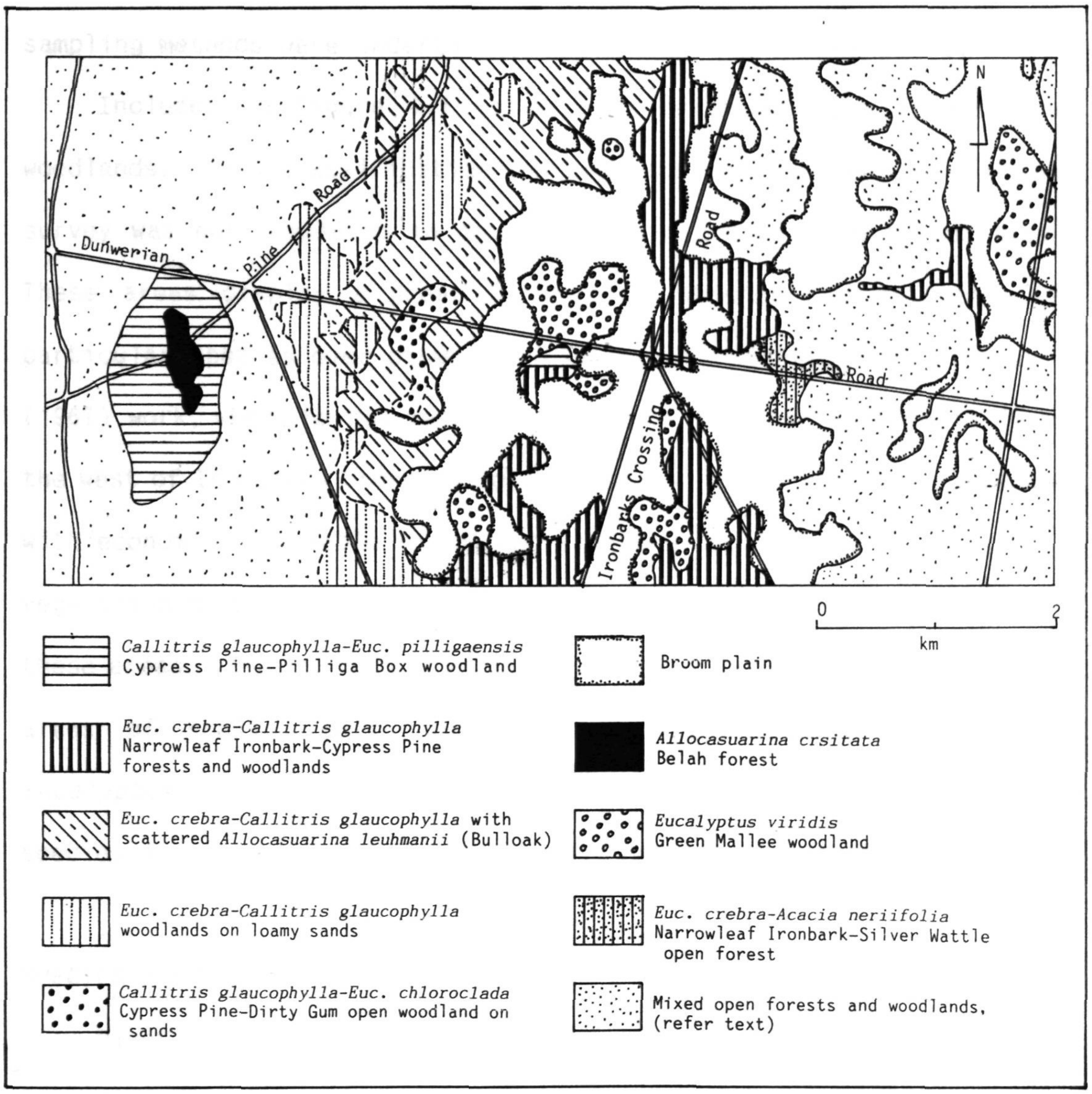

Figure 6-1 Plant communities of the study area as recognised from this study.

however, given the difference in time between sampling (1940s for Lindsay and the late 1980s for this thesis) and the purpose for which sampling methods were undertaken, similarities are very close.

Included in Figure 6-1 is an area of mixed open forests and woodlands. This classification was used for those areas where ground survey was not completed in detail and air photos were relied upon. These areas display a great variety of species and dominance of particular species over others. This is demonstrated from Lindsay's (1967) work, where he has mapped a number of communities especially to the west of Ironbarks Crossing Road. Lindsay (1967) was more concerned with economically viable forest and woodland species and therefore his vegetation mapping reflected this concern resulting in more detail in these areas. The mixed open forests contain a variety of species. For areas of shallow soils over bedrock, particularly low crests, *Eucalyptus trachyphloia* is often a component in the overstorey. This species is present in the vicinity of Sites V3 and V4 (Fig. 3-2).

SPECIES RICHNESS

Plant collections were made at various intervals throughout the period of field survey (Table 6-1). In the 21 quadrats sampled, 185 vascular plants were recorded from 55 families. The main plant families are Poaceae (37 species/sub-species), Myrtaceae (12 species), Asteraceae (12 species), and Chenopodiaceae (10 species) (Appendix 7). Only five introduced species were recorded representing less than 3% of the total number of species.

Based on individual quadrats alone the richest site is the Mallee (*Eucalyptus viridis*) having a total of 55 species. However, when sites are combined into their community types the richest community is the

Table 6-1 Sampling of vegetation sites

OCT 86	MAY 87	OCT 87	MAR 88	MAY 91	JUL 91
V1	V1				
V2					
V3	V3		V3		
V4			V4		
V5					V5
V6	V6				
V7	V7			V7	
V8A	V8A	V8A		V8A	V8B
V9A				V9A/B	
V10A		V10A		V10A	V10B
V11A			V11A		V11B/C
	V12A				V12A/B
	V13	V13			
	V14				V14

Ironbark-Pine (*Eucalyptus crebra-Callitris glaucophylla*). Richness of all sites is presented in Table 6-2.

VEGETATION-SOILS RELATIONSHIPS

No statistical analyses of the vegetation data have been conducted, being outside the scope of this present study. However, the data collected are available for later study and may confirm some of the observations made during this study as well as demonstrating some differences within communities that are unclear at the present time. Some observations as a result of this study are discussed below.

Table 6-2. Species richness for each community.

Community	Number of species	Percentage of total
Eucalyptus crebra-Callitris glaucophylla	68	36.7
Melaleuca shrublands	65	35.1
Eucalyptus crebra-Acacia neriifolia	61	32.9
Eucalyptus viridis	55	29.7
Allocasuarina cristata	49	26.5
Callitris glaucophylla-Eucalyptus chloroclada	45	24.3
Eucalyptus pilligaensis-Callitris glaucophylla	34	18.3

Species distribution

From the species list (Appendix 7) it can be seen that some species are widespread, occurring in several communities and on different soils whilst others are quite specific to particular soil types. For example, *Melaleuca uncinata* is not confined to the broom plains, and can be found commonly in the understorey of the mallee and mixed open forest communities. *Callitris glaucophylla* can be found on the deep sands of the sand monkeys and in the texture contrast soils. Conversely, *Eucalyptus cloroclada* and *Xanthorrhoea australis* subsp. *angustifolia* is found only on the deep sands, such as the sand monkeys, and *Acacia triptera*, a common broom plain species was not recorded elsewhere for this study. To detail and attempt to explain these relationships, multivariate analysis is required, and will be the subject of future study.

The distribution of other species is also of interest in relation to fire history. As discussed in Chapter 3, time since fire for the majority of the study area to 1991 was 40 years. Smaller outbreaks occurred within several of the broom plains (refer Fig. 3-2) giving a time since fire of 25 years. From this study, the distribution of *Acacia triptera* is confined mostly to the broom plains where the shrubs can form impenetrable thickets. These thickets are most noticeable within the fires scars dating 1966-1967, although this species can also be found in scattered areas outside the fire boundary. Cunningham *et al* (1981) have recorded this species in partly cleared mallee. This may indicate that it colonises disturbed areas such as resulting from fire, and that it has a community longevity of between 25 and 40 years.

Regeneration of *Callitris glaucophylla*, White Cypress Pine.

According to Lacey (1972) the most important factor influencing the occurrence of cypress pine regeneration is soil texture through its effect on drainage. This can be demonstrated within the study area. *Callitris glaucophylla* is widespread throughout the study area, where sandy topsoils are present, and as Lacey (1972) comments, sandy loams are the most common soil texture favoured by cypress pine.

It is not recorded in the quadrats for the *Eucalyptus crebra-Acacia neriifolia* (Sites V3 and V4) where the soils were uniform, shallow and rocky, but it does occur adjacent to these sites. It was not recorded, or seen, in the *Allocasuarina cristata* community (Site V11), where the soils are heavy textured, comprising grey-brown and brown self-mulching clays. It was only found on one of five broom plain sites and that site was adjacent to the mallee. The more frequent wet soil conditions in the broom may apparently mitigate against it.

Within the study area there appear to be several different generations of pine regrowth. Site V13 contains several examples.

There is an abundance of cypress pine in the order of 3-4m in height and having a diameter at breast height (dbh) of 5-10 cm. Also present, but much fewer in number, are cypress pines standing 10-12 m high and having a dbh of 25-35 cm diameter.

Species variability within the broom plains

There is an apparent variation in species composition within and between the different broom plains. Thickets of particular species occur to the exclusion of others. For example, at the western end of the broom plain Site V9 comprises dense thickets of *Melaleuca uncinata* forming an almost solid band along the boundary between the broom plain and the adjacent ironbark-pine forest. This is most noticable on air photos. Similar banding occurs in other broom plains, as also seen on air photos. Site V9 (Fig. 3-2) is located in the lowest topographical position within the broom plains and from soil moisture measurements this area was also the driest (Fig. 5-5, 5-6 and 5-7).

As mentioned previously, dense thickets of *Acacia triptera* can be found more commonly in areas that were burnt in the 1966-1967 fires, but not exclusively within this fire boundary. The wetter areas of the broom plains tend to be dominated by *Calytrix tetragona, Micromyrtus sessilis* and *Baeckea densifolia*. Further, there are areas that contain all the above species as co-dominants. These patterns can be found within the same broom plain.

Species variability within the mixed open forests/woodlands

The mixed open forests which cover a large portion of the study area demonstrate a subtle variability in their species composition, not only for the dominant trees present but also in the shrubby component of the understorey.

The *Eucalyptus pilligaensis* - *Callitris glaucophylla* (Site V14) occurs typically on slightly heavier soils (fine sandy clay loam topsoils over yellow-brown clay). Although both these dominant species can be found elsewhere in the study area on lighter textured topsoils, the understorey species found adjacent to this site include *Atalaya hemiglauca* and *Canthium oleifolium* were not recorded at other sites, and *Eremophila mitchellii* was also recorded for the Belah community on gilgai soils. The presence of these understorey species within the Pilliga represents the easterly limit of their geographic range which extends through the north western plains and far north western plains of New South Wales, as well as semi-arid Queensland, South Australia and the Northern Territory; these species are more semi-arid adapted.

Distribution of *Eucalyptus viridis*

From air photos and field observation, the distribution of *Eucalyptus viridis* appears to be related to the occurrence of the broom plains. These two communities are usually found together, although it is unclear at present why this is so. Cunningham *et al* (1981) report that the land on which this species grows is generally regarded as inferior, whilst Groves (1981) comments that this species is commonly found on gravelly sand over clay soils, and Boland *et al* (1992) describes sands or sandy loams with some clay in the subsoil. This observation needs to be tested in other areas beyond the study area.

CONCLUSIONS

Drainage and soil moisture and its effect on species/community distrubution.

Species and community distribution in the study area can be attributed to the depth and nature of the underlying substrate, and to soil texture and its effect on drainage.

The occurrence of the mallee community relates to the proximity of bedrock to the surface and the extreme *in situ* development of the clay subsoils displaying domes and columns. The nature of the harsh clay subsoils, by way of their capability to deflocculate rapidly, means that any water percolating through the topsoils is prevented from any further vertical movement into the subsoils due to the watertight seal created. As the topsoils in this community are shallow they quickly become waterlogged. The water then moves downslope by sub-surface flow and drains into the broom plain where downslope water movement is slower.

Approximately half way though the broom plain, between Sites SM6A and SM7 (refer Fig. 5-2) is a small band of *Eucalyptus viridis* on a bedrock rise. Water ponds for several days after moderate rainfall in the adjacent broom plain. From Figures 5-5, 5-6 and 5-8 this patch seems to influence water flow, by ponding upslope both on the surface and at depth. Downslope of this section the soils are drier.

Broom plains are found on slopes rather than in the lowest topographical situations as suggested by Mitchell *et al* (1982). Further, they have a lower slope angle, becoming flatter, than the adjacent mallee which may influence the rate at which soil water moves downslope. From field observations there is subsurface flow in the mallee soils downslope into the broom plain soils where further subsurface flow, although probably much slower, would be expected (this could be tested with dye tracing experiments). The topsoils are deeper in the broom plain compared to the Mallee top soils, being consistent with the accumulation of rainwashed sediment from upslope. Further, the topsoils are wettest within the broom plains and it is in this part of the profile that most root growth is found. This contrasts with the Mallee and Ironbark-Pine communities where root growth is deeper and soils are damper in the lower horizons.

The Ironbark-Pine community has some of the driest soil. This is probably due more to its position in the landscape, the deeper topsoils and subsoils, the more open understorey allowing for greater evapotranspiration and the uptake of moisture by the large tress present.

The sand monkey community, *Callitris glaucophylla - Eucalyptus chloroclada*, is typical of the medium-coarse sands found throughout the study area and carries distinctive understorey components preferring deep sandy soils such as *Brachyloma daphnoides* and *Triodia mitchelliana*. Drainage at these sites is good due to the coarse nature of the soil.

The *Allocasuarina cristata* community is confined to the grey-brown and brown self-mulching clays, which are uncommon within the study area. After moderate rainfall the gilgai depressions fill with water which may last for several weeks. A characteristic of this site is that many of the *Allocasuarina cristata* grow around the edges of the depressions where subsurface moisture may last for longer periods so being opportunistic in their use of this resource.

Conductivity

The significance of the conductivity results presented in Chapter 5 to species/community compostion and distribution are uncertain. There are patterns in the conductivity over the transect measured, i.e. higher levels are recorded in the subsoils of the Mallee and Ironbark-Pine communities compared to the broom plain. These differences may reflect differences in the soil moisture content with the wetter broomplain soils having lower conductivity compared to the other communities perhaps demonstrating the flushing of cations. The highest conductivities were recorded in the shallow subsoils of the mallee or at deeper levels in the Ironbark-Pine communities. This aspect of the soil/vegetation relationship requires further investigation.

Fire

No wildfire was experienced within the study area throughout the period of study. This meant that for all sites, excluding Site V5, the last wildfire was 1951, giving a total of 40 years since fire up to the close of fieldwork in 1991. As noted in Chapter 3 small outbreaks affected sections of the broom plains on the southern side of Dunwerian Road during 1966/1967 (refer Fig. 3-2).

Hart (1995) found that the rate of litterfall and decomposition in the Mallee and Ironbark/Pine woodlands and forests had reached a steady state after 36 years. It is probable that this period of time is an over-estimate as no data are available on litterfall and decomposition in this part of the forests prior to her study. Hart (1995) also reported on comments from Birk & Simpson (1980, cited in Hart 1995) that it is unlikely that eucalypt forests ever reach a steady state of litter accumulation-decomposition rates unless protected from fire which has been the case at least in this part of the forests. In contrast, due to the minor wildfire outbreaks in the broom plains during 1966/1967 Hart (1995) found that this community had not yet reached a steady state after 24 years.