CHAPTER 3

STUDY AREA, GENERAL FOREST DESCRIPTION AND METHODOLOGY

INTRODUCTION

An understanding of the forest environment is an essential requirement for studying current processes of soil formation and vegetation dynamics. This chapter describes the land systems present within the study area, and reviews the literature concerning soils and vegetation of the region.

LOCATION OF THE STUDY AREA

The study area is situated in the Pilliga East Forest (grid reference 711500mE 660580mN on the topographic map Cubbo 1st edition 1:50,000 series, 8736-N, Central Mapping Authority 1974). Initial investigations covered the area between Junction Road in the east to Etoo Creek in the west (Fig 3-1). Vegetation and soil sites are located along Dunwerian and Pine Roads, between Junction Road and Greens Road, and soil moisture sites are on Dunwerian Road (Fig. 3-2).

Field work was conducted from late 1986 to 1991, mostly between March and October of each year. For soil moisture studies, fieldwork was carried out from March 1988 to September 1990.

As noted previously, wildfire affected the entire study area in 1951. In 1966 and 1977, small fires along Dunwerian Road (Fig. 3-2) affected parts of each broom plain. Vegetation and soil sites were not placed within these more recent fire scars (except for site V5 where there was no option). This meant that all but one site had similar

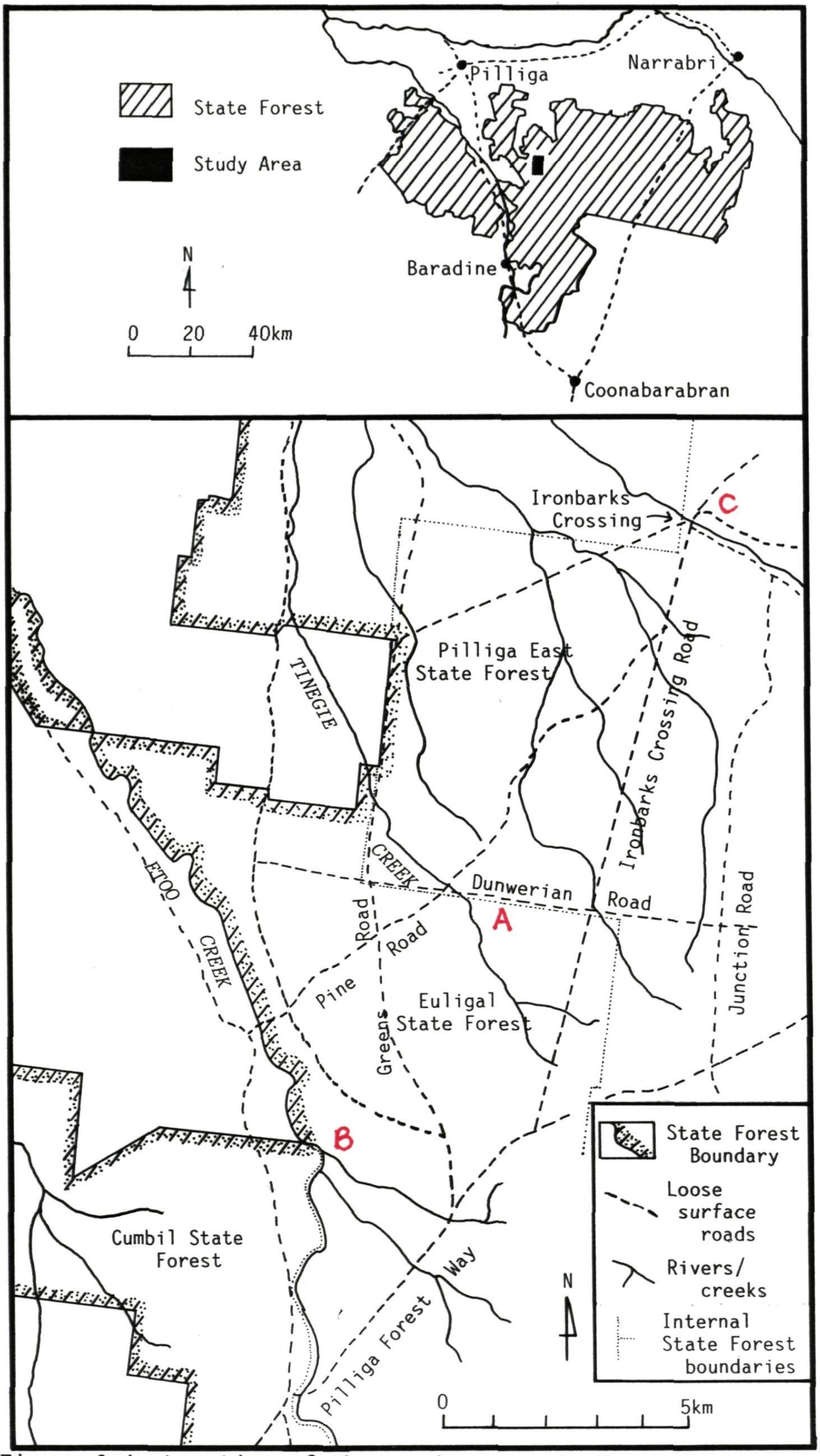


Figure 3-1 Location of the study area. A, B and C refer to the locations of Figs 4-7, 4-8 and 4-9 in Chapter 4.

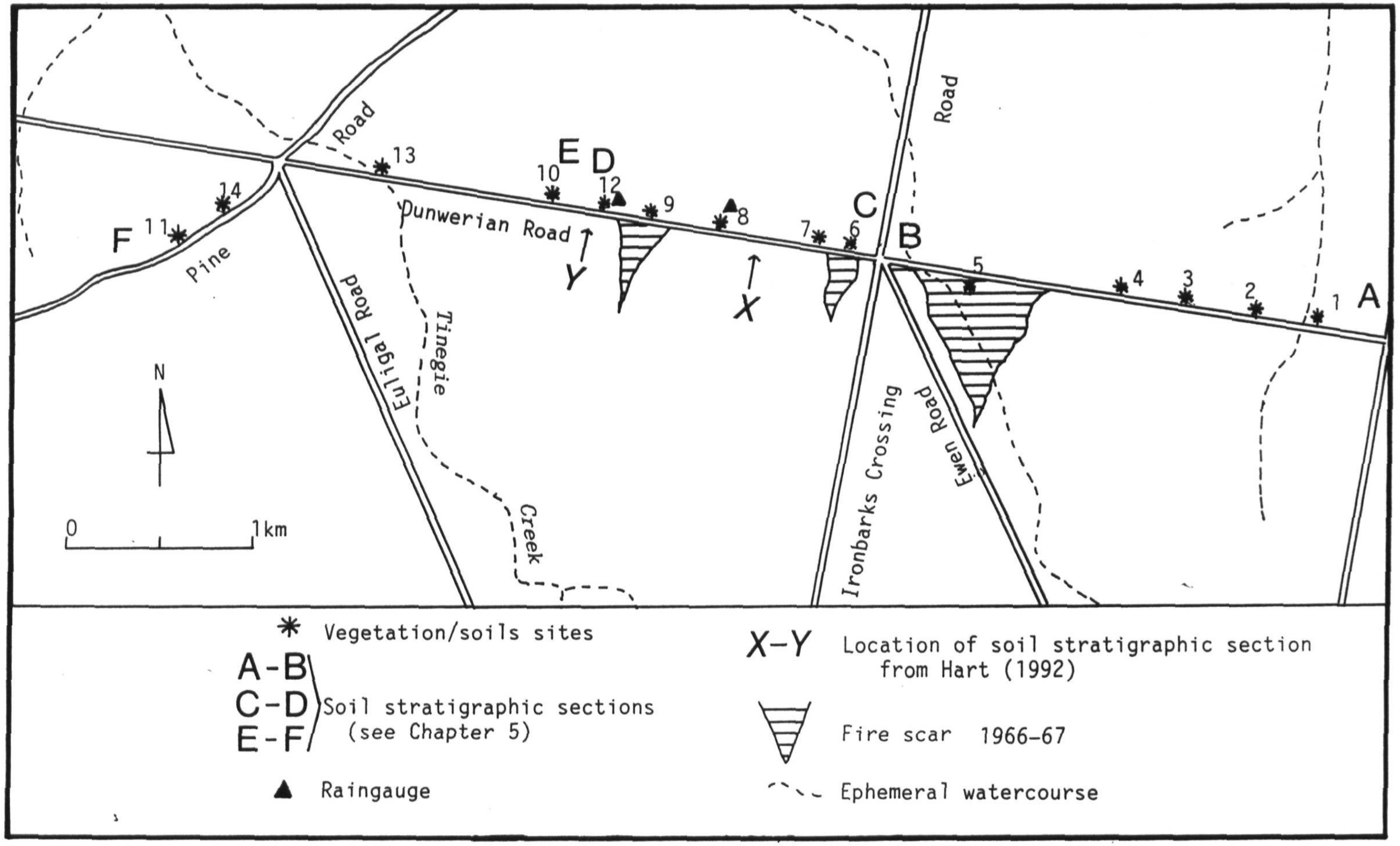


Figure 3-2 Location of vegetation and soil profile sites, and fire scars. A-B, C-D and E-F indicate the location of soil stratigraphic sections presented Chapter 5.

fire histories at least since 1951.

Table 3-1 documents rainfall for the study period at two different locations, one in the mallee woodland (Site V8) and one on the sand monkey (Site V10). These two sites are only 0.8 km apart yet the data collected differs. This might be attributed to the nature of rainfall events, such as storms, to foliage cover differences between the two sites, or evaporation differences from the rain gauges. The most likely effect is greater rain interception and stem flow in the mallee community compared to that of the sand monkey community where the canopy is more open (Plates 3-1a and 3-1b respectively).

Baradine is the nearest meteorological station some 35 km to the south west (Fig. 1-1). Total rainfall for Baradine during the study period (January 1988 to September 1990) was 1927.5 mm. Table 3-1 presents rainfall for this station over the same period and a comparison can be made. The figures are reasonably consistent.

Table 3-1. Rainfall record during the study period - Sites: Mallee (V8) and Sand Monkey (V10), and a comparison with Baradine Meteorological Station (053002).

Date	Week	**Mallee Site**		**Sand Monkey Site**		**Baradine**	
			cummulat.		cummulative		cummulat.
		mm	mm	mm	mm	mm	mm
11.12.87	0		date of installation				
18.03.87	14	198.0	198.0	187.0	187.0	235.6	235.6
30.04.88	21	134.5	332.5	136.5	323.5	145.7	381.3
04.05.88	22	3.5	336.0	1.0	324.5	0.4	381.7
12.08.88	35	140.0	476.0	152.0	476.5	163.8	545.5
02.10.88	43	97.5	573.5	110.0	586.5	107.6	653.1
25.02.89	63	130.0	703.5	172.0	758.5	145.2	798.3
10.05.89	73	117.5	821.0	174.0	932.5	204.0	1002.3
15.07.89	82	180.0	1001.0	229.0	1161.5	195.3	1197.6
29.09.89	99	33.5	1034.5	53.5	1215.0	70.6	1268.2
05.03.90	122	162.0	1196.5	201.0	1416.0	232.3	1500.5
03.06.90	135	253.5	1450.0	259.5	1675.5	319.0	1819.5
25.09.90	153	113.0	1563.0	132.0	1805.5	108.0	1927.5

Plate 3-1a Habit and canopy of *Eucalyptus viridis*, mallee, which intercepts rainfall.

Plate 3-1b Open canopy characteristic of the sand monkey community resulting in less rainfall interception

PREVIOUS ENVIRONMENTAL DESCRIPTIONS

Land Systems

One land system has been recognised for the region comprising two sub-systems, the Pilliga Uplands and the Pilliga Alluvials (Mitchell *et al* 1982). The two sub-systems are divided by a nominal boundary along the edges of alluvial sediments in the present streams. Two units are recognised within the Pilliga Uplands; Bugaldie and Cubbo as well as a Broom Plain component. One unit is recognised within the Pilliga Alluvials; Gwabegar, together with two components; Belah Forest and Brigalow Scrub. The units represent repeating patterns of topography, soils and vegetation.

Description of units

The study area overlaps the Pilliga Uplands and the Pilliga Alluvial sub-systems. Figure 3-3 presents the land systems occuring in the vicinity of the study area.

Cubbo Unit

This unit is similar to the Bugaldie Unit ((see Mitchell *et al* (1982) for description)) but lacks the topographic extremes and extensive rock outcrops of that unit. It occurs as the lower undulating country typical of Pilliga East State Forest and the Nature Reserve.

Sandstone outcrop is limited to low ridges and rocky waterholes, and may be exposed in road cuttings. Lower slopes and creek flats are covered and/or filled with colluvial and alluvial sands. Bedrock is usually within 1 or 2 m of the surface. Maximum relief is 50 m with an average relief of 5 - 20 m; slopes are commonly 2 - 5^0.

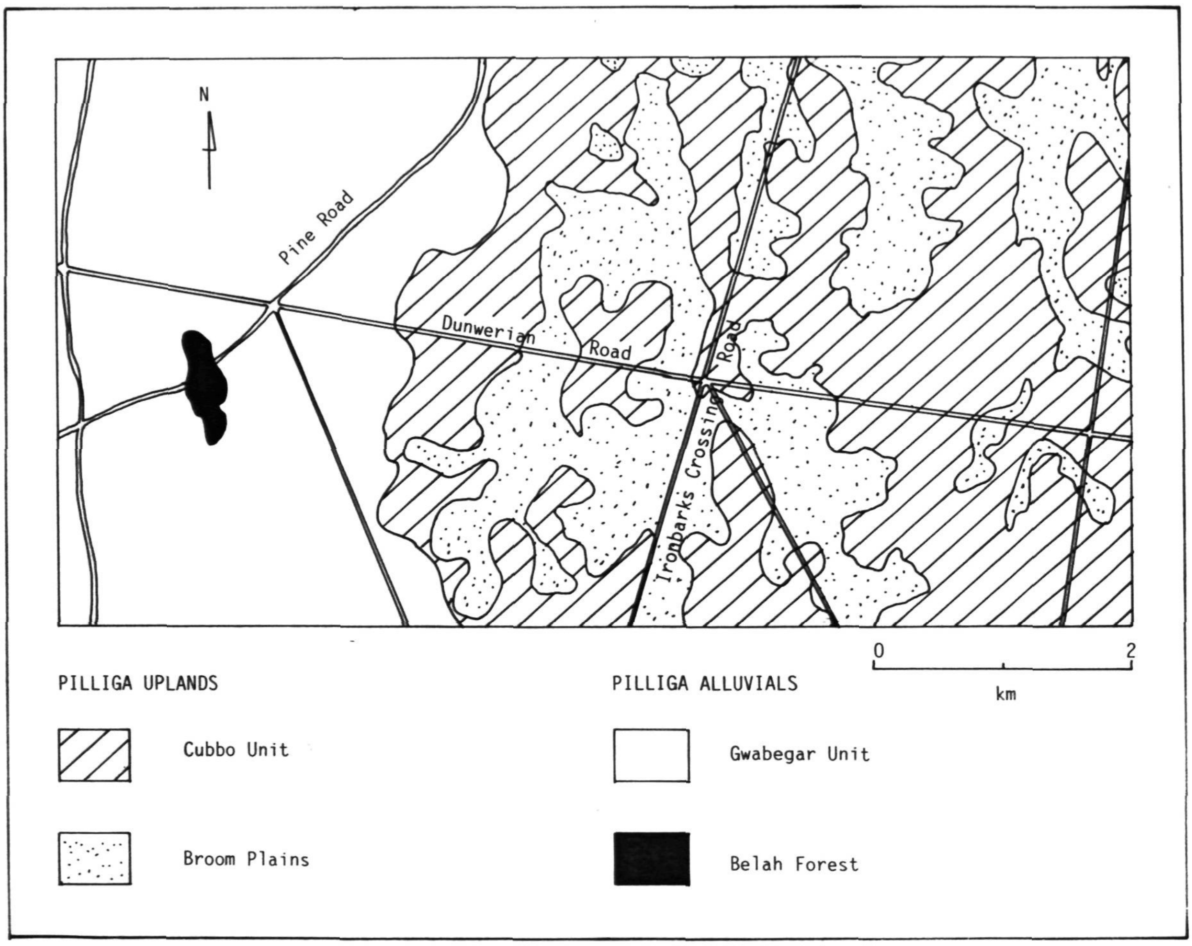


Figure 3-3 Land systems of the study area (modified from Mitchell *et al* 1982).

Shallow stony sandy loams (Uc5 Northcote 1966), thickening downslope, are typical of the rocky ridges. On the lower slopes and flatter areas harsh texture contrast soils (solodized-solonetz profiles (Dy2.42, Db1.42) occur where surface sands overlie *in-situ* weathered sandstone and shale sequences. 'A' horizons are hard setting when dry but saturate readily during wet periods and have a low bearing strength when saturated. Bleached A2 horizons are common. Yellow brown alluvial sands and some gravels have accumulated to 1 to 2 m in first order stream lines, second and third order streams have deeper sands in wider valleys.

Low stony ridges are dominated by an open forest or woodland of *Eucalyptus crebra, E. dwyeri, E. pilligaensis* and various *Acacia* species. In the higher areas to the south, there is *Eucalyptus macroryhncha* subsp. *macrorhyncha, E. dealbata, Callitris endlicheri* and *Angophora floribunda. E. trachyphloia, C. endlicheri* and *E. melanophloia* are common throughout the Nature Reserve together with patches of mallee scrub dominated by *E. viridis* and *E. dwyeri.* Ridges are mostly absent at the northern end of the unit.

Streamlines are typicaly dominated by *Eucalyptus blakelyi, A. floribunda* and *E. trachyphloia.* A diverse shrubby understorey is present.

Broom Plains

Broom plains, common within the central part of Pilliga East State Forest, are extensive areas of nearly flat, poorly drained country. They support a dense heath or scrub of many forest and woodland understorey species including *Melaleuca uncinata, Acacia triptera, Allocasuarina* spp., *Micromyrtus ciliata* and *Cryptandra* spp. Vegetation structure and floristics of the broomplains is extremely variable and may relate to fire history.

Gwabegar Unit

The Gwabegar unit merges with the Cubbo unit particularly on the northern and western edges of the Cubbo Unit. It is distinguished by the absence of sandstone bedrock near the surface, having a total cover of fluvial sediments. The overall altitude is 220 m with a local relief of 1 to 3 m on creek banks, sand monkeys and gilgai.

The plain is a complex fluvial depositional area of coalescing outwash fans. Prior stream patterns are visible on airphotos and are evident on the ground by slightly higher sinuous lines of deep yellow sands, locally called 'sand monkeys'.

Soils vary across this unit according to the depositional parent material. Stream beds and banks are characterised by deep white to yellow brown raw sands. Sand monkeys and terraces are characterised by deep (>2 m) yellow earths. Fine pink-brown sands often cover grey or brown clays beyond the stream lines forming harsh texture contrast soils, and uniform grey or brown self-mulching clays are found beyond the limits of over-bank wash.

Eucalyptus blakelyi is common along stream banks. Terraces carry *E. melliodora* and *Angophora costata.* A woodland of *Callitris glaucophylla* and *E. chloroclada* is typical of the sand monkeys with an understorey of *Xanthorrhoea glauca* subsp. *angustifolia* and *Brachyloma daphnoides*. Vegetation on the texture contrast soils away from the stream lines is characterised by open forests of *Callitris glaucophylla, Allocasuarina leuhmanii, E. pilligaensis, E. populnea* and *E. crebra*. Understorey species are different from those of the Cubbo

Unit, commonly associated with more semi-arid to arid environments, and include; *Geijera parvifolia, Capparis mitchellii, Ventilago viminalis, Atalaya hemiglauca, Grevillea striata, Myoporum mitchellii, Dodonaea spp.*, and *Acacia homalophylla.*

Belah Forest

Areas of grey and brown clays having pitted microtopography, or gilgai, and support a forest of *Allocasuarina cristata.*

SOILS - A REVIEW

At a small-scale, soils of the Pilliga region have been described and mapped as a single unit (Stephens 1961) or as several broad units (Northcote 1966; Northcote & Skene 1972; Northcote *et al* 1975; Soil Conservation Service of New South Wales 1978; Hubble & Isbell 1983; Premiers Department 1950; McGarity 1977). Stephens (1961) mapped the area as solonetz and solodized-solonetz (Great Soil Groups). Northcote (1966) divided the area into three units; sandy solodised soils in the south east (Gn2.2); sandy soils with mottled yellow clayey subsoils (Dy5) and associated solodised (Dy5.42) and solodised-solonetz (Dy5.43) soils in the central region; and sandy soils with mottled yellow clayey subsoils associated with the solodised-solonetz (Dy5.43) soils in the west.

For the study area, duplex soils comprising a sandy to loamy topsoil over pedal, mottled yellow or grey clay subsoils with a conspicously bleached A2 horizon (Dy5.42) are mapped. These soils are generally acid in the topsoil becoming neutral in the subsoil.

Northcote & Skene (1972) mapped the distribution of sodic soils for the Pilliga region and found that the soils were both (i) non-alkaline, including red and yellow sandy solodic soils and the solodized-solonetz (Map Unit NS1), and (ii) alkaline duplex soils referred to as solonized brown soils (Map Unit AS3) (Great Soil Groups). The authors comment that these soils have a low permeability in their clayey subsoils allowing for the development of a perched water table. CSIRO (1983) discussed the poor water regime of these soils and attributed it to slow wetting of the B horizons followed by saturation of the A2 horizon (refer also Mitchell *et al* 1982).

The soils have been examined from an agricultural viewpoint by Jensen (1912, 1914), Waring (1950), Stephens (1953), Warburton (1956), Davidson (1964), Clough (1969), Curtis (1975), Peasley (1975) and Hubble & Isbell (1983). Jensen (1914) demonstrated that the Pilliga soils tend to be low in moisture, organic matter content, nitrogen, phosphate, calcium, potassium and pH compared to the other similar sandstone-derived soils. Warburton (1956) commented that the solodized-solonetz were the poorest soils in the district and confirmed Jensen's (1912) analyses of low nitrogen and phosphate. In short, the general opinion is that the soils are infertile, highly erodible and unsuitable for intensive agriculture.

Within the Pilliga region various types of gilgai can be found. Stace *et al* (1968) discuss gilgai soils generally outlining their genesis and classification. The Pilliga is illustrated as having 'normal' gilgai carrying a distinctive vegetation cover including *Allocasuarina cristata*, *Acacia harpophylla* and *Eucalyptus pilligaensis* and *E. populneus*. Normal gilgai is apparently the most common form, consisting of mounds and shelves with no particular orientation, with variations in morphology occurring on this theme. Earlier reports of such gilgai include Jensen 1912; Premiers Department 1950; Hallsworth *et al* 1955; Warburton 1956. Isbell (1962) mapped the gilgai soils in relation to the distribution of Brigalow. These gilgai soils are characterised by their strong development of microrelief, their deep profiles and their texture of uniform medium to heavy clay, the surfaces of which are self-mulching.

Downes & Sleeman (1955) mapped the soils of the adjacent Macquarie Region. Whilst not directly covering the Pilliga the soils they described are not unlike the study area. They grouped the soils on the basis of topography and soil association, and it is the Coonilliga Combination that extends into the Pilliga forests. This combination is characterised by sandy solodized and sandy solodic soils with the solodized-solonetz occurring in the drier areas. The authors comment that variations in soil series within these groups are due largely to parent material and differ in colour, stoniness and texture. The positions of different soils in relation to topography vary according to the sequences of underlying beds exposed by dissection. The presence of ironstone in some soils was considered to be of geological origin.

Studies on soil genesis within the forest have been undertaken by Waring (1950) and Hallsworth & Waring (1964). Waring (1950) mapped the soils of the Pilliga into four divisions, three of which occur within the present day forest boundary. Of these, the study area for this thesis falls within the Talluba Division which is dominated by the Merriwindi Sandy Loam with Yarrie Sandy Loam occupying lower topographic positions and Moongi Sand bordering most creeks. Gilgai are of minor importance, and lithosols and residual laterite cappings were reported. Soil types are described and discussion on the probable genesis of the solodized-solonetz is given commenting that the 'deep phase' is often adjacent to the boundaries of the Moongi sands.

Hallsworth and Waring (1964) confined their more detailed studies to the soils showing solonetzic morphology in the Pilliga because they were interested in the classical theory regarding the genesis of these soils. They recognised four types of solodized-solonetz. Two occur on what they refer to as the laterite residuals (the Newell Sandy Loam on the indurated zone and the Talluba Sandy Loam on the pallid zone). The other two are the Merriwindi Sandy Loam and the Yarrie Sandy Loam which overlie extensive areas of alluvium.

Whilst studying phytoliths within some Australian soils, Hart (1992) desribed a soil stratigraphic sequence for the study area and this is presented in Figure 3-4 and will be discussed further in Chapter 6.

VEGETATION - A REVIEW

Vegetation of the region has been described generally by Fry (1909), Jensen (1912), Rupp (1932 - species list with occasional reference to general localities), 'Blue Gum' (1954), Biddiscombe (1963), Anon. (1972), Peasley (1975), Rolls (1981), Chiswell (1982), Cooney (1986) and Austin and Williams (1988). More thorough studies were completed by Jensen (1912), de Beauzville (1915a), Maiden & Cleland (1920) and Lindsay (1967).

Jensen (1912) divided the Pilliga scrub into four divisions, namely 1. The Northern, or Namoi Division, 2. The Western, or Baradine Division, 3. The South-eastern, or Bohena Division and 4. The Volcanic Patches. For each of these he described the geology and soils in terms of their agricultural potential and discussed the plant species encountered at length. Interestingly, he made no reference to changes

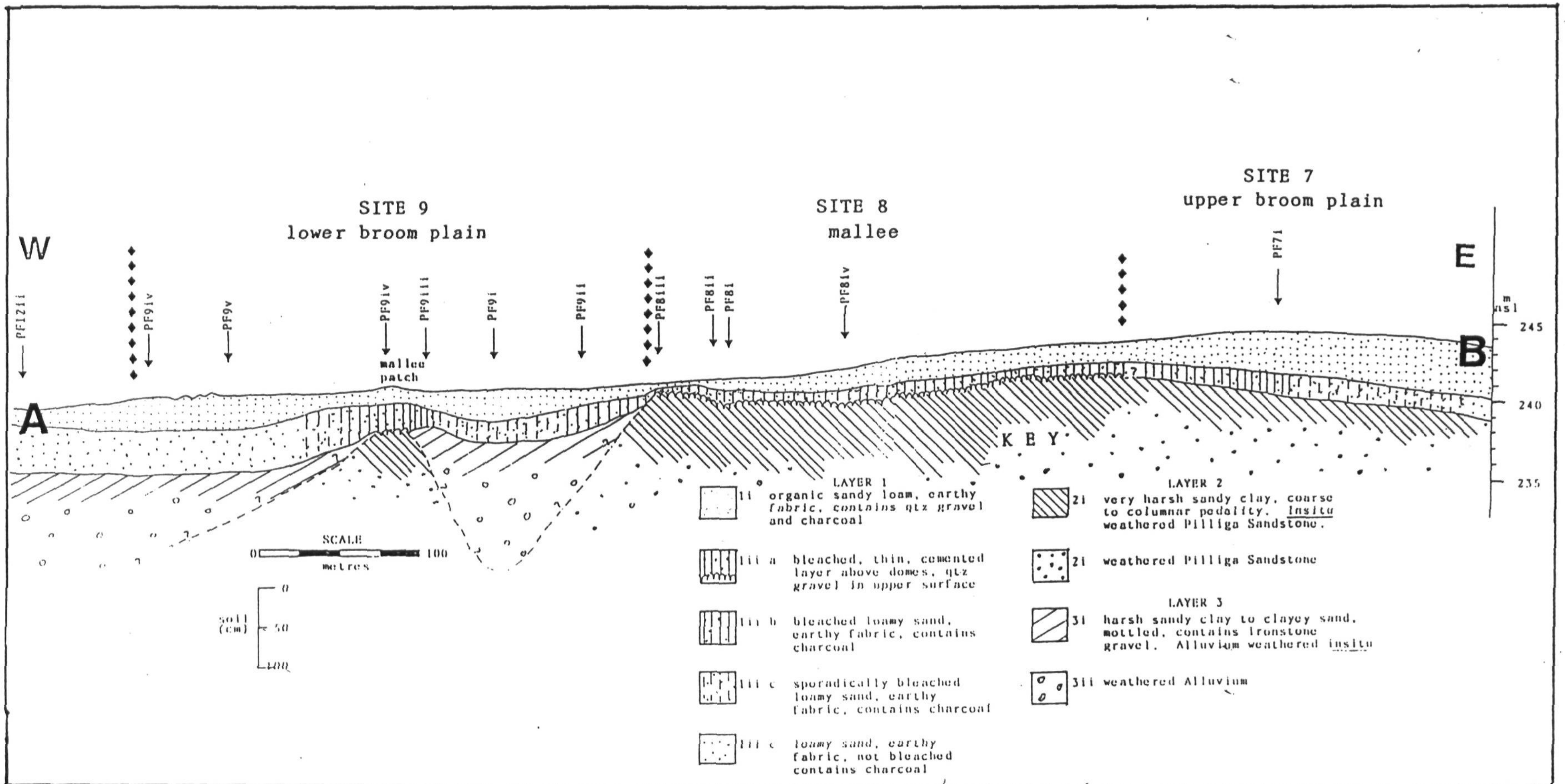


Figure 3-4 Stratigraphic section A-B along Dunwerian Road, showing relationships between soil materials, Sites 7,8,and 9. Vertical exaggeration 10X. (modified from Hart 1992)

in vegetation structure or composition in the previous 35 to 40 years of settlement and land use, however, he did comment on an area comprising much of what is now Pilliga East State Forest, as 'almost unknown country'. At the time of this survey, local residents and stockmen informed Jensen that the land in the Parishes of Coghill, Cook and Dunwerian (the present study area being within Dunwerian) was considered as being '...very poor, barren, sandy and stony, ironbark ridges and here and there creek beds filled with deep white sand.' (Jensen 1912: p5).

Maiden and Cleland (1920) recognised nine vegetation types within the forests. These are as follows, as transcribed from their text. Current nomenclature is listed in Appendix 1.

I. Pure White Pine (*Callitris robusta*) forests.

II. Mixed White Pine and Ironbark forests.

III. Open forest of *Eucalyptus dealbata*, Box, Ironbark and Oak (*Casuarina Leuhmanni*).

IV. Land adjacent to the banks of creeks and shallow watercourses.

V. Gilgai country with Belah (*Casuarina lepidophloia*) and Brigalow (*Acacia harpophylla*).

VI. The Box-Budda type

VII. Bloodwood rises

VIII. Ironbark ridges.

IX. Broom Plains

A discussion of each of these types is given including soil type and the associated tree, shrub and herbaceous species found. A detailed annotated species list is given which is presented by Family.

The management plan for the Pilliga Management Area (Forestry Commission 1987) follows the survey work of Lindsay (1967), the field work being carried out during the period 1945-1953. Forest Type maps produced as a result of this survey are still used as a basis for forest management. The maps are based on the results of strip assessment surveys (1 in 10 chain strips) and show species associations at a scale of 1:50,000; the details have been transcribed onto the relevant topographic maps. Figure 3-5 presents Lindsay's (1967) forest types for the study area. As this work was directed towards the more economical cypress pine - eucalypt forests resources not all plant communities are recognised, for example; the mallee and belah communities.

FIELD METHODS

Soils

Table 3-2 lists the plant communities sampled, the location of vegetation and soil profile sites and soil moisture sites described below.

1. Soil profile descriptions

An inital topographical survey for the main field site was undertaken. This survey enabled the accurate mapping of both the soil sites and the different plant communities recognised along a topographical gradient. As a result, perceptions held by Mitchell *et al* (1982) as to the location of these plant communities came into question. For example, the broom plains within the study area were actually found on slopes between bedrock ridges, and often where slope angles changed becoming less steep, rather than occupying the lowest topographical situations.

Fourteen soil sites were chosen along a 7 km topographical

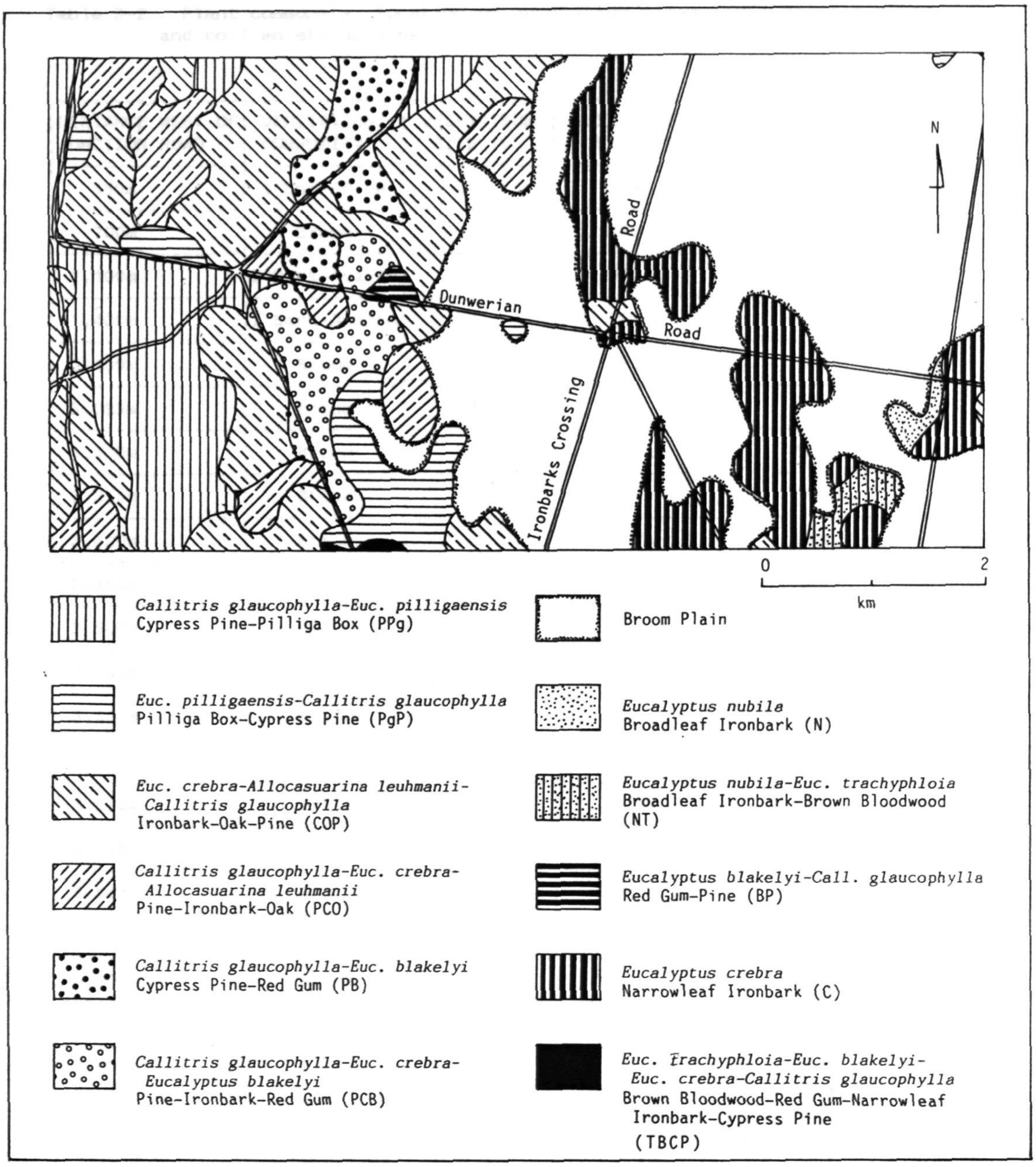


Figure 3-5. Forest types of the study area as recognised by Lindasy (1967).

Table 3-2. Plant community, location of vegetation sites, soil profile sites and soil moisture sites.

DISTANCE WEST OF JUNCTION ROAD	VEGETATION COMMUNITY	VEGETATION SITE (V)	SOIL PROFILE SITE (SP)	SOIL MOISTURE SITE (SM)
350m	I'bark-Pine	V1	SP1	-
700m	Broom	V2	SP2	-
1,100m	I'bark-Acacia	V3	SP3	-
1,400m	I'bark-Acacia	V4	SP4	-
2,100m	Broom	V5	SP5	-
3,093m	Broom	V6	SP6	-
3,300m	Broom	V7	SP7a	SM1
3,350m	Broom	-	-	SM1a
3,400m	Broom	-	SP7b	SM2
3,450m	Broom	-	-	SM2a
3,500m	Mallee	-	-	SM3
3,550m	Mallee	-	-	SM3a
3,600m	Mallee	-	-	SM4
3,653m	Mallee	V8a/V8b	SP8a	SM4a
3,696m	Mallee	-	SP8b	SM5
3,746m	Broom	-	SP9a	SM5a
3,803m	Broom	V9a	SP9b	SM6
3,846m	Broom	-	SP9c	SM6a
3,900m	Broom	-	-	SM7
3,950m	Broom	-	-	SM7a
4,000m	Broom	-	-	SM8
4,021m	Broom	V9b	SP9d	SM8a
4,100m	I'bark-Pine	V12a	SP12	SM9
4,150m	I'bark-Pine	-	-	SM9a
4,187m	I'bark-Pine	-	-	SM10
4,400m	I,bark-Pine	V12b	-	-
4,469m	Gum-Pine	V10a/V10b	SP10	-
5,458m	I'bark-Pine	V13	SP13	-
5,800m	Box-Pine	V14	SP14	-
6,702m	Belah	V11	SP11	-

gradient in conjunction with vegetation sites (Fig. 3-2). For this thesis soils sites are prefixed by letter 'SP' and vegetation sites prefixed by letter 'V'. Soils for each site were described. Profile descriptions are presented in Appendix 2 and soil stratigraphy will be discussed in relation to contemporary surface processes.

2. Soil moisture

As discussed previously, soils in the study area are dominated by nutrient-poor harsh texture contrast profiles, which may be overlying in-situ weathered Pilliga Sandstone or alluvium derived from it. Given that these soils carry different plant communities (broom plains, mallee, mixed open forests) it was hypothesised that soil moisture content and soil water movement may play an important role in plant community distribution. It was therefore decided to measure soil moisture along a topographical gradient (ridge crest to depression) to gain a better understanding of soil moisture dynamics (Fig. 3-6).

Soil moisture was measured gravimetrically and by in-field recording. These sampling sites were located along a shorter, 0.9 km gradient from ridge crest to depression covering broom plains, mallee, and ironbark-pine communities. Nineteen sites (SM1, SM1A, SM2, SM2A, SM3, SM3A, ... SM10) were placed 50 metres distant from the road edge to avoid disturbance and extra run-on water from table drains. Sites were also placed approximately 50 metres apart downslope.

a. Gravimetric moisture determination.

For gravimetric sampling, soil samples were collected at 10 cm intervals down the profile either to bedrock, or to a depth of about 1 metre. The soil samples were collected with a Jarret Auger (4 cm

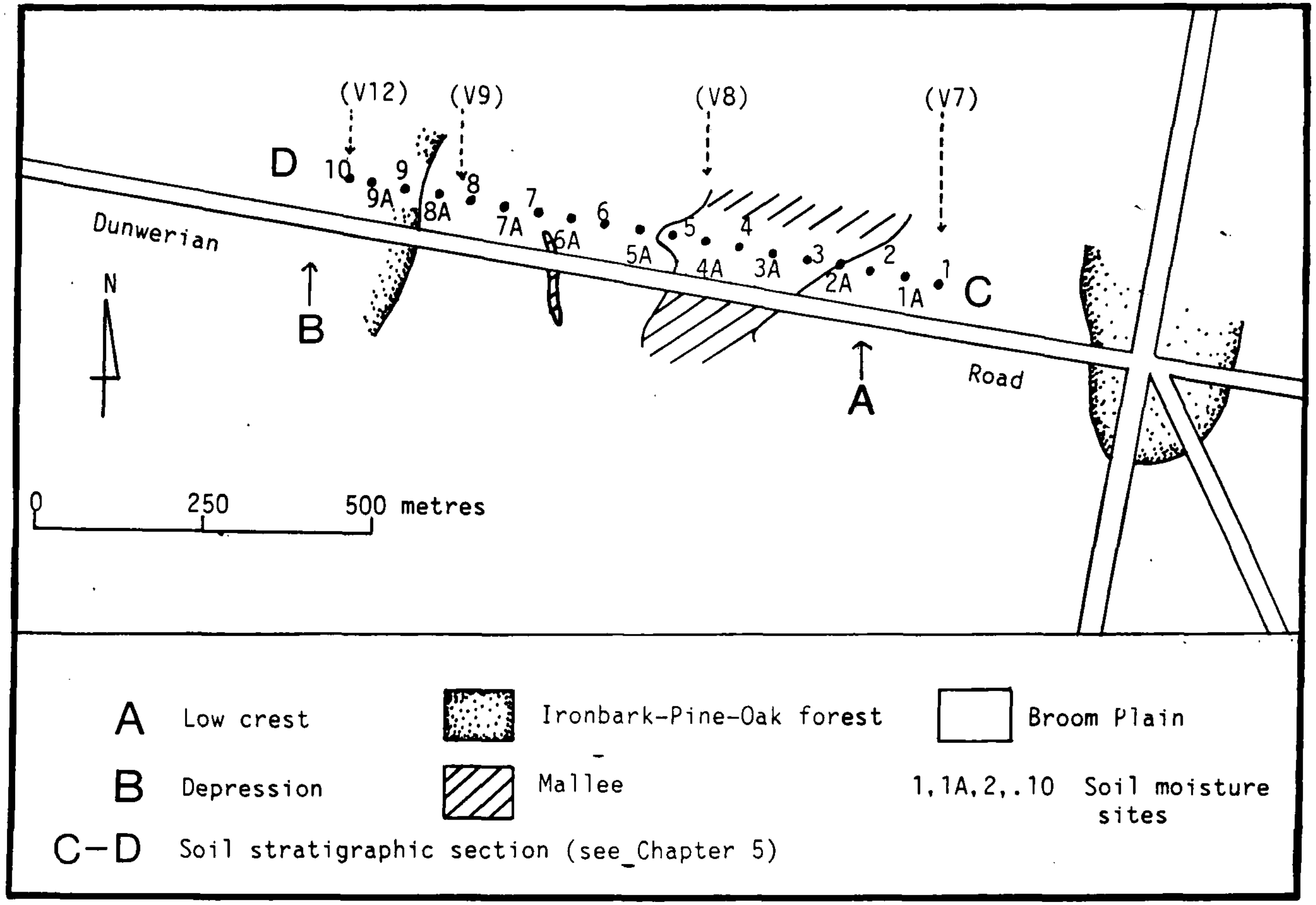


Figure 3-6 Location of soil moisture sites (1, 1A, 2, 2A,...10). Vegetation sites also indicated (V7, V8, V9, V12).

diameter), and enough soil was collected to at least duplicate each sample and obtain some idea of the variability in soil moisture both within the sample and between samples. Samples were packed and stored in airtight containers and transported back to the laboratory where the initial, or wet, weighing was done. Sample sizes averaged 100 - 110 gms. Following wet weighing the samples were oven dried for 24 hours at 105^0 C, reweighed and the percentage moisture calculated. Results are presented in Appendix 3.

b. **In-field soil moisture measurement**

Electrical resistance blocks were employed for *in-situ* moisture determination (Bouyoucos & Mick 1948; Bouyoucos 1965; Austalian Water Resources Council 1974; Walker 1976). In principle, when an electric current is passed from one electrode to another through a porous body, the resistance to the transmission of the current will be inversely proportional to the water content of the body (Curtis & Trudgill 1974). This measurement is a non-destructive one in which the porous block is permanently buried at the measuring point. Moisture content is derived from the measured electrical resistance between electrodes in the plaster of paris block, and the appropriate empirical calibration curve (Australian Water Resources Council 1974). Resistance is measured on a Wheatstone bridge. The specifications of the moisture blocks are given in Table 3-3. Once installed within the soil, the blocks were expected to have a life span of approximately 18 months.

At each soil site, soil was carefully removed by a 5 cm diameter Jarret Auger. Blocks were placed vertically down the profile at 10-15 cm, 15-35 cm, 50-70 cm, with the electrical leads coming out of the hole and marked for future identification. Due to the variability in

Table 3-3. Specifications of blocks

Outside dimensions	55mm x 24mm diam.
Absorbent material between and encasing electrodes	plaster of paris
Distance between electrodes	12mm

soil depth, some sites had more blocks installed than others.

Soil was then carefully replaced in the same sequence in order to minimize disturbance. Leads were covered to prevent possible damage and resistance was measured on subsequent visits.

3. Soil salinity

Salinity relates to the presence of water soluble salts of sodium, calcium and magnesium, which may be present in the soil as chlorides, sulphates or carbonates. Because of certain features visible on air photos, such as abrupt boundaries between plant communities, it was considered that soil salinity levels may also have an effect on species/community distribution. Therefore, it was decided to measure soil salinity along the same gradient as the soil moisture tests.

Salinity is usually determined by measuring the electrical conductivity of a 1:5 soil:water suspension (EC 1:5) (Hazelton & Murphy 1992). The standard unit of measurement of electrical conductivity is deci-siemens per metre (dS/m). Soil texture needs to be considered when measuring conductivity.

Soil salinity was measured within plant communities and across plant community boundaries. A conductivity meter was used in the field. Soil samples collected for gravimetric determination were also tested for salinity levels and pH using Hanna Instruments DiST WP Conductivity & Total Dissolved Solids Tester and pHep3 meter respectively. Results are presented in Appendix 4.

Vegetation

1. **Field methods**

Direct gradient analysis is a method for establishing the way in which species are distributed and vegetation changes along environmental gradients. For this study, a transect containing fourteen quadrats arranged along the same 7 km environmental - topographical gradient was investigated, Sites V1 to V14. These quadrats were placed subjectively in order to sample the range of vegetation types as described by Lindsay (1967) and Mitchell *et al* (1982), and observed on air photos and in subsequent field traverses within the study area. The range of topography included ridge, east and west facing slopes, depression areas and other communities on unusual soil types, namely gilgai soils and sand monkeys. It should be noted that environmental gradients are complex, and soil characteristics such as moisture, acidity, nutrient status, pH, organic content, salinity and bedrock (type and depth) are all potentially important factors. For the study area, the climatic conditions are generally the same throughout, although there were differences in rainfall collected between the mallee and sand monkey sites as recorded in Table 3-1 discussed previously.

Figure 3-2 indicates the location of the quadrats. Originally, one quadrat per community was chosen with a sampling area of 20 X 20

m. These were placed at least 20 to 50 metres from the road verge to eliminate any possible edge disturbance from road maintenance works, and were located within areas that visually best represented each community. Duplicate sites with larger quadrats of 20m X 50m were subsequently added. Species - area curves were completed within the ironbark-pine forests, sand monkey, broom plain and mallee communities (Appendix 5) and these demonstrate that the larger quadrat size of 20m X 50m sampled each community more effectively.

All sites were sampled on several occasions and at different times of the year to record between season variability and to obtain a more accurate record of species richness (Table 3-4). Duplicate sites were also chosen within each community, and these were sampled once.

Dominant species for each stratum were recorded following the methods of McDonald *et al* (1984). All species were recorded with a measure of their frequency and cover; that is, stratum, growth form, cover, and population numbers. An example of the recording sheets is presented in Appendix 6. The structural type for each quadrat was identified following Specht (1970).

2. **Identification**

For each site, plant species were identified and listed on the recording sheets in the order that they were observed, and for the 20 x 50 m quadrats within the following nested subquadrats of 1x1m, 5x5m, 10x10m, 20x20m, and 20x50m (Fig. 3-7). Species not able to be identified in the field were collected and numbered for later identification with assistance from staff of the National Herbarium of New South Wales.

Species recorded during this study are presented in Appendix 7.

Table 3-4. Permanent quadrat sampling times for vegetation.

Site #	OCT 86	MAY 87	OCT 87	MARCH 88	MAY 89	MAY 91	JULY 91	
V1	*	*	destroyed by bulldozing					
V2	*							
V3	*	*		*				
V4	*			*				
V5	*						*	
V6	*	*				*		^ upper broom
V7	*	*						^ plain
V8a	*	*	*			*		^ mallee
V8b							*	^
V9a	*							^ lower broom
V9b						*		^ plain
V10a	*		*	*T	*	*		^ sand monkey
V10b								^
V11a	*			*				
V11b							*	
V11c							*	
V12a		*				*		^ ironbark
V12b							*	^ pine
V13		*	*					
V14		*					*	

^ - quadrats associated with soil moisture studies

T - traverse only

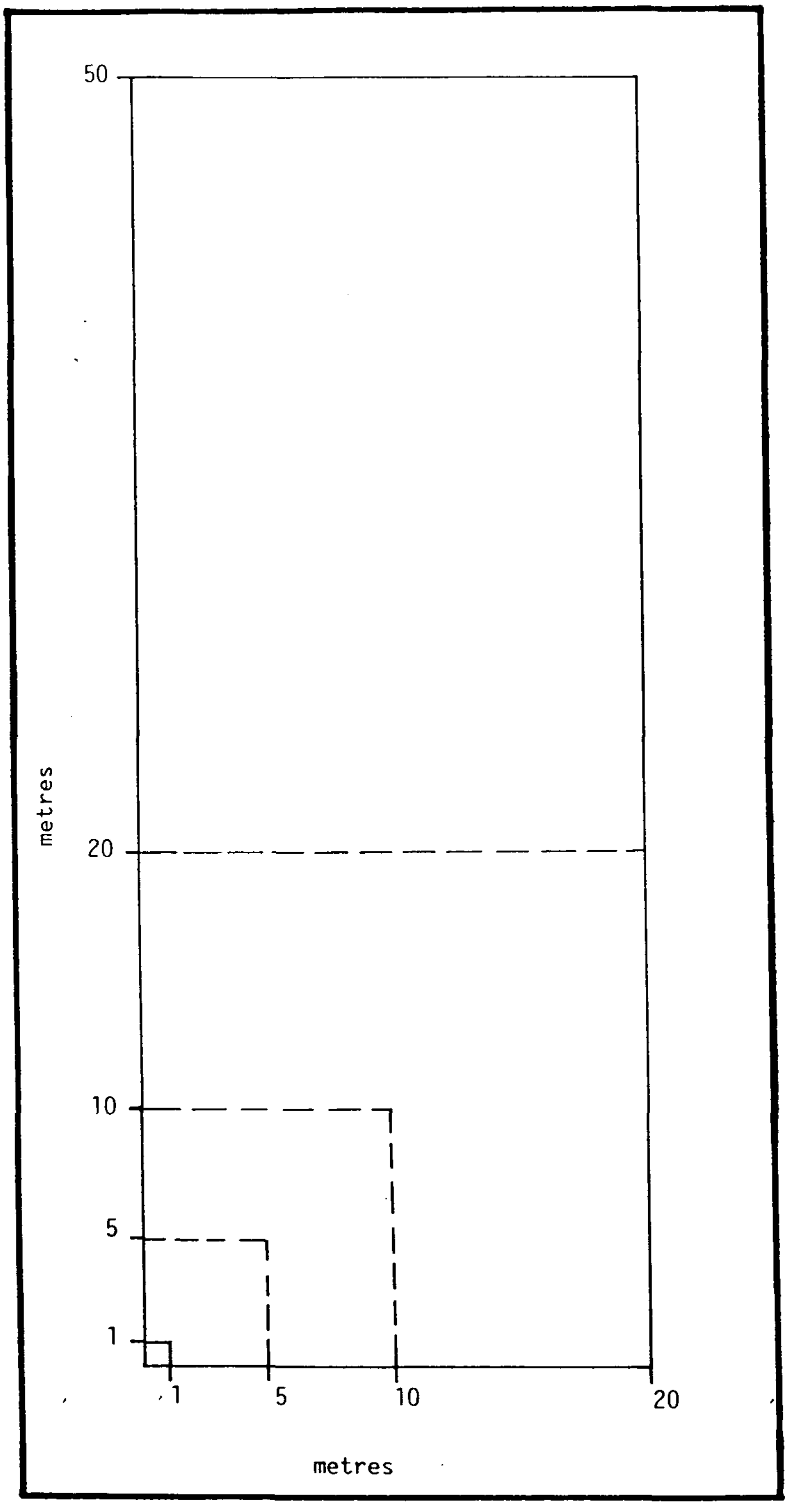


Figure 3-7 Nested sub-quadrats used for sampling vegetation.

Nomenclature follows the National Herbarium of New South Wales. A field herbarium was produced to aid in-field identifications.

Fire

Fire affects soil in a number of ways including the chemical, structural and water properties of the soil, the micro-flora and cryptogamic crusts (mosses, lichens, algae and liverworts), litter and soil fauna. The structure of the shrub and herbaceous layers are also altered in response to fire, especially to fire interval times (Benson 1985; Fox & Fox 1987) and variability of fire intervals (Morrison *et al* 1995).

The fire history of the Pilliga Scrub since 1951 is well documented by Mitchell *et al* (1982) and State Forests at Baradine. Given the length of time since fire (45 years for the majority of the study area and 29-30 years for parts of one large broom plain, Fig. 3-2) it was considered possible that during the course of fieldwork a wildfire might occur, consequently ceramic tiles were buried in the surface soil as part of a strategy to monitor the effects of a potential wildfire. These tiles were marked with heat sensitive crayons and buried vertically adjacent to the following soil moisture sites: SM1, SM1A, SM2 (broom plain); SM3, SM4, SM4A, SM5 (mallee); SM5A, SM6, SM6A, SM7A, SM8A (broom plain); SM9, SM10 (ironbark-pine woodlands).

In the event of fire, it was hoped that the tiles would give an indication of the soil temperatures reached, to what depth within the soils the temperatures penetrated, and to compare the temperature results between the different plant communities. This is of particular interest for several reasons including the potential increased runoff and its effect on soil moisture, and the regeneration potential of fire sensitive species such as *Callitris glaucophylla.*

SUMMARY

The study area lies within the boundary zone of the two recognised sub-systems of the Pilliga Land System (Mitchell *et al* 1982), having a combination of low rocky ridges and extensive areas of alluvial and colluvial sands.

The soils are, for the most part, texture contrast profiles. They are derived from Pilliga Sandstone or aluvial/colluvial sediments overlying the sandstone. Deep sands and self-mulching clays are also present. The Pilliga soils are infertile, highly erodable and unsuited to intensive agriculture, although they support a diverse array of trees, shrubs and groundcover.

The vegetation is dominated by mixed *Eucalyptus crebra-Callitris glaucophylla* forests and woodlands and other less extensive communities including the *Melaleuca uncinata-Calytrix tetragona* broom plains, *Eucalyptus viridis* woodlands and *E. pilligaensis-Callitris glaucophylla* woodlands. The tree density is different to what was believed to be the case at the time of European settlement. Rolls (1981: pp 1 & 245) reports that a large proportion of the forest area comprised grasslands dominated in the east by three or four large ironbarks to the hectare and in the centre and west by three to four large pines to the hectare. The present tree density has not been quantified but from data collected during vegetation sampling a measure of density can be estimated within the study area. For *Eucalyptus crebra* a conservative estimate is a density of 25 trees per hectare. For *Callitris glaucophylla* a conservative estimate would be 50 trees pers hectare.

Density is variable due to natural regeneration patterns overlain by selective culling and the effects of fire; there may be 100 pines to the hectare in one area and 30 pines in another.

The role of fire in determining plant species, and community distribution and composition is unclear, but as Rolls (1981) has indicated, a change in fire regimes from Aboriginal pre-settlement times through early settlement and finally to management under State Forests, may have altered the forest structure to some degree.

CHAPTER 4

EUROPEAN HISTORY

HISTORICAL RECORDS

Documentary evidence pertaining to Australian vegetation and environments prior to or shortly after settlement is quite limited. However, a great deal of information can be obtained from explorers' journals and other historical records including parish maps, portion plans and surveyors field books, and miscellaneous surveys such as railway surveys. A number of reports have indicated the potential value of these documents for the purpose of establishing vegetation change since settlement (Jeans 1978; Harrington *et al* 1979; Sheail 1983; Oxley 1987b; Mitchell 1991; Denny 1992; Pickard 1993). Such sources were used as part of this study.

There are a number of institutions that hold relevant historical information. The Archives Authority of New South Wales (Sydney and the repository at Kingswood) hold the early edition parish maps, field books, journals, some surveys, old photomosaics as well as Annual Returns of Runs. The names of many of the runs held have been used subsequently to name the various Parishes within the forests. The study area is located in the County of Baradine where the Parishes of Dunwerian, Coomore and Euligal abut one another (Fig. 4-1). The Crown Lands Plan Room (Department of Conservation & Land Management, C.& L.M., formerly Department of Crown Lands) has a number of large multiple parish surveys, portion plans, railway and other surveys which often have detailed descriptions of the vegetation. They also hold

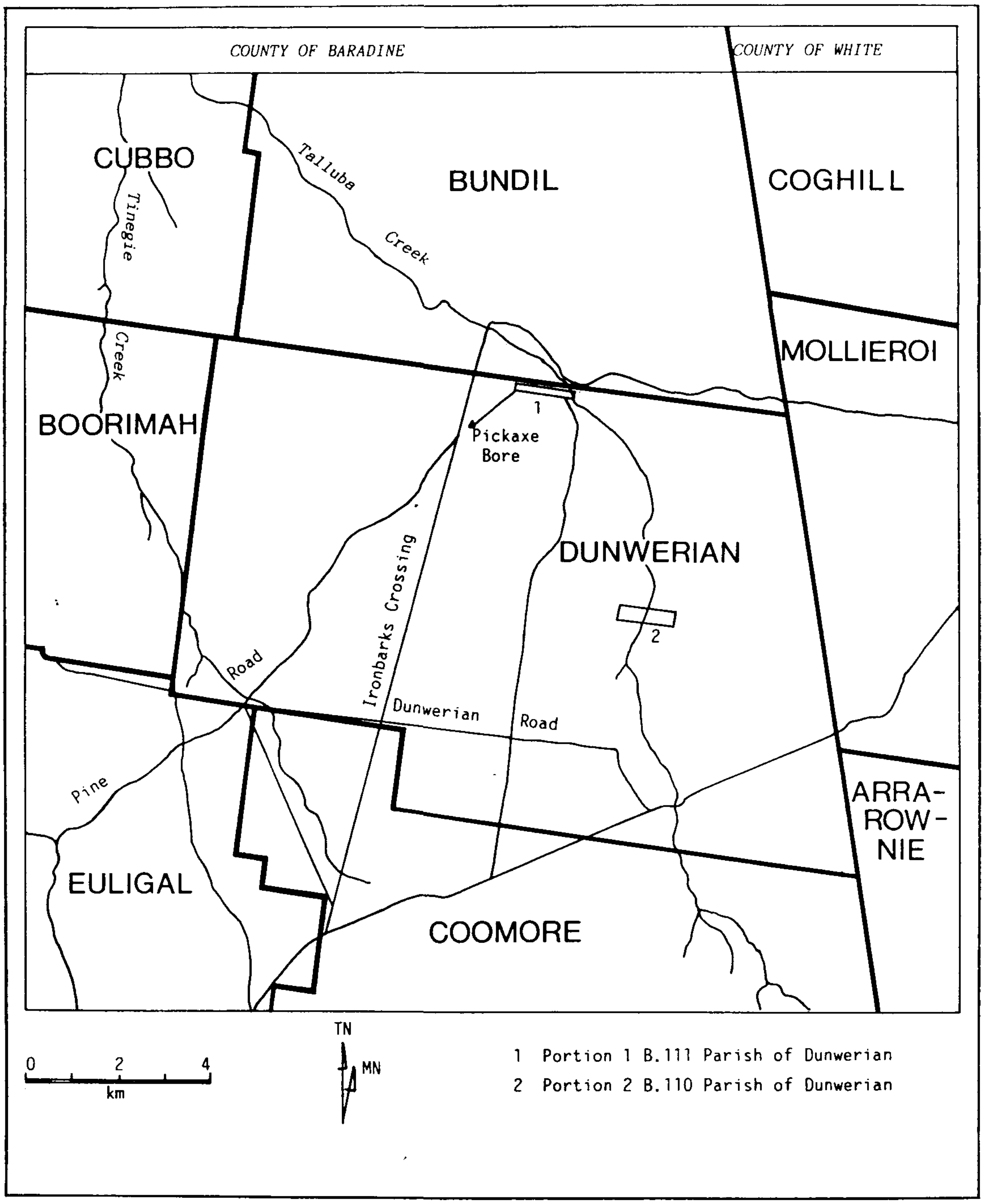


Figure 4-1 Parishes covering the study area. The location of the two surveyed portions in the Parish of Dunwerian is indicated (refer Figs 4-4 and 4-5).

records on Pastoral Holdings. The Mitchell and State Libraries hold Parliamentry Debates, Royal Commissions and Government Gazettes. Lands Titles Office also have portion plans and other surveys. Records held by State Forests at the Baradine Forestry were also investigated.

USING PRIMARY SOURCE MATERIAL

Searching historical documents is fraught with difficulties. It is time consuming and often difficult to find relevant information particularly if cataloging is not thorough and items are lumped in miscellaneous files. Further, the financial costs can be considerable.

As with any historical investigation there are dangers in the interpretation of the information located.

In the first instance it is essential to evaluate the reliability of the material used. Primary source materials are generally more valuable than secondary materials but this does not mean that one is faultless and the other useless, value judgements need to be made in every case. As James (1967) states; the reliability of a source can be tested by comparing it with other confirmed reliable sources. Whatever the case may be, in any study of history special attention must be paid to specifying the reliability of sources.

In the case of the Pilliga forests, the settlement history has been generally described by Vincent (circa. 1939) the then Minister of Mines and Forests. There is no referencing in his article which makes it difficult for later reseachers to follow up on the details given. Subsequent articles repeat the same story ('Blue Gum' 1954; Ryan 1969; Anon. 1972; Anon 1975; Rolls 1981; Forestry Commission 1987). Rolls (1981) presents a much more detailed account of the same story, although his referencing of articles and documents is also incomplete making the task of confirming his version difficult.

Interpretation of primary source material is open to the personal judgement and opinion of the researcher, as illustrated by Rolls' (1981) interpretations from Oxley's (1820) journal. One example, mentioned in Chapter 1 of this thesis, and discussed later in this Chapter, is the identity of the kangaroo rat recorded by Oxley in 1818. Oxley (1820: p270) comments 'These woods abound with kangaroo rats, ...'. From this comment Rolls (1981) has assumed this species to be the Rufous Rat Kangaroo, or Rufous Bettong, and claims that grazing by this species was one of the major factors limiting cypress pine regeneration. Another example is the incidence of fire. Oxley (1820: p268) writes '...when we entered a very thick forest of small ironbarks which had been lately burnt...'. Rolls (1981: p7) extends the observation to suggest that this fire was the result of Aborigines burning the area. Oxley (1820: p270) describes a prickly grass which was not eaten by his horses. Rolls (1981: p7) identified this as a species of *Triodia*, or spinifex grass without consideration of other possibilities, such as species of *Lomandra* (Jacobs pers. comm.).

All the above examples may not, at first glance, seem especially troublesome, but if this information is uncritically accepted, then the assumptions and identifications regarding species present, food preference, and fire regimes may influence management decisions.

From information collected for this thesis it is clear that even early documentation is fraught with problems such as transcription errors and phonetic spellings. For example, this is most noticable in the spelling of run names. These include 'Milchomi' which is also spelt 'Milihomi' or 'Milchommie'; variations on 'Kiambir' include 'Kiamber', 'Kiamberie', 'Keamberie'; and 'Merrumborough' is also found as 'Merianborough'. In this thesis the run 'Dunwarian' can also be spelt 'Dunwerian'. When reference is made to this run the spelling will follow the appropriate source information. All these variations on the spelling of run names have come from the New South Wales Government Gazettes from 1847.

Parish maps provide a good starting point for investigating early settlement and land ownership. However, problems are encountered with these maps with respect to consistency of parish boundaries, and the Parish of Dunwerian is a good example. The tracing of the Cubbo Holding (Deposited Plan No. 650, circa. 1886, held at C.& L.M.) has an overlay of the parish maps and includes the Parish of Dunwerian (Fig. 4-2). The boundaries as marked on this deposited plan are in conflict with the first edition parish map published in 1894 (held at State Archives) and can be compared with the boundaries in Figure 4-1. The maximum error between these two parish maps is difficult to calculate given the lack of common identifiable features and the differences of scale. However, as the study area lies on the boundary between the Parishes of Dunwerian, Coomore and Euligal, most sites are within this area of error, meaning that care needs to be taken when interpreting maps and surveys of the area.

The question of whether old survey plans and other primary source material is useful in helping to establish a history of vegetation change since settlement has been addressed by Mitchell (1991) and Pickard (1993). For example, Pickard (1993), in investigating the subdivision of 'Momba' Station, once the largest property in western New South Wales, found that the absence of information on survey plans did not necessarily indicate the absence of a feature. Further, changes in the landscape were difficult to detect from these plans

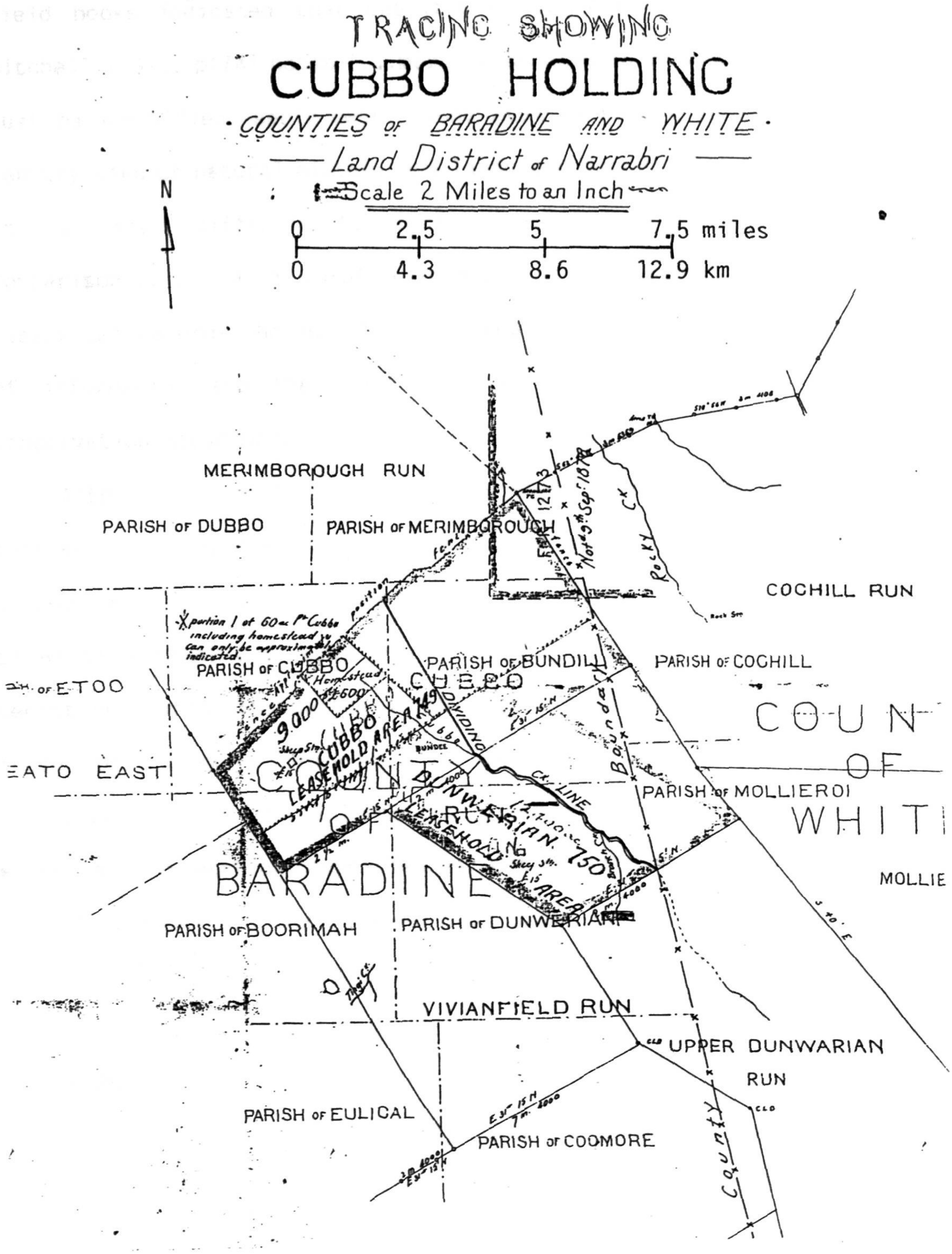


Figure 4-2. Plan of Cubbo Holding 1886 comprising the runs of 'Cubbo' and 'Dunwerian'. Adjacent runs also given. Compare with Fig. 4-1. Note location of Portions 1 and 2 in the Parish of Dunwerian.

although other data, such as archived reports, old photographs and field books indicated that qualitative changes had occurred. As Mitchell (1991: p174) notes '...most works have an inherent bias which must be identified, early decriptions must be read with a nineteenth century view of natural history and landscape description in mind, and it is often difficult to locate specific places to make a comparison...'. With careful interpretation however, the use of historical records should not be underestimated as a valuable source of information and they have much to offer present and future conservation management planning.

Although all of the forested area seems to have been claimed by settlers and graziers by the 1880s, it is unclear as to how heavily grazed the central parts of the forest, including the study area, east of Baradine Creek ever was. Survey maps from the 1870s to the 1930s depict vegetation boundaries in this core area which are similar to those of today. However, as mentioned previously, careful interpretation of the information given on these old surveys is essential. Vegetation boundaries may not change but the structure and age of communities can change over time. It is this sort of information that is difficult to interpret or is often not available.

EXPLORERS

John Oxley's expedition of 1818 were the first Europeans to enter the forested area of the Pilliga region. They travelled through the southern parts of the forests within the Bugaldie Land System, described previously. Whilst in this section of country Oxley (1820) described open and clear country which was good for travelling. This country lies in what is now Yarrigan State Forest, south east of

Baradine (Fig. 1-1). Several days later (August 12) he passed through forest so thick that they could hardly turn their horses. On August 18, in what is now the Pilliga Nature Reserve, he came upon a forest of young, recently burnt ironbark saplings. In these examples, Oxley was describing country well to the south of the study area, which differs in local climatic patterns (due to its closer proximity to the Warrumbungle Ranges), topography, soils and vegetation. However, from these comments it appears that the structure of the forest varied from an open and grassy environment to being quite densely vegetated much as might be expected given the significance of fire as a major factor influencing vegetation patterns.

SETTLEMENT HISTORY

Various articles and maps relating to settlement of the region differ on the first dates of settlement (McLean 1847; Roberts 1924; Vincent circa 1939; Rolls 1981); but settlement appears to have begun about 12 to 15 years after Oxley's expedition of 1818. Roberts (1924) maps regional settlement as follows: east of Baradine Creek 1831-1835, and west of Baradine Creek 1836-1840. This settlement appears to have been largely confined to the southern and western portions of the forest, the present Pilliga Nature Reserve and in the eastern areas, where more reliable sources of water were to be found.

Rolls (1981) has presented a map of runs compiled and drawn at the Occupation of Lands Office in Sydney, a copy of which is given as Figure 4-3. According to the title block, the original map is dated 1881 but unfortunately the archived location of the original is unknown (Wakeman pers. comm. 1995; King pers comm. 1995). From early, official records (for example Government Gazettes of 1847) the original or early

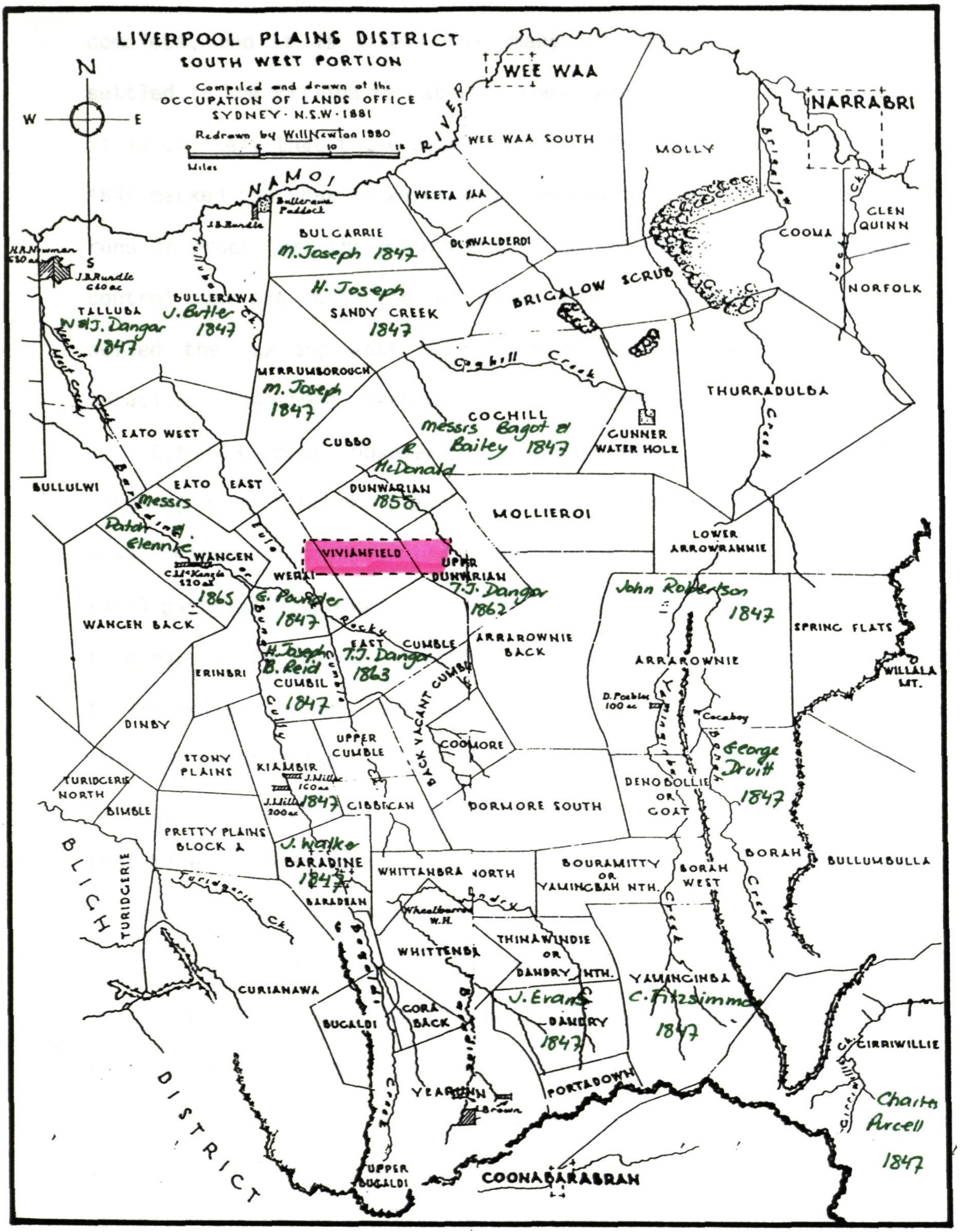


Figure 4-3 Map of runs for the Pilliga Forest region (from Rolls 1981). Lessees for runs annotated (source: NSW Government Gazettes). ▬▬ = Study area.

run owners are annotated on this figure. These annotations are not complete, and it is likely that many of these run owners had been settled in the Pilliga forests for some years prior to 1847. Further, it is unlikely that these people would be all the original squatters. 1847 marked the year in which squatters were required to survey their runs in order that the government of the day could keep some sort of control over the activities of these people (and there were many) who defied the law and went beyond the 19 Counties of the limits of location. Even then, perhaps not all people responded.

C.& L.M. does, however, hold other maps that can be used for locating particular runs and holdings in the vicinity of the study area. Firstly there is Reuss & Brownes Map of New South Wales shewing (sic) pastoral runs and squattages (circa 1860). Two points concerning this map can be raised. Firstly, the run boundaries bear no relation to run boundaries on later maps, and it is unclear at this point why this may be the case. Secondly, for the study area the map is blank. Although this blank area may indicate that there was no settlement at that time, such an interpretation is not consistent with other claims and another explanation may be involved. For example; it is possible that no survey had then been completed for this part.

A second and more useful map is the Index Map of New South Wales shewing (sic) Pastoral Holdings (1886). This map contains runs boundaries similar to those of Figure 4-3 and, most importantly, the map contains file numbers relating to deposited files for runs and pastoral holdings (a pastoral holding comprised a number of amalgamated runs). It also shows an extensive blank area covering a portion of the study area which again suggests (but does not prove) that no settlement had taken place (Wakeman pers. comm.). By 1886 survey should have been more or less complete, perhaps indicating that this area of the Pilliga was not favoured for grazing or agriculture.

Run names can also be cross-referenced to reports which list the run number and name, the lessee or tenant, the estimated area of the run, the annual rental, assessment, commencement of tenure and term of tenure, and the appraised rental (Anon. 1865-1866; Department of Mines 1879). These reports, although not providing information regarding actual stock numbers carried on individual runs, are useful for tracing ownership over time giving an insight into the length of time particular parcels of land were under occupation.

For this thesis, taking into consideration the changes to Parish boundaries as discussed earlier, the study area falls mostly within the boundaries of 'Vivianfield', and partly within the runs 'Werai' and 'Upper Dunwarian' (Fig. 4-2 and 4-3). Adjacent runs in close proximity are 'East Cumble' and 'Dunwarian'.

An outline of the history of settlement in the Pilliga in the 19th century with particular reference to the study area, is presented below, and has been put together from both primary and secondary sources. Dates, details and source information are given. Items prefixed by AO indicate State Archives Reference Numbers. Some of the information presented can be cross-referenced to Figure 4-3.

It is believed that the first settlers moved into the area east of Baradine Creek (also known as Bungle Gully) during the 1830s. This has been reported by Roberts (1924) and Rolls (1981). Details regarding settlement are unclear in terms of exact places or time.

During 1836-1840 settlement west of Baradine Creek began (Roberts 1924). Again, this reference presents a general pattern of settlement rather than specific places or years.

McLean (1847) produced a map of squatting districts. This map shows no settlement within the Pilliga forests and is in conflict with Roberts (1924) and Rolls (1981), as well as information presented below. McLean's map is also inaccurate with respect to run descriptions in the Government Gazettes (various dates from 1847) (refer Fig. 4-3) and the Nominal Return of Licence of Runs (1847 - AO 4/7068).

The Nominal Return of Licence of Runs (1847 - AO 4/7068) includes a number of run desriptions for the greater Pilliga but does not include the study area. Most of these runs are found on better agricultural land well to the north of the study area where soils are better and water more reliable. Of these Returns, the closest run to the study area is 'Coghill' (Fig. 4-3) which was leased at that time by Messrs. Bagot and Bailey.

Messrs Patch and Glennie held 'Wangen' and 'Pilliga' runs during 1848 (Government Gazette various dates). In contrast to this Vincent (circa 1939) suggested that 'Wangen' was the first run held within the Pilliga forests in the year 1854 and leased by C. McKenzie. This example demonstrates some of the problems encountered when using secondary source material, throwing doubt on some of Vincent's account.

In 1874 a survey for fencing of G. Loder's run was completed, and shows the runs 'Sandy Creek', 'Coghill', 'Meriumborough' and 'Dunwarian' (Anon 1874) (see Fig. 4-3 for the location of these runs). Although the survey was not closed, and errors could be considerable, it can be matched to the 1:50,000 topographic map. This can be achieved by locating dwellings and creeks, although some creek names and/or spellings have changed. As a result, part of this survey lies within the study area, and specifically describes the presence and location of broom plains, pine, ironbark and oak forest, and dense scrubby ridges which can be seen today to be in the same relative positions on airphotos and in ground survey.

The year 1875 saw the introduction of sheep to the area (Vincent circa 1939; Rolls 1981).

The first timber reserves were established in 1877 together with the appointment of the first Forest Ranger (Rolls 1981, Forestry Commission 1987).

During 1885, T.G. Danger sold 'Bullerawa' to D. McRae who combined this run with eight other runs to form the 'Bullerawa Pastoral Holding'. This Holding combined the runs Talluba, Bullerawa, Eato West, Eato East, Werai, Vivianfield, East Cumble, Back Vacant Cumble and Coormore (Fig. 4-3). 'Vivianfield' was said to consist of very poor ironbark and thick pine scrubs. Some fencing had been done. These comments may have been made in 1882 or 1885 as the dates are not clear on the documents (Deposited File No. 441, held at C.& L.M.).

In 1878 surveys were completed for Portions 1 and 2 in Dunwarian Parish (Chatfield 1878). The surveyor was Chatfield but his field books are not held at either the Plan Records Room of C.& L.M. or the Archives Authority of New South Wales. Portion 1 B.111 (Fig. 4-4) was held by S. Dempsey/W. Bolton (possibly a survey for a sale by Dempsey to Bolton), and was located within the boundaries of the Cubbo Holding which comprises 'Cubbo' and 'Dunwarian' runs. Portion 2 B.110 (Fig. 4-5) was held by Thomas Cain and was located within the boundaries of 'Upper Dunwarian' run. Annotations regarding the vegetation are also given on these survey plans. Portion 1 B. 111 did not come under the legal control of State Forests until sometime in the 1980s (Nicholson pers. comm. 1989).

Figure 4-4. Portion B.111 Parish of Dunwerian. A description of the vegetation is given. See also Figs 4-1 and 4-2 for location.

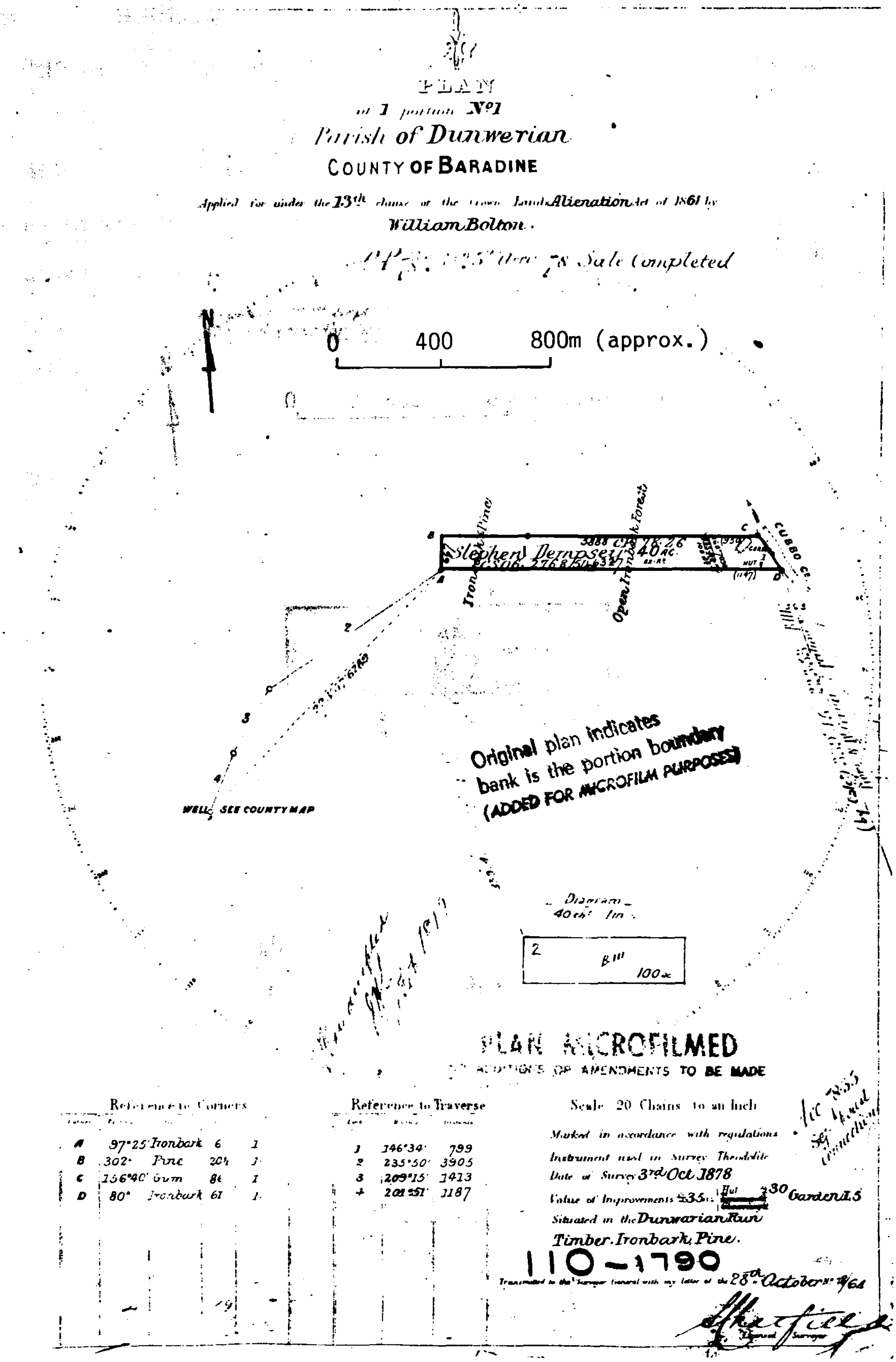
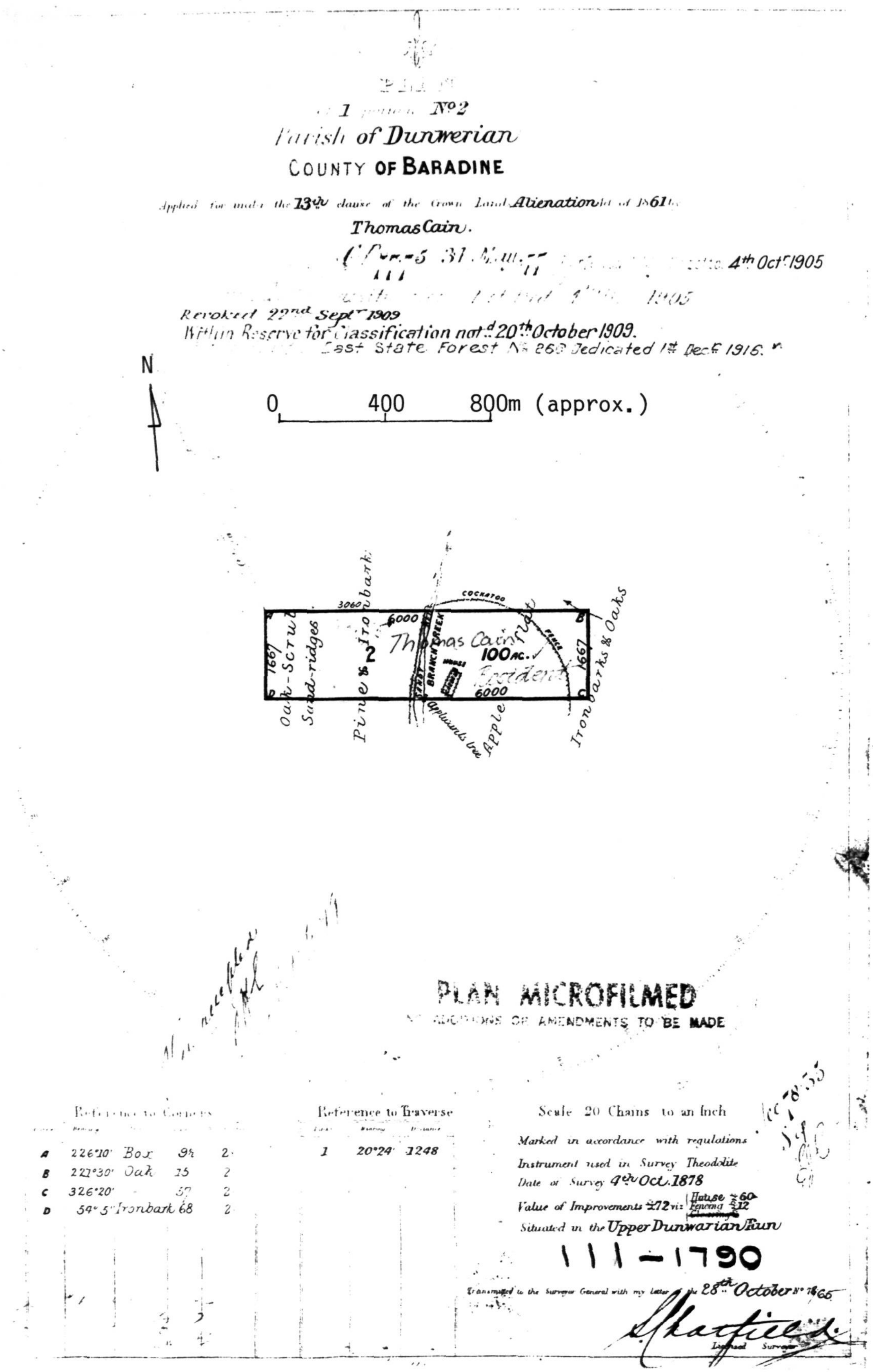


Figure 4-5. Portion 2 B.111 Parish of Dunwerian. See also Figs 4-1 and 4-2 for location.



Vincent (circa 1939) claims that the Crown apparently did not receive any lease payments from runs within the Pilliga after 1888. No supporting evidence has been found for this comment, and in fact the year 1892 was the last year of the annual return for 'Cubbo' holding (north of 'Vivianfield', refer Figure. 4-2 and 4-3).

Table 4-1 presents Lessee details for the runs covering, and adjacent to the study area. This information can be found in the New South Wales Government Gazettes, here abbreviated to GG and appropriate year of publication. Comments from the Government Gazette are also given.

SUMMARY

There are conflicting reports concerning the time of first settlement, ranging from the early 1830s to the early 1850s. However, it seems more likely that settlement probably occurred sometime during the late 1830s to early 1840s. For this period of time, documentary records concerning descriptions of the land, such as surveys and notebooks are unavailable, so that changes to the vegetation are unclear. As can be seen from Table 4-1, land within the study area was taken up much later and was held for a much shorter duration unlike other areas to the north and west.

The extent of land alienation, likely intensity of grazing use and dates of abandonment of holdings seem to be at odds with the general claim of Rolls (1981) and others. Because of the necessity for reliable sources of water, land was first taken up along the main rivers and creeks. Unoccupied crown lands away from water, was probably used opportunistically.

Table 4-1. Runs within the study area and history of lease ownership. (GG = New South Wales Government Gazette reference). See Fig. 4-3 for locations.

'Vivianfield'	
1876?	T.G. Dangar Accepted tender. (GG 1876)
1877	Appraisal - T.G. Dangar Occ Crown Lands Report 1879
1882	Appraisal - probably still T.G. Dangar
'Dunwarian'	
1858	Lessee R. McDonald, rented annually (Anon. 1865-6)
1859	Moses Joseph Rent not paid. (GG 1859)
1862	Lease transferred from Moses Joseph to Patrick Quinn. (GG 1862)
1862	Lease transferred from P. Quinn to Gavin Jamieson (GG 1863)
1864	Lease transferred from G. Jamieson to R. McDonald (GG 1865)
1866?	R. McDonald Conversions. GG 1866
1868	Lease transferred from R. McDonald to G. Loder (GG 1869)
1869	Lease transferred from G. Loder to The Commercial Banking Co. (GG 1870)
1871?	Appraisal - The Commercial Banking Co. (GG 1871)
1875	Lease transferred from The Commercial Banking Company to G. Loder (GG 1876)
1876?	Run Appraisal - Lessee G. Loder (GG 1876)
1879	Lessee G. Loder (Dept. of Mines 1879)
1878	Survey of Portion 1 B.111, Parish of Dunwerian, for S. Dempsey/W. Bolton (Plan Records Room, C.& L.M.)
1882?	Run Appraisal - Lessee B.B. Campbell (GG 1882)
	Lease transfer sometime between 1879 and 1882?
	Rolls (1981) comments that the Campbells' were associated with 'Cubbo' and 'Dunwarian' for over forty years, possibly from this time.
'Upper Dunwarian'	
1862	Thomas G. Dangar Lease Tender Accepted (GG 1862)
1863	T.G. Dangar transferred lease to J.B. Rundle (GG 1864)
1863	J.B. Rundle transferred lease to R. Napier (GG 1864)
1866?	R. McDonald Conversions (GG 1866)
	Lease transfer sometime between 1863 and 1866?
1868	Lease transferred from R. McDonald to G. Loder (GG 1869)
1869	Lease transferred from G. Loder to The Commercial Banking Co. (GG 1870)

Table 4-1 Continued

'<u>Upper Dunwarian</u>' continued ...	
1871?	Run Appraisal - Lessee The Commercial Banking Co.(GG 1871)
1875	Lease transferred from The Commercial Banking Company to G. Loder (GG 1876)
1876	Run Appraisal - Lessee G. Loder (Occ Crown Lands Report 1879)
1878	Survey of Portion 2 B.110, Parish of Dunwerian, for T. Cain (Plan Records Room, C.& L.M.)
1882?	Run Appraisal - Lessee B.B. Campbell (GG 1882)
	Lease transfer sometime between 1876 and 1882?
1882?	Lease forfeited - B.B. Campbell (GG 1882)
'<u>Werai</u>'	
1847	Lessee G. Pounder (Rolls 1981) - 300 cattle and 5 horses
	Lease transfer sometime prior to 1862?
1862?	J. Eason transferred lease to W. Deacon & T. Brown (GG 1863)
1863	Deacon & Brown transferred lease to H.J. Adams (GG 1864)
1865?	H.J. Adams Conversions (GG 1865)
1870?	Run Appraisal - Lessee Rev. W. Tyrrell (GG 1870)
	Lease transfer sometime between 1865 and 1870?
1865-1870	Boiling down works at Euligal Crossing (Rolls 1981). Rolls (1981) unsure of lessee.
1875	Run Appraisal - Lessee T.G. Dangar (Occ. Crown Lands Report 1879)
'<u>East Cumble</u>'	
1863	T.G. Dangar Lease Tender Accepted (GG 1863)
1863	T.G. Dangar transferred lease to J.B. Rundle (GG 1865)
1866	Lessee J.B. Rundle
1871?	Run Appraisal - Lessee J.B. Rundle (GG 1871)
1876?	Run Appraisal - Lessee J.B. Rundle (GG 1876)
1882?	Run Appraisal - Lessee J.B. Rundle (GG 1882)

CRITICAL QUESTIONS ARISING

Given this historical review it is apparent that some aspects of accepted belief concerning pine regrowth events of the nineteenth century as described by Rolls (1981) are unclear.

Three important questions were investigated by Mitchell (1991) and Norris *et al* (1991).

1. The reality and significance of the important critical nineteenth century climatic events.
2. The evidence for pre-existing pine scrubs, other periods of pine regeneration and the actual timing of the main regeneration events in the Pilliga.
3. The importance of stored seed, predation and fire in pine regeneration.

The results of this work are presented below. A copy of Norris *et al* (1991) is located in Appendix 8.

An understanding and knowledge of long-term rainfall/climate patterns has important implications for plant growth. Although this subject is not within the scope of this research, the fact that conditions were generally drier earlier this century may have been important in discouraging or reducing plant growth, in particular, cypress pine regeneration. There was concern over the apparent lack of pine regeneration over most of its natural range during the first part of this century (Lindsay 1948).

Cypress pine regeneration is dependent upon the favourable conditions of a number of environmental factors. These include seed supply, seed viability, soil type, soil moisture, stand density, shrub, grass and litter cover, grazing, fire and rainfall (Lacey 1972). The following paragraph is a synopsis of the natural regeneration cycle of cypress pine compiled from the works of Hawkins (1966) and Lacey (1972 & 1973).

Seed dissemination occurs from the months of October to January. Seed production is affected by high stand density which suppresses flowering. There is no seed dormancy and germination occurs during autumn to early winter in the year following flowering when there is good soil moisture following high rainfall. Seed viability is greatest in heavy seedfall years. The highest germination rates occur between temperatures of 15-20^{0}C, whilst germination is reduced to zero at temperatures greater then 25^{0}C. In contrast, Scott (1970) found that germination rates of 50-90% occurred within 6 weeks in the temperature ranges of 20-30^{0}C, and her studies indicated that the optimum temperature for germination was 20^{0}C.

The timing of rainfall is critical because if good rainfalls in the following year are late, such as August or September, regeneration rates will be low due to declining seed viability. Summer is not favourable to regeneration due to high temperatures and the low frequency of effective rainfall events, and resulting low soil moisture levels.

1. The weather patterns

Rolls suggested that '... the four or five good years between 1879 and 1887...' (Rolls 1981: p205) were the important years for pine regrowth in the Pilliga. This climatic pattern and the alleged drought between 1875 and 1878 are difficult to confirm because the only official records starting that early are from Narrabri Bowling Club Station No. 054120 on the north eastern edge of the region (Fig. 1-1).

Figure 4-6 presents rainfall as a measure of percentage deviation from mean annual rainfall from 1871 to 1895. At this station the record shows rainfall was 24% below average in 1875, average in 1876, and 26% below average in 1877 (Fig. 4-6). Nicholls (pers. comm. 1991) has confirmed that 1877 was an *El Nino* 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 this period, these being 1879 (36% above average), 1886 (38% above average) and 1887 (13% above average) (Bureau of Meteorology 1989).

From 1881 rainfall records are also available for Baradine and Coonabarabran (refer Fig 2-3, Chapter 2). 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 1890s 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 three 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 1892/1894 seems likely to be more important climatically than the late 1870s as the actual period of the late nineteenth century pine regeneration event in the Pilliga (seed set and germination in the late 1870s may have been possible but seedling survival during the period 1880 to 1885 was probably low). This suggestion is supported by the acceptance of the 1890s as the period of regeneration by Anon.

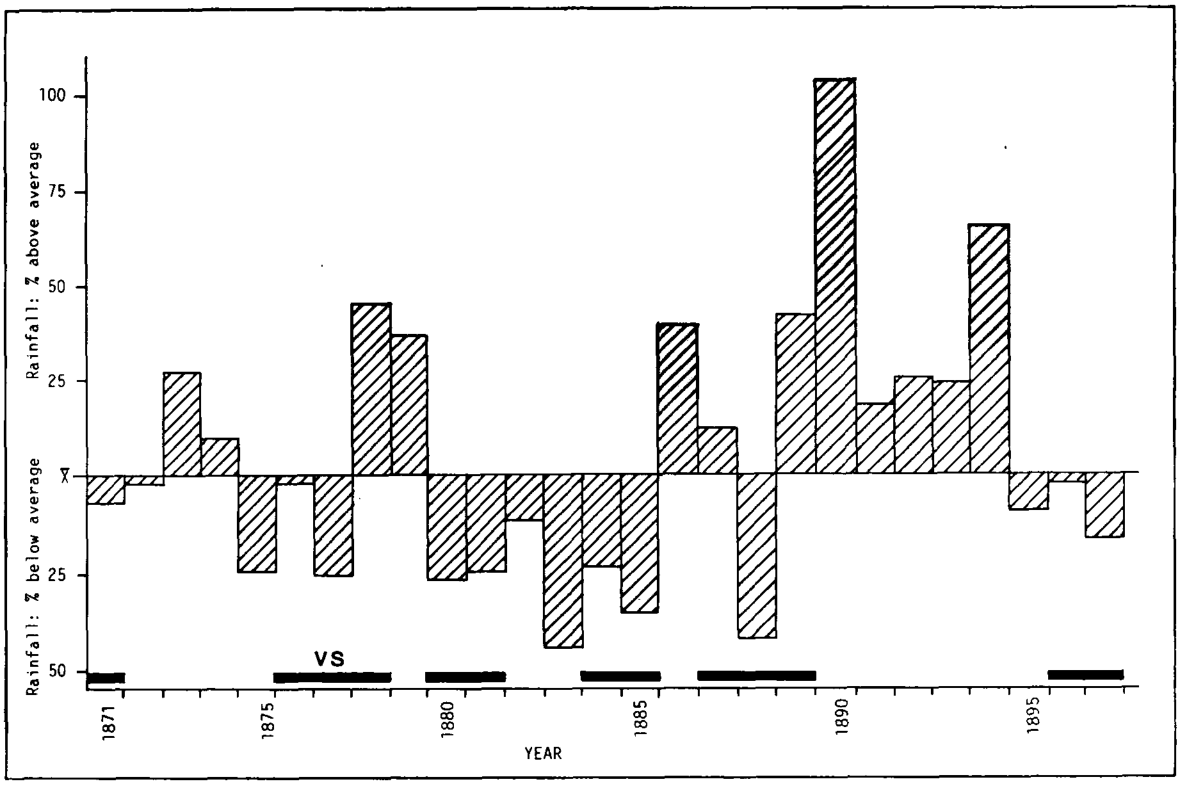


Figure 4-6 Rainfall as a measure of percent deviation from the mean annual rainfall for the years 1871-1897 for Narrabri Bowling Club (054120). ENSO years are indicated (VS = very strong ENSO event).

(1975), McDonald (1976), the Pilliga Management Plan (Forestry Commission 1987) and Nicholson (pers. comm. 1989).

The circumstances of the 1950/1951 regeneration event also support 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 1917/1918 when rabbits were recorded as attacking seedlings and destroying that crop (Forestry Commission 1918) and in 1932/34 in east Pilliga forests where there had been no sheep grazing and very few cattle (Lindsay 1948).

The 1950/1951 regeneration event first became apparent throughout most of the natural range of the white cypress pine in eastern Australia in 1953/1954 when the seedlings from the 1952 seed year (Forestry Commission 1953/1954) were overtopping the grasses. This observation is consistent with the normal two year flowering and cone formation cycle for the species (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. This coincidence of a subsequent wet period was important in consolidating the regeneration and also has a parallel in the 1890s rainfall sequence.

The above discussion centres on rainfall, but it is also believed that temperature is important in that mild summers are necessary for seedling establishment (Forestry Commission 1987). Temperature data for Baradine (Station 053002) for the years 1950-1956, presented in Table 4-2 support this. For the months October through to the following May, the critical time for seedling establishment, the temperatures recorded generally lie on or below average. Some

Table 4-2. Mean daily maximum temperature (^{0}C) for Baradine Forestry (Station 053002). Mean daily maximum temperature (A), and highest temperatures recorded (B) from 1950-1956 are also given for comparison.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1950	33.8	30.8	30.7	25.3	21.2	15.0	16.3	17.2	22.2	23.1	24.9	32.0
1951	30.8	31.8	30.3	23.0	20.6	17.4	16.3	16.3	23.3	24.9	30.6	32.2
1952	37.5	32.1	28.8					17.9	21.2	24.8	27.7	32.2
1953	32.2	28.4	30.3		19.3	17.4			22.6	25.3	28.4	34.1
1954	30.9	28.2		27.2	21.4	17.2	18.2	20.8	22.3	25.1	27.9	31.1
1955	32.1	30.7	30.6	25.6	18.9	16.5	15.2	17.1	21.2	23.4	27.9	29.4
1956	31.2	27.7	29.3	24.3	18.5	16.1	15.0	17.5	20.7	23.1	28.2	32.5
A	33.2	32.0	30.2	25.7	20.8	17.3	16.4	18.2	21.7	25.8	29.2	32.3
B	37.5	36.6	33.0	28.7	23.4	20.5	18.8	22.7	25.8	30.9	33.8	36.0

Source: Climate & Consultancy Section, Bureau of Meterology, 1996.

months (underlined) are higher than average, but not significantly so. All months were well below the highest temperatures recorded (Table 4-2).

Conclusion

The years 1879 to 1886 may have seen some pine regeneration due to the above average rainfall in 1879 but seedling mortality was probably high due to the following below-average rainfall years of 1880-1886, and probable low soil moisture conditions during these years. The good rains of 1886 and 1887 and the following wet years of 1889 to 1894 probably meant that pine regeneration had a greater chance of survival and it is most probable that it was during this latter period of time that major pine regeneration occurred.

This pattern of regeneration as a result of consecutive above-average rainfall years can also be seen in the 1950s regeneration event, especially for the years 1954-1956.

2. **Pre-existing scrubs and other regeneration events**

The 19th century pine regeneration event as described by Rolls (1981: p185) was considered to be unprecedented. However, a number of primary sources describe thick scrub and cypress pine regeneration events elsewhere in eastern Australia at other times, even from the earliest known settlement, indicating that scrub encroachment was not solely a post-settlement phenomenon. Acting District Surveyor Finley, when discussing the pine scrubs in the surveying districts directly north of the Pilliga region, commented in 1881 that very large areas within most of the Counties had been overrun with scrub. '... It is not of recent growth, but has been in existence - so far as I can ascertain - from the earliest settlement of the country...' (Anon. 1881: p4). Unfortunately there are few records which relate directly to the Pilliga, and in particular the study area.

The journals of Oxley (1820), Sturt (1833) and Mitchell (1839,

1848) describe journeys down the Lachlan, Macquarie and Bogan Rivers respectively, and all specifically mention on many occasions that the lighter red soils away from the rivers often supported scrub including *Callitris* species (heavier clay soils on the floodplains where *Callitris* does not grow). 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 (drays etc) which confined them to clearer country.

Other evidence concerning the condition of the study area 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...' (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). A. Dewhurst was the District Surveyor for Pilliga (Anon. 1881) and neighbouring areas. In his report to the Surveyor General he remarks 'Very extensive scrubs exist in the Counties of White and Baradine, ... the sandy nature of the county is particularly favourable to the production of scrub and undergrowth, and, with exceptional areas, they are of little value for either agricultural or pastoral purposes' (Anon. 1881: p204). He goes on to say that where these scrubs are indigenous the character of the soil is such that the country is considered worthless for pastoral or agricultural purposes.

Date *et al* (in press) comment that the central area of the forest was overgrazed in drought during the late nineteenth century. Their source for this comment is unclear, and given severe drought, grazing over a wider area of the forests would be very limited by the availability of watering points. There is one known bore (now sealed) near the study area, known to be in existence from as early as 1878 (Fig 4-4) and which is still named on the Cubbo 1:50,000 topographic map (Central Mapping Authority 1974) as Pickaxe Bore. This point warrants further investigation of original surveys and County plans as State Forests do not hold records concerning the number and distribution of bores within the forests, and the dates when they were put down.

Examination of Department of Lands records shows the majority of runs were held along the main watercourses such as the Namoi River and Baradine and Bohena Creeks, as well as in the foothills of the Warrumbungles. Other runs penetrated the forest area. As Rolls (1981: p163) reports, various runholders had access to other runs further into the core of the forest. In relation to the study area, for example, the Dangar brothers had access to the runs 'Eato East', 'Eato West', 'Vivianfield', 'Dunwerian', 'Coghill', 'Cumbil', 'Upper Cumbil', 'Back Vacant Cumbil' (Fig. 4-3) but it is unknown at present how often they ventured in there and how many stock they ran.

Bullerawa Pastoral Holding, which seems to have come into existence around 1885 and owned by D. McRae, comprised nine former runs including those within the study area. The nine runs were 'Bullerawa', 'Talluba', 'Eato West', 'Eato East', 'Werai', 'Vivianfield', 'East

Cumble', 'Back Vacant Cumble' and 'Coomore' (Fig. 4-3) and comprised approximately 259,600 acres. Rolls (1981: p190) comments that most of the runs were already overgrown by 1885, and mentions that D. McRae's station manager, reporting to a Land Board Meeting, that he would not venture into the forest for fear of being lost. The Manager stated that '...there has been no stock on it (presumably parts of the pastoral holding) in my time...' (however long that was) (Rolls 1981: p190). Reference to the Land Board Meeting papers is not given by Rolls (1981) and they were not located during research for this thesis.

The Deposited File for the Bullerawa Pastoral Holding is held at C.& L.M. in the keeping of the Historical Officer. The file gives information respecting the runs within the holding and includes; run name, registered lessee (D. McRae, as above), area of each run, date of last appraisement (from 1875 to 1883), estimated pastoral capabilities at last appraisement, rent, and date of lease determination. Several annotations are given. In particular, for 'Vivianfield', which covers most of the study area, the run was '... reported to consist of very poor ironbark and thick pine scrubs. Improvements fencing. No value given...' (Bullerawa Pastoral Holding, Central Division, Deposited File No. 441). The estimated pastoral capability for 'Vivianfield' was 1,000 sheep (appraised 1882) but actual numbers are not known. 'Vivianfield' covered an area of approximately 23,600 acres (9551 ha) which, on the above appraisal, gives a pastoral capability of 1 sheep per 23.60 acres (9.5 ha). This very low carrying capacity estimate is probably due to the scrubby nature of the area rather than as a result of climate or soil factors.

Cubbo Pastoral Holding comprised the runs 'Cubbo' and 'Dunwarian' (Deposited File No. 650, C.& L.M.), and it appears that the Campbell family owned these from about 1882 until 1910-1920 (Government Gazette various dates; Rolls 1981: p206).

As earlier settlers departed, runs were divided and/or combined and occupation licenses were issued, some of which cover the study area and were issued in the name of J.N. Phelps. This occupation licence appears to have been revoked in 1903 (annotation on Dunwerian Parish Map 1st Edition 1894, Archives Office). Stocking rates are unknown, and no further information in relation to this licence has been found. The Parish of Dunwerian, which covers parts of the runs 'Vivianfield', 'Dunwarian' and 'Upper Dunwarian' was dedicated State Forest in March 1917. This means that the Campbell family held 'Cubbo' and 'Dunwarian' for approximately thirty five years before their land was resumed for inclusion into Pilliga East State Forest (see Table 4-1).

Only one written work has been found which directly supports the open structure of the forest as described by Rolls (1981). Maiden & Cleland (1920) in their report on the botany of the Pilliga Scrub, commented that '... old hands state that up to about thirty-five years ago (ie about 1885) it was all open forest country'. Although it is unclear as to what area of the forest this comment refers to (i.e.; into the core area or just along the main roads) it is interesting because it comes from two reliable observers/recorders.

Other accounts supporting current belief have all been written after Rolls (1981) and there is a real possibility that these people are either conciously or unconciously accepting and repeating his model, for example; various articles published by the Forestry Commission (Chiswell 1982; Cooney 1986). The Forestry Commission (1987), Date *et al* (in press) and Don Nicholson (pers. comm.) also mention folklore from descendents living today '... the Pilliga scrub wasn't there 70 or 80 years ago...'. This would approximate 1900 to 1910. It is conceivable that these recollections do relate to the early 1890s regrowth of pine as recognised by Forestry Commission (1987) but at least equally likely that "folklore" is also repeating Rolls who established it.

It has been difficult to locate nineteenth century maps covering the forest in the vicinity of the study area. One example, as discussed earlier in this chapter, is the survey for fencing for G. Loder's Run (Anon. 1874) and contains descriptions of the vegetation encountered which is similar to that observed in the field today. Two Portion plans dating from 1878 in the Parish of Dunwerian (Plan Records Room, C.& L.M.) give similar information (Fig. 4-4 and Fig.4-5) (see also Fig. 4-1 and 4-2 for the location of these Portions). Portion plans only cover a very small part of the forest, but the notes regarding vegetation detail in 1878 closely match the vegetation patterns on 1970 air photographs and those that can be observed in the present forest. Plate 4-1 is a photograph of a section of Portion 2 in the approximate location of the house and garden. *Angophora floribunda* are present as indicated on that plan.

Figures 4-7(a), 4-8(a) and 4-9(a) are tracings from topographical surveys conducted in 1914 (Lands Department 1914a & b). See Figure 3-1 for the location of these areas. Figures 4-7(b & c), 4-8(b & c) and 4-9(b & c) are tracings from air photographs taken in 1938 and 1970.

Figure 4-7 covers the study area. The locations and boundaries of the Ironbark and Pine open forest, as well as the broom plains and belah have remained fairly consistent over time, the greatest differences being between the 1914 survey and the 1938 photos. This most probably reflects the method of survey used in 1914 compared to

Plate 4-1 Photo of Portion 2 B. 110, Parish of Dunwerian, taken in the approximate location of the house and garden east of Talluba Creek (refer Fig. 4-5). *Angophora floribunda* present and some pine.

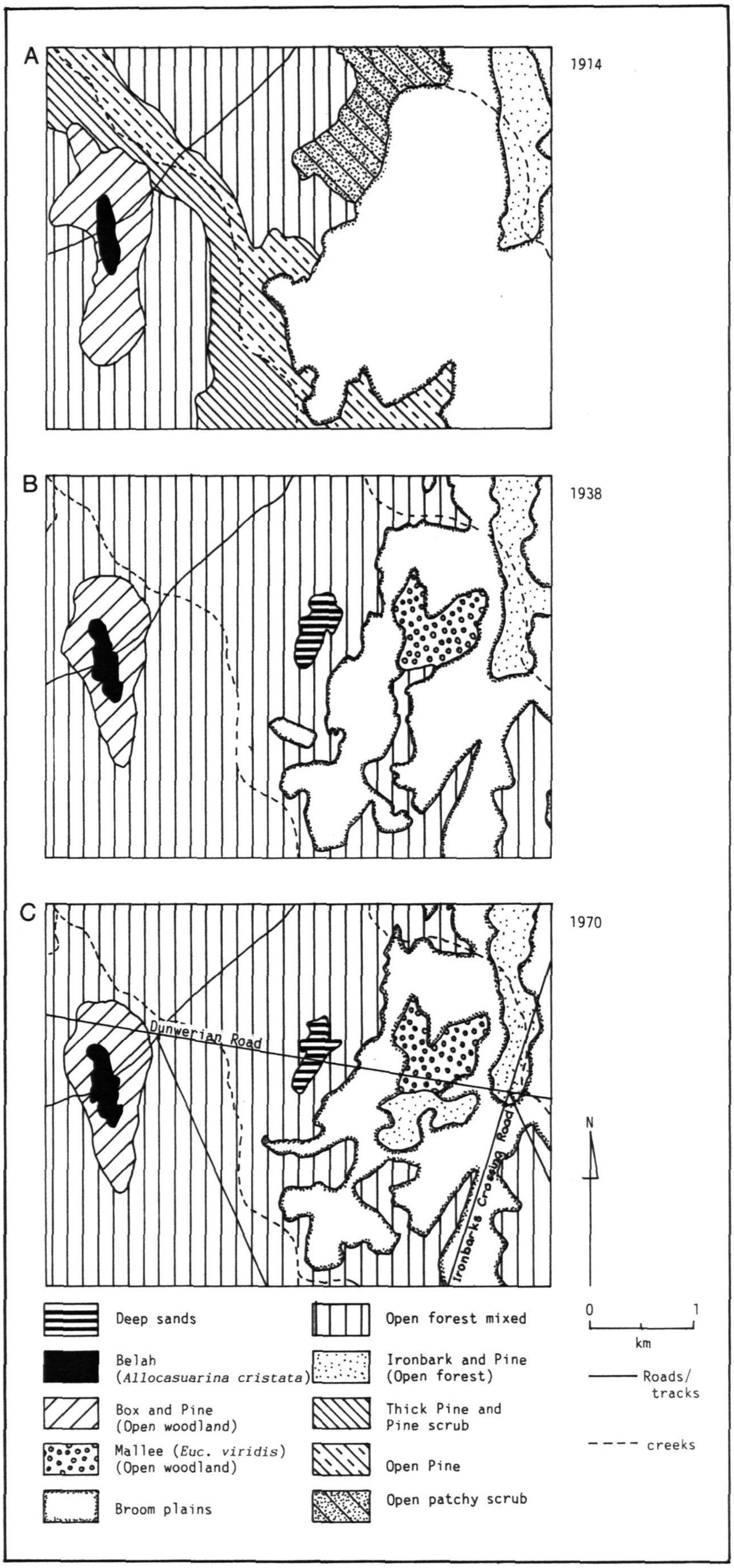


Figure 4-7 Tracings from a 1914 survey (A) and airphotographs taken in 1938 (B) and 1970 (C), of the study area. See 'A' in Figure 3-1 for location.

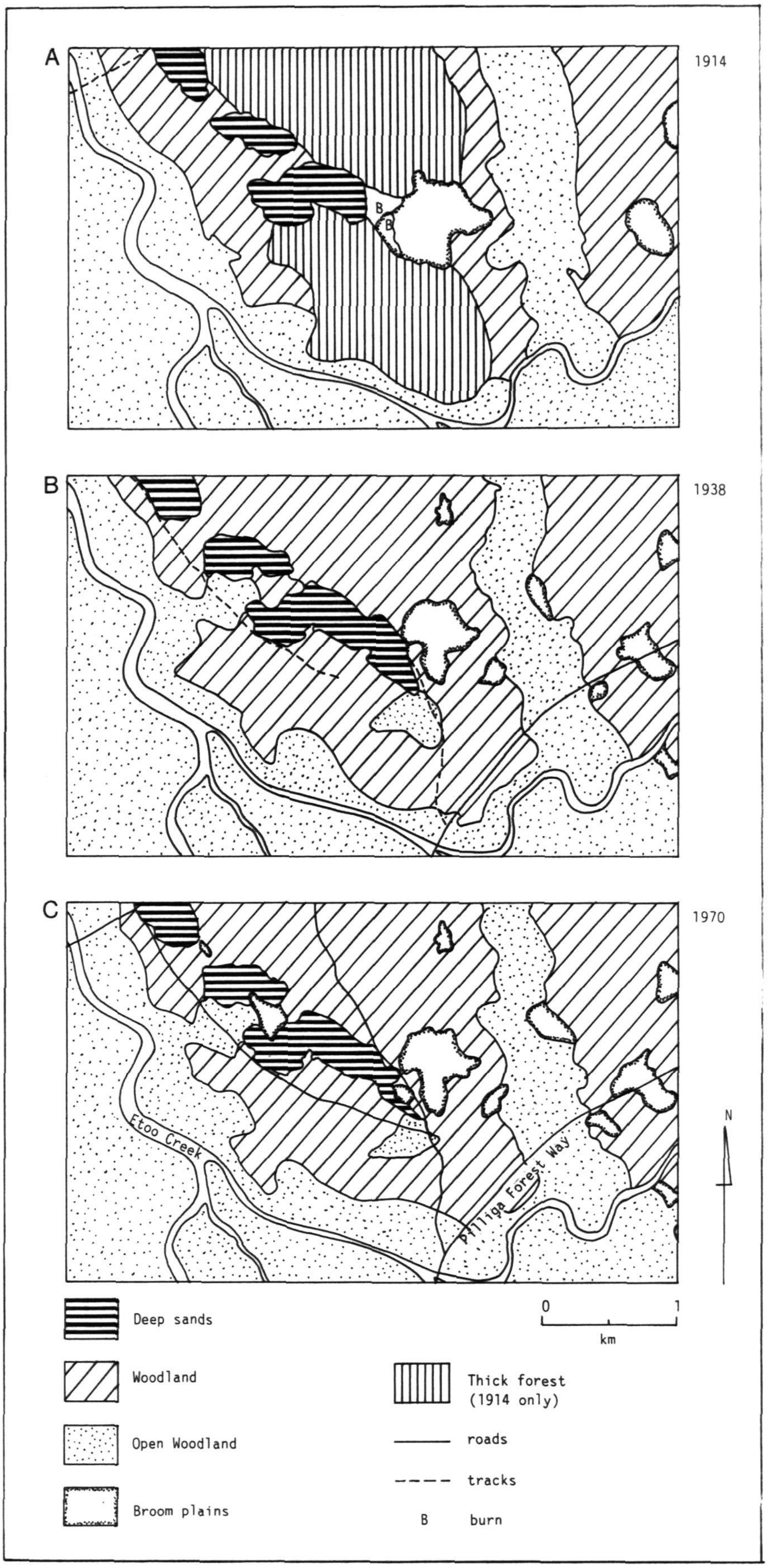


Figure 4-8 Tracings from a 1914 survey (A) and airphotographs taken in 1938 (B) and 1970 (C), of the Etoo and Rocky Creek area. See 'B' in Figure 3-1 for location of this area. (redrawn from Norris *et al* 1991)

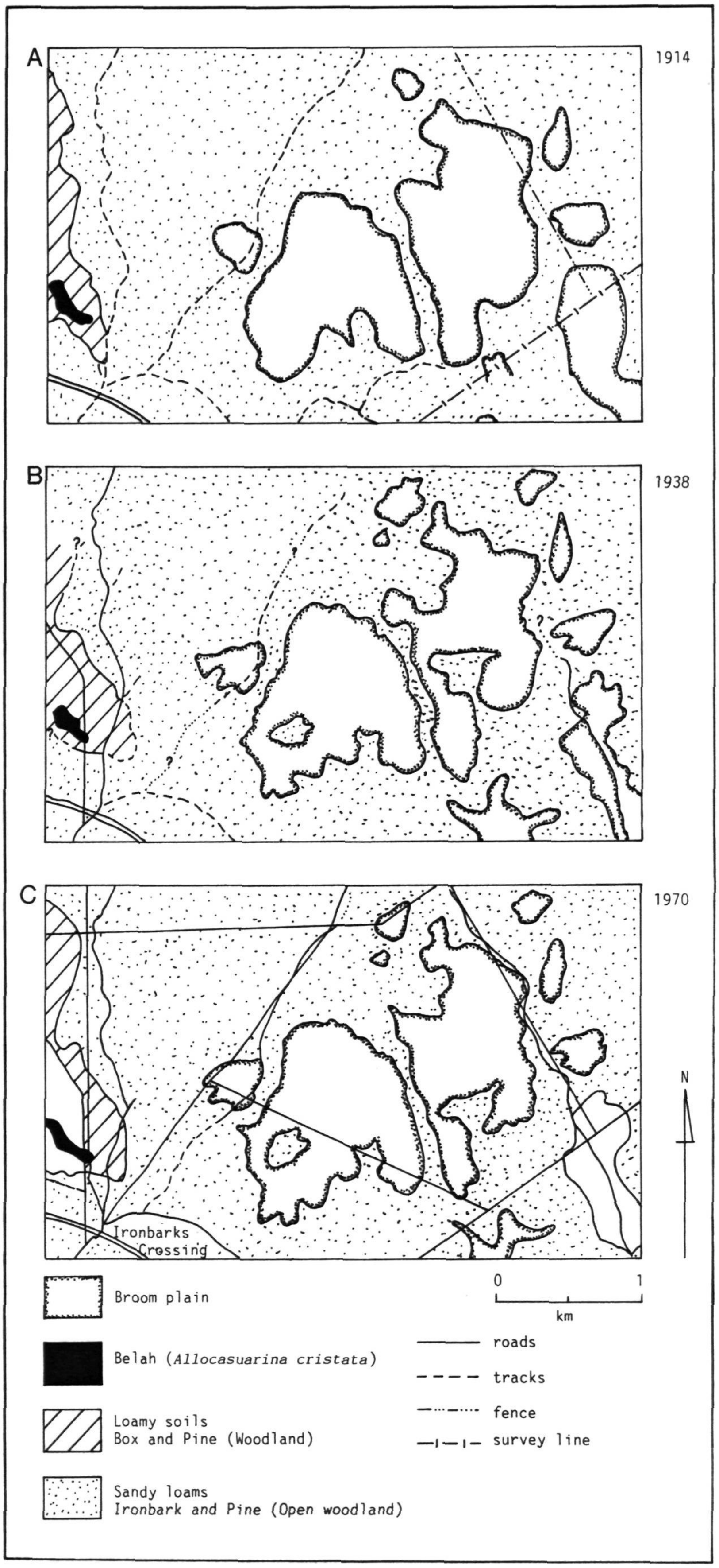


Figure 4-9 Tracings from a 1914 survey (A) and airphotographs taken in 1938 (B) and 1970 (C), of the area north and east of Ironbarks Crossing (redrawn from Norris *et al* 1991). See 'C' in Figure 3-1 for the location of this area.

the advantage of using aerial photography. Figure 4-8 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. 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 Department 1914a]) to the north and south of the sands and 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 4-9 is an area north and east of Ironbarks Crossing on Talluba Creek outside of the study area but included because it supports the interpretation of Figures 4-7 and 4-8 (Central mapping Authority 1974, Cubbo 1:50,000, grid ref. 615714). Again, the vegetation patterns seem not to have changed since 1914 (Lands Department 1914b), and indications are that the density is also similar. Further, from the survey of G. Loder's run in 1874 (Anon. 1874) the broom plains and other vegetation communities have been in existence at least from this time.

3. Stored seed, predation and fire

It has been suggested (Fosbery 1913; Rolls 1981) that large stores of pine seed available on mature trees or in the soil is another important factor for successful cypress pine regeneration. This idea is not supported by the studies of Hawkins (1966) and Lacey (1972, 1973) which showed that seed was normally shed in a period of about four weeks in summer and that seed viability under field conditions was as low as 1% several months after seed fall. There is no dormancy in the seeds.

Rolls (1981: p7) suggested that grazing of young pine by rufous rat kangaroos was an important factor limiting regrowth densities, therefore having a positive effect on maintaining an open structure to the forests. Oxley (1820: p270) refers to the prevalence of 'kangaroo rats', but no other primary source confirming the identity of this species in the Pilliga has been found. This point has been discussed previously in Chapter 1, however, it is likely that Oxley was referring to the Rufous Bettong (Rufous Rat-kangaroo) especially as there has been a recent sighting in Pilliga East State Forest (Elder-Shaw, pers. comm 1995).

Habitat preference for the Rufous Bettong include a dense ground vegetation of shrubs, grass or tussocks. Its diet usually consists of grasses and herbs as well as roots and tubers (Strahan 1983). No preference for cypress pine seedlings has been recorded.

With regard to fire, it has been found that there is 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 1951/1952), pine regeneration was apparently just as successful in areas which were not burnt elsewhere in the Pilliga, and regeneration was abundant over most of the natural range of *Callitris glaucophylla* 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. Because of this, a current State Forest management objective is to prevent wildfires occurring within young pine stands. This is achieved by hazard-reduction burns in areas adjacent to these stands (Forestry Commission 1987).

CONCLUSIONS

From the primary source material so far located, it is apparent that the present forested areas have been utilised to varying degrees over time. Changes in land use after settlement have no doubt caused modifications to the vegetation structure within the forests, particularly those areas having more reliable water and better soil conditions, for example, such as along and west of Baradine Creek, especially Pilliga West State Forest where pine regeneration did close over former grazing lands in the 1890s (Mitchell *et al* 1982). From Oxley's (1820) descriptions it seems that the pre-settlement vegetation he observed was forests and woodlands with an open structure as well as areas that were densely vegetated, possibly reflecting patterns of fire.

Current beliefs are for a single major pine regeneration event during the 1880s. From the information collected for this thesis, it seems that areas of thick pine scrub were present well before this period (Anon. 1874; Carver 1878; Anon. 1881), and that during the latter part of the 19th century several periods of pine regrowth probably occurred.

For the study area, it is suggested that the impact of grazing was never as intense as in other areas nearer the main streams (eg., Baradine Creek) due to the poor and scrubby nature of the landscape, limited water supply and possibly its remoteness. Much of the study area was not taken up until well into the 1870s, although other run holders may have previously used the land from time to time. The study area comprised land that appears to represent some of the last land ever to be taken up because of its poor agricultural and pastoral value. The area may have been used opportunistically when favourable conditions allowed, and as Date *et al* (in press) have alleged, it may have been more heavily grazed in drought conditions. This point requires further investigation.

Another important point to establish is the nature of the vegetation structure at the time of settlement. That is, how has the structure altered from the 1830s-1840s to the 1870s-1880s? This period of time is critical because as Mitchell (1991) argues, it is apparent that most of the environmental damage to the semi-arid and arid rangelands of New South Wales was done within the occupation span of the first generation of European settlers. From the early surveys and portion plans it is clear that many of the vegetation communities within the study area as recognised today were present during the mid 19th century. However, most of the surveys and plans examined for this thesis date from 1870 to 1880. This means that there is some 40 years of settlement however sparse, to account for. This aspect also requires further investigation.