CHAPTER 7

DISCUSSION AND CONCLUSIONS

INTRODUCTION

The present day vegetation structure and floristics of the Pilliga forests at large have developed under the influence of long term environmental change with some modification from human occupation, settlement and land use. For the study area the impacts of human occupation were low, due in part to the limited availability of water and the agriculturally poor soils in this area.

ADDRESSING THE AIMS

1. TO IMPROVE UNDERSTANDING OF THE RELATIONSHIPS BETWEEN VEGETATION, SOIL, TOPOGRAPHY, CLIMATE AND FIRE IN THE CENTRAL PART OF THE FOREST.

Chapter 2 reviewed some of the literature on the origins of the modern flora which can be seen as arising from the influence of a number of factors including: climatic change during the Pleistocene; fire; ENSO events; Aboriginal occupation and at least some European impact.

Floristically elements of this vegetation have been present over the longer term of 10,000 years as demonstrated by the work of Dodson & Wright (1989). However, the structural changes of the forests over this time are more uncertain given the possible duration of Aboriginal occupation (at least 5,000 years) and the subsequent effects of European settlement and land management within the study area. There is no indication from Oxley's (1820) account that the structure of the forests of ironbarks and cypress pine was different from the present. That is not to say that is was not different, qualitative descriptions are not always given, and as Pickard (1993) remarks, the absence of information on surveys, or in any other primary source, does not necessarily indicate the absence of a feature. The vegetation Oxley described represented the typical mosaic structure reflecting fire patterns.

The present vegetation of the study area comprises open forests and woodlands dominated by mixed communities including *Eucayptus crebra* - *Callitris glaucopylla; E. crebra* - *Acacia neriifolia; E. pilligaensis* - *C. glaucophylla; E. chloroclada* - *C. glaucophylla; E. viridis*, the uncommon Belah community of *Allocasuarina cristata* and shrublands dominated by *Melaleuca uncinata, Calytrix tetragona,* and *Micromyrtus sessilis.* Like the vegetation of the Sydney Hawkesbury Sandstone, the Pilliga forest vegetation is species rich, especially in the understorey species, and is developed on nutrient poor soils.

Distribution of plant communities and species variability

Beadle (1948) and Noy-Meir (1974) report that the patterns in vegetation within the arid and semi-arid regions of south eastern Australia can be attributed to soil texture and rainfall, and in particular to the depth of wetting. Eldridge (1988) found that the distribution of *Atriplex* and *Maireana* is affected by the availability of soil moisture, which in turn is influenced by soil texture and its effect on drainage.

This thesis set up a model of soil/slope moisture change and vegetation. From the data collected as part of this study, the role of soil moisture is recognised as an important factor in species and community distribution within the study area and probably over a greater area. Despite numerous problems with data collection, which need to be rectified in future work, it was possible to conclude that the results do support the hypothesis that soil moisture is a major control on the distribution of plant species and communities within the study area. Other factors which may also be of influence include: soil morphology; activity of soil fauna; the nature and depth of the underlying parent material (bedrock, alluvium); soil conductivity; and the direct or indirect effect of slope. This is especially the case for those communities occurring on the sand monkeys and the gilgai soils where soil morphology and texture are stronger influences than adjacent topography.

Fire

As no major fires occurred during this study, measuring the effects of fire and post fire germination rates and patterns could not be undertaken. Further, with the long time since fire, the influences fire may have to community dynamics can only be speculated upon. Further speculations concern the extent to which Aboriginal peoples used 'fire stick farming' in this part of the forest, the frequency they burned, and the area that was burnt. State Forest management policies is for hazard reduction burning in the more sensitive areas of cypress pine growth.

Benson (1985) found that for fire-sensitive shrubs in Hawkesbury Sandstone a period of seven to eight years is required for regular flowering and for some species, an extra year is needed to develop mature seed. Although the Pilliga forests receive much less rainfall than Sydney, it does seem likely that the study area at least may have undergone an unusually long period without fire. Birk & Simpson (1980, cited by Hart 1995) comment that it is unlikely that eucalypt forests ever reach a steady state in litter accumulation and decomposition unless they are protected from fire. Hart (1995) has found that at least the Ironbark-Pine forests and Mallee communities had reached a steady state sometime before 36 years after fire.

Mitchell *et al* (1982) suggested that broom plains may be a fire related feature, the distribution of which may change over time. However, from early surveys, portions plans and aerial photography it is clear that the boundaries of these communities have remained virtually unchanged since 1914, and probably since the 1870s. It can be assumed that they were present even before this time. From this study, it is concluded that the distribution of these communities is influenced by topography, dainage and soil texture, three factors that would have been stable over hundreds or thousands of years. This implies that for the study area, the dramatic changes to the vegetation as described by Rolls (1981) did not occur.

Annual species

Within the study area the six communities described are based on the perennial species recorded. However, as some sites were sampled more than once, at different seasons and preceeding rainfall events there are notable changes in some the annual and short-term perennial species. For example, the dominant grass genera in the understorey of the Ironbark-Pine forests change from *Stipa* to *Aristida*, from early summer to late autumn respectively. After moderate to heavy rainfall periods the herbaceous layer in the broom plains was characterised by the presence of species such as *Drosera* spp., *Angianthus pusillis* and *Centrolepis strigosa*, all growing in moist to wet topsoil.

Introduced species

Of the 185 species recorded from the quadrats, five are introduced species. This respresents 2.7% of the total number of species. Comparable studies in semi-arid rangelands generally demonstrate a greater proportion of introduced species. For example; Norris & Thomas (1991) found 17% introduced flora on rocky outcrops and ranges in central and south-western New South

Wales, Porteners (1993) recorded 21% exotic species during her mapping of the Hay Plain vegetation on south western New South Wales, Fox (1991) recorded 7% exotic species for vegetation along the Ana-Branch Mildura 1:250,000 map, Sivertsen & Metcalfe (1995) recorded 20% for the New South Wales southern wheat belt vegetation. In contrast, Wade (1992) found a similar proportion of introduced species when surveying the Brigalow (*Acacia harpophylla*) communities west of the Culgoa River in north western New South Wales.

From these comparable studies, the percentage of exotic flora within the study area is low. A number of studies emphasise the importance of disturbance for the introduction of exotic species (Anderson 1977; Kitching & Jones 1981; Fox & Fox 1986). The low percentage of introduced flora recorded for the study area may be attributed to the lack of long term intensive disturbance from agricultural or pastoral activites supporting the hypothesis that the study area was not greatly utilised last century.

Further research

A number of points raised as a result of soil studies need to be tested elsewhere within the Pilliga forests. These include the following:

a) The relationship of domes in the subsoils to the proximity to bedrock.

b) The extent to which the domes are found and any relationship with the broom plain and Mallee vegetation.

c) More detailed investigation into stratigraphy of the gilgai clays both within the study area and for other gilgai sites outside the study area having similar microrelief. This includes obtaining pollen and datable sediments.

d) As with point c) above, a closer examination of the sand monkey soils and their stratigraphic relationship within the landscape.

e) Further testing the model of soil moisture/soil salinity and soil water movement with improved sampling/recording techniques over more frequent intervals and along other topographic gradients.

f) Investigate more fully ENSO patterns for this part of the Pilliga region, and overlaying on these patterns of pine regeneration.

g) Dendochronolgy studies on *Callitris glaucophylla* to obtain a better understanding of the regeneration patterns within this part of the forest.

h) More survey and archaeological interpretation of Aboriginal occupation is required. As Roberts (1991) has demonstrated, the utilisation of the forest by Aboriginal peoples was much greater than previously believed, and given the archaeological sites found within close proximity to the study area, this area of research could be expanded.

2. PRIMARY SOURCE DOCUMENTATION AND THE VALIDITY OF THE PILLIGA FOREST PARADIGM AS DESCRIBED BY ROLLS (1981)

As a result of the historical research and field work undertaken for this thesis, the forest environment, at least within the study area, appears to have remained floristically similar over the past 150 years of white settlement. However, establishing the structure of the forest in the nineteenth century is more difficult. In terms of historic change there is no data for the first two decades of European settlement. From about 1831, the demand for more land to house an expanding population and increasing herd numbers meant that pioneers moved out beyond the nineteen counties of the 'limits of location'. In order to have some control over a spreading population, runs were to be surveyed. This was not achieved until 1847 at the earliest and even then, not all squatters had their land surveyed. From this point onwards there are helpful site specific original descriptions as presented in Chapter 4. The question of what changes may have occurred within the first few decades of settlement within the study area still remains.

Rolls' (1981) account of the settlement history of the Pilliga demonstrates extensive use of primary source material but as Pickard (1982) comments '... you need to sort things out...'. The independent research presented here in Chapter 4 has demonstrated that Rolls' account should not be accepted as an historically accurate document for all areas of the Pilliga forests. Many of his references could not be traced, and he was sometimes inaccurate with his interpretation of material from cited sources which could be checked (Oxley 1820 for example). In short, his work should be considered more as a quasi-historical narrative concerning the history of the Pilliga in general, but for specific historical aspects, such as cypress pine regeneration events, other primary source documentation and information presented in the scientific literature should be addressed. For the study area, the general model of environmental change - that the forest environment is an artefact of 150-160 years of European land management - does not seem apply. This has support directly from settlement patterns as described in Chapter 4, from old surveys and plans indicating vegetation communities that are still present today, from a range of aerial photography (although only from this century), and indirect support from the low level of introduced plant species which could be regarded as an indicator of disturbance.

3. EVALUATION AND SIGNIFICANCE OF VEGETATION CHANGE AND DYNAMICS

It is important to mention that the study area comprises a small proportion of the Pilliga forests, and that the conclusions drawn from this study may not apply to other areas of the forest country. For example, Mitchell *et al* (1982) comment that scrub encroachment did close over former grazing runs in Pilliga West State Forest. The whole Pilliga forests cover an enormous area with a complex settlement and land management history.

Grazing of native vegetation, especially grazing of cypress pine by introduced stock (cattle, sheep and rabbits) has no doubt affected regeneration of cypress pine and other more palatable species, including grasses. Grazing and the effects of other agricultural and pastoral activities have probably been negligable in the study area compared to other areas of the forests.

All this is not to say that the general Pilliga scrub story as presented by Vincent (circa. 1939) and Rolls (1981) is totally without foundation. Cypress pine regeneration events are episodic and depend on rare event conjunctions. This thesis has confirmed that two main regeneration events occurred, ie; in the 1890s and the 1950s. These events are not so apparent in the study area. In neither case is there a clear link with conditions changed by European land use, rather they were climatically exceptional seasons of the sort that probably always initiate a cypress pine regeneration event. If these are ENSO related, there should be evidence of such regeneration events in the pine sizes, and dendochronolgy, in the forest, and perhaps in logs harvested in the late 19th century and used in extant structures, such as from buildings.

Further research

Items requiring further study include the following:

a) More detailed archival research should be undertaken. This should include a full analysis of the returns of runs.

b) An attempt should be made to locate the missing sources used by Rolls (1981). All his papers pertaining to the book *A million wild acres* are now housed in the National Library in Canberra (Rolls pers. comm. 1996).

c) A study of bulletins and annual reports from the first forestry officers appointed.

d) Locating records of land resumptions for State Forests.

e) Locating private papers. For example, the Australian National University Archives is a potential source not yet examined.

f) Field identification of specific sites on portion plans within the forest, especially homesteads, yards, fences, and dams. An attempt should be made to estimate the number of stock that may have been present on runs and properties to compare with the return of runs figures.

g) Some ambiguities exist concerning pine regeneration that require clarification. For example, the temperatures at which pine seed viability is reduced, becoming non-viable. Lacey (1972) reported 25°C was the maximum temperature whilst Scott (1970) found 30-35°C.

4. IMPLICATIONS OF THE STUDY FOR PRESENT AND FURTURE FOREST MANAGEMENT

Management

Successful management of any natural system must constantly question the validity of its models, especially where they rely on relatively poor documentation or interpretation of primary sources. This thesis has demonstrated some examples, and these are i) the basis on which cypress pine regenerates, and ii) that dense scrub cover was unknown at the time of first settlement. In order to successfully continue harvesting this important timber, a detailed understanding of the history of environments in which this species grows and what factors influence its regeneration is paramount.

There is no argument with the observation that increasing densities of woody shrubs are a serious management problem in many parts of the rangelands in New South Wales as described by Booth (no date) and that white cypress pine is one of the problem species. However, the general belief that only two periods of cypress pine regeneration occurred within the Pilliga and that dense scrub cover was virtually unknown at the time of first settlement when open woodlands and grassy plains were the norm, has helped to establish perceptions on which management decisions for the Pilliga have been based and which have been extended to other Australian forest areas.

Climatic records suggest that there were at least two main opportunites for extensive pine regeneration. There is also evidence that pine did regenerate at other times in the twentieth century (e.g. 1974) but may not have survived well because of rabbits or subsequent unfavourable weather.

European History

One of the main points raised from this study is the importance of careful interpretation of primary source material in establishing the vegetation patterns and environments at the time of settlement, and the changes that may have occured following that settlement. Every area to be investigated should be treated on its own merits rather than in the broader scale. For example, vegetation change in south western New South Wales has been quite extensive with loss of taxa and in some instances, loss of communities such as the *Acacia pendula* shrublands as described by Moore (1953). As mentioned in Chapter 1 of this thesis there are numerous reports concerning the widespread changes to vegetation following settlement, the impact of which varies with the settlement patterns, management practices and environment of each particular area.

For the Pilliga region the intensity and impact of settlement and land management has been widespread but variable in its effects and generalizations are dangerous.

Conservation

There are seven conservation reserves within the total forests (Fig. 1-1). Of these, the Gilgai Flora Reserve (No. 41) was established for its gilgai country and associated flora. When comparing this site to the gilgai found within the study area, it is clear that both sites differ. For the Gilgai Flora Reserve the topography of the gilgai is more of shallow extensive pans rather than the dramatic depressions of Site V11. Further, other gilgai, similar to those of the Gilgai Flora Reserve, can be found in Pilliga West State Forest and these are surrounded by *Eucayptus populnea* (Plate 7-1).

The study area is in part of the forest where minor ironbark sleeper cutting and some broom harvesting is done. Although the impacts of these activites are probably low, and keeping in mind that the forests have been set aside for that purpose (amongst other things) some thought needs to be given to the future of some of the communities. Some problems have been recognised by Date *et al* (in press). These include grazing by introduced animal species such as horses and pigs as observed within the study area, and the logging of large hollow-bearing ironbarks which provide shelter for birds and mammals.

The broom plains within the study area are variable in their species composition. State Forests have set aside Lanes Mill Broom Flora Reserve (FR4) under their conservation policy but given the variability in the vegetation of the broom plains, it is desirable to survey all of the major broom plains and reserve a representative selection. Adjacent Mallee communities should also come under protection given the observed association they have with broom plains.

In summary, all gilgai, sand monkey, broom plain and Mallee communities need further survey work to record how different they are from one another and subsequently, a comprehensive set of reserves needs to be set aside.

Plate 7-1 Gilgai present within Pilliga West State Forest. These gilgai are broader and flatter compared to the Belah Site (Site V11) within the study area, and are surrounded by *Eucalyptus populnea*.

Aboriginal sites and historic sites.

Given the work of Roberts (1991) more survey and protection of Aboriginal sites is required. Several sites are found within close proximity of the study area, and given the suggested minimum use of this part of the forest last century and under State Forest Management for most of this century, it is possible that many more sites may be found along other water courses within the study area. These should be located and registered.

A number of historic sites are also indicated from the archival maps and these all need evaluation.

Soil-slope-vegetation model

The model of soil moisture-slope-vegetation as presented in this thesis, is an important input in understanding the forest resource and managing those areas with higher timber values. It is a contribution towards a more scientific base for management as it helps to explain the distribution of the plant communities within the study area, in particular, the more economically valuable species including *Callitris glaucophylla, Eucalyptus crebra,* and the Broom, *Melaleuca uncinata.*

The results of this research need to be tested in other similar areas within the forests in order to confirm the soil moisture-slope model presented here.

AREAS FOR FUTURE RESEARCH

From this study, a number of important issues have been raised and require further investigation. Those not mentioned in the points above are listed below.

a) A number of plant species have been recorded as a result of this study that are not listed in the Management Plan (Forestry Commission 1987).

A vegetation survey would be an appropriate step in the direction of increasing knowledge of the composition of plant species.

b) A thorough statistical analysis of vegetation and soils is desirable to fully examine vegetation-environmental relationships over a broader area. This can be achieved by classifying the data already collected using multivariate anaylsis. For example, Le Broque & Buckney (1995) found that within the Hawkesbury Sandstone soils the major vegetation gradient from open forests and woodland to heath communities correlated with a soil nutrient-pH-texture environmental gradient. Communities on Narrabeen Shale correlated with a slope-nutrient, or a moisture-texture-shade environmental gradient. Keith & Myerscough (1993) found a strong moisture-nutrient gradient within heath communities on Hawkesbury Sandstone. The model of soil moisture and the effect of topography and soil texture on drainage as presented for the study area demonstrates similar relationships to these other studies, and should be tested through more effective analysis.

c) Continous measurement of permanents quadrats helps to shed light on the annual species turnover within and between seasons and over a number of years following different climatic conditions.

d) In order to test the results of the vegetation distribution patterns as a result of soil moisture (soil texture through its effect on drainage) as described in this thesis, a study over a wider area of the forests is required.

e) To test the suggestion that Mallee and broom plain communities are often found together, and the possible relationship of the mallee to bedrock, a survey of a greater area is required.

f) Recent studies have emphasized the role of cryptogamic crusts within the soil plant environment (Eldridge & Greene 1994; Eldridge & Bradstock

1994). The influence of cryptogamic crusts on movement of surface water in the broom plains is of interest. Lichens are the most common component in the crusts within the broom plains and bind with the leaf and flower litter dropped from *Calytrix tetragona, Melaleuca uncinata, Micromyrtus sessilis* and other species. This surface litter component may slow the movement of surface water allowing ponding and time for infiltration into the soil.

g) The role of soil fauna and their influence on soil formation. This is especially important within the soils of the mallee communities where the activity of termites and other ant species is most prevalent.

h) To further investigate the early settlement within the study area, especially for the period 1830 -1870. This investigation would include the location of watering points, and information on occupation licences and grazing leases for example.

i) Further investigation of historical documents for information on the distribution and abundance of broom plains. If the distribution of these communities is related to fire, and as fire regimes have altered post settlement and during settlement history, (for example, the exclusion of fire except low-key hazard reduction in special areas), then the broom plains as seen today may be decreasing in extent and number. From old survey plans within the study area this decrease has not been indicated, but for other areas of the forests the story may be different. For example, the broom plains found in the vicinity of Salt Caves are variably interspersed with *Callitris glaucophylla* and *Eucalyptus crebra*. This is especially common in the broom plain located at the intersection of Pine Creek Road and Well Road, west of Five Ways Corner.