WESTERN ARID REGION
LAND USE STUDY - PART III

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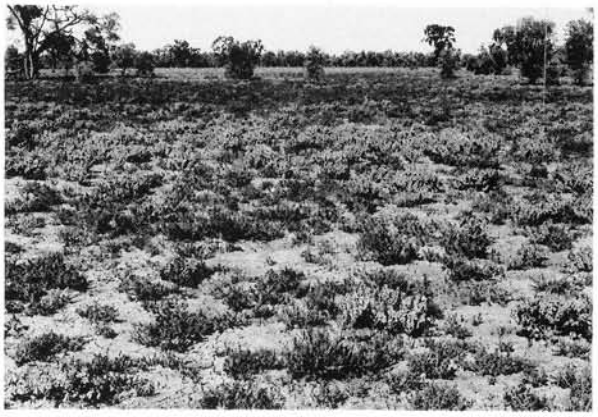

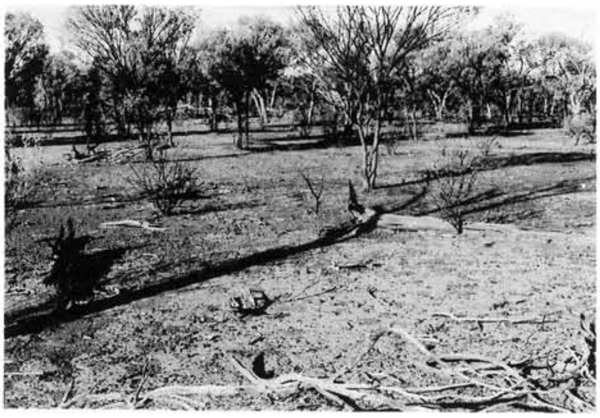

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Western Arid Region Land Use Study Part III

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Division of Land Utilisation

Queensland Department of Primary Industries
Brisbane 1990

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FOREWORD

The Division of Land Utilisation has, since 1970, been engaged in the conduct of land use studies in the pastoral lands of western Queensland. The western grazing lands, which are utilised for sheep husbandry and beef cattle production, cover some 60 million hectares of land in an arid and semi-arid environment. These lands support 60% of sheep numbers and 15% of the cattle numbers in the State and as such represent a valuable resource.

This report, which is a companion volume to earlier reports published progressively since 1974, describes the physical environment and catalogues the land resource data for about 5 million hectares of land which runs from Charleville in the northern portion down to the New South Wales border.

The information reported in this study is relevant to the 1990s and outlines the land use problems that pastoralists face as they approach the twenty-first century.

The report outlines the pathways for long-term, safe management of these fragile grazing lands, and indicates the safe stocking parameters for the principal Land Systems that have been identified.

I commend this publication to graziers, grazier organisations, Local Authorities and Government Departments who have a commitment to maintain the western pastoral lands in a highly productive state.

Dr J.C. Andrews

DIRECTOR

DIVISION OF LAND UTILISATION

ACKNOWLEDGMENTS

The authors recognise that, with the passage of time since the survey was conducted, some of the text has become out of date. However, with the resignation of two of the senior authors in the interim, one in 1980 (R. Purdie) and one in 1986 (J. Mills), after preparation of the manuscript, publication would have been deferred further to allow thorough updating. A supplementary list of papers published since 1980 has been included for reader convenience (Appendix VI), courtesy of Charleville regional office of the Department of Primary Industries.

The authors are grateful to:

- Mr N.W. Dawson for supervision throughout the survey and Messrs E.J. Turner, D.J. Ross and S.E. Macnish for technical and editorial input to the report.
- Mr G.A. Tuck for assistance especially during the field phase of the project.
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- Mrs C.R. Smith for typing the final draft with dedication and enthusiasm.
- The Agricultural Chemistry Branch staff, for their assistance with the analysis of soil samples.
- Mr K. Rosenthal, for presentation of morphological data in the Microfiche, and computer programming.
- Mr K. Hughes, for his assistance with geology and geomorphplgy, and the field work.
- A special thanks to Mrs V.J. Eldershaw, for compilation and final editing; a task made difficult by the long period since commencement of the report and the resignation of two of the senior authors.

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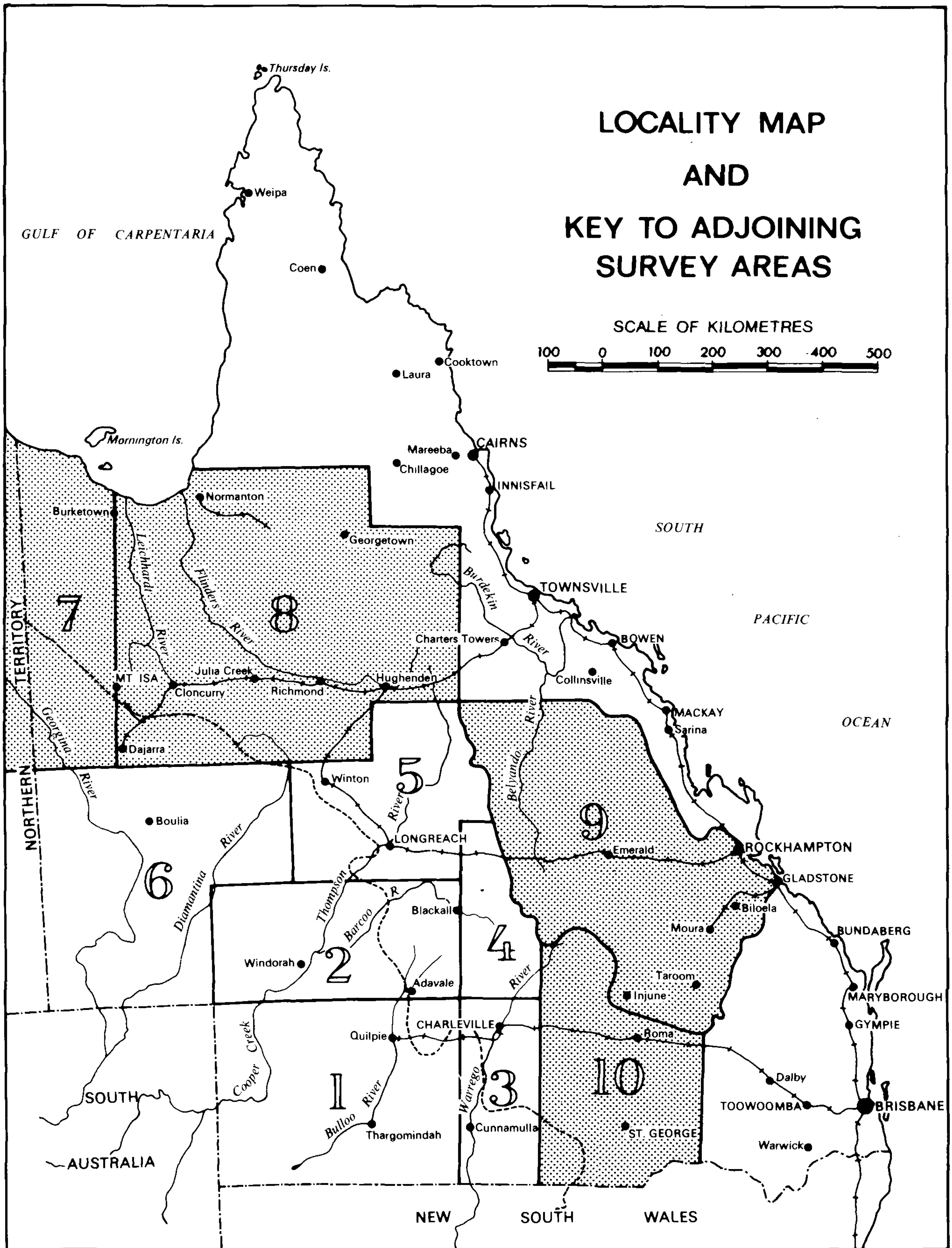

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380mm (15") Isohyet ....

Division of Land Research (C.S.I.R.O.) ....

SUMMARY

This study focuses on 5 million hectares of pastoral lands in western Queensland, encompassing Charleville in the north and continuing south to the New South Wales border.

The region receives less than 500 mm average rainfall per annum, with 60 - 70% falling in summer (October to March). Rainfall decreases in the southern portion, receiving 25% less per annum. Rainfall is very variable with periods of drought frequently extending beyond one year. Evaporation rates exceed precipitation. Temperatures range from 34.4°C (mean summer maximum) to 7.8°C (mean winter minimum) for Charleville.

The region is part of the Great Artesian Basin (containing portions of the Eromanga, Adavale and Surat Basins) and is formed over basement rocks which are predominantly low grade metamorphics of the Ordovician to Devonian ages. Uplift followed by shallow marine deposition, form a series of geologic layers. Tertiary and Cretaceous sediments cover a major part of the land surface. The erosion products have formed large areas of Quaternary sand sheets. The area is drained by the Warrego River and its tributaries.

A survey was carried out to provide an inventory of the land resources of the area: soils, vegetation, land systems and current land use. Soil and vegetation categories were mapped at a scale of 1:500 000 and forty land systems have been described. Industry in the area is presently based on the grazing of natural pastures by sheep and/or cattle.

On the basis of the resource inventory, there is concern for the long term future of the area west of the Warrego River. This area is characterised by instability and decreasing productivity associated with land degradation. Recommendations on this and other, more regional, aspects have been defined.

CONCLUSIONS

The area comprises three distinct regions and major differences are evident in productivity and stability between these regions.

- The mulga lands west of the Warrego River are unstable and the productivity of substantial areas has been reduced by erosion and the invasion of unpalatable shrubs.

- The mulga lands east of the Warrego River are stable in an ecological sense, in that dense mulga scrubland is the state these systems naturally move towards. However, from a productivity point of view, the major problems for producers in this area are the control of this mulga regrowth and the invasion of undesirable *Aristida* species into areas where mulga has been removed.

- The alluvial plains, alluvial woodlands, and gidgee lands associated with the Warrego River in the southern half of the region are relatively stable, highly productive areas for the production of wool, mutton and beef.

The substantial downtrend in condition of the land resources in the mulga areas to the west of the Warrego must be arrested, and if possible reversed, if efficient pastoral production from this area is to continue.

Recommendations

1. There is a need for further research, development and extension of management strategies which will maintain unstable mulga lands in a state which offers maximum productivity in the long term. One of the specific objectives of such work should be to define practical pasture condition standards which indicate when land is being over utilised.

2. There is a need for a continuing recording program to monitor the condition of mulga lands and provide information on long term trends in condition and productivity.

3. Regional financial surveys are needed to provide information on costs and returns on properties typical of various resource regions. This information should be updated regularly, and provide land administrators and those responsible for devising land management systems with information on the needs of managers and the options available to them.

4. Careful regional planning is needed. Charleville has become a major regional centre for the entire south-western Queensland area. The provision of new bitumen roads west to Morney and south to New South Wales has further increased its importance as a regional centre. There is a need to expand the services and attractiveness of this major regional centre in an endeavour to get people to remain in and to do business in the region. The decentralisation of Government services into such towns should be continued. Public service incomes boost the economy of regional centres such as Charleville and are particularly important in maintaining the local economy during periods of drought and price downturns for rural products.

5. Tourism and National Parks. Tourism can provide a certain degree of outside stimulus to the economy of western centres but modern facilities, professional management and promotion of the various tourist attractions is necessary. While there are no national parks in the survey area, there are attractive destinations to the north-east and west of the region.

A flora and fauna reserve which formed a corridor across the Warrego River from the ranges in the west to the sandplains of the east of the Warrego would include a wide diversity of plants and animals. This reserve would help rare species to maintain their numbers during drought periods. The ready access from the bitumen road south to the major population centres in the southern states could also mean a substantial number of potential visitors to such a reserve. Careful management of these areas will be needed to prevent dense mulga scrub from predominating and reducing the biological diversity found in open mulga savannah lands.

6. Management Strategies for Mulga lands. Current management recommendations are as follows:

- Stocking strategies should concentrate on matching stock numbers to the feed available. Studies to date indicate that stocking to consume 20% of the pasture available at the end of summer will maintain the condition of the land without loss of productivity. In areas of <400 mm rainfall, the felling of mulga scrub for stock feed should be limited to drought periods of a one year in ten frequency.

- To facilitate adjustment of stock numbers and the stocking of land in this manner, larger property sizes than many of those presently existing, are necessary in the mulga lands west of the Warrego. A size of 60 000 ha is adequate under present conditions; more than 50% of properties in this area are below this size.

- In >400 mm rainfall areas, the use of fire to control mulga densities and unpalatable shrubs has shown promise and needs further investigation and demonstration.

- The differential effects that sheep and cattle have on the pastures they are grazing needs to be further investigated, with a view to determining both optimum utilisation levels for each animal and complementarity in the diets.

Chapter 1

EARLY SETTLEMENT

by J.R. Mills[1] and A. Lee[2]

The first inhabitants of the Warrego country were aboriginal tribes who were thought to have been in the area for at least 20 000 years (Blake 1979). It is likely that the frequent burning or "firestick farming" practised by the aboriginals to produce new pasture growth and to attract game had a profound effect on the vegetation. This burning may have resulted in a predominance of open wooded grasslands which made excellent grazing lands, much sought after by the first settlers. In fact, it was not until the advent of large machinery in the late 1950's that wildfires became more infrequent, and this has seemingly resulted in a general increase in shrub and tree densities throughout much of the region.

Tindale (1974) shows on an accompanying map what is known of the names and distribution of tribes throughout the area. The best known tribes in the area appear to have been the Badjiri, Koamu, Morowari, Kalali and Maranganji in the Cunnamulla district, and the Kungarri, Kunga and Wadjalong in the Charleville area. Facets of aboriginal culture such as their techniques for building native wells in waterless areas and their legends to scare children away from deep waterholes show that this society had evolved sound and practical methods for dealing with some of the difficulties presented by life in this area.

As european settlement spread throughout the area, aboriginal camps formed on many of the larger stations. With the subdivision of the larger holdings, these camps broke up, with the last at Tinnenburra closing down in the late 1930's. Many aboriginals were moved to Cherbourg, while others found jobs as stationhands and domestics on properties. With the decline of the pastoral industry and later (1967) the granting of award wages to aboriginals, many became unemployed. Large camps formed on the outskirts of Charleville and Cunnamulla where they lived in poor conditions. Social welfare programs have since improved the health standards of aboriginals and also provided them with conventional housing in these two towns.

Major Sir Thomas Mitchell, Surveyor-General of New South Wales, was the first explorer to approach the study area. He set out from Buree, western New South Wales, in December 1845, to find an overland route to the Gulf of Carpentaria. With him were Edmund Kennedy, his second-in-command, Dr. Stephenson, and 26 men, most of whom were convicts on probation. Mitchell proceeded through the Roma and Mt. Abundance districts to the Warrego River, and thence northwards to the Nive River, naming rivers and mountains as he went. On encountering the Barcoo River (which he named Victoria River) running in a north-west direction (presumed to be to the Gulf of Carpentaria), Mitchell was forced to return.

In a subsequent expedition in 1847, Kennedy explored the Warrego area in more detail. Kennedy followed Mitchell's route and attempted to follow the Barcoo north but found it turned south, becoming Cooper Creek. On his return journey, Kennedy followed the Warrego River south, passing close to the present sites of Charleville, Wyandra and Cunnamulla. He remarked on the excellent condition of this country, comparing it favourably with the best in Australia.

Other explorers who passed through the area were Gregory (in 1858) and Landsborough (in 1862). While searching for Burke and Wills, Landsborough travelled south from the Gulf of Carpentaria and down the Warrego River. At Coongoola, they found the first station established on the Warrego, occupied by a Mr. Williams.

The favourable reports of the Warrego district by both Kennedy and later, Landsborough, resulted in a great rush for new land, particularly after the separation of Queensland in 1859 (McManus 1903). A new Land Act was passed, which required that all runs be stocked by 8th of April 1863. Squatters were striving to arrive first on their respective runs with their stock, for whoever failed to have his stock on his run by the day appointed by the Act, forfeited the land. It then became the property of anyone who could first stock it. This Act was passed to prevent "owners" of new land from keeping it unstocked thereby preventing others from taking it up.

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[1] Formerly Land Resources Branch, Department of Primary Industries.

[2] Department of Lands.

In 1861, J.T. Allen and his associates took up Burenda, the upper Nive, the Ward and the upper Langlo. Between 1859 and 1861, Thomas Dangar submitted tenders for the present Tinnenburra, Cuttaburra, Baroona and South Coongoola areas; most of the pioneering on these stations was done by his manager Mr. Conn.

In 1862-1863, Gowrie Station (the present site of Charleville) was formed and stocked by Messrs Flood and Gordon. In 1862, the runs Egoline, Glenelg, Karrol, Koralling, Querundi, Thara and Warra were surveyed by the Land Commissioner for Warrego (Mr. F.T. Gregory).

In 1868, Yarrawonga was taken up and in 1869 the Bignells took up Dillalah and later, Widgeegoara. Also in the later 1860's, James Tyson bought the original Tinnenburra runs of Thomas Dangar, and in a short time owned a vast area of country west of the Warrego, stretching from Wyandra to south of the New South Wales border.

Blake (1979) writes that much of this land had become available as a result of a slump in wool and cattle prices. Many settlers carried large debts and were unable to pay the Crown rental, resulting in forfeiture of the leases.

In 1866, a small town was established at Miller's crossing on the Warrego and in 1868, William Tully surveyed streets and allotments and named the town "Charleville".

Other notable landholders in the last century were James Rutherford of Cobb and Co. fame who purchased Cunnamulla Station (now Burrenbilla) and later, Claverton Downs. Simon Fraser purchased the huge runs of Bundaleer and Thurulgoonia in 1883, and in 1887, had the first artesian bore sunk. The availability of artesian water was the key to the development of much of the pastoral lands in the southern part of the survey area.

In 1867, a petition was made asking for the creation of a reserve so that allotments and sections could be laid out for the town of Cunnamulla (Warrego and South West Queensland Historical Society 1972). This was carried out and sales of allotments in Cunnamulla took place on 27 April, 1869; 18 allotments being purchased for an average price of eight pounds twelve and tenpence per acre. Development of the town quickly followed, with the erection of houses, a store, hotel, courthouse and lock-up.

The first Lands Office controlling land acquisition and transfer was located at St. George, but as the tempo of settlement increased, the need for more local control became urgent, and in 1863, a Lands Office was opened in Roma. This was regarded as a "great boon" to residents of the Warrego area, as Roma was considered to be much closer.

In 1868-1869, the Government of the day brought in new legislation to promote closer settlement of the larger runs (De Satage 1901). Pastoral lessees were given a 21-year lease over their blocks at a sliding scale of rent. When the expiry date of the 21-year lease was drawing near, the Government took action to resume (by the Grazing Farm Acts of 1884 and 1886), up to one half of the total run area. These resumed areas were re-issued as "grazing farms", of areas not exceeding 20 000 acres for 21 years, at an initial rent of a half-penny per acre, per annum. It was hoped that eventually, such grazing farms would pave the way for "smaller holdings growing endless crops of wheat and maize", however, the irregularities of good seasons were to prevent this.

Local Government came to the area in 1879 after a new State Government brought in "The Divisional Boards Act" (Finn 1947). By a proclamation issued under this Act, the whole of Queensland was divided into "Divisions", the forerunners of our present "Shires". The Murweh Division was proclaimed a local authority, and was amongst the first of the rural Shires established in Queensland.

The discovery of artesian water also gave settlers new hope that perhaps the Warrego area could be opened for widespread cultivation of agricultural and horticultural crops. Agriculture was still in the experimental or trial and error stage, and by 1893 in the Cunnamulla district, 31 702 acres had been taken up as agricultural farms. Many crops were being tried, and in Charleville it was reported by Mr R.A. Moore, the Land Commissioner, that he looked forward "with great confidence to a not very distant date when the district will take its place with Warwick and Roma in the production of wine. The climate and soil here are considered by good authorities eminently suitable for viticulture, but some capital and a few practical men who thoroughly understand the matter are required to give it an impetus."

Gradually, however, it was realised that the district's rainfall was too unreliable for nearly all crops, leaving the grazing industry to provide the commercial backbone of the district. Subdivision of larger holdings continued up until the late 1960's, before the declining profitability of the pastoral industry combined with the drought periods characteristic of the region, resulted in a process of aggregation of holdings which has continued until the present.

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Chapter 2

PHYSIOGRAPHY, GEOLOGY AND CLIMATE

by J. R. Mills[1]

Physiography and stratigraphy of the area have been described in some detail by Senior *et al.* (1969). The geology of the three 1:250 000 geological sheets has been described by Senior (1971) and Thomas (1971) in the Bureau of Mineral resources 1:250 000 Geological series - Explanatory notes. This chapter summarises the detailed descriptions presented by these authors.

PHYSIOGRAPHY

The survey area is drained by the Warrego River and its tributaries, the Langlo, the Ward River and Angellala Creek. This drainage system originates to the north of the area and flows south into New South Wales, finally joining the Darling River. Mabbutt (1969) estimated that the Warrego River drained 50 000 sq. km north of the state border and had a potential yield of 860 x 10^6 cumec/annum.

The much smaller Nebine Creek is the only other notable drainage system, running south down the eastern edge of the survey area to join the Culgoa River.

Elevation ranges from 335 - 425 m in the north to 120 - 145 m in the south along the state border.

Five major physiographic units are recognised:

1. **Dissected Tracts.** This units comprises ranges of low rounded hill and mesas, formed as a result of partial erosion of the Tertiary land surface during the Quaternary. These remnants have cappings of resistant chemically altered Cretaceous rocks, or more rarely, silicified Tertiary sandstones, which were originally part of the Tertiary land surface. The dissected tracts occur in the north of the Charleville sheet and along the western margin of the Charleville and Wyandra sheets.

2. **Uplands.** These consist of gently undulating, sloping plains associated with structural uplands such as the Angellala Tableland, and red soil plains associated with the flanks of the Moriarty Range and in the east, the Nebine Ridge. These red earth soils have been produced by weathering of the chemically altered Cretaceous rocks. Surface gravel and ironstone shot derived from these rocks are widespread throughout these areas. The soils are usually relatively shallow and overlie an intact or moderately stripped Tertiary land surface.

3. **Rolling Downs.** Small areas of rolling downs occur in the north eastern region of the Charleville sheet where erosion has locally removed the layer of chemically altered rocks and exposed fresh or weathered Cretaceous sediments. These areas are usually fringed by scarps and associated sediments with a cover of silcrete or altered Cretaceous rock fragments.

4. **Alluvial Plains.** The Warrego River deposited large accumulations of alluvium in structurally low areas during the Tertiary and Quaternary. In the south, between the Eulo and Nebine Ridges, the alluvium spread out over the Cunnamulla Shelf to form broad alluvial plains up to 150 km in width. These plains were described by Whitehouse (1947) as a fine example of a divergent river system.

5. **Sandplains.** These aeolian land surfaces have formed flat plains over alluvia and parts of the Tertiary land surface. A belt of sandplain fringes the Warrego floodplain, and south from Charleville this sandplain lies dominantly to the east of the floodplain. A similar belt of sandplain is associated with the upper reaches of Angellala Creek.

Numerous islands are scattered across the Warrego floodplains, and occasional irregular longtitudinal dunes (running north-south) are developed on these islands.

South of the Angellala Tableland between the Warrego River and Nebine Creek, extensive flat plains of red earths and aeolian sands occur. These sandplains comprise mainly aeolian sands which

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[1] Formerly Land Resources Branch, Department of Primary Industries.

are well sorted, fine to medium quartz sands, with reddish coatings of iron oxides, and increasing clay admixture in the subsurface horizons.

Some low sand dunes oriented north-south are present in the southern part of the Wyandra sheet. The entire plain is dotted with numerous claypan lakes. Many of these lakes have a low sand lunette developed on the eastern fringe.

STRATIGRAPHY

Stratigraphy of the region is shown in Table 2.1. The region is comprised of the south-eastern part of the Eromanga Basin, with some Adavale Basin and Surat Basin sequences present in the Charleville sheet. The Eromanga and Adavale Basins are both sub-basins of the Great Artesian Basin. Discussion of the geology of the Great Artesian Basin relevant to this area may be found in Whitehouse (1947), Ogilvie (1954), Tanner (1966, 1968), and Heikkla (1966).

Basement rocks are predominantly low-grade metamorphics, varying in age from Ordovician to Devonian. Some granite intrusions occur in the Nebine Ridge area. Folding and metamorphism of the basement rocks probably occurred at the end of the last Silurian to early Devonian orogeny, and sediments of the Adavale Group were deposited in the troughs (Senior *et al.* 1969). Volcanic sediments of the Gumbardo Formation were laid down during unstable conditions early in the Middle Devonian. Following this period, members of the Log Creek Formation were laid down during more stable marine conditions. After further uplift and erosion, members of the Etonvale Formation were deposited under shallow marine conditions. This was followed by a continental period of floodplains and saline lakes during which the Buckabie Formation was deposited (Tanner 1968).

Limited areas of Permian sediments remain following downwarping of basement rocks and subsequent erosion and removal of most Triassic sediments during the Permian/Triassic period.

During the Jurassic, fluvial and lacustrine sediments of the Injune Creek Group were deposited in basins. This was followed by the deposition of the fluvial Hooray Sandstone over the whole area during the Upper Jurassic to Lower Cretaceous period. Shallow marine conditions returned during the Lower Cretaceous, and as the Rolling Downs Group of sediments were deposited through the Cretaceous, conditions changed to paralic and then fluvial, lacusterine and paludial. During this latter phase, the Winton Formation sediments were deposited in fresh water environments. Peneplanation and deep chemical alteration of the exposed Cretaceous sediments then occured, followed by deposition of Tertiary fluvial sediments. Tertiary sediments west of the present position of the Warrego River have been classified by Senior *et al.* (1969) as part of the depositional basin of the Glendower River system. Local occurrences of similar sediments to the East of the Warrego River are thought to be correlates of a similar age deposited by other smaller river systems. The Glendowner and other Tertiary sediments were silicified and leached during the latter part of the Tertiary period.

The next event was the deposition of thick, alluvial Cainozoic deposits in structurally low areas (Senior 1971). Deposition continued during the Quaternary with extensive, thin sheets of locally derived colluvium in the form of sand and red earth covering much of the area. Broad stretches of alluvium, together with sand sheets and sand islands, were deposited by the distributory system of the Warrego River. Cainozoic and other, more recent deposits occur, with a thickness of 116 m recorded in the vicinity of Wyandra.

The red quartzose sand fraction of these Cainozoic deposits is thought to have been derived by reworking of Tertiary fluvial deposits. The red earth fraction has been formed from chemically altered Winton Formation sediments.

ECONOMIC GEOLOGY

Approximately 288 bores were providing flowing artesian water in the area in the area in 1971. The majority of bores obtain water from the Hutton Sandstone, and this water is generally suitable for stock and domestic use. It is unsuitable for irrigation due to the high levels of sodium salts.

Loss of pressure in the Hutton Sandstone aquifer, due to over-production through uncontrolled bores, has caused a number of bores to cease flowing. This has occurred in the more elevated parts of the Charleville sheet, and to a lesser extent the Wyandra sheet. Recent investigations suggest that the Artesian Basin has reached a state of equilibrium at present levels of use (Body, personal communication 1982).

No economically significant hydrocarbon discoveries have been reported in the area.

Table 2.1 Stratigraphy

Age and Rock Unit (Map symbol)	Lithology	Thickness (m)	Environment
Quaternary			
(Qa)	Sand, silt, clay, soil, minor gravel	0-90	Fluvial
(Qs)	Quartz sand	10	Aeolian
(Qr)	Sandy red earth, minor gravel	1-5	Fluvial & aeolian
(Qc)	Gravel, mostly silcrete	Superficial	Colluvial or alluvial
	Unconformity		
(Cz)	Medium to coarse quartzose sandstone, conglomerate	0-60	Fluvial
	Unconformity		
Tertiary			
Glendower Formation (Tg)	Silcrete (silicified quartz sandstone), quartzose sandstone, sandy conglomerate	0-10	Fluvial
(T)	Silcrete, quartzose sandstone, sandy conglomerate	10	Fluvial
Upper			
(Kld-Kw)	Kaolinised, ferruginised, and silicified sediments		
Winton Formation (Kw)	Labile sandstone, siltstone, mudstone, in part calcareous; minor coal	up to 360	Fluvial, lacustrine and paludal
Mackunda Formation (Klm)	Labile sandstone, siltstone, mudstone, in part calcareous; cocquinite		Paralic
Allaru Mudstone (Kla)	Mudstone, siltstone, in part calcareous minor limestone	0-150	Shallow marine
Toolebuc Limestone (Klo)	Calcareous shale	0-15	Shallow marine
Wallumbilla Formation (Klu)			
Coreena Member (Klc)	Labile sandstone, siltstone, mudstone, in part calcareous	135-340	Shallow marine
Doncaster Member (Kld)	Mudstone, minor sandstone and siltstone, in part calcereous		
Upper Jurassic Lower Cretaceous			
Hooray Sandstone (J-Kh)	Sublabile sandstone, quartzose sandstone, conglomerate, minor siltstone	195-240	Fluvial
Westbourne Formation (Juw)	Siltstone, quartzose sandstone, micaceous sandstone, minor lignite and coal	80-135	Fluvial
Upper			
Adori Sandstone (Ja)	Labile sandstone, siltstone, micaceous sandstone, minor lignite and coal	25-45	Fluvial
Birkhead Formation	Calcareous sublabile sandstone, siltstone, micaceous sandstone, minor lignite and coal	60-105	Fluvial
Middle			
Hutton Sandstone (Jlh)	Quartzose sandstone, minor, siltstone and mudstone	75-170	Fluvial
Evergreen Formation (Jlc)	Sandstone, siltstone, mudstone	15-40	Shallow marine, estuarine, lagoonal

Table 2.1 Stratigraphy

Lower			
Precipice Sandstone (Jlp)	Sandstone, siltstone, mudstone	10-40	Fluvial
Lower Permian			
(P1)	Sandstone, siltstone, conglomerate	0-240	Continental
	Unconformity		
Upper Devonian to Lower Carboniferous			
Buckabie Formation (D-Cb)	Red sandstone, siltstone, mudstone (varicoloured in part)	Several thousand metres in troughs	Continental & shallow marine
Etonvale Formation (Dme)	Siltstone, mudstone, sandstone, in part calcareous; dolomite	Maximum in excess of 600	Shallow marine
Cooladdi Dolomite Member	Silty and argillaceous dolomite; minor limestone	0-90	Shallow marine
Middle Devonian			
Log Creek Formation	Mudstone and siltsone; minor quartz sandstone, labile and sublabile sandstone	Maximum in excess of 750	Shallow marine, continental
Bury Limestone Member	Limestone, dolomite, minor calcareous siltstone	?	Shallow marine
Gumbardo Formation	Arkose and arkosic conglomerate	Maximum in excess of 750	Continental
	Unconformity		
Pre Devonian			
(Pz)	Schist, phyllite, granite, quartz-biotite gniess		

CLIMATE

The climate of the area is typically arid. It is characterised by four main features: low annual rainfall (total), unreliable rainfall patterns, high evaporation rates, and winter frosts in the eastern parts of the area.

Annual average rainfall ranges from <300 mm in the south to 550 mm in areas to the north and east of Charleville (Figure 2.1 and Table 2.2). Variability of rainfall in the area is illustrated by the data in Table 2.3, resulting in sporadic growth periods of varying duration.

Table 2.2 Charleville rainfall for the period 1880-1980

Annual rainfall	Years out of 100
175-300 mm	20
301-400 mm	25
401-550 mm	26
551-700 mm	11
>700 mm	18
Average since 1880	486 mm

During the period (1880 - 1980), there have been 38 years with rainfall above the average and 62 years with rainfall below the average. Paroo and Murweh Shires have been drought declared for almost half of the last 20 years. This seasonal variation has an overriding effect on management systems within the region.

The effectiveness of rain is influenced by the fact that 60 - 70% of the annual total falls in summer (Table 2.3). Annual evaporation rates for Charleville average 2655 mm. Maximum evaporation rates of 300 mm per month occur in summer. Winter evaporation is much less, typically 75 mm in July.

Temperatures range from a mean summer maximum at Charleville of 34.4°C to mean winter minimum of 7.8°C. Mean relative humidities for the same centre range from 45% in summer to 56% in winter.

Frosts are common during winter in areas to the east of the Paroo River and south of Blackall. This places a considerable limitation on the type of plant which will survive in these areas, and has important implications for plant introduction programmes.

Table 2.3 Mean monthly and annual rainfall with summer (Oct to Mar) and winter (Apr to Sept) components for selected centres

Location	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Year	Summer (Oct-Mar)	Winter (Apr-Sep)	Summer %
Charleville	70	62	62	32	24	29	29	19	22	35	42	60	486	331	156	68
Cunnamulla	43	52	42	25	27	27	22	17	19	25	26	38	363	226	137	62

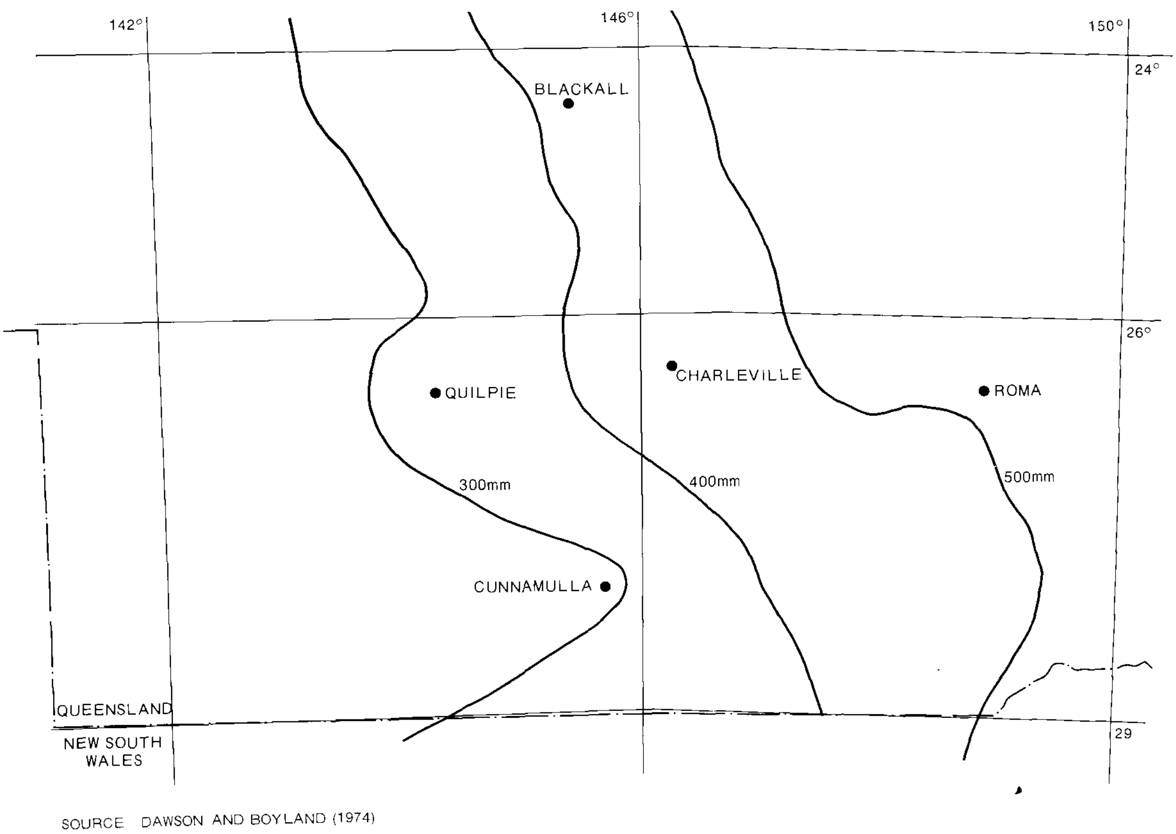

FIGURE 2.1 ANNUAL RAINFALL.

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Chapter 3

SOILS

by C.R. Ahern[1] and J.R. Mills[2]

Dominant soils of the area were previously mapped and described at a scale of 1:2 000 000 in the Atlas of Australian Soils, Sheets 3 and 4 (Northcote *et al.* 1966, Isbell *et al.* 1967).

This chapter describes the principal soils of the survey area, using profile descriptions from some 270 detailed sample sites. Figure 3.1 shows the distribution of these sites. Sampling procedures are described in Chapter 4.

Ten major soil groups and 19 soil profile classes have been recognised. The major soil groups closely follow the Great Soil Groups described by Stace *et al.* (1968) with minor modifications. The distribution of the major soil groups is represented in the accompanying map (1:500 000 scale) as 7 mapping units.

Frequency distributions of analytical data for major soil groups and soil profile classes are presented in Microfiche 2 (Chemical Tables). Soil morphological and chemical descriptions for the land units delineated in the survey are given in Appendix V.

Analytical data were derived from analysis of 82 profiles and 239 bulk surface samples. Samples for analysis were selected to describe the more productive land types in detail, and to provide analytical information on surface properties of all land units.

SOIL DEVELOPMENT

The principal geological and climatic events which have governed soil development in the area have been described by Senior *et al.* (1969), Senior (1971) and Thomas (1971), and are summarised as follows:

- Jurassic to Cretaceous sediments of the Eromanga Basin form a cover to the whole area.

- Slight erosion of these sediments formed an extensive, flat plain.

- Deep chemical alteration of the upper sediments (Cretaceous Rolling Downs Group) during the late Cretaceous to early Tertiary period to form the Tertiary land surface.

- Further erosion of this Tertiary land surface during the Quaternary, resulting in:

    (i) Alluviation of the structural lows, notably that occupied by the Warrego River where alluvium 116 m thick has been recorded. This alluviation along the Warrego River has produced a floodplain dotted with sand islands. The floodplain spreads considerably into a large distributory network in the south.

    (ii) Reworking of Cainozoic sediments (possibly late Tertiary fluvial deposits) to form extensive sandplains (sandy, red earth soils).

    (iii) Breakdown of chemically-altered, Cretaceous and Tertiary rocks to form red soil plains (loamy, red earth soils).

    (iv) Formation of dissected tracts in the north and west of the area.

MORPHOLOGICAL CHARACTERISTICS OF THE MAJOR SOILS

Cracking clay soils formed through deposition of alluvium by the Warrego River, occupy 21% of the area. These soils range from light to heavy-textured clays with varying quantities of silt and sand

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intermixed. These soils are very deep (> 150 cm) and generally have cracking surfaces with a thin, weak crust over a weakly self-mulching layer. Lime and/or gypsum are present in most profiles below 60 cm. These soils lose little water through runoff in normal rainfall events due to very low gradients, and have relatively high initial infiltration rates.

Minor areas of sedentary, cracking clay soils occur in the north-east, and have developed by weathering of fresh Cretaceous sediments.

Texture contrast soils occur on the lower slopes of gently undulating plains and in local run-on areas. These soils generally have sandy clay loam to sandy loam A horizons ranging from 10 to 60 cm thick overlying light to medium clay subsoils. Deep (>120 cm) soils predominate. Surfaces are hardsetting and tend to have relatively dense vegetative cover, improving infiltration rates of these soils.

Loamy, red earths occupy 40% of the area. These soils occur on gently undulating to sloping plains and vary in depth from 30 to >120 cm depending on their topographic position. Light, sandy clay loam textures predominate. Surfaces are hardsetting and frequently overlain with gravel or ironstone shot. Structure is massive. Infiltration rates depend on the condition of the soil surface, and range from very low on scalded or eroded surfaces, to moderate for well-grassed surfaces.

Sandy, red earths occur as almost flat sandplains, and are sometimes intermixed with loamy, red earths. Depths range from 40 to >120 cm. The soils are massive and textures are predominantly sandy loam. Surfaces are hardsetting, but infiltration rates are relatively high.

Earthy sands and siliceous sands occur either as sand islands or levees on the floodplain of the Warrego River, or as flat sandplains fringing the eastern edge of the Warrego floodplain. Textures range from loamy sand to loose sand. The earthy sands have massive structure and infiltration rates are high.

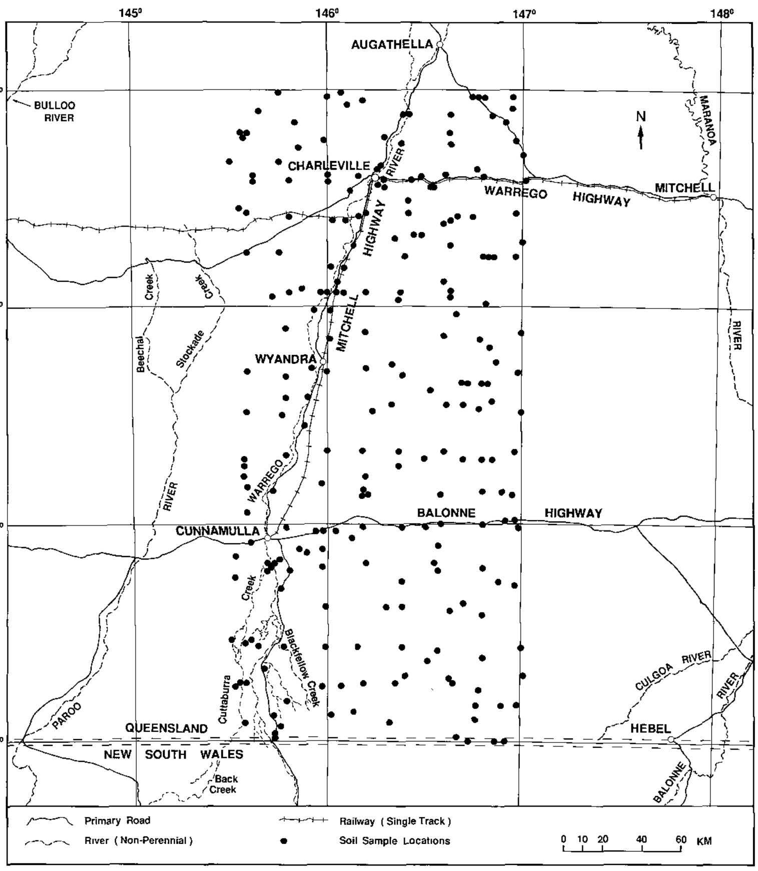

Figure 3.1 Distribution of soil sampling sites

Table 3.1. Characteristics of soil profile classes, geology, P.P.F., vegetation and site number

Description	Geology	P.P.F.	Vegetation	Sites
BROWN CLAYS ON GENTLY UNDULATING PLAINS *				
Red Brown and Grey Clays on Gently Undulating Plains (A)				
A1 Mt. Pleasant				
Moderately deep to deep, red, brown and grey clays in run-on areas. Surfaces hardsetting to cracking. Soil reaction is neutral.	Undifferentiated Quaternary deposits	Uf5.12 Uf6.12 Uf6.31 Ug5.23 Ug5.24	Box/ mulga/ (rarely brigalow) open woodlands	18, 21, 563, 575, 601
A2 Yo Yo				
Shallow to moderately deep, brown to dark, reddish brown cracking clays. Surfaces are cracking, with thin, weak crusts. Soil reaction is alkaline to neutral.	Cretaceous Doncaster and Coreena sediments	Ug5.32 Ug5.38	Mitchell grass open tussock grassland	7, 501, 603
A3 Mooloothulla				
Deep reddish brown cracking clays in scarp retreat zones. Reaction ranges from alkaline to medium acid. Surfaces are cracking with slight to moderate gilgai development.	Cretaceous Doncaster and Coreena sediments	Ug5.38	Brigalow shrublands	24, 605
ALLUVIAL SOILS, CRACKING CLAYS AND TEXTURE CONTRAST SOILS				
Alluvial Clay Soils (B)				
B1 Tego				
Alluvial, clay soils with amounts of silt and sand inter-mixed. Textures range from light to medium clay. Soil reaction is alkaline to neutral. Soils are very deep and surfaces may be hardsetting or cracking.	Quaternary alluvium	Ug5.24 Uf6.13 Uf6.23 Uf1.42 Uf6.12 Um5.52	Coolibah/ yapunyah/ brigalow open woodlands predominate	135, 222, 242, 245, 503, 535, 538, 553, 557, 567, 573, 625, 629
B2 Gerah				
Alluvial, grey-brown, cracking,clay soils of heavy texture. Soils are very deep, and soil reaction is alkaline. Surfaces are cracking, with silty crusts.	Quaternary alluvium	Ug5.24 Ug5.34	Coolibah/ yapunyah open woodlands predominate	1, 42, 102, 210, 218, 219, 225, 226, 228, 234, 235, 237, 508, 509, 514, 515, 520, 528, 529, 530, 531, 532, 533, 541, 550, 611, 617, 632, 634, 636
B3 Wallal				
Reddish brown, alluvial, clay soils of medium texture. Soils are deep to very deep, and soil reaction is alkaline to neutral. Surfaces may be cracking or hardsetting.	Quaternary alluvium	Ug5.34 Ug5.38 Uf6.12	Open herbfields/ short grass grasslands	25, 229, 539, 546, 576, 624
B4 Noorama				
Brown to reddish brown, cracking, clay soils of medium to heavy texture. Soils are very deep, and soil reaction is alkaline. Surfaces are cracking with weak crusts.	Quaternary alluvium	Ug5.34 Ug5.38 Ug5.24 Ug5.25 Ug5.39	Mitchell grass tussock grasslands	127, 134, 203, 212, 221, 227, 236, 239, 243, 512, 513, 544, 548, 572, 608, 615

B5 Bundaleer

Reddish brown to brown, alluvial , clay soils with textures increasing down the profile from sandy clay or light to medium clay surface horizons to medium-heavy clays at depth. Soils are very deep, and soil reaction is alkaline to neutral. Surfaces may be cracking with well-developed sandy crusts, or hardsetting.	Quaternary alluvium	Ug5.38 Ug5.34 Ug5.28 Uf6.12 Uf1.43	Gidgee, sandalwood low woodlands	111, 204, 211, 247, 521, 549, 574, 577, 579, 610, 651

Scalds (C)

C1 Toolonga

Reddish brown, alluvial, clay soils with textures ranging from silty clay loam to medium clay. Soils are deep to very deep with alkaline soil reaction. Surfaces range from hardsetting to cracking and strongly crusting.	Quaternary alluvium	Ug5.34 Ug5.39 Uf6.12 Uf6.13	Nil. Occasionally very sparse forbs, short grasses and shrubs	502, 518, 540, 591

Texture Contrast Soils on Alluvia (D)

D1 Bando

Reddish brown to brown, alluvial, texture contrast soils. Sand to sandy clay loam surface horizons usually less than 50 cm thick overlie sandy, light to medium clays. Soils are deep to very deep with hardsetting surfaces.	Quaternary alluvium	Dr2.12 Dr2.13 Dr2.53 Dr5.52 Dr5.53 Dr2.62 Db3.53 Dy2.12 Dy2.13	Gidgee low woodlands predominate with occasional box, coolibah and ironbark	8, 9, 118, 201, 202, 213, 231, 238, 241, 244, 534, 542, 606, 616, 633

INTERMIXED RED EARTHS AND TEXTURE CONTRAST SOILS ON FLAT TO GENTLY UNDULATING PLAINS

Texture Contrast Soils on Gently Undulating Plains (E)

E1 Brumby

Reddish brown, texture contrast soils, with light, sandy clay loam surface horizons 20-50 cm deep overlying sandy, light to medium clay subsoils. Soils are generally deep and have alkaline soil reaction. Surfaces are hardsetting.	Redistributed Quaternary	Dr2.12 Dr2.13 Dr2.53 Dr3.51 Dr3.12 Dr2.72 Dr2.52 Db2.13 Dy2.12 Gn2.12 Uf1.43	Box, mulga low open woodlands	3, 11, 16, 112, 124, 128, 133, 232, 562, 569, 571, 586, 589, 596

RED EARTHS

Loamy Red Earths (F)

F1 Loddon

Shallow, massive, loamy, red earths, with predominantly uniform, light, sandy clay loam to clay loam textures. Soil reaction is acid. Surfaces are hardsetting.	Redistributed Quaternary erosion products	Um1.43 Um5.52 Um5.51 Gn2.11 Uc1.43	Mulga, occasionally box low open woodlands	10, 13, 14, 17, 30, 34, 40, 108, 114, 115, 140, 504, 505, 519, 545, 559, 560, 580, 582, 594, 602, 604, 627

F2 Halton

Moderately deep, massive, loamy, red earths, with predominantly uniform, light, sandy clay loam textures. Soil reaction is acid. Surfaces are hardsetting.	Redistributed Quaternary erosion products	Um1.43 Um5.51 Um5.52 Um6.13 Gn2.11 Gn2.12	Mulga low woodlands	2, 15, 23, 29, 33, 39, 47, 106, 132, 139, 205, 206, 526, 537, 552, 556, 561, 581, 583, 613, 626

F3 Maxvale

Shallow to moderately deep, red earths, with both uniform and gradational textures ranging from light, sandy clay loam to clay loams and sandy clays. Soil reaction is acid. Surfaces are hardsetting. Hardpans of varying permeability are present at depths usually ranging from 40 to 80 cm.	Redistributed Quaternary erosion products	Dr3.5 Gn2.12 Um1.43	Box/ mulga low open woodlands	26, 32, 44, 107, 109, 116, 131, 136, 137, 215, 240, 547, 570, 588, 598, 607, 609, 612, 621, 623, 628, 631, 637

F4 Brunell

Deep, loamy, red earths with gradational textures ranging from light, sandy clay loam to sandy clay and light clay at depth. Soil reaction is neutral to alkaline. Surfaces are hardsetting.	Redistributed Quaternary erosion products	Gn2.12 Um1.43	Mulga, box, ironbark woodland	592, 599

SANDY RED EARTHS

Sandy Red Earths (G)

G1 Prairie

Shallow, sandy, red earths with uniform, sandy loam textures, or sandy loams, grading into sandy clay loams at depth. Soil reaction is acid. Surfaces are hardsetting.	Redistributed Quaternary erosion products	Gn2.11 Uc1.43 Uc1.23 Uc5.11	Mulga/ box low open woodland	22, 105, 120, 125, 223, 558, 564, 566

G2 Mayvale

Deep, sandy, red earths with uniform, sandy loam textures, or occasionally, gradational profiles with textures increasing from sandy loam to light, sandy clay loam at depth. Soil reaction is predominantly acid. Surfaces are hardsetting.	Redistributed Quaternary erosion products	Uc1.23 Uc1.43 Um5.51 Um5.52 Gn1.11 Gn2.11 Gn2.13	Mulga low open woodland	20, 28, 36, 44, 45, 46, 117, 119, 121, 129, 207, 214, 240, 507, 510, 554, 587, 590, 593

G3 Elmina

Deep, sandy, red earths of sandy loam texture, with increases in clay and/or iron and manganese content at depths of 70 to 120 cm restricting drainage and forming hardpans of varying permeability. Soil reaction is acid. Surfaces are hardsetting.	Redistributed Quaternary erosion products	Gn2.12 Gn1.11 Um1.43 Uc1.43	Box/ mulga low open woodland	45, 105, 123, 129, 138, 207, 510, 554, 593

EARTHY SANDS

Earthy Sands (H)

H1 Bowra

Very deep, earthy sands. Profiles are uniform, loamy sands, occasionally increasing to light, sandy clay loam or heavier textures at depth. Soil reaction is acid. Surfaces are predominantly hardsetting in appearance, but readily break up into loose sand grains.	Quaternary sand deposits	Uc1.23 Uc1.43 Gn2.12	Wiregrass open grassland to mulga shrubland	5, 35, 43, 110, 220, 233, 524, 525, 527, 543, 622

H2 Myola

Very deep, earthy sands. Profiles are uniform, loamy sands, occasionally increasing to light, sandy clay loam or heavier textures at depth. Soil reaction is acid. Surfaces are	Quaternary sand deposits	Uc1.23 Uc1.43 Gn2.12	Wiregrass open grassland to mulga shrubland	31, 38, 104, 130, 230, 511, 536, 568, 630

predominantly hardsetting in appearance, but readily break up into loose sand grains.				
SILICEOUS SANDS				
Siliceous Sands (I)				
I1 Randwick				
Very deep, red to brown, siliceous sands. Profiles are uniform sands, with minimal profile development. Soil reaction is acid. Surfaces are loose.	Quaternary sand deposits	Uc1.23 Uc1.22	Cypress pine open woodland	113, 209, 516, 517, 522, 618
LITHOSOLS				
Lithosols (J)				
J1 Minitta				
Very shallow, red to reddish brown, gravelly lithosols, with sandy loam to light, sandy clay loam textures. Gravel and grit are intermixed. Soil reaction is acid. Surfaces are hard-setting, frequently with gravel pavements.	Partially weathered altered Cretaceous sediments	Uc1.43 Um1.43	Mulga shrublands	4, 27, 37, 41, 101, 122, 126, 208, 217, 246, 506, 523, 551, 578, 595, 597, 614, 620, 635
J2 Rollo				
Very shallow, dark brown, gritty lithosols, with fine, sandy loam texture. Soil reaction is alkaline.	Partially weathered Quaternary limestone	Um1.13	Open grassland	555

* The headings given in bold are the names of the seven mapping units from the accompanying soils map. Headings given in italics refer to the 10 major soil groups discussed throughout Chapters 3 and 4 and show only generalised relationships to mapping units.

DESCRIPTIONS OF MAJOR SOIL GROUPS

The soils of the area have been arranged into 10 major soil groups and 21 soil profile classes (SPC's) on the basis of soil properties, geological and vegetation factors. Soil profile classes are groupings of soils such that the variation in certain profile features within the group, is much less than the variation between the groups. The characteristics of these SPC's are given in Table 3.1 which also shows the generalised relationship between the seven soil mapping units and the 10 major soil groups. (See also Chem tables microfiche).

RED, BROWN AND GREY CLAYS ON GENTLY UNDULATING PLAINS (A)

There are considerable chemical and physical differences between the three soil profile classes in this group, reflecting the influence of different parent materials and positions in the topographic sequence on soil development.

Three soil profile classes have been described. Mt. Pleasant SPC comprises predominantly red clays formed in run-on areas of the mulga land zone. Yo Yo SPC comprises cracking clay soils (supporting mitchell grass) which have been derived from fresh Cretaceous sediments. Mooloothulla SPC contains cracking clay soils (supporting brigalow) which have formed in scarp retreat zones where a thin veneer of transported material overlies the sedentary clay soils.

Lab pH shows little change down most profiles but big differences between profiles. The Mt. Pleasant SPC is generally neutral to medium acid while Yo Yo SPC is neutral to moderately alkaline. Mooloothulla SPC, which supports brigalow, varies from very strongly acid at depth in one profile to strongly alkaline in another. This range in values is not common on brigalow soils.

All surface electrical conductivity (EC) values are very low; Mt. Pleasant SPC is low throughout; medium values occur at depth in Yo Yo SPC; high values occur at depth in Mooloothulla SPC. These higher values are associated with the occurrence of gypsum as well as chloride.

All surface soils analysed were non saline, and only one site in Mooloothulla SPC had a saline subsoil. Sites in the Yo Yo SPC often had sodic surfaces and sodic subsoils.

Mt. Pleasant SPC generally had lower clay content (20-43%) and lower cation exchange capacity (CEC) (8-12 m.equiv./100g). CEC/clay ratio (0.22-0.46), base saturation, exchangeable cations and ESP were also lower than the other soil profile classes. Coarse sand content (12-22%) and Ca/Mg ratios were higher than other SPC's in this group.

The remaining soil profile classes had clay content of 48-53%, CEC of 32-40 m. equiv./100 g, CEC/clay ratio of 0.55-0.91 and coarse sand contents of 3-13%. Thus, there is a difference between the SPC's in clay type or the proportion of clay minerals present, as well as the amount of clay. Calcium is the dominant cation in all profiles.

Exchangeable and replaceable potassium (K) values for the group range from medium to very high, indicating adequate K levels. Total K values range from medium on the Mt. Pleasant SPC to high on the other SPC's. Individual profiles were relatively uniform with depth.

Acid and bicarbonate extractable phosphorus (acid P and bicarb. P) were generally very low for Mt. Pleasant SPC, low on Yo Yo SPC and medium on Mooloothulla SPC. Phosphorus deficiencies [3] may occur on all except the Mooloothulla SPC. Total phosphorus (total P) values were medium with high values recorded at the surface under the brigalow woodlands of Mooloothulla SPC.

Organic carbon (Org C) levels were low to medium while total nitrogen (total N) levels are very low to medium. High Org C and total N levels occur on the brigalow sites. Carbon/nitrogen (C/N) ratios vary from 10-19. Total sulphur (total S) values range from low on Mt. Pleasant SPC to medium on Yo Yo and high on Mooloothulla SPC. Very high values occur at depth in Yo Yo SPC, associated with gypsum.

Iron levels [4] are adequate (mean surface value of 64 ppm). Manganese levels are medium to high, copper medium and zinc levels low. Available soil water capacity (AWC) is low to medium for Mt. Pleasant SPC and high for Yo Yo SPC.

ALLUVIAL CLAY SOILS (B)

This group consists of clay soils laid down as alluvium by the distributory system of the Warrego River. Five soil profile classes have been identified in this group based on differences in texture and surface characteristics.

Tego soil profile class comprises lighter-textured, alluvial soils with significant amounts of silt and sand intermixed. Gerah SPC consists of strongly-structured, heavy cracking clay soils with silty crusts. Wallal SPC consists of medium-textured, alluvial clay soils with a tendency towards surface scalding. Noorama SPC consists of strongly-structured, cracking clays of medium to heavy texture. Bundaleer SPC contains medium to heavy-textured, alluvial clay soils with sandy or lighter-textured surface horizons.

Laboratory pH ranges from slightly acid to strongly alkaline. The overall mean value for profiles in this group is 7.9. Most individual profiles increase in pH down the profile, reaching a maximum at the 60 cm sampling depth, while pH at the 120 cm sampling depth is usually lower on those profiles which have appreciable salts at this depth. The most alkaline SPC is Noorama, which supports open mitchell grass tussock grassland.

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[3] There is no field evidence of P deficiencies affecting plant or animal growth on Yo Yo SPC, and it is likely that available P levels are adequate for the growth of native pastures under semi-arid climatic conditions.

[4] Attempts to indicate possible trace elements deficiencies or toxicities using the criteria of Viets and Lindsay (1973) for DTPA extractable iron and the ratings of Bruce and Rayment (1982) for DTPA extractable zinc, copper and manganese are made in the broad sense. These criteria have been developed for sensitive crops from wetter areas and not native vegetation which may have substantially different requirements in the semi-arid climates.

Electrical conductivity values are generally very low to low in the surface. Occasional medium to high values were recorded in Tego SPC. These sites are typified by scaldy, hardsetting surfaces. Chloride values are generally very low in the surface and increase to medium to very high values at the base of the profile. A few sites have very low values throughout. Lowest EC and Cl levels occur in Gerah SPC. This SPC is more frequently flooded than the other soil profile classes. Most soils are non sodic at the surface, while all 23 analysed profiles had sodic to strongly sodic subsoils.

Most clay contents range from 35%-70% with a mean profile value of approximately 50%. This is the highest clay content of all the soil groups in this survey area. The Wallal and Bundaleer SPC's have much lower surface clay contents (mean bulk surface value = 35% and 30% respectively) than the other profile classes. There is little difference in mean silt contents between all SPC's but fine sand is highest in the surface of Wallal SPC (bulk surface = 39%) and coarse sand content is generally >20% in Bundaleer SPC which supports gidgee. Soil textures for Tego SPC show this profile class also has lighter-textured surface soils.

Cation exchange capacity values range from 10-42 m.equiv./100 g with a mean profile value of about 20 m.equiv/100 g. The Gerah and Noorama soil profile classes had highest mean CEC values. CEC/clay ratios are generally greater than 0.5 (group profile mean = 0.63). This suggests a considerable contribution of 2:1 lattice (expanding) clays, particularly on those sites with the highest CEC/clay ratios.

Most soils are >90% base-saturated in the surface, with base saturation increasing down the profile to give typically fully base-saturated subsoils. Calcium is the dominant cation in all profiles (mean Ca/Mg ratio >2). Exchangeable calcium changes little down most profiles except where clay and CEC values increase down the profile (that is, profiles with coarse-textured surfaces). Magnesium/CEC ratio also shows little change in the upper part of the profile but increased at the base of some profiles. Exchangeable sodium increases substantially down most profiles and in a few cases, is of the same order as magnesium values at the 120 cm depth. This is likely to cause restricted drainage on these soils due to clay dispersion. Exchangeable and replaceable K values are generally high to very high in the surface, decreasing with depth. All surface values exceed 0.2 m.equiv./100 g which was considered a critical deficiency level for plant growth by Crack and Isbell (1970) for soils in North Queensland. Total K levels are generally medium to high.

Most total P values are medium except for Noorama SPC where some low values were recorded. Bundaleer SPC which supports gidgee woodlands showed a distinct reduction in total P values with depth. This was also evident to some extent in Tego SPC. Cycling of P to the surface by trees and shrubs is probably responsible for these nutrient gradients. The Wallal and Noorama SPC's which support grasslands have very uniform profiles with no surface accumulation of total P.

Acid P values are extremely variable ranging from very low to very high. Generally the surface values of the grassland soils (Wallal and Noorama SPC's) have low to very low acid P. Bundaleer SPC (gidgee woodlands) has medium to high surface values but these reduce sharply with depth. Bicarb. P is also extemely variable, ranging from very low to high. Most of the 22 surface values for Wallal and Noorama SPC are very low. Generally, the grassland soils appear to have limited available P levels on most sites, while many of the woodland soils appear to have adequate extractable P at least in the surface. The soils involved produce native pastures of excellent quality during the erratic growth periods typical of this area and there is no evidence to suggest that P availability is limiting native pasture production or animal growth.

Organic carbon and total N levels are typically very low to low, with the very low values generally confined to Wallal and Noorama SPC's. The mean C/N ratio is 12.3 showing that nett mineralisation of nitrogen should not be a problem. The grassland soils have a narrower range of values than the woodland soils.

Extractable iron levels appear adequate while manganese and copper levels are medium. Some zinc levels are very low to medium.

Available soil water capacity ranges from low for the surface of the lighter-textured soils, to very high. The higher values occur in Gerah and Noorama SPC's.

SCALDS (C)

These are alluvial, clay soils with firmly crusting, scalded surfaces over strongly-structured subsoils. Surfaces frequently show evidence of deflation. Lab pH is neutral at the surface, increasing to moderately to strongly alkaline at 120 cm. EC and Cl values are very low to low at the surface, increasing to high levels at 120 cm. Soils are non saline throughout, while surfaces are usually sodic and subsoils are strongly sodic.

Clay content is variable in the surface and generally lower than the alluvial clays (Group B). Silt and fine sand fractions are higher than the alluvial clays, while coarse sand is lower. The scalds appear to have a particle size distribution which predisposes them to pack closely and become impermeable.

Clay activity (CEC/clay ratio) is generally lower in the surface (0.45-0.55), increasing with depth to about 0.7. This lower clay activity at the surface suggests a much lower proportion of 2:1 swelling clays. This reduces any swelling and shrinking effects in the surface and further contributes to the formation of hardsetting and impermeable surfaces.

Soils are usually greater than 75% base-saturated in the surface and fully base-saturated at depth. Calcium is the dominant cation throughout. Exchangeable and replaceable K levels are medium to high, showing no fertility limitation due to this element. Total K levels are medium to high.

Total P values are medium. Surface acid P values are very low to medium with high values at depth. Bicarb P is very low to low. These soils appear to have limited available P in the surface, similar to many of the grassland soils of the alluvial clays.

Organic carbon and total N levels are very low and are the lowest of all the alluvial soils. This reflects the bare surfaces of those soils which have been subject to wind or water erosion of the original surface layer. C/N ratios are variable with surface values ranging from 7 to 25.

Total S values are low at the surface but higher values occur at depth associated with gypsum. Total S values for the profile are in the region of 0.01%. This is the level below which responses to S have been recorded in Queensland soils (Andrew *et al.* 1974).

Extractable iron levels appear adequate, copper and manganese levels medium, and zinc levels very low to low.

Available soil water capacity is low to medium in the surface with medium values at depth. Low infiltration rates due to impermeable, hardsetting surfaces mean these soils are much less likely to reach maximum water-holding capacity than are the other alluvial clay soils.

TEXTURE CONTRAST SOILS ON ALLUVIA (D)

This group consists of alluvial, texture contrast soils formed by the deposition of varying thicknesses of sandy material over alluvial clay soils. Surfaces are hardsetting.

Lab pH is predominantly neutral at the surface, with some slightly to mildly alkaline values recorded. pH increases down individual profiles, though at different rates, to give mildly to very strongly alkaline pH at 120 cm.

Electrical conductivity and Cl values are very low in the surface with many sites remaining low throughout the profile. On the sites where medium to high EC's occur, gypsum and/or sodium chloride are the principal salts. Those sites with appreciable salts have them located much lower in the profile than the alluvial clays group (B). Profiles are non saline throughout. Surface soils are non sodic while subsoils are sodic to strongly sodic. This implies a high degree of susceptibility of these subsoils to erosion where slope or water movement is sufficient to create an erosion gradient.

Clay content is variable in the surface (mean bulk surface value = 17%), and increases are expected for texture contrast soils with depth. Fine sand contents are usually greater than 40% and are relatively uniform down most profiles until 120 cm. Coarse sand content is extremely variable between sites, ranging from 11% to 48% in the surface, usually decreasing down most profiles as clay % increases.

CEC/clay ratios range from 0.48-0.62 in the surface, generally increasing with depth to a range of 0.7 to 0.8 at 120 cm. Generally, clay activity values are of similar order to the alluvial clay soils (B), suggesting similar mixtures of clay minerals with a high proportion of 2:1 expanding lattice type clays. Soils are generally greater than 75% base-saturated in the surface, and fully base-saturated by 60 cm.

Calcium is the dominant cation in all profiles. Ca/Mg ratios are usually greater than 2.0 in the surface (mean bulk surface = 2.6), decreasing down all profiles to a mean of 1.4 at the 120 cm depth. Both exchangeable Ca and Mg increase with depth with increasing CEC and clay content.

However, Ca often peaks at 60 cm depth while Mg usually increases sharply to 120 cm depth. Exchangeable Na values increase sharply down all profiles, with highest values recorded at the base of the profile. These ratios suggest restricted drainage in the lower part of the profile.

Surface exchangeable and replaceable K values are generally high to very high, decreasing down most profiles. Some of the sites supporting gidgee have almost a fivefold reduction in exchangeable K by 120 cm depth. However, extractable K is considered adequate for plant needs. Total K values are medium to high and show more variability than usual, down individual profiles.

Total P values are medium to high in the surface with some low values recorded at depth. Generally, total P decreases with depth, particularly on the sites supporting gidgee. Acid P values are generally medium to high in the surface (mean bulk surface = 52 ppm) with most profiles decreasing with depth. Very high values were recorded at 60 cm and beyond on two sites, skewing the group mean to show considerable acid-extractable P at depth. Bicarb. P is generally medium in the surface with low and high values also recorded (mean bulk surface = 34 ppm). Values decrease at the 10-20 cm depth. Generally, extractable P values at the surface suggest adequate P. This assessment may be misleading where sites have low values below the surface, particularly if surface soil is eroded, or trees (which play an important role in increasing surface nutrient levels by nutrient recycling) are completely removed.

Organic carbon values are predominantly low, with very low values on bare sites. Values decreased sharply at 20 cm depth. Total N values are very low to low. Surface C/N ratios range from 8 to 17 (mean bulk surface = 13.5) decreasing at 20 cm. This suggests nett mineralisation of nitrogen should be adequate at most sites.

Surface total S values are predominantly low; however, because some sites are barely above the 0.01% S level, S may become limiting if organic matter content is depleted through vegetation loss and soil erosion. Total S values increase at depth on some sites when gypsum occurs, though to a lesser extent than group B.

Surface extractable iron values appear adequate, while copper, manganese and zinc levels are medium.

Available soil water capacity generally follows clay content, ranging from very low to medium in the surface (mean bulk surface = 7%), increasing with depth to 9.8% at 60 cm.

TEXTURE CONTRAST SOILS ON GENTLY UNDULATING PLAINS (E)

These soils have been formed on lower slopes and run-on areas of the mulga land zones by colluvial processes such as erosion products from chemically-altered, Cretaceous sediments transported down slope. Hard-surfaced, weakly-structured A horizons overlie sandy clay subsoils.

Lab pH ranges from strongly acid to neutral at the surface. pH increases sharply in most profiles below the 30 or 60 cm depths to give neutral to strongly alkaline values at 120 cm.

Electrical conductivity and Cl values are very low throughout most profiles with slight increases occurring at depth. Soils are non saline throughout and non sodic in the surface. No data is available for subsoils, but they are expected to be non sodic also.

Surface clay content is variable (mean bulk surface = 24%). Fine sands range from 33-57% at the surface, and are usually greater than the coarse sand content.

Cation exchange capacity at the surface is low, ranging from 6-15 m.equiv./100 g. CEC/clay ratios, when adjusted for organic matter contribution, range from 0.19-0.37, suggesting a substantial contribution of kaolinitic (1:1 lattice) clay minerals. Ca is the dominant cation at the surface and is probably sufficient for plant growth on most soils, becoming marginal on the sandier soils. Mg values of less than 1 m. equiv./100 g occur in half the surface soils analysed, indicating possible limitations to plant growth if higher levels are not available lower in the profile.

Exchangeable and replaceable K values are medium to very high in the surface, decreasing with depth. All values are greater than 0.2 m. equiv./100 g. K is considered adequate on these soils. Surface total K is low to high with most values in the medium range (mean bulk surface = 0.66% K).

Surface total P values are medium (mean bulk surface = 0.031% P). Acid and bicarb. P values are predominantly very low in the surface, decreasing sharply with depth. An occasional low to medium value may occur at the surface. Low P levels are likely to place a limitation on the types of pasture species which can be introduced into these areas. Native species are likely to have adapted to the conditions and the extent to which low P levels reduce productivity of these species is unknown.

Organic carbon values are low (mean bulk surface = 0.8%) with an occasional medium value and all sites decrease sharply with depth. Total N values are also low (mean bulk surface = 0.057% N) with some very low values recorded at the 20 cm depth. C/N ratios are variable ranging from 8 to 20 (mean bulk surface = 14.3), but generally indicate nett mineralisation of nitrogen is adequate. Total S values are low. Extractable iron values appear adequate; manganese, copper and zinc levels are medium.

Available soil water capacity is very low to low at the surface with values expected to increase slightly as clay content increases with depth.

LOAMY RED EARTHS (F)

These soils predominate throughout the mulga land zones and have formed on landscapes of redistributed erosion products derived from altered, Cretaceous sediments and occasionally (in upland areas) by direct weathering of the Tertiary land surface. Textures are light, sandy clay loam, or finer.

Profiles may be either gradational or uniform massive earths with hardsetting surfaces. Four soil profile classes have been recognised in this group. Lodden SPC comprises shallow, loamy red earths (<50 cm depth) and Halton SPC moderately deep, loamy red earths. Maxvale SPC is made up of shallow to moderately deep soils with hardpans at depth. Brunell SPC comprises deep, loamy red earths grading into light clays at depth.

Lab pH ranges from extremely acid to neutral in the surface. There is little difference between the soil profile classes in the bulk surface analyses, although the trend is for Maxvale SPC to have higher pH values. Loddon SPC has relatively uniform individual profiles both in lab and field pH with no trends evident. Values at depth range from extremely acid to medium acid. These shallow, red earths have similar values to those recorded by Dawson and Ahern (1974) to the west of this area. Halton SPC shows little pH change to 60 cm but increases to medium acid to neutral values at the base of the profile.

All profiles in Maxvale SPC increase in lab and field pH with depth. pH at the base of the deeper profiles is typically slightly acid to moderately alkaline. It is not uncommon for alkaline values to occur at the base of profiles in deep red earths as reported in other surveys by Dawson and Ahern (1974) and Ahern and Wilson (1990). These higher pH values are associated with the occurrence of hardpans.

Brunell SPC also increased in field pH with depth, with a moderately alkaline pH recorded at 120 cm. Low pH in the upper profile places limitations on the introduction of pasture species for these soils and may also cause aluminium toxicity problems.

Electrical conductivity and Cl are typically very low throughout the profile except in Maxvale SPC which has a trend to increasing values at the base of profiles where hardpans were recorded. While these values are still low, restriction of water movement by the hardpan seems to have resulted in reduced leaching and higher salt levels. This is supported by the higher base saturation values recorded in this SPC.

Some higher than usual EC and Cl values were recorded at sites in the Loddon and Halton SPC's where only surface samples were analysed. Results are typical for these soils and appear to be influenced by surface characteristics at particular sites. For example, site 504 is a bare site (bulk surface EC = 0.24 mS cm^{-1}, 0.025% Cl), while an adjoining vegetated site (bulk surface EC = 0.07 mS cm^{-1}, 0.005% Cl), is considerably lower. In addition, the bare site has much higher ESP (bulk surface = 4.4%) than the vegetated one (bulk surface = 1.8%). Occurrence of these "soda patches" is restricted to localised spots of limited significance. All surfaces and most subsoils of the loamy red earths are non sodic, except for Maxvale SPC which has some sodic subsoils associated with hardpans.

Surface clay content for the loamy, red earths is variable, ranging from 16-37% (mean bulk surface = 24%), increasing with depth on many profiles and typically reaching a maximum at the base of the profile. Loddon SPC tends to have less clay in the surface than the other SPC's and mean clay content for these profiles was 6% less than in Halton and Maxvale SPC's.

Surface CEC values range from 7 to 17 m.equiv./100 g (mean bulk surface = 10.3). Loddon and Halton SPC's generally have higher CEC in the surface than down the profile. This is due to the contribution to CEC made by organic matter in the surface soil. The CEC contribution from organic matter in the surface of the red earths can be 50-90% of the CEC attributable to clay minerals. Maxvale SPC generally increases in CEC with depth as clay content increases and also possible changes occur in clay composition to more active clay minerals (evidenced by a mean CEC/clay ratio of 0.4 at the 50-60 cm depth compared to 0.26 for Halton SPC at the same depth). CEC/clay ratios of Halton SPC suggest higher kaolinitic (1:1 lattice) clay content than the other soil profile classes.

Most surface soils of the loamy red earths are less than 50% base-saturated (mean bulk surface = 39%). Base saturation increases with depth down most individual profiles. There is a trend towards increasing base saturation from Loddon to Halton to Maxvale soil profile classes. This is also reflected in their field and laboratory pH values.

Calcium is the dominant base cation (mean bulk surface Ca/Mg ratio = 3.6). However, this ratio varies between SPC's. Highest values are recorded on the Halton SPC (mean bulk surface = 4.5). The trend for individual sites is variable but the ratio generally decreases lower in the profile. This is particularly evident for sites showing hardpan development (Maxvale SPC) where some Ca/Mg values less than 1.0 were recorded. Although Ca is the dominant cation in the surface, hydrogen and/or possibly aluminium may be dominant at very strongly acid sites. Exchangeable Ca values are variable with over a third of the sites having less than 2 m.equiv./100 g . Ca/CEC values are generally low, indicating calcium may be limiting on the more acid sites.

Most surface soils have less than 1 m.equiv./100 g of exchangeable Mg, highest values generally occurring in Maxvale SPC. Magnesium could be limiting to plant growth on many sites. Exchangeable Mg generally increases down the profile except on Loddon SPC where values decrease. The Maxvale SPC has relatively high exchangeable Mg values associated with hardpans in these profiles.

Surface exchangeable and replaceable K ranges from medium to high with occasional very high values (mean bulk surface = 0.72 and 0.52 m.equiv./100 g respectively). Values decrease slightly with depth. Maxvale SPC has higher values than the other SPC's for replaceable and exchangeable K in both the surface and the profile. All surface K values easily exceed the 0.2 m.equiv./100 g critical level (Crack and Isbell 1970) and available K should not be a limitation to plant growth on the loamy, red earths. Surface total K levels are low to medium (mean bulk surface = 0.54%). There is a slightly increasing trend with depth on some profiles with two sites of Maxvale SPC reaching 1.0% K at depth. This value is similar to values for the alluvial soils and possibly indicates that the lower sampling depths encountered buried alluvia.

Surface total P values are medium (mean bulk surface = 0.031% P), generally decreasing down the profiles to low values at depth. Halton SPC generally has lower values than the other SPC's. Surface acid extractable P values are predominantly very low, with some low and occasional medium values recorded (group mean bulk surface = 6.7 ppm). Values decrease sharply with depth. Halton and Loddon SPC's have mean values of about 2 ppm P at 20-30 cm depth, while the corresponding value for Maxvale was 4.7 ppm. Bicarbonate extractable P values are similar to acid extractable P (mean bulk surface = 5 ppm) and trends within soil profile classes are identical.

In considering the importance of this, it is noted that mulga soils to the east of this area have recorded animal growth/survival responses to S, P and N. The very low levels of available P measured here, even in the surface, will limit the establishment of pastures with "normal" P requirements such as buffel grass. The concentration of available P in the surface soil through vegetation recycling also indicates the importance of maintaining surface cover to prevent erosion of the surface soil in which adapted native species are able to re-establish after drought periods.

Organic carbon and Total N levels are very low to medium (mean bulk surface = 0.86% C, 0.05% N), decreasing to 20 cm. Maxvale SPC is generally lower than the other soil profile classes, reflecting the bare ground and decreased perennial pasture production under the shrublands commonly found on these soils. C/N ratios generally range from 10-22 (mean bulk surface = 15.9), with the range reducing at the 20 cm depth. Some of the higher values would limit nett nitrogen mineralisation.

Surface total S is predominantly low, with occasional medium values occurring. A number of sites had values of < 0.01% S which corresponds to a possible response level (Andrews *et al.* 1974). Total S is concentrated in the surface and is associated with organic matter, showing the susceptibility of the soils to nutrient loss and a decline in productivity if vegetative cover is removed, allowing erosion of the surface soil.

Extractable iron values are all greater than 4.5 ppm (mean bulk surface = 31 ppm), suggesting adequate levels. Manganese values are medium, with some high values (mean bulk surface = 41 ppm). Copper and zinc values are medium to low (mean bulk surface = 0.6 ppm Cu and Zn). The Maxvale SPC generally has higher copper and zinc levels.

SANDY RED EARTHS (G)

These soils have been formed in areas where Quaternary sand sheets have covered the Tertiary land surface. Three soil profile classes have been recognised, differentiated by soil depth and the presence of hardpan layers. Prairie SPC consists of shallow (<50 cm) sandy, red earths, Mayvale SPC of deep, sandy, red earths and Elmina SPC of deep, sandy, red earths with hardpans of varying permeability, at depths of 70 to 120 cm.

Lab pH of the surface soil varies from very strongly acid to slightly acid (mean bulk surface = 5.5), with the group mean increasing at the base of the profile due to the influence of hardpans in Elmina SPC. Prairie SPC has uniform individual profiles, with pH strongly to slightly acid. Mayvale SPC has relatively uniform individual profiles but some increase (< 1 pH unit) at the base of the profile. Elmina SPC generally increases slightly to 60 cm and substantially at the base of the profile, where neutral to mildly alkaline values are most common. High acidity is likely to be a problem on the more acid sites, particularly in the establishment of introduced pasture.

Electrical conductivity and Cl are very low in the surface (mean bulk surface = 0.029 mS $1 cm^{-1}$, 0.002% Cl) and do not increase with depth except at the base of some sites in Elmina SPC where values were still low. This increase is likely to be due to restricted drainage caused by hardpans in Elmina SPC. Soils are non saline throughout. Surfaces are non sodic but sodic subsoils may occur at the base of profiles in Elmina SPC.

Clay content of most surface soils is between 11% and 20% (mean bulk surface value = 16%). Fine sand ranges from 30-44% (mean bulk surface value = 36%), coarse sand 25-55% (mean bulk surface value = 42%) while silt content is a low 3-13% (mean bulk surface value = 7%). Prairie SPC has higher mean silt content both in the surface and the profile than the other SPC's. Clay content often increases at the base of the profile in Elmina SPC.

Surface CEC ranges from 6 to 11 m.equiv./100 g soil (mean bulk surface = 8.0), the higher values occurring on sites with higher clay content. CEC on some sites decreases below the surface due to reducing organic matter, while increases (associated with increasing clay %) occur at the base of some profiles in Elmina SPC. CEC/clay ratios are generally of a similar order to the loamy, red earths.

About one third of the surface soils were less than 20% base-saturated. There is generally an increase with depth, down the profile. Values reflect the acidic pH and highly leached nature of these soils. Hydrogen is the dominant cation on the more acid soils. Of the basic cations, Ca is dominant over Mg and Na (mean bulk surface Ca/Mg ratio = 4.3), but Ca/CEC values are very low (mean bulk surface = 0.17%). It has been suggested that aluminium toxicity may be a problem on these soils. Ca/CEC values increase down the profile, particularly in Elmina SPC. Exchangeable Ca values are low, ranging from 0.1 to 2.9 m.equiv./100 g (mean bulk surface = 1.4). Exchangeable Mg levels are even lower, with almost half of the 20 sites having less than 0.2 m.equiv./100 g Mg at the surface, and only one site more than 1 m.equiv./100 g. Mg values increase slightly with depth but are still low except at the base of some Elmina SPC sites.

Both Ca and Mg may be limiting to plant growth and pasture development on these soils. Values of exchangeable Ca and Mg for the sandy, red earths of this survey are lower than in equivalent sandy, red earths to the west of this area. This is thought to be due to more thorough leaching of these soils by the higher rainfall received in this area.

Exchangeable and replaceable K are medium to high at the surface (bulk surface K value = 0.5, 0.4 m.equiv./100 g, respectively), decreasing down the profile. Most sites have adequate extractable K. Total K is low to medium in the surface (mean bulk surface = 0.43% K), with little change down individual profiles.

Total P is medium to low in the surface (mean bulk surface = 0.024% P), decreasing considerably with depth (mean at 60 cm = 0.01% P). Surface acid and bicarbonate extractable P values are very low to low, (mean bulk surface acid P = 6 ppm, bicarb. P = 4 ppm), decreasing with depth. The extractable values suggest P deficiencies limit plant growth and will severely limit the types of pasture which may be introduced onto these soils.

Surface organic carbon levels are low to medium, decreasing sharply with depth. Total N values are very low to low in the surface, decreasing with depth, though not as sharply as organic carbon. C/N values are variable, ranging from 12 to 30 in the surface (mean bulk surface = 17.8) with ratios generally decreasing to 20 cm. These values suggest nett mineralisation of N on many sites would limit plant growth. Total S values are low in the surface and down the profile. Many values are less than or close to 0.01% S, suggesting S deficiencies are likely on some sites even when other nutrients and moisture are sufficient.

Extractable iron levels appear adequate (mean bulk surface = 19 ppm). Manganese levels are medium (mean bulk surface = 21 ppm). Copper and zinc are low to medium (mean bulk surface = 0.4 ppm for Cu, 0.45 ppm for Zn).

Available soil water capacity is very low to medium in the surface (bulk surface = 4.6%), generally decreasing with depth (50-60 cm = 2.6%), reflecting the contribution of organic matter to water holding capacity in these soils of low clay content.

EARTHY SANDS (H)

The earthy sands were formed by the transportation and sorting of Quaternary erosion products to form sandplains over old land surfaces (Myola SPC) and levees and sandhills associated with alluvia (Bowra SPC). Textures are loamy sand or coarser with single-grain structure. Surfaces appear hardsetting but break up readily. Profiles are very deep.

Lab pH of surface soils range from very strongly acid to mildly alkaline (mean bulk surface = 6.1). Many profiles show no trend, though some sites increase at the 30 to 60 cm depths and then decrease again at the base of the profile, while other sites increase substantially at the base of the profile (mean 120 cm = 6.5).

Electrical conductivity and Cl values are very low throughout the profile. Soils are non saline and expected to be non sodic. Calculated ESP values are unreliable on soils with CEC values as low as 1 m.equiv./100 g, and exchangeable sodium values are at the limit of detection for the method used.

Clay content is very low, generally ranging from 5-15% in the surface (mean bulk surface = 9%). Some profiles increase slightly with depth. Silt content is even less than clay on all analysed samples (mean bulk surface = 4%). Fine sand content is commonly 25-35% and coarse sand usually greater than 50%.

Surface CEC ranges from 3-10 m.equiv./100 g in the surface, organic matter being the major contributor. The calculation of base saturation is subject to error where low clay and CEC values occur. Indications are that these soils are unsaturated. Ca is the dominant basic cation throughout (mean bulk surface Ca/Mg = 3.7). Exchangeable Ca and Mg values are very low, (mean bulk surface Ca = 1.65; Mg = 0.45 m.equiv./100 g) indicating deficiency problems on the more highly-leached acid soils in the group.

Surface exchangeable and replaceable K values are medium to low (mean = 0.3 m.equiv./100 g), decreasing with depth. A minor number of sites recorded K values < 0.2 m.equiv./100 g. Thus, K is probably sufficient for plant growth under normal circumstances but may be limiting on some sites when a number of good seasons follow each other. Total K is predominantly low, with some medium values recorded (mean bulk surface = 0.42% K). The lowest values occur on the sandplains associated with the old Tertiary land surface (Myola SPC) and highest values are associated with levees and bases of the sandhills on the Warrego alluvia (Bowra SPC).

Total P values are medium to low in the surface (mean bulk surface = 0.025% P), decreasing down the profile on all analysed sites (mean 120 cm value = 0.012% P). The higher and lower values generally follow the trend described for total K. Acid and bicarbonate extractable P range from very low to medium in the surface, and typically decrease sharply with depth. Similar to total P and K, the higher extractable P values are associated with Bowra SPC while the very low values are associated with Myola SPC. Phosphorus in Bowra SPC is suitable for good plant growth, moisture permitting, while the very low levels in Myola SPC would be deficient for plant growth.

Surface organic carbon levels are low to very low (mean bulk surface = 0.52% C), decreasing with depth. Total N levels are predominantly very low with occasional low values (mean bulk surface = 0.03% N). C/N ratios are variable, ranging from 10 to 23 (mean bulk surface = 17.4). This suggests that nett mineralisation on already very low nitrogen soils will be limited at many sites.

Surface total S values are low (mean bulk surface = 0.008% S), decreasing down the profile. Only one site of the 14 analysed exceeds 0.01% total S and many are considerably less, indicating that S deficiencies are likely on the earthy sands. Mean-converted total C:N:S ratio of the surface soil is 226:10:2.9 but results are variable.

Extractable iron values are adequate (mean bulk surface = 14 ppm). Manganese values are medium (mean bulk surface = 16 ppm). Copper and zinc values are low to medium (mean bulk surface = 0.35 ppm Cu; 0.5 ppm Zn), indicating zinc and copper may be limiting on some sites.

Available soil water capacity is very low (mean bulk surface = 2.5%) decreasing with depth (mean 60 cm = 1.3%). This reflects the effect of organic matter in the surface almost doubling the very low water storage capacity.

SILICEOUS SANDS (I)

These soils are formed by transportation and sorting of Quaternary erosion products to form levees and wind-shaped sand dunes. Loose, single-grain structure predominates. Textures are sandy to loamy, coarse sands.

Lab pH (surface values) range from neutral to strongly acid. Also surface values of EC and Cl levels are very low and soils are non sodic. CEC values range from 1-5 m.equiv./100 g soils with Ca the dominant cation. Extractable K surface values range from very low to fair.

Acid P and bicarb. P values range from very low to fair. C and N values are predominantly very low. Available water capacity is very low.

LITHOSOLS (J)

This soil group is characaterised by very shallow profiles and the strong influence of different parent material on soil properties of the two soil profile classes.

Soils of the Rollo SPC have formed from partially weathered Quaternary limestone, have dark-brown colours, gritty, fine sandy-loam textures and an alkaline reaction trend. They are limited in extent, mainly occurring around lakes with open grassland vegetation.

Soil analyses was non-detailed and limited to one site on this SPC. pH was 8.5, EC and chloride were very low, replaceable potassium medium, organic carbon low, total nitrogen very low, acid P low and bicarb. P very low.

The Minitta SPC supports mulga and is formed on partially weathered altered Cretaceous sediments. These soils are reddish brown with gravelly, sandy-loam to light sandy clay loam textures. Surfaces are hard setting, frequently with gravel pavements.

The soil chemical properties of the Minitta SPC are very variable depending on the degree of organic matter build up through recycling by vegetation. The mulga vegetation provides substantial leaf drop and has probably been able to extract some additional nutrients through root exploitation of cracks and crevices in the shallow weathered parent material.

Laboratory pH is very strong to medium acid (4.5 - 6.0), reflecting the influence of organic matter (the site with pH 4.5 had 2.5% organic carbon).

Electrical conductivity and chloride values are very low. Soils have high coarse sand and fine sand fractions (mean 31% and 44% respectively). Clay content ranges from 11 - 23% (mean 17%). Cation exchange capacity ranges from 6 to 15 m. equiv./100g with organic matter contributing substantially on some sites. Cations are very low (Ca 0.3 - 2.2, Mg 0.1 - 0.4, Na 0.02 - 0.1 m. equiv./100g) with the exception of potassium which had medium to high fertility values, reflecting cycling by vegetation.

Acid extractable phosphorus values were very variable ranging from very low (3 ppm) to high (64 ppm); mean 16 ppm. Bicarbonate phosphorus values ranged from very low (2ppm) to medium (35 ppm); mean 10 ppm. Higher phosphorus values were usually associated with organic matter build up.

Organic carbon and total nitrogen values ranged from 0.4 to 2.5% and 0.02 to 0.14% respectively, having the highest and close to the lowest values recorded in the entire survey.

Available water capacity ranged from 3 to 8% but profile water storage is extremely low because of the shallow soil depth. While it is known that mulga has the ability to extract water at greater matric potential than most other plants, it must also efficiently exploit cracks and crevices to effectively increase soil depth (and water availability) in order to survive drought periods on soils with such low profile water capacity.

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Chapter 4

SOIL CHEMICAL AND PHYSICAL PROPERTIES

by C.R. Ahern[1]

This chapter discusses important soil analytical properties with assistance of graphs and tables of data. Additional tables of data arranged by soil property/soil group or soil property /soil profile class are provided in "Chemical Tables" Microfiche (2 cards). Analytical data together with morphological information for individual sites can be consulted in "Site List" Microfiche (3 cards).

Sampling and analysis

During the survey, 82 complete profiles and 239 bulk surface samples (nine 0-10 cm cores were bulked at each site to provide the bulk surface sample), were analysed. Sampling and selection of profiles for analysis were biased towards the more productive land types.

Emphasis was placed on fairly comprehensive surface sampling of all soil types as surface properties are considered the best indicators of the stability of soils and their capacity to allow plant establishment in the arid environment.

Methods of analysis are given in Appendix II and follow those previously described in this series of WARLUS reports. The values to which various ratings ("fair", etc.), refer are given in Appendix I. All bulk surface samples were analysed for laboratory pH, electrical conductivity (EC), chloride (Cl), acid extractable phosphorous (acid P), bicarbonate extractable phosphorous (bicarb. P), organic carbon (Org. C), total nitrogen (total N), cation exchange capacity (CEC) and exchangeable cations. Profiles selected for detailed analysis were analysed for the above, together with total phosphorus, potassium, sulphur, -1/3 and -15 bar moisture and particle size analysis at depths of 0-10, 20-30, 50-60 and 110-120 cm. Organic carbon and total nitrogen determinations were carried out on surface depths and 10-20 cm depths only.

SOIL pH

pH is a measure of the degree of acidity or alkalinity of a soil. It is easily and cheaply measured in the field using field pH kits (Raupach and Tucker 1959) and in the laboratory using electrodes (in this case 1:5 soil:water suspension was used) (Bruce and Rayment 1982).

Plants vary considerably in their pH requirements for optimum growth and are usually tolerant to a range of two pH units. Extremes of pH are known to have certain general effects such as:

- In extremely acid soils, plants may be affected by aluminium or manganese toxicity.
- In highly acid soils, CEC is usually low, soils have low levels of base saturation and levels of the cations calcium, magnesium and potassium may be very low and limiting to plant growth.
- High pH indicates possible high exchangeable sodium percentage or the presence of alkaline earth carbonates.
- High or low pH influences the solubility of trace elements which can result in deficiencies or toxicities.
- Low pH may limit the efficiency of the microbiological processes which decompose organic matter.

For all surface soils sampled in the survey area, laboratory pH is highly correlated with clay%, CEC, base saturation, and all the basic exchangeable cations (Table 4.1). This shows that broad interpretations are possible from a simple pH test of the surface soil. Acid pH usually indicates a strongly leached soil with low CEC, base saturation and exchangeable cations, while alkaline pH suggests a clay soil with high CEC and cation status.

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Table 4.1 Correlation coefficients of Laboratory pH of the surface soils with various factors.

	All sites	Alluvials (B,C,D)	"Sandy" (F,G,H,I,J)	Red Earths (F,G)
Number values	169	65	98	62^{NS}
Clay	0.61***	0.65***	-0.27**	-0.11^{NS}
CEC	0.72***	0.71***	-0.27**	0.12^{NS}
Cations	0.82***	0.73***	0.43***	0.60***
Base sat %	0.87***	0.44***	0.75***	0.69***
Ca	0.80***	0.71***	0.77***	0.65***
Mg	0.79***	0.62***	0.65***	0.47***
Na	0.65***	0.48***	0.01^{NS}	-0.02^{NS}
ESP	0.55***	0.30*	0.22*	-0.11^{NS}
Tot K	0.80***	0.65***	0.18^{NS}	0.30*
AD Moist	0.66***	0.66***	-0.22*	0.15^{NS}
Field pH	0.83***	0.68***	0.64***	0.50***

*** P <0.001; ** P <0.01; * P <0.05; NS P >0.05

However pH appears to be a poor indication of clay% and CEC in the soil groups with coarser textured surfaces, such as groups F, G, H, I, J (Table 4.1). This is largely due to reduced range for pH, clay and CEC, and other factors such as organic matter being important.

In the survey area, laboratory pH ranged from 4.3 (extremely acid) for the surface of a loamy red earth, to 9.6 (very strongly alkaline) at the base of the profile on a texture contrast soil on alluvia. The distribution of laboratory pH for all analysed sites is shown in Chem table Microfiche$_1$, M.01 (for soil groups), and O.09 (for soil profile classes).

Subdivision of all soils into soil groups and soil profile classes generally results in a narrower range of pH values. This result is partially expected since field pH is used by the soil surveyor to assist him in classifying soils. pH is an important factor in both Great Soil Group (Stace *et al.* 1968) and Principal Profile Form (Northcote 1974) soil classifications.

The two chief influences on soil pH appear to be (a) parent material, and (b) degree of weathering/leaching soils have experienced.

For surface soils, laboratory pH of the bulk 0-10 cm sample is highly correlated with field pH of the 0-10 cm sample from the described profile:

Lab pH = 0.88 field pH + 0.982 $(r_{257} = 0.83^{***})$

Lab pH of the analysed profiles is also highly correlated with the corresponding field pH on the same sample:

Lab pH = 0.9147 field pH + 0.680 $(r_{403} = 0.86^{***})$

The correlation of field and lab pH for groups of soil (for example, alluvial soils, red earths, etc.) are lower than the grouping for all soils.

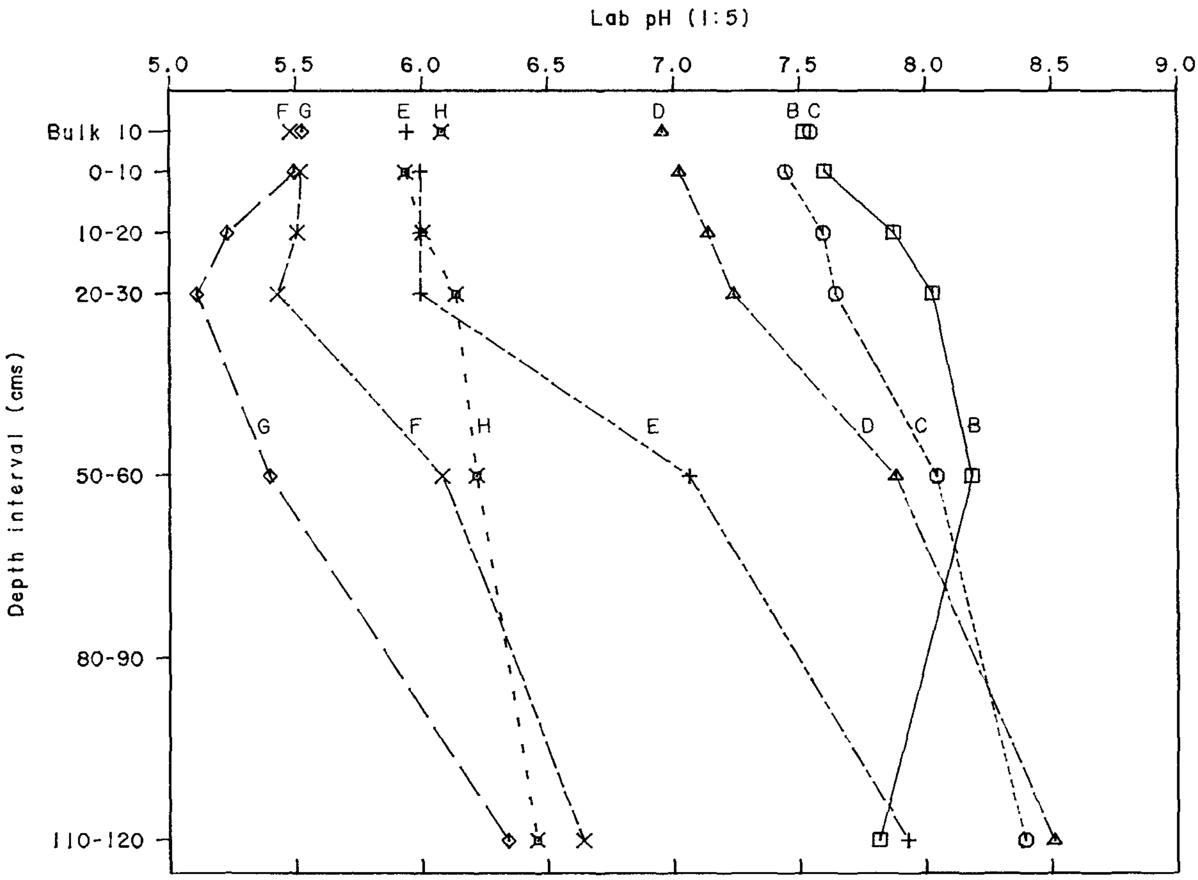
Figure 4.1 shows the mean laboratory pH for each sampling depth of most of the soil groups. The red brown and grey clays on the plains (A) are not shown because of their diversity of soil profile classes (discussed in Chapter Three on soil groups). Lack of analysed profiles prevents the siliceous sands (I) and lithosols (J) from being represented.

Field pH values of the siliceous sands (I) show this group to be similar to earthy sands (H) except that mean pH decreases slightly with depth rather than slightly increasing as the earthy sands (H) do.

Using mean pH, two distinct groupings of soils appear:

(i) The clays, scalds and texture contrast soils (B,C,D) of alluvial origin
(ii) The lighter textured red earths, earthy and siliceous sands (F,G,H,I).

Figure 4.1 Mean laboratory pH (1:5) of soil groups by depth



The surface means of each alluvial group (B,C,D) have significantly (P <0.01) higher pH than each of the lighter textured groups (F,G,H,I,J). The same also applies when profile means are considered. Texture contrast soils on the plains (E) are significantly (P <0.01) lower in mean surface pH than each of the alluvia soils (B,C,D) but due to a sharp increase in pH with depth, mean values are closer at the 120 cm depth (see Figure 4.1). Alluvial clays (B) have significantly (P <0.01) higher mean surface pH than the texture contrast soils on alluvia (D) but lower mean values at 120 cm due to occurrence of salts in the clay soils.

These alluvial soils have similar pH characteristics to alluvial clays of other western Queensland surveys (Dawson and Ahern 1974, Mills and Ahern 1980, Turner and Ahern 1978). pH of the alluvial soils is less alkaline than the sedentary soils. Alkalinity may be a problem at depth on alluvial soils, particularly where salt levels are low and pH is high. Profiles with a distinct alkaline trend usually have pH modified at depth if high salt levels are encountered.

Loamy and sandy red earths (F,G) and texture contrast soils (D,E) have similar mean pH profile shape and values increase with depth below 30 cm. This is similar to what has been found in other western Queensland surveys (Mills and Ahern 1980, Ahern and Wilson 1990). These soils have leached surfaces with higher clay content at depth.

The loamy red earths (F), sandy red earths (G) and lithosols (J) are the soils in which plant growth is most likely to be affected by acidic or low pH conditions. This may have an effect on plant calcium levels particularly for soils low in calcium. O'Hagen (1966) found that optimum plant calcium levels were reached in mulga seedlings on red earths in western New South Wales at a pH range of 5.8 to 6.1. In this pH range, efficient symbiosis resulted in gains of organic carbon and nitrogen in both surface and subsurface horizons, increasing the biological activity in the soils.

Mulga is the dominant vegetation on the red earths (F,G) and lithosols (J). Of the 107 sites in these soil groups analysed, 77 had pH values less than 5.8. In addition, over a third of the sites belonging to texture contrast soils on the plains (E) and earthy sand groups had surface pH less than 5.8. Thus many of the soils with coarse textured surfaces appear to have less than optimum pH conditions for gains in organic carbon and nitrogen. Ahern (1975) discussed the importance of organic matter in the stability and fertility of the red earths.

Buckman and Brady (1969) have stated that nitrification and nitrogen fixation are only vigorous in soils well above pH 5.5 and they warn that at low pH, appreciable amounts of iron, manganese and aluminium are soluble, and may in fact reach toxic levels. Silcock (personal communication) has observed that low pH affected the growth of grasses on sandy red earths in the Charleville area.

SOLUBLE SALTS

Presence of appreciable soluble salt in the soil is an important land use limitation. Concentration of soluble salts in the soil and the resulting soil solution reduces the amount of soil moisture available to plants because higher osmotic suction is required to remove water from the soil. This limitation to plant usage of soil moisture is of particular concern to an arid or semi-arid environment where soil moisture is very low for much of the year. To offset this problem, adapted species (gidgee, salt bush, etc.) often have the ability to extract water from soils with high salt content, beyond that possible for normal plants. Some plants have varying tolerances to different salts. Eaton *et al.* (1941) have indicated a tendency for some common crops to be twice as tolerant to sulphate as to chloride. No information exists for ion specific effects on native vegetation in this area.

Salt concentration and even the type of salt can have an effect on the physical properties of the soil. A predominance of sodium salts will have the long term effect of creating a sodic soil by exchange mechanisms. While electrolyte levels are high, the resulting soil may be well flocculated but, if the salt concentrations are reduced, the sodic soil becomes highly dispersed, resulting in very poor soil structure.

Method

Electrical conductivity of either saturation extracts or specific soil water ratios is the most widely used test for estimating soluble salts. Northcote and Skene (1972) have used chloride values from a 1:5 soil:water extract for rating surface and subsoil salinity in Australia. In this survey, a 1:5 soil:water solution has been employed for the measurement of electrical conductivity and chloride.

If the 1:5 solution EC value was high and the chloride values low, a 1:50 soil:water solution was used for conductivity measurements in addition to the 1:5 measurement. This 1:50 EC was useful in indicating gypsum content of the soils but the results used in calculations, tables, figures, etc. relate to the 1:5 measurement only. When analysed, total sulphur results were also useful in indicating if high gypsum levels were present at depth in the profile.

Soluble salts can be estimated from electrical conductivity by using the factor of Piper (1942)

$$\%TSS = EC \text{ mS cm}^{-1} \times 0.336 \quad \text{(at 25°C)}$$

This factor was derived for an average mixture of salts common to Australia and is likely to be in error on soils with high sulphate, bicarbonate or calcium ions.

Gypsum

Soils with crystalline gypsum present are particularly difficult to analyse for soluble salts. The 1:5 EC measurement is greatly affected by the size of gypsum crystals present, and its resulting solubility.

While gypsum has a theoretical solubility of 0.2% (Merck Index), soils of many times that amount of gypsum may show conductivity readings of less than half that for an apparent saturated solution. In addition, repeatability of a result is grossly affected by crystal size in the subsample. This also applies to the 1:50 EC measurement.

Gypsum is present in many alluvial clay soils at depths ranging from just below the surface to deep in the profile. The depth of occurrence is an important guide to the moisture regime of the profile. Frequently flooded soils have salts deep in the profile or may have low salts throughout. On the non-flooded soils, the depth to where gypsum crystals first occur is a generally accepted indication of the depth of regular wetting.

Because naturally occurring gypsum usually has low solubility in arid areas, its affect on plants is much less than that of more soluble salts such as sodium chloride. Thus high soil gypsum contents can be tolerated by many native plants.

The occurrence of gypsum in the profile of the alluvial clays is often accompanied by a reduction in the measured laboratory pH of a 1:5 soil: water extract. This is because gypsum is an acid salt with a pH in water of about 5.2.

Electrical conductivity and chloride

Electrical conductivity and chloride are strongly correlated for all analysed samples.

Cl = 0.082 EC - 0.001 $(r_{492} = 0.83^{***})$

For all surface samples, EC and chloride are significantly correlated $(r_{250} = 0.49^{***})$ but with only 25% prediction. This relatively poor correlation is caused by the alluvial soils $(r_{91} = 0.45^{***})$ as a much stronger relationship exists for the red earths (F,G) $(r_{94} = 0.77^{***})$ and other soils with coarser textured surfaces (F,G,H,I,J) $(r_{131} = 0.75^{***})$.

The reason for the poor relationship between surface EC and chloride on the alluvial soils (B,C,D) is that gypsum and other salts contribute substantially to the EC on many alluvial sites. Correlation between EC and total sulphur in the surface is high $(r_{93} = 0.975^{***})$. Chloride salts only average 30% of the total salt content of the surface of alluvial soils (B,C,D) although it can be much higher in individual sites.

For alluvial profiles (B,C,D), EC and chloride are highly correlated $(r_{185} = 0.86^{***})$ while a highly significant, but lower correlation exists between EC and total S $(r_{142} = 0.55^{***})$. This lower correlation for total sulphur is due to the fact that the 1:5 soil water extract for EC measurement seldom dissolves all the gypsum present at depth in these soils.

The distribution of electrical conductivity and chloride, by depths for soils groups and SPC's, are given in Chem table microfiche, O.01, C.02, D.10 and I.10. Soil chloride values at the surface range from 0.001% for many of the coarse textured soils to 0.1% on the alluvial clay soils (B). The highest value at depth was 0.465% at 60cm also on an alluvial clay soil. This site also had highest 1:50 EC (converted to 1:5) of 9.5 mS cm^{-1}.

Figures 4.2 and 4.3 show plots of mean electrical conductivity and chloride with depth for the soil groups. The red earths (F,G), earthy sands (H), siliceous sands (I) and lithosols (J) are not represented as they have very low EC and chloride values throughout the profile and are non saline. They are highly leached soils and often are coarse textured throughout the profile.

The scalds (C) have the highest mean chloride values of all the soil groups. By reference to Figures 4.2 and 4.3 it can be seen that chloride is the major salt until 60 cm. While mean chloride only increased by a further 17% to the 120 cm depth, EC increased by over 100% due to the presence of gypsum. If 1:50 EC's are considered, the increase in EC is even greater.

The alluvial clays (B) have lower mean chloride values than the scalds until the 120 cm depth is reached, where the mean value exceeds that of the scalds (C). The mean profile shape of EC for both soil groups C and D are similar. Since chloride salts are easily dissolved, the concentration of chloride high in the profile of the scalds (C) suggest the scalds have less water movement through the profile than the alluvial soils (B).

For the scalds, the mean profile ratio (0.68) of calculated EC due to chloride/EC measured is significantly greater $(P < 0.01)$ than that for the alluvial soils (0.45). The alluvial clays have much higher mean clay and coarse sand content than the scalds, but lower silt and fine sand. This particle size combination of higher fine sand and silt for the scalds, particularly in the surface, may lead to a more compact soil layer, and this may account for the suggested lower water movement through the scalded profiles. Both soil groups are generally non saline in the surface with saline subsoils occurring on a minority of sites.

$$\frac{\text{EC calculated for NaCl}}{\text{EC measured}} = \frac{\text{\%Cl} \times 6.64}{\text{EC measured}}$$

The Yo Yo SPC (A2) of the brown and grey clays on the downs have highest EC values due to the presence of gypsum but mean chloride values are similar to the texture contrast soils on alluvia (D) (Figure 4.3). The Mount Pleasant SPC (A1) has low EC and chloride values throughout and is similar to the loamy red earths (F).

The texture contrast soils on alluvia (D) have much lower mean EC and chloride than the alluvial clays (B) for all depths. When the mean profile EC is considered, the texture contrast soils have significantly $(P < 0.05)$ lower EC (mean profile value = 0.17 mS cm^{-1}) than the alluvial clays (mean profile value = 0.48). The difference in salt content is probably due to the texture contrast soils on alluvia (D) having much lower clay and silt content than the alluvial clays (B), and greater leaching of salts has occurred on the texture contrast soils.

Figure 4.2 Mean electrical conductivity (1:5) of the finer textured soil groups by depth

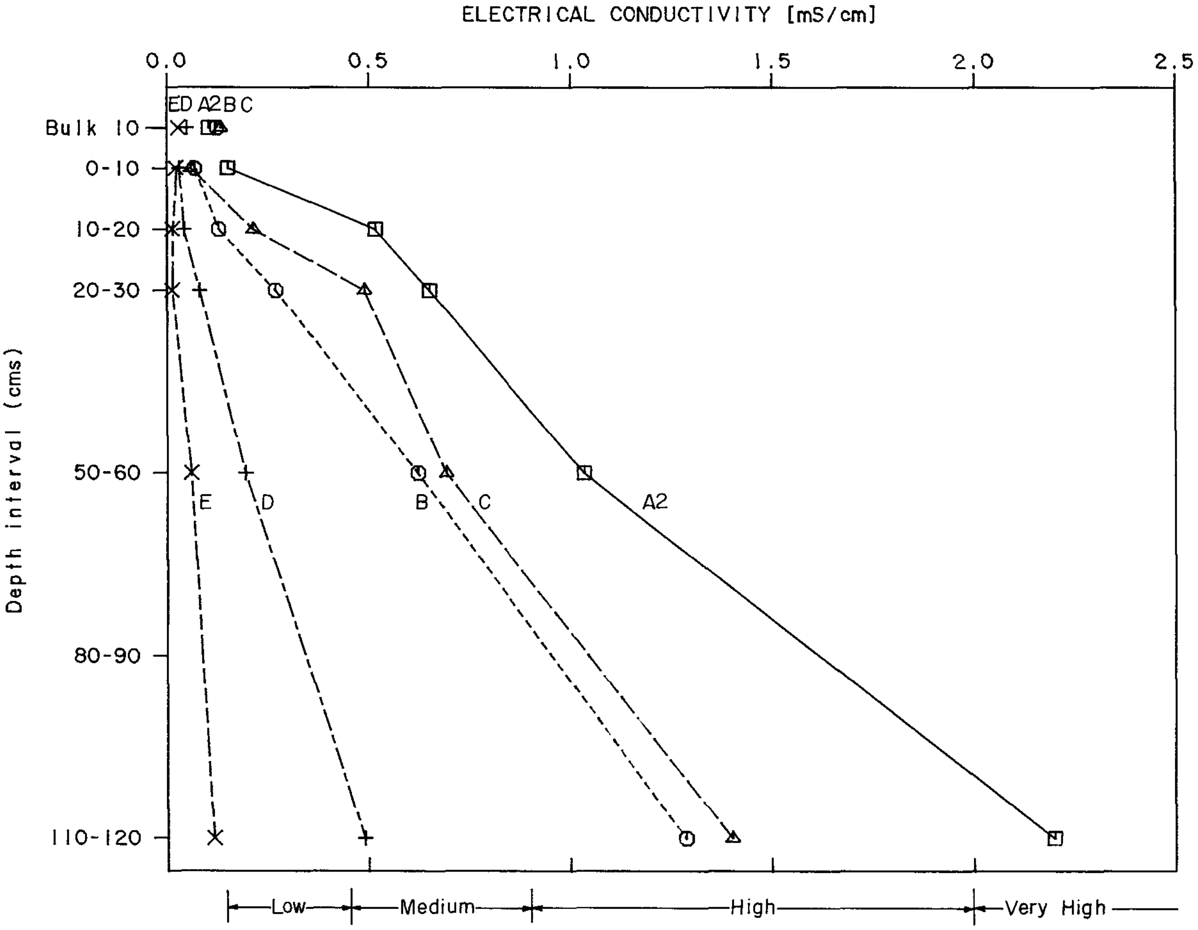
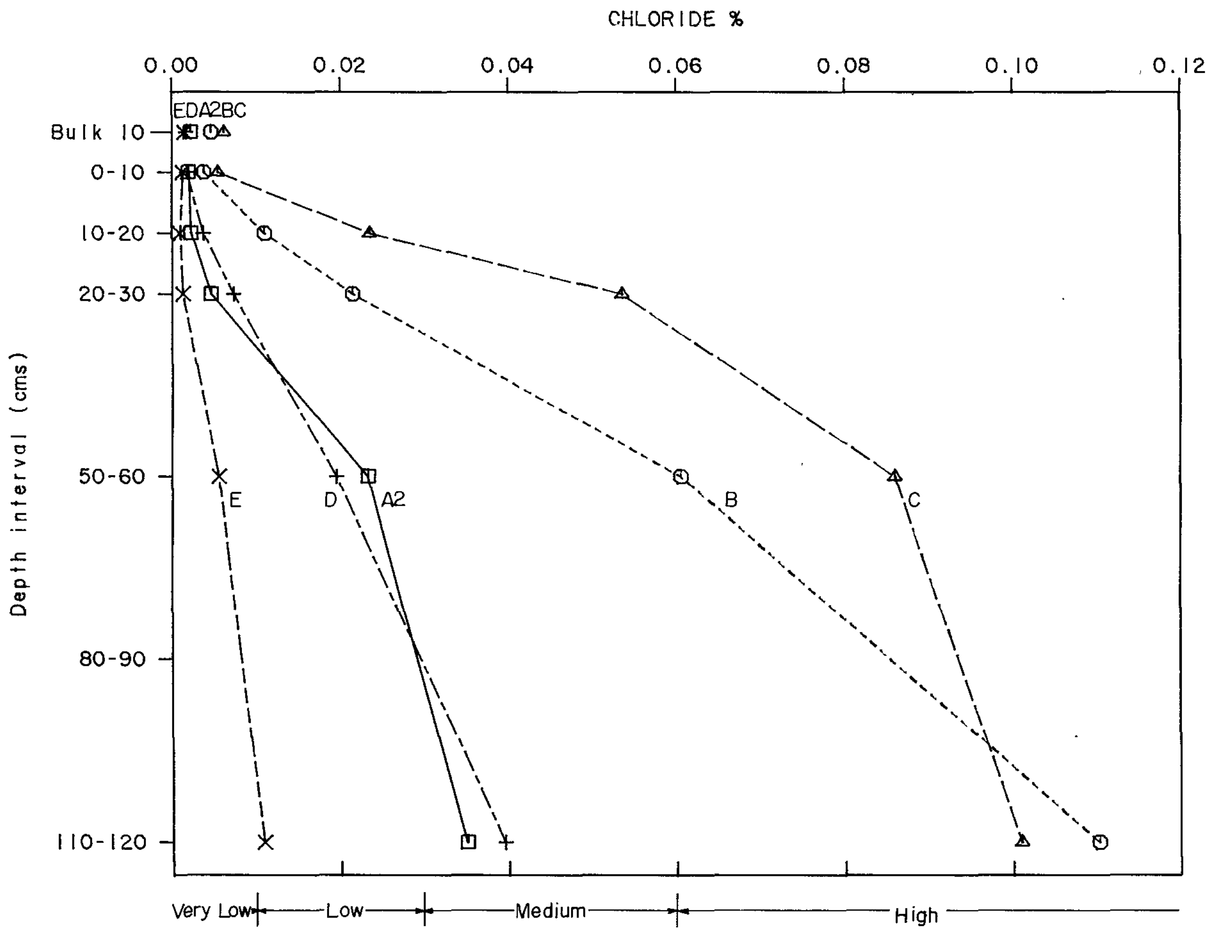


Figure 4.3 Mean chloride content (1:5) of the finer textured soil groups by depth



The texture contrast soils on the plains (E) have lower mean EC and chloride than the texture contrasts on alluvia (D) for all analysed depths. The difference in mean EC of the surface is highly significant ($P < 0.01$). However the proportion of chloride salts to total salts in the texture contrast soils on the plains (E), is significantly greater ($P < 0.01$) than the texture contrast soils on alluvia.

The EC and chloride values for the texture contrast soils on the plains are much lower than that reported in adjoining surveys to the west and north west (Dawson and Ahern 1974, Mills and Ahern 1980) but similar to that recorded by Turner and Ahern (1978) to the north. Thus EC and chloride levels of the texture contrast soils on the plains in eastern higher rainfall areas are generally much lower than those for western areas.

CATION EXCHANGE CAPACITY AND EXCHANGEABLE CATIONS

Method effects

Many of the soils of south west Queensland contain appreciable salts as discussed earlier. The method used to measure basic cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) involves a pre-wash step with 60% alcohol to remove soluble salts. Gypsum, which is sparingly soluble in its natural crystalline form, is usually only partly removed by the washing step. If on alkaline to neutral soils, the sum of cations exceeds the CEC, calcium values may be inflated by dissolution of gypsum. The presence of large quantities of gypsum can be roughly checked by comparing the electrical conductivity with chloride values, and 1:5 EC with 1:50 EC values.

Alcoholic ammonium chloride buffered at pH 8.5 is used to extract cations, as this extractant suppresses the solubility of calcium and magnesium carbonates (Tucker 1954). The CEC of very strongly alkaline to alkaline soils (pH>8.5) may be underestimated (Gupta *et al.* 1982). For this survey errors are likely to be very slight on all but the most alkaline soils.

A more important effect of the method used is the likely overestimation of CEC on the highly weathered acid soils (Gillman *et al.* 1982). The soils most likely to be affected are red earths (F,G) and lithosols (J). Overestimation is likely to be greatest in the surface horizons, as pH generally increases down the profile. Base saturation and individual cation percentages of CEC may be lower than if CEC was determined at the natural pH of the soil, while CEC/clay values may be higher.

Cation exchange capacity

Cation exchange capacity (CEC) is defined as the sum of exchangeable cations held on the surface of the exchange complex, which includes soil minerals and particles, particularly clay and organic matter. Because of the variability of mineralogical composition and organic matter content, the make-up of the cation exchange capacity may vary from soil to soil. The CEC from inorganic sources comes mainly from the clay fraction, but different clay minerals have different surface areas or exchange capacity. The CEC per gram of clay gives an indication of whether highly active 2:1 clay minerals such as smectite or vermiculite are present, or whether low surface area and low activity 1:1 minerals such as koalinite are dominant. This is important for predicting how soils will react to such things as wetting and drying, supply and retention of nutrient, susceptibility to erosion, etc.

Correlations between pH and CEC

In this survey, acidic pH is usually associated with low CEC and low basic cations, while alkaline pH suggests higher cation and CEC status. This statement is supported by a highly significant linear correlation between CEC and laboratory pH.

For all analysed samples:

$$\text{CEC} = 6.53\ \text{Lab pH} - 27.2 \qquad (r_{490} = 0.73^{***})$$

For all profiles (without bulked surface samples):

$$\text{CEC} = 6.41\ \text{Lab pH} - 26.1 \qquad (r_{271} = 0.72^{***})$$

For all bulked surface samples:

$$\text{CEC} = 6.77\ \text{Lab pH} - 29.0 \qquad (r_{167} = 0.72^{***})$$

These equations predict that, when all soils in the survey are considered, CEC approaches zero at surface pH of around 4.3 and high CEC can be expected on alkaline soils.

On the alluvial soils (B,C,D) CEC and laboratory pH are highly correlated, though the regression equation is very different to the equation for all soils.

CEC = 11.6 pH - 64 $(r_{63} = 0.71^{***})$

For profiles, factors such as salts, carbonates and ESP have considerable effect on pH of neutral to alkaline soils. This is reflected in the linear regression equation for profiles only accounting for 12% of the variation $(r_{145} = 0.35^{***})$ of CEC being explained by pH.

On the red earths (F,G) the correlation in the surface is non-significant showing that within a limited range on acidic soils, pH is not a reliable indicator of CEC. However on these soils, the sum of the cations is strongly correlated to pH.

Sum of cations = 2.3 pH - 9.26 $(r_{60} = 0.60^{***})$

This equation predicts that the sum of basic cations approaches zero at pH 4.1, which is in good agreement with an estimated zero CEC at pH 4.3 for all bulk surface samples using the earlier equation for CEC.

As discussed earlier, CEC was determined at pH 8.5 for this survey and is likely to be much higher on soils such as the red earths, than if determined at the natural pH of the soil. This may be a contributing factor to the poor r^2 value for red earths.

Correlations of particle size with CEC

Cation exchange capacity is strongly related to clay content of all surface soils and all profiles. Regression equations are shown in Table 4.2.

The alluvial soils (B,C,D) have CEC and clay strongly correlated while coarser textured soils have weaker, though still highly significant correlations. Thus clay is a dominant influence on CEC of the clay soils but other factors are important on the coarser textured soils.

When the red earths (F,G) are considered, the regression equation for CEC and clay has a much lower slope than the alluvial soils (B,C,D) reflecting difference in clay activity.

Silt is significantly correlated with CEC in the surface $(r_{122} = 0.41^{***})$ and profile $(r_{272} = 0.55^{***})$ for all sites. Correlation of CEC with silt is very poor on the alluvial soils, but on the coarser textured soils (F,G,H,I,J) it is higher than with clay %.

Bulk surface samples	CEC = 0.45 silt + 4.7	$(r_{66} = 0.75^{***})$
Profile	CEC = 0.68 silt + 1.7	$(r_{104} = 0.76^{***})$

This suggests a substantial contribution to CEC from the silt fraction on the coarser textured soils.

Contribution of organic matter to CEC

CEC is correlated with organic carbon and total nitrogen at the surface for the coarser textured soils (F,G,H,I,J),

CEC = 6.4 OC + 3.5 $(r_{87} = 0.68^{***})$
CEC = 124 Tot N + 2.8 $(r_{87} = 0.74^{***})$

but not for all soils or alluvial soils (B,C,D).

This shows organic matter also has a significant contribution to the overall CEC of the coarser textured soils. Because of lower clay contents, it can expected that the relative contribution of organic matter to the CEC on coarser textured soils is much greater than that for fine textured soils.

Table 4.2 Linear correlations of the form CEC = a + b clay% for individual and combinations of soil groups.

	Mean CEC/clay	No. Pairs	Slope (b)	Intercept (a)	R
Combination of soil groups					
All sites: total	0.55	378	0.59	-1.9	0.93***
profile	0.56	272	0.61	-2.6	0.92***
B0 - 10	0.53	124	0.54	-1.0	0.92***
Alluvial soils (B,C,D): profile	0.625	146	0.53	+2.5	0.93***
B0 - 10	0.57	42	0.53	+0.3	0.94***
Coarser textured: (F,G,H,I,J) profile	0.485	92	0.31	+2.9	0.76***
B0 - 10	0.50	68	0.25	+4.0	0.69***
Loamy / Sandy RE: (F,G) profile	0.40	71	0.32	+1.5	0.66***
Texture Contrast: (D,E) B0 - 10	0.54	16	0.33	+3.4	0.92***
Individual soil groups					
Alluvial clays (B): profile	0.62	114	0.51	+3.3	0.88***
B0 - 10	0.56	32	0.55	-0.5	0.91***
Scalds (D): B0 - 10	0.62	8	0.38	+3.1	0.92**
Texture Contrast: (E) B0 - 10	0.46	8	0.37	+1.8	0.98***
Loamy red earths (F): profile	0.40	44	0.21	+4.8	0.40**
B0 - 10	0.45	36	≠	≠	0.27^{NS}
Sandy red earths (G): B0 - 10	0.50	14	0.27	+3.5	0.56*
Earthy sands (H): B0 - 10	0.61	11	0.46	+1.1	0.78**

≠ Equation values not given where regression is non significant or R < 0.5; however correlation coefficient is given.

Table 4.3 Calculated contribution of organic matter to the total CEC of bulk surface samples for the soil groups.

Soil Group	OC W&B (%)	OM[1] calc. (%)	CEC_{OM}[2] (m.equiv./100g)	CEC_M[3]	CEC_{OM}/CEC_M (%)
RB & G clays (A)	0.82	1.8	3.7	27.0	14%
Alluvial clays (B)	0.58	1.3	2.6	24.6	11
Scalds (C)	0.33	0.74	1.5	16.0	9
TC on alluvia (D)	0.63	1.4	2.8	11.3	25
TC on plains (E)	0.80	1.8	3.6	10.4	34
Loamy red earths (F)	0.86	1.9	3.8	10.3	37
Sandy red earths (G)	0.78	1.7	3.5	8.0	43
Earthy sands (H)	0.52	1.2	2.3	4.9	48
Siliceous sands (I)	0.36	0.79	1.6	3.00	53
Lithosols (J)	0.98	2.2	4.4	9.6	45

[1] Organic matter = 2.236 x OC (see text)
[2] CEC_{OM} = 2 x OM (see text)
[3] CEC_M = measured CEC of fine earth

Table 4.3 shows the percentage CEC calculated from organic matter/CEC measured, for the soil groups. Thomas and Hipp (1968) state the CEC of organic matter lies between 50 to 250 m. equiv./100 g. On irrigated soils, Pratt (1957) found exchange capacity increased at 4.9 times the rate of organic carbon increase, or 2.8 times the rate of organic matter increase. There is no reason to expect a factor as high as this on arid and semi-arid soils, since most vegetation has a high lignin content.

Coughlan (1969) used a correction for organic matter of CEC_{OM} = 2 x organic matter. This factor has been used in Table 4.3. Organic matter has been calculated from Walkley and Black organic carbon values using the equation:

Organic matter = 2.236 organic carbon (Walkley and Black) values.

The basis for this latter equation is discussed in the section on organic carbon later in the chapter.

Points to note about Table 4.3 are:

(a) The method used for determining CEC may overestimate CEC, particularly on acidic, non base-saturated surface soils (E,F,G,H,I,J). This means that effective CEC may be considerably lower than measured CEC and the ratio of CEC_{OM}/CEC_M may be even higher on coarse textured soils.

(b) The arbitrary factor used for calculating CEC_{OM} is for purposes of comparison and may vary from soil to soil or with different vegetation communities.

(c) The relative contribution from organic matter to the overall CEC increases substantially from clay soils to coarser textured soils.

(d) The actual CEC measured decreases substantially from clay to coarse textured soils.

(e) The combination of (c), (d) and (a) means that any loss of organic matter from the surfaces of coarse textured soils will have a very large effect on the overall CEC of the soil.

Distribution of CEC for soil groups

Distributions of CEC values for all soil groups and profile classes are given in Chem table microfiche, P.03 and L.12.

A plot of mean CEC by depth for soil groups is shown in Figure 4.4. The red, brown and grey clays on gently undulating plains (A) had to be separated into profile classes (A1,A2) due to their big differences in mean CEC as shown in Figure 4.4. Cation exchange capacity for Mt. Pleasant SPC (A1) is significantly ($P < 0.05$) less than Yo Yo SPC (A2) for mean surface soils (B10) and mean profile.

The Yo Yo SPC (A2) has high CEC, typical of Mitchell grass downs on relatively unweathered Cretaceous sediments reported by Turner and Ahern (1978) to the north, and Mills and Ahern (1980) to the north west. In contrast, the Mt. Pleasant SPC (A1), predominantly red clays formed in run on areas of the mulga land zone, has CEC values similar to the loamy red earths (J).

In Figure 4.4, CEC values reflect the clay content of the soils. This can be expected in a general way since CEC and clay are highly correlated for all analysed samples (r_{378} = 0.92***).

The alluvial soils (B,C,D) have lower mean CEC in the surface than the rest of the profile due to lower clay content. Figure 4.4 shows there is a big difference between the mean values of groups B,C and D at each plotted depth interval.

The earthy sands (H) and siliceous sands (I) have very low CEC values throughout the profile as expected from the low clay contents. Unlike the loamy and sandy red earths (F,G) silt is poorly related to CEC for earthy sands (H) but organic matter has a much stronger correlation (r_{12} = 0.92***; bulk surface data).

Clay activity

Clay minerals determine the activity of a clay and the proportions of these clay minerals have a major effect on the CEC of the soil.

Figure 4.4 Mean cation exchange capacity of soil groups by depth

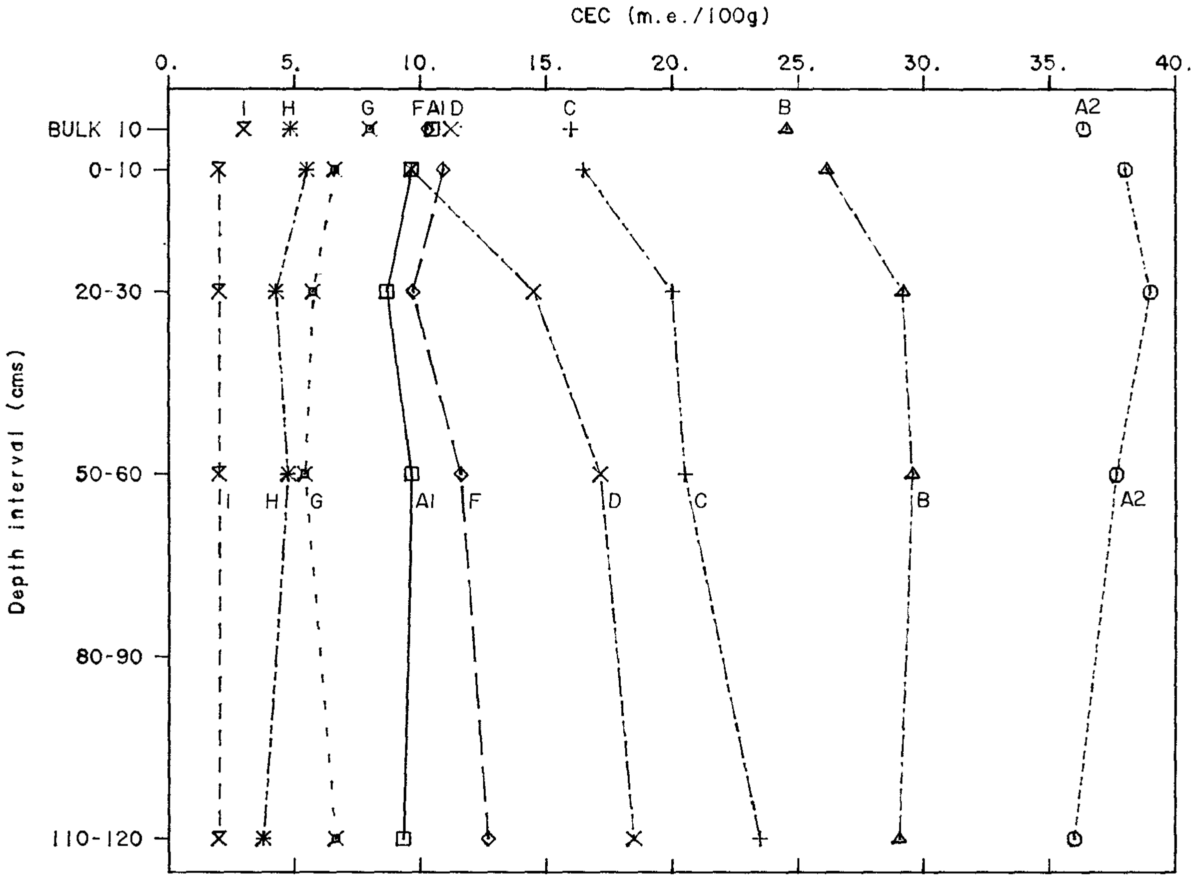
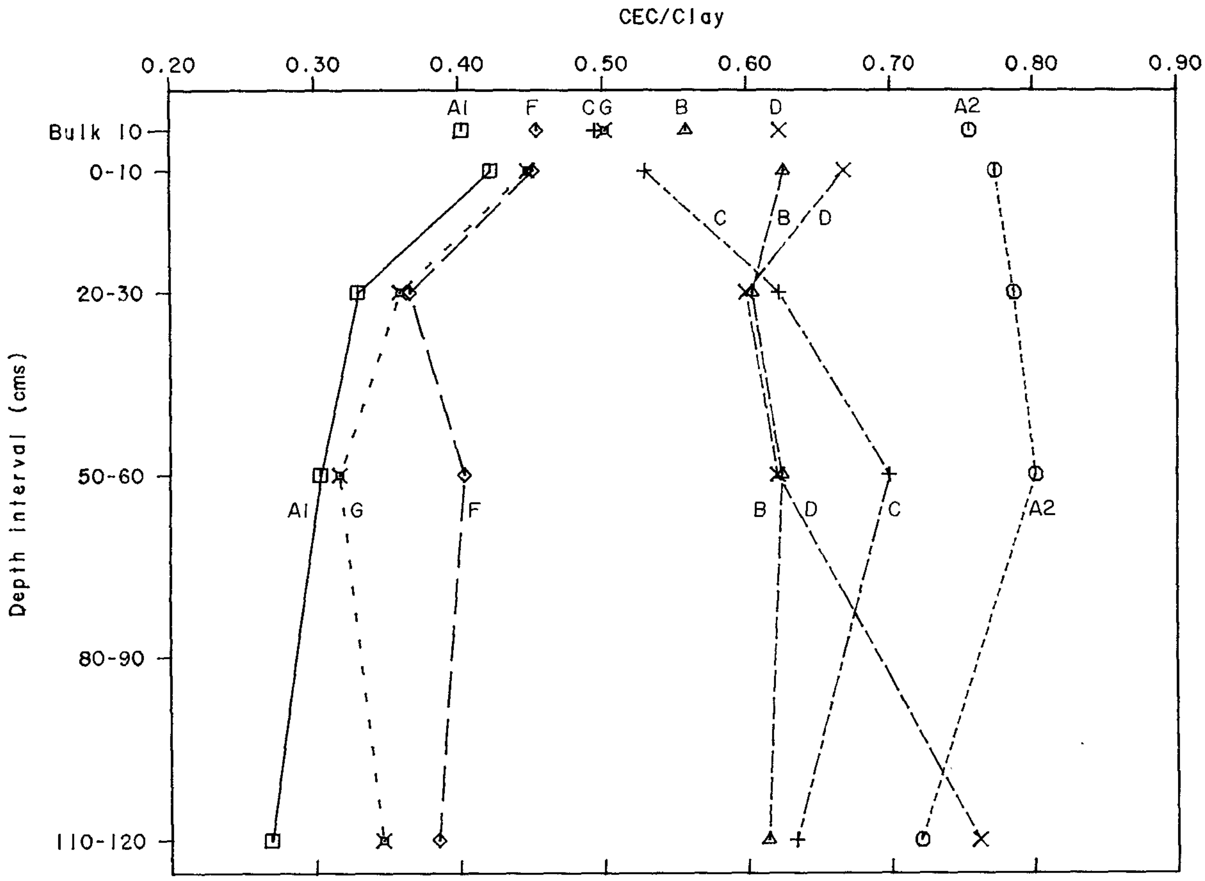


Figure 4.5 Mean CEC/clay ratio of soil groups by depth



No determinations of clay mineral type are available for the survey, but CEC/clay ratios of the non surface depths will be used to indicate soil groups which are dominated by high or low activity clay minerals. Where only surface values are available, approximate estimates can be made for organic carbon contribution to CEC by using formulae discussed in the CEC section.

A plot of mean CEC/clay by depth for some soil groups is shown in Figure 4.5. The coarse textured soils (H,I,J) are not plotted due to low number of values. Three distinct groups appear in this figure. The red earths (F,G) and red clays of the Mt. Pleasant SPC (A1) have low CEC/clay values indicating a high proportion of kaolinitic type clay minerals. These soils are derived from Tertiary land surfaces, quaternary deposits or redistributed erosion products derived from altered Cretaceous sediments.

The alluvial soils (B,C,D) have mean CEC/clay profile values >0.6, suggesting a predominance of 2:1 clay minerals. These values are similar to those reported for major alluvial soils of other western Queensland surveys. The bulge in CEC/clay values at 60 cm depth on the scalds (C) is probably not significant as only two profiles were analysed. The lower CEC/clay in the surface is verified by bulk surface samples and if corrected for organic matter the values would be even lower. This suggests the scald areas have much less 2:1 clay minerals and more 1:1 clay minerals in the surface, than either the alluvial clays (B) or texture contrast soils on alluvia (D).

The cracking clay soils (supporting Mitchell grass) derived from relatively unweathered Cretaceous sediments, Yo Yo SPC (A2), have very high CEC/clay values (mean sub-surface values as high as 0.8). This indicates a very high proportion of 2:1 clay minerals (probably smectite). Similar high values have been recorded on cracking clay soils developed from relatively unweathered Cretaceous sediments in other Western Queensland surveys.

The limited data available for the lithosols (J) and the Myola SPC of the earthy sands (H) suggests these soils are similar in CEC/clay, when corrected for organic matter, to the red earths (F,G) and that kaolinite could be expected to be one of the main clay minerals.

The siliceous sands (I) and the Bowra SPC of the earthy sands (H) are associated with alluvia, and CEC/clay values indicate clay minerals similar to other alluvia soils.

Low CEC is a major limitation to plant growth for the coarse textured soils, particularly since water holding capacity and nutrient status are largely dependent on CEC in low clay soils.

Exchangeable cations

The principal exchangeable cations in soils are calcium, magnesium, sodium, potassium, aluminium and hydrogen. The latter two have not been determined for this survey. The cations in exchangeable form are in near equilibrium with those in the soil solution and constitute a valuable source of nutrients important for plant growth.

Exchangeable cations have an ability to affect the physical structure of the soil. Calcium dominated clays usually have good physical structure, while soils with high sodium and/or magnesium are easily dispersed and predisposed to impermeability, surface crusting and poor aeration.

The relative proportion of cations to CEC and to other cations has a strong effect on the pH of the soil - another important fertility consideration. For all analysed samples in this survey, pH is strongly correlated with exchangeable calcium (r_{440} = 0.77***), magnesium (r_{440} = 0.76***), sodium (r_{440} = 0.60***) and potassium (r_{440} = 0.37***).

Calcium

The distribution of exchangeable calcium for the soil groups by depth, is shown in Chem table microfiche$_1$, N.02 and for profile classes microfiche$_1$, O.11.

The Yo Yo SPC (A2) has the highest exchangeable calcium values for this survey (mean profile value = 27 m. equiv./100 g). This is followed by the alluvial clays (B) (mean profile value = 18), scalds (C) (mean profile value = 10) and texture contrast soils on alluvia (D), (mean lower profile value = 10 m. equiv./100 g).

The Mt. Pleasant SPC (A1) has mean calcium values of approximately 4 m. equiv./100 g for most of the profile). This mean value is greater than the loamy red earths (F) for the upper profile, but less than (F) for the lower profile. Since Lodden (F1) and Halton (F2) SPC's are shallow, most of the values at depth from the loamy red earths belong to Maxvale SPC (F3), which has increasing calcium with depth (generally associated with hardpan development).

The sandy red earths (G) have lower mean calcium values than the loamy red earths (F) in line with the lower CEC and clay content (Figure 4.6). Mean calcium values of the sandy red earths increase low in the profile due to the Elmina SPC (G3). This soil profile class is similar to the Maxvale SPC (F3) of the loamy red earths. It has varying degrees of hardpan development, which is also associated with an increase in cations and base saturation.

The earthy sands (H) have similar calcium values to the sandy red earths (G) for most of the profile despite having lower clay content. This is mainly attributed to the higher calcium values of Bowra SPC (H1) associated with the alluvia. Bowra SPC has significantly ($P < 0.01$) lower mean profile clay content than Myola (H2) but higher mean calcium values. Mean Ca/CEC for Bowra is significantly greater than Myola for the surface ($P < 0.05$) and for the entire profiles ($P < 0.01$).

The siliceous sands (I) and lithosols (J) have extremely low mean calcium values (<1 m. equiv./100 g). Low calcium values may be a limitation to plant growth on the more acid and low calcium sites of the coarser textured soils (F,G,H,I,J).

Linear regression equations involving laboratory pH and exchangeable calcium for the coarser textured soils and red earths are given below:

Coarser textured soils (profiles) (F,G,H,I,J)

Exch. Ca = 2.5 pH - 12 ($r_{104} = 0.77^{***}$)

Red earths only (profiles) (F,G)

Exch. Ca = 3.0 pH - 14 ($r_{69} = 0.86^{***}$)

Loamy red earths only (profiles) F

Exch. Ca = 2.9 pH - 13.4 ($r_{52} = 0.88^{***}$)

These equations generally predict exchangeable calcium values of two m. equiv./100 g or less when the lab pH drops below 5.6 to 5.3 depending which equation is used. A similar result is reached if equations for the bulk surface sample data only is used. Thus, when cation data is not available, pH can be used as a rough guide to indicate low calcium levels on the coarser textured soils, particularly red earths.

O'Hagen (1966) in a study of mulga soils in north-western New South Wales, found optimum plant calcium levels were reached in mulga seedlings at a pH range of 5.8 to 6.1. Results from this survey show that all of the twenty sites from the loamy red earths (F), with surface pH of 5.8 or higher, have exchangeable calcium greater than 2 m. equiv./100 g, and half of the six sites from the sandy red earths (G) with bulk surface pH of 5.8 or higher are greater than 2 m.equiv./100g Ca. Thus the optimal pH of O'Hagen (1966) may also correspond to a pH, at least in this survey, where calcium levels are adequate for plant growth.

Magnesium

The distribution of exchangeable magnesium for soil groups by depth, is shown in Chem table microfiche$_1$ A.03 and for soil profile classes microfiche$_1$ D.12. The relative trend for all soil groups generally follows that described for exchangeable calcium, except that magnesium values are much lower than those for calcium.

All soil groups and profile classes show an increase in mean exchangeable magnesium with depth, except for the shallow SPC's of the red earths, siliceous sands and lithosols (see Figure 4.7). Generally the maximum magnesium value in a profile is found at the lowest sampling depth or the base of the profile. While some of this increase with depth is often associated with increases in texture and CEC, the distribution of Mg/CEC values (Chem table microfiche$_1$ A.05) shows there is a positive increase in magnesium beyond that due to CEC increases.

Sharp increases in exchangeable magnesium occur on red earths with restricted drainage or hardpan development, resulting in magnesium becoming the dominant cation at depth in some profiles. Relatively high magnesium and sodium levels at these sites compared to other red earths, may be a factor in producing hardpans.

Figure 4.6 Mean exchangeable calcium of the coarser textured soil groups by depth

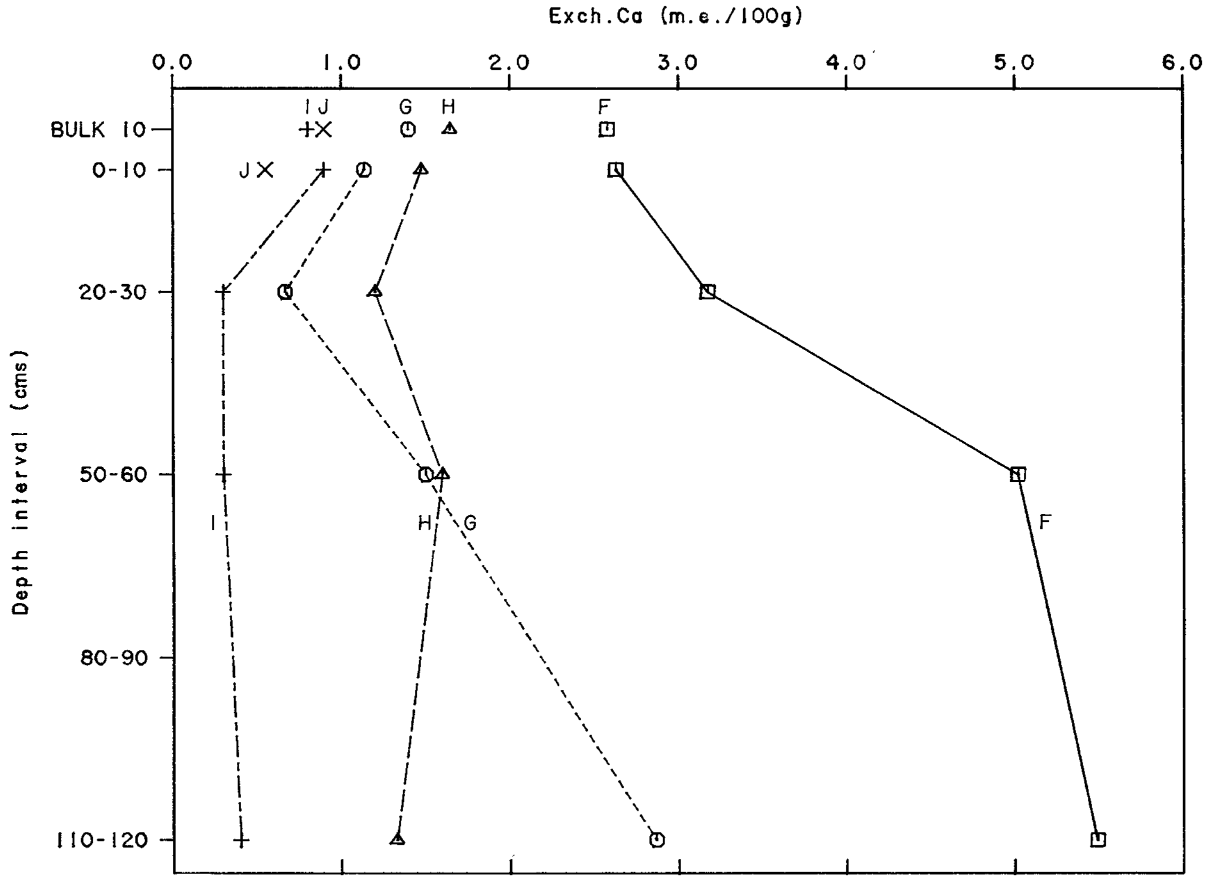
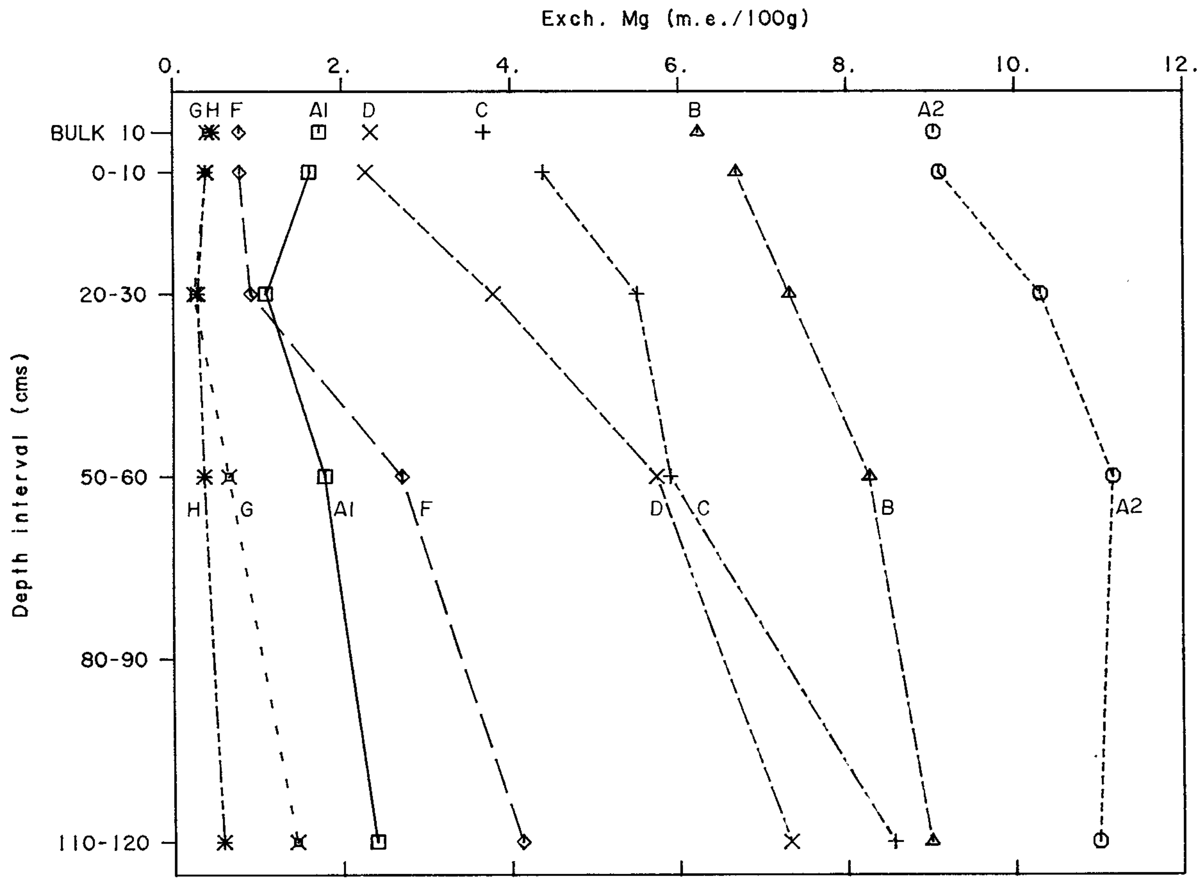


Figure 4.7 Mean exchangeable magnesium of soil groups by depth



From a fertility aspect, most of the coarser textured soils (G,H,I,J) have magnesium values less than 0.5 m.equiv./100g (Figure 4.8) showing that low magnesium could be a limitation to plant growth.

Only a third of the 42 loamy red earth (F) sites, chiefly from the Maxvale SPC (F3), have magnesium values greater than 1.0 m. equiv./100 g. Many of the texture contrast soils on the plains (E) have low surface magnesium levels.

Sodium

Exchangeable sodium is highly correlated with clay% (profiles, r_{272} = 0.63***; bulk surface samples, r_{122} = 0.73***) for all sites in the survey, showing higher sodium can generally be expected on the clays, and low sodium on the coarse texture soils.

Exchangeable sodium percentage (ESP) is also highly correlated with clay% for all sites but it has lower correlation coefficients than exchangeable sodium. However these correlations are much lower for broad groupings, such as alluvial soils (B,C,D) and coarser textured soils (F,G,H,I,J), than for all sites.

Exchangeable sodium and ESP are highly correlated with laboratory pH for all sites as shown below:

	Na	ESP	No. of values
Bulk surface samples	0.65***	0.55***	124
Profiles	0.58***	0.57***	274

Correlations with pH are lower for profiles of the alluvial soils (B,C,D) but higher for profiles of the coarser textured soils (F,G,H,I,J).

The distribution of exchangeable sodium for soil groups by depth is shown in Chem table $microfiche_1$ C.03 and for soil profile classes, H.12. These distributions generally follow that indicated by the correlations with clay discussed earlier, in that the sandier soils have low sodium and clay soils higher sodium.

The earthy sands (H), siliceous sands (I), lithosols (J), Prairie (G1) and Mayvale (G2) SPC's of the sandy red earths, and the shallow Loddon SPC (F1) of the loamy red earths, all have very low exchangeable sodium, generally less than 0.2 m. equiv./100 g throughout their profiles. Some sites of the Maxvale (F3) and Elmina (G3) SPC's have a sharp increase in exchangeable sodium associated with the occurrence of hardpans as discussed for magnesium. These sites are mainly responsible for the highly significant correlation between pH and exchangeable sodium for profile values on the red earths (F,G) r_{81} = 0.69***, as the remaining soil profile classes have negligible sodium.

Except for the Mt. Pleasant SPC (A1), the highest surface and profile values for exchangeable sodium occur on the clay soils (B,C,A2,A3), and sodium increases down most individual profiles of these soils (see Figure 4.9). The texture contrast soils on alluvia (D) have low surface sodium (mean bulk surface value = 0.25 m. equiv./100 g) but the mean value increases tenfold by 120 cms (2.7 m. equiv./100 g).

Sodicity

Sodicity is the presence of a high proportion of sodium ions to other cations in a soil and is measured as ESP (100 times the exchangeable sodium divided by the soil cation exchange capacity). The U.S. Salinity Laboratory Staff (1954) classify soils with ESP values >15% as "sodic soil" but in Australia, Northcote and Skene (1972) classify soils with ESP of 6-14 as sodic and ESP of 15 or more as strongly sodic. This latter terminology has been used in this report as many workers (Skainberg *et al.* 1982, Singer *et al.* 1982) have reported effects on soil physical properties at ESP's less than 15.

Relationships between ESP, chloride and electrical conductivity have been discussed in the section on salts. The distributions of exchangeable sodium percent for soil groups by depth is shown in Chem table $microfiche_1$ C.05 and for soil profile classes D.16.

Since ESP is highly correlated with exchangeable sodium for both bulk surfaces (r_{122} = 0.85***) and profiles (r_{272} = 0.95***) for all sites, generally what was said for exchangeable sodium for soil groups applies also for ESP. Figure 4.9 shows mean exchangable sodium values down the profile for various soil groups.

Figure 4.8 Mean exchangeable magnesium values of the coarser textured soil groups by depth

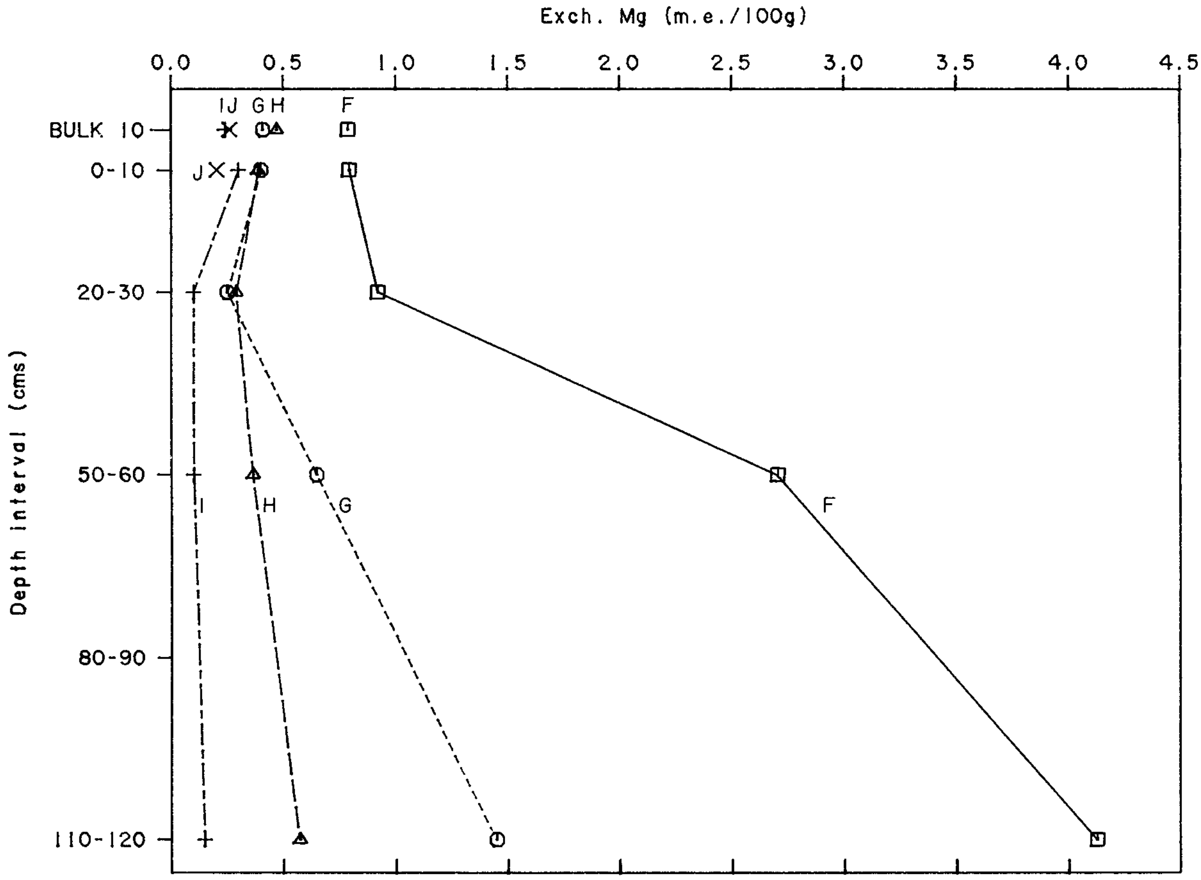
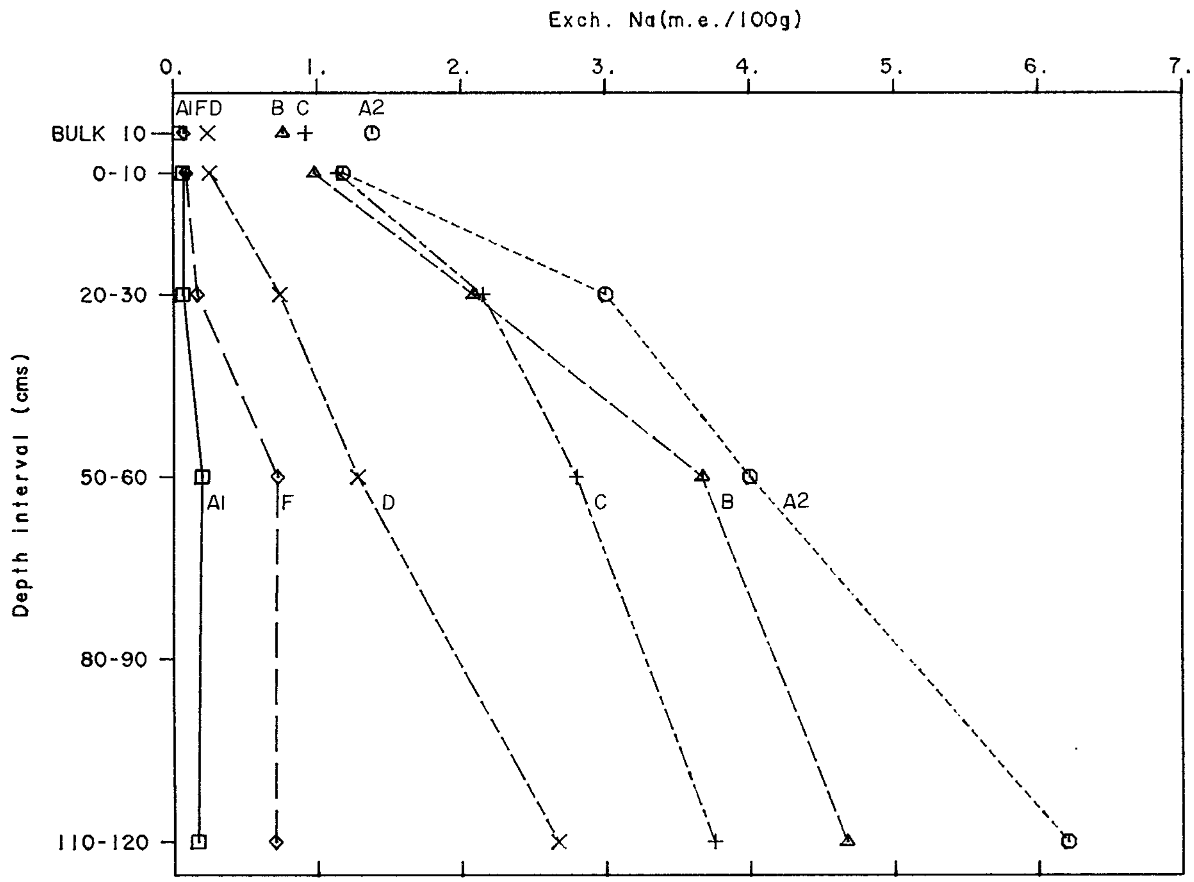


Figure 4.9 Mean exchangeable sodium of soil groups by depth



The scalds (C) are the most sodic of all soil groups, both on the surface and throughout the profile (Figure 4.10). Similar mean values are obtained for the sedentary clays (A2) and alluvial clays (B). The Mt. PLeasant SPC (A1) is characteristic of red clays supporting mulga and has very low ESP levels similar to the red earths. The remaining coarse textured soil groups have low ESP except where hardpan development has occurred in some profiles.

Base saturation

Percent base saturation is defined as 100 times the sum of the basic cations (Ca, Mg, Na, K) divided by CEC. For all sites base saturation is significantly correlated with laboratory pH (profiles, r_{272} = 0.83***; Bulk surface samples, r_{167} = 0.71***). Correlation coefficients are highest on the coarser textured soils (F,G,H,I,J) and lowest on the alluvial soils (B,C,D).

Steinhardt and Mengal (1981) found a significant correlation between pH and base saturation, but added that no common relationship between pH and % base saturation has been developed to fit all soils. In this survey, the coarse textured (lower pH also) soils (F,G,H,I,J), both collectively and individually, have high correlations between laboratory pH and base saturation. The alluvial soils (B,C,D) have lower but still highly significant correlations. This may be due to the fact that most of the lower depths of the alluvial soils are fully base saturated, but may have different pH values.

Values of greater than 100% base saturation are recorded on some of the alkaline clay soils. This is generally due to gypsum dissolving and increasing the exchangeable calcium values.

Polemio and Rhoades (1977) have indicated that the method of Tucker (1954), which is similar to the method used for this survey, may underestimate CEC in alkaline soils. Thus values greater than 100% base saturation on some of the more alkaline sites may be due to a slight underestimation of CEC.

PARTICLE SIZE ANALYSIS

The distribution of particle sizes in a soil can have an effect on many soil properties including soil structure, water holding capacity, CEC, cations, base saturation, pH, salt content, natural fertility, ability to hold nutrients, drainage and hydraulic conductivity.

Field textures, which give an approximation of particle size distribution, are an important factor in allocating a soil to a soil group. The Australian classification schemes principal profile form (Northcote 1974) and Great Soil Groups (Stace *et al.* 1968) use field texture to separate many of their groups. The soil groups of this survey are based on Great Soil Groups and the use of field texture to distinguish between soil groups is reflected in the graphs of mean particle size (clay, silt, fine sand and coarse sand) for the various soil groups, Figures 4.11 to 4.14.

Clay

Distribution of clay content by depth for the soil groupings is given in Chem table microfiche, G.03 for the soil groups and A.13 for the soil profile classes. In the survey area, clay content ranges from 69% on the Warrego alluvial clays to 2% on the earthy and siliceous sands of the dunes.

Figure 4.11 shows the mean clay percentage by depth for many of the soil groups. The alluvial clay soils (B) and clays belonging to the Downs (Yo Yo SPC, A2) have highest clay contents. The scalds (C) associated with the alluvia have much lower clay content (mean <33%) and thus do not have the advantage of cracking and self mulching to assist in maintaining good surface physical properties. The texture contrast soils on alluvia (D) have similar mean clay contents of the surface to the sandy red earths (G) but clay content increases with depth to values closer to the loamy red earths (F). The Mt. Pleasant SPC (A1) (not shown in Figure 4.11) has similar, though slightly higher, mean profile values to the loamy red earths (F), and considerably lower values than the Yo Yo SPC (A2). The siliceous sands (I) (not plotted) have values lower than the earthy sands (H).

There is a clear separation between the mean clay% of loamy red earths (F) and sandy red earths (G) (Figure 4.11). This separation into different groups is further justified when correlations of clay% with CEC and various moisture characteristics of Table 4.4 are considered. The sandy red earths (G) have stronger correlation with clay% for all listed factors than the loamy red earths (F) showing clay% is a more important factor on the coarser textured soils. This is also reflected in the correlation values for "sandy soils" (F,G,H,I,J) which includes earthy sand (H), siliceous sands (I) and lithosols (J).

Figure 4.10 Mean exchangeable sodium percentage (ESP) of soil groups by depth

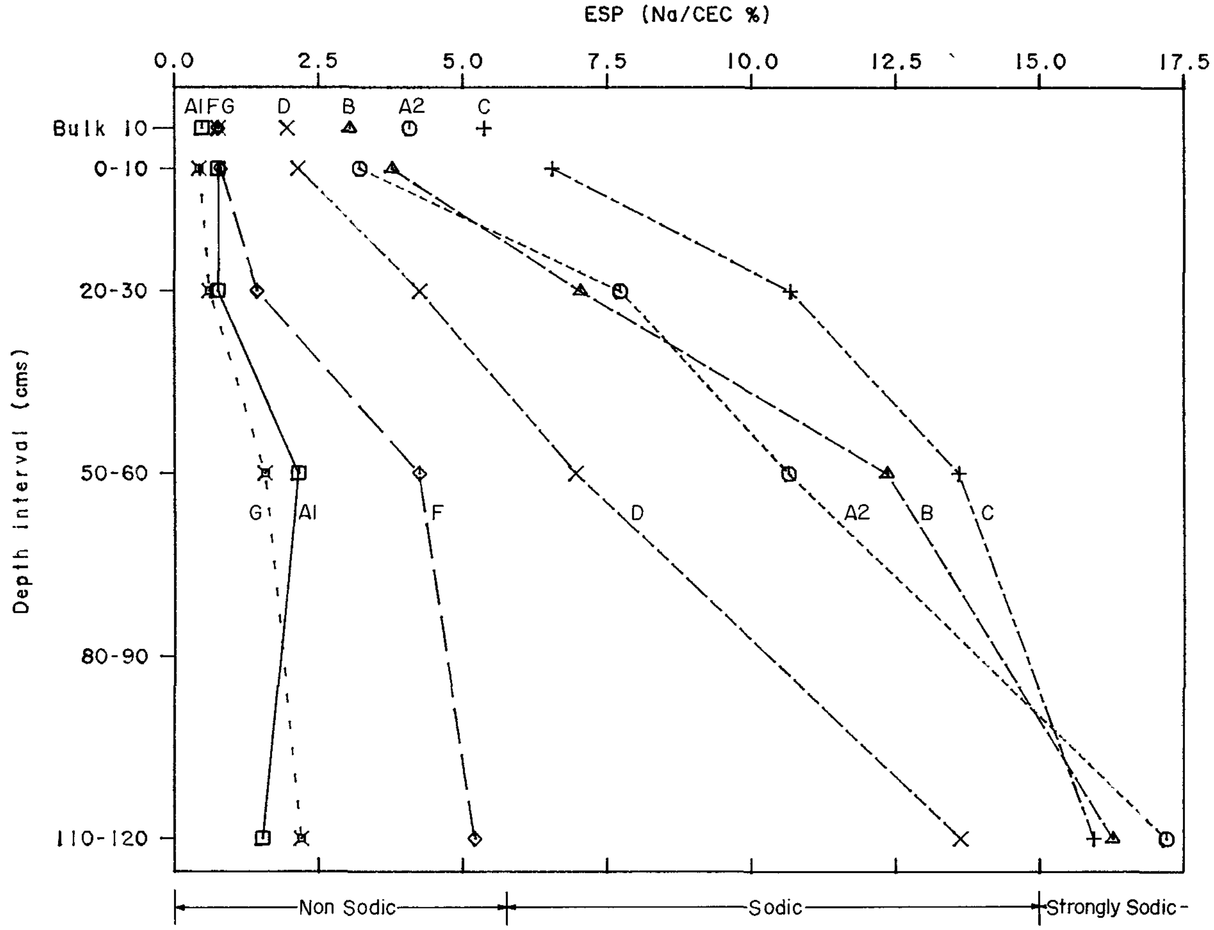
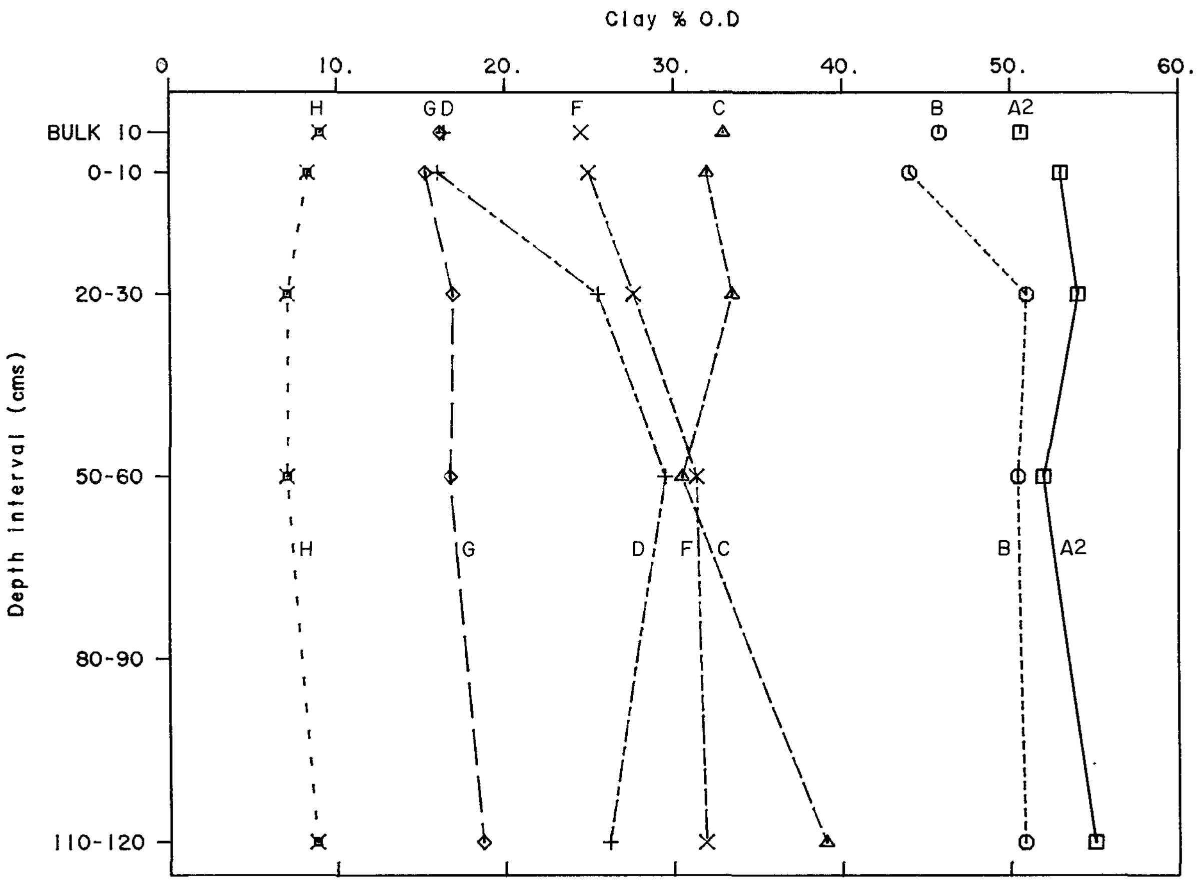


Figure 4.11 Mean clay content of soil groups by depth



For all soil profile samples, clay percentage is highly correlated ($P < 0.001$) with CEC, cations, moisture characteristics, base saturation and laboratory pH. This emphasises the important contribution of clay content in determining soil properties.

When alluvial soils (B,C,D) only are considered, pH and base saturation are poorly correlated with clay%. This may be explained by the fact that in many profiles, pH increases down the profile and is not accompanied by an increase in clay%. Salt content and carbonates also influence pH. Most alluvial soils are base saturated or close to it below the surface, irrespective of clay content. However, variation of pH is well correlated ($r_{40} = 0.65^{***}$) with clay content for surfaces only.

Moisture characteristics, in particular -15 bar water retained, are highly correlated with clay%, although on the coarser textured soils, available water capacity has a poor linear correlation to clay%, Table 4.4.

Table 4.4 Correlations of clay% with CEC, cations, moisture characteristics and laboratory pH for profile samples (Bulk surface not included.)

	All Soils	"Alluvia" (B,C,D)	Alluvial Clays (B)	"Sandy" Soils (F,G,H,I,J)	Red Earths (F,G)	Loamy Red Earths (F)	Sandy Red Earths (G)
CEC	0.92***	0.93***	0.88***	0.74***	0.66***	0.45***	0.66***
Σ Cations	0.87***	0.87***	0.80***	0.56***	0.54***	0.42**	0.64***
AD Moist	0.82***	0.72***	0.53***	0.65***	0.56***	0.40**	0.73***
-1/3 bar	0.92***	0.90***	0.84***	0.81***	0.70***	0.49***	0.67***
-15 bar	0.95***	0.93***	0.88***	0.91***	0.85***	0.71***	0.94***
AWC	0.85***	0.80***	0.71***	0.59***	0.43***	0.23^{NS}	0.26^{NS}
Exch.Ca	0.84***	0.80***	0.65***	0.53***	0.53***	0.41**	0.63***
Exch.Mg	0.83***	0.78***	0.73***	0.50***	0.48***	0.37**	0.62***
K	0.57***	0.52***	0.61***	0.48***	0.31**	0.03^{NS}	0.64***
Lab. pH	0.60***	0.25**	0.20*	0.21*	0.45***	0.40**	0.60***
Base Sat.	0.64***	0.25**	0.15^{NS}	0.32***	0.47***	0.42**	0.51**
No.pairs for all characteristics	274	146	116	106	83	54	29
No.pairs for moisture characteristics	222	112	88	90	72	48	24

Silt

The distribution of silt content for soil groups is given in Chem table microfiche, I.03 for the soil groups and F.13 for the soil profile classes. Mean silt contents of all soil groups are less than clay content, usually appreciably. Figure 4.12 shows a plot of mean silt content by depth for many of the soil groups. Generally, mean silt values are a little higher in the surface than for the remainder of the profile, with slight increases occurring again at the 120 cm depth in some groups.

Highest mean silt values above 60 cm depth occur on the scalds (C). This has important implications for soil packing and porosity, particularly when values are much higher than the alluvial clays (B) and texture contrast soils on alluvia (D), see Figure 4.12. The high silt content of the Yo Yo SPC (A2) does not adversely affect soil structure as this soil has high clay content, is a cracking clay, and the soil structure is dominated by a clay matrix.

The Mt. Pleasant SPC (A1) (not shown) has higher mean silt content than the loamy red earths (F), though less than Yo Yo SPC (A2) and the scalds (C).

For the loamy red earths (F) silt is more strongly correlated with the factors in Table 4.4 (except for the -15 bar and AD moisture) than clay%. Thus much of the silt in the red earths may be fine silt (close to colloidal size) as increases in the silt fraction correspond to increasing CEC, cations and water holding capacity on these soils. It is also possible that the PSA method used does not completely disperse loamy red earths soils.

Sands

The distribution of fine and coarse sand contents for soil groups is given in Chem table microfiche$_1$ K.03 and L.03 for the soil groups and I.13 and M.13 for the soil profile classes.

Fine sand contents range from 10% on the alluvial clays (B) to 59% on the siliceous sands (I) and coarse sands range from 1% on the alluvial clays to 75% on the earthy sands (H).

A plot of fine and coarse sand contents by depth for certain soil groups is given in Figures 4.13 and 4.14. The scalds (C) have highest mean fine sand contents but very low mean coarse sands. This, together with the high silt contents, suggests that particle size distribution may be a factor in the formation of scalds.

Other soil groups with high fine sand contents are the texture contrast soils (D) and loamy red earths (F). The clay soils (B, A2) have low coarse and fine sand contents as expected.

Coarse sand/fine sand ratio

Figure 4.15 shows the mean ratio of coarse/fine sand for the soil groups. The distribution of this ratio is shown in Chem table microfiche$_1$, F.04 (soil groups) and O.14 (soil profile classes). The earthy sands (H) have mean ratio >2 and as high as 3. The sandy red earths (G) have a ratio >1 and high sand contents. Both these soils groups are well drained.

On the lower end of the scale, the scalds (C) have very low coarse/fine Sand ratios (<0.25) and high silt content. These factors contribute strongly to the formation of hard setting, tightly packed soil surfaces that are characteristic of scalds.

Other soil groups such as loamy red earths (F) and texture contrast soils (D) also have low coarse/fine Sand ratios and tendency to hardsetting surfaces. This contrasts with the sandy red earths (G) which have coarse/fine Sand >1, high sand content and generally loose surfaces. The mean coarse/fine Sand ratio profile for Mt. Pleasant SPC (A1) lies between (F) and (D).

Low coarse/fine Sand ratios on clay soils such as (B) and (A2) are probably less important as these soils' structures will be dominated by the high clay content.

ORGANIC CARBON AND TOTAL NITROGEN

General importance of organic matter

Soil organic matter is a key component of the soil, influencing fertility, moisture holding capacity, soil structure and susceptibility to erosion. Ahern (1975) discussed the importance of organic matter in reducing erosion in the mulga lands of South-West Queensland. The organic matter content of soil is relatively stable under natural vegetation, but under grazing and disturbance by man, it can decline substantially. This applies in particular to overgrazing and clearing, leading to loss of the soil's protection from wind and water erosion. Maintenance of soil organic matter at adequate levels to ensure long term stability, involves identifying soils at risk and developing non-destructive management practices.

In this survey area, the coarser textured soils are generally more fragile due to their lower fertility, lower water holding capacity, and, in the case of the mulga lands, the use of trees and shrubs for drought fodder. The clay soils, with the exception of the red clays from the Mt. Pleasant SPC, have greater natural stability due to their soil structure and higher fertility.

Some of the alluvial clay soils with lighter textured surfaces are subject to "scalding" if overgrazed. While particle size distribution is considered a factor in susceptibility of scald formation, maintenance of organic matter in the upper profile is important to prevent hard setting surfaces.

Figure 4.12 Mean silt content of soil groups by depth

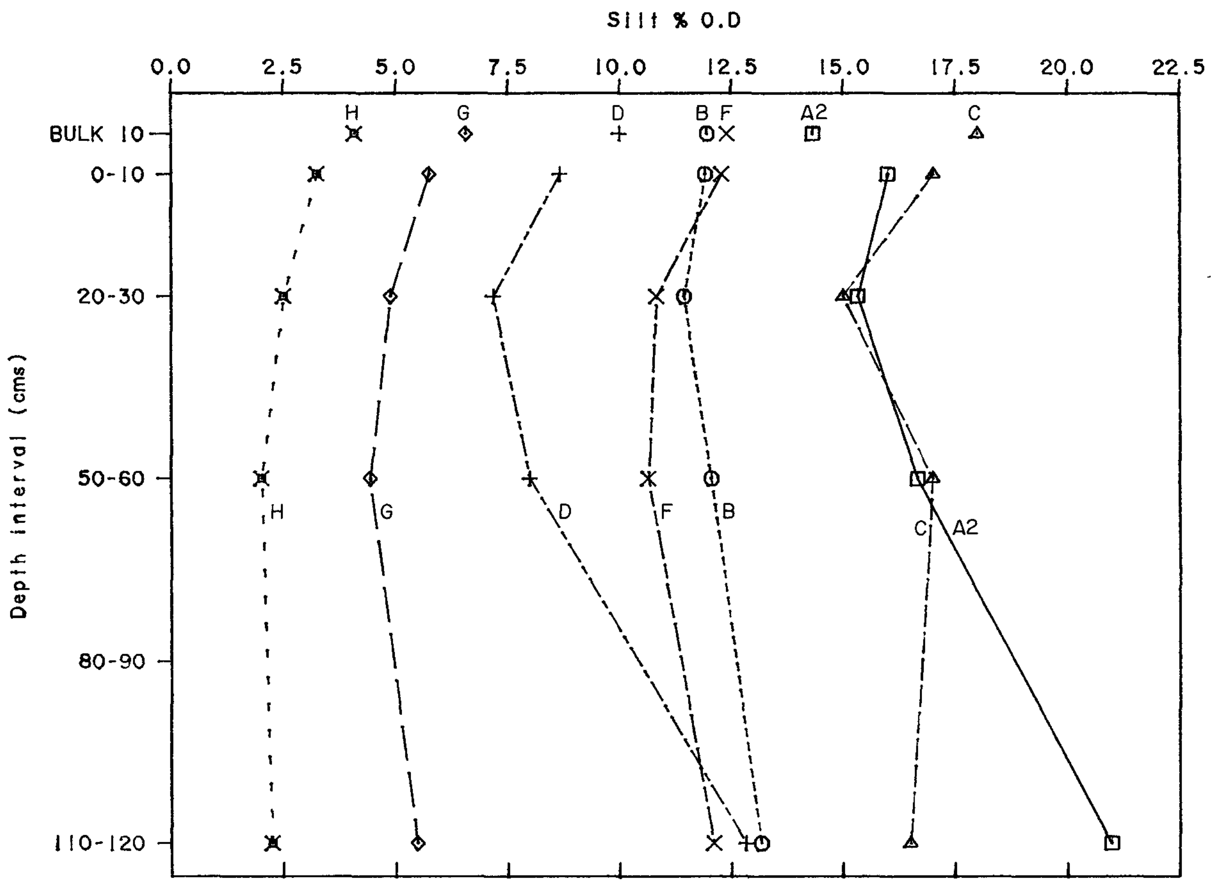


Figure 4.13 Mean fine sand content of soil groups by depth

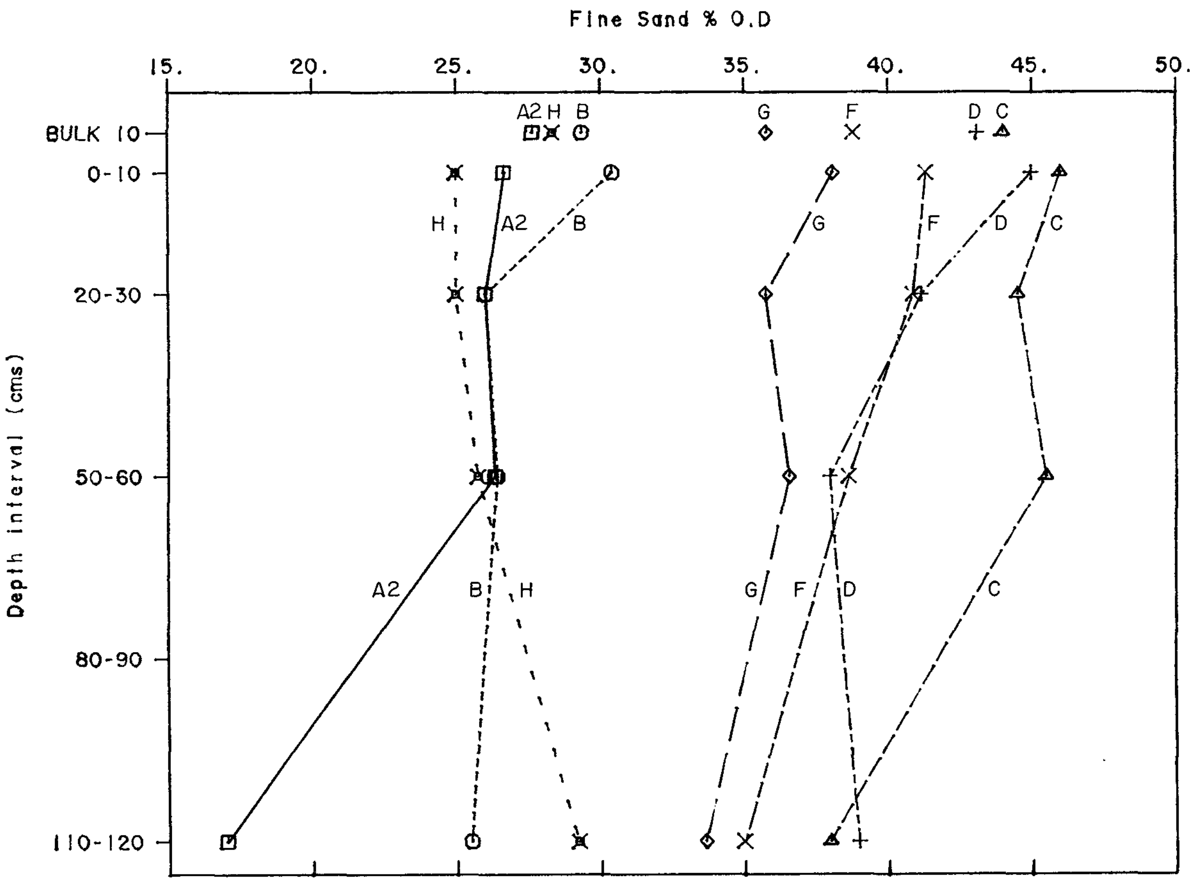


Figure 4.14 Mean coarse sand content of soil groups by depth

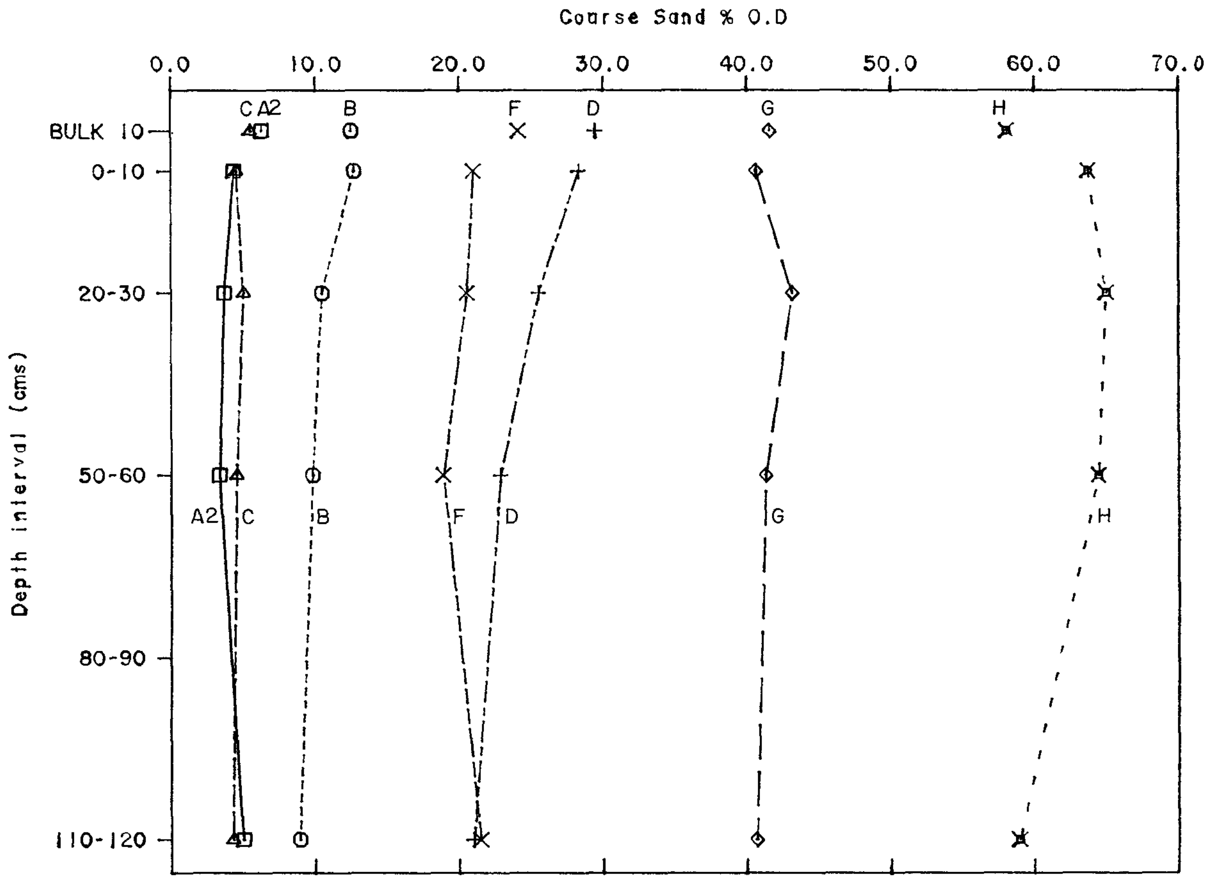
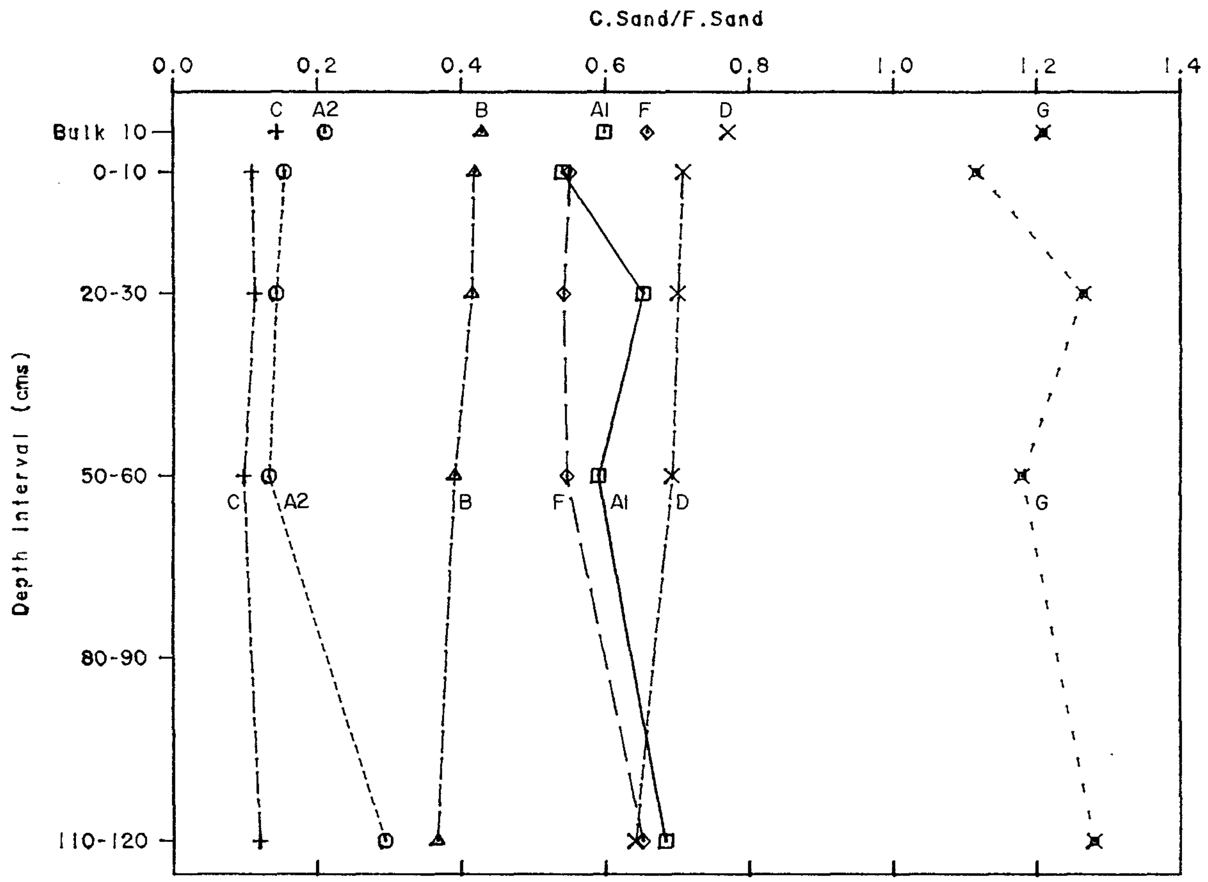


Figure 4.15 Mean coarse/fine sand ratio of soil groups by depth



Method

Organic matter in soils has a complex composition and there is no routine chemical method suitable for separating all its components. Organic carbon is usually determined by oxidation methods, then multiplied by a factor to estimate organic matter content. The conventional factor used is 1.72 which assumes that organic matter contains 58% carbon. This factor has been shown to be in error for many soils, for example, Broadbent (1953) suggested 1.9-2.0 and Howard (1965) said the factor was too low in most cases.

The common methods used for the determination of organic carbon in soils involve (a) complete combustion, (b) loss on ignition, and (c) partial wet oxidation. The digestion procedure used in this survey is the wet oxidation method of Walkley and Black (1934) and unless otherwise stated, results are uncorrected Walkley and Black values.

This method is subject to interferences from chlorides (Walkley 1935), carbonates and gypsum (Dewan *et al.* 1959). These substances sometimes occur, in quantity, in soils of this survey.

Various workers (Walkley and Black 1934, Walkley 1935, Dewan *et al.* 1959) have documented conversion factors for calculating total carbon from Walkley and Black values. Little *et al.* (1962), established a factor for Queensland soils:

Total C% = 1.3 x Walkley and Black values.

This factor has been used earlier in calculations of organic matter contribution to CEC and is used here to calculate total C:N:S ratios, but not used for C/N ratios. Thus:

Organic matter% = (1.72 x 1.3) organic carbon (Walkley & Black)
= 2.236 organic carbon (Walkley and Black)

Young (1976) gives a range of 0.5-1% total organic matter content of the topsoil for semi arid zones and 1-2% for dry savanna zones for tropical soils. The overall mean for organic matter for this survey (1.6%), is higher than that suggested by Young (1976) for semi arid zones and more in line with that suggested for dry savanna zones. This is probably due to the fact that in this survey, higher carbon levels occur in wooded areas, particularly on those soils supporting mulga or brigalow.

Correlations

Organic carbon and total nitrogen are highly correlated for all analysed samples, as shown by the regression equation:

OC = 12.61 tot. N + 0.08 $(r_{437} = 0.82^{***})$.

Surface total nitrogen is significantly, though poorly, correlated with total phosphorus for all soils $(r_{167} = 0.32^{***})$, while organic carbon is not significantly correlated with total P.

Dawson and Ahern (1974) found a higher correlation between total N and digest P $(r = 0.46^{***})$ in the area further west of the present survey. Charley and Cowling (1968) have shown that phosphorus plays an important role in determining the extent of nitrogen build-up in soils, at least within certain climatic limits. Hubble and Martin (1960) demonstrated a higher correlation coefficient $(r = 0.68)$ for Queensland surface soils and Jackson (1962) in Central Australia, also had a higher correlation $(r = 0.69)$. Both these workers were using digest total phosphorus and not x-ray total phosphorus. Dawson and Ahern (1974) found higher total P values are obtained by x-ray method than by digestion procedures on Western Queensland soils. As these higher values would contain extra fixed or immobilised phosphorus, lower correlations of total N with total P (x-ray) would be expected. An additional complication is that both grassland and shrubland are represented in this survey data. It could be expected that different relationships, particularly where legumes are involved, would exist for grassland and shrubland.

Carbon and nitrogen bulk surface samples are not significantly correlated with total sulphur for all soils. This is probably due to the presence of sulphates such as gypsum in the clay soils. When restricted to the "sandy" group of soils, both nitrogen and carbon have highly significant correlations with total sulphur $(r_{87} = 0.79^{***}; 0.69^{***}$ respectively).

Total nitrogen and organic carbon are also highly correlated with CEC on the "sandy" soils $(r_{87} = 0.74^{***}; 0.68^{***})$. This is because organic matter contributes substantially to the total CEC on these soils as discussed in the section on CEC.

Moisture holding characteristics (-1/3 bar, -15 bar, AWC, ADM %) are also correlated with total nitrogen and organic carbon on the "sandy" soils grouping. This is because of the increase in CEC due to organic matter and the effect of organic matter improving soil structure.

All soils

The mean organic carbon for surface soils in the survey is 0.71%. This is similar to the value (0.73%) reported by Turner and Ahern (1978) to the north of the present area, but considerably higher than the adjoining area to the west (0.49% Dawson and Ahern 1974). A general reduction of organic carbon values in a westerly direction is attributed to reduction in average rainfall. Dawson and Ahern (1974) and Dawson *et al.* (1976) found organic carbon content correlated with mean annual rainfall.

The mean total nitrogen value for all surface soils is 0.049% N, with total nitrogen following a similar trend to that discussed for organic carbon.

Soil groups

Frequency distributions of organic carbon (Walkley and Black) and total nitrogen for soil groups are given in Chem table microfiche$_1$ A.01 and B.01, and I.08 and K.08 for soil profile classes. Organic carbon values range from 0.2% on the siliceous sands (I) to 2.5% on the lithosols (J).

A bar graph of mean organic carbon and total nitrogen values for the soil groups is shown in Figure 4.16. Lowest organic carbon values for clay soils occur on the scalds (C). This can be expected, since these soils are currently devoid or close to devoid of vegetation.

The red clays (A1) have higher mean organic carbon values than the other clay soils. This is attributed to nutrient cycling by the mulga vegetation as the red clays have inherently low fertility status.

Within the alluvial clays (B), the SPC's with the lowest organic carbon and total nitrogen values are Wallal (B3) and Noorama (B4), both of which support grasslands.

The influence of vegetation is further seen in the texture contrast soils (Figure 4.16). The more fertile texture contrast soils on alluvia (D), have lower organic carbon and total nitrogen than the texture contrast soils on the plains (E), that predominantly support mulga/box woodland.

The loamy red earths (F) have the highest mean organic carbon content of the soil groups in the survey (Figure 4.16). This is followed by the lithosols (J), texture contrast soils on the plains (E), red clays of Mt. Pleasant SPC (A1) and sandy red earths (G), all of which support mulga vegetation and have similar parent material. These groups also show a greater drop-off in values to the 20 cm depth than the clay soils (A2,B,C). This sharp decrease in organic carbon values to 20 cm is characteristic of red clays and red earths supporting mulga vegetation and is a common occurrence in other western Queensland surveys.

C:N ratios

Total nitrogen values generally reflect organic carbon levels except for the coarser textured soils (G,H,I) which have relatively lower nitrogen levels than their carbon contents would have indicated. These soils have higher C/N ratios.

The mean carbon/nitrogen value for all surface soils is 14.9, but there is considerable variation between groups.

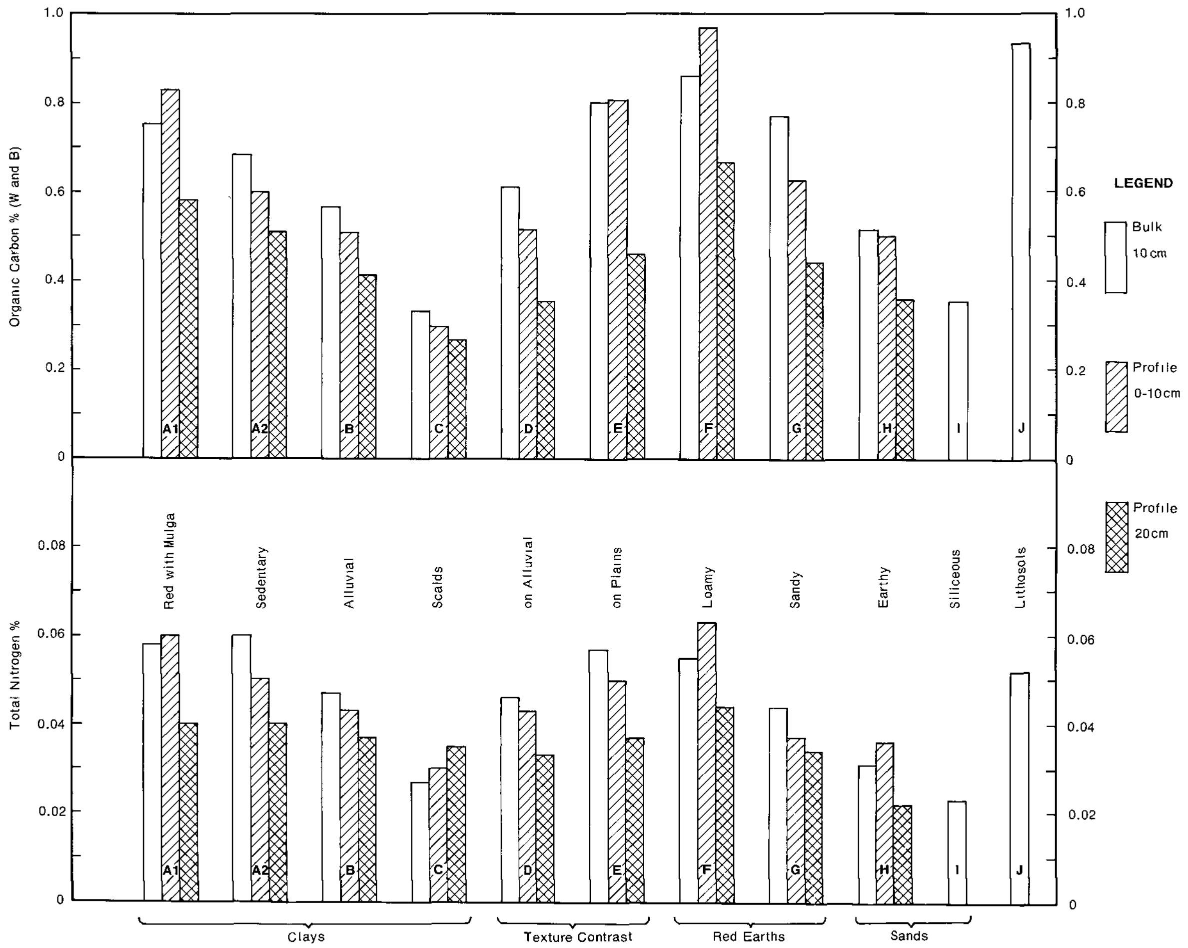
The distribution of C/N ratios for the soil groups is given in Chem table microfiche$_1$ K.05 and D.17 for soil profile classes.

Generally, the mean values for clay soils (A,B,C) and texture contrast soils (D,E) indicate nett mineralisation of nitrogen is favorable. Some of the loamy red earths (F) and many of the sandy red earths (G), earthy sands (H) and lithosols (J) have a high C/N ratio, indicating nett release of nitrogen to the soil would be low.

C:N:S ratios

Total C:N:S ratios for the soils groups are given in Table 4.5. Values for total sulphur on the alluvial clays (B), Yo Yo SPC (A2), scalds (C) and texture contrast soils on the alluvia (D) are inflated by the presence of gypsum.

Figure 4.16 Mean organic carbon and total nitrogen of soil groups



Isbell and Smith (1976) recorded mean C:N:S ratios for red earths in North Queensland of 220:10:1.4. The red earths (F,G), texture contrast soils on the plains (E) earthy sands (H) siliceous sands (I), and lithosols (J) have similar total C:N ratios but much higher sulphur ratios (approximately twice that of Isbell and Smith 1976). This suggests sulphur may be in greater proportional supply due to lower leaching losses under semi-arid to arid conditions.

Table 4.5 Mean bulk surface total carbon:nitrogen:sulphur ratios for soil groups. (Total C = OC x 1.3).

Soil Group		C%	:	N%	:	S%
Red clays, mulga (Mt Pleasant SPC)	(A1)	171		10		2.1
Brown and Grey clays (Yo Yo SPC)	(A2)	148		10		6.5
Alluvial clays	(B)	164		10		10
Scalds	(C)	171		10		4.0
Texture Contrast on alluvia	(D)	175		10		3.4
Texture Contrast on plains	(E)	185		10		2.3
Loamy red earths	(F)	208		10		2.7
Sandy red earths	(G)	231		10		2.4
Earthy sands	(H)	226		10		2.9
Siliceous sands	(I)	192		10		3.4
Lithosols	(J)	222		10		2.9

PHOSPHORUS

Total phosphorus

The distribution of total phosphorus by soils depths for soil groups and soil profile classes are shown in Chem table microfiche, H.02 and C.11.

Total P values range from 0.124% on a texture contrast soil on alluvia (D) to 0.008% P on a surface sample of siliceous sand (I). The mean for all surface soils is 0.031% P (CV = 32%). This is similar to the value of 0.03% P estimated by Wild (1958) for Australian soils but considerably lower than the value of 0.055% for surface soils that Norrish and Rosser (1983) calculated from "The Handbook of Australian Soils" by Stace *et al.* (1968). It is also lower than the means recorded in other published surveys in western Queensland: 0.033% P (Mills and Ahern 1980); 0.038% P (Turner and Ahern 1978); and 0.041% P (Dawson and Ahern 1974). In this area there is little "Downs" country which usually recorded higher P values in the other western Queensland survey areas. Most recorded values in this survey belong to two broad groups, (i) alluvial soils (B,C,D), which had the highest values; (ii) highly leached coarser textured soils, with low values.

Figure 4.17 Mean total phosphorous of soil groups by depth

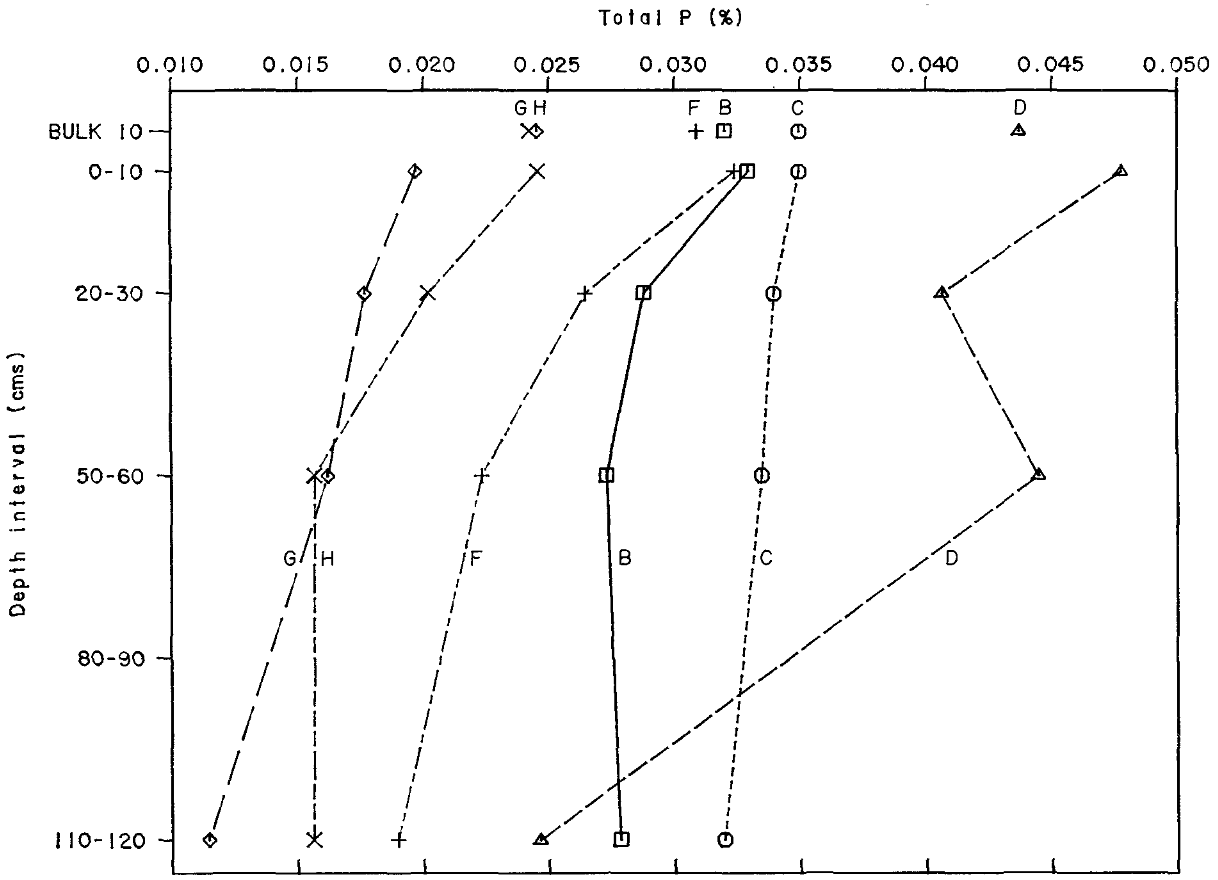


Figure 4.17 shows mean total phosphorus values for some soils plotted by depth. The clay soils (B,C) supporting mainly grasses, have relatively uniform mean total phosphorus values with depth with only slightly higher mean surface values. The texture contrast soils (D), supporting gidgee, and red earths (F,G) supporting mulga, have a sharply declining mean phosphorus trend with depth. The higher surface values for these groups is attributed to trees extracting phosphorus from the profile and then depositing it on the surface via litter fall. While a "biological pumping action" operates for all plants (Norrish and Rosser 1983), data obtained in this survey indicates that shrubs and trees are more efficient at nutrient recycling than grasses.

The mean values for the red, brown and grey clays on the plains (A) are similar to the loamy red earths (F) with little difference between the Mt. Pleasant (A1) and Yo Yo (A2) soil profile classes. The siliceous sands (I) have the lowest values of the survey (mean surface value = 0.02% P), but these are higher values than those recorded by Stace *et al.* (1968). This is attributed to the alluvial influence on some sites. Siliceous sands from desert dune systems generally have mean values in the order of 0.01% P (Ahern and Wilson 1990).

Using pot experiments for exotic perennial grasses, Winkworth (1964) found responses to added phosphorus on red earth, mulga woodland, and spinifex sand plain soils from the Alice Springs area. He concluded that introduction of exotic perennial grasses on these soils would be severely hampered by phosphorus deficiency. The total phosphorus values for these central Australian soils was about 0.01% P using boiling HCl extract (approximately 0.015% P by x-ray).

In the present survey, the loamy red earths (F) and the surface of the sandy red earths (G) supporting mulga, have higher total P than Winkworth's soils, but the earthy sands (H) and the siliceous sands (I) have similar or lower values. Thus total P values for earthy and siliceous sands (H,I), and some sandy red earths (G) may limit growth of some exotic perennial grasses and probably native species as well.

Extractable phosphorus

Two methods of determining extractable phosphorus were used in this survey:

- Acid extractable (0.005% M H_2SO_4) - generally useful on acid soils. Bruce (1966) concluded it was a preferable method for use in tropical pastures in north east Queensland.
- Bicarbonate extractable (0.5M $NaHCO_3$ adjusted to pH 8.5) - can be considered a better estimate of plant response on neutral to alkaline soils, (Colwell 1963).

For all surface samples of this survey, the ratio of bicarb. P/acid P is negatively correlated with lab pH (r_{249} = -0.48***) and exchangeable calcium (r_{167} = -0.42***). A stronger correlation between bicarb. P/acid P ratio and lab pH (r_{91} = -0.60***), and exch. Ca (r_{63} = -0.60***), exists for the surface soils of neutral to strongly alkaline alluvial soils (B,C,D).

Graham (1955) states conditions such as high calcium carbonate and calcium salt levels in soils lead to low availability of natural phosphate. The clay soils (B,C,A2) of this survey often have gypsum or carbonate present. Srivastava and Pathak (1968) concluded that an extractant dissolving only aluminium and iron bound phosphates (bicarbonate extraction) would be best for determining available P on calcareous soils. The acid extraction method dissolves calcium phosphates which are generally unavailable to plants in alkaline soils. Thus the bicarbonate test is a better indication of plant available phosphorus on alkaline soils.

Mean ratios of bicarb. P/acid P on surface soils of the soil groups vary from 0.54 on the alluvial clays (B) to 0.85 on the loamy red earths (F) (Table 4.6).

The red earths (F,G), texture contrast soils on the plains (E) and earthy sands (H) have mean bicarb.P/acid P ratios between 0.75 and 0.85, which is considerably higher than that for alluvial soils. These soils have mean pH of 6.0 or less in the upper profile, and either test may be acceptable for interpretation of phosphorus availability.

On a vegetation basis, soils supporting grasslands generally have lower bicarb/acid P ratios than woodland or shrubland soils, even within a soil group such as alluvial clays (B). This is demonstrated by the very low mean ratio (0.36) for the Noorama SPC, which supports Mitchell grass.

Simple linear regression equations relating bicarb. P to acid P for the surface soils are given for most soil groups and some combinations of soil groups in Table 4.6. Equation (1) for all sites would not be appropriate for relating the two extractable phosphorus soil tests, due to large pH differences between alluvial soils and the coarser textured soils. Equation (2) is suitable for alluvial soils (B,C,D) and equation (3) is suitable for the coarser textured soils (E,F,G,H,I,J). Note the substantial difference in slope and intercept values between equations (2) and (3). Data for the sedentary clays (A2, A3) is limited but values are closest to the alluvial soils.

The practical application of these relationships is that if a soil can be placed into one of two broad groups, a good estimate of bicarb. P can be obtained from acid P values using either equation (2) or (3). [Much of Queensland Department of Primary Industries historic records contain acid P values only.]

Interpretation of extractable P results from this survey are general only, as most soil test calibrations have been done on crops in wetter areas and little is known about phosphorus requirements of the native vegetation in arid and semi-arid regions. However, Christie (1975) has shown 25 ppm (acid P) to be a critical level for buffel grass establishment on a red earth from the Charleville area.

Acid P

The distribution of acid extractable phosphorus for soil groups is given in Chem table microfiche, D.01 and for soil profile classes O.08. Values range from 1 ppm on some of the coarse textured groups (E,F,G,H) to 380 ppm on a sample from the texture contrast groups on alluvia (D). Large differences between individual soil profile classes within the red, brown and grey clay (A), alluvial clay (B) and earthy sand (H) soil groups occur. Some discussion of these differences appear in Chapter 3 under their respective soil group headings.

The chief influences on acid P levels are parent material and vegetation. The alluvial soils (B,C,D) in Figure 4.18 have the highest mean values for acid P while the soils with Quaternary/Tertiary influence (E,F,G) have considerably lower mean acid P values.

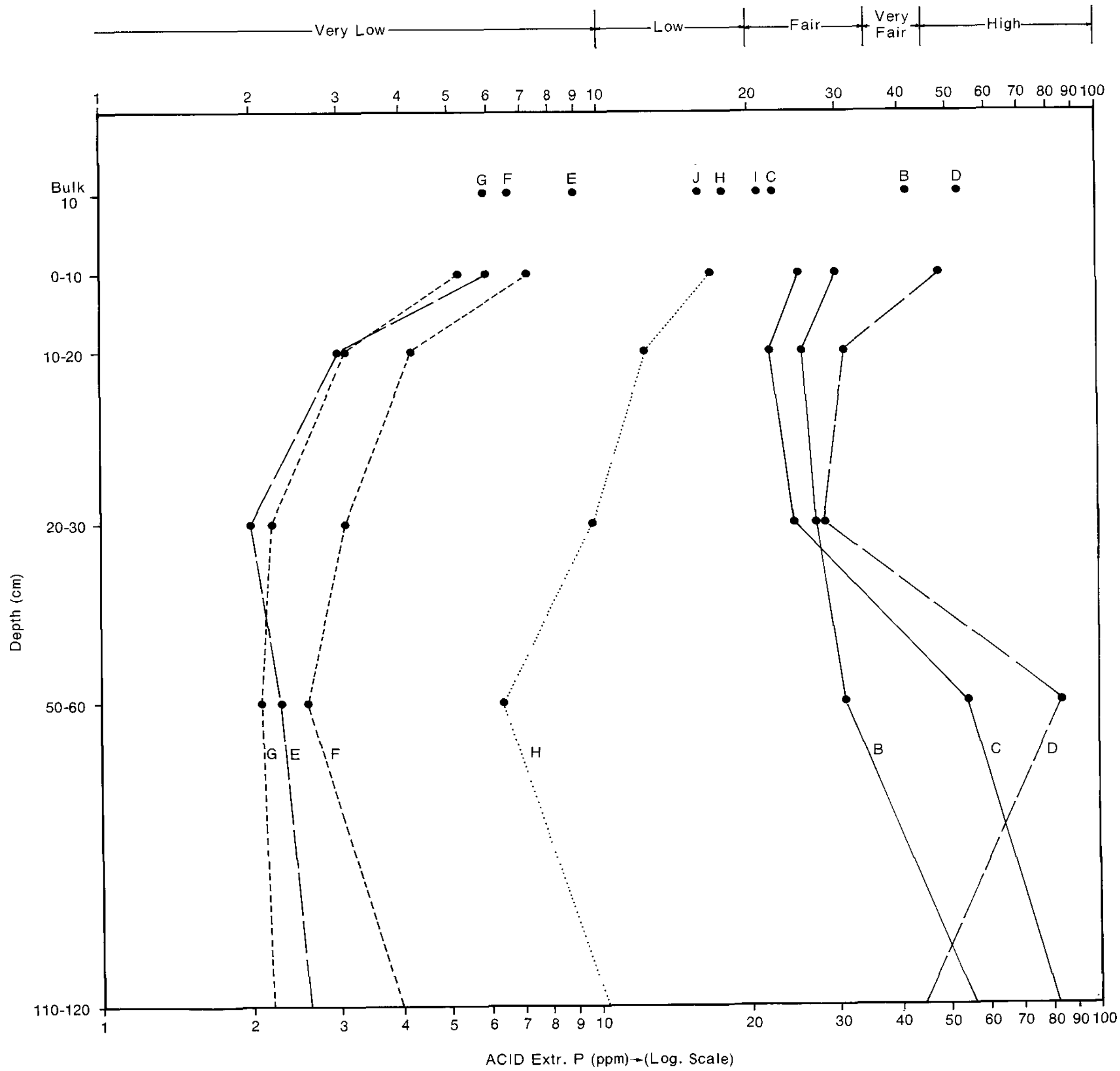
The earthy sands (H) have mean acid P values midway between these two groups. The two SPC's making up group (H), have very different values. Bowra SPC, which has a strong alluvial influence, has higher values than Myola SPC, which supports mulga vegetation. Significant differences between phosphorus values of soils developed from the same parent material, but having different vegetation, have also been documented by Ahern and Macnish (1983) for soils on the Darling Downs, well to the east of the present survey.

Table 4.6 Linear regression equations relating bicarbonate P with acid P for surface samples.

Grouping	Equation	Correlation coefficient	No. of values	Ratio BP/AP
1 All sites	BP = 0.41AP + 36	0.89***	251	0.71
2 Alluvial Soils (B,C,D)	BP = 0.35AP + 7.5	0.81***	93	0.57
3 Coarser Textured Soils (F,G,H,I,J)	BP = 0.58AP + 1.1	0.95***	132	0.80
4 Mulga Soils (A1,F,G)	BP = 0.625AP + 0.8	0.88***	100	0.84
5 Red Earths (F,G)	BP = 0.63AP + 0.7	0.88***	95	0.825
6 Alluvial Clays (B)	BP = 0.34AP + 6.8	0.81***	74	0.54
7 Texture Contrast on Alluvia (D)	BP = 0.405AP + 12.8	0.90***	15	0.67
8 Texture Contrast on Plains (E)	BP = 0.75AP + 0.5	0.94***	15	0.84
9 Loamy Red Earths (F)	BP = 0.64AP + 0.8	0.89***	71	0.85
10 Sandy Red Earths (G)	BP = 0.48AP + 1.2	0.82***	24	0.75
11 Earthy Sands (H)	BP = 0.55AP + 1.8	0.96***	20	0.78
12 Siliceous Sands (I)	BP = 0.61AP + 1.5	0.97**	6	0.68

*** P, 0.001; ** P, 0.01

Figure 4.18 Mean acid extractable phosphorous of soil groups by depth



In this survey, vegetation has a noticeable effect on low acid P soils by concentrating extractable P in the surface, via a biological pumping action as discussed earlier in the total P section. A sharp decrease below the surface is shown for the red earths (F,G) and texture contrast soils on the plains (E) (Figure 4.18). These three soil groups are dominated by mulga or mulga/boxwood low woodlands.

An additional effect of vegetation (trees) in arid areas, is the lateral relocation of phosphorus in relation to under canopy and between canopies. Ebersohn and Lucas (1965) showed surface acid P values were extremely low between poplar box trees, but had up to a twentyfold increase in values beneath the canopy. The corresponding extractable potassium values changed less than threefold.

Fluctuations of surface values (0-10 cm) from the profile sampling can often be attributed to location in relation to tree canopies. Taking of a bulk 0-10 cm surface sample (nine cores taken fifteen metres apart on a triangular course) smooths out localised effects and gives a better assessment of the surface soil phosphorus than the single 0-10 cm sample from the profile. Mean acid P values for soil groups (F,G) for the bulk surface samples (B 0-10) are within 0.6 ppm of their respective mean (0-10) value from profile sampling (Figure 4.18). These groups have large numbers of sites. The texture contrast soils on the plains (E) have only three analysed profiles with profile (0-10) values (fifteen sites with bulk surface values) and have 3 ppm acid P difference between the mean bulk surface and mean profile (0-10) values (Figure 4.18). Thus, if large numbers of samples are involved, the bulk surface and profile (0-10) samples give close results for the surface mean of the soil group. Bulk surface sample is subject to less variation in assessing site fertility when sample numbers are low.

The acid extractable phosphorus values for the red earths (F, G), texture contrast soils on the plains (E) and Myola SPC (H2) of the earthy sands are very low to low. Thus phosphorus is likely to limit growth and establishment of introduced and native pastures, except in favorable microhabitats as stated by Christie (1975). Pressland (1982b) found addition of phosphorus to a mulga soil with 15 ppm acid P improved water use efficiency of three grasses native to mulga lands and one exotic grass (*Anthephora pubescens*). Pressland (1982a) found that a more water efficient exotic species had slow growth and could not compete with native species except under higher soil phosphorus levels than those normally found in the mulga country of south west Queensland.

On the alluvial soils, Bundaleer SPC (B5) and the texture contrast soils (D) supporting gidgee, show a concentration of acid P in the upper profile due to nutrient cycling. Acid P values are much higher than for the mulga lands, and surface phosphorus values are unlikely to be a limitation to pasture establishment.

Clearing of gidgee areas for buffel establishment would need to be approached carefully due to low P values below the surface on many profiles. Gidgee clearing and buffel establishment on higher P soils near Blackall has been a success. However, soils with a lower P profile were not successful after the first few years. Presumably problems began when surface P was used up.

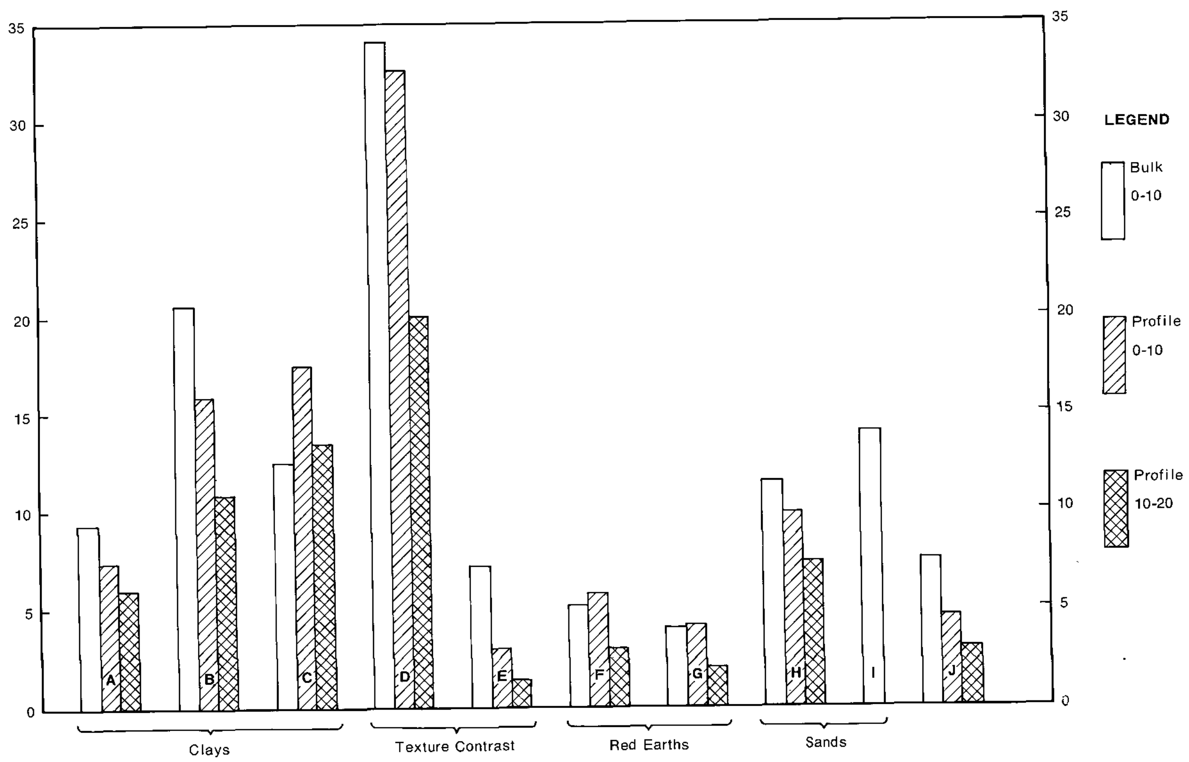
Bicarbonate extractable phosphorus

The distribution of bicarbonate extractable phosphorus for soil groups and profile classes is given in Chem table microfiche$_1$ F.01 and D.09. Values range from 1 ppm on some coarse textured soils, to 68 ppm on the alluvial clays (B). Figure 4.19 shows mean bicarb. P for each soil group.

The red earths (F,G), texture contrast soils on plains (E), and lithosols (J) all have very low bicarb. P values. Both acid and bicarb. P values are closely related on these soils (see regression equation 3, Table 4.6) and either extractable P test may be used for interpretation since the soils are acid to neutral. The siliceous sands (I) and earthy sands (H) have higher bicarb. P values than the red earths, etc., attributed to alluvial influence.

The bicarb. P test is more suitable for P interpretation on alkaline soils (see earlier discussion). Highest bicarb. P values occurred on the alluvial soils (B,C,D). Within these soil groups, values are generally low to high on the woodlands (B1,B2,B5,D), while the grasslands (B3,B4) had very low to low values. Field observations show these grasslands produce high quality native pasture when soil moisture conditions are adequate (see discussion on alluvial clays in Chapter 3).

Figure 4.19 Mean bicarbonate extractable phosphorous of soil groups to 20 cm



Sorn-Srivichai *et al.* (1984) found Olsen P values (bicarb. P) decreased in limed soils, but yield and P uptake by ryegrass were not affected. They concluded that when high concentrations of calcium are involved, reduced P levels are an artifact of the Olsen method, but phosphorus availability to plants was unaffected.

The alluvial soils have neutral to alkaline pH values with high calcium levels. Gypsum is often present in quantity. It is probable on these soils that the bicarb. P test underestimates P availability to native pastures, making it difficult to select the most appropriate extractable P test for alluvial soils.

POTASSIUM

Total potassium

Total potassium for the survey area ranges from 0.13% on the siliceous sands (I) to 1.53% on the alluvial clays (B). The distribution of total K by depth for soil groups and soil profile classes are given in Chem table microfiche$_1$ J.02 and G.11.

Figure 4.20 shows mean total K by depth for soil groups. By comparison with Figure 4.11 it can be seen that potassium values follow clay content, with exceptions being attributed to parent material differences.

In Figure 4.20, the plot of mean total K of soil groups by depth, the alluvial soils (B,C,D) have highest total K. Yo Yo SPC (A2), not plotted, also has similar mean total K values to group B. Mean clay content (compare Figure 4.11 with 4.20) and clay activity or parent material source, appear to be strongly related.

For all surface soils total K is highly correlated with laboratory pH, clay%, air dry moisture %, CEC, sum of cations, -1/3 bar, -15 bar and available water capacity (see Table 4.7). Thus, total K has highest values on alkaline, base saturated, high clay content soils, and lowest on acidic, leached soils of low clay content. The correlation with CEC/clay ratio was very poor.

Table 4.7 Correlation of total potassium with various factors for bulk surface and profile samples.

Factor	Bulk Surface Sample (n = 169)	Profile (n = 273)
	r	r
Lab. pH	0.80***	0.39***
Clay	0.80***	0.32***
A.D. moist.	0.75***	0.35***
CEC	0.82***	0.41***
Sum of cations	0.83***	0.42***
CEC/Clay	0.26***	0.60***
Base Saturation	0.71***	0.38***
Ca	0.80***	0.55***
Mg	0.82***	0.24***
-1/3 bar	0.81***	0.39***
-15 bar	0.77***	0.37***
AWC	0.81***	0.38***

*** P <0.001

When the profile correlations are examined (Table 4.7), CEC/clay ratio is the highest correlated factor, while clay and moisture characteristics correlations are much lower. Since CEC/clay is an indicator of clay activity in non-surface horizons, total K values may be influenced by clay type or parent material.

Mt. Pleasant SPC (A1) has similar mean total K and clay percentage to the loamy red earths (F). Both these soils (A1) and (F) have considerably lower total K than texture contrast soils on alluvia (D) (Figure 4.20) despite higher clay content. Parent material differences are probably the cause of the texture contrast soils on alluvia having higher total K than the red clays (A1) and loamy red earths (F) which are derived from redistributed Quaternary erosion products. CEC/clay ratios for (A1) and (F) are substantially lower than group (D), see Figure 4.5.

Within the earthy sands group (H), the Bowra SPC (H1) has more than double the total K values of the Myola SPC (H2) despite lower clay content. This is also attributed to parent material influence as Bowra SPC is associated with alluvia, while Myola SPC has similar parent material as the red earths. In Figure 4.20 the sandy red earths (G) and the earthy sands (H) have similar mean total K. This is because the higher values from Bowra SPC (H1) increase the mean for the soil group (H).

The change in total K from loamy red earths (F) to sandy red earths (G) to Myola SPC (H2) is in rough proportion to the difference to clay content. The soils have similar parent material and belong to the mulga land zone.

Correlations between soil tests for potassium

Total potassium of all bulk surface samples is significantly correlated with exchangeable (r_{167} = 0.84***) and replaceable potassium (r_{167} = 0.85***).

The correlation of exchangeable K with total K for profile samples is much lower (r_{270} = 0.36***) probably because exchangeable K usually decreases with depth while total K values have little change with depth. Also, total K may increase with depth on soils such as texture contrast soils (D) which have increasing clay content down the profile (see Figure 4.20).

Table 4.8 shows the correlation coefficients of total K with exchangeable and replaceable K for "alluvial", coarser textured, mulga dominant, and some individual soil groups. The earthy sands (H) have non-significant relationships. This is attributed to parent material differences between soil profile classes within the group. Correlations between exchangeable and replaceable potassium are highly significant (P <0.01) for all groupings except the earthy sands, showing a close correspondence between the two methods. The mean ratio of repl. K/exch. K is 0.78 for all surface soils, with a trend for the very sandy soils to have a higher ratio.

Figure 4.20 Mean total potassium of soil groups by depth

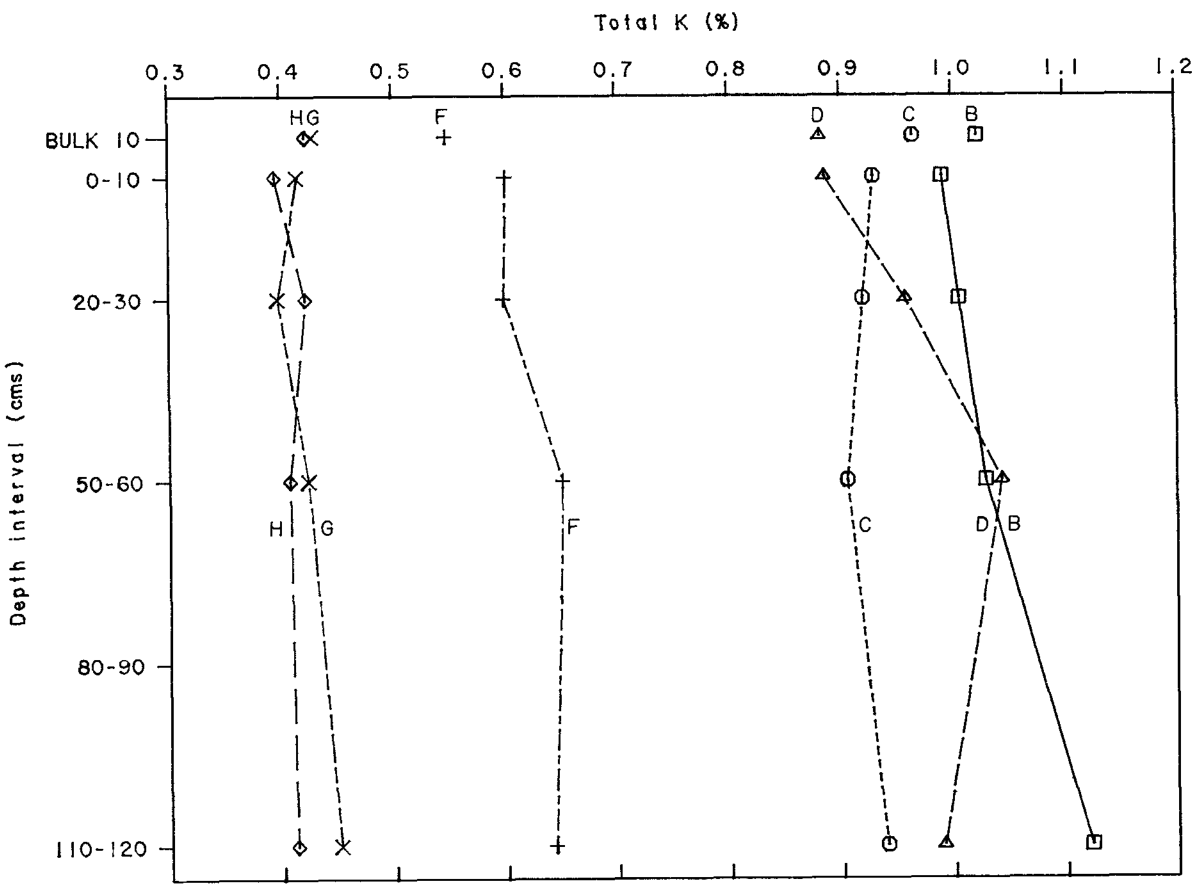


Table 4.8 Linear correlation coefficients of soil potassium tests for bulk surface samples.

	n	r TK with EK	r TK with RK	r EK with RK
Combination of soil groups				
All sites	169	0.84***	0.85***	0.95***
Alluvial soils (B, C, D)	65	0.82***	0.80***	0.95***
Coarser Textured Soils (F,G,H,I,J)	89	0.60***	0.70***	0.86***
Mulga Dominant (A1, F, G)	64	0.63***	0.70***	0.82***
Individual soil groups				
Alluvial Clays (B)	51	0.82***	0.79***	0.95***
Texture Contrast Soils on Alluvia (D)	12	0.88***	0.91***	0.96***
Texture Contrast Soils on plains (E)	9	0.93***	0.75*	0.88**
Loamy Red Earth (F)	42	0.46**	0.62***	0.73***
Sandy Red Earths (G)	20	0.80***	0.76***	0.90***
Earthy Sands (H)	14	0.09^{NS}	0.51^{NS}	0.46^{NS}
Siliceous Sands (I)	5	0.88*	0.79^{NS}	0.98**

*** P <0.001; ** P <0.01; * P <0.05; NS P >0.05.
TK = Total K, EK = Exch K, RK = Repl K.

For surface soils in this survey area, the regression equation,

exch. K = 1.26 repl. K + 0.01 (r_{167} = 0.95***)

can be confidently used to predict exchangeable potassium from replaceable potassium which is more commonly supplied by Queensland Department of Primary Industries.

At low repl. K values (0.2 m. equiv./100 g) on sandy soils there is an approximate 1:1 relationship. Thus for practical purposes either measurement may be used on sandy soils.

Exchangeable and replaceable potassium

The use of chemical extractants to predict plant response is limited by the soils' ability to provide, at different rates, variable amounts of non-exchangeable potassium. This ability is both soil and plant specific. Graley (1981) found availability of potassium was dependent on the cropping system, the particular plant species and soil type.

Various critical levels have been suggested for exchangeable or replaceable potassium, but usually values quoted relate to pot experiments on particular crops or soils and few generalisations are justified. The value of 0.2 m. equiv./100 g soil (exch. K) as a critical level is common (Williams and Lipsett 1960, Piper and de Vries 1960, Crack and Isbell 1970, etc). Graley and Nicholls (1979) suggested a range of 0.2-0.4 m. equiv./100 g soil (exch. K) as marginal levels. This is supported by Young (1976) on tropical soils.

For replaceable potassium, von Stieglitz (1953) uses 0.2 m. equiv./100 g as a critical level on Queensland sugar cane soils. Skene (1956) uses 0.3 m. equiv./100 g K as a marginal level for loams and clay loams and 0.25 for sands and sandy loams for Victorian pastures. Sobulo (1983) found 0.32 m. equiv./100 g HCl extractable K and 0.38 m. equiv./100 g ammonia acetate exchangeable K, were critical soil levels for maize on a range of Nigerian soils. He also found the two extractants were highly correlated.

The distribution of exchangeable potassium by soil groups and profile classes is shown in Chem table microfiche, G.01 and F.09. Surface exchangeable potassium values range from 2.7 m. equiv./100g for an alluvial clay (B) to 0.09 m. equiv./100 g K on a siliceous sands (I). Values decrease down almost all profiles. The lowest profile value recorded was 0.03 m. equiv/100 g K on an earthy sand (H).

Only 3.6% of surface sites are less than 0.2 m. equiv./100 g exch. K (mainly the earthy sands [H] and siliceous sands [I]). Soil potassium levels are adequate for the other soil groups as shown by the bar graph of mean exch. K for soil groups (Figure 4.21). Low values may occur on the sandy red earths (G), particularly below the surface.

If marginal values (0.2-0.4 m. equiv./100 g K) are considered, some loamy red earth (F), many sandy red earth (G) and most earthy sands (H) sites, fall within this category.

The distribution of replaceable potassium by soil groups and profile classes is shown in Chem table microfiche, C.01 and M.08.

Replaceable K results for bulk surface samples on an additional 82 sites beyond the 169 analysed for both repl. and exch. K were available. When the criteria for critical and marginal levels of repl. K discussed earlier are applied, results closely follow those discussed for exch. K.

MOISTURE CHARACTERISTICS

Air dry moisture

Air dry moisture (ADM) can readily be determined using only limited equipment, such as a temperature controlled oven and weighing facility. It can be a useful indicator of clay content, cation exchange capacity or of other moisture characteristics. Shaw and Yule (1978) developed a regression equation for calculating plant available water capacity (PAWC) using air dry moisture, which was suitable for clays of the Emerald Irrigation Area. Air dry moisture correlates well with available soil water capacity (AWC) of this survey (Table 4.9) but no field measurements of PAWC are available.

In this survey, mean air dry moisture of soil group profiles (Figure 4.22) reflects cation exchange capacity (see Figure 4.4) closer than clay content (see Figure 4.11). This is also verified in the linear regression equations for estimating CEC and clay content from ADM for all profile samples (see Table 4.9).

ADM % is a better prediction of CEC than clay content on these soils because there is a distinct difference in CEC/clay ratio between the more active clays (A2, B, C, D) and the lower activity red clays (A1), red earths (F, G) and some of the earthy sands (H2) (see Figure 4.5). In addition, on the coarse textured soils (F, G, H, I, J) grouping, ADM is significantly correlated with silt % (see Table 4.9) although both slope and intercept for the silt equation are less than half that for the clay equation.

In summary, a relatively simple, low cost test (air dry moisture) is a useful approximate guide to clay and CEC content of these soils.

The distribution of ADM % by soil group and profile class is given in Chem table microfiche, O.03 and B.14. Values range from 10.9% on the sedentary clays (A2) to 0.4% on the siliceous sands (H2).

In Figure 4.22 the red clays with mulga (A1) are not shown, but their mean ADM values are less than the loamy red earths (F) for other than the bulk surface. For the red clays with mulga, mean ADM % down the profile reflects the plot of CEC by depth (Figure 4.4).

There is a gross difference in ADM % between Mt. Pleasant SPC (A1) and Yo Yo SPC (A2). This identifies not only some difference in clay%, but also large differences in CEC and clay activity (CEC/clay). By combining a relatively simple ADM test with field texture, it is possible to identify soils with different clay activities and indicate different parent material.

Table 4.9 Linear regression equations for predicting characteristics from air dry moisture of the form (y = a + bx) using profile values; where x = ADM %.

	a	b	regression coefficient
All soils Profiles			
Clay%	12.2	5.61	r_{277} = 0.82***
CEC m.equiv./100 g	2.24	4.09	r_{272} = 0.90***
Sum of cations	-2.86	5.03	r_{272} = 0.92***
AWC	2.18	1.9	r_{220} = 0.84***
Alluvial (B,C,D) Profiles			
Clay%	14.05	5.67	r_{146} = 0.72***
CEC	7.73	3.38	r_{144} = 0.75***
Sum of cations	4.36	4.07	r_{144} = 0.81***
AWC	5.25	1.45	r_{110} = 0.64***
Coarser Textured Profiles (F,G,H,I,J)			
Clay	11.46	4.68	r_{106} = 0.65***
Silt	3.67	2.09	r_{106} = 0.60***
CEC	2.87	2.71	r_{104} = 0.85***
Sum of cations	-1.65	3.08	r_{104} = 0.85***
AWC	0.98	2.07	r_{88} = 0.70***

Available soil water capacity

Available soil water capacity (AWC) is conventionally estimated as the difference between water held at -1/3 bar and -15 bar matrix potentials on disturbed samples using a pressure plate apparatus in the laboratory.

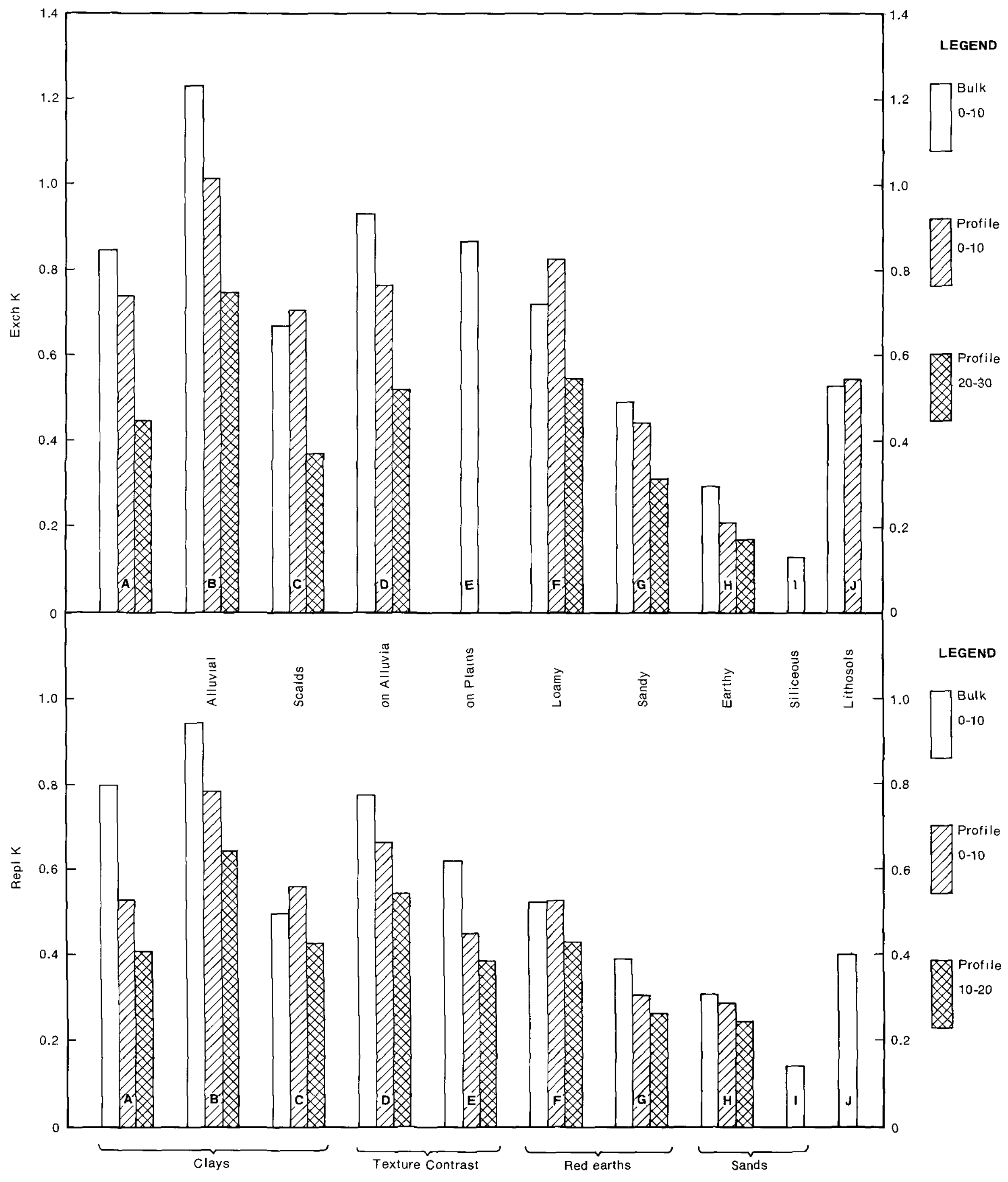
The -15 bar measurement is meant to approximate wilting point. McCown (1971) found -15 bar moisture content provided a good estimate of the lower limit of available water on freely drained profiles. It can underestimate the real lower storage limit in the lower part of the root zone due to insufficient root length density (Ritchie *et al.* 1972). However, some native trees in this region, such as mulga, have been shown to extract water at much greater matrix potentials than -15 bar.

Winkworth (1973) points out that mulga tissue is capable of withstanding low water potentials, and can extract soil water to -120 bar. Burrows (1973) showed that 100% of mulga seedlings survived on rewatering after being subjected to soil water potentials of -500 bar. Pressland (1982b) says it is probable that photosynthesis and growth are negligible when tissue water potentials fall below -15 bar.

The -1/3 bar measurement is subject to controversy in its ability to emulate field capacity. Shaw and Yule (1978) have shown the -1/3 bar measurement overestimates the water held by clay soils, particularly at depth. Hall and Heaven (1979) state that measurement of field capacity in swelling clay soils is thought to be impossible due to delayed wetting of the profile. Clay soils wet very slowly and as they expand they have the ability to hold more water. For sandy and permeable soils, Hall and Heaven (1979) suggest that drainage is a continuous process and that there is a significant moisture loss after 48 hours in the absence of further rainfall, making it difficult for a recognisable field capacity to be achieved on many soils. Gardner (1971) states that the difference between -1/3 and -15 bar measured in the laboratory is not a satisfactory measure of available water. Peterson *et al.* (1971) state that for general soil characterisation and the problem of relating data to other studies, the selection of -1/3 bar and -15 bar measurements is desirable until soil physicists can propose (with some degree of unity) another system of simple measurement.

Taking into account the above limitations, -1/3 bar and -15 bar laboratory measurements and their difference (AWC) are used to discuss moisture characteristics of soils in this survey.

Figure 4.21 Mean exchangeable and replaceable potassium of soil groups to 20 cm



For all surface soils, -1/3 bar and -15 bar moisture are highly correlated (r_{120} = 0.98***) and similarly for all analysed samples (r_{397} = 0.98***). A comparison of Figures 4.24 and 4.25 shows a strong similarity between the mean values of -1/3 bar and -15 bar for the soil groups with depth. The relative positions of the soil groups and their trends with depth are almost identical. The plot of available soil water capacity (AWC) with depth, (Figure 4.23) also has great similarity.

For surface soils available soil water capacity is highly correlated with clay% and CEC for all soils (see Table 4.10) and most individual soil groups. AWC is also highly correlated with silt for all soils, but the correlation coefficient is lower than that for clay or CEC.

When the soils are grouped in "alluvial" and coarser textured soil categories, silt is not correlated with moisture characteristics on the alluvial soils (see Table 4.10) but highly correlated with moisture characteristics on the coarser textured soils grouping.

Of the soils in the coarser textured grouping, the sandy red earths (G) have the highest correlations of silt with AWC (r_{11} = 0.74**), -1/3 bar (r_{11} = 0.88***) and -15 bar (r_{11} = 0.91***). The loamy red earths (F) have moderate correlations. The earthy sands (H) have silt correlated with -1/3 bar (r_9 = 0.82**), AWC (r_9 = 0.63**), but not -15 bar. Thus, silt appears to be an important factor in water retention properties of the coarser textured soils.

The distribution of -1/3 bar moisture, -15 bar moisture and available soil water capacity by depth for the soil groups are shown in Chem table microfiche$_1$ H.04, J.04 and L.04. The distributions by soil profile classes are shown in Chem tables microfiche$_1$ D.15, G.15 and H.15. Values for AWC range from 21% on the alluvial clays to less than 1% on siliceous sands.

The cracking clay soils (A2, A3, B2, B4) when dry, have high infiltration rates due to cracks, but on wetting, the soil swells, closing cracks, and infiltration rates are reduced. The clay soils have medium to very high AWC and when wet to depth, supply sufficient water for plant growth for many months. Some of the alluvial cracking clays are subject to flooding, resulting in a complete wetting of the profile. While these soils are highly productive, they do not hold as much moisture as the heavy clays of the Channel Country do after flooding.

When the cracking clay soils are dry, they require heavy falls of rain to wet them beyond field capacity, as shown by their high -15 bar moisture. The alluvial clays with lighter textured surfaces, Tego (B1), Wallal (B3) and Bundaleer SPC (B5) have lower AWC in the surface increasing with depth. These soils take less rain than the heavier cracking clays (B2, B4) to wet beyond field capacity as shown by their -15 bar moisture values. They are highly regarded by the graziers because they respond to moderate rainfall, which is more common than the higher rainfall necessary to wet the heavier clays when dry.

The texture contrast soils on alluvia (D) have lower water holding capacity than the clays, particularly in the surface, but can be wet by moderate rainfall as shown by -15 bar measurements. While having very low to medium surface available moisture, values increase with depth due to higher clay content.

The scalds (C) have lower AWC than the alluvial clays (B) mainly due to lower clay content. These soils are bare or close to bare and have hard setting surfaces, low infiltration rates and high run off. As a result, actual water storage would normally be much lower than that suggested by laboratory measurements. Low AWC may be a contributor to the scald process, but not necessarily a causal factor. The natural tendency to form hard setting surfaces seems mainly associated with particle size distribution (high silt and fine sand) and other factors such as overgrazing, wind and water erosion are contributing factors in scald formation.

Most of the loamy red earths (F) have low AWC (mean bulk surface value = 6.4%) with little change in the mean value with depth. Maxvale SPC (F3) has higher AWC than the other SPC's due to increasing clay content with depth. This SPC (F3) often has hardpan development between 40-80 cm, limiting water movement. Thus, although laboratory values indicate increasing AWC with depth, many profiles would normally only wet to shallow depths, limiting the amount of moisture stored. Earlier results for cations, EC and chloride values confirm the reduced water movement in the profile when hardpans are encountered. The other SPC's (F1, F2) decrease in AWC with depth due to a drop off in organic matter below the surface.

Since loamy red earths (F) often have hardsetting surfaces, water loss through run off can be a problem, depending on the position in the landscape. Soils which receive run on water generally support dense mulga. Where lands are in good condition, the loamy red earths can respond to lighter falls of rain and are important in providing short term feed after moderate falls of rain.

Figure 4.22 Mean air dry moisture of soil groups by depth

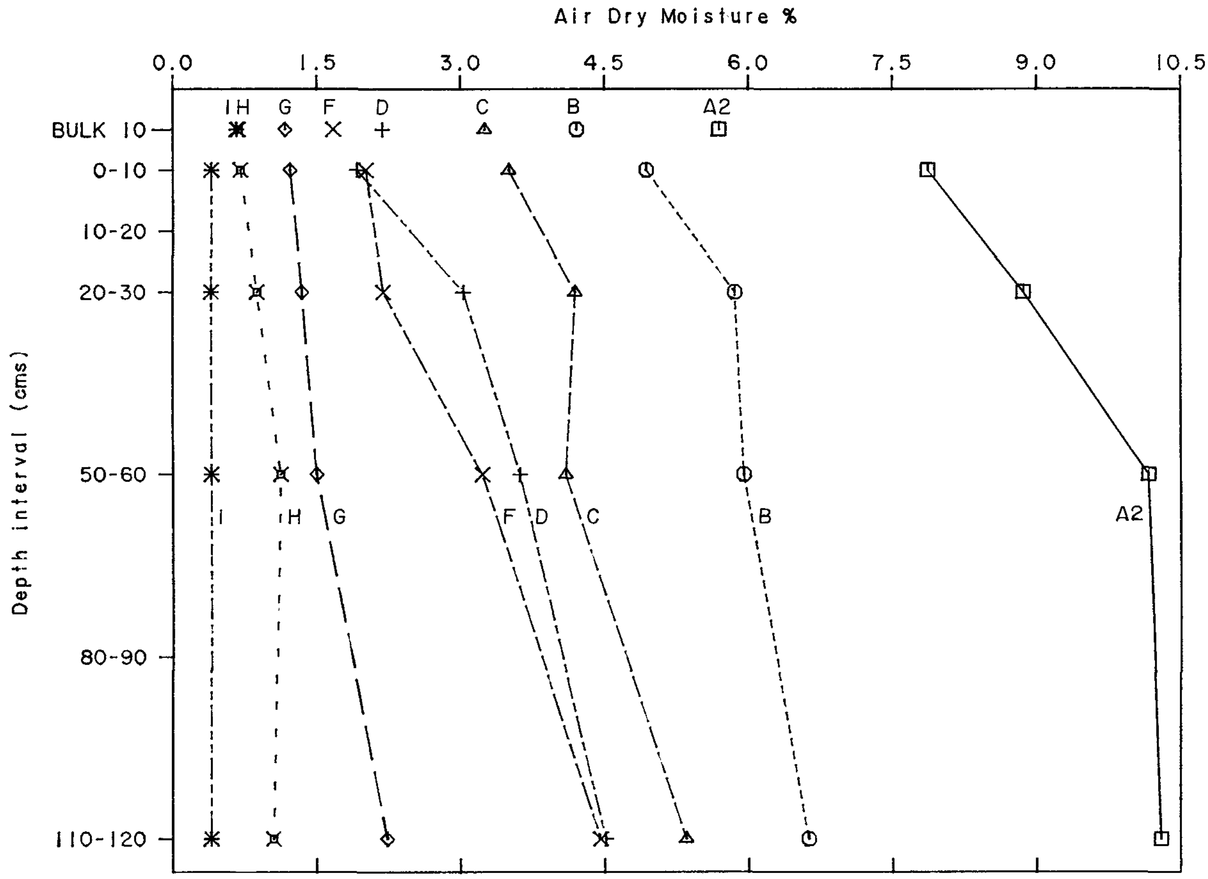


Figure 4.23 Mean available soil water capacity (AWC) of soil groups by depth

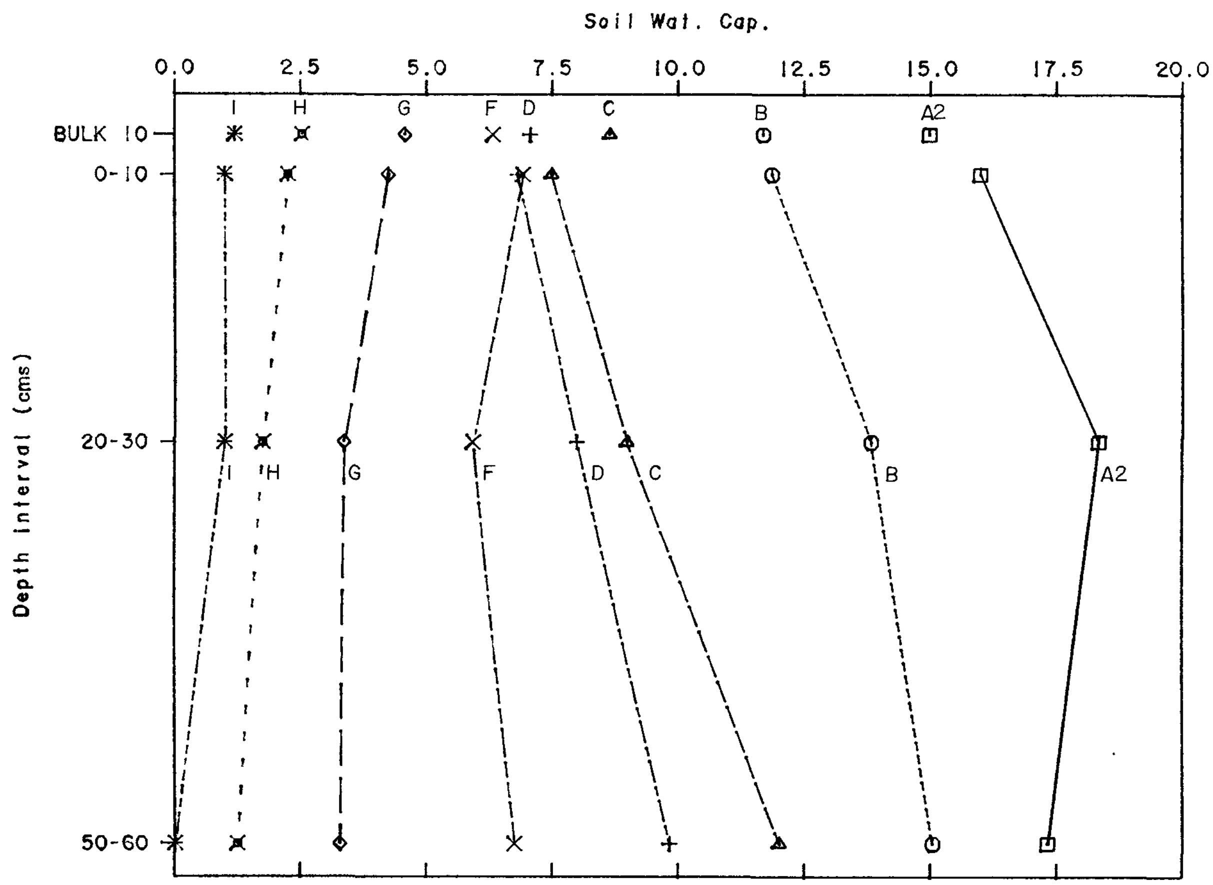


Figure 4.24 Mean - ⅓ bar moisture characteristic of soil groups

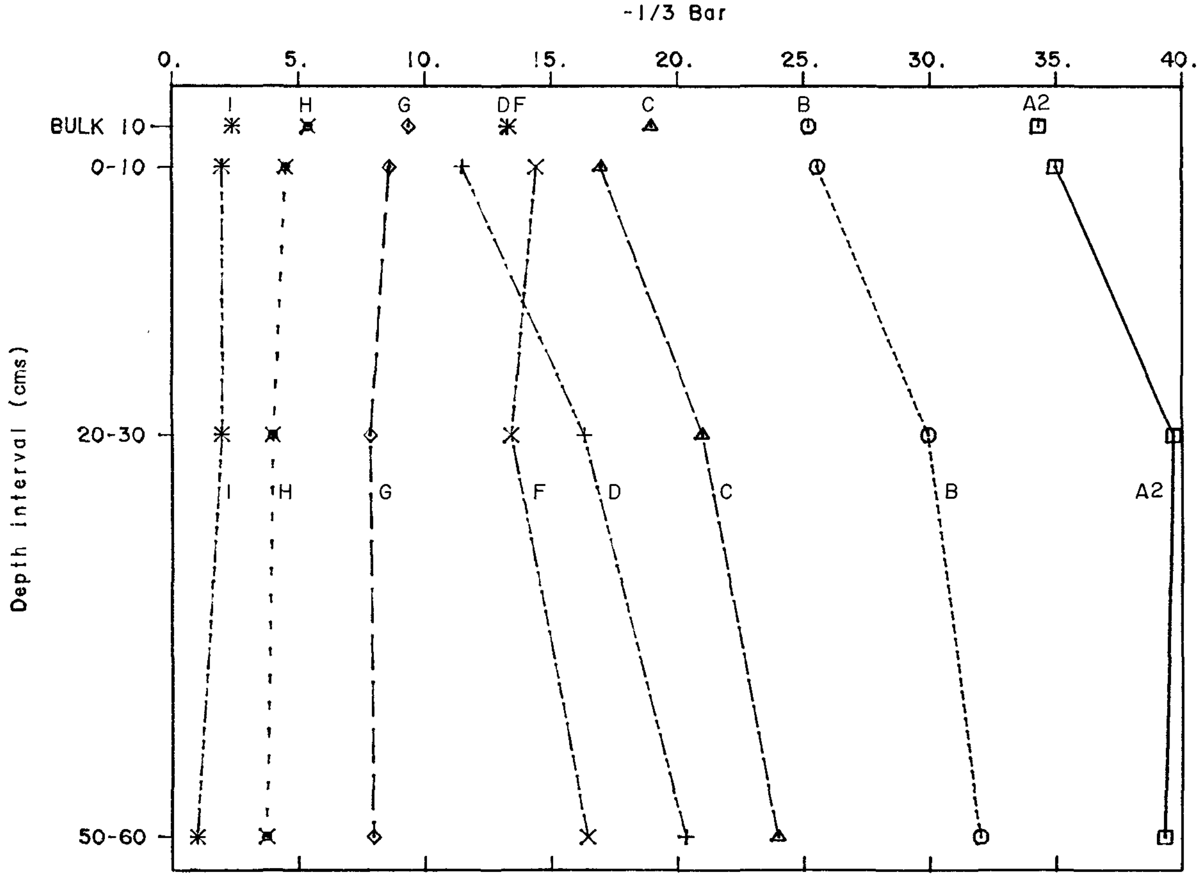
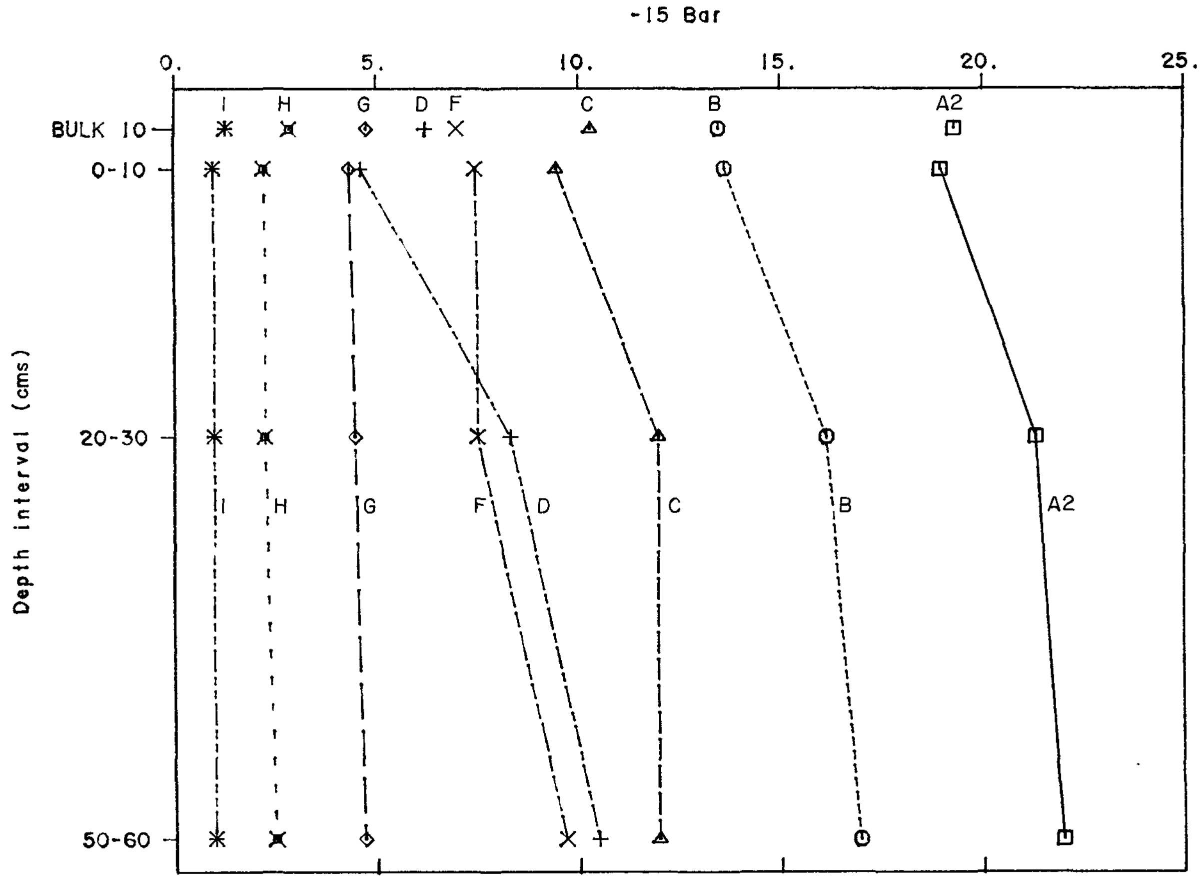


Figure 4.25 Mean -15 bar moisture characteristic of soil groups



The sandy red earths (G) have very low to low AWC (mean bulk surface value = 4.6%) with values generally decreasing with depth. Some run off can be expected as surfaces are hardsetting, however it takes little water to wet these soils to greater than wilting point (bulk surface value, -15 bar = 4.8%). Response to light rain is usually quick, but short lived, due to the low waterholding capacity of the soil.

Table 4.10 Correlation coefficients of moisture characteristics (-1/3, -15, AWC) with clay, silt and CEC for bulk surface samples.

	-1/3 bar(%)	-15 bar(%)	AWC(%)
All soils (n = 122)			
Clay (%)	0.95***	0.95***	0.87***
Silt (%)	0.49***	0.46***	0.49***
CEC (m. equiv %)	0.96***	0.96***	0.90***
Alluvial Soils (B,C,D) (n = 41)			
Clay (%)	0.96***	0.97***	0.87***
Silt (%)	0.19^{NS}	0.18^{NS}	0.20^{NS}
CEC (m. equiv %)	0.96***	0.96***	0.89***
Coarser Textured Profiles (F,G,H,I,J) (n = 67)			
Clay (%)	0.86***	0.85***	0.69***
Silt (%)	0.85***	0.77***	0.75***
CEC (m. equiv %)	0.86***	0.85***	0.72***

*** P <0.001; NS P >0.05

The earthy sands (H) and siliceous sands (I) have loose surfaces with high infiltration rates but very low AWC.

The lithosols (J) have surface AWC values approaching those of loamy red earths (F), but have low profile water storage due to very shallow soil depths. Run off from sloping hardsetting surfaces also results in water loss.

From the point of view of property management it would be ideal to have a combination of the highly productive alluvial soils plus an area of red earths supporting mulga for drought reserves. This would allow movement of stock to the red earth soils to take advantage of light falls of rain during a period when the clay soils are dry and grazed out, as well as having mulga available for stockfeed during extended drought.

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Chapter 5

VEGETATION

by R.W. Purdie * and W.J.F. McDonald**

INTRODUCTION

The vegetation of the survey area was first described after exploratory expeditions by Kennedy in 1847 and Landsborough in 1862, and during subsequent occupation of the land by settlers during the 1860's (Heathcote 1965).

Quantitative studies of the plants and vegetation were begun by Francis (1925, 1935) and Everist (1935), with Blake (1938) providing general descriptions and a broad-scale map of communities over the whole area. Holland and Moore (1962) described and mapped a portion of the vegetation in the south-east, while descriptions of vegetation types in other areas were given by Allen and Roe (1948), Everist (1949) and Cowie (1967). The vegetation of the surrounding region has been described and mapped in varying detail. Areas to the south were covered by Beadle (1948), James (1960) and Pickard (unpublished data), to the west and north-west by Boyland (1974, 1980), to the north by Beeston (1978) and to the east by Pedley (1974). Other pertinent descriptions of vegetation associations in adjacent areas include those of Davidson (1954), Burrows and Beale (1969) and Roberts (1972).

ENVIRONMENTAL AND BIOTIC FACTORS

Although climate determines which species occur in the area, soil and topographic factors determine the local composition and distribution of the plant communities. Man-induced disturbances, such as burning, grazing and clearing, have further modified the communities in most areas, in addition to natural fires and grazing by native animals.

The annual rainfall in the area decreases from north to south, and from east to west. There is a summer rainfall pattern throughout the area, with 35 - 45% of precipitation occurring in January to March, and only 15-25% in June to September. The proportion of rain received during the winter months increases slightly from north to south (Bureau of Meteorology, Brisbane).

The seasonality of rainfall is important for many species in the area. *Acacia aneura* grows throughout the region because of the presence of both summer and winter components (Nix and Austin 1973) which are necessary for its successful regeneration (Preece 1971a, 1971b). The occurrence of *Eucalyptus largiflorens* and *E. intertexta* predominantly in southern areas may be related to winter rainfall requirements (Pedley 1974).

Over half the total species in the area are ephemerals or short-lived perennials, whose germination requirements result in distinct seasonal floras. Grasses usually predominate after summer rainfall, and a range of forb species after winter rainfall. The general nature of these seasonal responses and factors affecting them are discussed by Purdie (1990). In the survey area, the response of such species to rainfall in *Astrebla* associations is described by Roe (1941, 1962) and Allen and Roe (1948), while the response of herbage species in *Acacia aneura* communities is described by Silcock (1973, 1975, 1977) and Silcock and Williams (1976).

The actual amount of rainfall received in any one precipitation event also has a profound effect on the floristic composition and structure of the ground flora, the effect varying with soil type. *Astrebla* spp and associated ephemeral herbs growing on the cracking, clay soils require 50-75 mm or more of rain for a good growth response (Allen and Roe 1948, Everist 1964), while species growing on the loamy earths, sandy earths, and earthy sands respond to rainfalls of only 25 mm or more (Allen and Roe 1948, Silcock 1975). In the period from 1965-1979, rainfalls of 25 mm varied from 0-10/year, but averaged 4.6/year in the north and 3.0/year in the south. Rainfalls of 50 mm or more averaged less than one per year in all areas (Bureau of Meteorology, Brisbane).

After a series of wet seasons, short-lived perennial grasses may increase in abundance and become co-dominant with longer-lived grass species. *Aristida latifolia* (Purcell and Lee 1970), and *Dichanthium sericeum* (Holland and Moore 1962, Williams and Roe 1975) show such a response in

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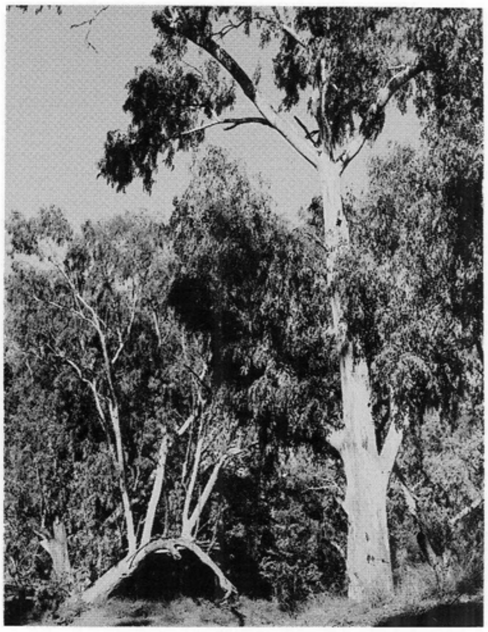
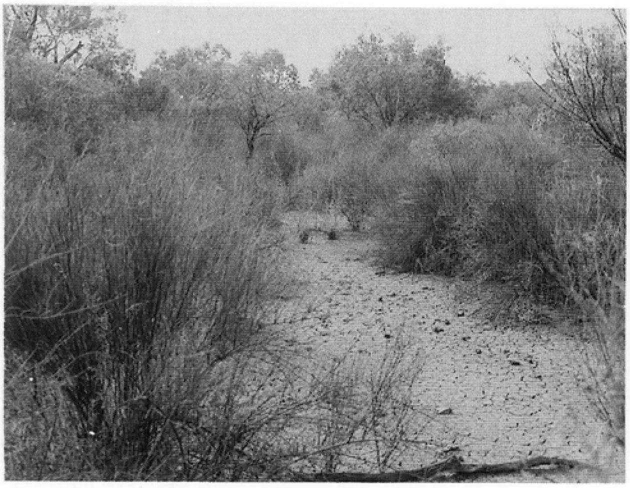
A rare occurrence of grass trees in a spinifex area.

Caustic vine or pencil caustic is an easily recognised poisonous plant.

High mulga densities are common on the sandplains and in eastern areas.



River red gum woodland along the Warrego River.



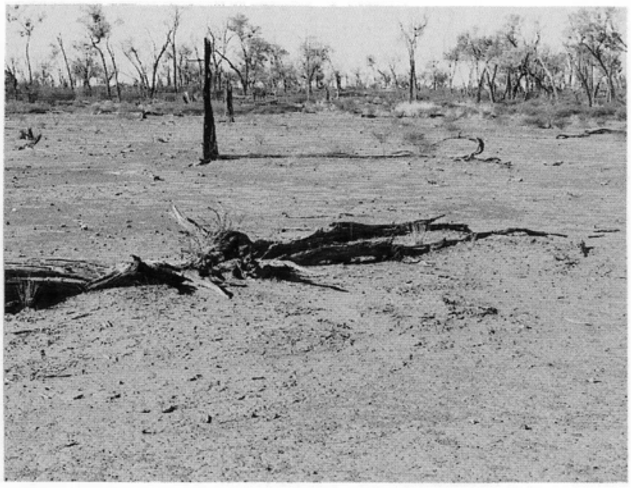
Lignum occurs on flooded areas and swamps throughout the area.

Old man saltbush occurs in isolated areas in the south east.

Gully erosion occurs in popular box drainage lines and on local alluvia.

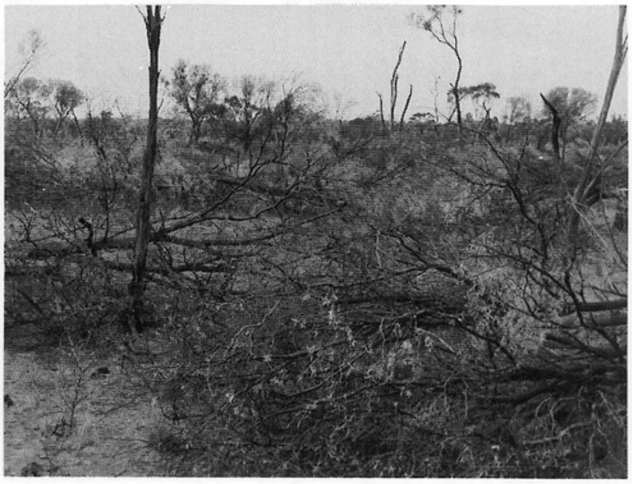
Invasion of woody weeds such as sandlewood has occurred in drainage lines and run-on areas.

Woody weed invasion of the dissected residual land zone.



Sheet erosion and turkey bush invasion (background) is common in the hard mulga lands in the west.

Pronounced sheet erosion showing terracettes.



Mulga is frequently felled to feed stock during drought periods.

Astrebla associations, while *Aristida* spp. behave similarly in *Acacia aneura* communities. Because there is a high degree of variability in the seasonal incidence, amount received and reliability of rainfall in the area, the structure and floristic composition of the ground strata in all communities may vary from place to place and year to year.

Plant associations on the alluvial plains of the major rivers periodically benefit from floods, which may be initiated by rainfall in regions to the north. The flooding frequency affects the distribution of many species on the alluvia. *Eucalyptus microtheca, E. camaldulensis, Muehlenbeckia cunninghamii* and *Chenopodium auricomum* occur in habitats with the highest flooding frequencies, *Eucalyptus ochrophloia* in areas with generally low flooding frequencies, and *Astrebla lappacea* in areas rarely or never flooded.

Although the growth, flowering and germination patterns of the tree, shrub and herb species are related to temperature requirements as well as rainfall, the effects of temperature as a limiting factor are generally unknown. Burrows (1973) noted that high soil temperatures in summer may restrict the germination of *Acacia aneura* seeds in the area, while Silcock (1975) considered that low soil temperatures in winter may limit the germination and emergence of herb species. Frosts may be an important factor affecting seedling survival in northern areas. In the Charleville region from 1965-1979, an average of 9, 17 and 10 frosts per month occurred in May, June and July, respectively, with a maximum of 20 per month in May and July and 30 per month in June (Bureau of Meteorology, Brisbane).

Changes in vegetation due to soil differences may occur gradually, as with *Acacia aneura* low woodland grading into *Triodia* hummock grassland, or *A. aneura-Eucalyptus populnea* low woodland grading into *E. populnea* woodland. Other changes occur abruptly, such as with *Callitris columellaris* and *Aristida* spp. on sandhills, and *Eucalyptus microtheca* or *Astrebla* spp. on adjacent alluvial plains. These variations in community structure and/or floristic composition are usually due to the effects of soil type and topography on the soil moisture availability. Factors which determine the latter, such as runoff, rates of infiltration, and soil storage capacity, are discussed for *Eucalyptus populnea* soils by Webb *et al.* (1980), and for *Acacia aneura* soils by Dawson and Ahern (1973). In *A. aneura* communities, redistribution of water by stem flow is also important in increasing the storage of water at depth in the soil (Pressland 1973, 1976a).

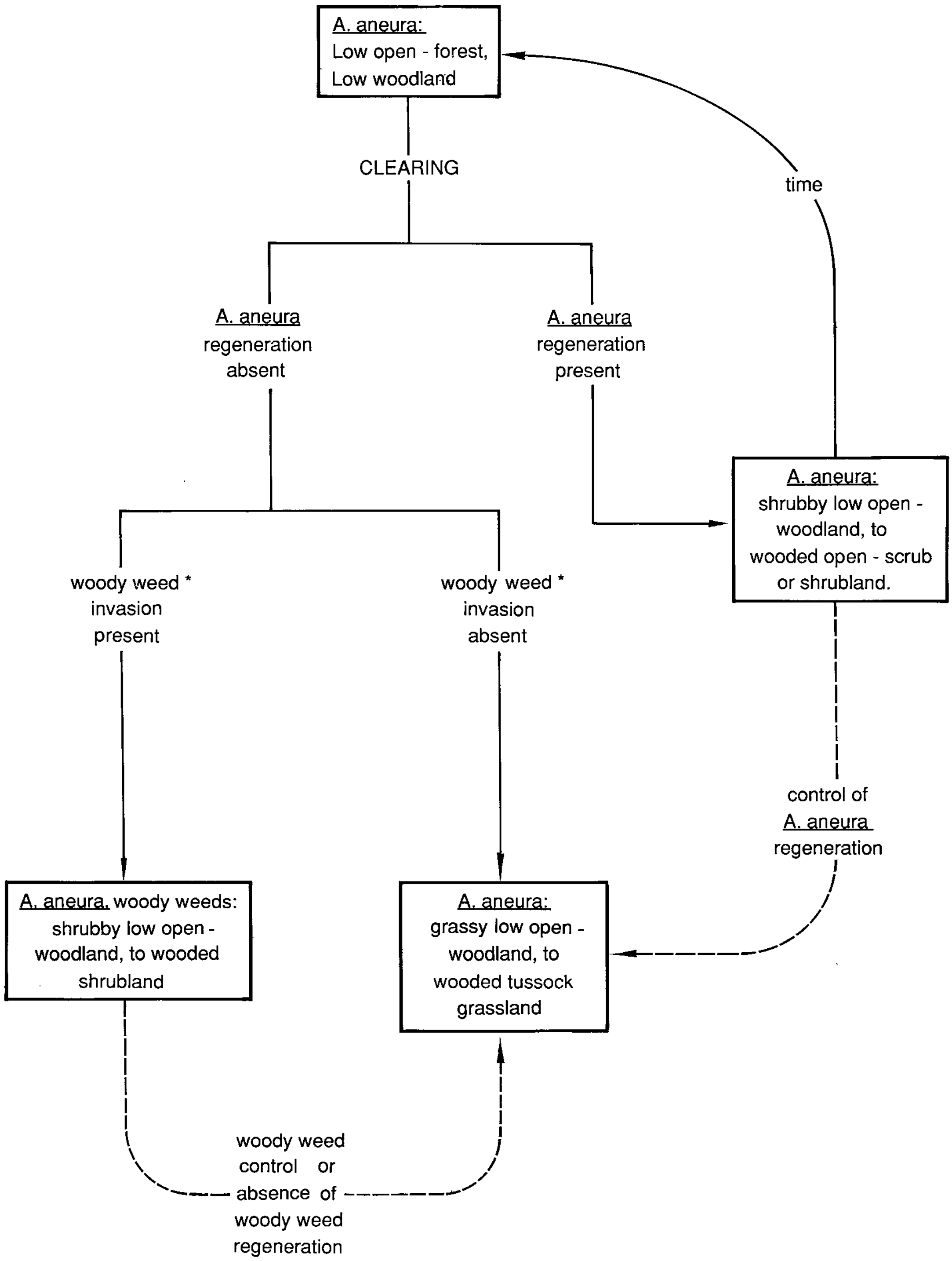
Since european settlement, the floristic structure and composition of most vegetation in the area have been affected to some degree by clearing, burning and/or grazing by domestic stock. Clearing has been extensively used for easier stock management, and to increase the productivity of the herbage species. The latter is usually attributed to increased soil moisture availability (Beale 1971), although overgrazing after clearing may lead to soil exposure and compaction, and to the development of scalds (Tunstall and Webb 1981). The quantitative and/or qualitative effects of clearing have been described for communities dominated by *A. aneura* (Beale 1973, Burrows 1973, Pressland 1975, 1976b), *A. aneura-Eucalyptus populnea* (Holland and Moore 1962), *E. populnea* (Cowie 1967, Walker *et al.* 1972, Tunstall *et al.* 1981), *Acacia cambagei* (Ebersohn 1970), and *A. harpophylla* (Holland and Moore 1962, Cowie 1967).

The effects of clearing in *A. aneura* and *A. aneura-Eucalyptus populnea* associations, which are the most extensive in the survey area, are summarised in Figures 5.1 and 5.2, respectively. It can be seen that a wide range of communities may develop as a result of clearing. Structurally and floristically different communities may occur side by side, due to variations in the degree and success of the clearing operations. Species in the area noted to recover by vegetative regrowth after fire are indicated in Appendix IIIA.

Fire has been frequently used during clearing operations to remove woody debris, and is also used regularly in many areas to remove unpalatable grass biomass (e.g. of *Triodia, Aristida, Heteropogon*), and to control *Acacia aneura* regeneration or woody weeds after clearing of *A. aneura* and *Eucalyptus populnea* communities. The effects of burning in the latter have been described by Holland and Moore (1962), Moore and Walker (1972), Pedley (1974), Hodgkinson (1979), Walker and Green (1979) and Wilson and Mulham (1979). The effects of fire in *Acacia harpophylla* communities are described by Johnson (1976), in *Callitris columellaris* woodlands by Hawkins (1966) and Pedley (1974), in *Triodia mitchellii* hummock grasslands by James (1960) and Holland and Moore (1962), and in *Astrebla* tussock grasslands by Purcell and Lee (1970).

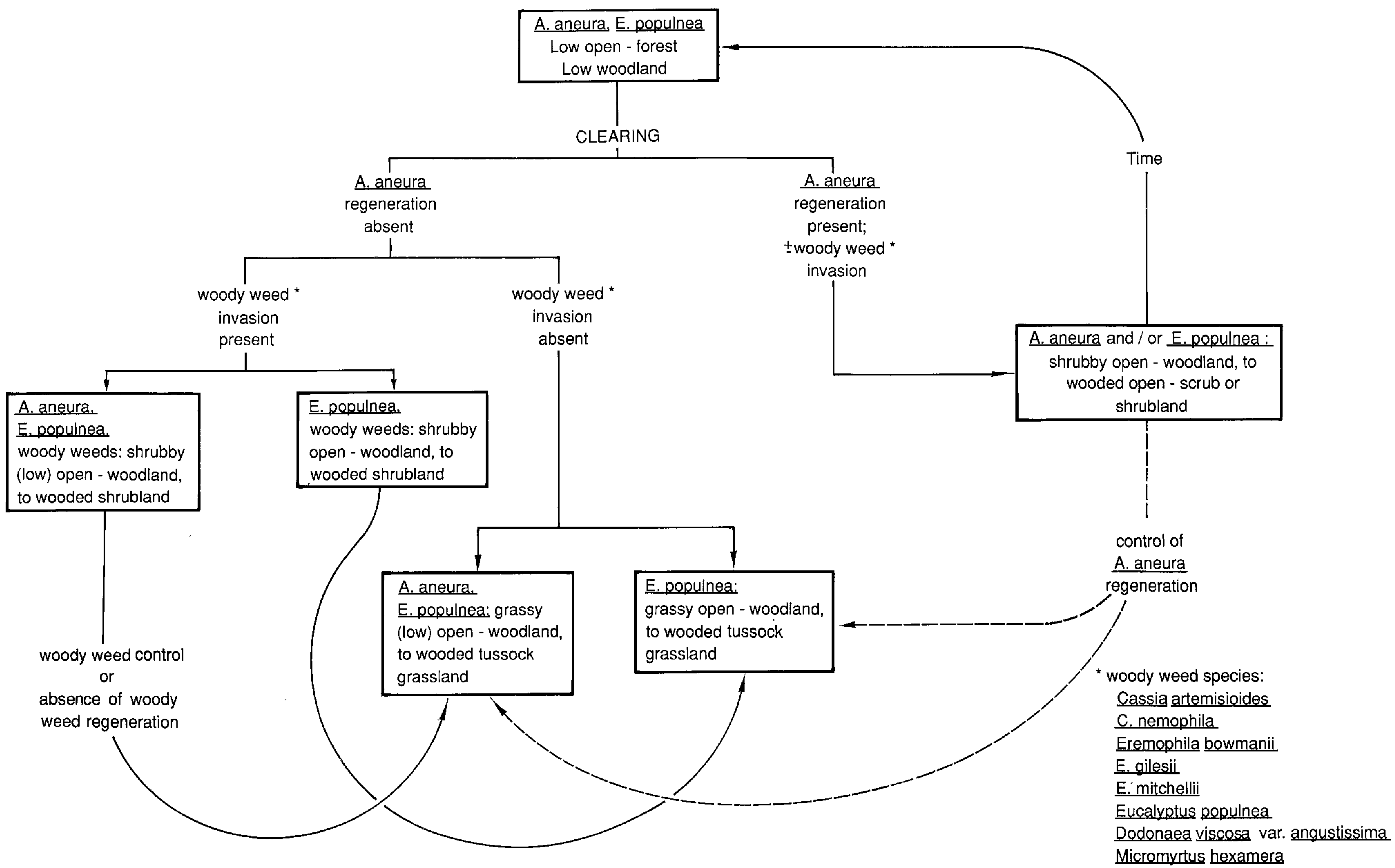
Although sensitive species such as *Callitris columellaris* and *Acacia aneura* are easily killed by fire, many tree and shrub species in *A. aneura, A. aneura-Eucalyptus populnea*, and *Triodia* communities show fire stimulated seed germination and/or vegetative regrowth (Purdie 1990), and often form prominent shrub strata after burning. Thus both the structure and tree or shrub dominance of the vegetation can change markedly. The effects of fire on the grass and forb species have not been documented, although most species appear to regenerate, at least after burns of low

FIGURE 5.1 EFFECTS OF CLEARING IN A. ANEURA ASSOCIATIONS



* woody weed species: Dodonaea viscosa var. angustissima, Eremophila bowmanii, E. gilesii, E. sturtii, Olearia subspicata.

FIGURE 5.2 EFFECTS OF CLEARING IN ACACIA ANEURA, EUCALYPTUS POPULNEA ASSOCIATIONS



intensity. However, selective grazing of the herb species after fire may lead to changes in the floristic makeup of the ground stratum.

Grazing by sheep and cattle has probably affected the composition of the ground strata of most communities, irrespective of burning. Differences in the palatability of species, food preferences of sheep and cattle, and grazing pressures all affect the makeup of the ground flora. The effects of grazing on *Astrebla* tussock grasslands have been described by Roe and Allen (1945), Davidson (1954), Griffiths and Barker (1966), Weston and Moir (1969), Griffiths *et al.* (1974), Lorimer (1978) and Orr (1979). Grazing in *Acacia aneura* communities has been discussed by Allen and Roe (1948), Newman (1973), Beale (1975) and Pressland (1976b). In the *A. aneura* associations in the area, the enormous variation in the floristic composition of the ground stratum caused by clearing, burning and grazing largely over-rides the variation caused by different soil types, which include red earth, sandy, loamy or stony red earths, red earthy sands, red hardpan soils and lithosols.

FLORISTICS

Species collected or known to occur in the area are listed in Appendix IIIA. Plant nomenclature follows that of the Queensland Herbarium (Catalogue of Plants, unpublished data, 1990), where all voucher specimens have been lodged. Since the survey data were collected after seasons of high rainfall, the plant list probably represents the majority of species occurring in the area.

A total of 690 taxa were recorded (Table 5.1), of which 72% were dicotyledons and 27% monocotyledons. Pteridophyta and one gymnosperm comprised the remaining species. The flora contains both temperate and tropical elements, as well as genera which are endemic in arid areas in Australia (Burbidge 1960, Beadle 1966, Herbert 1966). Annual and short-lived perennial herbs comprised 46% of the dicotyledons, 71% of the monocotyledons, and 54% of the total flora. Trees and shrubs accounted for 26% of the total flora, while long-lived perennial herbs and subshrubs comprised the remaining 20%.

Table 5.1 Number of families, genera, and species recorded.

	Families	Genera	Species	Habit* T**	S	P	H
Angiosperms							
Dicotyledons	74	221	498	40	139	90	229
Monocotyledons	11	73	181	-	1	52	128
Gymnosperms	1	1	1	1	-	-	-
Pteridophyta	4	4	10	-	-	-	10
Total	90	299	690	41	140	142	367

* See Appendix IIIA for explanation of codes. ** no. of species

The species density of 1 species/73 km^2 is similar to that of the area to the north (1 species/67 km^2; Beeston 1978), but higher than for areas to the west (1 species/over 140 km^2; Boyland 1974, 1980). The latter difference probably reflects more favourable seasonal conditions while collecting the current survey data, higher annual rainfall and greater habitat diversity over smaller areas in the east.

Families containing ten or more species are listed in Table 5.2. These families accounted for 70% of the total flora, with the Mimosaceae, Myrtaceae and Myoporaceae containing 42% of all tree and shrub species. Many of the families contain a high proportion of annual and short-lived perennial plants. For example, these plants comprise 90% of the Asteraceae, 96% of the Cyperaceae, 73% of the Fabaceae, and 70% of the Poaceae. All fourteen families are also important components of the vegetation in the surrounding areas (Pedley 1974, Boyland 1974, 1980, and Beeston 1978).

Trees and shrubs of the genus *Acacia* are the most widespread dominants in the area. Although 30 species of *Acacia* were recorded, only two occupy >5% of the area. The most extensive species is *A. aneura*, which dominates 24 000 km^2 or 48% of the area. The eastern *A. aneura* communities lie in the most mesic section of the species' range in Australia (Nix and Austin 1973), and form low open forests typical of the mesic region. *A. cambagei* is the other important dominant species, occurring mostly on the southern alluvial plains.

Table 5.2 Families containing ten or more species.

Family	No. Genera	No. Species	Larger Genera (no. species)
Poaceae	52	141	Aristida (23), Eragrostis (20), Panicum (6), Enneapogon (7), Digitaria (6), Chloris (5), Eriachne (5)
Asteraceae	25	68	Calotis (8), Brachyscome (6), Helipterum (5)
Chenopodiaceae	15	57	Sclerolaena (17), Atriplex (10), Maireana (9), Chenopodium (5)
Fabaceae	20	39	Swainsona (7), Indigofera (5)
Mimosaceae	3	32	Acacia (30)
Malvaceae	5	29	Sida (14), Abutilon (7)
Cyperaceae	7	24	Cyperus (14)
Myrtaceae	8	25	Eucalyptus (15)
Amaranthaceae	6	15	Ptilotus (8)
Goodeniaceae	5	14	Goodenia (7)
Myoporaceae	2	14	Eremophila (12)
Solanaceae	4	11	Solanum (6)
Euphorbiaceae	8	10	
Convolulaceae	8	10	

Species which occupy <5% of the area, but which are locally dominant, include *A. catenulata* and *A. petraea* on dissected residuals, *A. harpophylla* on the northern low hils and undulating plains, *A. victoriae* on sandy levees, and *A. microsperma* and *A. omalophylla*, which is found predominantly on claypans. Several shrub species are important in the *Triodia* communities including *A. gnidium, A. leptostachya, A. maitlandii* and *A. burbidgeae.* Species such as *A. aprepta, A. bancroftii*, and *A. pendula* are at their south-western limits of distribution in Queensland.

Species of *Eucalyptus*, which dominate 17% of the area, become more important in higher rainfall areas to the east (Pedley 1974) and north (Beeston 1978). *E. camaldulensis, E. microtheca* and *E. ochrophloia* are widespread on cracking clay soils associated with the river systems and floodplains, particularly in the south, while *E. pilligaensis* and *E. largiflorens* are restricted to the alluvia in the south-eastern corner. *E. populnea* is a widespread co-dominant with *Acacia aneura*, particularly in eastern areas, and becomes dominant in drainage systems on texture contrast soils. *E. melanophloia* may be co-dominant with *Acacia aneura* in eastern areas, with *Triodia* on the sandplains, and with *Callitris columellaris* on northern sandhills. *E. nubila*, which occurs rarely in the area, is probably at its western limits of distribution.

Shrub species of *Cassia, Eremophila* and *Dodonaea* are important throughout the area in *Acacia* and *Eucalyptus* woodlands because of their ability to increase after disturbance, thereby causing woody weed problems. The most widespread species are *Eremophila mitchellii, E. gilesii, Cassia nemophila* and *C. artemisioides*.

Among the grass-dominant associations, *Astrebla lappacea* occupies 5% of the area and communities containing *Callitris collumellaris* occupy 7% of the land. These occur on levees and low sandhills associated with the Warrego River, Angellala Creek and alluvial plains in the south of the area, while the *A. lappacea* associations occur on cracking clays, *Triodia mitchellii* is also an important species, occupying 2.4% of the area, mainly on earthy sands. Species of *Aristida, Digitaria, Eriachne* and *Eragrostis* are important components of the ground flora on lighter soils, while species of *Bothriochloa, Chloris, Dichanthium, Eragrostis, Isellema* and *Sporobolus* are common components of the herb stratum on heavier soils and run-on situations. Although grass species were more common than forbs during the survey, the latter become abundant after heavy winter rainfall. Important genera include *Calotis, Brachyscome* and *Helipterum* (Asteraceae), *Sclerolaena* and *Atriplex* (Chenopodiaceae), *Swainsona* and *Indigofera* (Fabaceae), *Sida* and *Abutilon* (Malvaceae), *Ptilotus* (Amaranthaceae), and *Goodenia* (Goodeniaceae).

The number of families, genera and species which occur in the land zones are given in Table 5.3. The land zones containing the highest numbers of species were the wooded alluvial plains (37% of the total species recorded), and the sandhills, gidgee lands and claypans, whose flora comprised approximately 33% of the total species in the area. Compared with the other land zones, these lands exhibit greater habitat diversity in terms of soil fertility and soil resistance status. With the exception of the downs land zone, the spinifex sandplains, mulga sandplains and hard mulga lands contained the lowest number of species. This probably reflects the very low nutrient levels and less favourable moisture status of the soils, and on the sandplains, lack of habitat diversity. The very low species count on the downs was partly due to the very small area of downs found in the region and consequently a much lower level of sampling compared with the other land zones.

The life form distribution of species in each land zone is indicated in Table 5.4. The dissected residuals and spinifex sandplains contained both the greatest number and highest proportion of trees and shrubs, as well as the lowest proportion of annual and short-lived perennial species. This life form spectrum probably reflects the harsh nature of the habitat, particularly the low moisture status, in which a deep-rooted perennial habit is presumably the most advantageous for the long-term survival of species. On the sandplains, frequent burning has probably also resulted in strong selection for woody perennial species rather than herbaceous plants.

Table 5.3 Number of families, genera and species in each land zone

Land Zone	Total number			Area
	Families	Genera	Species	(km^2)
Sandhills	48	125	218 (32%)*	4570
Spinifex sandplains	43	93	138 (20%)	1200
Mulga sandplains	40	95	162 (23%)	3580
Soft mulga lands	44	115	191 (28%)	10940
Hard mulga lands	38	90	158 (23%)	8840
Dissected residuals	43	95	178 (26%)	2630
Gidgee lands	42	110	210 (30%)	2660
Downs	20	43	58 (8%)	100
Poplar box lands	40	104	180 (26%)	1620
Wooded alluvial plains	54	142	257 (37%)	8150
Open alluvial plains	40	109	189 (27%)	4390
Claypans	49	126	237 (34%)	1000

* % of total number of species in the whole area

Table 5.4 Life form distribution of species in land zones

Land Zone	Trees Shrubs	Subshrubs Herbs [1]	Annuals Herbs [2]
Sandhills	61 (28%)[3]	46 (21%)[3]	111 (51%)[3]
Spinifex sandplains	57 (41%)	32 (23%)	49 (36%)
Mulga sandplain	43 (27%)	34 (21%)	85 (52%)
Soft mulga lands	35 (18%)	45 (24%)	111 (58%)
Hard mulga lands	36 (23%)	35 (22%)	87 (55%)
Dissected residuals	71 (40%)	36 (20%)	71 (40%)
Gidgee lands	51 (24%)	35 (17%)	124 (59%)
Downs	15 (26%)	8 (14%)	35 (60%)
Poplar box lands	35 (19%)	46 (26%)	99 (55%)
Wooded alluvial plains	52 (20%)	52 (20%)	153 (60%)
Open alluvial plains	30 (16%)	34 (18%)	125 (66%)
Claypans	43 (18%)	52 (22%)	142 (60%)

[1] Long-lived perennial herbs [2] Short-lived perennial herbs
[3] Number of Species (% of total number of species in each land zone)

Subshrubs and long-lived perennial herbs constitute approximately 20% of the flora of most land zones. Although they account for only 15-17% of the species on the downs, open alluvia and wooded alluvial plains, long-lived perennial grasses, such as *Astrebla* spp. and *Eragrostis setifolia*, are dominant over large areas of these zones. The very low proportion of subshrubs and longer-lived herbs in the gidgee lands (13% of the total) reflects the predominance of annual and short-lived perennial herbs in this land zone.

The overall importance of the more ephemeral species in the vegetation throughout the area is indicated by the fact that they comprise 60-70% of the total flora in seven of the twelve land zones, and account for less than 50% of the total species in only two land zones. Although the open alluvial plains and gidgee lands contain the highest proportion of annuals and short-lived perennials, the wooded alluvia contain the highest total number, probably because of the better moisture relations and the higher nutrient levels in the soil. Land zones containing a low number and proportion of ephemerals generally have a poor moisture status and are of very low fertility.

VEGETATION CLASSIFICATION

The vegetation of the area was classified in a way similar to previous WARLUS reports, with emphasis placed on the floristic composition and structural formation, and plant associations in the sense of Beadle and Costin (1952) being recognised.

The structure of the vegetation at each site was classified using a modified version (Table 5.5) of the scheme proposed by Specht (1970). The problems encountered in using the original scheme were the same as those discussed by Pedley (1974), and a similar approach was adopted to overcome them. Since much of the vegetation is <10 m tall, an additional height class was used to describe shrub communities. Where two predominant strata occurred, the association was qualified by a term describing the nature of the stratum which contributed least to the biomass. These terms included wooded (where the tree density was less than 25/ha), shrubby, grassy, herbaceous and forby.

Table 5.5 Structural formation recorded (modified from Specht 1970)

Life form and Height of Predominant Stratum*	Projective Foliage Cover of Predominant Stratum* 30-70%	10-30%	<10%
Trees 10-30 m	Open-forest	Woodland	Open-woodland
Trees 5-10 m	Low open-forest	Low woodland	Low open-woodland
Shrubs 5-8 m	Open-scrub	Tall shrubland	Tall open-shrubland
Shrubs 2-5 m	-	Shrubland	Open-shrubland
Shrubs <2 m	Low open-scrub	Low shrubland	Low open-shrubland
Hummock grasses	Hummock grassland	Open-hummock grassland	Sparse-hummock grassland
Tussock grasses	Tussock grassland	Open-tussock grassland	Sparse-tussock grassland
Grasses	Grassland	Open-grassland	Sparse-grassland
Herbs	Herbland	Open-herbland	Sparse-herbland
Forbs	Forbland	Open-forbland	Sparse-forbland
Sedge	Sedgeland	Open-sedgeland	-

* Predominant stratum is the layer which contributes most to the biomass. A tree is a woody plant more than 5 m tall, usually with a single stem. A shrub is a woody plant less than 8 m tall, either multi-stemmed or branched close to ground level, infrequently with a single stem.

The difference between many communities was slight, particularly in those dominated by *Acacia aneura* and *Eucalyptus populnea*. This is a natural result when species dominance is determined by the subjective decision as to which species contributes most to the biomass, and when vegetation structure is classified using arbitrary divisions of continuous attributes. Because of the added complication of extreme variability in structure and/or floristic dominance due to disturbance, fairly broad associations have been delineated which are thought to represent most closely the natural 'climax' vegetation. Variations caused by clearing and grazing, and due to changing seasonal conditions, are noted where appropriate in the association descriptions.

MAJOR STRUCTURAL FORMATIONS

Thirty-one structural formations were recorded (Table 5.5), ranging from open forest to sparse herbland, although some, such as those dominated by forbs, herbs and sedges, occurred infrequently.

The most common formation was low woodland, which was dominated by *Acacia* spp., and developed on a variety of soils ranging from sandy red earths to red and brown, cracking clays. Woodland commonly developed in moister habitats such as run-on areas and drainage lines, and was frequently dominated by *Eucalyptus* spp.. The associated soils were predominantly brown and grey cracking clays and red, texture contrast soils. Woodland dominated by *Callitris* was present on sandhills associated with the major rivers. Low open woodland and open woodland formations were frequently induced by clearing or thinning of the original vegetation. Tall shrublands developed mostly on shallow earths and lithosols, particularly in drier areas west of the Warrego River. Low shrublands were frequently associated with the clearing of low woodlands, and were either dominated by the regenerating dominant *Acacia* or by woody weed species.

Hummock grasslands were confined to sandplains and occasional sandhills, while tussock grasslands were widespread on cracking clay soils, and were developed best on the southern alluvial plains. Sparse tussock grasslands and seasonally variable herblands and forblands were mostly associated with degraded tussock grasslands on the alluvial plains.

DESCRIPTION OF VEGETATION

Vegetation map

A vegetation map of the area is enclosed with the report, at a scale of 1:500 000. Each map unit is based on one or more land systems in which one major vegetation group is predominant, with other associations making only a small contribution. Land systems in which two or more vegetation types contribute significantly to the vegetation are mapped as a complex.

Vegetation associations

The natural vegetation of the area has been described in terms of 42 plant associations given in Table 5.6. To enable easier use of the Table, the vegetation has been divided into types dominated by either trees and shrubs or by grasses, herbs or sedges. The associations have been listed alphabetically under the appropriate type. Each association is described in terms of its range of structural parameters, frequently occurring species, characteristic land form, and the principal soil groups on which it occurs. Many of the associations are not, or are poorly conserved in Queensalnd (Specht *et al.* 1974).

The associations summarise the more detailed land unit vegetation descriptions given in Appendix V, and are cross referenced to the appropriate units in each case. Unusual vegetation types of limited areal extent have been covered in the closest related association.

While the vegetation descriptions refer to their 'natural' state in 1976-77, it is re-emphasised that all areas sampled have been subject to decades of disturbance both through clearing and/or grazing by domestic stock. As a result, the vegetation structure and probably the floristic composition have often been drastically altered in many areas. Because of their widespread and relatively stable nature, several induced associations caused by disturbance have been included in the descriptions. Because the data were collected after several years of above-average and after periods of high summer rainfall, grass species were predominant in the ground strata throughout the associations. Their cover and biomass were much higher than could be expected during normal, drier years.

The vegetation associations described in the table have each been assigned to one of the ten following major floristic groups. The groups are ordered according to structural formation, from woodland to grassland, except for the claypan associations which exhibit a variety of structural forms. Cross reference is given to the component associations in each group.

1. Cypress pine (*Callitris columellaris*) predominant and related associations.

(Vegetation associations 5.a, 5.b, 7.c)

These associations are restricted to the sandhills associated with the major rivers and their alluvial plains, and occupy 7% of the area. *Eucalyptus tessellaris* and *E. dolichocarpa* are prominent in the north (5.b) but are usually absent in the south (5.a). *Geijera parviflora* (7.c) is associated with the communities on lower slopes in southern areas, and often grades into *Acacia aneura - A. excelsa* (1.d). The soils characteristic of these associations are red or yellowish red, earthy sands.

The most common structural formation is woodland, with open woodland in cleared areas and on lower slopes. A shrub stratum is usually prominent only in disturbed vegetation. The ground stratum is dominated by grasses, although the cover and floristic composition vary with the degree of disturbance, seasonal conditions and topographic position.

The floristic diversity is relatively low, with approximately 20% of all species occurring in the associations.

2. Eucalypt (*Eucalyptus* spp.) predominant and related associations.

(Vegetation associations 6.a, 6.b, 6.d, 6.f, 6.g, 6.h, 6.i, 6.k, 7.a, 7.b)
These associations are widespread along river channels and drainage lines, and occupy 17 % of the land. *E. camaldulensis* and *E. microtheca* (6.b) predominate along the channels of the Warrego, Langlo and Ward Rivers, while *E. microtheca* (6.f) and *E. ochrophloia* (6.g) are dominant on shallow

drainage channels on the alluvial plains, with *E. largiflorens* (6.d) common in such areas in the south-east. *Atriplex nummularia* (7.a) and *Chenopodium auricomum* (7.b) frequently occur in associated swamps on the wooded alluvia. The soils on which these associations occur are predominantly grey and brown, alluvial, cracking clays. *Eucalyptus populnea* (6.h, 6.i, 6.k) is dominant on drainage systems through the mulga land zones, with *E. camaldulensis* (6.a) well-defined drainage channels. These soils are predominantly red earths, red clays and red, texture contrast soils. *E. populnea* (6.k) is also associated with the alluvial plains in some areas.

The structural formations vary most with the soil moisture availability, which depends on soil type and depth, and the flooding frequency. On the alluvial plains, associations range from woodlands along the larger channels, to low open woodlands on the flat plains which are rarely flooded. *E. ochrophloia* and *E. populnea* associations may be structurally-altered by thinning. A low shrub stratum composed of *Chenopodium auricomum, Muehlenbeckia cunninghamii* and *Eremophila bignoniiflora* is often prominent in poorly-drained areas on the alluvia, while *E. mitchellii* often forms a conspicuous shrub stratum below *E. populnea*. The floristic composition and cover of the ground strata vary considerably depending on the moisture availability, degree of disturbance and grazing pressure.

The floristic diversity of the associations is relatively high, with 26% of all species occurring with *E. populnea*, and 37% of all species present in the remaining associations on the wooded alluvial plains. Approximately 60% of the species in the *Eucalyptus* associations are ephemerals or short-lived perennials.

3. Mulga (*Acacia aneura*) predominant and related associations.

(Vegetation associations 1.a - 1.g, 6.c, 6.e, 6.j, 8.a)

These associations are the most widespread in the area, occupying 48% of the land. They occur predominantly on flat to undulating plains, on sandy or loamy red earths or less commonly on red hardpan soils, with minor occurrences on stony lithosols on the tablelands and dissected hills, mostly in the west. *Acacia excelsa* (1.d) and *Archidendropsis basaltica* (1.e) may be co-dominant on sandier soils, *Eucalyptus populnea* (1.f) co-dominant on loamier soils, and *E. terminalis* (1.d) co-dominant on lithosols. *E. intertexta* (6.c) is dominant in some areas on sandy, flat plains, while *E. melanophloia* (6.e) frequently predominates on upper slopes and ridges, and plains in eastern areas. Where *Acacia aneura* has been cleared and failed to regenerate, *Eucalyptus populnea* (6.j) or *Aristida* spp. (8.a) are often dominant.

All associations have been thinned or cleared at some stage. As a result, there is great structural and floristic complexity, with both gradual changes and sharp disjunctions between adjacent communities. The structure and floristic composition are also affected by moisture availability, which varies with the landscape, soil type and soil depth.

The structural formations range from low open forest, predominantly in central-eastern areas, through low woodland, to tall shrubland mostly west of the Warrego River. Low woodland occurs most frequently throughout the area. A low shrub stratum is frequently present in disturbed, open communities, and is composed of either *Acacia aneura* regeneration or woody weeds. The floristic composition of the ground stratum is highly variable, and depends mostly on the degree of disturbance, grazing history, and seasonal conditions. *Aristida* spp. are particularly common in open vegetation after wet summers.

Although very widespread, the *A. aneura* associations contain only 20-30% of the total species in the area, of which approximately 60% are ephemerals or short-lived perennials.

4. Gidgee (*Acacia cambagei*) predominant associations.

(Vegetation associations 2.a, 2.b, 2.c)

Although occupying only 7% of the land these associations are relatively widespread on old, alluvial plains in central and southern areas (2.a, 2.b), and on other alluvial plains which are subject to local flooding (2.c). In the latter areas, *Eucalyptus ochrophloia* becomes dominant in wetter habitats. The soils are grey and brown, cracking clays, and reddish brown, texture contrast soils. Minor areas occur on lithosols at the foot of ranges in the north.

Structural formations range from (low) open forest, to low open woodland after disturbance. Low woodland predominates on the old alluvial plains. A shrub stratum of *Eremophila mitchellii* is prominent on texture contrast soils (2.b), while *Chenopodium auricomum, Muehlenbeckia cunninghamii, Eremophila bignoniiflora* or other shrubs may be conspicuous in wetter areas on grey, cracking clays (2.c). The ground stratum varies with the soil type, moisture availability, flooding frequency, seasonal conditions, and clearing and grazing history. It contains a large component of chenopodiaceous species, as well as other ephemeral and perennial herbs.

The floristic diversity is relatively high, with 27% of all species occurring in the associations. On the old alluvial plains, up to 60% of the species may be ephemerals or short-lived perennials.

5. Brigalow (*Acacia harpophylla*) predominant associations.

(Vegetation associations 3.a, 3.b, 3.c)

These associations are relatively limited in extent, occupying <1% of the land. They occur predominantly on undulating plains and low hills in the north and north-east, on sedentary, brown to reddish brown, cracking clays, and shallow stony lithosols. Other areas are associated with the alluvial plains in the south-east, where they occur on grey and brown, cracking clays. On the alluvia, various *Eucalyptus* spp. may be present (3.b), or the communities may grade into, or be inter-mixed with *Acacia cambagei* associations. On the low hills and associated plains, *Eucalyptus thozetiana* (3.c) is often co-dominant or dominant on the upper slopes.

The structural formations grade from low woodland to tall shrubland with increasing moisture stress, and thus, vary with the soil type and depth, and topographic position. Clearing has also affected the structure in some areas. A shrub stratum is usually present on shallower sedentary soils, and may occur in some alluvial areas. The floristic composition of the ground stratum varies with the soil type, degree of disturbance and the seasonal conditions.

The floristic diversity is relatively low, with approximately 20% of all species occurring in the associations.

6. Other Acacia (*Acacia* spp.) predominant and related associations.

(Vegetation associations 4.a, 4.b, 4.c, 6.l)

These associations are very limited in extent, and occupy <5% of the area, predominantly in the north and west. *Acacia catenulata* (4.a) and *A. petraea* (4.c) occur on the dissected tops and scarps of low hills, while *Eucalyptus thozetiana* and associated shrubs including *Acacia microsperma* (6.l) occur on the scarps and slopes. The soils are shallow stony lithosols. *A. microsperma* and *A. omalophylla* (4.b) are common on claypans located in the mulga land zones, and occur on grey and brown, alluvial clays.

The structural formations range from open scrub to shrubby open woodland, with tall shrubland occurring most frequently. On the residuals, a lower shrub stratum is often conspicuous below the dominants, and the ground stratum is usually very sparse. On the claypans, lower shrubs are rarely present, and the ground stratum is seasonally variable.

Floristic diversity is medium, with 24% of all species occurring in these associations, and one third of them being trees or shrubs.

7. Spinifex (*Triodia mitchellii*) predominant associations.

(Vegetation association 8.i)

This association occurs on flat to gently undulating plains on red to yellowish red sands, and occupies 2% of the area. *Eucalyptus intertexta, Acacia aneura* (6.c) frequently fringe the association and often grade into it, while *Callitris columellaris* (5.a) is associated with it in some areas.

The structural formations range from hummock grasslands with or without a tree or shrub stratum of *Eucalyptus melanophloia*, to *E. melanophloia* tall open shrubland or low open woodland with a *Triodia* hummock grass stratum. A lower shrub stratum is frequently present, the shrub density often is related to the fire history. The ground between the grass hummocks is usually bare, except after rainfall, when ephemeral herbs may become abundant.

The floristic diversity is relatively low, with the associations containing 20% of the total species in the area. A high proportion of these (40%) are trees and shrubs.

8. Mitchell grass (*Astrebla lappacea*) predominant and related associations.

(Vegetation associations 8.b, 8.c, 8.e)

These associations are widespread on the older, rarely flooded alluvial plains associated with the major river systems, mainly in the central and southern areas. Minor occurrences are associated with undulating plains in the north-east. The associations occupy 8% of the area, and occur on brown, reddish brown or greyish brown, cracking, clay soils of alluvial and sedentary origin.

The structural formations range from tussock grassland to open tussock grassland, or sparse herbland (8.e) in areas degraded by overgrazing. The communities on the alluvial plains (8.b) are usually treeless, but those on the undulating plains (8.c) have trees and shrubs associated with them on shallow rises and upper slopes, where they may grade into *Acacia harpophylla* (3.a). In the tussock grassland associations, up to 75% of the species may be ephemerals or short-lived perennials, and hence, the composition varies considerably with seasonal conditions. Both floristic structure and composition have also been altered by past land use.

The overall floristic diversity of these associations is relatively low, with approximately 20% of the total species occurring in them.

9. Short-grass predominant associations.

(Vegetation associations 8.g, 8.h)

These associations are limited in extent occupying about 3% of the area, they occur predominantly on levees and rarely flooded alluvial plains associated with the Warrego River in central areas. Minor occurrences are also associated with alluvial *Acacia cambagei* and *Astrebla lappacea* associations. The soils are brown and reddish brown alluvial clays.

The floristic composition and structure vary with seasonal conditions and past land use, but the structural formations usually range from sparse to open grassland or herbland. A variety of scattered trees and shrubs are frequently present. *Acacia victoriae* is common on the levees (8.g) and *Atalaya hemiglauca* frequent on the alluvial plains (8.h). These species form open shrublands or low open woodlands in some areas.

The floristic diversity of the associations is low, with only 16% of the total species occurring in them.

10. Claypan associations.

(Vegetation associations 3.b, 4.b, 6.f, 7.a, 7.b, 8.d, 8.f)

These associations occur on claypans which are scattered throughout the mulga land zones, particularly east of the Warrego River in central and southern areas, but occupy less than 1% of the land. The soils are predominantly grey and brown, alluvial clays.

The floristic composition and structure vary widely. Sedges and ephemeral herbs form sedgelands or seasonal herblands and open herblands (8.d) on treeless claypans. Swampy areas support *Eragrostis australasica* (8.f) open hummock grasslands, or *Chenopodium auricomum* (7.b) or rarely *Atriplex nummularia* (7.a) low shrublands or low open shrublands. In some areas *Acacia microsperma* or *A. omalophylla* (4.b) form tall shrublands, while *A. harpophylla* (3.b) or *Eucalyptus microtheca* (6.f) form (low) open woodlands. The associations may occur singly, or in combination, to form a vegetation complex in the one claypan area.

The floristic diversity is quite high, with approximately 33% of all species in the area occurring in the associations.

Table 5.6. Vegetation associations

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1. MULGA (*ACACIA ANEURA*) PREDOMINANT ASSOCIATIONS

1.a *Acacia aneura*	Low open forest	Height: 8-9m PFC: 30-55% Trees/ha: 500-3750

Other frequently occurring species:

Trees: *Acacia excelsa* (in places), *Eucalyptus populnea* (in places), *Grevillea striata* (in places).

Graminoids: *Aristida calycina* var. *praealta, Digitaria hystrichoides, D. brownii, D. breviglumis, Eragrostis lacunaria, Monachather paradoxa, Thyridolepis mitchelliana.*

Forbs: *Sclerolaena convexula, Cheilanthes sieberi, Euphorbia drummondii, Goodenia glabra, Hibiscus sturtii, Sida filiformis.*

Comments:

Widespread on flat to gently undulating plains. Soils are acid, moderately deep to deep red earths, sandy red earths and loamy red earths. Shrubs are usually absent except after clearing. The ground stratum is grassy, and the cover varies from 5-50%. Clearing results in *A. aneura* low open woodland, rarely *Eucalyptus populnea* open woodland, or wooded tussock grassland. *Eremophila gilesii* and/or *A. aneura* low shrubs are frequently prominent.

Characteristic of land units 39, 45, 48, 53, with minor occurrences in 46. Occurs in land systems H1, M5, M4, S1 with minor occurrences in M2.

1.b *Acacia aneura*	Low woodland	Height: 7-10m PFC: 10-30% Trees/ha: 100-1000

Other frequently occurring species:

Trees: *Eucalyptus populnea.*

Low shrubs: *Acacia aneura* (loamy soils); *Cassia* spp., *Dodonaea viscosa* ssp. *angustissima, Eremophila sturtii, Micromyrtus hexamera* (sandy soils); *Eremophila gilesii.*

Graminoids: *Amphipogon caricinus, Aristida calycina* var. *praealta, A. jerichoensis, Digitaria hystrichoides, D. brownii, Eragrostis lacunaria, Eriachne helmsii, Monachather paradoxa, Themeda triandra, Thyridolepis mitchelliana.*

Forbs: *Calotis cuneata, Cheilanthes sieberi, Euphorbia drummondii, Goodenia glabra, Trachymene ochracea, Velleia glabrata.*

Comments:

Widespread on gently undulating plains, with limited areas on flat plains west of the Warrego River. Soils are acid, moderately deep to deep red earths, sandy red earths, loamy red earths, and red hardpan soils, and shallow, stony, red earths. Low shrubs are sparsely scattered except after disturbance. The ground stratum is grassy, and the cover varies from 10-60%. Clearing results in *A. aneura* and/or *Eucalyptus populnea* low open woodland or open woodland, or wooded tussock grassland. *A. aneura* low shrub regeneration is prominent on loamy soils, while *Cassia* spp., *Eremophila* spp., and *Dodonaea viscosa* ssp. *angustissima* low shrubs are frequently prominent on the sandier soils.

Characteristic of land units 39, 42, 44, 46, 47, 52 with minor occurrences in 43, 45, 50, 53. Occurs in land systems H3, H4, M2, M3, S2, with minor occurrences in H1, M5, S1, R3.

1.c *Acacia aneura*	Tall shrubland to low woodland	Height: 6-9m PFC: 10-20% Tall shrubs or trees /ha: 150-500

Other frequently occurring species:

Trees: *Eucalyptus populnea.*

Low shrubs: *Acacia aneura, Cassia artemisioides, Dodonaea sinuolata* ssp. *acrodentata, Eremophila bowmanii, E. gilesii, E. mitchellii.*

Graminoids: *Aristida calycina* var. *praealta, A. jerichoensis, A. jerichoensis* var. *subspinulifera, Digitaria hystrichoides, D. brownii, Eragrostis eriopoda, E. lacunaria, Eriachne mucronata* (in places), *Monachather paradoxa, Panicum effusum, Thyridolepis mitchelliana.*

Forbs: *Cheilanthes sieberi, Dysphania glomifera, Euphorbia drummondii, Evolvulus alsinoides, Maireana villosa, Sida filiformis, Solanum ellipticum.*

Comments:

Widespread on undulating to gently undulating plains and slopes of low hills, particularly west of the Warrego River. Soils are predominantly acid, shallow, stony, red earths and lithosols. Low woodlands develop in more favourable situations. A low shrub stratum is usually prominent on steeper slopes. The ground stratum is grass dominant, and usually sparse. Clearing results in a *Eucalyptus populnea* shrubby low open woodland, shrubby or wooded tussock grassland, or low shrubland dominated by *A. aneura* or other low shrub species.

Characteristic of land units 38, 54, 55. Occurs in land systems H2, R3, with minor occurrences in H1, R1, R2.

1.d ***Acacia aneura, A. excelsa***	Low woodland	Height: 8-9m PFC: 15-30% Trees/ha: 250-625

Other frequently occurring species:

Shrubs: *Dodonaea viscosa* ssp. *angustissima, Eremophila sturtii, Alectryon oleifolius.*

Graminoids: *Aristida calycina* var. *praealta, A. holanthera, Enneapogon avenaceus, Eragrostis eriopoda, E. lacunaria, Panicum effusum, Perotis rara, Thyridolepis mitchelliana.*

Forbs: *Abutilon otocarpum, Calotis cuneata, Helichrysum ramosissimum, Hibiscus sturtii, Portulaca* spp., *Ptilotus polystachyus.*

Comments:

Widespread on low sandhills associated with the alluvial plains in the south. Soils are acid, deep, red, earthy sands. *A. excelsa* low woodland occurs in some places. A shrub stratum may be prominent after disturbance. The ground stratum is grassy, and the cover ranges from 10-50%. Clearing results in low open woodland, wooded tussock grassland or wooded (low) shrubland.

Characteristic of land unit 62. Occurs in land system D1.

1.e ***Acacia aneura Eucalyptus* spp. *Archidendropsis basaltica***	Woodland to open woodland	Height: 9-11m PFC: 10-305 Trees/ha: 250-850

Other frequently occurring species:

Trees: *Eucalyptus populnea, E. melanophloia, Geijera parviflora, Ventilago viminalis.*

Shrubs: *Eremophila longifolia, E. mitchellii, Alectryon oleifolius.*

Graminoids: *Ancistrachne uncinulata, Aristida calycina* var. *praealta, A. calycina* var. calycina, *Digitaria brownii, Enteropogon acicularis, Eragrostis lacunaria, Thyridolepis mitchelliana.*

Forbs: *Abutilon fraseri, Euphorbia drummondii, Evolvulus alsinoides, Goodenia glabra, Hibiscus sturtii.*

Comments:

Limited in extent. Occurs predominantly on gently undulating plains in the north-east and north, on acid, deep, sandy, red earths. An emergent tree stratum and sparse shrub stratum are usually present, with the shrubs becoming more common after disturbance. The ground stratum is grassy, and the cover varies from <10-30%. Clearing results in an *A. basaltica* tall shrubland, or shrubby or wooded tussock grassland.

Characteristic of land unit 51. Occurs in land system S3.

1.f ***Acacia aneura, Eucalyptus populnea***	Low woodland, rarely woodland	Height: 8-10(-11)m PFC: 10-25% Trees/ha: 125-500

Other frequently occurring species:

Trees: *Brachychiton populneus* (in places).

Low shrubs: *Eremophila bowmanii* (in places), *E. gilesii, E. mitchellii* (in places).

Graminoids: *Aristida calycina* var. *praealta, Digitaria hystrichoides, D. brownii, D. breviglumis, Eragrostis lacunaria, Eriachne helmsii, Monachather paradoxa, Panicum effusum, Themeda triandra, Thyridolepis mitchelliana.*

Forbs: *Cheilanthes sieberi, Euphorbia drummondii, Goodenia glabra, Hibiscus sturtii, Sida filiformis, S. brachypoda, Solanum ferocissimum.*

Comments:

Widespread east of the Warrego River on undulating to gently undulating plains. Soils are acid, moderately deep to deep, loamy red earths, shallow stony red earths, and minor red hardpan soils. Low shrubs are usually sparsely scattered except after disturbance. The ground stratum is grassy, and the cover varies from 10-55%. Clearing results in *E. populnea* open woodland, *A. aneura* - *E. populnea* low open woodland or wooded tussock grassland. Dense *A. aneura* low shrub regeneration is frequently present.

Characteristic of land units 40, 43 and 49, with minor occurrences in 52. Occurs on land systems H1, M1, M2 with minor occurrences in M3.

1.g ***Acacia aneura, Eucalyptus terminalis***	Tall shrubland to low woodland	Height: 6-10m PFC: 10-30% Tall shrubs or trees /ha: 200-450

Other frequently occurring species:

Low shrubs: *Acacia aneura, Cassia artemisioides, C. sturtii, Dodonaea sinuolata* ssp. *acrodentata, D. petiolaris, Eremophila goodwinii, E. latrobei, Prostanthera suborbicularis.*

Graminoids: *Aristida holanthera, A jerichoensis, Digitaria hystrichoides, D. brownii, Eragrostis eriopoda, E. lacunaria, E. microcarpa, Eriachne mucronata, Monachather paradoxa, Panicum effusum, Themeda triandra, Thyridolepis mitchelliana.*

Forbs: *Brunonia australis, Euphorbia drummondii, Evolvulus alsinoides, Maireana villosa, Ptilotus leucocoma, Sida filiformis, Solanum ferocissimum.*

Comments:

Limited in extent. Occurs predominantly on the tablelands of dissected hills west of the Warrego River in southern areas. Soils are acid, stony lithosols. Low shrubs are usually more prominent after disturbance. The ground stratum is frequently very sparse, and composed of grasses. Clearing results in *A. aneura* and/or *E. terminalis* shrubby tall open shrubland or low open woodland, or wooded or shrubby tussock grassland. In some areas in the south-east, *Acacia brachystachya* tall shrubland is the dominant vegetation.

Characteristic of land unit 41. Occurs in land system R3, with minor occurrences in H1, H2, H4.

2. GIDGEE (*ACACIA CAMBAGEI*) PREDOMINANT ASSOCIATIONS

2.a ***Acacia cambagei***	Low woodland, rarely low open forest	Height: 8-9m PFC: 10-25(-30)% Trees/ha: 150-1000

Other frequently occurring species:

Low shrubs: *Enchylaena tomentosa, Eremophila mitchellii.*

Graminoids: *Brachyachne convergens, Chloris pectinata, Dactyloctenium radulans, Eragrostis setifolia, Enteropogon acicularis, Sporobolus* spp., *Tripogon loliiformis.*

Forbs: *Sclerolaena* spp., *Chenopodium desertorum* ssp. *microphyllum, Hibiscus trionum, Malvastrum americanum, Portulaca oleracea, Salsola kali, Sida trichopoda, Trianthema triquetra.*

Comments:

Limited in extent. Occurs on old alluvial plains associated with the Warrego River, predominantly in central areas. Soils are usually very deep, neutral to alkaline, brown, alluvial, cracking clays. Sparsely scattered shrubs are frequently present. The ground cover varies seasonally from 5-20%, and is composed of shortgrasses and ephemeral herbs. Clearing results in low open woodland in which perennial tussock grasses may become more common.

Characteristic of land unit 35. Occurs in land system G3.

2.b ***Acacia cambagei,*** ***Eremophila mitchellii***	Shrubby low woodland	Trees: Height: 8-9m PFC: 10-25% Trees/ha: 150-800 Shrubs: Height: 2-4m PFC: 5-40% Shrubs/ha: 50-1000

Other frequently occurring species:

Trees: *Atalaya hemiglauca, Flindersia maculosa.*

Low shrubs: *Eremophila glabra, Myoporum deserti.*

Graminoids: *Aristida anthoxanthoides, A. contorta, Chloris pectinata, Dactyloctenium radulans, Enneapogon polyphyllus, Enteropogon acicularis, Eragrostis setifolia, E. parviflora, Eriochloa pseudoacrotricha, Paspalidium constrictum, Sporobolus* spp., *Tripogon loliiformis.*

Forbs: *Abutilon oxycarpum, Sclerolaena* spp., *Malvastrum americanum, Salsola kali, Sida fibulifera, S. everistiana, Solanum esuriale, Trianthema triquetra.*

Comments:

Widespread on old alluvial plains associated with the Warrego River, particularly in the south, on very deep, acid, reddish brown, alluvial, texture contrast soils with a sandy surface. Minor areas also occur on scarps of hills in the north, on shallow, stony lithosols. *E. mitchellii* forms a prominent shrub stratum. The ground cover is composed of shortgrasses and ephemeral herbs, and varies seasonally from 10-50%. Clearing results in low open woodland in which the shrub densities usually increase. In southern areas, *A. cambagei - A. harpophylla* low woodland develops on lighter-textured soils.

Characteristic of land units 34, 36, and is associated with land unit 57. Occurs in land system G2, with minor occurrences in G1, R1.

2.c ***Acacia cambagei*** ***Eucalyptus ochrophloia***	Low woodland, layered open forest	Height: 8-10(-12)m PFC: 15-40% Trees/ha: 250-500

Other frequently occurring species:

Low shrubs: *Chenopodium auricomum, Eremophila bignoniiflora, E. maculata, E. mitchellii, E. polyclada, Muehlenbeckia cunninghamii.*

Graminoids: *Astrebla squarrosa, Enteropogon acicularis, Eragrostis setifolia, Eriochloa pseudoacrotricha, Paspalidium jubiflorum, Sporobolus caroli.*

Forbs: *Sclerolaena* spp., *Chenopodium desertorum* ssp. *microphyllum, Sida fibulifera.*

Comments:

Limited in extent. Occurs west of the Warrego River in the centre and north, on alluvial plains which are usually adjacent to low hills from which they receive local runoff. Soils are predominantly alkaline, deep, grey and brown, alluvial clays. *E. ochrophloia* forms a sparse emergent tree stratum above *A. cambagei*, except in wetter areas with gilgaied soils, where it is the dominant species in layered open forest. A low shrub stratum is usually present and becomes more prominent after disturbance. The ground stratum contains both grasses and forbs, and the cover varies seasonally from <10-25%. Clearing may result in a forby low open woodland, or a wooded low shrubland.

Characteristic of land units 17, 19. Occurs in land system W2.

3. BRIGALOW (*ACACIA HARPOPHYLLA*) PREDOMINANT ASSOCIATIONS

3.a *Acacia harpophylla*	Low woodland to tall shrubland, rarely open scrub	Height: 4-9m PFC: 15-30(-40)% Trees or tall shrubs /ha: 225-1000

Other frequently occurring species:

Trees: *Atalaya hemiglauca, Brachychiton rupestris, Flindersia maculosa.*

Shrubs: *Capparis loranthifolia, Eremophila mitchellii, Geijera parviflora, Hakea leucoptera, Alectryon oleifolius.*

Graminoids: *Enneapogon* spp., *Enteropogon acicularis, Paspalidium constrictum, Sporobolus caroli.*

Forbs: *Abutilon oxycarpum, Sclerolaena* spp., *Portulaca oleraceae, Sida fibulifera.*

Comments:

Limited in extent. Occurs on undulating plains in the north, on deep to very deep, brown to reddish, cracking clays with surface stone. Scattered emergent trees and shrubs are usually present. The seasonally variable ground cover is sparse to open, and composed of both grasses and forbs. Clearing usually results in *A. harpophylla* shrubland.

Characteristic of land unit 33. Occurs in land system G1.

3.b *Acacia harpophylla*	Low woodland to tall shrubland, rarely open shrubland	Height: 6-10m PFC: (5-)10-30% Trees or tall shrubs /ha: 100-500

Other frequently occurring species:

Trees: *Eucalyptus largiflorens* (in places), *E. microtheca* (in places), *E. ochrophloia* (in places).

Low shrubs: *Eremophila* spp., *Myoporum deserti* (in places).

Graminoids: *Dichanthium sericeum, Enteropogon acicularis, Eragrostis* spp., *Eriochloa pseudoacrotricha, Paspalidium* spp., *Sporobolus* spp.

Forbs: *Alternanthera denticulata, Sclerolaena* spp., *Chenopodium desertorum* ssp. *microphyllum, Malvastrum americanum, Marsilea* spp., *Sida trichopoda.*

Comments:

Very limited in extent. Occurs predominantly in the south-east, on alluvial plains which frequently have well developed gilgai micro-relief but is also present on some claypans in central and northern areas. Soils are deep to very deep, grey and dark brown, alluvial, cracking clays which are frequently alkaline. Shrubs form a prominent stratum in some areas. The ground cover varies from <10 - 25%, and contains both ephemeral and perennial herbs.

Characteristic of land units 15, 37, 68. Minor occurrences in land systems A2, G2, L2, W8.

3.c *Acacia harpophylla, Eucalyptus thozetiana*	Low woodland to wooded tall shrubland or rarely open scrub	Height: 7-10(-11)m PFC: 15-30(-40)% Trees or tall shrubs /ha: 300-1100

Other frequently occurring species:

Trees: *Eucalyptus cambageana* (in places).

Shrubs: *Capparis loranthifolia, Carissa ovata, Eremophila mitchellii, Geijera parviflora, Alectryon oleifolius, Myoporum deserti.*

Graminoids: *Enteropogon acicularis, Eragrostis lacunaria, Paspalidium caespitosum, P. constrictum, Sporobolus actinocladus, S. caroli.*

Forbs: *Sclerolaena* spp., *Rhagodia hastata, Portulaca oleracea.*

Comments:

Limited in extent. Occurs on low hills and associated undulating plains in the north-east, on shallow, stony lithosols. *E. thozetiana* usually forms an emergent tree stratum above *A. harpophylla*, but may develop into an open woodland with an *A. harpophylla* stratum below. A sparse shrub stratum is often prominent. The ground cover is usually sparse, and composed of forbs and grasses. Clearing results in shrubland dominated by *A. harpophylla, E. thozetiana* or *Eremophila mitchellii.*

Characteristic of land unit 57. Occurs in land system R1, with minor occurrences in G1.

4. OTHER ACACIA (*ACACIA* SPP.) PREDOMINANT ASSOCIATIONS

4.a *Acacia catenulata*	Tall shrubland to open scrub	Height: 5-7m PFC: 15-40% Tall shrubs/ha: 750-1000

Other frequently occurring species:

Trees: *Eucalyptus melanophloia* (in places), *E. thozetiana* (in places).

Tall shrubs: *Eucalyptus exserta* (in places).

Low shrubs: *Dodonaea sinuloata* ssp. *acrodentata, Eremophila latrobei.*

Graminoids: *Aristida caput-medusae, Paspalidium rarum, Sporobolus caroli.*

Forbs: *Sida filiformis.*

Comments:

Limited in extent. Occurs on dissected tops and scarps of low hills in northern areas, on shallow stony lithosols. Emergent trees and a prominent low shrub stratum may be present. The ground stratum is extremely sparse, and dominated by grasses. *Acacia stowardii* low shrubland occurs in some areas.

Characteristic of land unit 58. Minor occurrences in land systems R1, R2.

4.b *Acacia microsperma* or *Acacia omalophylla*	Open scrub to tall shrubland	Height: 4-7m PFC: 15-40% Shrubs/ha: 625-3750

Other frequently occurring species:

Trees: *Casuarina cristata* (in places).

Graminoids: *Diplachne fasca, Eragrostis parviflora, E. setifolia, Eriochloa pseudoacrotricha, Paspalidium jubiflorum, Sporobolus* spp..

Forbs: *Sclerolaena* spp., *Eryngium supinum, Marsilea drummondii, Pratia puberula.*

Comments:

Limited in extent. Occurs on claypans usually located in mulga lands zones, on deep to very deep, light grey, alluvial clays. *Casuarina cristata* forms low open woodland in some areas. The ground stratum contains scattered perennial grass tussocks, and ephemeral herbs which become seasonally-abundant.

Characteristic of land unit 66. Occurs in land system L2, with minor occurrences in L1.

4.c *Acacia petraea*	Tall shrubland	Height: 4-6m PFC: 10-30% Tall shrubs/ha: 1000-4375

Other frequently occurring species:

Trees: *Eucalyptus melanophloia, E. nubila* (in places).

Tall shrubs: *Acacia aneura, A. aprepta* (in places), *A. sparsiflora* (in places), *Eucalyptus exserta* (in places).

Low shrubs: *Dodonaea* spp., *Eremophila* spp., *Prostanthera suborbicularis.*

Graminoids: *Amphipogon caricinus, Aristida nitidula, Eragrostis lacunaria, Eriachne mucronata, Paspalidium caespitosum, Thyridolepis mitchelliana.*

Forbs: *Sida filiformis.*

Comments:

Limited in extent. Occurs on scarps of dissected low hills mostly west of the Warrego River, with minor occurrences on the tops of isolated low hills and minor scarps in the east. Soils are shallow, stony lithosols. Emergent trees and a low shrub stratum are frequently present. The ground stratum is grass-dominant, and usually very sparse. In eastern areas, *A. petraea* may be replaced by *A. aprepta* or *A. sparsiflora.*

Characteristic of land unit 56. Minor occurrences in land systems R1, R2, R3.

5. CYPRESS PINE (*CALLITRIS COLUMELLARIS*) PREDOMINANT ASSOCIATIONS

5.a *Callitris columellaris*	Woodland	Height: 10-11m PFC: 10-20% Trees/ha: 75-200

Other frequently occurring species:

Low trees: *Acacia aneura, A. excelsa, Geijera parviflora.*

Shrubs: *Acacia murrayana, Alstonia constricta, Canthium oleifolium.*

Low shrubs: *Dodonaea viscosa* ssp. *angustissima, Eremophila sturtii.*

Graminoids: *Aristida biglandulosa* (in places), *A. holanthera, Eragrostis eriopoda, Eriachne aristidea, Perotis rara, Triraphis mollis, Triodia mitchellii* (in places).

Forbs: *Abutilon* spp., *Calotis* spp., *Nicotiana velutina, Podolepis jaceoides.*

Comments:

Limited in extent. Occurs on upper slopes and crests of dunes and sandhills, predominantly associated with the alluvial plains in the south, but also, to a limited extent, associated with spinifex sandplains, and claypans occurring the central eastern mulga land zones. Soils are deep, acid, red, earthy sands. Shrubs are usually prominent only after disturbance. The ground cover is grass-dominant, and varies from 5-40%. Clearing results in open woodland to wooded tussock grassland or shrubland.

Characteristic of land unit 61. Minor occurrences in land system D1, with very minor occurrences in S2, N1.

5.b ***Callitris columellaris, Eucalyptus tessellaris, E. dolichocarpa***	Woodland	Height: 10-11(-15)m PFC: 10-20% Trees/ha: 125-225

Other frequently occurring species:

Trees: *Eucalyptus melanophloia* (in places).

Low trees: *Acacia excelsa*.

Shrubs: *Alstonia constricta*.

Graminoids: *Aristida holanthera, Eragrostis lacunaria, Eriachne helmsii, Heteropogon contortus, Panicum effusum, Perotis rara, Triraphis mollis*.

Comments:

Widespread on undulating sandhills associated with the Warrego River and its major tributaries in the north, and to a lesser extent, in central areas. Soils are deep, acid, red to yellowish red, earthy sands. *E. tessellaris* and *E. dolichocarpa* frequently form a sparse, emergent tree stratum above the *C. columellaris*. Shrubs are rarely prominent. The ground stratum is grass-dominant, and the cover varies from 10-50%. Clearing produces a *C. columellaris*, or *E. tessellaris - E. dolichocarpa* open woodland or wooded tussock grassland. *C. columellaris* low scrub regeneration may be prominent. In some areas, *Eucalyptus melanophloia, Callitris columellaris* woodland occurs, in which *C. columellaris* forms a distinct low tree stratum below *E. melanophloia*.

Characteristic of land unit 63. Occurs in land system D3, with minor occurrences in D2.

6. EUCALYPT (*EUCALYPTUS* SPP.) PREDOMINANT ASSOCIATIONS

6.a ***Eucalyptus camaldulensis***	Woodland to open woodland	Height: (9-)10-11m PFC: 10-30(-35)% Trees/ha: 50-100

Other frequently occurring species:

Trees: *Eucalyptus populnea*.

Tall shrubs: *Eremophila mitchellii, Melaleuca trichostachya*.

Graminoids: *Arundinella nepalensis* (in places), *Bothriochloa ewartiana, Chrysopogon fallax, Dichanthium sericeum, Leptochloa digitata* (in places).

Comments:

Occurs along major drainage lines in mulga land zones, on red and brown alluvial clays, and stony substrates. Scattered shrubs may be present. The ground cover varies from 5-15%, and is dominated by perennial grasses.

Characteristic of land unit 1. Occurs in land system W1.

6.b ***Eucalyptus camaldulensis, E. microtheca***	Woodland, rarely open forest	Height: 10-12m PFC: 15-30(-40)% Trees/ha: 100-125

Other frequently occurring species:

Tall shrubs: *Acacia salicina, A. stenophylla, Eremophila bignoniiflora, Melaleuca trichostachya*.

Graminoids: *Bothriochloa* spp., *Chrysopogon fallax, Leptochloa digitata, Paspalidium jubiflorum, Sporobolus mitchellii*.

Forbs: *Lomandra longifolia, Xanthium pungens.*

Comments:

Widespread along the channels of the major rivers, on alluvial, grey and brown, cracking clays. Minor areas are associated with sandhill drainage lines. *E. microtheca* woodland to open woodland develops in some areas. A tall shrub stratum is often prominent. The ground cover is frequently sparse, and dominated by perennial grasses.

Characteristic of land units 2, 24, and associated with land unit 21. Occurs in land systems W6, W7, with minor occurrences in D2, D3.

6.c *Eucalyptus intertexta* ***Acacia aneura***	Open woodland, rarely woodland	Height: 11-12m PFC: 5-10(-20)% Trees/ha: 25-50 Low trees/ha: 150-2000

Other frequently occurring species:

Trees: *Eucalyptus melanophloia* (in places), *E. populnea* (in places).

Shrubs: *Eremophila mitchellii* (in places).

Graminoids: *Aristida calycina* var. *praealta, Eragrostis eriopoda, E. lacunaria, Monachather paradoxa, Panicum effusum, Themeda triandra, Thyridolepis mitchelliana.*

Forbs: *Cheilanthes sieberi, Euphorbia drummondii, Hibiscus sturtii, Maireana villosa.*

Comments:

Limited in extent. Occurs on flat plains predominantly associated with soft mulga in the central-east, where it also frequently forms an intergrade community fringing spinifex communities. Minor areas occur in the north-west with soft mulga. Soils are predominantly deep, sandy, red earths. The *A. aneura* usually forms a low tree stratum below the *E. intertexta*, and scattered shrubs may be present. The ground cover is grass-dominant, and varies from 10-40%. Clearing results in an *E. intertexta* open woodland.

Characteristic of land unit 30. Minor occurrences in land systems M2, M3, S1, N1.

6.d *Eucalyptus largiflorens*	Low woodland	Height: 6-8m PFC: 20-30% Trees/ha: 100-250

Other frequently occurring species:

Tall shrubs: *Acacia omalophylla* (in places).

Low shrubs: *Muehlenbeckia cunninghamii.*

Graminoids: *Eragrostis setifolia, Paspalidium jubiflorum.*

Forbs: *Atriplex* spp., *Sclerolaena* spp.

Comments:

Very limited in extent. Occurs in the south-eastern corner on swampy alluvial plains, on very deep, alkaline, grey alluvial clays. Scattered shrubs may be present. The ground stratum is sparse, and dominated by perennial grasses.

Characteristic of land unit 14. Minor occurrences in land system W8.

6.e *Eucalyptus* ***melanophloia,*** ***Acacia aneura***	Woodland, rarely low woodland	Height: (9-)10-13m PFC: 10-30% Trees/ha: 250-1625

Other frequently occurring species:

Trees: *Brachychiton populneus* (in places), *Eucalyptus populnea*.

Graminoids: *Amphipogon caricinus, Aristida calycina* var. *praealta, A. jerichoensis, A, jerichoensis* var. *subspinulifera, Digitaria hystrichoides, D. brownii, Eragrostis lacunaria, Monachather paradoxa, Panicum effusum, Themeda triandra, Thyridolepis mitchelliana*.

Forbs: *Cheilanthes sieberi, Euphorbia drummondii, Goodenia glabra, Sida filiformis, Solanum ferocissimum*.

Comments:

Limited in extent. Occurs predominantly on upper slopes and ridges, and on minor undulating plains, in association with *A. aneura* in the Arabella and Sommariva land systems in the north-east. Soils are acid, shallow to moderately deep, loamy, red earths. *A. aneura* often forms a lower tree stratum below the *E. melanophloia*. Shrubs are generally absent. The ground stratum is grassy, and the cover varies from 15-30%. Clearing results in an *E. melanophloia* open woodland or wooded tussock grassland.

Associated with land units 40, 49. Occurs in land systems H1, M1.

6.f *Eucalyptus microtheca*	Low open woodland, occasionally wooded tussock grassland, rarely low woodland	Height: 5-10m PFC: <5-10(-30)% Trees/ha: <25-150

Other frequently occurring species:

Tall shrubs: *Acacia stenophylla, Eremophila bignoniiflora*.

Low shrubs: *Muehlenbeckia cunninghamii*.

Graminoids: *Astrebla* spp., *Cyperus bifax, Dichanthium sericeum, Eragrostis setifolia, Iseilema* spp., *Panicum decompositum*.

Forbs: *Alternanthera nodiflora, Goodenia fascicularis, Hibiscus trionum, Marsilea* spp., *Minuria integerrima, Plantago drummondii, Phyllanthus maderaspatensis, Polymeria longifolia*.

Comments:

Widespread on the alluvial plains, where it occurs along seasonally-flooded drainage lines and anastomosing channels, and on flat plains. Minor occurrences are associated with claypans located in mulga land zones. Soils are very deep, grey and brown, alluvial, cracking clays. Low woodland may develop along larger drainage lines, while wooded tussock grassland occurs on drier areas of the flat plains. Scattered shrubs are usually present, and a distinct low shrub stratum frequently develops along wetter channels and swamps. The ground stratum is usually dominated by perennial grasses, although ephemeral herbs are seasonally abundant. The cover varies from <10-60%.

Characteristic of land units 6, 10, 11, 12, 20. Occurs in land systems W4, W5, W8, with minor occurrences in L2.

6.g *Eucalyptus ochrophloia*	Woodland to open woodlands	Height: (9-)10-11m PFC: 5-15% Trees/ha: 150-200

Other frequently occurring species:

Trees: *Acacia cambagei, Eucalyptus microtheca*.

Low shrubs: *Chenopodium auricomum, Eremophila bignoniiflora, Muehlenbeckia cunninghamii*.

Graminoids: *Astrebla* spp., *Cyperus gilesii, Dichanthium sericeum, Eragrostis setifolia, Eriochloa pseudoacrotricha, Iseilema* spp.

Forbs: *Atriplex muelleri, Sclerolaena* spp., *Hibiscus brachysiphonius, H. trionum, Portulaca oleracea, Sida trichopoda.*

Comments:

Limited in extent. Occurs on infrequently flooded drainage lines on alluvial plains associated with the Warrego River, predominantly in central areas, with minor occurrences on inter-channel flats associated with the major rivers in the north-west. Soils are usually neutral to alkaline, deep to very deep, grey or brown, alluvial cracking clays. Low shrubs are scattered in drier areas, but form a prominent stratum in wetter habitats. The ground stratum consists of perennial grasses and ephemeral herbs, and the cover varies seasonally from 5-20%. Clearing often results in a low open woodland.

Characteristic of land unit 5, and associated with 10. Occurs in land systems W3, with minor occurrences in W7, W8.

6.h *Eucalyptus populnea*	Woodland to open woodland, rarely low woodland	Height: (8-)10-11m PFC: (5-)10-25% Trees/ha: 25-500

Other frequently occurring species:

Trees: *Acacia aneura, Eucalyptus melanophloia.*

Shrubs: *Eremophila glabra, E. longifolia, E. mitchellii.*

Graminoids: *Aristida calycina* var. *praealta, Bothriochloa ewartiana, Digitaria brownii, Enneapogon avenaceus, Eragrostis elongata, E. lacunaria, E. microcarpa, Panicum effusum, P. subxerophilum, Themeda triandra.*

Forbs: *Sclerolaena birchii, Brunoniella australis, Calotis cuneata, Euphorbia drummondii, Goodenia heterochila, Haloragis* spp., *Justicia procumbens, Solanum ferocissimum, Velleia glabrata.*

Comments:

Occurs predominantly along drainage systems, but is also associated with the edges of claypans, in mulga land zones east of the Warrego River. Central channels are absent from the drainage systems. Soils are acid, moderately deep to deep, red earths and red clays, with scalded, texture contrast soils on the claypans. A sparse shrub stratum may be present, and the grass-dominant ground cover varies from <5-50%.

Characteristic of land units 27, 65. Occurs in land system E3, with minor occurrences in L2.

6.i *Eucalyptus populnea*	Low woodland to low open woodland	Height: 7-10m PFC: 10-40% Trees/ha: 50-375

Other frequently occurring species:

Trees: *Acacia aneura.*

Shrubs: *Eremophila mitchellii.*

Graminoids: *Bothriochloa ewartiana* (sandy soils), *Chloris pectinata, Enteropogon acicularis, Eragrostis elongata, E. microcarpa, Heteropogon contortus* (sandy soils), *Panicum effusum, Themeda triandra.*

Forbs: *Calotis* spp., *Cheilanthes sieberi, Dianella longifolia* var. *stupata, Evolvulus alsinoides, Goodenia heterochila.*

Comments:

Occurs on drainage systems which are predominantly associated with mulga land zones, although minor areas are associated with sand-hill drainage lines. Central drainage channels are usually absent. Soils are mostly moderately deep to deep, red earths, sandy red earths and red, texture contrast soils, and are usually acid. A sparse shrub stratum may be present. The ground stratum is grass dominant, and the cover varies from 15-60%.

Characteristic of land units 26, 28, 31, minor occurrences in 1. Occurs in land systems B2, B4, with minor occurrences in D1, D2, D3, W1.

6.j ***Eucalyptus populnea***	Grassy open woodland	Height: 10-12m PFC: 5-10% Trees/ha: 25-100

Other frequently occurring species:

Shrubs: *Acacia aneura, Eremophila gilesii, E. mitchellii.*

Graminoids: *Amphipogon caricinus, Aristida calycina* var. *praealta, A. jerichoensis, Digitaria hystrichoides, Eragrostis eriopoda, E. lacunaria, E. microcarpa, Eriachne helmsii, Monachather paradoxa.*

Forbs: *Sclerolaena birchii, Calotis cuneata, Cheilanthes sieberi, Euphorbia drummondii, Goodenia glabra, Ptilotus polystachyus.*

Comments:

Widespread on flat to undulating plains on acid, shallow to moderately deep, loamy red earths, sandy red earths, red hardpan soils, and shallow, stony red earths. It is an induced association which develops after successful clearing of *Acacia aneura* low open forest and low woodland associations. A sparse shrub stratum of *A. aneura* or other shrubs is often present. The ground stratum is grass-dominant, and the cover varies from 15-60%.

Characteristic of land units 38, 43, 46, 48, and 52 after clearing. Occurs in land systems H2, M2, M3, M4.

6.k ***Eucalyptus populnea, Eremophila mitchellii***	Shrubby woodland to shrubby open woodland, rarely shrubby low woodland	Height: (8-)10-11m PFC: 10-35% Trees/ha: 25-125 Shrubs/ha: 100-1250

Other frequently occurring species:

Shrubs: *Eremophila glabra, Cassia* spp. (in places).

Graminoids: *Aristida* spp., *Bothriochloa decipiens, Chloris* spp., *Digitaria brownii, Enteropogon acicularis, Eragrostis lacunaria, E. microcarpa, Panicum effusum, P. subxerophilum, Paspalidium constrictum, Themeda triandra.*

Forbs: *Abutilon* spp., *Alternanthera denticulata, Centipeda* spp., *Convolvulus erubescens, Euphorbia drummondii, Sida* spp..

Comments:

Occurs predominantly along drainage systems associated with mulga land zones, and on flat, alluvial plains associated with the Warrego River in northern areas. Minor areas are associated with scalded plains on the tops of low hills occurring in the Nebine land system. Soils are acid to neutral, and predominantly moderately deep to deep, red earths and texture contrast soils. *E. mitchellii* forms a prominent shrub stratum, while other scattered, low shrubs may occur. The ground stratum is grassy, and the cover varies from 10-55%.

Characteristic of land units 3, with minor occurrences in 8, 25, 29. Occurs in land systems A3, B1, with minor occurrences in D2, L1, L2, M2, W1.

6.l ***Eucalyptus thozetiana, various shrubs***	Shrubby open woodland to wooded tall shrubland, rarely wooded low shrubland	Trees: Height: (9-)10-12m PFC: <10% Trees/ha: <25-100 Shrubs: Height: 2-4(-6)m PFC: 10-30% Shrubs/ha: to 2500

Other frequently occurring species:

Trees: *Eucalyptus cambageana* (in places).

Tall shrubs: *Acacia aneura, A. microsperma, Capparis loranthifolia, Dodonaea sinuloata* ssp. *acrodentata, Eremophila oppositifolia* var. *rubra, E. mitchellii, Geijera parviflora.*

Low Shrubs: *Phebalium glandulosum* (in places).

Graminoids: *Enteropogon acicularis, Leptochloa decipiens, Paspalidium caespitosum, Sporobolus caroli.*

Forbs: *Dysphania rhadinostachya, Dysphania glomifera, Hibiscus sturtii, Sida filiformis.*

Comments:

Limited in extent. Occurs on slopes and scarps of dissected hills, predominantly west of the Warrego River in northern areas. Soils are shallow stony lithosols. *Acacia microsperma* tall shrubland often occurs on lower scarp retreat zones. The ground stratum is usually very sparse, and dominated by grasses.

Characteristic of land unit 59. Occurs in land system R2.

7. MISCELLANEOUS ASSOCIATIONS

7.a ***Atriplex nummularia***	Low shrubland to low open shrubland	Height: 1-1.5m PFC: 5-15% Shrubs/ha: to 1250

Other frequently occurring species:

Trees: *Eucalyptus microtheca.*

Graminoids: *Chloris pectinata, Dactyloctenium radulans, Eragrostis* spp., *Sporobolus* spp..

Forbs: *Atriplex* spp., *Sclerolaena* spp..

Comments:

Extremely limited in extent. Primarily occurs around springs which are infrequently present on the alluvial plains in the south. Soils are scalded, grey, cracking clays.

Characteristic of land unit 13. Very minor occurrences in land system W8.

7.b ***Chenopodium auricomum***	Low shrubland to low open shrubland	Height: <=1m PFC: 5-15% Shrubs/ha: 500-2250

Other frequently occurring species:

Trees: *Eucalyptus microtheca* (in places).

Tall shrubs: *Eremophila bignoniiflora.*

Graminoids: *Cyperus* spp., *Dichanthium sericeum, Eleocharis pallens, Elytrophorus spicatus, Eragrostis setifolia, Iseilema* spp., *Panicum* spp..

Forbs: *Alternanthera indica, Alternanthera nodiflora, Sclerolaena* spp., *Hibiscus trionum, Marsilea drummondii.*

Comments:

Very limited in extent. Occurs in swamps which are frequently associated with drainage lines and sandhills on the alluvial plains, and in claypans. Soils are deep, grey, cracking clays. The ground stratum is frequently dominated by sedges.

Characteristic of land unit 9. Minor occurrences in land systems D1, D2, L1, W2, W3.

7.c *Geijera parviflora*	Low open woodland	Height: 6-8m PFC: 5-10% Trees/ha: 25-75

Other frequently occurring species:

Low trees: *Acacia excelsa, Atalaya hemiglauca, Grevillea striata, Ventilago viminalis.*

Shrubs: *Capparis loranthifolia, Dodonaea viscosa* ssp. *angustissima, Eremophila sturtii, Hakea leucoptera, Myoporum* spp..

Graminoids: *Aristida calycina* var. *praealta, A. holanthera, Enneapogon* spp., *Eragrostis lacunaria, Triraphis mollis.*

Forbs: *Abutilon fraseri, Sclerolaena* spp., *Boerhavia diffusa, Sida atherophora.*

Comments:

Limited in extent. Occurs on levees and lower slopes of sandhills associated with the Warrego River in central and southern areas. Soils are acid, loamy sands and texture contrast soils. Shrubs are usually present, and frequently become very dense after disturbance. The ground stratum is grassy, and the cover varies from 10-25%. In some areas the association develops after clearing of *Callitris columellaris.*

Characteristic of land unit 60. Minor occurrences in land systems D1, D2, with very minor occurrences in D3.

8. GRASS, HERB OR SEDGE PREDOMINANT ASSOCIATIONS

8.a *Aristida* spp.	Wooded tussock grassland to wooded open tussock grassland	Height: <1m PFC: 10-60%

Other frequently occurring species:

Trees: *Acacia aneura, Eucalyptus populnea.*

Shrubs: *Acacia aneura, Eremophila gilesii, E. glabra.*

Graminoids: *Amphipogon caricinus, Aristida calycina* var. *praealta, A. jerichoensis, A. jerichoensis* var. *subspinulifera, A. holanthera, Digitaria brownii, Eragrostis eriopoda, E. lacunaria, Monachather paradoxa, Themeda triandra, Thyridolepis mitchelliana.*

Forbs: *Sclerolaena birchii, S. convexula, Calotis cuneata, C. lappulacea, Cheilanthes sieberi, Euphorbia drummondii, Sida brachypoda, Trachymene ochracea, Velleia glabrata.*

Comments:

Occurs on flat to undulating plains on acid, shallow to deep, loamy red earths and sandy red earths, and shallow, stony red earths. It is an induced association resulting from the successful clearing of *Acacia aneura* associations. Scattered trees are usually present, and a low shrub stratum may be prominent. Where *A. aneura* regeneration occurs, the association will eventually revert to *A. aneura* low woodland.

Associated with land units 40, 42, 44, 46, 47. Occurs in land systems H1, H4, M2, S2.

8.b ***Astrebla lappacea***	Tussock grassland to open tussock grassland	Height: <0.75m PFC: 10-60%

Other frequently occurring species:

Low shrubs: *Maireana aphylla* (in places).

Graminoids: *Aristida anthoxanthoides, Astrebla elymoides, Brachyachne convergens, Dichanthium sericeum, Digitaria divaricatissima, Eragrostis setifolia, Iseilema* spp., *Panicum decompositum, Sporobolus actinocladus.*

Forbs: *Sclerolaena muricata, Goodenia fascicularis, Hibiscus trionum, Malvastrum americanum, Rhynchosia minima, Sida trichopoda.*

Comments:

Widespread on flat, alluvial plains, on very deep, neutral to alkaline, brown, reddish brown and greyish brown, cracking clays. Very sparsely scattered low shrubs occur in some areas. *Astrebla elymoides* and *Dichanthium sericeum* are co-dominant on the heavier soils, and usually increase during wetter years throughout the associations. Ephemeral herbs may be seasonally co-dominant or abundant.

Characteristic of land units 4, 16. Occurs in land systems A1, A2.

8.c ***Astrebla lappacea***	Tussock grassland to open tussock grassland	Height: <0.75m PFC: 10-35%

Other frequently occurring species:

Trees: *Acacia pendula, Flindersia maculosa.*

Tall shrubs: *Alectryon oleifolius, Hakea leucoptera.*

Low shrubs: *Eremophila glabra, Maireana aphylla.*

Graminoids: *Aristida leptopoda, A. platychaeta, Dichanthium sericeum, Digitaria divaricatissima, Eriochloa pseudoacrotricha, Iseilema membranaceum, Panicum decompositum.*

Forbs: *Calotis cuneifolia, Lotus cruenta, Sida fibulifera.*

Comments:

Very limited in extent. Occurs on gently undulating plains in the north-east, on shallow, brown, cracking clays with scattered surface pebble. Scattered trees and shrubs may be present, and are usually associated with low rises. *Dichanthium sericeum* and/or ephemeral herbs may be seasonally co-dominant or abundant.

Characteristic of land unit 32. Occurs in land system F1, with minor occurrences in G1.

8.d ***Ephemeral herbs, sedges***	Seasonal herbland or open herbland, or sedgeland	Height: <0.3m PFC: 10-40%

Other frequently occurring species:

Low shrubs: *Halosarcia halocnemoides* (in places), *Sclerostegia tenuis* (in places).

Graminoids: *Cyperus* spp., *Dichanthium sericeum, Eleocharis pallens, Elytrophorus spicatus, Eragrostis* spp., *Eriachne ovata.*

Forbs: *Alternanthera indica, Alternanthera denticulata, Centipeda* spp., *Craspedia chrysantha, Eryngium supinum, Marsilea* spp., *Mimulus* spp., *Swainsona* spp..

Comments:

Limited in extent. Occurs in claypans located in mulga land zones, on deep, grey to brown, alluvial clays. The ground stratum contains many ephemeral herbs which become seasonally abundant.

Characteristic of land unit 69. Occurs in land systems L1, L2.

8.e *Ephemeral herbs*	Sparse-herbland, occasionally open grassland	Height: <0.3m PFC: usually <10%, seasonally to 30%

Frequently occurring species:

Graminoids: *Aristida ramosa* (texture contrast soils only), *Dactyloctenium radulans, Iseilema membranaceum, Brachyachne convergens, Chloris pectinata, Neurachne munroi* (texture contrast soils only), *Sporobolus actinocladus, S. caroli, Tragus australianus, Tripogon loliiformis.*

Forbs: *Atriplex eardleyae, A lindleyi, A. spongiosa, Sclerolaena calcaratha, S. dicantha, S. divaricata, S. lanicuspis, Maireana coronata, Portulaca oleracea, Salsola kali, Trianthema triquetra.*

Comments:

Very limited in extent. Occurs in overgrazed areas on alluvial plains on very deep, brown to reddish brown to grey-brown,cracking clays. Minor areas are associated with scalded fringes of claypans and some drainage lines, on texture contrast soils. On scalded surfaces the ground is bare or the cover extremely sparse. Seasonal, open grassland often develops in areas where surface scalding is absent.

Characteristic of land units 3, 8 and associated with overgrazed 4. Minor occurrences in land systems A1, A2, D1, G2, L1, L2, W1, W8.

8.f *Eragrostis australasica*	Open hummock grassland	Height: 1m PFC: 5-10(-15)%

Other frequently occurring species:

Trees: *Eucalyptus microtheca* (in places).

Low shrubs: *Chenopodium auricomum, Muehlenbeckia cunninghamii.*

Graminoids: *Diplachne fasca, Eragrostis parviflora.*

Forbs: *Alternanthera indica, Alternanthera nodiflora, Sclerolaena* spp., *Frankenia uncinata, Marsilea* spp..

Comments:

Very limited in extent. Occurs on claypans frequently located in mulga land zones, on very deep, grey, alluvial, cracking clays. Scattered low shrubs may be present in some areas.

Characteristic of land unit 67. Minor occurrences in land systems L1, L2.

8.g Shortgrasses, *Acacia victoriae*	Shrubby open grassland to open shrubland	Grasses: Height: <0.5m PFC: 5-20% Shrubs: Height: 2-4m PFC: <10% Shrubs/ha: <25-500

Other frequently occurring species:

Trees: *Atalaya hemiglauca, Eucalyptus populnea, E. terminalis, Ventilago viminalis.*

Graminoids: *Aristida* spp., *Bothriochloa* spp., *Chloris* spp., *Enneapogon* spp., *Sporobolus actinocladus.*

Forbs: *Sclerolaena* spp., *Boerhavia diffusa, Convolvulus erubescens, Evolvulus alsinoides, Lotus cruenta*.

Comments:

Limited in extent. Occurs on levees associated with the major rivers in the northern and central areas, on very deep, brown, sandy, alluvial clays and clay-loams. Sparsely scattered trees are frequently present. The ground stratum is usually sparse, and dominated by shortgrasses and ephemeral herbs.

Characteristic of land unit 20. Occurs in land system D2, with minor occurrences in D1.

8.h Shortgrasses, forbs ***Atalaya hemiglauca***	Wooded sparse- to open grassland or herbland, occasionally low open woodland	Grasses: Height: <0.5m PFC: 5-25% Trees: Height: 9-10m PFC: usually <10% Trees/ha: <100

Other frequently occurring species:

Trees: *Acacia excelsa* (in places), *Eucalyptus populnea* (in places), *Flindersia maculosa* (in places).

Tall shrubs: *Alectryon oleifolius*.

Graminoids: *Aristida* spp., *Chloris* spp., *Enneapogon avenaceus, Sporobolus actinocladus*.

Forbs: *Abutilon* spp., *Atriplex muelleri, Sclerolaena* spp., *Goodenia fascicularis, Sida* spp.

Comments:

Limited in extent. Occurs predominantly on flat, alluvial plains not normally subject to flooding, on very deep, alkaline, reddish brown, alluvial clays. Minor areas are associated with low rises on the mitchell grass plains, scalded soils in gidgee, and limestone rises around the edges of claypans. The ground stratum is usually sparse, but varies seasonally.

Characteristic of land units 18, 23, 70. Occurs in land system A3, with minor occurrences in A1, A2, G2, G3, L1.

8.i *Triodia mitchellii, Eucalyptus melanophloia*	Wooded or shrubby open hummock grass- land to grassy low open woodland or tall open shrubland	Grasses: Height: 1m PFC: 15-30(-60)% Trees/tall shrubs: Height: 6-10m PFC: <10% Plants/ha: <25-200

Other frequently occurring species:

Trees: *Angophora melanoxylon* (in places), *Eucalyptus dolichocarpa* (in places).

Shrubs: *Acacia maitlandii, Acacia* spp., *Dodonaea boroniifolia, D. peduncularis, Eucalyptus exserta* (in places), *Grevillea juncifolia*.

Graminoids: *Aristida calycina* var. *praealta, A. holanthera, Eragrostis eriopoda, Panicum effusum, Triodia marginata* (in places).

Forbs: *Brunonia australis, Goodenia glabra, Pimelea trichostachya, Stackhousia viminea, Trachymene ochracea*.

Comments:

Widespread on flat to gently undulating plains on deep, acid, red to yellowish red sands. There is frequently a gradation from hummock grassland to low open woodland or tall open shrubland communities. *E. melanophloia* forms a low woodland in some areas. A prominent shrub or low shrub stratum occurs in many areas. The structure, shrub density and floristic composition of the association are affected by fire.

Characteristic of land unit 64. Occurs in land system N1.

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Chapter 6

LAND SYSTEMS

by J.R. Mills[1] and R.W. Purdie[2]

The survey area covers 50 000 km^2 of land in south-western Queensland. The area is within the arid zone and is used almost solely for grazing purposes.

The survey was carried out to provide an inventory of the land resources of the area. The data was interpreted and assessed to identify the factors influencing the condition of the land resources, and the likely effects of current methods of land use in the long term.

SURVEY METHODS

Survey procedures were similar to those described by Dawson and Boyland (1974) and used in other surveys in this series. These procedures are based on the land system concept defined by Christian and Stewart (1968). Areas shown on the map as land systems are defined as "areas or groups of areas throughout which there is a recurring pattern of topography, soils and vegetation". The individual and relatively homogeneous parts of this recurring pattern are called land units.

Land systems were mapped on 1969 black and white aerial photographs with a scale of 1:84 000, and mapping was transferred from these photographs to working maps at a scale of 1:250 000. These maps were assembled at a scale of 1:500 000 to form the published land system map.

Descriptions of the land systems and land units are based on detailed soil and vegetation descriptions at 272 sample sites. A further 340 reconnaissance sites provided less detailed observations on landform, soils and vegetation.

Approximately half of the detailed sample sites (134) were chosen using a 20 km grid placed over a map of the survey area, and sampling the photo pattern in which each grid point occurred. The remainder of the detailed sample sites were chosen to fully describe the land units defined in the area. Sampling was biased to provide a greater number of observations on the more productive land units. Where possible, sites were spread over the geographic distribution of the land units to reflect climatic changes and other variations.

Data were collected at the detailed sample sites using standardised descriptions and recording sheets. This information including soil analytical data, is contained in Microfiche 1.

LAND SYSTEMS

Forty land systems have been described, and grouped into 12 broad land zones. The land systems and land zones are shown on the accompanying land systems map at a scale of 1:500 000.

Dyeline prints of the land systems mapping at a scale of 1:250 000 are available for use by other persons working in the area.

The relationship of land systems with each other and within the topographic sequence is shown in Figure 6.1. Land system names have been chosen from areas where the land systems occur, but do not imply any single geographic area to which the land system is confined.

Sandhills land zone (D)

This land zone comprises the levee sands associated with the Warrego River, which vary from flat sand sheets to wind-formed sandhills, occasionally topped with longitudinal sand dunes.

Three land systems have been described in this land zone, based on vegetation and landform differences.

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[1] Formerly Land Resources Branch, Queensland Department of Primary Industries.

[2] Formerly Botany Branch, Queensland Department of Primary Industries.

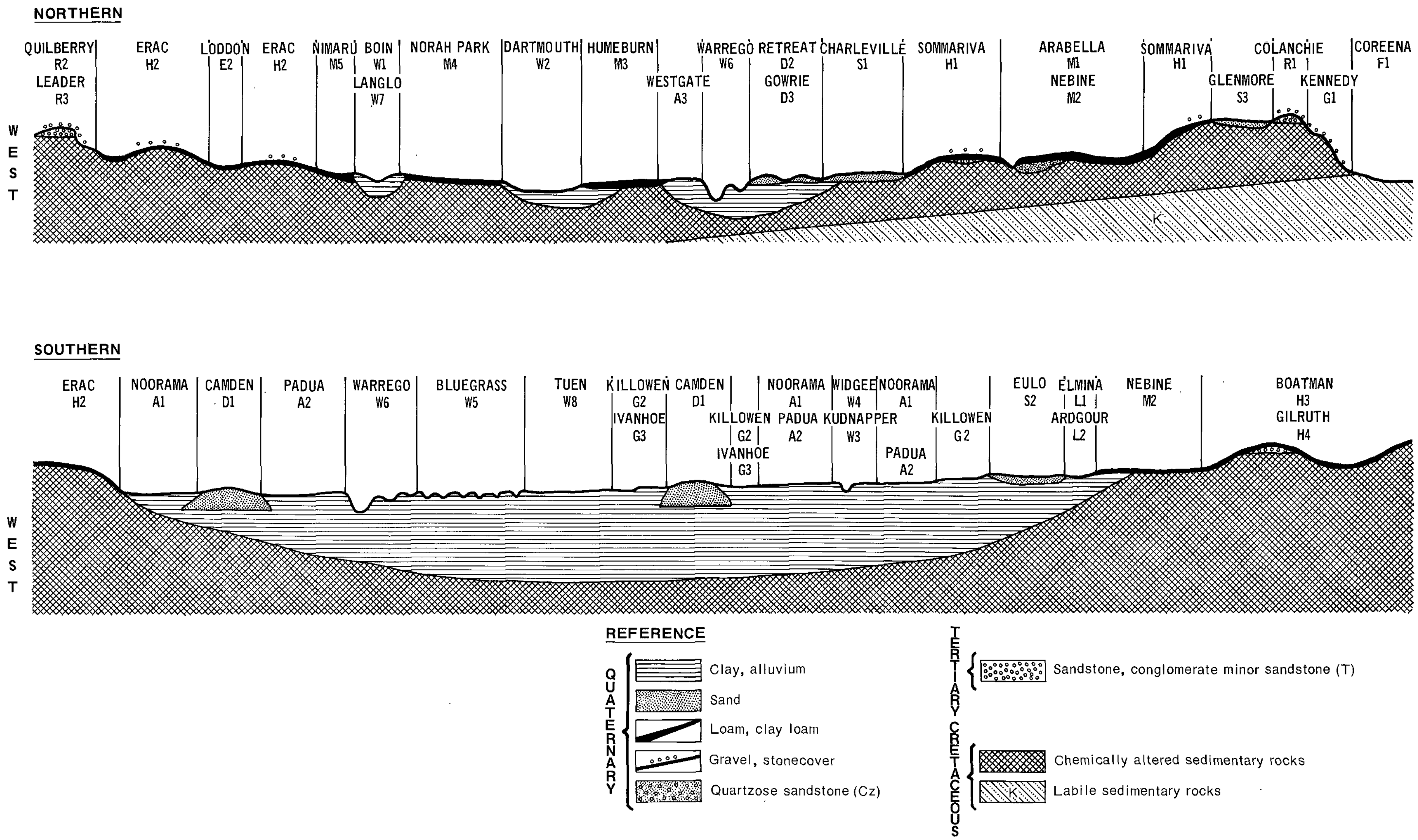
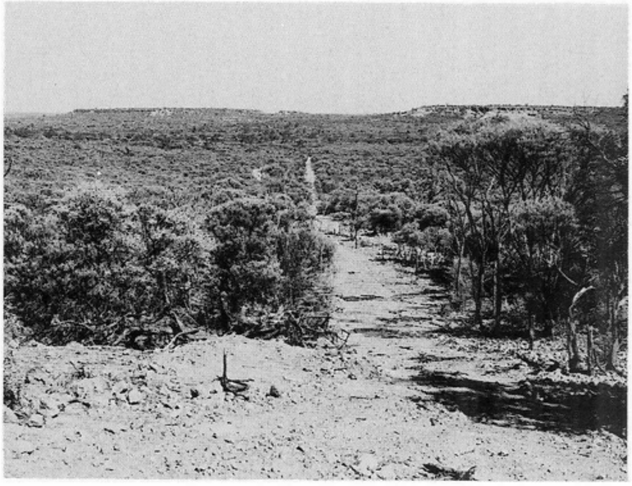
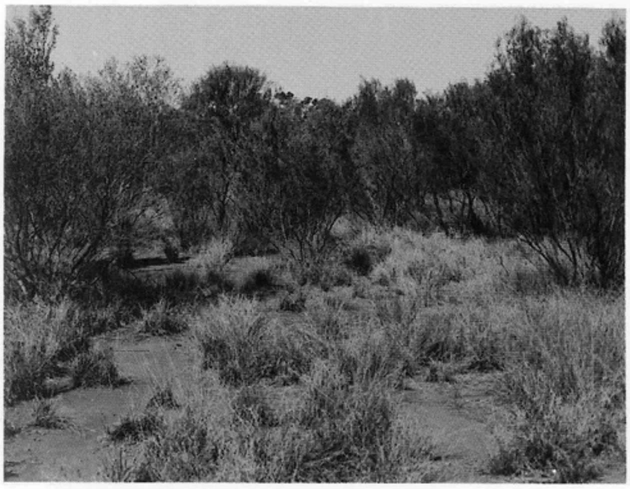


FIGURE 6.1 Diagrammatic cross section illustrating idealised relationship between land systems and geology.

Erac land system in good condition.



Dissected hills and scarps of Quilberry land system.

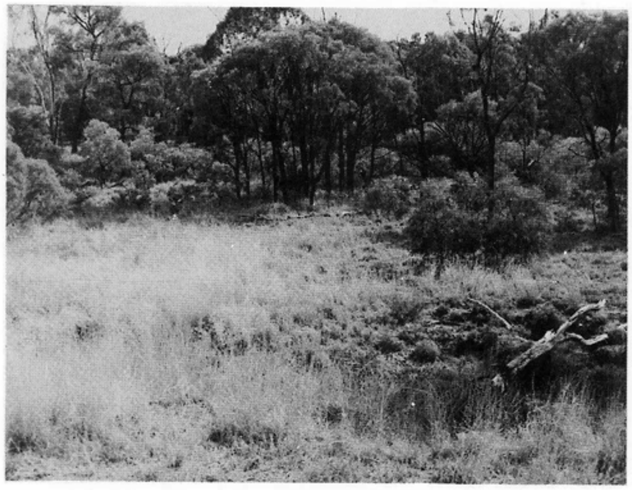


Shrub infested sandplains of Eulo land system.

Soft mulga lands of Norah Park land system in good condition.

Low sandhills of Camden land system.

High forage levels in drainage lines of Halton land system.

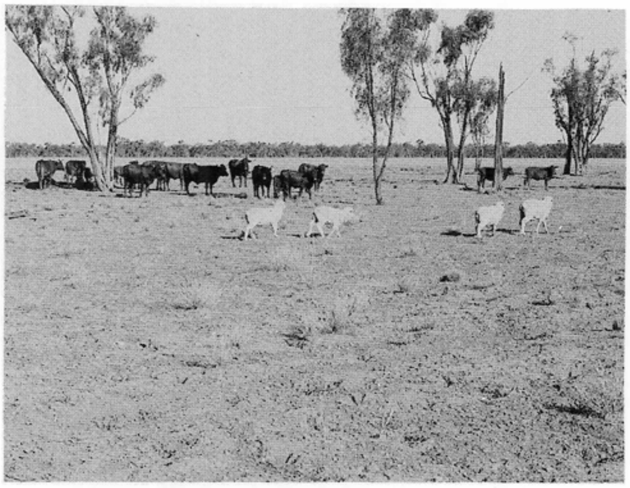


Undulating brigalow lands of the Kennedy land system.

Rolling mitchell grass plains of the Coreena land system.

Gidgee areas provide shade on the Killowen land system.

Flat mitchell grass plains of the Noorama land system.



The frequently flooded heavy clay soils of the Kudnapper land system.

Heavy clay soils in flooded coolibah areas of the Tuen land system.

Camden land system comprises wind-shaped sandhills on the alluvial plains of the Warrego distributory system in the southern part of the area. These sandhills are usually low sand mounds and small areas of sandsheet with occasional isolated longitudinal dunes present. Soils are deep, red earthy sands, with limited areas of yellowish red, siliceous sands on the dunes. Mulga, ironwood, wilga, vinetree, beefwood and whitewood shrubby low woodlands predominate and provide valuable top feed in areas where reasonable tree densities still exist. Invasion of these areas by sandhill hopbush and turpentine is common. Cypress pine woodlands occur on the crests of the sandhills and once provided a valuable source of timber.

Retreat land system comprises sand levees adjacent to the Warrego River in its middle reaches, above the extensive distributory system where Camden land system occurs. These sandsheets have frequent minor channels flowing through them and are subject to partial inundation during major floods. Very deep, alluvial soils predominate, ranging from loamy sands in the highest areas to sandy clays (most common) and alluvial texture contrast soils, with heavy, grey clays in the channels. Wilga, beefwood and ironwood predominate and shrubby areas of gunda-bluey are characteristic. Minor areas of cypress pine occur on the higher, sandier soils.

Gowrie land system comprises levees and sandsheets associated with the Warrego River in its upper reaches. These sandsheets consist of deep, yellowish red, earthy sands occurring above normal flood levels. Cypress pine, carbeen, and longfruited bloodwood predominate, with extensive areas of coarse wiregrasses. Minor areas of wilga, beefwood and mulga/ironwood occur on the lower parts of these levees.

Spinifex sandplains land zone (N)

Shelbourne land system consists of relatively flat sandplains which have formed a fairly deep cover (>120 cm) over the Tertiary land surface. Red to yellowish red, earthy sands predominate, supporting spinifex hummock grassland with scattered ironbark and occasionally, a shrubby overstorey of wattles (*Acacia* spp.).

Mulga sandplains land zone (S)

These sandplains were formed by the spreading of red quartzose sand over the Tertiary land surface and in places over Quaternary alluvium. It is thought that these sands may be the upper reworked portion of late Tertiary fluvial deposits (Senior *et al.* 1969). These deposits would have been derived from erosion of the quartzose (sandy) sediments of the Tertiary period. Three land systems have been recognised on the basis of vegetation differences. Soils throughout the sandplain land are predominantly sandy-loam or coarser in texture.

Charleville land system comprises flat plains (sandsheets) of sandy, red earth soils which are generally adjacent to upper parts of the Warrego River or Angellala Creek. Occasional scattered claypans occur throughout. Extremely dense stands of whipstick mulga occur locally.

Eulo land system occurs mainly in the south of the area and comprises extensive sandplains of low relief, which occur along the eastern side of the Warrego, south of 27°S latitude. Shallow to moderately deep, sandy, red earths predominate. Mulga and poplar box woodlands are characteristic. Many areas have significant populations of woody weeds which affect productivity and management.

Glenmore land system comprises gently undulating sandplains which have covered the Tertiary land surface adjacent to the upper reaches of the Warrego River and Angellala Creek. Deep, sandy, red earths occur throughout, supporting low woodlands of mulga, poplar box and (characteristically) eastern dead finish. These lands are quite productive where tree densities are lower. Buffel grass has been established in some of the eastern areas.

Soft mulga land zone (M)

Arabella land system contains gently undulating plains with a significant proportion of drainage or run-on areas ("flats"). Soils are mainly shallow to moderately deep, loamy, red earths which have been laid down over the Tertiary land surface. Mulga, poplar box low woodlands occur with silver-leaved ironbark and kurrajong becoming more frequent in eastern areas. Poplar box woodland predominates in the "flats" with sandalwood evident in some paddocks. This land system is quite productive where tree densities are kept in check and there have been sporadic successes with the establishment of buffel grass on these soils.

Nebine land system comprises flat plains of shallow to moderately deep, red earths which range from loamy to sandy in texture. These soils were derived by weathering and redistribution of erosion products from the Tertiary land surface. Mulga, poplar box open forest to open woodland predominates. Areas of extremely dense mulga frequently reduce pasture production in the north, while stands of cassias and sandhill hopbush are present in the south. This land system is productive when tree and shrub densities are low, but the predominance of wiregrass means much of the pasture is of low nutritive value.

Humeburn land system comprises flat plains adjacent to alluvium. Soils are shallow to moderately deep, loamy, red earths, and red, texture contrast soils, frequently with hardpans present. They were derived by weathering of the Tertiary land surface and redistribution of the resulting erosion products. Mulga, poplar box woodland to open woodland predominates with frequent areas of sandalwood and turkey bush. Productivity is quite high when in good condition, but many areas have been degraded and productivity subsequently reduced.

Norah park land system contains gently undulating plains sloping down to adjacent alluvia or run-on areas. Soils are shallow to moderately deep, loamy, red earths deposited following erosion of the Tertiary land surface. Mulga open forest to mulga, poplar box open woodland is the dominant vegetation. When in good condition, this land system is productive, but complete removal of mulga and continued heavy stocking can cause degradation and loss of productivity.

Nimaru land system consists of flat to gently sloping concave plains forming run-on areas. Soils are moderately deep and deep, loamy, red earths. Groved mulga open forest to low woodland with scattered poplar box predominates. These areas are some of the most productive mulga lands when mulga densities are at desirable levels.

Hard mulga land zone (H)

Sommariva land system comprises gently undulating to undulating plains, and is confined to areas east of the Warrego River. Soils are predominantly shallow to moderately deep, loamy, red earths with ironstone shot or gravel cover. They have formed as superficial deposits laid down following erosion of the Tertiary land surface. Mulga low woodland to low open woodland with scattered poplar box and ironbark or kurrajong occurs. These areas are quite productive where mulga densities are at desirable levels, though wiregrasses tend to dominate in some seasons and small areas have been degraded by top soil loss and green turkey bush invasion.

Erac land system consists of gently undulating plains sloping up to dissected low hills, and is confined to areas west of the Warrego River. This land system is a continuation of the Kyeenee land system described by Dawson (1974). Soils are shallow to very shallow, loamy, red earths with scattered gravel or ironstone shot on the surface. Soils have developed from thin deposits of erosion materials laid down as the Tertiary land surface was eroded. Mulga low woodland to tall shrubland predominates. Significant areas have been degraded by top soil loss and/or turkey bush and hopbush invasion. When in good condition, these lands are moderately productive, but should not be consistently overgrazed for lengthy periods.

Boatman land system comprises gently undulating plains confined to the east. Soils are shallow to moderately deep, loamy, red earths with ironstone shot and gravel commonly present on the surface. Soils have developed on thin deposits of erosion material derived from weathering of the Tertiary land surface. Mulga low open forest to mulga poplar box open woodland predominates. These areas are quite productive where mulga densities are kept at desirable levels, though wiregrasses may dominate the pasture in some seasons.

Gilruth land system is composed of very gently undulating plains with scattered small depressions. Soils are shallow to very shallow, sandy, red earths which have been laid down as Quaternary deposits over the Tertiary land surface. Mulga-poplar box low woodland predominates. These lands are quite productive though wiregrasses dominate the pasture in some seasons and green turkey bush has invaded certain areas.

Dissected residuals land zone (R)

Three land systems have been described in this land zone. The three systems are distinguished by differences in soil, vegetation and topography. All the dissected residual land systems are basically unstable lands. Regardless of man's activities, these areas would be experiencing normal geological rates of erosion.

Colanchie land system consists of undulating plains, dissected low hills and scarps where chemically altered and fresh Cretaceous sediments have been exposed and exhibit a thin cover of Quaternary debris. Soils are very shallow lithosols with intermixed gravel. The vegetation is distinctive with brigalow, scattered mountain yapunyah and Dawson gum. This is the most productive of the dissected residual land systems with moderate seasonal production of forbs and shortgrasses. Clearing of the brigalow woodlands increases productivity, but is not generally recommended, as cleared slopes are subject to erosion and severe regrowth problems.

Quilberry land system consists of dissected hills, low scarps and associated scarp retreat zones. Soils are shallow gravelly lithosols formed from a thin Quaternary cover over strongly altered Cretaceous sediments. Bendee shrublands occur on the scarps and tops, with mountain yapunyah, Dawson gum, hopbush and sandalwood on the slopes. Bowyakka shrublands occur in scarp retreat zones in the north west. These lands are unstable and degraded by hopbush and sandalwood invasion in a number of areas. Productivity is low.

Leader land system comprises dissected tablelands and low hills in the west. Soils are shallow gravelly lithosols with some areas of exposed chemically altered, Cretaceous sediments. Mulga and western bloodwood shrublands predominate with lancewood on the scarps and scattered leopardwood, vinetree, wilga and boonaree on the slopes. Productivity of these areas is low. Some areas have been degraded by hopbush invasion.

Gidgee land zone (G)

These lands occur in scarp retreat zones where fresh or less strongly weathered, Cretaceous sediments have been exposed, and also in alluvial areas where a lighter textured surface horizon has been deposited over heavier alluvial soils.

Kennedy land system comprises gently sloping plains of deep to very deep, cracking clays usually with surface gravel pavements. These should be formed on fresh Cretaceous sediments in scarp retreat zones. Brigalow low woodlands predominate, though limited areas of gidgee low woodland occur in drier parts of the area. Productivity of these brigalow lands is low and can be substantially increased by scrub pulling operations, however, regrowth problems are severe and developed areas will need careful and sometimes, intensive management.

Killowen land system comprises flat plains in the south where very deep, alluvial, texture contrast soils have formed on alluvia laid down by the distributory system of the Warrego River. Gidgee woodlands predominate, frequently with an understorey of sandalwood. Productivity is somewhat limited but nutritional quality is high. Invasion of sandalwood and scalding of areas where the surface soil has been lost, have reduced productivity.

Ivanhoe land system consists of flat plains in the south. Soils are deep, alluvial, cracking clays formed on alluvia laid down by the distributory system of the Warrego River. Gidgee low woodlands predominate, but are usually sufficiently sparse not to warrant clearing. The gidgee areas provide a limited bulk of high quality forbs, resulting in high per animal production at moderate stocking rates.

Downs land zone (F)

Coreena land system comprises gently undulating plains of shallow, cracking clays formed on fresh Cretaceous sediments. Sparsely wooded mitchell grass tussock grassland predominates, is capable of high productivity and is regarded as inherently stable. Invasion of pastures by *Aristida* spp. had caused problems in areas to the north.

Poplar box land zone (E)

Poplar box land zone comprises plains formed by the spreading of Quaternary sands over the Tertiary land surface. Four land systems are recognised on the basis of soil and vegetation differences as well as drainage pattern.

Bendena land system comprises low sloping plains forming run-on areas, extending to four local alluvia. Poplar box, sandalwood on red earths and texture contrast soils predominate.

Loddon land system comprises low sloping plains forming run-on areas which extend to four local alluvia. Poplar box, mulga woodland on deep loamy red earths predominate.

Halton land system comprises gently undulating, slightly concave plains forming run-on areas draining into local alluvia. Poplar box woodland, with mulga or sandalwood on the upper reaches, have developed on deep, red clays and red earths.

Elverston comprises shallow drainage lines developed on flat plains, and occur throughout the area. Poplar box with mulga are common on the upper reaches while coolibah and herbfields occur on central areas. Soils are mainly deep sandy red earths.

Alluvial plains (open) land zone (A)

The alluvial plains land zone comprises predominantly open or only lightly wooded lands. Three land systems have been delineated on the basis of soil and vegetation differences.

Noorama land system comprises extensive, very rarely flooded, flat, alluvial plains. Soils are very deep, alluvial, cracking clays formed on recent alluvial deposits laid down by the Warrego River. Mitchell grass tussock grassland predominates and is capable of high levels of productivity while remaining stable.

Padua land system comprises flat alluvial plains most of which are inundated during major floods. Soils are heavy, alluvial cracking clays formed on deposits laid down by the Warrego River. Mitchell grass and/or bluegrass open tussock grasslands predominate, often wooded with scattered coolibah. These areas are capable of high productivity following flooding and are stable.

Westgate land system comprises flat, alluvial plains associated with the upper reaches of the Warrego River. Soils are very deep, alluvial clay soils, frequently with scalded surfaces. There are also areas of very deep, alluvial, texture contrast soils formed on recent alluvial deposits of the Warrego flood plain. Sparse open grasslands and herblands predominate with scattered whitewood and box. These lands are unstable and subject to widespread scalding and loss of the surface soils as well as sandalwood invasion on the texture contrast soils.

Alluvial plains, woodland land zone (W)

This land zone consists of eight different land systems which have been differentiated mainly on physiographic differences such as size and channel characteristics, or in one case, on soil differences.

Boin land system comprises narrow alluvial plains usually with a single, well-developed, main channel. Most drainage systems in the hard mulga land zones involve Boin land systems in their lower reaches. Soils are deep, alluvial, reddish brown clays and texture contrast soils. Scalded areas where top soil has been lost are widespread. Sandalwood invasion has occurred in some areas. River red gum and poplar box woodlands predominate. These are run-on areas and consequently, potentially highly productive, but are frequently in poor condition with subsequent reduced productivity.

Dartmouth land system consists of low-lying, alluvial plains with occasional poorly defined channels. These plains are readily flooded by runoff from surrounding hard mulga lands. Soils are very deep, brown and grey-brown, alluvial clays with gilgaied, grey, cracking clays in the lowest-lying areas. Soils are formed on recent alluvial deposits and carry gidgee and yapunyah low open forests and low woodlands, frequently with a shrub layer of sandalwood and/or ellangowan poison bush. These lands have limited productivity in the natural state because of the dense tree cover. Clearing provides a major increase in productivity but invasion by shrubs such as sandalwood and ellangowan poison bush is a severe problem.

Kudnapper land system consists of broad and very shallow drainage lines on the flat alluvial plains associated with the distributory system of the Warrego River. Soils are very deep, grey-brown, cracking clays, with incipient gilgai in some areas. These areas of recent alluvia are normally only inundated by major rainfall events (>100 mm), and are characterised by yapunyah open woodlands with some associated coolibah and gidgee areas. These are stable lands, and highly productive following flooding. Substantial rainfalls are needed to produce a response during dry periods, though once these soils wet up, an extended growing period is assured.

Widgee land system comprises shallow drainage lines with one distinct main channel formed on the flat, alluvial plains of the Warrego River distributory system. Soils are very deep, alluvial, grey-brown, cracking clays formed on recent alluvia. Coolibah low woodland fringes the channel with scattered belalie and creek wilga. Lignum occurs in swampy areas. These are stable lands which are inundated following major rainfall events. Productivity is high following flooding, but very limited during dry periods.

Bluegrass land system comprises flat, low-lying, alluvial plains with a network of small anastomosing channels. These are "flood-out" areas and are inundated by moderate to major flooding in the Warrego River. Soils are very deep, alluvial, grey-brown, cracking clays of heavy texture formed on recent alluvia. Coolibah low open woodland predominates with areas of mitchell grass tussock grassland and lignum and Queensland bluebush intermixed. These areas are stable and highly productive, but require heavy rain or inundation to produce growth once dried out. However, heavy rain anywhere in the Warrego catchment is capable of producing flooding in these areas.

Warrego land system consists of the channels and interchannel areas of the Warrego River. It comprises a small number of large, braided channels which intermittently join to form a main channel and then separate again. The interchannel areas are inundated in moderate to major floods. Soils are very deep, alluvial clays and sandy-clays formed on recent alluvia. River red gum and coolibah fringing woodlands predominate, with an understorey of paper-barked tea-tree, belalie and doolan in the upper reaches of the river. These areas are moderately stable and productive and provide valuable permanent water for stock.

Langlo land system comprises braided channels and associated interchannel areas of the Langlo River. These lands are inundated in moderate to major floods. Soils are very deep, alluvial, cracking clays formed on recent alluvia and have lower sand contents than the soils of the Warrego land system. River red gum and coolibah fringing woodlands predominate, with areas of lignum and scattered yapunyah. These lands are stable and productive, and provide valuable permanent and semi-permanent stock water.

Tuen land system consists of flat, alluvial plains associated with the distributory system in the southern reaches of the Warrego River. Soils are very deep, alluvial, grey-brown, cracking clays formed on recent alluvia. Coolibah open woodlands predominate. These areas are only inundated in major floods. Mitchell grass/bluegrass open tussock grasslands with scattered coolibah are characteristic. These areas are highly productive and relatively stable.

Claypan land zone (L)

Elmina land system comprises claypans, and seasonal lakes. Soils are shallow to moderately deep, poorly drained, grey clays formed on recent alluvia with scalded, reddish brown clays around the margins. These claypans are characteristically devoid of trees and shrubs with herblands, sedgelands, swamp canegrass or bluebush as the dominant vegetation. These lands are capable of moderate productivity following rain or inundation by runoff from surrounding lands, but heavy grazing pressures limit production.

Ardgour land system comprises claypans and seasonal lakes. Soils are shallow to moderately deep clays formed on recent alluvia, with some reddish brown, alluvial sandy-clays. These claypans are characteristically wooded with coolibah and/or poplar box, yarran, or brigalow woodlands or shrublands. Sedgelands and herblands are the predominant ground layer. These areas are capable of moderate productivity following rain or inundation by runoff from surrounding lands, but productivity is limited by the constant heavy grazing pressure on these areas. Scalding and some erosion is evident on the fringes of this land system.

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Chapter 7

CURRENT LAND USE

by J.R. Mills[1] and A. Lee[2]

SOCIAL ORGANISATION

The survey area lies in the Murweh and Paroo Shires. The towns of Charleville and Cunnamulla are the administrative headquarters of the respective Shires, and most of the population is concentrated in these two towns.

Table 7.1 shows Shire and town populations over a period of 95 years. A decline of 29% occurred in the Murweh Shire between 1961 and 1981 with an apparent levelling out of this decline over the last five years. Paroo Shire population declined by 34% over the same 20-year period. Populations in the towns of Charleville and Cunnamulla have declined by 7.5% and 14%, respectively, over the last five years. Populations in the towns are now comparable with or below those recorded in the 1890's when the infrastructure in the area was first developed.

Table 7.1 Population statistics

	1891	1961	1971	1976	1981	1986
Murweh (Shire)		7845	6053	5585	5650	5410
Paroo (Shire)		4099	3310	3021	2700	2490
Charleville (town)	3211	5154	3948	3802	3523	3588
Cunnamulla (town)	2114	2234	1805	1897	1627	1697

Source: Australian Bureau of Statistics (Census Statistics)

There is a considerable danger that the movement of people out of the area is resulting in a loss of the more highly motivated and skilled individuals. This is due to the inability of the pastoral industry and the local economy, which is pastoral industry based, to provide adequate financial benefits to retain people in the area.

Charleville is firmly established as the regional centre and most services are available in the town. A permanent population of State and local government, bank and stock agent employees has provided some stability for the town during droughts and periods of low prices for primary products. The recent drought-related slump in the local pastoral industry, together with the long-term prospect of costs increasing at a greater rate than returns, indicate that a conscious, planned policy is necessary to maintain and upgrade Charleville as a major regional centre. This is essential if the town is to continue to provide the appropriate services to the pastoral industry and community. It is most important that families have access to an attractive, modern and reasonably large regional centre to prevent further loss of skilled people from the area to centres in the east of the State.

COMMUNICATIONS

All properties in the area are serviced by telephones and the majority of properties, with the exception of the northern part of the area, are connected to rural power. Television reception is possible within 50 km of Charleville and Cunnamulla where ABC television transmitters are situated. ABC radio stations at St. George and Longreach, and a commercial radio station at Charleville service the area.

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[1] Formerly Land Resources Branch, Department of Primary Industries.

[2] Department of Lands.

TRANSPORT

Sealed bitumen roads run east-west, connecting Brisbane with Charleville and Quilpie and also north-south from Augathella to Charleville, Wyandra, Cunnamulla and south to Bourke. Cunnamulla and Quilpie are connected by rail to Charleville and thence to Brisbane. Two passenger trains and a number of goods trains run to Brisbane each week, as well as daily bus and road freight services to Charleville. Four airline flights connect Charleville to Brisbane each week, and light aircraft can be chartered in Charleville and Cunnamulla.

EDUCATION

Primary schools are located at Augathella, Charleville, Wyandra and Cunnamulla. High school education to year 12 level is available in Charleville. The School of the Air operates from Charleville, and in conjunction with the Primary Correspondence School, provides lessons to grade 8 standard for children on properties throughout south-western Queensland. The Priority Country Area Program has itinerant teachers based at Charleville who provide assistance to Primary Correspondence School pupils throughout the south-west.

Secondary education still constitutes a major cost for those people in the area who wish to equip their children with the higher educational standards necessary to enter Tertiary courses. Country parents and a number of town families have traditionally elected to send children away to boarding school during their secondary years. However, the very considerable cost (over $5000 /child/annum in 1984) and decreasing profitability in the pastoral industry, have meant that some families are now choosing to move from the west to major provincial centres on or near the coast. In these centres, a greater variety of courses taught by more experienced teachers is available, and there is access to improved sporting and cultural facilities for older children. The retention of a greater number of experienced teachers by the local high school would be one step towards solving the secondary education dilemma which faces many families.

LAND TENURE

Rural land in the study area is held under different types of tenure, with the majority held as either Grazing Homesteads (32%) or Grazing Homestead Freeholding Leases (36%). Table 7.2 shows statistics of rural land held under leasehold or freehold tenure as at 31 January, 1979, together with the Lands Department estimated carrying capacity. Individual properties held by the same owners have been grouped into a single aggregation. All carrying capacity estimates are based on sheep numbers.

Table 7.3 relates the size of holding to carrying capacity for sheep. Most aggregations (74%) are in the range of 5 000 - 30 000 ha, with these accounting for approximately 60% of the total carrying capacity. The aggregate size found most commonly in the area is in the range 15 000 - 17 500 ha.

In Table 7.4, aggregations are placed into a range according to carrying capacity for sheep. The most common carrying capacity in the area is in the range 5 000 - 7 000 sheep.

THE PASTORAL INDUSTRY

Almost all commercial pastoral activity is confined to sheep and cattle, with a very small number of goats run on a semi-commercial basis for mohair (and possibly cashmere) production. Sporadic harvesting of wild goats, pigs and kangaroos is carried out when prices for these animals are favourable.

Gross value of agricultural production from Murweh and Paroo Shires is shown in Table 7.5. Stock numbers for these Shires are shown in Figure 7.1, plotted against actual summer rainfall (October - March) composite average for Charleville and Cunnamulla. These figures show the very high stock numbers carried in the area during the first half of this century. The relative increase in cattle numbers, particularly in Murweh Shire, over the period since 1970 reflects the trend towards cattle in the mulga areas of this Shire.

Figure 7.2 shows fluctuations of stock numbers (converted to sheep equivalents, 1 beast = 8 sheep), compared with rainfall. (Both figures are expressed as a 5-year moving average). The effect of extended periods of drought can be seen, especially those of 1901-3, 1916-17, 1946-47, 1965-66, and 1980-83.

Table 7.2 Types of tenure and estimated carrying capacity

Tenure	No. of properties	Area (ha)	Carrying capacity (Sheep)
Special Lease Purchase Freehold	1	259	160
Occupation Licenses	2	16 317	5 101
Perpetual Lease Selections	2	978	342
Stud Holdings	2	33 152	18 121
Agricultural Farms	3	2 809	711
Pastoral Holdings	12	334 911	114 320
Preferential Pastoral Holdings	14	277 528	85 204
Freehold	9	36 156	18 398
Grazing Homesteads Perpetual Leases	32	280 790	109 657
Special Leases	53	29 828	11 714
Grazing Farms	86	496 019	175 155
Grazing Homesteads	217	2 066 061	784 980
Grazing Homesteads Freeholding Leases	249	1 930 627	768 680
Totals	682	5 505 441	2 092 543

Table 7.3 Range of holding aggregates and estimated sheep carrying capacity.

Range of holding aggregates (ha)	No. of aggregates	Range of carrying capacity (Sheep)	Total Carrying capacity (Sheep)
1 - 5 000	14	129 - 2 520	17 800
5 000 - 7 500	14	1 866 - 3 900	36 810
7 500 - 10 000	19	2 319 - 5 410	63 872
10 000 - 12 500	20	3 401 - 6 418	98 303
12 500 - 15 000	21	3 589 - 8 020	112 805
15 000 - 17 500	31	4 123 - 8 398	193 830
17 500 - 20 000	22	5 010 - 9 275	154 964
20 000 - 22 500	23	5 240 - 12 100	178 119
22 500 - 25 000	13	7 857 - 12 719	127 508
25 000 - 27 500	11	3 800 - 13 651	105 582
27 500 - 30 000	13	8 102 - 13 362	137 166
30 000 - 35 000	21	9 122 - 16 555	248 202
35 000 - 40 000	8	12 323 - 16 408	116 964
40 000 - 50 000	14	11 147 - 26 153	234 963
50 000 - 60 000	3	12 294 - 24 140	49 403
60 000 - 80 000	2	23 085 - 23 956	47 041
80 000 - 110 000	5	26 419 - 40 196	169 211

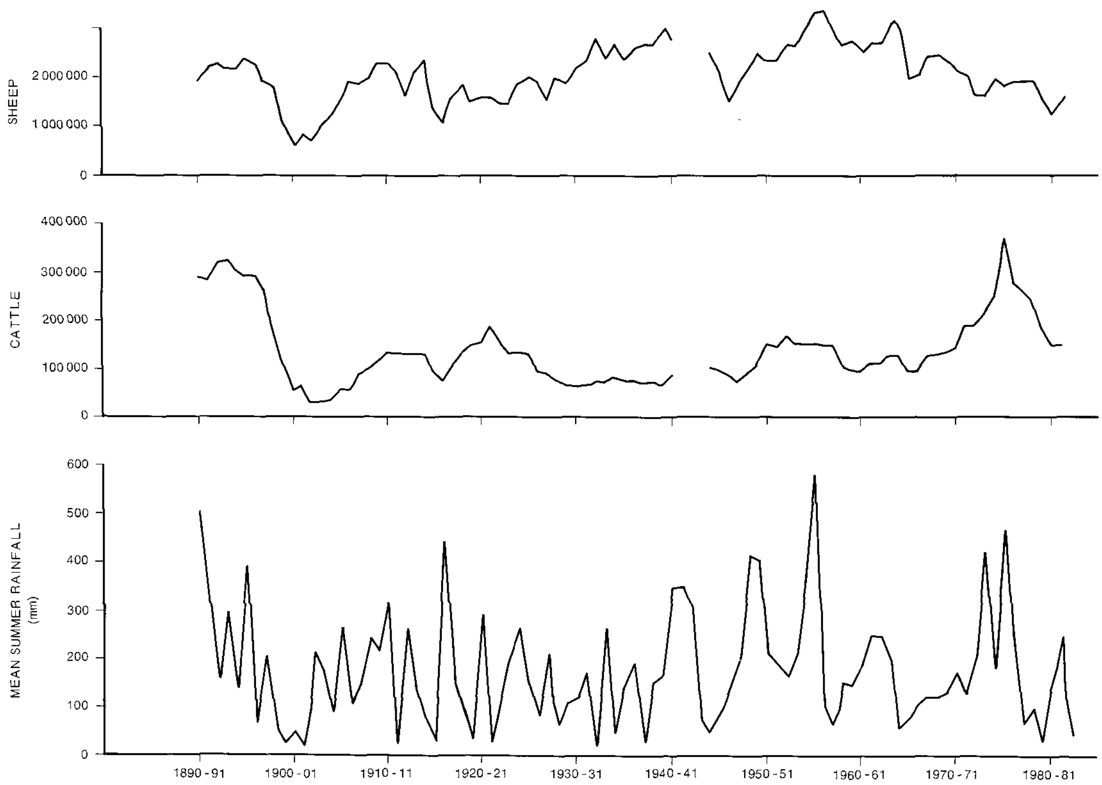

FIGURE 7.1 SHEEP AND CATTLE POPULATIONS FOR MURWEH AND PAROO SHIRES AND ACTUAL SUMMER RAINFALL (OCTOBER - MARCH) FOR CHARLEVILLE AND CUNNAMULLA 1890 - 1984.

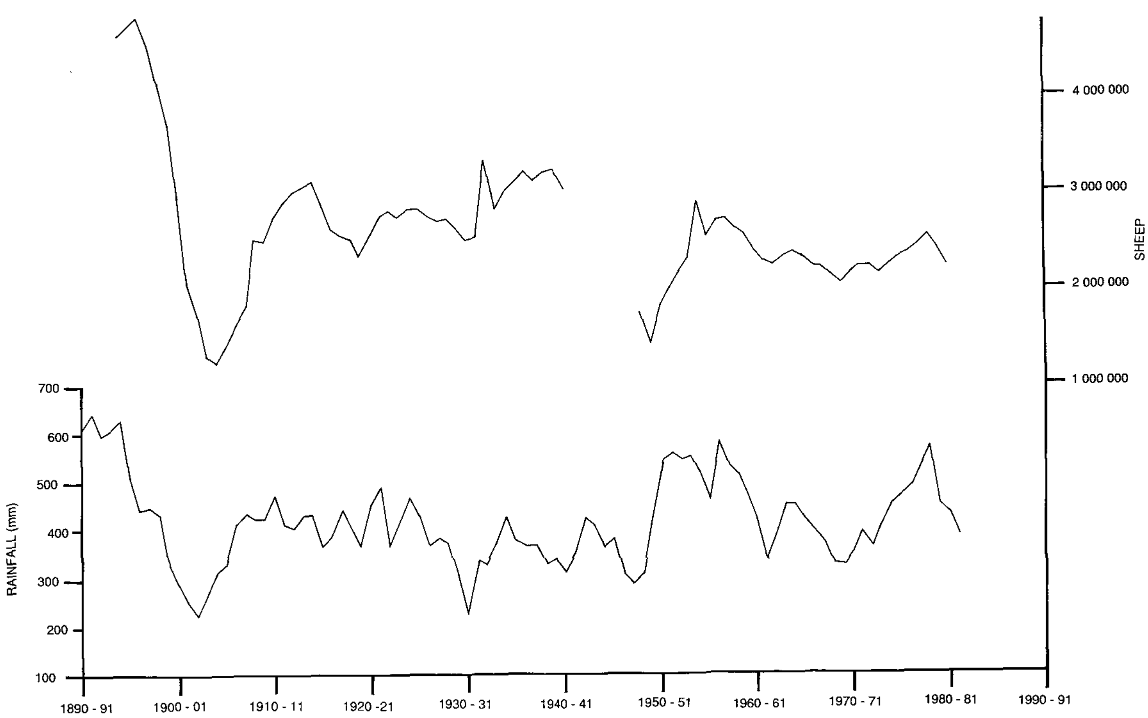

FIGURE 7.2 FLUCTUATIONS OF STOCK NUMBERS (CONVERTED TO SHEEP EQUIVALENTS 1 BEAST = 8 SHEEP) PLOTTED AGAINST RAINFALL (BOTH EXPRESSED AS A 5 YEAR MOVING AVERAGE,) 1890 -1984.

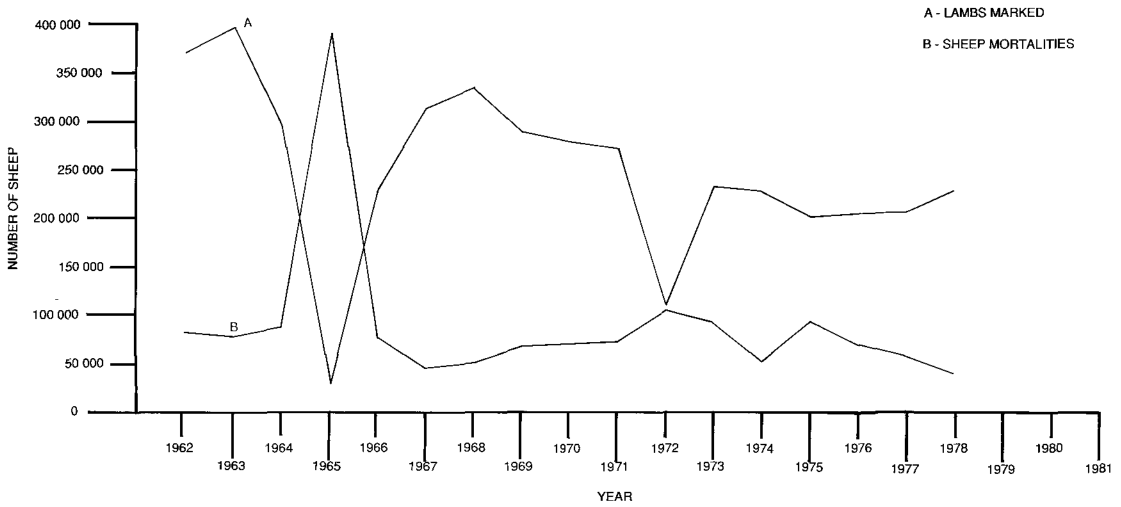

FIGURE 7.3 REPRODUCTIVE PERFORMANCE FOR SHEEP IN THE MURWEH AND PAROO SHIRE AREAS OVER THE PERIOD 1962 - 1978.

FIGURE 7.4 WOOL CUTS IN THE MURWEH AND PAROO SHIRE AREAS OVER THE PERIOD 1962 - 1978

Table 7.4 Number of holding aggregations in each sheep carrying capacity range.

Range of Sheep carrying capacity	No. of Aggregations
1 - 2 000	14
2 000 - 3 000	17
3 000 - 4 000	21
4 000 - 5 000	14
5 000 - 6 000	39
6 000 - 7 000	28
7 000 - 8 000	17
8 000 - 9 000	18
9 000 - 10 000	14
10 000 - 11 000	18
11 000 - 12 000	7
12 000 - 13 000	12
13 000 - 14 000	7
14 000 - 15 000	3
15 000 - 16 000	7
16 000 - 17 000	5
17 000 - 18 000	1
18 000 - 19 000	2
19 000 - 20 000	-
20 000 - 21 000	-
21 000 - 22 000	1
22 000 - 23 000	-
23 000 - 24 000	2
24 000 - 25 000	1
25 000 - 30 000	2
Above - 30 000	4
Total	254

Table 7.5 Gross value of agricultural production in Murweh and Paroo Shires

Year	Gross value of agricultural production ($'000) Murweh Shire	Paroo Shire
1960/61	7 542	6 662
1961/62	7 300	7 640
1962/63	7 948	8 994
1963/64	10 014	11 748
1964/65	8 568	9 391
1965/66	5 930	5 828
1966/67	7 076	6 758
1967/68	7 856	8 207
1968/69	9 947	10 234
1969/70	8 224	8 998
1970/71	5 607	5 759
1971/72	6 534	7 129
1972/73	10 387	11 890
1973/74	11 002	11 151
1974/75	6 524	7 588
1975/76	8 129	9 167
1976/77	10 570	13 053
1977/78	12 187	14 380
1978/79	21 757	21 757
1979/80	25 456	22 174

Sheep breeding is the main enterprise throughout the alluvial land zone in the south. Lambings of 80-110% and wool cuts of 6 kg or more are common. The Cunnamulla area is recognised as some of the best sheep country in Queensland, and is colloquially known as "the salad bowl".

A number of sheep studs are found in the Cunnamulla area, and these supply medium wool sires to commercial flocks throughout the south of the state. Though cattle are found throughout the area, most properties carry less than 50% of their stock equivalents in the form of cattle.

Dry sheep predominate in the mulga land zones to the west of the Warrego, with some breeding on properties with alluvial frontage country. Properties in this region have an average 33% of their total stock equivalents as cattle (Mills 1981).

East of the Warrego, dry sheep and cattle predominate, with some sheep breeding in the mulga land zone where well developed, run-on areas occur. Properties in this eastern mulga region carried 45% of their total stock equivalents as cattle (Holmes 1981). Further information on industry distribution may be found on the map "Resource Regions of South Western Queensland" (Mills 1980).

Breeds

Medium to strong woolled (21-24 microns) peppin merino sheep predominate almost exclusively throughout the area, though the diameter of the wool produced is largely dependent on seasonal conditions.

Cattle herds have traditionally been Hereford or Shorthorn based, but increasing numbers of cattle with an infusion of Brahman or Afrikander blood are found in the area.

Domestic animal composition and performance

The area carried approximately 881 700 sheep and 85 600 cattle in 1980/81, or 8.3% of the state's sheep flock and 0.9% of the cattle herd. The 1981/82 sheep numbers were the lowest recorded in the area since 1916, due to drought. Average stock numbers over the last 10 years considered, represent 11.7% of the state sheep flock and 1.3% of the cattle herd.

Breeding ewes made up 42% of the flock over the period 1974 to 1984 in the Murweh Shire and 50% of the flock in Paroo Shire, the higher figure for this shire reflecting the high proportion of breeding ewes in the Cunnamulla district.

Cows and heifers made up 57% of the cattle herd in Murweh Shire and 53% of the herd in Paroo Shire over this same period. Reproductive performance for sheep in the Murweh and Paroo Shires is shown in Figure 7.3. Lambings exceed mortalities considerably in all but severe drought years when few sheep are joined. The figures show a net sheep surplus for disposal of around 180 000 a year from the survey area over the 10-year period 1970-71 to 1980-81. This level of reproductive performance compares very favourably with the state average.

Wool cuts are shown in Figure 7.4 and again the area averages around 0.25 kg above the state average, except in drought years.

DROUGHT MANAGEMENT

Management and financial performance during drought periods have a large bearing on the economics of pastoral enterprises. Statistics show that the Paroo and Murweh Shires have been drought declared for almost half of the last 20 years, with individual droughted properties being more severely affected. It is becoming accepted that in areas such as the study area, "drought is a normal experience in rangeland and grazing practices must be adjusted to the fact" (Newman 1971). On the statistics available, it follows that management must have sufficient flexibility and reserves to cope with extended major drought periods every 15 years on average without causing permanent damage to the land resource. The drought strategies commonly adopted by breeding properties are: to sell all wethers, cast for age ewes and sell or agist ewe weaners which have not cut their two teeth. The remaining breeding nucleus is spread out over as much area as possible. If drought conditions continue for a number of years, this remaining breeding nucleus may be sent on agistment or sold. This area recovers slowly from drought and premature build up of stock numbers should be avoided.

Mulga properties rely much less on agistment and generally sell off some stock and feed the remainder on mulga. A number of breeding properties have bought mulga blocks where wethers can be run in good seasons and their breeding nucleus can be kept intact during drought periods. Forced sale of the entire breeding flock means the virtual loss of any extra genetic gains made through breeding and culling on the particular property. Most operators are extremely reluctant to sacrifice these gains.

Continuing heavy reliance on mulga feeding in the lower rainfall areas west of the Warrego can cause permanent damage to the hard mulga lands and associated frontage country. Current recommendations are to stock this type of country conservatively during dry seasons, to maintain mulga densities at about 175 shrubs/ha and to avoid felling mulga except during severe drought periods of the order of 1 in 10 year frequency.

PROPERTY SIZE AND VIABILITY

Economic surveys by Holmes (1981) in mulga lands east of the Warrego, and Childs (1974) and Mills (1981) in mulga lands west of the Warrego provide valuable data on the financial status of properties in the mulga lands. Carrying capacities for mulga lands are discussed in Chapter 8.

1. West of the Warrego

Comparative data are shown in Table 7.6. The survey by Mills (1981) was carried out during the "good" seasons of 1974-79 while the survey of Childs (1974) in mulga lands west of the Warrego was carried out during the drier years (though not extreme drought) of 1967-79.

All properties west of the Warrego had "reasonable" positive cash flows during the good years of the mid-1970's, but during the drier (and more typical) years of the 1960's, smaller properties had negative returns to capital and management. The larger aggregates were able to maintain reduced, but still positive returns. There is a higher frequency of dry periods west of the Warrego, and frequent severe droughts such as 1965, 1972 and 1979-83 occur. Most properties could be expected to have negative returns during these droughts and it is essential for properties to be of sufficient size to maintain a positive cash flow during all but the most severe drought years. The data indicate that an average minimum flock size of 7 500 sheep appears necessary to maintain positive returns during normal dry periods. The level of debt has a major bearing on the returns to capital and management of properties in the area.

Table 7.6 Economic data comparing dry and good seasons.

Dry seasons (1967-70)[1]	Bottom 25%	Average 25%	Top
Return to Capital and Management	-2 900	10 700	30 000
Area (ha)	23 500	42 100	97 200
Sheep numbers	4 500	7 600	16 400
Cattle numbers	116	254	623

Good seasons (1974-79)[2]	Smallest 5	Average 10	Largest 3
Cash Income (after interest)	20 124	34 192	49 132
Area	27 500	43 300	74 100
Sheep Nos.	6 300	10 000	16 000
Cattle Nos.	448	623	933
Income/Family Unit	12 623	14 774	16 089

Sources: [1] Childs (1974)
[2] Mills (1981)

Income derived from cattle comprised <20% of overall income of the properties surveyed. Income from cattle also showed considerable fluctuations and is usually at its lowest during drought periods when the property is in its worst cash flow position. It is suggested where properties carry both sheep and cattle, minimum property sizes should be determined on the basis of income from the sheep enterprise only. Money earned from the cattle enterprise is most likely to be at a maximum in good years, when taxation considerations mean it may tend to be reinvested in property improvements.

Pasture utilisation trial data from mulga lands east of Charleville (Charleville Pastoral Laboratory, unpublished data) indicate that an average stocking rate* of 1 sheep to 6 ha produces the best returns from wool during dry seasons. It is considered essential that the property be able to maintain a positive cash flow at stocking rates low enough to come through normal dry seasons without having to fell mulga for stock. Observations indicate that the increased grazing pressure and disturbance of the ground storey caused by frequent mulga felling results in undesirable changes to the pasture and soil surface followed by invasion of unpalatable shrubs.

A stocking rate of the order of 1 sheep/6 ha is recommended for normal dry seasons in the lower rainfall (<400 mm) hard mulga lands west of the Warrego. These low stocking rates should not cause further damage to the land resource. A property size of the order of 60 000 ha is then necessary if 7 500 sheep (Childs 1974) are taken as the minimum economic flock size.

2. Mulga lands east of the Warrego

Pasture utilisation trials carried out in this area by the Charleville Pastoral Laboratory indicate that a stocking rate of 1 sheep/6 ha provides the best returns from wool during dry seasons. Holmes (1981) found that the actual stocking rates during the good seasons of the 1970's were 1 sheep/3.85 ha and 1 beast/38 ha. Returns from cattle accounted for less than 20% of net income and showed wide fluctuations during the survey period. Accordingly, where properties run both sheep and cattle, property size should be based on the more stable sheep enterprise. There is no evidence to suggest that larger properties in the eastern mulga zone provide higher incomes. This may reflect increased management difficulties in thickly timbered country, or simply that the survey did not include a large enough sample to reveal any increases in efficiency and income on larger properties. (Surveys were designed to sample properties with resident owner operators. There is a tendency for larger aggregations in this area to have absentee owners and run cattle only.)

Evidence suggests that properties running the maximum number of stock which can be handled by the labour available in the family unit are the most likely to maintain positive cash flow (Holmes, personal communication). The survey data showed that an average of 5400 sheep were carried through the good seasons of the 1970's by single family unit properties. To run this number of sheep through dry periods at conservative stocking rates (that is 1:7 ha), would require a property in the order of 38 000 ha. It is envisaged that on a property of this size, substantial income would be derived from cattle in some years. This income would increase the very low net incomes (after interest) of $13 400 per property recorded during the 1970's survey. On a property of this size there is also scope for increasing sheep and cattle numbers during good years when a more favourable cash flow may allow casual labour to be employed. Fires may be an essential part of a stable management system in this country and these larger properties would make it possible to lock up areas to build up fuel for fires. It would also allow the re-establishment and seeding of native grasses in these burnt areas in the absence of grazing pressure**.

Limited data are available on the viability/size aspects of cattle-only properties east of the Warrego. A substantial proportion of properties in this area are used as bullock depots or breeding blocks, usually in conjunction with fattening properties further east. Most of these properties have absentee owners.

Under present economic conditions, cattle enterprises would appear to need substantially more area than sheep enterprises, though area would not be as limited by labour and mustering constraints as for the sheep properties. Gross margins indexed to 1983 prices from the Eastern Mulga Survey of $28.78/head and estimated fixed costs of $35 000 (same as for a smaller sheep property) indicate a herd of 1 600 head is required for a return of $11 000 to management and capital during dry years (before interest and depreciation). In theory, this would require around 100 000 ha if the dry season carrying capacity is assumed to be 1 beast/60 ha. This is much lower than the carrying capacity of 1 beast/38 ha recorded on the mixed sheep and cattle properties during the good years of the 1970's. This estimate assumes no overlap of diet between sheep and cattle. If, as is more likely, a 50% dietary overlap occurs in dry periods, then a dry season stocking rate of 1 beast to 40 ha indicates an area of 64 000 ha may be adequate.

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* Actual stocking rates varied from (1 sheep / 2.2 ha) to (1 sheep / 11.1 ha) over 5 years.
** Influence of native animals grazing is discussed in Chapter 8.

3. Cunnamulla plains

The only survey data for the Cunnamulla Plains area is that of Childs (1974) over the years 1967-70. During this period of average to slightly below average rainfall, properties with 6 000 or more sheep had "reasonable" positive returns to capital and management. Data are summarised in Table 7.6. Given the general cost price squeeze since this survey, the current Lands Department recommendation of 8 000 sheep appears appropriate for this area. This would suggest a minimum property size of the order of 20 000 ha.

OVERVIEW

Property sizes have been calculated on the basis of the minimum area necessary to provide positive cash flows or returns in all but severe drought years (estimated 1 in 10 year frequency). Product prices have a substantial effect on viability. Few properties, even in the more favoured areas, would remain in business if beef or wool prices fell to the depressed levels experienced between 1969 and 1978. The general, low profitability of enterprises in the area (the majority of which can provide only a moderate wage for the operator and no return at all to capital), is of concern. There have been substantial improvements in industry efficiency over the past 20 years, but these improvements are lagging behind as the gap between costs and returns closes. In economic terms, the price being paid for pastoral enterprises is far beyond their worth in an economic sense. This reflects the "way of life" value which is built into property prices. As profitability seems likely to continue to decrease, it appears there may be a trend to owners with off-farm incomes in the more marginal lands as well as a substantial increase in the size of properties.

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CHAPTER 8

RESOURCE USE

by J.R. Mills[1] and R.W. Purdie[2]

PASTURES

The pasture plants of the survey area are native species, many of which are adapted to survive on nutrient deficient soils. The drought tolerant, long lived perennial grasses are frequently dominant, and their biomass fluctuates with changing environmental conditions from year to year. The plants possess both deep and shallow root systems, but need substantial rainfalls in warmer months to initiate growth, flowering and seed set. Their nutritional quality is often low, and they are eaten in only small amounts if other herbage is available. They do however, provide the long term standby forage for stock when other herbage is not available and in times of drought.

The shorter lived perennial grasses are less drought tolerant, but they respond rapidly to relatively light falls of summer rain due to their shallow, fibrous root systems. They flower more quickly and often produce more seed than the longer lived species. Their annual biomass may fluctuate widely and rapidly with changing seasonal conditions each year. Although their nutritional quality is variable, they provide important medium term standover feed for stock.

When seasonal conditions are favourable, ephemeral grasses and forbs become abundant for a short time, and are selectively grazed by cattle and sheep[3]. Although their annual biomass is usually lower than that of the perennial grasses, their nutritional value is generally much higher, and they are a major determinant of annual production levels. Because the plants are drought intolerant, they reach sexual maturity quickly, (for example, within 3-4 weeks of germination) and then dry off. Both grasses and forbs may provide standover feed of high quality in the short term, although the grasses frequently disintegrate quickly.

The nutritional value of different herbage species varies considerably, but forbs generally have higher crude protein, nitrogen and phosphorus levels than either the ephemeral or perennial grasses. The quality of individual plants also varies with their age, the time of year, seasonal conditions and habitat, while their value to stock depends on their digestibility (Griffiths and Barker 1966, Weston and Moire 1969, Beale 1971, Newman 1973, Griffiths *et al.* 1974, Lorimer 1978, Beale 1975, Orr 1975).

The quality of the pasture depends largely on its botanical composition. Where a variety of annual and perennial grass and forb species are present, stock are able to selectively graze species, or parts of plants, which are highly nutritious, even though the bulk of the pasture is of low quality (Allen and Roe 1948, Lorimer 1978, Beale 1975). The composition of the pasture depends on such factors as past and present seasonal conditions, time of the year, previous pasture management (including grazing history, clearing, use of fire), current grazing pressure and type of grazing animal, and tree or shrub density. Pasture utilisation is generally uneven, and varies with the food preferences of animals, condition of stock, palatabilities of the herbage plants present, wind direction, and location of shade and watering facilities (Allen and Roe 1948, Orr 1979).

In terms of animal production, pasture management should aim at retaining the longer lived perennial species (long term maintenance of animals), while promoting the ephemeral forb component (short term animal productivity). Overgrazing can result in permanent loss of the perennials, replacement of palatable species with unpalatable ones, and soil erosion if areas become denuded. Hence, ground cover should always be maintained, particularly where soils erode easily. Under such situations, the presence of low quality, unpalatable perennials is preferable to no plants at all.

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[1] Land Resources Branch, Department of Primary Industries.

[2] Formerly Botany Branch, Department of Primary Industries.

[3] Grasses predominate after summer rainfall and forbs after winter rainfall, although some forbs in the Convolvulaceae, Fabaceae and Malvaceae also became abundant in summer.

The pastures in the survey area have been divided into eight broad types, based on their species composition and the upper strata dominants. Since most of the data were collected after seasons of above average summer rainfall, grasses were abundant, but forbs rarely so. The pastures groups are similar to those of Pedley (1974), and are described below with a brief summary of the major factors affecting their utilisation and management.

Within each pasture type, the herbage species often have distinct distributions related to their habitat requirements. Detailed accounts of the pastures at this level are given in the Land Unit descriptions in Appendix V.

a. Poplar box pasture

This occurs predominantly on texture contrast soils with poplar box, or poplar box and mulga communities. The characteristic species are long lived perennial grasses, including desert and pitted bluegrass, belah grass, kangaroo grass, and *Panicum subxerophilum*. A variety of shorter lived perennial wiregrasses (*Aristida calycina* var. *calycina, A. calycina* var. *praealta, A. ramosa*) and lovegrasses (*Eragrostis lacunaria, E. microcarpa*) are common, particularly in open areas. The ephemeral armgrasses (*Brachiaria* spp.) and *Chloris* spp. may be abundant in summer, while forbs such as *Abutilon* spp., *Calotis* spp., *Centipeda* spp., *Glycine* spp. and *Goodenia heterochila* may be abundant in winter. The perennial forbs *Brunoniella australis, Hibiscus sturtii, Rostellularia adscendens and Sida* spp. also occur frequently.

The herbage yield increases with clearing (Walker *et al.* 1972) provided woody weed invasion does not occur. Overgrazing encourages both woody weeds such as sandalwood, butterbush and silver cassia, as well as unpalatable species such as the wiregrasses and galvanized burr.

The pasture species respond to moderately light rainfalls (25-50 mm). Where areas receive run-off from adjacent mulga lands, the pasture is often favoured by stock, particularly if there is little response from the mulga pasture.

Poplar box pasture can provide high quality short term feed, particularly from winter forbs, and medium term forage in reasonable bulk, although of moderate quality. However, it may not provide long term drought feed because of preferential grazing of poplar box pasture by stock ranging in adjacent mulga country.

b. Mulga pasture

These pastures are the most extensive in the survey area, and mulga, mulga - poplar box, and mulga - silver-leaved ironbark communities occur. They are characterised by perennial grasses, including the long lived grey beardgrass, kangaroo grass, mulga mitchell, mulga oats, rock grass, woollybutt grass, woolly wanderrie, and the shorter lived wiregrasses (*Aristida calycina* var. *praealta, A. jerichoensis*), the lovegrasses (*Eragrostis lacunaria, E. microcarpa*), hairy panic grass and *Digitaria* species. Perennial forbs such as *Hibiscus sturtii* and *Sida* spp. are frequent, as are the ephemeral caustic weed, mulga fern, mulga nettle, wild parsnip, *Goodenia glabra, Velleia glabrata*, and daisies *Calotis cuneata* and *Brachyscome whitei*.

Both the species composition and herbage yields fluctuate widely with seasonal conditions and tree density (Allen and Roe 1948, Roberts 1972, Beale 1975, Silcock 1975). In dense mulga the herbage yield may be less than 100 kg/ha, increasing to over 3 000 kg/ha after clearing (Pressland 1976). The unpalatable wiregrasses frequently become dominant in cleared areas, particularly if grazing pressure has resulted in the decrease of palatable species such as mulga mitchell, mulga oats and *Digitaria* spp. (O'Donnell *et al.* 1973, Pressland 1976). Wiregrass dominant pasture generally provides inadequate nutrition for stock (McMeniman 1972, Newman 1973), and results in low wool prices because of seed contamination of fleeces.

Mulga pasture responds to rainfall of >25 mm (Allen and Roe 1948, Silcock 1975), although the soil must remain moist for at least 30 days for good seedling establishment and growth (Silcock 1977). Such rainfall produces high quality short term feed, particularly from forb species, and medium to long term grass forage of high bulk but usually low quality.

Pasture management designed to improve herbage production is often thwarted by dense mulga regeneration, woody weed invasion, or an increase in wiregrass and other undesirable herbage plants. Measures to control wiregrass include grazing by cattle and pasture burning. Low intensity fires in autumn are probably most effective, since the destruction of a large proportion of wiregrass seeds reduces later competition with seedlings of preferred perennial grasses. Destocking after a burn also allows regrowth of palatable species, and better competition with wiregrass regrowth.

c. Cypress pine pasture

This pasture is associated with cypress pine, carbeen and long fruited bloodwood growing on deep, earthy sands. It is characterised by perennial wiregrasses, most of which are short-lived, and a variety of annual herbs. The dominant wire grasses include *Aristida calycina* var. *praealta*, *A. biglandulosa*, *A. holathera* and *A. inaequiglumis*. Woollybutt grass and *Digitaria* spp. are also present. Ephemeral species include comet grass, purple plume grass, small burr grass, and forbs from the Asteraceae, Convolvulaceae, Cucurbitaceae and Fabaceae. Overgrazing may result in an increase in undesirable species such as black spear grass, three-awned wanderrie, *Abutilon* spp., *Sclerolaena* spp. and *Sida* species.

The pasture responds rapidly to light rainfalls of 25 mm (Allen and Roe 1948, Holland and Moore 1962), and is an important source of high quality, short term forage. Medium term herbage is generally of low quality even if abundant, while long term perennial standover is often absent. In a few cases, extensive stands of buffel grass have become established in this pasture.

d. Gidgee - brigalow pasture

This pasture is associated with gidgee and brigalow ± yapunyah on alluvial cracking clays and texture contrast soils, and with brigalow ± mountain yapunyah or Dawson gum, and gidgee on sedentary cracking clays. The pasture contains perennial and annual grasses, and a large variety of highly nutritious, short lived perennial and annual forbs. The dominant perennials include belah grass, curly windmill grass, and (on alluvial clays) neverfail grass, and the forbs ruby saltbush, *Abutilon* spp., *Sida* spp. and *Chenopodium desertorum* spp. *microphyllum*. The ephemeral grasses include comb chloris, fairy grass, katoora, kerosene grass and yellow threeawn. Many of the shorter lived perennial and ephemeral forbs are from the family Chenopodiaceae. Frequent species include burrs (particularly *Sclerolaena divaricata* and *S. lanicuspis*), saltbushes (*Atriplex* spp.), *Maireana* spp., and soft roly-poly. Pigweed, red spinach and numerous Asteraceae are also common.

The forbs are generally encouraged by clearing, although woody weed and regrowth problems may also occur. The pasture on texture contrast soils responds quickly to moderately light falls of rain, but heavier falls are needed for a response on cracking clays.

The gidgee-brigalow pasture is most valuable for its short term and medium term high quality forage. Alluvial gidgee pasture produces some of the best wool cuts in the survey area. Although long term standover feed is frequently lacking, in alluvial areas it may be available on adjacent mitchell grass pasture.

e. Alluvial eucalypt pasture

This pasture occurs mostly on the grey and brown, cracking, clay soils in association with coolibah and yapunyah on the alluvial plains, and with river red gum and coolibah along the rivers. It is characterised by the long lived perennial grasses neverfail, rat's tail couch and Warrego summer grass, with bluegrasses (*Bothriochloa* spp.), golden beardgrass and umbrella cane grass in wetter areas and along channels. The short lived perennials Queensland bluegrass and native millet, and annuals button grass, flinders grass, early spring grass and sedges (*Cyperus* spp.) occur frequently. A variety of forbs are present and may become seasonally abundant. Characteristic species include smooth minuria, raspweeds (*Haloragis* spp.), *Polymeria* spp., *Psoralea* spp. and *Sida* species.

The pasture responds to heavy rainfall or flooding. Overgrazing results in the loss of the perennial grasses and high quality ephemerals, and an increase in unpalatable burrs (*Sclerolaena* spp.) and saltbushes (*Atriplex* spp.). Pasture in good condition provides high quality forage in the short and medium term, and medium quality long term drought feed.

f. Mitchell grass pasture

Occurring on red to brown and grey-brown, cracking clay soils of the alluvia and undulating downs, this pasture is dominated by the long lived perennial, curly mitchell grass. Barley mitchell grass occurs rarely in the survey area, but hoop and bull mitchell are common in progressively wetter habitats. At the time of the survey, the short lived perennial Queensland bluegrass was a frequent codominant. This species increases during more favourable seasons (Everist and Moule 1952, Holland and Moore 1962, Williams and Roe 1975). The pasture also contains a large number of ephemeral species, particularly forbs from the Asteraceae, Chenopodiaceae, Convolvulaceae, Fabaceae and Malvaceae, which become seasonally important. Button grass, flinders grass and pepper grass may contribute up to 62% of the botanical composition in summer, and forbs such as Australian carrot, cow vine, plantain, silky goodenia up to 25% in winter (Roe and Allen 1945). Recorded yields in mitchell grass pasture range from 1 700 - 3 000 kg/ha (Ebersohn 1970, Lorimer

1978) depending on seasonal conditions and grazing pressure. Average basal area is approximately 4% (Roberts 1972).

Although curly mitchell grass produces a minor growth response after summer rainfall of 15 - 40 mm, falls of 50 - 75 mm are required for good growth, germination and seed set of both the mitchell grass and the ephemerals (Everist 1964, Allen and Roe 1948). The nutritional value of mitchell grasses is relatively low, and ephemeral herbs are grazed in preference if available (Weston and Moir 1969, Lorimer 1978). Overgrazing results in a decrease in the basal area of the perennial grasses (Orr 1979) and an increase in less palatable ephemerals such as burrs, saltbushes, twin-leaf, button grass and flinders grass.

This pasture is one of the most valuable in the survey area because the dry mitchell grass provides abundant long term standover for drought feed, and the nutritious ephemerals provide high quality, short term forage. Pasture management should aim to maintain a balance between the perennial grasses and the ephemeral forbs. Sustained heavy grazing is tolerated by the ephemerals while they are abundant, and by mature mitchell grass culms so long as they are not grazed shorter than 15-20 cm above ground level (Allen and Roe 1948, Jozwick *et al.* 1970).

g. Short-grass pasture

This pasture occurs on reddish brown, alluvial clays, often in association with whitewood, and on sandy, grey and brown clays associated with gunda-bluey on levees. It is characterised by the presence of short lived perennial and ephemeral herbs. The dominant species include kerosene grass, yellow threeawn, feather-top wiregrass, *Aristida platychaeta*, comb chloris, winged chloris and bottlewasher grasses (*Enneapogon avenaceus, E. polyphyllus*), and a variety of forbs, particularly from the Chenopodiaceae, Convolvulaceae and Malvaceae.

The pasture frequently appears to be overgrazed, probably because it responds to rainfall more quickly than adjacent mitchell grass pasture, producing short term high quality feed which is preferentially grazed by stock from the adjacent areas. Little or no medium to long term standover forage is available because of the lack of high yielding or long lived perennial species. Where stock have no access to other pasture types, severe overgrazing of the shortgrass pasture may lead to soil erosion and the development of scalds.

h. Spinifex pasture

In the survey area this is a minor pasture associated with silver-leaved ironbark on sandplains, and rarely with cypress pine on sandhills. The hummock grasses, *Triodia mitchellii* and *T. marginata*, are dominant, and can occupy up to 70% of the ground space in mature stands. A variety of other perennial and ephemeral grasses and forbs may occur in the space between the hummocks and in the litter below the trees. Although these herbs respond to relatively light falls of rain (25 mm; Allen and Roe 1948), stock find access is often difficult. Mature spinifex is highly unpalatable except for the seed heads, making the pasture of little value, but young regrowth after fire is eaten readily by stock. Hence the pasture is burnt regularly, often with the hope of eliminating the spinifex entirely. Although Pedley (1974) noted that burning may effect this in areas to the east, little success was noted in the survey area. While the forb component may temporarily increase after burning, the spinifex appeared to regenerate readily, and soon reoccupied the ground space. However, frequently after burning, dense woody weeds regenerate from vegetative regrowth and/or fire stimulated seed germination, further reducing the value of the pasture. The spinifex pasture will probably continue to be only of limited value for a short time after burning.

TOP FEED

Top feed species are those edible trees and shrubs eaten by stock. The more common species in the area are listed in Table 8.1, with notes on their habit, palatability, toxicity, edible parts, grazing animal and general distribution. Many of the species are described and illustrated by Everist (1969).

The top feed plants have two main roles in the area. Species such as berrigan, leopardwood, vinetree, whitewood and wilga always appear grazed if within reach of stock, and provide additional protein to supplement the normal diet even when plenty of herbage is available. During drought conditions, top feed species are an important standby feed, providing a maintenance diet for stock in the absence of herbage. Some species, such as belalie, bendee, nelia, cottonbush and mint bush, although eaten under drought conditions, are rarely grazed if other forage is present.

The food value of top feed plants depends on a variety of interacting factors. Their nutrient content varies between species, between different parts of the plant and at different times of the year

(Everist 1969, Leigh *et al.* 1978, McDonald and Ternouth 1979). The amount eaten depends on accessibility of the edible parts, their palatability to stock and the food preference of the animals. The latter varies between sheep and cattle, as well as with native animals such as kangaroos (Griffiths and Barker 1966), and also changes with the availability of other forage which in turn, varies seasonally (Beale 1975). After consumption, the actual nutritional gain to animals depends on the digestibility of the plants. While some top feed species such as fuchsia bush, doolan, leopardwood and plumwood have high digestibilities, others such as beefwood and belah have very low values and may not provide adequate nutrition to maintain stock (Leigh *et al.* 1978, McDonald and Ternouth 1979).

Although some of the top feed species may be toxic, they usually cause death only if they are the sole component of the diet and animals are placed under stress.

The most important top feed species in the area is mulga, mainly because it is extremely widespread, abundant and accessible and is palatable to stock, with even fallen leaves and pods being readily eaten by sheep (Allen and Roe 1948). It may comprise 3-67% of the diet of sheep during normal seasons, with consumption being highest in winter (Beale 1975). In drought periods, mulga is used as a reserve feed to maintain stock, and is cut or lopped to make the foliage accessible to the animals (Everist 1969).

Many top feed species are not widespread, occurring infrequently in only a few land zones, and are of limited drought reserve value. Other species, such as berrigan, black fuchsia, boonaree, ellangowan poison bush, ironwood, vinetree and wilga, occur infrequently in most land zones but become frequent or abundant in specific land systems where they constitute an important drought reserve.

Of the non mulga lands, the wooded alluvia and sandhill land zones have the greatest variety and abundance of top feed species. On the floodplains of the Warrego River, land systems in these zones (for example, Bluegrass, Camden, Dartmouth, Kudnapper, Retreat, Tuen, and Widgee) are important sources of top feed for animals in adjacent open alluvial land systems.

Because of the importance of top feed plants, management should always aim at allowing continual regeneration of the species, particularly in non drought periods when conditions suitable for regeneration may prevail. If trees are to be cut for drought feed, the species selected and the methods of cutting employed must be related to the ability of the plants to recover. If cut correctly, boonaree, bottletree, ironwood, kurrajong, mulga, vinetree, whitewood and wilga are able to recover relatively quickly by vegetative growth under succeeding favourable environmental conditions. Management techniques for the use and regeneration of top feed species common in the area are discussed by Everist (1969).

GRAZING CAPACITIES

Table 8.2 gives estimated long term grazing capacities for land systems in the area. These figures are conservative in that they are appropriate for normal dry seasons (5 out of 10 years) and indicate stocking rates which should be able to be sustained through all but severe drought periods of the order of 1 in 10-year frequency. During good seasons, which are considered to comprise 3 to 4 out of 10 years, stocking rates could be increased considerably above the figures shown. This may be desirable both from a commercial point of view to maximise returns, and in some cases from a biological point of view to control the establishment of dense areas of mulga and other woody shrubs. For example, surveys (Holmes 1981, Mills 1981) showed stocking rates of 1 sheep to 3.8 ha in mulga lands east of the Warrego River and 1 sheep to 4.7 ha in mulga lands west of the Warrego during the good seasons of the 1970's. However, once dry seasons recommence it is essential on the more sensitive types of country to reduce stocking rates if degradation of sensitive areas (such as the hard mulga lands) is to be prevented.

The condition and past grazing history of different paddocks have considerable influence on the number of stock which can be safely carried. The main principle is to match stock numbers according to the feed available.

Table 8.1 Common top feed species

Common name	Scientific Name	Pal (1)	Hab (2)	Land zone (3) T S M H R G F E W A D L	Pois (4)	Animal (5)	Edible part (6)	Comments
Beefwood	Grevillea striata	H	T	- X X X - - - - - - F -		SC	F	
Belah	Casuarina cristata	M	T	- - - - X - - - - - - C		SC	F	
Belalie	Acacia stenophylla	M	S	- - - - - - - - F - - X			F	Of some value during drought only.
Bendee	Acacia catenulata	M	S	- - - - C - - - - - - -			D	Of some value during drought only.
Berrigan	Eremophila longifolia	H	S	X X X X X - - X X - X X	T	SC	F	Eaten readily; not toxic in the field.
Bitter bark	Alstonia constricta	M	S	X X X X C - - - - - X -	T	SC	F	Can cause stock losses.
Black fuchsia	Eremophila glabra	M	S	X X X X X X X F X X X F		SC	F	
Boobialla	Myoporum acuminatum	H	S	- - - - - X - - - - C -	T	S	F	Toxic if eaten in large amounts.
Boonaree	Alectryon oleifolius	H	S	- X X - X X X X X X X X	T	SC	F	Eaten readily but should not be cut for stock in absence of other feed, especially if with young leaves.
Bottle tree	Brachychiton rupestris	H	T	- - - - - X - - - - - -	T	C	F	Cattle eat the pulp in the stems when the trees are cut; the pulp may contain nitrate and cause death of animals.
Brigalow	Acacia harpophylla	L	T	- - - - C C X - X - - C			DS	Of little value.
Broombush	Apophyllum anomalum	H	S	- - - - X X - - - X - X		SC	B	
Bumble	Capparis mitchellii	H	S	- - - - - X - - - X X -		SC	Fl	Eaten readily.
Cotton bush	Maireana aphylla	H	S	- - - - - X X - X F - -		S	F	Grazed in dry periods.
Creek wilga	Eremophila bignoniiflora	H	S	- - - - - - - - F X - X		SC	F	Eaten readily.
Doolan	Acacia salicina	L	T	- - - - - - - - C - X -		S	PF	Grazed during drought only.
Eastern dead finish	Archidendropsis basaltica	H	T	- C - - - X - - - - - -		SC	F	Leaves are shed during drought.
Ellangowan	Myoporum deserti	H	S	X X X - X A X X X X X X	T	SC	F	Eaten readily but can cause death of hungry travelling stock.
Emu apple	Owenia acidula	H	T	- - - - X X - - - X X -		SC	F	Eaten readily.

Table 8.1 Common top feed species

Common name	Scientific Name	Pal (1)	Hab (2)	Land zone (3) T S M H R G F E W A D L	Pois (4)	Animal (5)	Edible part (6)	Comments
Fuchsia bush	Eremophila maculata	H	S	- - - - - X - X X - - X	T	SC	F	Eaten readily; may cause death in hungry travelling stock.
	Eremophila latrobei	M	S	- - - - C - - - - - - -	C	S	F	Grazed in dry periods; not toxic in the field.
Gidgee	Acacia cambagei	L	T	- - - - C A - - A C - X		S	D	Widespread but of little value.
Green turkey bush	Eremophila gilesii	L	S	X A A C C X - C - - X X		S	I	The foliage is never eaten; is usually considered a woody weed.
Gunda-bluey	Acacia victoriae	H	S	- X - - - - - - X X C X		SC	F	Eaten readily.
Ironwood	Acacia excelsa	M	T	X X X - - X X X - - A -		SC	F	Eaten readily.
Kurrajong	Brachychiton populneus ssp. trilobus	H	T	X X X X - - - - - - X -		SC	F	Eaten readily; may cause stock losses if only component of diet.
Leopardwood	Flindersia maculosa	H	T	- - - - X F - - - X X -		SC	F	Eaten readily.
Lignum	Muehlenbeckia cuninghamii	M	S	- - - - - X - X A X - F		SC	B	Young shoots eaten readily.
Lignum fuchsia	Eremophila polyclada	H	S	- - - - - X - - C X - -		SC	BF	
Lime bush	Eremocitrus glauca	M	S	- - - - - - C - - X - -		S	F	
Mint bush	Prostanthera suborbicularis	M	S	- X C C A - - - - - - -		S	F	Grazed in dry periods.
Mulga	Acacia aneura	H	T	C A A A A - - A X - C X		S	FPD	Most important drought reserve fodder because abundant and widespread.
Myall	Acacia pendula	M	T	- - - - - - X - - - - -		SC	F	
Myrtle tree	Canthium oleifolium	H	S	X X - - X X - X - - F -		S	F	
Narrow-leaf bumble	Capparis loranthifolia	M	S	- X X - X X - X X - X -		SC	F	
Needlewood	Hakea leucoptera	M	S	- - - - - X C - - - X -			F	Of limited value; leaves needle-like.
Nelia	Acacia oswaldii	M	S	X X X - - - - X X - X	X		F	Eaten when little else available.
Nipan	Capparis lasiantha	H	S	- - - - X X - - X - -	-	SC	F	Eaten readily.
Old man saltbush	Atriplex nummularia	H	S	- - - - - X - - C X - -		SC	F	More favoured as foliage dries.

Table 8.1 Common top feed species

Common name	Scientific Name	Pal (1)	Hab (2)	Land zone (3) T	S	M	H	R	G	F	E	W	A	D	L	Pois (4)	Animal (5)	Edible part (6)	Comments
Parkinsonia	Parkinsonia aculeata	M	S	-	-	-	-	-	-	-	-	-	X	-	-		S	F	
Plumwood	Santalum lanceolatum	H	S	-	-	-	-	X	X	-	-	-	X	X	X		SC	F	Eaten readily.
Queensland bluebush	Chenopodium auricomum	H	S	-	-	-	-	-	X	-	-	C	X	-	C	C	SC	F	Eaten readily; not toxic in the field.
Turpentine mulga	Acacia brachystachya	M	S	-	-	-	X	C	-	-	-	-	-	-	-			F	Of little value.
Vinetree	Ventilago viminalis	H	T	-	X	-	-	X	X	-	X	X	X	F	-	T	SC	F	Eaten readily; not toxic in the field so long as diet is mixed.
Western dead finish	Acacia tetragonophylla	H	S	-	X	-	X	X	-	-	X	-	-	X	X		SC	F	Leaves shed during drought.
Whitewood	Atalaya hemiglauca	H	T	-	-	-	-	X	F	-	X	X	X	F	-	T	SC	F	Eaten readily; rarely causes stock losses.
Wilga	Geijera parviflora	H	T	-	X	X	-	X	X	-	X	X	-	A	X		S	F	Eaten readily.
Yapunyah	Eucalyptus ochrophloia	M	T	-	-	-	-	-	X	-	-	A	-	-	C			F	
Yarran	Acacia omalophylla	M	T	-	-	-	-	-	-	-	X	C	-	-	C		S	FP	

1. Palatability: see Appendix III for codes.
2. Habit: see Appendix III for codes.
3. Land zone: see Appendix III for codes.
4. Poisonous species: see Appendix III for codes.
5. Type of grazing animal: S = sheep; C = cattle.
6. Edible part of plant:
   B = branchlets, young stems
   D = dead, fallen leaves
   F = foliage
   I = inflorescence, flowers
   P = seed pods
   S = suckers

Table 8.2. Long term grazing capacity and stability of land systems

Grazing capacity and stability of Land systems	Comments
SANDHILLS	
D1 Camden Slightly unstable under grazing Mediocre to fair condition Capacity 1 sheep to 4 ha	Grazing capacity seasonal, responds to light falls of rain with short growth period. Can provide good quality winter herbage, but summer grasses tend to be of lower quality. Frequently invaded by sandhill hopbush and turpentine which restrict pasture growth and mustering difficult. If mulga is present maintain 175 shrubs/ha.
D2 Retreat Stable to slightly unstable under grazing Fair condition Capacity 1:2.4 ha	Subject to relatively high stocking rates because of proximity to water, and some seasonal scalding and soil erosion due to excessive runoff has ocurred. Areas of galvanized burr are characteristic of overgrazed areas, and some increase in gunda bluey densities has occurred in recent years, but is regarded as a seasonal phenomenon. These areas respond to moderate falls of rain and provide a limited bulk of high quality forbs and short grasses.
D3 Gowrie Stable undergrazing Mediocre condition Capacity 1:3.4 ha	Grazing capacity is seasonal, with short growth periods following even light falls of rain. Winter rains produce a moderate bulk of forbs, while summer rains frequently result in heavy bulk of relatively unpalatable wiregrass. Minor areas carry high densities of immature cypress pine seedlings and low shrubs. Buffel grass has established successfully in some areas adjacent to the river.
SPINIFEX SANDPLAINS	
N1 Shelbourne Slightly unstable under grazing Mediocre condition Capacity 1:8	Generally only grazed after rain or when spinifex seed heads are available. Spinifex forms a stable cover but frequent burning has resulted in a dense understorey of wattles appearing in some areas.
MULGA SANDPLAINS	
S1 Charleville Unstable under grazing Poor condition Capacity 1:4 (plus 1:50 cattle)	Sandy surfaces with high infiltration, so this system can respond to lighter falls of rain. Many areas have a history of heavy stocking and where mulga has been removed, green turkey bush and wiregrasses frequently predominate. Mulga densities are very high in some areas (2500 shrubs/ha), severely limiting production. Disturbance should be limited to reducing mulga densities to the equivalent of 175 shrubs/ha. Sheep can be used to control mulga regrowth, but continuous high grazing pressures will bring about a reduction in condition and productivity.
S2 Eulo Unstable under grazing Poor to fair condition Capacity 1:4 (plus 1:50 cattle)	Sandy surfaces limit runoff and allow a response to lighter falls of rain. Heavy infestations of unpalatable woody shrubs such as sandhill hopbush, turpentine, cassias and green turkey bush. Where necessary, regrowth of mulga to densities equivalent to 175 shrubs/ha may be encouraged by stocking, mainly with cattle, until an improvement in condition occurs.

S3 Glenmore

Slightly unstable under grazing
Good to mediocre condition
Capacity 1:3

Sand surfaces limit runoff and allow a response to lighter falls of rain. Wiregrasses and green turkey bush occur occasionally on areas cleared of mulga, so maintenance of mulga densities at the equivalent of 175 shrubs/ha is recommended unless this country is being developed with buffel grass. Buffel grass has been successfully established in some areas and further development is possible.

SOFT MULGA LANDS

M1 Arabella

Slightly unstable under grazing
Good to mediocre condition
Capacity 1:3

Mulga densities need to be controlled for maximum production, and density equivalent to 175 shrubs/ha represents the best compromise between production and stability. Wiregrasses frequently predominate in areas completely cleared of mulga and severely affect sheep production. Limited areas of buffel grass have been successfully established. There is evidence that in some circumstances, small cool fires and a predominance of cattle may bring about an improvement in the condition of these lands. Stock lightly (1:6 ha) during dry periods to maintain cover.

M2 Nebine

Slightly unstable under grazing
Fair to poor condition
Capacity 1:5 (plus 1:50 cattle)

Mulga densities need to be controlled for maximum production, and a density equivalent to 175 shrubs/ha represents the best compromise between production and stability. Wiregrasses frequently predominate in areas completely cleared of mulga and make these areas unsuitable for grazing sheep. Stock lightly during drought periods to maintain cover.

M3 Humeburn

Unstable under grazing
Poor to mediocre condition
Capacity 1:3.5

Invasion by unpalatable woody shrubs is a major problem in these lower slope areas which receive some run-on water. Mulga densities should be maintained at the equivalent of 175 shrubs/ha. Efforts should be made to limit the grazing pressure on these areas by appropriate location of fences and waterpoints, and conservative stocking (with sheep) during dry periods.

M4 Norah Park

Slightly unstable under grazing
Mediocre to fair condition
Capacity 1:5 (plus 1:50 cattle)

Green turkey bush and wiregrasses create problems on this land system. Mulga should be maintained at densities equivalent to 175 shrubs/ha to maximise stability and control invasion of unpalatable plants while maintaining production. Conservative stocking (with sheep) during dry seasons.

M5 Nimaru

Slightly unstable under grazing
Mediocre to fair condition
Capacity 1:3.5 (plus 1:50 cattle)

These areas receive run-on water and are very productive if maintained in fair condition. High mulga densities in some areas should be reduced to the equivalent of 175 shrubs/ha if possible. Green turkey bush is present in some areas. These lands should be conservatively stocked during dry seasons.

HARD MULGA LANDS

H1 Sommariva

Slightly unstable under grazing
Mediocre to fair condition
Capacity 1:5 (plus cattle)

Increased runoff from these sloping lands means a reasonable ground cover is important to get the maximum benefit from rainfall. Areas of green turkey bush, silver turkey bush and wiregrass occur. These problems are minimised by maintaining mulga densities at the equivalent of 175 shrubs/ha and conservative stocking with sheep during dry seasons. Mulga densities may need to be reduced in some areas to improve productivity.

H2 Erac

Unstable under grazing
Very poor to fair condition
Capacity 1:5 (plus 1:50 cattle)

This land system is extremely susceptible to irreversible changes in the form of green turkey bush invasion and sheet erosion during and immediately following dry periods. Significant areas are in very poor condition. The maintenance of mulga densities at the equivalent of 175 shrubs/ha is essential for stability. Stocking rates for sheep should be reduced if summer rains fail, and 1 sheep to 8 ha is an appropriate dry season stocking rate. Mulga felling for stock should be limited to severe drought periods of the order of a 1 in 10 years frequency as the high grazing pressure and disturbance associated with mulga feeding frequently lead to further degradation and loss of productivity.

H3 Boatman

Slightly unstable under grazing
Mediocre under grazing
Capacity 1:4 (plus 1:50 cattle)

Maintain ground cover by conservative stocking during dry periods. Mulga densities should be kept to the equivalent of 175 shrubs/ha for maximum production and stability, and to help prevent wiregrass invasion. Heavy stocking with sheep may be necessary to control mulga regrowth following good winter rains.

H4 Gilruth

Slightly unstable under grazing
Mediocre to fair condition
Capacity 1:5

Maintain ground cover and mulga densities equivalent to 175 shrubs/ha by conservative stocking during dry periods. Mulga felling should not be practised more often than 1 year in 10 to stop further loss of desirable species. Mulga regrowth in good seasons may need to be controlled with sheep.

DISSECTED RESIDUALS

R1 Colanchie

Unstable under grazing
Mediocre condition
Capacity 1:7

This land system has limited productivity. Clearing of brigalow on the lower slopes frequently leads to dense brigalow regrowth and sometimes gully erosion, and is not recommended.

R2 Quilberry

Unstable under grazing
Mediocre condition
Capacity 1:8

These areas are of limited productivity. Dense stands of hopbush (and sandalwood) occur in many areas. Excessive grazing pressure during dry periods should be avoided as excessive runoff from these areas can cause erosion problems on the associated land systems.

R3 Leader

Unstable under grazing
Mediocre condition
Capacity 1:8

These areas have limited productivity and stands of hopbush, cassias or sandalwood occur in some areas. Mulga and other edible shrub densities should be maintained at least at the equivalent of 175 shrubs/ha or more.

GIDGEE LANDS

G1 Kennedy

Slightly unstable under grazing
Mediocre condition
Capacity 1:2.5

In the natural state, these lands provide useful grazing at moderate stocking rates. Clearing increases productivity considerably, but is often followed by dense regeneration of brigalow suckers unless managed very carefully.

G2 Killowen

Slightly unstable under grazing
Fair condition
Capacity 1:4 (natural state)

These areas are subject to sandalwood invasion, and there is some scalding around the margins of the gidgee and encroaching into the gidgee areas during drought periods as the A horizon (topsoil) is eroded. Stocking pressure should be limited during dry periods to maintain stability.

G3 Ivanhoe

Stable under grazing
Fair condition
Capacity 1:4

These areas are relatively stable and though subject to heavy grazing pressure, no evidence has been seen of a long-term downtrend in condition. Development of these areas is unlikely under present pastoral systems, though some clearing of flooded gidgee areas has been undertaken.

DOWNS

F1 Coreena

Stable under grazing
Good condition
Capacity 1:1.2

Highly productive mitchell grass pastures. Mitchell grass stands over well and provides reasonable nutrition, while seasonal forbs provide high levels of nutrition. During very extended drought periods carrying capacities may decline to low levels. Invasions of mitchell grass pastures by white speargrass and feathertop has caused problems in other downs land systems.

POPLAR BOX LANDS

B1 Bendena

Unstable under grazing
Fair condition
Capacity 1:3

These areas receive runoff water from light to moderate falls of rain and produce a wide variety of forbs and a considerable bulk of grasses when in good condition. Sandalwood invasion has occurred in many areas. Ground cover should be maintained to prevent gully erosion and discourage further woody weed invasion.

B2 Loddon

Slightly unstable under grazing
Fair to very good condition
Capacity 1:2

These are run-on areas which receive runoff water from light to moderate falls of rain and have considerably higher production potential than surrounding lands. A wide variety of forbs and a considerable bulk of grasses are produced after rain. Ground cover should be maintained to prevent gully erosion and possible establishment of unpalatable shrubs.

B3 Halton

Slightly unstable under grazing
Good to very good condition
Capacity 1:2

Run-on areas which receive water from moderate to light falls of rain and have relatively high productivity. A wide variety of forbs and a considerable bulk of grasses are produced in season. Dense stands of box limit productivity in some instances. These areas occur in the north-east where rainfall is higher and more reliable, some dryland cropping has been carried out on these flats.

B4 Elverston

Slightly unstable under grazing
Mediocre condition
Capacity 1:3

Run-on areas forming drainage lines through sandplains. These areas respond to lighter falls of rain and receive limited run-on water. Increasing densities of unpalatable shrubs are common, and ground cover should be maintained to minimise further shrub invasion.

ALLUVIAL PLAINS (OPEN)

A1 Noorama

Stable under grazing
Good condition
Capacity 1:2

Highly productive, relatively stable mitchell grass pastures which provide adequate grazing with a high proportion of seasonal forbs. Prolonged overgrazing (e.g. stock routes) can lead to a decline in surface soil condition, principally in areas of lighter soils, but under normal management, the trend in condition appears stable. Feathertop has been recorded in certain seasons on some parts of this land system.

A2 Padua Stable under grazing Very good condition Capacity 1:2	Highly productive, stable pastures of mitchell grass and bluegrass providing substantial bulk, with a high proportion of seasonal forbs. Heavy falls of rain are necessary to saturate the soils, and result in extended growth periods.
A3 Westgate Unstable under grazing Poor to mediocre condition Capacity 1:3	These areas are reasonably productive when in good condition, but scalding and topsoil loss are widespread and perennial grass cover sparse to non-existent. This land will respond to lighter falls of rain and provides valuable grazing if managed carefully. Maximum ground cover needs to be maintained to prevent further soil loss during dry periods.

ALLUVIAL PLAINS, WOODLANDS

W1 Boin Unstable under grazing Poor to mediocre condition Capacity 1:3.5	These areas are extremely prone to degradation because they provide water and shade and a seasonal pasture of forbs and short grasses of good nutritional quality but very limited bulk. Scalding and topsoil loss are widespread. These areas receive run-on water and respond to moderate falls of rain. Maintenance of adequate ground cover and conservative stocking rates in dry seasons throughout the entire catchment is desirable to prevent the downtrend in condition in these areas from continuing.
W2 Dartmouth Slightly unstable under grazing Mediocre condition Capacity 1:4	The lands are normally relatively unproductive because of high tree densities and unpalatable shrub invasion in heavily grazed areas. Most of these areas are seasonally flooded by run-off from surrounding mulga lands, and clearing produces dramatic increases in productivity. Regular burning appears necessary to control shrub regrowth.
W3 Kudnapper Stable under grazing Good condition Capacity 1:2.5	These areas are stable and highly productive following flooding or heavy falls of rain. Adequate perennial grasses are available, together with a wide range and significant bulk of seasonal forbs.
W4 Widgee Stable to slightly unstable under grazing Good to mediocre condition Capacity 1:2.5	These drainage lines are generally stable in good condition, but become increasingly scalded towards the southern boundary. Seasonal flooding or heavy falls of rain produce a substantial bulk of high quality pasture.
W5 Bluegrass Stable under grazing Very good condition Capacity 1:2.5	Flood-out areas requiring flooding or heavy rains to produce (seasonal) growth. These areas are flooded from moderate to high level floods in the Warrego and produce an adequate bulk of pasture of very high nutritional quality. Grazing capacity of this land system is very limited in the absence of flooding or significant summer rains.
W6 Warrego Stable under grazing Good condition Capacity 1:2.5	These lands are stable and provide good quality pasture following flooding or heavy rains. Frequent waterholes provide stockwater. Noogoora burr is a seasonal problem.
W7 Langlo Stable under grazing Good condition Capacity 1:2.5	Stable lands which provide good quality pasture following flooding or heavy rains. Frequent waterholes provide stock water.

W8 Tuen Stable under grazing Good condition Capacity 1:2.5	Infrequently flooded areas which produce a substantial bulk of grasses and forbs of excellent nutritional quality following heavy rain or flooding.

CLAYPANS

L1 Elmina Slightly unstable under grazing Mediocre to poor condition Capacity 1:3	Open swamp or claypan areas ranging from scalds to canegrass swamps. High grazing pressures are concentrated on these areas and appear to be extending the scalded and eroded areas around the margins of the claypans. Moderate falls of rain or run-on water and a limited bulk of forbs and grasses of good nutritional quality.
L2 Ardgour Slightly unstable under grazing Mediocre to poor condition Capacity 1:3.5	These wooded claypans or swamps are subject to high grazing pressure which has led to some scalding and erosion around the fringes of these areas. Light to moderate falls of rain produce run-on water and a limited bulk of forbs and grasses of good nutritional quality.

Data presented in Figure 8.3 show the major fluctuations in stock numbers for Murweh and Paroo Shires over a period of 90 years plotted against the summer rainfall (average of Charleville and Cunnamulla). Five major falls in stock numbers were recorded over the 90-year period coinciding with prolonged deficiences in summer rainfall in the years 1898-1901, 1917-1920, 1943-45, 1964-67 and 1977-1981. Major falls in stock numbers occurred if summer rains were below average (274 mm) for three or more consecutive years. This pattern is tempered by the seasons immediately preceeding, (for example, 1956/57 to 1960/61 would have been a severe drought period had it not been for record summer rainfall over the two years 1954/55 and 1955/56). Also high winter rainfall as in 1978 can delay an impending decline in stock numbers.

Historically, greatest damage has been done to country when drought periods were followed a run of good seasons, and stock numbers were abnormally high at the beginning of the drought period (Condon *et al.* 1969, Dawson and Boyland 1974). This can be seen in the fluctuations of estimated stock numbers for the area (Table 8.3). The table shows high sheep and cattle numbers in the 1890's, which were reduced during the 1901-1903 drought to less than 1/3 and less than 1/10, respectively, of their former populations. Reductions in stock numbers of a comparable magnitude occurred in 1916-17, and to a lesser extent in 1946-47, 1965-66 and 1980-83.

Using the grazing capacities given in Table 8.2, the survey area was estimated to have a long term carrying capacity of 1 362 000 sheep and 46 000 cattle. This compares with an estimated (from Shire figures) average number of sheep carried in the survey area from 1890-1981 of 1 385 000 and 78 000 cattle. The Lands Department rated carrying capacity for the area is 1 827 700 sheep. If total sheep equivalents are calculated (1 beast = 8 sheep), 2 010 056 sheep equivalents have been carried over the period 1890-1981 as against an estimated long term grazing capacity of 1 674 000 sheep equivalents.

More importantly, over the past 20 years, for nearly half of which Murweh and Paroo Shires have been drought declared, the area has carried an average of 1 473 000 sheep and 99 000 cattle. These figures indicate higher stocking rates than recommended, particularly during drought. If these higher stocking rates occur in the more stable land zones this may not have any significant effect on the country. Evidence suggests permanent damage to the mulga lands (particularly the hard mulga lands west of the Warrego River) is likely if higher stocking rates than those recommended are consistently used during dry periods.

Overall, a carrying capacity of 1 300 000 sheep and 50 000 cattle appears to be a reasonable long term assessment of the safe carrying capacity of the area, with due allowance for droughts. Further research on the extent of dietary overlap between sheep and cattle in mulga country will enable a more accurate assessment of cattle carrying capacity. If little dietary overlap occurs, it may be possible to increase safe cattle carrying capacity of the area to match the actual figure carried over the last 20 years of 100 000.

Table 8.3 Stock populations (Murweh and Paroo Shires)

Year	Beef Cattle	Sheep	Year	Beef Cattle	Sheep
1890-91	215 698	1 226 341	1935-36	47 040	1 699 100
1891-92	208 696	1 521 014	1936-37	47 642	1 835 919
1892-93	226 353	1 816 228	1937-38	39 091	1 821 712
1893-94	223 049	1 473 618	1938-39	41 967	1 826 393
1894-95	204 661	1 574 819	1939-40	39 622	2 062 942
1895-96	204 498	1 681 545	1940-41	46 032	1 802 317
1896-97	196 639	1 651 139	1941-42		
1897-98	174 971	1 386 061	1942-43		
1898-99	109 049	1 342 954	1943-44		
1899-00	62 398	882 802	1944-45	56 394	1 618 668
1900-01	36 117	450 452	1945-46	50 545	1 325 845
1901-02	36 091	582 660	1946-47	44 653	964 258
1902-03	19 871	562 073	1947-48	43 896	1 272 337
1903-04	21 082	719 091	1948-49	51 386	1 472 537
1904-05	23 192	902 140	1949-50	67 328	1 619 148
1905-06	35 037	1 087 147	1950-51	86 444	
1906-07	48 481	1 333 867	1951-52	84 484	1 546 858
1907-08	49 421	1 278 126	1952-53	94 780	1 480 768
1908-09	57 509	1 341 543	1953-54	92 216	1 775 976
1909-10	66 489	1 544 191	1954-55	86 362	1 830 428
1910-11	75 865	1 520 543	1955-56	85 351	2 007 128
1911-12	77 521	1 386 587	1956-57	84 025	2 198 165
1912-13	76 462	1 078 929	1957-58	78 741	
1913-14	78 805	1 353 583	1958-59	60 119	2 166 914
1914-15	83 470	1 513 469	1959-60	54 548	1 988 994
1915-16	54 848	945 599	1960-61	51 445	1 790 142
1916-17	49 613	671 203	1961-62	57 146	1 870 720
1917-18	66 820	442 655	1962-63	61 329	1 670 571
1918-19	80 468	1 159 589	1963-64	72 993	1 760 721
1919-20	86 689	947 722	1964-65	71 816	1 895 173
1920-21	89 842	1 001 607	1965-66	56 766	1 307 347
1921-22	111 122	1 022 531	1966-67	55 881	1 378 485
1922-23	92 429	933 125	1967-68	69 100	1 689 082
1923-24	84 304	991 466	1968-69	77 107	1 685 772
1924-25	85 553	1 184 258	1969-70	80 917	1 632 385
1925-26	79 304	1 252 233	1970-71	85 141	1 527 703
1926-27	60 480	1 295 292	1971-72	107 378	1 421 094
1927-28	52 690	1 033 514	1972-73	109 638	1 136 367
1928-29	47 516	1 313 852	1973-74	128 346	1 182 507
1929-30	38 153	1 176 699	1974-75	148 656	1 364 703
1930-31	35 228	1 420 814	1975-76	153 922	1 293 449
1931-32	38 316	1 492 814	1976-77	164 872	1 354 941
1932-33	47 563	1 880 155	1977-78	156 752	1 341 931
1933-34	46 149	1 684 451	1978-79	139 771	1 357 286
1934-35	48 782	1 868 169	1979-80	106 530	1 101 605
			1980-81	85 627	881 667

LAND DEGRADATION

Land degradation is the term used to describe changes in the condition of country which are undesirable. These changes range from subtle changes in species composition of the pasture, which are extremely difficult to document because of seasonal fluctuations, to spectacular examples of soil erosion. While soil erosion is one of the final steps in the degradation process, a certain rate of soil movement may be regarded as a naturally occurring geological process.

The acceleration of this process by man is obviously less likely in flat areas, where erosion gradients are very low and active geological erosion has virtually ceased. Degradation of these areas usually occurs through vegetation changes such as the invasion of wiregrasses or woody shrubs. In the case of texture contrast soils, loss of topsoil through wind erosion and subsequent scalding can occur.

In this survey, degradation refers to changes which render the country less productive than its potential in terms of wool and meat production. Land in good condition for pastoral production allows maximum preservation of species diversity of native flora. This is becoming an important criteria in land management.

It is well recognised that the main biological problem in the management of lands in this semi-arid area is coping with the frequent drought periods. The matching of stock numbers to quantity and quality of feed available during drought periods presents considerable managerial problems, suggesting (see Chapter 6) that structural changes in the form of larger properties are needed to facilitate this in certain regions. Even sensitive lands which are potentially susceptible to land degradation may be able to withstand occasional periods of over-use without harm as for example, during severe drought periods of 1 year in 10 frequency. What appears to cause irreversible damage is continued over-use in the drier 5 out of every 10 years over long periods of 20-50 or more years.

The area surveyed has been grazed by domestic livestock for a little over 100 years. Experience in arid lands in other states of Australia and overseas countries with a longer history of use suggests that denudation and loss of productivity is likely to occur within a relatively short period. There are already substantial areas where productivity and management have been significantly affected by land degradation. Subjective estimates of degradation range from 12% of mulga lands east of the Warrego, to 25% in the hard mulga lands west of the Warrego (Mills 1980). Dawson and Boyland (1974), Skinner and Kelsey (1964), Roberts (1972), Burrows and Beale (1969) and Anson (unpublished report) have all recognised undesirable changes in mulga lands in south-western Queensland.

Because only a limited proportion of the land types susceptible to degradation are affected, an excellent opportunity exists to keep land degradation within acceptable limits by implementation of sound management practices. This means matching stock numbers to the feed available and stocking conservatively during dry periods. There is an immediate need to define practical pasture condition standards which can be used by graziers and extension workers to gauge when an area is being over-utilised. This would allow adjustments to be made before permanent damage occurs. A program to monitor the condition of sensitive land types is also necessary to determine long term trends.

The prevention of further degradation of sensitive areas is a high priority, as the rehabilitation of degraded areas is grossly uneconomical at present or in the future. If rehabilitation is required, the considerable expenditure required will need to come from Government sources. Individual landholders would be unable to finance expenditure of this magnitude, given the low productivity of the country involved.

Increasing public concern for the environment suggests that the maintenance of land in acceptable condition to maintain productivity, biological diversity and other alternative uses, will be an important requirement to be met by future land managers. A much smaller expenditure, to encourage the adoption of sound management practices, will produce considerable future savings by maintaining the lands in acceptable condition.

An assessment of the condition and trend of all land units is given in Appendix V. Table 8.2 presents stability and condition assessments for the various land systems. An overall summary of condition and degradation problems in the various land zones follows.

Sandhills land zone

These are stable to slightly unstable, low sandhills which are stabilised under normal conditions by vegetation. Unpalatable woody shrubs such as sandhill hopbush (*Dodonaea viscosa* ssp. *angustissima*) and various wattles (*Acacia* spp.) are common on Camden and to a lesser extent, Retreat land systems. Black speargrass (*Heteropogon contortus*) occurs on Gowrie and Retreat land systems, while wiregrasses may predominate in some seasonal conditions on Camden land system.

During drought periods, when vegetative cover is denuded, limited sand movement occurs. Where present, mulga and other edible shrubs should be maintained (by lopping only) to minimise sand movement.

Sandplains land zone

The spinifex sandplain (Shelbourne land system) has been burnt frequently, and in some areas dense stands of fire tolerant shrubs (*Acacia, Grevillea* and *Eucalyptus* spp.) have resulted.

On the mulga sandplains, Charleville and Eulo land systems are basically unstable when in a desirable state for grazing and require careful management. Unpalatable woody shrub invasion is the major problem, with dense mulga regrowth also a problem following good seasons. The serious degradation problems evident in these land systems mean conservative stocking during drought periods and maintenance of adequate mulga (equivalent to 175 shrubs/ha) is necessary. Glenmore land system appears to be relatively stable and has been successfully developed with buffel grass in some areas.

Mulga land zones

The soft mulga land zone is slightly unstable when in a desirable state for grazing and needs careful management. Humeburn and Nebine land systems already have significant areas which are in poor condition. The main problems are wiregrass invasion or dense mulga regrowth (Nebine land system), and woody weed (*Eremophila mitchellii, E. gilesii*) invasion (Humeburn land system). Smaller areas of Norah Park land system. have wiregrass or turkey-bush (*Eremophila gilesii*) problems. Arabella and Nimaru land systems are generally free from permanent degradation effects at this time.

The hard mulga lands vary from slightly unstable (Sommariva, Boatman and Gilruth land systems) to unstable (Erac land system). Limiting mulga densities to optimum levels for pasture production is the main problem with Boatman and Sommariva systems, which occur in the eastern, higher rainfall region. Soil loss problems are not as pronounced in this area, where the higher and more reliable rainfall normally produces a reasonably dense ground cover.

Erac land system in the drier western region, is extremely unstable, and substantial areas have been degraded by the invasion of turkey bush (*Eremophila gilesii*) or hopbush (*Dodonaea viscosa*) or by loss of surface soil. Available nutrient levels are low in all mulga soils, but when the system is in good condition, a build-up of nutrients occurs in the top 10 cm of soil as a result of nutrient recycling processes (Dawson 1974, Charley and Cowling 1968). The nutrient recycling process is regularly disrupted by the removal of mulga under heavy grazing during drought. If regrowth of further pasture and mulga is prevented by continued heavy grazing, the bare, friable surface soil is quickly eroded. A hardsetting, impermeable surface is left, and much of the nutrient build-up is lost in the eroded soil. The lack of both moisture (due to lowered infiltration) and nutrients leads to large areas of bare ground which in turn, causes increased runoff, more soil loss, less plant growth, and so on. The hard surface and lack of soil water and nutrients present an extremely adverse environment for plant establishment compared with the same area in good condition.

Once the degradation cycle starts in this fashion, the re-establishment of desirable species under grazing is extremely difficult due to high utilisation of the small amount of vegetation present. Brown (personal communication) has shown that 80% of perennial grasses at a site in Arabella land system died during a 2-year drought period and were replaced by seedlings. There is a high probability of species change as these seedlings re-establish if high utilisation levels remove the more palatable plants. Large areas of bare ground are frequently invaded by unpalatable woody shrubs. The superior ability of the shrubs' large root systems to extract soil moisture (even in the seedling stage) and unpalatability favour their survival.

A basic principle in maintaining the mulga lands in acceptable and productive condition is the maintenance of an adequate density of mulga trees to stabilise the system without unduly reducing pasture production. Everist (1949) and Beale (1973) indicate that a density of 175 shrubs/ha or 1 tree every 8 m represents an optimal balance between pasture production and stability.

Mulga lands east of the Warrego River appear to receive sufficient rainfall to regenerate mulga adequately in most areas. Management of mulga densities by strip-clearing has been recommended by Pressland (1976) as the best practical approach to the ideal of a savannah type grassland. Fire is thought to have played an important role in restricting shrub densities in these lands before settlement.

Dissected residuals land zone

These remnants of the Tertiary land surface are still actively eroding, and man's activities on this rate of erosion is difficult to establish. The residuals are of inherently low productivity, but provide a valuable drought reserve at low stocking rates. They are also important areas for the preservation of flora and fauna diversity.

Table 8.4 Major woody weed species.

Common name	Comments	Occurrence
Brigalow (*Acacia harpophylla*)	Regeneration after clearing, particularly from suckering, may be a problem in communities on sedentary clays in the north-east, and on alluvial in the south east. The uneven size (age) structure of many populations suggests continuous natural regeneration at least in recent years. Control measures have been discussed by Johnson (1976).	G1, R1 systems; south-eastern parts of G2 and W8 clays systems; unit 14.
Budda bush (*Eremophila sturtii*)	Restricted to sandy, red earths and red, earthy sands in areas mostly south of Cunnamulla. It is frequently a problem after disturbance of mulga. Plants were observed to produce vegetative regrowth after fire.	Sandhills and levees (D1, D2 systems); sandplain mulga (S2 system).
Butterbush (*Cassia nemophila*)	Most commonly a problem in run-on situations in poplar box, sandalwood flats, and in areas with water spreading (Batianoff and Burrows 1973). It is sometimes a problem on sandier portions of cleared Nebine land system (M2): the shrubs are frequently associated with poplar box trees (higher nutrient levels); dramatic fenceline effects suggests grazing management as a means of control. Purcell (1966b) noted that young seedlings are heavily grazed by stock. Disturbance stimulates profuse suckering and seed germination (Burrows 1974a), and burning may further exacerbate the problem (Hodgkinson 1979, Wilson and Mulham 1979). Seeds may be polyembryonic and produce more than one seedling (Randall 1970).	B1 system; unit M4 of M2 system; unit R1 occasionally.
Green turkey bush (*Eremophila gilesii*)	A widespread and frequently serious weed, occurring in all mulga land zones. Very high densities occurred in disturbed areas where mulga had been thinned. The plants are easily killed by defoliation at ground level, apparently being unable to sucker from underground buds or roots: seeds may germinate through most of the year given adequate moisture; sheep and a wingless grasshopper selectively graze the flowers and can be used to help control seed set (Burrows 1973, 1974b). The plants are relatively short lived (10-20 years (Smith 1957)); areas were seen where the plants were dead/dying, soil surface had grassed over and there were no signs of further regeneration.	Sandplain mulga (S1, S2 systems); Soft mulga (M2, M3, M4 systems); Hard mulga (H1, H2, H4 systems, unit H4); Residuals (unit R1)
Eastern dead-finish (*Archidendropsis basaltica*)	A problem in the north-eastern mulga sandplains where densities occurred after thinning of mulga.	S3 system
Ellangowan poison bush (*Myoporum deserti*)	Although widespread and occurring in most land zones, it is usually only a problem after clearing of gidgee, and gidgee-yapunyah communities. It frequently occurs with sandalwood. Plants may be able to produce vegetative regrowth after fire (Hodgkinson 1979).	Gidgee land zone; unit A17 (W2 system); unit L4 (L2 system).

Table 8.4 Major woody weed species.

Common name	Comments	Occurrence
Hopbushes (*Dodonea sinuolata* ssp. *acrodentata* *D. viscosa*, *D. petiolaris*)	Chiefly restricted to the residual land zone where they occur on scarps below disturbed mulga, bendee and *D. sinuolata* ssp. *acrodentata* is more often a problem than the other species.	Residual land zone; unit H4.
Mountain yapunyah (*Eucalyptus thozetiana*)	Seedling regeneration and vegetative regrowth may be a problem in cleared brigalow on shallow sedentary clays in the north-eastern residuals.	unit R4 (R1 system)
Mulga (*Acacia aneura*)	Although an important drought reserve plant, dense regeneration greatly reduces herbage growth and makes animal management difficult. Dense rgeneration after thinning was recorded in all mulga land zones and in some poplar box flats. Regeneration can be controlled to a degree by sheep grazing seedlings and saplings. For a discussion of regeneration see section on timber treatment.	Sandplain mulga (S1, S2 systems); Soft mulga (M1, M2, M3, M4 systems); Hard mulga (H1, H2, H3, H4 systems, unit 4); Residuals (unit R1); Poplar box flats (B1, B4 systems).
Shrubby daisy-bush (*Olearia subspicata*)	Restricted to sandy, red earths. It is frequently a problem after disturbance of mulga, particularly east of the Warrego River between Wyandra and Cunnamulla. Plants were observed to produce vegetative regrowth after fire.	unit M5 (S2 system); unit M4 (M2 system).
Sandalwood (*Eremophila mitchellii*)	A widespread species occurring in all land zones except the spinifex sandplains, but becoming a problem after disturbance most commonly in [a] poplar box communities on texture contrast soils, usually in run-on areas of mulga land zones, and [b] alluvial gidgee communities on reddish brown, texture contrast soils with a sandy surface. Regeneration from both vegetative regrowth and seedlings is rapid after disturbance (Beetson and Webb 1977), and plants were observed to produce regrowth after fire. The uneven size (age) structure of many communities suggests continuous regeneration at least in recent years. Control measures have been discussed by Beetson and Webb (1977).	B1, B4 systems; G2 system; unit A7 (A3 system); unit A17 (W2 system); unit B6 (M2 system); unit R6 (R2 system).
Sandhill hopbush (*Dodonaea viscosa* ssp. *angustissima*)	Restricted to sandy, red earths and red, earthy sands. It is frequently a serious problem after disturbance of mulga communities. Fire may stimulate seed germination and vegetative regrowth (Walker and Green 1979, Wilson and Mulham 1979).	Sandplain mulga (S2 system); unit M4 (M2 system); lower slopes of southern sandhills (D1 system).
Silver cassia (*Cassia artemisioides*)	Silver cassia reacts in a similar way to butterbush, but is less of a problem in the area.	unit M4 (M2 system).
Silver turkey bush (*Eremophila bowmanii*)	May become a problem in some mulga land systems after thinning of the original communities, particularly west of the Warrego River. It is not as widespread a problem as green turkey bush. Plants may be able to produce vegetative regrowth after fire (Hodgkinson 1979).	unit H3 (H1 system); unit M3 (S1 system); unit M15 (M3 system); unit R1.

Gidgee land zone

Kennedy land system occurs in scarp retreat zones and is often so densely wooded that productivity is very low. Dense brigalow and gidgee scrubs have been cleared in a number of areas. Brigalow regrowth usually occurs, though productivity is greatly increased for a short period. Development should only be undertaken if management has sufficient flexibility to spell these areas until there is sufficient fuel for a hot fire.

Killowen and Ivanhoe land systems occur on the alluvial plains of the Warrego distributory system. Killowen land system is subject to sandalwood (*Eremophila mitchellii*) invasion and there are associated scalded areas where the lighter textured A horizon has been wind eroded during drought periods. Ivanhoe land system appears stable.

Poplar box lands

These are productive land systems which receive runoff from associated mulga lands. Bendena is an unstable land system which suffers from sandalwood (*Eremophila mitchellii*) invasion in many areas. Some instances of gully erosion also occur. The maintenance of adequate ground cover in these run-on areas during drought periods is essential to limit erosion and discourages the establishment of sandalwood. Loddon and Halton land systems are somewhat more stable and should remain productive if there is maintenance of adequate ground cover. Elverston land system is in the early stages of shrub invasion and maximum ground cover should be maintained.

Alluvial plains

Noorama and Padua land systems are stable and productive. Feathertop (*Aristida latifolia*) has been noted on Noorama land system, but this is believed to be a seasonal occurrence only (Orr, personal communication). Some areas of lighter soils in Noorama land system show signs of scalding similar to that occurring on Westgate land system. Westgate land system is unstable, and loss of topsoil and frequent scalding are evident over much of its distribution. The contribution of man's activities towards this damage is not known. Manipulation of stocking rates on this land system to maintain plant cover and retain topsoil is important to avoid further damage. There is considerable sandalwood (*Eremophila mitchellii*) invasion in sandier areas where topsoil remains.

Alluvial plains (woodlands) and Miscellaneous land zones

Boin land system comprises frontage country associated with the mulga lands and is badly degraded in many areas by soil erosion. Dartmouth and to a lesser extent, Elmina and Ardgour land systems, are also degraded in some areas. Management should endeavour to limit grazing pressure on these land systems, but the degradation of "sacrifice" areas associated with watering points is difficult to avoid. Maintenance of adequate ground cover on the remainder of the catchment helps to limit grazing pressure on these land systems. Other land systems in this land zone are thought to be relatively stable, though seasonal problems such as Noogoora burr (*Xanthium pungens*) occur.

WOODY WEEDS

Woody weeds in the area are those shrub and tree species which usually have little or no top feed value, and reach densities such that herbage growth is suppressed and stock management made difficult. These species typically invade communities after a disturbance. Areas which have been cleared are highly vulnerable. The problem is sometimes exacerbated if fire has been used in the clearing operations or in managing the resulting native pasture. Woody weeds are also likely to become prominent in overgrazed areas, particularly if the soil surface has been affected by erosion.

Species which become woody weeds exhibit a number of traits which are thought to contribute to their success (Burrows 1976, Hodgkinson 1979, Tunstall *et al.* 1981). Woody weed species show greater nutrient absorption and more efficient use of N and P in dry matter production than herbage plants. Woody weed seedlings and mature plants are better able to survive periods of water stress because of higher physiological drought tolerance, higher seedling root extension rates, and larger mature root systems which enable better water absorption. The species are usually unpalatable, and if stock are present, herbage plants are preferentially grazed. This favours the presence of woody weeds which then actually suppress further herbage growth because they utilise the resources available more efficiently. Most woody weed species are able to regenerate rapidly after disturbance, given favourable environmental conditions, either through vegetative regrowth from stems and/or roots, and/or from seed germination (see Table 8.4). Such regeneration is often stimulated by fire or mechanical injury to the plants. Once established, the woody weeds then retain the space because of their longevity.

The extent of woody weed invasion depends on a variety of factors including the type and severity of disturbance, and the amount of seed available for germination (Burrows 1971, Hodgkinson *et al.* 1980). The presence or absence of stock, the type of animal and grazing pressure exerted if present, the time of disturbance during the year, and subsequent environmental conditions, are also important. Invasion is often associated with years of above average rainfall (Beeston and Webb 1977), although minor regeneration probably occurs in the intervening drier years. In the survey area, the uneven size (age) structure of many woody weed populations suggested that the recent run of above average seasons has been favourable for their build-up.

The major woody weed species which occur in the area are listed in Table 8.4, with notes on their occurrence and factors affecting their weed status. Other species which cause minor problems are listed in Table 8.5.

The greatest woody weed problems occur in the mulga land systems, where widespread scrub clearing has been carried out. Although an important top feed species, mulga itself is often a problem, with the density of regeneration populations often exceeding that of the original populations. Densities as high as 8218$\pm$1173 stems/ha have been recorded in the Charleville area (Burrows and Beale 1970). Where mulga regeneration is low, other woody weed species are frequent invaders. Such species include sandalwood and butterbush on red, texture contrast soils, green and silver turkey bushes on stony or loamy, red earths with/without pronounced hardpans, and turkey bushes, budda bush, sandhill hopbush and *Olearia subspicata* on sandy, red earths.

Brigalow, mountain yapunyah, ellangowan poison bush and sandalwood may also cause woody weed problems after clearing in some gidgee and brigalow communities.

Because woody weeds lower the carrying capacity of the land, their prevention or control is desirable. To a large extent, cost and manpower requirements dictate which control measures are used. Common methods applied to species in the area, and their effectiveness, are summarised below.

(a) Fire. Burning is generally not effective in mature stands because of lack of fuel to carry a fire. Sensitive species such as mulga are killed by fire, but burning stimulates vegetative regrowth and seed germination of many species. Fire is more likely to be effective for such species if used when the plants are very young, provided sufficient fuel is present. Burning may result in the loss of nutrients from an already nutrient-deficient system if ash is washed or blown away. The burnt soil surface may provide a less favourable seedbed for the germination of desired herbage species (Burrows 1974a).

(b) Grazing. Grazing by sheep or cattle is of little value in mature stands since the plants are generally unpalatable and eaten only under extreme drought conditions. In New South Wales, forced grazing by goats has proved ineffective in controlling most established woody weeds in the poplar box lands (Harrington 1979). Selective grazing by sheep and grasshoppers of green turkey bush flowers may prevent seed set in mature plants (Burrows 1973). Where the seedlings of woody weeds are palatable, heavy stock grazing can be used to help reduce regeneration, such as for mulga (Burrows 1973), and butterbush (Purcell 1966a, Moore and Walker 1972). Adjustment of stock numbers to encourage stronger competition from herbage (Burrows 1974a, Hodgkinson 1979), and edible shrub species may also help reduce woody weed establishment.

(c) Mechanical methods. Unless the root systems of the plants are completely removed from the soil, mechanical clearing may only stimulate suckering, as well as induce seed germination (Batianoff and Burrows 1973).

(d) Chemical methods. These are generally too expensive and labour intensive to be economical.

More detailed discussions of plant biology and specific control measures are available for some woody weeds. These include brigalow (Johnson 1976), green turkey bush (Burrows 1971, 1973), mulga (Burrows 1976), sandalwood (Beeston and Webb 1977), and butterbush, sandhill hopbush, budda bush and other species common in mulga (Moore and Walker 1972, Harrington 1979, Walker and Green 1979, Wilson and Mulham 1979).

HERBACEOUS WEEDS

The following species, which cause economic losses through wool contamination , are a problem in some areas.

Table 8.5 Minor woody weed species

Common name	Scientific name	Occurrence
Acacias	Acacia gnidium	T1 system
	A. leptostachya	T1 system
	A. maitlandii	T1 system
	A. burbidgeae	T1 system
Belah	Casuarina cristata	Unit L2
Black fuchsia	Eremophila glabra	Units B1, L1, L4
Boobialla	Myoporum acuminatum	Unit S2
Bowyakka	Acacia microsperma	Units L2, R6
Butterfly bush	Petalostylis labicheoides	S1, S2 systems
Colony wattle	Acacia murrayana	Unit S3
Coolibah	Eucalyptus microtheca	Unit 17; major water courses
Cypress pine	Callitris columellaris	Unit S5
Doolan	Acacia salicina	Major water courses
Firebush	Cassia pleurocarpa	Sandplain and soft mulga
Fuchsia-bush	Eremophila latrobei	Unit R5
Gundabluey	Acacia victoriae	Unit A28
Honeysuckle oak	Grevillea juncifolia	T1 system
Hopbush	Dodonaea peduncularis	T1 system
Hopbush, hairy	Dodonaea boroniifolia	T1 system
Limebush	Eremocitrus glauca	F1 system
Needlewood	Hakea leucoptera	F1 system
Micromyrtus	Micromyrtus hexamera	Unit M4
Mintbush	Prostanthera suborbicularis	Units H4, M7
Parkinsonia	Parkinsonia aculeata	D2 system
Phebalium	Phebalium glandulosum	Unit R4
Poplar box	Eucalyptus populnea	Unit E8
Thryptomene	Thryptomene hexandra	Unit H4
Yarran	Acacia omalophylla	Units A14, L2

Black speargrass (*Heteropogon contortus*): occurs on levees associated with the major creeks and rivers (units A21, B8, S5). It is encouraged by moderate grazing, burning and above average rainfall (Shaw 1957, Bisset 1962, Tothill 1969); may be controlled by chemicals, burning and heavy grazing, or cultivation and the introduction of buffel grass (*Cenchrus ciliaris*) (Bisset 1962, Cowie 1967, Purcell 1966a, Isbell 1969).

Galvanized burr (*Sclerolaena birchii*): widespread in most land zones in overgrazed areas on a range of soil types; increases after consecutive good summer and winter rain, particularly after drought (Everist *et al.* 1976, Auld 1976a); seedlings are palatable before the spines harden (Auld 1976a); mature plants are eaten when they become infested with a mite which prevents spine development (Young, personal communication); control measures have included chemical spraying, introduction of buffel grass, and heavy grazing by sheep (Everist *et al.* 1976, Auld 1976b).

Noogoora burr (*Xanthium pungens*): common along the major creeks and rivers where the vegetation has been disturbed; becomes abundant after summer rainfall; is an annual whose seeds remain viable for several years; can be controlled by repeated chemical spraying (Everist 1974) and possibly by biological means (Wapshere 1974).

TIMBER TREATMENT

Tree thinning by cutting, and to a lesser extent, by ring-barking, has been carried out mainly to increase the herbage production of the native pastures, although some species such as gidgee and cypress pine have been used for fence posts, firewood, or buildings. Mulga, gidgee and brigalow communities have been most affected, with poplar box, yapunyah and mountain yapunyah communities to a lesser degree. Regeneration problems from vegetative regrowth can usually be expected with brigalow and eucalypts, and from seed germination or growth of suppressed seedlings for mulga and eucalypts. Woody weeds, which may also be a problem, were discussed previously.

Although mulga communities are extremely widespread in the area, their herbage yield is low where tree densities are high (see earlier in chapter). Extensive areas have been cleared in most land systems, however, severe regeneration often follows, particularly in the Charleville, Nebine and Boatman land systems. The greatest problem associated with the regeneration of mulga after felling appears to have been its unpredictability. Property managers never sure whether, and how much will occur. Although the potential regeneration is determined by the amount of viable seed available for germination, the actual amount of regeneration depends on the extent of seed germination and seedling survival. The main factors which affect these parameters in cleared mulga are summarised below.

1. Seed reserves. Although trees are able to flower at any time of the year (Burrows 1976), fruits set only after summer rain, and seeds mature only with good follow-up rain in winter (Preece 1971b). Only a small proportion of seeds are naturally soft at maturity, but 75% may be viable unless severely infested with larvae of seed wasps (Preece 1971a). The seeds fall below the parent tree but may be dispersed away from it (Preece 1971a). Most of the seeds are thought to remain viable in the soil for 2-3 years (Burrows 1974a) but some may remain viable for longer (Silcock 1975).

2. Seed germination. Before germination can occur the seeds must become soft. Burning may promote softening (Everist 1949), but fire is not essential for germination (Burrows 1973). Most seeds become soft in the field due to natural aging which occurs after 12 months (Preece 1971a). The seeds germinate at temperatures from 15 - 36°C, with 20 - 30°C, the temperature typical of wet soil in summer, being the optimum range (Preece 1971a). Germination occurs in seasons with average rainfall (Silcock 1975), but is probably greatest after prolonged wet weather in summer (Burrows 1973).

3. Seedling survival. Seedlings are able to survive prolonged periods of water stress (Burrows 1973), but are selectively eaten by sheep (Everist 1949). The amount of regeneration may be affected by the time lapse between clearing and the last seed set of trees, by the time of year clearing is carried out, and by subsequent environmental and biotic conditions. Massive regeneration can be expected when favorable moisture and temperature conditions coincide with the presence of large numbers of soft, viable seeds after clearing. In New South Wales, this probably occurs only once in every nine years (Preece 1971a). Burrows (1973) stressed that in Queensland, in the absence of grazing or with light grazing, some mulga recruitment occurs continuously in most years.

In view of the unpredictability and uncontrollable nature of most factors affecting mulga regeneration, grazing is the only factor which a property manager can manipulate with any degree of certainty to try to prevent regeneration problems. Heavy stocking with sheep in the dry winter months is most effective for control (Burrows 1974a). At the same time, however, grazing management should aim to maintain the long term stability and productivity of the herbage (Pressland 1976).

Because of its value as a top feed species and its role in stabilising the ecosystem, strips of mulga should always be left during any clearing operation as drought reserves (Burrows 1974a, Pressland 1975), in >400 mm rainfall areas. In lower rainfall areas, 175 shrubs/ha should be maintained (Dawson and Boyland 1974).

POISONOUS PLANTS

Plant species in the area known to be toxic under field conditions are listed in Table 8.6. Summaries of the land zones in which they occur and toxic agents present, are given. Detailed descriptions of all these species, their toxic components, symptoms of poisoning, and remedial treatments are included in Everist (1974).

Deaths from poisoning frequently occur in stock which are suffering from drought starvation, or hunger and stress after mustering or transportation. Frequently, the poisonous plant is the only dietary component because it has been cut for drought feed (for example, boonaree), has become seasonally abundant (for example, button grass), or is the only species present in holding yards and paddocks. The extent of stock losses depends on the condition of the animals, the composition of the pasture, and the growth stage of the plants, all of which vary with seasonal conditions. Sheep, cattle and horses may react differently to the same species.

Table 8.6. Poisonous plant species

Common name	Scientific name	Land Zone[1] T	S	M	H	R	G	F	E	W	A	D	L	Poisonous component[2] Ox	Ni	EO	CG	OG	AL	OT	UT	Comments
TREES																						
Bitter bark	Alstonia constricta	X	X	X	X	C	-	-	-	-	-	X	-	-	-	-	-	-	X	-	-	
Boonaree	Alectryon oleifolius	-	X	X	-	X	X	X	X	X	X	X	X	-	-	-	X	-	-	-	-	Moist young leaves highly toxic
Bottle tree	Brachychiton rupestris	-	-	-	-	-	X	-	-	-	-	-	-	-	X	-	-	-	-	-	-	Only the pulp in the stems is toxic
Kurrajong	Brachychiton populneus ssp. trilobus	X	X	X	X	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	X	Seeds are particularly toxic
Whitewood	Atalaya hemiglauca	-	-	-	-	X	F	-	X	X	X	F	-	-	-	-	-	-	-	-	X	Usually not toxic in the field
SHRUBS																						
Boobialla	Myoporum acuminatum	-	-	-	-	-	X	-	-	-	-	C	-	-	-	X	-	-	-	-	-	
Corkwood	Duboisia leichhardtii	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	X	-	-	Occurs rarely
Ellangowan poison bush	Myoporum deserti	X	X	X	-	X	A	X	X	X	X	X	X	-	-	X	-	-	-	-	-	Most common in disturbed gidgee
Fuchsia-bush	Eremophila maculata	-	-	-	-	-	X	-	X	X	-	-	X	-	-	-	X	-	-	-	-	
Tobacco tree	Nicotiana glauca	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	X	-	-	Found only in pulled gidgee-yapunyah (unit 17)
GRASSES																						
Buffel grass	Cenchrus ciliaris	-	X	X	X	X	X	-	X	X	-	C	-	X	-	-	-	-	-	-	-	Valuable introduced pasture plant only occasionally a problem
Button grass	Dactyloctenium radulans	-	-	X	-	-	A	-	X	A	A	X	X	-	-	-	-	-	-	-	X	Common in overgrazed areas
Hairy panic	Panicum effusum	X	F	F	F	X	X	-	F	-	X	X	X	-	-	-	-	-	-	-	X	
Native couch grass	Brachyachne convergens	-	-	-	-	-	F	X	-	X	F	-	X	-	-	-	X	-	-	-	-	
Purple plume grass	Triraphis mollis	X	X	X	X	-	X	-	X	-	-	F	X	-	-	X	-	-	-	-	-	

Table 8.6. Poisonous plant species

Common name	Scientific name	Land Zone[1] T	S	M	H	R	G	F	E	W	A	D	L	Poisonous component[2] Ox	Ni	EO	CG	OG	AL	OT	UT	Comments
FORBS																						
Annual saltbush	Atriplex muelleri	-	-	-	-	-	X	-	-	X	-	-	X	X	X	-	-	-	-	-	-	Common in overgrazed areas
Bathurst burr	*Xanthium spinosum*	-	-	-	-	-	-	-	-	X	X	-	-	-	-	-	-	X	-	-	X	
Birdsville indigo	Indigofera linnaei	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	X	
Black crumbweed	Chenopodium melanocarpum	-	-	X	X	-	X	-	-	-	-	-	-	-	-	-	X	-	-	-	-	
Blackberry nightshade	Solanum nigrum	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	X	-	-	
Blue parsnip	Trachymene glaucifolia	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	X	
Boggabri	Amaranthus mitchellii	-	-	-	-	-	-	-	-	X	X	-	-	X	X	-	-	-	-	-	-	
Broughton pea	Swainsona procumbens	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	X	
Caltrop	Tribulus terrestris	-	X	-	-	-	X	-	-	-	X	X	-	-	X	-	-	-	-	X	-	
Caustic weed	Euphorbia drummondii	X	F	F	F	X	X	X	F	X	F	X	X	-	-	-	-	-	-	-	X	
Crested goosefoot	Chenopodium cristatum	-	-	X	X	-	X	-	X	-	X	X	X	-	-	-	X	-	-	-	-	
Golden billy-buttons	Craspedia chrysantha	-	X	-	-	-	X	-	-	-	X	X	X	-	-	-	-	-	-	-	X	
Gomphrena weed	Gomphrena celosioides	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	
Mexican poppy	Argemone ochroleuca	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-	-	-	X	-	-	Common in disturbed areas
Morgan flower	Morgania floribunda	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-	-	-	-	-	X	
Mulga fern	Cheilanthes sieberi	X	F	A	F	X	X	-	F		-	-	X	X	-	-	-	-	-	-	X	
Munyeroo	Portulaca oleracea	-	X	X	X	X	X	-	X	X	X	X	X	X	X	-	-	-	-	-	-	
Native parsnip	Trachymene cyanantha	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	
Native tobacco	Nicotiana velutina	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	X	-	-	
Nettle-leaf goosefoot	Dysphania glomifera	-	-	-	X	X	F	-	-	X	-	-	-	-	-	-	X	-	-	-	-	
New Zealand spinach	Tetragonia tetragonioides	-	-	-	-	-	-	-	-	X	-	-	-	X	-	-	-	X	X	-	-	
Noogoora burr	Xanthium pungens	-	-	-	-	-	-	-	-	X	X	-	-	-	-	-	-	X	-	X	X	Common in disturbed areas
Parakeelya	Calandrinia balonensis	-	X	X	-	-	-	-	-	-	-	X	-	X	-	-	-	-	-	-	-	
Potato bush	Solanum ellipticum	-	X	F	X	X	X	-	X	X	-	X	X	-	-	-	-	-	-	X	-	

Table 8.6. Poisonous plant species

Common name	Scientific name	Land Zone[1] T	S	M	H	R	G	F	E	W	A	D	L	Poisonous component[2] Ox	Ni	EO	CG	OG	AL	OT	UT	Comments
Poverty bushes	P. elongata	-	-	-	-	-	-	-	X	-	-	-	F	-	-	-	-	-	-	-	X	
	Pimelea simplex ssp. continua	X	-	-	-	-	-	-	-	-	X	-	X	-	-	-	-	-	-	-	X	
	P. trichostachya	X	X	X	-	-	-	-	-	X	-	X	-	-	-	-	-	-	-	-	X	
Prickly paddy melon	Cucumis myriocarpus	-	-	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	X	
Purple-leaved goosefoot	Chenopodium atriplicinum	-	-	-	-	-	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	
Red spinach	Trianthema triquetra	-	-	-	-	-	F	X	-	X	F	-	X	X	X	-	-	-	-	-	-	
Soda bush	Neobassia proceriflora	-	-	-	-	-	X	-	-	X	X	-	-	X	-	-	-	-	-	-	-	Common in overgrazed areas
Soft roly-poly	Salsola kali	-	-	X	-	-	F	X	-	X	X	X	X	X	X	-	-	-	-	-	-	Common in overgrazed areas
Twinleaf	Zygophyllum ammophilum	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	X	
Wild parsnip	Trachymene ochracea	X	F	X	X	X	-	-	X	-	-	-	X	-	-	-	-	-	-	-	X	
Yellow wood sorrell	Oxalis corniculata	X	X	X	X	X	-	-	X	X	-	X	X	X	-	-	-	-	-	-	-	
	Hypericum gramineum	-	-	X	X	-	-	-	X	-	-	-	X	-	-	-	-	-	-	X	X	

1. Land zone: see Appendix III for codes.

2. Poisonous component:
   - Ox = oxalates
   - Ni = nitrates
   - EO = essential oils
   - CG = cyanogenetic glycosides
   - OG = other glycosides
   - AL = alkaloids
   - OT = other known toxins
   - UT = uncertain or unknown toxins

The majority of poisonous species in the area are herbs, many of which become abundant for a short period after favorable seasonal conditions. Some species become a problem only in overgrazed areas (for example, annual saltbush, button grass, poverty bushes, soda bush, soft roly-poly) or after disturbance such as clearing (for example, ellangowan poison bush). Others are widespread in a variety of land zones. No species which necessitate land being specially fenced off from stock are present. Many of the species, although potentially poisonous, are highly palatable to stock and provide valuable herbage or top feed. They can be eaten without ill-effect while other non-toxic species are contained in the diet.

Species most likely to cause stock losses in the survey area include caustic weed, hairy panic, mulga fern, potato bush and wild parsnip in the mulga land zones, poverty bushes on the claypans, and button grass, ellangowan poison bush and fuchsia-bush on the alluvial land zones.

Stock losses can be minimised by preventing conditions conducive to the build-up of poisonous plants (particularly overgrazing), and by not stocking potentially dangerous areas. A local knowledge of poisonous species and the conditions under which they can cause animal deaths is invaluable.

PESTS

Feral pigs are a major problem in thickly timbered country and in the alluvial land zones. Green shoots and other vegetative material comprise the major part of pig diets. Graziers commonly believe that pigs which have learned to kill lambs during dry periods when the normal vegetative diet is not available remain killers for the rest of their lives. Examples of pigs lowering lambing percentages by 40% or more have been documented by Plant *et al.* (1978), who also noted that pigs are rarely observed in daytime. It has also been suggested that hunting and shooting are not effective methods of pig control.

In Queensland, control of pigs is most effectively accomplished by poisoning of dead carcasses or by baiting with 1080 (sodium fluoro acetate). Baits are poisoned free of charge by the Shire representatives of the Coordinating Board. Effective control is usually only achieved where all properties in an area bait. A significant number of graziers are reluctant to participate in 1080 baiting campaigns because of the high rate of loss of station dogs.

Dingoes are a serious problem in the north-east and other wild dogs are common around towns in the area. Baiting and trapping are carried out by landholders with dingo problems. This has limited effect where large numbers of dingoes living in the Carnarvon Ranges are freely able to move into the sheep country. The restoration of an effective dingo barrier fence will considerably improve the situation for sheep properties in the north-east.

Rabbits and foxes occur in limited numbers, and are not presently believed to present a serious problem to the pastoral industry. The effectiveness of myxomatosis in controlling rabbit populations has been questioned, but no sound evidence of declining effectiveness is available.

Kangaroos, regarded by the grazing industry as a major problem, were observed in large numbers in the area and during times of drought. There are some observations suggesting kangaroo populations may contribute to destabilising mulga lands during drought periods.

The high degree of mobility of kangaroo populations, and abundance of permanent waters, mean that large numbers of kangaroos are able to congregate on feed resulting from scattered rains during drought periods. Such feed is then utilised extremely heavily. This free movement of kangaroos also makes it difficult to save paddocks of feed for special flocks of sheep such as lambing ewes or weaners. It also makes it impossible during drier years to successfully spell paddocks or allow feed to build up to carry a fire.

Various workers have investigated kangaroo diets in south-western Queensland and found that the common grey kangaroo (*Macropus giganteus*) is predominantly a grass eater. Even towards the end of the severe 1965/66 drought period, grey kangaroo diets at Gilruth Plains in February 1967 comprised 73% grass and 27% dicotyledons, compared with a sheep diet at the time of 33% grass and 67% forbs (Griffiths *et al.* 1974). The rarer western red kangaroo (*Macropus rufus*) had a similar diet to the sheep. They also concluded that food consumption of kangaroos at Gilruth Plains was slightly less than that of sheep on a feed consumed/kg liveweight basis.

The maintenance of adequate perennial grasses is essential for reducing runoff and maintaining stability and productivity on most land systems. The effect of the kangaroos' high level of grass consumption on land stability needs closer investigation.

Estimates of kangaroo numbers in the survey area are not available. Estimates of kangaroo numbers in the Western Division of New South Wales, (which comprises 31 m ha of arid lands immediately to the south of the survey area), range from 3 million in 1975-76 to 5 million in 1980. During this period, sheep numbers ranged from 9.7 million in 1976 to 7.3 million in 1980. The extent of kangaroos movement during drought periods is illustrated by an aerial survey estimate of 3.7 kangaroos for every sheep or 1 kangaroo to 2.4 ha in the Milparinka region alone in 1980.

DEVELOPMENT POTENTIAL

Development potential of the area is severely limited by the low and unreliable rainfall experienced. Kennedy land system can be developed with buffel grass in areas where brigalow occurs. Very careful and intensive management is needed to control brigalow regrowth and large scale development of these brigalow areas is not generally recommended at this time.

Establishment of buffel grass in mulga lands has not been generally successful even in the east of the area. Possible technological advances in seed preparation may increase the probability of successful establishment in the higher rainfall mulga lands.

Considerable areas of mulga have been cleared to the east of the Warrego, usually to feed stock during drought periods. These areas now carry a good body of native grasses with subsequently increased productivity. However, in many areas dense mulga regrowth occurs, or where mulga has been completely removed for an extended period, wiregrasses tend to predominate. If new technology allows buffel grass to be reliably established in these areas, productivity and management of these lands will be dramatically improved.

Areas of Dartmouth land system have had productivity dramatically increased by clearing and allowing native species to colonise. Frequent flooding means high productivity from these areas. However, regrowth problems are normally severe and burning is required (at least initially) to control regrowth.

Irrigation, using water from the Ward and Warrego Rivers, is carried out on a number of small (10 ha) farms and has in some cases been fairly successful. Salt problems have occurred in some localities and the presence of salt at depth in many profiles indicates a cautious approach is needed to large scale irrigation projects. The lower reaches of the Warrego contain large areas of level, cracking clay soils, and flows in the Warrego River appear adequate to enable ring tanks or billabongs to be filled in at least some years. It may be possible to select well-drained areas to minimise salt problems, and development of drip irrigation systems for crops such as cotton may help reduce both water use and salting problems (though increased capital outlay is required). There is potential for development of a limited number of irrigation areas on the Warrego if salting problems can be minimised by careful site selection or new technology.

FLOODING

Significant areas of Bluegrass, Tuen and Kudnapper land systems are inundated by floods of 6 to 7.5 m in the Warrego at Cunnamulla. Floods below 4.5 m provide little benefit and in fact a gauge reading of 1.5 m is necessary before the river begins to run out of the Cunnamulla town waterhole.

Of the major distributory channels, the Cuttaburra Creek begins to run at the same time as the Warrego itself while other channels further south such as the Tuen and Thurulgoonia Creeks begin to run at approximately 4 m on the Cunnamulla gauge. Floods below 5 m at Cunnamulla result in limited flooding and heights of 6 to 7 m provide good general flooding in the area south of Cunnamulla. At heights of 7 m and above water runs west from Warrego via Leader Creek, the Gum Holes and Moonjaree Creek into the Paroo River system.[1]

In high floods of 8.5 m or more, the Widgee and Kudnapper Creeks which normally bring water north into the Warrego, change direction and act as distributory channels, flowing south out of the Warrego. These creeks do not spread out to the same extent as those running out of the river south of Cunnamulla, and eventually disappear in areas of Tuen and Killowen land systems close to the New South Wales Border.

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[1] Information on flooding supplied by A. D. Tannock (personal communication).

The highest recorded flood at Cunnamulla is 10.09 m in April 1956. No records are available prior to 1956, though a large flood in 1910 which was probably over 11 m is recalled by some residents. Above Cunnamulla, the Neemunmulla swamp and the lake at Talpa are inundated by local rains and a number of claypans, swamps and "hollows" in the area east and north east of Cunnamulla are flooded by local rains.

Heavy falls of rain in the catchments of the Langlo, Ward, Nive, Warrego Rivers and Angellala Creek are necessary to produce major flooding in the lower Warrego. Normally, few sheep are lost by drowning as it takes 4 days for the flood peak to reach Cunnamulla town from Bakers Bend, where the last major tributary (Angellala Creek) enters the Warrego. This generally allows time for stock to be moved from low lying areas unless previous flooding or rain interferes.

Runoff over the 42 865 km^2 catchment above Wyandra averaged 13 mm annually over the period 1967-1978. A mean annual discharge of 548 627 megalitres was recorded over this period at Wyandra ranging from a minimum of 42 239 megalitres (1968-69) to a maximum of 1 412 773 megalitres in 1972-73. Flows have been recorded during January, February and March of all years for which records are available .

TOURISM

Tourism is at a maximum in the winter months of April to August and has increased markedly since completion of the Stockman's Hall of Fame in Longreach.

The sealing of the Charleville-Cunnamulla road has improved access from the major population centres in the southern States of Australia. The sealing of the Charleville-Quilpie road is increasing access to Birdsville and Simpson Desert. From Cunamulla, there is also bitumen nearly to Thargomindah. Charleville and Cunnamulla are also connected by good bitumen roads to Brisbane.

There is an active tourist association in Charleville and it has succeeded in promoting various attractions in the town. It is also felt that the towns of Charleville and Cunnamulla could be promoted as a starting point for tours into the far west of the State now that good roads enable most motorists to travel safely and comfortably through this area.

There is also some potential for tourist ranch operations in the area, and pig hunting and other forms of shooting and fishing are available along the Warrego River.

Tourism offers considerable opportunities for the area to generate extra income which is not dependent on seasonal conditions and the uncertain future of the pastoral industry. The Charleville and Cunnamulla districts and areas to the west have a number of attractions. A continuing promotional campaign run with professional guidance is necessary to fully exploit the potential of the industry in this area.

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APPENDIX I

LIST OF ABBREVIATIONS, SYMBOLS, RATINGS AND TERMS *

Abundance:	a qualitative indication of the density or aerial biomass of a species throughout a particular vegetation type, land unit or land zone
A.D. Moist:	Air dried moisture (see Appendix II)
Av. H_20 :	Available water (see Appendix II)
A.P. :	Acid extractable P (see Appendix II)
Association:	stable plant communities which have the same dominant species and the same structural formation
A.W.C. :	available soil water capacity - the difference between equilibrium moisture contents at suctions of -33 kPa and -1500 kPa
Available water rating:	Available water %

Available water %	
>16	Very high
13-16	High
9-12	Medium
5-8	Low
<5	Very low

Biomass:	total weight of aerial and underground organs of a plant
Biotic factors:	the influence of animals on plant communities
Bulk rating of herbage:	a rough indication of aerial biomass based on PFC values:

PFC <1%	Limited, very low
1 - 10%	Low
10 - 20%	Medium
20 - 50%	High
>50%	Very high

B.P. :	Bicarbonate extractable P (see Appendix II)
C :	Organic carbon (see Appendix II)
Ca :	Calcium
$CaCO_3$:	Calcium carbonate, lime (see Appendix II)
C.E.C. :	Cation exchange capacity (see Appendix II)
Cl :	Chloride (see Appendix II)
Claypan:	areas (sometimes scalded) with hard, massive surface soil which are predominantly clayey
C/N :	ratio of % organic carbon to % total nitrogen

* This is not a complete list of terms, but rather a list of terms which are used, but not adequately defined in the Concise Oxford Dictionary.

Condition: the character of the vegetal cover and the soil under man's use, in relation to its potential

Condition classes:

Condition	Description
Excellent	No erosion. Few or no bare spaces. General ground cover greater than 50 percent. Very high proportion of valuable pasture species.
Very good	No erosion. Some bare spaces. General ground cover greater than 30 percent. High proportion of valuable pasture species.
Good	Occasional minor sheeting by wind or water erosion with some bare spaces - (10 to 30 percent). General ground cover 20 - 30 percent. Moderate to high proportion of valuable pasture species.
Fair	Some minor sheeting by wind or water erosion with some rilling and gullying - frequent bare spaces (30 - 50 percent). General ground cover 10 - 20 percent. Moderate proportion of valuable pasture species.
Mediocre	Frequent moderate sheeting by wind or water erosion (50 - 60 percent bare space) with moderate rilling and gullying. General ground cover 5 - 10 percent. Moderate to low proportion of valuable pasture species.
Poor	Frequent moderate and severe sheeting by wind or water erosion (60 - 70 percent bare spaces) with severe rilling and gullying throughout. General ground cover less than 5 percent. Low proportion of valuable pasture species.
Very poor	Extensive moderate and severe sheeting by wind or water, or scalding (70 - 90 percent bare space) with extensive moderate and severe rilling and gullying, especially on drainage lines and flats.

Dominant species: species which contribute most to the biomass of a plant community in any given area

Edaphic factors: the influence of the physical, chemical and biological characteristics of the soil on plant communities

E.C. : Electrical conductivity mS/cm (see Appendix II)

Endemic: species whose natural distribution is confined to a particular region or to an unusual type of habitat

Erosion classes:

Class	Description
1	Little or no erosion
2	Wind erosion - scalding with little or no drift
3	Wind erosion or scalding with moderate or plentiful drift
4	Wind erosion - wind sheeting with little drift
5	Wind erosion - wind sheeting with moderate to plentiful drift
6	Wind erosion - drift and dune activation
7	Water erosion - sheet erosion with or without associated rilling and gullying
8	Water erosion - gully erosion with or without associated sheet erosion
9	Water erosion - gullying and sheet erosion and lower slopes of steep rocky hills and ranges
10	Special class - sandhill - claypan complex
11	Special class - sloping scalds
12	Special class - scalding and hummocking

E.S.P. :	Exchangeable sodium percentage. Ratio of exchangeable sodium to cation exchangeable capacity expressed as %
Ex :	Exchangeable
Ferricrete:	a ferruginous natural material formed in a zone of iron oxide or hydroxide accumulation in the earth's crust
Floristic diversity:	see species diversity
Fluctuating climax:	a term used to denote a condition which appears relatively stable but which in reality is in a state of unstable equilibrium
Forb:	herbs other than grasses, grass-like plants and ferns (mostly dicotyledons)
Frequency:	the percentage of times a species is present when sampling a vegetation type, land unit or land zone

Frequency per abundance rating:

	Frequency	Abundance
Abundant (=dominant species)	High (>50%)	Usually high
Frequent	High (>50%)	High
Common (=locally abundant)	Low (<50%)	High
Infrequent	Low (<50%)	Always low

F.S. :	Fine sand
G.C. :	Grazing capacity
Gilgai:	small scale surface undulations, the alternate hummocks and hollows of which show some degree of regularity
Graminoid:	grass and grass-like herbs (usually from the families Poaceae and Cyperaceae)
Grove:	clumps of trees or shrubs roughly aligned with the contour and forming a banded pattern
Herb:	non-woody plants forming the ground stratum
Hummock grass:	large, perennial, evergreen sclerophyllous grasses which are usually >40 cm tall in the vegetative state, and whose aerial parts are drought resistant. Usually refers to *Triodia* spp and *Zygochloa paradoxa* but is also taken to include *Eragrostis australasica*
Ht :	Height
K :	Potassium
K (Total):	Potassium (Total) X-ray fluorescence. See Appendix II
K rating:	Exchangeable K, m. equiv./100 g soil

m. equiv. per 100 g	Rating
<.15	Very low
.15 - .24	Low
.25 - .34	Fair
.35 - .54	Very fair
>.55	High

Crack and Isbell (1970) use value of 0.2 m. equiv./100 g ex.K as critical deficiency level.

Land system: an area or group of areas throughout which there is a recurring pattern of topography soils and vegetation

Land unit: a group of related sites associated with a particular landform within a land system and wherever the land unit recurs it has the same sites and similar, within defined limits, soils, vegetation and topography

Land zone: a broad grouping of land systems based on similarity of physiography, soils, vegetation and geomorphology

Limiting factor: environmental factor limiting the growth and reproduction of a species

Mallee: small *Eucalyptus* plants with a shrub-like habit in which many stems arise from a large swollen root or lignotuber

Mantled pediment: gently undulating to undulating bedrock plains, sloping away from adjacent hills which carry a veneer of transported detritus the thickness of which varies from place to place

m. equiv./100 g : milli equivalents per 100 grams

Mesic: moist

Mg : Magnesium

N : Nitrogen (see Appendix II)

Nitrogen ratings:

Rating	% Total N
Very low	<0.05
Low	0.05 - 0.09
Fair	0.10 - 0.14
Very fair	0.15 - 0.24

Na or Na+ : Sodium

Org C : Organic carbon

P :
Phosphorus
Phosphorus (acid extraction N/100 H_2SO_4)
- see Appendix II
Phosphorus (bicarbonate extraction)
- see Appendix II
Phosphorus (Total) X-ray fluorescence

Phosphorus ratings:

Acid extraction		Bicarbonate extraction	
<11	Very low	<11	Very low
11 - 20	Low	11 - 20	Low
21 - 35	Fair	21 - 30	Fair
36 - 45	Very fair	31 - 40	Very fair
46 - 100	High	>40	High

PFC : Projective foliage cover, that is, the percentage of area covered by the foliage of plants, as estimated by the vertical projection of the foliage onto the ground

PFC ratings:
Dense PFC 30-70%
Open PFC 10 - 30%
Sparce PFC <10%

pH ratings:

Rating	pH
Extremely acid	<4.5
Very strongly acid	4.5 - 5.0
Strongly acid	5.1 - 5.5
Medium acid	5.6 - 6.0
Slightly acid	6.1 - 6.5
Neutral	6.6 - 7.3
Mildly alkaline	7.4 - 7.8
Moderately alkaline	7.9 - 8.4
Strongly alkaline	8.5 - 9.0
Very strongly alkaline	>9.0

Phytogeography: the study of the geographical and evolutionary relationships of plant species

PPF : Principal profile form (Northcote 1974)

Rainfall rating: rainfall received in a single precipitation event:

Light	12-25 mm
Medium	25-50 mm
Heavy	>50 mm

Relic: populations or taxonomic groups now occupying a restricted part of a region where once abundant

RP : Representative profile

Run-on areas: an area which benefits from runoff water either by the water lying for a period or by water moving over the area

Saline: Northcote and Skene (1972)

Salinity ratings: Saline subsoil - >0.3% NaC1 or >0.18% C1

Rating	E.C.	% C1
Very low	<0.015	<0.01
Low	0.16 - 0.45	0.01 - 0.03
Medium	0.46 - 0.90	0.04 - 0.06
High	0.91 - 2.0	0.07 - 0.20
Very high	>2.0	>0.20

Saltpan: the term has been applied to soils with loose, puffy surface soil containing visible salt crystals. They commonly have a surface crust which is easily broken

Sandplain: gently undulating to flat plains with well sorted fine to medium quality sand with reddish coating of iron oxides with increasing clay admixtures in sub-surface horizons. Little if any dune development

Scald: those areas which are bare because of wind and water erosion

Seasonally abundant: refers to ephemeral, annual or short-lived perennial herbs whose biomass is high only for a short period after seasonal high rainfall or flooding

Si : silt

Silcrete: a siliceous natural material formed in a zone of silica accumulation in the earth's crust

SMU : Soil mapping unit

SPC:	Soil profile class. A three-dimensional soil body so that any profile within the body has a similar number and arrangement of major horizons whose attributes, primarily morphological, are within a defined range. All profiles within the soil type have similar parent materials (R.C. McDonald, personal communication).
Sodic:	Northcote and Skene (1972) sodic E.S.P. 6 - 14 strongly sodic E.S.P >14
Species diversity:	(floristic-, herb-, tree-, shrub-diversity): an indication of the richness and evenness of the flora of a particular region or vegetation type
Structural formation:	the structure of a plant community as determined by the life form, height and PFC of the dominant species (see Table 5.5)
Topfeed:	edible trees and shrubs
Topfeed ratings:	limited <25/ha scattered 25-100/ha abundant >100/ha
Woody weeds:	unwanted trees and shrubs that frequently reach high densities after vegetation is disturbed

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SYMBOLS

- Clay, alluvium
- Sand
- Loam, clay loam
- Gravel, stonecover
- Quartzose sandstone (Cz)
- Sandstone, conglomerate minor sandstone (T)
- Chemically altered sedimentary rocks
- Labile sedimentary rocks

SYMBOLS

- Mulga
- Coolibah
- Ironwood
- River red gum
- Long fruited bloodwood
- Silver leaved ironbark
- Carbeen
- Eastern dead finish
- Yapunyah
- Black box
- Western bloodwood
- Dawson gum
- Whitewood
- Poplar box
- Mountain yapunyah
- Brigalow
- Sandlewood
- Forest gum
- Rough-barked apple
- Beefwood
- Myall
- Swamp canegrass
- Boonaree
- Needlewood
- Boree
- Yarrah, bowyakka
- Gidgee
- Vinetree
- Lancewood and/or bendee
- Cypress pine
- Wilga
- Bastard mulga
- Hopbush
- Spinifex
- Lignum

APPENDIX II

SOIL ANALYTICAL METHODS

by C.R. Ahern

SAMPLE PREPARATION

All samples were dried at 40°C in a forced air draught. Gravel was sieved out using a 2 mm sieve, while samples not containing gravel were ground to less than 2 mm. All determinations were carried out using the less than 2 mm soil fraction. All results are reported on an air dry basis except where indicated.

PARTICLE SIZE DISTRIBUTION

Particle size distributions were determined by a modification of the hydrometer method of Piper (1942). The modifications were that the soils were dispersed with sodium hexametaphosphate and sodium hydroxide and samples high in gypsum were sieved with 0.2 mm sieve after an initial boiling treatment prior to an acid treatment. Results are reported on an oven dry basis.

With soils containing carbonate, the sum of particle sizes may be less than 100% where acid treatment was used.

ELECTRICAL CONDUCTIVITY

A 1:5 soil:deionised water suspension was shaken for an hour and the electrical conductivity (EC) was measured at 25°C.

A 1:50 soil:water suspension was generally used on soils with EC greater than 1 mS/cm, particularly if gypsum was suspected of being present. EC 1:50 values were converted to approximate EC 1:5 values by multiplying by a factor of 10.

Soluble salts can be estimated approximately from electrical conductivity readings by using the factor of Piper (1942).

$$\% \text{ TSS} = \text{EC mS/cm} \times 0.336 \text{ at } 25°\text{C}.$$

This factor can be in error, particularly on arid soils with unusually high concentrations of sulphates, bicarbonates, or calcium salts.

pH

After determination of electrical conductivity, the pH of the same 1:5 suspension was measured with a glass electrode and saturated calomel reference electrode.

CHLORIDES

After conductivity and pH readings were complete, potassium alum was added to the 1:5 soil water suspension. Chlorides were determined on the stirred suspension with a specific ion electrode (Haydon *et al.* 1974). Results were reported as % Cl.

ORGANIC CARBON

The wet oxidation method of Walkley and Black (1934) was used on a finely ground sample. The reduced chromic ion (Cr^{+++}) was read colorimetrically (Sims and Haby 1971). Results reported are uncorrected Walkley and Black values (% C).

TOTAL NITROGEN

The sample was finely ground. Selenium catalyst was used in a semi-micro Kjeldahl digestion. An auto analyser system was used for estimation of ammonium in the digests using a procedure similar to that of Crooke and Simpson (1971).

EXTRACTABLE PHOSPHORUS

Acid Extractable P (0.005 M H_2SO_4) was determined by the Kerr and von Stieglitz (1938) method. Readings were carried out using an auto analyser technique.

Bicarbonate Extractable P (0.5 M Na HCO_3 adjusted to pH 8.5), was determined by the Colwell (1963) method.

REPLACEABLE POTASSIUM

Potassium was extracted by shaking air dry soil and 0.05 M HCl (von Stieglitz 1953) at a soil:solution ratio of 1:40 for 4 hours. Potassium in the centrifuged extract was determined by flame photometry.

TOTAL PHOSPHORUS, TOTAL POTASSIUM, TOTAL SULPHUR

About 3g of soil sample was very finely ground and pelleted with boric acid. The pellet was then exposed to a beam of X-rays in a Phillips 1410 vacuum X-ray spectrograph. Simple linear calibration was used to obtain percentage phosphorus, potassium and sulphur from fluorescent intensities.

EXCHANGEABLE CATIONS (Ca Mg Na K)

A method similar to that of Loveday (1974) was used.

After pre-washing with 60% ethanol, exchangeable cations were removed with 1M NH_4 Cl at pH 8.5 in 60% ethanol. Absorbed ammonium was removed with 0.5M sodium sulphate.

Ammonium and chloride in the sodium sulphate leachate were determined on an auto analyser using colorimetric methods. The difference in milliequivalents was reported as the cation exchange capacity (CEC).

Measurements for soil with low CEC are not as precise as those for soils of high CEC. Calculated ratios such as CEC/clay may have considerable error when CEC is low, particularly if clay percentage is also low.

Exchangeable calcium may be slightly inflated on soils containing gypsum.

DTPA EXTRACTABLE COPPER, ZINC, MANGANESE AND IRON

The method of Lindsay and Norwell (1978) is used for these micronutrients (0.005 M DTPA, 0.01 M $CaCl_2$ and 0.1 M triethanolamine, adjusted to pH 7.3, at a soil solution ratio of 1:2, with shaking for 2 hr). All four elements are determined by atomic absorption spectrophotometry and reported as ppm.

MOISTURE CHARACTERISTICS

Moisture percentage at matric potentials of -33 kPa and -1500 kPa was determined on samples ground to less than 2 mm. A pressure plate apparatus of Soil Moisture Equipment Co. of California was used. Results are reported on an oven dry basis.

'Available soil water capacity' was approximated by the difference between these two laboratory measurements.

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WARLUS III - SPECIES LIST

Family and species	Lf	N	S	M	H	R	G	F	E	W	A	D	L	Pal	Tox	Misc	Common name
		Land zone															
ACANTHACEAE																	
Brunoniella australis	P	-	X	X	-	-	-	-	X	X	-	X	X	L	U	-	
Rostellularia adscendens	P	X	-	X	-	-	-	-	X	X	-	-	-	L	S	-	
AIZOACEAE																	
Glinus lotoides	H	-	-	-	-	-	-	-	-	-	-	-	X	L	U	D	
Trianthema triquetra	H	-	-	-	-	-	F	X	-	X	F	-	X	M	T*	D*	Red spinach
Zaleya galericulata	H	-	-	-	-	-	-	-	-	X	-	-	-	L	S	D	Hogweed
ALISMATACEAE																	
Damasonium minus	H	-	-	-	-	-	-	-	-	X	-	-	X	L	U	-	
AMARANTHACEAE																	
Achyranthes aspera	P	-	X	-	-	-	-	-	-	-	-	X	-	L	U	I	Chaff flower
Alternanthera denticulata	P	-	X	X	X	X	X	-	F	X	X	-	X	L	S	-	Lesser joyweed
Alternanthera nodiflora	P	-	-	X	X	-	X	-	X	X	-	-	X	L	S	-	Common joyweed
Alternanthera pungens	P	-	-	-	-	-	-	-	-	X	-	-	-	L	U	-	Khaki weed
Amaranthus mitchellii	H	-	-	-	-	-	-	-	-	X	X	-	-	H	T	-	Boggabri
Gomphrena celosioides	P	X	-	X	-	-	-	-	-	-	-	-	-	L	T	I	Gomphrena weed
Nyssanthes erecta	P	-	-	-	-	-	-	-	-	-	-	X	-	L	U	I	
Ptilotus atriplicifolius	P	-	-	X	-	-	-	-	-	-	-	-	X	M	U	-	
Ptilotus exaltatus var. *semilanatus*	P	-	-	-	-	-	X	-	-	-	-	-	-	M	U	-	
Ptilotus gaudichaudii var. *parviflorus*	H	-	-	X	X	X	-	-	-	X	-	-	-	L	U	-	
Ptilotus leucocoma	P	-	X	X	X	X	-	-	-	-	-	X	-	L	U	-	
Ptilotus nobilis	P	-	-	-	-	-	X	-	-	-	X	-	-	L	U	-	
Ptilotus obovatus	P	-	X	X	-	X	X	-	X	-	-	X	X	M	U	-	
Ptilotus pedleyanus	S	-	-	-	-	C	-	-	-	-	-	-	-	L	U	-	
Ptilotus polystachyus	P	-	X	X	X	X	X	-	-	-	X	X	-	M	U	-	Fox brush, pussy tails
AMARYLLIDACEAE																	
Calostemma luteum	H	-	-	-	-	-	-	-	-	X	X	-	-	M/L	S	-	Wilcannia lily
Crinum flaccidum	H	-	-	-	-	-	-	-	-	X	-	-	-	M/L	S	-	A lily
APIACEAE																	
Acrtinotus paddisonii	H	X	-	-	-	-	-	-	-	-	-	-	-	L	U	-	
Daucus glochidiatus	H	-	-	-	-	-	X	-	-	X	F	-	X	H	U	-	Australian carrot
Eryngium plantagineum	H	-	-	-	-	-	X	-	-	X	-	-	X	H	U	-	Blue devil
Eryngium supinum	H	-	-	-	-	-	X	-	-	X	-	-	X	H	U	-	A blue devil
Trachymene cyanantha	H	-	-	X	-	-	-	-	-	-	-	-	-	M	T	-	Native parsnip
Trachymene glaucifolia	H	-	-	-	-	-	-	-	-	-	-	X	-	M	T	-	Blue parsnip
Trachymene ochracea	H	X	F	X	X	X	-	-	X	-	-	-	X	M	T	-	Wild parsnip
APOCYNACEAE																	
Alstonia constricta	S	X	X	X	X	C	-	-	-	-	-	X	-	M	T	W	Bitter bark, quinine tree
Carissa ovata	S	-	-	-	-	C	-	-	-	-	-	-	-	H	U	-	Currant bush
Parsonsia eucalyptophylla	V	-	-	-	X	-	-	-	X	X	-	X	-	H	S	-	Woodbine, gargarloo
ASTERACEAE																	
Acanthospermum hispidum	H	-	X	-	-	-	-	-	-	-	-	X	-	M	C	I	Starr burr
Acomis macra	H	-	-	-	-	-	-	-	-	-	-	-	X	M	U	-	
Actinobole uliginosum	H	-	-	-	-	-	X	-	-	-	-	-	-	M	U	-	
Brachyscome ciliaris var. *lanuginosa*	H	-	-	-	-	-	-	-	-	X	X	X	X	H	U	-	Native daisy
Brachyscome curvicarpa	H	-	-	-	-	-	-	-	-	-	X	-	-	H	U	-	
Brachyscome marginata	H	-	-	-	-	-	-	-	-	-	X	-	-	H	U	-	
Brachyscome melanocarpa	H	-	-	-	-	-	-	X	-	-	X	-	-	H	U	-	
Brachyscome trachycarpa	H	-	-	-	-	-	-	-	-	-	-	-	X	H	U	-	
Brachyscome whitei	H	X	X	X	X	X	X	-	-	X	X	X	-	H	U	-	
Calotis cuneata	H	X	X	F	F	X	X	X	X	X	X	X	X	H	U	-	
Calotis cuneifolia	H	-	-	-	-	-	-	X	X	-	X	-	-	L	U	D*	
Calotis erinacea	P	-	-	-	-	-	-	-	-	-	-	C	-	M	U	D	
Calotis hispidula	H	-	-	X	-	-	X	-	-	X	X	-	-	H	U	-	Bogan flea
Calotis lappulacea	H	X	X	X	X	X	X	-	X	-	-	X	X	M	U	-	
Calotis multicaulis	H	-	-	-	-	-	-	X	-	-	-	-	X	M	U	-	
Calotis scabiosifolia	H	-	-	-	-	-	-	-	-	-	X	-	-	M	U	-	
Calotis squamigera	H	-	-	-	-	-	-	X	-	-	-	-	-	M	U	-	

APPENDIX IIIA

(A) PLANT SPECIES LIST

by R.W. Purdie, M.B. Thomas and W.J.F McDonald

LIST OF SPECIES OCCURRING IN EACH LAND ZONE

Families are arranged alphabetically, genera are listed alphabetically within the families, and species are listed alphabetically within genera. The presence of species in the land zones is indicated by the symbols A, F, C, or X, which represent the frequency/abundance ratings (see Appendix I for definition of Abundant, Frequent, Common or Infrequent). The following information is given in the columns of the table:

a) Habit or Lifeform:
- H = annual or short lived perennial herb.
- P = woody perennial forb, subshrub and long-lived perennial graminoid.
- S = shrub
- T = tree
- V = vine

b) Land zones:

N = Spinifex sandplains	F = Mitchell grass downs
S = Mulga sand plain	E = Poplar box lands
M = Soft mulga lands	W = Wooded alluvial plains
H = Hard mulga lands	A = Open alluvial plains
R = Dissected residuals	D = Sandhills
G = Gidgee lands	L = Claypans

c) Palatability rating:

L = Low or unknown　　M = Medium　　H = High

d) Toxicity values:

- T = Toxic with feeding trials
- C = Known to contain poisons
- S = Suspected on field evidence
- U = Unknown or not suspected
- * = Toxic if the only component of the diet

Note: plants known to be toxic are not always dangerous and may be useful components of the diet; see Resource Use chapter, Poisonous plants.

e) Miscellaneous:

- D = Herb indicating disturbance due to clearing, overgrazing, scalding or along bore drains.
- * = Probable indicator of overgrazing
- I = Introduced, naturalised species
- R = Species note to recover after fire by vegetable reqrowth
- W = Woody weed species

WARLUS III - SPECIES LIST

Family and species		Land zone															
	Lf	N	S	M	H	R	G	F	E	W	A	D	L	Pal	Tox	Misc	Common name
Cassinia laevis	S	X	-	-	-	X	-	-	-	-	-	-	-	L	U	I	Wild rosemary, cough bush
Centipeda cunninghamii	H	-	-	-	-	-	-	-	X	X	-	-	X	L	U	-	
Centipeda minima	H	-	-	X	-	-	-	-	X	-	-	-	-	L	U	-	Spreading sneezeweed
Centipeda thespidioides	H	-	-	X	-	-	X	-	X	X	X	-	X	L	U	-	Desert sneezeweed
Chrysocoryne pusilla	H	X	-	-	-	-	-	-	-	-	-	-	-	L	U	-	
Craspedia chrysantha	H	-	X	-	-	-	X	-	-	-	X	X	X	H	S	-	Golden billybuttons
Eclipta platyglossa	H	-	-	-	-	-	-	-	-	X	-	-	-	L	U	-	White eclipta
Epaltes australis	H	-	-	X	X	-	-	-	X	-	-	-	-	M	U	-	
Eriochlamys behrii	H	-	-	X	X	-	-	-	-	-	-	-	X	L	U	-	
Flaveria australasica	H	-	-	-	-	-	X	-	-	-	-	-	-	L	U	-	Speedy weed
Glossogyne tannensis	H	X	X	X	X	-	X	-	X	-	X	X	-	M	U	I	Native cobblers peg
Gnaphalium diamantinensis	H	-	-	-	-	-	-	-	-	X	-	-	-	M	U	-	
Gnaphalium luteoalbum	H	-	-	-	X	-	-	-	-	-	-	-	-	M	U	-	
Gnaphalium polycaulon	H	-	-	-	-	-	-	-	-	X	-	-	-	M	U	-	
Helichrysum ramosissimum	P	-	-	X	X	-	-	-	X	-	-	X	-	H	U	-	Yellow buttons
Helichrysum sp. Q9	H	-	-	-	X	-	X	-	-	-	-	-	-	M	U	-	Yellow everlasting
Helipterum anthemoides	H	-	-	-	-	-	X	-	X	X	X	-	-	M	U	-	
Helipterum floribundum	H	-	-	X	X	-	-	-	-	-	X	-	-	M	U	-	Paper daisy
Helipterum molle	H	-	-	X	-	-	-	-	-	-	-	-	-	M	U	-	Golden paper daisy
Helipterum moschatum	H	-	-	-	-	-	X	-	-	-	-	X	-	M	U	-	Musk sunray
Helipterum pterochaetum	P	-	-	-	X	X	-	-	-	-	-	-	-	M	U	-	
Isoetopsis graminifolia	H	-	X	X	X	X	-	-	X	-	-	-	-	H	U	-	Grass cushions
Ixiolaena brevicompta	H	-	-	-	-	-	-	-	-	-	X	-	-	H/M	U	-	
Ixiolaena leptolepis	H	-	-	-	-	-	-	-	-	-	X	-	-	H/M	U	-	Stalked ixiolaena
Ixiolaena sp. Q1	H	-	-	-	-	-	X	-	X	-	-	-	-	H/M	U	-	
Millotia greevesii var. *glandulosa*	H	-	-	-	-	-	X	-	-	-	-	X	X	M	U	-	
Minuria integerrima	H	-	-	-	-	-	X	-	-	F	-	-	X	H	U	-	Smooth minuria
Minuria leptophylla	*H*	*X*	-	*X*	-	-	-	-	-	-	-	-	-	*H*	*U*	-	
Olearia ciliata	H	-	-	-	-	-	-	-	-	-	X	-	-	L	U	-	
Olearia subspicata	S	X	C	S	S	-	-	-	-	-	-	X	-	L	U	WR	A turkey bush
Olearia xerophila	P	-	-	-	-	X	-	-	-	-	-	-	-	L	U	-	
Pluchea tetranthera	S	-	-	-	-	-	-	-	-	C	-	-	X	L	U	-	
Podolepis arachnoidea	H	X	-	-	-	-	-	-	-	-	-	-	-	M	U	-	
Podolepis jaceoides	H	-	-	-	-	-	-	-	-	-	-	X	-	M	U	-	
Podolepis longipedata	H	-	-	-	-	-	-	-	-	-	-	X	-	M	U	-	
Pterocaulon redolens	H	-	-	-	-	-	-	-	-	-	-	-	-	L	U	-	
Pterocaulon sphacelatum	H	X	X	X	X	-	X	-	X	-	X	X	-	L	U	I	A ragweed
Rutidosis sp. Q1	H	-	X	-	-	-	-	-	-	-	-	-	-	L	U	-	
Senecio glossanthus	H	-	-	-	-	-	X	-	-	-	X	-	-	M	U	-	
Senecio quadridentatus	H	-	-	-	-	-	X	-	-	-	-	-	-	L	C	-	Cotton fireweed
Sigesbeckia orientalis	H	-	-	X	X	-	-	-	-	-	-	-	-	L	U	I	
Sonchus oleraceus	H	-	-	-	-	-	-	-	-	X	X	-	X	H	U	I	Common sowthistle
Streptoglossa adscendens	H	-	-	-	-	-	X	-	-	X	X	-	-	H	U	-	
Stuartina muelleri	H	-	-	-	-	-	X	-	-	-	-	-	-	M	U	-	
Tagetes minuta	H	-	-	-	-	-	-	-	X	-	-	-	-	L	U	-	
Verbesina enculioides	H	-	-	-	-	-	X	-	-	-	-	X	-	M	T	I	Wild sunflower
Vittadinia dissecta var. *hirta*	H	-	-	-	-	-	-	-	-	-	-	X	-	M	U	-	
Vittadinia pustulata	H	-	-	-	F	-	-	-	-	X	X	-	-	M	U	-	
Vittadinia sp.	H	-	-	F	-	-	X	-	-	X	-	-	-	M	U	-	
Xanthium pungens	H	-	-	-	-	-	-	-	-	X	X	-	-	L	T	I	Noogoora burr
Xanthium spinosum	H	-	-	-	-	-	-	-	-	X	X	-	-	L	T	I	Bathurst burr
ASCLEPIADACEAE																	
Rhyncharrhena linearis	V	-	-	-	-	X	-	-	-	-	-	-	-	L	U	-	
Sarcostemma australe	S	-	-	-	-	X	-	-	-	-	-	-	-	M	T	-	Caustic vine
BIGNONIACEAE																	
Pandorea pandorana	V	-	-	-	-	X	X	-	-	-	-	-	-	L	U	-	Wonga vine
BORAGINACEAE																	
Cynoglossum australe	P	X	-	-	-	-	-	-	-	-	-	X	-	L	U	I	
Heliotropium curassavicum	P	-	-	-	-	-	-	-	-	-	-	-	X	L	U	-	
Heliotropium paniculatum	H	-	-	-	-	-	-	-	-	-	-	-	X	L	U	-	
Heliotropium strigosum	H	-	-	X	-	-	-	-	-	-	-	-	-	L	U	-	
Heliotropium tenuifolium	H	-	X	X	-	-	-	-	-	-	-	-	-	L	U	-	
BRASSICACEAE																	
Alyssum linifolium	H	-	-	-	-	-	-	-	-	X	-	-	-	H	U	-	
Arabidella eremigena	H	-	-	-	-	-	-	-	-	X	X	-	-	H	U	-	Yellow cress
Cuphonotus andraeanus	H	-	-	-	-	X	X	-	-	X	-	-	X	H	U	-	
Harmsiodoxa blenniodiodes	H	-	-	-	-	-	X	-	-	-	X	-	-	H	U	-	Hairy cress, purple stock

WARLUS III - SPECIES LIST

Family and species	Lf	N	S	M	H	R	G	F	E	W	A	D	L	Pal	Tox	Misc	Common name
		Land zone															
Lepidium africanum	H	-	-	-	-	-	-	-	-	-	-	X	-	H	U	I	Pepper cress
Lepidium papillosum	H	-	-	-	-	-	-	-	-	-	-	-	X	H	U	-	
Lepidium rotundum	H	-	-	X	-	-	-	-	-	-	-	-	-	H	U	-	A pepper cress
Lepidium strongylophyllum	P	-	-	-	-	X	-	-	-	-	-	-	-	M	U	-	A pepper cress
Stenopetalum nutans	H	-	-	X	-	-	-	-	-	-	X	-	-	H	U	-	
BRUNONIACEAE																	
Brunonia australis	P	X	-	X	X	X	-	-	-	-	-	-	-	L	U	-	Cornflower
CACTACEAE																	
Opuntia stricta	S	-	X	-	X	-	X	X	X	-	-	-	-	L	U	-	Prickly pear
CAESALPINIACEAE																	
Cassia artemisioides	S	X	X	X	X	F	X	-	C	-	-	X	-	L	U	W	Silver cassia
Cassia circinnata	S	-	-	-	X	-	-	X	X	-	X	-	X	L	U	-	
Cassia nemophila var. *nemophila*	S	X	X	C	-	C	X	-	C	X	-	X	X	L	U	W	Butter bush
Cassia nemophila var. *zygophylla*	S	-	X	-	-	X	-	-	X	-	-	-	X	L	U	-	
Cassia oligophylla	S	-	-	-	X	X	-	-	-	-	-	-	-	L	U	-	
Cassia phyllodinea	S	-	-	-	-	-	X	-	-	-	-	-	-	M	U	-	Silver cassia
Cassia pleurocarpa	S	-	C	C	X	-	-	-	-	-	-	X	-	L	U	WR	Fire bush
Cassia sturtii	S	-	-	-	X	F	-	-	-	-	-	-	-	M	U	-	
Petalostylis labicheoides	S	-	C	X	-	-	-	-	-	-	-	-	-	L	U	WR	Butterfly bush
CAMPANULACEAE																	
Pratia concolor	P	-	-	-	-	-	-	-	-	X	-	-	-	L	U	-	
Pratia puberula	P	-	-	-	-	-	-	-	X	X	-	X	X	L	U	-	
Wahlenbergia gracilis	H	-	-	X	X	-	-	-	-	-	X	-	X	L	U	-	Native bluebell
Wahlenbergia graniticola	H	-	-	X	-	-	-	-	-	-	-	-	-	L	U	-	Native bluebell
Wahlenbergia queenslandica	H	-	-	-	-	-	-	-	X	-	-	-	-	L	U	-	Native bluebell
Wahlenbergia sp.	H	-	X	-	-	-	-	-	-	X	-	-	-	L	U	-	Native bluebell
CAPPARIDACEAE																	
Apophyllum anomalum	S	-	-	-	-	X	X	-	-	-	X	-	X	H	U	-	Broom bush, mustard bush
Capparis lasiantha	S	-	-	-	-	X	X	-	-	X	-	-	-	H	U	-	Nipan, split jack
Capparis loranthifolia	S	-	X	X	-	X	X	-	X	X	-	X	-	M	U	-	Narrow leaf bumble
Capparis mitchellii	S	-	-	-	-	-	X	-	-	-	X	X	-	H	U	-	Bumble, wild orange
CARYOPHYLLACEAE																	
Polycarpaea corymbosa	H	X	-	-	-	-	-	-	-	-	-	X	-	L	U	-	
Sagina apetala	H	-	-	-	-	-	-	-	-	-	-	X	-	L	U	-	
Spergularia rubra	H	-	-	-	-	-	-	-	-	X	-	-	-	L	U	-	
Stellaria media	P	-	-	-	-	-	-	-	-	X	-	-	-	L	U	-	
CASUARINACEAE																	
Allocasuarina inophloia	S	C	-	-	-	-	-	-	-	-	-	-	-	L	U	R	Thready-bark oak
Casuarina cristata	T	-	-	-	-	X	-	-	-	-	-	-	C	M	U	-	Belah
CHENOPODIACEAE																	
Atriplex angulata	H	-	-	-	-	-	-	-	-	X	-	-	-	M	U	-	
Atriplex eardleyae	H	-	-	-	-	-	X	-	X	X	X	X	-	L/M	C	D	A saltbush
Atriplex elachophylla	H	-	-	-	-	-	-	-	-	-	-	-	X	M	U	-	A saltbush
Atriplex leptocarpa	H	-	-	-	-	-	-	-	-	X	-	-	X	M	U	D*	
Atriplex limbata	H	-	-	-	-	-	-	-	-	-	-	-	X	M	U	D	
Atriplex lindleyi	H	-	-	-	-	-	X	X	-	X	X	-	-	L	U	D*	A saltbush
Atriplex muelleri	H	-	-	-	-	-	X	-	-	X	X	-	X	H	T*	D*	Annual saltbush
Atriplex nummularia	S	-	-	-	-	-	X	-	-	C	X	-	-	H	C	-	Oldman saltbush
Atriplex semibaccata	H	-	-	-	-	-	X	-	-	-	-	-	X	M	U	-	Pop saltbush
Atriplex vesicaria	P	-	-	-	-	-	X	-	-	-	X	-	-	M	U	-	Bladder saltbush
Chenopodium auricomum	S	-	-	-	-	-	X	-	-	C	X	-	C	H	C*	-	Queensland blue bush
Chenopodium cristatum	H	-	-	X	X	-	X	-	X	-	X	X	X	M	T	-	Crested goosefoot
Chenopodium melanocarpum	H	-	-	X	X	-	X	-	-	-	-	-	-	M	T	-	Black crumbweed
Chenopodium desertorum ssp. *anidophyllum*	P	-	-	-	-	-	X	-	-	-	-	-	-	M	U	-	
Chenopodium desertorum ssp. *microphyllum*	P	-	-	X	-	-	F	X	-	X	-	X	X	H	U	-	
Dissocarpus biflorus var. *cephalocarpus*	H	-	-	-	-	-	-	X	-	X	-	-	-	L	U	D	

WARLUS III - SPECIES LIST

Family and species		Land zone															
	Lf	N	S	M	H	R	G	F	E	W	A	D	L	Pal	Tox	Misc	Common name
Dissocarpus paradoxus	H	-	-	-	-	-	X	-	-	X	-	X	X	M	U	-	Curious saltbush
Einadia hastata	P	-	X	-	-	X	X	-	-	X	-	X	X	M	U	-	
Einadia nutans ssp. *eremaea*	P	-	-	X	X	-	X	-	X	X	-	X	-	M	U	-	Climbing saltbush
Einadia nutans ssp. *linifolia*	P	-	-	-	-	-	X	-	-	X	-	-	X	M	U	-	
Enchylaena tomentosa	S	-	-	X	-	X	F	X	-	X	X	X	X	M	C	-	Ruby saltbush
Enchylaena tomentosa var. *glabra*	S	-	-	-	-	-	X	-	-	X	-	-	-	M	U	-	
Halosarcia indica ssp. *leiostachya*	S	-	-	-	-	-	-	-	-	-	-	-	C	L/M	U	-	Samphire
Halosarcia pergranulata ssp. *divaricata*	S	-	-	-	-	-	-	-	-	-	-	-	C	M	U	-	Samphire
Maireana aphylla	S	-	-	-	-	-	X	X	-	X	F	-	-	H	U	-	Cotton bush
Maireana brevifolia	S	-	-	-	-	-	X	-	-	-	-	X	-	M	S	-	
Maireana coronata	H	-	-	-	-	-	X	X	-	X	F	-	X	M	U	D*	
Maireana decalvans	S	-	-	-	-	-	X	-	-	X	-	-	-	L	U	-	
Maireana enchylaenoides	H	-	-	-	-	-	-	-	-	X	-	-	-	L	U	-	
Maireana microphylla	P	-	-	-	-	-	-	-	X	-	-	-	-	L	U	D	
Maireana schistocarpa	S	-	-	-	-	-	X	-	-	-	-	-	-	L	U	-	
Maireana triptera	S	-	-	-	-	-	X	-	-	-	-	-	-	M	U	-	
Maireana villosa	H	X	X	X	X	X	X	-	X	-	-	X	-	M	U	-	A cotton bush
Malacocera tricornis	H	-	-	-	-	-	-	-	-	X	-	-	-	L	U	-	Soft horned saltbush
Neobassia proceriflora	H	-	-	-	-	-	X	-	-	X	X	-	-	M	T	D*	Soda bush
Rhagodia spinescens	S	-	-	-	-	-	S	-	-	X	X	X	-	M	U	-	A berry saltbush
Salsola kali	H	-	-	X	-	-	F	X	-	X	X	X	X	H	T	D*	Soft roly poly
Scleroblitum atriplicinum	H	-	-	-	-	-	-	-	-	X	-	-	-	M	T	-	Purple leaved goosefoot
Sclerolaena andersonii	H	-	-	-	-	-	X	-	-	-	X	X	X	L	U	-	
Sclerolaena anisacanthoides	H	-	-	-	-	-	X	-	-	X	X	-	-	H	C	D*	Yellow burr
Sclerolaena bicornis	H	-	-	-	-	-	X	-	X	X	F	X	X	L	U	D*	Goathead burr
Sclerolaena bicornis var. *horrida*	H	-	-	-	-	-	-	X	X	X	X	-	-	L	U	D	
Sclerolaena birchii	H	-	X	X	X	X	F	-	X	X	X	X	X	L	U	D*	Galvanized burr
Sclerolaena calcarata	H	-	-	-	-	-	X	X	-	X	X	-	X	H	C	D*	Red burr
Sclerolaena convexula	H	-	X	F	X	-	-	-	X	-	X	X	X	M	U	D	Copper burr/buck bush
Sclerolaena decurrens	H	-	-	-	-	-	-	-	-	-	-	-	X	L	U	-	
Sclerolaena diacantha	H	-	-	-	-	X	X	-	-	X	X	-	-	L	U	D*	Grey copper burr
Sclerolaena divaricata	H	-	X	-	-	X	X	-	-	X	X	X	X	H/M	U	D*	Gidgee burr
Sclerolaena intricata	H	-	-	-	-	X	-	-	-	-	-	X	-	L	U	-	
Sclerolaena lanicuspis	H	-	-	-	-	-	X	-	-	X	X	-	X	M	U	D	Woolly spined burr
Sclerolaena parviflora	H	-	-	-	-	-	-	-	-	X	-	-	-	L	U	-	
Sclerolaena muricata	H	-	-	-	-	-	X	X	X	X	F	-	X	L	S	D*	Prickly or black roly-poly
Sclerolaena muricata var. *semiglabra*	H	-	-	-	-	-	-	-	-	-	-	-	X	L	U	-	
Sclerolaena muricata var. *villosa*	H	-	-	-	-	X	-	-	-	-	-	-	-	L	U	-	
Sclerolaena tricuspis	H	-	-	-	-	X	X	-	-	X	-	-	X	L	U	D*	Three-spined roly-poly/ giant red burr
Sclerostegia tenuis	S	-	-	-	-	-	-	-	-	X	-	-	-	M/L	U	-	A samphire
Stelligera endecaspinis	H	-	-	-	-	-	X	-	-	X	-	-	-	M	U	-	
CLUSIACEAE																	
Hypericum gramineum	H	-	-	X	X	-	-	-	X	-	-	-	X	L	T	-	
COMMELINACEAE																	
Commelina cyanea	H	-	-	-	-	-	-	-	-	X	-	-	-	H	U	0	Scurvy weed, wandering jew
CONVOLVULACEAE																	
Bonamia media	H	-	-	-	-	-	-	-	-	-	-	X	-	M	U	-	
Convolvulus erubescens	H	-	X	X	X	-	-	-	X	X	F	X	X	H	U	-	Australian bindweed
Cressa cretica	H	-	-	-	-	-	-	-	-	-	-	-	X	L	U	-	
Dichondra repens	H	-	-	-	-	-	-	-	-	X	-	X	-	L	U	-	Kidney weed
Evolvulus alsinoides	H	X	X	F	F	X	-	-	X	-	-	X	-	H	U	-	
Ipomoea lonchophylla	H	-	-	-	-	-	-	-	-	X	F	-	X	H	C	-	Cow vine
Polymeria longifolia	H	-	-	-	-	-	-	-	-	X	X	-	X	M	U	-	
Polymeria marginata	H	-	-	-	-	-	X	-	-	-	X	X	-	M	U	-	
Polymeria pusilla	H	-	-	-	-	-	-	-	X	X	-	-	X	M	U	-	
Porana commixta	H	-	-	-	-	X	-	-	-	-	-	-	-	L	U	-	
CRASSULACEA																	

WARLUS III - SPECIES LIST

Family and species	Lf	N	S	M	H	R	G	F	E	W	A	D	L	Pal	Tox	Misc	Common name
		Land zone															
Crassula sieberiana	H	X	-	-	-	-	X	-	-	-	X	X	X	L	U	-	
CUCURBITACEAE																	
Citrullus colocynthis	HV	-	X	-	-	-	-	-	-	-	-	X	-	L	C	-	Colocynth
Citrullus lanatus	HV	-	-	X	-	-	-	-	-	-	-	X	-	L	S	-	Piemelon
Cucumis myriocarpus	V	-	-	-	-	-	X	-	-	-	-	X	-	L	T	-	Prickly paddy melon
Cucumis melo	V	-	-	-	-	-	-	-	-	-	X	-	-	L	S	-	Paddy melon, gooseberry cucumber
Momordica balsamina	V	-	-	-	-	-	-	-	-	-	-	X	-	L	S	-	Balsam apple
CUPRESSACEAE																	
Callitris columellaris	T	X	X	-	-	-	-	-	-	-	-	A	-	M	U	-	Cypress pine
CYPERACEAE																	
Bulbostylis barbata	H	X	X	X	X	X	-	-	-	X	X	X	X	L	U	-	A sedge
Cyperus bifax	H	-	-	-	-	-	-	X	-	F	-	-	X	H	U	-	Downs nut-grass
Cyperus bulbosus	H	-	-	-	-	-	-	-	-	-	-	-	X	L	U	-	Nalgoo
Cyperus castaneus	H	-	-	-	X	-	-	-	-	-	-	-	-	L	U	-	
Cyperus castaneus var. *brevimucronatus*	H	-	-	-	X	-	-	-	-	-	-	-	-	L	U	-	
Cyperus concinnus	H	-	-	-	-	-	-	-	X	X	-	X	X	L	U	-	
Cyperus dactylotes	H	-	-	-	-	-	X	-	-	X	-	X	X	L	U	-	
Cyperus difformis	H	-	-	-	-	-	X	-	-	X	X	-	X	L	U	D	
Cyperus gilesii	H	-	-	-	-	X	X	-	X	X	X	-	X	M	U	-	
Cyperus gracilis	H	-	-	-	-	X	-	-	-	X	-	-	-	L	U	-	Slender sedge, whisker grass
Cyperus gymnocaulos	H	-	-	-	-	-	-	-	-	X	-	-	-	L	U	-	
Cyperus iria	H	-	-	-	-	-	-	-	-	X	X	-	X	M	U	-	
Cyperus squarrosus	H	-	-	-	-	-	-	-	-	X	-	-	-	L	U	-	
Cyperus subpinnatus	H	-	-	-	-	-	-	-	X	X	-	X	-	L	U	-	
Cyperus victoriensis	P	-	-	-	-	-	-	-	-	X	-	-	-	H	U	-	Channel nut-grass
Eleocharis pallens	H	-	-	-	-	-	-	-	X	C	-	-	C	L	U	-	Pale spike-rush
Eleocharis pusilla	H	-	-	-	-	-	-	-	-	X	-	-	X	M	U	-	
Fimbristylis dichotoma sens lat.	H	X	-	X	X	F	-	-	X	-	X	X	X	M	U	-	
Fimbristylis microcephala	H	-	-	-	-	-	-	-	X	-	-	-	-	M	U	-	
Fimbristylis neilsonii	H	-	-	X	-	-	-	-	-	-	-	-	-	L	U	-	
Lipocarpha microcephala	H	-	-	-	X	-	-	-	-	-	-	-	-	L	U	-	
Schoenoplectus dissachanthus	H	-	-	-	-	-	-	-	-	X	-	-	X	L	U	-	
Schoenus apogon vel. aff.	H	-	-	-	X	-	-	-	-	-	-	-	-	L	U	-	
Schoenus subaphyllus	H	X	-	X	-	-	-	-	-	-	-	-	-	L	U	-	
DICRASTYLIDACEAE																	
Dicrastylis lewellinii	P	C	X	-	-	-	-	-	-	-	-	-	-	L	U	-	
Spartothamnella puberula	S	X	X	X	X	-	-	-	-	-	-	-	-	L	U	-	
DROSERACEAE																	
Drosera burmannii	H	X	-	X	-	-	-	-	-	-	-	-	-	L	U	-	A sundew
Drosera indica	H	-	-	-	X	-	-	-	-	-	-	-	-	L	U	-	A sundew
DYSPHANIACEAE																	
Dysphania glomulifera	H	-	-	X	X	F	-	-	X	-	-	-	-	M	T	-	Nettle-leaf goosefoot, red crumbweed
Dysphania rhadinostachya	H	-	-	X	X	X	-	-	-	X	-	-	-	M	C	-	Green crumbweed
EHRETIACEAE																	
Ehretia membranifolia	S	-	-	X	-	-	-	-	X	-	-	-	-	H	C	-	Peach bush
Halgania cyanea	P	X	-	-	-	-	-	-	-	-	-	-	-	L	U	-	
ELATINACEAE																	
Bergia pedicellaris	H	-	-	-	-	-	-	-	-	X	-	-	-	L	U	-	
Bergia trimera	H	-	-	-	-	-	-	-	-	X	-	-	X	M	U	-	
EPACRIDACEAE																	
Leucopogon mitchellii	S	X	-	-	-	-	-	-	-	-	-	-	-	L	U	R	

WARLUS III - SPECIES LIST

Family and species	Lf	N	S	M	H	R	G	F	E	W	A	D	L	Pal	Tox	Misc	Common name
		Land zone															
EUPHORBIACEAE																	
Acalypha eremorum	S	-	-	-	-	C	-	-	-	-	-	-	-	L	U	-	
Croton phebalioides	S	-	-	-	-	C	-	-	-	-	-	-	-	L	U	-	
Euphorbia drummondii	H	X	F	F	F	X	X	X	F	X	F	X	X	M	U	-	Caustic weed
Euphorbia tannensis ssp. *eremophila*	H	-	X	X	X	X	-	-	-	-	X	X	-	M	U	-	Desert spurge
Petalostigma pubescens	T	X	-	-	-	-	-	-	-	-	-	X	-	M	U	-	Quinine berry
Phyllanthus fuernrohrii	H	-	-	X	-	-	-	-	X	-	-	-	-	L	S	-	
Phyllanthus maderaspatensis	H	-	-	-	X	X	X	-	X	X	X	-	X	M	U	-	
Poranthera microphylla	H	X	X	X	-	-	-	-	-	-	-	-	-	M	C	-	
Ricinocarpos bowmanii	S	C	-	-	-	-	-	-	-	-	-	-	-	L	U	-	Wedding bush
Sauropus trachyspermus	H	-	-	X	-	-	-	-	-	-	-	-	-	M	U	-	
FABACEAE																	
Aeschynomene indica	H	-	-	-	-	-	-	-	-	X	-	-	X	M	S	-	Budda pea
Crotolaria dissitiflora	H	-	-	-	-	-	X	-	-	-	X	-	X	M	S	-	Grey rattlepod
Crotolaria smithiana	P	-	-	-	-	-	-	-	X	-	-	X	-	L	U	-	
Daviesia acicularis	P	X	-	-	-	-	-	-	-	-	-	-	-	L	U	R	
Desmodium brachypodum	H	-	X	X	-	-	X	-	X	-	-	X	-	M	U	-	
Desmodium campylocaulon	H	-	-	-	-	-	X	-	-	-	X	-	-	H	U	-	
Glycine canescens	V	-	X	X	X	X	-	-	X	-	-	X	-	H	U	-	
Glycine clandestina	V	-	-	X	-	-	-	-	X	-	-	-	-	H	U	-	Twining glycine
Glycine falcata	H	-	-	-	-	-	-	-	-	-	X	-	-	H	U	-	
Glycine tomentella	H	-	-	-	-	-	-	-	X	-	-	X	-	H	U	-	Woolly glycine
Glycyrrhiza acanthocarpa	P	-	-	-	-	-	-	-	-	-	-	-	X	L	U	-	
Indigofera brevidens	S	-	-	-	-	X	-	-	-	-	-	-	-	L	U	-	
Indigofera colutea	H	-	-	-	-	-	-	-	-	-	-	X	-	L	U	-	Sticky indigo
Indigofera hirsuta	H	-	-	-	-	-	-	-	-	-	-	X	-	L	U	-	Hairy indigo
Indigofera linifolia	H	-	-	-	-	-	-	-	-	-	-	X	-	M	S	-	Native indigo
Indigofera linnaei	H	-	-	-	-	-	-	-	-	-	-	X	-	H	T	-	Birdsville indigo
Jacksonia turneriana	S	C	-	-	-	-	-	-	-	-	-	-	-	L	U	-	Dwarf dogwood
Kennedya prorepens	P	X	-	-	-	-	-	-	-	-	-	-	-	M	U	-	
Lotus cruenta	H	-	-	-	-	-	X	X	-	X	X	X	-	H	C	-	Red-flower lotus
Medicago polymorpha var. *vulgaris*	H	-	-	-	-	-	-	-	-	-	X	-	-	H	S	-	Burr trefoil, burr medic
Mirbelia pungens	P	X	-	-	-	-	-	-	-	-	-	-	-	L	U	R	
Muelleranthus trifoliolatus	H	X	X	X	-	-	-	-	-	-	-	-	-	M	U	-	
Parkinsonia aculeata	S	-	-	-	-	-	-	-	-	-	X	-	-	M	U	WI	Parkinsonia, Jerusalem thorn
Psoralea cinerea	H	-	-	-	-	-	-	-	X	C	F	-	-	M	U	-	Annual verbine
Psoralea patens	H	-	-	-	-	-	-	-	-	X	-	-	-	M	U	-	Bullamon lucerne
Psoralea tenax	H	-	-	-	-	-	X	-	-	X	X	-	X	M	U	-	Emu foot
Rhynchosia minima	H	-	-	-	-	-	X	-	X	X	F	-	-	M	U	-	
Sesbania cannabina	H	-	-	-	-	-	X	-	-	-	-	-	-	M	U	D	Sesbania pea
Swainsona campylantha	H	-	-	-	-	-	-	-	-	-	X	-	-	M	S	-	
Swainsona microphylla ssp. *affinis*	H	-	-	-	-	-	-	-	X	-	-	-	-	M	S	-	
Swainsona oroboides	H	-	X	X	-	-	-	-	-	-	-	-	-	M	S	-	Kneed swainsona
Swainsona parviflora	H	-	-	X	-	-	-	-	-	-	-	-	-	M	S	-	
Swainsona phacoides	H	-	-	-	-	-	-	-	-	-	-	X	X	M	S	-	
Swainsona procumbens	H	-	-	-	-	-	-	-	-	-	-	-	X	M	T	-	Broughton pea
Swainsona stipularis	H	-	-	-	-	-	-	-	-	-	-	X	-	M	S	-	
Tephrosia sphaerospora	H	-	-	-	-	-	-	-	-	-	-	X	-	L	U	-	
Trigonella suavissima	H	-	-	-	-	-	-	-	-	-	-	-	X	H	U	-	Cooper clover
FLINDERSIACEAE																	
Flindersia maculosa	T	-	-	-	-	X	F	-	-	-	X	X	-	H	U	-	Leopardwood
FRANKENIACEAE																	
Frankenia serpyllifolia	P	-	-	-	-	-	-	-	-	-	-	-	X	L	U	-	
Frankenia uncinata	P	-	-	-	-	-	-	-	-	-	-	-	X	L	U	-	
GENTIANACEAE																	
Centaurium spicatum	H	-	-	-	-	-	-	-	-	X	-	-	X	L	U	-	Native centaury
GERANIACEAE																	
Erodium crinitum	H	-	-	X	X	-	X	-	-	-	-	X	-	H	U	-	Blue crowfoot

WARLUS III - SPECIES LIST

Family and species	Lf	Land zone N	S	M	H	R	G	F	E	W	A	D	L	Pal	Tox	Misc	Common name
GOODENIACEAE																	
Catosperma goodeniacea	P	X	-	-	-	-	-	-	-	-	-	-	-	L	U	-	
Dampiera adpressa	P	X	-	-	-	-	-	-	-	-	-	-	-	L	U	-	
Goodenia cycloptera	P	-	-	-	-	-	-	-	-	-	-	-	X	L	U	-	
Goodenia disperma	S	X	-	-	-	X	-	-	-	-	-	-	-	L	U	-	
Goodenia fascicularis	H	-	-	-	-	-	X	X	-	F	F	-	X	M	U	-	Silky goodenia
Goodenia glabra	H	X	X	F	X	X	-	-	-	-	-	X	-	M	U	-	
Goodenia havilandii	H	-	-	-	X	-	-	-	-	-	-	-	-	H	U	-	
Goodenia heterochila	P	-	X	X	X	-	-	-	X	-	-	X	-	L	U	-	
Goodenia lunata	H	-	X	-	-	-	-	-	-	-	-	-	X	M	U	-	
Scaevola sp. Q2	P	C	-	X	-	-	-	-	-	-	-	-	X	L	U	-	
Scaevola depauperata	S	X	-	-	-	-	-	-	-	-	-	-	-	L	U	-	
Scaevola spinescens	S	-	-	-	-	X	-	-	-	-	-	-	X	L	U	-	
Velleia connata	H	X	-	-	-	-	-	-	-	-	-	-	-	M	U	-	
Velleia glabrata	H	-	X	X	X	X	-	-	X	-	-	-	X	H	U	-	Pee-the-bed
GYROSTEMONACEAE																	
Codonocarpus cotinifolius	T	-	X	-	-	-	-	-	-	-	-	-	-	L	S	-	Desert poplar
HALORAGACEAE																	
Haloragis aspera	P	-	-	-	-	-	-	-	-	X	-	X	X	L	U	-	Raspweed
Haloragis glauca f. glauca	P	-	-	-	-	-	-	-	-	X	-	-	-	L	U	-	Grey raspweed
Haloragis odontocarpa	H	-	X	X	X	-	-	-	X	-	-	-	-	H	U	-	Mulga nettle
Myriophyllum striatum	P	-	-	-	-	-	-	-	-	X	-	-	X	L	U	-	A milfoil
HYDROCHARITACEAE																	
Ottelia ovalifolia	P	-	-	-	-	-	-	-	-	X	-	-	-	L	U	-	Swamp Lily
JUNCACEAE																	
Juncus aridicola	P	-	-	-	-	-	-	-	-	X	-	-	-	L	U	-	A reed
Juncus usitatus	P	-	-	-	-	-	-	-	-	X	-	-	-	L	U	-	A reed
LAMIACEAE																	
Basilicum polystachyon	P	-	-	-	-	X	-	-	-	X	-	-	-	L	U	-	
Microcorys queenslandica	S	X	-	-	-	-	-	-	-	-	-	-	-	L	U	R	
Prostanthera suborbicularis	S	-	X	C	C	A	-	-	-	-	-	-	-	M	U	-	Mind bush, mountain saltbush
Teucrium intergrifolium	S	-	-	-	-	-	X	-	-	X	X	-	X	L	U	-	Green germander
Teucrium racemosum	S	-	-	-	-	-	-	-	-	X	-	-	X	L	S	-	Grey germander
LAURACEAE																	
Cassytha pubescens	V	X	-	-	-	-	-	-	-	-	-	-	-	L	U	-	Dodder
LILIACEAE																	
Bulbine alata	H	-	-	-	-	-	X	-	-	X	-	-	-	M	S	-	A native leek
Bulbine bulbosa	H	-	-	-	-	-	-	-	-	X	-	-	-	L	S	-	A native leek
Dianella longifolia var. *stupata*	P	X	X	X	X	-	-	-	X	-	-	X	-	L	S	-	
Tricoryne elatior	H	-	X	-	-	-	-	-	-	-	-	-	-	L	U	-	Yellow rush lilly
LORANTHACEAE																	
Amyema maidenii	-	-	-	-	X	-	-	-	-	-	-	-	-	-	H	U	Mistletoe
Amyema quandong	-	-	-	-	-	-	-	X	-	-	-	-	-	-	H	U	Mistletoe
Lysiana exocarpi ssp. *tenuis*	-	-	-	-	-	-	-	-	-	-	-	-	X	-	H	U	Mistletoe
Lysiana subfalcata	-	-	-	-	-	-	-	-	-	-	-	-	X	-	H	U	Mistletoe
LYTHRACEAE																	
Ammannia multiflora	H	-	-	-	-	-	X	-	-	X	-	-	X	H	U	-	
MALVACEAE																	
Abutilon calliphyllum	S	-	-	-	-	X	-	-	-	-	-	-	-	L	U	-	
Abutilon fraseri	P	-	X	X	X	X	X	-	F	X	X	X	X	L	U	D	A flannel-weed
Abutilon leucopetalum	S	-	-	-	X	-	-	-	-	-	-	-	-	L	U	-	Lantern bush

WARLUS III - SPECIES LIST

Family and species	Lf	N	S	M	H	R	G	F	E	W	A	D	L	Pal	Tox	Misc	Common name
Abutilon malvifolium	H	-	-	-	-	-	X	-	-	X	X	-	X	M	U	D*	
Abutilon otocarpum	P	-	X	X	X	-	X	-	X	-	X	X	F	M	U	D	Flannel-weed, desert chinese lantern
Abutilon oxycarpum	P	-	-	X	-	-	F	-	X	X	X	X	X	L	U	-	
Abutilon oxycarpum var. *subsagittatum*	P	-	-	-	-	X	X	-	X	-	-	-	-	L	U	-	
Hibiscus brachysiphonius	H	-	-	-	-	-	X	-	-	X	X	-	-	M	U	-	
Hibiscus sturtii var. *sturtii*	P	X	X	X	X	F	X	-	X	-	X	X	-	M	U	-	
Hibiscus sturtii var. *grandiflorus*	P	-	-	F	X	X	-	-	F	-	X	-	-	L	U	-	
Hibiscus trionum	H	-	-	-	-	-	X	X	-	F	F	-	X	L	U	D*	Bladder ketmia
Lawrencia glomerata	P	-	-	-	-	-	-	-	-	-	-	-	X	L	U	-	
Lawrencia squamata	P	-	-	-	-	-	-	-	-	-	-	-	X	L	U	-	
Malvastrum americanum	H	-	-	X	X	F	X	X	F	F	X	X	-	M	C	D	Malvastrum
Malvastrum coromandelianum	H	-	-	-	-	-	-	-	-	-	-	X	-	L	U	-	Prickly malvastrum
Sida acuta	P	-	-	-	-	-	-	-	X	-	X	-	-	L	U	-	
Sida ammophila	P	-	-	-	-	-	-	-	-	-	X	-	-	L	U	-	
Sida atherophora	H	-	X	-	-	-	-	-	-	-	X	-	-	L	U	D	
Sida brachypoda	P	-	X	X	X	-	-	-	X	-	X	-	-	L	U	D	
Sida corrugata	H	-	-	-	-	-	-	-	X	X	X	X	-	M	U	-	Corrugated sida
Sida everistiana	P	-	-	-	-	X	F	-	X	-	-	-	-	L	U	-	
Sida fibulifera	P	-	-	X	X	X	F	X	X	X	X	X	X	M	U	-	Silver sida
Sida filiformis	P	X	F	X	X	F	-	-	X	-	X	X	X	M	U	-	
Sida goniocarpa	P	-	-	-	-	-	X	-	-	-	X	-	-	M	U	D	
Sida pedunculata	P	-	X	X	X	X	-	-	X	-	-	-	-	M	U	-	
Sida platycalyx	P	-	X	X	-	-	-	-	-	-	-	-	-	L	U	-	Lifesaver burr
Sida rohlenae	P	-	-	-	-	-	-	-	-	-	-	X	-	L	U	-	
Sida trichopoda	P	-	-	-	-	-	F	X	X	F	F	-	X	H	U	D*	High sida
Sida sp. nov. "BOX"	H	-	-	-	-	-	-	-	X	-	-	-	-	L	U	-	
MELIACEAE																	
Owenia acidula	T	-	-	-	-	X	X	-	-	-	X	X	-	H	U	-	Emu apple
MENYANTHACEAE																	
Nymphoides crenata	P	-	-	-	-	-	-	-	-	X	-	-	X	L	U	-	
MIMOSACEAE																	
Acacia aneura	T	C	A	A	A	A	-	-	A	X	-	C	X	H	U	W	Mulga
Acacia aprepta	S	-	-	-	-	C	-	-	-	-	-	-	-	L	U	-	
Acacia bancroftii	T	X	-	-	-	X	-	-	-	-	-	-	-	L	U	-	
Acacia bivenosa ssp. *wayi*	S	-	-	-	-	-	-	-	-	-	-	X	-	L	U	-	Marpoo
Acacia brachystachya	S	-	-	-	X	C	-	-	-	-	-	-	-	M	U	-	Turpentine mulga
Acacia burbidgeae	S	C	-	-	-	-	-	-	-	-	-	X	-	L	U	W	
Acacia cambagei	T	-	-	-	-	C	A	-	-	A	C	-	X	L	U	-	Gidgee
Acacia catenulata	S	-	-	-	-	C	-	-	-	-	-	-	-	M	U	-	Bendee
Acacia cowleana	S	X	-	-	-	-	-	-	-	-	-	-	-	L	U	-	
Acacia deanei	S	-	X	-	-	-	-	-	-	-	-	X	-	M	U	R	Green wattle
Acacia decora	S	X	X	-	-	X	-	-	-	-	-	-	-	L	U	-	
Acacia excelsa	T	X	X	X	-	-	X	X	X	-	-	A	-	M	U	-	Ironwood
Acacia farnesiana	S	-	-	-	-	-	-	-	-	X	-	X	-	H	U	-	Mimosa bush
Acacia gnidium	S	C	-	-	-	-	-	-	-	-	-	-	-	L	U	W	
Acacia harpophylla	T	-	-	-	-	C	C	X	-	X	-	-	C	L	C	-	Brigalow
Acacia leptostachya	S	C	-	-	-	-	-	-	-	-	-	-	-	L	U	W	
Acacia longispicata	S	-	-	-	-	X	-	-	-	-	-	-	-	L	U	-	
Acacia maitlandii	S	A	-	-	-	-	-	-	-	-	-	-	-	L	U	W	
Acacia microsperma	T	-	-	-	-	C	-	-	-	X	-	-	C	M	U	-	Bowyakka
Acacia murrayana	S	X	X	X	-	-	-	-	-	-	-	F	-	L	U	WR	Colony wattle
Acacia omalophylla	T	-	-	-	-	-	-	-	X	C	-	-	C	M	U	-	Yarran
Acacia oswaldii	S	X	X	X	-	-	-	-	X	X	-	X	X	M	X	-	Nelia
Acacia pendula	T	-	-	-	-	-	-	X	-	-	-	-	-	H	U	-	Myall
Acacia petraea	T	-	-	-	-	C	-	-	-	-	-	-	-	L	C	-	Lancewood
Acacia salicina	T	-	-	-	-	-	-	-	-	C	-	X	-	L	S	W	Doolan
Acacia sparsiflora	T	-	-	-	-	C	-	-	-	-	-	-	-	H	S	-	
Acacia stenophylla	S	-	-	-	-	-	-	-	-	F	-	-	X	M	U	-	Belalie
Acacia stowardii	S	-	-	-	-	X	-	-	-	-	-	-	-	L	U	-	Bastard mulga
Acacia tetragonophylla	S	-	X	-	X	X	-	-	X	-	-	X	X	H	U	-	Western dead-finish
Acacia victoriae	S	-	X	-	-	-	-	-	-	X	X	C	X	H	U	-	Gunda-bluey
Archidendropsis basaltica	T	-	C	-	-	-	X	-	-	-	-	-	-	H	U	W	Dead-finish
Neptunia gracilis	P	-	-	-	-	-	-	-	-	X	X	-	-	H	U	-	Native sensitive plant

WARLUS III - SPECIES LIST

Family and species	Lf	N	S	M	H	R	G	F	E	W	A	D	L	Pal	Tox	Misc	Common name
		Land zone															
MYOPORACEAE																	
Eremophila bignoniiflora	S	-	-	-	-	-	-	-	-	F	X	-	X	H	S	-	Creek wilga, gooramurra
Eremophila bowmanii	S	X	X	C	X	X	-	-	-	-	-	-	-	L	U	W	Silver turkey bush
Eremophilla gilesii	S	X	A	A	C	C	X	-	C	-	-	X	X	L	U	W	Charleville turkey bush/ green turkey bush
Eremophila glabra	S	X	X	X	X	X	X	X	F	X	X	X	F	M	U	-	Black fuchsia
Eremophila goodwinii	S	X	-	-	X	C	-	-	-	-	-	-	-	L	U	-	
Eremophila latrobei	S	-	-	-	-	C	-	-	-	-	-	-	-	M	T	-	
Eremophila longifolia	S	X	X	X	X	X	-	-	X	X	-	X	X	H	T	-	Berrigan, dogwood
Eremophila maculata	S	-	-	-	-	-	X	-	X	X	-	-	X	H	T	-	Fuchsia bush
Eremophila mitchellii	S	-	X	X	X	C	A	X	A	A	C	X	X	L	U	WR	Sandalwood
Eremophila oppositifolia var. *rubra*	S	-	-	-	-	X	-	-	-	-	-	-	-	L	U	-	Mountain sandalwood
Eremophila polyclada	S	-	-	-	-	-	X	-	-	C	X	-	-	H	U	-	Lignum fuchsia
Eremophila sturtii	S	-	-	-	-	-	-	-	-	X	-	C	X	L	U	W	Budda bush
Myoporum acuminatum	S	-	-	-	-	-	X	-	-	-	-	C	-	H	T	-	Boobialla, water bush
Myoporum deserti	S	X	X	X	-	X	A	X	X	X	X	X	X	H	T	W	Ellangowan poison bush
MYRTACEAE																	
Angophora melanoxylon	T	X	-	-	-	-	-	-	-	-	-	X	-	L	U	-	Rough-barked apple
Baeckea sp.	S	C	-	-	-	-	-	-	-	-	-	-	-	L	U	-	
Calytrix longiflora	S	C	-	-	-	-	-	-	-	-	-	-	-	L	U	R	Fringe myrtle, heather
Eucalyptus camaldulensis	T	-	-	-	-	-	-	-	-	A	-	-	X	L	U	-	River red gum
Eucalyptus cambageana	T	-	-	-	-	X	X	-	-	X	-	-	-	L	U	-	Dawson gum, blackbutt
Eucalyptus dolichocarpa	T	X	X	-	-	-	-	-	-	-	-	X	-	L	U	-	Longfruited bloodwood
Eucalyptus exserta	S	X	-	-	X	F	-	-	-	-	-	-	-	L	U	-	Mountain box, bendo
Eucalyptus intertexta	T	X	X	C	-	-	-	-	C	-	-	-	-	L	U	R	Forest gum
Eucalyptus largiflorens	T	-	-	-	-	-	X	-	-	C	-	-	-	L	U	-	Black box
Eucalyptus melanophloia	T	A	X	C	C	X	-	-	X	-	-	X	X	L	U	R	Silver-leaved ironbark
Eucalyptus microtheca	T	-	-	-	-	-	X	-	X	A	X	X	A	L	U	W	Coolibah
Eucalyptus nubilia	T	-	-	-	-	X	-	-	-	-	-	-	-	L	U	-	
Eucalyptus ochrophloia	T	-	-	-	-	-	X	-	-	A	-	-	C	L	U	-	Yapunyah
Eucalyptus pilligaensis	T	-	-	-	-	-	-	-	-	X	-	-	-	L	U	-	Ribbon box, gum-topped box
Eucalyptus populnea	T	X	F	F	F	X	X	-	A	A	C	X	A	L	U	WR	Poplar box
Eucalyptus terminalis	T	X	-	-	X	X	-	-	-	-	-	X	X	L	U	-	Western bloodwood
Eucalyptus thozetiana	T	-	-	-	-	A	X	-	-	-	-	-	-	L	U	W	Mountain yapunyah
Homalocalyx polyandrus	S	-	-	-	-	X	-	-	-	-	-	-	-	L	U	-	
Melaleuca densispicata	S	-	-	-	-	-	-	-	-	X	-	-	-	L	U	-	
Melaleuca trichostachya	S	-	-	-	-	-	-	-	-	X	-	-	-	L	U	-	Paper barked tea-tree
Melaleuca uncinata	S	C	-	-	-	-	-	-	-	-	-	-	-	L	U	R	
Micromyrtus hexamera	S	X	-	C	X	-	-	-	-	-	-	-	-	L	U	W	
Thryptomene hexandra	S	-	-	C	C	-	-	-	-	-	-	-	-	L	U	W	
Thryptomene parviflora	S	X	-	-	-	-	-	-	-	-	-	-	-	L	U	-	
NYCTAGINACEAE																	
Boerhavia diffusa sens. lat.	H	-	-	-	-	X	X	-	X	X	X	X	X	H	S	-	Tar vine
OLEACEAE																	
Jasminum didymum ssp. *lineare*	V	-	-	-	-	-	-	-	-	X	-	X	X	L	U	-	Jasmine
OXALIDACEAE																	
Oxalis corniculata	H	X	X	X	X	X	-	-	X	X	-	X	X	M	T	-	Yellow wood sorrel
PAPAVERACEAE																	
Argemone ochroleuca	H	-	-	-	-	-	-	-	-	-	X	X	-	L	T	I	Mexican poppy
PITTOSPORACEAE																	
Bursaria incana	S	-	-	-	-	X	-	-	-	-	-	-	-	M	U	-	
Pittosporum phillyraeoides	S	-	-	-	-	-	-	-	-	-	-	X	-	H/M	U	-	Meemeei, cattle bush
PLANTAGINACEAE																	
Plantago drummondii	H	-	-	X	-	-	X	X	X	X	X	-	X	H	U	-	A plantain
POACEAE																	
Alopecurus geniculatus	H	-	-	-	-	-	-	-	X	-	X	-	-	L	U	-	

WARLUS III - SPECIES LIST

Family and species	Lf	N	S	M	H	R	G	F	E	W	A	D	L	Pal	Tox	Misc	Common name
		Land zone															
Amphipogon caricinus	P	X	X	A	A	X	-	-	X	-	-	-	X	M	U	-	Grey beard grass
Ancistrachne uncinulata	P	-	C	-	-	-	-	-	-	-	-	-	-	H	U	-	Hooky grass
Aristida anthoxanthoides	H	-	-	-	-	-	F	-	-	X	F	-	-	M	U	-	Yellow threeawn
Aristida biglandulosa	H	-	-	-	-	-	-	-	-	-	-	C	-	L	U	-	Two-gland threeawn
Aristida blakei	H	-	-	-	-	-	-	-	-	-	-	X	-	L	U	-	
Aristida calycina var. *calycina*	H	X	X	X	X	-	-	-	X	-	X	X	-	L	U	-	Dark wire grass
Aristida calycina var. *praealta*	H	X	A	A	A	X	X	-	A	C	-	A	X	M	U	D	Number 8 wire grass
Aristida caput-medusae	H	-	-	-	-	C	-	-	-	-	-	-	-	L	U	-	Many headed wire grass
Aristida contorta	H	-	X	X	X	X	X	-	X	-	X	-	X	M	U	D	Kerosene grass
Aristida gracilipes	H	-	-	X	X	X	-	-	-	-	-	-	X	L	U	-	Slender wire grass
Aristida helicophylla	H	X	-	-	-	-	-	-	-	-	-	-	-	L	U	-	
Aristida holathera	H	X	X	X	X	X	X	-	-	-	-	A	X	M	U	-	Erect kerosene grass
Aristida inaequiglumis	H	-	-	-	-	-	-	-	-	-	-	C	-	L	U	-	
Aristida ingrata	H	-	-	-	-	-	-	-	X	-	-	C	-	M	U	-	
Aristida jerichoensis	H	X	C	A	A	F	X	-	X	-	-	-	X	M	U	D	Jericho threeawn
Aristida jerichoensis var. *subspinulifera*	H	X	X	C	F	-	-	-	-	-	-	X	X	M	U	D	
Aristida latifolia	H	-	-	-	-	-	X	X	-	X	A	-	-	M	U	D	Feather top wire grass
Aristida leptopoda	H	-	-	-	-	-	-	X	X	-	-	-	-	L	U	D	White spear grass
Aristida muricata	H	-	-	-	-	-	-	-	-	-	X	-	-	L	U	-	
Aristida nitidula	H	-	-	-	-	X	-	-	-	-	-	-	-	L	U	-	
Aristida obscura	H	-	X	X	X	X	-	-	X	-	-	-	-	M	U	-	Brush threeawn
Aristida platychaeta	H	-	-	-	X	X	X	F	-	X	X	-	-	L	U	-	
Aristida psammophila	H	-	-	-	-	-	X	-	-	-	X	-	-	L	U	-	
Aristida ramosa var. *scaberula*	H	-	X	-	-	-	X	-	X	-	X	X	-	L	U	-	Prickly threeawn
Aristida ramosa var. *speciosa*	H	-	-	-	-	X	-	-	-	-	X	X	X	L	U	-	Wire grass
Arundinella nepalensis	H	-	-	-	-	-	-	-	-	X	-	-	-	L	U	-	Reed grass
Astrebla elymoides	P	-	-	-	-	-	X	X	-	F	A	-	X	H	U	-	Hoop mitchell grass
Astrebla lappacea	P	-	-	-	-	-	X	A	-	F	A	-	X	H	U	-	Curly mitchell grass
Astrebla pectinata	P	-	-	-	-	-	-	-	-	-	C	-	-	H	U	-	Barley mitchell grass
Astrebla squarrosa	P	-	-	-	-	-	-	X	-	X	C	-	-	M	U	-	Bull mitchell grass
Bothriochloa bladhii	P	-	-	-	-	-	-	X	-	X	-	X	-	L	U	-	Forest blue grass
Bothriochloa decipiens	P	-	X	X	-	-	X	-	F	X	X	X	X	L	U	-	Pitted blue grass
Bothriochloa ewartiana	P	-	-	X	-	-	-	-	X	X	X	C	X	H	U	-	Desert blue grass
Brachiaria foliosa	P	-	-	-	-	X	-	-	-	-	-	-	-	L	U	-	
Brachiaria gilesii	H	-	-	X	-	X	X	-	X	-	-	X	X	H	U	D	Hairy-edged arm grass
Brachiaria piligera	H	-	X	X	-	-	X	-	X	X	-	X	-	L	U	D	Hairy arm grass
Brachiaria subquadripara	H	-	-	X	-	-	-	-	-	-	-	X	-	H	U	D	Green summer grass, arm grass millet
Brachyachne convergens	H	-	-	-	-	-	F	X	-	X	F	-	X	H	T	D	Native couch grass, spider grass
Cenchrus ciliaris	P	-	X	X	X	X	X	-	X	X	-	C	-	H	T	I	Buffel grass
Chloris divaricata	H	-	X	-	-	-	-	-	-	-	-	-	-	H	U	D	Slender chloris
Chloris pectinata	H	-	X	X	X	X	F	X	F	F	F	X	F	H	U	D*	Comb chloris
Chloris truncata	H	-	-	-	-	-	-	-	X	-	-	-	-	M/H	U	D*	
Chloris ventricosa	H	-	X	-	-	X	X	-	F	X	X	X	-	H	U	D	Tall chloris
Chloris virgata	H	-	X	-	-	-	X	-	-	X	-	X	-	L	U	D	Feather top rhodes grass
Chrysopogon fallax	P	-	-	-	-	-	-	-	-	X	X	X	-	H	U	-	Golden bear grass
Cymbopogon obtectus	H	X	X	X	X	X	X	-	-	-	-	-	-	M	U	-	Kapok grass, silky head, barb wire grass
Cymbopogon refractus	H	-	X	X	-	-	-	-	-	-	-	-	-	L	U	-	
Cynodon dactylon	P	-	-	-	-	-	-	-	-	-	X	-	-	H	U	D	Couch grass
Dactyloctenium radulans	H	-	-	X	-	-	A	-	X	A	A	X	X	H	T	D*	Button grass
Dichanthium sericeum	H	-	-	-	-	-	X	A	A	A	A	X	F	H	U	-	Queensland bluegrass
Digitaria breviglumis	H	-	C	X	X	X	-	-	-	-	X	X	-	H	U	-	
Digitaria brownii	H	X	F	F	F	X	X	-	F	-	-	X	X	H	U	D	Cotton panic grass, silver spike grass
Digitaria coenicola	H	-	-	-	-	-	-	-	-	-	X	-	-	H	U	-	Finger panic grass
Digitaria divaricatissima	H	X	X	X	X	-	X	X	X	X	F	X	X	H	U	D	Blowaway grass
Digitaria hystrichoides	H	X	A	A	F	X	X	-	F	X	-	X	X	H	U	D	Silky umbrella grass
Digitaria hubbardii	H	X	X	X	X	-	-	-	X	-	X	X	X	H	U	-	
Diplachne fusca	H	-	-	-	-	-	X	-	X	C	-	-	F	M	U	-	Water grass, brown beetle grass
Echinochloa colona	H	-	-	-	-	-	-	-	X	C	-	-	X	H	C	D	Awnless barnyard grass
Elytrophorus spicatus	P	-	-	-	-	-	-	-	-	X	-	-	F	L	U	-	Spike grass
Enneapogon avenaceus	H	-	-	-	X	X	X	-	-	X	F	X	X	H	U	-	Ridge grass
Enneapogon clelandii	H	X	X	-	-	X	X	-	-	-	-	-	X	L	U	-	
Enneapogon intermedius	H	-	-	X	-	-	X	-	-	-	-	X	X	L	U	-	
Enneapogon lindleyanus	H	-	-	X	-	-	X	-	-	-	-	-	-	M	U	-	A bottle washer grass
Enneapogon nigricans	H	-	-	-	-	X	X	-	-	-	-	-	-	M	U	-	A bottle washer grass
Enneapogon oblongus	H	-	X	-	-	-	X	-	-	-	-	-	-	L	U	-	
Enneapogon polyphyllus	H	-	X	X	F	X	X	-	-	X	X	X	-	M	U	-	A bottle washer grass
Enteropogon acicularis	P	-	X	X	X	X	A	X	A	F	X	X	X	H	U	-	Curly windmill grass, spider grass

WARLUS III - SPECIES LIST

Family and species		Land zone															
	Lf	N	S	M	H	R	G	F	E	W	A	D	L	Pal	Tox	Misc	Common name
Eragrostis australasica	P	-	-	-	-	-	-	-	-	X	-	-	C	M	U	-	Swamp cane grass
Eragrostis basedowii	H	-	X	X	X	-	-	-	-	-	-	-	X	M	U	-	
Eragrostis cilianensis	H	-	-	X	-	-	-	-	X	X	X	X	-	M	U	D	Stink grass
Eragrostis confertiflora	H	-	-	-	-	-	-	-	-	X	-	-	-	M	U	-	Spike love grass
Eragrostis dielsii	H	-	-	-	-	-	-	-	-	-	-	-	X	H	U	-	
Eragrostis elongata	H	-	X	X	X	X	X	-	F	X	-	X	F	H	U	-	Clustered love grass
Eragrostis eriopoda	P	X	A	A	F	X	-	-	X	-	-	A	X	M	U	-	Woollybutt grass
Eragrostis kennedyae	H	-	-	-	-	-	-	-	-	-	-	-	X	M	U	-	Small-flowered love grass
Eragrostis lacunaria	H	X	A	A	A	F	-	-	A	X	X	F	X	M	U	D	Purple love grass
Eragrostis leptocarpa	H	-	X	X	X	-	X	-	X	X	-	X	X	H	U	-	Drooping love grass
Eragrostis leptostachya	H	-	-	-	-	-	X	-	-	-	-	-	X	M	U	-	
Eragrostis microcarpa	H	-	X	A	X	X	C	-	A	X	X	X	A	M	U	-	
Eragrostis parviflora	H	-	X	X	X	X	X	-	X	X	X	-	F	M	U	-	Weeping love grass
Eragrostis pergracilis	H	-	X	X	X	X	-	-	-	-	-	-	X	M	U	-	
Eragrostis setifolia	P	-	-	-	-	-	C	-	X	A	F	X	F	M	U	-	Neverfail grass
Eragrostis sororia	H	-	X	X	X	-	-	-	-	-	-	-	-	M	U	-	
Eragrostis spartinoides	H	-	-	-	X	-	-	-	-	-	-	-	-	L	U	-	
Eragrostis speciosa	H	X	X	X	-	-	-	-	-	-	-	X	-	L	U	-	Handsome love grass
Eragrostis tenellula	H	-	-	X	-	-	X	-	-	X	-	-	X	M	U	-	Delicate love grass
Eragrostis xerophilla	P	-	X	-	-	-	-	-	-	-	-	-	-	L	U	-	Knotty-butt neverfail grass
Eriachne aristidea	H	X	X	-	X	-	-	-	-	-	-	X	-	M	U	D	Threeawn wanderrie
Eriachne helmsii	P	X	F	F	X	X	-	-	X	-	-	X	X	M	U	-	Woollybutt wanderrie
Eriachne mucronata	P	X	X	X	C	A	-	-	-	-	-	X	-	M	U	-	Rock grass
Eriachne ovata	P	-	-	-	-	-	-	-	-	-	-	-	C	M	U	-	
Eriachne pulchella	H	-	-	-	-	X	-	-	-	-	-	-	-	M	U	-	Pretty wanderrie
Eriochloa pseudoacrotricha	H	-	-	-	-	X	F	X	X	F	F	-	F	H	U	-	Early spring grass
Eulalia aurea	H	-	X	X	X	-	-	-	X	X	X	-	X	H	U	-	Silky browntop
Heteropogon contortus	H	-	X	-	-	-	-	-	X	X	-	C	-	M	U	D	Black spear grass
Homopholis proluta	P	-	-	-	-	-	-	-	-	-	X	-	X	H	U	-	
Iseilema fragile	H	-	-	-	-	-	-	-	-	C	-	-	-	H	U	-	
Iseilema membranaceum	H	-	-	-	-	-	X	A	-	A	C	-	X	H	U	-	Small flinders grass
Iseilema vaginiflorum	H	-	-	-	-	-	-	-	-	C	A	-	X	H	U	-	Red flinders grass
Leptochloa decipiens	H	-	X	-	-	X	-	-	-	-	-	-	-	M	U	-	
Leptochloa digitata	P	-	-	-	-	-	-	-	-	X	-	-	-	M	U	-	Umbrella cane grass
Melinis repens	H	-	X	X	X	-	-	-	X	-	-	-	-	L	U	I	Natal grass, red natal
Monachather paradoxus	P	X	A	A	A	X	-	-	X	-	-	X	X	H	U	-	Mulga oats, bandicoot grass
Neurachne munroi	P	-	-	-	-	-	-	-	-	-	-	-	X	M	U	D	Dwarf mulga grass
Neurachne queenslandica	P	-	-	-	-	-	-	-	X	-	-	-	-	M	U	-	
Oxychloris scariosa	H	-	-	-	-	-	X	-	-	-	X	-	X	L	U	D*	Large-flowered chloris, winged chloris
Panicum buncei	H	-	-	-	-	-	-	-	-	X	-	-	-	H	U	-	
Panicum decompositum	H	X	X	-	X	-	X	F	X	F	F	X	X	H	S	-	Native or wild millet
Panicum effusum	H	X	F	F	F	X	X	-	F	-	X	X	X	H	T	D	Hairy panic
Panicum laevinode	H	-	-	-	-	-	X	-	-	X	-	-	X	M	U	-	Pepper grass
Panicum queenslandicum	H	-	-	-	-	-	-	X	-	-	-	-	X	M	U	-	Yabila grass
Panicum subxerophilum	P	-	X	X	X	-	-	-	A	X	-	-	X	M	U	-	
Paspalidium caespitosum	P	-	-	-	X	X	X	-	X	-	X	-	X	M	U	-	Brigalow grass
Paspalidium constrictum	P	X	X	X	X	X	F	-	F	X	X	X	X	M	U	-	Belah grass
Paspalidium jubiflorum	P	-	-	-	-	-	X	-	-	X	-	-	X	M/H	U	-	Warrego summer grass
Paspalidium rarum	H	X	-	X	X	X	-	-	X	-	X	-	-	H	U	-	Shot grass
Perotis rara	H	X	X	X	X	X	X	-	X	-	-	F	X	M	U	-	Comet grass
Phragmites australis	P	-	-	-	-	-	-	-	-	-	-	-	X	L	U	-	Common reed
Pseudoraphis spinescens	H	-	-	-	-	-	-	-	-	X	-	-	-	M	U	-	Mud grass
Schizachyrium fragile	H	X	-	-	-	X	-	-	-	-	-	-	-	L	U	-	
Setaria surgens	H	-	X	X	-	-	-	-	-	-	-	F	-	L	U	I	
Sporobolus actinocladus	H	-	-	-	-	X	F	X	X	X	F	X	X	H	U	D*	Katoora
Sporobolus australasicus	H	-	-	-	-	-	-	-	-	X	-	-	X	H	U	-	
Sporobolus caroli	H	-	-	-	-	X	F	X	X	F	F	X	F	H	U	D*	Fairy grass
Sporobolus mitchellii	P	-	-	-	-	-	X	-	-	A	X	-	-	L	U	-	Rat's tail grass
Stipa blakei	P	-	-	-	-	-	-	-	X	-	-	-	-	L	U	-	
Stipa scabra	P	-	-	X	-	-	-	-	X	-	-	-	X	L	U	-	
Thellungia advena	H	-	-	-	-	-	-	X	-	X	-	-	-	M	U	-	Collibah grass
Themeda avenacea	P	-	-	-	-	-	-	-	X	-	-	-	-	H	U	-	Native oat grass
Themeda triandra	P	X	X	A	C	X	-	-	A	-	-	X	X	H	U	-	Kangaroo grass
Thyridolepis mitchelliana	P	X	A	A	A	F	-	-	F	-	-	X	-	H	U	-	Mulga mitchell
Thyridolepis xerophylla	P	-	-	X	-	-	-	-	-	-	-	-	-	H	U	-	Mulga mitchell
Tragus australianus	H	-	X	X	X	X	X	-	X	-	X	X	X	M	U	D*	Small burr grass
Triodia marginata	P	A	-	-	-	-	-	-	-	-	-	-	-	L	U	R	Spinifex
Triodia mitchellii var. *mitchellii*	P	A	-	-	-	-	-	-	-	-	-	C	-	L	U	R	
Triodia mitchellii var. *breviloba*	P	X	-	-	-	-	-	-	-	-	-	-	-	L	U	-	
Tripogon loliiformis	H	-	X	X	X	F	F	-	F	X	X	X	X	H	U	-	Five-minute grass
Triraphis mollis	H	X	X	X	X	-	X	-	X	-	-	F	X	H	T	I	Purple plume grass

WARLUS III - SPECIES LIST

Family and species		Land zone															
	Lf	N	S	M	H	R	G	F	E	W	A	D	L	Pal	Tox	Misc	Common name
Uranthoecium truncatum	H	-	-	-	-	-	-	-	-	-	X	-	-	M	U	-	Flat-stem grass
Yakirra australiense	H	X	-	-	-	-	-	-	-	-	-	-	-	L	U	-	Bunch panic
POLYGALACEAE																	
Polygala linarifolia	H	X	-	X	-	-	-	-	-	-	-	-	-	L	U	-	
POLYGONACEAE																	
Muehlenbeckia cunninghamii	S	-	-	-	-	-	X	-	X	A	X	-	F	M	U	-	Lignum
Persicaria lapathifolia	P	-	-	-	-	-	-	-	-	X	-	-	-	L	U	-	
Polygonum plebeium	H	-	-	-	-	-	-	-	-	X	-	-	-	L	U	-	
Rumex brownii	P	-	-	-	-	-	-	-	-	X	-	-	-	L	U	-	Swamp dock
Rumex tenax	P	-	-	-	-	-	-	-	-	X	-	-	-	L	U	-	A dock
PONTEDERIACEAE																	
Monochoria cyanea	P	-	-	-	-	-	-	-	-	X	-	-	-	L	U	-	
PORTULACACEAE																	
Calandrinia balonensis	H	-	X	X	-	-	-	-	-	-	-	X	-	H	T	-	Broad-leaf parakeelya
Calandrinia polyandra	H	-	-	X	-	-	-	-	-	-	-	-	-	M	-	-	
Calandrinia ptychosperma	H	-	X	X	-	-	-	-	-	-	-	-	-	M	C	-	
Calandrinia stangnensis	H	-	-	-	-	-	-	-	X	-	-	-	-	M	U	-	
Calandrinia volubilis	H	-	-	-	-	-	X	-	-	-	-	-	-	M	C	-	
Portulaca filifolia	H	-	X	X	X	X	-	X	-	-	-	X	-	M	C	-	
Portulaca oleracea	H	-	X	X	X	X	X	-	X	X	X	X	X	H	T	-	Munyeroo
PROTEACEAE																	
Grevillea juncifolia	S	A	-	-	-	-	-	-	-	-	-	-	-	L	U	-	Honeysuckle oak
Grevillea striata	T	-	X	X	X	-	-	-	-	-	-	F	-	H	U	-	Beefwood
Hakea fraseri	T	-	X	-	-	-	-	-	-	-	-	X	-	L	U	-	Corkwood oak
Hakea ivoryi	T	-	X	X	X	-	-	-	X	-	-	X	X	L	U	-	Corkwood
Hakea leucoptera	S	-	-	-	-	-	X	C	-	-	-	X	-	M	U	-	Needle wood
Hakea tephrosperma	S	-	-	-	-	-	-	-	X	-	-	-	-	L	U	-	
RANUNCULACEAE																	
Ranunculus pentandrus var. *platycarpus*	H	-	-	-	-	-	-	-	-	X	-	-	-	L	S	-	A buttercup
RHAMNACEAE																	
Alphitonia excelsa	T	X	-	-	-	-	-	-	-	-	-	-	-	H	U	-	Red ash, soap tree
Ventilago viminalis	T	-	X	-	-	X	X	-	X	X	X	F	-	H	T*	-	Vinetree, supple jack
RUBIACEAE																	
Canthium latifolium	S	-	-	-	-	X	-	-	-	-	-	-	-	H	U	-	
Canthium oleifolium	S	X	X	-	-	X	X	-	X	-	-	F	-	H	U	-	Myrtle tree
Hedyotis trachymenoides	H	-	-	X	-	-	-	-	-	-	-	-	-	L	U	-	
RUTACEAE																	
Eremocitrus glauca	S	-	-	-	-	-	-	C	-	-	X	-	-	M	U	-	Lime bush
Geijera parviflora	T	-	X	X	-	X	X	-	X	X	-	A	X	H	U	-	Wilga
Phebalium glandulosum	S	-	-	-	-	C	-	-	-	-	-	-	-	L	U	-	
SANTALACEAE																	
Exocarpos aphyllus	S	-	-	-	-	X	-	-	-	-	-	-	-	H	U	-	Cherrywood
Exocarpos sparteus	S	X	-	-	-	-	-	-	-	-	-	-	-	M	U	-	
Santalum lanceolatum	S	-	-	-	-	X	X	-	-	-	X	X	X	H	U	-	Plumwood
SAPINDACEAE																	
Alectryon oleifolius	S	-	X	X	-	X	X	X	X	X	X	X	X	H	T	-	Boonaree/rosewood
Atalaya hemiglauca	T	-	-	-	-	X	F	-	X	X	X	F	-	H	T	-	Whitewood
Dodonaea boroniifolia	S	F	X	X	-	-	-	-	-	-	-	X	-	L	U	W	Hairy hopbush
Dodonaea peduncularis	S	F	-	-	-	-	-	-	-	-	-	-	-	L	U	-	A hopbush
Dodonaea petiolaris	S	-	-	-	X	A	-	-	-	-	-	-	-	L	U	W	Large-fruited hopbush
Dodonaea sinuolata ssp. *acrodentata*	S	-	-	-	C	A	-	-	X	-	-	-	-	L	U	-	A hopbush
Dodonaea stenophylla	S	-	-	-	-	X	-	-	-	-	-	-	-	L	U	-	Narrow-leaved hopbush

WARLUS III - SPECIES LIST

Family and species		Land zone														
	Lf	N	S	M	H	R	G	F	E	W	A	D	L	Pal	Tox	Misc	Common name
Dodonaea viscosa ssp. *angustissima*	S	X	X	C	-	-	X	-	-	X	-	A	-	L	U	W	Sand-hill hopbush
Dodonaea viscosa ssp. *spatulata*	S	-	-	-	X	X	-	-	-	X	-	-	-	L	U	W	Sticky-leaved hopbush
SCROPHULARIACEAE																	
Mimulus gracilis	H	-	-	-	-	-	-	-	-	X	-	-	X	L	U	-	
Mimulus prostratus	H	-	-	-	-	-	-	-	X	-	-	-	X	L	U	-	
Mimulus repens	H	-	-	-	-	-	-	-	-	-	-	-	X	L	U	-	
Morgania floribunda	P	-	-	-	-	-	-	-	-	-	X	-	X	L	T	-	Morgan flower
Morgania glabra	H	-	-	-	-	-	-	-	-	X	X	-	-	L	U	-	
SOLANACEAE																	
Duboisia leichhardtii	S	-	-	-	-	-	-	-	-	-	-	X	-	M	T	-	
Lycium ferocissimum	S	-	-	-	-	-	-	-	-	-	-	X	-	L	S	I	African box thorn
Nicotiana glauca	S	-	-	-	-	-	-	-	-	X	-	-	-	L	T	-	Tree tobacco
Nicotiana megalosiphon	P	-	-	-	X	-	-	-	-	-	-	-	-	L	U	-	
Nicotiana velutina	P	-	-	-	-	-	-	-	-	-	-	X	-	L	T	-	
Solanum coactiliferum	H	X	-	-	-	-	-	-	-	-	-	-	-	L	U	-	
Solanum ellipticum	P	-	X	F	X	X	X	-	X	X	-	X	X	L	T	D	Potato-bush
Solanum esuriale	P	X	X	X	-	-	F	-	X	X	X	X	-	H	S	D	Quena
Solanum ferocissimum	P	-	X	F	X	X	-	-	X	-	-	X	-	L	S	D	Narrow-leaved gin's whisker
Solanum nigrum	H	-	-	-	-	-	-	-	X	-	-	-	-	M	T	I	Black-berry nightshade
Solanum parvifolium	H	-	X	X	X	-	-	-	-	-	-	-	-	L	U	-	
SPIGELIACEAE																	
Mitrasacme alsinoides	H	-	-	X	-	-	-	-	-	-	-	-	-	L	U	-	
STACKHOUSIACEAE																	
Macgregoria racemigera	H	-	-	-	X	X	-	-	-	-	-	-	-	L	U	-	Carpet-of-snow
Stackhousia viminea	P	X	-	-	-	-	-	-	-	-	-	-	-	L	U	-	
STERCULIACEAE																	
Brachychiton populneus	T	X	X	X	X	-	-	-	-	-	-	X	-	H	T	R	Kurrajong
Brachychiton rupestris	T	-	-	-	-	-	X	-	-	-	-	-	-	H	T	-	
Hannafordia bissellii	S	C	-	-	-	-	-	-	-	-	-	-	-	L	U	-	
Keraudrenia collina	S	X	-	-	-	-	-	-	-	-	-	-	-	L	U	R	
Keraudrenia integrifolia	S	X	-	-	-	-	-	-	-	-	-	-	-	L	U	-	
Melhania oblongifolia	P	X	X	X	X	X	-	-	-	-	-	-	-	L	U	-	
TETRAGONIACEAE																	
Tetragonia tetragonioides	H	-	-	-	-	-	-	-	-	X	-	-	-	H	T*	-	New Zealand spinach
THYMELIACEAE																	
Pimelea elongata	H	-	-	-	-	-	-	-	X	-	-	-	F	L	T	-	
Pimelea linifolia ssp. *linifolia*	P	X	-	-	-	-	-	-	-	-	-	-	-	L	U	R	
Pimelea microcephala	S	X	-	-	-	-	X	X	X	-	X	X	-	L	S	-	Rice flower, flax weed
Pimelea penicillaris	S	-	-	-	-	-	-	-	-	-	-	C	-	L	U	-	
Pimelea simplex ssp. *continua*	H	X	-	-	-	-	-	-	-	-	X	-	X	L	T	D*	
Pimelea trichostachya	H	X	X	X	-	-	-	-	-	X	-	X	-	L	T	D	Poverty bush, broom bush
TILIACEAE																	
Corchorus olitorius	P	-	-	-	-	-	-	-	-	X	-	-	-	L	S	I	Jute
TYPHACEAE																	
Typha angustifolia	P	-	-	-	-	-	-	-	-	-	-	-	X	M	U	D	Bullrush
VERBENACEAE																	
Verbena officinalis	P	-	-	-	-	-	-	-	-	X	X	-	X	L	S	-	Common verbena
Verbena tenuisecta	P	-	-	-	-	-	-	-	-	X	-	X	-	L	S	-	
VIOLACEAE																	
Hybanthus aurantiacus	P	-	-	-	-	X	-	-	-	-	-	-	-	L	S	-	

WARLUS III - SPECIES LIST

Family and species	Lf	N	S	M	H	R	G	F	E	W	A	D	L	Pal	Tox	Misc	Common name
						Land zone											
Hybanthus monopetalus	P	X	-	-	-	-	-	-	-	-	-	-	-	L	U	-	
XANTHORRHOEACEAE																	
Lomandra leucocephala	P	-	-	-	-	-	-	-	-	-	-	X	-	L	U	-	Mat rush
Lomandra longifolia	P	-	-	-	-	-	-	-	-	X	-	-	-	M	S	-	Long-leaved mat rush
Lomandra patens	P	-	-	-	-	X	-	-	-	-	-	-	-	M	S	-	
Xanthorrhoea johnsonii	S	C	-	-	-	-	-	-	-	-	-	-	-	L	S	R	Grass tree, black boy
ZYGOPHYLLACEAE																	
Tribulus terrestris	H	-	X	-	-	-	X	-	-	-	X	X	-	H	T	-	Caltrop
Zygophyllum apiculatum	P	-	-	-	-	X	X	-	-	-	-	-	-	L	S	-	Gall weed
Zygophyllum iodocarpum	P	-	-	-	-	-	X	-	-	-	-	X	-	M	U	-	
Zygophyllum simile	H	-	-	-	-	-	-	-	-	-	X	-	-	M	T	-	Twin-leaf
AZOLLACEAE																	
Azolla filiculoides var. *rubra*	H	-	-	-	-	-	-	-	-	X	-	-	-	L	U	-	Duck weed
MARSILEACEAE																	
Marsilea sp. aff. *M. angustifolia*	H	-	-	-	-	-	-	-	-	-	-	-	X	M	S	-	Nardoo
Marsilea drummondii	H	-	-	-	-	-	-	-	X	X	X	-	F	M	S	-	Nardoo
Marsilea exarata	H	-	-	-	-	-	-	-	-	X	-	-	-	M	U	-	Nardoo
Marsilea hirsuta	H	-	-	-	-	-	-	-	X	X	-	-	X	M	S	-	Nardoo
OPHIOGLOSSACEAE																	
Ophioglossum lusitanicum	H	-	-	-	X	-	-	-	-	-	-	-	-	L	U	-	
Ophioglossum petiolatum	H	-	-	-	X	-	-	-	-	-	-	-	-	L	U	-	
Ophioglossum polyphyllum	H	-	-	-	X	-	-	-	-	-	-	-	-	L	U	-	
SINOPTERIDACEAE																	
Cheilanthes distans	H	-	-	-	-	-	-	-	-	-	-	-	X	M	S	-	Rock fern
Cheilanthes sieberi	H	-	F	F	F	X	-	-	X	-	-	-	X	M	S	-	Mulga fern, rock fern

APPENDIX IIIB
Common names - scientific names for the more common species

Common name	Scientific name
Annual saltbush	*Atriplex muelleri*
Arm grass millet	*Brachiaria subquadripara*
Australian carrot	*Daucus glochidiatus*
Barley Mitchell grass	*Astrebla pectinata*
Bathurst burr	*Xanthium spinosum*
Beefwood	*Grevillea striata*
Belah	*Casuarina cristata*
Belah grass	*Paspalidium constrictum*
Belalie	*Acacia stenophylla*
Bendee	*Acacia catenulata*
Berrigan	*Eremophila longifolia*
Birdsville indigo	*Indigofera linnaei*
Bitter bark	*Alstonia constricta*
Black-berry nightshade	*Solanum nigrum* ssp. *nigrum*
Black box	*Eucalyptus largiflorens*
Black crumbweed	*Chenopodium melanocarpum*
Black fuchsia	*Eremophila glabra*
Black spear grass	*Heteropogon contortus*
Bluegrass	*Dichanthium* spp.
Blue parsnip	*Trachymene glaucifolia*
Bloodwood	*Eucalyptus* spp.
Boggabri	*Amaranthus mitchellii*
Boobialla or waterbush	*Myoporum acuminatum*
Boonaree	*Alectryon oleifolius*
Bottle tree	*Brachychiton rupestris*
Bottle washer grasses	*Enneapogon* spp.
Bowyakka	*Acacia microsperma*
Box	*Eucalyptus* spp.
Brigalow	*Acacia harpophylla*
Broombush	*Apophyllum anomalum*
Broughton pea	*Swainsona procumbens*
Budda bush	*Eremophila sturtii*
Buffel grass	*Cenchrus ciliaris*
Bull Mitchell grass	*Astrebla squarrosa*
Burrs	*Sclerolaena* spp.
Butter bush	*Cassia nemophila*
Butterfly bush	*Petalostylis labicheoides*
Button grass	*Dactyloctenium radulans*
Caltrop	*Tribulus terrestris*
Carabeen	*Eucalyptus tessellaris*
Cassias	*Cassia* spp.
Caustic weed	*Euphorbia drummondii*
Charleville turkey bush	*Eremophila gilesii*
Colony wattle	*Acacia murrayana*
Comb chloris	*Chloris pectinata*
Comet grass	*Perotis rara*
Coolibah	*Eucalyptus microtheca*
Corkwood	*Hakea ivoryi*
Cotton bush	*Mairena aphylla*
Cow vine	*Ipomoea lonchophylla*
Creek wilga	*Eremophila bignoniiflora*
Crested goosefoot	*Chenopodium cristatum*
Curly Mitchell grass	*Astrebla lappacea*
Curly windmill grass	*Enteropogon acicularis*
Cypress pine	*Callitris columellaris*
Daisies	*Calotis cuneata*; Brachyscome whitei
Dawson gum or blackbutt	*Eucalyptus cambageana*
Desert blue grass	*Bothriochloa ewartiana*
Doolan or sally wattle	*Acacia salicina*

Common name	Scientific name
Early spring grass	*Eriochloa pseudoacrotricha*
Eastern dead finish	*Archidendropsis basaltica*
Ellangowan poison bush	*Myoporum deserti*
Emu apple	*Owenia acidula*
Fairy grass	*Sporobolus caroli*
Featherton wire grass	*Aristida latifolia*
Fire bush	*Cassia pleurocarpa*
Flinders grass	*Iseilema* spp.
Forest gum	*Eucalyptus intertexta*
Fuchsia bush	*Eremophila maculata*
Galvanized burr	*Sclerolaena birchii*
Gidgee	*Acacia cambagei*
Golden beard grass	*Chrysopogon fallax*
Golden billybuttons	*Craspedia chrysantha*
Gomphrena weed	*Gomphrena celesioides*
Green turkey bush	*Eremophila gilesii*
Grey-beard grass	*Amphipogon caricinus*
Gunda-bluey	*Acacia victoriae*
Hairy hopbush	*Dodonaea boroniifolia*
Hairy panic grass	*Panicum effusum*
Honeysuckle oak	*Grevillea juncifolia*
Hoop Mitchell grass	*Astrebla elymoides*
Hopbush	*Dodonaea* spp.
Ironbark	*Eucalyptus* spp.
Ironwood	*Acacia excelsa*
Kangaroo grass	*Themeda triandra*
Katoora	*Sporobolus actinocladus*
Kerosene grass	*Aristida contorta*
Kurrajong	*Brachychiton populneus*
Lancewood	*Acacia petraea*
Leopardwood	*Flindersia maculosa*
Lignum	*Muehlenbeckia cunninghamii*
Lignum fuchsia	*Eremophila polyclada*
Lime bush	*Eremocitrus glauca*
Long friuted bloodwood	*Eucalyptus dolichocarpa*
Love grasses	*Eragrostis* spp.
Mexican poppy	*Argemone ochroleuca*
Micromyrtus	*Micromyrtus hexamera*
Mint bush	*Prostanthera suborbicularis*
Mitchell grasses	*Astrebla* spp.
Morgan flower	*Morgania floribunda*
Mountain box or bendo	*Eucalyptus exserta*
Mountain yapunyah	*Eucalyptus thozetiana*
Mulga	*Acacia aneura*
Mulga fern or rock fern	*Cheilanthes sieberi*
Mulga mitchell	*Thyridolepis mitchelliana*
Mulga mitchell	*Thyridolepis xerophila*
Mulga nettle	*Haloragis odontocarpa*
Mulga oat grass	*Monachather paradoxa*
Munyeroo or pigweed	*Portulaca oleracea*
Myall	*Acacia pendula*
Myrtle tree	*Canthium oleifolium*
Narrow-leaf bumble	*Capparis loranthifolia*
Native couch grass or spider grass	*Brachyachne convergens*
Native or wild millet	*Panicum decompositum*
Native parsnip	*Trachymene cyanantha*
Native tobacco	*Nicotiana suaveolens*
Needlewood	*Hakea leucoptera*
Nelia	*Acacia oswaldii*
Nettle-leaf goosefoot or red crumbweed	*Dysphania glomulifera*
Neverfail grass	*Eragrostis setifolia*
New Zealand spinach	*Tetragonia tetrogonioides*
Nipan or split jack	*Capparis lasiantha*

Common name	Scientific name
Noogoora burr	*Xanthium pungens*
Oldman saltbush	*Atriplex nummularia*
Paper-bark tea-tree	*Melaleuca trichostachya*
Parakeelya	*Calandrinia* spp.
Parkinsonia	*Parkinsonia aculeata*
Pepper grass	*Panicum laevinode*
Phebalium	*Phebalium glandulosum*
Pigweed	*Portulaca filifolia*
Pitted bluegrass	*Bothriochloa decipiens*
Plantain	*Plantago* spp.
Plumwood	*Santalum lanceolatum*
Poplar box	*Eucalyptus populnea*
Potato bush	*Solanum ellipticum*
Poverty bush	*Pimelea trichostachya*
Prickly paddy melon	*Cucumis myriocarpus*
Purple leaved goosefoot	*Chenopodium atriplicinum*
Purple plume grass	*Triraphis mollis*
Queensland bluebush	*Chenopodium auricomum*
Queensland bluegrass	*Dichanthium sericeum*
Raspweed	*Haloragis aspera*
Rat's tail couch	*Sporobolus mitchellii*
Red spinach	*Trianthema triquetra*
Ridge grass	*Enneapogon avenaceus*
River red gum	*Eucalyptus camaldulensis*
Rock grass	*Eriachne mucronata*
Rough barked apple	*Angophora floribunda*
Ruby saltbush	*Enchylaena tomentosa*
Saltbushes	*Atriplex* spp.
Sandalwood	*Eremophila mitchellii*
Sandhill hopbush	*Dodonaea viscosa* ssp. *angustissima*
Silky goodenia	*Goodenia fascicularis*
Silver cassia	*Cassia artemisioides*
Silver-leaved ironbark	*Eucalyptus melanophloia*
Silver turkey bush	*Eremophila bowmanii*
Small burr grass	*Tragus australianus*
Smooth minuria	*Minuria integerrima*
Soda bush	*Neobassia proceriflora*
Soft roly-poly	*Salsola kali*
Spinifex	*Triodia basedowii*
Swamp cane grass	*Eragrostis australasica*
Three-awned Wanderrie	*Eriachne aristidea*
Thryptomene	*Thryptomene* spp.
Tobacco tree	*Nicotiana glauca*
Turkey bush	*Eremophila gilesii*
Turpentine mulga	*Acacia brachystachya*
Twin-leaf	*Zygophyllum simile*
Umbrella cane grass	*Leptochloa digitata*
Vinetree or supplejack	*Ventilago viminalis*
Warrego summer grass	*Paspalidium rarum*
Wattles	*Acacia* spp.
Western bloodwood	*Eucalyptus terminalis*
Western dead-finish	*Acacia tetragonophylla*
White spear grass or feathertop wire grass	*Aristida latifolia*
Whitewood	*Atalaya hemiglauca*
Wild parsnip	*Trachymene ochracea*
Wilga	*Geijera parviflora*
Winged or large-flowered chloris	*Oxychloris scariosa*
Wire grasses	*Aristida* spp.
Woollybutt grass	*Eragrostis eriopoda*
Woollybutt Wanderrie	*Eragrostis helmsii*
Yapanyah	*Eucalyptus ochrophloia*
Yarran	*Acacia omalophylla*
Yellow threeawn	*Aristida anthoxanthoides*
Yellow wood sorrel	*Oxalis corniculata*

APPENDIX IV

LAND SYSTEMS
by J.R. Mills and R.W. Purdie

Sandhills
- D1 Camden
- D2 Retreat
- D3 Gowrie

Spinifex sandplains
- N1 Shelbourne

Mulga sandplains
- S1 Charleville
- S2 Eulo
- S3 Glenmore

Poplar box lands
- E1 Bendena
- E2 Loddon
- E3 Halton
- E4 Elverston

Soft mulga lands
- M1 Arabella
- M2 Nebine
- M3 Humeburn
- M4 Norah park
- M5 Nimaru

Hard Mulga lands
- H1 Sommariva
- H2 Erac
- H3 Boatman
- H4 Gilruth

Dissected residuals
- R1 Colanchie
- R2 Quilberry
- R3 Leader

Gidgee lands
- G1 Kennedy
- G2 Killowen
- G3 Ivanhoe

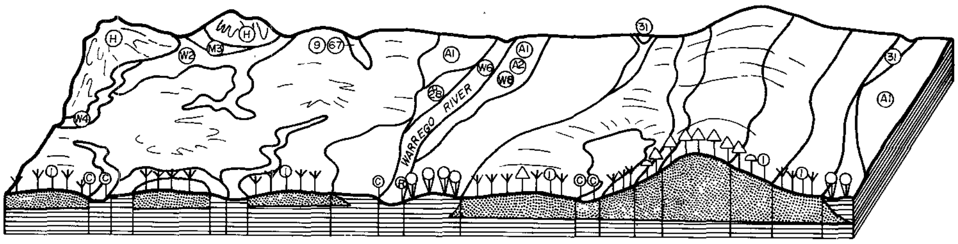
Downs
- F1 Coreena

Alluvial plains (open)
- A1 Noorama
- A2 Padua
- A3 Westgate

Alluvial plains, woodlands
- W1 Boin
- W2 Dartmouth
- W3 Kudnapper
- W4 Widgee
- W5 Bluegrass
- W6 Warrego
- W7 Langlo
- W8 Tuen

Claypans
- L1 Elmina
- L2 Ardgour

D1 Camden (3 470km²)



Land Unit and / or Associated Land System	62	A2 W3	3	62	3	W3 W4	62	A1, A2 W8	W6	G2	62	W8 L2	62	60	61	60	62	G2	A1
Sites											D35, E525, E527, E622				D209, D220, D230, D233				
Est. % of Land System			<1					15		20	40	5			10	10			

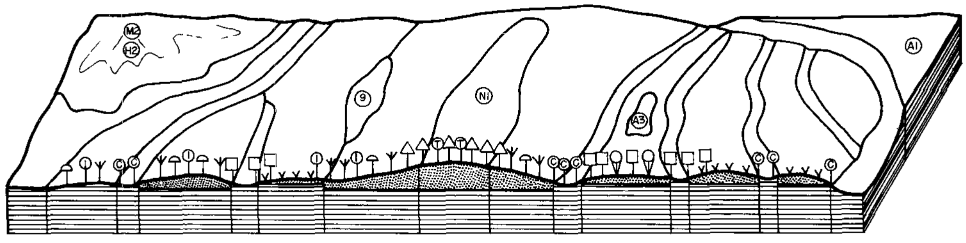
LANDFORM: Sand mounds and low dunes on alluvial plains. Slopes <10%, median 1%.

GEOLOGY: Quaternary sands. Qs.

SOILS: Predominantly deep, red, earthy sands, Uc1.23, Uc1.43, with limited areas of yellowish red, siliceous sands, Uc1.23, Uc1.22, where dunes are better developed. Alluvial texture contrast soils occur around the fringes of the sand mounds, Dr2.13, Dr2.53, and heavy, alluvial, clay, soils occur in the drainage lines and swamps, Ug5.24.

VEGETATION: Grassy, cypress pine woodland to open woodland on the crests of the sand-hills. Wilga, vinetree, beefwood and whitewood shrubby low open woodland, or mulga, ironwood low woodland on the slopes, gidgee low woodland fringes the sand-hills, and poplar box, coolibah or yapunyah (low) woodland occurs along drainage lines. (Minor coolibah low woodland, Queensland bluebush low open shrubland or swamp canegrass open hummock grassland occur in internal drainage swamps.)

D2 Retreat (940km²)



Land Unit and / or Associated Land System	A3	60	21 31	60	21 31	22	60	63	60	21 31	7	21 31	22	21 31	22	W6		
Sites									D110, D201, E543				E573, E619					
Est. % of Land System								5-10	20	15-20	5-10		45-50					

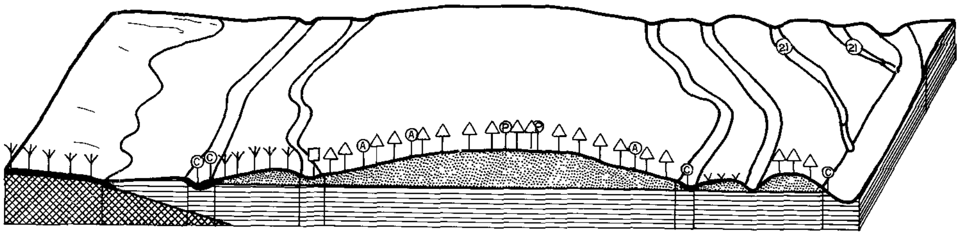
LANDFORM: Flat to gently undulating plains or levees with frequent channels. These areas occur adjacent to major streams. Relief <3m.

GEOLOGY: Quaternary alluvium. Qa, Qs.

SOILS: Very deep, brown, alluvial soils, Uf1.42, with minor areas of red to yellowish red, loamy sands, Uc1.23. Alluvial texture contrast soils, Dr2.13, Dr2.52 and heavy, grey, alluvial clays, Ug5.24, occur in the channels.

VEGETATION: Gundabluey open shrubland to shrubby open grassland or herbland with scattered western bloodwood, poplar box, vinetree and whitewood. Wilga, beefwood and ironwood low open woodland, and minor areas of cypress pine woodland occur on sandier soils. (Coolibah or poplar box woodland is present along associated drainage lines, and minor box/gidgee, sandalwood shrubby woodland on associated plains.)

D3 Gowrie (160km^2)



Land Unit and/or Associated Land System	S, M, H Land Zones	A3	21	60	31	63	21	D2	W6	W6	D2
Sites						D5, D43, E618					
Est. % of Land System		10	5	5	5-10	60		10-20			

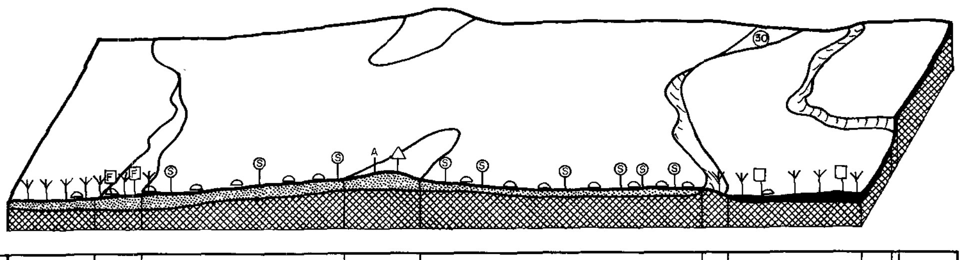
LANDFORM: Flat to very gently undulating plains composed of levees and sandsheets on alluvia, fringing major streams. Relief <3m.

GEOLOGY: Quaternary alluvium. Qa, Qs.

SOILS: Very deep, yellowish red, earthy sands predominate, Uc1.23. Minor areas of deep brown and reddish brown, alluvial soils, Uf1.42, Uf6.12, occur around the fringes of the sand-hills.

VEGETATION: Grassy cypress pine woodland to open woodland with scattered carbeen, long-fruited bloodwood and silver-leaved ironbark, with minor areas of wilga, beefwood, ironwood and/or mulga low woodland to low open woodland. (Gundabluey open shrubland to shrubby, open grassland or herbland occurs on associated levees, and poplar box or coolibah woodland along the drainage lines. Adjacent plains support a shortgrass sparse grassland with scattered whitewood and poplar box.)

N1 Shelbourne (1 200km^2)



Land Unit and/or Associated Land System	S2	30	64	61	64	H3 H4	M2		
Sites					D38, D113, D130, E511, E568				
Est. % of Land System		5		< 2	90	< 5			

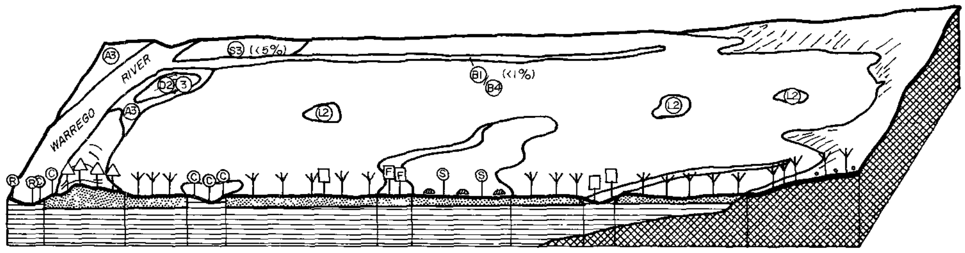
LANDFORM: Flat to gently undulating plains. Relief <5m. Slopes typically <1%.

GEOLOGY: Quaternary sand sheet. Qs.

SOILS: Very deep, red to yellowish red, earthy sands, Uc1.23.

VEGETATION: Spinifex, silver-leaved ironbark wooded or shrubby hummock grassland to grassy low open woodland or tall open shrubland, frequently with honeysuckle oak, Acacia spp., hopbush and other shrubs, forest gum, mulga. Spinifex grassy (low) woodland to (low) open woodland occurs in marginal areas. Cypress pine, rough-barked apple and long-fruited bloodwood are sometimes prominent on sandy ridges.

S1 Charleville (930km^2)



Land Unit and/or Associated Land System	W6	D2, D3	45	L2	45	30	N1	45	B4 W1	45	H1	
Sites					D20, D31, D28, D36, E590, E592, E593							
Est. % of Land System		< 5		< 5	85	< 1	5		< 1			

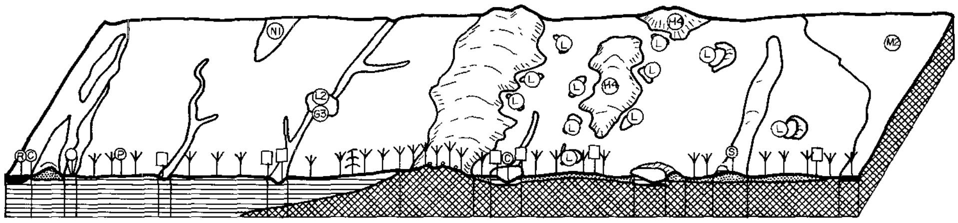
LANDFORM: Flat plains. Slopes <1%.

GEOLOGY: Quaternary sand sheet. Qs.

SOILS: Deep to very deep, sandy, red earths, Uc1.43, Uc1.23, Gn2.12, predominate.

VEGETATION: Predominantly mulga low open forest to low woodland, with scattered poplar box, beefwood, and ironwood, and green turkey-bush often prominent. (Minor areas of spinifex, silver-leaved ironbark wooded hummock grassland occur, with forest gum in marginal areas. Poplar box woodland fringes infrequent drainage lines, and brigalow low woodland to tall shrubland occurs on minor scattered claypans.)

S2 Eulo (2 140km^2)



Land Unit and/or Associated Land System	A1 A3	D1 D2	G 3	47	E 4	47	E 4	47	H4	44	L1 L2 E4	44	L1 L2	D1 61	44	N1 61	44	M 2	
Sites						D103, D119, D214, E554						D136, D137, D206, E547							
Est. % of Land System						40	<5		5-10			40	5-10	<1		< 1			

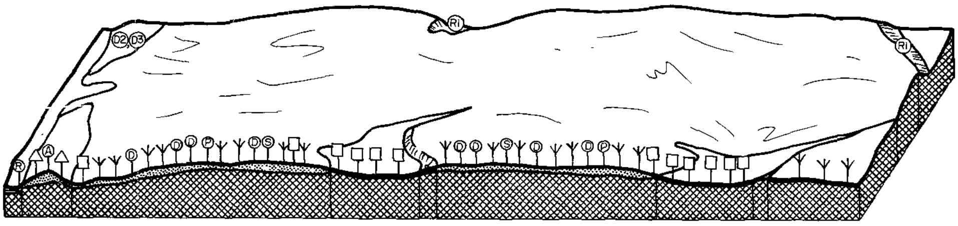
LANDFORM: Predominantly flat to gently undulating plains with slopes <1% and relief <4m. Small claypans occur frequently and occasional low rises are present.

GEOLOGY: Quaternary sand sheets. Qs.

SOILS: Shallow to moderately deep, sandy, red earths predominate, Um1.43, Uc5.21, Gn2.12. Minor areas of yellowish red, earthy sands, Uc1.23, occur as low sand-hills, and shallow, sandy, red earths are associated with the low, gravelly rises, Uc1.43.

VEGETATION: Mulga low woodland, with scattered beefwood, ironwood, corkwood and long-fruited bloodwood, to wooded tussock grassland, frequently with sand-hill hopbush, budda bush, green turkey-bush and butter bush. On loamier soils (and associated hard mulga land systems), mulga low woodland with scattered poplar box, to mulga, poplar box open woodland occurs. (Drainage systems support poplar box low woodland, with coolibah, yarran, bowyakka or belah low woodland/tall shrubland, and/or wooded herbland or sedgeland where claypans develop. Minor areas of spinifex, silver-leaved ironbark wooded hummock grassland occur on the plains.)

S3 Glenmore (510km^2)



Land Unit and / or Associated Land System	W1	D2 D3	51	E3	H1	51	E3	H1	M1	M1	51	R1
Sites						D16, E600						
Est. % of Land System		< 5		5-10	<1	90						

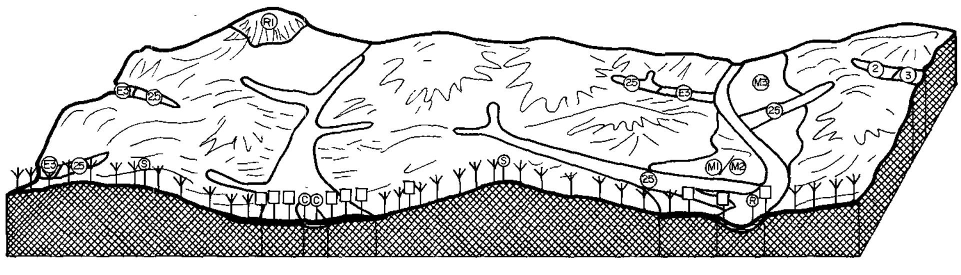
LANDFORM: Gently undulating plains. Slopes 1-2%. Relief <5m.

GEOLOGY: Quaternary sands over the Tertiary land surface. Qs.

SOILS: Deep, sandy, red earths predominate, with minor areas of red to yellowish red, earthy sands adjacent to alluvial plains, Uc1.43. Red clays are present in the run-off areas, Uf6.12.

VEGETATION: Predominantly mulga, poplar box, eastern dead finish low woodland to shrubby, low open woodland with scattered silver-leaved ironbark, vinetree, ironwood, wilga, and boonaree. Minor poplar box woodland to open woodland occurs on associated drainage systems.

E1 Bendena (340km^2)



Land Unit and / or Associated Land System	H1	25	W2	25	H1 / M1	M1 / M2	W1 W7	H1 / M1		E2 E3	
Sites		D11, D21, D106, D116, D124 E562, E569, E586, E589									
Est. % of Land System		80	< 2		5-10	5-10	< 2			10	

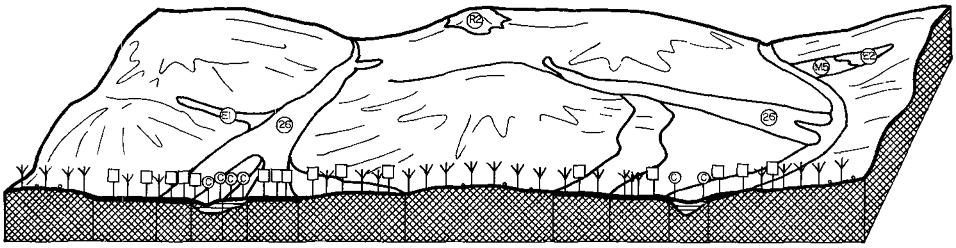
LANDFORM: Gently sloping, slightly concave plains, forming run-on areas. These areas extend to form drainage systems running down to local alluvia.

GEOLOGY: Quaternary erosion products covering the Tertiary land surface. Qr.

SOILS: Moderately deep to deep, reddish brown, texture contrast soils predominate, Dr2.13, Dr2.53, Dr2.72, Dy2.12. Associated are minor areas of shallow to moderately deep, red earths, Um1.43, Gn2.12, Uf5.12, and (rarely), alluvial, cracking clays, Ug5.24.

VEGETATION: Predominantly poplar box, sandalwood shrubby woodland to open woodland, becoming a grassy, poplar box woodland where flats are better developed, Very rarely, brigalow low woodland occurs in central run-on areas.

E2 Loddon (420km^2)



Land Unit and / or Associated Land System	H2	M4	26	W1	W2	26	M4	H2	M4	M5	W1	H2	
Sites						D109, D133, E552, E556, E623							
Est. % of Land System				< 5	< 5	80	5			10			

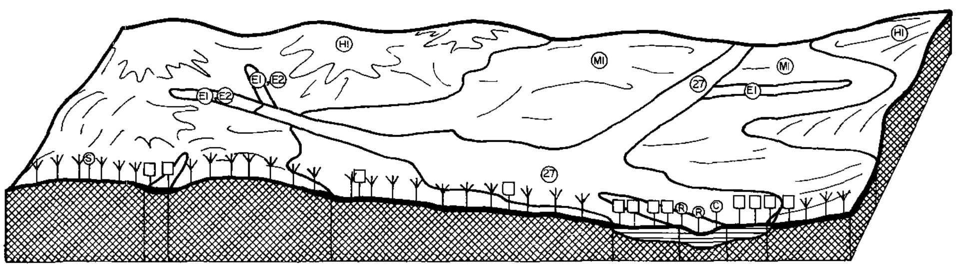
LANDFORM: Gently undulating slightly concave plains, forming run-on areas which extend to join local alluvia.

GEOLOGY: Quaternary erosion products covering the Tertiary land surface. Qr.

SOILS: Moderately deep to deep, loamy, red earths predominate, Gn2.12, Um1.43, Um5.52.

VEGETATION: Predominantly poplar box, mulga low woodland to low open woodland. Rarely river red gum or coolibah woodland in the lower reaches or brigalow and gidgee low woodland/tall shrubland in central run-on areas.

E3 Halton (200km^2)



Land Unit and / or Associated Land System	H1	E1 E2	H1	M1	27	W1	27	M1	M1	H1
Sites					D18, D32, E537, E601					
Est. % of Land System		< 10		5	85	5				

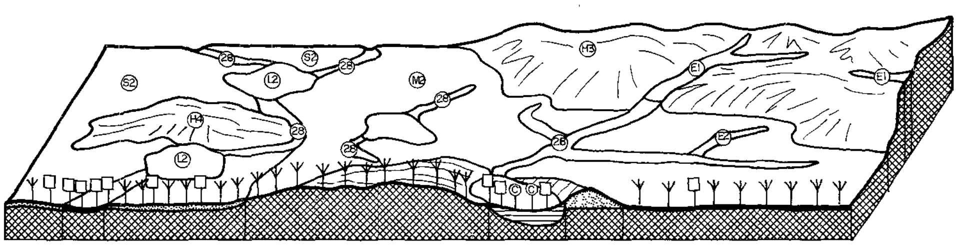
LANDFORM: Gently undulating, slightly concave plains, forming run-on areas draining onto local alluvia.

GEOLOGY: Quaternary erosion products over the Tertiary land surface. Qr.

SOILS: Moderately deep to deep, red clays, Uf6.12, and associated areas of loamy, red earths, Gn2.12, Um1.43.

VEGETATION: Predominantly poplar box (low) woodland to (low) open woodland, with mulga or sandalwood common in the upper reaches. Rarely, coolibah woodland in central areas.

E4 Elverston (660km²)



Land Unit and/or Associated Land System	S2	28	S2	H4	L2	28, D1	M2	M2		E1	H3
Sites		D44, E565			E557						
Est. % of Land System		85	5		< 10	< 1				5	

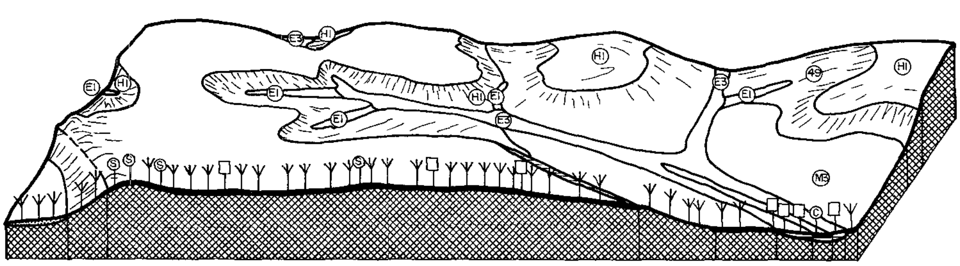
LANDFORM: Shallow drainage lines developed on flat plains.

GEOLOGY: Redistributed Quaternary erosion products. Qr, Qs.

SOILS: Moderately deep to deep, sandy, red earths, Uc1.43, and reddish brown clays, Uf6.31, predominate.

VEGETATION: Predominantly poplar box low woodland to low open woodland, with mulga often predominant, and sandalwood common in the upper reaches. Minor poplar box or coolibah woodland, and/or herbland and sedgeland occur in well-developed central areas.

M1 Arabella (2 270km²)



Land Unit and/or Associated Land System	S1	H1	49	H1	M3	B3	W1	B3	M3	M3	49	H1
Sites			D13, D15, D22, D23, D29, D39, E581, E587, E598, E599, E626, E627									
Est. % of Land System		5-10	85		5-10							

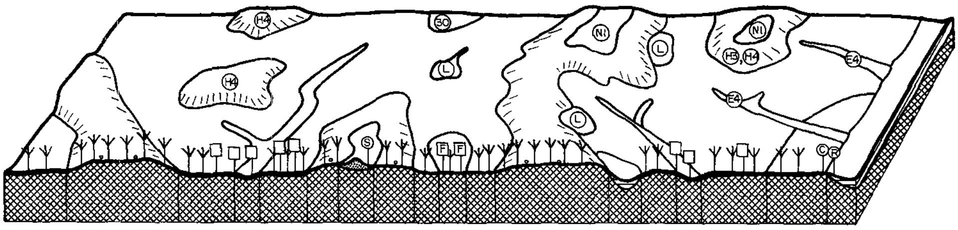
LANDFORM: Gently undulating plains, with well-defined, run-on areas. Slopes <3%. Relief to 20m.

GEOLOGY: Superficial Quaternary cover over the Tertiary land surface. Qs. Qr.

SOILS: Shallow to moderately deep, loamy, red earths, Um1.43, Um5.51, Um5.52, Gn2.11. Surface gravel and ironstone shot cover are common on the crests of the the rises. Deep, red, texture contrast soils (frequently with hardpans), Dr2.52, Dr3.12, Dr3.5, and red clays, Uf6.12, occur in the run-on areas.

VEGETATION: Predominantly mulga low woodland with emergent poplar box, silver-leaved ironbark and scattered kurrajong, to mulga, poplar box, silver-leaved open woodland. Silver-leaved ironbark, mulga woodland is common on upper slopes, ridges and in eastern areas. . Poplar box woodland to open woodland, with sandalwood prominent in some areas, occurs in the drainage systems, (and mulga, box low woodland on the associated flat plains).

M2 Nebine (6 590km²)



Land Unit and / or Associated Land System	M1, S2	H4	43, 46	E4	43, 46	H4	N1	H4	43 46	30	43 46	H3, H4	L1 L2	43	E1 E4	43	M1, S2	W1	
Sites			D46, D104, D105, D112, D121, D123, D129, D207, D223, E507, E558, E564, E631		D45, D131, D132, D205, D215, D240, E556, E628														
Est. % of Land System					70		< 5			< 5		15	5		5				

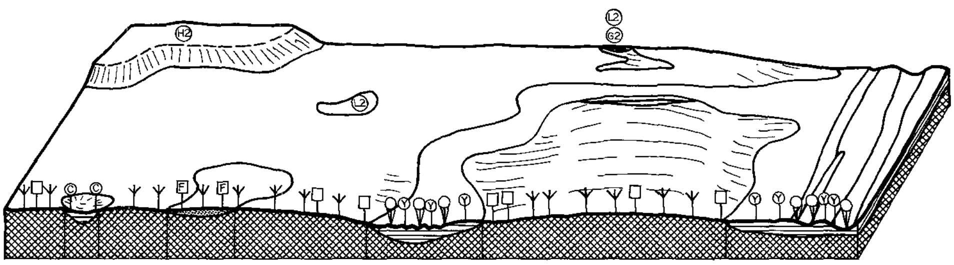
LANDFORM: Flat plains with occasional low rises. Slopes <1%. Relief <5m.

GEOLOGY: Superficial Quaternary deposits over the Tertiary land surface. Qs, Qr.

SOILS: Shallow to moderately deep, sandy, red earths and loamy, red earths, Um1.43, Gn2.12, Uc1.43, Uc1.23. Very shallow to shallow, loamy, red earths and sandy, red earths with surface gravel or ironstone shot cover are associated with low rises. Moderately deep to deep, reddish brown clays, texture contrast soils occur in the drainage lines, Uf6.31, Uf5.12, Dr2.13, Dr2.53, Dr2.72, Dy2.12. Minor areas of red to yellowish red, earthy sands are present, Uc1.23.

VEGETATION: Mulga, poplar box low open forest, to poplar box, mulga open woodland, with butter bush, green turkey-bush, sand-hill hopbush and Micromyrtus hexamera conspicuous in sandier areas. Minor forest gum, mulga woodland to shrubby open woodland and spinifex, silver-leaved ironbark wooded hummock grassland occur on the plains. Poplar box, mulga/sandalwood low woodland occurs in the drainage systems with minor areas of claypan vegetation. (Associated hard mulga land systems support mulga, poplar box low woodland.)

M3 Humeburn (1 150km²)



Land Unit and / or Associated Land System	52	L2 G3	52	30	52	W2	52	W2	
Sites							D3, D26, E596, E607, E609, E612, E621, E637		
Est. % of Land System		5		< 5		5-10	85		

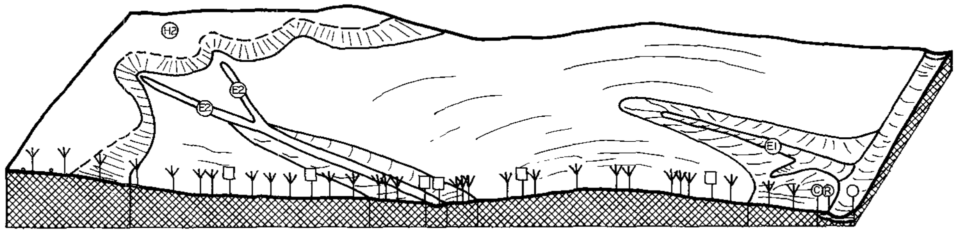
LANDFORM: Flat plains, grading into alluvia on the lower slopes. Slopes <1%. Relief <10m, typically 3-5m.

GEOLOGY: Quaternary cover over the Tertiary land surface. Qr.

SOILS: Shallow to moderately deep, loamy, red earths, Um1.43, and red, texture contrast soils, Dr2.52, Dr3.12, Dr3.5. Hardpan layers are frequently present at depths ranging from 30 to 100cm. Minor areas of sandy, red earths Um5.42 and alluvial, clay soils, Ug5.24, Ug5.34, are present.

VEGETATION: Predominantly mulga, poplar box low woodland, to mulga, poplar box, turkey-bush shrubby (low) open woodland. Poplar box, sandalwood shrubby low open woodland is common in lower areas adjacent to the alluvia. Minor forest gum, mulga shrubby open woodland occurs on the plains, and brigalow or gidgee low woodland or tall shrubland on scattered claypans. (Associated alluvia support gidgee, yapunyah open forest to low woodland.)

M4 Norah Park (600km^2)



Land Unit and / or Associated Land System	H2	48	M5	E1 E2	M5	48	M5	W1	
Sites		D2, D17, D19, D33, D34, E504, E505, E613							
Est. % of Land System	10	75	10	5					

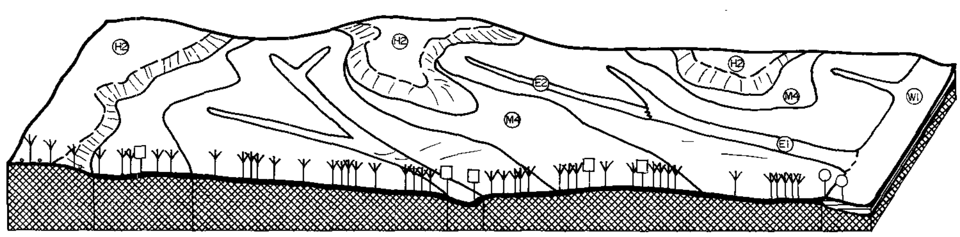
LANDFORM: Gently undulating plains with slopes <1% sloping down to run-on areas and local alluvia. Relief typically 5-10m.

GEOLOGY: Superficial Quaternary deposits over the Tertiary land surface. Qr.

SOILS: Shallow to moderately deep, loamy, red earths, Um1.43, Um5.51, Gn2.11, predominate. Limited areas of deep, loamy red earths and texture contrast soils, Dr2.13, Dr2.12, Dr2.53, Dr2.72, occur in the drainage lines and run-on areas. On the upper slopes, soils grade into shallow, loamy, red earths, Um1.43, usually with ironstone shot and gravel cover.

VEGETATION: Predominantly mulga low open forest with emergent poplar box, to mulga, poplar box open woodland. Poplar box/mulga, sandalwood shrubby woodland to open woodland occur in the drainage systems. Minor groved mulga low woodland occurs on associated run-on plains (M5 land system), and mulga, poplar box/green turkey-bush low woodland to tall shrubland on associated hard mulga land systems.

M5 Nimaru (330km^2)



Land Unit and / or Associated Land System	H2	M4	53	E2	53	W1	
Sites			D47, D107, D117				
Est. % of Land System		10-20	80	5			

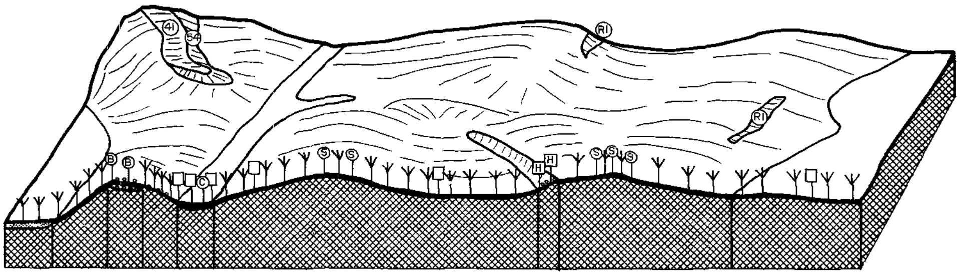
LANDFORM: Flat to gently sloping, slightly concave plains, forming run-on areas. Slopes <2%. Relief <8m.

GEOLOGY: Redistributed Quaternary deposits over the Tertiary land surface. Qs, Qr.

SOILS: Moderately deep, loamy, red earths predominate, Um1.43, Um5.52, Gn2.11. Limited areas of deep, red earths, Gn2.12, Um1.43, occur in the drainage lines.

VEGETATION: Predominantly groved mulga low open forest to low woodland with scattered poplar box. Associated drainage systems support poplar box mulga low woodland to low open woodland. Mulga, poplar box low open forest to tall shrubland is present on the associated, hard mulga land systems.

H1 Sommariva (1 000km^2)



Land Unit and / or Associated Land System	S1	40	41 50	54	E1 E3	40	R1	40	M1	
Sites						D14, D30, D37, D40, E588, E594, E602				
Est. % of Land System			< 2	< 5	5	75	5		10	

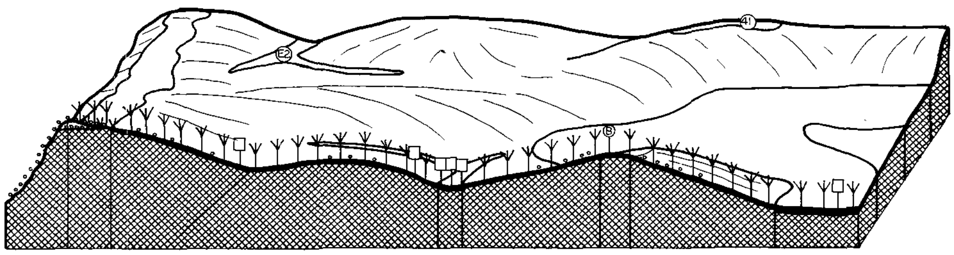
LANDFORM: Gently undulating to undulating plains, frequently grading into low rises on the upper slopes. Slopes <3%. Relief to 15m.

GEOLOGY: Superficial Quaternary cover over the Tertiary land surface. Qr.

SOILS: Shallow to moderately deep, loamy, red earths, Um1.43, Um5.57, Gn2.12, predominate. Surface gravel or ironstone shot cover is common. Minor areas of shallow, gravelly lithosols, Um1.43, Uc1.43, occur on the low rises. Moderately deep to deep, texture contrast soils, Dr2.13, Dr2.53, Dr2.72, Dy2.12, and red clays, Uf6.12, are associated with the 'flats' and drainage lines.

VEGETATION: Predominantly mulga low woodland to low open woodland with scattered poplar box, kurrajong and silver-leaved ironbark, to silver-leaved ironbark, mulga woodland. Minor mulga, western bloodwood low woodland occurs on the tops of low hills, and mulga, poplar box, hopbush shrubby low woodland, or rarely brigalow tall shrubland, on steeper slopes. Poplar box/sandalwood woodland occurs on minor associated drainage lines.

H2 Erac (3 490km^2)



Land Unit and / or Associated Land System	R2	54	38	E2	38	41	38	M4		M5		
Sites			D10, D126, D217, E519, E545, E580									
Est. % of Land System		< 5	80	< 5		2		10-15				

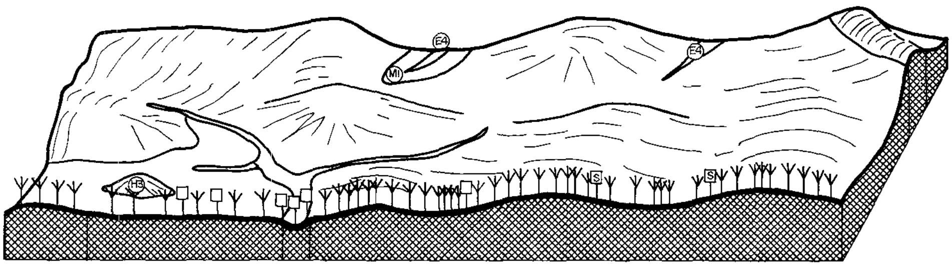
LANDFORM: Gently undulating plains, sloping up to dissected, low hills. Slopes <3%. Relief to 15m.

GEOLOGY: Superficial Quaternary deposits over the Tertiary land surface. Qr.

SOILS: Shallow to very shallow, loamy, red earths predominate. Surfaces are frequently scattered with gravel and ironstone shot, Um1.43, Gn2.11, Uc5.31. Moderately deep to deep, loamy, red earths are associated with the drainage lines or 'flats', Gn2.12, Um1.43, Um5.52.

VEGETATION: Predominantly mulga low woodland/tall shrubland with emergent poplar box, to mulga tall open shrubland or mulga, poplar box open woodland with green turkey-bush often conspicuous. Minor mulga, western bloodwood low woodland or mulga, hopbush shrubby low woodland occur on low hills. Poplar box, mulga low woodland is present in minor associated drainage systems.

H3 Boatman (2 490km^2)



Land Unit and / or Associated Land System	H1	M2	E1 E4 W1	39		R1	39
Sites				D108, D114, D115, D139, D140, D208, E559, E560, E561, E582, E583, E584, E585			
Est. % of Land System		10-15	< 5	85			

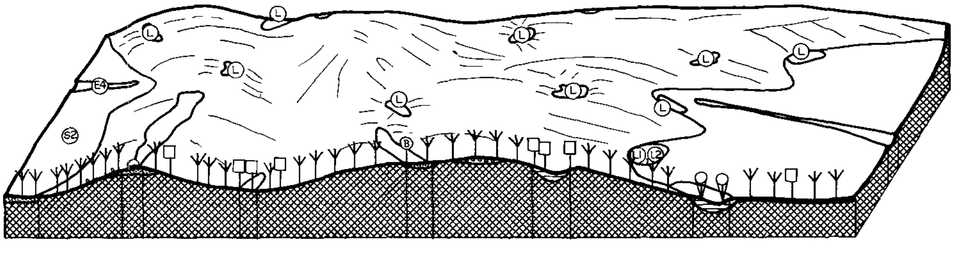
LANDFORM: Gently undulating plains. Slopes <2%. Relief 3-20m.

GEOLOGY: Superficial Quaternary deposits over the Tertiary land surface. Qr.

SOILS: Shallow to moderately deep, loamy, red earths, Um1.43. Ironstone shot and gravel are commonly present on the surface. Minor areas of reddish brown, texture contrast soils, Dr2.13, Dr2.53, Dr2.72, Dr2.12, occur in the associated 'flats' and drainage lines.

VEGETATION: Predominantly mulga low open forest with scattered poplar box, to mulga, poplar box (low) open woodland. Minor drainage systems support poplar box (low) woodland to (low) open woodland, with conspicuous mulga or sandalwood.

H4 Gilruth (1 860km^2)



Land Unit and / or Associated Land System	S2	42	N1	42	L1 L2	42	41	42	L1 L2	42	G Land Zone	M2	M2	E4	M2
Sites						D120, D122, D138		D120, D122, D138							
Est. % of Land System	5		<5			70	< 1		5-10			10-15			

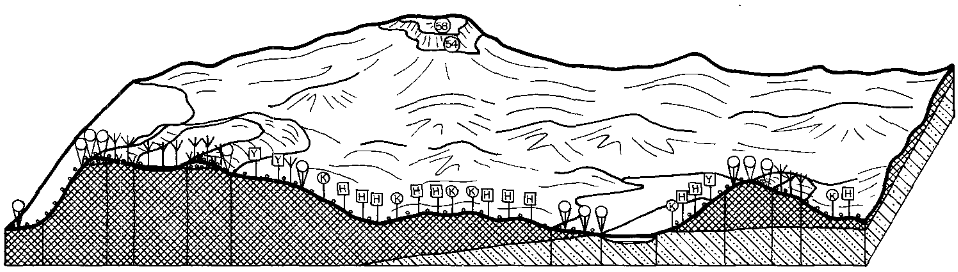
LANDFORM: Very gently undulating plains with scattered, small depressions. Slopes <1%. Relief typically 5m.

GEOLOGY: Superficial Quaternary cover over the Tertiaty land surface. Qs.

SOILS: Very shallow to shallow, sandy, red earths, Uc1.23, Uc1.43. Surfaces are frequently scattered with ironstone shot. Minor areas of moderately deep, earthy sands, Uc1.23, may occur on the tops of the rises. Moderately deep, light-textured, alluvial soils, Dr2.13, Ug5.24, Gn2.11, occur in the depressions.

VEGETATION: Predominantly mulga, poplar box low woodland to wooded tussock grassland. Minor mulga, western bloodwood low woodland or spinifex, silver-leaved Ironbark wooded hummock grassland occur on the tops of low hills. Claypan depressions support poplar box or coolibah (low) woodland to (low) open woodland, herbland and/or sedgeland. Mulga, poplar box low open forest to shrubby open woodland occurs on the associated flat plains.

R1 Colanchie (1 090km²)



Land Unit and / or Associated Land System	G Land Zone	58	54	H1	54 58	57	G1	F1	57	56	H1	57	
Sites		D4	D27, E506			E578, E604, E635							
Est. % of Land System		10	10-15	5		60	5	< 5		5			

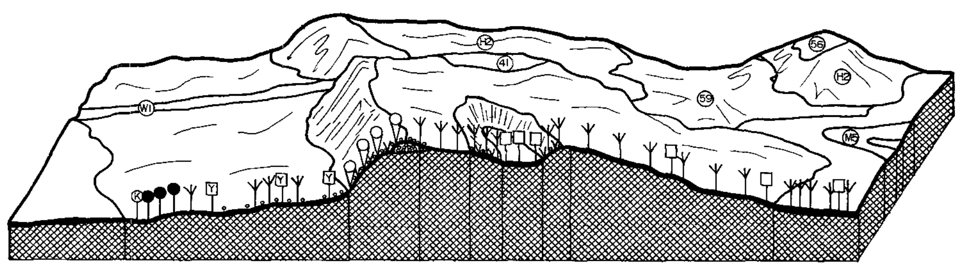
LANDFORM: Undulating plains, sloping up to dissected low hills and scarps. Slopes 3-10%. Relief to 15m.

GEOLOGY: Redistributed Quaternary deposits over chemically-altered and fresh, Cretaceous sediments. These altered sediments are exposed along the scarps.

SOILS: Very shallow lithosols, Um1.43, Uc1.13, Uc1.43, with gravel and grit intermixed, predominate. Surfaces are frequently covered with gravel, and stone and rock may be exposed at the tops of the scarps.

VEGETATION: Brigalow low woodland/tall shrubland with emergent mountain yapunyah or Dawson gum, or rarely, gidgee, hopbush shrubby low woodland, on the slopes and undulating plains. Bendee tall shrubland to mulga, poplar box/silver-leaved ironbark/sandalwood (shrubby) low woodland occurs on the dissected tops. Isolated hills support lancewood, mulga, mountain box, silver-leaved ironbark tall shrubland. (Associated land zones contain brigalow or gidgee low woodland, or Mitchell grass tussock grassland.)

R2 Quilberry (890km²)



Land Unit and / or Associated Land System	M4	59 , Minor 54	58	H2	54	E1 E2 W1	54	H2	M4	M4	E1 W1	M5	M4
Sites		E597, E614	D4		D27, E506								
Est. % of Land System		40-50	10-15		10	5		25	< 5				

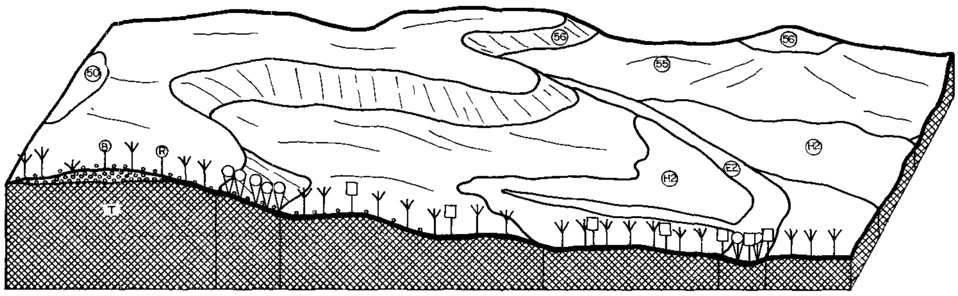
LANDFORM: Dissected hills, low scarps and sloping plains in scarp retreat zones. Slopes to 10%. Relief to 20m.

GEOLOGY: Chemically-altered, Cretaceous sediments with superficial covering of Quaternary material. Q., AKlc, AKw.

SOILS: Shallow, yellowish red lithosols, Um1.41, Um1.43, Uc1.13. Surfaces are scattered with gravel, and gravel and grit occur throughout the profile. Exposed rock is common at the tops of the scarps.

VEGETATION: Bendee tall shrubland to mulga, hopbush. Rarely, western bloodwood, shrubby low woodland/tall shrubland on the dissected tops. Mulga, poplar box low woodland/tall shrubland, frequently with mountain yapunyah, Dawson gum, sandalwood and hopbush, on the slopes, and bowyakka tall shrubland in the lower scarp retreat zones. (Minor poplar box, mulga/sandalwood woodland in associated drainage lines, and minor mulga low open forest on adjacent plains.

R3 Leader (650km^2)



Land Unit and / or Associated Land System	41	56	55	H2	E2,W2	M5	M5	H2	55
Sites	D41, D101, D125, D246, E526, E620	E551, E595	E523						
Est. % of Land System	25	15	30	25	5				

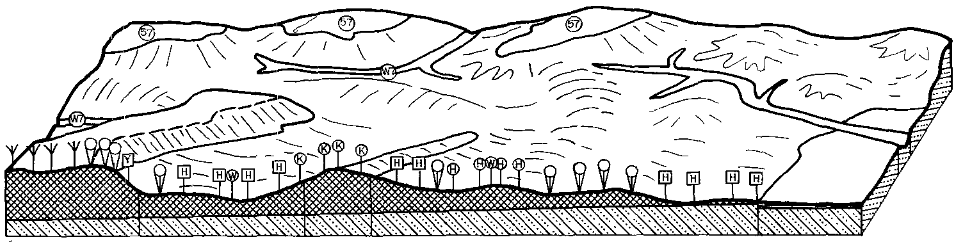
LANDFORM: Dissected tablelands and low hills. Slopes 5-10%. Relief 15m.

GEOLOGY: Chemically-altered, Cretaceous sediments with a superficial covering of Quaternary erosion products. AKw.

SOILS: Very shallow, brown to reddish brown, gravelly lithosols, Um1.43 , Uc1.43. Surfaces have stone and gravel cover. Exposed rock is common along the scarps.

VEGETATION: Mulga, western bloodwood tall shrubland to low woodland on the tableland, frequently with mint bush, hopbush, Cassia and Eremophila spp. Mulga, lancewood, mountain box, hopbush shrubby tall shrubland to tall open shrubland occurs on the upper slopes. Mulga tall shrubland to low woodland with scattered poplar box occur on the lower slopes, while vinetree, wilga, leopardwood and boonaree are frequently prominent. (Minor, associated drainage lines support poplar box, mulga low woodland or gidgee, yapunyah low woodland.)

G1 Kennedy (400km^2)



Land Unit and / or Associated Land System	R1	33	54	33	F1		W7	
Sites			E604, E635	D24, E605				
Est. % of Land System	5		10-15	80	< 5		<2	

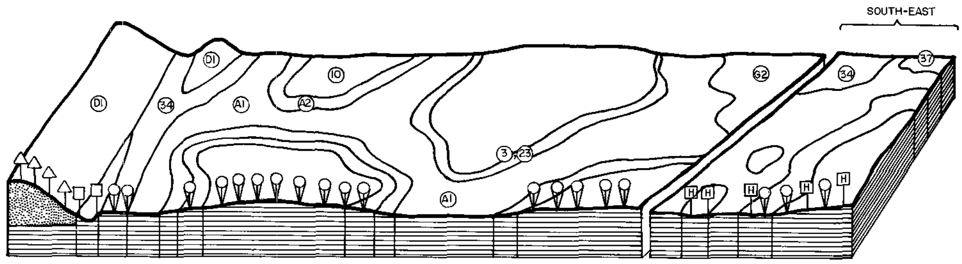
LANDFORM: Gently sloping plains. Slopes <3%. Relief 10 m.

GEOLOGY: Cretaceous Coreena/Doncaster formations. Klc, Kld.

SOILS: Deep to very deep, reddish brown to brown, heavy, cracking clays, Ug5.38. Surface gravel pavements are common.

VEGETATION: Predominantly brigalow low woodland/tall shrubland with scattered bottle tree, whitewood and leopardwood. Rarely, gidgee low woodland. Brigalow, mountain yapunyah or Dawson gum shrubby woodlands occur on associated low hills. (River red gum, coolibah fringing woodland is present along minor drainage systems, and Mitchell grass tussock grassland on associated plains.)

G2 Killowen (2 030km²)



Land Unit and / or Associated Land System	D1	31	34	A1	3 23	G3	34	G3	3 23	A1	3 23	34	W8 G3	37	W8	15	36	36	15	A1 A2	37
Sites							D118, D135, D202, D204, D213, D232, D238, D241, D244							E 541		E 538	D231, D245, D247				
Est. % of Land System	5-10	<5					70	10	5	5				10	20	10	60				

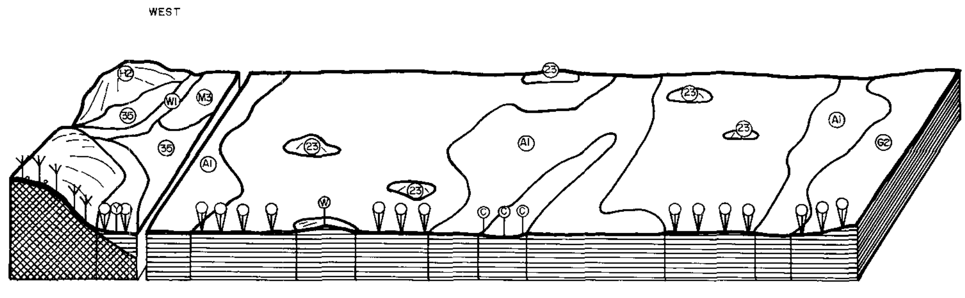
LANDFORM: Flat plains. Slope <1%. Relief 0-3m.

GEOLOGY: Quaternary sands over alluvium. Qs/Qa.

SOILS: Very deep, reddish brown, alluvial, texture contrast soils predominate, Dr2.13, Dr2.53, Dr2.62, Dr3.53, Dy2.13, Db2.13, Um2.13, Um5.52. Limited areas of very deep, brown to reddish brown, alluvial, cracking clay soils occur, Ug5.34, Ug5.38, Uf6.12. Around the fringes of the gidgee areas, these soils commonly have scalded surfaces.

VEGETATION: Gidgee low woodland to low open woodland with scattered whitewood and leopardwood, and sandalwood frequently prominent. Sparse grassland, herbland and whitewood low open woodland occur on fringing, scalded areas. In south-western areas, gidgee, brigalow low woodland to open woodland, occasionally brigalow tall shrubland, occurs.

G3 Ivanhoe (230km²)



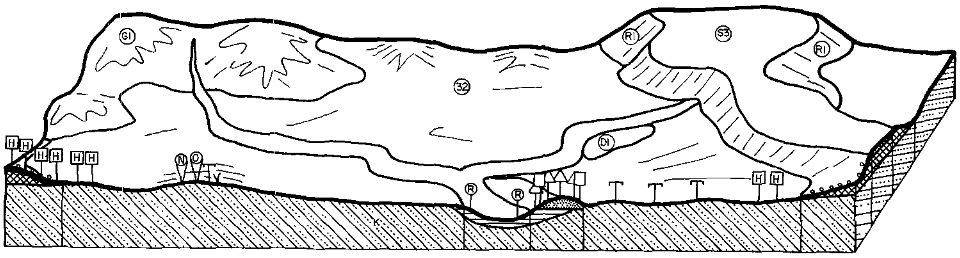
Land Unit and / or Associated Land System	H2/M3	W2	A1	35	23	35	A1	W4 W8	A1	35	A1	G2	
Sites				D1, D111, D211, E521, E549, E574, E579									
Est. % of Land System		5-10		70	< 5			10	< 5			10-20	

LANDFORM: Flat plains. Slopes <1%. Relief to 1m.

GEOLOGY: Quaternary alluvium. Qa.

SOILS: Very deep, brown, alluvial, cracking clays predominate, Ug5.34, Ug5.38, Uf6.12. Associated are minor areas of alluvial, grey-brown, cracking clays, Ug5.24, and reddish brown, alluvial, texture contrast soils, Dr2.13.

VEGETATION: Predominantly gidgee low woodland to low open woodland, occasionally with scattered sandalwood on texture contrast soils, and with minor scattered whitewood low open woodland on associated scaldy areas. (Associated are Mitchell grass tussock grassland and coolibah low open woodland on the plains, and coolibah low woodland along drainage lines. West of the Warrego River gidgee, yapunyah low open forest to low woodland is common in associated flood areas.)



Land Unit and / or Associated Land System	G1	32	W7	D2	32	R1	R1	S3	R1	32
Sites		D7, E501, E603								
Est. % of Land System	15	75	5-10	< 1						

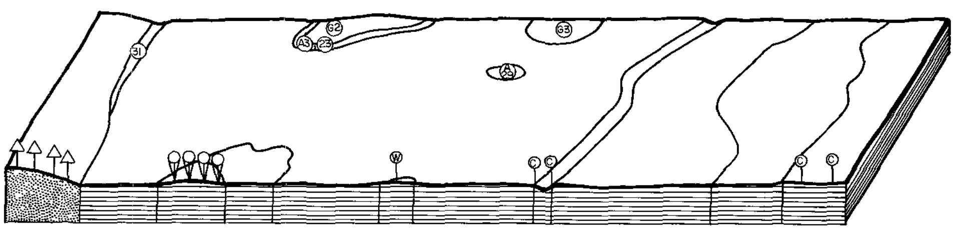
LANDFORM: Gently undulating plains. Slopes <1%. Relief to 12m.

GEOLOGY: Cretaceous Coreena/Doncaster formations. Klc, Kld.

SOILS: Shallow, dark brown to reddish brown, cracking clays, Ug5.38, Ug5.32. Surfaces are commonly scattered with gravel.

VEGETATION: Predominantly Mitchell grass tussock grassland to open tussock grassland, seasonally with bluegrass. Lower slopes are sparsely wooded with myall, and upper slopes with myall, needlewood, leopardwood and boonaree.

A1 Noorama (3 430km²)



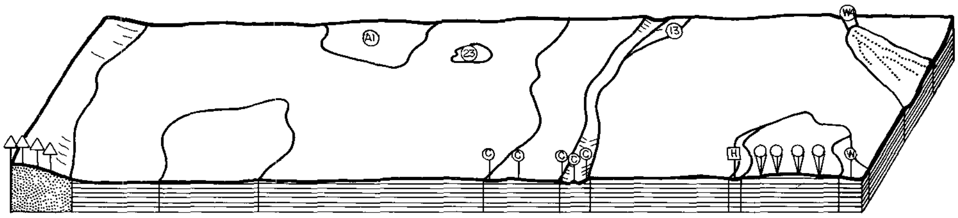
Land Unit and / or Associated Land System	D1	4	G2, G3	3	4	23	4	W4	4	A2	W8	
Sites					D127, D134, D203, D212, D221, D227, D228, D236		D239, D243, E512, E513, E531, E546, E548, E572		E608, E615			
Est. % of Land System			< 5	5	70	< 2		< 5		10-15	5-10	

LANDFORM: Extensive, flat, alluvial plains.

GEOLOGY: Recent alluvia. Qa.

SOILS: Very deep, reddish brown to brown, cracking clays, Ug5.34, Ug5.38.

VEGETATION: Predominantly Mitchell grass tussock grassland to open tussock grassland. Areas of Mitchell grass, bluegrass tussock grassland and sometimes coolibah low open woodland, occur on the plains, with coolibah or yapunyah (low) woodland to (low) open woodland along drainage lines. Minor, sparse herblands, grasslands or whitewood low open woodland occur on areas of lighter, clay soils.



Land Unit and / or Associated Land System	D1	16	A1	16	W8	W3 W4	16	15	G2, G3	3 23		16	W5	16
Sites				E533, E544										
Est. % of Land System			15-20	55	15	5		<2	up to 10 in south east	<5				

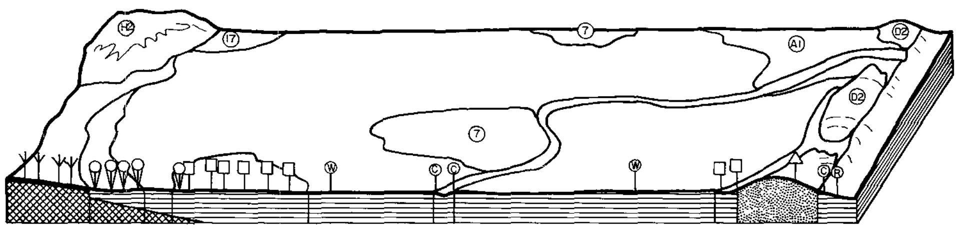
LANDFORM: Flat, alluvial plains.

GEOLOGY: Quaternary alluvia. Qa.

SOILS: Very deep, grey-brown, cracking clays of heavy texture, Ug5.24, predominate.

VEGETATION: Seasonally variable, Mitchell grass/bluegrass open tussock grassland, with areas of coolibah low open woodland to wooded tussock grassland. Drainage lines support coolibah or yapunyah (low) woodland to (low) open woodland. (In south-eastern areas, gidgee low woodland, minor brigalow low woodland and minor whitewood low open woodland are associated.)

A3 Westgate (350km^2)



Land Unit and / or Associated Land System	H, M1, S Land Zones	G3	18	7	18	W4	18	31	D2	W6 W9	
Sites				E557, E633			E576, E624				
Est. % of Land System		5		25		<2	60	<2	5-10		

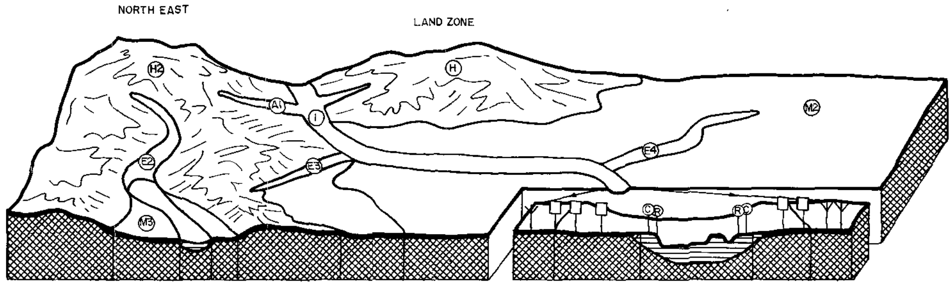
LANDFORM: Flat, allivial plains.

GEOLOGY: Quaternary alluvia. Qa.

SOILS: Very deep, reddish brown, alluvial, clay soils (frequently scalded), Uf6.12, Uf1.43, predominate. Limited areas of very deep, yellowish red, texture contrast soils, Dr2.53, are also present.

VEGETATION: Sparse to open grassland or herbland with scattered whitewood and poplar box. Poplar box/gidgee, sandalwood shrubby woodland to low open woodland is present on areas of texture contrast soils. (Minor gundabluey open shrubland occurs on associated levees, and coolibah, poplar box or gidgee (low) woodland in drainage line and run-on areas.)

W1 Boin (650km^2)



Land Unit and / or Associated Land System	H Land Zone	M3	W1 W2	M3	H Land Zone	M4	M5		M3 M5	8, E Land Zone	1	8, E Land Zone	M2			M2
Sites										E502, E591	D25					
Est. % of Land System									5	35	60		<1			

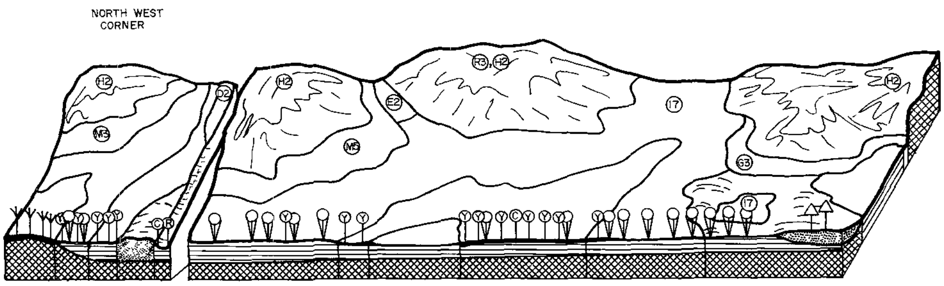
LANDFORM: Narrow, alluvial plains with distinct, main channel.

GEOLOGY: Quaternary alluvia. Qa.

SOILS: Predominantly deep to very deep, alluvial, reddish brown, clays, Uf6.12, and red and brown, texture contrast soils. Scalded areas are common.

VEGETATION: River red gum, poplar box, rarely coolibah, fringing woodland to open woodland. Sparse herbland of burr, saltbush and shortgrass occurs on adjacent, scalded areas, with poplar box, sandalwood shrubby open woodland on the margins of the scalds.

W2 Dartmouth (1 130km^2)



Land Unit and / or Associated Land System	M3 G2	17	19 W3	D2	W7	17	19	L1, 9	19	17	D1, G2		A1	G3	H2
Sites	E612	D9	E 611						E651	E553, E610					
Est. % of Land System	20	40	30	5	5			5	25	60	10				

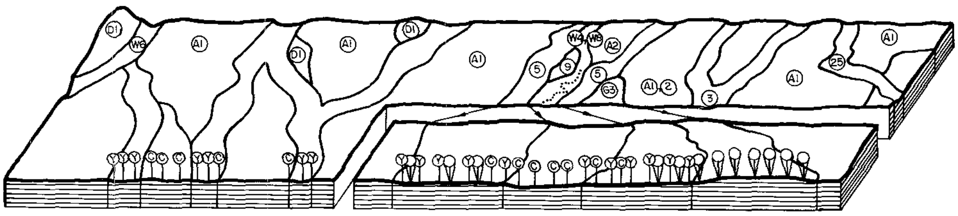
LANDFORM: Low-lying plains, forming swamps and run-on areas.

GEOLOGY: Recent alluvia. Qa.

SOILS: Very deep, brown and grey-brown, alluvial, clay soils, Ug5.38, Uf6.13, predominate, with gilgaied, grey, cracking clays, Ug5,24, in the frequently flooded areas.

VEGETATION: Predominantly gidgee, yapunyah, sandalwood, Ellangowan poison bush shrubby low open forest to low woodland, with yapunyah, gidgee layered open forest and creek wilga, lignum and lignum fuchsia in wetter areas. Minor Queensland bluebush low open shrubland, swamp canegrass open hummock grassland, herbland or sedgeland, occur in central swampy areas. (Associated land systems support gidgee low woodland and sand-hill vegetation.)

W3 Kudnapper (610km²)



Land Unit and/or Associated Land System	A1	5	W8	5	A1	5	A1		A1	5	W4, W8	5	G3	A1 A2		G3	5	G3	A1
Sites										D102, E508, E520									
Est. % of Land System										85	< 10		5-10						

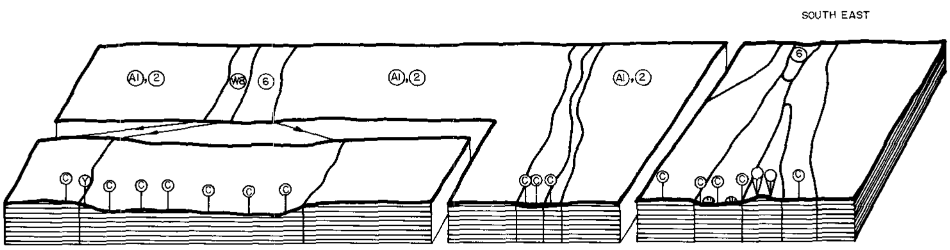
LANDFORM: Broad, shallow drainage lines comprised of a single, sometimes indistinct channel on flat, alluvial plains.

GEOLOGY: Quaternary alluvia, Qa.

SOILS: Very deep, grey-brown, cracking clays, Ug5.24, Ug5.25, Ug5.34, predominate. Incipient gilgai micro-relief is developed in some areas.

VEGETATION: Predominantly yapunyah woodland to (low) open woodland with minor gidgee and coolibah intermixed, and minor areas of Queensland bluebush low open shrubland in swamps. Coolibah low woodland occurs where drainage channels are better developed. Associated are minor areas of coolibah low open woodland to wooded tussock grassland, and gidgee low woodland.

W4 Widgee (430km²)



Land Unit and/or Associated Land System	W8	6, Minor 5	A1, A2		A1, 2	6	W8	A1, 2		W8	12	G3	W8	A2	
Sites		D218, D225, E514, E515									E532				
Est. % of Land System	10	90								40	50	< 5		10	

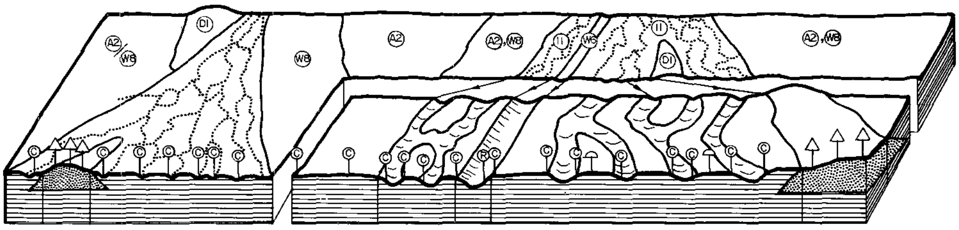
LANDFORM: Shallow drainage lines on flat, alluvial plains with one distinct channel.

GEOLOGY: Quaternary alluvia. Qa.

SOILS: Very deep, alluvial, grey-brown, cracking clays, Ug5.24, Ug5.25, Ug5.34, predominate.

VEGETATION: Predominantly coolibah low woodland to low open woodland, with scattered belalie and creek wilga, and with lignum prominent in swampy areas in the south-east. (Associated are coolibah wooded tussock grassland, Mitchell grass/bluegrass tussock grassland and, in the south-east, minor gidgee, brigalow low woodland.)

W5 Bluegrass (1 590km²)



Land Unit and / or Associated Land System	11	D1	11		A2, W8	11	W6	11	D1		11	
Sites								D42, D222, D226, D234				
Est. % of Land System					10-20		< 2	70-80	5			

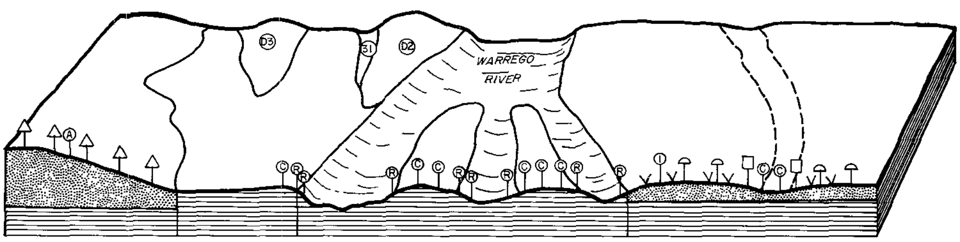
LANDFORM: Flat, low-lying, alluvial plains. These plains are seasonally flooded and covered by a network of small, shallow, anastomosing channels.

GEOLOGY: Quaternary alluvia. Qa.

SOILS: Very deep, alluvial, grey-brown, cracking clays predominate.

VEGETATION: Predominantly coolibah low open woodland to wooded or shrubby tussock grassland with scattered creek wilga, belalie, lignum and Queensland bluebush, and minor areas of Mitchell grass-bluegrass open tussock grassland. Minor river red gum, coolibah fringing woodland occurs along major drainage channels. (And minor cypress pine woodland on associated levees.)

W6 Warrego (310km²)



Land Unit and / or Associated Land System	D Land Zone	A1 (south) A3 (north)	2	D2	
Sites			E528, E617		
Est. % of Land System		10	60-70	20-30	

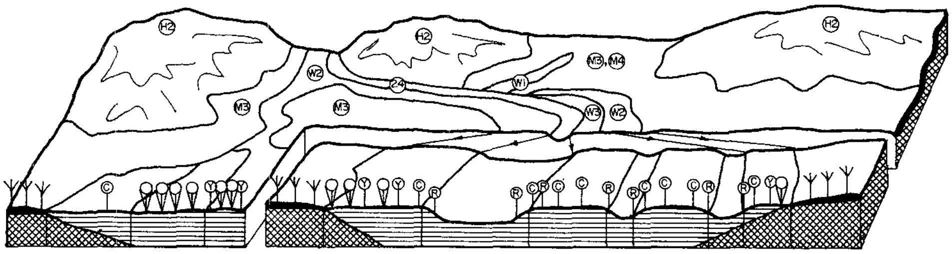
LANDFORM: Alluvial plains with a small number of large, braided channels; these braided channels frequently form into one main channel for a short distance before dividing again.

GEOLOGY: Quaternary alluvia. Qa.

SOILS: Very deep, alluvial, clay and sandy clay soils, Ug5.24, Ug5.28.

VEGETATION: Predominantly river red gum, coolibah, paper-barked tea-tree, belalie, doolan shrubby woodland fringing the Warrego River channels. Gundabluey open shrubland or wilga, ironwood, beefwood low open woodland occur on associated levees. (Associated plains support Mitchell grass tussock grassland in the south, and sparse to open grassland or herbland, with scattered whitewood and poplar box in the north.)

W7 Langlo (310km²)



Land Unit and / or Associated Land System	M3	A1, W8	G3	W2		M3	W2, W8	24	10	24	10	24	W2,W8	M3, A1		
Sites								E636								
Est. % of Land System							10	80	10							

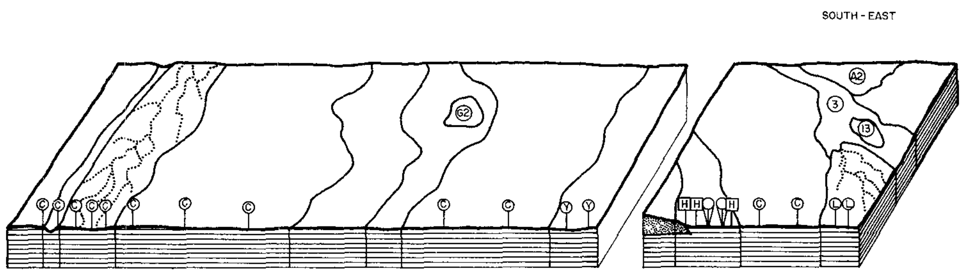
LANDFORM: Alluvial plains with braided channels. These channels occasionally form together for a short distance into a single main channel before dividing again.

GEOLOGY: Quaternary alluvia. Qa.

SOILS: Very deep, alluvial, cracking clay soils, Ug5.24.

VEGETATION: Predominantly river red gum, coolibah, belalie, creek wilga, lignum shrubby woodland along major channels, with coolibah, occasionally yapunyah low open woodland on the inter-channel areas. Associated, fringing alluvia support gidgee, yapunyah low open forest to low woodland, or coolibah low open woodland to wooded tussock grassland.

W8 Tuen (3 120km²)



Land Unit and / or Associated Land System	A1	W4	11	20	A2	A1	20	5		D1	G2	20	11 14		3	G2
Sites				D210, D219, D235, D237												
Est. % of Land System		10	10	65	10	< 5		< 5			25	50	25			

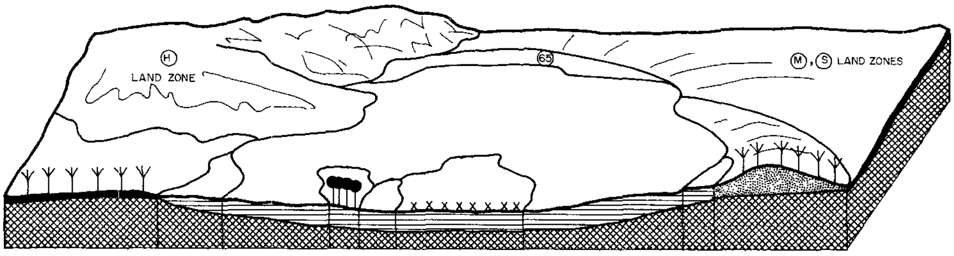
LANDFORM: Flat, alluvial plains.

GEOLOGY: Quaternary alluvia. Qa.

SOILS: Very deep, alluvial, grey-brown, cracking clays, Ug5.24.

VEGETATION: Coolibah, neverfail grassy low open woodland to wooded tussock grassland. Coolibah, or rarely, yapunyah (low) woodland to (low) open woodland and Mitchell grass/bluegrass open tussock grassland occur on associated plains, and coolibah woodland along drainage lines. In the south-east, associated areas of black box, brigalow or gidgee, brigalow low woodland, and rarely, old man saltbush low shrubland, are present.

L1 Elimina ($310 km^2$)



Land Unit and / or Associated Land System	M2	3	69	66	9	67	69	70	S2	M2
Sites							E509			
Est. % of Land System		10-15		< 5	< 2	10-15	70	< 2		

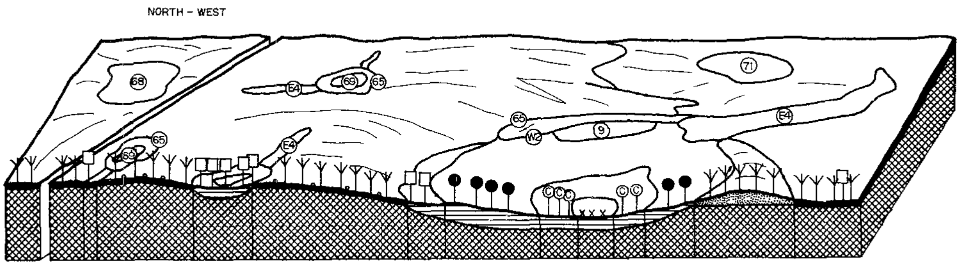
LANDFORM: Claypan depressions and seasonal lakes.

GEOLOGY: Quaternary alluvia. Qa.

SOILS: Predominantly shallow to moderately deep, poorly-drained, grey clays, Ug5.24. Reddish brown clays with scalded surfaces, frequently occur around the margins of the claypans, Ug5.34, Uf6.12.

VEGETATION: Predominantly herbland or sedgeland, with swamp canegrass open hummock grassland, or rarely, Queensland bluebush low shrubland, in central swamps. Minor poplar box open woodland and sparse herbland is present around the scalded margins. (Ridgegrass grassland occurs on exposed areas of limestone.)

L2 Ardgour ($690 km^2$)



Land Unit and / or Associated Land System	M3 S1		H4	E 4	H4	65	H4	8	69, 66	71	67	71	69, 66	S2	M2/S2	
Sites						D128, E510, E563			E509, E567	E557						
Est. % of Land System -						5		5-10	60-70	20	5					

LANDFORM: Claypan depressions and seasonal lakes.

GEOLOGY: Quaternary alluvia. Qa.

SOILS: Predominantly shallow to moderately deep, alluvial, clay soils, Ug5.24. Reddish brown, alluvial, sandy clays, Uf6.23, are common. Gilgaied micro-relief is associated with brigalow areas.

VEGETATION: Variable coolibah, poplar box, yarran, bowyakka, belah or brigalow (low) woodland tall shrubland to (low) open woodland. Often associated are sedgeland, herbland, and minor swamp canegrass open hummock grassland in central swamps. Fringing poplar box woodland to open woodland and sparse herbland occur on scalded, marginal areas.

APPENDIX V

LAND UNITS

by J.R. Mills and R.W. Purdie

Explanatory notes

Occurrence: The land system(s) in which each unit is a major or (minor) component is listed.

Landform: General landform pattern or element types (see McDonald *et al*.1984) are given.

Geology: see Chapter 2.

Soils: The description covers the following aspects:

- A general description of the soil with any distinguishing attributes.
- Principal Profile Form (Northcote 1974).
- General soil fertility ratings: see Appendix 1.
- Soil mapping units (see Table 3.1).

(see Chapter 4 for detailed soils information.

Vegetation: A general description is given, in which dominant species are listed in their order of importance, and other species alphabetically. The description covers the following aspects:

- Structural form: See Table 5.5, Chapter 5
- Tree and shrub strata: The average height and density ranges are given for the dominant species, woody weeds and topfeed species. PFC ratings (see Appendix I) are sometimes given for the shrub stratum.
- Ground stratum: PFC ratings or the average range of PFC values are given for the stratum as a whole. Species are described in terms of their habit and their frequency/abundance rating (see Appendix 1).
- Herbage summary: The table is included only for land units which predominate in the more important land systems. The following information is given for each herbage group (see Resource Use chapter, Pastures section) in the table:

  a) Total number of species recorded for the unit (Total);

  b) Average number of species per site in the unit (x/site);

  c) Total number of species with high palatability ratings (H.P.);

  d) Total number of species with medium palatability ratings (M.P.);

  e) Number of HP and MP species which may become seasonally abundant (S.A.)

  (see Appendix III for palatability ratings of species)

When using the table it should be remembered that the data represent the herbage present after seasons of above average summer rainfall, and thus represent the maximum herbage potential.

- Land unit species list: A complete list of species recorded for each land unit was prepared. Species were listed alphabetically within groups related to their habit (tree/shrub/graminoid/forb) and their frequency/abundance rating.

Land Use: The following aspects are discussed:

- Type of animal
- Soil
- Herbage
- Response of herbage to rainfall
- Woody weeds
- Topfeed
- Poisonous plants
- Water resources
- Special management problems or techniques
- Condition and trend (see Appendix I)
- Development potential, if any.

LAND UNIT 1

(Land systems W1 B2 B3 G3 H3 M1 M2 M4 M5 R2 S1 S3 W7)

LANDFORM:

Narrow, alluvial plains with a main channel.

GEOLOGY:

Recent alluvia. Qa.

SOILS:

Deep to very deep, alluvial soils. Brown to reddish brown clays predominate where the unit is well-developed. On smaller streams, red and brown, texture contrast soils predominate, with crusting, sandy-clay-loam surfaces overlying sandy and silty, alluvial clays, Uf6.12.

VEGETATION:

River red rum (*Eucalyptus camaldulensis*) and/or poplar box (*E. populnea*) fringing woodland to open woodland (9-11 m; 50-200/ha) along the channels, with occasional clumps of *Melaleuca trichostachya* tall shrubs. Scattered *Eucalyptus microtheca* trees with *Acacia aneura* and *Eremophila mitchellii* tall shrubs may occur on minor flats adjacent to the channels. The ground stratum is usually sparse, and dominated by the perennial grasses *Arundinella nepalensis, Bothriochloa ewartiana, Chrysopogon fallax* and *Leptochloa digitata* (5-15%).

Woody weeds: negligible.

Top feed: negligible.

LAND USE:

These areas are unstable and generally in poor to mediocre condition. They provide valuable shade and water for stock and provide ephemeral but highly nutritious, shortgrass and forb pastures of low bulk in season. This unit receives considerable run-on water, and combined with concentration of grazing pressure on this type of country means both sheet and gully erosion is widespread, particularly in western areas. Drought grazing capacity is low, but run-on water may produce a response after light rainfalls (<25 mm). Fertility is generally low. Management should aim to maintain sufficient surface cover on this and adjacent units to prevent excessive runoff from causing further erosion problems.

LAND UNIT 2

(Land systems W6 A3 D1 D2 D3 S1 W3 W5)

LANDFORM:

Main channel and braided channels of the Warrego River. Relief ranges from 3 m deep and 10 m wide to 10 m deep and 40 m wide in large billabongs.

GEOLOGY:

Recent alluvia. Qa.

SOILS:

Very deep, alluvial, clay soils. Heavy grey to grey-brown, cracking clays with firm crusts of silt and sand, predominate. Bands of coarse sand occur throughout the profile and form sand bars in the channels, Ug5.24, Ug5.28.

VEGETATION:

River red gum (*Eucalyptus camaldulensis*; 10-12 m), coolibah (*E. microtheca*; 10-11 m) fringing woodland (100-125/ha). An open to sparse tall shrub stratum of *Acacia stenophylla, A. salicina* and *Melaleuca trichostachya* is frequently present. The ground stratum is open to sparse, dominated by the perennial grasses *Paspalidium jubiflorum, Leptochloa digitata, Bothriochloa ewartiana, B. bladhii* and *Sporobolus mitchellii* (<10%). *Lomandra longifolia* may be locally abundant. The annual grass *Eriochloa pseudoacrotricha, Dichanthium sericeum* and *Panicum laevinode*, and forbs *Haloragis aspera, Tetragonia tetragonioides* and *Xanthium pungens* may be seasonally abundant.

Top feed: usually sparse (<25/ha).

Weeds: *Xanthium pungens* has become very abundant and widespread during the last run of good seasons.

LAND USE:

This unit is relatively stable and provides valuable shade and water for stock. Permanent waterholes occur frequently along the river, and a few of the larger holes support small (2-10 ha) irrigation schemes, growing citrus or fodder. Noogoora burr is a problem in these channels and effective control has not been possible. There are frequent reports of waterholes in the river silting up in recent times.

LAND UNIT 3

(Land systems A2 D1 D2 D3 G2 W8)

LANDFORM:

Flat, alluvial plains.

GEOLOGY:

Recent alluvia. Qa.

SOILS:

Very deep, alkaline, reddish brown clays of medium texture predominate, with firm, sandy-loam surface crusts 1 cm thick. Deflated and scalded areas are common. Gypsum and manganese frequently occur at depth in these profiles, Uf6.12, Ug5.34.

ANALYSES (3 sites)

pH	mildly to strongly alkaline throughout
O.C.	very low
T.N.	very low
A.P.	variable, generally low at the surface with high values at depth
B.P.	very low at the surface
K	high
E.C.	low to very low at the surface, becoming high at depth
Cl	low at the surface, becoming high below 30 cm depth (saline subsoil)
E.S.P.	sodic surfaces (especially > 6%) becoming strongly sodic (especially > 14%) at depth
C.E.C.	21-25 m equiv./100 g soil
Ca	50 % of C.E.C. at the surface
A.W.C.	medium

VEGETATION:

Badly scalded areas are frequently devoid of any vegetation. Less scalded "islands" support a sparse to seasonally open grassland or herbland. Dominant shortgrasses and annual grasses include *Sporobolus actinocladus, S. caroli, Chloris pectinata,* (<5%), *Brachyachne convergens* and *Dactyloctenium radulans* (seasonally abundant). The forbs *Sclerolaena calcarata, S. diacantha, S. divaricata, Maireana coronata, Dysphania rhadinostachya, Trianthema triquetra, Atriplex spongiosa* and *Portulaca oleracea* occur on both "islands" and scalds, and may be seasonally abundant.

Woody weeds: absent.

Top feed: absent.

LAND USE:

These areas are unstable and in poor to very poor condition and production has been severely reduced. Many of these areas occur along old stock routes which were formerly subject to heavy grazing pressure. During better seasons, a limited cover of highly nutritious shortgrasses and forbs may establish on this unit, but unless perennials become established, the areas will revert to scalds in poor seasons. Relatively low fertility and salt problems make regeneration of these areas difficult but good seasons and low utilisation levels by both domestic and wild animals should bring about a gradual improvement in the condition of these areas. Reclamation by mechanical means is expensive and is unlikely to be permanent unless utilisation levels are controlled.

LAND UNIT 4

(Land systems A1 A2 A3 D1 G2 G3 S2 W2 W3 W4 W6 W8)

LANDFORM:

Extensive, flat, alluvial plains.

GEOLOGY:

Recent alluvia. Qa.

SOILS:

Very deep, reddish brown to brown, cracking clays. Reaction is neutral to alkaline. Textures are medium to medium-heavy clays with quantities of sand and silt intermixed. Surfaces have crusts which range from firm to self-mulching, Ug5.34, Ug5.38.

ANALYSES (18 sites)

pH	neutral to mildly alkaline at the surface, becoming strongly alkaline at depth
O.C.	very low
T.N.	very low
A.P.	variable, generally low; fair to high values at depth
B.P.	very low
K	high
E.C.	very low at the surface, frequently high at depth
Cl	very low, occasionally saline at depth
E.S.P.	lower than 6%
C.E.C.	24-20 m equiv./100 g soil for the surface
Ca	50% of C.E.C. for the surface
A.W.C.	high
B.D.	1.1 - 1.3

VEGETATION:

Mitchell grass tussock grassland to open tussock grassland which is dominated by perennial grasses but which contains a large number of short-lived perennial grasses, annual grasses and annual forbs. *Astrebla lappacea* is dominant (10-50%), with *A. elymoides* frequently abundant (5-30%), and *A. pectinata* occasionally abundant. The short-lived perennial grasses *Dichanthium sericeum, Panicum decompositum* and *Digitaria divaricatissima* occur frequently (< 10%), while the annual grasses *Iseilema membranaceum* and *I. vaginiflorum*, and annual forbs *Brachyscome* spp., *Hibiscus trionum, Goodenia fascicularis, Daucus glochidiatus, Plantago drummondii, Ipomoea lonchophylla, Rhynchosia minima* and others, may be seasonally abundant. In overgrazed areas, the annual grasses *Iseilema* spp., *Dactyloctenium radulans*, and *Aristida anthoxanthoides*, and forbs *Atriplex* spp., *Sclerolaena* spp., *Malvastrum americanum* and *Sida trichopoda* are common.

Herbage summary

	No. of species			
	Total	High Pal.	Medium Pal.	Seasonally abundant (18 sites)
Long-lived perennial grasses	6	4	2	
Other graminoids	23	14	3	9
Forbs	62	20	25	31

Woody weeds: absent

Top feed: negligible

LAND USE:

These lands are moderately stable and generally in good condition at the time of survey. Old stock routes are frequently in poor condition. This unit provides a moderate bulk of perennial grasses and forbs which is of excellent nutritional quality because of the high component of forbs in the pasture. During drought periods, perennial grasses and forbs stand over well and provide an above maintenance diet. However, in extended drought periods (>1 year), pasture supply may be exhausted. Soils require heavy rainfalls (> 50 mm), to produce a pasture response if dried out completely. Some areas with lighter-textured, reddish brown clays can respond to smaller rainfalls. These areas are also susceptible to feathertop (*Aristida latifolia*) invasion during years of heavy summer rainfall (D. Orr, personal communication). Fertility is low but obviously adequate for native species. Water-holding capacity is high, and combined with low runoff, allows extended growth periods following significant rains. This unit is highly productive in its native state and development is not considered feasible. Management should aim at maintaining a cover of perennial grass to prevent wind and water movement from causing a deterioration in surface soil condition.

LAND UNIT 5

(Land systems W3 A2 D1 W8)

LANDFORM:

Very shallow (< 0.5 m), broad drainage lines ("watercourses") on flat, alluvial plains.

GEOLOGY:

Recent alluvia. Qa.

SOILS:

Very deep, medium to heavy-textured, grey-brown, cracking clays with neutral to alkaline reaction. Surfaces are self-mulching under soft crusts. Lime and gypsum are frequently present at depth, Ug5.24, Ug5.25, Ug5.34.

ANALYSES (3 sites)

pH	neutral to moderately alkaline at the surface
O.C.	low
T.N.	very low
A.P.	very fair to high
B.P.	low to very fair
K	high
E.C.	very low in the surface, very high at depth
Cl	very low in the surface, high at depth
E.S.P.	<6% at the surface
C.E.C.	18-29 m. equiv./100 g soil at the surface
Ca	generally > 50% of C.E.C. at the surface
A.W.C.	medium
B.D.	1.1

VEGETATION:

Yapunyah (*Eucalyptus ochrophloia*) woodland to open woodland/low open woodland (9-11 m; 150-200/ha) with scattered *E. microtheca* and *Acacia cambagei* trees. Scattered *Eremophila bignoniiflora* tall shrubs and low shrubs *Muehlenbeckia cunninghamii* and *Chenopodium auricomum* are frequent. The ground stratum is sparse to seasonally open, and dominated by the perennial grasses *Eragrostis setifolia, Astrebla elymoides* and *A. lappacea* (3-10%), and the shorter-lived *Dichanthium sericeum*. The annual grasses *Iseilema membranaceum, Brachyachne convergens, Dactyloctenium radulans, Eriochloa pseudoacrotricha* and *Panicum laevinode* may be seasonally abundant. A variety of forbs occur infrequently but may be seasonally abundant. The more frequent species include *Atriplex muelleri, Sclerolaena* spp., *Hibiscus* spp., *Malvastrum americanum, Portulaca oleracea* and *Sida trichopoda.*

Herbage summary

	No. of species			
	Total	High Pal.	Medium Pal.	Seasonally abundant (4 sites)
Long-lived perennial grasses	5	3	1	
Other graminoids	13	10	2	7
Forbs	32	14	8	14

Woody weeds: *Eucalyptus ochrophloia* regeneration may be a problem after clearing in wetter areas (750/ha).

Top feed: scattered shrubs (usually < 25/ha).

LAND USE:

This land unit is stable. Condition is seasonal: these areas are inundated by high level general floods and local runoff, and provide a moderate bulk of high quality pasture for an extended period following flooding. These drainage lines serve as distribution channels for higher level floods in the Warrego River. Considerable grazing pressure is concentrated on these lands but a long-term decline in condition is not readily apparent. High grazing pressures and the need for substantial rains (> 50 mm), or flooding, to produce a response from this unit mean it has limited drought standover value.

Banks and other structures may be used to hold water up in these drainage lines. Where this is done, a pasture species which will persistently withstand inundation and then grow rapidly to make use of the good fertility and water-holding capacity of these soils is needed.

LAND UNIT 6

(Land systems W4 A1 A2 A3 D1 G3 W3 W8)

LANDFORM:

Shallow (usually < 1 m) drainage lines ("watercourses") on flat, alluvial plains.

GEOLOGY:

Recent alluvia. Qa.

SOILS:

Very deep, alkaline, grey-brown, cracking clays of heavy texture. Surfaces are uneven and may display incipient gilgai development. Silty surface crusts may occur and structure is massive where the unit is well-developed. Lime is present in the profile at depth, Ug 5.24, Ug 5.25, Ug 5.34.

ANALYSES (4 sites)

pH	neutral to mildly alkaline
O.C.	low to very low
T.N.	low to very low
A.P.	generally high
B.P.	ranges from low to high
K	high
E.C.	very low
Cl	very low
E.S.P.	6%
C.E.C.	15-28 m equiv./100 g soil
Ca	65% of C.E.C.
A.W.C.	medium
B.D.	1.4

VEGETATION:

Coolibah (*Eucalyptus microtheca*) low woodland to low open woodland (9-10 m; 25-150/ha) with scattered *Acacia stenophylla* and *Eremophila bignoniiflora* tall shrubs and *Chenopodium auricomum, Maireana aphylla* and *Muehlenbeckia cunninghamii* low shrubs. The groundstratum is sparse to seasonally open, dominated by the perennial grasses *Eragrostis setifolia* and *Astrebla elymoides* (5-20%), with *A. lappacea, Paspalidium jubiflorum, Sporobolus mitchellii* and *Bothriochloa decipiens* locally abundant (5-15%). The short-lived perennial grasses *Dichanthium sericeum* and *Panicum decomposition*, and annual grasses *Iseilema membranaceum* and *Eriochloa pseudoacrotricha* are frequent and may be seasonally abundant. The forb diversity is relatively low but species such as *Psoralea cinerea, Goodenia fascicularis* and *Marsilea drummondii* may be seasonally abundant.

Herbage summary:

	No. of species			
	Total	High Pal.	Medium Pal.	Seasonally abundant (4 sites)
Long-lived perennial grasses	9	4	3	
Other graminoids	19	11	4	6
Forbs	15	1	8	5

Woody weeds: not a problem.

Top feed: scattered shrubs (usually < 25/ha).

LAND USE:

These lands are relatively stable and condition varies considerably according to seasonal conditions. These areas are inundated by high level, general floods and local runoff. Following flooding, this unit produces a moderate to heavy bulk of highly palatable, perennial and annual grasses, which provide high levels of nutrition. The forb component in these areas appeared to form a comparatively limited part of pasture available for consumption by animals at the time of the survey. High grazing pressure on this unit does not appear to have caused a recognisable downtrend in condition. Drought carrying capacity of this unit is limited as available grasses stand over well but are quickly consumed. A very limited amount of scattered top feed is available.

The high fertility and availability of soil moisture following flooding mean this unit has some potential for development with species which can persist and grow rapidly following inundation. Management should be aimed at maintaining a reasonable cover of perennial grasses which can provide a substantial bulk of pasture over their growing period.

LAND UNIT 7

(Land system A3)

LANDFORM:

Small rises ("islands") of very low relief (< .25 m) on flat, alluvial plains.

GEOLOGY:

Recent alluvium. Qa.

SOILS:

Very deep, yellowish red, alkaline, texture contrast soils. Fine, light, silty to sandy-clay-loams overlie alluvial clays. Surfaces are hardsetting. Lime occurs at depth in the profile, Dr2.53, Uf1.43.

ANALYSES (1 site)

pH	slightly acid
O.C.	low
T.N.	low
A.P.	high
B.P.	high
K	high
E.C.	very low
Cl	very low
A.W.C.	low to medium

VEGETATION:

Poplar box (*Eucalyptus populnea*), occasionally gidgee (*Acacia cambagei*), woodland to open woodland/low open woodland (9-11 m; 75-100/ha) with a tall shrub stratum of sandalwood (*Eremophila mitchellii*; 2-4 m; 100-400/ha) and scattered *Pimelea microcephala* low shrubs. The ground stratum is usually sparse, and dominated by the perennial grass *Enteropogon acicularis* (3-10%). The short-lived perennial grasses *Aristida calycina, A. ramosa* and *Chloris ventricosa*, longer-lived *Bothriochloa decipiens* and shortgrasses *Chloris pectinata, Oxychloris scariosa, Digitaria coenicola* and *Sporobolus caroli* are frequent and/or locally abundant. Forbs are infrequent but may be seasonally abundant.

Woody weeds: *Eremophila mitchellii* may be a problem (up to 500/ha).

Top feed: negligible.

LAND USE:

These areas are unstable and in poor to moderate condition at the time of survey, with evidence of an uptrend in condition. Evidence of previous erosion and degradation is widespread. Scalded areas frequently result where the coarser- textured surface sands are blown away, and some sandalwood invasion is evident. Good quality shortgrasses are present and provide above maintenance nutrition but bulk is very limited.

Drought grazing capacity is low with an absence of readily edible top feed. However, the unit can respond to lighter rainfalls during dry periods. Considerable care should be taken to prevent vegetative cover declining to a point at which soil loss begins to occur.

LAND UNIT 8

(Land systems L1 L2 W1)

LANDFORM:

Scalded margins of minor, alluvial plains.

GEOLOGY:

Recent alluvia. Qa.

SOILS:

Deep to very deep, alkaline, alluvial soils. Textures range from silty clay-loam to medium clay. Surfaces are severely scalded, with firm crusts of silt and sand 1-2 cm thick. Minor quantities of lime and gypsum occur at depth, Uf6.13, Uf6.12.

ANALYSES (2 sites)

pH	surfaces are neutral, become strongly alkaline at depth
O.C.	low
T.N.	low
A.P.	low to fair
B.P.	low to fair
K	low to very fair
E.C.	very low in the upper profile, becoming high at depth
Cl	very low in the upper profile, becoming high at depth.
A.W.C.	low to medium
C.E.C.	11 m. equiv./100 g soil
B.D.	1.5

VEGETATION:

Badly scalded areas are devoid of vegetation but less scalded areas support a sparse herbland dominated by the forbs *Sclerolaena convexula, S. divaricata, S. calcarata, S. tricuspis, Atriplex eardleyae* and *Maireana coronata*, and the shortgrasses *Aristida contorta* and *Sporobolus actinocladus* (< 5%). *Aristida ramosa* and *Neurachne munroi* may be locally abundant. "Islands" or low rises are dominated by the grasses *Aristida* spp., *Eragrostis lacunaria, E. leptocarpa, Chloris pectinata* and *Enneapogon avenaceus*. Scattered *Eucalyptus populnea* trees, *Eremophila mitchellii* and *Alectryon oleifolius* tall shrubs, and *Eremophila glabra, Cassia circinnata*, and *Myoporum deserti* low shrubs often occur on the margins of scalded areas.

Woody weeds: *Eremophila mitchellii* may be a problem on marginal areas (1-5 m; 300-500/ha).

Top feed: Scattered shrubs on marginal areas (< 25/ha).

LAND USE:

These areas are unstable and in very poor condition. Severe scalding has reduced the productivity of the majority of this unit to nil. There is little evidence of recovery. Considerable soil loss (up to 0.3 m), has occurred in many areas. Fertility is low but is thought to be adequate for native pastures. Mechanical reclamation of some of these areas is technically feasible but expensive and unlikely to be permanent unless grazing pressure can be substantially lowered.

LAND UNIT 9

(Land systems D1 D2 L1 W2 W3)

LANDFORM:

Minor, low-lying swamp depressions on alluvial plains, or less frequently, in claypan areas.

GEOLOGY:

Recent alluvium. Qa.

SOILS:

Very deep, alkaline, grey-brown, alluvial, cracking clays. Textures range from light to medium-heavy, and contain varying amounts of silt and sand. Surfaces are uneven and frequently have thin, silty crusts, overlying well-structured to massive clays. Lime and gypsum are present at depth, Ug5.24.

ANALYSES (1 site)

pH	moderately alkaline throughout
O.C.	low
T.N.	low
A.P.	high
B.P.	very fair
K	high
E.C.	very low
Cl	very low
A.W.C.	high
B.D.	1.2

VEGETATION:

Queensland bluebush (*Chenopodium auricomum*)low shrubland to low open shrubland (< 1 m; 500-2250/ha), occasionally with scattered *Eucalyptus microtheca* low trees and *Eremophila bignoniiflora* tall shrubs. The ground stratum is usually sparse and dominated by the sedge *Eleocharis pallens* or the perennial grass *Eragrostis setifolia* (3-8%). The shorter-lived grasses *Dichanthium sericeum, Diplachne fusca, Elytrophorus spicatus* and sedge *Cyperus iria* occur frequently. The forbs *Alternanthera nodiflora, Hibiscus trionum, Marsilea drummondii* and others may be seasonally abundant.

Woody weeds: absent.

Top feed/browse: *Chenopodium auricomum* (as above).

LAND USE:

These areas are relatively stable and in fair to mediocre condition. Nutritional value of bluebush is high and this plant stands over well, though bulk is very limited. Seasonal flooding and high water-holding capacity mean these areas have an extended growing season. Continued overstocking may result in the eventual disappearance of bluebush.

LAND UNIT 10

(Land systems A1 A2 D1 G3 W3 W4 W5 W7)

LANDFORM:

Extensive swamp depressions, usually channelled, and associated with major rivers.

GEOLOGY:

Recent alluvium. Qa.

SOILS:

Very deep, alkaline, brown to grey-brown, cracking clays. Textures range from silty clay to heavy clay. Surfaces are well-structured to massive with weak crusts. Lime occurs at depth in the profile, Ug5.34.

ANALYSES (2 sites)

pH	neutral at the surface, becoming moderately alkaline at depth
O.C.	low
T.N.	low
A.P.	high
B.P.	very fair
K	high
E.C.	very low, becoming low to medium at depth
Cl	very low, may range to medium at depth
A.W.C.	high throughout the profile

VEGETATION:

Coolibah (*Eucalyptus microtheca*) low open woodland (7-9 m; 50/ha) with yapunyah (*E. ochrophloia*) sometimes common. Scattered *Acacia stenophylla* and *Eremophila bignoniiflora* tall shrubs and *E. polyclada, E. maculata and Muehlenbeckia cunninghamii* low shrubs are frequent. The ground stratum is open to seasonally dense, dominated by the perennial grasses *Eragrostis setifolia* and *Sporobolus mitchellii* (5-25%), with *Astrebla squarrosa* and *A. lappacea* occasionally locally abundant (10-20%). The short-lived perennial grass *Dichanthium sericeum*, annual grass *Iseilema fragile*, sedge *Cyperus bifax* and forbs *Alternanthera nodiflora, Goodenia fascicularis, Haloragis glauca, Marsilea drummondii, Minuria integerrima, Neptunia gracilis, Phyllanthus maderaspatensis* and *Polymeria longifolia* are frequent and may be seasonally abundant.

Woody weeds: absent.

Top feed: scattered shrubs (usually < 25/ha).

LAND USE:

This unit is stable and in fair or better condition. Grasses present provide above maintenance levels of nutrition but bulk is limited. Drought standover value is low and top feed very sparse. Flooding or heavy rains (> 50 mm) are generally required to produce a response from this unit. Because of its high fertility and extended growing season following flooding, it may be possible to introduce species which are adapted to this situation and capable of high levels of production.

LAND UNIT 11

(Land systems W5 A2 W8)

LANDFORM:

Low-lying, seasonally flooded, alluvial plains("floodouts") with a network of small anastomosing channels fed by a major channel.

GEOLOGY:

Recent alluvium. Qa.

SOILS:

Very deep, alkaline, alluvial, grey-brown, cracking clays. Textures are heavy to medium-heavy clay with sand and silt intermixed. Surface structure ranges from self-mulching to massive with large sinkholes and depressions, Ug5.24, Ug5.28, Ug5.34.

ANALYSES (4 sites)

pH	neutral to mildly alkaline at the surface, becoming strongly alkaline at depth
O.C.	low to very low
T.N.	very low
A.P.	variable, generally fair
B.P.	fair
K	high
E.C.	very low at the surface, occasional high values at depth
Cl	very low at the surface, occasional high values at depth
E.S.P.	lower than 6%
C.E.C.	range of 16-33 m equiv./100 g soil
Ca	normally > 60% of C.E.C.
A.W.C.	very high, occasionally medium
B.D.	range from 1.1 to 1.4, median 1.1

VEGETATION:

Coolibah (*Eucalyptus microtheca*) low open woodland/tall open shrubland to wooded/shrubby tussock grassland (< 9 m; < 100/ha). *Acacia cambagei* and *A. harpophylla* may be common adjacent to larger channels. Scattered *Eremophila bignoniiflora* and *Acacia stenophylla* tall shrubs, and *Muehlenbeckia cunninghamii* and *Chenopodium auricomum* low shrubs are frequent. The seasonally variable ground stratum is open to dense, and dominated by grasses. The short-lived perennials *Dichanthium sericeum* and *Panicum decompositum*, and annual *Iseilema membranaceum* are dominant (20-25%). The annuals *Elytrophorus spicatus, Diplachne fusca, Eragrostis tenellula* and *Cyperus bifax* are seasonally common in the smaller channels. A variety of seasonally abundant forbs occur, particularly in the channels. The more frequent species include *Aeschynomene indica, Goodenia fascicularis, Hibiscus trionum, Marsilea drummondii*, and *Polymeria longifolia*. In wetter areas, the sedge *Eleocharis pallens* and perennial grass *Eragrostis setifolia* may be locally dominant (5-50%).

Herbage summary

	No. of species			
	Total	High Pal.	Medium Pal.	Seasonally abundant (4 sites)
Long-lived perennial grasses	5	3	2	
Other graminoids	17	8	3	8
Forbs	29	8	19	15

Woody weeds: absent.

Top feed: *Eremophila bignoniiflora* tall shrubs are sometimes common (up to 75/ha).

LAND USE:

These areas are stable and in very good condition. Nutritional value is very high and bulk is adequate, except in poor seasons when floods fail. High water-holding capacities provide an extended growing season but during prolonged drought periods production from this unit is negligible, and heavy rains or flooding are needed to restore this unit to normal condition and productivity. Because of the benefits of seasonal flooding of this unit,the introduction of higher-yielding species to take advantage of this moisture and the relatively high fertility levels may be possible. There are some indications that old man saltbush previously existed in these areas.

LAND UNIT 12

(Land system W4)

LANDFORM:

Well-defined, shallow drainage lines on alluvial plains. Drainage lines range from 20-50 m in width and up to 2 m deep.

GEOLOGY:

Quaternary alluvium. Qa.

SOILS:

Very deep, alluvial, cracking, clay soils. Grey-brown clays of heavy texture predominate. Minor areas of lighter-textured soils occur where substantial amounts of sand and silt are intermixed. Reaction is alkaline. Surfaces are well-structured and range from flat with silty crusts to soft and uneven with large sinkholes and depressions. Lime occurs throughout the profile, Ug5.24.

VEGETATION:

Coolibah (*Eucalyptus microtheca*) low open woodland (8-9 m; 25-50/ha), occasionally low woodland, with scattered *E. ochrophloia* and *Acacia cambagei* trees. A tall shrub stratum of creek wilga (*Eremophila bignoniiflora*) and belalie (*Acacia stenophylla*) (2-4 m; 180-250/ha) and a low shrub stratum of lignum (*Muehlenbeckia cunninghamii*, < 1 m; up to 1000/ha) are present. The ground stratum is usually very sparse although occasionally the perennial grasses *Eragrostis australasica* and *E. setifolia*, and sedge *Eleocharis pallens* may be locally abundant.

Woody weeds: absent.

Top feed: *Eremophila bignoniiflora, Acacia stenophylla* (as above).

LAND USE:

These channels are slightly unstable and are in poor to mediocre condition with scaldy surfaces and dense stands of lignum occurring over certain areas. A very limited bulk of good quality pasture is produced following seasonal flooding or significant (> 50 mm) rainfalls. This unit is of negligible value during drought periods. There is a possibility of introducing species which can take advantage of the seasonal flooding and adequate fertility.

LAND UNIT 13

(Land system A2 W8)

LANDFORM:

Margins of drainage lines and swamps formed on extensive, flat, alluvial plains.

GEOLOGY:

Quaternary alluvium. Qa.

SOILS:

Very deep, alkaline, alluvial soils. A thin, yellowish grey, sandy-loam, A horizon with a firm, sandy crust overlies medium-textured clay subsoils in which sandbands may be present. Lime occurs at depth in the profile. Dy2.12.

VEGETATION:

Old man saltbush (*Atriplex nummularia*) low shrubland to low open shrubland (1-1.5 m; up to 1250/ha) with scattered *Eucalyptus microtheca* trees. The ground stratum is sparse, although grasses and forbs may be seasonally abundant, e.g. *Sporobolus* spp., *Eragrostis* spp., *Dactyloctenium radulans, Chloris pectinata, Panicum decompositum, Atriplex* spp., *Sclerolaena* spp. and *Maireana* spp. The perennial grass *Eragrostis setifolia* may be locally abundant (< 5%).

Woody weeds: absent.

Top feed: *Atriplex nummularia* (as above).

LAND USE:

These areas are unstable and in mediocre condition. Soil surface condition is generally poor in this land unit and scalding is widespread. Much of this scalding may be a natural phenomena. Old man saltbush provides a highly palatable and nutritious perennial fodder which is also valuable as a drought reserve. However, the lack of accompanying grass and herbage species limits the bulk available on this unit. Old man saltbush is susceptible to overgrazing and there are indications that it may have originally been widely-distributed throughout the south of the survey areas. Management should aim to allow bushes to grow out of eight of grazing animals before subjecting them to extreme grazing pressure such as occurs in drought periods.

LAND UNIT 14

(Land system W8)

LANDFORM:

Extensive swamp depressions (relief < 1 m) on flat, alluvial plains.

GEOLOGY:

Quaternary alluvium. Qa.

SOILS:

Very deep, alluvial, silty, grey clays of light to medium texture. Reaction is alkaline. Surfaces have firm, silty crusts. Lime occurs at depth in the profile, Ug5.24.

VEGETATION:

Black box (*Eucalyptus largiflorens*) low woodland (6-8 m; 100-250/ha) with *Muehlenbeckia cunninghamii* low shrubs often prominent and occasional groves of *Acacia omalophylla* tall shrubs. The ground stratum is sparse, and dominated by the perennial grasses *Eragrostis setifolia* and *Paspalidium jubiflorum* (< 5%). *Sclerolaena* spp. and *Atriplex* spp. may be locally common.

Woody weeds: *Acacia omalophylla* can form dense stands (3-4 m; up to 12 000/ha); the plants are able to sucker from sub-surface roots some distance from the parents.

Top feed: negligible.

LAND USE:

These areas are stable to slightly unstable and in poor condition. Little stockfeed is produced and this unit appears to be naturally unproductive in the native state. Soils tend to have scalded surfaces. Potential productivity of these areas is high due to seasonal flooding and adequate fertility levels. Regrowth problems and possible establishment difficulties, because of the unfavourable soil surface conditions (linked to salt levels), will make development of these areas an uncertain proposition.

LAND UNIT 15

(Land systems A2 G2 W8)

LANDFORM:

Occasionally flooded, alluvial plains, with well-developed gilgai micro-relief.

GEOLOGY:

Recent alluvium. Qa.

SOILS:

Very deep, grey, alluvial soils. Textures are predominantly silty, light clays with surface crusts of silt and sand. Lime and gypsum occur throughout the profile. Ug 5.24.

VEGETATION:

Brigalow (*Acacia harpophylla*) low woodland (8-10 m; 100-475/ha) with scattered *Eucalyptus largiflorens* or *E. microtheca* trees. *Acacia cambagei* trees are occasionally abundant. Scattered, low shrubs of *Atriplex nummularia, Muehlenbeckia cunninghamii* and *Rhagodia spinescens* may be present. The ground stratum is sparse, with the perennial grasses *Eragrostis setifolia* dominant and *Paspalidium jubiflorum* and *Sporobolus mitchellii* locally abundant (< 5%). *Atriplex* spp. and *Sclerolaena* spp. may be seasonally and/or locally common.

Woody weeds: *Acacia harpophylla* regeneration.

Top feed: scattered shrubs (< 25/ha).

LAND USE:

These areas are slightly unstable and in mediocre to poor condition. Ground cover is sparse and production of perennial forage low, though limited bulk of herbage may appear after good rains. These areas have development potential because of their adequate fertility and seasonal flooding but regrowth problems could be expected to be severe.

LAND UNIT 16

(Land systems A2 A1 D1 G2 W3 W4 W5 W8)

LANDFORM:

Flat, alluvial plains.

GEOLOGY:

Recent alluvium. Qa.

SOILS:

Very deep, grey-brown, cracking of heavy texture. Reaction is alkaline. Surfaces are widely-cracking and self-mulching, with very thin, weak crusts. Lime occurs at depth in the profile, Ug5.24.

ANALYSES (2 sites)

pH	moderately alkaline at the surface
O.C.	very low
T.N.	very low
A.P.	fair to high at the surface
B.P.	low to fair at the surface
K	high
A.W.C.	high at the surface

VEGETATION:

Mitchell grass/bluegrass open tussock grassland. *Astrebla elymoides* and *A. lappacea* are the dominant perennial grasses (5-15%), with the shorter-lived *Dichanthium sericeum* highly abundant and often dominant during favourable seasons (15-30%). *Astrebla squarrosa* may be locally abundant along drainage lines. The sedge *Cyperus bifax* and grasses *Dactyloctenium radulans, Eriochloa pseudoacrotricha, Iseilema vaginiflorum*, and *Panicum decompositum* become seasonally abundant. A variety of forbs may be present. Seasonally common species include *Boerhavia diffusa, Brachyscome* spp., *Hibiscus trionum, Plantago drummondii, Psoralea* spp. and *Rhynchosia minima.*

Woody weeds: absent.

Top feed: negligible.

LAND USE:

These areas are stable and in very good condition. Some replacement of mitchell grass by the short-lived perennial bluegrass was evident following a run of good seasons. This unit provides ample bulk of grass and herbage species of high nutritional quality. Considerable rainfalls (< 50 mm), are required to produce a response on this unit but once wet up, a long growing season occurs. Perennial grasses provide drought standover fodder throughout the early stages of drought periods. This unit is highly productive in its native state and development is not considered feasible.

LAND UNIT 17

(Land systems W2 A3 B1 B2 G3 M3 R3 W7)

LANDFORM:

Alluvial plains, seasonally flooded by local catchment runoff.

GEOLOGY:

Quaternary alluvium. Qa.

SOILS:

Very deep, brown and grey-brown, alluvial clays of light to medium texture, with silt and sand bands. Reaction is alkaline. Surface structure ranges from cracking and weakly self-mulching to firm crusts of silt and sand up to 5 cm thick. Lime and gypsum are present at depth in the profile, Uf6.13, Ug5.38.

ANALYSES (3 sites)

pH	slightly acid
O.C.	low to fair
T.N.	low
A.P.	high
B.P.	very fair
K	high
E.C.	very low
Cl	very low

VEGETATION:

Gidgee (*Acacia cambagei*) low woodland (8-10 m; 250-500/ha) with emergent yapunyah (*Eucalyptus ochrophloia*, 10-12 m) trees frequent. Scattered, emergent Dawson gum (*E. cambageana*) may be present in marginal areas. Scattered *Eremophila mitchellii* tall shrubs, and *E. glabra, Muehlenbeckia cunninghamii, Myoporum deserti* and *Chenopodium auricomum* low shrubs are frequent. The ground stratum is usually sparse, with scattered tussocks of the perennial grasses *Enteropogon acicularis, Eragrostis setifolia* and *Paspalidium jubiflorum* frequent. In more open areas, the shortgrasses *Sporobolus caroli, S. actinocladus* and *Chloris pectinata* become dominant (< 5%), while the grasses *Eriochloa pseudoacrotricha* and *Dactyloctenium radulans* and forbs *Boerhavia diffusa* and *Portulaca oleracea* may be seasonally abundant. *Atriplex* spp., *Sclerolaena* spp., and *Sida fibulifera* are often common in more open areas.

Woody weeds: *Eucalyptus ochrophloia, Eremophila mitchellii, Myoporum deserti* and *Pluchea tetranthera* may form dense stands after clearing (2-5 m; 2000-3000/ha).

Top feed: scattered shrubs (< 25/ha).

LAND USE:

These lands are stable and unproductive in the natural, developed state, becoming unstable when developed by clearing. Condition in the native state is poor with some poisonous plants present. Cleared areas provide ample bulk of good quality pasture suitable for breeding and fattening. These areas are seasonally flooded and can benefit from small rainfalls, which produce runoff from the surrounding mulga country. Cleared areas provide some drought standover pasture. The high fertility and seasonal flooding of these areas provides considerable potential for development by clearing. However, severe woody weed problems follow clearing in some instances and careful management and the use of fire may be necessary to maintain this unit in stable and productive condition.

LAND UNIT 18

(Land systems A3 A1 D2 D3 S1 S2 W6 W7)

LANDFORM:

Flat, alluvial plains.

GEOLOGY:

Recent alluvium. Qa.

SOILS:

Very deep, alkaline, reddish brown, alluvial, clay soils. Sandy-loam A horizons are 10-15 cm thick and have firm crusts of silt and sand which occasionally exhibit small cracks. Subsoils are medium-textured clays with silt and sand intermixed. Lime is present at depth in the profile, Uf6.12.

VEGETATION:

Sparse grassland to herbland with scattered whitewood (*Atalaya hemiglauca*) and poplar box (*Eucalyptus populnea*) trees and *Alectryon oleifolius* tall shrubs. The ground stratum is dominated by the shortgrasses *Sporobolus actinocladus, Chloris pectinata, C. scariosa* and *Aristida platychaeta*. The annual grasses *Aristida contorta, A. anthoxanthoides, Enneapogon avenaceus* and forbs *Atriplex muelleri, Sclerolaena lanicuspis. Crassula sieberiana, Goodenia fascicularis* and *Sida* spp. are frequent and may be seasonally prominent.

Woody weeds: absent.

Top feed: negligible.

LAND USE:

These lands are unstable and in poor to mediocre condition, with widespread scalding and loss of topsoil evident. Some improvement in ephemeral ground cover is evident during better seasons. When in fair or better condition, these areas produce a limited bulk of good quality shortgrasses and herbage which provides an above maintenance level of nutrition for grazing animals if lightly stocked. These areas can respond to lighter rainfalls (> 20 mm), but because of the lack of bulk, have little standover value during drought periods. Management should aim to maintain ground cover, to prevent further scalding and topsoil loss. Limited areas have been partially revegetated by furrowing treatments.

LAND UNIT 19

(Land system W2)

LANDFORM:

Seasonally flooded depressions on alluvial plains.

GEOLOGY:

Recent alluvia. Qa.

SOILS:

Very deep, alkaline, grey, cracking, clay soils of medium texture. Gilgai micro-relief up to 1 m deep and 8 m in diameter is typical. Surfaces have firm, silty crusts over a thin (1 cm) self-mulching layer, Ug5.24.

VEGETATION:

Yapunyah (*Eucalyptus ochrophloia*: 10-12 m), gidgee (*Acacia cambagei*: 8-10 m) layered open forest to low open woodland (100-500/ha) with a sparse to open shrub stratum of *Eremophila bignoniiflora, E. polyclada, E. maculata* and *Muehlenbeckia cunninghamii*. The ground stratum is usually very sparse where the tree density is high, becoming open where the tree density is low, and dominated by the perennial grasses *Eragrostis setifolia, Astrebla squarrosa*, and *Paspalidium jubiflorum*. Annual grasses and forbs may become seasonally abundant in more open areas.

Woody weeds: absent.

Top feed: shrubs as above.

LAND USE:

In the natural state, these areas are stable and in poor condition for livestock production, providing very little pasture except in areas where tree density is low. Seasonal flooding and adequate fertility mean these areas have potential for development by clearing, though careful management may be needed to control regrowth problems.

LAND UNIT 20

(Land system W8)

LANDFORM:

Flat, alluvial plains, seasonally flooded.

GEOLOGY:

Quaternary alluvium. Qa.

SOILS:

Very deep, alluvial, grey-brown, cracking clays. Textures are predominantly medium-heavy clay. Reaction is alkaline. Surfaces are uneven and often pitted with small depressions (< 0.1 m deep). A self-mulching layer is occasionally present under a weak crust. Subsoils have moderate to strong, blocky structure. Lime is present throughout the profile with gypsum at depth, Ug5.24.

ANALYSES (4 sites)

pH	moderately alkaline at the surface
O.C.	low
T.N.	very low
A.P.	high
B.P.	fair
K	high
E.C.	very low at the surface
Cl	very low at the surface
E.S.P.	< 6% at the surface
C.E.C.	24-31 m equiv./100 g soil
Ca	> 50% of C.E.C.
A.W.C.	high
B.D.	median 1.0

VEGETATION:

Coolibah (*Eucalyptus microtheca*) low open woodland to wooded tussock grassland (5-7 m; 50/ha) with scattered *Eremophila bignoniiflora* tall shrubs and *E. polyclada, Maireana aphylla* and *Muehlenbeckia cunninghamii* low shrubs. The ground stratum is sparse to open and varies seasonally. The dominant species are the perennial grasses *Eragrostis setifolia*, with or without *Astrebla elymoides* and *A. lappacea* (5-25%). The short-lived perennial grasses *Dichanthium sericeum* and *Panicum decompositum*, and annuals *Aristida anthoxanthoides, Dactyloctenium radulans* and *Iseilema membranaceum* are frequent and may be seasonally prominent. The forb diversity is moderately high with the seasonally abundant species *Brachyscome whitei, Calotis hispidula, Daucus glochidiatus, Goodenia fascicularis, Ipomoea lonchophylla* and *Plantago drummondii* occurring frequently.

Herbage summary

	No. of species			
	Total	High Pal.	Medium Pal.	Seasonally abundant (4 sites)
Long-lived perennial grasses	6	4	2	
Other graminoids	14	12	1	7
Forbs	32	11	11	16

Woody weeds: absent.

Top feed: scattered shrubs (usually < 25/ha).

LAND USE:

This unit is stable and in good condition when seasonal conditions are favourable. These areas produce a substantial bulk of herbage and grasses of high nutritional quality which provides an excellent grazing animal diet. The heavy soils of this unit require substantial rainfalls (> 60 mm), to respond when dry but once wet up, provide an extended growing season. The perennial grasses and herbage stand over well and provide a useful drought reserve, though once this is exhausted in extended drought periods, the unit is of little value. Development potential is limited to possible introduction of species which make better use of the high fertility and water-holding capacity of these soils.

LAND UNIT 21

(Land systems D2 D3 W6)

LANDFORM:

Minor, outside channels of major rivers. Relief ranges up to 2 m deep and 30 m wide.

GEOLOGY:

Recent alluvium. Qa.

SOILS:

Very deep, layered, alluvial soils. Reddish brown, loamy sands of variable depth overlie alkaline, brown, sandy-clays, Db2.53. Very deep, grey, alluvial clays occur along the channel floors, Ug5.24.

VEGETATION:

Coolibah (*Eucalyptus microtheca*) woodland to open woodland (10-11 m; 50-100/ha), occasionally with *E. camaldulensis* trees present. Scattered *Acacia stenophylla* tall shrubs may occur. The ground stratum is open to dense, depending on seasonal conditions, and dominated by the perennial grasses *Bothriochloa decipiens, Heteropogon contortus, Dichanthium sericeum, Sporobolus mitchellii* and *Leptochloa digitata* (5-40%). Forbs are infrequent, but may be seasonally prominent.

Woody weeds: absent.

Top feed: negligible.

Weeds: *Heteropogon contortus* may be a problem in some areas.

LAND USE:

These areas are stable and in fair condition. However, significant infestations of black speargrass (*Heteropogon contortus*) may make these areas unsuitable for grazing by sheep if the area affected increases. Perennial grasses provide an ample bulk of moderate quality pasture best suited to cattle fattening as only small amounts of herbage are present. This unit can respond to moderate rainfalls (>25 mm), and provides a useful bulk of low to very low quality feed during drought periods. The grass maintains reasonable nutritional quality through periods of winter frosts. Management should aim to eliminate or at least limit black speargrass infestations.

LAND UNIT 22

(Land system D2).

LANDFORM:

Flat to very gently undulating levees of the Warrego River.

GEOLOGY:

Quaternary alluvia. Qa.

SOILS:

Very deep, brown, alluvial soils. Textures range from sandy-clay-loam to sandy-clay, with bands of clayey-sand at depth. Reaction is alkaline. Surfaces are hardsetting, Uf1.42.

ANALYSES (2 sites)

pH	neutral
O.C.	low
T.N.	very low
A.P.	variable (low-high
B.P.	variable (low-high)
E.C.	very low
Cl	very low

VEGETATION:

Gundabluey (*Acacia victoriae*) open shrubland to shrubby open grassland (2-4 m; to 500/ha) with scattered *Eucalyptus terminalis, E. populnea, Atalaya hemiglauca, Acacia excelsa* and *Ventilago viminalis* trees. The ground stratum varies seasonally, but the shortgrasses *Enneapogon avenaceus, E. polyphyllus, Chloris pectinata* and *Sporobolus actinocladus* are usually dominant (< 5%). The perennial grasses *Aristida* spp., *Bothriochloa ewartiana, Heteropogon contortus*, and *Themeda triandra* may be locally abundant. A variety of forbs may be present with species such as *Boerhavia diffusa*, and *Convolvulus erubescens*, with *Evolvulus alsinoides* and *Lotus cruenta* becoming seasonally prominent.

Woody weeds: *Acacia victoriae* occasionally.

Top feed: *Acacia victoriae* (as above).

LAND USE:

These areas are slightly unstable but are generally in fair condition. Some improvement in condition has occurred during good seasons but increased gundabluey densities are also evident. Shortgrasses and herbage species provide a limited bulk of pasture of high nutritional quality. Occasional infestations of black speargrass have been recorded on this unit and these areas may be unsuitable for grazing sheep. These areas can respond to lighter rainfalls (> 15 mm), but otherwise have limited drought standover value, with limited gundabluey top feed being available. Development of these areas is not considered feasible unless new pasture species can be found and introduced.

LAND UNIT 23

(Land system A1 A2 G2 G3)

LANDFORM:

Isolated, small rises on extensive, alluvial plains. Relief typically < 0.3 m.

GEOLOGY:

Quaternary alluvium. Qa.

SOILS:

Very deep, reddish brown, alluvial soils. Reaction is alkaline. Textures are sandy, light to medium clays. Surfaces are firmly crusting, occasionally cracking, Ug5.36, Uf6.12. Minor areas with thin loamy-sand surface horizons occur. These areas have hardsetting surfaces, Dr2.13.

ANALYSES (2 sites)

pH	neutral to mildly alkaline at the surface
O.C.	very low
T.N.	very low
A.P.	very low to fair
B.P.	very low to fair
K	very fair to high
E.C.	medium to very high values at depth
Cl	low to high values at depth
E.S.P.	one profile recorded a sodic surface (E.S.P. = 8.5%)
A.W.C.	medium to low

VEGETATION:

Whitewood (*Atalaya hemiglauca*) low open woodland to wooded grassland/sparse grassland (9-10 m; < 100/ha). Scattered *Flindersia maculosa* and *Acacia excelsa* trees and *Alectryon oleifolius* tall shrubs may be present. The ground stratum is sparse to seasonally open, dominated by *Aristida latifolia* and the shortgrasses *Chloris pectinata* and *Sporobolus actinocladus* (5-25%). The grasses *Aristida contorta, Enneapogon avenaceus, Iseilema membranaceum* and *Tripogon loliiformis* may be seasonally abundant. A variety of forbs occur infrequently but may be seasonally prominent. More frequent species include *Sclerolaena* spp., *Pterocaulon sphacelatum, Sida* spp., and *Abutilon* spp..

Woody weeds: absent

Top feed: *Atalaya hemiglauca* and other trees as above.

LAND USE:

These areas are slightly unstable and are generally in poor condition, with limited vegetative cover. Pastures are sparse with shortgrasses and a variety of herbage species in season providing good nutritional quality but very limited bulk. These areas are able to respond to lighter rainfalls but provide little standover feed during drought periods. Management should aim to maintain adequate vegetative cover on these areas, particularly where signs of soil loss were evident.

LAND UNIT 24

(Land system W7 B1 F1 G1 W2)

LANDFORM:

Braided channels, with one or more main channels. Main channels range up to 8 m deep and 40 m wide, while the braided channels are usually < 3 m deep and 30 m wide.

GEOLOGY:

Quaternary alluvium. Qa.

SOILS:

Very deep, alluvial, clay soils. Heavy, dark-brown and grey, cracking clays predominate. Surfaces are weakly crusting over a self-mulching layer which may be up to 3 cm thick. Subsoils are strongly structured, Ug5.24.

VEGETATION:

River red gum (*Eucalyptus camaldulensis*), with or without coolibah (*E. microtheca*), fringing woodland (10-12 m; < 100/ha) with *Acacia stenophylla* and *Eremophila bignoniiflora* tall shrubs. *Muehlenbeckia cunninghamii* low shrubs may be abundant. The ground stratum is usually sparse and dominated by the perennial grasses *Sporobolus mitchellii*, *Leptochloa digitata* and *Chrysopogon fallax* (< 5%).

Woody weeds: negligible.

Top feed: scattered shrubs.

LAND USE:

These seasonally flooded channels are relatively stable and provide shade and water for stock, with a number of permanent waterholes. A limited bulk of pasture in the form of perennial tussock grasses is available along the banks of the channels.

LAND UNIT 25

(Land systems E1, W3)

LANDFORM:

Very gently sloping,slightly concave plains, forming run-on areas ("box flats") which drain onto local alluvial plains.

GEOLOGY:

Quaternary erosion products over the Tertiary land surface.

SOILS:

Moderately deep to deep, alkaline, reddish brown, texture contrast soils predominate. Clay-loam A horizons 20 to 60 cm deep overlie light to medium clay subsoils. Surfaces are hardsetting. A sporadic bleach was recorded in some profiles. Lime may be present at depth, Dr2.13, Dr2.53, Dr2.72, Dy2.12 Minor areas of shallow to moderately deep, red earths occur. Textures are sandy-clay-loam throughout, with deeper profiles grading into light clays, Um1.43, Gn2.19, Uf5.12.

ANALYSES (9 sites)

pH	medium to strongly acid at the surface, becoming mildly to strongly alkaline at depth
O.C.	low to fair
T.N.	low
A.P.	very low to low
B.P.	very low to low
K	high
E.C.	very low throughout
Cl	very low throughout
E.S.P.	negligible
C.E.C.	9-16 m. equiv./100 g soil
Ca	30% of C.E.C. at the surface
A.W.C.	low

VEGETATION:

Poplar box (*Eucalyptus populnea*) woodland to open woodland (10-11 m; 25-125/ha) with a conspicuous tall shrub stratum of sandalwood (*Eremophila mitchellii* 2-5 m; 250-1250/ha). *Cassia nemophila*, *Eremophila glabra* and *Acacia aneura* may also form a locally prominent, low to tall shrub stratum. The sparse to dense ground stratum is dominated by the short-lived perennial grasses *Eragrostis microcarpa*, *Aristida calycina* var.*praealta* and *Chloris pectinata* (10-40%), while *Digitaria brownii*, *Eragrostis lacunaria* and *Panicum effusum* are frequent and may be locally abundant. The perennial grass *Paspalidium constrictum* is common (< 10%), and *Bothriochloa decipiens*, *Chloris ventricosa*, *Enteropogon acicularis*, *Panicum subxerophilum* and *Themeda triandra* are abundant. *Eragrostis elongata*, *Eriochloa pseudoacrotricha* and *Brachiaria gilesii* may be seasonally abundant. The forb diversity is high but individual species usually occur infrequently. *Hibiscus sturtii* and *Sida* spp. may be locally abundant, and *Alternanthera denticulata*, *Calotis cuneata*, *C. lappulacea*, *Convolvulus erubescens*, *Euphorbia drummondii*, *Plantago drummondii* and others may become seasonally abundant.

Herbage summary

	No. of species Total	High Pal.	Medium Pal.	Seasonally abundant (9 sites)
Long-lived perennial grasses	11	5	5	
Other graminoids	30	14	10	9
Forbs	60	13	17	22

Woody weeds: *Eremophila mitchellii*, often with one or more of *E. glabra*, *Cassia nemophila*, *C. artemisioides* and *Acacia aneura* can reach high densities (1-5 m; 250-3250/ha).

Top feed: *Acacia aneura* may be common (1-4 m; up to 625/ha).

LAND USE:

This unit is unstable with indications of increasing densities of sandalwood and *Cassia* spp.. Condition is fair, with a substantial bulk and diversity of grasses and forbs which provide nutritional levels at least adequate for maintenance of grazing animals. This unit receives runoff water from the surrounding mulga country and so, can respond to lighter storm rains which produce runoff. Perennial grasses stand over well and form a useful drought reserve. Fire may be useful for removing excessive dry feed produced in good seasons. Though these areas are of low fertility, the levels of production obtained from native pastures can be improved by water spreading or ponding schemes. However, the high cost of these schemes has meant that few have been implemented. Management should aim to maintain sufficient ground cover to prevent excessive runoff from starting gully erosion and also to prevent further establishment of woody weed species.

LAND UNIT 26

(Land systems B2 B3 B4 G2 M5 R2 R3 W2)

LANDFORM:

Very gently sloping, slightly concave plains, forming run-on areas ("box flats") which join local alluvia.

GEOLOGY:

Quaternary erosion products over the Tertiary land surface.

SOILS:

Moderately deep to deep, acid to neutral, loamy, red earths. Surfaces are hardsetting have sandy-clay-loam to fine, sandy-clay-loam textures, grading into sandy-clay-loams and light, sandy-clays at depth, Gn2.12, Um1.43, Um5.52.

ANALYSES (5 sites)

pH	medium to slightly acid at the surface, becoming moderately to strongly alkaline at depth
O.C.	low to fair
T.N.	low to very low
A.P.	very low to fair
B.P.	low to very low
K	high
E.C.	very low throughout
Cl	very low to low throughout
E.S.P.	negligible at the surface
C.E.C.	13-17 m equiv./100 g soil at the surface
Ca	28-40 % of C.E.C. at the surface
A.W.C.	medium
B.D.	1.2

VEGETATION:

Poplar box (*Eucalyptus populnea*) low woodland to low open woodland (7-9 m; 25-100/ha) with mulga (*Acacia aneura*) usually prominent. Scattered *Eucalyptus microtheca* trees may occur in wetter areas. A well-defined shrub stratum is absent although scattered *Eremophila mitchellii, E. glabra* and *E. gilesii* may be present. The ground stratum is open to dense, and dominated by *Themeda triandra* and the short-lived perennial *Eragrostis microcarpa* (10-50 %). The perennials *Enteropogon acicularis* occurs frequently, while *Thyridolepis mitchelliana, Themeda avenacea*, and in wetter areas, *Eragrostis setifolia* may be locally abundant. The short-lived perennials *Chloris pectinata* and *Panicum effusum* are frequent, with *Aristida jerichoensis*, and in wetter areas, *A. psammophila* and *Dichanthium sericeum* locally abundant. *Brachiaria gilesii* and *Dactyloctenium radulans* may be seasonally abundant in highly disturbed areas. A variety of forbs can occur but are usually infrequent, although they may become seasonally abundant.

Herbage summary:

	No. of species			
	Total	High Pal.	Medium Pal.	Seasonally abundant (5 sites)
Long-lived perennial grasses	10	4	6	
Other graminoids	24	13	8	8
Forbs	26	3	9	8

Woody weeds: *Eremophila gilesii* may be a problem in marginal areas (< 0.5 m; to 5000/ha).

Top feed: *Acacia aneura* trees may be common (7-8 m; 50-100/ha).

LAND USE:

This unit is slightly unstable. It is presently in good condition following a run of good seasons, but some areas have previously been invaded by Charleville turkey-bush. Excessive runoff from the adjoining mulga lands has caused active gully erosion on small areas of this unit. These lands provide a substantial bulk of perennial grasses of adequate nutritional value, and a maintenance diet for sheep and cattle. This unit responds to lighter rainfalls (> 15 mm), which receive runoff from the adjacent mulga lands. Perennial grasses provide useful drought standover feed, and mulga top feed may be available in some areas. Burning may be used to remove some of the bulk of feed produced in good seasons and to control mulga regrowth. Development of these areas is unlikely on a commercial scale because of low and unreliable rainfall and the low fertility of these areas. Management should aim to maintain adequate ground cover to prevent woody weed invasion and soil erosion.

LAND UNIT 27

(Land systems B3 B1 H1 M1 S3 W1)

LANDFORM:

Gently sloping (< 1%), slightly concave plains ("box flats"), draining onto local alluvia.

GEOLOGY:

Quaternary erosion products over the Tertiary land surface.

SOILS:

Moderately deep to deep, acid, red clays and associated areas of loamy, red earths. Textures range from fine, sandy-clay-loam to light clays, and may grade into medium clays to depth. Surfaces are hardsetting, Uf6.12, Um1.43, Gn2.12.

ANALYSES (4 sites)

pH	medium to slightly acid at the surface increasing to mildly alkaline at depth
O.C.	low to fair
T.N.	low to very low
A.P.	very low throughout
B.P.	very low
K	high
E.C.	very low throughout
Cl	very low throughout
E.S.P.	negligible
C.E.C.	9-12 m. equiv./100 g soil
Ca	30-60% of C.E.C.
A.W.C.	low
B.D.	1.4

VEGETATION:

Poplar box (*Eucalyptus populnea*) woodland to open woodland/low open woodland (8-11 m; 25-250/ha), occasionally with scattered *Acacia aneura* and *Eucalyptus melanophloia* trees. Scattered *Eremophila mitchellii* and *E. longifolia* tall shrubs are frequent. The ground stratum is open to dense, and dominated by the perennial grass *Themeda triandra* and the shorter-lived *Aristida calycina* var. praealta (8-30%). The perennials *Bothriochloa decipiens, B. ewartiana* and *Panicum subxerophilum*, and perennials *Aristida calycina* var. *calycina* and *Eulalia aurea* may be locally abundant (8-25%), while *Digitaria brownii* and *Panicum effusum* are frequent. A variety of forbs may be present but are usually infrequent, although they may be seasonally abundant. *Brunoniella australis, Goodenia heterochila, Rostellularia adscendens* and *Solanum ferocissimum* are more frequent species.

Herbage summary

	No. of species			
	Total	High Pal.	Medium Pal.	Seasonally abundant (4 sites)
Long-lived perennial grasses	11	6	2	
Other graminoids	27	11	10	5
Forbs	29	7	9	7

Woody weeds: absent.

Top feed: scattered shrubs (< 25/ha).

LAND USE:

These areas are stable and in good condition. Signs of erosion or woody weed invasion are absent after a run of good seasons. Palatable perennial grasses predominate and provide a substantial bulk of sufficient nutritional quality for at least a maintenance diet for sheep and cattle. These areas will respond to lighter rainfalls (>20 mm), and receive run-on water from the surrounding mulga country. Perennial grasses stand over well in drought periods. Burning (cool fires) may be useful to run over excessive bulk of dry grass and control eucalypt seedling regrowth. On two properties, these areas have been cropped with some success in spite of their fertility and relatively low water-holding capacity. Waterspreading schemes to make better use of run-on water are technically feasible but costly. Management should aim to maintain adequate ground cover to control water movement and prevent seedling regrowth.

LAND UNIT 28

(Land systems B4 H2 H4 L2 M2 S1 S2 W2)

LANDFORM:

Shallow drainage lines on flat plains.

GEOLOGY:

Quaternary sand and red earth cover over the Tertiary land surface. Qs, Qr.

SOILS:

Moderately deep to deep, acid, sandy, red earths and reddish brown clays. The red earth textures range from sandy-loamto light, sandy-clay-loam. Surfaces are hardsetting and sinkholes are common, Uc1.43, Uf6.31.

ANALYSES (2 sites)

pH	slightly acid
A.P.	very low
B.P.	very low
E.C.	very low
Cl	very low

VEGETATION:

Poplar box (*Eucalyptus populnea*) low woodland to low open woodland (9-10 m; 25-125/ha) with *Acacia aneura* often prominent. A sparse tall shrub stratum of *Eremophila mitchellii* is sometimes present. The ground stratum is open to dense,and dominated by the perennial grasses *Themeda triandra* and *Panicum subxerophilum* and the shorter-lived *Aristida calycina* var. *praealta* (25-50%). *Paspalidium constrictum, Digitaria hystrichoides, D. brownii, Eragrostis microcarpa* and *Eulalia aurea* are frequent. Forbs may be seasonally abundant.

Woody weeds: *Eremophila mitchellii* and *Acacia aneura* may be a problem after disturbance (to 1000/ha).

Top feed: *Acacia aneura* may be common.

LAND USE:

These areas are slightly unstable and are in mediocre condition. There are increasing populations of woody weeds but ground vegetation is in fair condition and improving with favourable seasonal conditions. Perennial grasses and seasonal forbs provide a maintenance diet for sheep and cattle. These areas can respond to smaller rainfalls (>15 mm), and receive some run-on water. Perennial grasses provide a limited bulk of standover feed into drought periods. Management should aim to maintain adequate ground cover in these areas to restrict sandalwood invasion and decrease runoff.

LAND UNIT 29

(Land system M2)

LANDFORM:

Gently undulating, convex plains. Slopes <2%.

GEOLOGY:

Quaternary sand and red earth cover. Qs, Qr.

SOILS:

Shallow to moderately deep, acid, loamy, red earths. Textures range from light, sandy-clay-loam at the surface to sandy-clay-loam at depth. Surfaces are hardsetting and frequently scalded.

VEGETATION:

Poplar box (*Eucalyptus populnea*) low woodland (8 m; <100/ha) with a dense sandalwood (*Eremophila mitchellii*) tall shrub stratum (2-4 m; 500-750 ha). The ground stratum is usually extremely sparse, with scattered tussocks of the short-lived perennial grasses *Aristida jerichoensis* and *Eragrostis lacunaria*, and scattered *Sida* spp. and *Sclerolaena* spp..

Woody weeds: *Eremophila mitchellii* (as above)

Top feed: Negligible.

LAND USE:

These areas are in poor condition with significant areas of bare ground and signs of sheet erosion evident. Sandalwood invasion is characteristic. Condition appears to trend downward. Little palatable pasture is available. High runoff limits response to rainfall. This unit is very limited in extent and the general management recommendation to maintain adequate ground cover by adjusting grazing pressure applies.

LAND UNIT 30

(Land systems M2 M3 S1 N1)

LANDFORM:

Flat plains. Slopes <1%.

GEOLOGY:

Quaternary sand sheet. Qs.

SOILS:

Deep to very deep,alkaline, sandy, red earths. Textures are light, sandy-clay-loam throughout. Surfaces are hardsetting, Um5.42.

VEGETATION:

Forest gum (*Eucalyptus intertexta*) open woodland (11-12 m; 25-35/ha) frequently with a mulga (*Acacia aneura*) sparse to open tall shrub/low tree stratum. Scattered *Eucalyptus melanophloia* trees may be present in sandier areas. In minor drainage areas, forest gum woodland (11-12 m; 50/ha) may develop with *Eucalyptus populnea* forming a lower tree stratum (9-10 m; 25/ha) and *Eremophila mitchellii* a tall shrub stratum (2-4 m; 250-750/ha). The ground stratum is open to dense, dominated by the perennial grass *Thyridolepis mitchelliana* (5-10%), under denser mulga but being replaced by the shorter-lived perennial *Aristida calycina* var. *praealta* in more open areas. The perennials *Eragrostis eriopoda, Monachather paradoxa* and *Themeda triandra*, and shorter-lived perennials *Digitaria* spp., *Eragrostis lacunaria* and *Panicum effusum* are frequent.

Woody weeds: *Eremophila mitchellii* in drainage areas.

Top feed: *Acacia aneura* is usually present (as above).

LAND USE:

The unit is stable and in mediocre condition. Forbs are lacking, and palatability and nutritional value of perennial grass pastures is low. These areas can respond rapidly to light rainfalls (>15 mm), and provide a limited standover of low quality pasture in drought periods.

LAND UNIT 31

(Land systems A1 A3 D1 D2 D3 G2 W6)

LANDFORM:

Minor drainage lines on extensive, alluvial plains.

GEOLOGY:

Recent alluvium. Qa.

SOILS:

Very deep, neutral, alluvial soils. Textures increase from loamy sands and sandy-clay-loams at the surface to sandy and silty clays at depth. Surfaces are hardsetting, Dr2.13, Dr5.52, Db1.52, Uc1.23.

ANALYSES (4 sites)

pH	slightly acid to neutral
O.C.	low
T.N.	very low
A.P.	variable, usually high
B.P.	variable, usually very fair to high
K	high
E.C.	very low
Cl	very low

VEGETATION:

Poplar box (*Eucalyptus populnea*) low woodland (8-10 m, 100-375/ha), occasionally with *Eucalyptus melanophloia* trees prominent. Scattered shrubs frequently occur, including *Canthium oleifolium, Eremophila mitchellii, Geijera parviflora* and *Myoporum acuminatum*. The ground stratum is open to dense, and dominated by the perennial grasses *Bothriochloa decipiens, B. ewartiana* and *Themeda triandra*, and the shorter-lived species *Chloris ventricosa* and *Heteropogon contortus* (15-40%). Scattered tussocks of *Aristida calycina* var. *calycina, Chrysopogon fallax* and *Enteropogon acicularis* are frequent, while *Paspalidium constrictum* and *Aristida ramosa* may be locally abundant. A variety of forbs can occur, some of which may be seasonally abundant. More frequent species include *Calotis lappulacea, Euphorbia drummondii, Goodenia heterochila* and *Wahlenbergia* spp..

Herbage summary

	No. of species			
	Total	High Pal.	Medium Pal.	Seasonally abundant (4 sites)
Long-lived perennial grasses	9	6	1	
Other graminoids	32	7	8	3
Forbs	18	3	5	5

Woody weeds: Massed germination of *Eucalyptus populnea* in past good seasons has resulted in dense stands of trees (up to 2500/ha) in some areas.

Top feed: Scattered shrubs (<25/ha).

Weeds: *Heteropogon contortus* may become dense in favourable seasons.

LAND USE:

These areas are slightly unstable, the main problem being invasion by black speargrass. Condition is seasonal but generally mediocre to poor with coarse perennial grasses best suited to cattle, predominating. Nutrition is adequate during growth periods but lacking at other times. Drought standover value is limited. Ellangowan poison bush was present at some sites. Very sparse top feed is available. Fire may be used to clear away low quality pasture in good seasons. Fertility is adequate for native pastures and introduction of buffel may be feasible.

LAND UNIT 32

(Land systems F1 G1 R1)

LANDFORM:

Gently undulating plains. Slopes <1%.

GEOLOGY:

Cretaceous sediments. Coreena member, Doncaster member. Klc. Kld.

SOILS:

Shallow, alkaline, dark brown to reddish brown, cracking clays of medium to heavy texture. Surfaces are cracking with weak crusts and are scattered with gravel, Ug5.32, Ug5.38.

ANALYSES (3 sites)

pH	moderately alkaline to neutral at the surface, moderately alkaline throughout the profile
O.C.	low to very low
T.N.	low to very low
A.P.	low to fair at the surface,low throughout the profile
B.P.	low to very low
E.C.	very low at the surface, becoming medium at depth
Cl	very low at the surface

VEGETATION:

Mitchell grass, bluegrass tussock grassland to open tussock grassland, with scattered *Acacia pendula* low trees in some areas. The perennial *Astrebla lappacea*, and in favourable years the shorter-lived *Dichanthium sericeum*, are dominant (5-25%). *Astrebla elymoides* and *A. squarrosa* may be abundant in wetter areas. The short-lived perennials *Aristida leptopoda, A. platychaeta, Digitaria divaricatissima* and *Panicum decompositum* occur frequently, while the annuals *Eriochloa pseudoacrotricha* and *Iseilema membranaceum* may be seasonally abundant. The forbs *Calotis cuneata, Goodenia fascicularis, Lotus cruenta* and *Plantago drummondii* may also be seasonally prominent. Shallow rises support a variety of trees and shrubs, the most common being *Acacia pendula, Flindersia maculosa, Alectryon oleifolius, Hakea leucoptera, Eremophila glabra* and *Maireana aphylla*. The forbs *Sclerolaena* spp., *Atriplex* spp. and *Salsola kali* may be locally abundant on these rises.

Woody weeds: *Hakea leucoptera* may form dense groves on the rises.

Top feed: Trees and shrubs on rises.

LAND USE:

These are relatively stable areas in good condition. Perennial grasses and forbs provide a good balance of bulk and nutritional quality adequate for breeding and fattening sheep and cattle. White speargrass *(Aristida leptopoda)* has been recorded on this unit and may cause wool quality problems in seasons when good summer rains occur. Substantial rainfalls (>35 mm), are required to produce a response in this land when dry. Perennial grasses stand over well into the early stages of drought but the absence of top feed means carrying capacity is very limited during extended drought periods. Fertility is adequate for native pastures.

LAND UNIT 33

(Land systems G1 F1 R1)

LANDFORM:

Gently sloping plains. Slopes <3%.

GEOLOGY:

Cretaceous Coreena or Doncaster members. Klc, Kld.

SOILS:

Deep to very deep, reddish brown to brown, heavy, cracking clays. Surfaces have weak crusts, usually over a thin self-mulching layer. Stone and gravel pavements are characteristic, Ug5.38.

VEGETATION:

Brigalow (*Acacia harpophylla*) low woodland to tall shrubland (4-9 m; 225-1000/ha), occasionally gidgee (*A. cambagei*) low woodland. *Eucalyptus thozetiana* is sometimes an emergent tree on the upper slopes. Scattered *Atalaya hemiglauca, Flindersia maculosa* and *Brachychiton rupestre* trees, and *Capparis loranthifolia, Eremophila mitchellii, Geijera parviflora, Hakea leucoptera* and *Heterodendrum oleifolium* tall shrubs are usually present. The ground stratum is frequently sparse although annual grasses and forbs may be seasonally abundant. The dominant grasses include the perennials *Paspalidium constrictum* and *Enteropogon acicularis* and the shortgrass *Sporobolus caroli* (<5%). The forbs *Abutilon oxycarpum, Sida fibulifera*, and *Portulaca* spp. aff. *P. oleracea* occur frequently, while the subshrubs *Chenopodium pseudomicrophyllum* and *Enchylaena tomentosa* may be locally abundant.

Woody weeds: *Acacia harpophylla* regeneration (as above).

Top feed: Scattered trees and shrubs (usually <25/ha).

LAND USE:

These areas are slightly unstable to unstable, and in mediocre condition. Perennial ground cover is sparse and increasing densities of young brigalow shrubs indicate declining condition in some areas. Pasture bulk on this unit is limited but quality is good and provides adequate nutrition for fattening and breeding. Substantial rainfalls (>30 mm), or runoff water from adjacent scarps, is necessary to produce significant growth on this unit when dry. There is little drought standover feed or top feed. In most areas, there is insufficient pasture bulk to carry a fire hot enough to reduce brigalow densities. A number of areas have been developed by chaining but regrowth problems are very severe and development should only be undertaken with this in mind.

LAND UNIT 34

(Land systems G2 A1 D2 G3 W2 W8)

LANDFORM:

Flat, alluvial plains.

GEOLOGY:

Quaternary sands over alluvium. Qs/Qa.

SOILS:

Very deep, reddish brown, alkaline, alluvial texture contrast soils predominate. Thin, sandy-loam to sandy-clay-loam. A horizons overlie sandy, light to medium clay subsoils. Surfaces are hardsetting, Dr2.13, Dr2.53, Dr2.62, Dr3.53, Dy2.13, Db2.13, Uf6.12, Um5.52.

ANALYSES (9 sites)

pH	neutral to mildly alkaline at the surface, becoming moderately alkaline at depth
O.C.	low to very low
T.N.	low to very low
A.P.	generally, fair at the surface becoming low at depth
B.P.	fair
K	high
E.C.	very low at the surface, becoming high to very high at 120 cm
Cl	very low at the surface, becoming medium to high at 120 cm
E.S.P.	6%
C.E.C.	medium value 15 m equiv./100 g soil
Ca	usually 50% of C.E.C.
A.W.C.	medium to low
B.D.	medium value 1.4

VEGETATION:

Gidgee (*Acacia cambagei*) low woodland to low open woodland, the trees occasionally groved (8-9 m; 75-225/ha), with scattered *Atalaya hemiglauca* and *Flindersia maculosa* trees. A tall shrub stratum of sandalwood (*Eremophila mitchellii*; 2-4 m; 50-375/ha) is frequent, while scattered *E. glabra* and *Myoporum deserti* low shrubs may be present. The ground stratum is sparse to seasonally open, or dense in badly disturbed areas. A large number of shortgrasses and seasonally abundant grasses and forbs are present. The dominant shortgrasses are *Chloris pectinata, Sporobolus actinocladus* and *S. caroli* (5-10%) while the annuals *Aristida contorta, A. anthoxanthoides, Eriochloa pseudoacrotricha, Tripogon loliiformis, Dactyloctenium radulans* and *Enneapogon polyphyllus* may be seasonally co-dominants. The latter two may become dominant (20-50%) in badly disturbed areas. Scattered tussocks of the perennial grasses *Enteropogon acicularis, Eragrostis setifolia* and *Paspalidium constrictum* are frequent. The dominant forbs include a large number of *Sclerolaena* spp., the more important of which are *S. divaricata, S. birchii, S. lanicuspis* and *S. bicornis* (2-10%). *Abutilon oxycarpum, Malvastrum americanum, Sida fibulifera, S. everistiana, Salsola kali, Solanum esuriale, Trianthema triquetra* and *Portulaca oleracea* occur frequently, and may become seasonally abundant.

Herbage summary

	No. of species			
	Total	High Pal.	Medium Pal.	Seasonally abundant (9 sites)
Long-lived perennial grasses	4	2	2	
Other graminoids	33	17	10	15
Forbs	47	13	8	9

Woody weeds: *Eremophila mitchellii* may reach moderately high densities after disturbance (up to 600/ha).

Top feed: Scattered trees and shrubs (<25/ha).

LAND USE:

These areas are slightly unstable (because of the likelihood of sandalwood invasion and the encroachment of scalding around the margins). Limited areas are already in poor condition as a result of sandalwood invasion. Scalded areas frequently fringe this land unit. Pastures are predominantly forbs and shortgrasses, providing high nutritional levels but limited bulk. Rainfalls as light as 15 mm can produce some response on this unit in the cooler months. Drought standover value is very limited because of the small bulk of herbage and grass available. Gidgee has been burnt down to provide drought fodder in the past on some properties. Gidgee pods, leaf-fall, and sometimes young gidgee leaves are eaten by sheep, and provide reasonable nutrition at very low stocking rates. Disturbance appears to favour sandalwood establishment, and consistently high levels of utilisation appear to reduce the component of palatable forbs in the pasture. The appearance of scalded areas on old stock routes shows that complete removal of ground cover leads to wind-induced soil movement and loss of the sandy A horizon, leaving behind the scalded surface of the clay horizon. Development of this land unit is generally not feasible because of the scattered occurrence of this land unit. Management should aim to avoid consistent over-utilisation, and to maintain or increase the number of palatable pasture species which occur in this land unit, by not using heavy grazing pressure during drought periods.

LAND UNIT 35

(Land systems G3 A1 A2 A3 M3 S2 W2 W3 W4 W7 W8)

LANDFORM:

Flat, alluvial plains.

GEOLOGY:

Quaternary alluvium. Qa.

SOILS:

Very deep, brown, alluvial, cracking, clay soils with alkaline reaction. Textures are light to medium-heavy clay with sand and silt intermixed. Surfaces are cracking and crusting, Ug5.34, Ug5.38, Uf6.12.

ANALYSES (7 sites)

pH	neutral to mildly alkaline at the surface, becoming moderately alkaline at 120 cm
O.C.	low
T.N.	low
A.P.	high to fair throughout
B.P.	fair to high
K	high
E.C.	very low at the surface, becoming very high to high below 60 cm
Cl	very low at the surface, becoming high at 120 cm
E.S.P.	6%
C.E.C.	medium value 23 m. equiv./100 g soil
Ca	>55% of C.E.C.
A.W.C.	medium to high
B.D.	medium value 1.2

VEGETATION:

Gidgee (*Acacia cambagei*) low open forest to low open woodland (8-9 m; 150-100/ha). A shrub stratum is usually absent, but scattered *Eremophila mitchellii* tall shrubs may occur. *Enchylaena tomentosa* is a frequent subshrub. The ground stratum is sparse to open, but varies occasionally, and contains a large number of shortgrasses, forbs and annual herbage species. The dominant shortgrasses include *Sporobolus caroli, S. actinocladus* and *Chloris pectinata* (5-10%), while *Brachyachne convergens, Dactyloctenium radulans* and *Tripogon loliiformis* may be seasonally abundant. The perennial grass *Eragrostis setifolia* is frequent and may be locally abundant, (5-10%), while scattered tussocks of *Astrebla* spp. may be present. The dominant forbs include *Chenopodium desertorum* ssp. *microphyllum, Sclerolaena calcarata,* and *Dissocarpus biflorus* var. *cephalocarpus* (2-10%), while *Sclerolaena birchii, S. muricata, Malvastrum americanum* and *Sida trichopoda* are frequent. *Hibiscus trionum, Portulaca oleracea, Salsola kali* and *Trianthema triquetra* are frequent, and maybe seasonally abundant.

Herbage summary

	No. of species			
	Total	High Pal.	Medium Pal.	Seasonally abundant (7 sites)
Long-lived perennial grasses	8	3	5	
Other graminoids	26	14	6	14
Forbs	44	10	18	17

Woody weeds: not a problem.

Top feed: Scattered trees and shrubs (25/ha).

LAND USE:

These areas are stable. Condition is seasonal,ranging from mediocre to good. Heavy grazing pressure is placed on this land unit but evidence of a continuous downtrend in condition is not apparent. Pasture nutrition is adequate for breeding and fattening but bulk is limited. Substantial rainfalls (>25 mm), are required for a growth response on this unit when dry. Drought grazing capacity is very limited because of the lack of bulk in the pasture. Gidgee pods and leaf-fall and leaves off young shrubs provide some nutrition and gidgee trees have been burnt down in the past to provide drought fodder on some properties. Development of these lands has not been undertaken to date because of the scattered and patchy distribution of the unit. Sustained overgrazing of these areas should be avoided because of the danger of lowering, at least temporarily, the component of palatable herbage in the pasture.

LAND UNIT 36

(Land system G2)

LANDFORM:

Flat, alluvial plains.

GEOLOGY:

Quaternary alluvium. Qa/Qs.

SOILS:

Very deep, reddish brown, alluvial soils with alkaline reaction. Textures range from sandy-loam to sandy-clay. Surfaces are hardsetting, Dr2.53, Um5.52.

ANALYSES (3 sites)

pH	slightly acid to neutral at the surface, becoming strongly to very strongly alkaline at depth
O.C.	low
T.N.	very low to low
A.P.	fair to high at the surface, low at depth
B.P.	low to very fair
E.C.	very low throughout
Cl	very low throughout
E.S.P.	negligible
A.W.C.	low throughout

VEGETATION:

Gidgee (*Acacia cambagei*) and/or brigalow (*A. harpophylla*) low woodland to low open woodland (7-8 m; 100-450/ha). Scattered *Eremophila mitchellii* tall shrubs are frequent, while the subshrubs *Enchylaena tomentosa* and *Maireana triptera* maybe locally abundant. The ground stratum is sparse to seasonally open and dominated by perennial grasses, but contains a large number of shortgrass and forb species. The perennial grasses *Paspalidium constrictum, Eragrostis setifolia* and *Enteropogon acicularis* are locally dominant 95-10%), while the shortgrasses *Chloris pectinata, Sporobolus actinocladus* and *S. caroli* are frequent. The forbs *Sclerolaena lanicuspis, S. birchii, S. diacantha, Chenopodium desertorum* ssp. *microphyllum* and *Sida everistiana may be locally abundant (<5%), while Einadia* spp., *Abutilon* spp., *Sida fibulifera* are frequent. *Salsola kali, Erodium crinitum, Solanum esuriale, Calotis cuneata* and other species may be seasonally abundant.

Woody weeds: Not observed to be a problem at this stage.

Top feed: Scattered shrubs (<25/ha).

LAND USE:

These areas are stable at present, and in good to mediocre condition depending on the season. Palatable shortgrasses and forbs are numerous and provide high levels of animal nutrition but bulk is usually very limited.

Drought standover value is low. Moderate rainfalls (>20 mm), can produce some pasture response, particularly in winter months. Although fertility of these areas is adequate for native pastures, areas of this unit are often not large enough to develop on a commercial basis and regrowth problems with sandalwood and brigalow suckers will occur. The maintenance of adequate ground cover will help limit further sandalwood invasion.

LAND UNIT 37

(Land systems G2)

LANDFORM:

Flat, alluvial plains.

GEOLOGY:

Quaternary alluvium. Qa.

SOILS:

Very deep, grey-brown, alkaline, cracking clays. Surfaces have thin, weak crusts. Lime is present throughout the profile, Ug5.24.

VEGETATION:

Brigalow (*Acacia harpophylla*) tall shrubland to tall open shrubland (6-7 m; 200-425/ha), with occasional *Eremophila maculata* and *Maireana aphylla* low shrubs. The ground stratum is often extremely sparse and dominated by the perennial grass *Eragrostis setifolia* and the shorter-lived *Dichanthium sericeum* (2-8%). Various shortgrasses and annual herbs may be seasonally prominent.

Woody weeds: Absent.

Top feed: Negligible.

LAND USE:

These areas are stable, and in mediocre to poor condition. High levels of utilisation have reduced the component of palatable herbage in some areas but recovery is expected. Bulk of pasture is very limited though nutritional quality is good. Drought standover value is very low. Heavy rainfalls (>50 mm), are required for pasture response when this unit is dry. Decreasing grazing pressure during pasture growth periods may encourage an increase in ground cover and perennial grasses.

LAND UNIT 38

(Land systems H2 A3 B2 D2 G3 L2 M3 M4 M5 R2 R3 S1 W1 W2 W7)

LANDFORM:

Gently undulating plains. Slopes 3% or less.

GEOLOGY:

Superficial Quaternary deposits over the Tertiary land surfaces. Qr.

SOILS:

Shallow to very shallow, acid, loamy, red earths predominate. Surfaces are hardsetting. Gravel and ironstone shot are frequently present on the surface and occasionally throughout the profile, Um1.43, Gn2.11, Uc5.31.

ANALYSES (6 sites)

pH	strongly acid at the surface, becoming extremely to very strongly acid at 30 cm
O.C.	low
T.N.	low to very low
A.P.	very low to low at the surface, very low below 10cm
B.P.	very low
K	very fair to high
E.C.	very low throughout
Cl	very low throughout
E.S.P.	negligible
C.E.C.	medium 10 m. equiv./100 g soil
Ca	dominant cation, 3-30% of C.E.C.
A.W.C.	low
B.D.	1.4

VEGETATION:

Mulga (*Acacia aneura*) low woodland/tall shrubland (6-8 m; 150-375/ha) with scattered, emergent poplar box (*Eucalyptus populnea*). With disturbance, mulga tall open shrubland to shrubby tussock grassland or poplar box open woodland to wooded tussock grassland develops (<100/ha), often with a prominent shrub stratum of mulga regeneration or *Eremophila gilesii*. The ground stratum is frequently sparse but may be open in favourable situations, and is dominated by the short-lived perennial grasses *Aristida calycina* var. *praealta* and *A. jerichoensis* (5-30%). The perennial grasses *Eriachne mucronata* and *Eragrostis eriopoda* may be locally prominent (<5%), while scattered tussocks of *Monachather paradoxa* and *Thyridolepis mitchelliana* are frequent. The shortgrasses *Eragrostis lacunaria, Digitaria brownii* and *Aristida contorta* are frequent and may be locally abundant (<10%), while *Digitaria hystrichoides* and *Panicum effusum* are usually present. A variety of forbs occur, usually infrequently, and may be seasonally prominent. More common species include *Cheilanthes sieberi, Dysphania glomulifera, Euphorbia drummondii, Evolvulus alsinoides, Maireana villosa* and *Solanum ellipticum*. *Sida filiformis* may be locally abundant.

Herbage summary:

	No. of species			
	Total	High Pal.	Medium Pal.	Seasonally abundant (6 sites)
Long-lived perennial grasses	7	3	4	
Other graminoids	23	8	13	6
Forbs	34	6	16	15

Woody weeds: *Acacia aneura* regrowth (up to 500/ha) and *Eremophila gilesii* (0.5 m; to 2250/ha) may be a problem in disturbed areas.

Top feed: *Acacia aneura* (as above).

LAND USE:

These lands are unstable, with condition ranging from very poor to fair. Ground cover is extremely low in many areas and invasion by Charleville turkey bush is widespread. Mulga densities (particularly of mature trees) are generally low in areas in poor condition. A long-term downtrend in condition, with seasonal fluctuations, is in progress on a considerable proportion of this unit. Minor areas of dense mulga regrowth exist and cause loss of pasture production and management difficulties. For country in fair condition, nutrition is adequate for dry animals and bulk is adequate. Smaller rainfalls (<20 mm), will produce a response, particularly in run-on areas, when this unit is in good condition. Perennial grasses provide low quality standover feed in drought periods, and mulga top feed provides an excellent drought reserve if not over-used. As a guide it is suggested that felling top feed for sheep should only be resorted to no more than 2 to 3 years in 20 if the quality and productivity of the pasture are to be maintained, and that mulga densities should not be reduced below 170 trees/ha. Burning is not presently recommended in these lands under normal circumstances. The low fertility and water-holding capacity of these lands has limited the success of development for more intensive use to date. Conservative use of these lands, involving lower utilisation levels, particularly during drought periods, than have commonly been used to date, is essential to maintain the existing productivity of these lands. Management must maintain adequate ground cover in these lands during drought periods to prevent excessive runoff and loss of surface soil and the accompanying nutrients which have built up in the top few cm of soil.

LAND UNIT 39

(Land systems H3 B4 M2 N1)

LANDFORM:

Flat to gently undulating plains. Slopes 2% of less.

GEOLOGY:

Superficial Quaternary deposits over the Tertiary land surface. Qr.

SOILS:

Shallow to moderately deep, acid, loamy, red earths. Surfaces are hardsetting. Ironstone shot and gravel are usually present on the surface and in the lower parts of the profile, Um1.43.

ANALYSES (13 sites)

pH	strongly to very strongly acid throughout
O.C.	low to fair
T.N.	low
A.P.	very low throughout
B.P.	very low
K	high to fair
E.C.	very low throughout
Cl	very low throughout
E.S.P.	1%
C.E.C.	10-15 m. equiv./100 g soil
Ca	dominant cation, 9-10% of C.E.C.
A.W.C.	low
B.D.	1.5

VEGETATION:

Mulga (*Acacia aneura*) low open forest to low woodland (7-9 m; 150-2500/ha) with scattered, emergent poplar box (*Eucalyptus populnea*; 10-11 m; 25/ha), and shrubs usually absent, becoming a mulga or poplar box (low) open woodland after clearing, often with a conspicuous mulga shrub stratum, and occasionally with other shrubs e.g. *Eremophila mitchellii, E, gilesii*, and *E. glabra* locally conspicuous. The ground stratum varies with the tree density from open to dense, but is always dominated by grasses. The perennial *Thyridolepis mitchelliana* is almost always a dominant (5-30%), while *Amphipogon caricinus, Eragrostis eriopoda* and *Monachather paradoxa* are frequent and may be locally abundant (<30%). Of the short-lived perennials, *Aristida calycina* var. *praealta* is usually a dominant (5-35%), *A. jerichoensis* and *Eragrostis lacunaria* are locally abundant, and *Digitaria hystrichoides, D. brownii* and *Panicum effusum* frequent. A large number of forbs may occur and become seasonally prominent. More common species include *Calotis cuneata, Cheilanthes sieberi, Euphorbia drummondii, Goodenia glabra, Sida pedunculata, Solanum ellipticum, Trachymene ochracea, Velleia glabrata*. In the open forests, *T. mitchelliana* is usually the sole dominant, but becomes decreasingly abundant as the communities become more open. The short-lived perennial grasses, especially *Aristida* spp., become increasingly abundant in the latter, while forbs occur more frequently. In areas of extreme disturbance, *Abutilon fraseri, Sida brachypoda* and *Sclerolaena convexula* become locally abundant.

Herbage summary:

	No. of species			
	Total	High Pal.	Medium Pal.	Seasonally abundant (14 sites)
Long-lived perennial grasses	8	3	5	
Other graminoids	28	8	15	7
Forbs	46	8	20	18

Woody weeds: *Acacia aneura* regeneration can be extremely dense (2-4 m; to 5000/ha).

Top feed: *Acacia aneura* (as above).

LAND USE:

These lands are slightly unstable. Dense mulga and wiregrass infestations are problems in most areas and point to a decline in condition which may have slowed or stabilised in recent years. Condition is generally mediocre, with individual paddocks ranging from poor to good. Adequate bulk of palatable perennial grass and forbs is available on areas which are in better condition, and nutrition is adequate for maintenance of sheep and cattle. Where mulga densities are low, dense wiregrass pastures tend to predominate, nutritional quality is low, and grass seed problems occur both in wool and with young sheep. Areas of dense mulga carrying little pasture will respond to moderate rainfalls(>20 mm) when in fair condition. An adequate bulk of pasture usually stands over into drought periods, but nutritional quality may be very low. Normal management practice in these lands is to fell large areas of mulga during dry periods which provides both a maintenance diet for stock and opens up areas for native pasture growth. Development of these areas with introduced pasture species has been unsuccessful to date. Management should aim to control mulga densities and grass seed problems by strategic grazing with cattle and sheep.

LAND UNIT 40

(Land systems H1 B1 B3 H3 M1 R1 S1 S3)

LANDFORM:

Gently undulating to undulating plains. Slopes 3% of less.

GEOLOGY:

Superficial Quaternary cover over the Tertiary land surface. Qr.

SOILS:

Shallow to moderately deep, loamy, red earths. Surfaces are hardsetting, frequently with gravel or ironstone shot cover, Um1.43, Um5.51, Gn2.12.

ANALYSES (7 sites)

pH	slightly to very strongly acid throughout
O.C.	low to fair
T.N.	low to fair
A.P.	very low throughout
B.P.	very low
K	high to fair
E.C.	very low throughout
Cl	very low throughout
E.S.P.	negligible (<1%)
C.E.C.	8-11 m. equiv./100 g soil
Ca	dominant cation 15-45% of C.E.C.
A.W.C.	low to very low
B.D.	1.3-1.5

VEGETATION:

Mulga (*Acacia aneura*) low woodland (8-10 m; 150-500/ha) with scattered emergent poplar box (*Eucalyptus populnea*) and silver-leaved ironbark

(*E. melanophloia*) (10-12 m; 25/ha), to silver-leaved ironbark, mulga woodland in some areas (10 m, to 1500/ha). Infrequent, scattered *Brachychiton populneus* trees occur and shrubs are usually absent. With disturbance, a mulga, box and/or silver-leaved ironbark (low) open woodland to wooded tussock grassland develops (100/ha), sometimes with a sparse low shrub stratum of mulga, *Eremophila bowmanii* or *E. gilesii*. The ground stratum is sparse to open, dominated by the short-lived perennial grasses *Aristida calycina* var. *praealta* and *A. jerichoensis* (10-40%), and the perennial *Thyridolepis mitchelliana* (5-15%). The shortgrasses *Digitaria hystrichoides, D. breviglumis* and *Eragrostis lacunaria* are frequent and may be locally abundant (<10%), while *Panicum effusum*, and the perennials *Eragrostis eriopoda, Monachather paradoxa* and *Themeda triandra* are frequent. The forb species diversity is moderate, with some species becoming seasonally prominent. *Calotis cuneata, Cheilanthes sieberi, Euphorbia drummondii, Sida filiformis* and *Solanum ferocissimum* are frequent.

Herbage summary:

	No. of Species			
	Total	High Pal.	Medium Pal.	Seasonally abundant (6 sites)
Long-lived perennial grasses	14	7	7	
Other graminoids	28	9	13	8
Forbs	26	4	11	7

Woody weeds: *Acacia aneura* (to 2500/ha). *Eremophila bowmanii* (<1 m) and *E. gilesii* (<0.5 m) may be a problem after disturbance.

Top feed: *Acacia aneura* (as above).

LAND USE:

These lands are slightly unstable, and in mediocre to good condition at the present time. Charleville turkey bush and silver turkey bush occur in some areas, and wiregrasses predominate in some paddocks. For lands in good condition, shortgrasses and a moderate diversity of forbs provide adequate bulk and nutritional requirements for at least maintenance of sheep and cattle. These lands can respond to moderate rainfalls (>20 mm), if in fair or better condition. An adequate bulk of grass stands over into drought periods if pastures have been lightly utilised but quality and palatability may be very low where wiregrass predominates. Adequate mulga top feed is available for felling in most areas. Cool fires may be useful for reducing wiregrass densities if combined with careful stock management. Development of this unit is limited by low soil fertility. Limited areas and densities of buffel have been established where mulga has been cleared. Management should aim to control mulga densities and maintain palatable pasture species by strategic grazing with cattle and sheep.

LAND UNIT 41

(Land systems L2 H1 H2 R3)

LANDFORM:

Gently undulating (convex) plains. Slopes 1-4%.

GEOLOGY:

Superficial Quaternary deposits mixed with silcrete stone and boulder. Qr, Qc.

SOILS:

Very shallow to shallow, acid lithosols. Surfaces have dense stone and boulder pavement. Much of the profile is composed of gravel and stone, Um1.43, Uc1.43.

ANALYSES (3 sites)

pH	strongly acid
O.C.	very low to fair
T.N.	very low to low
A.P.	very low
B.P.	very low
E.C.	very low throughout
Cl	very low throughout

VEGETATION:

Mulga (*Acacia aneura*) tall shrubland/low woodland (6-8 m; 200-450/ha) with scattered, western bloodwood (*Eucalyptus terminalis*) trees always present (7-10 m; 25/ha) and silver-leaved ironbark, (*E. melanophloia*) and poplar box (*Eucalpytus populnea*) trees sometimes present. Frequently, a mulga, western bloodwood, low open woodland/tall open shrubland to wooded or shrubby stratum is usually present. *Prostanthera suborbicularis, Dodonaea sinuolata* ssp. *acrodentata, D. petiolaris* and *Eremophila gilesii* may be locally dominant, while *Cassia sturtii, C. artemisiodes, Eremophila latrobei* and *E. goodwinii* are frequent. Ground stratum is usually sparse but may be open in favourable situations, and is dominated by the perennial grasses *Eriachne mucronata* (5-15%), and *Thyridolepis mitchelliana* (<5%). *Amphipogon caricinus* may be locally dominant (5-10%), while *Eragrostis eriopoda, Monachather paradoxa*, and *Themeda triandra* occur frequently, with the latter two becoming common in run-on areas. *Aristida jerichoensis* is usually a co-dominant (<5%), and the shortgrasses *Aristida holanthera, Digitaria* spp., *Eragrostis lacunaria, E. microcarpa, Panicum effusum* and *Tripogon loliiformis* are frequent. A variety of forbs may be present, a number becoming seasonally prominent. Frequent species include *Brunonia australis, Euphorbia drummondii, Evolvulus alsinoides, Maireana villosa, Ptilotus leucocoma* and *Sida filiformis*.

Herbage summary:

	No. of species			
	Total	High Pal.	Medium Pal.	Seasonally abundant (6 sites)
Long-lived perennial grasses	8	3	5	
Other graminoids	23	8	13	7
Forbs	33	5	19	14

Woody weeds: *Acacia aneura* regrowth (as above), *Prostanthera suborbicularis, Dodonea sinuolata* ssp. *acrodentata* and *D. petiolaris* (1 m; to 1000/ha) and *Eremophila gilesii* (<0.5 m; to 1500/ha).

Top feed: *Acacia aneura* (as above) and other scattered shrubs as above.

LAND USE:

These areas are relatively stable, and are in mediocre to poor condition. The bulk of palatable pasture is very limited and depends on seasonal conditions. Rock grass is generally unpalatable but the green shoots of this plant and a variety of forbs and grasses provide adequate nutrition for maintenance of animals, particularly after winter rain. This unit will respond to light rainfalls (>13mm), and because of this, is of value during drought periods, through standover pasture on this unit is of limited use because of its low palatability. Mint bush and mulga provide a useful reserve of drought fodder. Rock grass is not easily damaged by burning. Management should aim to encourage the establishment of mulga and mint bush in this unit to provide a drought reserve.

LAND UNIT 42

(Land systems H4 B4 L2 M2 S2 N1)

LANDFORM:

Very gently undulating plains. Slopes to 1%.

GEOLOGY:

Superficial Quaternary cover over the Tertiary land surface. Qr.

SOILS:

Very shallow to shallow, acid, sandy, red earths. Surfaces are hardsetting and frequently scattered with ironstoneshot, Uc1.23, Uc1.43.

ANALYSES (3 sites)

pH	strongly acid throughout
O.C.	low
T.N.	low
A.P.	very low throughout
B.P.	very low throughout
E.C.	very low throughout
Cl	very low throughout

VEGETATION:

Mulga (*Acacia aneura*) low woodland to low open woodland (8-10 m; 100-375/ha) with scattered, emergent poplar box (*Eucalyptus populnea*; 10-11 m; <25/ha) to mulga, poplar box wooded tussock grassland after clearing (<100/ha). A sparse, low shrub stratum of *Eremophila gilesii* is frequently present. The ground stratum is open and dominated by the perennial grass *Amphipogon caricinus* (5-25%), and the shorter-lived perennials *Aristida calycina* var. *praealta* or *A. jerichoensis var. subspinulifera* (5-25%). The perennials *Thyridolepis mitchelliana* and *Monachather paradoxa* may be locally abundant (5-15%), while *Eragrostis eriopoda* tussocks are frequent. The shortgrasses *Aristida jerichoensis, Digitaria* spp., *Eragrostis lacunaria, E. microcarpa* and *Panicum effusum* are usually present. A variety of forbs may occur, some becoming seasonally prominent. Frequent species include *Calotis cuneata, C. lappulacea, Cheilanthes sieberi, Euphorbia drummondii* and *Maireana villosa*.

Woody weeds: *Acacia aneura* regrowth and *Eremophila gilesii* (<0.5 m; up to 1000/ha) may be a problem after disturbance.

Top feed: *Acacia aneura* (as above).

LAND USE:

These lands are slightly unstable. Present condition is mediocre to poor. In some areas, Charleville turkey bush and wiregrass densities are high, indicating a slight downtrend in condition. Bulk is generally adequate (except in areas in poor condition) but nutritional value is limited, particularly where wiregrass is dominant, providing a maintenance ration only. These areas can respond to smaller rainfalls (15-25 mm), when in reasonable condition. However, follow-up rain is needed to sustain growth or break drought conditions. A useful bulk of pasture stands over into drought periods but nutritional quality may be low. Mulga is available in some areas. Management should aim to encourage optimum mulga densities (175 trees/ha) and maintain adequate ground cover of palatable grass species.

LAND UNIT 43

(Land systems M2 B1 B4 H3 H4 C1 C2 S2 N1 W1)

LANDFORM:

Flat plains. Slopes to 1%.

GEOLOGY:

Superficial Quaternary cover over the Tertiary land surface. Qs/Qr.

SOILS:

Shallow to moderately deep, loamy, red earths with hardsetting surfaces. Reaction ranges from strongly acid to neutral. Ironstone gravel may be present in the profile and ferruginous patches may occur at the base of the profile, Um1.43, Gn2.12.

ANALYSES (7 sites)

pH	normally medium to strongly acid
O.C.	low
T.N.	very low
A.P.	low to very low
B.P.	low to very low
K	very fair to high
E.C.	very low throughout
Cl	very low throughout
E.S.P.	negligible
C.E.C.	8-12 m. equiv./100 g soil
A.W.C.	low
Ca	dominant cation
B.D.	1.4-1.6

VEGETATION:

Mulga (*Acacia aneura*; 7-9 m; 150-1000/ha), poplar box (*Eucalyptus populnea*; 10-11 m; <100/ha) low woodland, occasionally low open forest. With clearing, a poplar box with or without mulga open woodland to wooded tussock grassland develops, frequently with a prominent mulga shrub stratum. Scattered *Eremophila gilesii* and *E. mitchellii* shrubs are often present. The ground stratum is grass-dominant and varies with the tree density. In open forest, the perennial *Thyridolepis mitchelliana*, and shortgrasses *Eragrostis lacunaria* and *Digitaria hubbardii* may be dominant (<10%). More open communities are dominated by the short-lived perennials *Aristida calycina* var. *praealta* and *A. jerichoensis* (10-40%) with *Thyridolepis mitchelliana* frequently co-dominant (5-15%). *Aristida* spp. become increasingly abundant as the tree density decreases. The perennials *Amphipogon caricinus, Eragrostis eriopoda, Eriachne helmsii* and *Monachather paradoxa* are frequent and may be locally abundant (<15%). Similarly, the shortgrasses *Digitaria hystrichoides, D. brownii, Eragrostis lacunaria, E. microcarpa* and *Panicum effusum* occur frequently and may be locally prominent (<5%). A large number of forbs may occur, although they are usually infrequent, and several may be seasonally prominent. More common species include *Cheilanthes sieberi, Euphorbia drummondii, Maireana villosa, Ptilotus polystachyus, Sida pedunculata* and *Trachymene ochracea*.

Herbage summary:

	No. of species			
	Total	High Pal.	Medium Pal.	Seasonally abundant (7 sites)
Long-lived perennial grasses	10	4	5	
Other graminoids	24	9	12	8
Forbs	37	11	15	18

Woody weeds: *Acacia aneura* regeneration is frequently a problem after disturbance (to 1500/ha). *Eremophila gilesii* (0.5m), *E. mitchellii* (233 m) and *Eucalyptus populnea* may on occasions be a minor problem.

Top feed: *Acacia aneura* (as above).

LAND USE:

Slightly unstable lands in variable condition, ranging from fair to poor. Wiregrass infestations, dense mulga and some woody weed invasion are the main problems, occurrence varying considerably with the history of the particular paddock in question. There is evidence of a long-term downtrend in condition. Areas where mulga is very sparse or absent have the worst wiregrass infestations, which are unpalatable, and create grass seed problems for sheep. More palatable grasses, with a seasonal component of forbs, are associated with lower (175 trees/ha) mulga densities and a moderate bulk of pasture of fair nutritional quality. This pasture provides a maintenance diet for dry animals. Areas of dense mulga produce negligible pasture. This unit can respond to rainfalls (>20 mm), in normal seasons. There is adequate bulk of standover pasture but quality is usually very poor. Mulga top feed is available in most areas and is extensively utilised in drier years.

Cool fires have shown potential to control mulga and reduce the bulk of wiregrass. Careful management of areas immediately after firing is most important. These areas have limited development potential at present because of their low fertility and water-holding capacities. Management should aim to control mulga densities (optimum 175 trees/ha) and encourage palatable species by reducing grazing pressure during their growth periods.

LAND UNIT 44

(Land systems S2 A3 H4 M2 N1 W6)

LANDFORM:

Flat plains. Relief to 4 m.

GEOLOGY:

Superficial Quaternary cover over the Tertiary land surface. Qs.

SOILS:

Shallow to moderately deep, sandy, red earths. Reaction is acid to neutral. Surfaces are hardsetting. Textures are light, sandy-clay-loam at the surface and are either uniform throughout the profile Um1.43 or increase gradually to light clay at depth, Gn2.12, Gn2.11.

ANALYSES (4 sites)

pH	strongly to very strongly acid at the surface, becoming slightly acid to neutral at depth
O.C.	low
T.N.	very low
A.P.	very low
B.P.	very low
K	very fair to high
E.C.	very low to low
Cl	very low to low
E.S.P.	3%
C.E.C.	6-12 m. equiv./100 g soil
Ca	dominant cation, 8-24% of C.E.C.
A.W.C.	low to very low
B.D.	1.4 to 1.5

VEGETATION:

Mulga (*Acacia aneura*) low woodland (7-9 m; 100-250/ha) with scattered, emergent poplar box (*Eucalyptus populnea*; 10-11 m; <25/ha), to mulga, poplar box (low) open woodland or wooded tussock grassland (<50/ha) with clearing. A sparse, low shrub stratum of *Eremophila gilesii* may be present, and scattered *E. glabra* shrubs usually occur. The ground stratum is open to dense, and dominated by the short-lived perennial grasses *Aristida jerichoensis* and *A. calycina* var. *praealta* or *A. jerichoensis* var. *subspinulifera* which become increasingly abundant in cleared areas (5-40%). The perennials *Amphipogon caricinus, Monachather paradoxa, Thyridolepis mitchelliana, Eragrostis eriopoda* and *Themeda triandra* occur frequently, and the former three may be locally abundant and co-dominant (5-30%). The shortgrasses *Digitaria hystrichoides, D. brownii, Eragrostis lacunaria* and *E. microcarpa* are frequent, with the latter sometimes locally abundant. The forb diversity is relatively low, with some species becoming seasonally prominent. More common species include *Cheilanthes sieberi, Euphorbia drummondii, Evolvulus alsinoides, Maireana villosa, Trachymene ochracea* and *Velleia glabrata. Sclerolaena birchii, S. convexula* and *Sida brachypoda* are common in badly disturbed areas.

Herbage summary:

	No. of species			
	Total	High Pal.	Medium Pal.	Seasonally abundant (4 sites)
Long-lived perennial grasses	7	3	4	
Other graminoids	18	6	12	4
Forbs	20	5	91	10

Woody weeds: *Acacia aneura* regeneration (1-5 m; to 400/ha) is frequent in disturbed areas; *Eremophila gilesii* (<0.5; to 1500/ha) may also be a problem.

Top feed: *Acacia aneura* mulga (as above).

LAND USE:

These are slightly unstable lands, generally ranging from mediocre to good in condition. A long-term downtrend in condition is evident due to wiregrass and woody weed invasion and dense mulga regeneration. Areas with low mulga densities generally have a high component of wiregrass. When in good condition, this land unit provides adequate nutrition and bulk for good performance by dry animals. Areas where dense mulga or wiregrass predominate only provide a maintenance diet for little longer than the growing season. These lands will respond to lighter rainfalls (>20 mm), when in reasonable condition. Most areas provide an adequate bulk of standover feed but nutritional quality may be very low where wiregrasses predominate. Mulga top feed is available in most areas. Cool fires (preferably when soil moisture is high), may be useful to control mulga regrowth and reduce wiregrass bulk. Careful grazing management is essential following burning. Development potential of these areas is limited by low fertility and water-holding capacity. Generally, management should aim to control mulga densities (optimum 175 shrubs/ha) and encourage palatable pasture species by lowering the grazing pressure on these species during their growing season.

LAND UNIT 45

(Land systems S1 A3 H1 M1 W6)

LANDFORM:

Flat plains. Relief to 3 m.

GEOLOGY:

Superficial Quaternary cover over the Tertiary land surface. Qs.

SOILS:

Deep to very deep, sandy, red earths with minor areas of earthy sands. Reaction is acid, occasionally ranging to neutral. Surfaces are predominantly hardsetting. Textures are uniform sandy-loams, Uc1.43, loamy sands, Uc1.23, and light, sandy-clay-loams, Um1.43. Gradational profiles with fine, sandy-loams grading into light clays at depth also occur, Gn2.12.

ANALYSES (8 sites)

pH	usually strongly acid at the surface, becoming medium acid at depth
O.C.	low
T.N.	low to very low
A.P.	very low
B.P.	very low
K	low to fair
E.C.	very low throughout
Cl	very low throughout
E.S.P.	less than 1%
C.E.C.	5-8 m. equiv./100 g soil
Ca	dominant cation but generally 1 m. equiv./100 g soil
A.W.C.	very low throughout
B.D.	1.4 to 1.5

VEGETATION:

Mulga (*Acacia aneura*) low open forest to low woodland (8-9 m; 250-1500/ha), becoming a low open woodland (<175/ha) after clearing with an open shrub stratum of mulga or *Eremophila gilesii* often prominent. Sparsely scattered *Eucalyptus populnea, Grevillea striata* and *Acacia excelsa* trees are frequent. The ground stratum is grass-dominated and varies with the tree density. In open forest, the perennial *Thyridolepis mitchelliana* and shorter-lived *Digitaria breviglumis* are dominant (10-40%), and fern *Cheilanthes sieberi* common (<3%). In more open communities, the short-lived perennial *Aristida calycina* var. *praealta* is dominant (5-20%). *Thyridolepis mitchelliana* may be a dominant, or almost absent (1-15%), while the other perennials *Monachather paradoxa, Eriachne helmsii* and *Eragrostis eriopoda* are frequent and may be locally prominent (<10%). The shortgrasses *Eragrostis lacunaria, Digitaria hystrichoides* and *Panicum effusum* are usually present throughout. A variety of forbs, some seasonally prominent, may be present but are usually less common, in the open forest. Frequent species include *Euphorbia drummondii, Haloragis odontocarpa, Hibiscus sturtii, Muelleranthus trifoliolatus, Sida filiformis* and *Solanum ferocissimum*.

Herbage summary:

	No. of species			
	Total	High Pal.	Medium Pal.	Seasonally abundant (8 sites)
Long-lived perennial grasses	11	4	7	
Other graminoids	17	6	6	4
Forbs	28	7	14	14

Woody weeds: *Acacia aneura* regrowth may be extremely dense (4-7 m; to 5000/ha); *Eremophila gilesii, E. bowmanii* (<1 m), *Cassia pleurocarpa* and *Petalostylis labicheoides* (1-2 m) may also form dense stands in disturbed areas.

Top feed: *Acacia aneura* (as above).

LAND USE:

These lands are slightly unstable, and there are signs of a long-term downtrend. Present condition is variable but frequently poor where Charleville turkey bush or stands of dense mulga occur. Nutritional quality is adequate for dry animals. Bulk is limited by mulga densities in many areas. These lands will respond to lighter rainfalls (>25 mm), but low water- holding capacities allow only short growing periods. During drought periods, little palatable standover feed usually remains. Abundant top feed is present. Cool fires may be of use to control mulga regrowth but other effects of fire are unknown. Post-fire grazing management is extremely important and disturbance of this land unit often leads to invasion by Charleville turkey bush. Management should aim to achieve optimum mulga densities (175 shrubs/ha) by conservative stocking with sheep and cattle.

LAND UNIT 46

(Land systems M2 N1).

LANDFORM:

Flat plains. Relief <5 m.

GEOLOGY:

Superficial Quaternary cover over the Tertiary land surface. Qs.

SOILS:

Shallow to moderately deep, sandy, red earths with acid reaction. Surfaces are hardsetting. Textures are uniform, sandy-loams or loamy-sands throughout, Uc1.43, Uc1.23, Um1.43, or occasionally grade into light, sandy-clay-loams at depth, Gn1.11, Gn2.12.

ANALYSES (12 sites)

pH	strongly to slightly acid at the surface, becoming neutral to mildly alkaline at depth
O.C.	low
T.N.	very low
A.P.	very low throughout, with occasional low values recorded at the surface
B.P.	very low
K	fair to very fair
E.C.	very low throughout
Cl	very low throughout
E.S.P.	negligible
C.E.C.	6-11 m. equiv./100 g soil
Ca	dominant cation, 6-36% of C.E.C.
A.W.C.	very low throughout
B.D.	1.5

VEGETATION:

Mulga (*Acacia aneura*; 8-9 m; 200-3000/ha), poplar box (*Eucalyptus populnea*; 9-12 m; <100/ha) low open forest to low woodland. After clearing, a poplar box with/without mulga open woodland to wooded tussock grassland develops, in which a sparse to open low shrub stratum is frequent. Common shrub species include *Eremophila longifolia* (2-4 m), *Cassia nemophila, Eremophila glabra, E. gilesii*, and *Micromyrtus hexamera* (<2 m). The ground stratum is grass-dominant and varies with the tree density. The perennial *Thyridolepis mitchelliana* is usually dominant in open forest (5-15%), but remains frequent in more open communities (1-10%). In woodlands to wooded tussock grasslands, the short-lived perennials *Aristida calycina* var. *praealta*, and to a lesser extent, *A. jerichoensis*, are dominant (10-50%), and become more abundant as the tree density decreases. The perennials *Amphipogon caricinus, Eragrostis eriopoda* and *Monachather paradoxa* are frequent and may be locally abundant (usually <15%). The shortgrasses *Aristida holathera, Digitaria hystrichoides, Eragrostis lacunaria* and *E. microcarpa* occur frequently and are sometimes locally prominent (usually <15%). The annual grasses *Perotis rara, Triraphis mollis*, and sedge *Bulbostylis barbata*, are frequent. A large number of herbs may be present, many occurring infrequently, and may become seasonally abundant. Frequent species include *Cheilanthes sieberi, Calotis cuneata, Euphorbia drummondii, Goodenia glabra, Hibiscus sturtii, Ptilotus leucocoma, P. polystachyus, Sida filiformis, Trachymene ochracea* and *Velleia glabrata*.

Herbage summary:

	No. of species			
	Total	High Pal.	Medium Pal.	Seasonally abundant (14 sites)
Long-lived perennial grasses	9	5	4	
Other graminoids	25	7	13	4
Forbs	45	8	18	20

Woody weeds: *Acacia aneura* (as above), *Cassia artemisiodes, C. nemophila, Eremophila gilesii, Dodonaea angustissima* and *Micromyrtus hexamera* (to 2000/ha) are often a problem after disturbance.

Top feed: *Acacia aneura* (as above).

LAND USE:

These lands are slightly unstable and in poor to fair condition. Signs of a long-term downtrend in condition are evident. Areas in fair condition provide a limited bulk of palatable grasses and forbs of adequate nutritional quality. Little pasture is present under dense mulga stands. Areas where mulga has been totally removed are frequently in poor condition, with high wiregrass densities. These lands can respond to lighter rainfalls (>25 mm), but very low water-holding capacities severely limit growth periods. Drought standover value of wiregrasses is very low, though a limited bulk of better quality pasture may stand over in areas in fair condition. Mulga top feed is available in most areas. Cool fires may be of use in controlling mulga regrowth and removing dense wiregrass growth, but other effects of fire are unknown. Post-fire grazing management is most important as woody weeds are prolific in areas devoid of mulga, particularly in southern areas. The low fertility and water-holding capacity of this unit limit development potential. Management should aim to achieve optimum mulga densities (175 shrubs/ha) by conservative grazing with both sheep and cattle.

LAND UNIT 47

(Land systems S2 B4 L1 L2 M2 N1).

LANDFORM:

Flat plains. Relief <5 m.

GEOLOGY:

Superficial Quaternary cover over the Tertiary land surface. Qs.

SOILS:

Moderately deep, acid to neutral, sandy, red earths. Surface usually increasing slightly down the profile to light, sandy-clay-loams, Uc1.43, Uc5.21, Um1.43, Gn2.12.

ANALYSES (3 sites)

pH	medium acid to slightly acid at the surface and throughout the profile,changing to moderately alkaline at 120 cm
O.C.	low
T.N.	very low
A.P.	very low throughout
B.P.	very low
K	high to fair
E.C.	very low throughout
Cl	very low throughout
A.W.C.	low to very low
B.D.	1.5 - 1.6

VEGETATION:

Mulga (*Acacia aneura*) low woodland (7-9 m; 100-300/ha) with scattered, emergent *Eucalyptus polycarpa* (12-14 m), and scattered *Grevillea striata, Acacia excelsa* and *Hakea ivoryi* (8-9 m) trees (<25/ha). With clearing, a wooded tussock grassland frequently develops, in which a shrub stratum is often conspicuous. Frequent species include *Eremophila longifolia, Dodonaea viscosa* ssp. *angustissima* (92-3m), *Cassia nemophila* and *Eremophila gilesii* (<1 m). The ground stratum is open to dense and dominated by the short-lived perennial grasses *Aristida calycina* var. *praealta, A. jerichoensis* and *Eragrostis lacunaria* (10-40%). The *Aristida* spp. become more abundant after clearing. The perennial grasses *Monachather paradoxa, Thyridolepis mitchelliana* and *Eragrostis eriopoda* are frequent and may be locally abundant (<5%). *Eriachne helmsii* may be locally abundant (<5%), and *Themeda triandra* is frequent but rarely abundant. The shortgrasses *Aristida holathera, Digitaria brownii, Eragrostis speciosa*, and *Panicum effusum*, and the annual *Perotis rara*, are frequent and may be locally/seasonally abundant. A variety of forbs occur infrequently, and may be seasonally prominent. More frequent species include *Abutilon otocarpum, Calotis cuneata, Cheilanthes sieberi, Convolvulus erubescens, Euphorbia drummondii, Glycine canescens*, and *Ptilotus polystachyus. Sclerolaena* spp. may be common after bad disturbance.

Herbage summary:

	No. of species			
	Total	High Pal.	Medium Pal.	Seasonally abundant (4 sites)
Long-lived perennial grasses	7	3	4	
Other graminoids	18	6	11	4
Forbs	26	6	13	11

Woody weeds: In cleared areas the following species may form dense stands: *Dodonaea viscosa* ssp. *angustissima, Eremophila gilesii, E. sturtii*, and *Olearia subspicata. Acacia aneura* regeneration is not usually a problem but may be moderately dense (to 600/ha).

Top feed: *Acacia aneura* (as above) and other scattered trees and shrubs (<25/ha).

LAND USE:

These lands are slightly unstable, and range in condition from good (small areas) to poor (significant areas). A long-term downtrend is evident throughout much of the area involved. Where condition is poor, unpalatable wiregrasses or dense woody weeds dominate and low levels of nutrition are available. In areas in fair to good condition, a limited bulk of palatable grasses and forbs provides adequate nutrition for dry animals. Dietary quality is thought to improve considerably when winter rains occur. These lands can respond to lighter rainfalls (>25 mm), but growing period is limited by low moisture-holding capacity.

Drought standover pasture is either unpalatable in wiregrass- dominated areas or limited in bulk where better quality pastures occur. Mulga top feed is available in some areas. Cool fires may be used to control mulga regeneration and remove dense wiregrass growth but other effects of fire are unknown. The development potential of this unit is severely limited by its low water-holding capacity and fertility levels. Management should aim to achieve optimum mulga densities (175 shrubs/ha) by conservative grazing with both sheep and cattle.

LAND UNIT 48

(Land systems M4 B2 H2 L2 M5 R2 W1 W7)

LANDFORM:

Flat to very gently sloping plains. Slopes <1%.

GEOLOGY:

Superficial Quaternary cover over the Tertiary land surface. Qr.

SOILS:

Shallow to moderately deep, loamy, red earths with acid reaction. Surfaces are hardsetting. Textures range from light, sandy-clay-loam to light clay, commonly with a gradual increase in texture down the profile, Um1.43, Um5.51, Gn2.11.

ANALYSES (8 sites)

pH	medium acid to very strongly acid at the surface and throughout the profile, occasionally becoming neutral at 120 cm
O.C.	low to fair
T.N.	low
A.P.	very low throughout
B.P.	very low
K	very high to very fair
E.C.	very low throughout
Cl	very low throughout
E.S.P.	less than 4.5% for all sites usually <1%
C.E.C.	8-12 m. equiv./100 g soil
Ca	dominant cation, 16-36% of C.E.C.
A.W.C.	low throughout
B.D.	1.4-1.5

VEGETATION:

Mulga (*Acacia aneura*) low open forest to low woodland (8-9 m; 175-2000/ha) with scattered, emergent poplar box (*Eucalyptus populnea*; 10-11 m; usually <25/ha), becoming a mulga, poplar box open woodland to wooded tussock grassland after clearing. A sparse shrub stratum of mulga (2-7 m), or *Eremophila gilesii* (<0.5 m), may be present. The ground stratum is open to dense, depending on the tree density, and dominated by the short-lived perennial grasses *Aristida calycina* var. *praealta, A. jerichoensis* and *Eragrostis lacunaria* (5-40%), the *Aristida* spp. being highly abundant in open areas. Of the other perennials, *Thyridolepis mitchelliana* is dominant at the highest tree densities but may be very sparse in open areas (1-15%). *Eragrostis eriopoda* and *Themeda triandra* occur frequently, while *Monachather paradoxa* may be locally prominent (<5%). The shortgrasses *Digitaria hystrichoides, D. brownii* and *Panicum effusum*, and annual *Brachiaria gilesii* also occur frequently. A variety of forbs may be present, some of them seasonally prominent. Frequent species include *Cheilanthes sieberi, Euphorbia drummondii* and *Goodenia glabra*, and in more disturbed areas, *Solanum* spp., *Sclerolaena convexula* and *Dysphania glomifera*.

Herbage summary:

No. of species

	Total	High Pal.	Medium Pal.	Seasonally abundant (7 sites)
Long-lived perennial grasses	11	5	5	
Other graminoids	23	10	13	8
Forbs	36	8	14	13

Woody weeds: *Acacia aneura* regeneration (as above) and *Eremophila gilesii* (<0.5 m; to 1250/ha) may be problems after disturbance.

Top feed: *Acacia aneura* (as above).

LAND USE:

These are slightly unstable lands in mediocre to poor condition, showing signs of a long-term downtrend in condition in many areas. Paddocks in better condition have adequate pasture bulk, sufficient in nutritive value to provide a good maintenance diet. Paddocks in poor condition have significant populations of woody weeds and limited pasture of poor nutritional quality. These areas can respond to lighter rainfalls (>25 mm), but areas in poor condition commonly display only limited response to significant rainfalls (25-50 mm).

Drought standover value of the pasture is limited either in quality or in quantity but mulga provides leaf-fall and a top feed reserve in most areas. Burning is not presently recommended because of the general lack of ground cover throughout much of this land unit. Little development potential exists because of the low fertility and water-holding capacity of these lands. Management should aim to achieve optimum mulga densities (175 shrubs/ha) and maintain adequate ground cover.

LAND UNIT 49

(Land systems M1 B1 B3 H1 H3 S3)

LANDFORM:

Flat to very gently undulating plains. Slopes 3%.

GEOLOGY:

Superficial Quaternary cover over the Tertiary land surface. Qr.

SOILS:

Shallow to moderately deep, acid, loamy, red earths with hardsetting surfaces. Textures are light, sandy-clay-loam at the surface and may be uniform throughout the profile, Um1.43, Um5.51, Um5.52, or increase to sandy-clay-loams and sandy-clays at depth, Gn2.11.

ANALYSES (11 sites)

pH	generally strongly to very strongly acid at the surface and throughout the profile, occasionally becoming slightly acid to neutral at depth
O.C.	low to fair
T.N.	low
A.P.	very low throughout
B.P.	very low
K	very fair
E.C.	very low throughout
Cl	very low throughout
E.S.P.	<1%
C.E.C.	7-13 m. equiv./100 g soil
Ca	dominant cation, range 10-60% of C.E.C.
A.W.C.	low throughout
B.D.	1.3-1.6

VEGETATION:

Mulga (*Acacia aneura*) low woodland (8-10 m; 100-700/ha) with scattered, emergent poplar box (*Eucalyptus populnea*), silver-leaved ironbark (*E. melanophloia*) and to a lesser extent, *Brachychiton populneus* (10-12 m; usually <50/ha). On the upper slopes and ridges and in eastern areas, silver-leaved ironbark, and mulga woodland is more common. After clearing, mulga, poplar box, or silver-leaved ironbark open woodland to wooded tussock grassland develops, and a sparse to open shrub stratum of mulga is often present. The low shrub *Prostanthera suborbicularis* may be prominent on the upper slopes. The ground stratum is open to dense, and dominated by the perennial grass *Thyridolepis mitchelliana* (5-15%) and the shorter-lived *Aristida calycina* var. *praealta, A. jerichoensis* and *A. jerichoensis* var. *subspinulifera* (5-50%). The *Aristida* spp. becomes more abundant in open areas. The perennial grasses *Amphipogon caricinus, Monachather paradoxa*, and *Themeda triandra* are frequent and may be locally prominent (<5%), while the shortgrasses *Digitaria hystrichoides, D. brownii, D. breviglumis* and *Panicum effusum* occur frequently. A number of forbs may be present, some of which are seasonally common. Frequent species include *Cheilanthes sieberi, Euphoria drummondii, Goodenia glabra, Hibiscus sturtii, Sida filiformis*, and *Solanum ferocissimum*. *Goodenia heterochila* is occasionally locally abundant, and *Sclerolaena convexula* and *Sida brachypoda* are common on badly disturbed areas.

Herbage summary:

No. of species

	Total	High Pal.	Medium Pal.	Seasonally abundant (11 sites)
Long-lived perennial grasses	14	6	7	
Other graminoids	23	5	13	3
Forbs	43	7	19	14

Woody weeds: *Acacia aneura* regeneration (2-5 m, to 6000/ha) and *Prostanthera suborbicularis* (<2 m; 625/ha) may be common; in some areas moderately dense *Eucalyptus populnea* regeneration may occur.

Top feed: *Acacia aneura* (as above).

LAND USE:

These lands are slightly unstable and range from good to mediocre in condition. The long-term trend appears static. Areas in good condition produce a moderate bulk of fair quality perennial grasses and forbs. Areas in mediocre condition grow either unpalatable wiregrasses or dense stands of mulga, which limit pasture production to very low levels. Areas in fair to better condition will respond to lighter rainfalls (>25 mm), but areas in mediocre condition may show little response to rain up to 50 mm. A moderate bulk of palatable grass stands over into drought periods with browse and leaf-fall available from mulga and mint bush. Abundant mulga top feed is available in most paddocks. Cool fires may be beneficial in controlling mulga regrowth but other effects of fire are unknown. Low fertility and water-holding capacity limit the development potential of this unit under present technology, though limited areas of buffel grass have been successfully established. Management should aim to achieve optimum mulga densities (175 shrubs/ha) by varying the grazing pressure applied and the type of animal (i.e. sheep or cattle).

LAND UNIT 50

(Land systems H1 R3)

LANDFORM:

Flat to very gently undulating plains. Slopes 1% or less.

GEOLOGY:

Quaternary sand cover over the Tertiary land surface. Qs.

SOILS:

Moderately deep to deep red, earthy sands with acid reaction. Surfaces are hardsetting, Uc1.23, Uc1.43.

VEGETATION:

Mulga (*Acacia aneura*) low woodland/tall shrubland to low open woodland/tall open shrubland (5-8 m; 125-1250/ha). Scattered, emergent *Brachychiton populneus, Eucalyptus melanophloia* and *E. dolichocarpa* trees dominated by the perennial grasses *Thyridolepis mitchelliana* and *Eragrostis eriopoda* and the short-lived *Aristida calycina* var. *praealta* (10-40%). The perennial grass *Eriachne helmsii* is frequent and *Monachather paradoxa* locally common. A variety of annual grasses and forbs may become seasonally abundant.

Woody weeds: Negligible.

Top feed: *Acacia aneura* (as above).

LAND USE:

These areas are slightly unstable and in fair condition. A moderate bulk of fair quality grasses and seasonal forbs is produced, which provides adequate to good nutrition. These areas can respond to light rainfalls (>25 mm), particularly in winter. A moderate bulk of palatable perennial grasses stands over into drought periods, and mulga top feed and sometimes browse, is available in most paddocks. Little development potential exists at present. Management should aim to optimise mulga densities at 175 shrubs/ha.

LAND UNIT 51

(Land systems S3 F1 S1)

LANDFORM:

Gently undulating plains. Slopes 1-2%.

GEOLOGY:

Quaternary sands over Tertiary land surface. Qs.

SOILS:

Deep, sandy, red earths with neutral to alkaline reaction. Surfaces are hardsetting, Uc1.43.

VEGETATION:

Mulga (*Acacia aneura*) woodland to open woodland (9-11 m; 250-750/ha) with emergent poplar box (*Eucalyptus populnea*) and/or silver-leaved ironbark (*E. melanophloia*) (11-13 m; 100/ha). Scattered *E. dolichocarpa, Brachychiton populneus, Archidendropsis basaltica, Ventilago viminalis, Alectryon oleifolius*, and *Acacia excelsa* trees/tall shrubs occur frequently. In disturbed areas, a wooded eastern dead finish (*Archidendropsis basaltica*) tall shrubland to shrubby tussock grassland develops (5-7 m; to 2000/ha), in which the shrubs *Canthium oleifolium, Eremophila longifolia, E. mitchellii*, and *Geijera parviflora* and low shrubs *Cassia* spp. may be prominent. The ground stratum is open grass-dominant. The perennial *Thyridolepis mitchelliana* is dominant at the higher tree and shrub densities, while *Aristida* spp. become increasingly abundant and dominant in more open areas. The short-lived perennial grasses *Aristida calycina* var. *calycina, Digitaria brownii* and *Eragrostis lacunaria*, and longer-lived *Enteropogon acicularis* and *Ancistrachne uncinulata* are frequent. Forbs usually occur infrequently, but may become seasonally prominent.

Woody weeds: *Archidendropsis basaltica* and other shrubs (as above).

Top feed: *Acacia aneura* and other shrubs (as above).

LAND USE:

These areas are slightly unstable and in fair to good condition. A moderate bulk of palatable perennial grasses and seasonal forbs provides adequate to good nutrition. This unit can respond to lighter rainfalls (>25 mm), particularly in winter. A moderate bulk of palatable drought standover feed is available, together with a number of browse and top feed species. Buffel grass has become established in some disturbed areas and there may be potential for more of this type of development. Management should aim to achieve optimum densities of mulga and other edible tree species (175 shrubs/ha).

LAND UNIT 52

(Land systems M3 B1 D2 G3 M2 W1 W2 W7)

LANDFORM:

Flat to very gently sloping plains. Slopes 1%.

GEOLOGY:

Quaternary cover over Tertiary land surface. Qr.

SOILS:

A hardpan layer is frequently present at depths ranging from 30 to 100 cm. Reaction is acid in the loamy, red earth profiles, and neutral or alkaline for the texture contrast soils. Surfaces are hardsetting. Manganiferrous-staining and occasional concretions occur close to the hardpan, Um1.43, Dr2.52, Dr3.12, Dr3.5.

ANALYSES (5 sites)

pH	strongly to slightly acid at the surface and throughout the profile, occasionally becoming neutral at depth
O.C.	low
T.N.	low to very low
A.P.	very low to low throughout
B.P.	very low to low
K	very fair to high
E.C.	very low throughout
Cl	very low throughout
E.S.P.	<1%
C.E.C.	7-9 m. equiv./100 g soil
Ca	dominant cation, 20-40% of C.E.C.
A.W.C.	low throughout
B.D.	1.4-1.5

VEGETATION:

Mulga (*Acacia aneura*; 8-9 m; 200-1125/ha), poplar box (*Eucalyptus populnea*; 10-11 m; 25-150/ha) low woodland, becoming a mulga, poplar box open woodland (75-200/ha) with clearing, in which a shrub stratum of *Eremophila bowmanii, E. gilesii* (<2 m) or mulga (2-7 m), is often conspicuous. Scattered *Eremophila mitchellii* tall shrubs are usually present. On lower areas, a poplar box low open woodland with an *Eremophila mitchellii* tall shrub stratum may occur. The ground stratum is open to dense, and dominated by the short-lived perennial grasses *Aristida calycina* var. *praealta* or *A. jerichoensis* (5-40%), with *Thyridolepis mitchelliana* a co-dominant at the highest tree densities (1-15%). The shortgrasses *Digitaria brownii, Eragrostis lacunaria* and *Panicum effusum*, and perennial *Monachather paradoxa* occur frequently. A variety of forbs occur infrequently and may be seasonally prominent. Frequent species include *Evolvulus alsinoides, Cheilanthes sieberi, Hibiscus sturtii* and *Sida* spp..

Herbage summary:

	No. of species			
	Total	High Pal.	Medium Pal.	Seasonally abundant (7 sites)
Long-lived perennial grasses	10	4	6	
Other graminoids	27	13	14	11
Forbs	30	6	13	9

Woody weeds: *Acacia aneura* (as above), *Eremophila bowmanii* (<2 m; to 2500/ha) and *E. gilesii* (<0.5 m; to 1000/ha) are frequently a problem after disturbance. *Eremophila mitchellii* and *Cassia nemophila* may be a minor problem on lower areas.

Top feed: *Acacia aneura* (as above).

LAND USE:

These lands are unstable and in poor to mediocre condition. A long-term downtrend is evident with invasion by sandalwood and turkey bushes common. Nutritional value of pastures is at least adequate for the maintenance of dry animals, but in areas where unpalatable wiregrasses predominate, edible bulk is very limited. These areas can respond to moderate rainfalls (<25 mm), particularly in areas where shrub densities are low. This unit frequently receives run-on water from hard mulga lands upslope. Drought grazing capacity is limited by the bulk of palatable feed which stands over into dry periods, and the amount of browse accessible to stock. Adequate top feed is frequently available, but has been exhausted in some areas. Where sufficient fuel is available, fire may be of use in controlling the growth of sandalwood and turkey bushes on this unit. Other effects of fire are unknown but post-fire grazing must be carefully controlled. Management should aim to achieve optimum mulga densities (175 shrubs/ha) and maintain ground cover to prevent further invasion by woody weeds.

LAND UNIT 53

(Land systems M5 B2 M4 R2 R3 W1 W2)

LANDFORM:

Very gently sloping plains (run-on areas). Slopes 22%.

GEOLOGY:

Redistributed Quaternary material over the Tertiary land surface. Qr, Qs.

SOILS:

Moderately deep, loamy, red earths with acid to neutral reaction. Surfaces are hardsetting. Textures are light, sandy-clay-loam at the surface, sometimes increasing to sandy-clay-loam sandy-loams at depth, Um1.43, Um5.52, Gn2.11.

ANALYSES (3 sites)

pH	strongly to slightly acid throughout the profile
O.C.	low to fair
T.N.	very low to low
A.P.	very low throughout
B.P.	very low
K	fair to high
E.C.	very low throughout
Cl	very low throughout
A.W.C.	very low to low

VEGETATION:

Groved mulga (*Acacia aneura*; 8-10 m; 200-1000/ha in groves) with scattered, emergent poplar box (*Eucalyptus populnea*). A shrub stratum is usually absent although scattered *Eremophila gilesii* may be present. In the groves, the ground stratum is sparse to open, and dominated by mulga fern *Cheilanthes sieberi* (to 40% in good seasons), and the short-lived perennial grasses *Digitaria breviglumis* or *Aristida calycina* var. *praealta*. In the intergrove areas, the ground stratum is open to dense, and dominated by grasses. The perennials *Aristida calycina* var. *praealta, A. jerichoensis*, and *Themeda triandra* may be abundant (10-35%), while *Monachather paradoxa*, and *Thyridolepis mitchelliana* occur frequently. The short-lived perennial grasses *Brachiaria piligera, Digitaria hystrichoides, D. brownii* and *Eragrostis lacunaria* are frequent. A variety of forbs may be present and seasonally abundant. More frequent species include *Sclerolaena convexula, Euphorbia drummondii, Plantago drummondii, Sida pedunculata, Velleia glabrata* and *Vittadinia* spp..

Woody weeds: *Eremophila gilesii* may be a problem in some areas (<1 m; to 11250/ha).

Top feed: *Acacia aneura* (as above).

LAND USE:

These lands are slightly unstable, and in mediocre to poor condition. The trend is static. Areas in better condition produce a moderate bulk of palatable grasses and forbs which provide adequate or better nutrition for dry animals but areas in poor condition produce a very limited bulk of palatable pasture. These lands can respond to lighter rainfalls (>25 mm), which also produce runoff from surrounding mulga lands onto this unit. Drought standover pasture is usually very limited in bulk, though low mulga provides valuable browse and abundant mulga top feed is available. Development of these areas is not likely under present conditions due to the low fertility and water-holding capacity of these soils. Management should aim to achieve optimum mulga densities (175 trees/ha), and maintain adequate ground cover to prevent woody weed invasion and excessive run-off.

LAND UNIT 54

(Land systems G1 H1 H2 R1 R2)

LANDFORM:

Undulating plains and scarp retreat zones below dissected tablelands. Slopes 1-4% or more.

GEOLOGY:

Erosion products of chemically-altered sediments. Kla, Tg.

SOILS:

Very shallow, red to yellowish red, gravelly lithosols with acid reaction. Textures are gritty, gravelly, light, sandy-clay-loam or sandy-loam. Surfaces are hardsetting and frequently covered with gravel and stone, Um1.43, Uc1.43.

VEGETATION:

Mulga (*Acacia aneura*) low woodland/tall shrubland (7-9 m; 200-500/ha) with scattered, emergent poplar box (*Eucalyptus populnea*: 10 m; <100/ha), and a sparse to open low shrub stratum of hopbush (*Dodonaea sinuolata* ssp. *acrodentata*: <2 m; to 875/ha). With clearing, a shrubby poplar box, mulga low open wood land or a wooded mulga, hopbush low shrubland develops. The tall shrub *Eremophila mitchellii* and low shrubs *Cassia artemisioides, Eremophila bowmanii* and *Prostanthera suborbicularis* are usually present. The grassy ground stratum is usually sparse but varies with the tree and shrub density. Dominant species include the perennials *Amphipogon caricinus* and *Eriachne mucronata* (5-25%), and the shorter-lived *Eragrostis lacunaria, Aristida calycina* var. *praealta* and *A. jerichoensis* var. *subspinulifera* (5-15%). Scattered tussocks of the perennial *Thyridolepis mitchelliana* are usually present. The forb *Sida filiformis* occurs frequently but forbs are not usually prominent.

Woody weeds: *Acacia aneura* and *Dodonaea sinuolata* ssp. *acrodentata* (as above); *Eremophila bowmanii, E. gilesii* and *Cassia nemophila* may be a problem in some areas (<2 m; to 1250/ha).

Top feed: *Acacia aneura* (as above).

LAND USE:

This unit is naturally unstable and in poor to very poor condition. A very limited amount of palatable grasses and a negligible quantity of forbs are available on this land unit. These lands show some response to rainfalls when stocking rates are very low. A limited amount of leaf-fall and browse is available throughout these areas and becomes valuable at very low stocking rates. Limited mulga top feed is available in some areas. There is little potential for development of these lands which provide local alluvia with significant runoff water. Management should aim to maintain optimum mulga densities (175 shrubs/ha) on this unit.

LAND UNIT 55

(Land systems R3)

LANDFORM:

Undulating plains in scarp retreat zones, surrounding dissected tablelands.

GEOLOGY:

Quaternary erosion products derived from chemically-altered sediments. AKw.

SOILS:

Very shallow, reddish brown, gravelly lithosols. Reaction is acid. Surfaces are hardsetting with pavements of silcrete gravel and stone. Exposed rock is common. Texture is gritty, gravelly light, sandy-clay-loam, Um1.43.

VEGETATION:

Mulga (*Acacia aneura*) tall shrubland/low woodland to tall open shrubland/low open woodland (5-7 m; 125-250/ha) with scattered *Eucalyptus populnea* and *E. terminalis* low trees often present. The tall shrubs/low trees *Atalaya hemiglauca, Canthium latifolium, Eremophila mitchellii, Flindersia maculosa, Geijera parviflora, Alectryon oleifolius* and *Ventilago viminalis* are locally prominent, particularly on the lower slopes. An open, low shrub stratum of *Dodonaea* spp., *Cassia sturtii* and/or *Eremophila gilesii* may occur (<2 m; to 2500/ha). The ground stratum is usually sparse, and grass-dominant. Perennial species include *Eriachne mucronata* and *Thyridolepis mitchelliana* (<5%). The shortgrasses *Eragrostis lacunaria, Aristida* spp., and *Digitaria* spp. are usually present.

Woody weeds: *Dodonaea sinuolata* ssp. *acrodentata, Cassia sturtii* and *Eremophila gilesii* (as above).

Top feed: *Acacia aneura* and other trees/shrubs (as above).

LAND USE:

This unit is naturally unstable, and normal geological erosion is occurring. Condition is mediocre to fair. A very limited bulk of palatable grasses provides good nutrition at low utilisation levels. These areas will respond to small rainfalls (>15 mm). During dry periods, a limited amount of standover feed and browse provides a useful drought reserve at low stocking rates. Sparse top feed is available in some areas. Management should aim to maintain adequate mulga densities (175 shrubs/ha), and low utilisation levels on this land unit.

LAND UNIT 56

(Land systems R1 R2 R3)

LANDFORM:

Scarps surrounding dissected tablelands. Slopes 10% or more.

GEOLOGY:

Chemically-altered Cretaceous sediments. AKlw, AKlc.

SOILS:

Very shallow,brown, gravelly lithosols. Reaction is acid. Stone and boulder pavements and extensive areas of exposed rock are characteristic, Uc1.43.

VEGETATION:

Lancewood (*Acacia petraea*) tall shrubland to tall open shrubland (4-6 m; to 4375/ha) frequently with scattered, emergent *Eucalyptus melanophloia* trees, *Acacia aneura* trees/tall shrubs and/or *Eucalyptus exserta* tall shrubs. A sparse to open low shrub stratum commonly occurs, containing *Dodonaea sinuolata* ssp. *acrodentata, D. petiolaris, Cassia* spp., *Eremophila latrobei* and *Prostanthera suborbicularis*. In eastern areas, *Acacia sparsiflora* (8-9 m; to 1000/ha), may replace *A. petraea*, and shrubs such as *A. aprepta, Acalypha eremorum, Croton phebalioides* and *Carissa ovata* often form a conspicuous, low shrub stratum. The ground stratum is usually sparse to very sparse, and dominated by perennial grasses such as *Eriachne mucronata, Aristida nitidula* and *A. caput-medusae* (<10%). Scattered tussocks of *Thyridolepis mitchelliana, Amphipogon caricinus, Eragrostis lacunaria* and *Paspalidium caespitosum* are usually present.

Woody weeds: *Acacia petraea, A. sparsiflora* (as above); *Dodonaea sinuolata* ssp. *acrodentata* may occasionally form a dense stand (<1 m; to 5000/ha).

Top feed: Scattered shrubs (usually 25/ha).

LAND USE:

These areas are unstable and natural geological erosion is occurring. Little edible feed is usually present, though leaf-fall may be utilised in drought times.

LAND UNIT 57

(Land systems R1 B1 B2 F1 G1 H1 H2 H3 S3)

LANDFORM:

Undulating to sloping plains in former scarp retreat zones. Slopes <5%.

GEOLOGY:

Redistributed Quaternary deposits over chemically-altered, Cretaceous sediments. Q.

SOILS:

Very shallow, gravelly, yellowish red lithosols. Reaction is acid. Surfaces commonly have gravel pavements, Um1.43.

VEGETATION:

Brigalow (*Acacia harpophylla*) low woodland/tall shrubland (7-10 m; 250-1000/ha) with emergent mountain yapunyah (*Eucalyptus thozetiana*; 9-11 m) on Dawson gum (*E. cambageana*; 12-13 m), (usually <100/ha but sometimes much denser). Scattered *E. populnea, Atalaya hemiglauca* and *Flindersia maculosa* trees are often present. Scattered *Geijera parviflora, Alectryon oleifolius, Capparis loranthifolia*, and *Eremophila mitchellii* tall shrubs and *Myoporum deserti* and *Carissa ovata* low shrubs occur frequently. In some areas, a gidgee (*Acacia cambagei*) low woodland (9-10 m; 375-800/ha) occurs in which *Eremophila mitchellii* (2-4 m) and *Dodonaea sinuolata* ssp. *acrodentata* (<2 m), may form a conspicuous shrub stratum (to 1000/ha). The ground stratum is usually very sparse, with grasses being dominant. Frequent species include the perennials *Enteropogon acicularis, Paspalidium caespitosum*, and *P. constrictum* and the shortgrasses *Eragrostis lacunaria, Sporobolus actinocladus* and *S. caroli* (<5%). A variety of forbs occur infrequently, some of which are seasonally prominent. *Chenopodium desertorum* spp. *microphyllum* and *Sida everistiana* may be locally abundant.

Woody weeds: *Acacia harpophylla* and *Eucalyptus thozetiana* may both regenerate densely after disturbance. *Eremophila mitchellii* and *Dodonaea sinuolata* ssp. *acrodentata* may cause local problems (as above).

Top feed: Scattered trees and shrubs (<25/ha).

LAND USE:

These lands are slightly unstable, becoming highly unstable if cleared. Condition ranges from mediocre to good. Perennial grasses and shortgrasses and seasonal forbs provide good nutrition levels but bulk is limited and allows only light stocking rates. These shallow, gravelly soils can respond to lighter rainfalls (>25 mm). Drought standover capability is limited by lack of pasture bulk but limited browse and leaf-fall provide useful drought reserve at very low stocking rates. Development of these areas by clearing is not recommended because of severe regrowth problems.

LAND UNIT 58

(Land systems R1 R2)

LANDFORM:

Tops of dissected tablelands. Slopes to 10%.

GEOLOGY:

Chemically-altered, Cretaceous sediments. AKlm.

SOILS:

Bare rock with occasional pockets of very shallow lithosols. Gritty, sandy-loams with very high organic matter content (2.5%) were recorded, Uc1.13.

VEGETATION:

Bendee (*Acacia catenulata*) open scrub to tall shrubland (5-7 m; 750-1000/ha) with occasional, emergent *Eucalyptus melanophloia, E. thozetiana* and *E. exserta* trees. A low shrub stratum is sometimes present and dominated by *Dodonaea sinuolata* ssp.*acrodentata* and *Eremophila latrobei* (<2 m; to 2000/ha). Bastard mulga (*Acacia stowardii*) low shrubs may occur in some areas. The ground stratum is extremely sparse but grass-dominant. Frequent or locally prominent species include *Aristida caput-medusae, Paspalidium rarum* and *Brachiaria foliosa*. Forbs are usually rare, although *Sida filiformis* may be conspicuous.

Woody weeds: Shrubs (as above).

Top feed: Negligible.

LAND USE:

These areas are undergoing geological erosion and are of little value for grazing animals. Some leaf-fall may be consumed by animals in drought periods.

LAND UNIT 59

(Land systems R2)

LANDFORM:

Sloping to gently undulating plains. Slopes typically 5%.

GEOLOGY:

Quaternary erosion products over chemically-altered sediments. Q.

SOILS:

Very shallow, gravelly, acid, yellowish red lithosols. Textures are gritty, sandy-clay-loams. Surfaces are scattered with gravel, Um1.41, Um1.43.

VEGETATION:

Mountain yapunyah (*Eucalyptus thozetiana*), or occasionally, Dawson gum (*E. cambageana*), shrubby open woodland to wooded tall shrubland (10-12 m; 50-100/ha). The dominant shrub species are sandalwood (*Eremophila mitchellii*: 2-4 m; 250-625/ha) and hopbush (*Dodonaea sinuolata* ssp. *acrodentata*: 1.5-2.5 m; to 2500/ha), with scattered *Geijera parviflora, Capparis loranthifolia* and *Acacia aneura*. Bowyakka (*Acacia microsperma*) is frequently abundant on the lower slopes of dissected valleys (3-6 m; 500-750/ha), while *Ptilotus pedleyanus* or *Phebalium glandulosum* may be locally common on scarps (<1 m; to 1250/ha). The ground stratum is extremely sparse (<5%), and dominated by grasses. Frequent species include *Enteropogon acicularis, Eragrostis lacunaria, Leptochloa decipiens, Paspalidium caespitosum* and *Sporobolus caroli*.

Woody weeds: *Eremophila mitchellii, Dodonaea sinuolata* ssp. *acrodentata* and *Acacia microsperma* (as above).

Top feed: Scattered shrub (<25/ha).

LAND USE:

These areas are unstable and in mediocre condition. Sandalwood and hopbush are present in most areas. Sparse perennial grass pasture with seasonal forbs provides adequate nutrition but bulk is very limited. These areas can respond to lighter rainfalls (>20 mm), in winter. Drought standover value is low, with very limited pasture and browse available. Management should aim to maintain ground cover in these areas to minimise runoff and subsequent erosion problems.

LAND UNIT 60

(Land systems A3 D1 D2 D3 F1 S1 S2 S3 W1 W2 W6 W7)

LANDFORM:

Flat to gently sloping plains. Slopes 0-1%.

GEOLOGY:

Quaternary sands. Qs.

SOILS:

Very deep, red to yellowish red, loamy sands. Reaction is acid, occasionally alkaline where clay layers are encountered. Textures are loamy sand to sand throughout.

Sandy clays occur at depth in some profiles, Uc1.23, Dr2.13, Dr2.52.

ANALYSES (3 sites)

pH	slightly acid to neutral at the surface and throughout the profile, occasionally becoming very strongly alkaline at depth
O.C.	low to very low
T.N.	low to very low
A.P.	fair to high throughout
B.P.	fair to high
K	high
E.C.	very low throughout
Cl	very low throughout
A.W.C.	very low

VEGETATION:

Wilga (*Geijera parviflora*) low open woodland (6-8 m; <75/ha) in which *Acacia excelsa, Atalaya hemiglauca, Grevillea striata*, and *Ventilago viminalis* trees occur frequently, and *Eucalyptus populnea* and *Acacia aneura* occasionally. A sparse shrub stratum is usually present in which *Eremophila sturtii, Myoporum deserti, Hakea leucoptera*, and *Capparis loranthifolia* occur frequently. The ground stratum is open and dominated by the shortgrasses *Eragrostis lacunaria, Aristida holathera* and and *Enneapogon* spp. (10-15%). *Aristida calycina* var. *praealta, Cenchrus ciliaris* and the annual *Dactyloctenium radulans* may be abundant in badly disturbed areas. A variety of forbs may be present, some becoming seasonally prominent. Frequent species include *Boerhavia diffusa, Salsola kali, Abutilon* spp., *Sida* spp., and in badly disturbed areas, *Sclerolaena* spp..

Woody weeds: *Eremophila sturtii, Dodonaea viscosa* ssp. *angustissima* and *Myoporum acuminatum* may cause local problems.

Top feed: *Geijera parviflora* (as above) and scattered trees and shrubs (<25/ha).

LAND USE:

These lands are slightly unstable and in mediocre to seasonally good condition. There is evidence of a long-term downtrend in condition in some areas, with woody shrub and wiregrass invasion. A moderate bulk of grasses of limited palatability, and a substantial component of forbs in season, provide adequate nutrition for all classes of animals for limited periods following lighter rainfalls (>15 mm). A very limited bulk of drought standover pasture is available but response to lighter rainfalls provides valuable drought relief. Limited top feed and browse is available. Cool fires may be useful in removing a build-up of wiregrass but may damage valuable fodder trees. Disturbance of this unit favours the establishment of woody shrubs. Adequate fertility levels on this land unit suggest some potential for buffel grass establishment in high rainfall years. Management should aim to minimise disturbance to these areas to limit establishment of undesirable species.

LAND UNIT 61

(Land systems D1 B4 S2 N1)

LANDFORM:

Flat to slightly undulating plains. Slopes 1-10%.

GEOLOGY:

Quaternary sands. Qs.

SOILS:

Very deep, red to yellowish red sands and siliceous sands. Reaction is acid. Surfaces are loose, with occasional profiles firm to hardsetting, Uc1.23, Uc1.22.

ANALYSES (7 sites)

pH	slightly acid to neutral
O.C.	very low
T.N.	very low
A.P.	low to very fair
B.P.	very low to fair
K	very low to very fair
E.C.	very low throughout
Cl	very low throughout
A.W.C.	very low
B.D.	1.6-1.8

VEGETATION:

Cypress pine (*Callitris columellaris*) woodland, to open woodland or wooded tussock grassland/shrubland after clearing (9-11 m; 25-200/ha). Scattered *Acacia excelsa, A. aneura, Geijera parviflora* and *Canthium oleifolium* low trees/tall shrubs are often present, while *Angophora melanoxylon* occurs infrequently. A shrub stratum is usually absent in woodlands but frequently prominent in more open communities. Common species include *Dodonaea viscosa* ssp. *angustissima, Alstonia constricta* and *Acacia murrayana* (1-4 m; to 1800/ha). The subshrub *Calotis* is often locally prominent on the lower slopes, particularly in disturbed areas. The ground stratum is sparse to open, depending on the tree/shrub density, and is dominated by grasses. The shortgrass *Aristida holathera* and annual *Perotis rara* are dominant at higher tree densities (5-25%), while the short-lived perennials *Aristida calycina* var. *praealta* and *A. biglandulosa* are dominant in open areas (5-40%). The perennial *Eragrostis eriopoda* may be locally prominent (<5%), while the annuals *Eriachne aristidea* and *Triraphis mollis* occur frequently. In some areas, the hummock grass *Triodia mitchellii* is dominant (20-30%). The forb diversity is high, particularly in disturbed areas, and a number of species may be seasonally prominent.

Herbage summary:

	No. of species			
	Total	High Pal.	Medium Pal.	Seasonally abundant (7 sites)
Long-lived perennial grasses	7	3	3	
Other graminoids	7	6	8	7
Forbs	37	7	16	14

Woody weeds: *Acacia salicina, A. murrayana, Dodonaea viscosa* ssp. *angustissima* and *Eremophila sturtii* (as above) in disturbed areas.

Top feed: Scattered trees (<25/ha).

LAND USE:

This unit is slightly unstable and in poor condition. A downtrend in condition is evident in some areas where woody shrub invasion has occurred. Pasture quality is poor except following rain, when a moderate component of highly palatable and nutritious forbs may be present. These areas provide little standover pasture in dry periods, but can provide valuable drought relief following light rainfalls. Limited top feed and browse are available in most paddocks. Buffel grass has been established on this unit in some areas and this type of development may be feasible in areas with higher fertility in good years. The effect of fire on this unit needs further investigation. Management should aim to maintain fodder tree densities to prevent shrub invasion on this unit.

LAND UNIT 62

(Land systems D1 A1 A2 A4 G2 S2 W3 W4 W7 W8)

LANDFORM:

Flat to gently sloping plains. Slopes typically 1%.

GEOLOGY:

Quaternary sands. Qs.

SOILS:

Very deep, red, earthy sands with acid reaction. Surfaces may be loose or hardsetting. Textures are loamy sand to sand, frequently increasing to light, sandy-clay-loam at 120 cm, Uc1.32, Uc1.43.

ANALYSES (4 sites)

pH	strongly to slightly acid throughout the profile
O.C.	low to very low
T.N.	very low
A.P.	low to fair at the surface, very low below 20 cm
B.P.	low to very low
K	fair
E.C.	very low throughout
Cl	very low throughout
A.W.C.	very low throughout
B.D.	1.6

VEGETATION:

Mulga (*Acacia aneura*) low woodland (8-9 m; 250-625/ha), with scattered to abundant ironwood (*A. excelsa*), becoming a mulga or ironwood low open woodland to wooded tussock grassland (<100/ha), after clearing, in which a shrub stratum may be conspicuous. Frequent species include *Alectryon oleifolius, Eremophila sturtii* and *Dodonaea viscosa* ssp. *angustissima* (2-6 m). The grassy ground stratum is sparse to open, depending on the tree density. At higher densities, the perennial *Thyridolepis mitchelliana* may occur (<5%), while in open areas, the shorter-lived *Aristida calycina* var. *praealta* becomes dominant (5-50%). The perennial *Eragrostis eriopoda* occurs frequently and may be locally abundant (<10%), while the shortgrasses *Aristida holathera, Eragrostis lacunaria*, and *Panicum effusum* are also frequent and often locally prominent (<5%). The annuals *Perotis rara* and *Enneapogon avenaceus* are usually present. A variety of forbs may occur and be seasonally abundant. More frequent species include *Abutilon otocarpum, Calotis cuneata, Helichrysum ramosissimum, Hibiscus sturtii, Portulaca* spp. and *Ptilotus polystachyus*.

Herbage summary:

	No. of species			
	Total	High Pal.	Medium Pal.	Seasonally abundant (4 sites)
Long-lived perennial grasses	7	3	4	
Other graminoids	19	8	6	6
Forbs	24	5	12	9

Woody weeds: *Dodonaea viscosa* ssp. *angustissima* may be a local problem (<2 m; to 2000/ha).

Top feed: *Acacia aneura, A. excelsa* (as above).

LAND USE:

This unit is slightly unstable, and in mediocre to seasonally good condition. A moderate bulk of perennial grasses of rather limited nutritional value is supplemented by highly palatable forbs following rain, to provide a diet of reasonable nutritional quality. A limited bulk of drought standover pasture, together with some browse and mulga top feed, is available on this unit. Following light rainfalls (>20 mm), this unit provides valuable drought relief. Burning is presently not recommended because of the risk of destroying established mulga. Development does not appear feasible, though there is some possibility of establishing buffel in more fertile areas in high rainfall years. Management should aim to maintain optimum mulga densities (175 shrubs/ha), and adequate ground cover.

LAND UNIT 63

(Land systems D3 D2 S1 S3)

LANDFORMS:

Flat to very gently undulating plains. Slopes <1%.

GEOLOGY:

Quaternary sands. Qs.

SOILS:

Very deep, yellowish red, earthy sands of alluvial origin. Reaction is acid to neutral. Surfaces are hardsetting or occasionally loose. Textures range from sand to loamy sand, Uc1.23.

ANALYSES (3 sites)

pH	slightly acid to neutral at the surface, neutral to slightly alkaline at 120 cm
O.C.	very low
T.N.	very low
A.P.	very fair to high at the surface, decreasing below 30 cm depth
B.P.	fair
K	fair
E.C.	very low throughout
Cl	very low throughout
A.W.C.	very low
B.D.	1.4-1.6

VEGETATION:

Cypress pine (*Callitris columellaris*) woodland (10-11 m; 100-200/ha) with scattered, emergent carbeen (*Eucalyptus tessellaris*), long-fruited bloodwood (*E. dolichocarpa*), and occasionally silver-leaved ironbark (*E. melanophloia*) and *Angophora melanoxylon* (12-15 m; usually <25/ha), becoming a cypress pine, carbeen and/or bloodwood open woodland to wooded tussock grassland after clearing, sometimes with a dense cypress pine shrub stratum. Scattered *Acacia excelsa* low trees and *Alstonia constricta* tall shrubs are often present. The ground stratum is sparse to dense, deepening on tree density, and is dominated by grasses. Dominant species include the perennials *Heteropogon contortus* (10-40%), and *Eriachne helmsii* (<5%), the shorter-lived *Aristida holanthera* (5-10%), and the annual *Perotis rara* (5-40%). *Aristida calycina* var. *praealta* and *Setaria surgens* may become locally prominent in badly disturbed areas (<5%). The forb diversity is relatively low but some species may become seasonally important.

Woody weeds: *Callitris columellaris* regeneration may be a problem after disturbance.

Top feed: Negligible.

LAND USE:

These areas are slightly unstable and in poor condition with black speargrass invasion causing a downtrend in a number of areas. Bulk of pasture is adequate in more open areas, but nutritional quality is poor. Some palatable forbs may be present following winter rain. Sheep cannot be grazed in areas where black speargrass is prominent though cattle can make good use of this pasture. This unit can respond to lighter rainfalls (<20 cm), but growth periods are short. Drought standover value is very limited. Some areas of this unit have been successfully cleared and planted with buffel grass. Management should aim to control wiregrass and speargrass by grazing this unit with cattle in most seasons.

LAND UNIT 64

(Land systems T1 H4 M2 S1 S2)

LANDFORM:

Flat to gently undulating plains. Slopes 0-3%, typically <1%.

GEOLOGY:

Quaternary sand sheets. Qs.

SOILS:

Very deep, red to yellowish red, earthy sands. Reaction is acid. Surfaces are hardsetting. Textures range from loamy sand to sand, Uc1.23.

ANALYSES (5 sites)

pH	strongly to slightly acid throughout
O.C.	low to very low
T.N.	very low
A.P.	very low to low throughout
B.P.	very low
K	fair to very low
A.W.C.	very low throughout
B.D.	1.5-1.8

VEGETATION:

Silver-leaved ironbark (*Eucalyptus melanophloia*) low open woodland/tall open shrubland, occasionally low woodland, to wooded/shrubby hummock grassland (6-10m; 25-200/ha). Scattered, emergent *Eucalyptus dolichocarpa* and *Angophora melanoxylon* trees may occur on the deeper sands and *E.terminalis* low trees on shallow sands, while *E. exserta* may be locally abundant. In marginal areas, *E. intertexta* and *E. populnea* trees are frequently common. A shrub stratum is often present, the density and composition being highly variable and often associated with fire. Abundant species include *Grevillea juncifolia*, and *Acacia maitlandii*, with *A. aneura* in marginal areas (2-6 m), and *Dodonaea boroniifolia* and *D. peduncularis* (<1 m). The tall shrubs *Allocasuarina inophloia* and *Xanthorrhoea johnsonii*, (2-4 m), low shrubs *Acacia gnidium, A. leptostachya, Baeckea* sp., *Calytrix longiflora* and *Melaleuca uncinata* (1-2 m), and subshrubs *Daviesia acicularis, Dicrastylis lewellinii* and *Goodenia disperma* (<0.5 m), may be locally abundant. The ground stratum is dominated by the hummock grasses *Triodia mitchellii* and *T. marginata* (15-60%). Scattered tussocks of *Eragrostis eriopoda* and *Aristida holanthera* frequently occur between the hummocks, while *Aristida* spp., *Panicum effusum* and *Themeda triandra* are often present below the trees. In "hard" areas occurring in this unit, *Eriachne mucronata* is dominant (5-25%). A variety of forbs may occur infrequently, some becoming seasonally prominent.

Woody weeds: *Acacia* spp., *Dodonaea* spp. and other shrubs (as above) frequently form extremely dense stands (up to 1500/ha or more). Many species are able to produce vegetative regrowth after burning, while the seeds of others show fire-stimulated seed germination.

Top feed: Negligible.

LAND USE:

This unit is slightly unstable and becomes unstable when fire is used. Condition is poor and a downtrend in condition is occurring in some areas. Nutritive value of the spinifex- dominated pasture is low except during seasonal flushes when new growth is present on the spinifex and a component of palatable forbs is present. These areas can respond to light rainfalls (>15 mm), thus can provide limited relief during dry periods. Standover value of pastures during drought periods is very low. Burning of these areas is commonly practised and in some cases, has destroyed mulga and increased the area of spinifex, and produced dense regeneration of unpalatable shrubs. Burning does however, open the pasture up temporarily for growth of more palatable species and following rain, a fresh palatable shoot is produced on the spinifex. Regular burning should be restricted to areas of dense spinifex only, and the fire should be contained within this area.

LAND UNIT 65

(Land system L2).

LANDFORM:

Slightly concave depressions, normally circular. Relief to 2 m. ("Box hollows").

GEOLOGY:

Quaternary alluvium. Qa.

SOILS:

Predominantly moderately deep, red to grey, light-textured, alluvial soils. Textures range from sandy-loam to sandy-medium-clays, generally increasing to the latter at depth, Dr2.13, Ug5.24, Gn2.11.

ANALYSES (3 sites)

pH	moderately acid to neutral
O.C.	low
T.N.	very low
A.P.	very low
B.P.	very low
E.C.	very low
Cl	very low

VEGETATION:

Poplar box (*Eucalyptus populnea*) woodland to open woodland (9-11 m; 75-500/ha), occasionally with scattered *Acacia aneura, Hakea ivoryi* and *Eucalyptus melanophloia* low trees. Scattered shrubs may be present e.g. *Acacia oswaldii, A. tetragonophylla, Eremophila mitchellii* (2-4 m), *E. glabra* and *E. gilesii* (<1 m). The ground stratum is sparse to open and dominated by the short-lived perennial grasses *Eragrostis microcarpa, Aristida calycina* var. *praealta, A. jerichoensis* and *Digitaria* spp. (5-25%). The perennials *Panicum subxerophilum* and *Themeda triandra* and shortgrasses/annuals *Enneapogon avenaceus, Eragrostis lacunaria* and *E. elongata* occur frequently. In wetter areas, *Dichanthium sericeum, Eulalia aurea* and *Iseilema vaginiflorum* may be locally prominent. A variety of forbs may be present, some becoming seasonally prominent. The more frequent species include *Calotis cuneata, Euphorbia drummondii, Haloragis aspera* and *Velleia glabrata*.

Woody weeds: *Eremophila glabra* and *E. gilesii* may be a minor problem in some areas (<1 m; to 500/ha).

Top feed: Negligible.

Poisonous plants: *Pimelea elongata* is locally common in some areas (< 5%).

LAND USE:

These areas are relatively stable but in mediocre to poor condition due to continued, high grazing pressure. Shortgrasses and forbs provide a very limited bulk of pasture of good nutritional quality. Wiregrass may be present. These areas receive considerable run-on water therefore, can respond to small rainfalls which produce runoff. This makes these areas valuable during drought periods. Poisonous plants (*Pimelea* spp.) were recorded at some sites. The limited extent of these areas makes it impractical to implement specific management strategies at present.

LAND UNIT 66

(Land systems L2 L1).

LANDFORM:

Slightly concave depressions. Relief to 3m.

GEOLOGY:

Quaternary alluvium. Qa.

SOILS:

Moderately deep, alluvial soils. Alkaline, grey, cracking clays of light to medium texture, predominate.

Surfaces form strong, silty crusts and are subject to scalding in some areas, Ug5.24.

VEGETATION:

Tall, open scrub to tall shrubland/low woodland (4-7 m; 625-3750/ha) dominated by either belah (*Casuarina cristata*), yarran (*Acacia omalophylla*) or bowyakka (*A. microsperma*). A low shrub stratum is absent, but scattered *Eremophila glabra* and *Muehlenbeckia cunninghamii* may be present. The ground stratum is usually an extremely sparse tussock grassland or occasionally a sparse herbland. More frequent grasses include the perennials *Eragrostis setifolia* and *Paspalidium jubiflorum*, and the short-grasses/annuals *Eragrostis parviflora, Diplachne fusca, Eriochloa pseudoacrotricha* and *Sporobolus* spp.. Common forbs include *Marsilea drummondii, Pratia puberula, Eryngium supinum* and *Sclerolaena* spp..

Woody weeds: *Casuarina cristata, Acacia omalophylla* and *A. microsperma* (as above).

Top feed: Tall shrubs (as above).

LAND USE:

These areas are slightly unstable. Present condition is mediocre to poor, as a result of high grazing pressure. A limited bulk of pasture of good nutritional quality is produced on this unit. These areas receive considerable run-on water therefore can respond to smaller rainfalls during drought periods. Continued high utilisation levels and high salt levels in the soil mean scalding is common around the edges of these depressions. Unless areas are of sufficient size to fence off, little can be done to implement preferential management practices for these areas at present.

LAND UNIT 67

(Land system D1 L1 L2).

LANDFORM:

Slightly concave depressions. Swamps. Relief to 2m.

GEOLOGY:

Quaternary alluvium. Qa.

SOILS:

Very deep, alkaline, grey clays, with strong surface crusts which exhibit polygonal cracking. Textures are heavy clay with sand and silt intermixed, Ug5.24.

VEGETATION:

Swamp canegrass (*Eragrostis australasica*) open hummock grassland (1 m; 5-15%) with scattered Queensland bluebush (*Chenopodium auricomum*) and lignum (*Muehlenbeckia cunninghamii*) low shrubs. The ground stratum between the *Eragrostis parviflora, Iseilema membranaceum* and *Panicum decompositum* and the forbs *Alternanthera nodiflora, Aeschynomene indica, Sclerolaena* spp., *Marsilea* spp. and *Frankenia uncinata*. Scattered *Eucalyptus microtheca* low trees may be present in some areas.

Woody weeds: Absent.

Top feed/browse: Swamp canegrass and low shrubs (as above).

LAND USE:

These areas are relatively stable and in poor condition. Little pasture is available because of the periodic inundation and severe surface scalding. Swamp canegrass provides limited browse for stock. These areas harbour pigs, which are predators and disease carriers.

LAND UNIT 68

(Land system L2).

LANDFORM:

Slightly concave depressions. Relief to 3 m.

GEOLOGY:

Quaternary alluvium. Qa.

SOILS:

Deep, brown to grey-brown, alluvial, cracking, claysoils. Reaction is alkaline. Textures are sandy, medium heavy to light clay. Lime and gypsum are present in the profile at depth. Surfaces are weakly crusting and cracking, sometimes with well-developed, gilgai micro-relief, Ug5.23, Ug5.24.

VEGETATION:

Brigalow (*Acacia harpophylla*) low woodland/tall shrubland (7-8 m; 125-500/ha) sometimes with scattered, emergent yapunyah (*Eucalyptus ochrophloia*). A sparse shrub stratum of *Eremophila mitchellii, E. glabra* and *Myoporum deserti* may be present. The ground stratum is usually a sparse grassland or herbland. Dominant shortgrasses include *Sporobolus caroli, S. actinocladus* and *Chloris pectinata*. Scattered tussocks of the perennials *Eragrostis setifolia* and *Enteropogon acicularis* are usually present, while the short-lived perennials/annuals *Brachyachne convergens, Dichanthium sericeum, Eragrostis parviflora, Eriochloa pseudoacrotricha* and *Tragus australianus* occur frequently. *Cyperus* spp., *Marsilea* spp., *Eleocharis pallens* and *Elytrophorus spicatus* are common in gilgai depressions. A variety of forbs may occur, some of them seasonally, include *Sclerolaena* spp., *Chenopodium desertorum* ssp. *microphyllum, Trianthema triquetra, Euphorbia drummondii, Boerhavia diffusa* and *Sida* spp..

Woody weeds: *Myoporum deserti* and *Eremophila glabra* may be a minor problem (<1 m; to 325/ha); *Acacia harpophylla* regrowth is a problem in cleared areas (to 3750/ha).

Top feed: *Myoporum deserti* and *Eremophila glabra* (as above).

LAND USE:

These areas are slightly unstable and in mediocre condition. There is some evidence of a slight downtrend in the invasion of Ellangowan poison bush and black fuchsia in certain areas. Nutritional value of the shortgrass and forb pastures is good but bulk and subsequent standover bulk are limited and further reduced by the high grazing pressure on these areas. This unit receives useful run-on water and in drought periods, can respond to small rainfalls which produce runoff. Fertility levels are adequate for native species and this, combined with medium water-holding capacity and the advantage of run-on water, means these areas have reasonable potential for pasture production. However, consistent overgrazing means this potential is not achieved. This overgrazing cannot be prevented as this unit occurs as small, scattered areas which are usually not feasible to fence off.

LAND UNIT 69

(Land systems L1 L2 H4 M2 W2)

LANDFORM:

Slightly concave depressions ('Claypans and swamps'). Relief to 3 m.

GEOLOGY:

Quaternary alluvium. Qa.

SOILS:

Shallow to moderately deep, poorly-drained, grey clays. Reaction is neutral. Surfaces are massive, Ug5.24.

VEGETATION:

Sedgeland, open sedgeland, or herbland. The sedge *Eleocharis pallens* is frequently a dominant species (to 25%) while the perennial grasses *Eragrostis setifolia* and *Eriachne benthamii* and the annual grasses *Eragrostis parviflora, Diplachne fusca* and *Iseilema membranaceum* may be co-dominant or dominant. The grasses *Elytrophorus spicatus* and the sedges *Eleocharis pusilla* and *Cyperus* spp., occur frequently. A variety of forbs may be present and become seasonally abundant. These include *Aeschynomene indica, Alternanthera denticulata, Calotis multicaulis, Centaurium spicatum, Centipeda* spp., *Craspedia chrysantha, Eryngium supinum, Marsilea* spp., *Psoralea tenax, Swainsona* spp., and *Trigonella suavissima*. In some areas, scattered shrubs of *Muehlenbeckia cunninghamii, Halosarcia* spp. and *Sclerostegia tenuis* may be present and occasionally become locally abundant.

Woody weeds: Absent.

Top feed: Absent.

LAND USE:

These are stable areas in mediocre condition. The sedges of unknown palatability predominate. Small amounts of palatable annual forbs and grasses are present in season. High grazing pressures limit any increase in abundance of the more palatable species. This unit is flooded by run-on water and so, can respond to smaller rainfalls which create runoff. Little potential for development or preferential management exists, though lake bed farming may be possible.

LAND UNIT 70

(Land systems L1)

LANDFORM:

Fringes of swamp depressions. Slopes <2%. Relief to 3 m.

GEOLOGY:

Superficial, evaporitic lake deposits. Limestone. Ql. These deposits frequently underlie claypans and swamps in areas east and south of Wyandra. These deposits are exposed around the fringes of these depressions.

SOILS:

Very shallow, dark brown, alkaline lithosols. Textures are gritty, light and sandy-clay-loam. Surfaces are hardsetting, Um1.13.

VEGETATION:

Sparse to open grassland dominated by *Enneapogon avenaceus* (5-25%). Scattered tussocks of *Eragrostis setifolia, Enteropogon acicularis, Digitaria* spp., *Aristida contorta* and *Chloris pectinata* may be present. Forbs are usually rare although *Lawrencia glomerata* occurs frequently and may be locally prominent. Scattered *Ptilotus obovatus, P. atriplicifolius* and *Scaevola aemula* subshrubs may occur, while the low shrub *Lawrencia squamata* is occasionally locally abundant. *Hakea ivoryi, Eremophila longifolia* and *Acacia tetragonophylla* tall shrubs may be scattered sparsely.

Woody Weeds: Absent.

Top feed: Negligible.

LAND USE:

Areas are not of significant size. Possible scenic value where exposed around the margins of larger, more permanent swamps.

LAND UNIT 71

(Land systems L2 B4 D1 H4 M2 M3 S1 S2)

LANDFORM:

Slightly concave depressions. Swamps. Relief to 2 m.

GEOLOGY:

Quaternary alluvium.

SOILS:

Shallow to moderately deep, reddish brown, alluvial clay soils with sand and silt intermixed. Reaction is acid. Surfaces are hardsetting, Uf6.23.

VEGETATION:

Coolibah (*Eucalyptus microtheca*) low woodland to low open woodland (7-9 m; 25-200/ha). Scattered *Eremophila bignoniiflora* tall shrubs and *Muehlenbeckia cunninghamii* low shrubs occur frequently. The ground stratum is sparse to open, and usually grass-dominant. Locally abundant perennial grasses include *Eragrostis setifolia, Eriachne ovata*, and *Paspalidium jubiflorum* (<10%), *Dichanthium sericeum, Diplachne fusca, Eragrostis leptocarpa, E. parviflora, Eriochloa pseudoacrotricha* and *Panicum laevinode* may become seasonally prominent. A variety of forbs may be seasonally present, including *Aeschynomene indica, Centipeda* spp., *Convolvulus erubescens, Daucus glochidiatus, Eryngium supinum, Marsilea* spp., *Mimulus gracilis, Plantago drummondii* and *Psoralea tenax*.

Woody weeds: *Eucalyptus microtheca* regeneration may be a problem in some areas after local flooding.

Top feed: Negligible.

Poisonous plants: *Pimelea elongata* is abundant in some areas.

LAND USE:

These areas are stable and currently in poor condition. They can produce a moderate bulk of high quality grasses and forbs however, high grazing preserves severely restrict growth. They benefit from run-on water produced by light rainfalls on the surrounding mulga lands. Poisonous plants (*Pimelea* spp.) may produce St. George disease in cattle under certain conditions. Little potential for development or preferential management of these areas exists, except perhaps in some of the large swamps.

APPENDIX VI

SUPPLEMENTARY LIST OF RECENT REFERENCES

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INDEX TO CHEM TABLE MICROFICHE

by C R Ahern

Microfiche 1

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18
A	Org Carbon	E C (cont)	Exch Mg	A D M (cont)	Ex Mg/ CEC	**SOIL GROUP STATS.** Grp A	Grp I	BLANK	Acid P (cont)	pH (1 5) (cont)	Field pH (cont)	Ex Ca (cont)	Clay	Coarse Sand (cont)	C Sand/ F Sand (cont)	Ex. Mg (cont)	Bic P/ Acid P (cont)	Yo Yo (cont)
B	Tot N %	" "	" "	CEC/ Clay	" "	" " / Grp B	" "	BLANK	" "	" "	" "	" "	" "	ADM %	" "	" "	Repl K/ Ex K	Mooloothulla
C	Repl K	Chloride	Exch Na	" "	ESP	" "	Grp J / All soils	BLANK	" "	" "	Total P	" "	" "	" "	" "	" "	" "	Tego
D	Acid P	" "	" "	CEC/ (Clay and Silt)	" "	" " / Grp C	Grp A (Fertil) / Grp B	BLANK	Bicarb P	Elect Cond	" "	Ex Mg	" "	" "	-1/3 Bar Moist	ESP	C/N (W&B)	
E	" "	" "	CEC	" "	Ca/ Mg	" "	(Fertil) / Grp C (Fertil)	BLANK	" "	" "	" "	" "	Silt	" "	" "	" "	" "	Gerah
F	Bicarb P	Field pH	" "	Coarse/ Fine Sand	" "	" " / Grp D	Grp D (Fertil)	BLANK	Ex K	-	-	" "	" "	CEC/ Clay	" "	" "	Tot S/ Tot N	
G	Exch K	" "	Clay	" "	Acid P/ Tot P		Grp E (Fertil) / Grp F		" "	" "	Total K	" "	" "	" "	-15 Bar (Part only)	" "	" "	Wallal
H	" "	Total P	" "	-1/3 Bar Moist	" "	Grp E	(Fertil) / Grp G	**SOIL PROFILE CLASSES**	" "	" "	" "	Ex Na	" "	" "	Soil Wat Cap	Ca/ Mg	Tot C/ Tot N	
I	Fe (DTPA)	" "	Silt	" "	Bic P/ Tot P		Grp H (Fertil)	Org Carbon	" "	Chloride	" "	" "	Fine Sand	" "	" "	" "	" "	Noorama
J	Mn (DTPA)	Total K	" "	-15 Bar Moist	Repl K/ Ex K	Grp F	Grp I (Fertil) / Grp J	" "	Fe (DTPA)	" "	" "	" "	" "	" "	" "	" "	Ex K/ Sum Cat	
K	Cu / Zn	" "	Fine Sand	" "	C/N (W&B)	" "	(Fertil) / All soils	Tot N	Mn (DTPA)	" "	Total S	" "	" "	CEC/ (Clay & Silt)	Ex Ca	" "	" "	Bundaleer
L	Zn (DTPA)	Total S	" "	Soil Wat Cap	Tot S/ Tot N	Grp G	BLANK	" "	Cu (DTPA)	" "	" "	CEC	" "	" "	" "	Acid P/ Tot P	Ex K/ CEC	
M	pH (1 5)	" "	Coarse Sand	" "	Tot C/N x 1 3	" "	BLANK	Repl K	Zn (DTPA)	" "	" "	" "	Coarse Sand	" "	" "	" "	" "	Toolonga
N	" "	Exch Ca	" "	Exch Ca/ CEC	Ex K/ Sum Cat	Grp H	BLANK	" "	Zn (DTPA)	Field pH	" "	" "	" "	" "	" "	" "	**SOIL PROF. CLASS STATS.**	
O	Elect Cond	" "	A D Moist	" "	Ex K/ CEC	" "	BLANK	Acid P	pH (1 5)	" "	Ex Ca	" "	" "	C Sand/ F Sand	Ex Mg	Bic P/ Acid P	Mt Pleasant / Yo Yo	Bando

Microfiche 2

	01	02	03
A	**SOIL PROF CLASS STATS.** (cont)	H2	Elmina All Soils
B	Bando / Brumby	Randwick	BLANK
C	Loddon		" "
D	Halton	Minitta	" "
E		Rollo / All Soils	" "
F	Maxvale	**FERTILITY SPC DIST.** Mt Pleasant	" "
G		Yo Yo / Mooloothulla	" "
H	Brunell	Tego	" "
I	Prarie / Mayvale	Gerah / Wallal	" "
J		Noorooma	" "
K	Elmina	Bundaleer	" "
L		Loddon / Halton	" "
M	Bowra	Maryvale	" "
N		Brunell / Prarie	" "
O	H 2	Mayvale	" "