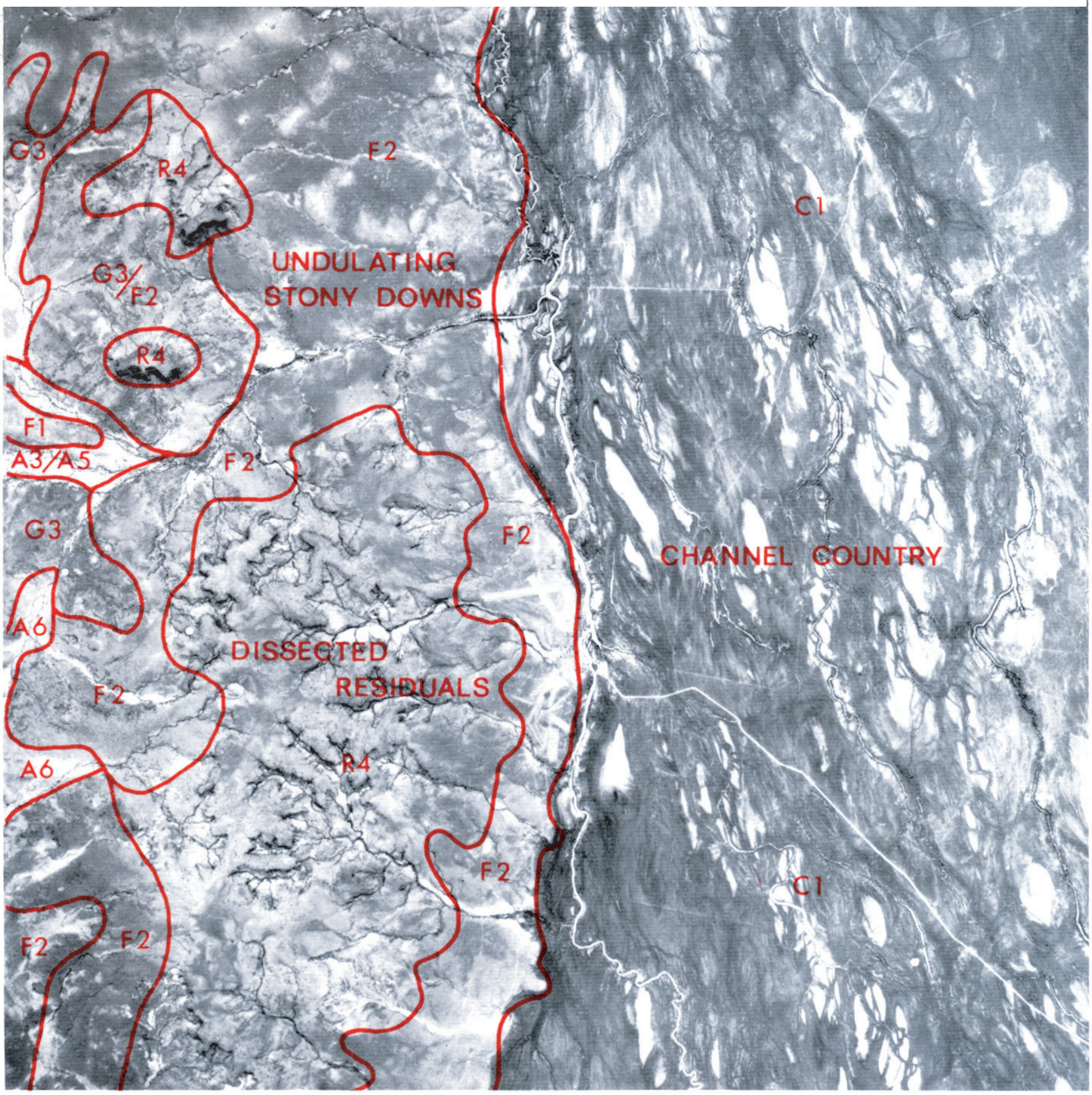
WESTERN ARID REGION

LAND USE STUDY - PART 1



TECHNICAL BULLETIN No 12

PUBLISHED BY THE DIVISION OF LAND UTILISATION
AUGUST 1974

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WESTERN ARID REGION

LAND USE STUDY

PART I

CONTRIBUTING ORGANIZATIONS

State Government

Department of Primary Industries

Department of Lands

Irrigation and Water Supply Commission

Australian Government

Division of Land Resource Management, C.S.I.R.O.

Department of Northern Development

Bureau of Agricultural Economics

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AUGUST 1974

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COVER PHOTOGRAPH: Part of one aerial photograph used for the land system mapping, showing the land zones and land systems near Durham Downs Station near Cooper Creek. This air photograph is Crown copyright and has been made available by courtesy of the Director of National Mapping, Department of Minerals and Energy.

ERRATA

p. 1, para 11, line 4: nearby not hearby

p. 10, Figure 2.10, title, line 2; trees not tress

p. 11, last line; Hounam not Hounan

p. 40, last para, line 2; 85% not 35%

p. 47, para 4, line 1; form not from

p. 47, para 11, line 3; needed not need

p. 48, line 1; delete a at end of line

p. 51, para 6, line 3; E. macdonnellii not A. macdonnellii

p. 52, Acacia cambagei predominant associations, para 4, line 2; form not forms

p. 54, Frequently occurring species, Sedges; C. iria not C iria

p. 56, line 1, under comment; delete disected

p. 56, Acacia aneura predominant association. Under structural formation "open scrub" not "open shrub"

p. 57, Acacia aneura, Eucalyptus populnea; sericeum not sericeium

p. 60, Floristic Association; Crotalaria cunninghamii not Crotalaria cunninghammii

p. 64, Frequently occurring species, line 6; spp not app

p. 74, para 11, line 2; occurring not occur

p.106, eighth last line (Acacia cyperophylla) not (Acacia aneura)

p.113, para 7, line 3; there are already

p.130, para 4; land not land's

The key to the geology, soil texture classes and vegetation symbols used in Appendix VII appear on Page 76 of the report. To the vegetation symbols should be added:

brigalow belah Cypress pine Dawson gum

Mountain yapunyah

Appendix III Site A29 - Numerals at the end of the lines are slightly misplaced.

Corrections to the Land System Map

Co-ordinates (000 yds) Marked on edge of map	Correction
410E 575N	Read as W5
232E 433N	S2 not R2
238E 435N	H3/H4 not D3/D4
240E 410N	M3 not D3
334E 768N	G5 not G3
340E 752N	G5 not G3
340E 756N	G5 not G3

Note: Lines under typing are where corrections have been made. They do not represent underlining.

Acknowledgments

Our special thanks are extended to the Divisional typists namely Linda Chapman, Kym Stone, Pat Lally and Roslyn Green who bore the brunt of the technical terms and our bad writing.

FOREWORD

A request for an investigation into the economic plight of graziers in the Jundah-Stonehenge region in far Western Queensland was submitted to the Queensland Government in 1967. The submission, by the Central and Northern Division of the United Graziers' Association of Queensland, resulted from the 1964-66 drought and its disastrous consequences to wool producers. Financial considerations, based on high interest charges and accumulated debt loads, were a constant burden on the smaller wool producers in the far south-west.

The Land Development Committee, when considering the matter, felt that in the absence of meaningful facts about the region it was essential that a physical inventory be undertaken. A meeting of all interested agencies in June 1968 made plans for undertaking a physical inventory of the resources. It was also apparent, because of the "extent" of the area, that broad scale mapping would be required if the overall task was to be completed in a reasonable time span.

The Commonwealth Division of National Mapping undertook to re-arrange their aerial photography programme, to ensure that high-level up to date photographs would be available. Officers of the Department of Lands and the Irrigation and Water Supply Commission agreed to co-operate. Active participation was forthcoming from the Bureau of Agricultural Economics, the Department of Northern Development and the C.S.I.R.O. Rangeland Research Unit.

This report, which is the result of considerable effort by a group of multi-discipline specialist officers within the Development Planning, Botany and Agricultural Chemistry Branches within the Department of Primary Industries, relates to Part I of the study embracing some 15 million hectares.

Field work, for Parts II to IV of the study, embracing a further 65 million hectares of pastoral land, is expected to be completed by 1980.

I should like to take this opportunity to express thanks to the Agencies who have co-operated to make this report possible. The report itself is a valuable classification and description of the soil and vegetation resources of the region at the present time, and as such forms the basis for further action as required. In the face of world rising population, allied with energy and pollution crises, the arid and semi-arid lands may attain a significance as yet unrealised in most quarters.

J.E. Ladewig
DIRECTOR
DIVISION OF LAND UTILISATION

ACKNOWLEDGEMENTS

We are indebted first to Mr A. Hegarty, Director of the Development Planning Branch, for his patience and guidance during the years this survey has been in progress.

Our thanks are due to other officers of the Development Planning, Botany and Agricultural Chemistry Branches, particularly Messrs S.L. Everist, B.J. Crack and R.C. Bruce. Special mention should be made of Mr R.J. Anson, Sheep and Wool Branch, who helped the team in their early understanding of the area and also for contributed comments.

Production of the final maps and diagrams was undertaken by Mr C.M. Ellis of the Drafting Section of the Division of Land Utilisation under the guidance of Mr P.H. Scott. The Division of National Mapping, Department of National Development, kindly supplied the base sheets for the preparation of the Land System Map and facilitated the aerial photograph programme.

Mr L.T. McKay and staff of the Lithographic Section of the Department of Lands were responsible for the excellent quality of the printed maps.

Mr J.E. Wright contributed the information on rabbits.

Mr R.A. Perry, Chief of the Division of Land Resources Management and Dr A.W. Moore, Division of Soils, C.S.I.R.O., assisted in the formulation of many of the basic concepts and gave freely of their experience.

The Department of Northern Development prepared material for the section on Transport.

Finally, special mention must be made of Mr G.A. Tuck who has been responsible for much of the collection and processing of the basic biological data.

AUTHORS

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SUMMARY

A comprehensive reconnaissance land systems study has been made of approximately 15 million hectares of pastoral land in far south western Queensland. This region lies within the 400 to 100 mm rainfall zone, with over eighty per cent of the rainfall occurring during the summer months. The winters are normally fine and mild although frosts occur. Appropriate climatic data for available stations are presented, and the incidence and reliability of the rainfall in relation to the pastoral industry are discussed.

The region forms part of the Eromanga Basin which is a sub-basin of the Great Artesian Basin. The geological sequence of the Eromanga Basin is based on a conformable succession of Jurassic, Cretaceous, and Tertiary sediments. All of these sediments were deeply weathered in the Tertiary period. Since then, Tertiary lateritic developments and Quaternary deposits have obscured the original sediments in many areas.

The lands of the area have been mapped into 53 land systems which are areas of country with similar patterns of land forms, soils and vegetation. Each land system is described in terms of its component "land units" which are parts of the landscape and are relatively homogeneous in landform, soil and vegetation.

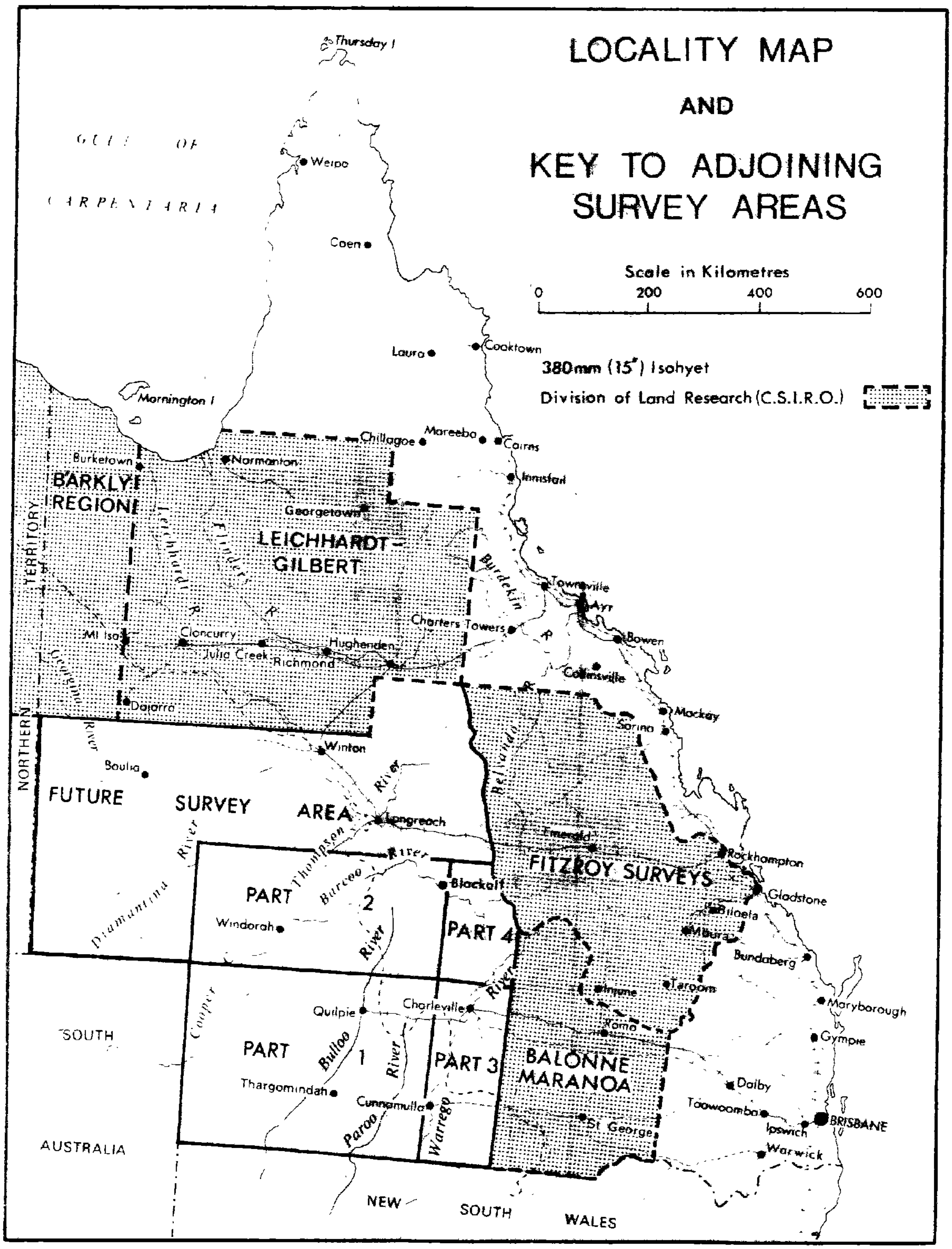
The boundaries of the soil mapping units are closely related to the geological boundaries, and in general terms the soil characteristics mirror the geomorphic processes associated with their development. Past climate and drainage have also had significant effects on soil development. It is apparent that the chemical alteration of the Cretaceous sediments, during the Tertiary period, and the subsequent erosion of the profile have been the dominant processes affecting soil distribution.

The vegetation has been classified into eighteen structural formations. Classification, follows Specht (1970), and is based on projective foliage cover, height and life form of the tallest stratum. The distribution of the plant communities can be obtained from the land system descriptions, and in a more general way from the vegetation map.

The suitability of the area for pastoral production is discussed. The grazing of natural pastures by either beef cattle or sheep is the most important form of land use in the area. Soil and climatic conditions, throughout the study area, are quite unsuitable for intensive use under cultivation and improved pastures. Mining, hunting and trapping, tourism and beekeeping are complementary industries contributing to income from the area.

Continued occupation of the area by man and his animals will depend on the skilful management of the vegetation and water resources in the region. Overstocking, and denudation of the soils in periods of drought, must be prevented if this region is to be maintained as a viable ecosystem for use by future generations.

Finally, some observations are made on the need to "reserve" considerable tracts of the rather unique vegetation communities. The opening of the area for tourism, in turn, presents a challenge for those administrators who are charged with maintaining a viable community in Western Queensland.


LOCALITY MAP
AND
KEY TO ADJOINING SURVEY AREAS
Scale in Kilometres
0
200
400
600
380mm (15") Isohyet
Division of Land Research (C.S.I.R.O.)
Thursday I
Weipa
Coen
Laura
Cooktown
Mornington I
Chillagoe
Mareeba
Cairns
Innisfail
Burketown
Normanton
Georgetown
BARKLY REGION
LEICHHARDT - GILBERT
Townsville
Ayr
Bowen
Charters Towers
Mt Isa
Cloncurry
Julia Creek
Richmond
Hughenden
Collinsville
Mackay
Sarina
Dajarra
Winton
Boulia
FUTURE SURVEY AREA
Longreach
Emerald
Rockhampton
FITZROY SURVEYS
Gladstone
Biloela
Blackall
PART 2
PART 4
Windorah
Bundaberg
Taroom
Injune
Maryborough
Gympie
Quilpie
Charleville
Roma
PART 1
PART 3
BALONNE MARANOA
Thargomindah
Cunnamulla
Dalby
Toowoomba
Ipswich
BRISBANE
St George
Warwick
NORTHERN TERRITORY
SOUTH AUSTRALIA
NEW SOUTH WALES
Leichhardt R
Flinders
Burdekin
Georgina
Diamantina River
Thompson River
Barcoo River
Belyando
Cooper
Bulloo
Paroo
Warrego
River

Early Settlement

The journey of Sir Thomas Mitchell, who had succeeded Oxley as Surveyor-General of New South Wales, to the country westward of the Darling Downs in 1845-6 led to the discovery of the Maranoa, flowing into the Darling, and the Barcoo flowing westward, as Mitchell thought to the Indian Ocean.

Subsequent examination by E.B. Kennedy proved that the Barcoo was identical with the Cooper Creek of Captain Sturt, discovered from South Australia. Kennedy added the Warrego to the list of Queensland rivers.

By the year 1859 an agitation for separation from New South Wales had been successful. Meanwhile, pastoral occupation and settlement had progressed northward and westward. In 1861 Burke and Wills crossed Queensland from the site of Birdsville to the Gulf of Carpentaria, but returned to perish on the banks of Cooper Creek. The expeditions sent out in search of the lost explorers opened up the western portion of the State.

Pioneer pastoralists began to establish themselves in the area during the 1860's. These settlers moved in mainly from the established pastoral areas of New South Wales. By 1869 they had established themselves on the best pastures and waterholes of the Paroo, Bulloo and Wilson Rivers and the Upper Cooper Creek (Kyabra Creek). Others moved up the Strzelecki Creek to Cooper Creek from South Australia. Pastoralists such as Hughes, Costello and Durack were in the forefront of this movement.

This initial phase of settlement occurred in a period of reasonable seasons but was followed by drought in the period 1868 to 1870. The period up to 1880 saw the greatest expansion of settlement in the area. During this period the frequent occurrence of drought, primitive conditions, hardship, loneliness, inadequate watering points and living areas caused a reduction in the number of small lessees.

From 1880 to the turn of the century, drought, pleuro-pneumonia, rabbits and the financial crisis of 1893 further reduced the number of individual landholders, while banks and pastoral companies grew in importance as landholders. By 1900 the banks and pastoral companies together controlled over fifty per cent of the leases.

Following poor seasons early this century the lending houses were willing to sell and pastoral companies and large scale operators increased their holdings. Since then the trend in the far western sector has been to amalgamate properties. The development of company properties extending in a chain from the north-west of the State to the Channel Country, is a feature of the region.

In the eastern section, mainly east of Quilpie and Thargomindah, subdivision of leases and closer settlement were a feature of the area until the mid 1960's. However, low wool prices and poor seasons have influenced a recent trend to amalgamate smaller leases in the eastern area.

Initial means of communications were tracks established by the early settlers, who usually settled near waterholes. Subsequently, transport routes followed the courses of the streams. At this time, Bourke in New South Wales was the main trading centre, as the costs of supplies and transport were considerably lower from that centre. Towns such as Hungerford, Thargomindah, Kyabra and Adavale were established on the bullock-wagon routes. Eromanga developed later as a result of a wool scouring plant which was set up on a nearby creek. By 1887 well developed postal services and mail-runs were established in the area (Allen, 1969). Mail contractors such as Cobb and Co. later took over nearly all the western mail-runs.

The railway line from Brisbane had reached Charleville by 1888 and by 1898 had been extended to Cunnamulla. The Charleville line was extended in 1917 to Quilpie. This all weather route to the coast, together with a levy on goods moving into New South Wales, resulted in a change of trade away from Bourke to Charleville, Cunnamulla and Brisbane.

The discovery of opals after 1890 led to the growth of towns such as Eromanga, Eulo and Thargomindah. After the turn of the century many of the small towns, which once had a number of hotels and other commercial businesses, gradually decreased in importance. In 1917 the railway line was extended from Charleville to Quilpie and since then this town has grown at the expense of other hearby centres.

At present, the towns of Toompine, Noccundra and Eromanga have hotels as their only commercial businesses, whilst Eulo and Thargomindah also support general stores.

Early land tenure

Prior to Queensland being created a separate colony in 1859, recognised land settlement was provided for under the Regulations and Ordinances in force in New South Wales; the pioneers in the outlying parts being grazing squatters who worked under a small rental, occupation license fee.

During the first Session of Queensland Parliament in 1860, four Land Bills were passed. One of them, "*The Unoccupied Crown Land Occupation Act of 1860*" gave the necessary authority for the leasing of land. Leases were granted in the first instance generally over areas of approximately 64 km^2 and later increased to approximately 256 km^2. There was no limitation on the number of leases or area that could be held.

This broadly was the tenure applicable in the early days. Settlement first took place in the eastern section in 1861. Over the ensuing years leasing gradually extended westerly to the South Australian border where leases were granted as late as 1875.

"*The Crown Land Act of 1884*" provided, among other things, for the amalgamation of these smaller leases into pastoral holdings and for the resumption of part thereof for future settlement. Pastoral Leases over consolidated areas were granted for terms of 15 years. The former lessees, provided application was made, could exercise their right under the Land Act to depasture stock on the resumed areas.

The resumed areas were later made available for selection under various selection tenures. The first selection in the Cunnamulla District was made available on May 1, 1884 over an area of 130 ha, as a Homestead Selection, under the *Crown Land Alienation Act of 1876* at a purchasing price of $125. Only a few selections were made available under this tenure. Future selection tenures were made available on a leasehold basis. In 1892 there were approximately 58 Pastoral Holdings and Occupation Licenses and 24 Grazing Selections in the study area.

Further legislation was enacted in 1901 and 1902 to provide for the renewal of Pastoral Holdings throughout the State. *"The Pastoral Holdings New Leases Act of 1901"* made provision for the granting of new leases with terms up to 28 years. *"The Land Act of 1902"* made provision for the classification of Pastoral Holdings in relation to future demand and depending upon classification, provided for leases to be granted with terms up to 42 years. These were subject to statutory resumption rights. Pastoral Leases with terms of 42 years were granted and resumptions therefrom have been made available as Preferential Pastoral Holdings and Grazing Selections.

The principle of leasehold tenure has been followed since separation from New South Wales in 1859. The only freehold land consists of several small portions west of Cunnamulla. These were originally made available as Homestead Selections. Two of these portions are situated in Comongin Holding east of the Bulloo River and were purchased in 1881. The other two parcels are situated in Nockatunga Holding and were purchased in 1883. The purchase price in each case was $1 per acre ($2.47 per ha). As station homesteads are erected on these freehold portions it is obvious that they were purchased for that purpose. Since 1957 the conversion of small Perpetual Leases to freeholding tenure has been allowed. This was later extended to include all Grazing Selections.

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Allen, A.C.B. (1968) – Marginal settlement – a case study of the Channel Country of south-west Queensland. *Aust. geogr. Stud.*, **6**: 1-23.

Allen, A. (1969) – Frontier towns in western Queensland: their growth and present tributary areas. *The Australian Geographer*, **11**: 119-137.

Climate

by R.E. Winkworth* and P.R. Thomas*

WEATHER AND CLIMATE

The climate of the area is arid, meaning that the low rainfall and high evaporation results in inadequate soil moisture for crop production. Rural industry is confined to grazing the native plants of the area and the climate largely determines the times at which plant growth will occur and the duration of growth periods.

The area lies in the so-called "south-easterly trades" region, that is, in the northern part of the high pressures or anticyclones moving in regular procession eastwards across the continent. In winter the anticyclones are centred at about 30°S and as the sun moves south the high-pressure centres move to the south of the continent at about 37°S. Even during summer the south-easterly trades persist, although, being further removed from the high pressure centre, the intrusion of tropical low pressures can occur. Most days are fine and sunny, often cloudless especially in winter, with cloudiness more common in summer. Higher temperatures in summer are the cause of more frequent dustiness during the season.

During winter the south-easterly situation is interrupted every 7 to 10 days by the passage of a trough of low pressure associated with mid-latitude depression centres well south of the continent. On most occasions the passage of the trough is only slightly noticeable although temperatures are usually below normal and frosts occasionally occur. On some occasions moist air swept in front of, and between, the high pressures will bring light falls of rain to this inland area.

Widespread, moderate to heavy rain occurs irregularly when high-level moist air intrudes from the Coral Sea into troughs, extending towards the equator, between the anticyclones. These upper-level low pressures produce rain in both winter and summer.

Another major source of summer rain is the monsoon, or tropical low pressure system, which intrudes inland bringing sporadic and often heavy rainfall from convectional thunderstorms. These are usually followed, on one or more occasions a year, by persistent and widespread rain.

A further source of summer rain is the tropical cyclone, or at least the rain depression forming in the wake of a cyclone which penetrates far inland. Cyclones move into the area from both the Coral and Arafura Seas about one year in three (Coleman, 1972) and the rains are often flood producing.

In the absence of a synoptic classification of events in the rainfall records, the degree to which each of the weather patterns providing rain contributes in a given season varies in a way not well known.

CLIMATE CHARACTERISTICS[1]

RAINFALL

Average annual rainfall decreases from 400 mm in the north-east of the area to less than 170 mm in the south-west. From 60 to 70 per cent of rain falls in summer and the stations in the south-east corner have the lowest proportion. The north-eastern sector with annual rainfall greater than 225 mm occupies 60 per cent of the area. The rate of decrease in rainfall across the north-eastern sector is double the rate across the remaining south-western sector. The north-west orientation of summer[2] and annual isohyets, compared to the north-south orientation of the winter isohyets reflect the course of incoming rain sources and amounts of rain reflect increasing aridity with distance from source. In the absence of pronounced relief, topography (see Chapter 3) has little or no influence on rainfall. The annual rainfall distribution shows two peak periods, a major one in summer and a minor one in winter, with troughs in March – April and August – September. These are features in common with the southern Alice Springs area (Slatyer, 1962). These features of the rainfall regime are illustrated by the monthly and seasonal rainfall for 9 rainfall stations in Table 2.1 and again as histograms on the isohyet maps of Figures 2.1 and 2.2.

Table 2.1. Average monthly and seasonal rainfall (mm).

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Summer Oct-Mar	Winter Apr-Sep	% Summer
Nappamerrie	11	41	22	12	7	10	11	9	4	13	6	14	160	107	53	67
Olive Downs	17	45	29	9	18	13	16	13	7	21	8	14	210	134	76	64
Tanbar	24	52	29	9	14	14	9	10	7	17	17	15	217	154	63	71
Thargomindah	27	38	39	17	20	18	15	13	9	23	22	27	268	176	92	66
Mt. Margaret	34	53	36	18	17	19	12	13	9	20	19	25	275	187	88	68
Eulo	38	55	49	19	23	28	18	13	14	27	29	28	341	226	115	67
Hungerford	26	39	42	20	28	23	17	14	12	27	24	23	295	181	114	61
Quilpie	46	54	51	18	25	23	16	13	13	26	28	31	344	236	108	69
Yarronvale	50	60	50	19	23	26	22	12	12	30	23	34	361	247	114	68

The number of wet days in a year decreases from about 40 in the north-east to about 20 in the south-west. From 25 to 50 per cent of all rainy days occur as isolated days of rainfall, the remainder therefore being grouped into large runs of continuous rainy days. These occurrences of rainfall, whatever their duration, are referred to here as rainfall events. Such an event is defined as beginning on a day which receives 1 mm of rain or more and ends on the last of 2 consecutive dry days. Thus an event is not interrupted by a single dry day.

* Division of Land Resources Management, C.S.I.R.O., Canberra, A.C.T.

1 The primary data and methods for this and succeeding sections are described in "Appendix I".

2 Summer is the season October to March, winter is April to September.

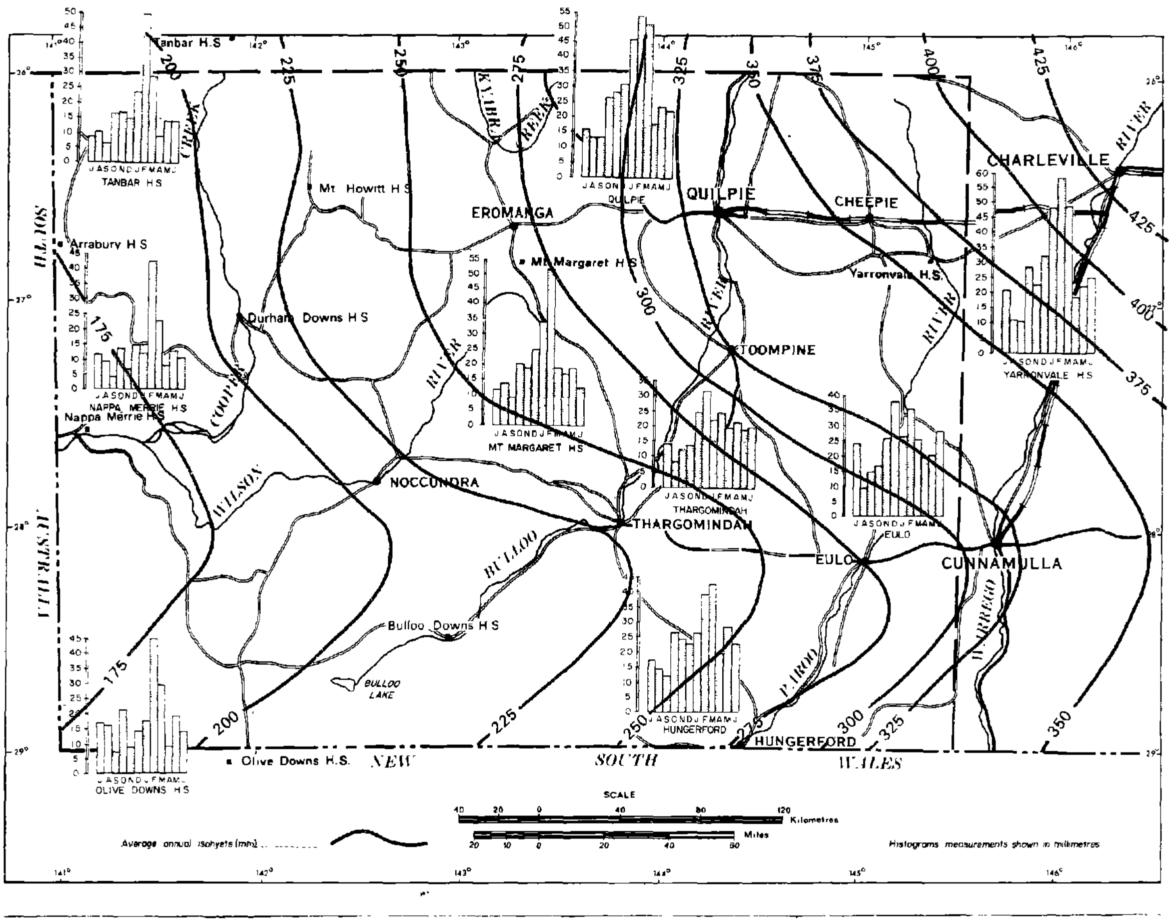

Fig. 2.1. *Average annual isohyets and histograms of monthly rainfall from July to June at selected locations.*

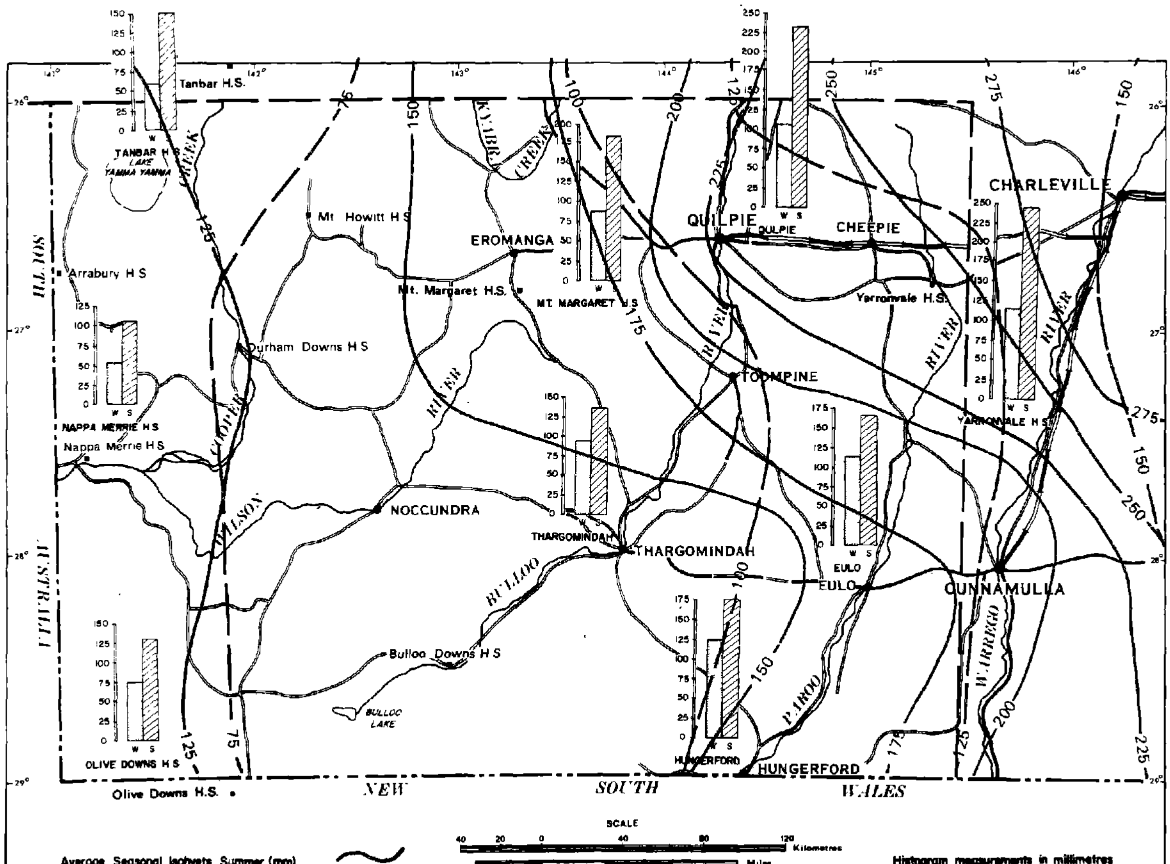

Fig. 2.2. *Average seasonal isohyets and histograms for selected locations.*

Table 2.2. Seasonal and annual frequencies of wet periods of specified durations.

Location	Season	Duration (Days) 1	2	3	4	5	6	7	8	9	>9	Total	% Summer
Nappamerrie	Summer	4.02	1.67	0.47	0.13	0.09	0.07	0.02	0	0.02	0	6.49	
	Winter	3.58	1.35	0.33	0.09	0	0	0	0	0	0	5.35	55
	Year	7.60	3.02	0.80	0.22	0.09	0.07	0.02	0	0.02	0	11.84	
Olive Downs	Summer	4.64	1.18	0.45	0.18	0.12	0.03	0.02	0	0	0	6.62	
	Winter	4.03	1.06	0.42	0.05	0.07	0.00	0.05	0	0	0	5.68	54
	Year	8.67	2.24	0.87	0.23	0.19	0.03	0.07	0	0	0	12.30	
Thargomindah	Summer	5.60	2.48	1.01	0.42	0.15	0.12	0.03	0.05	0	0	9.86	
	Winter	4.25	2.21	0.80	0.27	0.12	0.02	0	0	0	0	7.67	56
	Year	9.85	4.69	1.81	0.69	0.27	0.14	0.03	0.05	0	0	17.53	
Eulo	Summer	5.82	2.28	1.07	0.52	0.23	0.14	0.05	0.03	0.02	0.03	10.19	
	Winter	5.13	2.65	0.68	0.23	0.10	0.03	0	0.02	0	0	8.84	54
	Year	10.95	4.93	1.75	0.75	0.33	0.17	0.05	0.05	0.02	0.03	19.03	
Hungerford	Summer	5.81	2.22	0.88	0.22	0.22	0.13	0.05	0	0	0	9.53	
	Winter	5.50	2.10	0.78	0.23	0.10	0.02	0.02	0	0	0	8.75	52
	Year	11.31	4.32	1.66	0.45	0.32	0.15	0.07	0	0	0	18.28	
Quilpie	Summer	6.20	2.85	1.14	0.71	0.31	0.07	0.11	0.04	0.04	0.04	11.51	
	Winter	4.21	2.20	0.74	0.40	0.11	0.02	0.04	0.02	0	0	7.74	60
	Year	10.41	5.05	1.88	1.11	0.42	0.09	0.15	0.06	0.04	0.04	19.25	

The frequency of these events occurring decreases westward across the area from 19 to 12 per year. Within these events, the greatest amount of rain occurs in periods of 1 to 3 days duration. The likelihood of rain persisting for more than this duration (i.e. 4 or more days) is 0.5 per year in the west and 1 to 2 in the east of the area. Of the events which occur, from 54 to 70 percent have a 1 day duration, 18 to 27 percent have a 2 day duration and 7 to 10 percent have a 3 day duration. The proportion in each duration class change over the area so that the wetter north-eastern sector has fewer events per total wet days – i.e. more events of longer duration – and therefore relatively fewer single wet days and a greater frequency of 3 or more days duration events. The annual frequencies of wet periods of specified duration for selected rainfall stations are given in Table 2.2 and proportional frequencies in Figure 2.3.

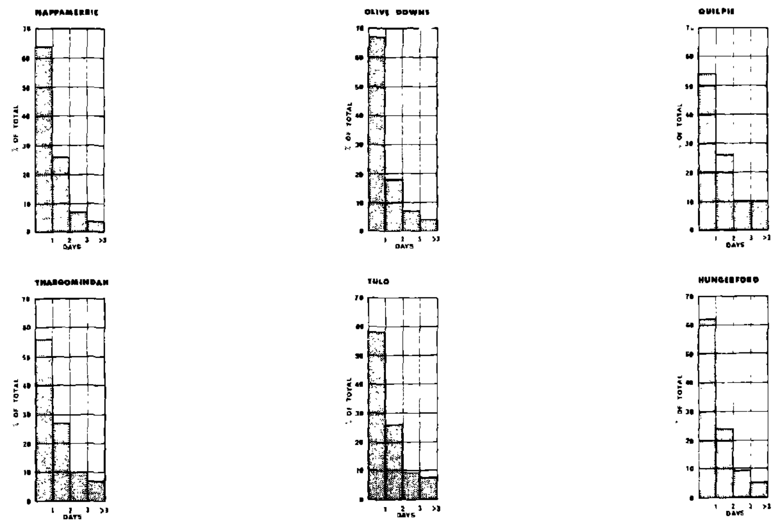

Fig. 2.3. *Proportions of wet periods of different durations comprising the average annual numbers at 6 locations.*

Even at Nappamerrie, which has an annual average of 160 mm, the amount of rain received per wet period ranges up to about 300 mm. The high variability of rainfall received per unit of time is illustrated by the percentiles of yearly rainfall totals given in Table 2.3. The high degree of variability applies to shorter periods of months, days, hours and less.

When considering rainfall events the frequency of light rains is high with a median value close to 25 mm per wet period and the 90th percentile in the vicinity of 150 mm. These features can be seen from Table 2.4 and Figure 2.4 where the occurrences of wet periods, arbitrarily classified into 25 mm classes, are summarised. Combined with the frequencies of different annual totals, it is seen that both light rains and dry years are common in the rainfall regime. This emphasizes a feature of arid areas where the less common wet periods, of relatively long duration and high rainfall yield, maintain the deceptive average values of the skewed distributions. Included in Table 2.4 are the frequencies of wet periods receiving less than 15 mm rain. This is a quantity sufficient only to wet soil and plant surfaces. These comprise 66 to 75 percent of all wet periods.

Table 2.3. Range and percentile distribution of yearly rainfall totals (mm).

Location	Lowest	10	50	90	Highest
Nappamerrie	51	60	117	311	530
Olive Downs	30	73	155	364	612
Thargomindah	30	82	260	407	723
Eulo	91	122	288	482	885
Hungerford	55	128	242	379	667
Quilpie	56	105	268	511	918

Unlike the duration of wet periods, the proportional frequencies of rain received in wet periods is the same in the wetter and drier sectors of the area (Figure 2.4). Generally there are slightly more wet periods in summer than winter for any specified duration and amount.

Table 2.4. Seasonal and annual frequencies of wet periods receiving specified rain.

		Amount (mm)												
Location	Season	<15	16-25	26-50	51-75	76-100	101-125	126-150	151-175	176-200	201-225	226-250	251-275	>275
Nappamerrie	Summer	4.71	0.78	0.64	0.13	0.07	0.07	0.05	0.02	0	0	0	0	0.02
	Winter	4.15	0.69	0.42	0.09	0	0	0	0	0	0	0	0	0
	Year	8.86	1.47	1.06	0.22	0.07	0.07	0.05	0.02	0	0	0	0	0.02
Olive Downs	Summer	4.34	1.00	0.70	0.33	0.13	0.07	0.00	0	0.03	0	0	0	0.02
	Winter	4.25	0.64	0.63	0.13	0.03	0	0.00	0	0	0	0	0	0
	Year	8.59	1.64	1.33	0.46	0.16	0.07	0.00	0	0.03	0	0	0	0.02
Thargomindah	Summer	6.85	1.00	1.35	0.36	0.10	0.07	0.05	0.07	0	0	0.02	0	0
	Winter	5.50	1.13	0.77	0.21	0	0.05	0	0	0	0	0	0	0
	Year	12.35	2.13	2.12	0.57	0.10	0.12	0.05	0.07	0	0	0.02	0	0
Eulo	Summer	6.57	1.07	1.58	0.40	0.27	0.13	0.07	0.03	0.02	0.02	0.02	0	0.01
	Winter	6.07	1.38	1.08	0.23	0.05	0.03	0	0	0	0	0	0	0
	Year	12.64	2.45	2.66	0.63	0.32	0.16	0.07	0.03	0.02	0.02	0.02	0	0.01
Hungerford	Summer	6.47	1.30	0.98	0.40	0.22	0.05	0.03	0.03	0.03	0	0	0.02	0
	Winter	6.52	1.03	0.88	0.23	0.07	0.02	0	0	0	0	0	0	0
	Year	12.99	2.33	1.86	0.63	0.29	0.07	0.03	0.03	0.03	0	0	0.02	0
Quilpie	Summer	8.00	1.21	1.13	0.60	0.29	0.15	0.07	0.04	0.02	0	0	0	0
	Winter	5.45	1.02	0.91	0.25	0.09	0	0.02	0	0	0	0	0	0
	Year	13.45	2.23	2.04	0.85	0.38	0.15	0.09	0.04	0.02	0	0	0	0

The longer and heavier rainfall events are summer predominant and it is only the lightest falls which sometimes are more numerous in winter (see Table 2.4). The summer proportions, averaged for all durations, range from 52 to 60 per cent at the various locations, and are identical for the proportions averaged for amounts.

TEMPERATURE AND RADIATION

The annual temperature regime is characterized by large seasonal and diurnal fluctuations as illustrated in Figure 2.5. At Eulo and Thargomindah the hottest month is January with mean maximum and minimum temperatures of 37oC and 23oC respectively. In the coldest month, July, the corresponding temperatures are 18oC and 5oC. The temperature curves bear a strong relationship to the annual radiation regime, (Figure 2.5) since there is little cloudiness and water vapour to influence incoming and outgoing radiation. Short duration depressions of temperature occur when it is raining and during inflows of southern air.

Differences in the rainfall regimes across the area could be responsible for warner conditions from east to west, though mean monthly temperature differences are slight. The number of days per year on which temperature exceeds 37.5oC increases from about 40 to 60, and the number of days when temperature falls below 2oC decreases from 7 to 4 from the east to west. The occurrence of mean maximum rainfall in differing months, at the various stations, would not be expected to effect the month in which mean maximum temperature occurred.

HUMIDITY

Humidity is low throughout the year. The rise and fall of relative humidity reflecting the seasonal changes in temperature limits, as shown for Thargomindah in Fig. 2.6. The rise in humidity in December represents a real increase in absolute humidity in the peak rainfall month.

Since the temperature of dew point is lower in dry air, the very low relative humidity values found in this area imply that minimum night temperature will rarely be less than dew point. Thus dew is a negligible source of free water.

EVAPORATION

Evaporation data within the area cover periods less than 5 years, too short to establish reliable averages. The evidence suggests that the annual evaporation would be from 2500 mm to 3000 mm. The mean monthly evaporation at Charleville presented in Figure 2.7 undoubtedly exemplifies the seasonal march of evaporation throughout the area. It is almost identical to the pattern at Alice Springs (cf. Slatyer, 1962). It is likely that evaporation increases slightly from east to west parallel to increasing temperatures and decreasing cloudiness.

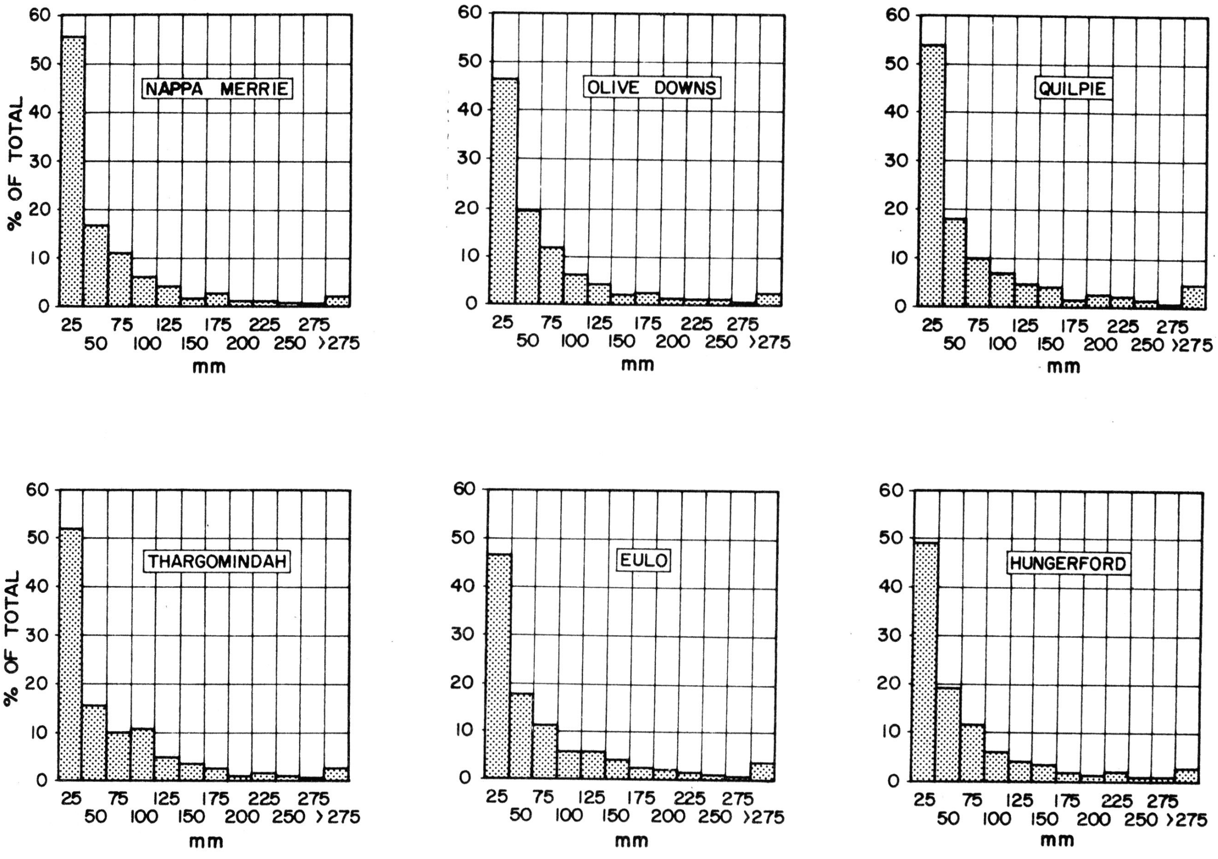

Fig. 2.4. *Proportion of wet periods of different amounts of rain comprising the average annual number at 6 locations.*

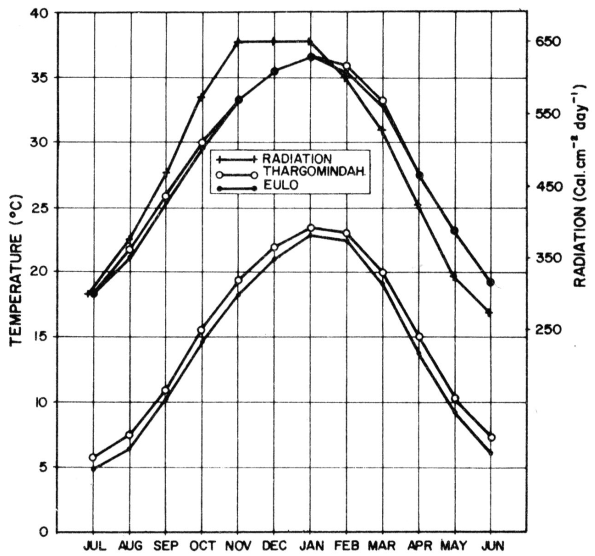

Fig. 2.5. *Mean monthly maximum and minimum temperatures at Thargomindah and Eulo. Estimated average daily total radiation for each month general to the whole area.*

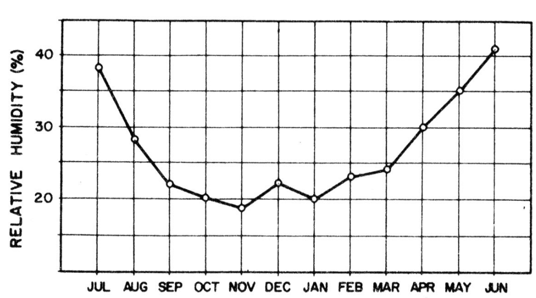

Fig. 2.6. *Mean monthly 3 pm relative humidity at Thargomindah.*

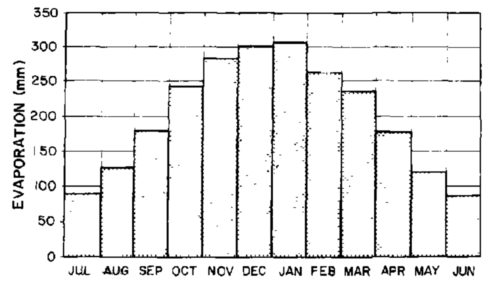

Fig. 2.7. *Mean monthly evaporation from a standard Australian tank evaporimeter at Charleville.*

CLIMATE-SOIL-VEGETATION RELATIONS

During rain, part of the precipitation enters the soil and if sufficient rain falls the vegetation grows. Under conditions of high radiation and low humidity soil-water returns rapidly to the atmosphere by evaporation from the soil and transpiration through plants. In the event of further rain the duration of growth can extend, though the infrequency of rainfall events leads always to dry soils and cessation of plant growth. Hence arid zone vegetation is characterized by distinct and relatively short growth periods separated by longer periods of inactivity. The time, duration, and frequency of the growth periods are primarily a function of rainfall and evaporation. In this area low winter temperatures may directly limit growth.

Estimates of growth periods

The grazing of natural vegetation by sheep and cattle is the primary use of land in the area. Estimates of the quantity and quality of forage resulting from rains of different amounts and at different times would be an invaluable aid to management of the native pastures (= range). The amount and kind of forage is dependent on present and past growth periods and present and past grazing. The complexity of the situation and lack of information precludes estimation from climatic data at present. However, it is possible to assess from climatic data the times when there is soil moisture available to permit plant growth.

Estimates of growth periods were made at several locations in the area and marginal to it, using simple water balance models described by McAlpine (1970). Basically, a weekly account is kept of the changes in soil-water storage, which is incremented by rainfall in excess of total evaporation and transpiration losses. In the absence of rainfall the soil store decreases by the amount of weekly evapo-transpiration. The general model becomes specific by defining (i) a value of maximum soil-water storage below which there are no losses of precipitation to run-off or deep percolation, and (ii) a relationship between free water (climatological) evaporation and the potential water loss by particular types of range, when water is freely available to it, and (iii) a relationship of potential to actual evapo-transpiration which can alter as the soil store changes.

Three models are used, all with potential range water losses assumed to be 0.8 of climatological evaporation. The model differed in maximum soil-water storage and the relationships of actual to potential evapo-transpiration, as follows:

Model 1. A maximum soil store of 100 mm and actual water loss set at 0.5 of potential in summer and 0.75 in winter when the soil store was greater than 50 per cent of maximum, changing to 0.25 and 0.375 when the store was less than 50 per cent of maximum.

Model 2. As for Model 1, except that the low rates of evapo-transpiration (0.25 and 0.375) were used at all levels of the soil store.

Model 3. As for Model 2, except that maximum storage was 38 mm.

The assumption of a single co-efficient (0.8) to relate free water and range evaporation grossly over simplifies the situation. In the area there are numerous range and soil types and marked differences in degree of plant cover between the wetter and drier parts. The choice of maximum soil water stores of 100 mm and 38 mm recognises the presence of deep and shallow soil profiles. It also may have virtue to distinguish the different depths of rooting of perennial and annual vegetation.

The changing co-efficients of actual water loss as the soil store alters in Model 1 (theoretically based on increasing resistance to water movement during drying) were taken from work with Alice Springs data. The final ratio of actual loss to evaporation of 0.2 (= 0.8 x 0.25) in summer was also taken from Alice Springs data (McAlpine, 1970; Winkworth, 1972; Fitzpatrick, *et al.*, 1967). The winter ratio of 0.3 was based on work by Farmer, Everist and Moule (1947) in Queensland. For positive soil storage to occur rainfall must exceed 0.4 or 0.2 of free water evaporation in a given week in summer and 0.6 or 0.3 of evaporation in winter for each model. Hence, in the hottest months the minimum value of effective rainfall is greater than 15 mm per week and in the coldest months greater than 7 mm per week. Ten to 15 mm should be added to these figures for wetting up surfaces.

Frequency and duration of growth periods

The frequencies of occurrence of growth periods defined in the three ways and having different durations were calculated. The incidence of growth periods closely reflects the rainfall regime (Table 2.5). At Nappamerrie in the dry south-western sector an average of just less than 3 growth periods occur in a year. In the north-eastern sector, with average annual rain of over 225 mm, from 4 to just less than 5 growth periods can be expected in an average year. More than 50 per cent of the growth periods have a duration less than 4 weeks, making up about 80 per cent of all periods in the south-west and about 60 per cent in the north-east. The frequency of wet periods decreases with increasing duration, (25 per cent or less have a duration of 4 to 7 weeks) and occur once a year in the wetter sector and about once in 2 to 3 years in the drier sector. Longer growth periods can be expected in 6 to 8 years out of 10 in the east, falling to less than half this frequency to the west. These may be important to the long term survival of the perennial woody vegetation.

The differences between models are slight. Differences are mainly due to the fragmentation of the longer growth periods of Model 2, more rapid evaporation in Model 1, and the smaller water store of Model 3. Models 1 and 3 usually show higher frequencies of short and total growth periods than Model 2. When they are not higher a small number of the shorter growth periods have been eliminated. The relative insensitivity of the model to changes in soil water storages and evaporation co-efficients reflects the low frequencies, particularly of long growth periods. Higher rainfall locations to the north and east of the area have proportionally more long and less short growth periods than places within the area.

These locations also exhibit larger differences between Model 2 vs Models 1 and 3, as exemplified by Charleville (Table 2.5 and Figure 2.8).

Table 2.5. Seasonal and annual frequency of growth periods of specified durations estimated by 3 models.

Location	Season	Duration (Weeks) Model 1 Max. Store 100 mm. Coeff. 0.4/0.2-0.6/0.3 <4	4-7	8-11	12-15	>15	All	Model 2 Max. Store 100 mm. Coeff. 0.2-0.3 <4	4-7	8-11	12-15	>15	All	Model 3 Max. Store 38 mm. Coeff. 0.2-0.3 <4	4-7	8-11	12-15	>12	All
Nappamerrie	S*	1.13	0.20	0.02	0	0	1.35	1.16	0.20	0.11	0	0.07	1.54	1.16	0.20	0	0	0	1.36
	W	0.96	0.16	0.11	0	0	1.23	1.02	0.16	0.11	0.14	0.02	1.35	1.02	0.18	0.09	0	0	1.29
	A	2.09	0.36	0.13	0	0	2.58	2.18	0.36	0.22	0.04	0.09	2.89	2.18	0.38	0.09	0	0	2.65
Thargomindah	S	1.53	0.42	0.02	0.03	0.13	2.13	1.37	0.37	0.09	0.09	0.06	1.98	1.47	0.52	0.09	0.02	0.05	2.15
	W	1.02	0.19	0.19	0.13	0.23	1.76	1.31	0.25	0.14	0.03	0.08	1.81	1.13	0.48	0.20	0.06	0.03	1.90
	A	2.55	0.61	0.21	0.16	0.36	3.89	2.68	0.62	0.23	0.12	0.14	3.79	2.60	1.00	0.29	0.08	0.08	4.05
Eulo	S	1.34	0.63	0.14	0.09	0.11	2.31	1.14	0.33	0.16	0.09	0.27	1.99	1.22	0.63	0.28	0.03	0.05	2.21
	W	0.89	0.42	0.19	0.17	0.14	1.81	0.66	0.36	0.14	0.09	0.20	1.45	1.00	0.44	0.33	0.20	0.03	2.00
	A	2.23	1.05	0.33	0.26	0.25	4.12	1.80	0.69	0.30	0.18	0.47	3.44	2.22	1.07	0.61	0.23	0.08	4.21
Hungerford	S	1.63	0.44	0.17	0.03	0.09	2.36	1.31	0.30	0.17	0.06	0.23	2.07	1.61	0.55	0.11	0.03	0.08	2.38
	W	1.09	0.47	0.20	0.13	0.11	2.00	1.05	0.33	0.17	0.11	0.13	1.79	1.19	0.45	0.23	0.14	0.05	2.04
	A	2.72	0.91	0.37	0.16	0.20	4.36	2.36	0.63	0.34	0.17	0.36	3.86	2.80	1.00	0.34	0.17	0.13	4.44
Quilpie	S	1.32	0.62	0.21	0.06	0.09	2.30	1.19	0.47	0.15	0.09	0.17	2.07	1.34	0.70	0.23	0.04	0.02	2.33
	W	1.49	0.32	0.13	0.09	0.06	2.09	1.38	0.34	0.06	0.02	0.13	1.93	1.55	0.32	0.23	0.09	0.02	2.21
	A	2.81	0.94	0.34	0.15	0.15	4.39	2.57	0.81	0.21	0.11	0.30	4.00	2.89	1.02	0.46	0.13	0.04	4.54
Charleville	S	1.25	0.58	0.34	0.20	0.27	2.64	0.95	0.23	0.14	0.08	0.56	1.96	1.39	0.75	0.45	0.06	0.14	2.79
	W	0.86	0.28	0.28	0.19	0.14	1.75	0.59	0.09	0.13	0.03	0.27	1.11	0.98	0.36	0.30	0.27	0.11	2.02
	A	2.11	0.86	0.62	0.39	0.41	4.39	1.54	0.32	0.27	0.11	0.83	3.07	2.37	1.11	0.75	0.33	0.25	4.81

* S Summer; W Winter; A Annual.

There is no suitable information to assess the accuracy of estimates of growth periods by any of the three models or to reveal whether the differences between models even broadly reflect various climate-soil-vegetation groupings.

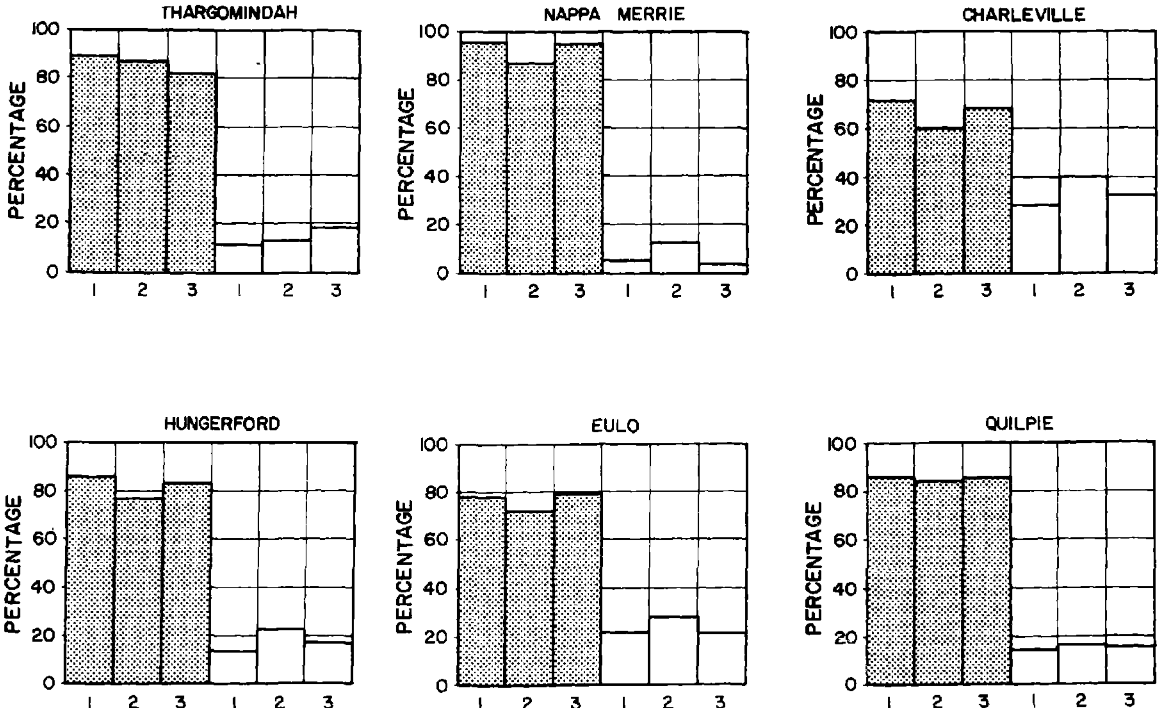

Fig. 2.8. *Proportion of estimated growth periods of different durations on the basis of annual frequencies calculated by 3 models. Shaded histograms refer to growth periods of less than 8 weeks. Unshaded histograms refer to growth periods equal to or greater than 8 weeks. The numbers 1, 2 and 3 refer to the models described in the text.*

Droughts

Floods and droughts are endemic climatic hazards. Drought is an ever present constraint on productivity. Floods occasionally cause losses which are offset by benefits to underground water recharge and long-term health of the range. Estimates of present and past growth periods might provide a prediction of drought in the absence of further rain.

Monthly drought maps compiled by the Sheep and Wool Branch of the Queensland Department of Primary Industries from December 1962 to September 1973 were used to identify drought periods at 8 locations, 4 in the eastern part of the area and 4 outside and east of it. No information was available for the area west of Quilpie and Hungerford. Estimated growth periods for 1963 to 1973 were calculated from the rainfall records at the 8 locations. Their time of occurrence and duration were considered in relation to the clearly identified droughts which are shown in Figure 2.9. Whilst variation of conditions within districts appeared on the maps, they are small scale and not drawn with enough accuracy to refer conditions to spot rainfall locations. Inconsistencies in the map records appear to arise from observer differences in defining drought. Missing records also diminished the opportunities for close comparison with the modelled growth periods. Drought was understood to be either a state of insufficient forage to maintain the growth of sheep, or worse, a state of starvation and death.

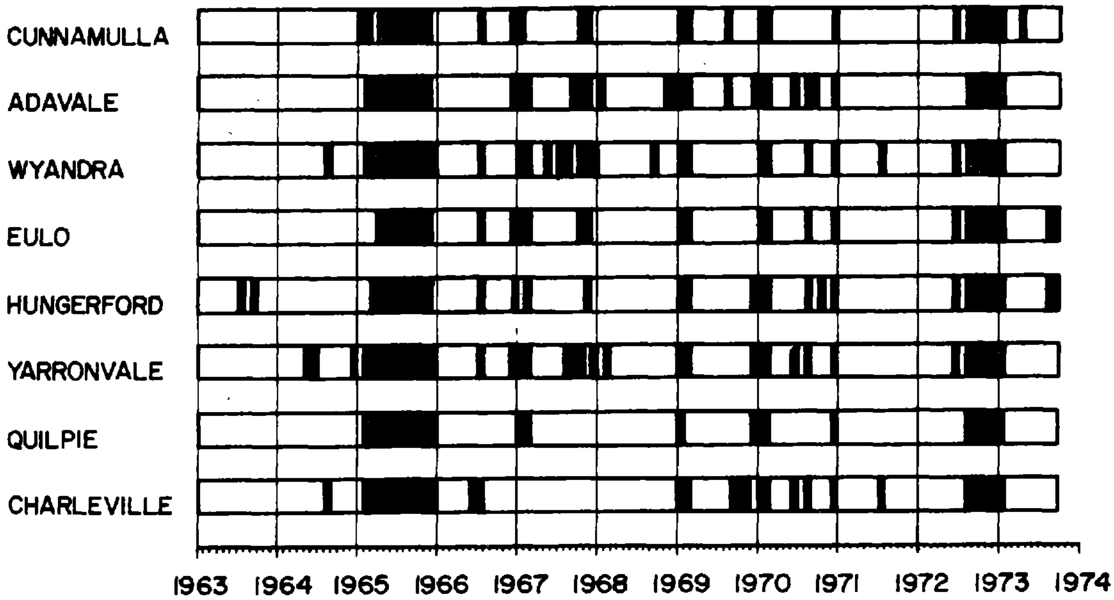

Fig. 2.9. *Estimated time of occurrence and duration (shaded area) of drought periods for 8 locations during the period July 1963 to March 1974.*

Data in Figure 2.9 indicate that occurrences of drought were common to most locations and local incidents were few and unimportant. Two long droughts, in 1965 and 1972-73, encompassed all or part of summer and winter. Five shorter droughts each occupied 1 to 3 summer months, and 2 occupied 1 to 2 winter months. The sequence of summer and winter drought in 1969-70 may have imposed severity parallel to other long droughts. In 10 years there were 2 summers and 7 winters without drought. Drought did not occur if there had been a growth period longer than 8 weeks *late* in the preceding summer. Summer growth periods shorter than this seem to prevent drought for up to 10 months, even in the absence of further summer rains. However, long growth periods *early* in one summer will not alone prevent drought in the next summer. Winter rains prevent or break winter drought but alone they do not appear to prevent summer drought, though possibly retarding its onset e.g. after a short late summer growth period and a winter growth period exceeding 12 weeks, drought was recorded before the year's end. Summer growth periods as short as 4 weeks can break a drought but not for very long.

Longer and more precise records of range condition and the validation of appropriate water balance models are needed to substantiate and improve the conclusions on drought prediction. At best, prediction seems confined to gauging drought from one summer to the next.

CLIMATE-ANIMAL RELATIONS

Research on the direct effects of climate on production of domestic animals was reviewed by Brown and Hutchinson (1973). Beyond reports of heat stress and possible death of young calves and lambs in summer, there were no research results applicable to the survey area. It is apparent that high temperatures affect the eating, drinking and resting behaviour of domestic animals, even when good quality forage is abundant. Animal production may fall below the potential during excessively hot weather.

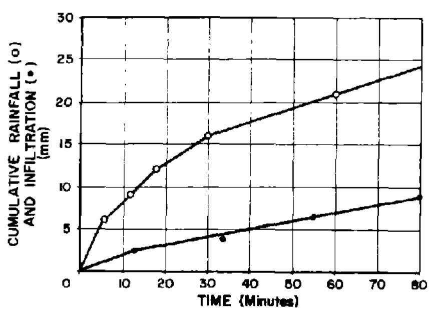

Fig. 2.10. *Rainfall intensity at Charleville exceeded on average once a year, plotted as cumulative rainfall against time, and the amount of water infiltrating into the soil between mulga tress at Charleville (infiltration data of T. Pressland — Charleville Pastoral Laboratory).*

Recharge of dams and tanks can be expected during heavy falls of rain producing significant amounts of run-off, probably from falls greater than 50 mm and certainly from greater than 75 mm. The frequency of recharge, according to Table 2.4, would be at least once a year in the drier western sector and at least twice a year in the eastern sector. Run-off occurs when rainfall exceeds the infiltration capacity of the soil. There are no data on rainfall intensity and soil infiltration rates from the area. Data from Charleville was used to construct Figure 2.10. The rainfall intensity which is exceeded on the average once a year, was plotted as cumulative rainfall along with the cumulative infiltration. This was done on red earth soil between mulga trees. Infiltration is exceeded by rainfall at all time, and run-off would be 66 per cent or more of rainfall in this situation. Analyses of rainfall intensity for frequencies of more than one a year are not available to define the predictions of run-off.

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Geology and Landform

by N.M. Dawson*

The region forms part of the Eromanga Basin which is a sub-basin of the Great Artesian Basin. The geology of the study area forms part of the region that has been investigated in some detail by Senior *et al.* (1968; 1969). The comprehensive reports and geological maps, prepared by these investigators, have been used as the basis for defining the overriding geological controls in the land systems mapping.

It is apparent that the geological sequence of the Eromanga Basin is based on a conformable succession of Jurassic, Cretaceous and Tertiary sediments. All of these sediments were deeply weathered in the Tertiary period. Since then, Tertiary lateritic developments and Quaternary deposits have obscured the original sediments in many areas.

There is a strong correlation between the geological landform units and the major soil and vegetation group in the area. The geological units as described by Senior *et al.* (1968; 1969) are recorded in the land unit and land system description and form the basis for the following description.

A summary of the geological sequence of events is recorded in Table 3.1.

Table 3.1. Stratigraphy of the area.

Age	Group	Rock Unit (Map Symbol)	Lithology	Thickness m	Environment
Quaternary		(Qa)	Clay, sand, silt, soil, minor gravel, locally gypsiferous.	Up to 170	Alluvial
		(Qs)	Quartz sand, mostly ironstained.	Superficial	Aeolian
		(Qr)	Red sandy soil, minor gravel.	Superficial	Eluvial and aeolian
		(Qc)	Gravel, mainly silcrete.	Superficial	Colluvial and alluvial
		(Qg)	Gravel, mixed clasts.	Superficial	Colluvial and alluvial
		(Qp)	Limestone, chalcedony.	Superficial	Valley floodplain
			UNCONFORMITY		
Tertiary		*Glendower Formation* (Tg)	Quartz sandstone, conglomerate, sandy conglomerate, breccia, siltstone; silcrete.	Up to 30	Fluviatile
			UNCONFORMITY		
Lower to Upper Cretaceous	*Rolling Downs Group*	*Winton Formation* (Kw)	Kaolinized, ferruginized, and silicified sediments.	Up to 100	Chemical alteration.
			Labile sandstone, siltstone, and mudstone, in part calcareous, minor coal.	0-1100	Fluviatile, lacustrine, paludal
		Mackunda Formation (Klm)	Labile sandstone, siltstone, and mudstone, in part calcareous, minor coquinite.	60-70	Paralic
		Allaru Mudstone (Kla)	Mudstone, minor calcareous labile sandstone.	190-420	Shallow marine
Lower Cretaceous		*Toolebuc Limestone* (Klo)	Limestone, calcareous shale, coquinite.	0-30	Shallow marine
		Wallumbilla Formation (Klu)	Mudstone siltstone, minor sandstone, in part calcareous.	0-330	Shallow marine
Upper Jurassic	*Injune Creek Group*	*Westbourne Formation* (Juw)	Siltstone, shale, quartzose sandstone.	0-120	Continental
Middle Jurassic		*Adori Sandstone* (Ja)	Labile sandstone, siltstone, claystone.	0-45	Continental
		Birkhead Formation (Jmb)	Calcareous sublabile sandstone, siltstone.	0-90	Continental
Lower Jurassic-Triassic		*Hutton Sandstone* (Jlh)	Quartzose sandstone, minor siltstone, shale. Interbedded sandstone, shale, siltstone.	0-420	Fluviatile
Permian		*Gidgealpa* and *Merrimelia Formations*	Sandstone, siltstone, coal, conglomerate (tillite?)	0-300	Paludal and fluvioglacial
			UNCONFORMITY		
Middle Devonian		(Dmg)	Granite, adamellite, quartz-muscovite schist, minor quartz veins.		Igneous, plutonic
Palaeozoic		(Pz)	Folded clastics, low-grade metamorphics.		Metamorphosed sediments.

* Development Planning Branch, Qd Dep. Prim. Inds.

TOPOGRAPHY

The area slopes both to the south and the west. Heights above sea level range from 373 m in the north-west corner to less than 54 m on the Cooper Creek at Nappa Merrie. Spot elevations for the area are recorded in Figure 3.1.

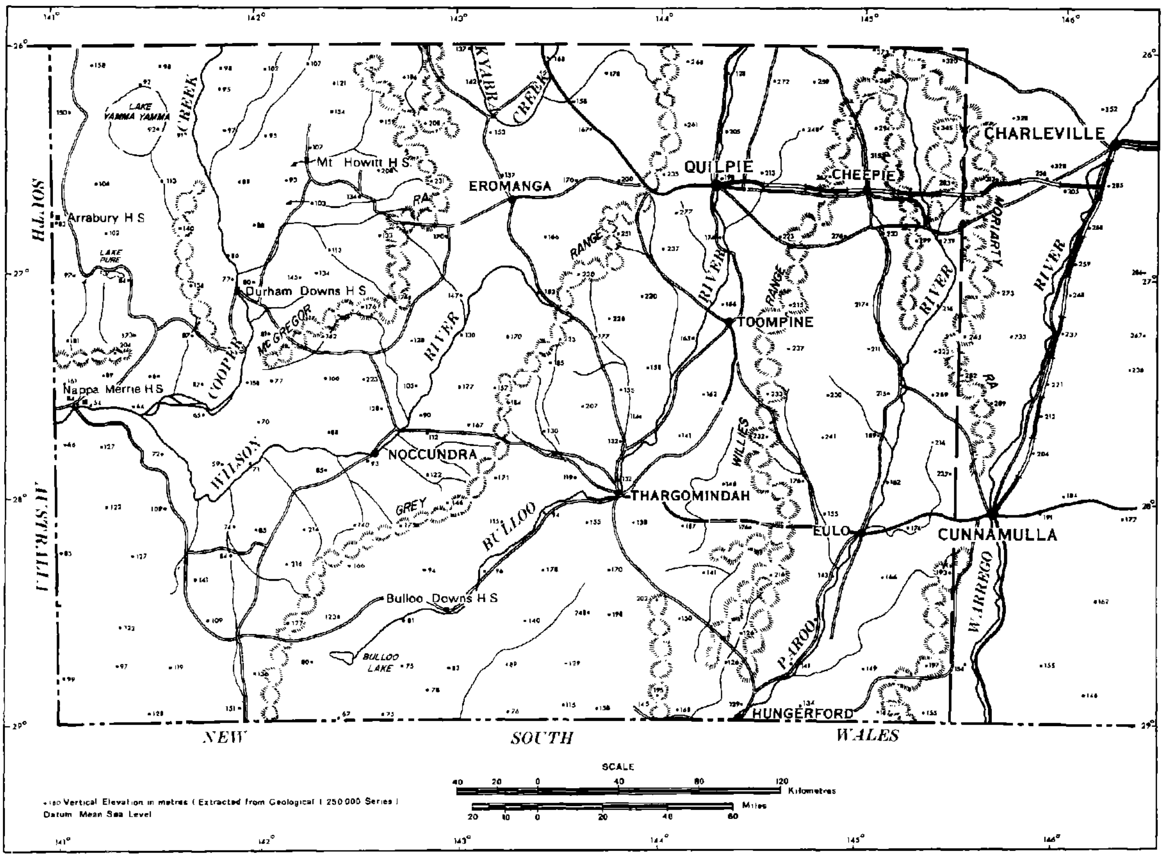

Fig. 3.1. *Topographic map.*

The main ranges in the area are the Grey, Moriarty and Willies Ranges. The Moriarty Range on the eastern boundary forms the western divide of the Warrego catchment. This range gradually loses its identity in the vicinity of the Eulo-Cunnamulla road where a continuous belt of alluvia links the Paroo and Warrego River alluvia. The Willies Range forms the catchment boundary of the Bulloo and Paroo Rivers. The Grey Range separates the Cooper Creek catchment from the Bulloo River. Within the Cooper Creek catchment the McGregor Range divides the catchment, while ranges on the western side of Cooper Creek at Durham Downs and in the vicinity of Nappamerrie form the boundaries of the limited catchment of Lake Pure.

Cooper Creek is the major drainage system in the area with a flood plain approximately 50 km wide at its widest point. This narrows down to a restricted outlet at Nappa Merrie near the South Australian border. In times of major flooding flood waters are diverted out of Cooper Creek into Lake Yamma Yamma. Much of this flood water comes from outside the area from the Barcoo and Thomson River catchments. The Wilson River and Kyabra Creek, both major tributaries of Cooper Creek, drain the area east of the McGregor Range. The alluvia of the Wilson River and Kyabra Creek are joined in the vicinity of Eromanga. Kyabra Creek sweeps down from the north toward Eromanga and then turns north to join the Wombunderry Channel of Cooper Creek north of Keroongooloo.

The Bulloo River, a major drainage system, has its source in the Gowan Ranges north of Adavale. The Bulloo River also has a well developed flood plain, particularly south of Quilpie and again between Thargomindah and Bulloo Downs Homestead. South-west of Bulloo Downs Homestead the Bulloo River runs into a series of lakes (Bulloo Lakes) and claypans which are intermingled with sand dunes.

The Paroo River has its catchment almost entirely within the area. North of Boobara Homestead the Paroo has a narrow alluvial plain. To the south this plain widens.

In the vicinity of Lake Dartmouth the drainage lines flow north to form part of the Warrego River Catchment.

West of the Willies Range the Dynevor and Currawinya Lakes form small catchments with limited runoff.

GEOLOGY

The Great Artesian Basin is an intracratonic basin bordered by strong positive structures (Twidale, 1972). It is a basin of internal drainage and has long been a depository for sediments. In the early Cretaceous there was a prolonged marine transgression. During the Cainozoic, lacustrine and fluviatile deposition alternated with weathering and erosion over much of the region. There has been little tectonic activity in this area since the mid Mesozoic.

For this study emphasis is placed on the exposed sediments of the Mesozoic and Cainozoic periods and only brief mention is made of the underlying rocks.

Geological sequence

Pre-Jurassic

Basement rocks in the area are low grade metamorphics intruded by granite along the Eulo Ridge, basalts in the north-west of the Quilpie sheet and early Paleozoic clastics.

Marine and continental sediments of Devonian to Carboniferous age occur in the Quilpie, Cooladdi and Warrabin troughs. Permian and Triassic sediments occur mainly in the major troughs.

Small local outcrops of the granite basement occur south and south-west of Eulo along the Eulo Ridge. In places these granites have been strongly weathered.

Jurassic sediments

Jurassic sediments of the Eromanga Basin sequence occur over the whole area.

The *Hutton Sandstone* (Jlh) which is predominantly a fluviatile sequence is the oldest Jurassic sediment present in the area. It is predominantly made up of fine to medium, quartzose sandstones with some coarse to pebbly beds. There are minor shale interbeds and coal seams. The *Hutton Sandstones* contain aquifers but are seldom tapped because of suitable aquifers higher in the Mesozoic sequence.

The *Birkhead Formation* (Jmb) which was apparently deposited in a lacustrine environment rests conformably on the *Hutton Sandstones*. The lithology is mainly carbonaceous mudstones and siltstones with interbeds of coal.

The *Adori Sandstone* (Ja) is conformable with the Birkhead formation. It is mainly medium to coarse, quartzose sandstone though in the southern part of the Cooper Basin interbeds of argillaceous sediments become numerous.

The *Westbourne Formation* (Juw) which is conformable on the Adori sandstone consists of interbedded medium quartzose sandstone, siltstone and mudstone with abundant carbonaceous material and their coal seams.

The *Hooray Sandstone* rests conformably on the *Westbourne Formation* in the west and unconformably on the basement on the Eulo Ridge. It consists of fine to medium, quartz sandstone with few interbeds of siltstone in the upper part and grades down into medium to coarse, quartz sandstone. Within the unit are numerous freshwater aquifers.

Cretaceous sediments

Sediments of the *Rolling Downs Group* were deposited over the whole of the area.

The *Wallumbilla Formation* (Klu) was deposited following a major marine transgression across a flat surface. It is a sequence of mudstones and siltstones with grey, concretionary limestone, minor lenticular sandstone, intraformational conglomerate and cone in cone limestone. The *Wallumbilla Formation* is made up of two members the *Doncaster Member* (Kld) and the *Coreena Member* (Klc).

The *Toolebuc Limestone* is a platy, grey, coarsely crystalline limestone with interbeds of grey, calcareous shale. The limestone does not cover the whole area and does not outcrop.

The *Allaru Mudstone* (Kla) is mainly a blue-grey mudstone which contains beds of calcareous siltstones. It conformably overlies the *Toolebuc limestone* (where it occurs) and the *Wallumbilla Formation* in the absence of the *Toolebuc Limestone*. This unit outcrops in a number of areas but these outcrops are generally strongly weathered.

The *Mackunda Formation* (Klm) contains argillaceous and arenaceous sediments, blue-grey mudstones and calcareous siltstones. The extent of this formation is not known and it does not outcrop in the area.

The *Winton Formation* (Kw) which consists mainly of interbedded, blue-grey mudstones and lithic and feldspathic sandstones, in part calcareous, is the most common outcropping unit in the area. The formation is a freshwater sequence and sediments are coal bearing and indicate an interplay of fluviatile and paludal conditions.

Within the area, the formation is frequently deeply weathered but in the structurally high areas relatively unweathered outcrops occur. The calcareous, labile sandstones commonly contain indurated concretions. These may join together to form bulbous concretionary bodies found on parts of the undulating Mitchell grass downs (Mt. Howitt Land System).

The close of the Winton deposition saw the termination of Mesozoic sedimentation. However, a brief recurrence of widespread sedimentation occurred in early Tertiary time.

Tertiary

After deposition in the Cretaceous, there was peneplaination with deep chemical alteration and deposition of fluviatile Tertiary sediment. These sediments are thickest in the area of the Cooper Basin. These sediments were subject to silicification at several levels to form beds of silcrete. Not all silcrete in the area is duricrust.

In the study area sediments of the *Rolling Downs Group* were deeply weathered during a period of internal leaching which took place in Upper Cretaceous or early Tertiary time. The thickness of the chemically altered sediments is variable but ranges up to 90 metres. In other areas the Tertiary sediments directly overlie fresh *Winton Formation* sediments.

The chemically altered beds consist largely of kaolinized sandstone and mudstone with numerous iron enriched interbeds. Iron staining and mottling is common. Silicified kaolinitic mudstone and sandstone beds occur throughout the full thickness of the altered beds. In areas where Tertiary sedimentation was thin, a weathered mantle formed on the top of the chemically altered beds. This mantle (duricrust) forms a resistant capping to hills and plateaux in the area.

Precious opal occurs in the *Winton Formation* within the zone of deep chemical alteration. A number of fields in the area are at present being mined.

The *Glendower Formation* (Tg) is a thin fluviatile sequence of quartzose, arenaceous sediments containing minor argillaceous interbeds which unconformably overlies chemically altered sediments of the *Winton Formation*. Large areas of the formation have been subject to intensive silicification during the Tertiary and possibly continuing to recent time. Beds of silcrete have been formed within this formation. This silcrete has been exposed by erosion and commonly forms hard caps to the hills. Thickness of this unit varies considerably.

The *Glendower Formation* has been subject to broad regional uplift together with folding, faulting and differential compaction. This has produced broad, open folds and monoclines. Where erosion penetrates the silcrete, scarps are usually formed.

The origin of silcrete remains controversial. Grant and Aitchison (1970) and Stephens (1971) consider two main origins.

Quaternary units

Thick Quaternary Alluvium (Qa) covers over 25 per cent of the area. Large areas of sediments are associated with the flood plains of the Bulloo and Paroo Rivers and Cooper Creek. Lacustrine deposits are extensive in the Dartmouth, Dynevor, Yamma Yamma and Bulloo Lakes areas. These deposits are mainly fine grained and predominantly clay material. Gypsum crystals are common in this material. At Lake Yamma Yamma over 100 m of alluvia has been recorded.

Dune and sheet sand (Qs) cover large areas in the south and west. In places this predominantly red, quartzose sand covers alluvium and in other areas the Tertiary landscape. It is thought that much of the Quaternary sand in the areas might be reworked, late Tertiary, fluviatile deposits.

The distribution of dunefields is strongly influenced by structural units with all major dunefields being concentrated in structural lows. Dunefields cover lacustrine and riverine sediments of late Pleistocene or early recent age.

Sandy red earths (Qr) occur throughout the area but are better developed in the east. These superficial deposits, which vary in thickness from a few centimetres to 4 m, cover the hills and flank the structural units grading into sheet and alluvial plains. The deposits generally thicken downslope. Surface veneers of ironstone and silcrete pebbles are common. Ironshot pellets are common within the red earth profile.

Silcrete gravel (Qc) mantles are widespread. These mantles are developed by erosion and slumping of the silcrete beds.

Chalcedonic limestone (Qp) and sandy limestone (Ql) occur, but are not widespread and outcrops are small. They are mainly confined to the west.

Landscape development

Mabbutt (1968) indicated that the present distribution of high and low ground closely follows the warping of simple or compound silcrete capped surfaces. The present relief of the area has been formed by erosion along axial tracts of anticlines and by deposition in synclinal lowlands. These processes of erosion and deposition have led to the formation of seven physiographic units.

These seven units have been regrouped into five units for the purpose of mapping their distribution (Figure 3.2).

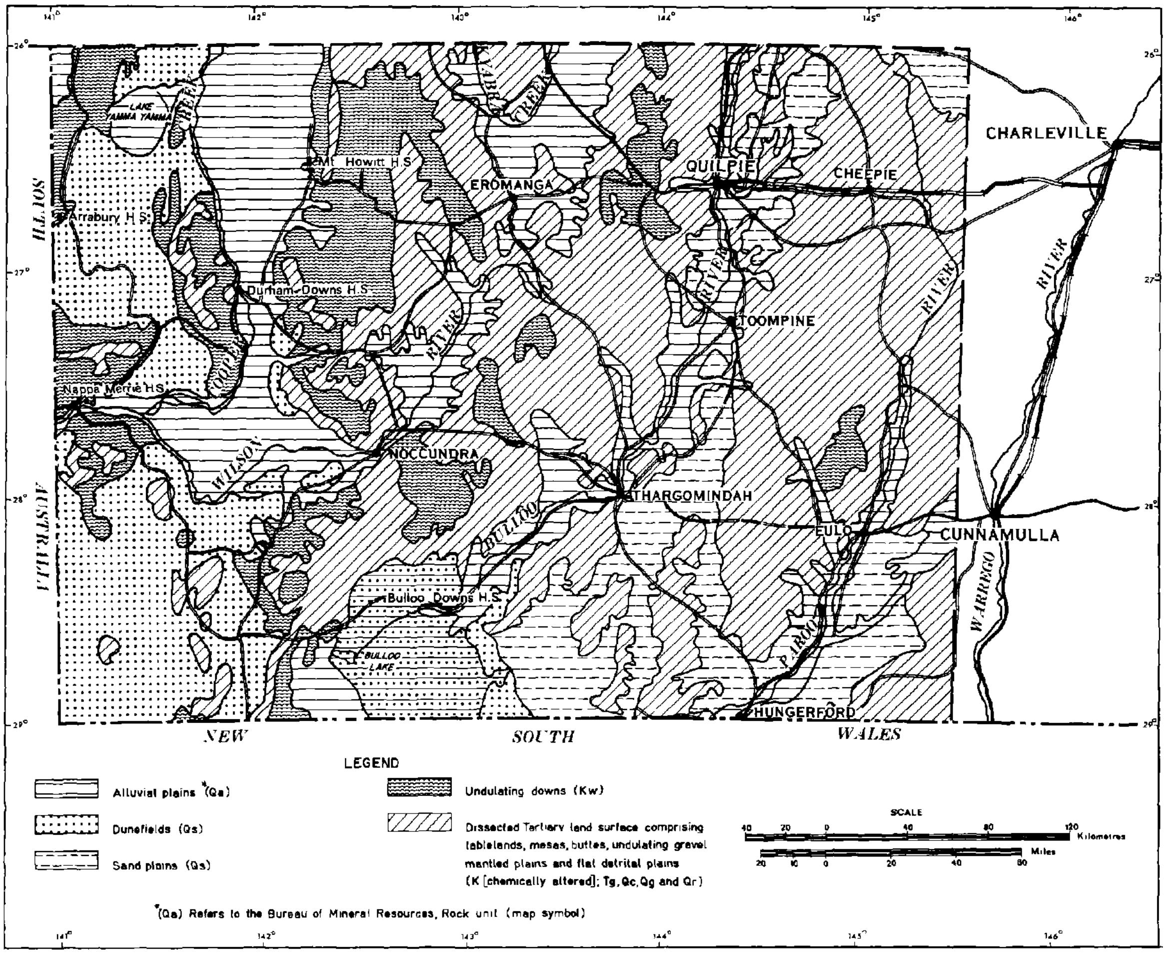

Fig. 3.2. *Major physiographic units.*

Dissected residuals

This unit comprises mesas, buttes and plateaux frequently with sloping backslopes. The surface is generally silcrete covered in the west but in the east the silcrete has been stripped exposing the weathered mantle of the Cretaceous sediments. In places the intact Tertiary surface is locally covered by thin, soil and sand mantles.

Once erosion penetrated this hard capping, exposing the less weathered Cretaceous sediments, simple scarp retreats formed. In places this erosion penetrated through to fresh Cretaceous sediments. In other areas only the mottled and pallid zones are exposed. The erosion of the softer sediments has accelerated the process causing blocks of the weathered mantle and silcrete to be broken off and deposited on the lower slopes.

Undulating plains

These plains take two forms, one type bounds the escarpments the other is formed on the eroded backslopes of the dissected residuals. In both cases they are made up of admixtures of silcrete and weathered mantle detritus. A mantle of silcrete gravel generally covers these plains but there are areas, particularly in the east, where silcrete cover does not occur.

Where these plains bound the escarpments, the original erosion may have penetrated the weathered zone exposing fresh materials. In this case either of two developments occur. Generally the fresh material. In the other development, where only a thin stone mantle of scree material covers fresh sediments, the undulating downs physiographic unit is formed.

Undulating downs

This unit has been formed by complete stripping of the Tertiary land surface in the structural anticlines. The stripping of this surface has left behind a thin mantle of stone and other detrital cover. Clay soils develop from the relatively unweathered Cretaceous sediments. This unit is commonly referred to as "stony downs" although in most cases the stone material could only be classified as pebble.

The stone and pebble cover varies considerably causing considerable change in pattern on the aerial photographs. This change is generally related to the degree of development of the desert varnish which coats the silcrete stone. This may cause a change in colour from buff to dark-reddish-brown or almost black. Size and density of stone cover also vary.

In a few areas, particularly in the vicinity of Windula and Cunnavilla Creeks the undulating downs has little, if any, stone cover.

Plains of redistributed detritus

On the backslopes of the dissected residuals and also on the lower parts of the scarps slopes, superficial deposits of fine, earthy material, derived from the erosion of the weathered mantle, have been deposited. The depth of this material varies from less than 30 cm to greater than 120 cm. This material has been deposited as alluvia, pediment mantles and fans. It may cover clay material.

On the pediment mantles and fans vegetation groves, roughly aligned with the contour, are common. In the vicinity of Eromanga, where this material commonly overlies clay material, "slump holes" are common in the grove areas.

Alluvial plains

The fine fraction (clay, silt and fine sand), eroded from the plains and uplands, have been deposited in the topographic lows of the various drainage basins. They have been deposited as valley fill, and in playa lakes.

The alluvia of the local streams tend to be mixed clay, silt and sand in the mid-sections becoming more sandy in the upper-sections.

The alluvia of the major rivers generally have very low gradient commonly being less than 1:5,000. A feature of the Paroo and Bulloo Rivers and Cooper Creek is that the alluvia are generally multi-channelled. In the upper parts of the Bulloo River and throughout the Paroo River catchment well defined braided channels commonly occur together with flat alluvial plains. On these plains seasonal swamps and higher occasionally flooded areas occur.

The mid and lower sections of the Bulloo and Wilson Rivers and Cooper Creek are characterized by an intricate pattern of channels, shallow flood depressions, backswamps and occasional waterholes. During flooding higher alluvial areas occur as islands. Whilst the banks of the major waterholes are high, the anastomosing channel systems have only low relief (<1 metre).

Associated with the channel systems are local swamps and drainage swamps. As well as these swamps, major lakes such as Yamma Yamma, Dartmouth and the Dynevor and Bulloo Lakes occur, acting as receptacle for overflow water. These lakes are gradually filling with fine material.

The lower parts of the Bulloo River and the Wilson River, at its confluence with Cooper Creek, flood into areas of dunefields, local swamps, playa lakes and claypans. On Cooper Creek and the Bulloo River, areas of low dunes with cemented aprons occur on the alluvia. As well isolated high dunes occur on the alluvia of Cooper Creek.

Sloping alluvial fans are not well developed in the area. They occur in association with creeks flowing out of the scarp retreat zone of the dissected residuals, particularly where the weakly weathered Cretaceous sediments are exposed.

Sandplains

The sandplains of the area are of aeolian origin. In places this material has been moved considerable distances over older higher landscapes. These sandplains may merge with the dunefields. Sandplains have developed over both alluvial plains and upland land surfaces.

Sandplains developed predominantly on old alluvia are common close to the Paroo River and Werai Creek. These plains are usually interspersed with claypans and alluvial deposits. Sand deposits are shallow being only a few metres above the surrounding alluvia. Ferruginous hardpans are common in the soils on these plains.

Sandplains occur on upland surfaces in two areas east of the Bulloo River. In the north the sandplains cover silcrete capped dissected residuals and rounded plains. In the south they occur mainly over gently undulating silcrete covered plains. The sandplains have very low relief and may show limited dune formation. Sand dune patterns may appear on the aerial photographs.

Dunefields

Dunefields are common in the south and west, the largest development being west of the Grey Range. Dunefields are spread over old alluvia and in places the lower slopes of undulating plains. Dunes take on a number of different forms.

By far the most common form is the reticulate dune. These dunes are common in drainage areas. A feature of these dunes are the claypan areas encompassed by the dunes. The dunes are broad with stable crests and height varies from 3 to 5 m. They grade into a type of dune which has longitudinal sections and converging and diverging ends linking the dunes. Claypans commonly occur in the interdune area. This type may, or may not, have mobile crests of loose sand. They have north to north-east orientation.

North of Lake Pure the dunes run into the well known longitudinal or sief dune type. They are parallel and have N.N.W. to N.N.E. orientation. Claypans are not common except on the edges of the dunefield. However, interdune flats are common. These dunes have mobile crests, steep, upper flanks and low sloping extended flanks. Dune heights range from 5 to 12 m compared with up to 30 m in the Simpson Desert. Distance between crests varies. In the study area, this dune type may merge into sandplains.

On the alluvial plains single dunes or small groups of dunes may occur. These dunes tend to be rounded, with mobile crests and vegetated flanks. In most cases this dune type is made up of red sand. However, on Cooper Creek yellow sand dunes occur.

On the edges of Lake Bindegolly, Lake Yamma Yamma and many of the other major lakes crescentic or near-crescentic dunes occur. These dunes are in many ways similar to lunettes. They occur mainly on the leeward sides of the lakes and are made up of salts (mainly calcareous), silt, sand and clay. They are presumably formed by deflation of the lake bed.

A feature of dunes fringing claypans or alluvia plains is the development of cemented aprons on the lower slopes. These supposedly originated from finer material leached from the dunes. Whitehouse (1947) mentioned the existence of clayey cores in dunes. The existence of pans or indurated clay cores and clayey cores was recorded in a number of situations particularly on these dunes on alluvial plains.

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Soils

by N.M. Dawson* and C.R. Ahern1

Broadscale mapping of the region was undertaken by Prescott (1931; 1944). Northcote 1966, Isbell *et al.* (1967) and Northcote *et al.* (1968) mapped the area for the Atlas of Australian Soils at a scale of 1:2,000,000.

More detailed soil studies, for selected projects within the study area, were undertaken by Blake (1938); Skerman (1947); Hubble and Beckmann (1956); Jessup (1960; 1961); Clark *et al.* (1969), Hubble and Reeve (1970) and Dawson and Ahern (1973).

Information, contained in the foregoing maps and reports, formed the basis for a rational approach to the current study of the principal soils found on some 15 million hectares of pastoral land in far south-western Queensland. This report studies the relationships between soils, geology and the recurring vegetation patterns, and discusses in some detail the effects that soils have on land use in the semi-arid environment.

SOIL DEVELOPMENT AND DISTRIBUTION

The development of soils in this area is closely related to geological boundaries, and soil characteristics mirror the geomorphic processes associated with their development. Past climate and drainage have also had significant effects on soil development. The chemical alteration of the Cretaceous sediments, during the Tertiary, and the subsequent erosion of this profile have perhaps been the dominant processes affecting soil distribution.

In more recent time, vegetation, soil fauna, introduced animals and man have significantly affected the characteristics of some soils. The ability of the leguminous shrubs to increase soil nitrogen and soil organic matter is a significant factor in soil development. Ebersohn and Lucas (1965) showed that trees such as poplar box[2] and western bloodwood significantly increase available nutrients, such as phosphorus and potassium, in the surface soil below these trees, by recycling and litter drop. Oldman saltbush also has the ability to build up salinity in its drip circle due to accumulations of salts in the leaves and subsequent leaf drop. In all instances significant changes in physical properties of the surface soil were associated with these chemical changes.

The removal of vegetation by stock or man, and also the scarcity of vegetation have significantly reduced organic matter and nitrogen levels. In many of these cases changes in the physical characteristics of the surface soil have resulted. Overgrazing and trampling by introduced animals, particularly around watering points, have caused erosion and subsequently permanent changes in soil. Rabbits have had significant effects on soils over large areas of the far south-west both by their burrowing activities and grazing habits. Cockroaches, termites, harvestor ants and other soil insects have affected soils by mobilizing soil nutrients. Termites and harvestor ants not only relocate plant nutrients but termites change the physical characteristics of soils by mound building.

In general, production from grazing lands is determined by climate, particularly rainfall. In those areas where rainfall is the same, differences in amount, and composition of vegetation are related to topography (in that it affects water distribution) and soil type. There is consequently a strong relationship between the soil mapping units and vegetation groups and this is recorded in Table 4.1. Perhaps the most important soil factors affecting vegetation development are clay type and clay percentage.

A map showing the distribution of major soil groups or complexes is enclosed.

The cracking clays (comprising the grey, brown and red clays) are by far the most important soil group in the area. They are associated with both the alluvial plains and fresh Cretaceous sediments on undulating plains.

The cracking clays occurring on alluvia are mainly grey and brown clays. The grey clays are predominant on the poorly drained and flooded areas of the major alluvial plains. They are particularly widespread and well developed on the flood plains of Cooper Creek and the Bulloo River. Grey clays with massive surfaces are common in the swamps and claypans of the alluvia.

Brown clays are associated with the grey clays on the alluvia of the major streams. They are predominant on the major tributary streams of the Bulloo River and Cooper Creek. These brown clays are best developed on the higher, less frequently flooded areas. On the Bulloo River alluvia, small areas of silty-surfaced texture contrast soils may be associated with the brown clays.

Red and brown clays are associated with the undulating downs which are derived from weakly weathered sediments of the Cretaceous *Winton Formation*. In places these soils carry a cover of siliceous pebble or stone derived from silcrete which frequently has a dark colour (desert varnish). This land type has been referred to as "stony downs". In a similar situation, but further up the slope, gidgee shrubland may also occur on red and brown clays. These soils commonly exhibit weak to moderate gilgai relief. In places these red and brown clays may not have a cover of stone. In these areas the surface soil is generally more friable with well developed crumb structure.

Associated with the "stony downs" are areas of mixed red clays and desert loams. These soils have dense stone cover. The desert loams have a thin, loamy surface overlying cracking, red clay. They are associated with the fresh sediments of the *Winton Formation* but occur on the upper slopes.

A complex of cracking clays, alluvial soils and texture contrast soils is associated with the local stream alluvia and some of the major drainage lines. On the major channels of the important streams a mixture of grey clays and clayey alluvial soils with sand bands are common.

On the local stream alluvia, texture contrast soils are associated with grey clays, brown clays and alluvial soils. In most cases these soils are developed from alluvial material and are at various stages of profile development. In some situations texture contrast soils have developed on the clay plains by the deposition of wind blown material over grey and brown clays. In the upper part of stream catchments, the soils frequently become more loamy and earthy in fabric. In these situations alluvial soils are also developed.

* Development Planning Branch, Qd Dep. Prim. Inds.

1 Agricultural Chemistry Branch, Qd Dep. Prim. Inds.

2 Both common names – botanic names and botanic names – common names are listed in Appendix V.

Table 4.1. Characteristics of the soil mapping units.

Soil Mapping Unit	Brief Description	PPF Recorded	Great Soil Group	Associated Vegetation
Cracking clays				
Red and brown clays on undulating plains				
Karmona (16)*	Deep to very deep, red clays with stony surfaces and weak gilgai microrelief.	Ug 5.37, Ug 5.38.	Red clays.	Herblands and gidgee tall open shrubland.
Arima (2)	Deep to very deep, red clays with loose surface soil.	Ug 5.38, Ug 5.22.	Red and brown clays.	Herblands.
Ackland (4)	Very shallow to shallow, red and brown clays with gravelly and stony surfaces, often crusting.	Ug 5.32, Ug 5.24.	Brown and red clays.	Gidgee tall open shrubland.
Red clays (mulga group)				
Ooliman (5)	Moderately deep to very deep, red clays associated with depressions in flat fan-plains.	Ug 5.37, Ug 5.38.	Red clays.	Mulga tall open shrubland.
Red and brown clays on alluvial plains				
Pinkilla (2)	Moderately deep to deep, red and brown clays overlying weathered sediments (sandstones and siltstones). Often with a thin, surface crust and stone intermixed.	Ug 5.32.	Brown clays.	Gidgee tall open shrubland and herblands.
Thylungra (8)	Very deep, red and brown clays with thin surface crusts.	Ug 5.34, Ug 5.37, Ug 5.38.	Brown and red clays.	Herblands.
Kihee (3)	Very deep, grey and brown clays with a thin, surface crust.	Ug 5.24.	Grey and brown clays.	Herblands and grasslands.
Grey clays				
Houdraman (3)	Very deep, heavy, grey and brown clays which are poorly drained.	Ug 5.24, Ug 5.25, Ug 5.34.	Grey and brown clays.	Bluebush, lignum, swamp cane grass low open shrubland.
Comongin (3)	Very deep, grey clays with weak gilgai development.	Ug 5.24, Ug 5.25.	Grey and brown clays.	Gidgee, yapunyah low open woodland.
Parragona (1)	Very deep, alkaline, brown and grey clays with weak to moderate gilgai micro-relief. Stone occurs on the puff.	Ug 5.24.	Grey and brown clays.	Herbland.
Cottesmore (6)	Very deep, grey and brown clays with moderate to strong gilgai development.	Ug 5.24, Ug 5.25, Ug 5.34.	Grey and brown clays.	Gidgee forby and grassy low open woodlands.
Tabbareah (8)	Very deep, heavy, grey clays with wide cracks when dry. Channel micro-relief is noticeable.	Ug 5.24, Ug 5.28.	Grey clay.	Bluebush, lignum herbaceous low open shrubland.
Currawinya (3)	Very deep, grey clays with a thin, honeycombed, surface crust.	Ug 5.24.	Grey clays.	Gidgee, yapunyah grassy low open woodland.
Wilson (2)	Very deep, grey clays with gypsum accumulations at the surface and increasing down the profile.	Ug 5.24.	Grey clay.	Gidgee forby tall shrubland to low woodland.
Claypans, scalds and saltpans				
Quilpie (3) (scalded)	Very deep, grey and brown clays with scalded, surface soil. Neutral to slightly alkaline.	Ug 5.24, Ug 5.25, Ug 5.34.	Grey and brown clays.	Sparse vegetation.
Wittenburra (3)	Very deep, grey clays with scalded surfaces. Hexagonal pattern of crusting on claypan areas. Strongly alkaline.	Ug 5.24.	Grey clay.	Sparse vegetation.
Wyara (2) (saltpans)	Very deep, grey and brown clays with crusting surfaces over loose, soft, clay. Strongly alkaline.	Ug 5.2.	Grey clay.	Sparse vegetation.
Tennappera (5) (claypan)	Very deep, grey clays with massive surface soil.	Ug 5.5, Ug 5.24.	Grey clay.	Sparse vegetation.
Desert loam				
Chastleton (3)	Shallow to moderately deep, texture contrast soils with thin, stone covered, clay-loam surface soil and a structured, red, clayey subsoil.	Dr 1.12, Dr 1.13.	Desert loam.	Herbland.

* (16) Indicates the number of detailed profile descriptions for that mapping unit.

Table 4.1. (continued)

Soil Mapping Unit	Brief Description	PPF Recorded	Great Soil Group	Associated Vegetation
Texture contrast soils				
Texture contrast soils on alluvia				
Ambathala (3)	Deep to very deep, red, texture contrast soils with acid to neutral, earthy, red, loams to clay-loams overlying alkaline, red, structured, light to medium clays. Lime and gypsum are present in the subsoil.	Dr 2.43, Dr 2.13.	Red brown earth.	Poplar box, sandalwood, mulga low open woodland.
Caiwarro (3)	Very deep, brown and red, clays with a thin, crusting/hardsetting, loamy surface.	Dr 1.13, Dr 1.12.	Solodic/alluvial soil.	Yapunyah, gidgee open woodlands.
Woorbil (3)	Very deep to deep, texture contrast soils with dark-reddish-brown, silty-clay-loams to silty-clays overlying and brown, medium clay.	Db 0.43, Dy 1.43.	Solodic/alluvial soil.	Bassia herbland.
Wanna (3)	Deep to very deep, texture contrast soil with red, sandy-loam to sandy-clay-loam surface soil and red, sandy-clay to clay subsoil.	Dr 2.12, Dr 2.13.	Solodic/alluvial soil.	Gidgee, coolibah low woodland.
Tintinchilla (2)	Shallow to deep, texture contrast soil with brown, sandy-loam to sandy-clay-loam surface soil and brown, sandy-clay subsoil.	Dy 2.42, Dy 3.43.	Soloth, solodized solonetz	Poplar box, mulga shrubby low open woodland.
Bygrave (6)	Moderately deep to very deep, texture contrast soil with a red, coarse-sand to loamy-coarse-sand surface soil and yellowish-red to red, sandy-clay-loam to sandy-clay subsoil. (In places this soil is cemented and hard due to erosion.)	Dy 5.53, Dr 4.33, Dr 4.13, Dr 1.56, Dr 2.12.		Acacia grassy tall open shrubland.
Texture contrast soils on undulating plains				
Whynot (3)	Shallow to moderately deep, red, texture contrast soil with a sandy-clay-loam overlying a pedal, medium clay. Overlying sandstone.	Dr 1.12.	Solodic/desert loam.	Gidgee, bassia forby tall open shrubland.
Bullawaria (3)	Shallow to moderately deep, red, texture contrast soil with clay-loam surface soils and alkaline, light to medium clay subsoil (frequently with hardpan).	Dr 2.53, Dr 2.13.	Red and brown hardpan soils.	Mulga tall open shrublands.
Lymbah (7)	Deep to very deep, texture contrast soil with a thin, red, clay-loam surface soil and a red, medium clay subsoil. (Associated with slump area.)	Dr 2.12, Dr 2.13, Dr 2.53.	Solodic/red brown earth.	Mulga tall open shrubland.
Alluvial soils*				
Coolah (5)	Very deep, grey clays with sand (and gravel in places) bands intermixed.		Alluvial soil/ grey clay.	Coolibah, river red gum, gidgee shrubby low open woodland.
Farnham (3)	Shallow to moderately deep, soils with gravelly, clay-loam and loam surfaces and yellowish-red, gravelly, sandy-clay subsoil.		Alluvial soil.	Gidgee and other Acacia shrubby tall open shrublands.
Tooratchie (1)	Very deep, grey clays overlain by loose, silty or sandy-clay.			Oldman saltbush low open shrubland.
Okena (3)	Deep soils with sandy-loam to loam surfaces and red, and brown sandy-clay-loam to loam subsoils, with sand bands intermixed.			Coolibah, river red gum low open woodland.
Tirtywinna (2)	Deep soils with red, sandy-loam surface soils and sandy-clay subsoils.			Mulga, poplar box, western bloodwood tall open shrubland.
Nockatunga (3)	Shallow to moderately deep, stony, red, loams to clay loams with earthy fabric.			Mulga tall open shrubland.
Prairie (1)	Very shallow, red, loam soil.		Alluvial soil.	Shrubby tall open shrubland.

* Refers to soils which are developed on alluvia but not necessarily alluvial soils as per Stace (1967). In many cases soil forming processes are noticeably active.

Table 4.1 (continued)

Soil Mapping Unit	Brief Description	PPF Recorded	Great Soil Group	Associated Vegetation
Red earths				
Shallow, loamy red earths				
Kulki (7)	Very shallow, earthy, red, loams to clay-loams with silcrete and ferricrete cover.	Um 5.31, Um 5.51, Gn 2.12.	Red earths.	Bastard-mulga sparse shrubland.
Corona (7)	Shallow, earthy, red, loam to clay-loam with thick silcrete cover.	Um 5.51, Gn 2.12.	Red earths.	Western bloodwood, mulga shrubby open tussock grassland.
Coparella (11)	Shallow, loamy, red earths with ironstone gravel throughout.	Gn 2.12, Um 5.51.	Red earths.	Mulga tall open shrubland.
Mt. Margaret (11)	Shallow to moderately deep, loamy, red earths with hardpans.	Um 5.51, Gn 2.12.	Red earth/red and brown hardpan soils.	Mulga tall open shrubland.
Deep, loamy red earths				
Tilkerie (4)	Moderately deep to deep, loamy surfaced, red earths with ironstone gravel throughout profile. Stony hard surface.	Gn 2.12, Gn 2.11.	Red earth.	Mulga tall shrubland to tall open shrubland.
Tinnenburra (9)	Moderately deep to deep, loamy surfaced, red earth with ironstone gravel in the profile. Organic staining in surface soil.	Gn 2.12, Gn 2.11,	Red earth.	Mulga tall shrubland to tall open shrubland.
Sandy red earths				
Napoleon (7)	Deep, sandy-loam to sandy-clay-loam surfaced, neutral, red earths.	Gn 2.12, Um 5.21, Um 5.52.	Red earth.	Mulga grassy tall open shrubland.
Springvale (2)	Shallow to moderately deep, sandy-loam to sandy-clay-loam surfaced, alkaline, red earths with iron hardpan.	Gn 2.13, Um 5.31.	Red earth.	Mulga, poplar box shrubby tâll open shrubland.
Gooyana (1)	Shallow to very shallow, scalded, sandy-loam to sandy-clay-loam surfaced, red earth with iron hardpan.	Gn 2.12.	Red earth/red and brown hardpan soils.	Mulga shrubby tall open shrubland.
Earthy sands				
Kotri (2)	Deep to very deep, neutral, red, earthy sands with loose surface soil.	Uc 5.21.	Earthy sand.	Mulga herbaceous tall open shrubland.
Booka (4)	Deep to very deep, alkaline, red, earthy sands with loose surface soil.	Uc 5.21, Gn 1.12.	Earthy sand.	Mulga, whitewood, shrubby herbland.
Titheroo (3)	Deep to very deep, neutral, red, earthy sands increasing in texture at the base of the profile.	Gn 1.12, Uc 5.21.	Earthy sand.	Mulga, spinifex shrubby hummock grassland.
Paroomatoo (2)	Shallow to very shallow, earthy sand with scalded surface and iron hardpan.	Uc 5.21, Um 5.31.	Earthy sand.	Sparse vegetation. Mulga, budda bush tall open shrubland.
Mirintu (1)	Shallow, earthy sands with loose surface and iron-pan.	Uc 5.31.	Earthy sand.	Mulga herbaceous tall open shrubland.
Siliceous sands				
Yanko (6)	Very deep, neutral, red, siliceous sands.	Uc 1.23.	Siliceous sands.	Whitewood, bluebush-pea shrubby forbland.
Chookoo (1)	Very deep, yellow, siliceous sands.	Uc 1.22.	Siliceous sands.	Shrubby sparse herblands.
Lithosols				
Woban (11)	Very shallow, stony, loamy, lithosols overlying weathered rock.	Um 1.43, Um 1.42, Um 1.21.	Lithosol.	Gidgee, mulga tall open shrubland.
Grey (19)	Very shallow, loamy, lithosols often with rock outcrops.	Um 1.43, Um 1.23.	Lithosol.	Acacia tall open shrublands.

Red earth soils occur on landscapes formed as a result of the dissection of the weathered mantle which has been formed by chemical alteration of the Cretaceous sediments. These soils commonly support mulga associations. The development of these mulga associations is closely related to water availability.

The earthy detritis derived from the erosion of the weathered mantle has been redistributed down slope as alluvia, pediment mantles and fans. The depth of this material which forms loamy, red earths varies considerably. It is generally deepest in the local run-on alluvial areas. On the gentle sloping plains adjacent to these areas mulga groves may occur. In the vicinity of Eromanga and in other areas, mainly west of the Grey Range, this material often overlies clays. In these situations a soil complex of red earths with hardpans, red clays in sink-holes (which are characterized by mulga groves aligned with the contour) and red texture contrast soils occurs.

Sandy, red earths occur on sandplains formed by the movement of aeolian sand over both the Tertiary upland surface and clayplains. The sandy, red earths over the upland surface are deep and acid to neutral. Small depressions of texture contrast soils occur on the plains as do outcrops of the older land surface. The sandy, red earths developed on the clay plains are moderately deep to deep, with neutral to alkaline soil reaction trends and with ferruginous hardpans. These plains are interspersed with claypans and clay alluvia. Very low dunes may develop in both these situations.

Both earthy sands and siliceous sands are associated with the dunefields. Dunefields occur mainly over lowlands with little local relief. Siliceous sands are associated with the mobile crests of dunes. These sands are generally red in colour. However, on the Cooper Creek alluvia small areas of yellow dunes occur. The earthy sands occur on the flanks of the dunes and in the swales. Areas of sandy, red earths are common on the lower slopes. In places clayey cores were recorded in the earthy sands and sandy red earths. Claypans frequently occur in the interdune area.

Fringing the major lakes and salinas, small areas of wind-blown material made up of salts (mainly gypsum), sand silt and clay may accumulate. This material forms crescentic or near crescentic shaped dunes.

Associated with the mesas, buttes and plateaux, which are remnants of the dissected landscape, are lithosols and shallow stony red earths. Shallow red earths with little silcrete cover occur on the eroded remnants. Exposed weathered rock and silcrete capping are common.

MORPHOLOGICAL CHARACTERISTICS OF THE SOILS

A feature of the area is the great diversity of soils with widely differing physical characteristics.

Red colours are predominant. They are associated with those soils with free drainage. This colouration is regarded as being caused by free iron oxides (Jackson, 1957). Grey and brown colours are mainly associated with cracking clays on the alluvia and the poorly drained parts of the undulating downs.

Cracking clays, siliceous sands, and earthy sands are predominantly very deep. However, close to the scarp retreats the red clays may be moderately deep overlying weathering sediments. The red earths range from very shallow to very deep, depth being related mainly to position on the landscape. Sandy, red earths are generally deep, but in places are moderately deep. Where this occurs they commonly overlie a weak hardpan. Desert loams range from moderately deep to deep soils. Lithosols are extremely shallow soils. Texture contrast soils range from shallow to moderately deep, on the sloping areas, to very deep, when developed on alluvium.

Stone or pebble pavements are a common feature of upland areas. These pavements comprise mainly silcrete pebble and boulder. On the gilgaied, red clays, pebbles are commonly denser on the puff. In the case of the desert loams these pebbles may be impregnated in a thin loamy surface soil.

Previous investigations (Jackson 1957, 1962) and Litchfield (1962, 1963) have noted the presence of thin surface crusts on arid soils. This feature not only occurs on the clay soils but is also common on the earthy sands on dunes. The crusts are thin, usually less than 1 cm thick and easily broken. Whilst the red earths mainly have massive surface soil, thin crusts may also form on these soils. Rogers (1972) has commented on the importance of lichens in soil crust formation on arid soils. He noted that where overgrazing occurs this crust may be destroyed increasing the susceptibility of these soils to erosion.

A large area of the clay soils and thin surfaced, texture contrast soils, associated with the alluvia, have been subject to wind and water erosion resulting in a scalded soil surface. These scalded areas occur in situations on the edges of dunes, on alluvia (particularly where the area has been subject to heavy stocking) and in dunefields. In parts the scalded surface is associated with a crust overlying a pedal clay soil. In other places, particularly on the claypans, it is associated with massive surfaced, grey clays. Some red earths have also been subjected to wind and water erosion leading to a scalded massive surface. This scalded appearance also occurs on the sandy red earths. This results in poor physical and chemical conditions for germinating seed.

Most of the clay soils crack. Widely cracking clay soils are associated with the grey clays of the "channel country" and poorly drained swamps. These cracks allow easy entry of flood-water until the surface seals and then infiltration rates become extremely low.

Gilgai microrelief is a common feature on the cracking clays. On the red clays and brown clays of the undulating downs and on the red and brown clays of the alluvia, gilgai microrelief is only weakly developed. Vertical amplitude in these cases seldom exceeds 30 cm. However, the grey clays associated with gidgee and brigalow woodlands are often strongly gilgaied.

An interesting microrelief pattern is associated with mulga groving on a soil complex. In this complex, red cracking clays are associated with sink-holes which vary from 20 to 100 cm deep. These sink-holes are surrounded by shallow, red earths and red, earthy surfaced, texture contrast soils. The sink-holes are closely aligned with the contour.

The red earths and sandy, red earths are massive with earthy fabric. The earthy sands, which have single grain structure and are loose when disturbed, may be massive *in situ* due to bridging of the sand particles by small amounts of clay. The siliceous sands are loose and single grained. The cracking clay soils are typically blocky with crumb, granular, platy or blocky structure occurring in the surface soils. Size ranges from fine crumb at the surface of some clay soils, to very coarse blocky, almost massive. The texture contrast soils have predominantly massive surface soil which may have an earthy fabric. In places where wind-blown sand overlies other material, surface structure similar to the earthy sands occurs. Subsoil structure of the texture contrast soils may be massive, blocky or columnar.

Infiltration rates vary considerably being closely related to surface soil characteristics. The siliceous sands, earthy sands, and sandy, red earths have high infiltration rates. The red earths vary considerably, depending on surface conditions, but generally have moderate to high infiltration rates. Run-off on the shallow red earths is high due to low moisture storage and generally poor vegetal cover. The cracking clay soils have high infiltration rates when dry and cracked, but infiltration is reduced to a very low rate when the surface of the soil becomes saturated and the cracks close. On the massive-surfaced, clay soils associated with claypan and swamp areas, ponded water may stand for prolonged periods, even when the subsoil remains relatively dry.

Calcium carbonate is common in a wide range of cracking clay soils and texture contrast soils. It occurs as both concretionary and soft lime. Gypsum also occurs in a wide range of soils. It is most common in the cracking clays of the undulating downs, the desert loams, and the clay soils of the alluvia. Manganese staining is common in the poorly drained, grey clays. Ironshot occurs both on the surface and within the profile of many of the red earths. Rounded ferruginous gravel is common in the red earth profiles and generally increases with depth.

Hardpans occur but are not widespread. They are mainly associated with red earths and sandy, red earths on pediments, fans and sandplains. Hard weathered rock forms the base of most profiles in the uplands.

THE SOIL MAPPING UNITS

During the course of this survey 227 soil profiles were examined and detailed descriptions made. At a further 600 sites less detailed recordings were made. Soils described at these sites have been grouped into 53 soil mapping units (SMU) based on easily distinguishable soil morphological characteristics. Further sub-division into soil series was not done due to the limited number of soil profile descriptions. It was difficult with our limited data to justify further sub-division, as soils, like vegetation, may grade from one into another. The descriptions of the soil mapping units will serve as point data from which further sub-division can be made on the basis of soil morphology and soil chemistry.

Table 4.1 presents a summary of the salient characteristics of the 53 SMU, more detailed descriptions being given in the text. The 53 SMU have been grouped into 15 major groups, the classification into these groups being based on great soil groups, specific soil characteristics, topography and in one instance vegetation.

The soil profiles have been described in terms of principal profile forms (PPF) (Northcote, 1965) and great soil groups (Stace *et al.*, 1968). These provide further description of the SMU although in many cases many of the soils occurring in this area do not conform with the established soil groups. This applies to texture contrast soils occurring on recent alluvia and where wind-blown sand overlies clay plains. Where a thin, fine textured surface deposit overlaid clay soils classification was also difficult. Some soil mapping units do not fit into a particular soil group but have some characteristics of a number of groups.

Cracking clays

These soils of high clay content are subject to seasonal cracking. The width of the cracks varies considerably. Calcium carbonate and gypsum may occur in the profile but their occurrence is variable. The soils are commonly alkaline but range from acid to strongly alkaline. Gilgai microrelief is common on the soils, the amplitude and the degree of development varying. The soils are formed from both alluvia on flat plains and fresh Cretaceous sediments on undulating plains.

There are three great soil groups within the cracking clays. The sub-division into these groups is based on soil colour. The red and brown clays have been considered jointly as in places they are closely interrelated. For this study the cracking clays are sub-divided into: red and brown clays on undulating plains, red clays associated with a particular mulga groving pattern, red and brown clays on alluvial plains, grey clays, and a group comprising claypans, scalds and saltpans.

Red and brown clays on undulating plains

Karmona SMU is a deep to very deep, red clay formed on the relatively unweathered sediments of the Cretaceous *Winton Formation*. The soils have a surface cover of stone (pebble) which is predominantly silcrete. The stone has a dark colouring commonly referred to as desert varnish. The soils have weak gilgai development, generally with less than 30 cm of amplitude. Stone is commonly concentrated in the vicinity of the gilgai mound.

The profiles are red to yellowish-red commonly becoming yellower with depth. They are generally very deep but in the shallower variants weathered sediments are encountered after 100 cm. Soil reaction is variable being predominantly neutral to slightly alkaline. In a few profiles the soils become slightly acid at depth but this is not common.

The soils are medium to heavy clays and are strongly structured. It is common to have a thin surface crust under which there is a self-mulching, granular surface soil. Beneath this, the structure is medium to coarse blocky. Gypsum is common after 30 to 45 cm usually increasing in amount with depth. Calcium carbonate is variable occurring in some soils but not others.

TSS (Total Soluble Salts) and Cl (Chloride) values are low in the surface, increasing to very high levels at depth. CEC (Cation Exchange Capacity) ranges are 25 to 35 m equiv. per 100 g. Ca (Calcium) and Mg (Magnesium) are co-dominant cations. Soils are sodic in the surface and strongly sodic down the profile. Clay content ranges from 40 to 60%. Nutrient levels are low to very low, with fair to low available P (Phosphorus), and low to very low C (organic carbon) and N (total nitrogen) levels. Available moisture values are high to very high.

Representative Profiles (R.P.) 36, 117, **162.**

Arima SMU is a deep, red clay developed from fresh sediments of the Cretaceous *Winton Formation*. Large sandstone concretions generally less than 30 cm in diameter may occur on the surface of these soils. The soils have very weak gilgai microrelief and crack widely.

The profiles are yellowish-red throughout and are strongly alkaline. The surface soils are loose and soft to walk on and there are few distinct peds. This condition may occur in the top 20 cm of the soil, but is usually common only in the first 10 cm. Below this, the soil has a strong blocky structure. A thin, easily broken, surface crust occurs. Carbonate is common throughout the profile and gypsum is common in the profile below 100 cm.

TSS and Cl levels are very low throughout the profile, with TSS levels increasing when gypsum occurs at the base of the profile. CEC values are greater than 30 m equiv. per 100 g. Ca is the dominant cation. Mg levels are relatively low. Soils are non-sodic in the surface becoming strongly sodic at depth. Nutrient levels are fair, with high levels of available P, but low to very low C and N levels. Available moisture values are very high.

R.P. **167.**

Ackland SMU comprises very shallow to shallow, red and brown clays which overlie freshly weathered *Winton Formation* sediments on, or near, scarp retreats. The soils have a surface cover of stone.

The profiles are brown and reddish-brown in colour and are neutral to alkaline. Textures are medium to heavy clays. Calcium carbonate may be present at the base of the profile. The soils have thin crusts in which stone is inter-bedded. Beneath this crust the soil has strong, medium, sub-angular blocky structure. This grades into decomposing parent material.

TSS and Cl are low in the surface increasing to high and very high levels. CEC is greater than 25 m equiv. per 100 g with Ca the dominant cation. Clay content is high with values of approximately 40%. Nutrient levels are fair, with fair to high available P levels and low C and N values.

R.P. **80.**

Red clays, mulga group

Ooliman SMU is a moderately deep to very deep, red clay which occurs in close association with red texture contrast soils and red earths on fan plains. The soils are associated with sink-holes in these plains. The amplitude of these depressions may vary from 10 cm to 1 m. The sink-holes are roughly aligned on the contour. This gives a grove appearance to the mulga shrubland developed on this SMU. It is thought that this SMU has developed where thin deposits of earthy material have been spread over clay plains. The sink-holes being best developed in areas of greatest water penetration.

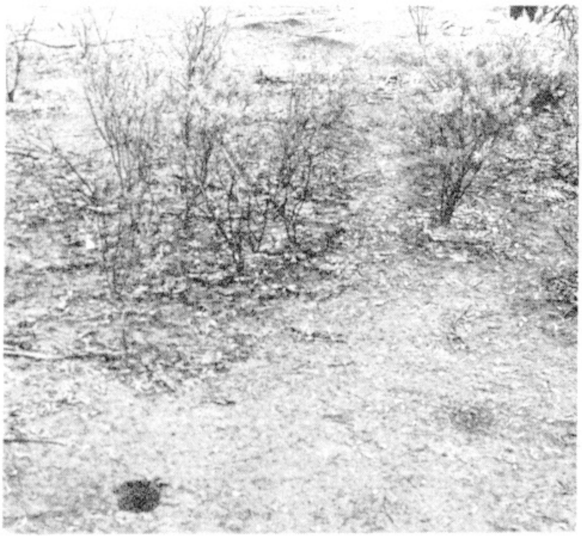
The profiles are red to yellowish-red in colour. Soil reaction is neutral at the surface and alkaline at depth. Calcium carbonate is present in all profiles and is best developed after 30 cm.

Textures range from light to heavy clays. The surface soils have a thin crust below which the soils are strongly structured being medium to coarse, sub-angular blocky.

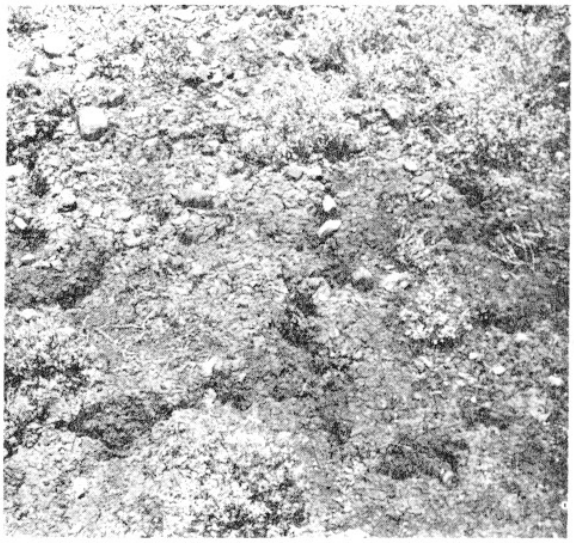
TSS and Cl are very low increasing only slightly with depth. CEC ranges from 10 to 20 m equiv. per 100 g. Ca and Mg are co-dominant cations with Ca increasing with depth. Clay content is predominantly higher than 45%. Nutrient levels are low, with very low P levels and low to very low C and N values. Available moisture is high to very high.

R.P. **149.**

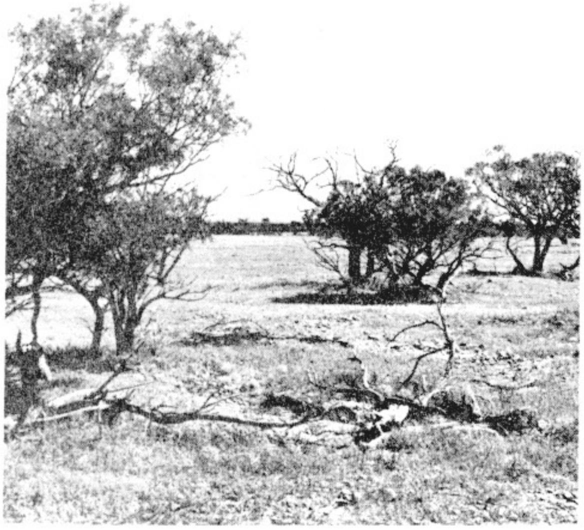
The grey clays of the "Channel Country" are productive following flooding. The soils crack widely when dry and subsequently allow rapid entry of flood water.



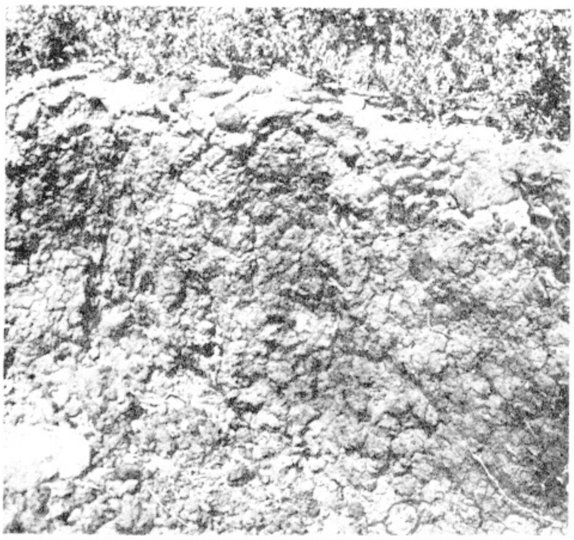
Red earth soils of low fertility, massive when dry but friable when moist. Litter accumulation is important as a source of nutrient recycling in the surface soil.



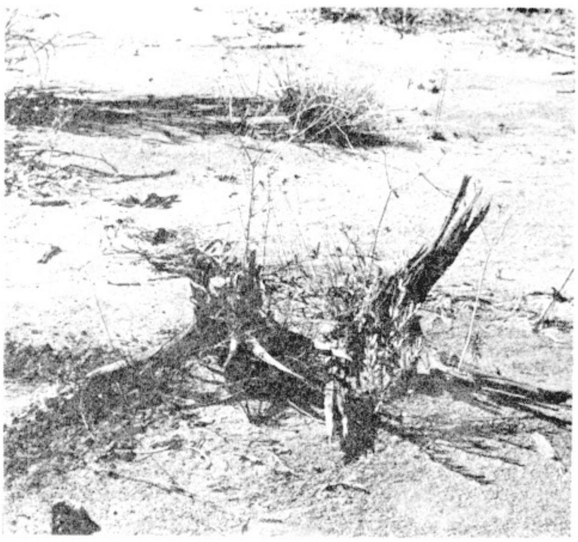
Cracking red and brown clays occur on undulating plains and have a variable surface pebble cover. Surface crusts form even on these self mulching soils.



Gilgai microrelief is a feature of the red and brown clays of the undulating gidgee lands. Gilgais trap moisture.



The desert loams are associated with the red and brown clays, but have a thin, massive, loamy surface soil with pebble intermixed.



Sandy red earths associated with the mulga sand plains are stable when protected by vegetation. Following fire or overgrazing sheet erosion seriously reduces nutrient levels.

Red and brown clays on alluvial plains

Pinkilla SMU is a moderately deep to deep, brown clay. It is associated with the local alluvia occurring on undulating plains which have been formed by the dissection of the *Winton Formation* sediments. The soils frequently have a stone cover and in places these stones may be intermixed within the profile. The weathered *Winton Formation* sediment underlie the profile.

Profiles are strong-brown throughout and are neutral to slightly alkaline. Textures are medium to heavy clays becoming lighter textured in the zone of contact with the underlying material. A surface crust is present, beneath which the soils have a strong, medium, blocky structure grading into strong, coarse, blocky structure. Gypsum may occur in the lower parts of the profile.

TSS and Cl values are high to very high. CEC values range from 17 to 26 m equiv. per 100 g with Ca the dominant cation. Soils are sodic in the surface and strongly sodic in the subsoil. Clay content ranges from 40 to 50%, decreasing at the base of the profile. Nutrient levels are fair, with fair available P levels and low to very low C and N. Available water is high.

R.P. **163.**

Thylungra SMU is a very deep, red-brown clay occurring on the higher level alluvial plains and on the clay alluvia of the major tributaries. These areas are not prone to regular prolonged flooding. There is little gilgai microrelief present.

Textures are predominantly medium to heavy clays with silty-clays occurring in the surfaces of many soils. It is common for textures to become lighter with depth.

A thin, silty-clay, platy crust is a feature of these soils. Below this crust the soils are strongly structured and have medium to coarse, sub-angular blocky structure. In places the surface soil may be scalded.

The profiles are red to reddish-yellow and reddish-brown at the surface and strong-brown to reddish-brown at depth. Soil reaction is mainly neutral with some soils becoming slightly alkaline with depth.

In places, near the outwashes from weathered sediments, ironshot may occur in the profile.

Gypsum is not common in this SMU and where it occurs it is restricted to the lower part of the profile. Gravel may occur at the base of some of the profiles.

TSS and Cl values are very low in the surface 10 cm increasing to high to very high values and reaching maximum values at 30 to 60 cm.

CEC values range from 20 to 25 m equiv. per 100 g with Ca the dominant cation. Soils are sodic in the surface to highly sodic in the subsoil. Nutrient levels are fair to very fair, with fair to high available P levels and very low C and N values. Available water is high to very high.

R.P. 170, **202.**

Kihee SMU comprises very deep, mainly grey-brown, clays which occur on flat alluvial plains that may be flooded occasionally. There is little gilgai microrelief. Natural rill erosion, due to flooding, occurs.

Soil colour ranges from light-yellowish-brown to brown. Soil reaction is neutral to slightly alkaline. Textures are predominantly heavy clays but may become medium clays at depth. A thin surface crust is a feature of these profiles. Beneath this crust the soils are self-mulching. This layer is usually 3 to 5 cm thick and below this the profile has strong, blocky structure.

Gypsum is common in the lower parts of the profile.

TSS and Cl values are low in the surface soil increasing to high to very high values at depth. CEC values range from 24 to 26 m equiv. per 100 g with Ca the dominant cation. Exchangeable Mg increases significantly down the profile. Nutrient levels are fair to low, with fair to low available P levels and very low C and N values. Available water is high to very high.

R.P. 136, **177**, 183.

Grey clays

Houdraman SMU comprises very deep, grey clays which occur in poorly drained back-swamps on the alluvia of the major rivers. The soils are weakly gilgaied with amplitude being less than 15 cm. The soils crack widely when dry.

Profile colours are grey to greyish-brown and frequently are strong-brown at depth. Mottling occurs in the surface soil(10 to 20 cm). Manganese staining occurs at depth. Soil reaction is slightly acid to neutral. Textures are heavy clays throughout. The surface soil is self-mulching, medium-granular. Beneath this, the soil is blocky and strongly structured. A surface crust occurs.

TSS and Cl values are very low in the surface increasing gradually to high values at depth. CEC decreases from 23 m equiv. per 100 g to 17 m equiv. per 100 g down the profile. Ca and Mg are co-dominant cations. Profiles are strongly sodic after 30 cm. Clay contents are generally greater than 50%. Nutrient levels are fair to high, with very fair to high available P levels, and low C and N values. Available water is high.

R.P. **16.**

Comongin SMU comprises very deep, grey and brown, clays occurring on the flat alluvial plains of the major streams. The soils are flooded occasionally. Soils are weakly gilgaied with an amplitude of less than 30 cm.

The soils are light-brownish-grey to brown at the surface becoming brown to strong-brown at depth. Profiles are neutral to strongly alkaline becoming slightly acid at depth.

Textures are heavy clays. A thin surface crust overlies a self-mulching, 2 to 5 cm thick layer with medium-crumb structure. Underlying this, the soil structure is medium to coarse-blocky.

Lime and gypsum occur in the lower parts of the profile, gypsum being more abundant. Manganese staining also occurs in the profile.

TSS and Cl values are low in the surface gradually increasing to high values. CEC ranges from 13 to 15 m equiv. per 100 g in the top 10 cm and from 20 to 25 m equiv. per 100 g elsewhere. Ca and Mg are co-dominant cations. Clay ranges from 45 to 55%. Nutrient levels are fair to very fair, with high to very high P levels and low C and N values. Available water is medium to high.

R.P. 14, 15, **75.**

Parragona SMU comprises grey clays. It occurs transitional to the outwash plains and the stony pediments of the undulating plains. The soils have weak to moderate gilgai microrelief. Stone (pebble) cover is common on the gilgai mounds.

The profiles are pale-brown in colour and are neutral to alkaline. They are heavy clays throughout. The surface soils have a hard crust beneath which the soil is self-mulching. Below this, the soils are coarse-blocky. Gypsum occurs in the surface soil, becoming more abundant with depth.

TSS values are medium in the surface increasing to very high at depth. Chloride values are very low in the surface rising to medium to high at depth. Available P levels are fair to very fair.

R.P. **126.**

Cottesmore SMU comprises very deep, grey and brown, clays occurring on alluvial plains. It is similar to Comongin SMU but this soil has strong gilgai microrelief development. Usually this SMU is associated with shallow braided channels.

Soil colours are light-grey to reddish-yellow. The profiles are weakly alkaline to alkaline. Soil textures are heavy clay throughout. Surface crusts are common beneath which the surface soil is self-mulching. Beneath this, the soils have strong-blocky structure. Lime may be present throughout the profile whilst gypsum occurs below 60 cm.

TSS and Cl are low in the surface 10 cm increasing to extremely high values at depth. CEC generally ranges from 20 to 30 m equiv. per 100 g. Soils are sodic in the surface and extremely sodic at depth. Ca is the dominant cation. Clay content ranges from 45 to 60%. Nutrient levels are fair, with fair available P levels and low C and N values. Available water is very high.

R.P. **10, 11, 137.**

Tabbareah SMU comprises very deep, grey clays associated with the flooded "channel country". As well as the channel microrelief, the area is also gilgaied, the amplitude of which varies considerably (5 to 60 cm). The soils crack very widely, with cracks varying from 5 to 15 cm wide and extending down to at least 60 cm. These cracks interlink forming blocks.

The profiles are light-brownish-grey to light-yellowish-brown in colour. They are predominantly neutral to slightly alkaline but frequently become more alkaline with depth.

Textures are heavy clays throughout. While the soils are self-mulching, a thin, platy crust may be present. Structure is strong being coarse blocky.

Gypsum and lime may be present in the lower parts of the profile. Manganese staining is common, indicating poor drainage conditions.

TSS and Cl values are low to very low, except at the base of the profile. CEC values generally are greater than 25 m equiv. per 100 g with Ca the dominant cation. Surface soils are non-sodic, but subsoils become sodic to very sodic. Clay contents generally are greater than 50%. Fertility is fair, with high to very high available P levels and low to very low C and N values. Available water is high.

R.P. **208, 209.**

Currawinya SMU comprises grey clays on flooded alluvial plains. There is no gilgai microrelief but there may be shallow, depressed, scalded areas associated with this soil.

The profiles are light-yellowish-brown to very-pale-brown in colour, neutral at the surface and becoming alkaline with depth. In one profile the soil becomes acid at 120 cm. The soils are mainly heavy clays but possess a sandy-clay vesicular surface crust which is commonly less than 2 cm thick. Beneath this crust, structure ranges from medium to coarse-blocky. Both lime and gypsum may be present below 60 cm.

TSS and Cl values are low increasing to medium to high values at the base of the profile. CEC is 20 m equiv. per 100 g with Ca^{+} dominant. Soils are non-sodic in the surface and extremely sodic in the subsoil. Clay ranges from 45 to 50%. Fertility is fair, with high available P levels and low C and N. Available water is high.

R.P. **67.**

Wilson SMU comprises grey clays with weak gilgai microrelief. It occurs on alluvial plains usually in association with shallow, braided channels. It is similar to Comongin SMU, the main difference being that *Wilson* SMU has abundant crystalline gypsum throughout the profile.

The profiles are pale-brown to very-pale-brown in colour and strongly alkaline throughout. Textures are medium to heavy clays. There is a thin, soft crust. Beneath this, the surface soil has a fine, sub-angular-blocky structure. The soil is very friable and soft when moist.

TSS values are very high due to large quantities of gypsum. Chloride values are very low throughout. CEC ranges from 24 m equiv. per 100 g in the surface 10 cm to 8 m equiv. per 100 g in the subsoil. Ca is the dominant cation and Mg is low. The soil is non-sodic in the surface becoming sodic at depth. Clay drops from 44 at the surface to 23%. Fertility levels are fair, with very fair to high available P and low to very low C and N. Available water is high.

R.P. **127.**

Claypans, scalds and saltpans

Quilpie SMU comprises grey and brown clays with scalded surfaces. They are associated with the grey and brown clays occurring on the flat alluvial plains. In most cases *Quilpie* SMU is a degraded form of these soils.

This SMU forms slightly deflated areas usually close to the streams and frequently on slight backslopes. Wind-blown material may form small rises.

Profiles are strong-brown to light-yellowish-brown in colour and neutral to slightly alkaline. Textures are medium to heavy clays. The characteristic of this SMU is the bare, hard, scalded, surface crust. This crust is 1 to 2 cm thick and is platy or vesicular. The scalded surface has fine surface cracks. Beneath this crust, the soils are strongly structured being granular to sub-angular-blocky at the surface and sub-angular-blocky below this. Hubble and Beckmann (1956) have discussed the formation of the scalded surface.

Manganese staining may be present in some profiles. In others gypsum occurs at the base of the profile.

The degree of development of the scalded surface varies considerably and this SMU merges into unaffected areas.

TSS and Cl values are medium to extremely high. CEC ranges from 10 to 20 m equiv. per 100 g. Ca is the dominant cation. Soils are non-sodic in the surface with extremely sodic subsoil. Clay is 40 to 50% in the top 30 cm and may decrease with depth. Fertility is low, with low available P levels, very low C and N, and low K. Available moisture is high.

R.P. **17, 172.**

Wittenburra SMU are very deep, grey clays associated with small claypans on alluvial plains. These commonly occur in the vicinity of sandplains or dunefields. Low sandy rises may occur on these flat deflated areas.

The profiles are commonly brown at the surface and become pale-brown to very-pale-brown with depth. They are strongly alkaline. Textures are medium to heavy clays in the upper parts of the profile usually becoming light clays at depth. The hard, thin (1 to 2 cm) surface crust which typically has a regular cracking pattern is commonly a sandy-clay. The crust is usually vesicular. Below this crust, the soil has strong, medium-blocky structure in the surface 5 to 10 cm and coarse blocky structure below this.

Lime is common below 20 cm. Gypsum is present in the lower parts of some profiles.

TSS and Cl values are very high. CEC ranges from 15 to 25 m equiv. per 100 g. Ca is the dominant cation with Mg increasing down the profile. Clay ranges from 40 to 50%. Soils are strongly sodic throughout. Fertility levels are fair, with fair to high P levels but very low C and N values. Although available water is medium to high infiltration rates are extremely low.

R.P. 9, **66**, 196.

Wyara SMU comprises very deep, grey clays associated with saltpans on the alluvial plains. They may occur on the edges of dunefields. In places these soils have been deflated leaving low rises and scalded depressions.

The profiles are yellowish-brown at the surface with lighter colours and mottling at depth. The soils are strongly alkaline throughout.

Textures are medium to heavy clays throughout. A thin vesicular crust is common on the low rises. Beneath the crust the soil has soft, fine medium-granular structure which grades into blocky structure after 6 cm. A feature of this SMU is the abundant lime and gypsum present throughout the profile.

TSS and Cl values are extremely high throughout. CEC values range from 20 to 25 m equiv. per 100 g. Ca is the dominant cation but Mg is also high. Soils are strongly sodic throughout. Clay ranges from 40 to 50%. Fertility levels are low, with fair to high available P levels and very low C and N values. Available moisture to plants would be limited by high salinity levels.

R.P. 63, 204

Tennappera SMU comprises very deep, massive surfaced, grey clays associated with poorly-drained claypans and swamps. The surfaces are frequently uneven due to deflation, and accumulations of soil material around the base of low shrubs and swamp cane grass.

The profiles are grey to very-pale-brown in colour and usually pinkish-grey at the surface. Textures are sandy-clays throughout although the surface may frequently be a silty-clay. The soils are poorly drained and may pond water for prolonged periods. The profiles are commonly gleyed and mottled. The surface soil is massive and hard when dry. Beneath this massive surface, the soils are medium to coarse-blocky, usually becoming massive again with depth. Both alkaline and neutral soil reaction trends occur. Calcium carbonate occurs in the alkaline profiles.

TSS and Cl levels are low. CEC ranges from 10 to 25 m equiv. per 100 g, mainly exceeding 15 m equiv. per 100 g. Ca is the dominant cation with some high Mg values. Soils are predominantly sodic at depth but some non-sodic profiles do occur. Clay ranges from 40 to 60%. Nutrient levels are fair, with fair to high available P levels and very low C and N values.

R.P. 192, 195, 219.

Desert loams

Desert loams are loamy surfaced, texture contrast soils. They occur in association with upper slopes of undulating plains which are derived from weathered Cretaceous sediments. *Chastleton* SMU is the only SMU in this group. The soils comprise shallow to moderately deep soils, with a thin (2 to 20 cm), massive, loam to clay loam surface soil and a strongly structured, sub-angular-blocky, medium to heavy clay subsoil. The surface soil is vesicular and easily pulverised. Profiles are red throughout. Surface soil is neutral to slightly alkaline and the subsoil is strongly alkaline to neutral. Both gypsum and lime may occur in the lower parts of the profiles.

The soils are generally weakly gilgaied. Stone patterns due to redistribution of stone on the mound are common. The stone pavement is predominantly of siliceous pebble and stone and is intermixed with the surface soil.

These soils are commonly associated with the red clay, *Karmona* SMU.

TSS and Cl are low in the surface and moderate to high in the subsoil. CEC ranges from 6 to 9 m equiv. per 100 g in the surface, and from 18 to 25 m equiv. per 100 g in the subsoil. Ca is the dominant cation. Soils are non-sodic in the surface and sodic to strongly sodic in the subsoil. Clay ranges from 13 to 20% in the surface and from 40 to 60% in the subsoil. Nutrient levels are low to fair available P levels and very low C and N values.

R.P. 201, 214.

Texture contrast soils

This includes all texture contrast soils other than the desert loams and those soils presently forming from alluvial material. It is difficult to place some of these soils in established great soil groups. The common feature of these soils is that they all exhibit a marked change in texture in the profile and that soil forming processes are active in their development. They are mainly associated with alluvial plains, alluvial fans and low dunes on alluvia.

The soils may be sub-divided into red-brown earths, solodized-solonetz, solodics, or hardpan soils. These soils are divided into those formed on alluvial plains and those formed on undulating plains.

Texture contrast soils on alluvia

Ambathala SMU comprises very deep, red-brown earths formed on old alluvial plains.

The soils have red, loam to clay loam A-horizons and red to yellowish-red, light to medium clay B-horizons. The thin A_2 may have a conspicuous or sporadic bleach. The surface soils is generally acid to slightly acid whilst the B-horizon has an alkaline soil reaction trend.

The surface soil is massive and hardsetting but may be friable when moist. The B-horizon has strong, medium, angular blocky structure in the top 60 cm. Concretionary lime is present in the B-horizon and gypsum is present in the lower part of the profile.

TSS and Cl are low in the surface and high in the subsoil. CEC increases from 10 m equiv. per 100 g in the surface to 26 m equiv. per 100 g at depth. Ca and Mg cations are co-dominant. The subsoil is highly sodic. Clay percentage ranges from 30 to 35% in surface and from 50 to 60% at the base of profiles. Fertility levels are low, with very low available P levels and low C and N values. Available water is medium to high.

R.P. 81.

Caiwarro SMU comprises very deep texture contrast soils developed on local alluvia.

The profiles have red, fine-sandy-clay-loam surfaces (10 to 20 cm) overlying red to reddish-yellow, light to medium clay B-horizons. The surface soils are slightly acid to neutral and the B-horizons are alkaline. Structure is blocky in the surface horizon and the B-horizon is strongly structured. A thin, hard, crust occurs on the surface. Lime and gypsum may occur in the lower part of the profile.

TSS and Cl values are generally very low in the surface with both high and low values being recorded in the subsoil. CEC ranges from 10 to 22 m equiv. per 100 g generally with the higher values at depth. Ca is the dominant cation.

Soils are commonly non-sodic in the surface with both highly sodic and non-sodic values being recorded in the subsoil. Nutrients levels are fair, with fair to high available P levels and low C and N values.

R.P. 68, 87.

Woorbil SMU comprises very deep, brown, solodic soils occurring on the broad alluvial plains.

The profiles are dark-reddish-brown to red, silty-clay-loams to silty-clays overlying brown, medium to heavy clays. A bleached A_2 may occur. The surface 5 cm commonly has moderate, medium-platy structure. Below this, the soils have moderate, fine sub-angular-blocky structure. The B-horizons has strong, medium, sub-angular-blocky structure. Surface soil is slightly acid to neutral and B-horizons are alkaline. Manganese concretions occur at the top of the B-horizon.

TSS and Cl values are very low throughout. CEC values vary from 5 to 17 m equiv. per 100 g. Ca is the dominant cation. Soils are sodic in the subsoil. Clay varies from 19 to 45%. Nutrient levels are low, with low to fair available P levels, low to very low C and N values and low to very low potassium level. Available water is medium.

R.P. 33.

Wanna SMU comprises deep, red, texture contrast soils occurring on recent alluvial parent material.

The soils are massive, red, fine-sandy-loams to sandy-clay-loams (10 to 30 cm) overlying red, sandy-clay B-horizons. Bleached A2 horizons do not occur. The surface soil is neutral to slightly acid and the B-horizon neutral to alkaline. There is some weak structure development in the surface 5 cm and weak, columnar structure may occur in the B-horizon. Ferruginous gravel occurs in the lower part of the B-horizon.

It is a complex of soils. TSS and Cl are low throughout in some soils, but in others may rise to high values in the subsoil.

CEC in surface soils ranges from 5 to 10 m equiv. per 100 g whilst subsoil values range from 11 to 18 m equiv. per 100 g. Ca is the dominant cation. Non-sodic profiles may occur or subsoils may be sodic to strongly sodic. Clay ranges from 11 to 25% at the surface and from 30 to 45% in the subsoil. Fertility levels are low, with low to very fair available P levels, and very low C and N values. Available water levels are moderate to high.

R.P. 55, 140, 156.

Tintinchilla SMU comprises deep, soloth and solodized-solonetz soils associated with depressions in the sandplains.

The soils are massive, (with the exception of some weak, sub-angular-blocky structure below the surface) brown, fine-sandy-loams to sandy-clay-loams, (10 to 20 cm deep) overlying columnar, brown , sandy-clay B-horizons. There is a bleached A2. The B-horizon may be mottled. The soils may be neutral throughout, or have alkaline soil reaction trends. In the alkaline soils, lime is common in the B-horizon. Mn staining is common throughout the B-horizons.

TSS and Cl values are very low. CEC values are less than 8 m equiv. per 100 g. Ca is the dominant cation. Soils are non-sodic. Clay ranges from 15 to 20% in the surface to 30 to 35% in the subsoil. Fertility is low to fair, with low to very fair available P and low C and N values. Available water is low.

R.P. 6, 100.

Bygrave SMU comprises moderately deep to deep, red, texture contrast soils associated with low dunes and sandplains. These overlie old alluvial plains.

The surface soils are loose, red, loamy-coarse-sands to coarse-sands (30 to 50 cm) overlying massive, red to yellowish-red sandy-clay-loams to sandy-clays. The surface soils are slightly acid to neutral and the B-horizons are the base of the profile. Lime commonly occurs at the base of the profile.

Associated with these soils are cemented areas, which result from the erosion of the surface soil and illuviation of clay from the dunes.

CEC values are low in the surface but may increase with depth to 12 m equiv. per 100 g, if clay percentage increases. Ca is the dominant cation, but Na may dominate at depth, when Ca is low. Exchangeable sodium values are extremely high in relation to other cations, particularly in the subsoil. This may be due to leaching of sodium salts, from the dunes through this SMU, leading to replacement of the Ca and Mg cations.

Nutrient levels are extremely low for both N and C with low to very low available P values.

R.P. 197, 211.

Texture contrast soils on undulating plains

Whynot SMU comprises shallow, red, texture contrast soils. It occurs on detrital slopes of the eroded gently undulating to flat Cretaceous sediments.

The soils are porous and easily pulverised, slightly acid, red, sandy-clay-loams overlying a neutral, red, medium clay with moderate, sub-angular-blocky structure. This overlies weathered sandstone.

TSS and Cl levels are low to very low. CEC ranges from 9 m equiv. per 100 g at the surface to 18 m equiv. per 100 g at depth. Ca is the dominant cation. Subsoils are strongly sodic. Fertility levels are low, with low available P, and low C and N levels.

R.P. 23.

Bullawaria SMU comprises shallow to moderately deep, red, texture contrast soils which occur on flat to gently undulating, alluvial fan-plains.

The soils comprise red, loams overlying red, light clays. They are slightly acid to neutral at the surface and alkaline depth. A feature of the soils is that they overlie a hardpan. For this reason they could fall into the classification of red, hardpan soil. The surface soil is characteristically earthy and massive. Some structure may develop in the top few centimetres, due to organic matter. Gravel occurs beneath the surface soil.

TSS and Cl levels are low to very low in the surface, and low to medium in the subsoil. CEC ranges from 8 m equiv. per 100 g in the surface to 14 to 23 m equiv. per 100 g in the subsoil. Ca is the dominant cation although in some profiles Mg may be high. Generally subsoils are sodic. Clay contents are 20 to 25% in the surface and 50 to 60% in the subsoil. Fertility is low, with low available P, and low to very low C and N. Available water is medium to high.

R.P. 209, 143.

Lymbah SMU comprises deep to very deep, red, texture contrast soils occurring on gently sloping alluvial fans.

The soils comprise red, clay-loams (10 to 30 cm) overlying red, light to medium clay subsoils. Surface soils are slightly acid to neutral. The upper parts of the B-horizons are slightly acid to neutral and the base of the profile is generally alkaline.

The surface soil is earthy and may be weakly structured due to organic matter accumulation in the surface. Beneath this, the soil is moderately well structured. Ferruginous gravel is common in the lower parts of the profile.

TSS and Cl values are very low. CEC values are from 9 to 13 m equiv. per 100 g increasing with depth. Ca is the dominant cation in the surface while magnesium becomes dominant in the subsoil. The soil is sodic at the base of the profile. Clay content ranges from 25% in the surface to 40 to 45% in the subsoil. Fertility is fair to low, with fair to low available P and low C and N values.

R.P. 116.

Alluvial soils

Soils in this classification are not necessarily alluvial soils as descrived by Stace *et al.* (1968). Many of these soils have advanced past the juvenile stages and soil forming processes are noticeable. In these soils sedimentary layering in the profile was observed. Profile characteristics vary considerably, but soils developed in this situation have characteristics similar to the parent material source. Profiles range from deep, grey clays with sand intermixed to shallow, earthy, loams with gravel intermixed.

The soils are mainly associated with levees, recent alluvial fans, recent local alluvia, and in some cases flood plains. They are commonly water eroded and wind erosion may cause degradation or agradation.

Coolah SMU is a deep, clay soil with sand bands interspread. It is associated with levee banks of the major drainage lines. This SMU has many of the characteristics of grey clays but it still exhibits sedimentary layering. River bank erosion of these soils is common and is a naturally occurring phenomenon. In most places it has been aggravated by stock movements to water.

The soils are grey to light-brown in colour. Textures are clay throughout although considerable amounts of sand and silt occur as bands in the clay. Surface soil is commonly platy. Beneath this layer, the soil may form blocky structural units. Gravel beds may occur in some profiles.

Farnham SMU is a shallow to moderately deep, texture contrast soil occurring on gently sloping, recent alluvial fans. These fans outwash from the dissected residuals.

Profiles are reddish-brown to yellowish-red in colour. Textures range from sandy-loam to sandy-clay-loam at the surface, to sandy-clay. The surface soil is hardsetting and the top 10 cm is massive. Beneath this, the soils are poorly structured tending to be massive. Profiles are alkaline becoming more alkaline with depth. Gravel and grit are common throughout the profile. Weathered sediments frequently underlie this soil.

TSS and Cl values are very low in the surface, increasing down the profile to low to medium values. CEC values are 9 m equiv. per 100 g in the surface and rise to 16 to 19 m equiv. per 100 g in the subsoil. Ca is the dominant cation. The soil is sodic to strongly sodic. Clay content ranges from 25 to 45%. Fertility levels are low, with low available P levels and low to very low C and N values. Available water is low.

R.P. 78.

Tooratchie SMU occurs mainly on the alluvia of Cooper Creek and is associated with oldman saltbush. Soil material blown up by wind, leaf drop and alluvia contribute to soil formation. This SMU has an uneven surface which is due to mounds forming around the base of both dead and living bushes of oldman saltbush.

The soils are light-yellowish-brown to pale-brown in colour. Medium clays are overlain by varying thickness (10 to 30 cm) of loose, sandy-clay or silty-clay material. A surface crust which cracks is common. Beneath this, the soil may be loose and moderately structured. The sand content of the surface soil varies considerably. Profiles are neutral to slightly alkaline at the surface becoming more alkaline with depth. Gypsum is common in the lower parts of the profile.

TSS values are low to medium but higher than adjacent types. Cl values are low, this being a characteristic of flooded soils. Both TSS and Cl tend to have their lowest values at 30 cm with accumulations in the surface and subsoil. Available P levels are high.

Okena SMU comprises very deep, texture contrast soils associated with recent alluvial material. There is little profile development. They are red to reddish-brown, sandy-loams to loams, (20 to 30 cm) overlying red and brown, sandy-clay-loams to fine-sandy-clay subsoils. Sand-bands are common. Soils are neutral to alkaline at the surface and alkaline at depth. They are poorly structured but may exhibit structure in the subsoil.

R.P. 132, 138.

Tirtywinna SMU is a deep, red, soil occurring on local alluvia originating from red earth and lithosol areas. The unit may be flat or may have shallow eroded channels. Layering is a feature of the surface soil.

The soils are typically red throughout, with some organic staining occurring in the surface soil. Soil reaction varies from slightly acid at the surface to slightly acid to slightly alkaline at depth. Textures are variable but gradually increase with depth. Surface textures range from sandy-clay-loams to clay-loams and textures may increase to light to medium clays at the base of the profile.

The surface soils are hardsetting at the surface. Below this, they are massive and have earthy fabric.

Concretionary ironstone may occur in the profile.

TSS values are medium to high, Cl is low in the surface and rises to very high in the subsoil. CEC values range from 9 to 15 m equiv. per 100 g. Ca is the dominant cation in the surface and decreases down the profile. Mg increases down the profile to become dominant. The soil is sodic at the base of the profile. Clay ranges from 14 to 30%. Fertility is low to very low, with low available P and very low C and N values.

R.P. 129.

Nockatunga SMU comprises shallow to moderately deep, stony, loams and clay-loams occurring on alluvia within the dissected residuals. Intermixed with the alluvia are rock and gravel.

Profiles are red throughout..Textures range from loams to clay-loams to light clays at depth. The soils have hardsetting surfaces and are massive throughout. They have an earthy fabric. Soil reaction trends vary from acid to neutral.

Prairie SMU comprises very shallow soils associated with drainage lines on slopes running out from the dissected residuals. These drainage lines have cut into weathered sediment and appear as a distinctive pattern on aerial photographs.

Soil colour varies from red to light-red. Textures are clay-loams at the surface and clays above the weathered rock. Profiles are slightly acid to neutral. They have weak to moderate-blocky structure.

Red earths

Red earths, as pointed out by Stace (1968), vary considerably in their physical properties. These soils are red to reddish-brown in colour, massive throughout, porous and earthy. They have gradual or diffuse horizon boundaries. The red earths have been sub-divided into two important groups; the loamy red earths which have loamy, hard surfaces, and the sandy red earths which, although massive, have more friable, loose sandy-loam surfaces.

The loamy red earths are formed both on weathered rock and on redistributed earthy detritus. Soil depth varies considerably and the loamy red earth soils have been sub-divided into shallow red earths, which are less than 50 to 60 cm deep, and deep red earths which are greater than 50 cm deep.

The shallow red earths are acid to neutral, loamy in texture and generally exhibit little change in texture down the profile. In the deeper loamy red earths, surface textures range from sandy-loams to clay-loams at the surface with clay content increasing down the profile. Some profiles are relatively uniform throughout.

Ferruginous gravel (up to 1 cm) is common at the base of many profiles and hard, black ironshot is common, both throughout and on the surface of some profiles. Surface stone with both silcrete and ferricrete is common, particularly on the shallow red earths. Whilst hardpans are recorded as a feature of one SMU, in most cases, weathered rock or buried truncated profiles form the base of profiles.

Shallow, loamy red earths

Kulki SMU comprises very shallow, red earths associated with gently undulating to undulating, stony, plains.

Profiles are red throughout and are acid to neutral. Surface textures are predominantly loams to clay-loams. Soils are massive and have earthy fabric. Surface soil is hardsetting and sometimes glazed due to erosion.

Ironstone and ironshot are common in the profile. Both silcrete and ferricrete stone may cover the surface and occur throughout the profile.

TSS and Cl values are very low. CEC values range from 8 to 10 m equiv. per 100 g. Ca is the dominant cation at depth. Clay content ranges from 25 to 30%. Fertility is very low for P, N and C.

R.P. **134.**

Corona SMU comprises shallow, red earths associated with the crests and upper slopes of convex gently undulating plains.

Profiles are red and predominantly acid. Textures are usually loams to clay-loams but on some deeper soils this may increase to light clay at depth. Silcrete stone is intermixed in the profile and a dense silcrete stone cover is a feature of these soils. In places a stone pattern may be evident. These soils overlie weathered sediments. Ferruginous gravel may also occur in the profile.

TSS and Cl values are generally very low throughout the profile. CEC is less than 7 m equiv. per 100 g. Ca is the dominant cation but exchangeable hydrogen may be high. Clay ranges from 20 to 35% with a slight increase down the profile. Fertility is very low with very low to low available P, N and C values. Moisture content is low to medium.

R.P. 3, **25,** 39, 54, **98.**

Coparella SMU comprises shallow to very shallow, red earths on gently undulating plains.

Profiles are red in colour and soil reaction ranges from acid to neutral. Textures are predominantly clay-loams in the surface, increasing in some cases to light clays at depth. The soils are massive throughout with a hardsetting surface. The surface may be glazed due to wind and water erosion. A surface cover of ironshot is common. Ironstone gravel is also common in the profile.

TSS and Cl values are very low. CEC values are less than 8 m equiv. per 100 g. Clay ranges from 20 to 35%. Ca is the dominant cation but exchangeable hydrogen may be high in the surface. Fertility is very low to low for P, N and C. Available water is low to medium.

R.P. **24,** 42, **69,** 79.

Mt. Margaret SMU comprises shallow, red earths, with hardpans, occurring on flat to gently undulating plains.

Profiles are red in colour and soil reaction ranges from acid to neutral. Textures are sandy-clay-loams to clay-loams at the surface and may increase to light clays at the base of the profile. Ironstone gravel is common throughout the profile and increases with depth. These soils are frequently associated with the intergrove area of a mulga grove pattern.

TSS and Cl values are very low. CEC is generally less than 9 m equiv. per 100 g with a few values up to 16 m equiv. per 100 g. Ca is the dominant cation but Mg may be high. Clay ranges from 25 to 40% generally increasing with depth. Fertility levels are low to very low for P, C, and N. Available water levels are medium.

R.P. 111, **114, 115, 148.**

Deep, loamy red earths

Tilkerie SMU comprises moderately deep to deep, red earths. It is associated with redistributed earthy material on gently undulating to flat, plains.

Profiles are red to yellowish-red, acid at the surface, becoming neutral, or in some cases, slightly alkaline at depth. They are sandy-clay-loams to clay-loams at the surface, gradually increasing in texture down the profile to light to medium clays. The soils are massive and earthy throughout, although the surface soil of some profiles exhibit weak pedological organisation when moist. This is due to organic accumulation within the top few centimetres.

Ironstone gravel is common within the profile, generally increasing with depth. Ironshot may occur on the surface of the soils.

TSS and Cl values are very low. CEC are generally less than 9 m equiv. per 100 g with one site reaching 13 m equiv. per 100 g. Ca is the dominant cation. Clay ranges from 30 to 50% increasing down the profile. Fertility is low, with very low available P values and low to fair C and N. Available water is low.

R.P. **1, 59, 179.**

Tinnenburra SMU comprises moderately deep to deep, red earths. It is associated with redistributed earthy detritus occurring on run-on areas.

The soils are similar to *Tilkerie* but generally organic matter is more abundant on the surface. The soils range from sandy-clay-loams to clay-loams at the surface commonly increasing in texture to light to medium clays at depth. The soils are acid to slightly acid at the surface becoming neutral at depth. Depth of the soil varies considerably depending on position within the run-on areas. The surface soil is free of gravel but ferruginous gravel occurs at the base of some profiles.

TSS and Cl values are very low. A wide range of values for both CEC (up to 16 m equiv. per 100 g) and clay (20 to 60%) occurs with values increasing down the profile. In most cases Ca is the dominant cation but Mg becomes dominant at the bases of some profiles. Fertility is low, with low to very low available P levels and low to fair C and N values. Available water is medium.

R.P. 2, **31, 41, 53,** 60, **71, 82, 96.**

Sandy red earths

Napoleon SMU is a deep to very deep, sandy red earth associated with gently undulating to flat ,sandplains. The soils are red and earthy and have acid to neutral soil reaction trend. Textures may be uniform or gradually increase down the profile. Surface texture ranges from sandy-loam to sandy-clay-loam at the surface, to sandy-clay-loams at the base of the profile. The soils are porous and less coherent than the loamy, red earths. Ironstone gravel may occur at the base of some profiles.

The soils are susceptible to wind and water erosion when bare.

TSS and Cl values are very low throughout. CEC is generally less than 5 m equiv. per 100 g but in a few cases reaches 7 to 8 m equiv. per 100 g at the base of the profile. Ca is the dominant cation but there is generally a significant increase in Mg at the bottom of the profile. Clay content range from 15 to 30% generally increasing down the profile. Nutrient levels are low, with low available P, C and N values. K (Potassium) values are low. Available water is low to very low.

R.P. 5, **7, 29,** 30, 77, 99, 101, **106.**

Springvale SMU comprises shallow to moderately deep, sandy red earths associated with flat to gently undulating, sandplains overlying clayplains.

These soils have similar physical characteristics to *Napoleon* SMU. The main differences are that this SMU is shallower, neutral to alkaline at depth and commonly underlain by a hardpan.

Profiles are red to yellowish-red, neutral at the surface and alkaline at depth. Textures range from sandy-loam to sandy-clay-loam and may increase gradually with depth. Ironstone gravel occurs in the lower profile. A ferruginous hardpan forms the base of the profile.

TSS and Cl values are very low with TSS increasing down the profile. CEC values are 6 to 9 m equiv. per 100 g. Ca is the dominant cation increasing down the profile. Clay content ranges from 15 to 30% generally increasing down the profile. Nutrient levels are low, with low to very fair available P levels and low C and N values. Available water is low.

R.P. 72, 73.

Gooyana SMU comprises shallow, sandy red earths associated with the edges of sandplains formed on alluvia.

Profiles are red and neutral, with textures ranging from sandy-loam to sandy-clay-loam. The soils are massive and earthy throughout and the surface is commonly scalded. A hard, indurated, ferrunginous hardpan forms the base of the profile.

TSS and Cl values are very low. CEC is less than 5 m equiv. per 100 g. Ca is the dominant cation. Exchangeable sodium increases with depth. Clay content ranges from 15 to 20%. Nutrient levels are very low to low, with very low to low available P, and very low C and N values. K values are low. Available water is very low.

R.P. 32.

Earthy sands

These soils, derived from aeolian sands, are predominantly red, loose, loamy-sands to sandy-loams with little profile development. In some cases the clay percentage may increase with depth. The soils have an earthy appearance, due to the bridging of sand grains by clayey material and iron-oxides (Stace *et al.* 1967), but are predominantly siliceous in nature. The soils are loose and weakly coherent.

Kotri SMU comprises deep to very deep, red earthy sands associated with low dunes on sandplains.

Profiles are red and neutral throughout. Textures range from loamy-sands to fine-sandy-loams. Surface soil is loose and coherence increases slightly with depth. Organic staining of the surface soil is common.

TSS and Cl values are very low. CEC is less than 3 m equiv. per 100 g. Ca is the dominant cation. Clay ranges from 8 to 10%. Nutrient levels are low, with very low available P, and very low C and N values. K values are low. Available water is very low.

R.P. 12.

Booka SMU comprises deep to very deep, red, earthy sands associated with the lower slopes of low dunes.

Profiles are red, acid to neutral at the surface and alkaline at depth. Textures vary from loamy-coarse-sands to loamy-sands at the surface. Texture may increase with depth to coarse-sandy-loams to sandy-loams. In some profiles clayey-sand bands may occur at the base of the profile. Surface soil is loose and very weakly coherent.

TSS and Cl values are very low. CEC ranges from less than 5 to 10 m equiv. per 100 g, the higher values being associated with increasing clay content. Ca is the dominant cation. Clay content is predominantly in the range 10 to 20%. Fertility levels are low to very low, with low to very low available P, and very low C and N values. Moisture content is very low.

R.P. 93, 103, 220.

Titheroo SMU comprises very deep, red, earthy sands on the extended flanks of dunes.

Profiles are red and slightly acid to neutral throughout. Textures range from loamy-coarse-sands at the surface, to coarse-sandy-loams to coarse-sandy-clay-loams at depth. Some profiles, further down the slope, may be underlain by clayey-sand and have a thin, hard crust. Characteristically, the soils are loose and weakly coherent.

TSS and Cl values are low to very low. CEC values range up to 6 m equiv. per 100 g varying with clay content. Ca is the dominant cation with Mg increasing at depth. Clay ranges from 10 to 20%, increasing down the profile. Fertility is very low, with very low levels of available P, C and N. K is low. Available water is very low.

R.P. 189.

Paroomatto SMU comprises shallow to very shallow, earthy sands occuring on the eroded edge of dunes.

Profiles are red and acid to neutral. Textures are loamy-sands to sandy-loams. A ferruginous hardpan is common. A scalded crust may form on the surface in some situations.

TSS, chloride values and available P, are very low.

R.P. 91.

Mirintu SMU comprises shallow, earthy sands on sandplains.

Profiles are red and slightly acid throughout. Textures range from loose, loamy-sands to sandy-loams. Soils are underlain by a ferruginous hardpan.

TSS and Cl values are very low whilst available P is low.

R.P. 90.

Siliceous sands

These soils derived from aeolian sand are very deep, and loose. They show little profile differentiation. They are associated with the mobile crests and upper slopes of sanddunes.The soils are dominantly quartzose and have a low clay content. They are not coherent. In some situations a clayey-sand band was recorded in the profile. This can be related to the clay core recorded by Whitehouse (1947). Clay content of the soils does not generally exceed 6% except where the clayey-sand band occurs. There are two SMU's in this group the major difference between the soils being colour.

Yanko SMU is a very deep, neutral red, siliceous sand.

All analytical values are very low. Clay content ranges from 2 to 15%. Available water is very low.

R.P. 174, 185, 190, 198, 221, 218.

Chookoo SMU is a very deep, yellow, siliceous sand. It is of limited extent being found mainly as isolated dunes on the Cooper Creek alluvia.

R.P. 206.

Lithosols

The main characteristics of lithosols are that they are shallow soils without horizon development (except for some organic staining in the A1 and limited soil surface structure). There are two SMU in this group, the sub-division into these units being based on the degree of weathering of the underlying rock and position of the unit on the landscape.

Woban SMU comprises very shallow, loamy, lithosols on the pediments of the dissected residuals. Soils are red to reddish-brown. Textures range from sandy-loams to loams. Weathered rock underlie the soils and is commonly actively weathering. Weathered rock is common in the profile. The soils generally have silcrete or ferricrete cover.

R.P. 19, 54, 57, 64, 160.

Grey SMU comprises very shallow, loamy, lithosols associated with weathered rock on the upper slopes of the dissected residuals. Soils are red to reddish-brown in colour, extremely shallow and acid to neutral. Texture ranges from sandy-loam to clay-loam. In one instance a light clay was recorded. Hard weathered rock underlies the soil and is frequently exposed. Silcrete and ferricrete stone is common on the surface of these soils. Organic matter staining may occur in the top few centimetres.

TSS and Cl values are very low. CEC is 6 m equiv. per 100 g and Ca is the dominant cation. Clay percentage is 24%. Nutrient levels are low, with very low available P values and fair to low C and N values.

R.P. 26.

SOIL ANALYSIS

During the course of the survey, a total of 823 samples from 197 profiles were taken for analysis. Representative profiles were analysed in detail. For other profiles and a larger number of surface samples, a less comprehensive set of analyses were undertaken. Summaries of the salient soil chemical features for each of the SMU's are given in the detailed description of these units and representative profiles are listed. Analytical data for sites are given in Appendix III.

The range of values used for ratings such as very high, high etc for each of the soil chemical attributes are listed in Appendix II. Analytical methods used are listed in Appendix IV.

For interpretation purposes the 53 SMU have been grouped into 15 soil groups. Data relating to these 15 groups have been presented as distribution tables to show the median characteristics of the soil groups and the range of values. This characterizes the important soil features of the area. Correlation co-efficients were calculated for a number of soil properties. These results indicate that strong relationships exists between various soil properties. Correlation co-efficients and levels of significance are listed in Table 4.2 and discussed in the relevant section.

Table 4.2. Correlation co-efficients between soil factors (0-10 cm).

Soil Factor	C	TP	AP	BP	% Clay
Group A (Clay soils)					
Nitrogen (N)	0.795***	0.59**			N.S.
Organic C (C)			N.S.		N.S.
Total Phosphorus (TP)			0.623**	0.752***	
Available P (acid) (AP)				0.848***	
Available P (bicarb) (BP)					
Group B (Red earth soils)					
N	0.795***	0.479**			0.708***
C			N.S.		0.646***
TP			N.S.	N.S.	
AP				0.916***	
All Data					
N	0.808***	0.456***			0.289**
C			N.S.		
TP			0.341**	0.414***	
AP				0.877***	

*** 0.1% significance level; ** 1% significance level; * 5% significance level.

The major soil chemical characteristics of the dominant vegetation communities are listed in Table 4.3.

Soil pH

Soil pH for soils in this area ranges from extremely acid (pH 4.1) to very strongly alkaline (pH 9.7). The distribution of pH for the soil groups, for all soils sampled, is set out in Table 4.4. The majority of soils are in the slightly acid to mildly alkaline range (pH 6.1 to 7.8).

The red and brown clays on undulating plains are predominantly neutral to moderately alkaline in the surface. Strongly acid to strongly alkaline horizons are recorded at 60 cm, but most profiles remain slightly acid to mildly alkaline throughout. The red and brown clays on the alluvia are predominantly slightly acid to neutral throughout. The grey clays on alluvia, are usually slightly acid to mildly alkaline at the surface but with a range of soil reaction from strongly acid to very strongly alkaline at 60cm. In these soils, gypsum is associated with a reduction in pH, while $CaCO_3$ is commonly associated with the more alkaline soils.

The texture contrast soils are medium acid to neutral in the surface, with many profiles tending to alkalinity with depth.

Most of the red earths, sandy red earths and lithosols are acid throughout. Many of these soils are strongly acid to very strongly acid in the surface horizons but tend to be less acid at depth. Profiles with moderately alkaline subsoils were recorded in these groups but this alkalinity may be inherited from underlying D-horizons.

The earthy sands and siliceous sands are strongly acid to neutral.

O'Hagan (1966), in a study of mulga soils in western New South Wales found that pH affects microbiological activity. He found that optimum plant calcium levels were reached in mulga seedlings at a soil pH range of 5.8 to 6.1. Under these conditions efficient symbiosis resulted in gains of organic carbon and nitrogen to both the surface and subsurface horizons. This resulted in higher biological activity in the soil.

Table 4.3. Analytical data for soils supporting the major vegetation communities.

Community	No. of Samples	Depth cm	TSS %	Cl %	Org. C %	N %	Tot. P (digest) %	Acid P ppm	Bicarb P ppm	Clay %	CEC m equiv. per 100 g.
Mulga		0-10	**< .01** *	**< .01**	**0.56**	**0.049**	**0.023**	**12**	**11**	**25**	**6**
dominant	64		0.00-0.03	0.00-0.02	0.2-1.3	0.02-0.09	0.011-0.035	5- 43	4-45	8-47	3-15
		20-30	**.02**	**< .01**						**32**	**8**
			0.00-0.21	0.00-0.05						7-64	3-21
		60-120	**.05**	**<.01**						**33**	
			0.01-0.39	0.00-0.19						9-61	
Gidgee		0-10	**0.13**	**0.05**	**0.47**	**0.05**	**0.025**	**38**	**24**	**39**	**15**
dominant	16		0.01-0.90	0.00-0.49	0.3-0.7	0.03-0.07	0.024-0.027	7-109	19-30	18-59	9-27
on		20-30	**0.45**	**0.20**						**45**	**19**
alluvia			0.02-1.99	0.00-1.09						25-55	8-27
		60-120	**0.81**	**0.24**						**44**	**18**
			0.01-2.33	0.00-0.56						24-59	8-25
Gidgee		0-10	**0.05**	**< 0.01**	**0.61**	**0.061**	**0.029**	**26**	**19**	**33**	**17**
dominant			0.01-0.24	0.00-0.01	0.3-1.5	0.02-0.12	0.023-0.034	7- 59	7-40	10-59	6-30
on	18	20-30	**0.51**	**0.19**						**43**	**24**
undulating			0.01-1.54	0.00-0.59						29-50	18-34
plains		60-120	**0.97**	**0.30**						**43**	**26**
			0.45-1.33	0.00-0.58						30-52	20-34
Herbfields		0-10	**0.24**	**0.07**	**0.42**	**0.042**	**0.023**	**23**	**16**	**41**	**24**
on			0.02-0.91	0.00-0.69	0.3-0.5	0.03-0.05	0.021-0.027	7- 81	6-27	13-52	6-36
undulating	12	20-30	**0.53**	**0.22**						**50**	**27**
plains			0.06-1.73	0.00-0.69						43-60	23-36
		60-120	**1.02**	**0.32**						**48**	**29**
			0.68-1.38	0.00-0.54						40-54	23-38
Herbfields		0-10	**0.04**	**< 0.01**	**0.43**	**0.048**	**0.028**	**34**	**34**	**51**	**20**
on			0.01-0.13	0.00-0.02	0.3-0.7	0.03-0.07	0.020-0.036	5-113	8-61	29-65	11-28
alluvia		20-30	**0.33**	**0.15**						**52**	**22**
			0.01-1.28	0.00-0.06						27-64	9-28
		60-120	**0.71**	**0.26**						**46**	**23**
			0.02-1.31	0.00-0.46						**28-62**	11-29

* Bold figures are mean values. Others represent the range of values.

Carbonate

Soft lime and concretionary lime is present in many of the clay and texture contrast soils. Table 4.5 indicates the distribution and amount of carbonate within the soil groups. The table also shows that carbonate is more common at depth than in the surface soil. It supports the conclusion of Jackson (1957) that lime is not as abundant in arid soils as in the soils of the more mesic semi-arid areas.

Field sampling showed that carbonate is more widespread than this table indicates. However, as Hubble and Reeve (1970) note, visible amounts of carbonate and gypsum may occur as isolated, discrete segregations and may be absent from the analysed sample.

Carbonate is most common in the red and brown clays of the undulating downs and in the grey clays, clay pans, scalds and saltpans of the alluvial plains.

The red and brown clays on undulating plains, which are developed on Cretaceous calcareous sediments, contain moderate amounts of carbonate. It is interesting that of the clay soils developed on the alluvia, the red and brown clays contain moderate amounts.

Gypsum

Gypsum occurs in large quantities, usually as a crystalline form, in many of the clay soils. All red and brown clays on the undulating plains, with the exception of the shallow brown clays, have gypsum present in the profile. Approximately 50% of the clay soils formed on alluvial plains have gypsum in some part of the soil profile. The amount commonly increases with depth and is normally associated with a decrease in pH. Gypsum occurs at the base of the profile on limited numbers of texture contrast soils.

In a 1:5 soil/water extraction gypsum does not always reach its theoretical solubility. Large crystals, which are common in these soils, are difficult to dissolve. As a result lower conductivity readings have been recorded in these cases, than would be expected if all the gypsum was dissolved.

Both gypsum and lime may occur together in the profiles.

Nitrogen and organic carbon

Total N (nitrogen) and C (organic carbon) levels in the surface 10 cm are low, with values seldom exceeding 0.1% for nitrogen and 1% for organic carbon. Most values occur in the range of 0.025% to 0.05% for nitrogen and 0.25% to 0.5% for organic carbon. Frequency distributions of C and N for the soil groups are given in Table 4.6 and 4.7 respectively.

Mean organic carbon value for all samples is 0.49%. This is slightly higher than Jackson's (1962)[1] figure of 0.36% for central Australia. Mean total N for all samples is 0.045%. This is higher than Jackson's (1962) figure of 0.039% but lower than Charley and Cowling's (1968) figure of 0.06% for arid areas of New South Wales.

1 Jackson does not specify depth of samples. This may account for variation.

Table 4.4. Frequency distribution of pH for soil groups.

Soil Group	Depth cm	<5	5.1-5.5	5.6-6.0	6.1-6.5	6.6-7.0	7.1-7.5	7.6-8.0	8.1-8.5	8.6-9.0	>9.0
1 Red and brown clays on undulating plains	0-10			1	1	3	3	6	5		
	50-60		1	0	3	2	1	6	1	1	1
2 Red clays (mulga group)	0-10				2	1	1	0	1		
	50-60		1					1	2	1	
3 Red and brown clays on alluvia	0-10			1	2	5	7	1			
	50-60			2	5	4	3				
4 Grey clays on alluvia	0-10			1	6	8	4	2	1	0	0
	50-60		1	1	3	4	4	4	2	1	2
5 Claypans, scalds, and saltpans	0-10				1	4	2	3	0	1	1
	50-60			2	1	1	0	3	3	1	1
6 Desert loams	0-10					1	2				
	50-60				1		1	1			
7 Texture contrast soils on alluvia	0-10		1	2	3	5	0	0	0	1	
	50-60			2	0	1	3	2	0	3	
8 Texture contrast soils on undulating plains	0-10			1	6	2					
	50-60					1	1	2	1		
9 Alluvial soils	0-10			1	3	2	3	2			
	50-60					5	3	2	1		
10 Shallow red earths	0-10	10	8	4	4	6	1				
	50-60	7	2	5	2	4					
11 Deep red earths	0-10	7	2	2	4						
	50-60	2	1	3	5	2	1	0	1		
12 Sandy red earths	0-10	4	3	3	2						
	50-60	4	3	1	1	1	0	0	1		
13 Earthy sands	0-10		2			5	1				
	50-60		1		1	3	1				
14 Siliceous sands	0-10		1		1		1				
	50-60		1	1		1					
15 Lithosols	0-10	3	2		4	1					
All soils	0-10	24	19	16	41	40	25	14	7	2	1
	50-60	13	11	17	22	29	18	21	12	7	4

Those soils which have higher C and N values commonly support either mulga, gidgee, or bendee, these species belonging to the genus *Acacia*, a member of the Leguminosae family. These species are commonly associated with red earths, and red, brown and grey clays. Extremely low values are recorded in the earthy sands and siliceous sands. The data for the major vegetation communities (Table 4.3) indicate that whilst the mulga and gidgee communities on undulating plains have the highest C and N levels they also have the widest range of values. The herbfield and gidgee on the alluvial plains have less variable values.

The C/N ratio for all soils, with the exception of the siliceous sands and lithosols, ranges from 6 to 17 with a mean value of 10.8. Approximately 50% of the values are within the range 10 to 12. Mean C/N values for soils developed on alluvia are lower than those occurring on undulating plains. Hubble and Reeve (pers. comm.), drawing conclusions from data they collected in Western Queensland, state that C/N ratio decreases with increasing aridity. Our data does indicate this trend to lesser degree. This relationship is probably masked by the limited range of aridity in this survey area and the large number of sites receiving run-on water.

There is a general trend for both N and C values to decrease with increasing aridity. The main exceptions are those sites in more favourable moisture situations. There was a significant correlation between organic carbon and rainfall (organic carbon = 0.0023 rainfall (mm) - 0.081).

In arid areas, small falls of rain may not initiate plant growth but may activate breakdown of organic matter by soil micro-organisms thus releasing nitrogen in the available ammonium and nitrate forms. When moisture storage is sufficient to initiate plant growth, this available nitrogen is utilised causing a flush of plant growth. This reduces the mineral nitrogen pool and in a series of good seasons large amounts of the nitrogen reserves may be tied up in an organic form, both in the soil organic matter and in the plant. The breakdown of soil organic matter and litter is an important process in nutrient availability. The survival and health of soil micro-organisms involved in this process is dependent of adequate levels of organic matter being present in the soil. Organic matter through its favourable effect on soil structure and in turn on soil porosity increases the capacity of soil to retain water.

Organic matter values are already low and animal management practices leading to overgrazing or erosion, may further reduce these levels, thus lowering moisture retention and nutrient recycling.

In the red earth soils a highly significant correlation ($r = 0.71$***) was found between total N and percent clay at 0 to 10 cm. The nitrogen increase with increase in clay is probably related to greater biological activity as a result of increased available moisture and nutrient retention.

Due to the low levels of total nitrogen, productivity of improved species of grasses sown in favourable situations, such as run-on areas, may be reduced by lack of available nitrogen at certain periods.

Table 4.5. Distribution of % $CaCO_3$ for soil groups.

Soil Group	Depth cm	% $CaCO_3$			
		< 0.2	0.2-1.0	1.1-2.0	2.1-5.0
1 Red and brown clay on undulating plains	0-10	15	1	3	–
	50-60	9	–	7	1
2 Red clays (mulga group)	0-10	5	–	1	–
	50-60	2	3	1	–
3 Red and brown clays on alluvia	0-10	16	–	–	–
	50-60	14	1	–	–
4 Grey clays on alluvia	0-10	19	1	2	–
	50-60	15	1	6	–
5 Claypans, scalds and saltpans	0-10	8	2	1	1
	50-60	6	–	3	3
7 Texture contrast soils on alluvia	0-10	11	1	–	–
	50-60	7	3	–	1
8 Texture contrast soils on undulating plains	0-10	9	–	–	–
	50-60	4	–	1	–
9 Alluvial soils	0-10	11	–	–	–
	50-60	10	1	–	–
All soils	0-10	94	5	7	1
	50-60	67	9	18	5

Non-leguminous crops under irrigation, or plants growing on waterspreading schemes, may suffer from nitrogen deficiency. This would result in reduced efficiency of water use. Nitrogen fertilizer may be required in these situations, particularly after initial development.

Table 4.6. Frequency distribution of % organic carbon (0-10 cm) for soil groups.

Soil Group	< 0.25	0.26-0.5	0.6-0.75	0.76-1	>1	Mean
1 Red and brown clays on undulating plains		10	3	0	1	0.54
2 Red clays		4				0.43
3 Red and brown clays on alluvia		5	2			0.49
4 Grey clay on alluvia		11	3	1		0.46
5 Claypans, scalds and saltpans	1	10				0.38
6 Desert loams		3				0.40
7 Texture contrast soils on alluvia	2	4	2			0.41
8 Texture contrast soils on undulating plains		8	0	1		0.44
9 Alluvial soils		5				0.38
10 Shallow red earths		9	4	3		0.55
11 Deep red earths		3	4	2	2	0.73
12 Sandy red earths		8	2	1		0.49
13 Earthy sands	5					0.20
14 Siliceous sands	3					0.13
15 Lithosols	1	1				0.25
All soils	12	81	20	8	3	0.49

Phosphorus

Available P (phosphorus) determinations (0.01 N H_2SO_4 extraction) were made on the 0 to 10 cm of all soils sampled and on 120 selected profile samples at 20, 30, 60 and 120 cm. Available P (0.5 M $NaHCO_3$ extraction) determinations were completed for the 0 to 10 cm on these selected profiles. P determinations were made at 0 to 10 cm and at the base. Where soils are deeper than 120 cm the 110 to 120 cm sample has been taken to represent the base of the profile. Phosphorus determinations were made by X-ray fluorescence and also by digestion with boiling HCl after ashing.

Table 4.7. Frequency distribution of % total nitrogen (0-10 cm) for soil groups.

Soil Group	< 0.025	0.025-0.05	0.06-0.07	0.07- 0.1	>0.1	Mean
1 Red and brown clays on undulating plains	1	9	3	0	1	0.05
2 Red clays (mulga group)		3	1			0.04
3 Red and brown clays on alluvia		4	3			0.05
4 Grey clays on alluvia		8	7			0.05
5 Claypans, scalds and saltpans	2	9				0.03
6 Desert loams		3				0.03
7 Texture contrast soils on alluvia	2	4	1			0.04
8 Texture contrast soils on undulating plains	1	7	0	1		0.04
9 Alluvial soils		5				0.04
10 Shallow red earths		9	3	3		0.06
11 Deep red earths		5	2	2		0.06
12 Sandy red earths	1	8	1			0.04
13 Earthy sands	3	2				0.02
14 Siliceous sands	3					<0.01
15 Lithosols		1			1	0.07
All soils	13	77	21	6	2	0.045

Table 4.8. Frequency distribution of % P* for soil group.

Soil Group	Depth	< 0.01	0.01-0.02	0.021-0.03	0.031-0.04	0.041-0.05	>0.05	Mean
1 Red and brown clays	0-10			2	1 (3)			0.027
on undulating plains	110-120			2	(2)	1	(1)	0.030
2 Red clays	0-10		3	1 (2)	(1)	(1)		0.020
(mulga group)	110-120		3	1 (2)	(1)	(1)		0.019
3 Red and brown clays	0-10		1	3 (1)	(3)			0.023
on alluvia	110-120		2	3 (3)	(1)			0.021
4 Grey clays	0-10			2	3	(2)	(3)	0.031
on alluvia	110-120		3	3 (1)	1	(4)		0.022
5 Claypans, scalds	0-10		3	1	(2)	(1)		0.020
and saltpans	110-120		2	1 (1)	1 (1)	(1)	(1)	0.025
6 Desert loams	0-10			1		(1)		0.021
	110-120			1	(1)			0.024
7 Texture contrast soils	0-10		1	2	1	(1)	(2)	0.025
on alluvia	110-120		1	1 (1)	1	1 (2)		0.029
8 Texture contrast soils	0-10		1	4	3 (2)	(4)	(2)	0.026
on undulating plains	110-120		1	6 (1)	(5)			0.023
9 Alluvial soil	0-10		1	2	(1)	1 (2)	(1)	0.027
	110-120			1	2 (2)	(1)	(1)	0.029
10 Shallow red earths	0-10		5	7 (2)	2 (3)	1 (7)	(3)	0.024
	Base		2 (1)	6 (2)	1 (4)	(1)	(1)	0.023
11 Deep red earths	0-10		3 (1)	5 (1)	3 (1)	(4)	(2)	0.025
	110-120		6 (3)	3 (3)	1 (4)			0.019
12 Sandy red earths	0-10		5	6 (2)	(5)		(2)	0.020
	110-120	1	9 (4)	1 (5)	(2)			0.016
13 Earthy sands	0-10	1 (1)	4	1 (1)	(2)	(1)		0.016
	110-120	1	5	(3)	(2)			0.012
14 Siliceous sands	0-10		2	(1)				0.014
	110-120		2 (1)	(1)				0.012
15 Lithosol	0-10		1	1		(1)		0.026
	Base		1	(1)				0.018
All soils	0-10	1 (1)	30 (1)	38 (10)	13 (23)	2 (25)	(13)	0.023
	Base or 110-120	2	37 (8)	29 (24)	7 (25)	2 (10)	(4)	0.021

* Numbers in brackets refer to P by X-ray flourescence. Other numbers are P by digest.

When results for P from the X-ray fluorescence method and digest methods were compared, highly significant correlations were achieved for both the 0-to 10 cm horizon ($r_{74} = 0.747$***), and the base ($r_{74} = 0.801$***).

As expected, higher values were obtained for P using X-ray fluorescence than the digest method. In the 0 to 10 cm layer, mean values for the red earths were 0.04% as against 0.023% and cracking clays 0.038% against 0.025%.

Mean values for all soils were 0.041% by X-ray fluorescence (0.023% digest) at 0 to 10 cm and 0.032% (0.021% digest) at the base of the profile.

When digest P was correlated with available P (acid extraction) for 0 to 10 cm it was found that a correlation did exist for the cracking clay soils group (r = 0.623***) but not for the red earth group. This, together with the fact that available P is much lower on the red earth group (13 ppm) than on the cracking clay soils (38 ppm), despite the fact that levels of digest P (red earths 0.022%, clays 0.025%) are similar, indicates that on the red earths, P may be unavailable due to formation of insoluble inorganic and organic compounds.

There is a strong correlation between available P (acid extraction) and available P (bicarbonate extraction) for the cracking clay soil (r = 0.848***), red earth soils (r = 0.916***) and all soils (r = 0.877***).

There appears to be a relationship between available P (acid) available P (bicarb) and pH. Generally the more alkaline a soil the lower the bicarbonate extractable P is, in relation to acid extractable P.

Jackson (1962), Charley and Cowling (1968) and others, have reported that phosphorus levels for soils of arid Australia are lower than those recorded in other countries. In this area, soils contain between 0.01% and 0.05% digest P, with means of 0.023% for the surface and 0.021% for the subsoil. This is consistent with both Jackson's (1962) and Charley and Cowling's (1968) results. A limited number of coarser textured soils have values slightly less than 0.01% for digest P. Table 4.8 shows the frequency distribution of % P at 0 to 10 cm and in the subsoil (either the base of the soil profile or 110 to 120 cm) for the various soil group. Results are presented for P by X-ray fluorescence and digest P.

Approximately 70% of cracking clay soils have digest P values greater than 0.02% at the surface while only 50% of the red earth soils have levels greater than 0.02%. At the base of the profile 55% of the cracking clays and 30% of the red earthy soils have values higher than 0.02%. The figures also indicate that the fresh Cretaceous sediments, in this area which form the parent material for red and brown clay soils on undulating plains, may have low values.

Table 4.9 shows the distribution of available P within the soil groups in the 0 to 10 cm layer. Figure 4.1 shows the distribution of mean available P at sample depths for the soil groups.

Table 4.9. Frequency distribution of available phosphate* ppm (0-10 cm) for soil groups.

Soil Group	<5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	>45	Mean
1 Red and brown clays on undulating plains		3	5	3	1	2	2	1		2	25
2 Red clays (mulga group)		4		1							8
3 Red and brown clays on alluvia	2	2	2	3	1			2	3	1	25
4 Grey clays on alluvia			2	2	3	2	4	3		6	43
5 Claypans, scalds and saltpans		1		1	1		1	2		6	49
6 Desert loams		1	1					1			19
7 Texture contrast soils on alluvia		2	3	1		1	1			4	29
8 Texture contrast soils on undulating plains		2	2	2	2	1					17
9 Alluvial soils		1	1	4		1	1		1	2	28
10 Shallow red earths	2	12	10	2	3	1					12
11 Deep red earths	2	8	3	1	1						10
12 Sandy red earths	1	3	4	3					1		15
13 Earthy sands		4	1	1	1			1			15
14 Siliceous sands		3									7
15 Lithosols	1	5	2		1					1	15
All soils	8	51	36	24	14	8	9	9	5	22	18

* Acid extraction.

The grey clays have higher values of both P and available P than most soil groups. In the grey clay group, 14% of the digest P is in the available P form at 0 to 10 cm and 20% at the base of the profile. At the other end of the scale are the red earths, earthy sands and siliceous sands. The deep red earths have 4% of digest P in the available form in the surface 10 cm, and 2% at the base of the profile. This group of soils accumulates available P in the surface soil. In the red earths the surface 10 cm contains 10 ppm of available P whereas at the base of the profile only 3 ppm P is present as available P.

Charley and Cowling (1968) noted this characteristic in New South Wales soils. They pointed out that not only is there a marked superficial build-up of some nutrients in the surface soil, but those soils at the poor end of the fertility spectrum show greater proportional accumulation in the topsoil. This characteristic is apparent in Figure 4.1.

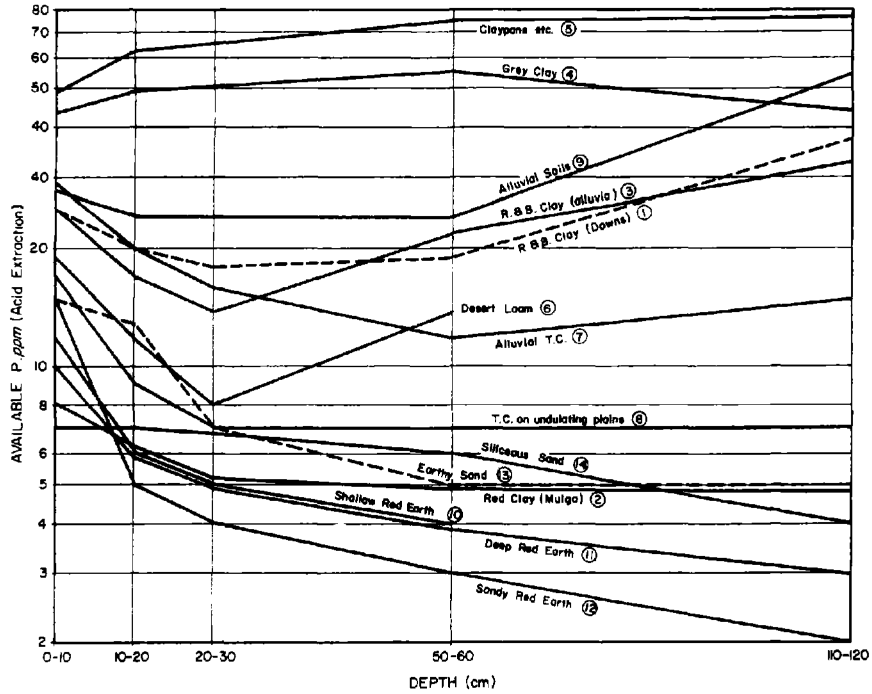


Fig. 4.1. *Mean values of available P, at sample depths, for the soil groups.*

The red and brown clays of the undulating plains, supporting gidgee and herbfield vegetation have moderate levels of available P and 9% of digest P in the available form at 0 to 10 cm and 13% at the base of the profile. The red clays, supporting mulga tall open shrubland, have low available P levels and only 4% of digest P in the available form at 0 to 10 cm and 3% at the base of the profile.

A highly significant correlation (r 0.46***) exists between total N and digest P (0 to 10 cm) for all sites. Charley and Cowling (1968) have shown that P plays an important role in determining the extent of nitrogen build-up in soils, at least within certain climatic limits.

O'Hagan (1966), Cowie (1968) and Christie (1970) show P as the main nutrient limiting plant growth in mulga soils. Christie (1970) indicates that 25 ppm available P is the critical level for buffel grass growth. O'Hagan (1966) showed that a significant correlation existed between digest P and stem dry matter production by mulga seedlings. Phosphorus fertilizer may be required to grow an economic crop and establish improved pastures under irrigation or waterspreading projects on those soils other than the cracking clays.

Higher calving rates and survival rates in beef cattle grazing on mulga soils have been demonstrated by phosphate supplementation through drinking water (Weller pers. comm.).

Available moisture

Available moisture was determined in the laboratory by calculating the difference in moisture held at 1/3 bar, and 15 bar.

The available moisture capacity figures for a number of selected profiles within the soil mapping units is listed in Table 4.10. This, however, may not be a true indication of available moisture. Winkworth (1973) has shown plants in this environment have the capacity to extract water held at higher pressures than 15 bar.

Available moisture ranges from less than 3% for the siliceous sands to 19% for some clay soils.

The ability of soils to store moisture may be limited by poor surface physical conditions, reducing water entry. The siliceous sands and earthy sands when moistened readily accept water and store moisture to considerable depth. However, the texture contrast soils and some clay soils have poor surface conditions, such as hardsetting, crusting and sealing characteristics, which restrict penetration under certain conditions. The red earths, whilst massive when dry, become friable, when moist, and readily accept water. Cracking of clay soils may facilitate water entry to the subsoil. This is particularly important on the flooded alluvial plains where surface cracks in the grey clays may be more than 10 cm wide. Once cracks close infiltration may be drastically reduced.

The laboratory determination provides a less reliable measurement of moisture available to plants in soils of high salinity because it does not take account of the effects osmotic concentration on soil water potential.

Allen (1963) at Cunnamulla noted that moisture did not penetrate below 75 cm on heavy clay soils. This is consistent with Brigg's (pers. comm.) findings, that under favourable conditions moisture did not penetrate below 1 m in a similar grey clay at Emerald. In most cases moisture does not penetrate below 60 cm. Jessup (1969) noted that "in saltbush country on desert loams, the distribution of salts down the profile shows that there is no significant water movement in the uneroded soils below depths of between 45 and 60 cm and in the 'scalds' below depths of 3 to 15 cm. Measurements of the amount of water held in the soils at field capacity, considered in relation to the rainfall regime support this conclusion".

Alizai and Hulbert (1970) found, under semi-arid conditions, that most rains do not wet soils to the bottom of the root zone, and then the amount of moisture available to plants is determined by evaporation and not by storage capacity. They found that when deep wetting occurs, heavier textured soils with greater storage are favoured, while shallow wetting favours lighter textured soils which have lower evaporative losses. Their findings were that more water evaporates from fine textured soils than coarse textured soils. This supports the hypothesis that differences in evaporation may help explain the more mesic vegetation on coarse than on fine textured soils in these areas, particularly after rain periods.

Jones (1969), at Hay, noted that the limited effectiveness of isolated summer rains for plant growth, is due to high evaporation rates and the requirement to wet soil back to wilting point before pasture growth recommences.

Table 4.10. % available moisture * for representative soils in soil groups.

Soil Group	Site	Comment	% Available Moisture 0-10 cm	20-30 cm	50-60 cm or base
1 Red and brown clays on undulating plains	A 80	Shallow, gidgee tall open shrubland	6	–	–
	A162	Undulating stony downs	14	15	15
	A167	Undulating soft downs	15	16	16
2 Red clays (mulga group)	A149		N.A.	13	15
3 Red and brown clays on alluvia	A 22	Shallow, gidgee	8	9	8
	A163	Local alluvia on undulating downs	11	13	12
	A177	Herbfield	N.A.	13	16
	A202	Herbfield	13	15	14
4 Grey clays on alluvia	A 11	Gidgee low open woodland	N.A.	18	19
	A 15	Gidgee (puff)	10	13	11
	A 16	Bluebush swamp	13	13	13
	A 67	Yapunyah open woodland	N.A.	10	13
	A127	Gidgee tall open shrubland	13	11	12
	A209	Channel country	12	13	13
5 Claypans, scalds and saltpans	A 66	Claypan	9	12	11
	A 92	Canegrass claypan	10	13	11
	A105	Saltpan, samphire	5	12	15
	A172	Scald	N.A.	13	14
6 Desert loam	A214	Herbfield	7	11	N.A.
7 Texture contrast soils on alluvia	A 6	Poplar box, mulga	7	4	7
	A 68	Yapunyah, gidgee	13	12	10
	A 87	Gidgee tall open shrubland	5	7	9
	A140	Gidgee, coolibah	8	9	13
	A176	Mulga sand ridge	5	9	–
	A197	Mulga sand ridge	3	3	4
	A211	Mulga, whitewood	N.A.	2	8
	B 1	Poplar box, mulga	12	10	12
	B 2	Mulga, poplar box	8	7	7
8 Texture contrast soils on undulating plains	A 57	Shallow	6	6	
	A109	Mulga tall open shrubland	9	11	13
	A143	Sparse vegetation	10	9	11
9 Alluvial soils	A 33	Herbfield	8	10	11
	A 78	Local alluvia	5	8	6
	A132	River red gum fringing woodland	10	8	10
10 Shallow red earths	A 3	Rock grass, mulga tussock grassland	N.A.	8	8
	A 39	Mulga tall open shrubland	7	9	–
	A 69	Mulga tall open shrubland	9	–	–
	A 89	Mulga tall open shrubland	6	–	–
	A114	Mulga tall open shrubland	10	11	10
11 Deep red earth	A 1	Mulga tall shrubland	6	5	6
	A 31	Mulga low woodland	4	6	8
	A 53	Mulga open scrub	6	6	5
	A 60	Mulga, poplar box	9	6	4
	A 82	Mulga, open scrub	9	8	9
	A179	Mulga, poplar box	6	5	7
12 Sandy red earths	A 29	Mulga tall open shrubland	3	5	5
	A 32	Poplar box, budda bush	4	4	5
	A 72	Mulga, poplar box	7	6	4
	A 77	Mulga tall open shrubland	5	3	3
13 Earthy sands	A 12	Mulga tall open shrubland	3	3	3
	A 88	Budda bush, hop bush	3	3	3
	A 90	Mulga, western bloodwood	4	3	3
	A 93	Herbfield	3	3	4
	A103	Mulga tall open shrubland	3	3	6
	A189	Spinifex hummock grassland	4	3	3
14 Siliceous sand	A174	Whitewood, bluebush pea	3	3	3
	A218	Mulga tall open shrubland	N.A.	3	3
15 Lithosols	A 26	Bendee, lancewood	8	–	–
	A134	Bastard mulga	7	8	–

* Calculated by difference of moisture held at 1/3 bar and 15 bar.

Soluble salts

The distribution of both % Cl (chloride) and % TSS (total soluble salts) for the soil groups are shown in Tables 4.11 and 4.12 respectively. The clay soils and texture contrast soils commonly have the high values whilst the red earths have low values. TSS and Cl generally increase with depth in all the soil groups. Chloride values commonly reach a maximum before 120 cm depth.

Table 4.11. Frequency distribution of % chlorides for soil groups.

	Soil Group	Depth cm	.01-.02	.02-.04	.05-.08	.09-.16	.17-.32	.33-.64	.65-1.28	>1.28
1	Red and brown clays on undulating plains	0-10	14	2	1	1		1		
		50-60	2				7	8		
2	Red clays (Mulga group)	0-10	5	1						
		50-60	1	4	1					
3	Red and brown clays on alluvia	0-10	15					1		
		50-60	2	2	3	2	3	3	1	
4	Grey clays on alluvia	0-10	17	4			1			
		50-60	7	1	2	2	5	3	2	
5	Claypans, scalds and saltpans	0-10	6	2		1	1	1		1
		50-60	3		2	2	1	2	2	
6	Desert loams	0-10	2					1		
		50-60	1		1			1		
7	Texture contrast soils on alluvia	0-10	11	1						
		50-60	7	2		2				
8	Texture contrast soils on undulating plains	0-10	9							
		50-60	2		1	1		1		
9	Alluvial soils	0-10	9	2						
		50-60	7	1	1		1		1	
10	Shallow red earths	0-10	29	1						
		50-60	8							
11	Deep red earths	0-10	15							
		50-60	15							
12	Sandy red earths	0-10	12							
		50-60	10							
13	Earthy sands	0-10	8							
		50-60	7							
14	Siliceous sands	0-10	3							
		50-60	3							
15	Lithosols	0-10	9	1						
	All soils	0-10	174	13	1	2	2	4		1
		50-60	75	10	11	8	17	18	6	

The red and brown clays on the undulating plains have very high Cl levels at 60 cm. The red and brown clays, grey clay and claypans on alluvia may also have high Cl value, but have a wide range of values. The texture contrast soils and alluvial soils, with the exception of a number of sites, have low Cl values. The undulating texture contrast soils have higher values at depth. The red earth soils all have low values.

A similar situation occurs with TSS. In these results the factor of 375 (Piper 1942) was used to convert conductivity to TSS. Those soils which have varying salt composition and high gypsum levels would require a different factor from Piper's to obtain accurate results. As an example, a soil containing NaCl as the principal salt would have a factor of 280 while a $CaSO_4$ dominated soil would require a factor of 450.

Leaching is low on many soils in the area, particularly the clays, due to limited water penetration. A build-up of salt below 30 cm is common in the fine textured soils. The frequently flooded grey clays associated with the "channel country" are an exception to this.

Hubble and Reeve (1970) have noted that high salinity in soil profiles in Western Queensland is associated with the presence of gypsum rather than Cl and occurs more in, or adjacent to, upland situations.

In those profiles with high salt levels, particularly in the surface soil, halophytic or salt tolerant vegetation has developed; the best example of this being samphire on saltpans. Jessup (1969) has shown that some plants, particularly saltbushes, can accumulate salts in the topsoil under their canopies. This is a result of leaf drop from plants with higher than normal levels of sodium chloride accumulations in the leaves. This significant build-up causes considerable physical changes in the soil.

Cations

Cation exchange capacity (CEC) and the major exchangeable cations have been determined for all detailed profiles.

CEC

The distribution of CEC per 100 g clay for each of the soil groups is recorded in Table 4.13. The red and brown clays of the undulating plains have high values, 35% having values higher than 50 m equiv. per 100 g of clay. This would indicate that montmorillonite is the dominant clay type. The red clays, supporting mulga, have lower values and would probably be made up of mixed montmorillonite and kaolonitic clay types.

Table 4.12. Frequency distribution of % total soluble salts (1:5 extract) for soil groups.

Soil Group	Depth cm	0.1	.02-.05	.06-.10	.11-.15	.16-.30	.31-.50	.51-1.0	1.0
1 Red and brown clays on undulating plains	0-10		10	4	1	2	0	2	
	50-60			1	0	0	2	9	4
2 Red clays (Mulga group)	0-10	5	1						
	50-60	1	4	1					
3 Red and brown clays on alluvia	0-10	2	11	2	0	0	0	1	
	50-60		2	1	3	1	5	1	3
4 Grey clays on alluvia	0-10	2	13	2	2	2	1		
	50-60		3	3	1	1	1	9	4
5 Claypans, scalds and saltpans	0-10		6	1	1	1	1	0	2
	50-60		1	0	0	1	0	2	6
6 Desert loams	0-10		1	1				1	
	50-60			1		1		1	
7 Texture contrast soils on alluvia	0-10	7	2	2	1				
	50-60	3	4	2	0	1	1		
8 Texture contrast soils on undulating plains	0-10	5	3	1					
	50-60	1	1	0	1	0	1	1	
9 Alluvial soils	0-10	5	3	1	2				
	50-60	2	4	1	1	1	1	0	1
10 Shallow red earths	0-10	16	13	0	1				
	50-60	3	5						
11 Deep red earths	0-10	12	3						
	50-60	11	4						
12 Sandy red earths	0-10	11	1						
	50-60	4	6	1					
13 Earthy sands	0-10	5	3						
	50-60	6	1						
14 Siliceous sands	0-10	1	2						
	50-60	3							
15 Lithosols	0-10	5	4	1					
All soils	0-10	76	76	15	8	5	2	4	2
	50-60	39	37	11	6	6	11	21	18

These values indicate that some soils in the red and brown clays, grey clays and claypans on alluvia have dominantly montmorillonitic type clay. The other clays, the texture contrast soils and alluvial soils are of mixed montmorillonitic/kaolonitic clay types.

The red earths and earthy sands mainly have values less than 30 m equiv. per 100 g of clay and are predominantly kaolonitic type clays.

It is difficult to obtain accurate figures for soils with low CEC. The values are meaningless when related to percentage clay for very low clay soils. For this reason the earthy sands and siliceous sands are omitted from Table 4.13. This applies to a lesser extent to the sandy red earths.

Exchangeable cations

Calcium is the dominant cation in all groups. On the red clays, supporting mulga, and the texture contrast soils on alluvia, magnesium values approach the calcium values. Table 4.14 indicates the relative importance of exchangeable calcium and magnesium for the major soil groups.

The exchangeable calcium and magnesium levels of the surface 10 cm of the deep red earths indicate a satisfactory plant nutrition level for these elements. In the shallow red earths and sandy red earths the lower calcium and magnesium status could indicate deficiency levels. Cowie (1968) showed calcium deficiency in the presence of applied phosphorus on red earths.

The distribution of exchangeable potassium values for each soil group in the surface 10 cm and at 50 to 60 cm is given in Table 4.15. Considering all soils, 90% have exchangeable potassium values greater than 0.4 m equiv. per 100 g of soil. Only one soil (a siliceous sand) has a surface value less than 0.2 m equiv. per 100 g, the value which Crack and Isbell (1970) consider a critical plant deficiency level.

Table 4.13. Frequency distribution of CEC per 100 g. clay for soil groups.

Soil Group	Depth cm	m-equiv. per 100 g. clay 10-30	30-50	50-70	>70
1 Red and brown clays on undulating plains	0-10		2	11	1
	20-30		1	10	2
	50-60		3	8	2
2 Red clay (mulga group)	0-10		2		
	20-30		2		
	50-60		2		
3 Red and brown clays on alluvia	0-10	1	4	1	
	20-30		5	1	
	50-60		4	1	
4 Grey clays on alluvia	0-10	1	13	1	
	20-30		13	2	
	50-60	1	14		
5 Claypans, scalds and saltpans	0-10		10	2	
	20-30		10	1	
	50-60		11	1	
6 Desert loams	0-10		1	2	
	20-30		1	2	
	50-60		1	2	
7 Texture contrast soils on alluvia	0-10		7	1	
	20-30	1	6	1	
	50-60	1	5	2	
8 Texture contrast soils on undulating plains	0-10	2	7		
	20-30	1	4	1	
	50-60	1	1	2	
9 Alluvial soils	0-10		5		
	20-30		5		
	50-60	1	3	1	
10 Shallow red earths	0-10	12	3		
	20-30	10	2		
	50-60	6		1	
11 Deep red earths	0-10	10	1		
	20-30	11			
	50-60	10	1		
12 Sandy red earths	0-10	10	1		
	20-30	10	1		
	50-60	9	1		

Table 4.14. Mean values of Ca /CEC and Mg /CEC for some soil groups.

Soil Group	Depth cm	Ca /CEC	Mg /CEC
1 Red and brown clays on undulating plains	10	0.64	0.35
	30	0.85	0.40
	60	1.35*	0.458
2 Red clays (mulga group)	10	0.52	0.43
	30	0.56	0.42
	60	0.60	0.41
3 Red and brown clays on alluvia	10	0.54	0.36
	30	0.54	0.37
	60	0.53	0.39
4 Grey clays on alluvia	10	0.64	0.32
	30	0.99	0.32
	60	1.26	0.32
5 Claypans, scalds and saltpans	10	0.63	0.31
	30	0.71	0.37
	60	0.87	0.39
6 Desert loams	10	0.70	0.35
	30	0.97	0.28
	60	0.74	0.28
7 Texture contrast soils on alluvia	10	0.54	0.23
	30	0.59	0.29
	60	0.59	0.32
8 Texture contrast soils on undulating plains	10	0.57	0.27
	30	0.55	0.35
	60	0.54	0.39
9 Alluvial soils	10	0.72	0.26
	30	0.61	0.25
	60	0.72	0.32
10 Shallow red earths	10	0.35	0.19
	30	0.41	0.27
	60	0.45	0.34
11 Deep red earths	10	0.47	0.21
	30	0.45	0.27
	60	0.53	0.36
12 Sandy red earths	10	0.28	0.11
	30	0.41	0.19
	60	0.50	0.19

* Ca /CEC ratios may be artificially high when gypsum is present.

Table 4.15. Frequency distribution of exchangeable potassium for some soil groups.

Soil Group	Depth cm	m equiv. per 100 g.				
		< 0.2	0.2-0.4	0.41-0.8	0.81-1.6	1.61-3.2
1 Red and brown clays	0-10			2	8	4
on undulating plains	50-60		3	8	2	
2 Red clay	0-10			1	2	1
(mulga group)	50-60			2	2	
3 Red and brown clays	0-10			2	5	
on alluvia	50-60		1	6		
4 Grey clays	0-10			5	6	4
on alluvia	50-60		4	2	9	
5 Claypans, scalds	0-10		2	1	8	1
and saltpans	50-60	2	1	1	8	
6 Desert loams	0-10			2	1	
	50-60		1	1	1	
7 Texture contrast soils	0-10		1	6	1	
on alluvia	50-60	1	2	3	2	
8 Texture contrast soils	0-10		1	8		1
on undulating plains	50-60		2	1	2	
9 Alluvial soils	0-10		1	1	3	
	50-60	2		2	1	
10 Shallow red earths	0-10		2	7	8	
	50-60	1	2	8	3	
11 Deep red earths	0-10			6	5	
	50-60		1	6	4	
13 Earthy sands	0-10		3	2		
	50-60		3	1	1	
14 Siliceous sands	0-10	1	2			
	50-60	2		1		
15 Lithosols	0-10		1	1		
All soils	0-10	1	13	44	47	11
	50-60	8	20	42	35	

Table 4.16. Frequency distribution of exchangeable sodium percentage (ESP) for some soil groups.

Soil Group	Depth cm	< 6	6.1-10	10.1-15	15.1-20	> 20	Mean
1 Red and brown clays	0-10	4	9	1			6.6
on undulating plains	20-30	1	2	6	1	3	14.2
	50-60	1		2	6	4	19.1
2 Red clay	0-10	4					1.7
(mulga group)	20-30	4					2.5
	50-60	4					3.3
3 Red brown clays	0-10	3	4				5.7
on alluvia	20-30	1	2	3			8.8
	50-60		2	3			9.3
4 Grey clays	0-10	9	4	1	1		6.2
on alluvia	20-30	4	4	4	1	2	9.2
	50-60	1	2	4	4	4	15.6
5 Claypans, scalds	0-10	3	1	3	2	3	15.3
and saltpans	20-30	2	2	2		6	23.4
	50-60	2	1	1	1	7	20.7
6 Desert loams	0-10	2		1			
	20-30		2	1			
	50-60		1	2			
7 Texture contrast soils	0-10	6	1	1			3.7
on alluvia	20-30	6				2	11.4
	50-60	3	2	1		2	16.2
8 Texture contrast soils	0-10	7	2				3.5
on undulating plains	20-30	3	1	2			7.3
	50-60	3	1	1			6.9
9 Alluvial soils	0-10	4	1				3.9
	20-30	2	1	2			6.9
	50-60	1	3	1			8.0
10 Shallow red earths	0-10	16		1			2.9
	20-30	11	3				4.3
	50-60	6	1				4.1
11 Deep red earths	0-10	11					2.8
	20-30	7	4				4.3
	50-60	9	2				4.2

Table 4.17. Frequency distribution of % clay for soil groups.

Soil Group	Depth cm	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	>55
1 Red and brown clays on undulating plains	0-10							1	3	1	4	3	1
	20-30									4	6	2	
	50-60								1	3	5	2	1
2 Red and brown clays on alluvia	0-10									3	0	1	2
	20-30										3	0	3
	50-60									1	1		3
4 Grey clays on alluvia	0-10						1		1	2	3	2	6
	20-30					1	0	0	0	0	3	5	6
	50-60					1	0	0	0	0	3	4	7
5 Claypans, scalds and saltpans	0-10				1	0	1	0	2	5	2	1	
	20-30								1	3	5	1	2
	50-60								2	2	3	2	3
6 Desert loams	0-10			1	1	0	0	0	0	0	1		
	20-30									0	1	1	1
	50-60								1	0	1	1	1
7 Texture contrast soils on alluvia	0-10	1	1	1	3	1	0	0	1				
	20-30	1	1	1				3		1	1		
	50-60		1			1	1	3	2				
8 Texture contrast soils on undulating plains	0-10			3	3	2	1						
	20-30								1	0	3	0	1
	50-60							2	0	1	1	0	1
9 Alluvial soils	0-10					2	2	0	1				
	20-30				1	0	2	1	0	1			
	50-60					1	2	1	0	1			
10 Shallow red earths	0-10			1	1	6	3	4					
	20-30					2	3	4	2	0	1		
	50-60				1	1	1	3	1				
11 Deep red earths	0-10					3	2	4	1	1			
	20-30						3	2	3	2	1		
	50-60						1	1	3	3	3		
12 Sandy red earths	0-10			4	5	2							
	20-30			1	5	4	1						
	50-60			1	5	2	1	1					
13 Earthy sands	0-10	1	4										
	20-30		3	2									
	50-60		2	1	1	1							
14 Siliceous sands	0-10	2	1										
	20-30	2	1										
	50-60	2	1										
15 Lithosols	0-10					1	1						
	20-30						1						
All soils	0-10	4	6	10	14	17	11	9	9	13	10	7	9
	20-30	3	5	4	6	7	10	10	7	11	24	9	13
	50-60	2	4	2	7	7	6	11	10	11	17	9	15

The clay soils with few exceptions are sodic (Northcote and Skene, 1972), at depth. The major exceptions are the red clays supporting mulga which have low exchangeable sodium percentage (ESP) values. A high proportion of the clays have extremely high values. Hubble and Reeve (1970) point out that such values of exchangeable sodium lead to undesirable physical properties; e.g. puddling, low permeability and impeded drainage. This may result in poor plant growth and restricted seedling emergence. Hubble and Reeve (*op cit*) also note that the effect of sodium saturation may become more serious, if salts are removed by leaching, because their presence in sufficient contration maintains flocculation of the clay These soils are notoriously unstable. They erode badly when bare and/or exposed, on any significant slope. The distribution values of ESP is given in Table 4.16 for eleven of the soil groups.

Particle size analysis

Particle size distribution and clay type are among the most important soil factors affecting vegetation development. Nutrient availability and available moisture is closely correlated with both percentage clay and clay type. The frequency distribution of percentage clay for the soil groups is set out in Table 4.17.

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Vegetation

by D.E. Boyland*

Vegetation of the area has been studied by many workers since European man first explored this area over 100 years ago. Our knowledge of the vegetation of this region grew from the rudimentary notes of early explorers to the detailed results of more recent workers. Sturt (1849) and Gregory (Mueller, 1859) were notable early explorers who collected plants in the area. The activities of other early explorers and botanists in adjacent areas resulted in a sound knowledge of the flora of Western Queensland by the beginning of the twentieth century.

Blake (1938) carried out the first major study of vegetation. Since then other workers have added to the knowledge of the vegetation. These include Skerman (1947), who studied the channel country and adjacent lands, Everist (1949), who worked in the mulga country, Burrows and Beale (1969), who carried out studies of structure and pattern in restricted mulga communities, and Clark *et al.* (1969), who were interested in locust control. Botanical studies carried out by Crocker (1946) in the Simpson Desert, by Beadle (1948) and by Condon (1949, 1961), in New South Wales, by Jessup (1951), in north-western South Australia, by Holland and Moore (1962), in the Bollon district by Pedley (in press), in the Balonne-Maronoa district, and by Perry *et al.* (1962), in the Alice Springs area are pertinent.

THE NATURE OF THE VEGETATION

As a result of the harsh climate, plants generally exhibit some mechanism to either avoid or resist drought. Some mechanisms include adaptation of plant form, anatomical characters, physiological characters and relationships between plants. Plants can be classified into perennial drought resisters, perennial drought evaders and annual drought evaders or escapees (ephemerals). Shreve (1951), Perry and Lazarides (1962), Everist (1964) and Kassas (1966) have discussed this aspect more fully.

Usually the plants from structurally simple associations, low in both height and projective foliage cover. The latter rarely exceeds 30% except in favoured situations. Although the associations are structurally simple they commonly exhibit distinct layering. If these layers are considered as separate stratum, then the vegetation of the upper stratum is not always associated with the same lower stratum vegetation. This has been observed in other arid areas (Perry, 1960). It appears these strata are independently distributed. Frequently only a few species contribute significantly to the biomass of each layer.

Vegetation of the area is dynamic. Changes may be due to fluctuating variations of climatic factors and modification of habitats. These include progressive changes, due to cumulative effects of litter etc, or changes caused by soil erosion and accidental, purposeful or natural catastrophies. The present status of vegetation is a reflection not only of recent land use but land use over a long period of time. A study of the history of land use is essential before attempting to evaluate the present status of vegetation.

The time scale in studying vegetation in arid regions is critical. Conclusions based on short term studies may be, and have often proved to be, very misleading. There is a basic need for long-term studies. This view is supported by Roberts (1972) who, when suggesting fields of basic and applied research for the pastoral laboratory at Charleville, stated that consideration must be given to " an acceptance of the necessity for certain long-term (20-30 year) projects". The work of Burrows and Beale (1969) and the research carried out at Koonamoore (Hall *et al.* , 1964) is to be commended for establishing bench marks for future studies.

Ideally, permanent transects or sites should be established though all vegetation types in Australia so that change can be monitored. Delineation of criteria that reflect the long-term condition, as distinct from the short-term seasonal fluctuations, is a major problem (Perry, 1972), but this problem could be solved by the monitoring of such transects or sites.

ENVIRONMENTAL FACTORS

As in other regions, climatic factors limit which plants can grow but landform and edaphic factors govern to a large extent the distribution of plants in a region.

Plant growth is dependent on local distribution and concentration of rainwater (Perry, 1970). Precipitation and run-off water are the main sources of moisture. Additional water for plant growth may result from flooding caused by general rain outside the area. The response of plants to these various sources of moisture varies.

Precipitation varies in both its seasonal and annual distribution and its reliability. On the shallow, red earths *Acacia aneura* (mulga) decreases in height and density from east to west and this may be related to the decline in precipitation.

The seasonality of precipitation is also of significance. Farmer, Everist and Moule (1947) postulated that *Acacia aneura* requires winter rain to regenerate. Davies (1968) supported this statement, with the observation that winter rain was need to produce mature fruits. Most of the grass species germinate and grow in summer and require adequate rainfall for growth in this period. Many forbs germinate at other times of the year.

The type, incidence and time of flooding is critical. Early winter floods result in winter growing herbage such as *Trigonella suavissima* (Cooper clover), *Senecio lautus* and *Craspedia spp.* whereas summer flooding results in grasses including *Echinochloa turnerana* (Channel millet) and *Panicum whitei* (Pepper grass) and summer growing forbs. *Trigonella suavissima* occurs after general flooding when the "channel country" has been immersed for some time. The minimum period of immersion required is not known. *T. suavissima* usually will not grow as a result of rain or localized flooding.

Other climatic factors affecting vegetation include temperature, winds and frosts. The relationship between temperature, soil and plant growth in arid regions is not well known. Everist (1949) observed a correlation between the eastern limit of *Acacia aneura* and the isotherm for January of mean screen temperatures. In this case we are of the opinion that edaphic factors and moisture requirements are also of importance. Smith (1957) observed that the eastern or south-eastern limit of distribution of *Eremophila gilesii* (Charleville turkey bush) runs more or less parallel to the western portion of the 40°F isotherm for the months of June and July. This suggests that low temperature may limit its distribution. Under suitable moisture conditions, germination of *A. aneura* is controlled to a large degree by temperature (Burrows, pers. comm.). Germination of grasses is governed to a large extent by temperature as well as moisture requirements.

Frosts are infrequent (Thargomindah, 4 days of frost per annum; Quilpie, 6 days of frost per annum; Adavale, 11 days of frost per annum; Anon, Bureau of Meteorology, pers. comm.) and the influence of frost on vegetation is not well documented.

Little is known of the effect of wind on the vegetation in this area.

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In arid regions, there are correlations between landform and the pattern and composition of vegetation. Physiographic and edaphic features control run-off, surface drainage and redistribution of the available water for plant growth. Slope and exposure also influence the effectiveness of any moisture available. On run-on areas, the height and density of *A. aneura* increases relative to that of *A. aneura* on adjacent areas. *A. harpophylla* (brigalow) can be observed on moisture favoured sites west of Quilpie, well outside its usual distribution limits.

Both the texture and depth of soil influence the nature of the vegetation developed on a soil. The physical texture and depth of soil governs, to a large degree, the amount and availability of water for plant growth. Soil surface characteristics are also important. Broadly, the soils may be grouped into two textural classes, the sandy and loamy textured soils, which are generally low in nutrient status, and the clay soils, which are moderately well supplied with nutrients. Overall, available soil moisture is the limiting factor governing plant growth, not the nutrient status of the soils.

The nutrient status of the soil may limit the growth of certain species and/or the potential productivity of the pasture. If the species present can readily utilize the available nutrients and available water then the presence of the species may prevent the invasion of other species. Moore (1970) presumes that when species are able to 'control' their environment in this way, the climax is attained.

Changes in soils may result in different vegetation types occurring. *A. clivicola* (bastard mulga) associations appear to be associated with shallow soils and exposure of parent rock. Both these factors are related to position on the landscape. *A. clivicola* associations are replaced by other associations as soil depth increases.

The effect of fire in this area is not well documented but fires do affect the composition of the flora. Fires are not a regular feature of the environment due to the paucity of dry matter in the lower ground layer and its poor ability to carry a fire. Grazing by domestic animals has been responsible for the reduction in frequency and intensity of fires. The effect of fire depends on intensity. This is governed by the amount of fuel, soil moisture, the time of the day and season.

In the fires of the 1950's, daytime fires killed *A. aneura*, while nighttime fires in the same area killed only the lower branches (Everist *et al.* 1958). Destruction of the canopy of *A. aneura* associations frequently leads to deterioration of the association and rapid colonization of denuded areas by species such as *Dodonaea* spp. (hop bushes) and *Codonocarpus cotinifolius* (desert poplar). Fire stimulates germination of *A. aneura* in some situations (Jessup, 1951).

In western Queensland it appears that fire has a deleterious effect on *Triodia basedowii* (spinifex) pastures although the firing of these pastures is still a practice. There are conflicting reports on the effect of fire on *Triodia* spp. pastures in other regions but different taxa are involved. Wilcox and Speck (1963) state that the *Triodia* spp. pastures in the Wiluna-Meekatharra area, Western Australia are used only after burning and there is no sign of deterioration in these pastures. The return of *Triodia* spp. dominance after burning has always occurred. In the Barkly region of Queensland and the Northern Territory, Christian and Stewart (1952) observed that frequent burning of *Triodia* spp. results in its destruction and in the establishment of ephemerals and perennial shrubs.

Many workers consider that the control of fire since settlement has greatly magnified the woody weed problem. This may be true in more mesic situations, but overall, the effect of fire on the ecosystems in far-western Queensland appears to be very deleterious. It may be responsible for the loss of nutrients, an increase in soil erosion and regeneration of trees and shrubs. Burning and wise management may be used to reduce unwanted shrubs, but the timing of burning is critical. The principles in the timing of burning appear to be avoidance of detrimental effects on the seedset and establishment of desired species but at the same time lessening or destroying competition from other species (Moore, 1962). There is an urgent need for a critical study of the effect of fire on the ecosystems.

Climatic and edaphic factors cannot always explain the distribution of plant associations. Seasonal history, usually not well documented, and natural disasters can influence the distribution of plant associations.

Vegetation of the region has been modified by man's activities. The cutting and pushing of trees, for fodder or pasture improvement and the overgrazing of existing pastures has resulted in the partial destruction of the original vegetation. Resulting from these activities, there has generally been a reduction of total plant cover and frequently a change of composition and/or dominance. The effects of man's interference can be seen in some *Acacia aneura* associations, on shallow, red earths, where pushing and cutting of trees have reduced vegetal cover to such a level that soil erosion occurs. The resultant loss of topsoil makes the task of revegetation much more difficult. Whether this erosion is due to clearing alone is not known.

Woody weeds may be a problem following clearing. Clearing of *Acacia aneura; Eucalyptus populnea*, (poplar box); *Eremophila mitchellii*, (sandalwood), shrubby low open woodland often results in dense regrowth of *Eremophila mitchellii*. Another troublesome species *Eremophila gilesii*, which occurs as a component of the lower shrub layer in some *Acacia aneura* and *A. aneura, Eucalyptus populnea* associations, usually persists and sometimes increases when such country is cleared (Smith, 1957). *Dodonaea attenuata* (a hop bush) and *Cassia* species may form dense stands following clearing or disturbance on sand plains. Another problem species following disturbance of some *A. cambagei* (gidgee) associations is *Myoporum deserti*, (Ellangowan poison bush).

Grazing affects the composition of *Triodia basedowii* open hummock grassland. In ungrazed situations, *T. basedowii* forms almost mono-specific stands. Following grazing, many forbs and grasses become established and other species besides *T. basedowii* contribute significantly to the biomass.

In some situations moderate grazing and selective thinning have beneficial effects. Both practices will reduce the transpiration surface and assist other plants in the competition for water. Partial thinning initially reduces the competition between plants for moisture and nutrients. Frequently a more productive and vigorous ground layer vegetation develops.

CLASSIFICATION OF VEGETATION

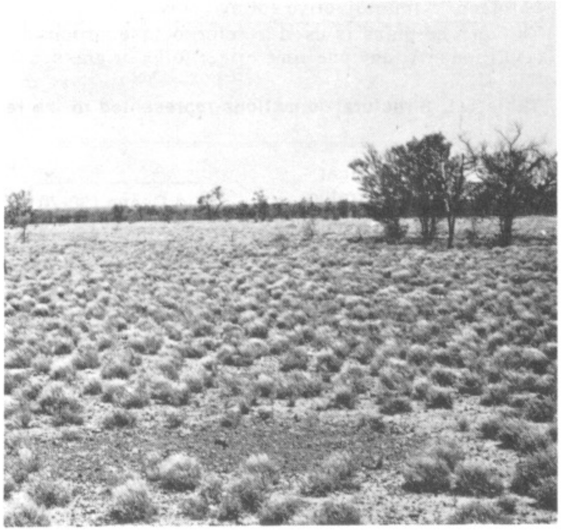
In this area, the nature of vegetation lends support for the continuum concept of vegetation (see McIntosh, 1967). Sudden disjunctions may occur between communities associated with differences in environmental factors such as change of soil and/or change in landscape but these disjunctions do not conflict with the continuum concept.

For the purposes of mapping, or the preparation of a vegetation inventory, classification of vegetation is necessary. This means applying arbitrary divisions to many attributes, which are of a continuous nature, so that vegetation can be divided into discernible units.

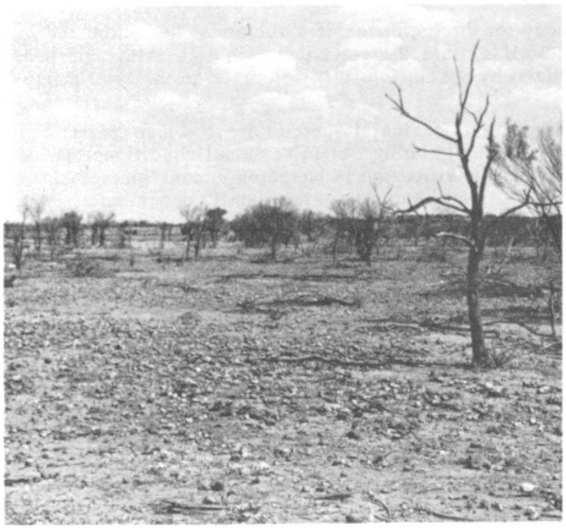
Attributes useful in describing vegetation are: the stratification of plant associations, the spatial distribution of growth forms, the presence and abundance of species. Considering these characteristics it is possible to recognize associations in the sense of Beadle and Costin (1952). Primary consideration is given to floristics. Structural formation is considered to be of secondary importance.

The structure of vegetation at sites is classified using a modification of the scheme proposed by Specht (1970), (Table 5.1). This is based on projective foliage cover and height and/or life form of the tallest stratum. Modification was necessary to eliminate some difficulties encountered in using Specht's scheme. Associations are assessed on the stratum which contributes most to the total biomass (perennial species only) and not necessarily the tallest stratum. This avoids the problem of how to classify an association with a sparse tall shrub stratum and a dense low shrub stratum. Nomenclature of structural formations follows that proposed by Specht (1970) with the addition of "sparse herbland" for the category of

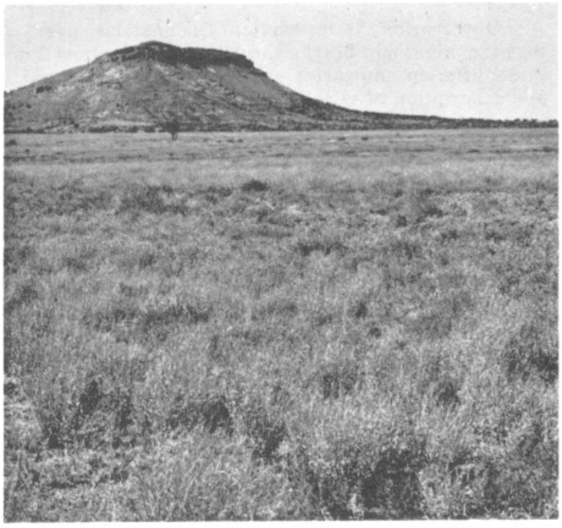
Mulga, poplar box tall open shrublands occur on flat plains mainly east of the Bulloo River. Productivity is enhanced by run-on water. This is Humeburn L.S.



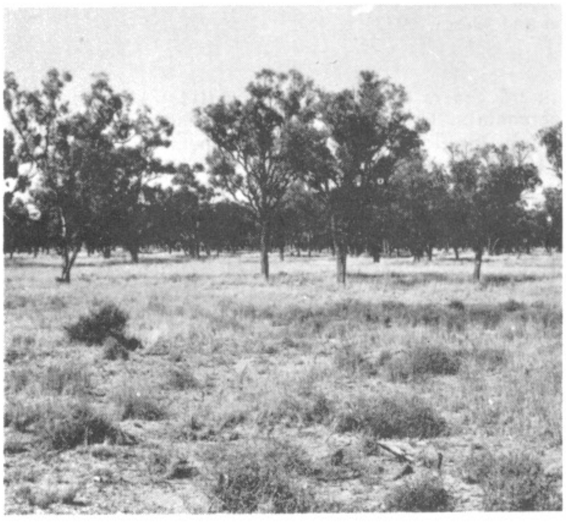
Whilst most pastures are utilized by the grazing animal the rock grass pasture shown is not commonly grazed even in drought. This is Bingara L.S.



Mulga density and height decreases with increasing aridity. In the west dead trees of mulga are common and ground vegetation is sparse on the undulating areas. This is Noccundra L.S.



The undulating downs which support Mitchell grass pastures in good seasons and short grasses and forbs in poor seasons are productive. This is Mt. Howitt L.S.



The gidgee yapunyah low open woodlands on alluvial plains which are representative of Norley L.S. are productive after flooding.

Standing dead trees are a feature of Bunginderry L.S. which supports boree, gidgee tall open shrubland on brown clays.

herblands with projective foliage cover (PFC) less than 10%. A term was not given to this category in Specht's scheme. The term herbland is used to refer to associations in which species composition and abundance is dependent on seasonal conditions. At any one time either forbs or grasses may predominate.

Table 5.1. Structural formations represented in the region.

Life Form and Height of Predominant* Stratum	Projective Foliage Cover of Predominant Stratum		
	Mid Dense (30-70%)	Sparse (10-30%)	Very Sparse (<10%)
Trees 10-30 m	Open forest	Woodland	Open woodland
Trees <10 m	Low open forest	Low woodland	Low open woodland
Shrubs 2-8 m	Open scrub	Tall shrubland	Tall open shrubland
Shrubs <2 m		Low shrubland	Low open shrubland
Hummock grasses 0-2 m		Hummock grassland	Open hummock grassland
Herbs include grasses, forbs and sedges	Herbland Tussock grassland Sedgeland Forbland	Open herbland Open tussock grassland Open sedgeland Open forbland	Sparse herbland Sparse forbland

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

Observations in far-western Queensland suggest that there is need for three classes of shrublands: low shrubland less than 2 m high, mid height shrubland ranging from 2 m to 6 m high and tall shrubland greater than 6 m high. Although these three different categories are recorded, only the two classes recognized by Specht (*op. cit*) were used in the final mapping and description of vegetation.

Usually perennial species were considered in classifying the vegetation. Perennial species are of a more permanent nature, are less subject to change and usually do not reflect minor variations in habitat or in seasonal conditions. There are situations where perennial species are absent or very sparse and the classification is based on annual species. In these instances it is emphasized that variation in abundance and composition of species is seasonally dependent.

Where there are two or more strata present, the associations are further qualified by a term describing the nature of the stratum which is secondary in contributing to the biomass. Terms used are wooded (referring to the presence of scattered trees in grassland), shrubby (shrubs conspicuous), grassy, herby and forby. In some tall open shrublands the term sparse is used to qualify the association where projective foliage cover is sparse. In herblands, forblands or grasslands there is only one stratum present. The qualifying term grassy or forby describes the species which are considered to be of primary importance in the case of herblands or of secondary importance in the case of forblands or grasslands.

It is stressed that associations are not absolute units. Variation may occur in structure and presence and abundance of species but predominant species remain relatively constant.

MAJOR STRUCTURAL FORMATIONS

Eighteen structural formations are present. These formations range from sparse herbland to open forest (Table 5.1). Tall shrubland and tall open shrubland are the most widely distributed formations. Together they occupy approximately 55% of the total area. Extensive areas (25%) support herblands of varying composition. By comparison the other formations including open forests, woodlands and open scrubs do not occupy large areas but they contribute significantly to the floristics of the area.

With the exception of flooded areas, the physiognomic complexity of the various associations declines with increasing aridity.

Some *A. aneura* communities form groves. The resulting pattern from these groves may be distinct or diffuse and is associated with two different soil complexes (Boyland, 1973; Dawson and Ahern, 1973).

FLORISTICS

Within the area 615 plant species were recorded. These represent 241 genera belonging to 74 families (Appendix V). Of these species 364 are perennials including both short and long-life perennials. This is not a complete list of species occurring, as the area was not completely traversed or collected in detail. In arid regions ephemeral species adjust their growth period to particular seasonal conditions (Shreve, 1951; Went, 1955; Everist, 1964) and it is possible many ephemerals may not have been observed during the limited time spent in field work.

Gramineae and Leguminosae are the largest families, being represented by 43 and 20 genera and 115 and 73 species respectively. Other floristically important families include Chenopodiaceae, Compositae, Malvaceae, Myoporaceae and Myrtaceae. Families represented by 5 or more species are listed in Table 5.2, in order of numbers of recorded species. These 21 families contain 519 species which is approximately 85% of the total species recorded. Of these 519 species, 298 are perennials. This represents 83% of the number of perennials listed for the area.

Table 5.3 illustrates the distribution of families, genera and species in the land zones. When the number of species is plotted against area for the various land zones then *Eucalyptus* predominant associations have a higher species diversity than normal for the area and the hard *Acacia aneura* land zone has a lower species diversity than normal.

There is the expected relationship between moisture-favoured sites and species diversity. The lack of species diversity in the channel alluvia could be accounted for by seasonal conditions. It is possible that only a limited number of species has adapted to growing and persisting under conditions experienced in this land zone. The poor species diversity of the undulating downs is to be expected, as there are several well adapted species which predominate. Other species have difficulty in competing with these species. Overall the species per area represents about 1 species per 240 km^2. For the Alice Springs area the comparable figure is approximately 1 species per 510 km^2 (Perry and Lazarides, 1962).

The four families Gramineae, Leguminosae, Chenopodiaceae and Compositae contain 53% of species recognised. The predominance of Gramineae, Leguminosae and Compositae is a normal feature of floras of most regions but rarely do these comprise more than 42% of the flora as they do here. The predominance of Chenopodiaceae is characteristic of the drier region of central Australia and to a lesser degree, other continents.

Table 5.2. Families represented by five or more species.

Family	No. of Genera	No. of Species	No. of Perennials
Gramineae	43	115	72
Leguminosae	20	73	55
Chenopodiaceae	12	70	46
Compositae	29	66	19
Malvaceae	6	22	17
Myoporaceae	2	21	21
Myrtaceae	5	21	21
Amaranthaceae	4	20	6
Cyperaceae	5	17	9
Cruciferae	5	13	1
Euphorbiaceae	3	11	1
Goodeniaceae	4	11	2
Solanaceae	3	9	7
Convolvulaceae	6	9	5
Proteaceae	2	8	8
Zygophyllaceae	2	8	0
Aizoaceae	3	6	1
Sapindaceae	3	6	6
Umbelliferae	3	6	0
Boraginaceae	3	5	0
Portulacaceae	2	5	1

There is a marked similarity in the composition of the flora of this area and that of both the Alice Springs area (Perry and Lazarides, 1962) and the Simpson Desert National Park (Boyland, 1970). The same four families contribute most to the flora of those regions. There appears to be a slight difference in the composition of the flora of this area and that of the Simpson Desert, as represented by Crocker's collections (Eardley, 1946). In this collection the largest representation of species is by the families Leguminosae, Chenopodiaceae, Myoporaceae and Amaranthaceae. The absence of Compositae and Gramineae from these ratings can be explained by the fact that many species of these families in the areas are ephemerals and their presence depends on seasonal conditions. In a check list of the flowering plants of the Simpson Desert and its immediate environs, prepared by Symon (1969), the four families with the largest representation were the same families as in this area but in the order Leguminosae, Chenopodiaceae, Compositae and Gramineae.

Table 5.3. Distribution of families, genera and species in the various land zones.

Land Zone	Dune-fields	Mulga Sand Plains	Soft Mulga	Hard Mulga	Dissected Residuals	Undulating Gidgee	Undulating Downs	Alluvial Plain, Woodlands		Channel Country	Other Alluvia
								Gidgee	Eucalypt		
No. of Families	51	30	40	35	39	26	19	32	44	25	37
No. of Genera	132	68	111	81	82	69	49	79	126	58	106
No. of Species	238	110	209	149	145	122	83	144	233	91	183
Approx. Area of Land Zone km^2	24720	8540	10240	24920	19730	7120	12790	4850	7800	11100	13700

Species of the genus *Acacia* are the most frequently occurring shrubs with a total of 25 species being recorded. These species are conspicuous on most land types, the exception being treeless undulating downs. *Acacia aneura* is the most widespread species and it is the co-dominant or predominant species in 82 sites out of 95 sites where it was recorded. It occurs on a wide range of soils from red, siliceous sands to shallow loams. It is best developed on red earths.

Acacia cambagei is widely distributed, occurring on shallow, loamy soils to cracking clays. It is best developed on clay soils. On the alluvial plains it is commonly associated with *Eucalyptus* spp.

A. petraea (lancewood) and *A. clivicola* are widespread on shallow soils associated with the dissected residuals throughout the region. *A. catenulata* (bendee) also is associated with the dissected residuals but is found mainly in the east of the region. These species are widespread.

The genus *Eucalyptus* is not well represented. Thirteen species have been recorded for the area but *Eucalyptus cambageana* (Dawson gum or blackbutt), *E. largiflorens; E. melanophloia* (silver-leaved ironbark), *E. polycarpa* (long-fruited bloodwood) and *E. tessellaris* (Moreton bay ash or carbeen) are restricted to the east of the region and are at the western limit of their range. In general *Eucalyptus* spp. are not well represented in that part of Australia north of the southern 250 mm (winter maximum) isohyet and south of the northern 375 mm (summer maximum) isohyet (Perry and Lazarides, 1962). *E. populnea* is widespread in the east on deep to moderately deep, loamy, red earths and red, texture contrast soils with *E. terminalis* (western bloodwood) widely distributed on shallow, red earths. *E. ochrophloia* (yapunyah) and *E. camaldulensis* (river red gum) are confined to the river banks and terraces. Other eucalyptus, including *E. exserta* (bendo), *E. papuana* (desert gum) and *E. thozetiana* (mountain yapunyah), have restricted habitat preferences.

Eremophila spp. are well represented with 19 taxa present out of the 23 recorded for Queensland. They reach their best expression in the various *Acacia aneura* associations though they occur in almost all situations. Some species are very selective in their requirements. *A. macdonnellii* is invariably associated with the dunes. Several species are troublesome weeds because of their capacity for rapid population increases, their adaption to a drier habitat and ability to escape grazing because of palatability. Undoubtedly, the major problem species in this region is *E. gilesii*. *E. bowmanii* (silver turkey bush) another troublesome species, favours *Acacia aneura* sandplain country and appears to be on the increase thus reducing productivity. *E. mitchellii* a problem species further east, also occurs but at present it only occupies very limited areas, mainly in the east. *E. sturtii* (budda) is the other troublesome species.

Grasses are numerous in almost all associations except some forblands developed on salinas and playas. *Eragrostis* has the largest representation with 19 species recorded. Eleven species of *Aristida* were collected. The *Aristida* spp. occur in many of the associations and frequently are predominant in the ground layer. Some species are very selective in habitats, while other species, such as *Aristida contorta* (kerosene grass) are widely distributed occurring in several habitats. The two shrub-like grasses *Zygochloa paradoxa* (sandhill cane grass) and *Eragrostis australasica* (swamp cane grass) are selective in site requirements, the former occurring on the unstable crests of dunes in the far west and the latter in swamp situations. *Triodia basedowii* is also selective occurring on dunefields and sand-dunes.

Many forbs occur and *Bassia* spp. and *Atriplex* spp. are very widespread. Members of Compositae are found throughout the area. Most of these are ephemerals and their presence and abundance are governed by the amount of precipitation received and the season in which it falls.

DESCRIPTION OF VEGETATION

Data are arranged in the following major floristic groups. These groups are ordered according to structural form.

Eucalyptus spp. predominant associations
Acacia cambagei predominant associations
Acacia aneura predominant associations
Acacia spp. *Atalaya hemiglauca*, herbaceous associations and associated herbland associations
Acacia clivicola, A. petraea, A. aneura, A. catenulata predominant associations
Shrubby chenopod predominant associations (including *Muehlenbeckia cunninghamii* associations)
Triodia basedowii predominant associations (including *Zygochloa paradoxa* associations)
Astrebla spp. Short grass forb predominant associations
Short grass forb predominant associations
Miscellaneous associations
Induced associations

Floristic associations within each major grouping are given in Table 5.4 with reference to their structural formation range, projective foliage cover, tree or shrub density and frequently occurring species. Broad distribution and soil type for each association are outlined. It is intended that the various land unit descriptions supplement this account of the vegetation. The map of the major vegetation groups included with this report is a compilation of various land systems based on the predominant vegetation of the land system.

Eucalyptus predominant associations

Associations dominated by various species of *Eucalyptus*, are not extensive (approximately 5% of the area) but contribute significantly to the flora.

These associations (Table 5.4) occur mainly on grey clays, alluvial soils and texture contrast soils associated with alluvial plains and braided channels. They are best developed along the Paroo and Bulloo Rivers and associated creeks but occur in varying degrees of complexity along all rivers and major creeks in the area. Limited areas of various *Eucalyptus* associations are found on pediments and eroded lower slopes of the dissected residuals mainly in the east.

Structurally the associations range from low open woodland to open forest. There is a tendency for a decrease in physiognomic complexity of the association with increasing distance from the main channel and increasing aridity.

Various species of *Eucalyptus* predominate depending on local variation in habitat. Floristically these associations are relatively rich (Table 5.5). Approximately 37% of total species recorded occur in these associations. Species diversity of the various associations decreases with increasing aridity.

Broad ecotones are frequently noticeable between these associations and adjacent associations.

Acacia cambagei predominant associations

These associations (Table 5.4) occur throughout the area and occupy approximately 10% of the area. They are developed in two different situations, one associated with the alluvia and the other on mantled pediments and scarp retreats of the dissected residuals.

Structurally, the associations range from woodland to sparse tall open shrubland. The alluvial soils, cracking clays, and texture contrast soils support woodlands to tall open shrublands. Sparse, tall open shrubland to tall open shrublands occur on cracking clays, and texture contrast soils associated with the mantled pediments and scarp retreats of the dissected residuals.

The number of species, genera and families recorded are given in Table 5.5. Of the total number of species recorded, 27% (56 species) are common in both situations. Chenopodiaceae make a major contribution to the flora of these associations not only in the number of different species present but the abundance in which these species occur. It appears there is a relationship between high total soluble salt values in the *A. cambagei* sites and the presence of chenopods.

A. cambagei associations form complexes with eucalypt predominant associations. *A. cambagei* associations also forms complexes with *A. aneura* associations.

Acacia aneura predominant associations

These associations (Table 5.4) are found throughout the area on flat to undulating plains. Their best development is in the east but well developed stands of *A. aneura* occur in western situations, especially associated with run-on areas. Soils vary from very shallow, red earths to deep, loamy and sandy red earths. *A. aneura* associations also occur on red, earthy sands in the west. These associations occupy approximately 35% of the area.

Structurally, these associations vary from open-scrub to sparse tall open shrubland with a tendency to a woodland in places. The physiognomic complexity of the associations is governed by the aridity of the area, depth and type of soil and position in the landscape. The type of mulga associations and their relationship to landscape in south-western Queensland has been discussed elsewhere (Boyland, 1973).

The species diversity of the different *A. aneura* associations varies greatly. There appears to be a decrease in species diversity with increasing height, projective foliage cover and density of *A. aneura* as associations grade from tall open shrubland to woodland.

The number of species, genera and families recorded is given in Table 5.5. These associations can be divided into three broad groups, the sandplain *A. aneura*, the *A. aneura* developed on the deep to moderately deep red earths and the *A. aneura* association on the deep red earths are most diverse with the sandplain *A. aneura* associations least diverse. This variation in floristic richness is undoubtedly caused by environmental differences, especially habitat variations.

Acacia spp., Atalaya hemiglauca, herbaceous associations

These associations (Table 5.4) are restricted to flat to gently undulating plains with relatively low dunes, mainly in the west. They occupy approximately 10% of the area. Soils are mainly red, earthy sands to sandy red earths.

Structurally, these associations vary greatly and include tall open shrubland, sparse tall open shrubland, wooded forblands and forblands.

Table 5.4. Description of floristic associations

Floristic Association	Structural Formation Range. Height, PFC, Trees/ha	Frequently Occurring Species	Comment
***Eucalyptus* predominant associations**			
Eucalyptus camaldulensis, E. microtheca	Low open woodland to open forest. Height: 7-12 m. PFC: 5-20% Trees/ha: 100-400.	Trees: *E. populnea* (in the east), *E. terminalis* (in the west). *Acacia cambagei.* Tall Shrubs: *Melaleuca linariifolia. Acacia stenophylla.* Low Shrubs: *Acacia tetragonophylla, A. victoriae, Chenopodium auricomum, Eremophila bignoniiflora, E. mitchellii, E. polyclada, E. sturtii, Muehlenbeckia cunninghamii, Myoporum acuminatum.* Grasses: *Dichanthium* spp., *Eragrostis* spp., *Eriochloa pseudoacrotricha, Eulalia fulva, Leptochloa digitata, Paspalidum* spp. Forbs: *Alternanthera* spp., *Atriplex* spp., *Bassia* spp., *Marsilea* spp.	Widespread, lining major channels. Floristics and structure vary. A well developed shrub layer may beconspicuous. Ground cover is variable. Over 100 species have been recorded from this association.
Eucalyptus microtheca	Low open woodland to woodland. Height: 6-10 m. PFC: 1-10%. Trees/ha: 40-200.	Shrubs: *Acacia stenophylla, Muehlenbeckia cunninghamii* Grasses: *Eragrostis* spp., *Eriochloa pseudoacrotricha, Eulalia fulva, Leptochloa digitata, Paspalidum* spp., Forbs: *Alternanthera* spp., *Atriplex* spp., *Bassia* spp., *Marsilea* spp.	Widespread along channels and creeks on alluvial soils and grey and brown clay soils. Less diverse than the previous association both in structure and floristics. A variant of that association.
Eucalyptus populnea, Eremophila mitchellii	Open woodland. Height: 8-12 m. PFC: 1-5%. Trees/ha: 20-60.	Shrubs: *Cassia artemisioides, Eremophila bowmanii, Myoporum deserti.* Grasses: *Aristida* spp., *Bothriochloa ewartiana, Chloris pectinata, Enteropogon acicularis, Eragrostis* spp., *Themeda australis.* Forbs: *Alternanthera* spp., *Bassia* spp.	Occurs in the east on texture contrast soils and red earths. Shrub layer is usually well developed. Ground cover is variable.
Eucalyptus populnea, Acacia aneura	Open woodland to woodland. Height: 8-12 m. PFC: 1-10%. Trees/ha: 20-100. Shrubs/ha: 50-250.	Shrubs: *Eremophila mitchellii, E. sturtii, E. gilesii, Myoporum deserti.* Grasses: *Aristida ingrata, Digitaria ammophila, Enteropogon acicularis, Eragrostis spp., Panicum decompositum, Tripogon loliiformis.* Forbs: *Bassia convexula, B. quinquecuspis, Convolvulus erubescens, Evolvulus alsinoides, Solanum* spp.	Occur in the east on loamy, red earths and texture contrast soils. A well defined shrub layer is usually present. Ground cover is not usually well developed. Frequently disturbed by clearing for grazing.
Eucalyptus ochrophloia	Low open woodland to woodland. Height: 6-12 m. PFC: 5-20%. Trees/ha: 50-400.	Trees: *Eucalyptus populnea* (in the east) *Acacia cambagei.* Shrubs: *Arthrocnemum* spp. *Chenopodium auricomum, Eremophila polyclada, Muehlenbeckia cunninghamii, Myoporum deserti.* Grasses: *Chloris pectinata, Dactyloctenium radulans, Enteropogon acicularis, Eragrostis dielsii, E. leptocarpa, E. setifolia, E. tenellula, Sporobolus caroli, S. mitchellii.* Forbs: *Alternanthera nodiflora, Atriplex spongiosa, Bassia bicornis, B. divaricata, B. quinquecuspis, Marsilea* spp. Sedges: *Cyperus fulvus, C. rigidellus, Eleocharis pallens.*	Mainly confined to alluvial plains on the Paroo, Bulloo and Wilson Rivers. Subject to occasional flooding. Soils are grey cracking clays and texture contrast soils. A well defined low shrub layer is not usually present. Ground cover is variable.

Table 5.4. Description of floristic associations (Cont'd)

Floristic Association	Structural Formation Range, Height, PFC, Trees/ha	Frequently Occurring Species	Comment
Eucalyptus microtheca	Low open woodland. Height: 5-9 m. PFC: 5-10%. Trees/ha: 60-250.	Shrubs: *Chenopodium auricomum, Eremophila maculata, Muehlenbeckia cunninghamii.* Grasses: *Chloris pectinata, Dactyloctenium radulans, Eragrostis dielsii, E. parviflora, E. setifolia, Panicum whitei, Sporobolus caroli.* Forbs: *Alternanthera nodiflora, Atriplex elachophylla, A. spongiosa, Bassia bicornis, B. quinquecuspis, Centipeda thespidioides, Marsilea* spp. Sedges: *Cyperus difformis, C iria, C. rigidellus.*	Occupies occasionally flooded areas in the west. Soils are cracking clays to texture contrast soils. A shrub layer is rarely developed. PFC may be very sparse and the association may approach a low shrubland with emerging trees.
Eucalyptus thozetiana	Low open woodland. Height: 6-10 m. PFC: 1-5%. Trees/ha: 20-120.	Trees: *Acacia microsperma, Eucalyptus cambageana.* Shrubs: *Acacia aneura, A. catenulata, Geijera parviflora.* Low Shrubs: *Eremophila mitchellii, E. oppositifolia, Scaevola spinescens.* Grasses: *Digitaria ammophila, Enteropogon acicularis, Eriachne mucronata.* Forbs: *Bassia divaricata, B. intricata, Kochia villosa, Salsola kali.*	*E. thozetiana* is widespread but there are only limited areas where it predominates. Occurs on scarps on lithosols and shallow, loamy, red earths. May form a complex with *Acacia cambagei* tall open shrubland.
***Eucalyptus* predominant associations of limited extent.**			
Eucalyptus melanophloia *Acacia aneura*	Woodland. Height: 8-11 m. PFC: 10-20%. Trees/ha: 100-200. Shrubs/ha: 50-300.	Trees: *Eucalyptus populnea, E. terminalis* (rare). Shrubs: *Cassia artemisioides, C. nemophila, Eremophila mitchellii.* Grasses: *Aristida jerichoensis, Chrysopogon fallax, Themeda australis.* Forbs: *Abutilon* spp., *Sida* spp.	Limited to the north-east. Soils are shallow, loamy, red earths and lithosols. A tall shrub layer is usually well developed. Ground cover is usually poorly developed.
Eucalyptus cambageana *Eremophila mitchellii*	Low open woodland to open woodland. Height: 7-12 m. PFC: 3-9%, Trees/ha: 40-120, Shrubs/ha: 25-300.	Trees: *Eucalyptus thozetiana.* Shrubs: *Acacia aneura, A. excelsa, Cassia artemisioides, C. nemophila* var *nemophila, Enchylaena tomentosa.* Grasses: *Aristida* spp., *Eragrostis* spp. Forbs: *Bassia birchii, B. paradoxa, Sida* spp., *Salsola kali.*	Limited to the east on flat plains. Soils are red, texture contrast soils. A tall shrub layer is well defined in places. Usually there is no well developed lower shrub layer. Ground cover is not well developed.
Eucalyptus tessellaris, E. polycarpa	Open woodland. Height: 6-10 m. PFC: 1-5% (up to 7.5%) Trees/ha: 20-80.	Trees: *Acacia excelsa, Alstonia constricta.* Shrubs: *Acacia murrayana, Canthium oleifolium.* Grasses: *Aristida* spp., *Chrysopogon fallax, Eragrostis* spp., *Paspalidum rarum.* Forbs: *Bassia* spp., *Sida filiformis.*	Confined to low sandy rises on plains in the east. Soils are deep, earthy sands and sandy red earths. There is no well developed lower shrubby layer.

Table 5.4. Description of floristic association. (Cont'd)

Floristic Association	Structural Formation Range, Height, PFC, Trees/ha	Frequently Occurring Species	Comment
Eucalyptus largiflorens	Open woodland. Height: 8-12 m. PFC: 5-10%. Trees/ha: 50-150.	Trees: *Eucalyptus microtheca.* Shrubs: *Cassia nemophila, Eremophila mitchellii, Muehlenbeckia cunninghamii.* Grasses: *Dichanthium sericeum, Eragrostis setifolia, E. tenellula, Sporobolus caroli.* Forbs: *Bassia diacantha, B. divaricata, B. tricuspis, Minuria integerrima, Teucrium racemosum.*	Restricted to alluvia in the south-east. Associated with the Paroo River. Limited areas. *Eucalyptus populnea* and *E. ochrophloia* may occur. Frequently there is a well developed lower shrub layer of *Eremophila* spp. Ground cover is sparse.
Eucalyptus thozetiana, Triodia longiceps	Low open woodland. Height: 5-7 m. PFC: 1-5%. Trees/ha: 30-120.	Shrubs: *Cassia* spp. Grasses: *Eriachne* spp., *Eragrostis* spp.	Limited to the east on shallow, loamy earths. Low shrubby layer absent. *Triodia longiceps* forms a well defined layer.
***Acacia cambagei* predominant associations**			
Acacia cambagei	Tall open shrubland to woodland. Height: 3-7 m. PFC: 5-20%. Trees/ha: 100-550.	Trees: *Eucalyptus ochrophloia, E. cambageana* (mainly in the north-east), *E. microtheca.* Shrubs: *Arthrocnemum* spp., *Chenopodium auricomum, Cassia desolata, Enchylaena tomentosa, Eremophila bignoniiflora, E. maculata, E. polyclada, Myoporum acuminatum, M. deserti, Rhagodia spinescens.* Grasses: *Chloris pectinata, Dactyloctenium radulans, Eragrostis dielsii, E. parviflora, E. setifolia, Sporobolus actinocladus, S. caroli, S. mitchellii.* Forbs: *Atriplex lindleyi, A. muelleri, A. spongiosa, Bassia bicornis, B. calcarata, B. divaricata, B. lanicuspis, B. quinquecuspis, Portulaca* sp. aff. *P. oleracea, Salsola kali, Threlkeldia proceriflora.*	Occurs on alluvial plains. Soils are grey clays. Shrubs usually do not form a well defined layer. Ground cover is variable depending on seasonal conditions. If disturbed shrubs may become a serious weed problem.
Acacia cambagei, A. harpophylla	Woodland (infrequently open woodland). Height: 6-10 m. PFC: 10-20%, Trees/ha: 100-350.	Shrubs: *Eremophila mitchellii, Geijera parviflora, Dodonaea cuneata, Myoporum deserti, Scaevola spinescens.* Grasses: *Dactyloctenium radulans, Enteropogon acicularis, Sporobolus caroli, Tragus australianus.* Forbs: *Atriplex* spp., *Bassia* spp., *Salsola kali.*	Not extensive. Found in moisture favoured sites on flat to slightly undulating plains. Soils are grey and brown cracking clays. A tall shrub layer is usually well defined. Ground cover is sparse. *Eucalyptus thozetiana* and *Ehretia membranifolia* may occur. In the east *A. harphophylla* forms a low woodland to woodland.
Acacia cambagei	Shrubby shrubland (infrequently tall open shrubland). Height: 5-7 m. PFC: 5-20%. Trees/ha: 150-550.	Shrubs: *Cassia desolata, C. nemophila, Eremophila mitchellii, E. polyclada, E. sturtii, Exocarpos aphyllus* (forms dense stands in places), *Myoporum deserti.* Grasses: *Chloris pectinata, Dactyloctenium radulans, Enteropogon acicularis, Eragrostis setifolia, Tragus australianus.* Forbs: *Bassia convexula, B. divaricata, B. parallelicuspis, Salsola kali, Solanum ellipticum.*	Occurs on flat alluvial plains. Soils are texture contrast soils formed on alluvia. Usually there is a well defined lower shrub layer. Ground cover is variable.

Table 5.4. Description of floristic associations (Cont'd)

Floristic Association	Structural Formation Range, Height, PFC, Trees/ha	Frequently Occurring Species	Comment
Acacia cambagei	Tall open shrubland. (infrequently tall shrubland). Height 4-7 m. PFC: 2-8% (15% in places). Trees/ha: 60-300 (490 in places)	Trees: *Flindersia maculosa*. Shrubs: *Arthrocnemum* spp. (in places). *Enchylaena tomentosa, Eremophila longifolia, Rhagodia spinescens, Myoporum deserti,* (in places). Grasses: *Chloris pectinata, Dactyloctenium radulans, Echinochloa colonum, Eragrostis cilianensis, E. pergracilis, E. tenellula, Enneapogon polyphyllus, Tragus australianus, Tripogon loliiformis*. Sedges: *Cyperus gilesii, C. iria*. Forbs: *Atriplex lingleyi, A. spongiosa, A. stipitata, Bassia bicornis, B. calcarata, B. divaricata, B. lanicuspis, B. longicuspis, B. paradoxa, Dysphania myriocephala, Lepidium rotundum, Kochia coronata, Portulaca* sp. aff. *P. oleracea, Trianthema triquetra, Zygophyllum ammophilum*.	Occurs on pediments and lower slopes of disected dissected residuals. Soils all stony, to red and brown, cracking clays and red texture contrast soils. Shrub layer not usually well developed . Ground cover is variable.
Acacia cambagei *A. aneura*	Tall open shrubland. Height: 3-5 m. PFC: 1-7%. Trees/ha: 30-180.	Trees: *Flindersia maculosa, Acacia oswaldii, Owenia acidula*. Shrubs: *Cassia artemisioides, C. desolata, C. phyllodinea, Rhagodia spinescens, Scaevola spinescens*. Grasses: *Brachiaria gilesii, Chloris pectinata, Dactyloctenium radulans*. Forbs: *Bassia divaricata, B. intricata, B. lanicuspis, B. tricuspis, Kochia coronata, K. triptera, K. villosa, Salsola kali*.	Restricted to mantled pediments and eroded lower slopes of the dissected residuals. Soils are stony clay-loams to light clays and red texture contrast soils. Low shrub layer not usually well developed. Ground cover is variable.
Acacia cana ± *A. cambagei*	Tall open shrubland to low open shrubland. Height: 6-10 m. PFC: 1-5%. Trees/ha: 20-140.	Shrubs: *Eremophila dalyana, E. maculata, Scaevola spinescens*. Grasses: *Astrebla pectinata, Dactyloctenium radulans, Sporobolus actinocladus, S. caroli*. Forbs: *Atriplex lingleyi, A. spongiosa, Bassia calcarata, B. divaricata, B. lanicuspis, Lepidium rotundum, Zygophyllum ammophilum, Z. apiculatum*.	Occurs on red and brown clays on undulating plains mainly in the central north. Frequently, *A. cana* forms pure stands. Dead trees of *A. cana* are common. Seedlings of *A. cana* are rare. Usually there is no well defined lower shrub layer. Ground cover is variable.
Acacia aneura **predominant associations**			
Acacia aneura	Open shrub. Height: 5.5-7.5 m. PFC: 26-36%. Shrubs/ha: 1500-2500.	Trees: *Hakea ivoryi*. Grasses: *Aristida contorta, Digitaria ammophila, D. brownii, Eragrostis microcarpa, Paspalidium rarum*. Forbs: *Cheilanthes sieberi, Phyllanthus maderaspatensis*. Sedge: *Fimbristylis dichotoma*.	Occurs in the east on flat plains, frequently on run-on situations. Soils are loamy red earths. *Eucalyptus populnea* is present in places. No well defined low shrub layer. Grasses and forbs form a variable ground cover.

Table 5.4. Description of floristic associations (Cont'd)

Floristic Association	Structural Formation Range, Height, PFC, Trees/ha.	Frequently Occurring Species	Comment
Acacia aneura	Tall shrubland, rarely low open woodland. Height 4-8 m. PFC: 10-20%. Shrubs/ha: 300-900.	Trees: *Eucalyptus populnea* (scattered). Low Shrubs: *Cassia artemisioides, C. nemophila* var. *nemophila, Eremophila gilesii.* Grasses: *Aristida contorta, A. jerichoensis, Digitaria ammophila, D. brownii, Eragrostis eriopoda, Enneapogon polyphyllus, Enteropogon acicularis, Monachather paradoxa, Paspalidium rarum, Themeda australis, Thyridolepis mitchelliana,* Forbs: *Cheilanthis sieberi, Evolvulus alsinoides, Ptilotus leucocoma, P. macrocephalus, Sida cunninghamii, S. filiformis, S. platycalyx.* Sedge: *Fimbristylus dichotoma.*	Occurs east of the Bulloo River, on flat plains with loamy red earths. A low shrub layer may be well developed but usually only scattered shrub occur. Ground cover is variable, either forbs or grasses may predominate.
Acacia aneura, Eucalyptus populnea	Tall shrubland to open woodland. Height: 5-8 m. PFC: 10-20%. Shrubs/ha: 300-750.	Low shrubs: *Cassia artemisioides, C. nemophila, Eremophila longifolia, E. mitchellii, E. gilesii (in places), E. sturtii (in places).* Grasses: *Aristida* spp., *Chloris pectinata, Dichanthium sericeum, Digitaria* spp., *Eriochloa pseudoacrotricha.* Forbs: *Alternanthera nodiflora, Bassia* spp., *Boerhavia diffusa, Euphorbia drummondii, Malvastrum spicatum, Solanum* spp.	Occurs on gently undulating to flat plains on loamy red earths. *Eucalyptus populnea* emerges above the canopy. *A. aneura* is very scattered and this association approaches *E. populnea, A. aneura* open woodland. *Eremophila gilesii* dense low shrub layer present.
Acacia aneura	Tall open shrubland rarely tall shrubland. Height: 4-6 m. PFC: 1-8% (rarely 12%), Shrubs/ha: 100-300 - (400).	Trees: *Acacia excelsa, Ventilago viminalis.* Shrubs: *Acacia tetragonophylla, Canthium latifolium, Cassia artemisioides, C. nemophila, Eremophila gilesii.* Grasses: *Aristida* spp., *Dactyloctenium radulans, Enneapogon polyphyllus.* Forbs: *Euphorbia drummondii, Kochia villosa, Ptilotus* spp., *Sida filiformis.*	Occurs on red earths on gently undulating to undulating plains. *Flindersia maculosa* may occur. Usually there is no well defined lower shrubby layer. Ground cover is variable.
Acacia aneura	Tall open shrubland infrequently tall shrubland (in the east). Height: 4-6 m. PFC: 1-7%. Shrubs/ha: 80-225.	Trees: *Eucalyptus terminalis, Grevillea striata.* Low shrubs: *Cassia* spp., *Enchylaena tomentosa, Eremophila* spp. Grasses: *Aristida contorta, Chloris pectinata, Dichanthium sericeum* (in the east), *Themeda australis* (in the east). Forbs: *Bassia* spp., *Salsola kali, Sida* spp.	Occurs on depressions on flat to gently undulating plains on red earths. *Eucalyptus terminalis* may become co-dominant. In the more mesic situations, *A. aneura* predominates. *Atalaya hemiglauca* and *Santalum lanceolatum* may occur. There is no well defined low shrub layer. Grasses are usually the main component of the ground flora.
Acacia aneura	A complex of tall open shrubland to tall shrubland in the grove, and open forbland to very sparse tall open shrubland (rare) in the intergrove. Height: 4-8m. PFC: 5-20%. Shrubs/ha: (groves) 150-600	Trees: usually confined to the groves *Eucalyptus populnea* (eastern) *E. terminalis* (eastern but mainly western), *Grevillea striata.* Tall shrubs: Isolated shrubs in the intergrove: *Acacia tetragonophylla, A. victoriae, Eremophila longifolia.* Low Shrubs: *Cassia artemisioides, C. desolata, C. nemophila, C. oligophylla, Eremophila gilesii, (rare)* Grasses: *Aristida contorta, Brachiaria miliiformis*, Chloris pectinata, Dichanthium affine*, D. sericeum*,*	Occurs on flat to low sloping plains. Groved mulga boundaries are diffuse and soils are moderately deep to deep loamy red earths. In the groves the soils are deeper and frequently lighter textured. In the west of the region boundaries are sharp and soils are deep, red cracking clays with shallow texture contrast soils confined to the intergroves. Usually a lower shrub layer is not well developed. Ground cover is very variable.

Table 5.4. Description of floristic associations (Cont'd)

Floristic Association	Structural Formation Range, Height, PFC, Trees/ha	Frequently Occurring Species	Comment
Acacia aneura (Cont'd)		*Digitaria brownii*, *Eragrostis* spp., *Iseilema* spp., *Tragus australianus*, *Themeda australis**, *T. avenacea**, Forbs: *Bassia* spp., *Alternanthera nodiflora**, *Calotis* spp., *Cheilanthes sieberi**, *Erodium crinatum**, *Ptilotus* spp., *Salsola kali*, *Sida platycalyx*, *Velleia glabrata*. * found only in the grove.	
Acacia aneura, *Eucalyptus populnea*	Sparse tall open shrubland to tall open shrubland rarely an open woodland. Height: 4-10 m. PFC: 1-9%. Shrubs/ha: 50-220. Trees/ha: 20-140.	Trees: *Acacia excelsa*, *Capparis loranthifolia*, *Grevillea striata*, *Hakea leucoptera*. Shrubs: *Eremophila mitchellii*. Low shrubs: *Cassia nemophila*, *Dodonaea attenuata*, *Eremophila sturtii*, *E. gilesii* (in places). Grasses: *Aristida contorta*, *Aristida ingrata*, *Eragrostis eriopoda*, *Eriachne helmsii*, *Monachather paradoxa*, *Tragus australianus*. Forbs: *Bassia birchii*, *B. convexula*, *Boerhavia diffusa*, *Euphorbia* spp., *Sida* spp.	Occurs on flat to gently undulating plains conspicuous in the south east on sandy red earths. A shrub layer is usually well developed. It may approach an open tussock grassland, where clearing has occurred, a serious woody weed problem may result. *Dodonaea* spp. and *Eremophila* spp. may form dense low shrublands with grasses and forbs almost excluded.
Acacia aneura, *Eucalyptus terminalis*	Tall open shrubland to tall shrubland. Height: 4-6 m. PFC: 1-10%. Shrubs/ha: 50-220.	Trees: *Grevillea striata*. Tall shrubs: *Eremophila longifolia*. Low shrubs: *Acacia tetragonophylla*, *Cassia helmsii*, *Eremophila gilesii*, Grasses: *Aristida contorta*, *Enneapogon polyphyllus*, *Eriachne pulchella*, *Fimbristylis dichotoma*, *Tragus australianus*, *Tripogon loliiformis*. Forbs: *Bassia bicornis*, *B. lanicuspis*, *Kochia villosa*, *Ptilotus gaudichaudii*, *P. macrocephalus*, *Salsola kali*, *Velleia glabrata*.	Occurs on run-on situations on flat plains in the west on loamy, red earths. There is no well defined low shrub layer. Ground cover is variable. A variant of this association occurs on extended flanks of dunes. *Owenia acidula* is conspicuous and *Eremophila* spp. are absent. Shrub density is less than 100/ha. Ground flora is variable.
Acacia aneura, *Acacia tetragonophylla*	Sparse tall open shrubland to tall open shrubland. Height: 2.5-4.5 m. PFC: 1-9%. Shrubs/ha: 25-200.	Trees: *Atalaya hemiglauca* (in places), *Eucalyptus terminalis*, *Flindersia maculosa* (in places), *Grevillea striata*. Shrubs: *Eremophila longifolia*. Low shrubs: *Cassia oligophylla*, *C. phyllodinea*, *Eremophila gilesii*, *E. maculata*. Grasses: *Aristida* spp., *Eragrostis* spp., *Eriachne* spp., *Fimbristylis dichotoma*, *Dactyloctenium radulans*, *Dichanthium* spp. Forbs: *Calotis* spp., *Fimbristylis dichotoma*, *Kochia* spp., *Ptilotus* spp., *Sida* spp.	Occurs mainly in the west on flat to undulating plains. Soils are shallow red earths or texture contrast soils on a hard pan. In places *Acacia aneura* may form almost pure stands with scattered *A. tetragonophylla*. There is no well defined low shrub layer. Ground cover is variable. Areas devoid of vegetation may occur.

Table 5.4. Description of floristic associations (Cont'd)

Floristic Association	Structural Formation Range, Height, PFC, Trees/ha	Frequently Occurring Species	Comment
Acacia aneura, Triodia mitchellii	Tall open shrubland. Height: 4-6 m. PFC: 1-9%. Shrubs/ha: 50-200.	Trees: *Eucalyptus terminalis* Shrubs: *Cassia artemisioides, C. nemophila, Eremophila bowmanii, E. gilesii.* Grasses: *Aristida* spp., *Eragrostis* spp., *Eriachne* spp. Forbs: *Bassia* spp., *Ptilotus* spp., *Salsola kali.*	Limited to the east on stony ridges on undulating plains. Soils are shallow, stony, red earths. There is no well developed low shrub layer.
Acacia aneura, Eragrostis eriopoda	Sparse tall open shrubland to tall open shrubland. Height: 3.5-7 m. PFC: 1-9%. Shrubs/ha: 40-220.	Trees: *Codonocarpus cotinifolius, Eucalyptus populnea, E. terminalis, Grevillea striata.* Low shrubs: *Cassia artemisioides, C. nemophila, Eremophila bowmanii, E. mitchellii, Dodonaea attenuata.* Grasses: *Aristida contorta, A. ingrata, A. jerichoensis, Eriachne helmsii, E. mucronata, Monachather paradoxa, Thyridolepis mitchelliana.* Forbs: *Evolvulus alsinoides, Kochia villosa, Ptilotus polystachyus, Sida cunninghamii, S. platycalyx, Trachymene cyanantha, T. ochracea,* species of Compositae.	Occurs mainly on gently undulating plains east of the Bulloo River. Soils are sandy red earths. Usually a low shrub layer is not well developed but *Eremophila* spp. forms a low shrub layer in places. Ground cover is variable, composed mainly of short tussock grasses. *Codonocarpus cotinifolius* becomes conspicuous after disturbances such as clearing or fire. May approach an open tussock grassland.
Associated Associations			
Acacia brachystachya A. aneura	Low open shrubland to tall open shrubland. Height: 1-2 m. PFC: 1-5%. Trees/ha: 10-60. Shrubs/ha: 50-250.	Low shrubs: *Acacia clivicola, Canthium latifolium, Cassia oligophylla, C. sturtii, Dodonaea petiolaris, D. tenuifolia* (rare), *Eremophila latrobei.* Grasses: *Aristida* spp., *Eragrostis eriopoda, Eriachne pulchella.* Forbs: *Kochia georgei, Ptilotus leucocoma, P. nobilis, P. obovatus, Sida* spp.	Limited areas occur mainly on shallow red earths. Scattered *Eucalyptus populnea* may occur. Lower shrub layer may be well defined. Ground cover is usually very sparse.
Eriachne mucronata, Eucalyptus terminalis	Wooded open tussock grassland. Height: 0.5 m. PFC: 1-9%. Shrubs/ha: variable 0-50.	Tall shrubs: *Acacia aneura* Low shrubs: *A. tetragonophylla, Cassia artemisioides, C. desolata, C. nemophila.* Grasses: *Amphipogon caricinus, Aristida contorta, A. jerichoensis, Eriachne helmsii, E. pulchella, Neurachne munroi, Thryidolepis mitchelliana.* Forbs: *Euphorbia drummondii, Kochia villosa, Ptilotus leucocoma, P. macrocephalus, Sida filigormis, Velleia glabrata.*	Small areas occur on undulating plains on shallow, red earths. There is no well defined lower shrub layer. The feature of this association is its constant floristic composition and relative abundance of species.
Acacia spp. Atalaya hemiglauca **Herbaceous predominant associations and associated forblands**			
Acacia aneura, Atalaya hemiglauca	Herbaceous tall open shrubland. Height: 3-5 m. PFC: 1-5%. Trees or Shrubs/ ha: 50-150.	Trees: *Hakea leucoptera, Grevillea juncifolia.* Shrubs: *Acacia tetragonophylla, A. ligulata, A. murrayana, Acacia calcicola* Low shrubs: *Cassia desolata, Dodonaea attenuata,*	Occurs on reticulate dunes and adjacent flat plains in the west, on red earthy sands to red, siliceous sands. In places *Acacia calcicola* becomes co-dominant. *Santalum lanceolatum, Owenia acidula*

Table 5.4. Description of floristic associations (Cont'd)

Floristic Association	Structural Formation Range, Height, PFC, Trees/ha	Frequently Occurring Species	Comment
Acacia aneura, Atalaya hemiglauca (Cont'd)		*Eremophila duttonii.* Grasses: *Aristida contorta, Dactyloctenium radulans, Enneapogon* spp., *Eragrostis* spp., *Eriachne* spp., *Plagiosetum refractum.* Forbs: *Bassia* spp., *Crotalaria eremaea, Ptilotus polystachyus, Salsola kali.*	and *Eremophila sturtii* may occur. Ground cover is variable.
Acacia spp., *Atalaya hemiglauca*	Forby tall open shrubland to sparse tall open shrubland. Height: 3-5 m. PFC: 1-5% (in places 1%). Trees or Shrubs/ha: 25-120.	Trees: *Acacia ramulosa, Eucalyptus terminalis, Grevillea striata.* Tall shrubs: *Acacia aneura, A. tetragonophylla.* Low shrubs: *Cassia* spp., *Eremophila duttonii.* Grasses: *Aristida* spp., *Dactyloctenium radulans, Tragus australianus.*	Occurs on low dunes in the central-south and west on red, earthy sands. *Acacia aneura* is conspicuous. *Atalaya hemiglauca* and *Eucalyptus terminalis* frequently occur and in places become predominant. *Ventilago viminalis* may occur. There is no definite lower shrub layer but scattered shrubs occur. This may approach a forbland.
Associated Forblands			
Crotalaria eremaea	Sparse forbland to open forbland. Height: 0.75 m. PFC: 0.5-5%.	Grasses: *Eragrostis basedowii, E. eriopoda, Eriachne aristidea, Plagiosetum refractum, Zygochloa paradoxa* (on mobile crests in the west of the region). Forbs: *Salsola kali, Tribulus hystrix* (in places), *T. terrestris, T. occidentalis, Bassia* spp.	Occurs on low reticulate dunes and parallel dunes with mobile crest. Soils are red or yellow siliceous sands. *Acacia dictyophleba* (in the west), *Atalaya hemiglauca* and *Owenia acidula* may occur. Large areas may be devoid of vegetation. It may form a complexes with *Zygochloa paradoxa* open hummock grassland.
Crotalaria cunninghammii	Sparse forbland. Height: 1 m. PFC: 1-5%.	Shrubs: Scattered *Crotalaria eremaea, Duboisia hopwoodii, Dodonaea attenuata, Cassia pleurocarpa.* Forbs: *Tribulus hystrix, Salsola kali.*	Occurs on the upper slopes and mobile crests of some sand-dunes on siliceous sands and earthy sands. Vegetation is sparse.
Salsola kali	Sparse forbland. Height: 0.5-1 m. PFC: 2%.	Shrubs: *Hakea leucoptera* (restricted to extended flanks). Grasses: *Eragrostis* spp., *Triraphis mollis.* Forbs: *Atriplex* spp., *Bassia* spp., *Crotalaria eremaea, Tribulus* spp.	Occurs on dunes in the west on earthy sands. Floristic composition is dependent on seasonal conditions. Vegetation is sparse.
Acacia clivicola, A. petraea, A. catenulata, A. aneura **predominant associations**			
Acacia petraea	Low open woodland to open woodland. Height: 4-10 m. PFC: 5-20%. Trees/ha: 200-500.	Trees: *Eucalyptus thozetiana, E. papuana.* Shrubs: *Acacia aneura, A. catenulata, A. ensifolia.* Low shrubs: *Canthium latifolium, Dodonaea petiolaris, D. tenuifolia, Eremophila latrobei, E. oppositifolia, Rhagodia spinescens, Scaevola spinescens.* Grasses: *Aristida contorta, A. jerichoensis, Eriachne mucronata, E. pulchella.* Forbs: *Kochia georgei, K. villosa, Ptilotus gaudichaudii, P. leucocoma, Sida aprica, S. cunninghamii, S. filiformis.*	Confined to scarps. In places *A. petraea* forms pure stands. Frequently there is a well developed low shrub layer. This association may form a complex with *A. catenulata* tall open shrubland and/or *A. aneura,* tall open shrubland and/or *A. clivicola* low open shrubland. In these situations it is difficult to delineate boundaries.

Table 5.4. Description of floristic associations (Cont'd)

Floristic Association	Structural Formation Range, Height, PFC, Trees/ha	Frequently Occurring Species	Comment
Acacia catenulata	Tall open shrubland to tall shrubland. Height: 5-10 m. PFC: 5-20%. Shrubs/ha: 100-700.	Trees: *A. petraea*, *A. aneura* (in places), *Eucalyptus exserta*, *E. papuana*, *E. thozetiana*. Shrubs: *Canthium latifolium*, *Dodonaea petiolaris*, *D. tenuifolia*, *Eremophila latrobei*. Grasses: *Digitaria ammophila*, *D. orbata*, *Eriachne mucronata*, *E. pulchella*, *Tripogon loliiformis*. Forbs: *Bassia birchii*, *B. convexula*, *B. tricuspis*, *Chenopodium rhydinostachyum*, *Cheilanthes sieberi*, *Kochia villosa*, *Salsola kali*, *Solanum ellipticum*.	Limited areas are associated with scarps on lithosols to shallow, earthy loams. *A. catenulata* may form pure stands. A lower shrub layer is usually well developed. Ground cover is sparse.
Acacia clivicola	Sparse low open shrubland to low open shrubland. Height: 0.5-1.5 m. PFC: 1-10%. Shrubs/ha: 50-350.	Shrubs: *Hakea collina*. Grasses: *Eriachne pulchella*. Forbs: *Bassia convexula*, *Kochia villosa*.	Restricted to dissected low hills and undulating plains. Soils are lithosols. *A. clivicola* may form pure stands. Scattered shrubs may occur. Ground cover is sparse.
Acacia clivicola, *A. aneura*	Sparse low open shrubland to low shrubland. Height: 1.0-2.0 m. PFC: 5-12%. Shrubs/ha: 50-350.	Trees: *Eucalyptus terminalis*. Shrubs: *Acacia tetragonophylla*, *Canthium latifolium*, *Dodonaea petiolaris*, *Eremophila latrobei*, *Scaevola spinescens*, *Phyllanthus rigens*. Grasses: *Aristida contorta*, *A. jerichoensis*, *Digitaria brownii*, *Eragrostis eriopoda*, *Eriachne pulchella*, *Thridolepis mitchelliana*, *Tripogon loliiformis*. Forbs: *Boerhavia diffusa*, *Calotis inermis*, *Euphorbia boophthona*, *Kochia villosa*, *Ptilotus exaltatus*, *Salsola kali*, *Velleia glabrata*.	Occupies very shallow, red earths and red lithosols on dissected undulating plains. In places *A. aneura* becomes very conspicuous and tends to be co-dominant. *Cassia* spp. are conspicuous in some situations. Ground cover is sparse.
Acacia clivicola, *Eucalyptus exserta*	Low open shrubland to low shrubland. Height: 1-2 m. PFC: 1-10%. Trees/ha: 10-50. Shrubs/ha: 50-350.	Trees: *Eucalyptus exserta*. Shrubs: *Eremophila latrobei*, *Eriostemon difformis*, *Phebalium glandulosum*, *Prostanthera suborbicularis*, *Westringia rigida*. Grasses: *Aristida* spp., *Eriachne pulchella*, *Eragrostis eriopoda*, *Tripogon loliiformis*. Forbs: *Bassia* spp., *Boerhavia diffusa*, *Kochia villosa*, *Ptilotus* spp., *Salsola kali*.	Confined to shallow, red earths and red lithosols on dissected plains and low hills. The lower shrub layer is usually well developed. *Acacia aneura*, *Eucalyptus papuana* and *E. thozetiana* may occur. Ground cover is sparse.
Shrubby Chenopod predominant associations			
Chenopodium auricomum	Low open shrubland to low shrubland. Height: 0.75-1.25 m. PFC: 5-15%.	Grasses: *Cyperus difformis* (sedge), *C. gymnocaulis* (sedge), *Elytrophorus spicatus*. Forbs: *Aeschynomene indica*, *Bassia stelligera*, *Damasonium minus*.	Small areas occur on grey clays in flooded depressions on alluvial plains. *C. auricomum* may form pure stands. Ground cover is variable.

Table 5.4. Description of floristic associations (Cont'd)

Floristic Association	Structural Formation Range, Height, PFC, Trees/ha	Frequently Occurring Species	Comment
Chenopodium auricomum, Muehlenbeckia cunninghamii	Low open shrubland to low shrubland Height: 0.75-2 m. PFC: 5-10% (up to 25%)	Grasses: *Dactyloctenium radulans, Elytrophorus spicatus, Eragrostis australasica, E. dielsii, E. setifolia, E. tenellula.* Forbs: *Aeschynomene indica, Alternanthera nodiflora, Calotis hispidula, C. multicaulis, Centipeda thespidioides, Damasonium minus, Daucus glochidiatus, Marsilea spp., Plantago pritzelii, Ranunculus pentandrus* var. *platycarpus.*	Associated with flooded depressions. Soils are grey clays. Either *C. auricomum* or *M. cunninghamii* may predominate. In places *Eucalyptus microtheca* low open woodland fringe the association.
Muehlenbeckia cunninghamii	Low open shrubland to tall open shrubland. Height: 2-3 m. PFC: 5-15%.	Shrubs: *Chenopodium auricomum.* Grasses: *Eragrostis australasica, E. dielsii, E. setifolia.* Forbs: *Aeschynomene indica, Alternanthera nodiflora, Centipeda thespidioides, Marsilea* spp. Sedges: *Cyperus difformis, C. iria, Eleocharis pallens.*	Restricted to periodically flooded depressions. Soils are grey clays. In places it forms an understorey to *Eucalyptus microtheca* open woodland.
Atriplex nummularia	Low open shrubland. Height: 1-2 m. PFC: 1-10%.	Shrubs: *Chenopodium auricomum.* Grasses: *Aristida anthoxanthoides, Chloris pectinata, Eragrostis dielsii, Sporobolus mitchellii.* Forbs: *Atriplex holocarpa, A. spongiosa, Boerhavia diffusa.*	Limited areas occur in the west on alluvial soils They are flooded for short periods of time. *A. nummularia* forms pure stands. *Acacia farnesiana* and *A. victoriae* may occur. Ground cover is usually sparse.
Arthrocnemum spp.	Low open shrubland. Height: 1 m. PFC: 1-10%.	Shrubs: *Pachycornia tenuis, Malacocera tricornis, Myoporum acuminatum* (rare). Grasses: *Cyperus gymnocaulis* (a sedge) *Dactyloctenium radulans, Eragrostis australasica, E. dielsii, Sporobolus actinocladus, S. caroli.* Forbs: *Atriplex elachophylla, A. lindleyi, A. spongiosa, Babbagia dipterocarpa, B. scleroptera, Bassia bicornis, B. biflorus, B. divaricata, B. lanicuspis, B. paradoxa, B. ventricosa, Frankenia hamata, Portulaca* sp. aff. *P. oleracea, Salsola kali, Zygophyllum ammophilum, Z. apiculatum.*	Occurs on the edge of salt lakes, and on small salt pans or clay pans. This association exhibits zoning on the margins of some salt lakes with *Cyperus gymnocaulis* forming a pure stand up to 3 m wide at the edge of the lakes. Grasses and forbs occur on slight rises. Trees are absent.
Channel country complex	Open herbland to low shrubland. Height: 0.75-2 m. PFC: variable 1-50%	Trees: *Eucalyptus microtheca* (scattered). Shrubs: *Chenopodium auricomum, Muehlenbeckia cunninghamii.* Grasses: *Brachyachne convergens, Chloris pectinata, Dactyloctenium radulans, Echinochloa turnerana, Eragrostis australasica, E. setifolia, E. tenellula, Eriochloa* spp., *Iseilema* spp., *Panicum whitei.* Forbs: *Atriplex* spp., *Bassia* spp., *Calotis hispidula, Calostemma luteum, Craspedia pleiocephala, Helipterum corymbiflorum, H. floribundum, Plantago pritzelii, Senecio lautus, Trigonella suavissima.*	Occurs on the flood plains of the Bulloo and Cooper Creek. Soils are grey clays. Composition varies. Some associations are characterized by perennial species and are of a more permanent nature, other by ephemerals of a temporary nature. After summer local flooding *D. radulans, Panicum whitei, Iseilema* spp. and *Chloris pectinata* usually predominate. *Atriplex* spp., *Bassia* spp., and composites conspicuous after winter local flooding. *Echinochloa turnerana* usually predominates, after early summer general flooding with *Craspedia pleiocephala* and *Trigonella suavissima* conspicuous after early winter flooding. Low open shrublands of *Chenopodium auricomum* and *Muehlenbeckia cunninghamii* are usually present. Limited areas of *Eucalyptus microtheca* low open woodland occurs with *E. camaldulensis, E. microtheca* open woodland fringing the main channel.

Table 5.4. Description of floristic associations (Cont'd)

Floristic Association	Structural Formation Range, Height, PFC, Trees/ha	Frequently Occurring Species	Comment
Associated Associations			
Eragrostis australasica	Open hummock grassland Height: 1-2 m. PFC: 1-10%,	Shrubs: *Chenopodium auricomum, Muehlenbeckia cunninghamii.* Grasses: *Eragrostis dielsii, E. leptocarpa, Diplachne muelleri.* Forbs: *Alternanthera nodiflora, Atriplex limbata, A. spongiosa, Bassia bicornis, B. divaricata, B. paradoxa, Centipeda thespidioides, Marsilea* spp., *Plantago pritzelii.* Sedges: *Cyperus fulvus, C. rigidellus, Eleocharis pallens.*	Occurs on periodically flooded low depressions. Soils are poorly drained grey clays. *E. australasica* may form pure stands. A degraded association with only scattered *E. australasica* and a few forbs may occur on claypans, in places *Eucalyptus microtheca, E. ochrophloia* and the shrubs *Acacia stenophylla, Eremophila bignoniiflora* and *Myoporum deserti* fringe this association.
***Triodia basedowii* predominant associations**			
Triodia basedowii	Open hummock grassland to hummock grassland. Height: 1 m. PFC: 5-30%. Shrubs/ha: 10-60 (may be higher in places).	Trees or Tall shrubs: *Eucalyptus terminalis, E. papuana, Grevillea juncifolia, Hakea divaricata, H. leucoptera, Acacia aneura, A. ramulosa.* Low shrubs: *A. ligulata* (lower slopes), *Cassia artemisioides, C. desolata, C. nemophila, C. oligophylla, C. pleurocarpa, Dodonaea attenuata, Eremophila* spp. Grasses: *Aristida browniana, C. contorta, Dactyloctenium radulans, Enneapogon polyphyllus, Eragrostis basedowii, E. eriopoda, Eriachne helmsii, E. mucronata, E. aristidea.* Forbs: *Calocephalus multiflorus, Calotis multicaulis, Crotalaria cunninghamii, C. eremaea, Euphorbia drummondii, E. wheeleri, Helipterum floribundum, H. moschatum, Lepidium rotundum, Nicotiana velutina, Ptilotus obovatus, P. polystachyus, Senecio gregorii, Trachymene glaucifolia.*	Occurs in the west on dunefields. Soils are red earthy sands. Trees may become very sparse. Where not disturbed an almost pure stand of *T. basedowii* may occur. *Acacia aneura* may form almost pure stands with a *T. basedowii* ground layer. Dead *A. aneura* may be a feature of this association. The low shrubs may form a dense layer with scattered tall shrubs or trees emerging. Floristics are variable. This association appears to be very susceptible to fire.
Zygochloa paradoxa	Open hummock grassland. Height: 1 m. PFC: 2%.	Grasses: *Plagiosetum refractum, Eriachne aristidea,* (rare). Forbs: *Crotalaria cunninghamii, C. eremaea, Blennodia pterosperma, Euphorbia* spp., *Ptilotus latifolius, P. polystachyus, Salsola kali, Tribulus hystrix.*	Restricted to the mobile crests of sand-dunes in the west. Soils are red, siliceous sands. *Z. paradoxa* forms scattered clumps usually with areas of bare sand between them. Floristically poor. In more protected situations *Grevillea stenobotrya* may occur. *Acacia dictyophleba* may occur on the crests.
Astrebla/short grass/ forb predominant associations			
Astrebla spp. Short Grass Forbs	Open herbland to herbland- Height: 0.5-1 m. PFC: variable depending on seasonal conditions 10-30%.	Grasses: *Astrebla lappacea, A. pectinata, Brachyachne convergens, Dactyloctenium radulans, Eragrostis* spp., *Iseilema* spp., *Panicum whitei, Sporobolus actinocaldus, Tragus australianus.* Forbs: *Atriplex lingleyi, A. spongiosa, Bassia divaricata, B. lanicuspis, Boerhavia diffusa, Lepidium rotundum, Portulaca* sp. aff. *P. oleracea, Salsola kali, Threlkeldia proceriflora.*	Occurs on undulating plains in the west. Soils are stony, red and brown clays. Composition depends on seasonal conditions. In moist situations *A. elymoides* and *A. squarrosa* are predominant. In places the forbs mainly *Atriplex* spp., *Bassia* spp., *Salsola kali, Threlkeldia proceriflora* predominate and grasses are rare. Trees are rare.

Table 5.4. Description of floristic associations (Cont'd)

Floristic Association	Structural Formation Range Height, PFC, Trees/ha	Frequently Occurring Species	Comment
Associated association Tall open shrubland			
Acacia cyperophylla	Tall open shrubland to tall shrubland. Height: 5-9 m. PFC: 1-5%. Trees/ha: 50-250.	Low shrubs: *Acacia tetragonophylla, Cassia helmsii, Cassia nemophila, Cassia oligophylla, Eremophila bignoniiflora.* Grasses: *Brachiaria miliiformis, Chloris* spp., *Eragrostis setifolia, Panicum* spp. Forbs: *Atriplex* app., *Bassia* spp., *Kochia* spp.	Limited areas occur on drainage lines on undulating plains mainly west of Cooper Creek. Soils are stony shallow to deep clay-loams and sandy-clays. *A. cyperophylla* may form almost pure stands. There is no well defined low shrub layer. *Acacia cambagei Atalaya hemiglauca, Bauhinia carronii, Eucalyptus camaldulensis* and *E. microtheca* may occur.
Short Grass/forb predominant association			
Short grasses and forbs	Sparse open herbland to herbland. Height: 0.5-0.75 m. PFC: 1-25%.	Shrubs: *Acacia cambagei, A. stenophylla, A. victoriae, Cassia* spp., *Eremophila polyclada.* Grasses: *Aristida* spp., *Dactyloctenium radulans, Chloris* spp., *Eragrostis* spp., *Iseilema* spp., *Panicum* spp., *Astrebla* spp. (rare). Forbs: *Atriplex* spp., *Bassia* spp., *Chenopodium* spp., *Salsola kali, Threlkeldia proceriflora.*	Occurs on alluvial plains. Soils range from red and brown clays to texture contrast soils. Grasses or forbs may predominate. Scattered trees or shrubs may occur.
Short grasses, forbs, *Acacia aneura*	Sparse herbland to open herbland. Height: 0.75 m. PFC: variable 1-15%. Shrubs/ha: 0-20.	Trees: *Eucalyptus terminalis.* Tall shrubs: *Acacia tetragonophylla* Low shrubs: *Cassia nemophila, C. desolata, C. helmsii, Enchylaena tomentosa, Eremophila bowmanii.* Grasses: *Dactyloctenium radulans, Enneapogon polyphyllus, Tragus australianus, Tripogon loliiformis.* Forbs: *Bassia* spp., *Euphorbia* spp., *Salsola kali, Velleia glabrata.*	Occurs on undulating plains in the west. Soils are red earths and earthy loams. Composition of the ground flora is dependent on seasonal conditions, with grasses or forbs predominating. The ass association may approach a sparse tall open shrubland.
Miscellaneous associations			
Callitris columellaris	Low open woodland to woodland. Height: 6-13 m. PFC: 1-5%. Trees/ha: 50-200.	Trees/Tall shrubs: *Acacia excelsa, A. murrayana, A. oswaldii, A. salicina, A. victoriae, Alstonia constricta, Atalaya hemiglauca, Grevillea striata.* Low shrubs: *Cassia nemophila, C. oligophylla, Dodonaea attenuata, Enchylaena tomentosa, Myoporum deserti, Rhagodia spinescens.* Grasses: *Aristida browniana, A. ingrata, Dactyloctenium radulans.* Forbs: *Bassia* spp.	Limited areas occur in the east on sandplains. Soils are earthy sands. Usually there is no well defined low shrub layer. Ground cover is variable.
Melaleuca uncinata	Tall open shrubland. Height: 2-4 m. PFC: 3-7%. Shrubs/ha: 50-200.	Trees: *Eucalyptus microtheca* (emerging). Low Shrubs: *Eremophila maculata.* Grasses: *Chloris pectinata, Cyperus difformis, Eragrostis kennedyae.* Forbs: *Alternanthera nodiflora, Centipeda thespidioides, Lepidium rotundum, Mimulus prostratus, Salsola kali,*	This association fringes claypans in the far-south-west occurring on the edges of dunes. There is no well developed low shrub layer. Ground cover is variable. In the east *Melaleuca adnata* forms a similar association.

Table 5.4. Description of floristic associations (Cont'd)

Floristic Association	Structural Formation Range, Height, PFC, Trees/ha	Frequently Occurring Species	Comment
Acacia calcicola, A. aneura	Tall open shrubland to tall shrubland. Height: 2-4 m. PFC: 3-12%. Shrubs/ha: 70-250.	Shrubs: *Acacia excelsa, A. ramulosa, A. tetragonophylla Santalum lanceolatum* (in places). Low shrubs: *Cassia phyllodinea, Enchylaena tomentosa, Eremophila duttonii, Rhagodia spinescens.* Grasses: *Chloris* spp., *Eragrostis* spp., *Tragus australianus.* Forbs: *Bassia* spp., *Ptilotus* spp., *Salsola kali.*	Occurs on flanks of reticulate dunes and adjacent flat plains in the south-west. Soils are red, siliceous sand to red earthy, sands. Tree density varies 10 to 25/ha. A low shrub layer is not well developed. Ground flora is variably. *A. calcicola* may form pure stands. A variant occurs on old alluvial plains. It comprises *A. calcicola* and *A. A. aneura* with scattered *Cassia* spp. and *Eremophila* spp.
Cassia phyllodinea	Low open shrubland. Height: 0.75-1 m. PFC: 1-10%. Shrubs/ha: 50-450.	Trees/Tall shrubs: *Atalaya hemiglauca.* Low shrubs: *Eremophila maculata.* Grasses: *Dactyloctenium radulans, Enneapogon polyphyllus, Eragrostis dielsii, E. setifolia, Sporobolus actinocladus.* Forbs: *Bassia lanicuspis, Kochia brevifolia, Portulaca* sp. aff. *P. oleracea, Salsola kali.*	Limited areas occur on alluvia. Soils are texture contrast soils. Trees are rare. Ground cover is variable.
Eremophila duttonii	Low open shrubland. Height: 0.75-1.25 m. PFC: 1-10%. Shrubs/ha: 50-450.	Trees: *Atalaya hemiglauca* (rare). Shrubs: *Acacia tetragonophylla, A. victoriae, Cassia* spp., *Eremophila sturtii, Rhagodia spinescens.* Grasses: *Aristida browniana, A. contorta, Eragrostis dielsii, Triraphis mollis.* Forbs: *Cleome viscosa, Helipterum floribundum, Josephinia eugeniae.*	Limited areas occur on sandplains mainly in the west. Soils are sandy loams. Trees are rare. In places *E. duttonii* forms pure stands.

The floristic composition of these associations is variable. The number of species, genera and families recorded are given in Table 5.5. Of the total number of species recorded, 140 are annuals. The number of species which were only recorded from these associations is 66. This represents approximately 30% of the total number of species recorded from these associations.

Some of the associations contributing to the vegetation of the dunefields could undoubtedly be divided into smaller more homogenuous units.

Acacia clivicola, A. petraea, A. aneura, A. catenulata **predominant associations**

These associations (Table 5.4) are found throughout the area and are restricted mainly to dissected residuals. Soils vary from shallow, red earths to lithosols. This complex of associations occupies approximately 12% of the area.

Structurally, these associations range from low open shrubland to low open forest. They occur mainly as tall open shrubland or low open shrubland. *A. petraea* and *A. catenulata* associations form low woodlands to low open woodland at the eastern limits of the area and in isolated pockets on the Grey Range.

Floristically, these associations are diverse. The number of species, genera and families recorded are given in Table 5.5. The number of species recorded represents approximately 23% of total number of species recorded. Of these 145 species, 31 were recorded exclusively from these associations.

A feature of the floristics of these associations is the virtual absence of Compositae. This may be due to seasonal conditions.

Within this complex, various associations become dominant with variations in habitat. All associations are not always a component of the complex. Frequently the associations grade into one another forming a continuum. Though these associations are of little economic value from a grazing point of view, they are interesting from a botanical aspect because of their species diversity and the presence of rare plants.

In places, *A. aneura* associations form complexes with these associations.

Shrubby chenopod predominant associations

These associations (Table 5.4) are best developed in the "channel country" of south western Queensland. This comprises mainly the flood plains of the Bulloo River and Cooper Creek where during floods the creeks form a network of channels of varying width and depth. Limited areas of these associations occur associated with poorly drained swamps on alluvial plains. Some associations are adapted to specific situations such as the margins of lakes. Soils are brown and grey clays. Altogether these associations occupy about 7.5% of the area.

Structurally, these associations range from low open shrubland to tall open shrubland and rarely shrubland. Frequently, these associations form complexes with *Eucalyptus microtheca* (coolibah) woodland low open to open woodland and various herblands.

These associations are floristically variable, but usually low in species diversity. Under certain conditions a large number of ephemerals do occur. It is these species, which appear in profusion after flooding, especially if the area has been submerged for a period of time, which provides the bulk of fodder most important for cattle fattening. The number of species, genera and families recorded is given in Table 5.5. Plants which occur in abundance following flooding include *Echinochloa turnerana, Craspedia pleiocephala* (yellow top), *Trigonella suavissima* and *Senecio lautus*.

In the "channel country" the various plant associations grade into one another. Delineation of the various associations is difficult and it is convenient to consider it as a complex.

Triodia basedowii **predominant associations**

These associations (Table 5.4) occur on dunefields and adjacent flat plains in the west. *Triodia basedowii* associations are usually restricted to the more stable slopes and inter-dune flats and are not commonly found on mobile crests. The mobile crests may support *Zygochloa paradoxa* association. *Z. paradoxa* forms a sparse hummock grassland which is floristically very poor. In good seasons this association approaches a forbland and species diversity increases with ephemerals occupying the bare areas between the clumps of *Z. paradoxa*. These associations occupy approximately 5 per cent of the total area. Soils vary from red, siliceous sands to red, earthy sands.

Structurally, the associations range from open hummock grassland to hummock grassland. Scattered low shrubs or low trees may emerge and may form a rather dense stand approaching a tall open shrubland or low open shrubland.

Floristically the associations are variable, the species present depending on local environmental conditions. Considering only the ground layer, *T. basedowii* forms almost pure stands in the undisturbed state. Once disturbed, by grazing or fire, species diversity increases. This phenomenon of species diversity decreasing as an association approaches the climax appears to be exhibited by several plant associations in this arid region. The number of species, genera and families recorded are given in Table 5.5. The large number of composites and the large proportion of annuals are interesting but not an unexpected feature of the flora. In fact, it would be unusual, if a large percentage of the species present were not ephemerals, particularly in a region where precipitation is so variable and unreliable.

In *Triodia basedowii* predominant associations there are undoubtedly many groups of plants which would be considered "plant communities" or better still "habitat types" in the sense of Wiedeman (1971). To delineate these, detailed study would have been necessary. One objective of this project was a basic inventory of the vegetation for land use and it was considered unnecessary to subdivide the *T. basedowii* predominant associations.

Astrebla spp., **short grass, forbs, predominant associations**

These associations (Table 5.4) occur in the west on flat to undulating downs. Limited areas are developed on the alluvial plains. These associations occupy approximately 8% of the area. Soils are predominantly, deep, stony, red and brown clays and shallow to moderately deep, stony, desert loams.

Structurally, these associations range from sparse open herbland to herbland depending on seasonal conditions. Either grasses or forbs may predominate. The appearance of the associations is usually characteristic, with the perennial tussock grasses widely scattered and with areas of bare ground between them. In good seasons these bare areas are occupied by other grasses and forbs.

Floristically the associations are variable but usually do not exhibit great species diversity. The number of species, genera and families is recorded in Table 5.5. Four species of *Astrebla* occur but *A. pectinata* (barley Mitchell grass) is the most abundant. *A. elymoides* (hoop Mitchell grass) and *A. squarrosa* (bull Mitchell grass) which favour moist situations do not occur frequently and are usually restricted to drainage lines. The latter species occupy the moister habitat. *A. lappacea* (curley Mitchell grass) is relatively rare.

Table 5.5. Number of species, genera and families recorded for the major vegetation groups.

Major Vegetation Group	No. of Species	No. of Genera	No. of Families	Major Families	Major Genera
Eucalyptus	233	126	44	Gramineae (48 species); Compositae (31 species); Leguminosae (25 species); Chenopodiaceae (29 species); Myrtaceae (14 species); Cyperaceae (10 species).	*Eucalyptus* (11 species); *Eragrostis* (10 species); *Bassia* (10 species); *Acacia* (9 species); *Cyperus* (8 species); *Atriplex* (6 species); *Eremophila* (6 species).
Acacia cambagei	207	90	48	Gramineae (44 species); Chenopodiaceae (42 species); Compositae (11 species); Leguminosae (11 species); Myoporaceae (11 species); Cyperaceae (7 species); Malvaceae (6 species); Amaranthaceae (5 species).	*Bassia* (13 species); *Eremophila* (9 species); *Cyperus* (7 species); *Eragrostis* (6 species); *Atriplex* (6 species); *Acacia* (5 species); *Cassia* (5 species).
Acacia aneura (overall)	318	139	48	Gramineae (71 species); Compositae (32 species); Leguminosae (29 species); Chenopodiaceae (25 species); Amaranthaceae (11 species); Euphorbiaceae (9 species); Myoporaceae (8 species).	*Eragrostis* (13 species); *Bassia* (11 species); *Aristida* (9 species); *Acacia* (8 species); *Cassia* (8 species); *Chenopodium* (6 species); *Ptilotus* (6 species).
Acacia aneura (deep to moderately deep, red earths)	209	111	40	Gramineae (60 species); Compositae (26 species); Leguminosae (16 species); Chenopodiaceae (15 species); Amaranthaceae (10 species); Malvaceae (6 species).	*Eragrostis* (12 species); *Aristida* (9 species); *Cassia* (7 species); *Bassia* (6 species); *Chenopodium* (6 species); *Ptilotus* (6 species).
Acacia aneura (shallow, red earth)	149	81	35	Gramineae (41 species); Chenopodiaceae (15 species); Leguminosae (13 species); Compositae (13 species); Amaranthaceae (7 species); Myoporaceae (6 species).	*Bassia* (8 species); *Eremophila* (7 species); *Eragrostis* (6 species); *Aristida* (6 species); *Cassia* (6 species); *Ptilotus* (6 species).
Acacia aneura (sandplain)	110	68	30	Gramineae (28 species); Leguminosae (15 species); Compositae (13 species); Chenopodiaceae (8 species); Solanaceae (5 species).	*Solanum* (5 species); *Acacia* (4 species); *Aristida* (4 species); *Bassia* (4 species); *Cassia* (4 species); *Eremophila* (4 species).
Acacia spp., *Atalaya hemiglauca*, herbaceous associations.	223	124	48	Gramineae (33 species); Chenopodiaceae (29 species); Leguminosae (29 species); Compositae (25 species); Myoporaceae (10 species); Amaranthaceae (8 species).	*Bassia* (14 species); *Acacia* (9 species); *Eremophila* (9 species); *Eragrostis* (8 species); *Cassia* (6 species); *Calotis* (5 species).
Acacia clivicola, *A. petraea*, *A. aneura*, *A. catenulata*	145	82	39	Gramineae (26 species); Leguminosae (17 species); Chenopodiaceae (15 species); Malvaceae (10 species); Amaranthaceae (8 species); Myoporaceae (6 species).	*Acacia* (9 species); *Ptilotus* (8 species); *Bassia* (7 species); *Eremophila* (6 species).
Shrubby chenopod	91	58	25	Gramineae (20 species); Chenopodiaceae (15 species); Compositae (12 species); Leguminosae (9 species).	*Bassia* (7 species); *Eragrostis* (5 species); *Atriplex* (5 species).
Triodia basedowii	151	73	34	Compositae (26 species); Chenopodiaceae (14 species); Gramineae (20 species); Leguminosae (9 species); Amaranthaceae (9 species); Myoporaceae (9 species).	*Bassia* (9 species); *Acacia* (9 species); *Eragrostis* (8 species); *Eremophila* (7 species); *Cassia* (6 species); *Calotis* (5 species); *Ptilotus* (5 species).
Astrebla spp., short grass, forb	83	49	19	Gramineae (26 species); Chenopodiaceae (14 species); Leguminosae (6 species); Malvaceae (6 species); Euphorbiaceae (5 species).	*Bassia* (6 species); *Euphorbia* (5 species); *Atriplex* (4 species); *Sida* (4 species); *Astrebla* (4 species).
Short grass, forb	181	98	36	Gramineae (35 species); Chenopodiaceae (34 species); Compositae (27 species); Leguminosae (19 species); Cyperaceae (6 species);	*Bassia* (11 species); *Acacia* (9 species); *Atriplex* (7 species); *Eragrostis* (5 species); *Helipterum* (5 species); *Calotis* (4 species); *Cyperus* (4 species); *Euphorbia* (4 species).

Under normal conditions, *Astrebla* spp. do not comprise the large percentage of the pasture that they do in the "Mitchell grass country " of the Blackall and Longreach district. Except in good seasons, *Astrebla* spp. rarely exceed 20% of the pasture and in many situations they comprise less than 10%. In very good seasons, *Astrebla* spp. may be 80% of the pasture. Blake (1938) draws attention to the fact that in areas within the 250 mm isohyet the *Astrebla* grasslands are restricted to crab-hole or gullies and several species contribute to pasture. Skerman (1947) makes similar comments. It appears that except for excellent seasons, *Astrebla* spp. do not comprise a major proportion of the pasture. Undoubtedly, this is due, in part, to the pressures of climate and the domestic grazing animal. How large a part the grazing animals play is problematical.

The vegetation of these associations is considered as one complex heterogenous association, the composition of which depends on seasonal conditions. It is expected that a more detailed study would result in the segregation of more homogeneous smaller associations.

Short grass, forb predominant association

Alluvial plains throughout the area support this association (Table 5.4) which occupies approximately 8% of the area. Soils range from grey and brown clays to texture contrast soils.

Structurally, this association forms sparse open herblands or herblands, depending on variation in habitat and seasonal conditions. Either grasses or forbs may predominate. Scalded areas denuded of vegetation may occur in conjunction with this association.

Floristically the association is variable. Many of the species are annuals and may be absent depending on environmental conditions. The number of species, genera and families recorded are given in Table 5.5. The four largest families Chenopodiaceae, Gramineae, Compositae and Leguminosae contribute approximately 63% of the species recorded.

More detailed studies would undoubtedly result in the segregation of more homogenous smaller groups, but at present this association is considered as one heterogenous association. In places *Iseilema* spp. (Flinders grasses) form an open tussock grassland as does *Dactyloctenium radulans* (button grass) but the same site under different seasonal conditions may support a forbland of *Atriplex* spp. and *Bassia* spp. This was observed on alluvial plains near Eromanga on successive visits. Because of this, and the fact that all sites could not be visited at the same time, or under the same conditions, a broad approach is necessary.

Miscellaneous

A limited number of plant associations occurs which are not readily classified into one of the major floristic groupings. These have been aggregated under this heading (Table 5.4).

Induced associations

These associations are the result of man's activities and fall into two broad categories. One is an incidental result of man's activities, such as associations developed along bore-drains. The other is where man has purposely modified an association for his own needs - for example an induced herbland where shrubs and trees have been cleared for increased yields from grasses and forbs. In some situations only part of the original vegetation is removed. This action may modify the structure and composition of the vegetation to a large degree.

Detail data on these modified associations are limited as excessively disturbed sites were avoided in sampling. Data collected indicated that the resulting associations are structurally more simple than the original association. The floristic composition and the contribution of the various species to the total biomass also vary.

Associations of bore-drains

Structurally, the associations are usually open herbland, open grassland or open sedgeland ranging to sparse herbland. In places, a low open shrubland of *Acacia farnesiana* or *A. victoriae* may develop.

Various species occur on the banks of, and in, the bore drains. *Atriplex* spp., *Bassia* spp. and *Chenopodium* spp. are conspicuous in some areas. Grasses including *Brachyachne convergens* (native couch grass), *Cyndon dactylon* (couch), *Paspalidium* spp., *Eragrostis* spp., *Dactyloctenium radulans* (button garss), and *Sporobolus* spp may be found. In places sedges are prominant especially *Cyperus gymnocaulis* and *Eleocharis pallens*. *Typha angustifolia* (bulrush) forms dense stands in some situations.

Associated with bore drains are areas devoid of vegetation or supporting a few scattered plants of *Arthrocnemum* spp., or *Pachycornia tenius* (a samphire). This occurs where the drains have broken and the areas have been inundated.

Associations of stock-routes

Usually the vegetation of these areas has been greatly affected by stock.

The relative abundance of palatable tree and shrub species is usually less in associations developed on stock-routes than in the same associations developed elsewhere. The vegetation of these stock-route associations is composed of a larger percentage of annual species than expected. Chenopodiaceae, in particular *Atriplex* spp., *Bassia* spp., *Salsola kali* (soft roly poly) and *Threlkeldia proceriflora* (soda bush) are more prevalent and Gramineae less abundant, than in the same associations away from stock-routes.

However, not all stock-routes support only degraded vegetation or vegetation greatly modified by stock. The condition and trend of vegetation is dependent on the histroy of land use and seasonal conditions. With the change to road-trains for transporting stock, pressure on the vegetation of stock-routes has been reduced and the vegetation is exhibiting an upward trend in places.

Induced herblands

In places shrubs and trees have been cleared, partially cleared or thinned, in an attempt to improve the natural pasture. If all the trees are removed this action may result in a grassland or herbland depending on seasonal conditions. While the removal of trees and shrubs unquestionably increases the dry-matter yield of grasses this practice has been disastrous in some situations. In *Acacia aneura* associations, *A. cambagei* associations and *Eucalyptus populnea* associations the growth of woody weeds reduces the bulk produced by grasses and forbs. The removal of trees and shrubs may accelerate soil erosion. Other questions to consider are the acceptance by the grazing animal of the grasses and forbs that are most likely to develop and the degree of harvesting of the additional materialby other species such as termites.

The overall question which must be considered is whether creation of artificial grasslands or herblands increases the long term productivity, without causing irreparable harm to the land resource.

However, clearing may be beneficial particularly in the east providing adequate timber is left to ensure shelter for animals, re-establishment of the species and protection against erosion. The resulting herbland which develops as a result of clearing or thinning, depends largely on the type of country involved. Seasonal conditions will govern whether a grassland or forbland develops.

Aristida spp. open tussock grasslands are the most common induced grasslands in the region. Usually these are the result of thinning or clearing various *Acacia aneura* associations developed on flat to gently undulating plains with red earths and texture contrast soils.

Woody weeds such as *Eremophila gilesii* and *Cassia* spp. and regrowth of *Eucalyptus populnea*, may be troublesome.

Induced grasslands are developed on sandplains. *Eragrostis eriopoda* (woollybutt grass) frequently predominates the ground layer. Woody weeds, mainly *Dodonaea* spp., *Eremophila* spp. and *Cassia* spp. may be a problem on disturbed sand-plains.

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Hydrology

UNDERGROUND WATER

Supplies of groundwater are obtainable throughout this area at depths ranging from less than 15 m to more than 2000 m. Yields, although small, are sufficient for stock use. Licensing conditions do not permit irrigation from bores penetrating aquifers of the artesian basin. Figure 6.1 shows the source and quality of groundwater resources in the area.

General

Underground water is available in some quantity in most of the formations above bedrock.

The *Hutton Sandstone,* where it is present, can supply artesian or sub-artesian water, but is rarely used except where quite shallow. Being at the base of the sequence it is usually too deep and other aquifers are encountered before it is reached.

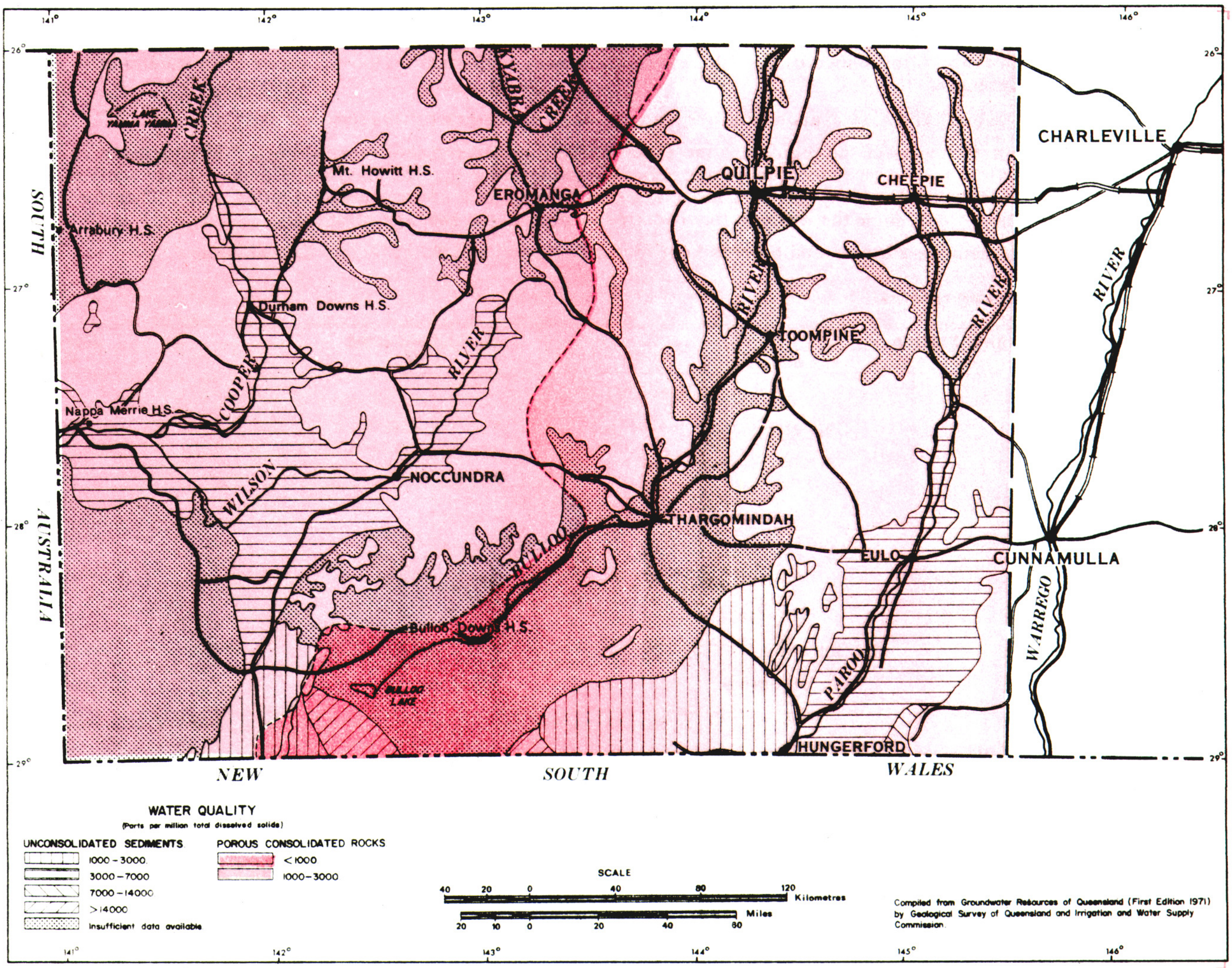


Fig. 6.1. *Groundwater Resources*

The *Hooray Sandstone,* one of the major aquifers of the artesian basin, is continuous throughout the area. However, due to the unevenness of the bedrock, its depth varies considerably. Towards the eastern part of the area, it exists at relatively shallow depths ranging from 360 m in the south to 510 m in the north. It dips westerly into the central-western part where it is more than 2100 m below the surface. In the south-eastern section (on the Eulo Shelf) the *Hooray Sandstone* outcrops. When it occurs at shallow depths the *Hooray Sandstone* is often tapped, however, over most of the area it is too deep, and sufficient supplies for stock water can be obtained from overlying sediments.

The *Rolling Downs Group* provides much of the deeper underground water used in this area. Artesian supplies are rarely, obtained, but sub-artesian supplies are extensive and common. The *Coreena Member* of the *Wallumbilla Formation* is an important sandstone aquifer where it is relatively shallow. This is mainly in the southern area. Elsewhere, lenticular sandstone aquifers of the *Winton Formation* can provide sufficient water for stock use.

Shallow sub-artesian supplies are obtained from the Tertiary and Quaternary sediments throughout the area. The Tertiary *Glendower Formation* is present over most of the area, at depth down to 60 m, but does not contain continuous aquifers. Consequently, although many bores succeed in tapping these shallow beds, there are many others which failed to locate a supply. The alluvium and associated Quaternary deposits are mainly superficial. However, the alluvium along some of the major streams reaches significant depths, and can supply useful stock water.

* Prepared by officers of the Irrigation and Water Supply Commission.

Yield

The deeper aquifers, the *Hutton Sandstone*, the *Hooray Sandstone* and even the sands of the *Wallumbilla* and *Winton Formations* can produce artesian flows if favourably located. However, quite a few of the artesian bores have since ceased to flow, due to declining artesian pressure, while other bores drilled to these aquifers have never flowed. Pumped supplies of from 2300 to 4600 l per hour and often much more, can be obtained from these deeper bores. Similar flow rates can still be obtained from artesian bores favourably situated.

Shallow aquifers of the Tertiary and Quaternary sediments will usually yield from 900 to 2300 l per hour. Some of the alluvial areas could produce at higher rates.

Quality

Water of suitable quality for stock use is obtained from all the major aquifers. Small quantities of saline waters are obtained from some sediments between the main aquifers but these can be cased and cemented out.

Generally, the deeper water from the Cretaceous and older sediments has a total dissolved salt content of between 600 and 3000 ppm, with most in the range of 800 to 1200 ppm. Fluoride content in most bores is low, but reaches 4.5 ppm in the southern part of the area.

Shallow supplies have a more varied quality, but most are still suitable for stock use. The range of total dissolved solids is from 300 ppm to more than 5000 ppm. The shallow water has a very low fluoride content.

SURFACE WATER

The main channel of the streams is usually well defined, consisting of a string of waterholes, many of which are never dry. During floods, the water is spread over a multitude of channels (especially in the case of Cooper Creek) which makes the assessment of discharges very difficult.

Mean annual pan evaporation - according to the evaporation maps published by the Commonwealth Bureau of Meteorology - is of the order of 2800 mm.

Due to the low rainfall and high evaporation, the surface water resources of this area are very poor.

The most important streams of the region are the Paroo and Bulloo Rivers and Cooper Creek. The discharge carried by these streams originates, to a large extent, in wetter regions outside the area. For instance, Cooper Creek receives a great deal of its discharge from the Thomson and Barcoo Rivers, i.e. from an area several hundred miles away. Therefore, it would be very difficult to determine the average runoff corresponding to the average rainfall.

Table 6.1 shows gauging stations and records kept by the Irrigation and Water Supply Commission.

Table 6.1. Streamgauging records.

Gauging Station		Catchment Area	Period of
Number	Location	km^2	Record
Paroo River			
424201	Caiwarro H/S	23569	1967 -
424202	Yarronvale	1890	1967 -
Bulloo River			
011202	Cowra	26754	1967 -
011203	Quilpie	15384	1967 -
Cooper Creek			
003101	Currareva	150220	1951 -
003101	Nappa Merrie	236985	1948 -

River flows and flooding

As the above table indicates, available discharge records for the Paroo and Bulloo Rivers are very short, therefore hardly suitable for long term conclusions.

During the 4 years of record available for the Paroo River at Caiwarro H/S., most of the annual discharge occurred between January and May. The mean annual discharge over the 4 year period was 280 mm.

The Bulloo River at Quilpie shows similar flow characteristics, regarding seasonal discharge, but the average runoff during the 4 years of record is only 89 mm per annum. This can be explained by the lower average rainfall in the Bulloo River catchment.

Cooper Creek represents a special case insofar that the bulk of the discharge it carries, originates in an area considerably wetter than the area. As a direct consequence of this, the discharge is decreasing downstream and the "high flow" period (due to long transmission time) may be delayed by as much as two months.

The 3 years of overlapping records, at Currareva and Nappa Merrie, show that the annual discharge over a 480 km stretch of the river, despite about 51800 km^2 increase in catchment area, decreased by 0.75 to 0.83 of its value. The main reason for this is the large transmission loss and the low runoff from the area concerned. Flow and river height for Cooper Creek at Currareva are given in Table 6.2.

The travel time of water between Currareva and Nappa Merrie is about one month. The slopes are low, the movement of water is slow, the spread of the water in many flood channels is considerable, evaporation and seepage in the sandy river-beds are high, hence the high transmission losses.

During floods, these river systems carry large quantities of water. Although the runoff is low, flood discharges (owing to the large size of the catchments) can be considerable. The main channel is not capable of accommodating major flood volumes, therefore the river breaks out into several minor channels. On occasions, the extent of flooding is such that the width of the stream is several miles with of course shallow depths.

Water quality

Samples of water have been analysed from certain streams in the area and this has shown that the water is suitable for domestic, stock and irrigation purposes.

Table 6.2. Major flows (4.7 m) in Cooper Creek at Currareva (1945-71).

Date	Height in Metres	Flow Cumecs	Date	Height in Metres	Flow Cumecs
23. 7.45	3.74	344	20. 3.55	7.78	3764
30. 1.46	5.47	899	4. 6.55	8.21	4262
14. 2.46	4.18	467	22. 2.56	6.58	2155
17. 2.47	4.88	689	1. 3.56	5.74	1087
10. 3.49	6.41	1862	9. 4.56	5.92	1238
29. 3.49	6.71	2349	11. 7.56	3.97	405
25. 1.50	6.99	2720	7. 1.57	6.21	1568
3. 3.50	6.25	1620	23. 1.57	6.44	1920
15. 3.50	7.42	3297	12. 4.59	5.51	924
18. 3.50	7.68	3628	11. 1.61	5.69	1025
25. 3.50	7.17	2949	28. 2.61	4.80	665
11. 4.50	7.27	3086	19. 1.62	5.31	1067
31. 7.50	4.96	715	31.12.62	5.22	805
6. 8.50	5.85	1173	16. 1.63	5.41	880
10.12.50	6.20	1551	11. 3.63	4.68	624
20. 1.51	7.88	3730	6. 4.63	8.16	4251
6. 2.51	7.32	3254	16. 1.66	5.96	1259
22. 1.53	4.37	511	10. 3.67	4.98	613
17. 2.53	5.13	777	18. 1.68	5.74	1001
21. 2.53	3.66	325	5. 2.68	6.91	2423
5. 3.53	4.86	681	4. 5.68	4.14	433
10. 3.53	3.91	390	16. 5.68	5.24	846
26. 1.54	6.18	1415	9. 3.71	7.63	
19. 2.54	6.72	2349			
28. 3.54	4.60	600			

by N.M. Dawson*

SURVEY METHODS

The objective of the resource sections of this survey were twofold. The first objective was to provide a systematic description of the land resources. This has been done by mapping the area into land systems and characterizing the area into a number of recognizable soil, vegetation, topographic land units. The second objective was to interprete collected field and analytical data in order to assess and identify the factors influencing land use of the area.

The type of survey can be described as a reconnaissance land survey. The sub-division of the area into mapping units has been based on aerial photograph interpretation with as detailed a level of field traversing and sampling as was possible within the time scale allowed.

The basic methodology of the survey is a slight modification of the land system approach. Mapped areas are described in terms of land systems which have been defined by Christian and Stewart (1953, 1968) as "an area or group of areas throughout which there is a recurring pattern of topography, soils and vegetation". Land systems are made up of one or more land units which are the individual components of the land system. The classification is based on the recurrence of similar sites or site sequences forming land patterns or systems. The land system approach has proved most useful in regions with homogeneous rock, climate and relief and where a steady state of dynamic equilibrium has been achieved.

In past surveys the land system description has been the important descriptive feature. When using reports of this type it is difficult to obtain detailed descriptions of the land units without consulting the various component sections. As well, valuable site information may not be presented. To alleviates such problems in this survey, the land system remains basically descriptive and shows the relationship between the land units. More emphasis has been placed on the description and assessment of the land units.

For each land unit there is a detailed description of landform, geology, soils, vegetation and land utilization factors. In the land unit descriptions soils are described in terms of principal profile forms, great soil groups, and soil mapping units, as well as in descriptive terms. One or more analyses of representative profiles within the units are included in the land unit description. The vegetation description includes lists of the predominant, frequent and infrequent species and their structural formation. The land utilization summary considers grazing capacity, availability of drought fodder, land utilization problems such as woody weeds, erosion and pests, together with an assessment of land use.

Mapping Techniques

Air photograph interpretation was conducted using 1969, 1:80,000 aerial photographs. Mapping of patterns in western Queensland is less complicated than nearer the coast, due to the strong relationship between topography and the development of land units within the major geological units. In addition, tonal differences reflecting changes in soils and vegetation are clearer than in the more mesic areas.

These factors enable mapping to be delineated at the land units level in many parts of the area. This was considered important in those areas where the land unit had special land use characteristics which necessiated its separation i.e. run-on areas in the mulga lands. Such level of mapping was possible mainly on those land units occurring as large areas or displaying distinctive patterns.

Burrows and Beale (1969) observed that not only is micro-topography an important factor in plant distribution but groups of communities merge into one another in a continuous pattern. Where this occurs it was not always possible to map out individual land units as map units. Where the size of each individual unit was small in a repeating pattern, separation at the final mapping scale was impossible.

There were other areas in which it was possible to map broadly, to encompass a number of distinctive land units, because the area was not significant to land use.

Both continuous and sharp boundaries may occur between land units depending on the geomorphic history, soil development and microrelief. In addition each land unit may support a range of plant species, and exhibits a variety of soil characteristics. The range of characteristics which is allowable within each land unit is described together with its modal characteristics. Continuous vegetation changes also occur with change of climate on each land unit. It is difficult, in some areas, to draw boundaries of land units. In this latter case boundaries drawn are artificial and are usually based on plant density.

In the land system map which is printed at a scale of 1:500,000 one land system (e.g. Eulo) may contain small areas of Paroo land system not easily mapped, but of significant size, occur within that area mapped as Eulo land system. In such cases, it has been indicated by means of colour that the area is predominantly Eulo (S2) and that Paroo (W7) occurs and is shown as $\frac{S2}{W7}$ or $\frac{\text{Orange 2}}{W7}$.

Mapping units used to prepare the final land system map are maintained on a set of 1:250,000 maps and on the aerial photographs at a scale of 1:80,000. Very few boundaries were lost in the prepaartion of the 1:500,000 land system map. The soil and vegetation maps at a scale of 1:1,000,000 were prepared by aggregating mapping units from the 1:250,000 base maps into a smaller number of soil and vegetation groups.

Field Sampling

Field sampling was conducted at the reconnaissance and detailed field sampling level. The main field survey was conducted during the periods April to May 1971 and July 1971, and involved a total exceeding 60 field days.

Early reconnaissance traverses following a number of roads and tracks were selected to obtain a random sample of the land units in the area. Preliminary air photo interpretation was conducted on these traverse routes to outline and identify boundaries of these units. Data regarding the characteristics of these map units were recorded during the traverses at approximately 600 sites.

Detailed sampling sites were not randomly selected. These sites were selected in the field, within the boundary of restricted length traverses across landscapes. These restricted length traverses were selected when air-photo interpretation had reached a satisfactory level over the whole area. Selection was designed not only to obtain sampling sites within the land system patterns but also to establish the relationships between adjacent land systems.

* Development Planning Branch, Qd. Dept. of Primary Industries.

Where possible three representative detailed sites for each land unit were obtained. These sites being spread over the area of major distribution of these land units to assess variability and modal characteristics. Those land units which were considered important in terms of land use were sampled more intensively than those of less importance. In some cases on the less important land units only reconnaissance level data were recorded.

A number of previously selected traverse sites had to be discarded due to disturbance. The 242 detailed sampling sites were selected as near to the undisturbed state as was possible. Sample sites were restricted in area, depending on the pattern on the aerial photograph, and also by ground checking physiographic, soil and vegetation features. Variation in these features at the sample site was described.

At reconnaissance sites the structural form, predominant species, tree and shrub population per ha, together with the great soil group and observable soil features and topography were recorded.

At each detailed site land characteristics were recorded on sheets using the descriptions outlined by Dawson (1972) for the collection, recording, processing and retrieval of data for land utilization studies. Infomation at sites was coded directly onto these sheets in the field. The location of each sites was recorded permanently on the aerial photograph, and co-ordinates were noted on the relevant data sheet.

Soils

Soil Profiles were described using criteria published by the USDA (1951). Soil profiles were sampled at fixed intervals (10, 20, 30, 60 and 120 cm), except in the case of texture contrast soils which were samples on the basis of distinctive changes in the profile. Profiles were samples using a 10 cm diameter soil auger and a spade.

Soil characteristics recorded include: depth, texture, Munsell colour, consistence, structure, pH, concretions, mottling, bleach and surface characteristics. The soils were classified into principal profile forms (Northcote 1965) and great soil groups (Stace *et al.* 1968).

Soils were sampled for analysis at the fixed intervals described earlier. These samples were analysed for pH, TSS, chlorides and available P according to the methods outlined in Appendix IV. Further analyses were conducted on representative profiles. Analytical details are set out in Appendix III.

Vegetation

As mentioned previously site data were recorded at two different levels. In all situations a buffer zone was left between the association under investigation and adjoining associations taking care not to transgress any ecotones. Ecotones may be expansive along some ecological gradients or not apparent where abrupt disjunctions between associations occur.

At reconnaissance sites the structural form, predominant species, tree and shrub population per ha were recorded.

At each detailed site the main object was to describe and catalogue the vegetation as accurately as possible in a limited time.

Five species were considered adequate to characterize any plant association in the region and the five species selected were those which contributed most to the biomass, species which apparently characterised the association. The height, diameter of stem and projective foliage cover of the five species were recorded. Regeneration, growth form and evidence of grazing were noted for these five species. The presence of up to eleven other species which contribute most to the association were recorded. Other information including all species present, height classes for species, trees or shrubs per ha where applicable and vegetation profile diagrams were recorded on the field sheets.

The range of height, project foliage cover (PFC) and diameter were estimated. PFC was used as an indication of vegetal cover as it can be assessed relatively accurately in broad classes without difficulty. It may have been preferable to use basal cover but basal cover of an association is much lower than the PFC 3-4% basal cover for a good Mitchell grass pasture (Everist, 1964) compared with 30-40% PFC and unless it was measured accurately would have little significance. In this type of survey time does not permit detailed measurements of all the parameters recorded. Trees per ha were estimated by counting the number of trees in 1/25 ha plot or multiple of it depending on tree density or based on average distances between trees. Diameter of trees was taken 30 cm above ground level.

The degree of disturbance, the agent responsible such as flooding, pulling by man, cutting for fodder, grazing and fire were noted. The percentage of dead trees was estimated.

To assess conditions and trend, the state of the perennial grasses, annual grasses, perennial herbage, annual herbage, topfeed and litter were recorded. Emphasis was placed on the destruction of, and grazing pressure on the topfeed and perennial grasses in assessing condition and possible trend.

Due to time scale and the lack of detailed knowledge of herbaceous species, the annual grasses and forbs did not assist significantly in assessing the condition or trend of the pasture.

Other Factors

In addition to the vegetation and soil characteristics, information on landform, position, slopes, elevation and relative relief were recorded together with geology, erosion, stone and geomorphology. Factors affecting land use such as flooding and the presence of rabbit warrens were recorded where applicable.

All field recordings, together with soil analytical data are stored on computer cards which serve as a data bank for the area. The INFOL programme used in conjunction with the CSIRO CDC 3600 and Cyber 76 computers has been used to sort and process these data. The recorded information can be readily retrieved for further analysis by other workers in Australia.

LAND SYSTEMS

The area has been mapped into 53 land systems which have been grouped into 10 broad land zones. A map, showing the extent and distribution of the land system has been published at a scale of 1:500,000, is attached.

The land systems descriptions (see Appendix VII) show the relationship between the land units within each system. The land units are the basis for classification and detailed descriptions of the 93 land units are given in Appendix VIII.

The relative importance of each land units is indicated by an estimate of its percentage of the land system as a whole. Where a particular sample site is of special importance in a land system it may also be listed. To assist in the development of a visual appreciation of the relationship between the land units, symbols representing great soil groups, vegetation species and geological units are shown on the vertical sections. A key to these symbols is given in Appendix II.

Due to mapping scale and the fact that land types are generally a continuum, boundaries of the land systems are not necessarily so sharply defined that they exclude contiguous land systems. As well, the land units are not pure non-variable units but in their description the range of characteristic is given.

Figure 7.1 shows the relationship which usually exists between land systems. This also gives some insight into the geomorphic development of the land systems and land units.

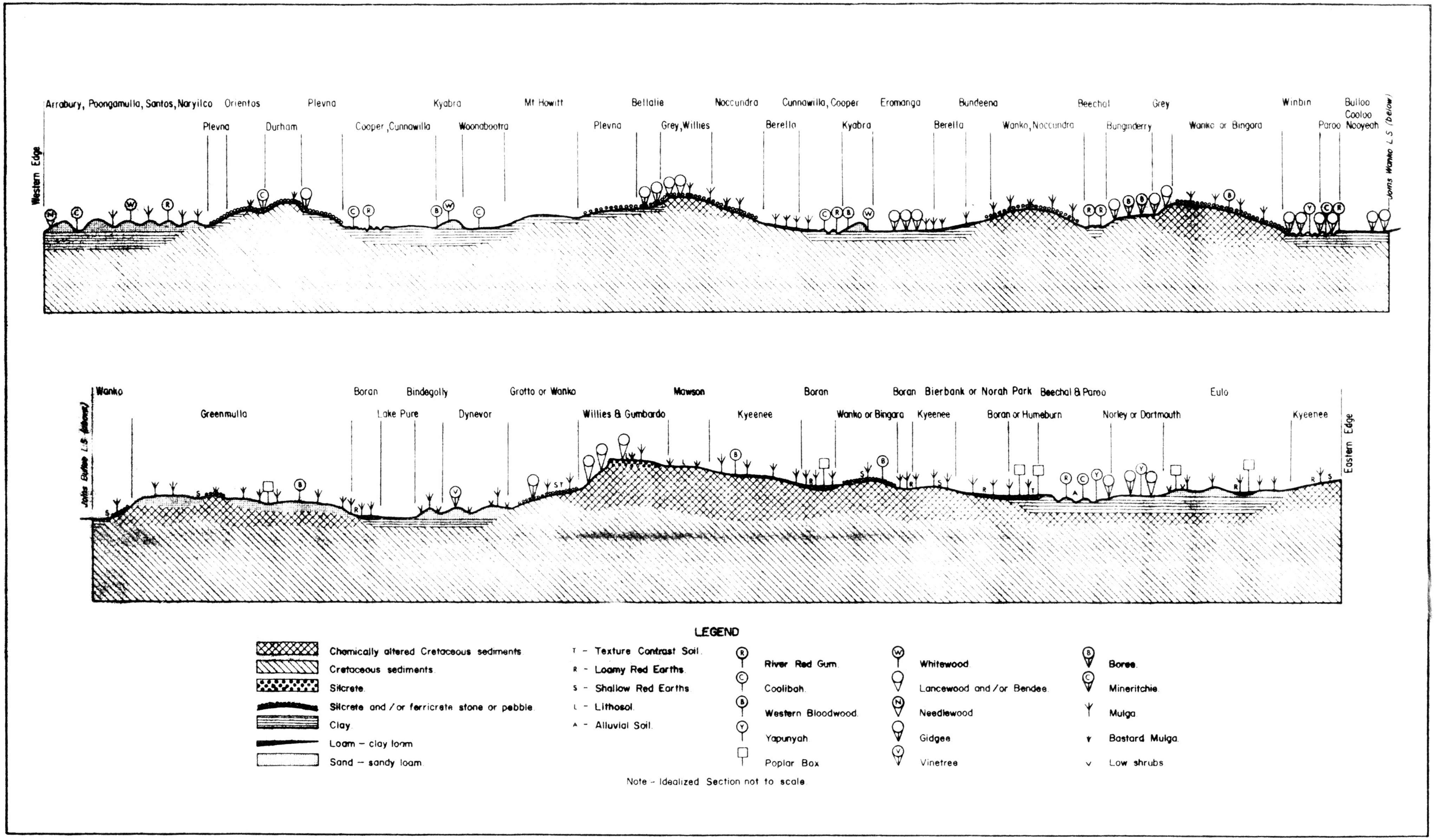


Fig. 7.1. *Idealised relationship between land systems.*

The land systems have been grouped into 10 land zones on the basis of similarity of physiography, soils, vegetation and geomorphic development. An even broader grouping of these zones shows that the three mulga land zones occupy 29% of the area. The alluvial plains which occupy 27% of the area, are the most productive. The Dunefields occupy 17% of the area, while the Dissected Residuals, which have little economic value, comprise 13% of the area. The Undulating Downs (9%) and Undulating Gidgee (5%) land zones are not as extensive in this area as they are further to the north.

Dunefields

The dunefield land systems predominate in the south-west and west of the area occurring mainly in the geological structural lows.

The eight land systems in this zone have been separated mainly on their structural form which is identified by characteristic aerial photograph patterns. Changes of vegetation and soils are related to these changes in micro-relief.

The dunefield land systems grade gradually from one type to another making boundaries difficult to draw.

Arrabury, Poongamulla and *Santos* land systems represent the best development in dunes. The tall dunes range in height from 4 to 12 m and support spinifex hummock grassland on the duneflanks with sandhill cangrass and bluebush pea on the mobile crests. Soils are predominantly red earthy sands with siliceous sands occurring on the mobile crests. Small areas of sandy red earths occur in the interdune area.

Arrabury land system comprises mainly longitudinal dunes with few claypans whilst Poongamulla and Santos have converging and diverging dunes. The dunes in Poongamulla are commonly higher than those dunes in the Santos land system. Mobile crests are only sporadic on Santos while they are continuous on Poongamulla. Grazing capacity is low, the median grazing capacity being assessed at less than 1 beast/km^2.

Naryilco land system is the most widely distributed of the dunefield land systems and comprises reticulate sand dunes 3 to 5 m high with claypans in the interdune area. The soils support a mixed vegetation with woollybutt grass being the main perennial grass and mulga the predominant shrub species. Other acacias are common and whitewood is well distributed across the land system. This land system is more productive than the previous land systems due to the increased palatability of the grass species, but these are more susceptible to overgrazing. Median grazing capacity has been assessed at 1.6 beasts/km^2.

East of the Bulloo River, the Naryilco land system grades into the *Clyde* land system which has many characteristics of a sandplain, but still has detectable low dunes. Soils are predominantly red, earthy sands and sandy red earths supporting mulga, whitewood, western bloodwood and woollybutt grass. Again due mainly to climatic influence median grazing capacity is higher being assessed at 1.9 beasts/km^2.

Kyabra land system occurs mainly as isolated dunes or small group of dunes on the alluvia of Cooper and Kyabra Creeks. The dunes do not have well developed flanks, but have mobile crests. Soils are predominantly siliceous sands and red, earthy sands. Bluebush pea is well developed on many dunes with mulga on the lower slopes. Yellow siliceous sands occur on some isolated dunes. Median grazing capacity is low being assessed as less than 1.6 beasts/km^2.

Dynevor land system is restricted to the poorly drained area running from Dynevor Downs to Hungerford. It comprises low dunes intermixed with claypans and playa lakes. Soils are predominantly red, earthy sands. The shrub layer is well developed on this land system mainly due to the improved moisture conditions. Well developed mulga tall open shrubland occurs on the dunes. Woody species such as budda bush occur on the eroded edges. Median grazing capacity has been assessed at 1.9 beasts/km^2.

Bindegolly land system is of limited area, mainly gringing the major playa lakes. Dunes are crescentic in shape when viewed from the air. Soils are mainly gypseous and calcareous sands supporting saltbushes, bassias and samphire low shrubland. Median grazing capacity is low being assessed at 1.7 beasts/km^2.

Mulga lands

The mulga lands have been divided into three land zones on the basis of geomorphic history, soil and vegetation development. The mulga sandplains are predominantly aeolian material, whilst the soft mulga land zone comprises material predominantly derived from transported detritus deposited as alluvia, pediment mantles and fans. The hard mulga lands are formed on gently undulating to undulating plains and have poor vegetation development. The mulga lands grade into the Dissected Residual land zone on the more elevated areas.

Mulga Sand Plains

The mulga sand plains occur mainly east of the Bulloo River and grade in the dunefields to the west and into some of the soft mulga land systems to the east. The mulga sandplains have been divided into two land systems based on the geology of the underlying material. Whilst the source of parent material of these plains may be of similar origin, the soils and vegetation developed vary considerably.

Greenmulla land system has been formed by the movement of aeolian sand over upland surfaces. The plains are of low relief and have few defined drainage lines. Soils are predominantly deep, acid to neutral, sandy red earths. Associated are red, texture contrast soils in local depressions and shallow, red earths on outcrops of the underlying material. Vegetation development varies considerably from woollybutt grass, mulga, western bloodwood open tussock grassland to mulga tall open shrubland. Groving of the mulga may occur on the gentle slopes at the edges of the plains. The land is basically stable but areas of wind and water erosion have caused degradation in some situations. Woody weeds have invaded some areas. This is productive land system with median grazing capacity being assessed at 3.5 beasts/km^2.

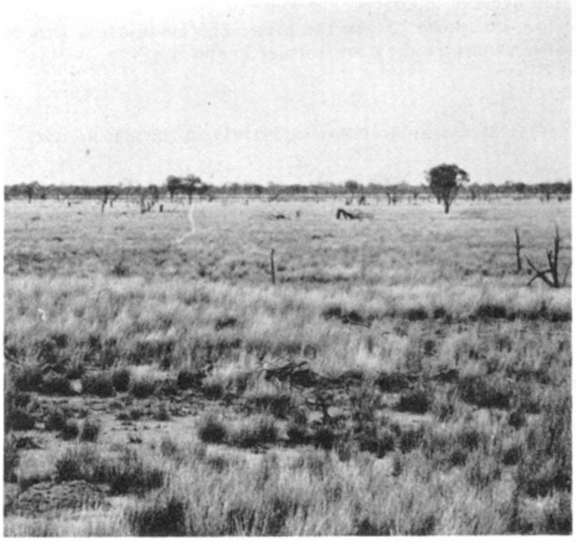
Eulo land system is best developed south of Eulo on plains of low relative relief. It is commonly interspersed with clay alluvia and small claypans occur as depressions in the plains. Soils are predominantly moderately deep, sandy red earths with alkaline soil reaction. They commonly have soft ferruginous hardpans. Small areas of neutral, sandy red earths occur as low dunes whilst loamy red earths occur in run-on depressions. Vegetation is mainly mulga, poplar box tall open shrubland with poplar box increasing in the run-on situations. Woody weed invasion in some areas have significantly affected grazing capacity. This land system is quite productive with a median grazing capacity of 3.4 beasts/km^2.

Soft Mulga Lands

The land systems in this land zone have been formed from soil and detritus transported down slopes and redistributed as alluvia, pediments, mantles and fans. In some land systems aeolian influence has also been significant. The depth of detritus which covers the surface varies but generally tapers off as the gentle slopes increase. Sub-division into five land systems has been mainly based on geomorphology, position, soil and vegetation development.

Boran land system comprises most of the narrow run-on areas associated with the mulga lands. The flat areas vary in width increasing towards the major streams. In the natural state gullies are not obvious and water tends to spread as a sheet over the area. Soils are predominantly loamy red earths. Soil depth varies considerably, commonly increasing downstream. Associated are red, texture contrast soils particularly in the downstream areas.

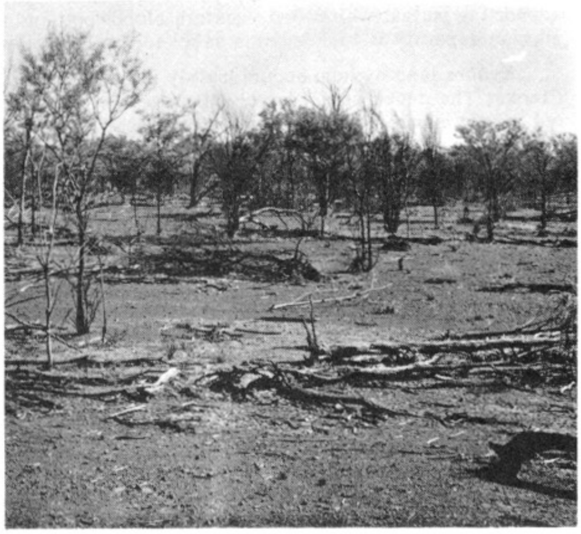
Vegetation is predominantly mulga tall open shrubland with density increasing in the more mesic areas. Poplar box is a common constituent east of the Grey Range with western bloodwood increasing to the west. The area has a potential for improvement by means of thinning, establishment of improved pasture species, and water-spreading. Woody weeds are a problem in many situations. In the east this land system frequently adjoins Humeburn land system. In its natural state, mulga density may restrict pasture growth but generally productivity is high with median grazing capacity being assessed at 3.2 beasts/km^2.



Greenmulla L.S. has deep sandy red earth soils and is productive and stable when well managed. Mulga density is commonly higher than depicted.

Claypans, which are periodically flooded, are characteristic of some dunefield land systems. Note the cemented apron fringing the dunes.

Plevna L.S. is the most widespread of the undulating downs land systems. Mineritchie on the local drainage lines is common west of Cooper Creek.



Kyeenee L.S. comprises mulga on moderately deep red earths has been subject to intensive use in the east, this resulting in reduced productivity.

Naryilco L.S. when used for strategic grazing provides useful fodder. It responds to light falls of rain.

Large waterholes are a feature of the main channels of the "Channel Country". This one is at the "dig tree" on Nappa Merrie.

Bierbank land system comprises detritus re-distributed on low sloping plains. On the lower slopes it may grade into Boran, Humeburn or other alluvial land systems whilst on the upper slopes it adjoins either the hard mulga lands or the dissected residuals. Soils are predominantly deep to very deep, acid to neutral, loamy red earths.

Vegetation is predominantly mulga tall shrubland to tall open shrubland. Poorly developed mulga groves may occur. This land system provides an important drought reserve and mulga density should be maintained for this purpose. Woody weeds such as Charleville turkey bush have invaded some areas and significantly reduced productivity. Median grazing capacity has been assessed at 2.9 beasts/km^2.

Humeburn land system is best developed in the east, adjacent to alluvia of the major streams such as the Paroo. It comprises mixed alluvial and superficial deposits on flat plains. Soils are predominantly red, texture contrast soils. Associated are deep, loamy red earths. Vegetation ranges from mulga, poplar box grassy tall shrubland to poplar box shrubby low open woodland. In most cases the land system has some improvement potential. Woody weeds such as sandalwood and Charleville turkey bush are a problem in places. Erosion on the edges on the plains is leading to serious deterioration in some areas. Productivity is high with median grazing capacity being assessed at 5.3 beasts/km^2.

Norah Park land system comprises superficial deposits on the higher parts of the landscape and occurs particularly in the north-east. It has some characteristics similar to the mulga sandplains. It occurs as gently undulating convex plains. Soils are predominantly deep, loamy, red earths supporting mulga tall shrubland with scattered poplar box. Associated are shallower red earths supporting mulga sparse tall open shrubland and silver-leaved ironbark. In its natural state mulga density is high and needs to be reduced to obtain optimum productivity. It also serves as a valuable drought reserve. Charleville turkey bush is a problem. Erosion is noticeable on some overcleared areas. Median grazing capacity has been assessed at 3.3 beasts/km^2.

Berella land system occurs mainly in the vicinity of Eromanga but also occurs in other areas west of the Grey Range. It is thought to be developed from superficial fan deposits overlying clay plains. Slopes are very low. A feature of this land system is the well developed mulga groves associated with a soil complex. This soil complex comprises shallow, red earths and shallow to moderately deep, texture contrast soils with earthy surfaces on the intergrove areas, with red cracking clays and red loamy surfaced texture contrast soils associated with sinkholes (gilgaied) in the well developed grove area. It forms a natural run-off, run-on situation leading to high productivity in the groves. In the areas where this land system occurs dense stands of mulga are not common and the grove areas provide valuable drought fodder. Median grazing capacity has been assessed at 2.4 beasts/km^2.

Hard Mulga Lands

The hard mulga lands are invariably adjacent to the Dissected Residual land zone. The dissection and erosion of the Tertiary land surface, together with warping has resulted in the formation of a number of different landscapes. The hard mulga lands have been formed as a result of these processes. They occur on the lower slopes of the scarp retreats and on the backslopes. Sub-division into the land systems has been based mainly on soil and vegetation characteristics, with minor geomorphic and climate influences.

Bundeena land system comprises flat to gently undulating plains associated with pediments, with a thin cover of soil and detritus. It is closely associated with the Berella land system which generally occurs on the lower slopes of this land system. Soils are predominantly gravelly, shallow to moderately deep, loamy, red earths and texture contrast soils with hardpans. Associated vegetation is mulga, western bloodwood tall open shrubland. Vegetation becomes sparse in places. There is little drought fodder in most instances and standing shrubs should be maintained wherever possible to prevent erosion and maintain productivity. Productivity is low with median grazing capacity being assessed at less than 2.2 beasts/km^2.

Kyeenee land system occurs mainly east of the Grey Range and is associated with thin, superficial deposits over weathered Cretaceous sediments. It occurs mainly on gently undulating convex slopes. Soils are predominantly shallow to moderately deep, loamy, red earths with ironshot concretions and gravel throughout the profile. Vegetation is predominantly mulga tall open shrubland. Density varies considerably depending on position, climatic factors and edaphic factors. In the more eastern areas this land system may provide valuable drought fodder. Over utilization has, however, led to sheet soil erosion and a subsequent loss of productivity. Productivity is variable being dependent mainly on climate with the median grazing capacity being assessed at 2.7 beasts/km^2.

Wanko and *Noccundra* land systems are very similar in terms of soil and geomorphic history but vegetation gradually changes from Wanko to Noccundra as the environment becomes drier. These land systems form gently undulating convex plains derived from the Tertiary *Glendower Formation.* Soils are shallow to moderately deep, acid, stony red earths. Associated are bouldery lithosols on the ridges. Vegetation grades from sparse mulga tall open shrubland on Wanko land system to sparse mulga and bastard mulga tall open shrubland on Noccundra. All shrub vegetation should be maintained to ensure stability. Median grazing capacity has been assessed at 2.2 beasts/km^2 for Wanko and 1.9 beasts/km^2 for Noccundra.

Bingara land system occurs mianly on the crests of tablelands and as gently undulating convex plains where these have been dissected. It is derived from the Tertiary *Glendower Formation.* Soils are shallow to moderately deep, stony red earths with variable silcrete cover. Silcrete boulder is common. Vegetation is predominantly rock grass, mulga, western bloodwood open tussock grassland. Rock grass has a low palatability and this leads to a stable system with low productivity. Median grazing capacity has been assessed at 2.1 beasts/km^2.

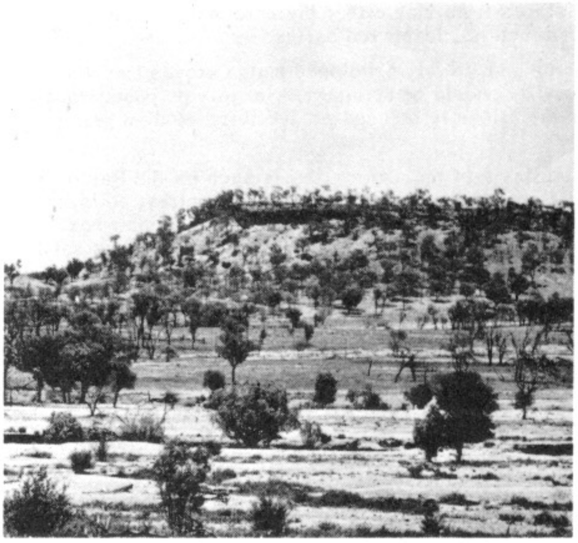
Dissected Residuals

The dissection and erosion of the Tertiary land surface has resulted in landscapes of mesa, buttes and tablelands. These residual landscapes are formed from deeply weathered Cretaceous sediments, which may, or may not, be capped by silcrete or ferricrete. Sub-division into the component land systems has been based on geomorphology and vegetation.

The dissected residual land systems form the backbone of the area in that they dominate the high areas forming the main ranges and catchment boundaries. In the east the backslopes of Gumbardo, Willies and Grey land systems grade into the mulga lands. Grey and Willies land systems commonly grade into the gidgee lands on the scarp retreat slope, but may in some cases grade into mulga wherever the scarp retreat does not penetrate past the weathered zone. The lower slopes of Durham and Orientos land systems grade into the undulating gidgee and undulating downs land zones. These land systems have limited grazing capacity and their best use is as a source of run-off water.

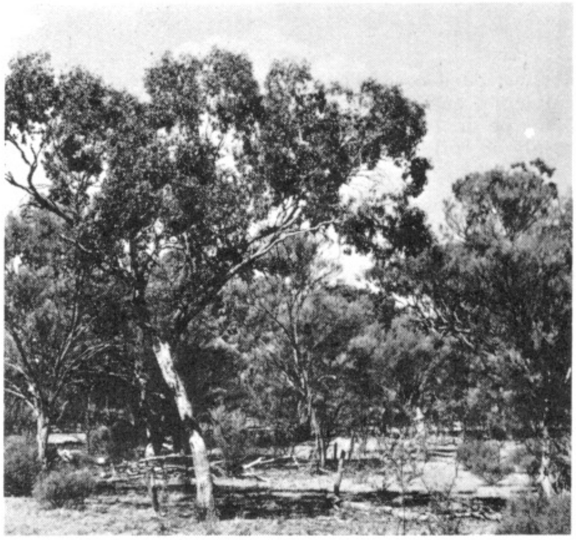
Orientos land system occurs mainly in the far south-west. It comprises dissected undulating plains with well defined dendritic drainage patterns associated with the dissection scarps. The layer of weathered rock is thin and less weathered sediments may be exposed. Soils are predominantly shallow, stony, red earths and lithosols. Desert loams are present wherever the less weathered sediments are exposed. Vegetation is sparse being predominantly bastard mulga, mulga, sparse tall open shrubland. Median grazing capacity is low being assessed at 2.2 beasts/km^2.

Mawson land system occurs throughout the area as low eroded remnants. Soils are poorly developed and are predominantly lithosols, with large areas of exposed weathered rock being common. Vegetation is predominantly bastard mulga low open shrubland. The assessed median grazing capacity is low being less than 1.7 beasts/km^2.

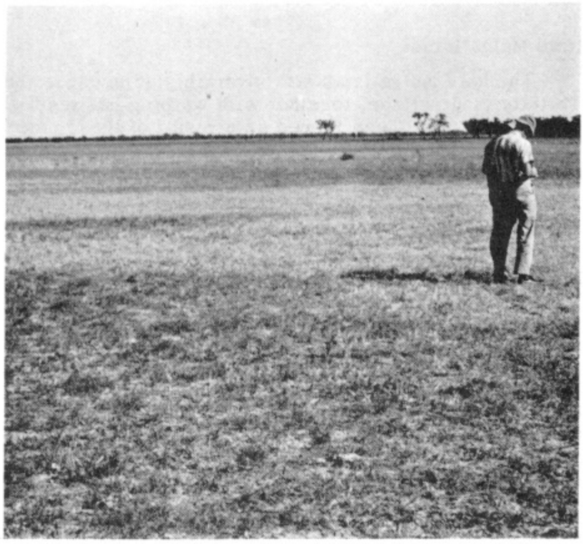


The dissected residual land systems have shallow soils and steep slopes. They have limited value for grazing but are important sources of run-off water.

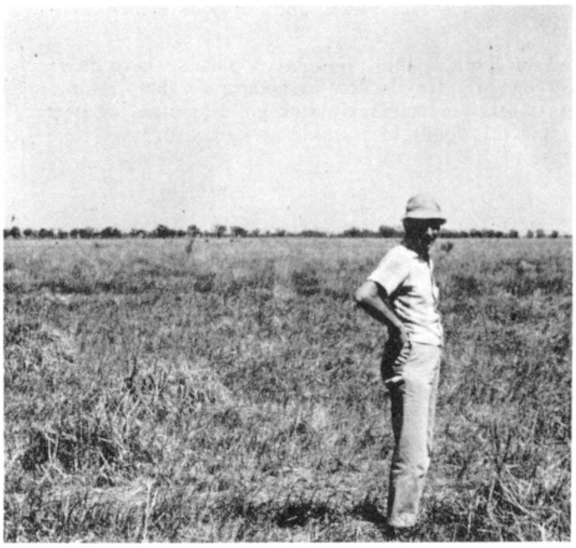
Norley L.S. comprises yapunyah low open woodland on grey clays is productive and a source of nectar for bees.



Mulga tall shrublands with emergent poplar box are common on Boran L.S. which receives run-on water.



Comongin L.S. comprises short grasses and forbs on grey clays occurs on flat alluvial plains.



After flooding Cooper L.S. produces a bulk of pasture the composition of which varies with season and depth of flooding.

The gidgee tall open shrublands of Bellalie L.S. occur on brown clays and are productive particularly in good seasons.

Grey land system comprises cuestas, dissected plateau, mesa and buttes with well developed scarp retreats. In many cases the backslopes gradually merge into undulating plains. Soils are predominantly lithosols and shallow red earths. Silcrete stone cover is common and silcrete boulder is present at most locations. Vegetation ranges from mulga tall open shrubland to bastard mulga low open shrublands on the upper slopes, to lancewood and bastard mulga on the scarps and frequently gidgee on the lower scarp retreat slopes. Median grazing capacity has been assessed at 2.0 beasts/km^2.

Durham land system occurs mainly west of Cooper Creek and forms dissected tablelands, mesa and buttes. It is closely associated with the undulating downs land systems. Silcrete stone and boulders are common and the depth of weathered material is thin. Soils are lithosols and shallow, red earths with outcrops of desert loams and cracking clays. Vegetation is predominantly bastard mulga low open shrubland with forbland on the outcrop areas. The median grazing capacity has been assessed at 2.3 beasts/km^2, but this land system has limited drought grazing capacity.

Willies land system comprises dissected tablelands, cuestas, mesas, and buttes, with well developed scarp retreats on at least one slope. Similar to Grey and Gumbardo land systems, the backslopes may grade into undulating plains. Ironstone gravel and ferricrete are common and small areas of silcrete occur. Soils are predominantly lithosols. Lancewood and bendee shrublands occur on the scarp and crests with mulga and bastard mulga. The median grazing capacity is low being assessed at 1.7 beasts/km^2.

Gumbardo land system occurs mainly in the eastern parts of the area and is associated with strongly dissected tablelands, cuestas and buttes. Scarp retreats commonly occur on the southern and western sides of this land system. Soils are predominantly lithosols and shallow red earths with exposed weathered rock common. Ironstone gravel and ferricrete are common. Vegetation is dense in places and comprises mainly bendee tall open shrubland to tall shrubland, with lancewood also common on the scarp retreats. Median grazing capacity has been assessed at 1.9 beasts/km^2.

Undulating Gidgee Lands

The undulating gidgee lands occur mainly where erosion of the Tertiary land surface has exposed less weathered Cretaceous sediments, the exception being Spring Creek land system which comprises dissected recent sediments. Land systems have been separated on the basis of extent of erosion into the fresh *Winton Formation* sediments and the subsequent soil and vegetation development. These land systems commonly occur on the lower slopes of the scarp retreat zone of the dissected residuals.

Grotto land system occurs mainly in those situations just below the scarp retreat, where erosion has only just penetrated the deeply weathered zone, and has resulted in a complex of both soil and vegetation. Mulga tall open shrubland occurs on the shallow, red earths which commonly occur on the higher areas. Both gidgee and mulga tall open shrubland occur on shallow to moderately deep, red, texture contrast soils and cracking clays associated with the depressions between between the ridges. Whilst the assessed median grazing capacity of 3.1 beasts/km^2 is comparable with some of the better mulga lands, this land system has limited drought grazing capacity. It is subject to severe erosion by overflow water. Maximum vegetation cover should be maintained on this land system.

Tilbooroo land system has many characteristics which make it similar to Bellalie land system. The main differentiating feature is its higher density of vegetation, mainly due to increased rainfall. The land system is associated with gently undulating to undulating plains formed from *Winton Formation* sediments. Soils are mainly gilgaied, stony, red and brown clays with some red, texture contrast soils. Vegetation is predominantly gidgee tall open shrubland to tall shrubland or open woodland. Median grazing capacity in the natural state has been assessed at 3.2 beasts/km^2. This may be improved by thinning the dense gidgee vegetation. Ellangowan poison bush and sandalwood may reduce productivity in cleared areas.

Bellalie land system occurs on, and west of the Grey Range. It comprises undulating plains which frequently fringe both the undulating downs and Dissected Residual land zones. This land system is formed on the Cretaceous *Winton Formation* sediments, and has a thin cover of stone and detritus which is derived from the erosion of the Dissected Residual land zones. Soils are predominantly moderately gilgaied, deep to very deep, stony, red and brown clays. Vegetation is gidgee forby tall open shrubland. Median grazing capacity has been assessed at 3.8 beasts/km^2. These lands should remain stable and productive, provided careful management is practised.

Bunginderry land system occurs in a narrow belt fringing the Grey Range, west of Quilpie. It has many of the characteristics common to Bellalie land system. Vegetation is predominantly boree, gidgee low open woodland with pure stands of boree and gidgee occuring as well. In places the density of dead standing trees is high. There has been very limited regeneration of the boree in these areas. Median grazing capacity has been assessed at 4.6 beasts/km^2. Under good management practices this land system is stable and very productive, due to the high content of Mitchell grass in good seasons.

Spring Creek land system has characteristics which are an intergrade between the alluvial plains, woodland land zone and other land systems in this land zone. In places the land system, which comprises recent sediments, forms flat alluvial plains. Further to the south these plains have been eroded forming a gently undulating landscape. Soils are predominantly grey cracking clays and brown, texture contrast soils. The major vegetation formation is shrubby low open woodland. Predominant species, which vary from site to site, are gidgee, brigalow, belah, Dawson gum and mountain yapunyah. Median grazing capacity has been assessed at 6.9 beasts/km^2.

Undulating Downs

The undulating downs in this area have been referred to as "stony downs". The undulating downs, tend to be mainly sedentary on the *Winton Formation*. They are commonly fringed on the upper slopes by the undulating gidgee lands. The basis for sub-division within this land zone has been geomorphology, which has influenced soil and vegetation development. The change from one land system to another is not abrupt, but rather gradual, resulting in overlap. The undulating downs are concentrated mainly west of the Grey Range. The silcrete cover which occurs on all these land system, with the exception of Mt. Howitt, remains following erosion of the Tertiary land surface. Both the Undulating Downs and Undulating Gidgee land zones are subject to gully erosion where over-utilization occurs, or where roads and tracks are poorly located or constructed. Whilst grazing capacities are fair on the undulating downs, despite low rainfall, drought grazing capacities are extremely low, due to lack of drought reserves.

Bransby land system is associated with low sloping plains and is best developed south of Noccundra. Soils are very deep, stony, red clays with weak gilgai microrelief. Vegetation fluctuates between Mitchell grass tussock grassland to short grasses and forbs depending on seasonal conditions. Vegetation bands occur. This land system is more productive than the other undulating downs mainly due to better moisture relationships. Median grazing capacity has been assessed at 4.2 beasts/km^2.

Plevna land system, which covers large areas in the west, comprises gently undulating to undulating plains. Soils are very deep, red and brown clays with moderate gilgai microrelief. Surface stone, which is mainly silcrete of variable colour, tends to accumulate in the vicinity of the puff and leads to characteristic air photo patterns. Vegetation fluctuates between Mitchell grass tussock grasslands and short grasses and forbs, depending on seasonal conditions. The gilgai depressions are more favourable sites for plant growth and serve a useful source of seed material. Median grazing capacity has been assessed at 3.8 beasts/km^2.

Mt. Howitt land system is of limited extent, mainly being confined to an area south and east of Mt. Howitt homestead. It is derived from fresh sandstones of the Cretaceous *Winton Formation* and usually occurs in association with structural highs of anticlines. Soils are different from other land systems in this land zone, in that they have loose surface soil and an absence of silcrete stone cover. Soils are red and brown cracking clays with soft, self-mulching surface soil. Vegetation is similar to Plevna land system. Banding patterns are characteristic on the aerial photographs and highlight geological changes. Median grazing capacity has been assessed at 4.0 beasts/km^2.

Nappamerry land system commonly occurs on the upper slope of Plevna land system. It is also closely related to Durham and Orientos land systems. It occurs on undulating to gently undulating plains which are occasionally dissected. The major differentiating feature of this land system is that it is comprised mainly of shallow to moderately deep, stony, desert loam soils intermixed with stony, red clays. Weakly developed gilgai microrelief is common. Vegetation is similar to Plevna land system although not as well developed. Median grazing capacity has been assessed at 3.2 beasts/km^2.

Alluvial Plains

The alluvial plains have been sub-divided into three major and one miscellaneous land zone on the basis of vegetation and flooding characteristics. The Alluvial Plains, Woodlands land zone was separated on the extent of tree and tall shrub cover. This land zone comprises woodlands and tall shrubland of gidgee, yapunyah, river red gum and coolibah. The Other Alluvia land zone has poorly developed tree and tall shrub layers, which occur on the watercourses. The third major land zone is the Channel Country which is subject to frequent inundation and exhibits characteristic channel drainage patterns. The miscellaneous group comprises lakes, playa lakes and claypan.

The alluvial plains are the major production areas. The periodic flooding of all, or parts of these plains, causes productive pasture growth. This has led to increased grazing pressure being applied to the alluvia and adjacent uplands. The alluvial plains have limited drought grazing capacity and graziers need to rely on adjoining country during droughts.

Alluvial Plains, Woodlands

Division of this land zone into its component land systems has been based mainly on vegetation and channel and floodplain characteristics.

Winbin land system is associated with the major tributaries and drainage lines. A characteristic of this land system is the numerous braided channels which are subject to frequent flooding. Channel depth varies from 0.5 to 3 m. Soils are predominantly grey clays with thin, surface crusts, but alluvial clay soils and texture contrast soils are also common. Vegetation is mainly gidgee, yapunyah open woodlands with river red gum and coolibah fringing the major channels. Productivity is high in the more open areas and the median grazing capacity has been assessed at 5.0 beasts/km^2. This may be lower in those areas where tree density is high, or wherever stream erosion reduces productivity.

Dartmouth land system occurs as limited areas in the Lake Dartmouth catchment. It comprises flat alluvial plains with few well defined drainage channels. Predominant soils are loamy surfaced, texture contrast soils intermixed with grey clays. Vegetation is complex, with yapunyah, gidgee low open woodland being predominant, but with patches of brigalow, belah and Dawson gum occurring. Productivity is high, with median grazing capacity being assessed at 4.8 beasts/km^2.

Norley land system is most widespread on the Paroo and Bulloo Rivers but small areas occur on the Wilson River. It comprises flat flood plains without defined channels. The soils are grey cracking clays commonly with associated claypans, the size of which vary with seasons. Vegetation is yapunyah grassy low open woodland with gidgee and coolibah associated in places. It is a productive land system, median grazing capacity being assessed at 3.9 beasts/km^2. Productivity is much higher, in the east, on the Paroo River. It is an important honey production area.

Beechal land system is widespread and has similar characteristics to Tickalara land system. It also grades into Winbin land system in some areas. The feature of this land system is that the braided channels, which are wooded with river red gum and coolibah and sometimes gidgee, are interspersed with flat plains supporting forblands. Soils are predominantly alluvial, texture contrast soils and grey and brown clays. Median grazing capacity has been assessed at 4.4 beasts/km^2.

Tickalara land system occurs with both braided channels but commonly has one major drainage channel frequently with waterholes interspersed. Flat plains, supporting forblands, are interspersed between the channels. The channels support coolibah and river red gum low open woodlands. Soils are brown clays. Productivity is high but variable depending on condition. Median grazing capacity has been assessed at 4.3 beasts/km^2.

Cooloo land system is best developed on the Bulloo River and Kyabra Creek. It comprises broad flood plains with few drainage lines. Soils are predominantly gilgaied, grey and brown clays supporting gidgee low open woodland. This land system is generally in good condition and the median grazing capacity has been assessed at 5.8 beasts/km^2.

Paroo land system comprises the main drainage sections of the major river and is made up of deep, braided channels, poorly drained swamp and small interchannel plains. Soils are a complex of alluvial, grey clays, alluvial soils and texture contrast soils. Vegetation is also complex, with river red gum and coolibah fringing the major channels, and gidgee and yapunyah on adjacent areas. The channels are frequently flooded and erosion of the river banks is common. Swamps support canegrass and lignum. Median grazing capacity has been assessed at 5.7 beasts/km^2.

Channel Country

The three land systems in this land zone occur mainly on Cooper Creek, the lower Bulloo River and Kyabra Creek. The largest development is on Cooper Creek. Sub-division into the respective land systems has been based on frequency of flooding and vegetation development.

Cooper land system comprises frequently flooded alluvial plains with a maze of shallow anastomosing channels. These serve as a natural irrigation scheme when floods occur. Associated are major channels with well developed waterholes in places. Soils are very deep, gilgaied, grey clays, which crack widely, and alluvial grey clays near the major channels. Vegetation comprises bluebush, lignum and coolibah with Cooper clover and/or channel millet dominating the groundflora after floods. Productivity is exceptionally high following flooding. The median grazing capacity has been assessed at 5.7 beasts/km^2.

Cunnawilla land system occurs adjacent to Cooper land system. It is less frequently flooded, but still exhibits channel country microrelief, although not as well developed. This land system has many characteristics which are similar to Eromanga land system. Soils are grey and brown clays which, in places have been scalded. Vegetation development is dependent on the frequency of flooding. Median grazing capacity is lower than the adjacent Cooper land system being assessed at 5.5 beasts/km^2.

Woonabootra land system comprises poorly drained lignum, canegrass and bluebush swamps which occur on most of the major streams. They are best developed on the lower Bulloo River. Soils are very deep, grey clays which crack widely. Vegetation varies from bluebush and lignum low open shrubland to swamp canegrass hummock grassland. Productivity is variable variable depending on plant composition. Median grazing capacity being assessed at 3.4 beasts/km^2. Where lignum and canegrass are major components this value is drastically reduced due to the low palatability of these species and reduction in quantity of other more palatable species.

Other Alluvia

The six land systems in this zone have been separated mainly on soil, vegetation and microrelief.

Comongin land system occurs mainly on the Bulloo River as flat flood plains. On these plains backswamps and shallow drainage lines occur. Soils are predominantly brown and grey clays with thin, loamy surfaced, texture contrast soils intermixed. Vegetation varies according to seasonal condition and frequency of flooding, and ranges from saltbush, bassia forbland to grasslands. Significant areas of this land system has subject to scalding, this being most common near waterholes and along the main channels. Following flooding, these scalded areas may be partially revegetated but revert back during poor seasons or with heavy stocking. Grazing capacity has been assessed at 5.4 beasts/km^2.

Eromanga land system is similar to Comongin land system. The major differences being that red and brown clays are more common, and substantial areas are more frequently flooded. Large areas have been subject to scalding. Median grazing capacity has been assessed at 5.8 beasts/km^2.

The *Nooyeah* land system occurs on alluvial plains which have frequently been deflated. Low rises of wind blown material may occur. It was considered that where scalded areas were large enough to map they should be separated from the more stable parts of the other land systems despite the fact that in good seasons some areas would be naturally revegetated.

This land system includes claypans and saltpans on the alluvial plains. Brown and grey clays and texture contrast soils with scalded surfaces, and a thick surface crusts occur. Vegetation is sparse, with bassias and saltbushes being colonizers in the more favourable years. Productivity is low and the median grazing capacity has been assessed at 1.7 beasts/km^2.

Bulloo land system is restricted mainly to the lower parts of the Bulloo River and Cooper Creek. It comprises low eroded dunes less than 1.5 m high scattered on flooded alluvial plains intermixed with swamps. Soils are predominantly grey clays and claypans on the plains, with texture contrast soils on the low dunes. Vegetation is complex comprising mainly low open shrublands of bluebush, lignum or old man saltbush and sparse herbfields. Productivity is low with median grazing capacity being assessed at 1.5 beasts/km^2.

Dingera land system is associated with the drainage lines flowing out of both the undulating downs and undulating gidgee land systems. These plains are only sparsely wooded, mainly on the drainage lines. Soils are predominantly brown clays sometimes scalded. Vegetation is variable depending on seasonal conditions and flooding. It ranges from bassia and saltbush forbland to Mitchell grass tussock grassland. The main channels are commonly lined with river red gum and coolibah fringing woodlands. Productivity is high with median grazing capacity being assessed at 5.8 beasts/km^2.

Warry land system comprises the alluvial plains of minor streams. Soils are predominantly texture contrast soils and medium textured alluvial soils. Vegetation is variable, changing considerably from the upper parts of the catchments to the lower parts. This land system is susceptible to serious erosion when watering points are located on it. Median grazing capacity has been assessed at 3.1 beasts/km^2.

Miscellaneous

Lake Pure land system comprises seasonally dry lakes which occur throughout the area. Some lakes are more saline than others and these are less productive even after flooding. Soils range from grey and brown alluvial clays to saltpans. Fodder production from these lakes varies depending on flooding. The largest of these, Lake Yamma Yamma, being productive following flooding, which occurs infrequently. Vegetation is variable, with bassias and saltbushes and more productive vegetation such as channel millet, cooper clover and bluebush on the flooded grey and brown clays and lignum, canegrass and samphire on the massive clays and saltpans. Productivity is variable with median grazing capacity being assessed at 2.5 beasts/km^2.

Epsilon land system comprises the flat claypans and small seasonal lakes associated with the dunefields. Soils are massive surfaced grey clays and cemented, texture contrast soils. Vegetation ranges from sparse vegetation, particularly during poor seasons, to bluebush and lignum low open shrubland. Productivity is low, median grazing capacity being assessed at 1 beast/km^2.

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Current Land Use

CHAPTER 8

by W.F.Y. Mawson*, H.C.D. Hunter+, I.B. Robinson* and N.M. Dawson*

SOCIAL ORGANISATION AND COMMUNICATIONS

There are approximately 220 properties in the area. At the 1971 census these properties were supporting an area population of 2,759 men, women and children. This is a reduction of nearly 30% since the 1961 census (see Table 8.1) and has resulted in a shortage of rural labour in western Queensland. There has been a reduction of 33% in the male permanent labour force over the 10 year period 1961-71. The relatively poor facilities and communications, together with attractive work opportunities elsewhere and lower property incomes in the wool enterprises have contributed to this decline. It is difficult to envisage this situation improving under present conditions. Reliable labour will continue to be a problem until pay or other economic conditions change. The shortage in the short-term will lead to an increase in contract labour. While labour continues to be in short supply difficulties could be expected in implementing management practices involving additional labour.

Table 8.1. Population figures at census for selected centres.

	1891[1]	1961[1]	1971
Charleville Town	3,211	5,154	3,948
Cunnamulla Town	2,114	2,234	1,805
Quilpie Town	N.A.	859	746
Thargomindah Town	338	163	157
Bulloo Shire	N.A.	772	575
Quilpie Shire	N.A.	2,534	1,690
Paroo Shire [2]	N.A.	622	494
Est. Area	N.A.	3,928	2,759
Whole State	393,718	1,518,828	1,823,362
Male Population on Holdings	N.A.	1,188	802
Female Population on Holdings	N.A.	677	566
Male Permanent Workers on Holding	N.A.	931	621

The CSIRO has been conducting research on building improvements to improve home conditions in hot areas. Fields of study include solar water heaters. home design and air-conditioning. There is a real need to improve living conditions in the area to at least the standard being achieved in the cities. The use of existing technology could aid this situation and further research would be justified.

Primary school facilities are available at Quilpie, Eromanga and Thargomindah. The Queensland Country Women's Association has a student hostel at Thargomindah enabling children to attend school during the week and visit parents at weekends. The 'school of the air' and correspondence lessons are available for young students unable to attend a school. The nearest high school is located at Charleville.

Costs of education, travel and transport are relatively high for people living in these areas. It follows that relatively higher incomes are needed if residents and employees in the area are to achieve a standard of living and education comparable to many dwellers in more easterly areas.

At present the area is serviced mainly by the towns of Quilpie, Charleville and Cunnamulla. However, in the far south-west mail runs from Broken Hill still service a number of properties. The towns of Thargomindah and Quilpie are head-quarters of the Bulloo and Quilpie Shires respectively and this contributes significantly to the stability of these towns.

TAA services some stations and towns as part of its "channel country" route.

Telephone facilities are available to many properties, mainly in the east, and the whole area is serviced by radio through the Flying Doctor Bases at Charleville and Broken Hill.

Hospital facilities exist at Thargomindah, Quilpie, Charleville and Cunnamulla. Not all these facilities are staffed by a resident doctor.

Table 8.2 illustrates the fluctuations in estimated gross income from the area over a eight year period (1962-69).

The main industry in the area is wool growing. The beef industry at present is going through a growth period. Income has historically fluctuated through time, not only due to seasonal conditions, but also in response to the demand for the different commodities. These fluctuations in the early period led to considerable changes in property ownership, and even today are a major hazard for primary producers.

Other industries contributing to the income of the area are mining for opals, beekeeping, and tourism.

TRANSPORT

Road, rail and droving have been used in the past for the movement of cattle into and out of the area. Droving is now of minor importance. Cattle walked to the railhead at Quilpie comprised 73% of total movements in 1962-63 but by 1971-72 the proportion had declined to one percent.

Road transport of stock, now possible as a result of the major road improvements completed during the past decade, has improved the flexibility of property management and led to savings in time and labour and to a reduction in the levels of transit weight losses.

* Development Planning Branch, Qd Dep. Prim. Inds.

+ Development Branch, Qd Dep. Lands

1 Excluding Aborigines.

2 One-third of (Shire population - Cunnamulla Township).

Table 8.2. Estimated value of production from the area (x $1,000).

	1962	1963	1964	1965	1966	1967	1968	1969
Bulloo Shire								
Agricultural, Poultry, Dairying and Bees	2	2	2	2	2	1	2	2
Mining, Forestry and Fishing				66	71	64	38	47
Pastoral	2,406	3,108	3,834	4,142	2,707	2,764	2,791	3,442
Paroo Shire *								
Agricultural, Poultry, Dairying and Bees	5	5	7	7	6	5	6	5
Mining, Forestry and Fishing	60	90	54	44	47	43	25	32
Pastoral	2,601	3,083	3,965	3,167	1,983	2,290	2,755	3,439
Quilpie Shire								
Agricultural, Poultry, Dairying and Bees	4	4	12	5	4	5	8	8
Mining, Forestry and Fishing				66	24	64	38	47
Pastoral	5,432	6,090	7,956	6,802	4,352	5,331	6,218	8,328
TOTAL	10,510	12,382	15,830	14,301	9,196	10,567	11,881	15,350

* One-third of the value of production has been apportioned to that part of Paroo Shire within the area.

Source:- Bureau of Census and Statistics.

The major roads serving the area are the Charleville-Quilpie-Boulia Road, the Charleville-Cunnamulla-Bourke Road and the Cunnamulla-Thargomindah Road. The Cunnamulla-Bourke section, the Quilpie-Windorah-Currawilla Beef Road and all but some small sections of the Cunnamulla-Thargomindah Road are bitumen surfaced. The balance of these roads are formed or gravelled.

Formed, but unsealed, roads carry traffic volumes ranging up to an annual average equivalent to 50 vehicles per day. Much of the traffic is seasonal and consists of cattle road trains which cause severe damage to unsealed road surfaces with attendant maintenance problems.

Quilpie, the western railhead on the Quilpie-Charleville-Roma-Brisbane line, is one of the most important stock shipment railheads in the State. Over the decade to 1972 an average of 39,447 cattle and 82,456 sheep was loaded annually at Quilpie (see Table 8.3). The Charleville to Cunnamulla branch line also serves a large pastoral district and draws stock from the eastern part of the area covered by the study. Figure 8.1 shows the location of the major communication routes in the area.

Integration with other regions

Despite its remoteness, the area has provided a link in the production chain connecting the beef cattle regions of northern Australia to eastern meat processing works. Cattle brought into the area in store condition are fattened and turned off to meatworks and slaughterhouses in eastern Queensland and New South Wales.

Beef cattle properties are concentrated in the western portion of the area. In 1972 only 24 properties were engaged solely in beef production but a further 197 properties ran both sheep and cattle.

The abundance of feed produced following the periodic flooding has earned the alluvial plains the title of 'opportunity country'. Haug and Hoy (1970) commented that "the need has been recognised to provide transport facilities to bring stock in quickly during the good seasons and to destock in times of drought, thus giving added flexibility to management".

Many of the properties, particularly those with country inundated by the periodic floods, are company-owned. The same companies also own, or have associations with, other properties throughout Queensland and the Northern Territory. In this way supplies of store cattle are usually readily available for transport into the area after flooding has occurred.

For cattle brought onto the flooded country the fattening period varies according to the condition and class of the cattle, the extent and the season of occurrence of flooding and management factors.

The extent to which the area is used for fattening imported cattle is illustrated by a recent Bureau of Agricultural Economics' analysis. In this, Girdlestone and Parsons (1973) estimated that the percentage turnoff of slaughter cattle from the South-West Plains* averaged 37.4% of total cattle numbers in 1967 when the Queensland average was 22.5%.

The Beef Cattle Industry Survey (1970), for the years 1962-63 to 1964-65, showed that 5.9% of properties in the "channel country" (including the whole of the Far Western and South Western Statistical Divisions) derived the major part of their income from fattening purchased store cattle. This percentage was exceeded only in south-eastern Queensland. The area covered by the study comprises only part of the "channel country" region as defined by the Bureau of Agricultural Economics. However, as it includes most of those properties with fattening as the dominant enterprise, the fattening of purchased stores would be the main enterprise on more than 5.9% of properties and a major subsidiary enterprise on the remainder.

* Note that regions referred to in this section do not coincide exactly with the survey area.

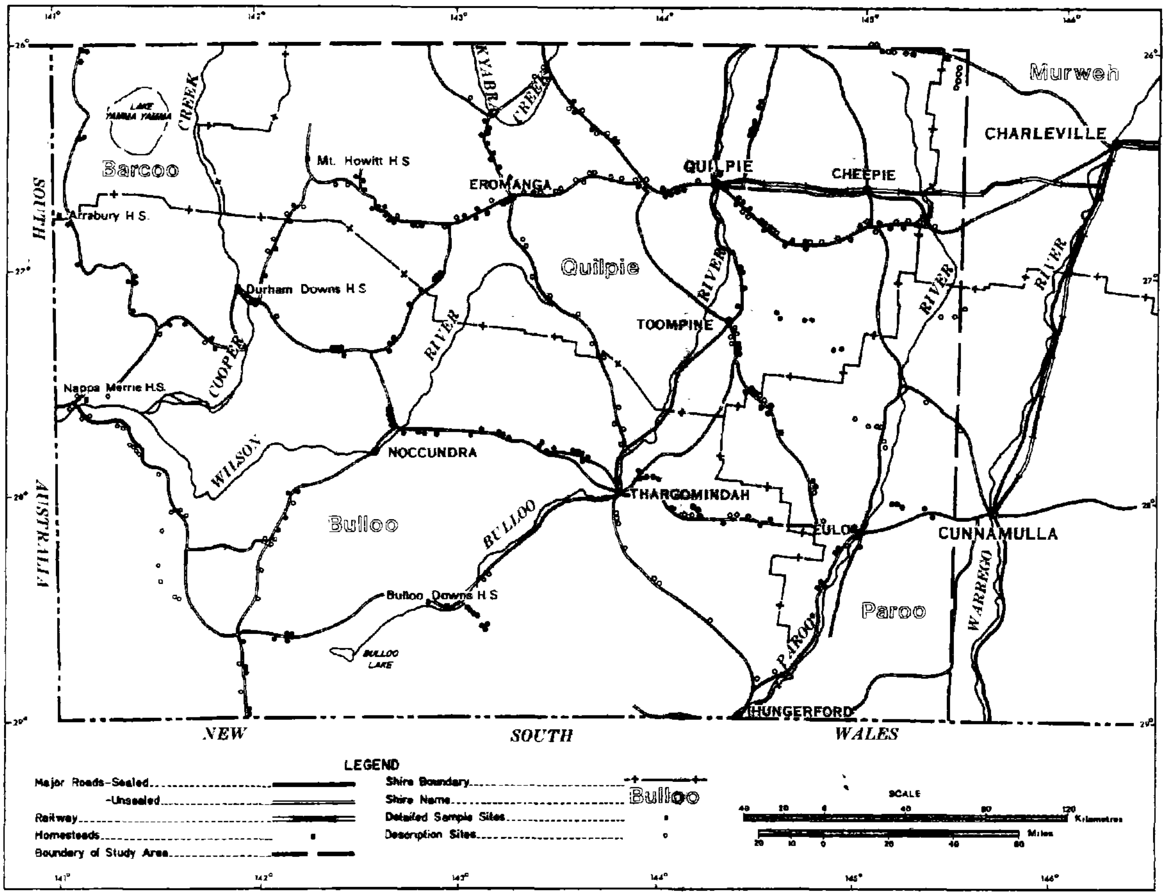

Fig. 8.1. *Study area showing towns, some homesteads, communication, streams and distribution of sample sites .*

The Bureau of Agricultural Economics has analysed cattle movements throughout Queensland for 1967. Although that was not a good flood year, cattle movements into the South-West Plains (comprising the Shires of Bulloo, Quilpie and Paroo) totalled 72,595 head. The areas of origin of these cattle (excluding intra-regional movement within the South-West Plains) indicated that nearly half the stock brought in (47.8%) came from areas to the east and north-east. Analysis of the records of Northern Territory store cattle crossings into Queensland at Lake Nash and Camooweal, and of cattle loadings at the Mt. Isa railhead, indicate that the great majority of stores from the Northern Territory are trucked into the "channel country" (both within and without the survey area) in years of good floods. This class of cattle is loaded onto rail for transport to eastern Queensland when the "channel country" experiences poor seasons. Inconsistencies in the pattern of movements can generally be explained in terms of droughts or abundant seasons elsewhere which impose an additional and overriding influence on the movement of stores. The average movement of Northern Territory cattle into the Queensland "channel country" is estimated to be between 26,000 and 30,000 head annually.

In summary, the movement of cattle into the south-west arid region is closely related to seasonal conditions in the region. In good seasons, particularly following flooding of the "channel country", the turnoff from the chains of company-owned properties in north Queensland and the Northern Territory provides the source of imported cattle. Additional cattle may be purchased from these areas. In some years there may also be a substantial movement of stores into the region from central and eastern Queensland.

An analysis of Stock Movement Permits for 1967 has made possible a more recent estimation of turnoff from the region. Girdlestone and Parsons (1973) estimated that, following the low flood of 1967, 39,400 cattle moved from the South-West Plains for slaughter in Queensland and New South Wales. Unpublished data indicate that a further 20,000 store cattle may have been moved out of the South-West Plains in 1967 lifting the total to about 60,000. In the drought year of 1969-70, 80,112 South-West Plains cattle were moved into New South Wales.

Table 8.3 shows the number of livestock, from within the area and nearby districts, which were loaded at railheads and sidings over the decade 1963 to 1972.

Table 8.3. Livestock loaded at railheads and sidings year ended 30th June.

		1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
Quilpie	Cattle	40,654	58,436	49,861	20,654	29,330	24,148	39,974	42,914	37,583	50,908
	Sheep	31,068	62,122	85,144	58,138	76,594	42,998	59,921	163,999	125,669	118,909
Cunnamulla	Cattle	6,392	9,088	6,500	5,705	3,716	3,770	4,903	7,996	4,880	6,974
	Sheep	57,206	47,482	21,563	33,995	21,809	30,887	22,075	32,063	138,368	107,961
Cheepie	Cattle	877	806	149	109	68	175	385	933	108	174
	Sheep	6,909	7,938	6,784	3,798	12,043	8,826	7,819	25,200	16,681	14,483

(Cattle includes calves.)

On the basis of unpublished border crossing information and the 1967 Bureau of Agricultural Economics' analysis, it would appear that the destinations of cattle from the South-West Plains are: Queensland about 60%; New South Wales about 35%; and South Australia about 5%.

Transport and inter-regional integration

Historically, far-northern Australia has been a major supplier of store cattle to the fattening areas in southern and eastern Australia. The Queensland "channel country" lies midway between the breeding areas in the Northern Territory and the markets of Brisbane, Sydney and Adelaide and is situated on one of the traditional stock routes to the south and south-east.

Because the "channel country" is opportunity country the numbers of cattle moving into and through the area vary widely with seasonal conditions. Following good floods, large numbers of cattle are brought into the area for a fattening period before resuming their onward movement to the main markets.

The cost of transporting cattle over immense distances, frequently exceeding 1,000 miles, from northern Australia to southern and eastern markets has always been a major consideration. These transport costs are incurred whether cattle are held for a number of months in the "channel country", or not. In the past, they have resulted in northern cattle breeders receiving relatively low paddock prices for store cattle.

While the main movement of northern store cattle continues to be to southern and eastern Australia, "channel country" pastoralists, with the natural advantage of cheap feed, are likely to remain competitive with other purchasers of store cattle. Recent developments threaten to reduce flow of store cattle southwards from northern Australia. Pasture improvement feedlot operation and agricultural activities in the Kimberley, the "Top End" of the Northern Territory and coastal north Queensland are generating a demand for store cattle in close proximity to the breeding areas.

LAND TENURE

As the area generally is not suited to cropping, the tenures adopted by various Governments over the years have been chiefly *Pastoral Holdings* and *Grazing Selections.* Land under these tenures has been made available having regard to the following factors:-

(a) the quality and fitness of the land for grazing purposes;

(b) the number of stock which the land may reasonably be expected to carry in average seasons;

(c) transport facilities available; and

(d) the natural supply of water, and the facilities for the raising and storage of water.

In the eastern part of the area tenures chiefly comprise *Grazing Homesteads* and *Grazing Farms,* some of which have been converted to *Grazing Homestead Freeholding Leases* in recent years. General disqualifications applying to all classes of selections are:-

> No person who is under the age of 18 years is qualified to acquire, hold or purchase land under any tenure of the Land Act. A person who is a trustee, agent or servant for another cannot hold a selection, save the provisions of Section 296 (2A) which allows family partnerships. Selections must be held in individual names - Companies or Corporations may not hold tenures.

Area disqualifications are:-

> The maximum area which any one person may hold as two or more grazing selections must not exceed 18 200 ha (in the case of poor quality land this maximum can be increased to 24 280 ha in order to obtain a living area). To control undue aggregation of the better quality grazing lands, and in addition to the State-wide maximum of 18 200 ha, a maximum area which may be held may be specified in respect of each district and this maximum may be considerably less than the 18 200 ha State maximum. Furthermore, the Land Act prescribes that a person shall not hold two or more grazing selections where the aggregate areas exceed 12 140 ha and the aggregate rentals for the first period exceeds $1,200 per annum. It is to be noted that this disqualification requires that both the prescribed area and rental limitations must be exceeded before the disqualification applies. Again it is also stipulated that any person who has an interest exceeding 12 140 ha in one or more Pastoral Leases shall not be competent to apply for or hold a Grazing Selection if the aggregate of the rents for the respective first periods of the Pastoral Lease and the Grazing Selection exceeds $1,200 per annum.

The maximum term of a Grazing Selection is 30 years - rental periods of 10 years duration. The rent of second and subsequent rental periods is determined by the Land Court. Grazing Homesteads which are made available for settlement are subject to personal residence for the first seven years and thereafter to the condition of occupation.

All Grazing Selections which do not substantially exceed a living area may be converted to freeholding tenure. Those in excess of a living area may be subdivided and only part equivalent to a living area converted. In the case of conversion the lessee is required to purchase the land by way of 40 equal annual instalments, free of interest.

In the central part of the study area tenures chiefly comprise *Grazing Selections* and *Preferential Pastoral Holdings.*

The tenure of Preferential Pastoral Holding is designed to deal with land on the fringes of the closer settlement areas, where it is necessary that blocks exceed the maximum area of 18 200 ha which applies to Grazing Selections. In effect, the Preferential Pastoral Holding is somewhat related to the Grazing Selection insofar as terms and conditions are concerned. Points of similarity are:-

(a) Preferential Pastoral Holding cannot be held by a Company or Corporation;

(b) it cannot be held by a trustee, agent or servant of another;

(c) personal residence and condition of occupation when first made available are similar;

(d) the notification opening land specifies a maximum area which may be applied for by one person.

Notwithstanding the limitations mentioned above in relation to Grazing Selections and Preferential Pastoral Holdings with respect to the maximum of the area or the aggregated areas, or both, of land that may be held by any one person under the tenure, the Minister may:-

(a) upon application by the lessee of such a holding or holdings comprising an area which is not a living area, permit such lessee to acquire by transfer an additional holding or holdings for the purpose of constituting a living area for the lessee concerned;

(b) permit any person who does not hold any such holding to acquire by transfer two or more holdings under the same class or mode of a class of tenure to be worked in conjunction provided the total areas of the holdings sought to be acquired is not substantially in excess of a living area.

In the western part of the study area tenures consist of *Pastoral Holdings* and *Pastoral Development Holdings*.

In the main, these tenures are used in the more remote parts of the State or in respect of land which, due to distance from rail, quality or high costs of development, render it necessary to make the areas available in excess of the limitations provided for other tenures.

Under ordinary Pastoral Holding or Pastoral Development Holding tenure there is no limit to the area which may be held by any one person. These may be held by Companies or Corporations and are not subject to the condition of personal residence or occupation.

The tenure Pastoral Development Holding is applied in respect of land which is unusually difficult and costly to develop. This tenure is generally found in the more remote areas. The term of the lease is determined having regard to the expenditure likely to be incurred on the development of the land but must not exceed 50 years.

Table 8.4. Types of tenure and estimated carrying capacity.

Tenure	No.	Area in ha	Estimated Carrying Capacity	
			Sheep	Cattle
Perpetual Lease Selection	1	518	183	
Grazing Farm	97	881,529	248,399	
Grazing Homestead	125	1,496,062	446,171	
Grazing Homestead Freeholding Lease	31	288,370	95,486	
Preferential Pastoral Holding	82	2,124,976	486,287	3,254
Pastoral Development Holding	12	1,440,551	215,825	8,350
Pastoral Holding	58	8,931,142	504,967	81,035
	406	15,163,148	2,007,268	92,639

Table 8.4 provides statistics of rural land held under leasehold tenure in the study area as at April 30, 1972 together with estimated carrying capacities of the various tenures. Special Leases have been excluded from the Table as this tenure is only used in the study area to legalize the inclusion of Camping and Water Reserves in selections and holdings, thus preventing the need and expense of fencing, which would serve no useful purpose. These reserves although leased may still be used for their gazetted purpose. It should be noted that the boundaries of the tenure areas listed in Table 8.4 do not coincide exactly with the boundaries of the survey area.

Tenures in this part of the State are chiefly held in aggregations in many cases by families or groups of families and also by Pastoral Companies.

Range of property sizes

Tables 8.5 and 8.6 set out the statistics of the area and estimated carrying range of aggregations for both cattle and sheep properties and Table 8.7 shows the number of properties with the carrying capacity range.

Table 8.5. Property size ranges and estimated carrying capacity (Sheep).

Property Size Range (ha)	No.	Estimated Carrying Capacity Range (Sheep)	Total Estimated Carrying Capacity
6,000 - 8,000	4	2,071 - 3,200	10,004
8,000 - 12,000	7	3,185 - 4,680	26,415
12,000 - 16,000	13	3,070 - 6,050	57,859 -
16,000 - 20,000	22	2,910 - 7,895	120,750
20,000 - 24,000	28	3,840 - 8,688	169,722
24,000 - 28,000	27	6,173 - 9,600	202,540
28,000 - 32,000	23	6,510 - 11,117	192,550
32,000 - 36,000	16	5,040 - 11,314	137,085
36,000 - 40,000	15	6,990 - 13,995	162,045
40,000 - 44,000	11	8,864 - 13,135	119,671
44,000 - 48,000	4	11,561 - 15,987	55,855
48,000 - 52,000	5	7,150 - 18,217	62,641
52,000 - 56,000	5	11,990 - 15,718	66,217
56,000 - 400,000	17	13,300 - 69,197	540,278
	197		

Of the sheep properties 144 (74%) are contained within the size range of 12 000 to 40 000 ha, and these account for approximately 50% of the estimated sheep carrying capacity. Over 25% of the estimated sheep carrying capacity are accounted for on properties exceeding 56 000 ha in size.

Cattle properties have a modal size range of 400 km^2 to 2,000 km^2 but this accounts for only 19% of the estimated carrying capacity. The highest proportion of cattle carrying capacity is found in the largest size range of 8,000 to 12,000 km^2 with a capacity for 65,400 head or 70% of the total estimated capacity.

Table 8.6. Property size ranges and estimated carrying capacity (Cattle).

Property Size (km²)	No.	Estimated Carrying Capacity Range (Cattle)	Total Estimated Carrying Capacity
200 - 400	4	647 - 1,260	3,614
400 - 2,000	10	360 - 3,466	17,915
2,000 - 4,000	2	2,960 - 4,880	7,840
4,000 - 6,000	2	5,620 - 24,484	30,104
6,000 - 8,000	2	9,020 - 11,000	20,020
8,000 - 12,000	4	14,803 - 17,100	65,400
	24		

In Table 8.7 properties are classified according to flock or herd size on the basis of estimated carrying capacity. Of the 197 sheep properties, 31 have an estimated sheep carrying capacity of 5,000 head or less. A total of 109 have flocks of less than 8,000 sheep. A flock range of between 5,000 and 12,000 head is revealed on 133 properties with a further 33 properties having an estimated carrying capacity in excess of 12,000 sheep.

Table 8.7. Distribution of estimated carrying capacity and number of properties.

Stock Nos. (Sheep)	No. of Properties	Stock Nos. (Cattle)	No. of Properties
2,000 - 3,000	4	1 - 1,000	5
3,000 - 4,000	11	1,000 - 2,000	4
4,000 - 5,000	16	2,000 - 3,000	5
5,000 - 6,000	24	3,000 - 25,000	10
6,000 - 7,000	32		
7,000 - 8,000	22		
8,000 - 9,000	21		
9,000 - 10,000	11		
10,000 - 11,000	11		
11,000 - 12,000	12		
12,000 - 13,000	7		
13,000 - 14,000	6		
14,000 - 15,000	1		
15,000 - 16,000	3		
16,000 - 17,000	2		
17,000 - 18,000	1		
18,000 - 19,000	2		
19,000 - 21,000	2		
Above 21,000	9		
	197		24

Living area standards (sheep)

In the annual report for 1970-71 the Lands Administration Commission published guidelines to "living areas" in terms of sheep numbers. These figures are intended as a basis only and are subject to variation according to local circumstances such as distance from adequate transport and water availability. In the longer term, property sizes are influenced by such factors as changes in technology, productivity capacity of properties, market prospects for the product and the cost of inputs. The standards applicable to the survey area are as follow:-

Cunnamulla district - open black soil country with belts of gidgee etc. - good breeding country with a 330 to 380 mm rainfall - 8,000 sheep.

Cunnamulla west - generally mulga country with areas of boree and gidgee and some flooded black soil country - rainfall 250 to 380 mm - 10,000 to 12,500 and over sheep.

Charleville west - land types similar to Cunnamulla west - rainfall 250 to 280 mm - 8,750 to 12,500 or more sheep.

From the foregoing it is evident that a flock of 8,000 sheep was considered a basic minimum guideline at that time. Reference to Table 8.7 indicates that over half the sheep properties carried less than 8,000 head. Since 1967 there has been a partial movement into cattle which helped to alleviate the position of the wool grower when wool prices plunged in 1970-71. The higher wool price of 1972-73 provided a breathing space but some reconstruction and amalgamation appears necessary in the longer term. The rapid fluctuations in wool prices, combined with the effects of prolonged drought have created unstable conditions in the wool growing sections of the area since 1965.

The average price of wool sold in Queensland over recent years is listed in Table 8.8.

The income earning capacity of sheep properties in this area is overwhelmingly influenced by the price of wool since wool proceeds account for approximately 90 percent of total income. Stability in wool prices is thus an important factor both to producers already engaged in the industry and policy makers who have responsibilities in relation to the size of living areas.

Table 8.8. Average wool prices.

Period	Average Price per kg (cents)
1967-68	95.89
1968-69	99.71
1969-70	82.68
1970-71	60.84
1971-72	73.37
1972-73	178.30

Source: Bureau of Census and Statistics, Queensland

In a paper entitled "Australian Wool Prices - Recent Developments and Outlook" included in the August 1970 edition of "The Wool Outlook" the Bureau of Agricultural Economics projected an average overall Australian greasy auction price of 40 cents per pound (88 cents/kg) plus or minus approximately 10% for the middle and latter part of the current decade. The latest short term forecast available at the time of preparation of this report is contained in "The Wool Outlook" (December 1972) in which the Bureau states, "Generally improved levels of world economic and textile activity have recently had a favourable influence in the demand for wool and are likely to continue in the immediate future. Since both short term supply and demand factors are expected to influence the market positively, prices for the rest of the season (1972-73) seem likely to remain at levels giving a seasonal average price close to the average to date (quoted as 147.48 cents per kg to the end of November 1972). However, generally improved conditions in the wool market remain susceptible to unforeseen trade and currency upheavals and will continue to be influenced by the price and availability of competing fibres".

THE PASTORAL INDUSTRY

Commercial pastoral activity, in relation to domestic animals, is confined to beef cattle and sheep production. Beef production comprises both breeding and fattening. In years of favourable pastoral conditions, particularly in the so-called "channel country" store cattle for fattening are sought from northern regions beyond the boundaries of the described area. Sheep production is confined largely to wool production, but with the greatest proportion of replacement animals bred within the area.

Sheep are confined to the east, the west and channel areas generally being devoted to beef cattle. Some cattle are run in conjunction with sheep in the east. Definite steps to replace some sheep with cattle were taken as a result of drought and low wool prices during 1970-72. The rise in wool prices in 1972 tended to halt this trend. Because of the aridity of the area the beef cattle and sheep population fluctuates considerably. Sustained drought periods lead to a reduction in stock numbers through sales, non-mating, mortalities and cessation of introduction of stock from other regions. The relative unavailability of replacement stock at the breaking of drought may result in a rather slow upturn in numbers.

Precise stock population figures for the area are not available. However, official statistics on Petty Sessions districts are available for the period 1897 to 1939 inclusive and on a Local Authority (Shire) basis from 1940 to date, with the exception of some gaps owing to war conditions. Two further problems in obtaining a continuous record have arisen. Firstly, the boundaries of the Petty Sessions[1] districts and the Shires do not coincide with the boundary of the area as described and this has necessitated apportionment of numbers within the area in some cases. Secondly, some of the local authority areas themselves have not remained a constant size.

For purpose of historical record the apportionments made in arriving at stock population from 1897 to 1972 are set out.

(a) Stock population by Petty Sessions districts 1897-1939

Period (inclusive)	Petty Sessions Districts Included
1897-1917	Thargomindah, Eulo, Hungerford Adavale (one-half), Cunnamulla (one-third), Charleville (one-fifth)
1918-1931	Thargomindah, Eulo, Hungerford, Quilpie, Adavale (one-half), Cunnamulla (one-third), Charleville (one-tenth).
1932-1939	Thargomindah, Eulo, Hungerford, Quilpie, Adavale (one-fifth), Cunnamulla (one-fifth), Charleville (one-tenth).

(b) Shires 1940-1972

1940-1972	Bulloo; Paroo (one-third of both sheep and cattle population), Quilpie (all sheep, two-thirds of cattle population).

Calculated on the foregoing basis stock population from 1897 to 1972 for the area appear in Table 8.9.

The cattle population was at its peak over the period 1897 to 1899. Drought during the first years of the twentieth century caused a remarkable decrease, the size of which exceeded 92 percent of the 1897 herd number. Other major droughts were experienced in the late 1920's; 1946-47; 1965-67 and 1969-1972. Sheep population has tended to move in parallel with cattle population in relation to drought but has shown a generally upward trend to the mid 1960's, after which a combination of drought and low wool prices over 1969-70 has resulted in something of a levelling out process.

Livestock numbers have been converted to cattle equivalents and examined on the basis of both 3 year and 5 year moving averages. Since it was considered that the 5 year moving average provides the best broad view of the relationship the data were then converted to indices for comparative purposes. Figure 8.2 depicts this relationship between rainfall and livestock numbers. In plotting livestock numbers the same figures are used as in Table 8.9 but sheep numbers have been converted to cattle by using a conversion equivalent of eight sheep to one bovine.

Rainfall has been calculated on the basis of the mean of annual falls at the five official recording centres of Adavale, Cunnamulla, Jundah, Cowley and Thargomindah. No allowance has been made for the effect of flooding resulting from rainfall beyond the boundaries of the area.

In order to facilitate the visual observance of trends in both rainfall and livestock population the data are presented in the form of indices. The base for the livestock population is the mean of the eight years 1897 to 1904, amounting to 266,916 cattle equivalents. Rainfall base is the mean of the five named centres for the ten year period 1895 to 1904, amounting to 281 mm.

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1 We are indebted to officers of the Justice Department for details of changes in Petty Sessions district boundaries 1897 to 1939.

Table 8.9. Stock populations 1897-1972.

Year	Beef Cattle ('000 head)	Sheep ('000 head)	Year	Beef Cattle ('000 head)	Sheep ('000 head)
1897	424.5	1,558.3	1935	97.7	1,588.9
1898	323.4	1,483.5	1936	108.1	1,586.7
1899	253.6	1,156.2	1937	89.0	1,346.8
1900	50.0	590.4	1938	84.0	1,313.9
1901	32.5	526.2	1939	75.6	1,708.2
1902	33.1	515.4	**1940**	83.3	1,682.6
1903	33.8	652.4	1941	87.7	1,973.7
1904	57.5	933.4	1942	N.A.	N.A.
1905	62.1	929.1	1943	N.A.	2,103.4
1906	84.2	1,120.1	1944	N.A.	2,052.0
1907	99.5	1,238.0	1945	117.8	1,762.0
1908	130.1	1,329.6	1946	111.0	1,411.9
1909	140.7	1,471.9	1947	90.4	1,169.8
1910	143.3	1,394.7	1948	92.9	1,334.2
1911	175.8	1,328.6	1949	114.8	1,448.1
1912	169.5	1,079.2	**1950**	122.1	1,551.9
1913	183.6	1,182.8	1951	139.0	1,510.3
1914	180.2	1,336.8	1952	128.5	1,439.0
1915	132.1	778.4	1953	138.5	1,653.5
1916	133.9	686.3	1954	154.7	1,743.3
1917	154.6	732.6	1955	159.9	1,945.3
1918	179.2	945.5	1956	155.9	2,181.0
1919	166.7	811.2	1957	173.7	2,181.0
1920	169.1	801.7	1958	149.4	1,934.0
1921	198.1	819.4	1959	111.6	1,620.3
1922	183.4	785.9	**1960**	99.3	1,749.8
1923	213.1	860.6	1961	129.3	1,813.2
1924	217.2	994.6	1962	133.1	1,615.7
1925	205.3	1,027.6	1963	133.1	1,732.5
1926	181.8	1,167.2	1964	147.8	1,972.1
1927	164.8	981.9	1965	158.3	1,972.9
1928	126.9	1,057.9	1966	92.4	1,291.1
1929	83.5	951.3	1967	78.3	1,293.1
1930	74.4	1,207.2	1968	109.5	1,689.5
1931	106.0	1,372.3	1969	131.8	1,712.1
1932	110.6	1,532.6	**1970**	122.2	1,555.5
1933	105.8	1,429.1	1971	102.3	1,471.5
1934	105.2	1,561.3	1972	129.4	1,438.1

Source: Bureau of Census and Statistics.

The Figure illustrates that the rainfall deficiency experienced at the beginning of the 20th century is the largest on record. Following the breaking of the drought at the beginning of the century there followed a 20 year period of generally above average rainfall until the mid 1920's. From this point until after the 1946 drought followed a period of generally below average falls. The decade from 1950 to 1960 was the wettest on record and has now been followed by a further long run of below average falls from the mid 1960's to 1972.

With the exception of the steep decline at the beginning of the century, when the index of stock numbers fell far below the rainfall index, stock numbers have tended to show somewhat less variation than rainfall and exhibit a "lag" of some two to three years compared to rainfall. This lag is evident in reaching a peak and commencing the downturn and also in reaching a trough and commencing the upturn. Probable explanations for this are the presence of standing hay and fodder trees and problems of organizing the transportation of a large number of animals under stress conditions.

Breeds

Beef cattle herds are predominantly of the Shorthorn breed with some influx of Santa Gertrudis and Santa Gertrudis cross sires since the late 1950's.

The placid temperament of the Shorthorn and relative ease of management under rangeland conditions have proved to be valuable characteristics.

Sheep flocks are of the Merino breed - many being based on the South Australian large-framed type which are generally considered to be more suited to the harder mulga lands. Smaller framed, finer wool types are also common, generally under the less harsh conditions.

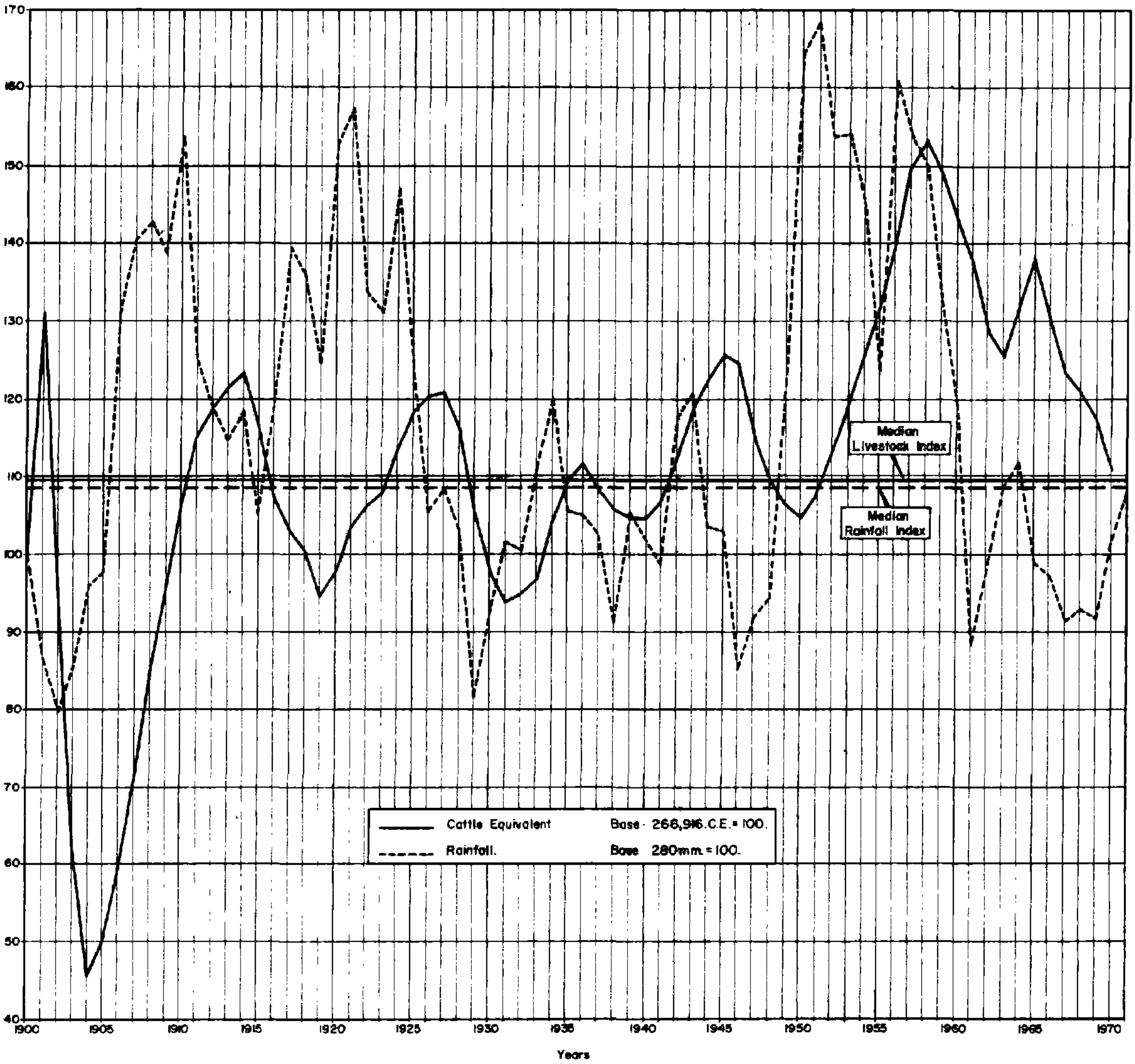


Fig. 8.2. *Index of 5 year moving average. Rainfall and cattle equivalent.*

Property Improvements

For convenience, the study area may be divided into two areas as far as station improvements are concerned. The western part is mainly used for cattle grazing and the eastern portion for the production of wool. Property facilities have been provided in accordance with the requirements of the different animals.

Sheep area

Station improvement throughout the sheep area chiefly consist of station buildings, yards, fencing and water improvements. Over the years, leases have been made available in this area with development conditions to obtain the optimum economic development of the region. Conditions have been imposed, depending on the then economic situation, to provide improvements relating mainly to fencing and water facilities.

It would appear from records that netting fences were erected shortly after the turn of the present century to prevent the ravages of the dingo in sheep flocks. These fences were extended until about the beginning of the second world war when such a large number of aggregations was included in group netting schemes, that over a large area the dingo was no longer a problem. However, after the good seasons in the early 1950's and the bush-fires resulting therefrom, many miles of netting fences were destroyed and later had to be restored when the dingo moved in from the cattle country. Now these fences are not in a dogproof condition as the dingo is largely controlled by poisoning operations carried out by landholders in conjunction with the Co-ordinating Board.

Subdivisional fencing chiefly consists of 6 wire sheep-proof fencing and ring-lock netting fencing, which has been erected by graziers from time to time as finance was available. In general terms, most aggregations are reasonably subdivided having regard to the number of sheep the properties may be expected to carry in average seasons. Sizes of paddocks vary according to the carrying capacity of the country. Many miles of subdivision fencing were erected during and after the boom years enjoyed by the wool industry in the 50's and early 60's.

The study area is in the artesian basin and a number of artesian bores is still providing water along many miles of bore-drains. Where this type of water is not available, supplies consist chiefly of earth tanks, dams, sub-artesian bores and wells. A number of creeks and river systems contain good natural permanent water-holes. Generally the area is sufficiently watered in relation to carrying capacity and water improvements have been provided so sheep may use practically all the available country.

Cattle area

Station improvements throughout the cattle area generally consist of station buildings, fencing, water improvements and yards. This area is sparsely timbered and has a low carrying capacity. Consequently, the area remained virtually in an unimproved state for many years. Graziers used the country on an open basis, with the natural water-holes in the river system determining the stock numbers.

Approximately 20 years ago the majority of Pastoral Leases in the area were renewed subject to substantial development conditions. These were to provide boundary and divisional fences, water improvements, holding yards, bronco yards, outstations and other buildings.

These conditions have been complied with and now all properties are fenced, subdivided so each has a large paddock and the necessary holding paddocks, have bronco yards for the working of stock, have water improvements where the country is suitable for grazing and the storage of water, have outstations where warranted and head station buildings.

Sown pasture

Wilson (1961) has reviewed the subject of sown pastures in South West Queensland within the 125 to 500 mm rainfall zones. To that date he states that the most adaptable have been the buffel grasses (strains of *Cenchrus ciliaris*). In general terms he considers that soils in most instances have poor structure and low fertility. Aridity is quoted as a major problem but over a 26 year period from 1935 to 1961 he considered that the summer rains would have permitted sown pasture establishment on at least 14 occasions, particularly in the 250 to 500 mm zone. He proceeds to point out that some seeds have the ability to remain in a viable state in the soil for 2 to 3 years during drought and on that basis considers there may be a place for sown pasture in the more favoured areas. Establishment and survival in the more arid section appears to be limited to areas of local advantage, for example in furrows designed to trap water during rain and so provide a more favourable micro environment.

While sown pasture in favourable years can be expected to provide a greater bulk of forage there are reservations concerning the wisdom of attempting to base managerial procedures on the expectation of this growth on an annual basis. The overriding limitation is availability of soil moisture and this factor is significant when considering the possibility of extensive areas of sown pasture.

Herd composition and performance

The composition of the beef cattle[1] herd has been examined for the period 1952 to 1972. Although numbers of breeders actually mated are not available the classification of "cows and heifers over one year" may be accepted as a reasonable guide to the intensity of breeding. The ratio of "cows and heifers over one year" to total cattle numbers (expressed as a percentage) for the area is compared to the State ratio of "beef cows and heifers over one year" to "total beef cattle", in Figure 8.3. From 1952 to 1959 the percentage for Queensland was generally higher, then followed a period to 1965 when the position was reversed except for one year. From 1965 there has been close agreement between the percentages for the area and the State as a whole, except for a marked drop in 1969 in the area which experienced a period of severe drought. The postulation is made, therefore, that the basis of beef cattle production in the area has been the maintenance of the breeding herd. Thus the productivity and maintenance of lands other than flooded areas is an essential aspect of the continuation of the industry in its present form.

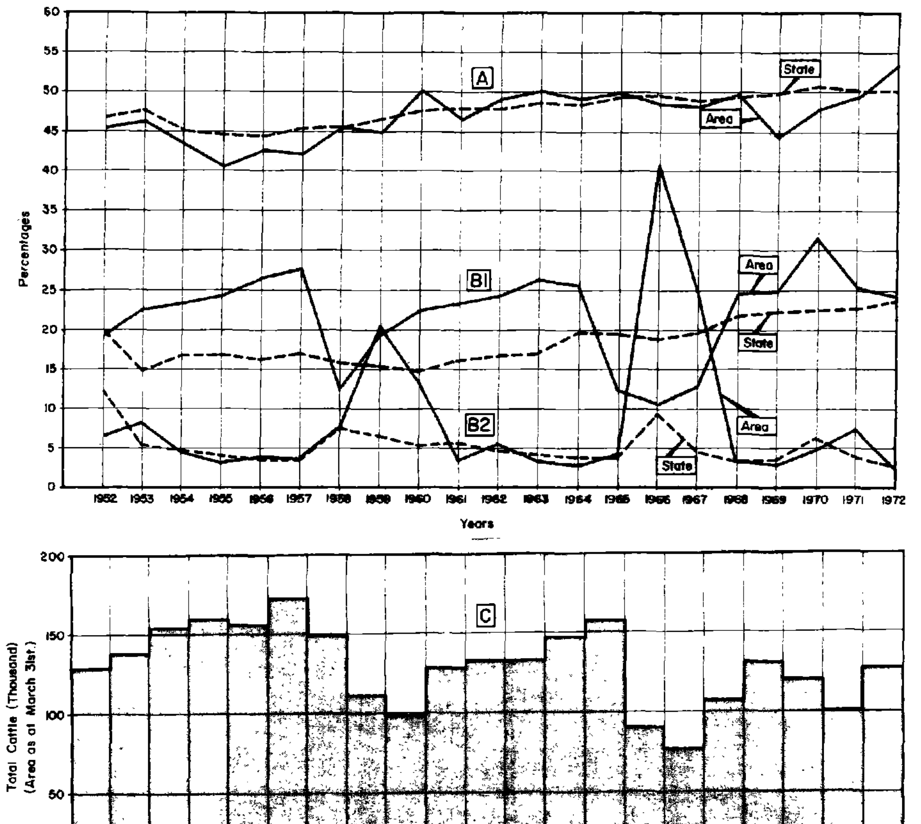


Fig. 8.3. *A % breeding cattle to total cattle*
B comparative efficiency factors based on total cattle
1 brandings; 2 mortalities
C total cattle number

1 The change in classification of "beef cattle" to "cattle for meat production" made by the Bureau of Census and Statistics in 1963, makes no significant difference to these data and the term "beef cattle" has been retained. There are virtually no dairy cattle in the study area.

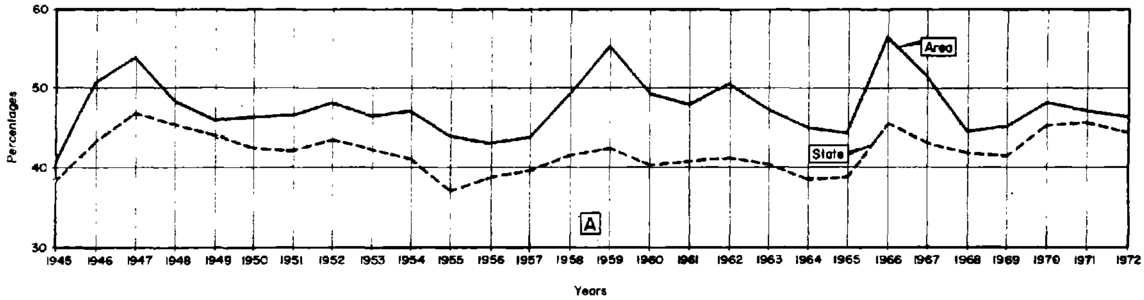
Figure 8.3 also portrays total cattle population in the area for the period 1952 to 1972 inclusive, where the effects of drought on the cattle population are clearly seen. These are reinforced by an examination of the ratio of mortalities to total cattle for both the area and the State. During the years 1957 to 1959 and 1964 to 1966 severe droughts were experienced in the area but these were in a relatively mild form in the easterly cattle areas of the State. As a result the rate of mortalities in the area far exceeded the State average over these periods and in fact exceeded the 40% level in 1966. The position tended to be somewhat reversed in the 1969 to 1970 drought when the rate of mortalities on a State basis exceeded that in the area.

The percentage of calves branded to total cattle in the area exceeds the State average in favourable pastoral years but has fallen below during the two droughts to which reference has been made. The 1964 to 1966 drought has proved to be particularly severe in this respect with brandings well below average in the area for three successive years.

Flock composition and sheep efficiency

As at March 1972 the area carried approximately 10% of the total sheep in the State. Sheep are concentrated in the south-eastern corner of the area. Virtually all are of Merino breed with the majority tending towards a large-framed animal producing wool of a fine to medium count. Wool sales comprise the largest source of revenue on the single enterprise sheep properties - probably in the vicinity of 90% of income - with livestock sales making up the remainder.

Figure 8.4 shows average weight of greasy wool per head for the period 1945 to 1972 for both the area and the State. With the exception of two bad drought years average wool cut per animal in the area has been higher than the State average, which also includes this area.



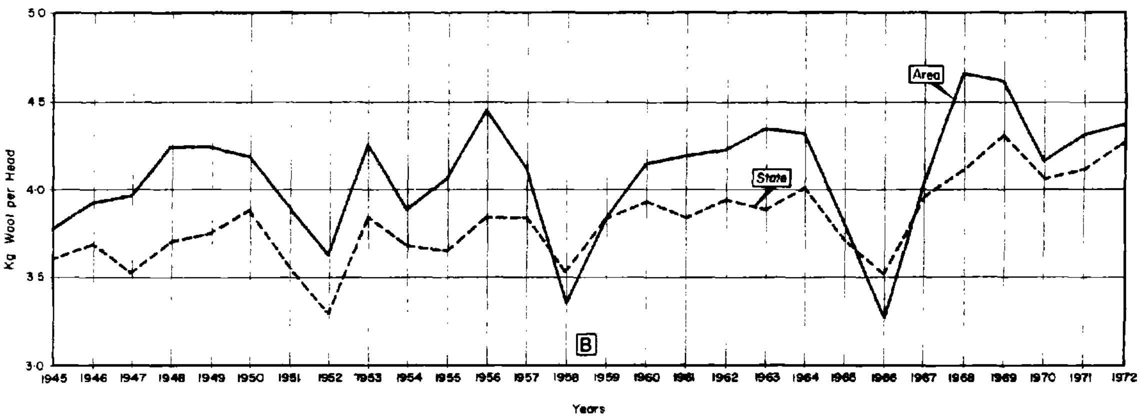


Fig. 8.4. *Comparative data. A % of breeding ewes to total sheep. B kg of wool per head.*

The area has a greater proportion of breeding ewes than the average of the whole state. The ratio of breeding ewes to total sheep for both the area and the State for the period 1945-1972 is also depicted in Fig. 8.4. For the whole of this period this ratio was higher in the area and it is of interest to note that the times of greatest divergence were during major droughts where it appears that the western flock-masters retained breeding females as a deliberate drought strategy.

Efficiency factors indicative of the performance of sheep in this area may be found in the number of lambs marked annually and the number of animals lost through drought and misadventure. The number of lambs marked for the period 1945-1972 is expressed as a percentage of breeding ewes rather than ewes actually mated. The choice of "breeding ewes" is a base in preference to "ewes mated" since it accounts for periods when sheep were deliberately not joined because of poor seasonal conditions. The percentage of lambs marked to breeding ewes is compared with similar data for the State flock and is illustrated in Fig. 8.5.

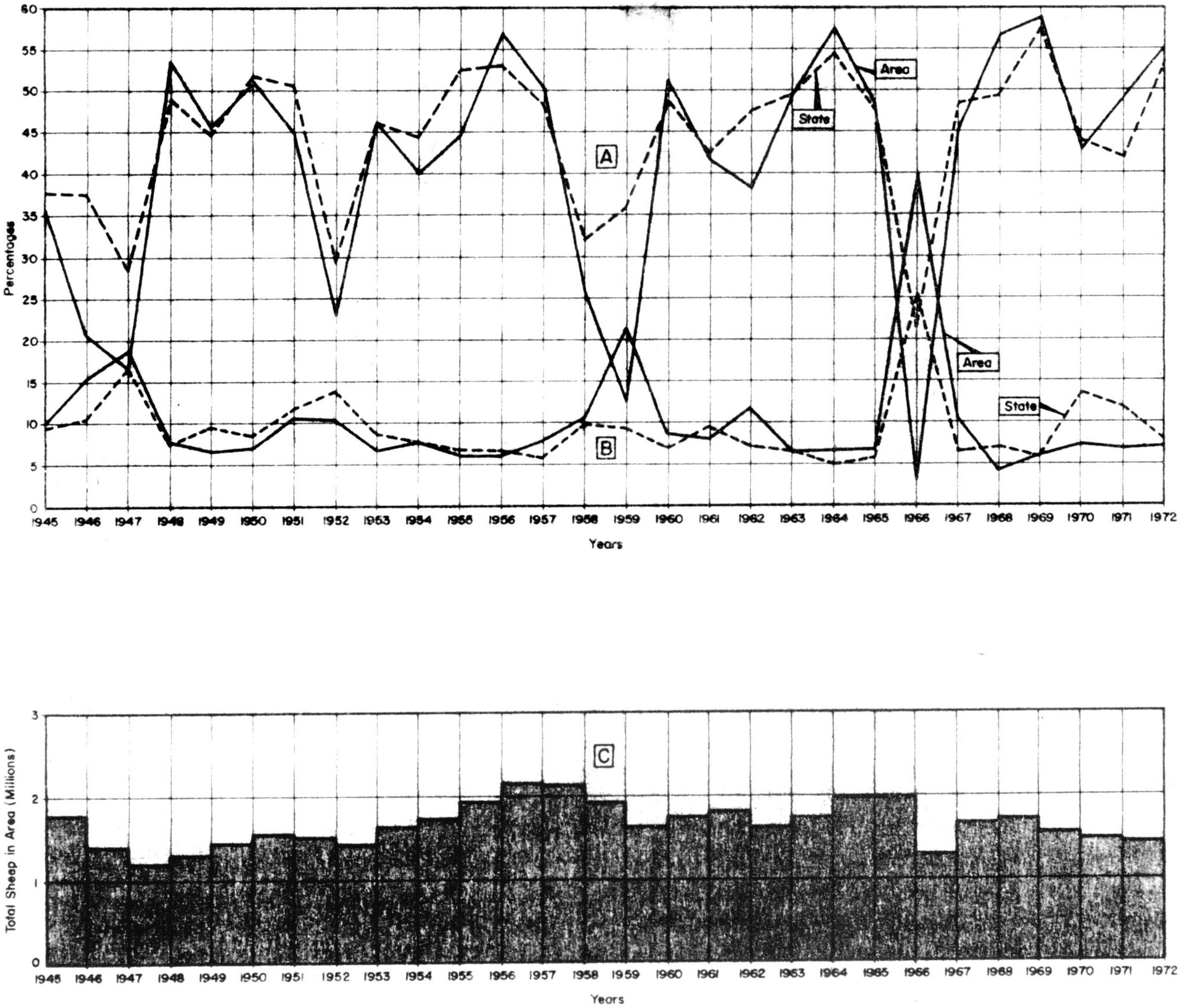


Fig. 8.5. *A % lambs marked to breeding ewes*
B % sheep mortalities to total sheep
C Total sheep numbers

The breeding performance of sheep in the area generally compares quite favourably with the State as a whole, with the exception of periods of severe drought. The lamb crop has fallen to low levels at four points over the data period - in 1947, 1952, 1959 and 1966 when the effects of the droughts immediately preceding those years become evident. On all four occasions the percentage of lamb markings in the area fell markedly below those for the State. They were probably also affected by a deiivearte policy of non-mating as a drought strategy, particularly in parts of the study area. Low lambings in one year were invariably followed by peaks the following year and in all cases the peaks in the area are higher than those for the whole state.

Objective comparisons of drought severity, either between years in the same area or between different areas in the same year, are extremely difficult. However, it is known that the drought of 1964 to 1966 was widespread throughout the major sheep areas of the State. If a comparison could be made on the basis of this drought it would appear that the area suffers more severely in terms of losses of normal lamb crops (down to 3.2% compared with the State's 21.4%) and in sheep deaths (up to 40% compared to 25.5% for the whole State). Recovery in terms of performance of existing animals is quite satisfactory by State standards but there is a suggestion that recovery to full capacity is slower in the area.

Population statistics are also shown in Figure 8.5. A comparison of the area and the whole State based on the period 1945 to 1972 shows that (a) the percentage of breeding ewes to total sheep in the area is higher than in the State as a whole - 47.5% compared to 41.9%; (b) lamb markings expressed as a percentage of breeding ewes are lower in the area (41.9%) compared to the State (44.7%); (c) sheep deaths expressed as a percentage of total sheep are fractionally higher in the area (9.63%) compared to the State (9.06%); (d) sheep deaths expressed as a percentage of lambs marked, which in gross terms is a measure of the seif-sustaining capacity of the enterprise, are the same (48.4%) for both the area and the State. However, examination of the figures for individual years indicates that the mean figures are heavily influenced by the 1964-

1966 drought during which lambings were very low and mortalities very high. Under these circumstances, it would be expected that median values for deaths would be lower than the mean. Median values for lambs marked would be higher than the mean.

Husbandry and drought management

Detailed description and discussion of husbandry practices at the individual property level are not proposed here. Many aspects are covered in articles by Moule (1952), Howard 1961), Anson *et al.* (1969), Weller (1969), Gibb (1961, 1966), Bell and Young (1967), Anson and Mawson (1969) and Burns (1971).

The arid nature of the area probably poses the greatest challenge to the producer and since drought also affects land use in both the short and long-term some attention is devoted to drought management and mitigation.

Drought is a constant feature of the annual seasonal picture. It assumes serious proportions when (a) the "wet" season in January to March fails to produce substantial falls and (b) when the "wet" season commences later in the calendar year but terminates very early the following year and is followed by a cold dry winter.

Drought strategies which may be practicable in other areas require modification because of distance - and consequent higher transport costs - and the extensive nature of some holdings, which increases problems of intensive stock management.

In terms of property management it is possible, from rainfall records from the property or nearby area, to calculate the times of the year when useful rains can be expected. The chances of experiencing useful falls in the event of failure of rain at the expected time can also be calculated. Such probabilities provide a guide to management (See Chapter 2).

A knowledge of the different land types on a property is invaluable, not only to normal operations but also in drought management. Some land types support grasses and forage which will persist and provide maintenance feed for stock for many months after the last fall of rain. Other land types produce quick growing plants which have little "stand over" value. See Table 9.1 for information on drought grazing capacities of the land units in the area. Combined with this characteristic is often the capacity to respond to light falls of rain - to the order of 12 mm, which would produce no response at all on other land types. Where a property has these different land types, in manageable areas, property management should aim at manipulating stocking times in order to obtain the best overall use. This will require fencing by management units and also the provision of an adequate water supply to the fenced areas. Reticulation from an established supply may be needed and in many cases could be cheaper than speculative searching for new supplies.

Protection of water supplies is another aspect which requires attention during the planning phase. To avoid damage and erosion in the vicinity of the water facility - be it bore, earth tank or gully dam - the pumping of water into troughs safeguards the structures and avoids losses through bogging and accidents during drought.

A policy of conservative stocking is frequently advocated as a means of drought mitigation. This is most effective when combined with controlled management of the pasture to ensure that advantage is taken of each type and that the pasture which becomes the reserve fodder supply is usable when the need arises. In this respect adequate fencing and water facilities are needed.

Regardless of the number of land types on the property, measures other than manipulation of pasture forage supplies, will become necessary in the prolonged droughts which are relatively common.

Where "topfeed" or forage trees and shrubs are available their use will play a vital role. A great deal of information relating to the identification, fodder, value, management and utilization of this material may be found in articles by Everist and Young (1967), Anson (1959, 1972), Gartner and Anson (1966), Everist *et al.* (1958) and Everist (1969).

Leaves from the fodder trees provide a maintenance type ration provided that sufficient quantity is available for stock numbers. In the feeding of fodder trees over a prolonged period, the remnants of the ground vegetation are placed under severe stress because animals are maintained on the area beyond the time when the ground vegetation would be subject to further denudation or trampling. The limited mobility of the scrub cutting operators practically limits the operation to major areas on the property and hence there is little likelihood that the whole flock or herd can be maintained on fodder trees for a lengthy period. It follows that a reduction in stock number either by sale, sending on agistment or letting them take their chance is a prerequisite to undertaking a scrub-cutting programme.

Transport costs, and the cost of materials, usually place severe restrictions on the purchase of fodder for drought feeding. However, the hand feeding of valuable stud animals, particularly males, may be justified. In the second case, highly concentrated feed supplements have become available in recent years and a combination of relatively low transport cost (per unit of nitrogen) and high cattle prices, has resulted in the use of these materials in the remote areas. There is evidence (Weller 1969) that the appetite of stock with access to such concentrates is stimulated to the stage where they consume plant material which would normally not be eaten. There is concern that permanent damage could result to valuable perennial plants under these circumstances.

With reference to manipulation of stock numbers there is evidence (Miller, Alexander and Mawson, 1973) that reduction of numbers by selling was a sound policy in the 1964 to 1966 drought. In order to do this effectively, stock must be sold while they are in sufficiently good condition to reach the selling point and the demand is such that a worthwhile return is obtained. The implication is that positive action is necessary before the drought develops to the stage where the market becomes over-supplied with animals which are in demand by a very limited range of buyers. Delay in implementing such a policy may negate the benefits to the extent that transport and selling charges equal or exceed the sale price. Judgement on numbers to be sold and the rate of selling is required. Not all decisions made can be expected to be the correct ones when viewed in retrospect. Irrespective of the classes of sheep to be sold first, most managers concentrate on retaining a nucleus of young ewes as a basis for rebuilding the flock when the drought ends. Selling early in a drought also prolongs the time when feeding of the remaining stock on the property will require another fodder source, in the form of a supplement or fodder trees.

Forwarding stock to agistment is a further method of reducing stocking pressure on a property. Its success is dependent on the availability of suitable agistment for the required length of time and where stock supervision is obtainable. The time factor is unpredictable and it is not unusual to find that stock have to be moved from one area of agistment to a second area, because the home property cannot accommodate the animals when the first agistment area has to be vacated. Agistment has the advantage over selling that new strains or types of animals are not introduced when restocking after drought. At this time the buyer may have a very limited choice of animals available to him.

Certain husbandry practices can also be adopted for drought mitigation purposes. Probably the most common one is non-mating of flocks. This reduces stress on the breeding portion of the flock to the extent that empty and dry ewes will survive much longer than ewes forward in lamb or attempting to rear a lamb. Early shearing may also be adopted where there is a likelihood that the handling involved in shearing at the regular time would impose too much stress on animals already in a weakened state. Because of the relatively short gestation period, double mating of ewes, if feasible under favourable pastoral conditions, is sometimes practised after drought in an effort to rapidly build up flock numbers.

The vast fluctuation in the quantity of ground forage available implies that a flexible stocking policy would be most appropriate. Major practical difficulties associated with buying and selling and a rapid turnover of stock, which is necessary for such a policy, lie in the availability of suitable animals. Were a whole area to attempt such a procedure, stock would have to be drawn from distant areas, probably purchased at a high price, incurring considerable transport charges because of distance, and possibly a percentage of such stock from another environment would not readily adapt themselves to the new conditions. It follows that most properties, excepting those which form part of a chain, do carry at least a portion of breeding animals which form the basis of the stock enterprise. The better properties may produce a surplus of sheep which enable others to engage to a greater degree in a wool growing rather than a breeding and wool growing enterprise.

As a result of distance from markets and the extensive nature of many properties, intensive drought relief measures at the property level are more difficult to implement and frequently less rewarding to the owner. The fact that he is located in an arid environment means that drought is a constant factor and the whole management is geared to these circumstances as the normal situation. While drought to some degree is constant there are periods, as evidenced from Figure 8.2 (5 year moving rainfall average), when a run of below average rain is experienced and a stage of severe and prolonged drought occurs.

ECONOMIC GUIDELINES FOR DETERMINING INCOMES

Some of the considerations relevant to determining what are appropriate or adequate levels of net income for graziers in the "western arid" are discussed. For illustrative purposes the situation of wool growers has been considered in greater detail. The principles outlined are just as valid for cattle producers or, for that matter, any other sort of primary producer. It is difficult to provide definite prescriptions as far as income levels are concerned. The simple fact is it is not possible to obtain general agreement in considering the distribution of income. Nevertheless, an assumption underlying this analysis is that it is possible and more important, useful, to provide guidelines for those making decisions that will affect income levels of graziers.

Much of the discussion is concerned with considerations of economic efficiency, as distinct from equity or income distribution. To the extent that this is so, there is less reason for argument about the income levels suggested. However, assessment of income to compensate for remoteness, lack of social facilities and riskiness of the environment is bound to give rise to debate and disagreement. Those who disagree with actual levels of income adopted can substitute according to their own beliefs.

Having roughly determined appropriate income levels by reference to economic criteria, an attempt is made to give the analysis greater practical significance by comparison of these levels with actual recorded incomes. This would not have been possible were it not for a survey by Childs (1973) of the Charleville Office of the Department of Primary Industries. Childs reported incomes, financial structure and physical data for different land types. Results for the "Black Soil, North" are not analysed in this study as they appeared to be inapplicable.

The final section of this analysis considers the effect that certain trends in wool prices and the general level of prices might have on the economic position of woolgrowers and ways in which their position may be protected.

Suggested Income Levels

Return to owner/operator

The problem associated with assessing what income should accrue to owner/operators for their personal labour contribution is largely one of determining the opportunity cost of their input. Not knowing important characteristics of these people, such as age, education, etc., it is impossible to be precise about incomes that they could earn in alternative occupations.

A reasonable comparison, which could be regarded as establishing a minimum level, appears to be the average weekly earnings per employed male unit calculated from wage and salary data for all Queensland Industries. The 1972-73 figure for this was $96.90/wk. or approximately $5,000 p.a. However, since it is intended that a comparison be subsequently made with recorded incomes, it is necessary to ensure that "theoretical" levels relate to the same time period. The average weekly earning per employed male unit for the survey period (1967-68 to 1969-79) was $64.57 or approximately $3,400 p.a. (Bureau of Census and Statistics, 1972-73). Hence, it will be assumed that owner/operators could earn at least this level of income were they to seek employment outside their present industry.

Returns to capital

Childs' survey indicated that capital, excluding land, to produce "reasonable" levels of net income (say $15,000 p.a.) for the different types of country would be approximately as follows:

Hard Mulga	$136,000
Soft Mulga	$92,000
Black Soil, South*	$90,000

For the owners of this capital alternative avenues exist for the investment of these funds. The long-term government bond rate has commonly been 6% for what is a risk - less investment. For the western woolgrower there is considerable risk involved. Most important types of risk are -

- that produced by climatic variation such as floods and droughts
- that deriving from the decline in profitability of the sheep enterprise with few alternatives available.

Faced with varying net income levels and the possibility of being rendered non-viable by such occurrences it is reasonable that woolgrowers would expect some compensation. Hence, it is assumed that a return on capital excluding land of 9% will be required.

Annual returns to capital for the above land types for the rate of interest specified would therefore be -

Hard Mulga	$12,240
Soft Mulga	$8,280
Black Soil, South	$8,100

Suggested levels of net income

So far it has been suggested that net income levels of approximately -

$15,600 p.a. for Hard Mulga

$11,700 p.a. for Soft Mulga and

$11,500 p.a. for Black Soil, South

* The Black Soil, South land type used by Childs roughly approximates the Other Alluvia and Alluvial Plains, Woodland, land zones of this report. The Hard and Soft Mulga land types are equivalent to the Hard and Soft mulga land zones of this report.

- would be required if woolgrowers in south-west Queensland are to be reasonably rewarded for their own labour input and input of capital.

"Real" Income

Agricultural economists have often debated whether farmers and graziers have "real" incomes in excess of cash incomes. Items discussed are

- fuel, food, etc. consumed by the farm family which is usually charged against the business operation.
- income taxation concessions which reduce the taxation burden. These were mostly removed in August, 1973.
- the relative appeal of farming as a way of life.
- capital gains from appreciating land values.

It has been suggested (Davidson, 1968) that failure to include such items has resulted in an under-statement of real income. However, others (e.g. McKay, 1967) have argued that there are other aspects of farming which, if values could be assigned to them, would negate the benefits cited by Davidson. These include the extra costs associated with education and recreation and the lack of health, social welfare and cultural facilities.

Because of the highly subjective nature of these factors and the fact that there is no general agreement as to whether their net effect is to increase or decrease "real" income, no adjustments will be made, on their account, to the levels of net income presented above.

Special considerations applying to south-west Queensland

Most of the factors considered above are general insofar as they compare or contrast the rural or farming environment as a single entity with the urban one. An important question is whether there are special considerations applying to the particular part of the rural environment under discussion - namely south-west Queensland.

Because this region is more remote than most it can be argued that the opportunities for participation in the whole spectrum of normal human activities is reduced for those involved in grazing enterprises even more than would be so for "farmers in general" who are located in generally less remote areas.

Likewise the risk of extreme rainfall variability is higher in south-west Queensland than most other rural areas of Australia. Thus, income levels are likely to be more variable and the risk of encountering a situation of complete non-viability is heightened. In addition, because of the nature of the climate, few, if any, alternative land use possibilities exist. This factor increases the risk associated with a decline in the profitability of the existing wool-growing enterprise.

It is often argued that appreciating land values represent a significant part of the total real income of farmers and graziers over a period. However, because of the special nature of the south-west Queensland region discussed above, it may well be that there is less likelihood of accruals of capital gains.

In the light of these special factors it appears reasonable to suggest that some extra remuneration would be required to offset the disadvantages applying. While it is relatively easy to identify the need for some sort of compensation of this nature it is difficult to establish a value for it. In this discussion it is assumed that an additional $1,000 p.a. would be appropriate. Thus, net income levels for the 3 types of country would be

$16,600 p.a. for Hard Mulga

$12,700 p.a. for Soft Mulga

$12,500 p.a. for Black Soil, South

Actual Income Levels

Childs survey for the years 1967-68 to 1969-70 provides information on actual levels of net income. Before comparing these reported levels with those derived above from standards of economic efficiency and equity, it is important to determine whether the survey results are likely to provide reliable guidelines as to future income levels.

In terms of seasonal conditions the 3 year period was somewhat below average thus income levels would be less than those "normally" expected on this account.

Wool prices during the period averaged 92.4 c/kg (42 c/lb). In terms of 1974-75 values*, i.e. after adjusting for increases in the general price level, woolgrowers would need to receive about 130 c/kg for their wool to be as well off in real terms in 1974-75 as they were in the period 1967-68 to 1969-70.

To determine whether the 3 years in question were "representative" or "normal" in the economic sense, comparison has to be made with wool prices forecasts by the experts. Two forecasts made in 1969 (B.A.E. and Lloyd, 1969) predicted equilibrium prices about 88 and 99 c/kg respectively. Since these levels were in real terms they have to be adjusted* to take account of increases in the general price level. The adjusted 1974-75 level is approximately 130 c/kg which suggests that the survey period can be said to be quite representative in terms of the economic situation likely to pertain in the longer-term.

Results for hard mulga

Results for the hard mulga country indicate that Dry Sheep Equivalents (D.S.E's) in the range of 9,000 to 12,000 would be required to produce adequate net income levels. Actually this conclusion was obtained by interpolation as there was only one survey property in this category. Details of the survey results forthe hard mulga zone are presented in terms of D.S.E. categories and are contained in Table 8.10 hereunder. The last row in this table shows returns to capital and management. These were obtained by deducting a sume of $3,000 p.a. from net income as an allowance for the grazier's labour. In order that a like with like comparison can be made between actual and theoretical incomes, this sum has to be added back on to returns to capital and management shown in table 8.10. A similar comment applies to Tables 8.11 and 8.12 appearing in this analysis.

It should be noted that the discussion is in terms of "D.S.E's". To say that flocks in the range of 9,000 to 12,000 D.S.E's are required can indicate a number of possibilities in terms of sheep/cattle combinations - for example

- about 8,000 sheep + 250 cattle
- about 9,000 sheep + 150 cattle
- about 10,500 sheep

It appears that in assessing D.S.E's, Childs has assumed that no non-competitive relationship exists. Further data are no doubt required on this and it has been suggested (Weller, 1971) that non-competitiveness up to a level of about 100 bovine breeders/6,000 sheep does exist.

* a 7% rate of inflation was adopted for 1974-75 and 10% for 1973-74. These rates will probably prove to be conservative.

Table 8.10. Results from survey of S-W Queensland sheep country by J. Childs - Hard Mulga*
Arranged in D.S.E. categories, 1967-68 to 1969-70.

	0-5,999 D.S.E's		6,000-8,999 D.S.E's		12,000 & More D.S.E's	
	Average	Range	Average	Range	Average	Range
Area (ha)	20.036	17,103 to 21,190	25,020	14,939 to 32,842	47,115	40,513 to 46,480
No. of sheep	3,487	2,897 to 3,878	4,882	4,042 to 6,051	9,556	8,744 to 10,858
No. of cattle	59	0 to 132	140	0 to 243	335	148 to 464
D.S.E's	4.677	3,787 to 5,976	7,327	6,338 to 8,724	13.920	12,078 to 16,538
Capital (Excl. Land) $	77,662	52,983 to 103,200	94,176	83,098 to 108,416	171,536	146,544 to 210,797
Capital (Incl. Land) $	100,107	63,424 to 123,464	124,036	103,180 to 141,922	225,772	186,571 to 279,976
Gross Income $	21,376	11,600 to 26,263	27,432	24,450 to 31,247	59,416	43,980 to 73,092
Return to Capital and Management $	3,316	1,083 to 5,475	4,350	− 5,238 to 10,164	18.512	11,337 to 23,833

* Information for 9,000-11,999 D.S.E. category not shown. Insufficient observations.

Of the hard mulga properties surveyed by Childs it appears that only 4 (or about 25%) have flock/herd sizes equal to or greater than the range 9,000 to 12,000 D.S.E's. This implies that something like 75% of these properties would appear to be too small given future predictions as to wool prices. On the assumption that Childs' survey is representative of this zone, a major property adjustment and reconstruction task is indicated.

From the survey data a property of about 10,500 D.S.E's (the mid-point of the 9,000 to 12,000 range) would have a net income of about $16,000 to $17,000 p.a. and capital excluding land of approximately $130,000. If the level of income is adjusted to the same level of capital used to derive the theoretical figures ($136,000) it appears that actual incomes in the period 1967-68 to 1969-70 were approximately equal to levels suggested by theoretical criteria.

Earlier it was suggested that the grazier's own labour resource could earn at least the average weekly "wage" per employed male unit. It could be argued, though, that there are more legitimate comparisons e.g. with self employed persons. Had this comparison been made it is likely that actual incomes would have been below levels indicated by economic criteria. This sort of situation has been not uncommon for rural industries and an obvious explanation is in terms of actual returns to factors (labour, management, capital) being below their opportunity cost. Pursuing this line of reasoning it could be concluded that, on balance, the graziers in question do obtain "psychic" rewards sufficient to compensate them for the shortfall in monetary income. Another possible interpretation is that the balance of psychic rewards is not positive and that graziers accept monetary rewards below market rates because they believe that their factors (e.g. their own labour) would not be readily acceptable in alternative uses. This belief may be real or imagined. If it is real then opportunity costs should be adjusted downwards and greater agreement between actual and theoretical income level would thus be obtained.

The value of capital warrants some specific discussion. Again in certain situations it may be somewhat unrealistic to apply an opportunity cost rate of interest to levels of capital revealed in surveys. For any one grazier, or relatively small numbers of graziers, it may generally be possible to realise the full value of capital invested by sale to another or others. However, in a period in which the general economic situation of the industry is depressed (as for wool during the latter part of the 1960's) a large number of sellers may exist in relation to buyers and there is no guarantee that full values for capital will be realised.

For the hard mulga properties it has been suggested that, on average, actual incomes were equal to or a little in excess of theoretical levels. In these circumstances a positive value for land is implied. However, if actual income levels do not cover the opportunity cost of labour and management and capital other than land, the inference must be that the land is worth nothing. Such a situation was a not unfamiliar one in the remote Queensland cattle areas until fairly recently and if in fact sales on the market indicate a positive value for the land component of total capital then this would suggest returns to other factors below their potential earning capacity in other uses.

Results for soft mulga

As for the hard mulga zone the survey results for the soft mulga suggest that 9,000 to 12,000 D.S.E's would be required to obtain income levels considered adequate in the terms defined. Details of the survey results for this land type are contained in Table 8.11.

Approximately 50% of the properties surveyed in this zone were in this size category or larger so it would appear that the extent of property amalgamation for the soft mulga will be less than that required for the hard mulga.

Comparing this level with the "theoretical" one, actual returns are substantially higher which is somewhat in contrast to the conclusion for the hard mulga zone. Climatic conditions may not have been equivalent, however, for both zones.

Table 8.11. Results from survey of S-W Queensland sheep country by J. Childs - Soft Mulga

	0-5,999 D.S.E's		6,000-8,999 D.S.E's		9,000-11,999 D.S.E's		12,000 & More D.S.E's	
	Average	Range	Average	Range	Average	Range	Average	Range
Area (ha)	15,616	10,225 to 25,910	16,189	13,704 to 18,426	29,152	23,076 to 32,758	44,781	12,024 to 68,016
No. of sheep	3,839	2,889 to 5,668	4,690	4,500 to 4,933	7,262	6,248 to 8,489	11,799	7,437 to 17,446
No. of cattle	53	0 to 121	96	27 to 198	182	0 to 296	574	336 to 889
D.S.E's	4,803	3,897 to 5,956	7,350	6,162 to 8,388	10,432	9,394 to 11,578	18,910	12,974 to 26,885
Capital (Excl. Land) $	78,060	47,480 to 101,608	88,282	58,814 to 111,313	116,423	99,532 to 136,089	206,605	133,116 to 257,680
Capital (Incl. Land) $	103,714	71,821 to 127,657	114,981	79,123 to 138,621	167,510	145,920 to 196,773	306,360	168,756 to 389,670
Gross Income $	22,814	15,947 to 32,003	25,826	22,837 to 28,864	53,619	39,192 to 81,504	79,429	33,151 to 126,376
Return to Capital and Management $	4,781	– 1,577 to 13,697	4,886	1,991 to 9,033	18,790	11,543 to 35,808	21,571	– 2,302 to 39,378

The survey data indicates the following financial characteristics for a property at the mid-point of this range -

Net income p.a. $22,000
Capital (excluding land) $116,000

For the soft mulga zone the differential between actual and theoretical levels of net income is of the order of $5,000 p.a. Again it was necessary to adjust levels of capital to enable a comparison to be made. This residual return of $5,000 can be regarded as a return to land and for a property of about 28,000 ha (the average area for the 9,000 to 12,000 D.S.E. category) this represents a return of $0.18/ha/annum. Capitalising this annual return on the assumption that a 9% return is required and ignoring the effect of income taxation a value for land of about $1.89/ha is indicated. The total value of land for the property would therefore be about $53,000 which is quite close to the value for land of $51,000 reported in the survey.

Results for black soil south

Once again sizes of 9,000 to 12,000 D.S.E's are indicated from the survey results. Properties of this size or larger constituted only 38% of those surveyed within the "Black Soil South" zone and substantial re-organisation of properties is therefore implied if it is accepted that the "equilibruim" level of returns to wool growing is likely to be roughly equivalent to that obtaining during the period 1967-68 to 1969-70. Details of the survey results for this land type are contained in Table 8.12.

For all zones some amalgamation of properties would have occurred subsequent to the survey period. After 1969-70 the industry experienced very depressed economic conditions which led to the implementation of rural reconstruction and farm build-up measures. The more recent economic recovery would have presumably slowed down this re-organisation.

Financial characteristics for the average property in the 9,000 to 12,000 D.S.E. category in the "Black Soil South" were -

Net income p.a. $23,000
Capital (excluding land) $120,000

As for the soft mulga, actual income levels are again significantly higher than those required on theoretical grounds in order that certain factors be rewarded in accordance with their opportunity cost. The differential is about $4,500 p.a. and again a positive value for land is implied.

Incomes In The Future

In times of high rates of inflation in the economy at large it is clearly unsatisfactory to suggest guidelines as to income levels without providing some indication of the extent to which they might need to be modified given continuing increases in the general level of prices, and in particular where the degree and/or rate of change is not uniform on input and output items.

Prices received and paid by woolgrowers in the past

The B.A.E's index of prices received and paid for various rural products provides data for the period 1960-1/1962-3 to the present time (B.A.E., 1973). It is obvious from this information that woolgrowers have experienced changing fortunes during this period.

Using an average of the 3 year period 1960-1 to 1962-3 as a base, by 1970-1 the price received for wool had fallen to 65% of its base period level. In addition costs paid by woolgrowers for their inputs such as plant and equipment, materials, labour and services had risen to 126% of their level in the base period. The combined effect of these movements is obtained by expressing them as a ratio of prices received to prices paid. This gives some sort of crude indication of the extent to which the economic position of the woolgrower has either improved or deteriorated.

Comparing 1970-71 with the base period in this way a ratio of 52 was derived. That is the woolgrower was about 48% worse off in these terms in 1970-71 than he was in the base period at the start of the 1960's.

Table 8.12. Results from survey of S-W Queensland sheep country by J. Childs - Black Soil South.

		0-5,999 D.S.E's		6,000-8,999 D.S.E's		9,000-11,999 D.S.E's		12,000 & More D.S.E's	
		Average	Range	Average	Range	Average	Range	Average	Range
Area (ha)		11,010	9,220 to 11,971	14,187	8,525 to 29,255	20,029	16,331 to 27,206	27,695	20,868 to 32,227
No. of sheep		3,566	3,159 to 3,866	5,176	4,221 to 5,845	6,475	6,150 to 7,033	11,625	9,723 to 13,750
No. of cattle		78	30 to 152	104	0 to 237	196	160 to 251	156	79 to 301
D.S.E's		4,911	4,642 to 5,242	7,191	6,563 to 8,408	10,543	9,783 to 11,730	15,430	12,746 to 17,136
Capital (Excl. Land)	$	77,305	57,594 to 92,187	92,094	57,148 to 161,837	119,617	109,025 to 125,780	163,794	99,420 to 253,336
Capital (Incl. Land)	$	113,882	84,923 to 129,445	134,454	82,416 to 219,643	189,744	173,108 to 206,460	232,857	161,274 to 324,594
Gross Income	$	24,515	16,810 to 33,863	36,003	24,243 to 42,865	57,869	52,302 to 64,957	87,154	75,085 to 96,054
Return to Capital and Management	$	2,048	-3,383 to 5,648	6,957	-17,293 to 15,397	19,665	18,726 to 20,905	39,164	24,791 to 49,224

In 1971-72 prices received for wool had recovered to 82% of their base period level but prices paid had continued to rise to 133% of their base level. Overall, though, the graziers situation had improved compared with the previous year with a rise of 62% of the base level. That is, other things remaining unchanged, such as output, he was 38% worse off in 1971-72 compared with his position in the base period.

By the first nine months of 1972-73 a dramatic further improvement had occurred. Prices received for wool rose to 172% of their base level and costs has risen to only 143% of their earlier level. For this year (based on the first three quarters) the ratio revealed that the graziers economic position had improved, *ceteris paribus*, by 20% over his position at the start of the decade (1960's) and by 58% compared with the situation in the previous year.

Despite the 1972-73 situation the most important observation about the behaviour of the ratio of prices received to prices prices paid for wool during the sixties and early seventies and indeed for most of the post-war period is that it was generally trending downwards.

Forecast future trends in the ratio

In a recent analysis (Harris, 1974) it has been suggested that there is no reason why the future "terms of trade" (an almost identical concept to the ratio used above) for agricultural products should not continue to deteriorate. While Harris is not specific for particular products it seems reasonable to conclude that the behaviour of wool prices will be similar to prices of other agricultural products vis-a-vis industrial goods.

Harris does make the important point that his forecast for ". . . . . a slight tendency for the terms of trade to move against agriculture in the long term" does not mean that money prices for agricultural products will remain constant. He anticipates that they will rise but at a rate below that of the general level of prices.

Ways of combatting future trends

The way that most Australian farmers were able to remain viable in the face of this inflationary trend was to employ new production techniques that resulted in productivity increases. For the woolgrower in the "western arid" portion of the Queensland sheep pastoral zone, however, it is generally considered that there are only limited increases to be obtained from improved technology. Hoogvliet (1973) indicated that productivity growth in the wool industry in the pastoral zone over the period 1957-1970 was quite small compared with that of other environments.

The diversification possibilities for woolgrowers in the western arid are also quite limited with only partial or complete changeovers to cattle (for some areas) being feasible alternatives.

Because of these limited opportunities it appears that the main way in which woolgrowers will be able to retain long-term viability is by increasing output through increases in flock and property size*. This conclusion suggests that property adjustment schemes similar to those operating at the present time may be required on a continuing basis in the future.

A simple example

It was suggested above that, as assessed in 1973-74, an appropriate level of net income for a woolgrower in the hard mulga country would be approximately $17,000 p.a. and that about 10,000 to 11,000 D.S.E's would be required to achieve this level of income.

In this simple example the objective is to determine what increases in flock size and Gross Income are required in order that the net income position of the grazier can remain the same in real terms in the future as it was in 1973-74 given certain assumptions about the rate of increase of wool prices and of prices generally.

In line with Harris's suggestion that agricultural product prices will rise in money terms but at lesser rates than that of products generally it has been assumed that wool prices increase at 2% p.a. and that the price of inputs and the general level of prices increase at 4% p.a. These actual figures are quite arbitrary and can easily be substituted by others if thought appropriate. It has also been assumed that the Gross/Net income relationship is 3 to 1 i.e. a Gross of $51,000 p.a. is required to earn a net income of $17,000 p.a., and that for simplicity economies of scale have been exhausted when flock sizes of 10,000 D.S.E's are achieved. A further simplifying assumption is that the effect of income taxation has been ignored. Given these assumptions it is possible to derive the information presented in Table 8.13.

* For a fuller treatment of possible financial outcomes of expansion of property size or changeover to cattle enterprises for western Queensland woolgrowers see "Rural Reconstruction in the Queensland Sheep Industry -Budgetary Guidelines" by I.B. Robinson and W.F.Y. Mawson, in Economic Analysis and Policy, No. 1 V. 3., pp. 18-44.

Table 8.13. **Adjustments in flock size required to maintain real levels of net income.**

	Year 0	Year 5	Year 10	Year 15
Gross income @ 2% p.a. ($)	51,000	56,309	62,169	68,641
Costs @ 4% p.a. ($)	34,000	41,368	50,327	61,231
Net income ($)	17,000	14,941	11,842	7,410
Net income @ 4% p.a. ($)	17,000	20,684	25,163	30,615
Required D.S.E.'s (approx.)	10,500	14,500	22,300	43,400

From the table it can be seen that the graziers' net income position has been analysed at three points in the future – 5, 10 and 15 years. Rows 1, 2 and 3 indicate gross income, costs and net income at these future points of time assuming that flock size remains constant at 10,500 D.S.E.'s. From Row 3 it is clear that the cost-price squeeze becomes progressively more severe and by year 15 residual net income has been substantially reduced.

For the woolgrower to maintain his income position in real terms his net income has to increase at 4% p.a. i.e. at the same rate as the increase in the general level of prices. Row 4 contains net income levels compounded at this annual rate.

By calculating gross income and costs per D.S.E., the increased number of D.S.E.'s required to generate the levels of net income in Row 4 can be derived. These are presented in Row 5.

The information in Row 5 vividly illustrates the long-term effect of costs inflating at a faster rate than wool prices. From Year 0 to Year 5 the required average annual increase in flock size is about 800 D.S.E.'s while the required increase from Year 10 to Year 15 is very much greater at about 4200 D.S.E. p.a.

What this table shows is that a situation of costs increasing faster than wool prices with no economies of scale or productivity increases is one that would not be sustainable for most woolgrowers in the long run (beyond about 10 to 15 years). In the unlikely event that such a situation should prevail in the future, the outcome would be a transformation of the present structure of the industry with a small number of huge holdings remaining.

A more likely situation is one where some economies of scale are achieved and where productivity gains accrue. The effect of these would be to reduce the required rate of expansion depicted above. Nevertheless the data in Table 8.13 does suggest that woolgrowers facing a continuing cost-price squeeze must both expand flocks and adopt any new technology if they are to survive.

While not examined in this section it should be noted that capital values will be affected by the trends described. Thus inflation will result in increased money values for improvements. If net income per hectare declines (as postulated) this implies a declining unit value for land and failure to expand property and flock size would mean that not only was annual income declining but also capital value. If expansion does take place in a way designed to maintain real income then the total capital situation of the woolgrower will likewise be maintained.

Need for caution

Most observers agree that in terms of the future demand/supply situation of natural resources and the consequent economic activity generated the present time is one of uncertainty and change. For these reasons it is unwise to extrapolate too far into the future. However, some degree of forward planning seems necessary and a balanced approach would therefore appear to consist of extrapolating in the above manner but with a continual need to revise (say every few years) the extrapolations in order that changing trends may be incorporated.

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Resource Use

CHAPTER 9

by N.M. Dawson, and D.E. Boyland

PASTURES

In arid areas forage supply comprises not only the ground flora but also many of the trees and shrubs. These topfeed species are essential in drought periods but are also utilized as a supplement when adequate ground forage is present. In any situation the presence, growth and composition of the pastures are predominantly controlled by rainfall. Due to the variability of precipitation the composition of the various pastures varies considerably.

Sheep generally prefer short soft grasses and forbs with a proportion of browse plants; cattle usually eat coarser grasses and some browse; horses rarely eat trees, shrubs or forbs if grasses are available. However, browse plants usually comprise some portion of an animal's diet. As the softer grasses and more palatable forbs die off, the animals are forced to consume more tussock grasses and topfeed.

Although the composition of the ground flora is usually variable, several broad groupings characterized by one or several species may be recognized. These groupings have specific habitat requirements but are distributed independently of the upper layers. Several pasture groupings may occur with the same upper storey. For example mulga tall open shrubland may be associated with the short grass — forbs pasture group, kerosene grass pasture group, spinifex pasture group, woollybutt pasture group, mid height perennial tussock grass group and wire grasses group.

Carrying capacity varies with the nature of the pastures. It also varies within the same pasture depending on seasonal conditions. As a result of this no attempt has been made to assess grazing capacity for the various groups except in broad terms. More detail descriptions of the pasture units are given in each land unit description.

Pasture Groups

Annual Pastures

Short grasses ± forbs pasture group: Short grasses and forbs contribute to the ground flora in most associations but there are areas where they predominate in the ground flora. The species are mainly annuals or behave as annuals. After summer rains grasses predominate. Usually they are short, less than 0.25 m high and form a variable ground cover. Species may include button grass, Flinders grasses, kerosene grass, love grasses and other species of *Eragrostis*. These species are grazed while green and some may stand over for several months. After winter rains, forbs are present, particularly saltbushes, burrs (*Bassia* spp.) and members of the daisy family. These provide a lush but temporary pasture which is palatable and nutritious. Drought resistance of this pasture is relatively low but the presence of saltbushes and burrs confers some degree of drought resistance.

Saltbushes (Atriplex spp.*) ± Burr (Bassia* spp.*) pasture group:* It is similar to the short grass, forb pastures but grasses are not common. The composition of species and their abundance is dependent on seasonal variation. After good rains it produces a lush, nutritive pasture which may stand over for some time.
The overall grazing capacity is low.

Kerosene grass (Aristida contorta) pasture group: This species is widespread in the area occurring mainly in mulga associations.

It is an annual, up to 0.35 m high, and is usually accompanied by many other annual short grasses and some perennial grasses such as woollybutt grass and forbs. It is palatable in its green state but palatability and nutritive value decrease with maturity.

Grazing capacity is very variable depending on seasonal conditions, which govern the composition of the pasture.

Perennial Pastures

Spinifex (Triodia basedowii) pasture group: Spinifex forms hummocks 1 to 2 m high (including the seed head) and up to 1 m in diameter. It frequently forms rings several metres in diameter. Basal cover is low and the interspaces between the clumps may be devoid of vegetation. These interspaces may support various perennial tussock grasses, such as woollybutt grass and *Eriachne* spp., annual grasses and forbs, in particular members of the daisy family.

The foliage is of a low nutritive value and not acceptable to stock, except after a burn when the yound shoots appear. It is reported that stock will eat the plant once it has blackened off and commences to break down. Seed heads are both palatable and nutritious.

Firing or grazing of these pastures increases species diversity. From the grazing point of view burnt or grazed pastures are more beneficial to livestock than spinifex in its undisturbed state. Excessive firing and severe overgrazing may lead to complete destruction of this pasture. Spinifex usually takes several years to recover from severe fires. This may render these pasture lands vulnerable to erosion.

Woollybutt grass (Eragrostis eriopoda) pasture group: This species is widespread and commonly forms pastures with other grasses such as mulga oat grass and *Eriachne* spp. Woollybutt grass forms tight erect tussocks, less than 0.4 m high, with a low basal cover. Forbs are present in favourable seasons and together with other short grasses form a variable ground layer. These pastures are moderately palatable and provide fodder well into a drought.

They are best developed within the mulga associations but are also associated with the spinifex pasture group as well as other dunefield associations.

Neverfail grass (Eragrostis setifolia) pasture group: These are restricted mainly to alluvial situation associated with eucalypt woodlands. They form open tussock grasslands less than 0.4 m high. Usually other grass species are present, especially rat's tail couch and comb chloris. Forbs occur under favourable conditions. Neverfail grass is a moderately acceptable and nutritious species. Because of the species diversity and the presence of some topfeed these are useful pastures, even though limited in extent.

Mitchell grasses (Astrebla spp.*) ± short grasses ± forbs pasture group:* These occur mainly on the undulating downs in the west. Mitchell grasses are drought resisting tussock species up to 0.75 m high. Usually the tussocks are widely spaced and in more arid areas favour depressions and drainage lines. They respond rapidly to good early summer rains and after such rains the interspaces are occupied by short grasses and forbs. During the droughts these spaces are bare. If short grasses and forbs are present the pasture has a high stocking rate, but as drier conditions prevail and the herbage is utilized animals are forced to survive on the dry mitchell grasses. Sheep can graze Mitchell grass selectively to obtain a ration with adequate protein but cattle tend to eat the whole plant which has a high fibre content. Under these conditions sheep may be maintained for longer periods than cattle.

Mid-height perennial tussock grass pastures: Small areas, mainly associated with eucalypt woodlands and run-on areas in the east, are characterised by mid-height perennial tussock grasslands. Predominant species may include kangaroo grass, native oats grass, golden-beard grass, desert blue grass, silky brown top, Queensland blue grass and some windmill grasses. These are all drought resistant species, their foliage drying off but standing over for extended periods. The resulting dry forage gives a sub-maintenance diet during drought after the more palatable and nutritious short grasses and forbs have been utilized.

Grazing capacities for this pasture are high and the pasture has the ability to carry stock well into a drought.

Wire grasses pasture group: These mid-height perennial grasses, mainly *Aristida* spp., predominate in the ground flora of many associations, especially the mulga poplar box and mulga associations. The height of the pasture is usually less than 0.75 m. Composition of the pasture varied greatly. Following good rains perennial grasses such as mulga oat grass and mulga Mitchell, and a large number of short grasses and forbs may be present. Wire grasses grow rapidly after adequate summer rains. They are usually coarse and consist of standing dry fibrous material. Nutritive value is moderate to low when green and very low when dry.

The grazing capacity varies. Access to topfeed is essential to maintain stock on these pastures.

Erect kerosene grass (Aristida browniana) pasture group: Small sandy areas associated with dunefields and sandplains support erect kerosene grass predominant pastures. It is a low perennial tussock grass up to 0.4 m high, acceptable to stock in the young stages, but when mature it has a low palatability and low nutritive value. In favourable seasons short grasses and forbs occur in the interspaces of the tussocks.

Overall grazing capacities are low.

Rock grass (Eriachne mucronata) pasture group: Limited areas are associated with the crests of gently undulating convex plains. The pasture is short, usually less than 0.35 m high, and is composed principally of rock grass with a few other scattered forbs and short grasses present. Rock grass retains fairly high protein levels on drying off. In places this pasture does not appear to be grazed by animals but in other situations rock grass is eaten readily.

Oldman saltbush (Atriplex nummularia) pasture group: Pastures characterised by oldman saltbush occur in areas which are seasonally flooded for short periods. Oldman saltbush grows up to 2 m high. The associated ground flora depends on seasonal conditions and density of the bushes. Where oldman saltbush is scattered annual grasses and forbs are present when conditions are favourable, but if the shrubs are very dense the interspaces are usually devoid of vegetation. Oldman saltbush is palatable and nutritious and can withstand heavy continuous grazing, provided it is given sufficient time to re-establish. It appears to be more palatable as it is drying off.

Queensland bluebush (Chenopodium auricomum) pasture group: These are not extensive in area but are important because of the high grazing capacity of the pasture. Queensland bluebush forms a low shrubland up to 1 m high and occupies heavy clay areas which are seasonally flooded.

Queensland bluebush responds very quickly to flooding and the area between the bushes usually supports both annual grasses and forbs. The species has a high protein and phosphorus content and is a palatable and nutritious fodder. It has the ability to regenerate when heavily grazed. However, continuous overgrazing will cause the death of the plant.

Cooper clover (Trigonella suavissima) pasture group: This pasture is associated with the "channel country" and occurs mainly after late summer, autumn or winter flooding.

This annual, up to 0.4 m high forms, dense stands with other scattered forbs, mostly from the daisy family. The pasture provides lush, highly nutritious pasture with a high grazing capacity.

The major restriction is that it is dependent on general flooding. Local flooding does not induce mass germination of this species.

Channel millet (Echinochloa turnerana) pasture group: This pasture is associated with the "channel country" but also occurs in other areas which are periodically flooded. Channel millet is an annual grass up to 2 m high, highly palatable and very nutritious. Other short grasses such as pepper grass and forbs are abundant after favourable summer floods.

Grazing capacity is high. Mass germination of channel millet is dependent on generalized flooding. Pepper grass frequently grows after local flooding.

Swamp cane grass (Eragrostis australasica) pasture group: Small areas occur on heavy clays periodically subjected to flooding. The shrub-like grass, up to 1.75 m high, forms a sparse ground cover. Forbs may occur after flooding with annual grasses infrequently present.

Swamp cane grass is coarse, low in nutrition and not readily eaten by stock. Some areas are fired as stock eat the young regenerating shoots.

Lignum (Muehlenbeckia cunninghamii) pasture groups: These occupy areas which are periodically flooded. The pastures consist of lignum bushes up to 3 m high forming almost impenetrable clumps in places. Following favourable seasons various forbs and some scattered short grasses may occur with it.

Lignum stems are heavily lignified and unpalatable but stock relish the young shoots. Overall grazing capacity is low.

Samphire (Arthrocnemum spp.*) pasture group:* These occupy saline parts of dry beds and the margins of lakes in the region. The pastures consist of a low shrubby layer, up to 0.75 m high of closely spaced samphire shrubs and other related genera. After good rains usually there are numerous forbs present and these provide limited fodder. Samphires are not acceptable forage. Overall the grazing capacity is low to moderate only because of the other forbs present.

TOPFEED

Topfeed (the edible trees and shrubs) is essential to the grazing industry in far-western Queensland. Frequently these edible trees and shrubs are the principal components of the vegetation and are a basic forage resource upon which long-term productivity is based. Even in seasons when there is adequate herbage some dependence on topfeed is usually necessary. In these periods the stock usually prefer the short grasses and forbs but topfeed acts as a source of protein to supplement the high-fibre, moderate to high energy diet provided by grasses. Topfeed is browsed when accessible to stock while the inaccessible portions can serve as a drought reserve to be made available to stock as required.

Although the palatable shrubs are sensitive to excessive grazing pressure, areas where these species have been totally removed resulting in destruction of sites by erosion, are not common. Even though these areas are limited, there are many situations where the numbers of edible shrubs and trees have been greatly reduced and the balance of the system upset. Excessive use of topfeed should be avoided to enable these species and other useful ground species to regrow and regenerate. The capacity for regrowth depends largely upon the kind of trees or shrub, seasonal conditions and the methods of utilization (Everist, 1969).

The method selected for utilization is governed by the nature and abundance of the species, the animals to be fed and the resources available in labour, money and machinery. Pushing of mulga may be the most economical method of use. Due to exacting conditions needed for a mass germination of mulga from the long-term viewpoint, unless mulga is very abundant, pushing may be totally unrealistic. Strip-pulling leaving adequate "seed trees" may be acceptable. Experiments in north-western New South Wales (Preece, 1971) indicated that suitable conditions for germination of mulga existed only once in every 9 years. According to Burrows (1973) environmental conditions in south-western Queensland favour continual re-generation in mulga populations as well as intermittent mass germination. Previous reports of only spasmodic regeneration occurring in mulga are due to stock browsing and killing seedlings in all but the most favourable seasons, rather than an actual failure of seed to germinate. Observations in far-western Queensland support the contention of Burrows.

Important factors governing the acceptability of species include the kind of animal the composition of the pasture and the season of use. Chippendale (1963) and Everist (1969, 1972) discuss the requirements of topfeed species. Species must be palatable, digestible, plentiful and accessible to stock either through the action of the animal or that of man. The degree to which a species is eaten depends on its abundance, accessibility and also on the presence and abundance of other more palatable shrubs.

The presence of topfeed may cause problems for managers. In areas where topfeed is absent, the manager knows when pastures have been utilized to a maximum without causing excessive damage. Because of the presence of topfeed, paddocks may be over-utilized with the result that some of the more acceptable ground layer species are virtually eliminated, or so damaged that regeneration is doubtful. This reduction of the more palatable species lessens competition and permits the less acceptable species to increase in numbers. This results in degradation of the pasture from the grazing point of view. Skilful management is required to use the vegetation so as to attain the highest livestock production consistent with the conservation of vegetation and other resources needed for long-term productivity.

The following are the principal topfeed species occurring in the area. Everist (1969) gives brief descriptions, distribution and usually photographs of these species. He also discusses the management techniques used to feed and maintain the important fodder species.

Bauhinia *(Bauhinia carronii)*. Eaten by cattle but is of little use in droughts due to shedding of leaves during late winter.

Beefwood *(Grevillea striata)*. Appears to be more acceptable to sheep than cattle but it is still a useful species.

Bendee *(Acacia catenulata)*. Frequently confused with *A. aneura* and is referred to in some areas as black mulga. There is no evidence of this species being grazed in the region. At times animals will eat the leaves resulting from a wind-fall. It is not considered a useful fodder plant.

Berrigan or emu bush *(Eremophila longifolia)*. Regarded as a useful fodder and is eaten in the field in large quantities without ill-effect. However, feeding tests have shown it to be poisonous to sheep.

Bitter bark *(Alstonia constricta)*. Usually eaten in the field by cattle and sheep without harmful effects but the leaves can cause stock losses.

Black fuchsia *(Eremophila glabra)*, Lignum fuchsia *(E. polyclada)*. Both are eaten to some extent by stock.

Boobialla *(Myoproum acuminatum)*. Toxic if eaten in excess but sheep eat small quantities apparently without any harmful effects.

Boonaree *(Heterodendrum oleifolium)*. Not abundant in this region but when available it is eaten with relish by sheep and cattle. Young leaves are cyanogenetic.

Boree *(Acacia cana)*. Not common in the region and there is little evidence of its being eaten. However, sheep have eaten it in some areas resulting in reported impaction after about 6 weeks' continuous grazing.

Bowyakka *(Acacia microsperma)*. Occurs only in isolated pockets but appears to be eaten readily by both sheep and cattle.

Bumble or wild orange *(Capparis mitchellii)*. The leaves are eaten readily and are usually considered excellent fodder. It is not extensive in this area. Narrow-leaved bumble *(Capparis loranthifolia)* occurs more commonly but appears to be less palatable.

Charleville turkey bush *(Eremophila gilesii)*. It is rarely eaten except for the flowers which sheep eat freely.

Coolibah *(Eucalyptus microtheca)*. Eaten to a limited extent. *Eucalyptus* spp. are not usually sort after by stock for fodder.

Dead finish *(Acacia tetragonophylla)*. Eaten at times but does not provide much bulk and because it drops its leaves under drought conditions it is of little use.

Doolan *(Acacia salicina)*. Eaten to a very limited extent.

Ellangowan poison bush *(Myoporum deserti)*. Both sheep and cattle eat it readily in the field but it has caused large stock losses in hungry travelling animals.

Emu apple *(Owenia acidula)*. Eaten readily by sheep and cattle.

Fuchsia bush *(Eremophila maculata)*. Frequently eaten in the field apparently without harmful effect and is considered a useful fodder. It yields large quantities of prussic acid and is definitely a danger to hungry or travelling stock. However, the change in methods of transporting stock has greatly reduced the incidence of stock losses from this plant.

Gidgee *(Acacia cambagei)*. Not regarded as a useful fodder plant but is included here because of its abundance. However, at times animals will eat the leaves blown down by wind and in places sheep eat the leaves if the trees are burnt down.

Gooramurra *(Eremophila bignoniiflora)*. Eaten freely by all classes of stock.

Gundabluey *(Acacia victoriae)*. Eaten readily but does not produce any bulk of forage.

Ironwood *(Acacia excelsa)*. Both sheep and cattle eat this species freely.

Leopardwood *(Flindersia maculosa)*. Leaves are eaten readily by both sheep and cattle and are regarded as excellent fodder. It usually does not occur in extensive stands.

Lignum *(Muehlenbeckia cunninghamii)*. Young shoots are eaten readily by cattle and is a useful feed in dry times.

Mineritchie *(Acacia aneura)*. Confined to the area west of Cooper Creek and although not abundant, cattle appear to eat this species readily.

Mulga *(Acacia aneura)*. The most important topfeed species, not because of any exceptional nutritional value but because it is palatable, widespread and abundant.

Nelia *(Acacia oswaldii)*. Where other fodder trees are scarce it is eaten to a limited degree.

Nipan or split jack *(Capparis lasiantha)*. Eaten with relish by stock but does not occur in any great abundance.

Plumwood or true sandalwood *(Santalum lanceolatum)*. It is one of the most palatable of all native species and is regarded as excellent fodder. It usually does not occur in large quantities.

Silver turkey bush *(Eremophila bowmanii).* Plentiful in some areas but apparently is not eaten by stock.

Turpentine mulga *(Acacia brachystachya).* Eaten at times but usually is ignored. Cattle frequently break it down with their horns but do not appear to graze it.

Vine tree or supple-jack *(Ventilago viminalis).* Generally regarded as one of the best native fodder trees. Although it has been shown that a pure diet of this plant can be toxic, no field losses have been reported. All stock eat it.

Whitewood *(Atalaya hemigaluca).* Readily eaten by sheep, cattle and horses and is one of the most sought after fodder plants.

Yarran *(Acacia omalophylla).* Eaten readily but is not abundant in the area.

The palatability of all species recorded is given in Appendix V.

GRAZING CAPACITY

The Department of Lands (1971) has published stocking rates for a number of different types of land in Queensland. These together with the guidelines to living areas is the basis of property design currently used in the area. Using the Department of Lands stocking rate assessments the area is assessed at maintaining 385,300 cattle equivalents. From Bureau of Census and Statistics data the median number of animals carried for the period 1897-1972 was approximately 293,600 cattle equivalents. Numbers ranged from 97,525 cattle equivalents in 1902 to 618,037 in 1897. Since the 1902 drought the highest numbers recorded were 446,300 cattle equivalents in 1957 and 404,912 cattle equivalents in 1965.

It is significant that some of the most devastating droughts have followed these periods of high stocking rate. Much of the damage to grazing country in the area has been the result of a build-up to high stocking rates during a run of favourable seasons and the failure to reduce stocking rate immediately pastoral conditions show signs of reversion towards average, or into drought.

The increased pressure placed on mulga and other fodder trees, in an attempt to maintain the high stocking rate in the face of drought, has led to the destruction of much of the drought reserve. This has added to the problem of arriving at a sound stocking policy.

Overgrazing*, from one cause or another, and overclearing of fodder trees for drought fodder has caused damage to grazing lands. It is in the interest of all concerned that further damage be curtailed. This will require the skill and co-operation of many people. Adherence to realistic stocking rates, rapid adjustment of stock numbers to drought conditions, stock and property management to avoid local overstocking, adequately-sized blocks and a well-informed advisory service are all important facets.

The grazing capacity and drought grazing capacity of each land unit has been assessed using the system described by Condon, Newman and Cunningham (1969). This system is based on rating scales for soils, topography, hilliness, tree density, land condition and average annual rainfall. The assessment of drought grazing capacity of the same units is based on the presence and frequency of species able to provide forage during prolonged drought; hilliness, condition and annual rainfall.

A range of values occurs for each land unit due to changes in rainfall, timber density and condition. For this reason a range of both grazing capacity and drought grazing capacity is given in the land use summary covering each land unit. A representative figure is also given. This is representative of the unit in its best condition in the area where the major proportion of the land unit occurs. The grazing capacity and drought grazing capacity have also been assessed for each of the land systems (Table 9.1) but this is for guidance only.

The calculated grazing capacity indicates the level of grazing which could be maintained in all but prolonged drought. Condon *et al., op. cit.* consider that most arid lands in good condition can carry stock into drought for 12 months at the assessed grazing capacity. If pre-drought levels of grazing are high or the country is in poor condition the carry-through period is shortened.

The drought grazing capacity is defined as one to which stock numbers should be reduced by the end of the third consecutive season of drought. Reduction to this figure is achieved by reducing stock numbers by 25% of the difference between grazing capacity and drought grazing capacity after 12 months without effective rain over the property. After 24 months without effective rain, reduce to half-way between grazing capacity and drought grazing capacity. At the end of the third year, reduce to drought grazing capacity. If the drought continues for four years, reduce to half the drought grazing capacity.

The assessed grazing capacity and drought grazing capacity for each land system appears in Table 9.1. Important qualifications should be noted as follows:

(a) the area assessment is made on the assumption that all land is available for grazing,

(b) that all land units are in similar condition to the sample from which the assessment has been made.

In fact neither of the above assumptions can be regarded as completely realistic. The sparse nature of the normal vegetation on some units does not justify heavy expenditure on water facilities to permit constant stocking, even if this were feasible for other reasons. Thus, some land is available only on a sporadic basis. Secondly, in order to make a satisfactory assessment it is necessary to choose sites which are in good condition and which have not be subjected to excessive thinning of the 'original' vegetation.

Having recognised these limitations the value of the assessment lies in the fact that it provides a systematic basis for the evaluation of components relevant to grazing capacity.

On the hypothetical basis the assessed carrying capacity of the region is 451,800 cattle equivalents. After three years of consecutive drought the carrying capacity in terms of cattle equivalents would be 93,000 cattle equivalents, a low level not so far recorded.

When the representative grazing capacity for the land systems is compared with the Department of Lands' grazing capacities it is observed that in most cases a similar figure is achieved for the limited range.

Calculation of the mean figure for the 87 year period 1879-1966 using the destocking strategy postulated previously the mean grazing capacity for the area was assessed at 368,000 cattle equivalents.

This takes into account 48 full stocking years; 19 at 25% reduction; 12 at 50% reduction; 6 at 75% reduction and 2 at full drought grazing capacity.

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* It should be emphasised that when overgrazing is mentioned this may take several forms. One is a concentration of stock on one section of a paddock, leading to local overgrazing, even though the average stocking rate would be satisfactory if stock were distributed over the whole area. The second likely situation is where stock numbers are maintained in the face of a rapidly dwindling forage supply - in other words a failure on the part of management to react quickly enough to early drought conditions. The third, and generally rare situation, is where average stocking rate is just too high for the particular type of land.

\+ Rainfall records at Thargomindah were used to calculate destocking strategy.

Table 9.1. Production characteristics of the land systems.

Land System	Erosion Class (Type)[1]	Natural Stability	Condition[2]	Productivity Reaction to Use	Median Grazing Capacity[3] beasts/km^2 [4]	Median Drought Grazing Capacity beasts/km^2	Comment
Dunefields							
D1 Arrabury	6	Stable	Fair to mediocre	Stable	0.8	0.2	Avoid overgrazing, maintain drought reserve; mainly for use as a drought reserve and maintenance area; responds quickly to rain; mainly forbs.
D2 Poongamulla	6	Stable	Fair to mediocre	Stable	0.7	0.1	Avoid overgrazing, maintain drought reserve; mainly for use as a drought reserve and maintenance area; responds quickly to rain; mainly forbs.
D3 Santos	6	Stable	Fair to mediocre	Stable	1.0	0.3	Avoid overgrazing, maintain drought reserve; mainly for use as a drought reserve and maintenance area; responds quickly to rain; mainly forbs.
D4 Naryilco	6, 10	Stable	Fair to mediocre	Stable to slight downward	1.6	0.4	Susceptible to wind and water erosion when bare. Maintain all topfeed; perennial grasses; responds quickly to rain.
D5 Kyabra	10	Unstable	Mediocre	Slight downward	1.5	0.3	Susceptible to overgrazing due to proximity to high quality grazing on alluvial plains.
D6 Clyde	5	Stable	Fair	Stable to slight downward	1.9	0.6	Susceptible to wind and water erosion when bare. Maintain all topfeed; perennial grasses; responds quickly to rain.
D7 Dynevor	5, 10	Stable	Fair to mediocre	Stable to downward	1.7	0.4	Woody weeds (mainly Budda bush and cassias) are a problem;scalded at base of low dunes; maintain topfeed; limited cover of perennial grasses; responds quickly to rain.
D8 Bindegolly	6, 10	Unstable	Mediocre	Downward	1.2	0.2	Very limited productivity.

1 Condon and Stannard (1957)
2 Condon, Newman and Cunningham (1969)
3 Median grazing capacity has been determined using the median physical characteristics recorded at representative sites and the median rainfall zone. Values shown will be generally high since most of the area will be in poorer condition than the sampling sites.
4 Basis grazing capacity is expressed in terms of adult bovines (a steer of 450 kg liveweight) per km^2. Eight dry sheep are taken as equivalent to one dry bovine. Conversion equivalents are -

1 bovine per km^2 = 1 bovine per 250 ac.
= 2.56 bovines per sq. mile
= 31 ac per dry sheep.

Table 9.1. (Cont'd)

Land System	Erosion Class (Type)	Natural Stability	Condition	Productivity Reaction to Use	Median Grazing Capacity beasts/km^2	Median Drought Grazing Capacity beasts/km^2	Comment
Mulga Sand Plains							
S1 Greenmulla	1, 5	Stable	Fair to good	Stable to slight downward	3.5	1.1	Woody weeds (mainly silver and Charleville turkey bushes and cassias) may be a problem. Maintain topfeed. Maintain vegetal cover to avoid wind and water erosion; perennial grasses; responds quickly to rain.
S2 Eulo	1, 5	Stable	Fair to good	Stable to slight downward	3.4	1.1	Woody weeds (mainly hopbush, Charleville turkey bush and cassias) may be a problem. Maintain topfeed; perennial grasses; responds quickly to rain.
Soft Mulga							
M1 Boran	1, 7	Stable	Fair to good	Stable to slight downward	3.2	1.7	Woody weeds (Charleville turkey bush and cassias). Mulga density may restrict pasture growth. Thin out in this situation. Potential for improvement. Perennial grasses in places; responds quickly to run-on water.
M2 Bierbank	1, 7	Stable	Fair to mediocre	Stable to slight downward	2.9	1.7	Woody weed (Charleville turkey bush). Avoid over thinning of mulga, maintain at least 175 mulga shrubs/ha; perennial grasses in places.
M3 Humeburn	1, 7, 8	Stable	Fair to good	Stable to downward	5.3	1.1	Woody weeds (sandalwood, Charleville turkey bush). Selective thinning and timber treatment may be practised on some areas. Perennial grasses; responds to run-on water.
M4 Norah Park	7	Stable	Fair to mediocre	Stable to downward	3.3	2.0	Charleville turkey bush is a problem in places. Subject to sheet erosion if over-cleared. Maintain 175 mulga shrubs/ha. Perennial grasses where thinned.
M5 Berella	1, 7	Stable	Good to mediocre	Stable to downward	2.4	0.8	Maintain at least 175 mulga shrubs/ha; perennial grasses mainly in the groves; responds to intergrove runoff.
Hard Mulga							
H1 Bundeena	2, 7	Slightly unstable	Mediocre	Slight downward to downward	2.2	0.8	Maintain all shrub cover; runoff is high; limited ground cover.
H2 Kyeenee	2, 7	Slightly unstable	Mediocre to fair	Slight downward to downward	2.7	1.3	Maintain at least 175 mulga shrubs/ha. Where reduced to below this level manage to maintain and increase; perennial grasses in places; runoff is moderate to high.
H3 Wanko	1, 7	Stable to slightly unstable	Fair to mediocre	Slight downward	2.2	0.6	Maintain all mulga. Perennial grass cover in places; runoff is moderate.

Table 9.1. (Cont'd)

Land System	Erosion Class (Type)	Natural Stability	Condition	Productivity Reaction to Use	Median Grazing Capacity beast/km^2	Median Drought Grazing Capacity beasts/km^2	Comment
H4 Bingara	1, 7	Stable	Good to fair	Stable	2.1	0.5	Limited use due to low palatability of rock-grass.
H5 Noccundra	1, 7	Slightly unstable	Mediocre to poor	Downward	1.9	0.6	Maintain all shrub cover and limit use; limited ground cover; high runoff.
Dissected Residuals							
R1 Orientos	7, 8	Unstable	Mediocre to poor	Downward	2.2	0.4	Maintain maximum cover; limited ground cover; high runoff.
R2 Mawson	7	Unstable	Poor to very poor	Downward	1.7	0.3	Main use as runoff area; extremely sparse ground cover; extremely high runoff.
R3 Grey	9	Unstable	Poor to mediocre	Downward	2.0	0.5	Maintain maximum cover; productive on lower slopes; high runoff.
R4 Durham	1, 8	Slightly unstable	Mediocre to poor	Slight downward	2.3	0.4	Maintain maximum cover; productive on lower slopes; high runoff.
R5 Willies	9	Unstable	Poor to mediocre	Downward	1.7	0.6	Maintain maximum cover; high runoff.
R6 Gumbardo	9	Unstable	Mediocre to poor	Slight downward to downward.	1.9	0.7	Maintain maximum cover; high runoff.
Undulating Gidgee							
G1 Grotto	7, 8	Unstable	Mediocre to poor	Slight downward to downward	3.1	0.9	Maintain maximum cover; high runoff limited area of perennial grasses.
G2 Tilbooroo	7	Stable to slightly unstable	Fair to mediocre	Slight downward	3.2	0.9	Clearing and thinning of gidgee leaving adequate shade. Woody regrowth, mainly sandalwood, Ellangowan poison bush and cassias a problem; good ground cover of forbs and/or grasses.
G3 Bellalie	1, 7	Stable	Fair	Stable to slight downward	3.8	0.6	Maintain in present state; no topfeed; good ground cover of forbs and/or grasses.
G4 Bunginderry	1, 7	Stable	Fair to good	Stable	4.6	0.8	Maintain in present state; no topfeed; good ground cover of forbs and/or grasses.
G5 Spring Creek	1, 7	Stable to slightly unstable	Fair to mediocre	Slight downward	6.9	0.9	Regrowth (mainly sandalwood) a problem. Clearing and thinning practical; ground cover responds to thinning of trees.
Undulating Downs							
F1 Bransby	1	Stable	Fair to good	Stable	4.2	0.3	Relative stable except near watering points; good ground cover of forbs and grasses; perennial grasses more abundant following seasons of good spring and summer rains. Better growth in gilgais.

Table 9.1. (Cont'd)

Land System	Erosion Class (Type)	Natural Stability	Condition	Productivity Reaction to Use	Median Grazing Capacity beasts/km^2	Median Drought Grazing Capacity beasts/km^2	Comment
F2 Plevna	1, 7	Stable	Fair to good	Stable to slightly downward	3.8	0.3	Relative stable except near watering points; good ground cover of forbs and grasses; perennial grasses more abundant following seasons of good spring and summer rains. Better growth in the gilgais.
F3 Mt. Howitt	1	Stable	Fair to good	Stable to slight downward	4.0	0.3	Relative stable except near watering points; good ground cover of forbs and grasses; perennial grasses more abundant following seasons of good spring and summer rains Better growth in the gilgais.
F4 Nappamerry	7	Stable to slightly unstable	Fair to mediocre	Slight downward	3.2	0.3	Relative stable except near watering points; site watering points away from this system. Growth of forbs and grasses in the gilgais.
Alluvial Plains, Woodlands							
W1 Winbin	7, 8	Stable to slightly unstable	Fair	Stable to slight downward	5.0	0.6	Frequently flooded. Small scalded areas interspersed. Maintain vegetation. Honey production area. Good ground cover of forbs and grasses.
W2 Dartmouth	1, 7	Stable	Good to fair	Stable	4.8	0.9	Occasionally flooded. Some clearing and thinning of trees may be practical. Woody regrowth (sandalwood, brigalow). Good ground cover of forbs and grasses.
W3 Norley	1, 2	Stable	Good to fair	Stable	3.9	0.5	Honey production area. Maintain all yapunyah. Flooded; ground cover of perennial grasses; claypans interspersed.
W4 Beechal	1, 7, 8	Slightly unstable	Fair to poor	Stable to downward	4.4	0.5	Subject to river bank erosion near watering points, particularly near permanent waters. Maintain all shrubs and trees. Ground cover variable.
W5 Tickalara	1, 7, 8	Slightly unstable	Fair to poor	Stable to downward	4.3	0.4	Subject to river bank erosion and over-grazing; scalded in places.
W6 Cooloo	1	Stable	Good to fair	Stable	5.8	0.5	Occasionally flooded; subject to over-grazing in many areas causing scalding. Good ground cover of forbs and/or perennial grasses.
W7 Paroo	1, 7, 8	Stable to slightly unstable	Fair to poor	Stable to downward	5.7	0.6	Frequently flooded; subject to severe bank and flood plain erosion due in places to stocking practices; ground cover variable.

Table 9.1. (Cont'd)

Land System	Erosion Class (Type)	Natural Stability	Condition	Productivity Reaction to Use	Median Grazing Capacity beast/km^2	Median Drought Grazing Capacity beasts/km^2	Comment
Channel Country							
C1 Cooper	1	Stable	Good to very good	Stable	5.7	0.3	Frequently flooded; species response varies according to time of flooding.
C2 Cunnawilla	1, 2	Stable	Good to fair	Stable to slight downward	5.5	0.3	Occasionally flooded; subject scalding in places. Ground cover of forbs and/or grasses.
C3 Woonabootra	1	Stable	Fair to good	Stable	3.4	0.4	Seasonally wet, in places woody plants such as lignum and swamp canegrass may be increasing; a drought reserve.
Other Alluvia							
A1 Comongin	1, 2	Stable	Fair to good	Stable to slight downward	5.4	0.5	Subject to overgrazing and scalding particularly near watering points. Occasionally flooded. Good ground cover of forbs and/or grasses.
A2 Eromanga	1, 2, 7	Stable	Fair to good	Stable to slight downward	5.8	0.4	Subject to overgrazing and scalding particularly near watering points. Occasionally flooded. Good ground cover of forbs and/or grasses.
A3 Nooyeah	2, 3	Unstable	Poor to very poor	Downward	1.7	0.1	Varying degrees of degradation occur on this unit. Reclamation is feasible but costly.
A4 Bulloo	2, 12	Unstable	Mediocre to poor	Downward	1.5	0.2	Naturally unstable but degradation has increased due to stocking.
A5 Dingera	1, 2	Stable to slightly unstable	Fair	Slight downward	5.8	0.4	Subject to scalding in places; good ground cover of forbs and/or grasses.
A6 Warry	2, 7	Slightly unstable	Fair to mediocre	Slight downward to downward	3.1	0.6	Maintain all shrub and tree vegetation; susceptible to serious erosion near watering points; responds to run-on water.
Miscellaneous							
L1 Lake Pure	1, 2	Stable	Fair to mediocre	Stable to slight downward	2.5	0.2	Seasonally inundated; excellent pastures following inundation.
L2 Epsilon	2, 3	Unstable	Mediocre to poor	Downward	1.0	0.1	Some areas seasonally inundated; degradation proceeding in many areas; some areas are productive following inundation.

CONDITION AND TREND

Perry (1962) points out that the basic concept behind any soundly based form of pasture utilization is to maintain the plant-animal system in a condition which gives the maximum livestock production consistent with the maintenance of land resources. A major problem in the assessment of condition and trend of the vegetation in Australia, and Queensland in particular, is that very little quantitative work has been carried out. As Roberts (1972) points out there is a need for long-term projects which will provide more reliable data for the assessment of the long-term condition and trend of pasture lands. The work initiated by Burrows and Beale (1969) will provide one means of assessing this but additional data on ground flora will be required.

In this regard there is a real need for more attention to be focused on soil characteristics. Soil properties (and subsequent changes) and their relationship to plant communities requires more study. This may be a valuable aid in the assessment of condition and trend of the vegetation.

For this report the condition (or relative vigour and abundance of desirable and undesirable plants and extent of soil erosion) has been assessed using the condition ratings of Condon, Newman and Cunningham (1969). The range of condition for each land system is reported in Table 9.1 together with reaction of land to use (trend). An indication of the natural stability is also given.

This assessment draws attention to those areas which are susceptible to degradation have suffered degradation and where degradation has been most severe.

Stock numbers as in most parts of Australia were at their highest prior to 1900. During this period up to twice the median number of stock were carried. However, this was followed by drought and phenomenal stock losses at the turn of the century Since this time adjusted numbers have fluctuated up and down by less than 20% of the median number until the 1950-70 period. During this period (1950-70) stock numbers have consistently been much higher than the median periods.

If the onset of drought is not recognized at an early stage, pasture damage and stock losses are likely to be heavy.

The majority of the land types in this area are still productive and reasonably stable although considerable degeneration has occurred on the hard mulga country and alluvial plains. The fact that the majority of these lands are still productive should not lead to complacency, as the period of use only just exceeds 100 years and there already signs of degeneration.

Condition and trend, grazing capacity and drought grazing capacity have been assessed for each of the land units. On each land unit there are obviously different developments of the vegetation due to slight changes in soil fertility, seasonal conditions, degree of erosion and past management practices. For this reason the observed range of these characteristics has been given. These observations highlight the significant differences which management practices have had on the condition of individual land units, almost making them unrecognizable..

The Dunefields

Generally of low productivity, these areas are commonly stable particularly where they are covered by spinifex hummock grassland. However, in prolonged drought or following fire and heavy grazing, considerable soil drift may occur causing loss of surface nutrients. Those land systems without spinifex protection, and vegetated mainly by woollybutt grass and acacias, are generally of higher productivity. They are more susceptible to erosion following heavy grazing, particularly in drought periods.

Most damage on these dunefields occur adjacent to more productive land systems such as Cooper and in the vicinity of watering points. In this regard, Kyabra land system appears more susceptible to overgrazing, due to the fact that is occurs as islands on the alluvial plains. Most damage occurs on the more productive flanks of these dunes.

Woody weeds though not a problem of the western dunefield may reduce productivity on Clyde and Dynevor land systems particularly on the lower slopes.

One observation made during the course of the survey, but not supported by quantitative data, was that sheep tended to cause more degeneration than cattle, leaving the ground quite bare and eroded in places.

The effects of fire on these land types are obvious for long periods particularly on the spinifex dunes. There is evidence of both beneficial and deleterious effects from firing.

Mulga Sandplains

Both land systems in this land zone are naturally stable. However, if vegetal cover is reduced, due to overgrazing and/or fire, they become susceptible to both wind and water erosion. Some bad examples of erosion can be seen despite the natural resistance of the soils to erosion. Scalded hard surfaces may be found on these areas, where once the sandy red earths had friable loose surfaces.

Both land systems are susceptible to invasion by woody weeds although species vary on each land system. Greenmulla land system is more susceptible to invasion of silver turkey bush, Charleville turkey bush and desert poplar whilst hopbush, Charleville turkey bush, cassias and budda bush are more prevalent on Eulo land system.

Soft Mulga Lands

In their natural state these land systems are all remarkably stable. With the exception of Berella and parts of Humeburn, mulga densities may be so high as to reduce productivity. Where this occurs some thinning may be justified. However, in most places all these land systems have been subject to over-clearing of the mulga for forage. This has lead, in some cases, to mediocre condition and a downward trend. Most of these land systems occupy more favourable sites and with careful management mulga regeneration can be expected.

Woody weeds are a major problem of these land systems, Charleville turkey bush being common on all land systems. Cassias are a problem on Boran land system particularly where it is disturbed. Sandalwood and poplar box may cause regeneration problems where clearing of vegetation has occurred in Humeburn land system.

Gully erosion, originating near the major watercourses, has intruded into some of these land systems and is threatening others. This applies particularly to the texture contrast soils on Humeburn land system. Serious loss of production will follow if erosion continues.

Practices used at Lanherne (Cull 1964) indicate that the construction of gully plugs, for waterspreading purposes, can halt this type of gully erosion on small gullies.

On Boran and Humeburn land systems particularly, some improvement practices such as sown grass species and water-spreading could be beneficial. The major factor in maintenance of condition will be matching both production and stability by maintaining a desirable number of mulga trees for stability and drought fodder purposes.

Hard mulga lands

With the exception of Bingara, the land systems in this land zone are naturally unstable, a condition which is aggravated by use. The degree of natural instability varies with the land system, aridity and productivity of adjacent land systems. These land systems are generally only in mediocre condition. The exception is Bingara land system which is in good condition, although not very productive.

The major contributing factor to the mediocre condition of these land systems is that they have shallow soils on slopes and have been used as drought reserve areas for stock. As a result, over a period of a hundred years, the density of top-feed has been reduced to low levels and erosion of the surface soil has proceeded. Damage has been most severe on those early-settled properties, with large areas of flooded country. In the early years stock numbers were built up in good years but not reduced in droughts.

Because of higher rainfall, Kyeenee land system is easier to maintain and can possibly be improved. Maintaining production on the other land systems will be more difficult. The build-up of mulga densities and ground cover seems the most feasible way to economically maintain these land systems in a productive state. The use of mechanical measures such as pasture furrows and pitting may not be economic at this stage but would speed the improvement process.

Dissected residuals

These land systems with shallow soils and steep slopes are naturally unstable and contribute to the high runoff from the area. Stock have poor access to them due to slopes and stoniness. With the exception of the lower slopes of these land systems they have little grazing value. There are areas with considerable drought fodder in these land systems, but little permanent water, so only those areas near permanent water can be utilized in drought. Timber destruction should not be encouraged except in the more eastern areas where tree density may be high.

Undulating gidgee

Condition of this land zone varies according to the particular land system.

Grotto land system is generally in poor to mediocre condition. This is due to timber destruction, overgrazing and also its natural instability.

Tilbooroo land system, although comprising stable soils, appears in only fair to mediocre condition due to woody regrowth, mainly sandalwood, Ellangowan poison bush and cassias. Salting in the local alluvia has resulted in a number of areas from the overclearing of gidgee on the undulating plains.

Bellalie and Bunginderry land systems are basically stable with gully erosion occurring in some places. These systems should be maintained in their present state. They are highly productive particularly after good seasons. Death of trees on these systems is a natural phenomenon.

Spring Creek land system supports gidgee and brigalow in the eastern area. Clearing of this land system may be practical in places. If adequate management levels are not maintained woody regrowth can be a problem.

Undulating downs

It is difficult to assess, both in this land zone and the undulating gidgee land zone, to what degree past seasons and past stocking rates have contributed to the fluctuating climax between forbs and grasses which now occur in these land zones. Due to their stone cover, gilgai micro-relief and cracking surfaces the soils are relatively stable, but pasture composition changes considerably. Whilst this is a natural phenomenon the fact that productivity may have been reduced is not discounted.

The main areas of instability and degradation in this land zone occurs near the local drainage lines and gullies. Erosion may occur on these gullies where severe disturbance has been caused by roads and inadequate siting of watering points. Salting has been noticed in some of the gully areas. Whilst the soils are stable in their present state, they become highly unstable when gullies cut back into them. Every effort should be taken to prevent this.

Alluvial plains, woodlands

Of these land systems the alluvial plains supporting gidgee shrubland and the yapunyah woodlands are in good to fair condition. On the braided streams natural erosion is occurring. The main areas in poor condition in this land zone are the alluvial plains associated with Paroo, Beechal and Tickalara land systems. The texture contrast soils are subject to scalding and pasture species change. This is commonly associated with overgrazing. In many cases riverbank erosion is caused by stock concentrations and flash flooding. Gully erosion on Beechal and Paroo land systems is quite severe in places. Reclamation of some of these areas will be extremely difficult and in some cases not practical.

Increases in lignum density has caused a reduction in productivity in some of the wetter areas.

Channel country

The frequently flooded plains of the "channel country" remain in good to very good condition, the main problem being associated with increases in woody species such as lignum. Land systems which fringe the productive "channel country" may be in poor condition.

Fringing the "channel country" are alluvial plains which are not frequently flooded. Overgrazing and scalding have caused considerable change to the pastures of these areas. Waterhole-silting was a problem noted by Whitehouse (1947) which could affect long-term productivity in this land zone. This damage is particularly noticeable near established watering points.

Other alluvia

It is difficult to determine, in the short span of this work, the degree of degeneration of native pastures on this land zone. It can be stated confidently, that there are large areas of this land zone which are in mediocre to poor condition due to overgrazing, the reduction of valuable species, and wind and water erosion. Reclamation of these areas is possible but is costly and slow.

Comongin, Eromanga and Dingera land systems are broad alluvial clay plains subject to flooding. These vary in condition with scalded areas interspersed particularly on the more susceptible soils near watering points. Nooyeah land system exhibits varying degrees of scalding. Most of this will be partially reclaimed (naturally) in the good seasons following flooding Other areas need treatment using mechanical conservation techniques.

Bulloo land system, comprising low dunes on alluvial plains, once supported a more favourable vegetation than presently exists. Scalded areas are increasing and it is very susceptible to overgrazing in drought years.

Warry land system is in fair condition, except in the vicinity of watering points where serious degradation occurs.

WOODY WEEDS

The grazing capacity of these lands depends largely on native plant species. Under suitable management a balance of species can be maintained to ensure long-term productivity but mis-management can readily cause deterioration and invasion by woody or other weed species. Woody weeds are recognised as a major problem in semi-arid grazing lands of eastern Australia (Burrows, 1973; Moore, 1969; Moore, 1971).

Major factors influencing the woody weed population include climate, fire, timber-clearing and grazing. These factors, or their effects, are either directly or indirectly affected by man's pastoral activities.

Fortunately, in this area shrub communities have not been greatly disturbed by large scale timber clearing and the problem of increased woody weeds resulting from this action is relatively small. An exception is Charleville turkey bush (*Eremophila gilesii*) which appears to invade cleared or disturbed areas of mulga.

Generally, the shrub invasion, or increased population of the problem plants in far western Queensland, appears to be related to bountiful rainfall years, change in the kind or number of grazing animals, fire or a combination of these factors.

The change in land use from sheep to cattle has undoubtedly accentuated the problem in places. In most years, sheep to a large degree control woody plants. Cattle are not as effective in checking increases in woody weed populations. The reduction in populations of rabbits and the lack of fires in recent times have also been suggested as possible cause of increases in woody plant populations. Evidence from the Land Administration Commission records is somewhat conflicting (Walker, pers. comm.).

Optimum management of woody plant communities is difficult to attain and for management to be successful it must be based on sound ecological principles (Burrows, 1973). In arid environments the soil-plant-animal relationship is dynamic. Interference with any component may upset the delicate balance.

Grazing management and biological control are undoubtedly the best techniques for controlling woody weeds in arid areas.

Despite the support for the use of fire as a method of woody weed control (Moore, 1973) it is usually only useful when species are young and small. Most species require wood in the fuel for a successful burn. Its use as a method of control is questionable. Not only does fire destroy useful species, but in arid areas, it frequently provides a suitable seed-bed for the re-establishment of the unwanted species as well as other problem plants. Fire may upset the nutrient status of the system by releasing or destroying nutrients stored in the plants and this may have a degrading influence on the system as a whole. Urgent studies are needed on the use of fire as a tool of management.

In the east agronomic methods such as stick raking may be useful for controlling woody weed control in Brigalow, poplar box and gidgee communities. In spite of the relative high initial cost return ratio it may be necessary to resort to such practices in order to maintain long-term productivity.

Because of the difficulties in obtaining labour, and high costs the use of herbicides for woody control in the area is unrealistic. Herbicides have a limited use for the treatment of small areas or for eliminating scattered shrubs. Tree injections with chemicals is probably the best technique for eucalypt control.

Ring-barking is useful for thinning of gidgee. Care should be taken to treat potential problem weeds such as sandalwood at the same time to reduce the incidence of future problems.

If clearing or pushing is considered to be essential to provide forage, a good grass or forb cover is needed within 12 to 18 months to restrict the growth of woody weeds. Increased densities are frequently the result of growth of suppressed seedlings or mass germinations as a result of reduced competition.

Under certain conditions the following woody species may cause a weed problem. Those marked with an asterisk are the species of major significance.

Belalie (*Acacia stenophylla*). In places forms dense stands along waterholes restricting access.

Budda bush (*Eremophila sturtii*)*. This species is a problem on low sandplains.

Butter bush (*Cassia nemophila*)*. *Cassia* spp. are a serious problem in some situations especially on water spreading developments (Batianoff and Burrows, 1973).

Charleville turkey bush (*Eremophila gilesii*)*. Undoubtedly the most serious problem weed in the area. It is increasing in density in areas where it occurs under both high stock numbers and areas where stock are excluded (Burrows, 1973). Spectacular control has occurred in some areas through the action of the wingless grasshopper (*Monistria pustulifera*). Because of the cost factor, mechanical and chemical control is limited (Burrows, 1973).

Coolibah (*Eucalyptus microtheca*). Usually it is not a problem. When country is flooded beyond the normal channel, mass germinations may occur resulting in dense stands.

Dawson gum or blackbutt (*Eucalyptus cambageana*). Only very limited areas of this species occurs in the far north-east of the area. It can be very troublesome following disturbance. Injection technique is the best to handle this species (Back, 1972).

Ellangowan poison bush (*Myoporum deserti*). Because of its poisonous properties it is sometimes considered a pest and should be eliminated from holding yards and stock routes. It is also a troublesome pest in some disturbed gidgee associations, where Ellangowan poison bush increases rapidly following disturbance.

Grey turkey bush (*Eremophila bowmanii*)*. It may form dense stands on the *Acacia aneura* sandplains. Although not as extensive as *E. gilesii* it appears to be on the increase in some of the more productive sandplain areas.

Hop bush (*Dodonaea attenuata*)*. This can be a troublesome weed on sandplains and dunefields.

Lignum (*Muehlenbeckia cunninghamii*). This may form dense stands limiting access to water. It is usually not a problem species in this area. These dense stands act as a refuge for wild pigs. It is the practices in some areas to burn the plants because stock relish the new growth and this readily reduces the problem.

Mimosa bush (*Acacia farnesiana*). This may form dense stands although on the downs it provides shelter to stock the population is increasing in numbers. This is probably a cyclic phenomenon.

Mulga (*Acacia aneura*). Although an extremely useful plant, in places it grows so dense, that it renders the land useless. Thinning is acceptable providing adequate seed trees are left. (Beale, 1973; Everist, 1949).

Noogoora burr (*Xanthium pungens*). Although this plant is not a woody weed but an annual forb it warrants mentioning as it forms dense stands along some creeks in the area. Some graziers have suggested that the range and density of infestations have increased. There is no evidence that this plant has increased its range since 1947.

Poplar box (*Eucalyptus populnea*)*. This can be a problem in disturbed county. Regeneration from lignotubers and the growth of suppressed seedlings may follow clearing or disturbance.

Sandalwood (*Eremophila mitchellii*). It is a problem in the east of the area especially on cleared, run-on, mulga, poplar box country. Stick raking is probably the most suitable technique for control in productive situations.

Silver cassia *(Cassia artemisioides)**. It can be a serious problem especially on water-spreading developments.

POISONOUS PLANTS

There are very few areas of Australia in which some plants known to be capable of causing stock losses are not present. The far south-west of Queensland is no exception. Not only are toxic plants responsible for large stock losses but they may hinder the management of properties, by rendering extensive areas of valuable grazing land useless, for all or part of the year. Many plants which are known to be toxic can be useful components of the pasture and may be eaten by animals without any ill effects. However, under certain conditions, losses due to these toxic plants may be extremely high.

Appendix V indicates species recorded from the area known to contain toxins, known to be toxic by feeding tests or suspected of being toxic on strong field evidence. Other plants have been suspected on vague or doubtful evidence but these are not indicated. Table 9.2 lists known toxic plants together with the chemical classification of the toxins. Generalized conditions leading to toxicity by the various toxins are given in Table 9.3.

Table 9.2. Known poisonous plants.

Common Name	Botanical Name	Oxalates	Nitrates	Essential Oils	Glycosides		Alkaloids	Other Known Toxins	Toxins Uncertain or Unknown
					Cyanogenetic	Others			
Annual saltbush	*Atriplex muelleri*	x	x						
Bathurst burr	*Xanthium spinosum*					x			x
Berrigan or emu bush	*Eremophila longifolia*								x
Bitter bark	*Alstonia constricta*						x		
Birdsville indigo	*Indigofera dominii*								x
Blackberry nightshade	*Solanum nigrum*						x		
Black crumbweed	*Chenopodium melanocarpum*				x				
Bluebush pea	*Crotalaria eremaea*						x		
Blue parsnip	*Trachymene glaucifolia*								x
Boggabri	*Amaranthus mitchellii*	x	x						
Boobialla	*Myoporum acuminatum*			x					
Boonaree	*Heterodendrum oleifolium*				x				
Button grass	*Dactyloctenium radulans*								x
Caltrop	*Tribulus terrestris*		x					x	
Caustic creeper	*Euphorbia drummondii*								x
Caustic vine	*Sarcostemma australe*								x
Creeping oxalis or yellow wood sorrel	*Oxalis corniculata*	x							
Crested goosefoot	*Chenopodium cristatum*				x				
Ellangowan poison bush	*Myoporum deserti*			x					
Flaxweed	*Pimelea trichostachya*								x
Gascoyne spurge	*Euphorbia boophthona*								x
Golden billy buttons	*Craspedia chrysantha*								x
Hairy panic	*Panicum effusum*								x
Keeled goosefoot	*Chenopodium carinatum*		x		x				
Limestone fuchsia	*Eremophila freelingii*			x					
Morgan flower	*Morgania floribunda*								x
Mulga fern or rock fern	*Cheilanthes sieberi*							x	
Munyeroo	*Portulaca sp. aff. P. oleracea*	x	x						
Native couch grass	*Brachyachne convergens*				x				
Native fuchsia	*Eremophila maculata*				x				
Native tobacco	*Nicotiana velutina*						x		
New Zealand spinach	*Tetragonia tetragonioides*	x				x	x		
Noogoora burr	*Xanthium pungens*					x		x	x
Parakeelya	*Calandrinia balonensis*	x							
Pituri	*Duboisia hopwoodii*	x							
Potato bush	*Solanum ellipticum*							x	
Prickly paddy melon	*Cucumis myriocarpus*								x
Purple plume grass	*Triraphis mollis*				x				
Red crumbweed	*Dysphania microcephala*				x				
Red spinach	*Trianthema triquetra*	x	x						
Sand twin-leaf	*Zygophyllum ammophilum*								x
Soda bush	*Threlkeldia proceriflora*	x							
Soft roly-poly	*Salsola kali*	x	x						
Thargomindah nightshade	*Solanum sturtianum*						x		
Tree tobacco	*Nicotiana glauca*						x		
Vine tree	*Ventilago viminalis*							x	
Whitewood	*Atalaya hemiglauca*								x
Wild parsnip	*Trachymene cyanantha*								x
Wild parsnip	*Trachymene ochracea*								x
	Eremophila latrobei			x					

Anson in Appendix X lists what he considers are the most important poisonous plants affecting sheep in the area. He discusses symptoms and characteristics of some of the more important species.

Table 9.3. Conditions leading to toxicity of specified toxins.

Toxin or Specific Disease	Conditions leading to Toxicity
Prussic acid	Field losses occur most commonly when: (a) animals are hungry or under stress (e.g. being driven); (b) prussic acid yielding plants are young or wet with dew or light rain.
Nitrate	Hungry animals under stress and nitrate-containing plants abundant.
Oxalates	Animals deprived of food for 24 hours or more and then released onto restricted areas where oxalate containing plants are abundant.
Alkaloids	Most losses are in travelling stock but some occur in house paddocks. Availability of feed may be an important factor.
Saponins	Most fatalities occur in travelling stock or stock concentrated on young regrowth, when feed is limited. Caustic vine is often eaten without apparent ill effect.
Essential oils	Field losses occur mainly in travelling stock. Rarely are animals grazing quietly in a paddock affected. Usually there is a delay of 1 to 3 days between eating the plant and the onset of symptoms. Ellangowan poison bush is usually responsible, boobialla and *Eremophila latrobei* are rarely involved.
Noogoora burr poisoning	Most cases occur when there is an early germination of noogoora burr or Bathurst burr, following spring rains, and stock consume large quantities of the very young seedlings, in the absence of other food. Most cases occur closer to the coast. Now there is doubt that glycosides are totally responsible, other toxins probably being involved.
Birdsville disease	Most cases occur in winter, spring or early summer, when Birdsville indigo is abundant, especially around the base of sand dunes, and other feed scarce. Birdsville indigo is widely distributed but only causes trouble in inland Australia.
St. George disease	Most cases occur when there is a shortage of feed and cattle are forced to graze among flaxweed. The disease is due to the inhalation and ingestion of small amounts of flaxweed (Clark, 1971). Flaxweed also causes gastro-enteritis in travelling stock, especially sheep. It is often green when other plants are dried off.

There is no easy way to determine if a plant is poisonous. Poisonous plants do not possess characteristic odours, taste or physical features that readily distinguish them from non-toxic plants. Our current knowledge is mainly the accumulation of many years of field observations by people aware of the importance of poisonous plants, supported by the results of feeding trials and chemical analysis.

Many factors govern the possibility of stock losses. Most important of these are the stage of growth of the plant, the condition of the plant and pasture, the kind and condition of animals and the environment. In some instances, changing patterns of land use have increased the relative importance of some toxic plants. The various forms of flaxweed, the cause of St. George disease in cattle, have become an important limiting factor under certain conditions in areas converting from sheep to cattle. The change to road transport of stock has also influenced the incidence of certain plant poisoning. Losses in travelling stock from plants such as native fuchsia and Ellangowan poison bush, have been greatly reduced but there have been increased losses from stock being unloaded into restricted yards where plants such as munyeroo and soda-bush are growing.

Treatment for some plant poisoning is available but success depends on correct diagnosis and quick application. It is best to recognise potential poison areas and devise a management system to minimise losses.

Everist (1974) has compiled all known information on poisonous plants in Australia. Detailed descriptions of plants as well as symptoms and treatments are given.

TIMBER TREATMENT

Tree and shrubs layers have been manipulated by man to supply drought fodder, increase productivity, remove unwanted or useless species and to supply building and fencing materials.

Initially most of the clearing was done in the more eastern areas and restricted to ringbarking and chopping. This was particularly prevalent during the depression. Poplar box, mulga and gidgee communities were the main communities treated. Mulga has been by far the most widespread treated species because of its suitability for drought feeding. Gidgee is useful for fence posts and building, and has also been thinned extensively. Relatively small areas of brigalow and gidgee have been developed by either pulling or ringbarking. There has been little sowing of pastures associated with the pulled areas.

The thinning of mulga, particularly west of the Paroo, is most noticeable. In many cases it is leading to a reduction in drought grazing capacity and an increase in erosion. Everist (1949) stated that there was no evidence that pushing of mulga made the mulga soils more susceptible to wind and water erosion, but did not discount that there was a possibility of this. In most cases he was concerned with the more favourable areas where mulga quickly regenerated. As well, the mulga densities (175/ha) recommended by Everist, conform with present day standards to prevent erosion. This is discussed in the erosion section. Anson (1959) also stressed that every effort should be made to (a) preserve existing stands of mulga by using lopping methods, which will not kill the tree and (b) to encourage regeneration on some areas. Where mulga is pushed large areas should be left uncleared. Clearing should be along the contour, or at right angles to the prevailing strong winds, depending on the degree of slope and exposure to wind.

In arid areas, the removal of species may upset the delicate balance within the system. Long-term productivity may be reduced by regeneration and/or other less productive species filling the vacuum created.

Eucalypts, particularly poplar box which is widespread in the east, may be removed by ringbarking and/or treatment with chemicals such as "Tordon"*. The removal of this species may lead to reduced recycling of nutrients and in some places increases in other woody weed populations. Regrowth has been discussed in other sections.

Species most likely to present problems if disturbed are:-

Bendee: In this region bendee communities should not be disturbed. Suppressed seedlings are a problem where disturbance occurs.

Bowyakka: This species should not be disturbed. Problems arise from suckering as well as suppressed seedlings.

Brigalow: A problem species mainly due to sucker regrowth.

Coolibah: If disturbed suppressed seedlings are a problem. In this area it should be left alone.

* Trade name for herbicide containing picloram.

Dawson gum: A problem species when disturbed due to suckering and suppressed seedlings.

Gidgee: Problems can arise following a bad pull through suppressed seedlings. Ringbarking generally presents fewer problems.

Mountain yapunyah: This species should not be disturbed. Problems arise mainly from suckering.

Mulga: When mulga is pushed then usually there are no problems. Under certain conditions suppressed seedlings or mass germination of new seedlings may cause problems on cleared areas.

Poplar box: A problem species, whether pushed or treated individually. Pulling results in suckering and regeneration from lignotubers as well as suppressed seedling problems. Individual treatment results in a suppressed seedling problem.

Silver-leaved ironbark: In this area this species should not be disturbed. A major problem of suppressed seedlings usually occurs after disturbance. Ringbarking often leads to suckering from below the cut.

Overall if species are treated individually either by chemical or manual methods the main problem which arises is due to an increase in species number as a result of suppressed seedlings. The problem of suckering is avoided.

Stands of millable timber in the area are almost non-existent. The main uses of timber in the area have been for fencing, yards and firewood. Local timber in the area have been used for construction purposes in residences and sheds.

The main timbers used for fencing, depending on availability, are beefwood, sandalwood, mineritchie, boree, gidgee, western bloodwood and bowyakka. Coolibah and river red gum are suitable as split posts.

Lancewood, mulga, mountain yapunyah and yapunyah whilst not satisfactory for posts are suitable for rails and shed construction.

Vinetree, boonaree and bauhinia while suitable for fencing are not widely used because of their fodder value and the difficulty of finding suitable logs in sufficient numbers.

PESTS

Rabbits

For convenience the area where rabbit infestation has been recorded is divided into three sections (see Figure 9.1).

In the most eastern section (Section A) rabbits are chiefly confined to the Warrego River system and its delta. In this area the rabbits live on the sandhills or sandy areas.

Rabbits population fluctuate according to weather conditions with the main increase in the autumn, winter and spring months. Any rain at these times will stimulate a quick growth of feed and rabbit breeding. In favourable seasons, when feed is abundant, rabbit damage is noticeable only in the vicinity of warrens. In average years damage is restricted to the sand country and a fringe of the adjoining black soil.

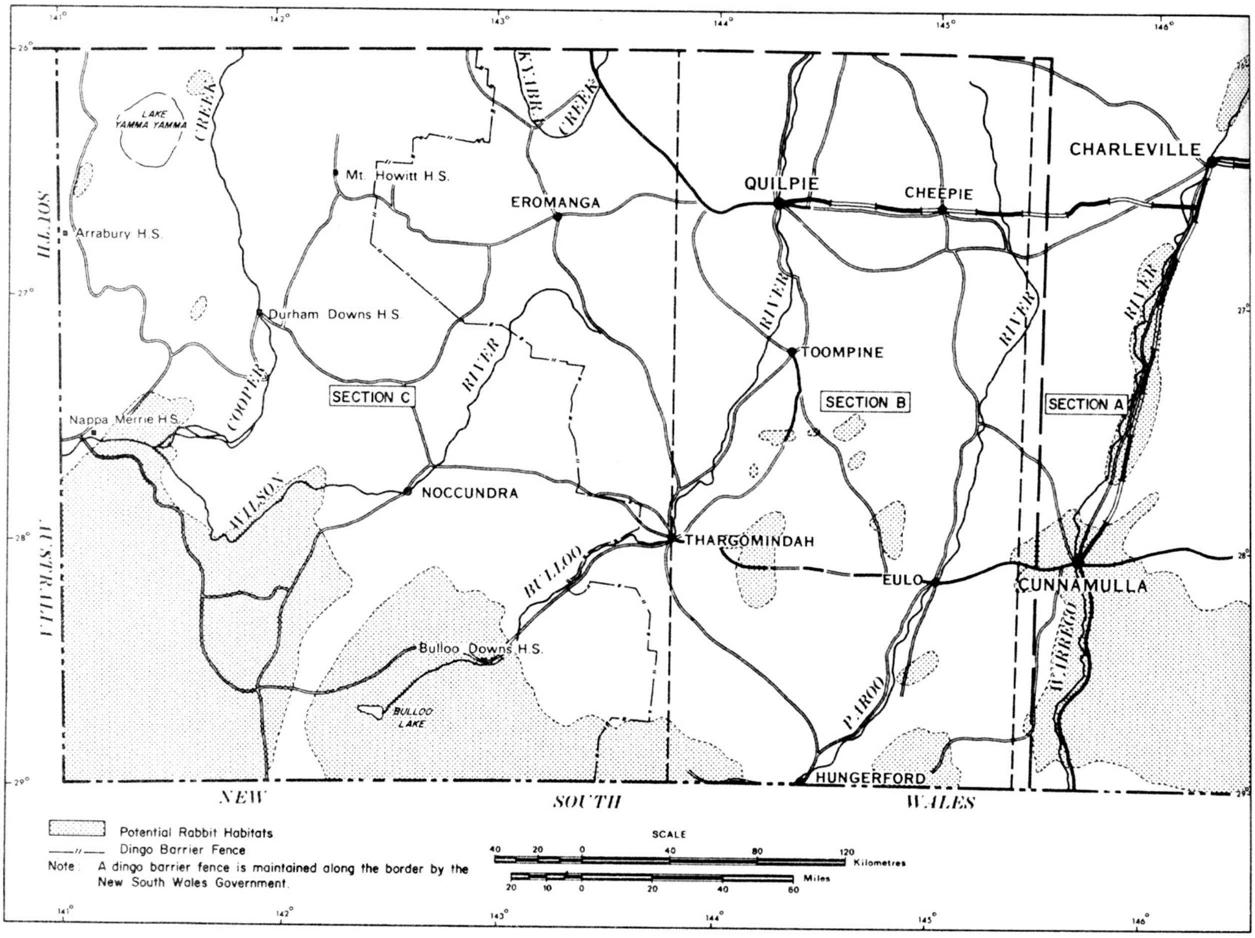


Fig. 9.1. *Potential rabbit habitats.*

The danger time is when a drought period sets in. Rabbits which have built up during previous good or average years, rapidly eat out all feed available. In the 1965 drought, rabbits were low in number, but were sufficient to quickly eat out the relatively small amount of feed which grew on the sandy areas following showers.

Many areas of sand now support only burrs. This may be a result of the constant and close grazing of desirable species by rabbits.

In the Warrego River to Thargomindah section (Section B) heavy and extensive infestation is evident on the following areas:

(a) Rockwell/Blue Lakes area of approximately 20 000 ha of sandy soil;

(b) Dynevor Lakes area of approximately 4 000 ha of sand and

(c) Bundoona Holding and adjacent scattered areas, about 2 000 ha on loamy soil.

Damage in these areas is similar to that in Section A. Other small and scattered infestations occur throughout this section but do not cause any great economic harm.

A survey of the Thargomindah west to the South Australian Border section (Section C) is incomplete but it is estimated there are 18 000 km2 of sandy country which may be subject to heavy infestation. Numbers vary considerably. Very few survive a severe drought, but they build up to plague proportions following two or more good years. In recent years a plague has occurred about every third year.

Because rabbits are still in relatively low numbers, little damage appears to be done in the first "good" season following a drought. The danger time is when feed starts to "dry off" after two or more good years. Rabbits, by then, are in plague numbers and rapidly eat out the ground vegetation.

In 1969, when drought was setting in, some showers did fall on the stations in the far south-west. The graziers concerned moved their cattle to take advantage of the fresh feed, but in all cases it was reported that rabbits had eaten out the country before the cattle arrived.

It is difficult to assess just how much feed rabbits eat. As a guide figures from Bulloo Downs Station are quoted. In the early 1960's, 256,000 pairs of rabbits were trapped (or shot) in one year. If it were assumed that 100 rabbits eat as much as one beast, 256,000 pairs would eat as much as 5,000 cattle. When it is realised that the rabbits caught represented only a portion of those living in the area, then the damage done is obviously considerable.

One story, often repeated by graziers, is that in the old days when rabbits were more numerous, they would, when feed was scarce, ringbark the sandalwood. Now, sandalwood is becoming a problem. This story takes no regard for the fact that when rabbits are in large numbers they destroy all other edible vegetation as well.

Pigs

Wild pigs are widespread, but occur mainly on, or near, the wooded alluvial plains, lignum swamps and drainage lines. They cause considerable damage to fences and to some extent pastures. In 1973 large numbers were present in Western Queensland. At present it seems control is impractical. Control would require a concerted effort by Shire Councils and landholders and costs would be considerable.

Anson (pers. com.) notes that individual killer pigs can kill twenty or more lambs daily. Table 9.4 provides details of the number of pigs on which bonuses were paid over the period 1956-70 for the three major shires.

Table 9.4. Pigs destroyed for which bonuses were paid 1956-70.

Paroo	Quilpie	Bulloo
74906	59521	4774

Dingoes

Dingoes are a serious menace to all sheep properties along the western Barrier Fence. They have been known to lower lambing percentages by 50% in the Eromanga and Thargomindah districts, and it has been found impossible to breed successfully in dingo infested country. Table 9.5 contains data on dingo destruction in three shires over the period 1956-70.

Table 9.5. Dingoes destroyed for which bonuses were paid 1956-70.

Paroo	Quilpie	Bulloo
176	12575	46023

Source:- Stock Routes and Pest Destruction Branch, Department of Lands.

Kangaroos

Following are the number of kangaroos harvested for skins and meat from the study area during 1973.

Table 9.6. Kangaroos harvested for skins or meat 1973.

	Paroo Shire	Quilpie Shire	Bulloo Shire	Total
Grey kangaroo	23,994	57,962	157	82118
Red kangaroo	8,852	29,515	7,815	46182
Wallaroo	213	1,171	nil	1384

Kangaroos are protected under Queensland fauna conservation laws and cannot be declared pests or vermin under any other statute. Their numbers fluctuate enormously from season to season. During drought periods kangaroos compete with domestic stock for available feed and thus assume "pest status" in the eyes of the landholder.

The commercial kangaroo industry, which is rigidly controlled, skims off surplus kangaroo populations. The State Fauna Authority uses this as a management tool to ensure the survival of the species in harmony with grazing animals.

Wedge-tailed eagle *(Aquila audax)*

Anson (pers. com.) considers that this bird is predominantly a predator of kangaroos, birds, lizards and rabbits. He considers that this bird has scarcely any adverse effect on the sheep industry and that continued persecution of this native predator is unwarranted. This is supported by data present in a review by Morris and Fox (1971).

Locusts

Both termites and locusts are a natural part of the south-west Queensland ecosystems, but outbreaks resulting from rapid population build-up can cause havoc and considerable loss of income to graziers. Large populations of locusts developing in western Queensland during late summer or early autumn can pose a threat to the more intensively cultivated lands further south.

The Australian Plague Locust, *Chortoicetes terminifera* has a great capacity for rapid increase. It has a potential of 35 to 50 fold for swarming populations and 55 to 80 fold for non-swarming populations in one generation. Swarming populations usually have two generations per year depending on climatic conditions (mainly in the months September to April). Higher counts are obtained in areas with green feed.

Oviposition is favoured in sites of sparse vegetation in loose soil. Outbreak areas occur where oviposition habitats are adjacent to food-shelter habitats. Most of these centres are produced as a result of a combination of severe droughts and damage due to trampling by the passage of stock, to and from watering places, and on stock routes (Clark, 1947). Rabbits have undoubtedly played an important part in facilitating soil erosion, thus rendering considerable sections of the country favourable as oviposition habitats.

Fluctuations in number between 1964-67, in the "channel country", suggested that marked increases in populations were associated with the occurrence of widespread and well-timed rainfall. Marked declines followed severe droughts (Clark, 1969). In order to undertake sustained flights, higher humidities than those generally prevailing in locust areas are required. For this reason there is an association between storms and night flights, provided the threshhold temperature for flight (21°C) is exceeded.

The plague locust prefers grasses as food. However, when the gut contents of 10 specimens in the Trangie areas were examined by Clark (1969a), the material consisted of 42% wheat, 38% *Diplachne fusca* 10% *Hordeum leporinum*, and less than 1% *Bassia* spp. and *Danthonia linkii.*

To date, little has been done to control locusts in these areas. Due to the vastness of the area control measures would be both difficult and costly.

Termites

Several genera of termites are represented in south-western Queensland. The different species may show different dietary preferences in obtaining their cellulose (usually wood, grass or debris). Such diets are not necessarily restrictive and can vary widely according to availability (Watson *et al.*, 1973).

Data on population are few. Watson and Gay (1970) estimated there were 350 subterranean *Drepanotermes* mounds per hectare during "outbreak" conditions, south of Eulo, between 1947 and 1956. These red earth ridges were originally dominated by mulga but density has declined through settlement, with a consequent increase in grass growth. Apparently termite populations build up in favourable seasons. Small colonies bud off established nests. With the onset of poorer conditions, the effect of the larger populations is really felt. This continues until such time as the population decreases under the adverse conditions. The nests can occupy up to 20% of the soil surface in dense infestations, the hard cap impeding water penetration and seed lodgement. The biomass of termites in pastures in drier areas may at least equal that of the grazing stock (Anon. 1971).

Plant nutrients may be tied up in the mound for a long time. Mounds of *Nasutitermes triodiae* may contain 60 tonnes of soil per hectare. Although these contain only 2% of available topsoil, the mounds lock up 5% of its nitrogen and phosphorus, 9% of its available calcium, 13% of its available potassium, and 22% of its available magnesium.

Drepanotermes perniger can commonly remove up to 100 kg/ha of material annually, most of it in a dry form. This must be regarded as normal re-cycling to the nutrient pool of the soil (Watson *et al.*, 1973). However, in poor seasons, the removal of this material lowers the supply available to stock, enhances erosion, and lowers the potential regenerative rate of the grasses involved.

The consumption of grass and forbs by termites near Alice Springs does not interfere directly with cattle grazing, but the relationships among termites, on mulga in south-western Queensland have led to unstable conditions (Watson *et al.*, 1973).

Termites and seed harvesting ants in this area have mainly been recorded on red earths, sandy red earths and earthy sands. Mounds are generally low and have a variety of different shapes. Again there is no economic method of control.

EROSION

In arid lands the susceptibility of soils to erosion is determined by many factors. These include the soil type, associated vegetation type and cover, disturbance to vegetal cover, disturbance of soil, slope and slope length. The degree is determined by the intensity of disturbance and grazing level and the nature of the rainfall. Throughout the field survey, records were kept on susceptibility to erosion, and the degree of erosion on the major soil types. These results indicate that 39% of sites were not susceptible to water erosion and 56% of sites not susceptible to wind erosion. Some 22% of sites were susceptible to sheet water erosion and 19% subject to sheet and shallow gully erosion. Only 13% were susceptible to gully erosion. Twenty-five percent of sites were susceptible to having part of the A horizon removed by wind erosion and 17% a major part of the A horizon removed. Only 1% could be regarded as having all the A horizon blown out by wind.

Table 9.1 shows the susceptibility of the land systems to the different types of erosion and the conditions of these lands.

In Western Queensland many people have commented on erosion in the area but few investigations of the extent and degree have been conducted. Skinner and Kelsey (1964) studied erosion in the mulga country and concluded that evidence indicated that parts of the mulga country have been subjected to serious accelerated sheet erosion. They also noted that the local alluvia exhibits scald and gully erosion. The Soil Conservation Service of New South Wales has for many years been investigating and documenting erosion effect and control measures in western New South Wales. Much of this information is relevant to Queensland and this experience has been utilized for this report.

Soil erosion in arid lands causes a two-fold problem, nutrient erosion and poor soil physical condition which results in reduced capacity for water infiltration.

Charley and Cowling (1968) have shown that not only do arid soils tend to accumulate the major plant nutrients in the surface soil but also the poorer soils tend to have a greater proportional accumulation in the surface. This is also borne out by soils data obtained during the survey (see Soils Chapter). Any loss of surface soil will significantly reduce the nutrient and organic matter store and subsequent affect plant establishment and growth.

Burrows (1972) indicates that over half the phosphorus requirements of plants of *Eremophila gilesii* could be provided from the organic pool. The loss of this store through fire or erosion of the surface soil, coupled with low phosphate levels in the remaining soil, may result in phosphate levels inadequate to support desirable plant species.

The loss of the 0 to 10 cm zone over 1 hectare of a red earth soil would result in the loss of 450 kg of total phosphorus, or 18 kg of available phosphorus and 1,080 kg of nitrogen. Not only does this represent the major part of the available nutrient pool (20% of the available phosphate is in the top 10 cm of a 120 cm profile), but this involved a value of $314 to replace the nitrogen and $75 for the total phosphorus or $4 for the available phosphorus per hectare at early 1974 costs. The probability of replacement of these nutrients under present conditions is extremely low.

The loss of this surface soil and organic matter may also lead to poor soil physical conditions of the eroded soil surface. This reduces the capacity for water infiltration, increases runoff and reduces the incidence of plant germination and survival.

Soil erosion and deterioration commonly follow drought, excessive rainfall or excessive grazing pressure and associated grazing management practices. Rabbits and plague locust may also significantly influence grazing pressure. The first two factors are natural processes and natural regeneration will follow. Once accelerated soil erosion commences due to combinations of these factors, a cycle commences which make reclamation difficult, unless it is arrested in the early stages (see Figure 9.2).

DROUGHT AND/OR EXCESSIVE RAINFALL + OVERGRAZING OR POOR MANAGEMENT PRACTICES

↓

SOIL EROSION

NUTRIENT EROSION → PHYSICAL CHANGES

LESS VEGETATION AND COVER ↔ MORE RUN-OFF

LESS LITTER → LESS ORGANIC MATTER

Fig. 9.2. *Erosion cycle.*

This will result in excessively low surface nutrient levels, bare surfaces, less desirable plant species and finally reduced grazing capacity with lowered drought tolerance.

Scalds, claypans and saltpans

Hubble and Reeve (1971) uses the term claypan to cover scalds, claypans and saltpans. In this report the term "scald" is used to describe those areas which are bare because of wind and water erosion. Claypans are areas (sometimes scalded) with hard, massive surfaced, soils, predominantly clayey. They are associated with dunefields, alluvial clay plains and playa lakes.

The term saltpan has been applied to soils with loose, puffy, surface soil containing visible salt crystals. They commonly have a surface crust which is easily broken.

All these soils have poor infiltration rates caused by the poor soil surface characteristics.

Natural claypans and saltpans may be bare or have a limited plant cover of adapted species such as swamp canegrass and samphire. There is little point in trying to change soil conditions in these locations. They are frequently seasonally inundated and serve as a source of temporary surface water.

Scalds are most commonly developed (a) on clay soils and texture contrast soils found on the backslopes of level or broad drainage plains and (b) on texture contrast soils occurring on local alluvial plains. The extent of development of these areas varies according to seasonal conditions. Some apparently degraded areas may be reclaimed naturally following inundation by flood water. Others are more permanent. Following detailed studies of this phenomena in Western New South Wales, Jones (1966, 1967, 1969) and Newman (1966) showed that ponding of water on these areas will in most cases lead to reclamation.

The affected areas may vary from year to year and frequently the less eroded areas may vegetate to a limited degree in good years but then revert to a scalded area in a period of poor years. It is suggested that reclamation on some of the texture contrast areas may be more difficult than on the clay plains. Reclamation of these areas, whilst not being economic at present, may need to be a condition of new expanded leases so that further spread of these types of erosion is avoided.

Hubble and Reeve (1971) points out that reclamation will be difficult when (a) the surface contains insufficient clay to facilitate cracking, (b) particle size grading is such that total porosity is low, or (c) a high degree of sodium saturation produces a surface seal of dispersed clay when the flocculating effect of salts is removed.

Jones (1969) found that those scald areas which were easiest to reclaim had the lowest soluble and exchangeable Na, the highest exchangeable Ca and the lowest pH. Indications were that scalds with a sand content of 50 to 70% appeared to be more difficult to reclaim than those with lower levels of 40 to 50%.

Sheet erosion

Sheet erosion, the most common form of erosion in the area, occurs naturally on most land types. Accelerated sheet water erosion frequently occurs in association with wind erosion. It affects all the sloping land types, to some degree. Sheet erosion may be associated with bare surfaces, high intensity rainfall or high winds.

A feature of the area is the high run-off rates of the lithosols and shallow red earths on the dissected residuals and gently undulating plains. Runoff from the dissected residuals usually follows the established drainage lines, while run-off from the shallow soils, on gently undulating plains, commonly spreads across these plains and causes erosion when the soils are bare.

The effects of sheet erosion has been most destructive on the soft and hard mulga lands and the mulga sandplains. Exposure of old roots is common on many degraded areas in these land zones. This is a result of the interaction of both wind and water erosion. It is exaggerated near watering points. In addition to the loss of nutrients, the soils may have a polished scalded appearance. This occurs on the sandy red earths as well as on the loamy red earths. Newman and Condon (1969) suggest, that in mulga lands, the bare areas between the mulga were originally small but have increased as erosion proceeds thus leading to a vicious circle of less vegetation, less nutrients, less moisture penetration, and even less vegetation. The vegetated islands get smaller and smaller and in some cases disappear.

The particularly badly eroded areas may be related to reduction of the vegetation to such a low density, that little resistance to wind and water erosion is offered. Where this occurs, the situation worsens at an accelerated rate. This is more pronounced on the loamy red earths than the sandy red earths.

Rill erosion following sheet erosion has been observed on many land types including the dunefields.

Sacrifice areas are common near watering points, yards and along stock routes. It is in these places that sheet, wind and water erosion have caused damage to other land types.

Gully erosion

Gully erosion is most commonly associated with texture contrast soils on local alluvia. It is most noticeable on the upper catchment of the Paroo and Bulloo Rivers and the tributaries of all of the major rivers. It is also a feature of some areas of the clay alluvia and frequently is associated with stock routes and roads. Once gully erosion is established in arid lands, it is very difficult to control. Some thought should be given to establishing the extent of this form of erosion, with a view to control. Whilst this may not appear economic in the short-term, the long-term benefits may justify expenditure of money.

A menacing feature of gully erosion is that once a new erosion gradient is established, it will gradually eat its way back across the productive alluvial plains and run-on areas which are the backbone of production in the area.

Flood erosion

The alluvial plains of the major rivers and tributaries are subject to flash flooding. This flooding may result from isolated storms or major falls on the high run-off areas of the upper catchment. Most of the catchments have a large proportion of dissected residual land systems which comprise mainly lithosols.

As a result of this flooding, quite serious erosion may occur on some of these flood plains, even though slopes are extremely low. This is particularly so in the upper parts of catchments. In the short-term this may result in a considerable loss of productivity, due to loss of nutrients. There may be some compensation on the more fertile soil types due to added soil moisture. The eroded fine particles are deposited further down the catchments in local basins as most of the streams have limited outlets.

Dunefield wind erosion

Dust storms are a regular feature of the south-west corner, with claims that much of the dust originates west of the Queensland border. The dunefields and sandplains are the natural result of aeolian movement of sand and contribute to these dust storms. During droughts the dunes become extremely bare and windblown. However, dust also originates from loosened soils on the alluvial plains and the undulating plains.

Due to the time limit of the survey and the lack of data available, it has been difficult to establish the seriousness of wind erosion in the dunefields, other than on those sheet eroded and and scalded areas. In the dunefields in the far south-west, it is difficult to see how wind erosion could be controlled, except by complete destocking of the area once a certain level of defoliation had occurred. In this regard spinifex is of value. It maintains the areas it has colonized in a remarkably stable state. In the spinifex areas the sands on the mobile crests of the dunes have always been susceptible to movement, although only over short distances.

Erosion products from sand-dunes and sandplains may encroach on to adjoining land systems and in these places degradation may occur due to surface soil changes and/or sand blasting. This is not extensive in the area.

There is plenty of evidence of degradation and erosion in dunefields where areas have been subject to severe overgrazing or burning, followed by overgrazing. This is evident even in the spinifex hummock grasslands where due to drought, fire or grazing pressure, a bare surface has resulted. This should be avoided in the area. Many of these examples adjoin watering points and the "channel country" and may be considered as sacrifice areas.

The dunes supporting spinifex hummock grasslands are more stable than those supporting woollybutt grass and forbs as the latter tend to be grazed down in drought, whilst the spinifex is less palatable. It may die in drought.

Associated with Bulloo Land System, and a number of other alluvial land systems, occur a series of eroded low dunes which may extend on to scalded areas and alluvia. In places, where these low dunes are overgrazed, they may encroach on to the floodplain and cause an increase in the scalded area.

Other factors causing erosion

It is considered that the predominant cause of accelerated soil erosion in the area is the excessive reduction of cover and trampling which is associated with overgrazing by commercial animals.

Rabbits, although not present to the same degree as in New South Wales, have been present in considerable numbers in South West Queensland. Where populations have been high, vegetation has been reduced and predisposing erosion conditions have been created. In water courses, pigs by their digging habits have also started erosion, but this has not been shown to be serious.

Termites have been shown to reduce cover, cause hardening and denudation of the soil surface. They cause severe erosion particularly in mulga lands. Watson and Gay (1970) considered that not only was the severe erosion near termite mounds due to the termites, but also it was attributable, in part, to the reduction of the mulga itself. Had more mulga remained, the termites would have gathered the relatively abundant mulga debris during drought, thus easing pressure on the grass tussocks.

Serious erosion has also been caused by the activities of man in the area. Shrub and tree destruction, associated with clearing and destructive lopping of mulga and other fodder trees for drought feeding, is a major contribution to soil erosion in the mulga lands. The pulling of mulga may not only reduce the drought carrying capacity of the land, but also reduced nutrient cycling and protective cover. It is accepted that in the east, mulga and other fodder trees may be reduced to increase ground cover and productivity. Everist (1949) considered that a tree density of 175 trees/ha would maintain a balance between maintaining adequate drought reserves and ground forage production. However, Beale (1973) shows that this tree density still depresses ground forage yields.

Burrows (1973) considers that mulga regeneration and establishment is not a problem except where excessive stock pressure is applied. The management policy in relation to fodder trees and shrubs on the harder country should aim at the maintenance of 175 trees/ha. This is particularly so west of the Paroo River.

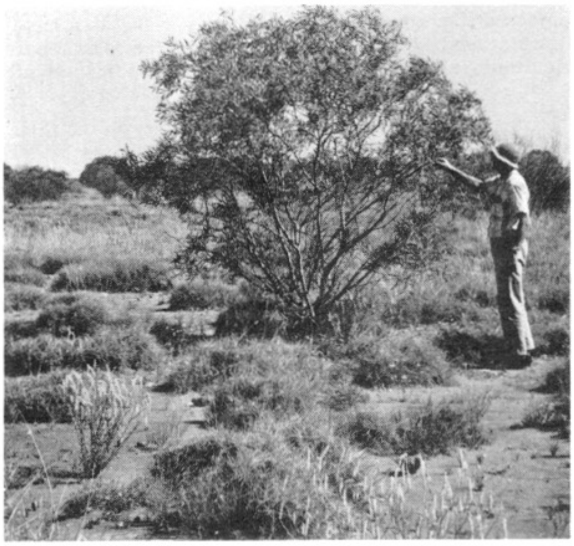
The possibility of strip clearing, a practical solution to maintaining windbreaks, drought fodder and productive grass areas needs closer investigation particularly in the denser mulga areas.

The location of roads, stock routes, gates and watering points have all had a noticeable effect on soil erosion. The location of these on the less erodible soil types will reduce but not completely eliminate these problems. Much damage has been caused in the area by the continual relocation of tracks, rather than the construction of adequately defined roads. The advent of road transport of stock has removed pressure from stock routes. Some of these areas should be grazed lightly as they can be a source of erosion, which affects adjacent land. The location of watering points near or in clumps of trees will assist in the reduction of erosion.

Erosion control and prevention

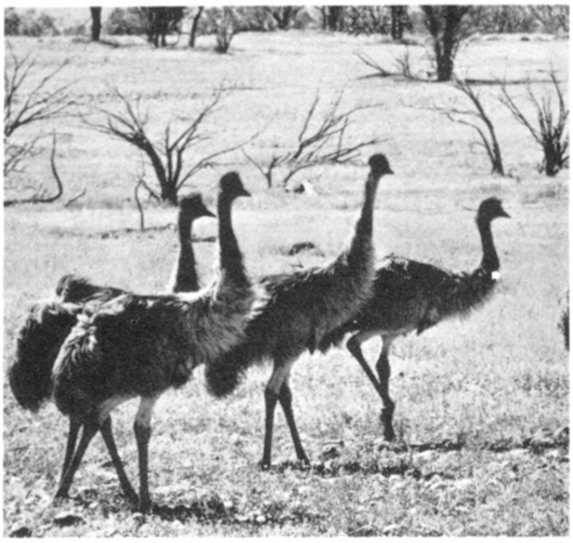
The basic resource in Western Queensland is land. Any degradation of this resource will lead to changes in human populations and reduced economic return from the area. With future demand for food and fibre products likely to increase, it is essential that the productivity of the area be stabilized within the capacity of the renewable resources of the area. The potential for increased productivity by such means as improved pastures and fertilizer practices in dryland arid areas is much lower than for the higher rainfall areas. There are many fields, however, where efficiency could be improved by management techniques. Future potential of the area is not easily predicted. For example it is possible that irrigation could be practised, using poor quality water on the large area of suitable soils, under changed technology and a different economic situation. Because of the unpredictability of markets and technology it is even more important that these areas be maintained in a productive state.

Historically, arid lands throughout the world have been subject to pressures which have led to degradation and loss of productivity. Most of these changes have been the result of lack of control over stocking rates or management practices. The history of intensive use in Western Queensland is only just over a century but already signs of



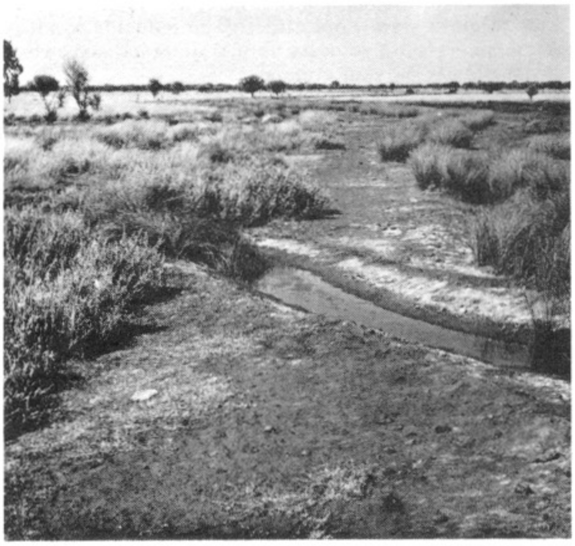
Spinifex stabilizes the more western dunefields. Growth between hummocks provides the most useful forage although seedheads of spinifex are grazed.

Inadequate siting of roads, tracks and watering points, together with overgrazing has lead to erosion of some productive local alluvial areas. Reclamation is difficult.



Wildlife populations fluctuate with seasonal conditions sometimes reaching plague proportions at the onset of seasonal declines.

Where mulga densities are high, some thinning may be desirable to increase productivity of the ground layer.



Bore-drains are used to distribute stock water over large areas avoiding stock concentrations at one point. Water use is, however, inefficient.

Excessive cutting and breaking of mulga in drought periods may lead to serious soil erosion and degradation of the pasture.

degradation are present in the mulga country and along river and creek frontages. In the national interest it would be wise now to implement programmes of reconstruction and land management which will lead to maintenance of the land resource and secure long-term productivity.

This study provides a systematic description of the land resources of the area. Present practices in the area have been assessed and means of maintaining the productivity of the different land types have been investigated. The report serves not only as a basis for the development of an effective agricultural research and advisory programme but provides resource data for use in the redevelopment of the area.

It has to be recognised that control measures which might be implemented now to maintain productivity in the area may not necessarily provide high economic return. However, if these programmes such as gully stabilization and vegetative cover maintenance are not implemented long-term stability and return will be prejudiced. Soil erosion is a process which is occurring naturally in arid land. However, as Condon, Newman and Cunningham (1969) point out, there is considerable difference between the gradual removal of soil from bare spaces into adjoining vegetated areas and the violent removal which takes place once an accelerated erosion cycle is commenced.

In a study of erosion in mulga areas Skinner and Kelsey (1964) considered that the answer to erosion lay in mechanical measures as well as through stocking restrictions. Roberts (1972) considers that more emphasis should be placed on grazing management than on mechanical measures of control. Probably a combination of both these factors will be necessary, according to the nature of the erosion and what is regarded as an acceptable level of loss from erosion.

It has been shown that the maintenance of ground cover is essential to reduce soil erosion. This means a level of stocking management which provides for a basic vegetative cover on the soil.

One of the biggest management problems is to devise a practicable system which allows sufficient flexibility in stocking rate to achieve this degree of vegetative cover and soil protection.

In Australia the most work on erosion control and prevention in arid areas has been conducted in New South Wales. The north western areas of New South Wales are similar to adjacent areas in Queensland.

The New South Wales Soil Conservation Service has placed emphasis on the adjustment of grazing capacity to safe grazing levels. Reduction of stock number under drought conditions is essential. This is considered to be the most logical way of containing degradation, providing adequate control can be maintained and leaseholders observe the property grazing capacities. This in itself will not completely arrest degradation as management itself will play an important part. Where degradation has occurred, because of soil erosion, it may be necessary to employ more conventional mechanical measures to bring the situation under control.

These processes need to be done at the property level, so that a whole programme of control and management may be planned in relation to the characteristics and condition of each land type.

Mechanical means of controlling both wind and water erosion have been employed in western New South Wales. Practices, such as short contour furrows, waterspreading and pondage banks, pitting and ripping, have lead to varying degree of success depending on soil type.

On sheet eroded, hard mulga lands at Cobar, Cunningham (1967) has shown that closely spaced, short, contour banks together with a spelling period can reclaim these types. Natural regeneration of plants occurs firstly in the furrow. Best results were achieved with a horizontal interval of 1.5 m between furrows, the break being staggered and the soil being thrown uphill with the ends turned up. Crossing of gullies should be avoided.

Pitting and ripping are processes which have been used in most arid areas of Australia and the United States. However, results of trials indicate that pitting is not as effective as ripping on most land types. The advantage of pitting is that it does not require levelling. Results on different soil types are variable. Both pitting and ripping tend to slake over quickly and their effectiveness is thus reduced over time.

In the Northern Territory, pitting and the use of introduced grasses, with applied fertilizer, has been most effective in reducing erosion on areas in the vicinity of Alice Springs. Whilst agronomic practices such as plant introduction, fertilizer application, furrowing and pitting may not be economic now, there are many areas where they may need to be applied to prevent further erosion elsewhere. To this extent such measures may be likened to the cost of an insurance premium.

Cunningham (1973) states that waterspreading can be used to control erosion, upgrade depleted pastures, establish improved pastures, reduce stock losses, aid management and produce grain and pasture seeds. Cull (1964) has shown this practice to be effective in Western Queensland. An important point made by Cull *op. cit.* is that where waterspreading is used in arid lands the carrying capacity of the property should not be increased. The main values of theses areas is for drought relief and as a means of improving management at joining and lambing. Batianoff and Burrows (1973) point out that shrub invasion may be a problem on these schemes - a factor which management needs to take into account.

The control of wind erosion is basically a matter of providing ground cover. Stannard (1959) has shown that the type of cover is as important as the actual cover. He found that good stands of grass were more effective in reducing wind erosion than upright saltbushes. Shrubs such as oldman saltbush will decrease wind velocity up to a distance somewhat greater than their own height, but they need to be in dense stands to completely prevent erosion.

On soils susceptible to wind erosion Marshall (1972) considers that if the value of the average distance between plants, divided by the massive height, exceeds 3.5 then a potential erosion hazard exists.

Cunningham and Walker (1973) point out that shrub cover alone will not necessarily prevent soil erosion, particularly on slopes which have a predisposition to erosion. In such locations, grass or other ground vegetation is required to ensure soil stability.

In badly scalded areas it may be necessary to first improve the environment for plant establishment to prevent further erosion. To do this, structures such as pondage banks have proved most successful.

The use of soil conservation structures in arid lands is not without problems, particularly on the texture contrast soils and soils with high exchangeable sodium in the subsoils. The soils are susceptible to piping which could create greater problems. Perry (1972) has also warned, from experience in the Northern Territory, that water retention on typically run-off areas will reduce the productivity of run-on areas. In some cases this may not be compensated for by increased production on the area where water has been retained.

Plants and soils are associated in a delicate balance in arid areas. The reduction of plant cover on the more erodible soils may lead eventually to severe degradation, which may be difficult to reclaim and in fact may never be reclaimed. For this reason the maintenance of the delicate plant/soil relationship is the most desirable form of erosion control.

Considering the advances already made into soil erosion control in parts of both New South Wales and the Northern Territory it is suggested that independent research on soil conservation measures may not be the best use of our limited resources. Translation of current knowledge into practical measures is an important task for extension workers in the area. Present numbers are inadequate for the task. Demonstration on the reclamation of degraded areas, not economically feasible to control in the short-term, but which prevent further destruction, could be valuable as a measure having longer term benefits.

The control of erosion on leases in the area is primarily the responsibility of leaseholders. When conservative stocking rates and management policies are defined, determination of property size follows. Properties too small to allow a desirable system of stocking and grazing management necessarily require re-structuring. This is a task for land administrators.

Although the leasehold system of tenure, as described elsewhere, is considerably more flexible than freehold, there remain fundamental issues of land resource use in arid environments which merit attention. As a generalisation, the producer in the arid areas of Queensland has less opportunity to benefit from advances in technology than has his counterpart in the climatically more favourable and less remote eastern areas.

In most rural industries costs beyond the control of the producer tend to increase faster than the return from his product. Hence the primary producer is under constant pressure to improve efficiency in order to maintain his relative place in society. Because of the limited opportunity a producer in this area has to increase efficiency of units of output, the total output becomes of relatively greater importance. This places emphasis on flock or herd size and hence property size. A suitable tenure system is thus one which permits periodic adjustment to property size in such a way that competent managers, whether or not they be owner/operators, obtain sufficient rewards to induce them to stay. It will be evident from this study that a competent and enlightened manager is indispensable if society is to obtain the benefits from the use of the resources of these lands.

Other factors affecting use

Pebble and stone accumulations mainly derived from the silcrete mantle may severely impede grazing by stock and mustering by horses. Where the stone becomes boulder size on the steeper slopes the land may become useless to commercial grazing animals. It has been found by some workers, notably Williams (1973) in the Northern Territory, that the stone or pebble cover on the soils may reduce erosion losses and assist in water penetration. While this does occur in some cases, there are also examples where the stone has increased run-off due not only to the stone cover but the pavement surface associated with the stone. In these situations a thin, hard crusting surface may bridge the stone restricting penetration due to decreased cracking and permeability. This is frequently associated with the desert loams. Gilgai microrelief, in these situations, may reduce moisture losses due to run-off and also prevent erosion.

Gilgai microrelief may be an asset providing a store for moisture which might otherwise run-off. On the stony downs where depressions are commonly small (less than 30 cm) these areas support much of the bulk of the pasture and allow the survival of many of the more important species. On the flat plains where they are well developed (greater than 30 cm) gilgais may also serve as temporary stock waters for short periods.

Perry (1972) states that run-off, run-on systems occur at all scales (microtopographic, local, regional and larger) and is a very important factor in the productivity of many Australian arid zone ecosystems.

Groving of mulga, particularly of the type associated with Berella land system, where noticeable depressions occur, also allows better use of water in the grove area than would be possible in the run-off intergrove area.

Flooding is a feature of the streams in this area and much of the production within the area is dependent on run-off from within, and outside, the survey boundaries.

On a small catchment basis the run-off, run-on situation is extremely important, particularly in mulga areas. The run-on areas are commonly flat, lacking defined drainage lines. They are interspersed among the gently undulating plains, widening with distance from the source. Mott (1973) has shown that species may survive in these more favourable areas during below average years and spread out in the better years. Anon. (1969) indicated that 18% of rainfall may be lost as runoff at certain times of the year from these areas. Goodspeed and Winkworth (1973) also state that run-off from an intergrove area (similar to hard mulga lands) ranged from 16% to 47% of rainfall. This may increase to 80% in a storm.

Where the local drainage lines have their source in steep dissected country run-off is extremely high, due to the limited soil moisture storage of the soils and steepness of slope. The Paroo and Bulloo Rivers obtain most of their run-off by this means. Both have large areas of dissected residual land systems in their catchment and both flood quickly after high intensity rains.

In the lower catchment, slopes decrease, and the rivers, particularly the Bulloo, fans out into broad alluvial plains. The Paroo has a narrow alluvial plain until Boobara, after that it spreads out to a wider flood plain, frequently with backswamps. Below Eulo the floodplain is intermingled with sandplains. Swamps are common. South of Quilpie the Bulloo River fans out into broad floodplains also with seasonal swamps. Below Bulloo Downs Homestead the river spreads into a maze of swamps, salinas and sand dunes. The back swamps serve a useful grazing reserve, their importance being closely associated with their frequency of flooding. Many of the swamps are subject to overgrowth by lignum, which reduces their value. Burning and grazing of the lignum has reduced this problem in parts of western New South Wales.

The "channel country" is best developed on Cooper Creek with smaller areas occurring on Kyabra Creek and the Wilson and Bulloo Rivers. Ogilvie (1947) estimates that during 57 years of recording 5 floods inundated the Cooper floodplain, and eight others irrigated a proportion of the higher level floodplains in addition to serving the channels and swamps. Table 9.7 compiled from a table prepared by Nimmo (1947) indicates during this period twenty-two (22) years were useless for pasture, nine providing feed only in the swamps, while twenty-six (26) years provided useful floods.

Table 9.7. Size and usefulness of "channel country" flooding, based on 57 floods occurring during the period 1890-1947.

Volume	Effect	Years of Occurrence
More than 4 million acre feet (4.9 Ml)	General inundation	5
2-4 million acre feet (2.4 - 4.9 Ml)	Very good	8
1-2 million acre feet (1.2 - 2.4 Ml)	Good	13
0.4-1 million acre feet (0.5 - 1.2 Ml)	Fair	9
0.25 - 0.4 million acre feet (0.3 - 0.5 Ml)	Useful	5
< 0.25 million acre feet (< 0.3 Ml)	Water very little pasture	17

Source: Bureau of Investigations Annual Report (1949).

Howard (1961) considered that the best floods are ones occurring in March and April. These provide good feed which will fatten cattle in 5 to 6 months over the winter-spring period. Improved roads have meant that cattle can be turned off 1 to 2 months earlier from these pastures thus avoiding summer loss of weight.

On most of the rivers there are deep water-holes which provide stock water.

The soils of the area have the ability to dry out well below accepted wilting points. This affects production in that it takes a large amount of rainfall to bring the soils up to wilting point and explains why arid soils do not always respond to initial falls of rain. Rainfall will activate the breakdown of organic matter and make available plant nutrients after droughts. This accounts for the flush of vegetation following a number of good falls of rain not only restoring the moisture balance but releasing soil nutrients from the organic store.

POSSIBLE AGRICULTURAL DEVELOPMENT

Plant introduction

In a similar climatic area, in the Northern Territory, Winkworth (1964) showed that the introduction of exotic perennial grasses such as buffel grasses *(Cenchrus ciliaris)* is limited on the spinifex sands and mulga red earths by phosphorus deficiency, whereas the younger floodplain soils grew stands of buffel grass without added phosphorus. It has been pointed out by a number of workers that phosphorus is important in the establishment stages of these grasses. Cowie (1968) and Christie (1970) showed that in this area phosphorus is the main limiting plant nutrient for improved species. Christie (1970) indicated that 25 ppm available P was a critical soil level for buffel grass. It can be seen from the soil data Table 4.9 that it is the soils developed on alluvial plains that mostly have values which exceed this figure. In many cases these support well developed native pastures. The other group of soils which reach this level of P are some of the red and brown clays associated with the undulating gidgee and undulating downs.

In the autumn of 1963, after good summer rains, Ebersohn (1970) showed that where introduced species, particularly buffel grass, were grown in mulga localities yields of 910 kg were obtained, compared with 545 kg from the native pastures. Comparing buffel grass on poplar box country, yields of 1,270 kg were obtained for those areas without run-on water and 2,540 kg for areas with run-on water. Biloela, American and Molopo buffels were the heaviest yielders.

Mott (1973), Silcock (1973) and O'Donnell, O'Farrell and Hyde (1973) suggest that plant introduction, plant germination and survival are restricted to the more mesic and fertile favourable sites such as run-on areas and where there is a significant build-up of surface mulch.

The Agriculture Branch of this Department is currently concerned with a programme of plant introduction and species evaluation for the area. It does seem that general application of plant introduction to the area will be rather limited, in the short-term, to the more favourable areas. However, the long-term future is clouded by our inability to predict either economic conditions or species suitability. Now phosphate nutrition of the introduced species is a major limitation to their spread. Whilst phosphate fertilizer can be introduced by a number of methods, it is not economic for general use and may be used more efficiently in the more favourable areas. However, the use of fertilizers and introduced species may be important in the reclamation of many previously productive, eroded areas, even though this may not be economic in the short-term.

Irrigation development

The high rates of evaporation, the lack of suitable dam sites plus present economic restraints rule out the possibility of moderate or large scale irrigation development by dams. Underground water use is restricted to household and stock purposes by law.

There could, however, be a future potential for irrigation of special crops in this area. Overseas results indicate that technology may be available for the use of saline water on many of the soils of the area, particularly the deep sandy red earths and earthy sands. The use of trickle irrigation techniques may eventually allow this.

The sandy red earths and earthy sand soils occur on flat plains and could be used for such development. Intense falls of rain occur in arid lands and these may leach any accumulated salts, in these soils, through the soil profile.

Large areas of cracking clay soils of moderate fertility adjoin many large water-holes in the area. Whilst it may be thought that such soils could be irrigated from these storages it is necessary to remember that they are probably more important as stock waters.

The development of areas for irrigation and special crops may be some time off. However, some thought could be given to the likely problems and likely suitable crops by Australian horticulturalists and agronomists, as a precautionary planning measure.

Special crops

In the future there may be a greater need for production of crops such as citrus, pistachios, avocados and other crops which have been shown to grow well in similar areas. There is a need for a programme, on an Australia-wide basis to assess the likelihood of production of this type of crop in these arid areas. Some intensive development of this nature, assuming a high level of management, could assist diversification and stability of the area.

Fertilizer practices

With the exception of some of the grey clay alluvia and the undulating downs all the evidence points to low phosphorus levels in Australian arid lands. Nitrogen levels are predominantly low also.

In arid lands generally it is true to say that the use of fertilizer is not an economic proposition. However, to adequately reclaim eroded areas this may be a necessary cost.

In some areas it may be necessary to use fertilizers to establish pasture species. This is only envisaged in the higher rainfall areas, where water spreading is practical. Work on method of fertilizer application may be investigated.

TOURISM AND RECREATION

The last few years have seen a tremendous increase in the use of the area for tourism and recreation. In a pastoral situation the prosperity and even maintenance of towns is heavily dependent on climate and any development which broadens the income base should be encouraged.

Tourists come into the area from southern States through the Warry and Wompa Gates and Hungerford. Other main points of entry are through Innamincka, the Eulo-Cunnamulla Road, the Charleville-Quilpie Road and the beef road from Windorah to Quilpie.

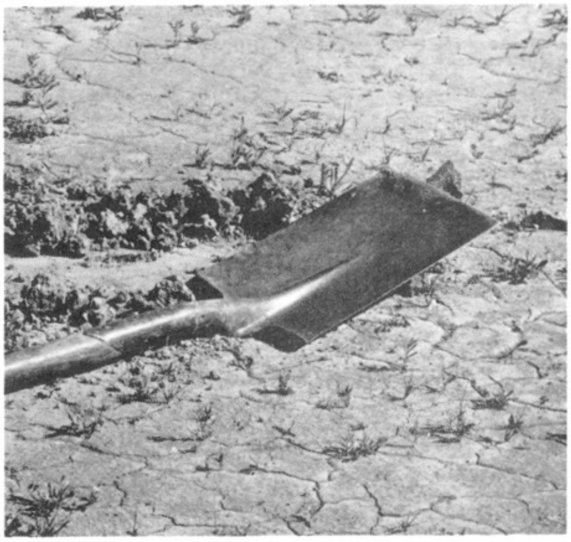
This area has many natural features which will attract tourists as roads and facilities develop. It has scenic grandeur due to its ruggedness and the varied colours of its soils, rock and vegetation. Of particular beauty are the scarps and remnant tablelands, the dunefields, the seasonal lakes and the permanent water-holes.

Native animals are abundant but not always readily seen. Both terrestrial and aquatic bird life is abundant, particularly near watering points. Kangaroos and wallabies are present over the whole area. Emu populations fluctuate and are frequently seen. Reptiles such as snakes and lizards may be sought out be interested persons. The dunes provide an excellent habitat for many types of lizards, hopping mice and desert rats.

The flora of the area can be extremely beautiful either as individual plants or as mass displays. Cassias, eremophilas, hopbushes, western bloodwood and crotalarias are plants which are spectacular when flowering. Others, such as desert gum in a spinifex community, are beautiful in a panoramic context. Mass displays of plants such as yellowtop on the "channel country" and the many flowering species in the dunefields are beautiful.

The stark contrasts of the area are also a feature. For example after flooding it is possible to pass from bare, bright red, soil to a green, field over a matter of metres.

The country was originally rich in aboriginal culture. Aboriginal artefacts are readily observed, particularly in the sandhills, on dissected tablelands and in those areas close to major water-holes. Aboriginal wells may be observed in a number of different situations.



Scalded areas on the soils of the alluvial plains have increased with settlement. Reclamation of these areas is technically feasible.

A heavy invasion of Eulo L.S. by Charleville turkey bush. This reduces pasture productivity and is difficult to control.

Water shed from the intergrove area in Berella L.S. is utilized in the grove area. Even in a 200 mm rainfall zone a bulk of feed is produced.

Sheep graze standing mulga particularly in drought. Overgrazing of the ground vegetation and subsequent soil loss may follow overuse of mulga particularly in drought.

Areas of gidgee woodland suitable for pulling are not widespread. Sandalwood regrowth may be a problem when cleared.

Ellangowan poison bush (foreground) may reduce productivity of the gidgee shrublands. It is also poisonous to stock.

Hunting and fishing attract some enthusiastic people to the area. Kangaroos, dingoes, pigs and wedge-tailed eagles have been the species most commonly shot. Permits and property owners' permission are necessary before shooting can legally be carried out. Yellow-belly fish are the most popular fish caught in the many water-holes on the Cooper and Kyabra Creeks and Bulloo and Paroo Rivers.

A major attraction of arid zones are not only the scenic grandeur but the wide open spaces, quietness and solitude of these areas. To provide this outlet for the growing cities there is a need to plan for parks, trails and camping facilities. Unless controlled to some degree, campers can cause havoc in western areas. Improved camping facilities would provide some means of control.

The area also supports a number of opal mining areas in the vicinity of Eulo, Toompine and Eromanga. The mines not only attract professional miners, but also tourists hoping to strike it rich during extended holidays. The department of Mines will supply to interested persons information regarding mining in the area.

One of the most neglected features of the area are the historical buildings and monuments.

From Charleville and Cunnamulla west to the South Australian border there are many excellent examples of early Australian architecture and innovation. Due to cost of maintenance some are falling into dis-use. These include hotels, property homesteads and outstations.

The "Dig Tree" on the Cooper at Nappamerrie is a monument which will need protection. Already with tourists travelling up to Innamincka from Tibooburra many visitors pass through this site. The tree is on the banks of a large and beautiful waterhole, fringed by coolibahs and well inhabited by bird life.

Other phenomena such as the mud-springs (or mud-volcanos as some of the locals refer to them), in the vicinity of Eulo, attract interest.

Finally, the pastoral industry with its extensive areas for sheep and cattle management is of interest to many city people. In some western areas advantage is being taken of ths interest and some properties cater for tourists, showing them a range of property activities during their stay.

The need for good facilities for tourists in the area is essential. The provision of one or more National Parks and Reserves in the area, together with a resident ranger and facilities along the lines of the New South Wales service at Mootwingee National Park, are needed. The "Dig Tree" on Cooper Creek and the diversity of country in the vicinity to the south and north of this area would be an important first consideration as a proposed Reserve. The development of facilities, at camping areas along the major routes, would assist the development of the Tourist Industry. At present the hotels at Quilpie, Toompine, Eulo, Hungerford, Cheepie, Thargomindah, Eromanga and Noccundra and a caravan park at Quilpie are the only accommodation facilities offering. With the advent of better major roads and the development of tourist facilities it is considered that tourism could contribute significantly to the area, particularly in the light of experience in New South Wales and the United States.

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Conclusions

CHAPTER 10

by N.M. Dawson and D.E. Boyland

1. The basic resource in western Queensland is land and it is essential that land productivity be stabilized

The basic resource in western Queensland is land. Any degradation of this resource will lead to changes in human population and reduced economic return to the area. With future demand for food and fibre likely to increase it is essential that productivity be stabilized within the capacity of the physical resources of the area.

The potential for increased productivity by such means as improved pastures and fertilizer practices in dryland arid areas is much lower than in higher rainfall areas. However, there are many situations where efficiency could be improved by management techniques. Future potential of the area is not easily predicted. For example it is possible that irrigation could be practised, using poor quality water on the large area of suitable soils under changed technology and in a different economic situation.

A land use being proposed for the area in some quarters is that of non-use. Whilst this practice might already be applied to some of the less productive areas it is suggested that most of the land types, properly managed, will continue to produce high quality food and fibre with low inputs of non-renewable resources and very limited pollution.

The unpredictability of markets and technology places emphasis on the importance of this land's being maintained in a productive state.

2. A knowledge of the different land types, and their reaction to use is necessary for property and regional planning

A knowledge of the different land types on a property is invaluable not only to normal operations but also in drought management and reconstruction. This report adds to the existing knowledge of land types in the area and provides the basis on which future land use recommendations can be made.

In this area the most important factors influencing productivity are rainfall and water re-distribution. Other environmental factors such as soil and slope also affect plant productivity. One of the major factors in achieving long term productivity is that of attaining a balance between shrub density and herbage production. Associated with this is the delicate soil-plant relationship in the communities. Gradual or rapid depletion of one variable such as soil organic matter may lead to a partial breakdown in the system and to land deterioration. There is a pressing need for a greater understanding of the effects of environmental factors, and particularly those of soil, on composition of the vegetation and on plant productivity.

3. Most of the land is productive but overgrazing has caused degradation of some land types

Settlement began in the late 1860's but much of the area has been stocked for less than 100 years. This study indicates that even in this relatively short period of use overgrazing has resulted in serious degradation of some land types.

The majority of the land is productive and reasonably stable although considerable degeneration has occurred on the hard mulga and alluvial plain land zones.

The dunefields, which are generally of low productivity, are stable when covered by plant material such as spinifex, but susceptible to deterioration in drought periods.

The mulga sand plains, which are naturally productive, have been degraded where poor management combined with fire or overgrazing has resulted in sheet erosion. The soft mulga is productive particularly where it receives run-on water. In some areas mulga density has been reduced to such levels that deterioration has followed.

The hard mulga lands have been subjected to intensive use in drought periods and as a result condition of this land type has deteriorated over large areas.

The undulating gidgee and undulating downs are productive but productivity and pasture composition fluctuate widely with seasonal conditions. These areas are stable except near drainage lines and gullies, and also where severe disturbance has been caused by inadequate siting of roads and watering points.

The alluvial plains are productive particularly following flooding. Overgrazing has resulted in scald development on some soils, and stream bank erosion near waterholes.

Gully erosion has occurred on texture contrast soils supporting poplar box/mulga in the east and this will be extremely difficult to control and reclaim.

4. Maintenance of high stocking rates in poor seasons is a major cause of deterioration

It is significant that many of the most devastating droughts in this area have followed periods of high stocking rates. Much of the damage mentioned previously has been due to delay in reducing stocking rates early in a drought phase, following a run of favourable seasons when stock numbers reach a high level. This fact, together with other circumstances, has led to over-utilisation of many of the more productive land types and to excessive thinning of mulga.

The area is capable of maintaining present stock numbers in good seasons. However, there is a real need for graziers to be able to considerably reduce numbers in unfavourable seasons. Under present circumstances this would in most cases protect the pasture but may subject smaller graziers to economic hardship.

5. Property sizes are inadequate in the sheep zone. A flexible tenure system is desirable to adjust to market conditions

This study shows that in most cases property sizes for cattle enterprises are generally adequate. However, in the sheep enterprise, more than 55% of the properties have assessed grazing capacities of less than 8,000 sheep. Data reported in this study suggest that numbers in excess of this would be required to generate adequate income levels.

What is a living area in an environment such as this will be highly dependent on markets and costs. In the long term it is essential that property tenure be flexible so that adjustments in size both up and down can be made if necessary. At this point in time there is a need for larger properties, particularly in the mulga lands. In some of the larger beef properties there could be a need for sub-division to allow better management of the areas.

6. It is essential to maintain a balance between topfeed and ground forage in mulga lands

The presence of topfeed has proved invaluable in the past but has also caused managerial problems. The thinning of mulga to densities of 175 shrubs/ha can considerably increase yields of ground forage while still maintaining a balance between drought reserve and ground forage production. Properly managed, these levels should allow adequate recycling of plant nutrients and maintain soil condition.

7. There is a need for a soil erosion control programme

Soil erosion is a major problem in the area and it is considered that the predominant cause of accelerated soil erosion is the excessive reduction of plant cover and trampling associated with overgrazing by commercial animals. The destruction of mulga and other fodder trees for drought feeding is a major contribution to soil erosion in the mulga lands. It not only reduces the drought carrying capacity of the land but reduces nutrient cycling and protective cover. Rabbits and termites have also aggravated the situation in some areas.

It is recognized that erosion control measures which may be implemented now to maintain productivity in the area may not necessarily provide high economic returns. However, if these programmes such as gully stabilization and vegetative cover maintenance are not implemented, long term stability and return will be prejudiced. Translation of the advances made into soil erosion control in arid areas of New South Wales and the Northern Territory is an important task for extension workers in the area.

8. Plant management programmes require definition

The success of current exotic forage species, such as buffel grass is limited to the moist and more fertile areas. In many instances soil nutrient levels will limit plant growth. However the application of fertilizer in the low rainfall areas is not economic.

Woody weeds such as Charleville turkey bush are recognised as a major problem and are generally related to either seasonal conditions or soil disturbance. Grazing management and biological control are the best techniques for controlling woody weeds. Herbicides have limited use because of the costs involved.

Fires have adversely affected the botanical composition of the principal vegetation communities. However, burning under strictly supervised conditions could be beneficial. Burning and wise management may be used to reduce unwanted shrubs, but the timing of burning is critical. Frequent or uncontrolled burning may result in loss of soil nutrients, an increase in soil erosion and the establishment of less desirable species. Its use is not generally recommended but further research is needed.

9. The continual decline in rural population may restrict implementation of desirable management practices

A major problem already facing the area is that of rural labour. There has been a 33% reduction in the male permanent labour force over the 10 year period 1961-1971. The poor infrastructure, more attractive living conditions elsewhere and lower property returns in the pastoral industries would appear to be important factors.

Reliable labour is likely to be a problem until there is a change in social and economic conditions. The current shortage means that difficulties could be expected in implementing management practices involving additional labour. Costs of education, travel and transport are relatively high for people living in these areas. It follows that relatively higher incomes are needed if residents and employees in the area are to achieve a standard of living and education comparable to many dwellers in more easterly areas.

It is evident from this study that a competent and enlightened manager is indispensable if society is to obtain benefits from the use of these lands.

10. Tourism needs encouragement

The value of these arid lands for recreation purposes is only now becoming apparent but the potential is great. There is a need to plan for parks, trails and camping facilities so that tourists can be managed to some degree. In an area where towns rely so heavily on the prosperity of the pastoral industry any development in the tourist industry strengthens the economic base of the community.

11. There is an urgent need for the reservation of different wildlife habitats, soil and vegetation associations and national monuments

At present there are no national parks in the area. The inland lakes are valuable wildlife habitats. There is a need to reserve representative areas of the major land types including mulga; gidgee; undulating stony downs; dissected residuals; alluvial plains and certain dunefield types.

The "dig tree" on Cooper Creek should be declared a national monument and possibly could best be included in a national park as the area surrounding the "dig tree" has an interesting range of land types.

Serious consideration should be given to the maintenance and restoration of examples of early architecture found in the area.

CLIMATE – DATA SOURCES AND METHODS

Data were obtained from the Bureau of Meteorology through the Information Officers at Brisbane, Sydney and Melbourne, and climatic averages from the publications cited in the following summary.

Section	Data Source
Rainfall	
a. Figures 2.1 and 2.2 and Table 2.1	Average monthly rainfall totals for the locations given in the survey area and 30 locations outside the area, for the standard period 1931-60 (Bureau of Meteorology, 1966).
b. Tables 2.2, 2.3 and 2.4 and Figs. 2.3 and 2.4	Daily rainfall (9 a.m. readings) for: Nappamerrie from 1923 to 1968 inclusive Olive Downs from 1905 to 1968 inclusive Thargomindah from 1905 to 1968 inclusive Eulo from 1905 to 1968 inclusive Hungerford from 1905 to 1968 inclusive Quilpie from 1921 to 1968 inclusive
Temperature, radiation and humidity see Figs. 2.5 and 2.6	Mean monthly temperatures and humidities of recording stations. (Bureau of Meteorology, 1956)*. In addition frequency analyses of temperatures over short terms for 8 locations in and near the area. Average monthly radiation (Bureau of Meteorology, 1964).
Evaporation see Fig. 2.7	Monthly totals from an Australian tank evaporimeter at Charleville for 18 years. Monthly evaporation totals for 6 locations in and near the area for less than 5 years based on Class A pan.
Estimated growth periods see Table 2.5 and Figs. 2.8 and 2.9	Daily rainfall (9 a.m. readings) for the locations and years given in the Rainfall section and for another 14 locations in an area adjacent to the survey area (1° latitude, 1° longitude). Weekly values of evaporation calculated from monthly estimates of standard tank evaporation (Fitzpatrick, 1963; Bureau of Meteorology, 1968).
Rainfall intensity see Fig. 2.10	Rainfall intensity analysis for durations of and multiples of 6 minutes and various return periods for 19 years of pluviograph records at Charleville.

Rainfall, evaporation and temperature were converted to metric units prior to any calculations.

The frequencies of wet periods of various durations and rainfall amounts were calculated by programme THOR, written for the CSIRO Cyber 76 computer. Inputs are daily rainfalls in LRFORMAT1. The user defines how wet periods begin and end, in terms of the rainfall received on single or consecutive days. The user also specifies the durations and class intervals of rain received per wet period required in each analysis. Each analysis provides frequencies of 10 specified durations and 6 amount classes for each week, and for any nominated groups of weeks. It also gives class and yearly totals. Any number of analyses are performed consecutively, if the user supplies sets of specifications with any one rainfall input. The programme is efficient, e.g. a run of 72 analyses of the 45 year Nappamerrie record was processed in six seconds, with a chargeable time of 13 seconds.

The selection of rainfall records was based on length of record, the similarity of the calendar years of record at different locations, on the number of missing records, and on lack of other faults, e.g. Mt Margaret and Yarronvale records have an uncharacteristic small number of light falls.

The estimation of growth periods and the frequencies of periods of various durations were calculated by the computer programme WATBAL developed by the CSIRO Division of Land Use Research, Canberra. Rainfall records had to satisfy the same selection criteria for WATBAL as for THOR.

* References are listed in the Climate chapter.

1 See Keig, G., and McAlpine, J.R. (1969) – Instructions for the preparation of daily rainfall data as input to Land Research climate programmes. CSIRO, Division of Land Research, Canberra, Tech. Memo. 69/8.

LIST OF ABBREVIATIONS, SYMBOLS, RATING AND TERMS*

A.D. Moist – Air dried moisture (see Appendix IV)

Av. H2O – Available water (see Appendix IV)

Available Water Rating – Available water %

12.1 – 15	High
8.1 – 12	Medium
5.1 – 8	Low
< 5	Very low

Avail. P (acid) – Available phosphorus, acid extraction (see Appendix IV)

Avail. P (bic) – Available phosphorus, bicarbonate extraction (see Appendix IV)

Available Phosphorus Ratings – Available Phosphorus ppm

Acid Extraction		Bicarbonate Extraction	
< 10 ppm	Very low	< 10	Very low
10 – 20	Low	10 – 20	Low
20 – 35	Fair	20 – 30	Fair
35 – 45	Very fair	30 – 40	Very fair
45 – 100	High	> 40	High
> 100	Very high		

Biomass – Total weight of aerial and underground organs of a plant

C – Clay

Ca – Calcium

CaCO3 – Calcium carbonate, lime

C.E.C. – Cation exchange capacity (see Appendix IV)

Cl – Chloride (see Appendix IV)

Claypan – Areas (sometimes scalded) with hard, massive, surface soil which are predominantly clayey

C/N – Ratio of % organic carbon to % total nitrogen

Condition – The character of the vegetal cover and the soil under man's use, in relation to its potential

Condition Classes –

Condition Class	Description
Excellent	No erosion. Few or no bare spaces. General ground cover greater than 50 per cent. Very high proportion of valuable pasture species.
Very good	No erosion. Some bare spaces. General ground cover greater than 30 per cent. High proportion of valuable pasture species.
Good	Occasional minor sheeting by wind or water erosion with some bare spaces – (10 to 30 per cent). General ground cover 20–30 per cent. 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 per cent). General ground cover 10–20 per cent. Moderate proportion of valuable pasture species.
Mediocre	Frequent moderate sheeting by wind or water erosion (50–60 per cent bare space) with moderate rilling and gullying. General ground cover 5–10 per cent. Moderate to low proportion of valuable pasture species.
Poor	Frequent moderate and severe sheeting by wind or water erosion (60–70 per cent bare spaces) with severe rilling and gullying throughout. General ground cover less than 5 per cent. Low proportion of valuable pasture species.
Very poor	Extensive moderate and severe sheeting by wind or water, or scalding (70–90 per cent bare space) with extensive moderate and severe rilling and gullying, especially on drainage lines and flats.

D.G.C. – Drought grazing capacity (see Chapter 9)

D.S.E. – Dry sheep equivalent

Dth – Depth

Ecotone – Transitional zones between two vegetation types

Edaphic – Conditions of the plant environment that are determined by the physical, chemical and biological characteristics of the soil

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* This is not a complete list of terms but rather a list of terms used which are not adequately defined in the concise Oxford Dictionary.

Erosion Class —

Class 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

Ex. cap — Cation exchangeable capacity (see Appendix IV)

Ferricrete — A ferruginous natural material formed in a zone of iron oxide or hydroxide accmulation in the earth's crust

Floristics — The kinds of species included in a community or a region

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 grass like plants and ferns

F.S. — Fine sand

G.C. — Grazing Capacity (see Chapter 9)

Gilgai — Small scale surface undulations, the alternate hummocks and hollows of which show some degree of regularity

Grove — Clumps of trees or shrubs roughly aligned with the contour forming a banded pattern

Ht — Height

K — Potassium

K Rating — Exchangeable K, m equiv/100 g

m equiv per 100 g	Rating
< 0.15	Very low
0.15 – 0.2	Low
0.2 – 0.3	Fair
0.3 – 0.5	Very fair
> 0.5	High

Crack and Isbell (1970) use value of 0.2 m equiv/100 g each 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.

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

Mobile crests — Crests of the sand dunes. These crests are generally not vegetated except for extremely scattered plants.

N — Nitrogen

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
High	0.25 – 0.49
Very high	> 0.50

Na or Na+ — Sodium

Org C — Organic carbon

P — Phosphorus

PFC — Projective foliage cover

pH Ratings —

Rating	pH
Extremely acid	< 4.5
V. strongly acid	4.5 – 5.0
Strongly acid	5.1 – 5.5
Med. acid	5.6 – 6.0
Slightly acid	6.1 – 6.5

pH ratings (continued)

Rating	pH
Neutral	6.6 – 7.3
Mildly alkaline	7.4 – 7.8
Moderately alkaline	7.9 – 8.4
Strongly alkaline	8.5 – 9.0
V. strongly alkaline	> 9.0

Playa — Deposits of sediments which form ephemeral lakes

PPF — Principle profile form

RP — Representative profile

Run-on area — An area which benefits from run-off water either by the water lying for a period or by water moving over the area.

Salina — Playas on which there are salt deposits.

Salinity ratings —

Rating	%TSS	%Cl
Very low	< 0.05	0.010
Low	.05 – 0.15	0.010 – 0.030
Medium	0.15 – 0.30	0.030 – 0.060
High	0.3 – 0.7	0.060 – 0.20
Very high	> 0.7	> 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.

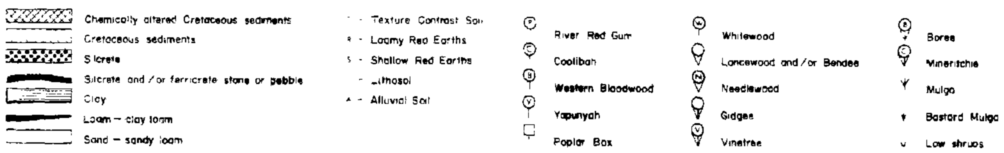
Si — Silt

Silcrete — A siliceous natural material formed in a zone of silica accumulation in the earth's crust.

SMU — Soil mapping unit

Species diversity — An indication of the richness and evenness of the flora of a particular region.

Symbols —



Topfeed — Edible trees and shrubs

Total N — Total nitrogen

Trend — Refers to the direction of change in condition of the grazing land.

T.S.S. — Total soluble salts

W.H.C. — Water-holding capacity

Woody weeds — An unwanted plant with secondary thickening.

ANALYTICAL DATA FOR REPRESENTATIVE SOIL PROFILES

by C.R. Ahern

Dth	pH H2O 1:5	A.D. Moist.	T.S.S. 1:5	T.S.S. 1:50	Cl	CaCO3	Org. C	Total N	Phosphorus Digest	Phosphorus X-Ray	Particle Size CS	FS	Si	C	Ex. Cap.	Ex. Cations Ca	Mg	K	Na	Avail. P Acid	Bic.	H2O 1/3 bar.	15 bar.	Av. H2O	Gravel
cm		%	% Air Dry Weight								% Oven Dry Weight				m equiv./100 g					ppm		%			
A1																									
10	5.0	1.6	0.01		0.002		1.3	0.07	0.032		21	44	10	29	8	3.2	0.5	0.65	0.1	6	7	15	9	6	25
20	4.7	1.8	0.01		0.003						17	42	7	33	7	2.9	0.7	0.4	0.2	5					28
30	4.6	2.0	0.01		0.003						16	38	8	40	7	3.2	0.9	0.35	0.2	4		16	11	5	41
60	4.9	2.7	0.01		0.004						22	25	5	48	5	2.5	1.1	0.25	0.3	3		17	11	6	58
120	5.8	2.8	0.02		0.006				0.014	0.015	14	26	12	50	9	3.0	3.4	0.25	0.5	1					44
A2																									
10	4.9	1.5	0.01		0.002		0.6	0.05	0.021	0.034	19	40	12	32	3-5	2.3	1.0	0.65	<0.1	11	10				
20	4.4	1.6	0.02		0.003						16	41	11	33	5	2.0	0.8	0.75	0.1	3					
30	4.4	1.6	0.03		0.004						16	42	11	35	5	1.9	0.9	0.65	<0.1	2					
60	4.9	1.8	0.01		0.002						16	40	9	37	3-5	1.9	1.5	0.45	0.1	2					
120	5.6	3.3	0.01		0.002				0.013	0.020	13	41	10	37	5	1.9	2.5	0.5	0.2	3					24
A3																									
10	4.1	1.4	0.03		0.006		0.5	0.05	0.015	0.026	11	54	9	28	5	1.1	0.5	0.5	<0.1	6	8	15	NA		8
20	4.4	1.5	0.02		0.002						10	54	9	31	3-5	1.0	0.3	0.5	0.1	2					4
30	4.5	1.5	0.02		0.002						8	54	8	33	3-5	1.3	0.5	0.55	0.2	2		15	7	8	
40	4.9	1.8	0.02		0.002				0.013	0.020	10	50	9	35	5	1.8	1.0	0.4	0.2	3		16	8	8	
A5																									
10	4.9	0.9	0.01		<0.002		0.7	0.05	0.015	0.029	43	37	6	17	3-5	1.4	0.5	0.45	0.2	15	17				
20	4.5	0.9	0.03		0.002						40	38	4	21	3-5	1.1	0.2	0.5	<0.1	2					
30	4.6	0.9	0.03		0.002						38	38	6	22	<3	1.1	0.4	0.55	<0.1	5					
60	4.7	1.0	0.02		0.003						38	38	5	22	<3	0.7	<0.1	0.35	<0.1	1					
120	5.9	1.1	<0.01		0.002				0.010	0.019	33	38	5	27	3-5	1.6	0.6	0.3	<0.1	1					
A6																									
10	5.3	1.0	0.01		<0.002		0.7	0.07	0.037	0.070	41	40	8	15	5	2.1	0.6	0.55	0.1	51	50	11	4	7	
20	4.7	1.1	0.01		0.002						36	44	9	15	3-5	2.4	0.3	0.5	<0.1	59					
30	5.4	0.9	<0.01		0.002						49	32	8	15	<3	2.3	0.1	0.35	<0.1	34		8	4	4	
60	5.9	2.3	<0.01		0.003						29	33	6	32	8	4.7	1.8	0.65	<0.1	45		16	9	7	
120	6.1	2.2	<0.01		0.002				0.048	0.112	41	24	8	30	6	5.2	1.9	0.6	0.1	63					
A7																									
10	4.7	1.1	0.01		<0.002		0.9	0.06	0.022	0.033	34	38	6	23	3-5	1.2	0.2	0.45	<0.1	16	15				
20	4.3	1.0	0.04		<0.002				0.015		33	40	5	22	3-5	0.8	<0.1	0.35	<0.1	2					
30	4.2	1.1	0.03		0.003						36	36	5	24	<3	1.0	0.2	0.3	<0.1	3					
60	4.4	1.4	0.02		0.002						29	37	7	28	<3	1.1	0.5	0.2	<0.1	3					
120	4.8	1.4	0.02		0.004				0.013	0.021	26	38	6	30	<3	0.7	0.8	0.15	<0.1	2					
A8																									
10	4.5		0.01		0.003															6	8				39
20	4.4		0.02		0.003																				52
30	4.4		0.03		0.004																				51
60	4.5		0.05		0.009																				
A9																									
10	6.7	4.8	0.35	0.3	0.148		0.3	0.03			9	32	19	42	16	7.2	4.8	1.45	3.1	38					
20	7.2	7.1	1.2	1.4	0.602						6	28	14	51	18	8.8	8.0	1.0	5.3	32					
30	7.6	7.1	1.35	1.6	0.630						7	32	11	47	19	10.9	9.9	0.8	5.5	37					
60	7.7	7.7	1.61	2.0	0.710						14	27	10	49	20	16.0	10.4	0.7	5.3	23					
120	7.8	9.5	1.76	2.1	0.925						3	16	16	61	23	10.8	11.3	0.9	7.3	14					
A10																									
10	6.4	4.6	0.04		0.018		0.7	0.07			8	36	15	42	17	7.8	6.0	1.2	1.1	35					
20	8.4	6.8	0.22	0.4	0.098	1.0					5	27	13	52	22	9.3	8.3	1.3	6.6	17					
30	8.2	7.9	0.75		0.354	1.7					7	22	14	51	24	12.1	9.5	1.1	9.6	18					
60	7.7	9.7	1.39	2.8	0.407	1.0					13	17	13	53	21	58	9.8	0.85	7.6	16					
120	7.3	10.4	1.34	3.8	0.462						14	13	11	57	21	71	9.1	0.85	7.4	16					
A11																									
10	8.3	7.9	0.15		0.037	2.0	0.3	0.05			2	21	13	59	27	25	8.0	0.75	2.9	23		NA	18		
20	7.2	6.8	0.04		0.005	1.1					3	27	12	54	24	18.2	7.9	1.5	8.2	35					
30	8.8	8.2	0.21		0.066	2.3					3	21	12	60	27	25	7.8	0.65	5.2	22		37	19	18	
60	8.2	8.6	0.60	0.9	0.320	1.9					3	20	9	65	28	15.8	7.8	0.75	9.6	19		39	20	19	
120	7.7	8.9	1.35	2.2	0.390	1.7			0.014		4	17	12	59	25	39	8.4	0.75	9.4	16					
A12																									
10	5.6	0.5	0.03		0.003		0.2	0.03	0.023	0.032	72	21	5	8	<3	0.8	0.1	0.3	0.1	37	45	4	2	2	
20	5.8	0.5	0.01		0.003						58	35	2	7	<3	0.8	0.2	0.2	<0.1	29					
30	6.3	0.6	0.01		0.002						70	24	2	7	<3	1.4	0.3	0.3	<0.1	18		4	2	2	
60	6.6	0.6	0.01		<0.002						50	41	2	9	<3	1.4	0.3	0.25	<0.1	10		4	2	2	
120	6.4	0.6	0.01		<0.002				0.011	0.023	50	43	2	9	<3	1.6	0.4	0.2	<0.1	8					

Dth cm	pH H_2O 1:5	A.D. Moist. %	T.S.S. 1:5	T.S.S. 1:50	Cl	$CaCO_3$	Org. C	Total N	Phosphorus Digest	Phosphorus X-Ray	Particle Size CS	FS	Si	C	Ex. Cap.	Ex. Cations Ca	Mg	K	Na	Avail. P Acid	Bic.	H_2O 1/3 bar.	15 bar.	Av. H_2O	Gravel
cm		%	% Air Dry Weight								% Oven Dry Weight				m equiv./100 g					ppm		%			
A13																									
10	6.3		0.02		0.003															38					
20	6.2		0.04		0.015																				
30	5.5		0.20	0.3	0.082																				
60	4.8		0.63	0.8	0.267																				
120	4.9		0.60	0.7	0.270																				
A14																									
10	6.9	4.7	0.03		0.014		0.6	0.06			1	42	18	44	15	8.0	7.5	0.75	0.8	65					
20	6.9	5.6	0.03		0.012						1	31	19	53	20	9.0	9.2	0.5	1.1	79					
30	6.3	5.4	0.33		0.136						1	26	20	55	21	8.2	9.3	0.3	2.7	78					
60	6.4	5.3	0.59	0.8	0.302						1	28	19	53	19	9.8	9.9	0.25	2.9	93					
120	6.1	5.3	0.62	1.2	0.302						1	25	24	52	17	17.1	8.9	0.2	3.0	33					
A15																									
5	6.9	2.5	0.03		0.020		0.4	0,06	0.025	0.045	1	53	13	34	13	7.4	5.0	0.55	1.2	31		23	13	10	
10	6.4	4.4	0.27		0.120						1	29	16	55	22	11.7	10.3	0.55	0.7	83					
20	6.8	4.0	0.30		0.140						1	33	15	50	21	12.5	8.5	0.45	1.2	114		27	14	13	
30	7.3	4.7	0.46	0.5	0.208						1	28	19	51	-	11.8	9.4	0.3	3.3	136		25	14	11	
60	7.1	4.8	0.76	1.5	0.264						1	27	18	52	22	24	10.0	0.2	3.5	113					
120	6.7	4.6	0.80	1.9	0.300				0.027	0.041	1	23	22	51	20	25	9.0	0.3	3.1	57					
A16																									
10	6.2	4.4	0.03		0.013		0.5	0.07	0.036	0.051	2	20	25	56	23	9.6	10.3	0.7	1.1	39	46	29	16	13	
20	6.3	4.6	0.09		0.039						1	21	23	56	20	11.6	10.3	0.35	1.7	44					
30	5.9	4.6	0.32	0.4	0.149						1	21	24	56	21	11.6	10.8	0.35	3.1	52		28	15	13	
60	5.7	4.6	0.52	0.6	0.257						1	19	25	56	19	8.0	9.2	0.3	3.9	67		29	16	13	
120	5.8	4.5	0.65	0.7	0.31				0.026	0.039	<1	28	25	47	17	6.4	8.1	0.25	2.8	38					
A17																									
10	6.3	4.3	0.02		0.019		0.5	0.05			<1	44	17	42	16	9.0	5.6	0.25	4.3	18					
20	5.8	5.1	0.95	1.1	0.472						<1	42	18	42	16	9.0	7.1	0.1	1.1	10					
30	5.8	4.9	0.78	0.9	0.389						<1	42	20	40	17	8.2	7.4	0.05	1.5	10					
60	5.9	5.0	1.10	1.3	0.578						<1	44	20	38	16	7.4	7.7	0.1	1.5	21					
120	6.6	3.2	0.14	0.2	0.066						<1	55	22	28	11	5.9	5.6	0.15	1.0	26					
A19																									
10	6.2	1.7	0.02		0.005		0.3	0.05	0.033	0.050	7	68	12	15	6	3.8	1.2	0.6	0.2	20	18				
20	6.2	2.6	0.02		0.007						19	51	9	22	8	5.7	1.8	0.6	0.3	11					
A20																									
10	5.8		0.01		0.005															33					
20	6.4		0.01		0.005																				
30	6.7		0.01		0.008																				
60	6.8		0.03		0.015																				
120	7.4		0.04		0.007																				
A22																									
10	7.2	5.1	0.02		0.005		0.5	0.07	0.023	0.035	8	25	7	60	21	11.0	7.5	0.6	0.6	16	18	21	14	8	
20	6.9	5.7	0.07		0.007						4	25	10	59	22	12.5	9.3	0.45	1.0	7		23	15	9	
30	7.0	6.0	0.11		0.019				0.023	0.024	5	30	20	49	25	12.9	11.6	0.15	1.6	5		24	16	8	
A23																									
10	6.2	2.3	0.02		0.009		0.3	0.05	0.028	0.042	9	58	14	23	9	4.2	1.8	0.4	0.3	14	15				
20	6.5	4.8	0.03		0.017				0.026	0.036	6	37	10	44	13	8.3	3.3	0.4	1.0	8					18
25	6.7	6.0	0.08		0.004						7	32	11	49	18	11.6	5.0	0.35	2.7	10					19
A24																									
10	5.0	1.7	0.02		0.004		0.5	0.05	0.028	0.041	25	47	6	24	3-5	1.6	0.7	0.75	0.2	10	10				29
20	4.9	1.9	0.03		0.009						32	42	7	20	3-5	2.0	0.8	0.7	0.1	3					46
30	5.8	2.5	0.03		0.008						31	42	7	22	3-5	1.9	1.4	0.4	0.2	4					63
50	5.7	2.4	0.02		0.008				0.024	0.030	41	38	6	18	3-5	2.2	1.9	0.3	0.2	3					64
A25																									
10	4.6	1.9	0.01		0.003		0.7	0.07	0.018	0.040	9	59	10	25	3-5	0.9	0.4	0.6	0.1	11	10				43
20	4.4	2.1	0.02		0.003						10	59	9	25	3-5	0.7	0.2	0.6	0.1	5					69
30	4.2	2.2	0.01		0.002						9	59	9	27	3-5	1.0	0.4	0.55	0.1	6					70
45	4.6	2.5	0.01		0.002				0.013	0.028	16	53	9	24	3-5	1.4	0.9	0.4	0.1	4					72
A26																									
10	4.6	1.6	0.01		0.002		2.0	0.11	0.032	0.042	11	54	12	24	6	2.0	0.4	0.4	0.4	7	6	17	8	8	9
A27																									
10	4.4		0.02		0.004															9	10				16
A28																									
10	7.3		0.02		0.005															13					
20	8.0		0.02		0.010	0.9																			
30	8.2		0.03		0.018	0.9																			
60	8.4		0.03		0.013	0.6																			
120	9.0		0.05		0.004	1.3																			
A29																									
10	5.3	1.0	0.01		<0.002		0.4	0.03	0.010		42	37	5	17	<3	0.4	<0.1	0.4	<0.1	3	5	8	5	3	
20	4.8	0.9	0.01		<0.002						37	42	5	19	<3	0.8	0.3	0.25	<0.1	5					
30	5.0	1.0	0.01		<0.002						37	41	4	20	<3	1.0	0.5	0.2	<0.1	3		9	4	5	
60	5.3	1.4	0.01		<0.002						35	40	4	20	3-5	1.2	0.9	0.2	<0.1	2		10	5	5	
120	6.0	1.3	0.01		<0.002				0.016	0.019	36	39	7	20	3-5	1.8	1.5	0.2	<0.1	3					

Dth cm	pH H_2O 1:5	A.D. Moist. %	T.S.S. 1:5	T.S.S. 1:50	Cl	$CaCO_3$	Org. C	Total N	Phosphorus Digest	Phosphorus X-Ray	Particle Size CS	FS	Si	C	Ex. Cap.	Ex. Cations Ca	Mg	K	Na	Avail. P Acid	Bic.	H_2O 1/3 bar.	15 bar.	Av. H_2O	Gravel vol
			% Air Dry Weight								% Oven Dry Weight				m equiv./100 g					ppm		%			
A30																									
10	4.9	0.7	0.01		<0.002		0.5	0.03	0.016	0.031	52	31	4	14	<3	0.6	0.1	0.35	<0.1	10	10				
20	4.8	0.7	0.01		0.002						54	32	2	14	<3	0.9	0.2	0.3	<0.1	4					
30	4.9	0.8	0.01		0.002						47	36	4	17	<3	0.8	0.2	0.35	<0.1	3					
60	4.8	1.1	0.01		0.002						38	39	3	19	<3	1.0	0.2	0.25	<0.1	2					
120	4.8	1.1	0.01		0.002				0.021	0.018	40	37	4	19	<3	1.1	0.4	0.2	0.1	2					
A31																									
10	5.3	1.4	0.01		0.002		0.5	0.06	0.018	0.029	35	38	8	23	5	2.0	1.0	0.70	<0.1	7	5	10	6	4	
20	5.1	1.5	0.01		0.002						36	38	8	21	3-5	0.9	0.6	0.55	<0.1	3					
30	6.2	2.1	0.01		0.005						32	38	6	27	7	1.5	3.2	0.8	0.7	3		13	7	6	
60	8.2	4.9	0.02		0.007				0.014	0.020	26	29	8	37	16	4.5	10.4	1.7	2.0	2		23	15	8	
A32																									
10	5.4	0.9	<0.01		<0.002		0.3	0.04	0.022	0.025	29	55	5	15	<3	0.4	0.2	0.3	0.1	11	13	7	3	4	
20	4.9	1.3	0.01		0.002						28	51	6	18	3-5	1.7	0.6	0.55	0.6	5		8	4	4	
35	5.1	1.2	0.03		0.012				0.018	0.035	21	57	7	19	3-5	2.2	1.5	0.5	0.6	5		9	4	5	
A33																									
10	6.1	3.2	0.01		0.004		0.3	0.05	0.025	0.040	3	55	11	36	11	6.0	3.4	0.35	0.4	18	19	16	8	8	
20	6.0	1.7	0.01		0.005				0.019	0.034	1	73	10	19	5	3.6	1.8	0.1	0.4	14	11				
30	5.8	2.4	0.01		0.005						1	58	18	27	9	5.0	2.1	0.1	1.2	17		16	7	10	
60	6.9	4.6	0.01		0.009						1	41	16	45	13	12.1	4.6	0.1	1.2	17		22	11	11	
120	8.0	4.4	0.02		0.006				0.023	0.036	<1	39	20	43	17	12.7	5.9	0.15	1.3	60					
A34																									
10	6.1	3.3	0.01		0.003		0.6	0.07			2	41	18	42	11	4.7	5.1	0.7	0.5	41					
20	6.7	4.8	0.02		0.008						1	36	16	51	14	8.8	6.9	0.55	1.2	10					
30	6.5	5.2	0.37	0.5	0.204				0.020		1	34	20	49	20	9.7	8.0	0.25	2.4	8					
60	6.5	5.0	0.65	0.7	0.310						<1	37	22	45	20	7.8	8.5	0.2	2.7	21					
120	6.7	4.8	0.62	0.7	0.300						<1	48	26	35	14	8.4	8.2	0.15	2.8	36					
A36																									
10	7.3	5.0	0.05		0.022		0.5	0.06			7	44	8	41	21	12.0	12.4	0.6	1.4	11					
20	6.8	5.5	0.74	0.8	0.358						5	44	8	43	22	8.3	14.2	0.45	2.3	9					
30	6.8	6.1	0.63	0.8	0.310						3	43	10	43	23	7.7	14.8	0.3	3.1	6					
60	5.5	11.0	0.88	5.1	0.264						23	28	12	44	20	76	15.0	0.25	3.4	9					
120	4.8	7.9	0.70	1.1	0.300						4	41	18	37	27	17.0	17.0	0.45	6.1	17					7
A37																									
10	6.8		0.90	1.1	0.50															7					
20	7.0		2.06	2.4	1.1																				
30	7.0		1.91	2.2	1.03																				
60	6.7		1.28	1.7	0.047																				
A38																									
10	7.6	6.5	0.14		0.003	0.8	0.4	0.05			7	36	8	47	23	20	9.8	1.65	0.7	17					
20	8.2	6.6	0.12		0.019	1.6					6	36	8	48	26	23	10.8	1.4	0.7	11					
30	7.9	7.1	0.88	1.2	0.470	1.8					5	35	9	47	25	18.1	13.0	0.85	3.0	11					
60	8.0	8.3	0.83	1.6	0.304	1.4					7	35	11	46	22	43	16.3	0.75	4.1	10					
120	7.5	9.7	0.93	2.3	0.330	1.3					12	30	11	47	23	47	18.2	0.85	4.4	15					
A39																									
10	4.5	1.6	0.01		0.002		0.4	0.04	0.015	0.035	12	58	11	23	3-5	0.6	0.2	0.4	0.1	6	5	13	6	7	5
20	4.7	1.8	0.01		0.002						8	59	12	26	3-5	0.8	0.2	0.4	<0.1	6					5
30	4.8	2.2	0.01		0.004						7	58	11	28	3-5	1.6	1.0	0.5	0.1	5		15	6	9	4
45	4.9	2.4	<0.01		0.004				0.026	0.027	7	58	11	29	5	2.2	1.6	0.5	0.2	5					9
A40																									
10	5.4		0.02		0.007				0.026	0.041										9	13				
20	5.0		0.01		0.002															4					2
30	5.2		0.01		0.004																				1
60	6.1		0.01		0.003																				
120	6.3		0.01		0.003				0.018	0.028															
A41																									
10	5.7	2.0	0.01		0.003		0.9	0.07	0.028	0.055	10	44	16	34	9	3.8	1.9	1.25	0.4	17	15				
20	6.3	2.0	0.01		0.004						10	44	12	39	8	5.2	2.1	1.1	<0.1	5					
30	6.8	3.2	0.01		0.003						9	40	13	42	7	5.5	2.3	1.15	0.1	4					
60	7.4	4.3	0.01		0.003						6	32	9	56	9	6.0	3.3	1.5	0.2	5					12
80	7.8	5.6	0.01		0.003				0.031	0.027	6	27	7	61	11	6.8	4.6	1.65	0.3	5					12
A42																									
10	5.6	2.0	0.01		0.004		0.5	0.05	0.031	0.046	14	45	12	33	3-5	2.0	0.8	0.75	0.1	8	5				
20	4.7	2.1	0.04		0.009						7	47	11	39	6	2.2	0.6	0.8	0.2	5					21
30	5.7	2.1	0.01		0.005						8	49	11	35	5	2.0	0.8	0.7	0.4	4					35
A43																									
10	5.4		<0.01		0.003										6	1.7	0.8	0.35	0.2	12	13				5
20	4.6		0.08		0.020										8	2.9	1.5	0.25	0.2	6					
25	4.6		0.12		0.038										10	3.7	2.5	0.1	0.3	6					19
A44																									
10	6.4		0.01		<0.002															50	40				24
A47																									
10	4.7		0.01		<0.002															9	7				27
A48																									
10	4.4		0.11		0.024		0.8	0.06			15	47	4	34	6	1.6	0.3	0.85	0.2	11	10				5
20	4.5		0.07		0.022						15	47	3	35	6	2.0	0.4	0.55	0.2	5					
30	4.5		0.14		0:027						13	42	3	42	8	2.4	1.6	0.5	0.2	3					

Dth	pH H_2O 1:5	A.D. Moist.	T.S.S. 1:5	T.S.S. 1:50	Cl	$CaCO_3$	Org. C	Total N	Phosphorus Digest	Phosphorus X-Ray	Particle Size CS	Particle Size FS	Particle Size Si	Particle Size C	Ex. Cap.	Ex. Cations Ca	Ex. Cations Mg	Ex. Cations K	Ex. Cations Na	Avail. P Acid	Avail. P Bic.	H_2O 1/3 bar.	H_2O 15 bar.	Av. H_2O	Gravel
cm		%	% Air Dry Weight								% Oven Dry Weight				m equiv./100 g					ppm		%			
A49																									
10	6.1		0.01		0.004															3	1				
20	5.9		0.01		0.003																				
30	5.8		0.01		0.003																				
60	4.9		0.01		0.003																				
120	5.1		0.02		0.004																				
A50																									
10	5.0		0.02		0.005				0.026	0.036										7	10				
20	5.2		0.03		0.005																				
30	6.9		0.04	0.1	0.018																				
A51																									
10	6.2	3.8	0.50	0.5	0.239		0.4	0.04			10	37	13	38	15	7.2	4.5	0.7	2.6	31					
20	6.6	7.5	1.80	2.1	0.900						8	26	10	50	24	9.2	10.2	1.3	5.9	42					
30	7.6	7.3	1.99	2.4	1.000	1.8					10	26	10	50	24	15.0	12.8	0.9	6.3	50					
60	7.7	8.6	1.61	2.3	0.890	1.7					7	23	11	51	25	17.2	12.5	0.9	6.9	37					
120	4.9	12.1	2.03	5.7	0.670						22	15	9	52	18	>80	9.5	0.6	6.6	12					
A52																									
10	5.9	4.8	0.07		0.013		0.4	0.04			16	35	8	42	17	10.4	5.8	0.9	0.2	21					
20	6.3	6.9	0.06		0.010						6	30	11	56	23	15.8	6.4	0.75	0.8	6					
30	6.8	6.5	0.08		0.032						6	29	10	58	25	16.6	6.3	0.65	0.9	5					
60	7.2	6.6	0.20		0.089	1.0					7	29	10	57	26	15.4	7.0	0.45	1.9	5					
120	7.4	6.6	0.30	0.4	0.137	2.8					6	30	10	57	26	15.8	7.5	0.4	2.4	6					
A53																									
10	4.8	2.3	0.01		0.004		0.8	0.09	0.025		7	36	12	45	8	2.4	1.4	0.95	0.3	5	4	18	12	6	
20	4.6	2.3	0.02		0.011						6	38	11	46	6	1.9	1.4	0.9	0.3	4					
30	4.9	2.4	0.01		0.004						8	37	10	47	6	2.1	1.9	0.9	0.5	4		17	11	6	
60	5.7	2.3	0.01		0.004				0.020		15	34	9	44	6	2.0	2.4	0.85	0.3	4		16	11	5	
65	5.8	2.5	0.01		0.004				0.019	0.032	8	37	9	47	7	2.2	3.0	0.8	0.4	3					36
A54																									
10	5.2	2.0	0.01		0.002		0.8	0.09	0.022	0.041	12	56	9	24	7	1.4	1.0	0.65	0.1	7	5				27
20	4.8	2.1	0.01		<0.002						15	51	9	26	5	1.0	0.5	0.6	0.1	4					42
A55																									
10	6.6	1.5	0.01		<0.002		0.3	0.04			4	75	9	17	3-5	3.4	1.4	0.6	0.3	13					
20	6.7	1.2	0.01		<0.002						8	77	6	11	3-5	2.2	1.0	0.35	0.7	5					
30	7.0	3.3	0.09		0.032						7	58	5	32	11	6.4	3.8	0.4	0.3	2					
60	7.5	3.9	0.05		0.018						4	59	5	34	14	7.8	5.0	0.3	1.9	4					
120	7.5	3.1	0.02		0.004						7	66	3	25	10	5.2	6.6	0.25	1.7	3					
A56																									
10	6.3		0.01		<0.002															12	7				
20	6.0		0.01		<0.002																				
A57																									
10	6.8	1.1	0.01		<0.002		0.4	0.04	0.023	0.037	13	60	10	16	<3	2.6	1.0	0.55	0.2	26	19	10	4	6	
20	7.0	3.1	0.07		0.015				0.024	0.031	13	30	7	47	10	7.4	2.4	1.15	0.7	20		17	11	6	
A58																									
10	4.8		0.02		<0.002				0.029	0.047										9	6				16
20	4.5		0.01		<0.002																				28
A59																									
10	4.9	2.2	0.02		0.001		0.7	0.05	0.028	0.045	11	40	12	40	6	2.0	1.3	1.0	0.2	8	7				
20	4.7	2.4	0.02		0.004						12	39	12	40	6	2.2	1.2	0.9	0.1	5					
30	5.2	2.5	0.01		0.002						10	39	10	44	6	2.4	0.7	0.7	0.1	4					
60	5.4	2.7	0.01		0.001						11	38	9	46	7	2.9	1.6	0.7	0.2	4					
120	6.1	3.0	0.01		0.001				0.020	0.028	7	40	9	47	6	3.2	2.7	0.7	0.2	3					
A60																									
10	6.2	2.8	0.01		<0.002		1.1	0.09	0.029	0.043	12	39	19	33	10	6.6	2.6	1.0	0.3	5	10	19	10	9	
20	6.4	2.7	0.01		<0.002						13	41	15	34	8	5.6	2.1	0.85	0.2	4					
30	6.5	2.7	0.01		<0.002						9	43	13	37	8	4.8	2.1	0.3	0.8	4		15	9	6	
60	6.6	2.3	0.01		<0.002						29	37	8	28	6	4.0	2.0	0.6	0.4	6		12	8	4	
120	7.7	4.5	0.02		<0.002				0.025	0.026	22	27	8	45	16	10.2	6.8	1.0	0.9	3					
A61																									
10	5.0		0.01		<0.002															9	10				
20	4.9		0.01		<0.002																				
30	4.7		0.02		<0.002																				
60	5.7		0.05		0.006																				14
120	6.3		0.06		0.008																				16
A63																									
10	8.0	7.2	3.56	4.3	1.775	2.3	0.4	0.04			1	36	18	43	25	14.7	8.2	0.3	10.0	55					
20	7.9	8.3	3.86	4.7	1.950	2.2					1	33	18	45	27	15.0	10.5	0.25	6.6	72					
30	8.1	7.8	2.85	3.5	1.385	2.1					1	35	18	46	23	19.7	10.8	0.25	7.0	94					
60	8.0	9.7	2.66	6.0	1.000	2.2					3	37	14	43	19	>40	9.4	0.2	6.5	82					
120	8.2	7.8	1.95	3.6	0.781	2.1					2	45	12	39	20	>40	9.3	0.2	8.2	74					
A64																									
10	6.5	1.8	0.03		0.008		0.3	0.03			23	57	9	12	3-5	3.0	1.2	0.6	0.5	19	19				22
20	6.0	2.3	0.20	0.3	0.092						23	54	9	15	6	5.4	2.4	0.3	0.5	10					29
A65																									
10	8.1	5.4	0.06		0.006	1.7	1.5	0.11			19	38	9	35	24	19.6	7.2	1.05	1.3	37					
20	8.9	6.6	0.14		0.023	2.5					10	35	9	46	33	26	13.2	0.65	4.8	12					
30	8.0	8.9	1.54	6.0	0.330	1.9					7	33	8	46	28	>80	13.0	0.40	5.8	11					
60	7.6	7.2	0.88	2.3	0.250	1.7					6	35	7	37	30	28	14.1	0.55	9.6	9					

Dth	pH H_2O 1:5	A.D. Moist.	T.S.S. 1:5	T.S.S. 1:50	Cl	$CaCO_3$	Org. C	Total N	Phosphorus Digest	Phosphorus X-Ray	Particle Size CS	FS	Si	C	Ex. Cap.	Ex. Cations Ca	Mg	K	Na	Avail. P Acid	Bic.	H_2O 1/3 bar	15 bar	Av. H_2O	Gravel
cm		%	% Air Dry Weight								% Oven Dry Weight				m equiv./100 g					ppm		%			
A66																									
10	7.8	2.9	0.06		0.018		0.5	0.05	0.029	0.049	20	36	4	41	15	8.8	4.2	1.25	2.4	55	42	19	10	9	
20	8.4	4.0	0.50	0.5	0.181	1.4					17	32	4	48	17	8.2	4.9	0.9	7.4	13					
30	8.3	4.1	0.41	0.5	0.170	1.3					15	34	6	44	17	7.9	5.6	0.7	5.3	11		25	13	12	
60	8.1	4.3	0.29	0.3	0.114	1.2					19	30	5	44	20	8.6	7.8	0.85	5.3	19		26	15	11	
120	8.2	4.0	0.29		0.105	0.9			0.014	0.022	20	33	6	40	20	8.8	8.4	0.9	3.7	13					
A67																									
10	7.8	3.6	0.03		0.002	1.5	0.8	0.07	0.034	0.057	14	36	7	46	21	14.0	6.7	2.5	0.8	93	58	NA	13		
20	7.6	3.6	0.02		0.002	0.8					14	35	6	46	20	13.2	6.8	1.7	0.9	79					
30	8.0	3.8	0.02		0.002	0.8					15	35	5	48	20	14.0	6.8	1.1	1.4	70		25	14	11	
60	9.1	4.5	0.06		0.007	1.7					15	31	5	47	20	19.2	7.8	0.7	3.2	67		29	15	14	
120	8.7	5.0	0.30		0.078	3.0			0.025	0.041	11	32	6	48	21	31	11.3	0.65	5.1	56					
A68																									
10	6.7	3.7	0.01		<0.002		0.6	0.07			2	42	22	37	14	9.0	5.0	1.2	0.2	58		23	11	13	
20	7.0	2.6	0.01		<0.002						3	55	15	29	10	5.8	3.2	0.65	0.2	17					
30	6.8	4.1	0.01		<0.002						2	45	11	44	15	9.4	5.8	0.7	0.5	44		24	11	12	
60	7.0	4.2	0.01		<0.002						3	45	12	40	16	10.4	6.8	0.55	0.5	10		22	12	10	
120	7.4	5.4	0.02		0.004						2	38	10	52	21	12.0	9.2	0.55	0.7	9					
A69																									
10	5.1	1.8	0.01		<0.002		0.6	0.06	0.027	0.041	10	50	10	33	7	1.7	0.2	0.85	<0.1	8	5	17	8	9	
20	4.8	2.1	0.01		<0.002				0.028	0.041	9	47	10	36	7	1.7	0.1	0.8	<0.1	5					
A70																									
10	4.8		0.01		<0.002															5	8				30
20	4.6		0.01		<0.002																				30
A71																									
10	6.2	1.6	0.01		<0.002		0.8	0.05	0.032	0.056	17	52	8	25	5	4.1	1.6	0.9	0.3	22	18				
20	6.5	1.6	0.01		<0.002			0.03			18	52	10	25	6	5.3	1.7	0.85	0.2	8					
30	6.5	1.7	0.01		<0.002						18	50	8	26	5	4.3	1.6	0.8	0.2	7					
60	6.4	2.2	0.02		0.003						18	49	7	31	6	5.3	2.5	0.7	0.2	5					
120	6.9	2.8	0.01		<0.002				0.019	0.035	14	45	7	36	10	6.7	3.6	0.65	0.4	5					
A72																									
10	6.5	1.1	0.01		<0.002		0.6	0.05	0.028	0.057	32	50	6	16	7	3.3	1.5	0.95	0.1	43	36	11	4	7	
20	8.5	1.4	0.02		<0.002						27	49	7	21	8	7.7	1.3	1.45	0.2	10					
30	8.1	1.4	0.02		<0.002						26	51	9	17	7	5.9	1.2	1.30	0.2	5		12	6	6	
60	8.2	1.6	0.08		0.010				0.017	0.030	23	57	9	15	8	7.9	2.0	1.0	0.2	5		10	6	4	
A73																									
10	5.7	1.2	0.01		<0.002		0.5	0.04	0.028	0.061	23	47	7	23	6	2.1	1.2	0.8	0.1	18	18				
20	5.9	1.6	0.01		<0.002						20	50	6	24	6	3.5	1.1	0.95	0.3	9					
30	6.3	1.5	0.01		<0.002						24	48	6	26	6	3.7	1.3	0.85	0.4	6					
60	7.0	2.3	0.02		<0.002				0.020	0.038	17	44	7	33	9	6.8	3.3	0.9	0.6	7					
A75																									
10	6.8		0.02		0.003															109					
20	8.2		0.03		0.003	1.0																			
30	8.9		0.1		0.029	2.2																			
60	8.9		0.29		0.115	1.3																			
120	7.2		0.37	0.5	0.136																				
A77																									
10	5.2	0.8	<0.01		<0.002		0.5	0.04	0.021	0.037	39	41	8	17	3-5	0.5	0.3	0.35	<0.1	15	13	10	4	5	
20	5.0	1.0	<0.01		<0.002						53	31	3	17	3-5	1.5	0.2	0.35	0.3	3					
30	5.1	1.0	<0.01		<0.002						32	46	4	21	3-5	2.1	0.4	0.45	0.3	2		8	5	3	
60	5.7	1.2	<0.01		<0.002						38	40	5	19	3-5	2.7	0.7	0.6	0.3	4		8	5	3	
120	6.0	1.4	<0.01		<0.002				0.020	0.027	33	43	4	20	<3	2.5	0.9	0.45	0.4	2					
A78																									
10	6.7	2.6	0.01		<0.002		0.3	0.03	0.044	0.064	10	57	7	29	9	6.4	2.1	0.55	0.5	16	14	12	7	5	
20	7.5	4.3	0.07		0.014						6	46	8	43	16	10.5	3.9	0.75	1.9	15					
30	7.8	4.5	0.15		0.042						6	46	8	42	19	12.0	4.5	0.7	2.3	16		20	12	8	12
50	7.6	4.5	0.14		0.036				0.040	0.048	13	47	8	33	16	9.8	4.3	0.55	2.5	7		18	12	6	29
A79																									
10	6.2	1.6	0.01		<0.002		0.6	0.05	0.048	0.079	8	60	11	21	6	2.4	1.2	0.95	0.2	22	21				
20	5.4	2.1	0.01		<0.002						7	55	11	29	7	3.0	1.2	0.6	0.3	8					
30	5.7	2.1	0.02		0.003						7	56	10	27	8	3.2	2.0	0.45	0.4	5					11
A80																									
10	7.0	5.4	0.08		0.009		0.5	0.05	0.034	0.031	8	33	19	40	26	17.3	7.1	2.1	2.2	26	19	22	16	6	11
20	6.8	7.1	1.10	1.2	0.515				0.027	0.032	18	38	23	22	29	18.0	7.7	1.3	2.4	51		25	18	7	16
A82																									
10	5.0	1.8	0.01		<0.002		0.7	0.05	0.031	0.044	16	44	9	34	7	1.8	0.6	0.7	<0.1	7	10	17	8	9	
20	5.0	2.1	0.01		<0.002						14	43	8	38	6	2.1	0.5	0.7	<0.1	4					
30	5.2	2.3	0.01		<0.002						13	43	9	40	7	2.8	1.2	0.7	<0.1	2		17	9	8	
60	5.6	2.4	0.01		<0.002						11	40	8	43	8	3.1	1.6	0.7	<0.1	3		18	9	9	
90	6.0	2.5	0.01		<0.002				0.023	0.031	11	40	7	45	9	3.6	2.6	0.65	0.1	2					
A83																									
10	7.7	6.2	0.02		0.003		0.5	0.04			7	25	7	61	22	10.6	9.4	1.35	2.1	5					
20	6.7	3.8	0.02		<0.002						20	30	6	41	14	5.4	5.6	1.5	0.6	12					
30	7.5	6.5	0.16		0.055						4	28	9	62	25	10.0	10.6	0.8	1.8	6					
60	7.2	6.8	0.40		0.163						3	27	11	59	26	10.4	12.6	0.6	2.2	11					
120	7.0	7.9	0.19	1.4	0.178						3	21	11	62	26	24	13.2	0.75	2.5	22					

Dth cm	pH H_2O 1:5	A.D. Moist. %	T.S.S. 1:5	T.S.S. 1:50	Cl	$CaCO_3$	Org. C	Total N	Phosphorus Digest	Phosphorus X-Ray	Particle Size CS	FS	Si	C	Ex. Cap.	Ex. Cations Ca	Mg	K	Na	Avail. P Acid	Bic.	H_2O 1/3 bar.	15 bar.	Av. H_2O	Gravel
		%	% Air Dry Weight								% Oven Dry Weight				m equiv./100 g					ppm		%			
A84																									
10	7.7		0.02		0.002															25					
20	7.9		0.02		<0.002																				
30	7.7		0.05		0.004																				
A85																									
10	6.7	1.4	0.01		<0.002		0.7	0.06			13	72	6	10	7	3.4	1.6	0.6	0.3	32					10
20	8.0	5.5	0.07		0.003	0.9					7	52	6	35	22	9.0	7.0	1.55	5.8	9					15
30	8.5	7.3	0.39	0.6	0.208	1.7					12	42	14	30	23	8.6	9.2	1.35	7.1	12					14
60	8.6	7.6	0.48	0.9	0.300	2.0					14	49	16	21	23	13.4	9.7	0.95	6.5	11					20
120	8.7	8.6	0.45	1.0	0.337	2.0					11	42	16	30	24	10.3	10.1	0.8	10.0	7					
A86																									
10	5.7	3.2	0.01		<0.002		1.0	0.12			4	63	8	28	11	5.0	2.1	0.65	0.2	48					
20	5.9	3.7	0.01		<0.002						6	57	8	28	14	6.4	2.8	0.75	0.2	41					13
30	6.1	4.5	0.01		0.003						7	50	10	34	16	7.4	3.7	0.85	0.2	58					
A87																									
10	6.2	1.8	0.01		<0.002		0.5	0.05			30	47	8	18	9	4.0	1.8	0.8	0.2	51		10	5	5	
20	6.6	1.9	0.01		0.002						36	42	6	20	9	4.4	2.0	0.7	0.7	27					
30	7.5	3.9	0.10		0.027						36	29	4	32	15	8.2	3.1	1.0	4.5	11		18	11	7	
60	8.7	5.9	0.34	0.6	0.170	2.9					30	27	4	37	22	16.7	5.3	0.85	6.4	10		26	17	9	
120	8.2	6.6	0.73	1.2	0.210	4.0					28	26	3	40	22	32	5.6	0.7	7.4	11					
A88																									
10	6.7	0.7	0.02		0.003		0.2	0.03	0.016	0.026	44	51	1	4	<3	1.4	0.5	0.4	0.3	14		3	2	1	
20	6.7	0.7	0.01		<0.002						57	37	2	6	<3	1.5	0.6	0.45	0.1	7					
30	6.6	0.7	0.01		<0.002						53	39	1	7	<3	1.3	0.7	0.55	0.1	2		3	2	1	
60	7.0	0.9	0.04		0.008						42	48	1	8	3-5	1.5	1.0	0.35	0.6	5		5	3	2	
70	7.3	1.9	0.08		0.035				0.015	0.033	43	39	2	16	6	3.0	1.6	0.45	1.6	4					
A89																									
10	6.8		0.01		<0.002															10	7	11	5	6	
20	6.7		0.01		<0.002																	13	7	6	
A90																									
10	6.7		0.01		<0.002				0.019	0.049										18	10	7	3	4	
20	6.8		0.01		<0.002																				
30	6.8		0.01		<0.002																	7	4	3	
60	6.5		0.01		0.002				0.014	0.035												7	4	3	
A91																									
10	5.6		0.01		<0.002															6					
20	6.2		0.01		<0.002																				
A92																									
10	7.4	3.9	0.02		0.002		0.5	0.03	0.019	0.034	6	36	6	53	17	9.0	6.2	1.2	1.2	33	24	19	10	9	
20	7.4	4.6	0.06		0.027						5	31	8	59	18	10.6	5.6	0.95	3.0	37					
30	7.9	5.9	0.30	0.5	0.204						4	23	7	65	23	11.0	8.4	1.0	4.9	67		27	14	13	
60	8.0	6.6	0.61	1.2	0.337						4	24	6	65	24	16.4	10.1	1.0	5.9	77		27	16	11	
120	8.1	5.4	0.41	0.8	0.320				0.024	0.042	12	38	5	45	20	9.4	8.0	0.75	4.5	101					
A93																									
10	7.1	0.9	0.01		<0.002		0.2	0.01	0.014	0.027	30	60	1	9	3-5	2.2	0.9	0.65	0.1	8	2	5	3	2	
20	7.0	1.1	0.01		<0.002						33	53	1	12	3-5	2.3	1.2	0.8	0.1	5					
30	7.0	1.1	0.01		<0.002						30	58	2	11	5	2.1	1.4	0.75	0.3	3		5	3	2	
60	7.1	1.6	0.01		0.002						27	55	2	17	6	2.7	2.4	0.5	0.5	4		9	5	4	
120	7.0	3.9	0.03		0.014				0.014	0.026	23	56	1	21	9	3.8	4.0	0.55	0.4	3					
A94																									
10	7.6	4.7	0.02		0.002		0.3	0.03			5	33	3	59	19	11.6	6.4	1.5	1.4	26					
20	8.0	5.6	0.01		<0.002	1.0					6	30	6	58	23	13.8	6.0	1.5	1.6	29					
30	8.6	5.6	0.02		0.003	1.4					5	29	6	60	22	15.2	5.6	1.35	2.5	42					
60	9.1	5.8	0.03		0.007	1.7					4	29	6	58	21	15.2	5.5	1.25	4.2	51					
A95																									
10	7.3	4.5	0.01		0.002		0.4	0.04			8	33	3	55	18	9.4	7.9	1.55	1.0	28					
20	7.7	4.8	0.02		0.003						8	30	3	56	19	11.8	6.6	1.25	1.7	17					
30	8.1	5.3	0.02		0.006						7	26	4	61	21	13.6	6.9	1.15	2.4	32					
50	8.3	5.5	0.02		0.007						4	27	4	58	23	13.2	7.1	1.2	3.0	50					
A96																									
10	6.5	1.5	0.01		<0.002		0.5	0.04	0.016	0.043	15	59	9	21	7	3.2	1.6	0.75	<0.1	15					
20	6.5	1.7	0.01		<0.002						23	48	8	25	6	3.3	2.0	0.75	<0.1	7					
30	6.5	1.9	0.01		<0.002						20	48	8	26	6	3.4	2.7	0.95	0.4	4					
60	6.7	2.7	0.01		<0.002						21	41	6	36	9	4.1	3.7	1.1	0.4	6					
120	7.1	3.2	0.01		<0.002				0.028	0.029	22	36	5	40	11	5.2	5.6	1.3	0.2	4					
A97																									
10	6.2		0.01		<0.002															26	21				
20	6.6		0.01		<0.002																				
30	7.0		0.01		<0.002																				
A98																									
10	5.2	1.4	0.01		<0.002		0.4	0.04			23	49	8	24	5	1.6	0.8	0.7	0.2	9	7				
20	4.7	1.6	0.02		0.002						21	52	9	22	3-5	1.7	0.6	0.5	0.2	4					
30	4.8	1.8	0.03		0.005						20	52	8	24	3-5	2.0	1.4	0.35	0.3	3					8

Dth	pH H_2O 1:5	A.D. Moist.	T.S.S. 1:5	T.S.S. 1:50	Cl	$CaCO_3$	Org. C	Total N	Phosphorus Digest	Phosphorus X-Ray	CS	FS	SI	C	Ex. Cap.	Ca	Mg	K	Na	Avail. P Acid	Avail. P Bic.	H_2O 1/3 bar	H_2O 15 bar	Av. H_2O	Gravel
cm		%	% Air Dry Weight								% Oven Dry Weight				m equiv./100 g					ppm		%			
A99																									
10	4.9	0.7	0.01		<0.002		0.3	0.02	0.013		49	35	4	13	<3	0.1	<0.1	0.25	<0.1	6	7				
20	4.8	0.8	0.01		<0.002						50	36	3	13	<3	0.8	<0.1	0.3	0.4	4					
30	4.8	0.8	0.01		<0.002						50	36	3	13	<3	0.6	<0.1	0.35	0.3	4					
60	5.2	0.9	0.02		<0.002						43	37	4	16	<3	1.4	0.8	0.5	0.2	3					
120	6.6	1.7	0.01		0.005				0.009	0.017	41	36	6	21	7	3.4	4.8	0.6	0.5	3					
A100																									
10	6.3		0.01		0.002															17	10				
20	7.4		0.02		<0.002																				
30	8.8		0.02		0.003	0.8																			
45	8.9		0.01		0.003	0.7																			
A101																									
10	5.6	1.2	0.01		<0.002		0.4	0.03	0.022	0.039	32	42	6	20	3-5	2.0	1.2	0.6	0.2	19	13				
20	5.1	1.3	0.01		<0.002						36	39	5	22	3-5	1.1	0.2	0.6	0.2	6					
30	5.0	1.3	0.01		<0.002						38	38	6	21	3-5	1.0	0.3	0.6	0.3	3					
60	5.3	1.4	0.02		0.002						30	45	6	23	5	1.7	1.6	0.65	0.4	3					
70	6.6	2.2	0.03		0.005				0.014	0.020	30	39	8	25	8	3.5	1.9	1.15	1.2	2					
A103																									
10	6.6	0.8	0.01		<0.002		0.2	0.02	0.018	0.035	45	45	1	10	3-5	3.7	0.7	0.7	0.2	21	20	4	2	1	
20	8.0	0.9	0.01		<0.002						41	48	1	11	5	3.8	0.7	0.6	0.4	18					
30	8.2	1.2	0.01		<0.002						39	48	2	13	5	4.8	0.7	0.6	0.4	9		5	3	2	
60	8.4	3.1	0.01		<0.002						34	41	1	24	10	8.1	2.0	1.2	0.4	4		13	7	6	
120	8.3	2.3	0.01		<0.002				0.012	0.029	35	45	1	19	8	6.4	2.5	0.95	0.5	4					
A105																									
10	8.7	1.9	0.02		0.002	0.6	0.3	0.03	0.014	0.024	51	29	1	19	9	7.5	2.6	0.85	1.1	38	12	10	5	5	
20	9.4	6.9	0.14	0.6	0.04	3.3					16	23	10	50	25	27	8.0	1.35	9.9	>150					
30	8.9	7.9	0.28	-	0.06	4.4					11	20	6	60	27	41	8.7	1.1	13.0	>150		29	18	12	
60	8.8	8.9	0.69	2.6	0.094	4.1					8	19	4	68	29	70	10.0	1.05	18.7	>150		36	21	15	
120	8.7	10.6	0.74	4.7	0.137	7.8			0.043	0.063	20	9	3	62	23	>99	9.0	0.9	19.5	>150					
A106																									
10	5.6	0.6	0.02		<0.002		0.3	0.03	0.019	0.034	55	32	4	14	3-5	2.0	0.4	0.25	0.3	13	10				
20	5.0	0.8	0.01		<0.002						50	35	4	16	3-5	1.3	0.2	0.35	0.3	4					
30	5.1	0.8	0.01		<0.002						45	39	5	16	3-5	1.3	0.2	0.35	0.3	5					
60	5.0	1.7	0.02		<0.002						39	41	5	19	3-5	2.5	0.2	0.35	0.3	4					
120	5.0	1.3	0.02		0.004				0.015	0.025	35	42	5	20	3-5	2.8	0.5	0.35	0.4	3					
A107																									
10	6.0		0.01		0.003															11	10				20
20	6.8		0.17	0.3	0.092																				10
A108																									
10	5.2		0.02		0.002															14	10				19
20	4.8		0.01		<0.002																				17
30	5.2		0.01		<0.002																				20
A109																									
10	6.4	1.8	0.01		0.002		0.5	0.05	0.011	0.041	13	54	13	24	8	3.8	2.1	0.75	0.1	10	10	15	6	9	
20	7.1	3.3	0.02		0.002						11	28	9	51	14	7.0	4.8	1.05	0.8	5					
30	7.8	5.5	0.02		0.004						3	21	11	64	21	10.4	7.3	1.4	1.4	5		27	15	11	
45	8.3	4.8	0.02		0.007				0.019	0.031	5	30	8	57	20	10.7	7.5	1.15	2.1	5		28	15	13	
A111																									
10	6.1	2.0	0.01		0.014		0.7	0.08	0.022	0.052	13	50	12	28	9	2.8	2.8	1.1	0.1	21	17				17
20	6.2	2.5	0.02		<0.002						10	48	9	35	9	3.3	2.4	0.9	0.2	7					
30	6.8	2.6	0.02		<0.002						8	49	10	36	9	3.2	2.4	0.8	0.2	5					
60	8.3	5.3	0.02		0.003				0.032	0.023	7	46	15	33	17	9.2	8.4	1.25	1.6	6					
A112																									
10	7.1	2.3	0.02		0.002		0.3	0.03			9	56	6	29	11	4.8	4.4	0.95	0.8	22					
20	7.1	2.8	0.02		0.007						5	54	6	33	12	5.2	5.0	0.85	1.0	16					
30	7.1	5.1	0.32	0.5	0.199						3	31	12	55	22	6.8	9.8	1.3	3.7	18					
60	6.6	7.1	1.56	4.1	0.604						9	31	8	40	19	64	11.6	0.85	2.6	38					
120	6.7	5.6	0.98	2.6	0.579						6	44	5	44	18	24	11.7	0.7	2.4	44					
A113																									
10	7.4		0.03		0.003															5					
20	7.4		0.05		0.012																				
30	7.1		0.34	0.5	0.213																				
60	6.4		0.63	0.7	0.299																				
120	6.4		0.76	1.6	0.263																				
A114																									
10	6.0	2.0	0.03		0.002		0.5	0.04	0.013	0.051	9	56	9	27	7	3.0	2.5	1.05	<0.1	18	15	17	6	10	
20	6.0	2.4	0.02		<0.002						9	52	9	32	8	3.6	2.2	1.05	<0.1	5					
30	6.2	2.6	0.02		0.002						8	52	8	33	8	3.8	2.5	1.05	0.1	5		18	7	11	10
40	6.5	2.6	0.02		0.002				0.028	0.039	9	51	8	33	9	4.1	2.7	1.2	<0.1	4		17	7	10	16
A115																									
10	6.4	2.5	0.02		<0.002		0.8	0.08	0.033	0.056	6	51	13	34	8	4.1	2.9	1.6	0.2	13	10				
20	6.0	2.7	0.01		<0.002						5	50	9	37	7	3.6	2.8	1.35	0.2	6					
30	6.2	3.0	0.01		<0.002						5	50	9	39	8	3.2	2.6	1.3	0.2	5					
45	6.4	2.9	0.01		<0.002				0.025	0.039	4	52	8	39	8	3.4	2.6	1.05	0.2	5					

Dth cm	pH H_2O 1:5	A.D. Moist. %	T.S.S. 1:5	T.S.S. 1:50	Cl	$CaCO_3$	Org. C	Total N	Phosphorus Digest	Phosphorus X-Ray	CS	FS	Si	C	Ex. Cap.	Ex. Cations Ca	Ex. Cations Mg	Ex. Cations K	Ex. Cations Na	Avail. P Acid	Avail. P Bic.	H_2O 1/3 bar	H_2O 15 bar	Av. H_2O	Gravel
		%	% Air Dry Weight								% Oven Dry Weight				m equiv./100 g					ppm		%			
A116																									
10	6.8	2.4	0.01		0.002		0.9	0.08	0.033	0.053	12	57	9	26	9	3.9	2.5	1.7	<0.1	21	14				9
20	6.7	3.5	0.01		0.002						7	48	7	42	10	4.1	3.6	1.25	0.2	7					11
30	6.4	3.9	0.01		<0.002						5	44	5	48	11	3.8	4.1	1.15	0.2	5					
60	6.7	4.8	0.01		<0.002						5	42	6	50	11	4.5	5.2	1.15	0.6	4					
120	6.9	5.5	0.01		0.004				0.023	0.035	3	40	7	48	13	5.6	6.7	1.35	1.0	5					
A117																									
10	8.3	6.6	0.03		0.002		0.3	0.03			2	25	9	61	35	24	10.2	1.6	4.1	10					
20	8.0	6.6	0.03		0.011						2	28	9	59	32	22	10.2	1.45	2.6	12					
30	7.7	6.7	0.11	0.2	0.069						2	31	8	55	33	21	10.0	1.35	3.3	10					
60	7.7	7.5	0.44	0.8	0.351						3	29	9	56	35	18.6	10.0	1.25	6.2	23					
120	7.9	7.5	0.57	1.3	0.398						3	29	10	54	31	24	10.3	1.35	6.8	-					
A118																									
10	7.8	5.1	0.09		0.023		0.4	0.04			4	42	7	46	28	13.0	11.4	1.1	1.8	11					
20	7.9	5.4	0.56	0.7	0.226	1.5					4	44	9	43	27	14.4	14.0	0.75	2.4	8					
30	7.9	6.0	1.07	2.1	0.320	1.7					5	42	7	44	27	37	14.2	0.55	3.3	7					
60	7.4	7.0	1.35	4.7	0.355						16	35	6	40	21	78	13.4	0.4	3.4	11					
120	7.3	7.3	1.2	3.6	0.391						12	37	7	43	23	62.	12.4	0.4	2.7	12					
A119																									
10	5.2		0.02		<0.002															10	10				26
20	5.0		0.02		<0.002																				36
30	5.2		0.01		<0.002																				17
A120																									
10	7.7	5.8	0.04		0.010		0.5	0.05			7	34	8	52	25	10.8	12.8	2.1	1.8	18					15
20	7.8	6.3	0.12		0.049						8	34	8	50	23	10.2	13.7	1.1	3.2	11					19
30	6.9	7.2	0.6	1.0	0.224						9	33	9	51	23	20	15.0	0.95	5.0	8					14
60	6.6	7.6	0.96	1.9	0.348						28	26	7	43	22	25	13.9	0.8	4.2	15					
120	6.7	9.5	1.16	2.3	0.408						11	30	9	52	23	43	17.1	0.85	4.8	25					
A124																									
10	6.3		0.01		0.002															23	18				16
20	7.1		0.02		0.004															7					
A125																									
10	6.3		0.02		0.005															15	14				
20	6.1		0.01		<0.002																				
30	6.4		0.01		<0.002																				
60	6.5		0.01		0.004																				
100	8.0		0.01		0.003																				
A126																									
10	7.3		0.22		0.005															34					12
20	6.8		0.3		0.044																				16
30	6.6		0.45	1.6	0.081																				8
60	6.4		0.55	1.8	0.098																				
120	6.9		0.9	5.3	0.10																				
A127																									
10	6.9	4.8	0.3	-	<0.002		0.6	0.05	0.024	0.040	8	38	7	46	25	28	1.6	1.45	0.3	40	19	25	12	13	
20	7.1	3.9	0.75	6.8	<0.002						13	38	5	31	11	>99	0.7	0.7	0.5	22					
30	7.2	3.6	0.79	6.9	<0.002						22	35	3	25	8	>99	0.2	0.45	0.5	15		30	20	11	
60	7.3	4.0	0.77	6.4	<0.002						32	29	5	23	6	>99	0.5	0.35	0.6	12		33	20	12	
120	7.2	4.3	0.8	6.9	<0.002				0.010	0.026	35	25	2	30	8	>99	1.1	0.4	0.6	8					
A128																									
10	7.2	2.0	0.02		<0.002		0.4	0.05	0.021	0.036	7	66	12	20	7	3.5	2.5	0.85	0.3	11	5				7
20	7.7	2.2	0.02		<0.002						6	65	11	21	7	3.7	2.5	0.75	0.4	6					9
30	7.0	6.3	0.02		0.004						6	44	6	46	17	9.7	5.9	0.8	1.6	5					
A129																									
10	6.4	2.4	0.11		0.008		0.4	0.05	0.019	0.039	7	65	6	22	9	7.7	3.0	0.9	<0.1	17	7				
20	6.7	1.9	0.06		<0.002						5	73	9	14	7	8.1	2.0	0.7	0.2	11					
30	7.1	4.0	0.21		0.360						3	53	11	31	13	6.2	4.9	0.8	1.0	6					
60	7.3	4.1	0.46		0.172						2	53	14	28	15	5.8	6.4	0.7	1.2	6					
120	7.0	3.3	0.39	0.5	0.163				0.022	0.036	2	62	9	25	10	4.0	5.6	0.6	1.2	9					
A130																									
10	4.8		0.02		<0.002															5	2				30
A132																									
10	8.0	2.4	0.07		0.017		0.5	0.05	0.023	0.046	5	69	6	23	11	8.8	2.1	1.4	0.9	56	32	16	6	10	
20	7.7	2.8	0.15		0.025						8	62	8	23	9	9.5	2.2	1.05	0.9	67					
30	7.1	3.2	1.13	1.3	0.62						11	65	6	20	10	6.6	1.9	0.65	0.3	76		15	6	8	11
60	6.7	4.7	1.7	1.9	0.803						9	59	5	28	13	10.7	4.0	0.8	1.2	85		19	9	10	8
120	8.6	3.6	0.07		0.007	0.6			0.037	0.072	9	58	7	25	13	29	3.0	0.9	1.2	>150					
A133																									
10	7.9		0.03		0.004	1.4														10	6				
20	8.0		0.05		0.010	1.1																			
30	8.3		0.07		0.023	1.4																			
60	8.1		0.51	0.6	0.226	1.7																			
120	8.1		0.68	1.6	0.196	4.1																			

Dth	pH H_2O 1:5	A.D. Moist.	T.S.S. 1:5	T.S.S. 1:50	Cl	$CaCO_3$	Org. C	Total N	Phosphorus Digest	Phosphorus X-Ray	Particle Size CS	FS	Si	C	Ex. Cap.	Ex. Cations Ca	Mg	K	Na	Avail. P Acid	Bic.	H_2O 1/3 bar	15 bar	Av. H_2O	Gravel
cm		%	% Air Dry Weight								% Oven Dry Weight				m equiv./100 g					ppm		%			
A134																									
10	5.3	2.2	0.02		<0.002		0.3	0.04	0.020		4	59	12	27	8	3.0	2.1	0.7	0.1	4	5				23
20	5.2	2.4	0.01		<0.002						4	59	12	28	9	3.4	2.6	0.7	0.2	4					6
30	5.6	3.0	0.02		0.003				0.018	0.029	6	57	12	27	10	4.8	3.7	0.75	0.3	3					
A136																									
10	7.1		0.02		0.004															21					
20	7.2		0.02		0.003																				
30	7.5		0.02		0.005																				
60	6.6		1.1	1.2	0.561																				
120	6.8		1.3	2.4	0.410																				
A137																									
10	7.1		0.02		0.006															8					
20	7.3		0.02		0.003																				
30	7.5		0.02		0.002																				
60	6.7		0.48	0.5	0.219											12.0	10.3	0.6	0.9						
120	6.7		0.66	1.3	0.272											22	11.2	0.5	1.2						
A138																									
10	6.9	3.0	0.03		0.005		0.4	0.03			4	68	4	26	11	7.5	2.9	1.25	0.1	19					
20	6.9	3.1	0.02		0.002						4	69	6	24	10	6.8	2.5	0.6	<0.1	11					
30	7.0	3.6	0.01		<0.002						4	65	5	28	13	9.4	3.0	0.35	<0.1	7					
60	7.0	3.3	0.01		<0.002						6	67	4	25	11	9.4	2.6	0.1	<0.1	5					
120	7.0	2.9	0.01		<0.002						12	65	3	22	11	8.6	2.2	0.15	<0.1	6					
A139																									
10	5.6		0.02		<0.002															12	13				
20	5.7		0.01		<0.002																				
30	6.0		0.01		<0.002																				
A140																									
10	6.4	1.9	0.01		0.001		0.4	0.03	0.027	0.049	4	64	12	20	9	3.8	2.3	0.65	0.2	33	24	15	6	8	
20	6.9	3.0	0.04		0.012						8	54	9	29	11	6.3	3.1	0.35	0.6	10					
30	6.8	5.0	0.21	0.3	0.088						5	38	7	48	18	10.5	6.6	0.25	0.8	6		21	12	9	
60	7.1	3.7	0.24	0.3	0.103						5	51	12	35	16	9.1	6.3	0.15	1.0	7		23	11	13	
120	7.5	-	0.28		0.114				0.035	0.041	36	24	10	31	13	8.8	5.3	0.1	0.4	10					32
A141																									
10	6.2		0.08		0.03															7	7				
A142																									
10	5.4		0.01		<0.002															12	10				
20	5.5		0.01		<0.002																				
A143																									
10	6.4	2.1	0.01		<0.002		0.3	0.02	0.022	0.031	8	58	20	19	8	2.5	3.3	0.55	0.2	12	11	16	6	10	31
20	6.3	5.8	0.05		0.014						3	35	15	50	17	8.2	7.2	0.85	0.8	6					10
30	6.7	6.5	0.12		0.045						2	27	16	57	21	11.0	9.7	0.75	1.1	7		25	16	9	
50	7.2	6.5	0.15		0.058				0.021	0.023	7	39	23	34	23	10.4	11.5	0.65	0.7	10		26	15	11	
A144																									
10	5.8		0.01		0.002		0.5	0.06	0.018	0.042	5	57	11	28	10	3.8	5.0	0.75	0.1	18	17				
20	6.6		0.01		0.002						6	43	10	43	14	6.4	7.4	0.75	0.4	9					
30	7.1		0.02		0.003						3	38	10	50	18	9.1	9.0	0.65	0.8	6					
50	7.5		0.02		0.004				0.021	0.025	3	37	9	52	21	10.2	9.5	0.55	1.0	6					
A145																									
10	6.2		0.01		0.002															7					
20	6.7		0.01		<0.002																				
30	7.0		0.01		0.002																				
60	7.5		0.07		0.029																				
120	8.0		0.19		0.078	2.0																			
A146																									
10	8.1	5.9	0.02		0.004	1.2	0.4	0.04	0.018	0.025	6	34	6	54	20	14.0	5.5	1.45	0.4	5	7				
20	7.5	6.2	0.01		<0.002	1.1					6	34	4	56	19	11.0	7.0	1.6	0.8	4					
30	8.0	6.3	0.02		<0.002	1.7					6	34	4	56	20	12.0	6.7	1.25	0.5	4					
60	8.3	6.6	0.03		0.002	1.5					6	34	4	56	20	13.0	7.4	1.0	0.6	3					
120	8.3	6.6	0.03		0.002	1.8			0.017	0.022	4	35	5	56	19	13.0	7.9	0.9	0.8	5					
A147																									
10	6.0		0.01		<0.002															9	10				15
20	5.5		0.01		<0.002																				16
30	5.7		0.01		<0.002																				4
60	6.3		0.02		<0.002																				
90	7.0		0.02		0.002																				
A148																									
10	5.6	2.9	0.02		<0.002		0.5	0.05	0.018	0.042	9	43	13	34	10	3.3	3.2	1.05	0.1	15	15				
20	5.2	2.9	0.02		<0.002						11	41	12	33	9	2.8	2.8	0.85	0.1	8					
30	6.0	4.6	0.02		<0.002				0.021	0.025	10	39	16	34	14	6.0	6.0	1.0	0.5	10	2				
A149																									
10	7.0	4.8	0.01		<0.002		0.4	0.03	-	-	5	40	7	47	15	6.4	7.7	1.8	0.1	-	-	-	-	-	
20	7.1	5.1	0.01		<0.002				0.020	0.027	4	37	10	52	17	8.0	7.9	1.6	0.1	7	2	22	13	10	
30	7.4	5.5	0.01		0.002						3	35	8	55	19	9.8	7.9	1.2	0.2	6		27	14	13	
60	8.0	5.7	0.02		<0.002	1.0					2	35	8	56	18	11.0	7.8	0.95	0.4	7		30	15	15	
120	8.3	5.9	0.02		<0.002	1.3			0.019	0.025	2	35	15	41	17	12.4	8.5	0.7	1.1	8					

Dth	pH H_2O 1:5	A.D. Moist.	T.S.S. 1:5	T.S.S. 1:50	Cl	$CaCO_3$	Org. C	Total N	Phosphorus Digest	Phosphorus X-Ray	Particle Size CS	FS	Si	C	Ex. Cap.	Ex. Cations Ca	Mg	K	Na	Avail. P Acid	Bic.	H_2O 1/3 bar.	15 bar.	Av. H_2O	Gravel
cm		%	% Air Dry Weight								% Oven Dry Weight				m equiv./100 g					ppm		%			
A150																									
10	7.2	3.5	0.01		<0.002		0.4	0.04	0.026	0.036	20	36	3	41	12	7.0	5.3	1.1	0.4	5	5				
20	7.0	4.4	0.01		<0.002						16	35	4	45	14	8.0	5.9	0.85	0.5	5					
30	7.2	5.3	0.01		<0.002	0.9					11	35	3	51	15	9.0	6.5	0.8	0.4	3					
60	7.7	5.4	0.02		0.003	1.0					10	36	4	50	16	10.0	6.4	0.7	0.5	3					
120	8.0	5.5	0.02		<0.002	1.0			0.018	0.027	8	37	4	51	16	11.0	7.2	0.55	0.6	2					
A151																									
10	6.3		0.01		0.002						20	36	3	41						8	7				
20	6.8		0.01		0.002						16	35	4	45											
30	7.1		0.04		0.007						11	35	3	51											
60	8.5		0.06		0.019	0.7					10	36	4	50											
120	9.0		0.05		0.014	1.3					8	37	4	51											
A153																									
10	6.7		0.02		0.008															25					54
20	6.0		0.75	0.8	0.371																				19
30	6.0		0.84	0.9	0.435																				26
A154																									
10	6.8		0.02		0.008															37					
20	6.4		0.09		0.025																				
30	6.2		0.36	0.4	0.154																				
60	5.8		0.69	0.9	0.390																				
120	5.7		1.04	2.7	0.429																				
A155																									
10	6.0	4.2	0.24		0.099		0.3	0.02			4	44	15	40	19	6.4	9.5	0.85	1.2	15					9
20	7.1	5.8	0.6	1.0	0.420						5	38	11	48	23	16.8	8.2	0.65	0.7	15					
30	8.0	6.2	1.28	1.4	0.585						4	38	15	43	25	21	10.4	0.45	1.0	13					
60	8.0	6.9	1.31	1.5	0.634						6	33	12	49	24	18.4	16.0	0.4	1.2	8					
120	5.5	8.8	1.33	3.6	0.500						14	27	11	52	20	>46	7.9	0.3	1.4	12					
A156																									
10	5.8	1.9	0.03		0.006		0.4	0.04			11	58	5	24	8	3.8	1.6	0.6	<0.1	50					
20	5.7	2.2	0.01		0.002						12	54	9	25	7	3.8	1.7	0.65	<0.1	36					
30	5.5	3.4	0.03		0.006						31	33	5	33	11	6.6	3.2	0.75	<0.1	21					
60	6.0	3.5	0.02		0.005						24	41	5	30	12	7.5	3.8	0.6	0.1	12					
120	7.3	-	0.01		0.004						31	39	10	24	14	9.5	5.0	0.45	0.5	15					11
A157																									
10	6.1	1.9	0.01		0.002		0.5	0.03	0.035	0.050	48	31	7	14	5	3.2	1.8	0.5	0.2	10	9				
20	7.0	4.6	0.01		0.003						18	28	7	47	15	7.3	4.4	0.5	1.2	7					
30	7.8	5.0	0.04		0.014						12	33	6	49	16	9.2	5.3	0.3	1.8	7					
60	7.9	4.6	0.32	0.4	0.136	1.1					11	39	8	41	17	10.2	3.8	0.2	1.7	7					
120	7.8	5.9	0.59	1.9	0.154	1.2			0.023	0.031	8	40	12	42	19	44	9.4	0.1	1.8	8					
A158																									
10	5.3		0.02		0.002															8	10				45
A159																									
10	6.1		<0.01		0.005															15	14				15
20	5.8		0.25		0.112																				54
A160																									
10	6.4	1.9	0.02		0.005		0.5	0.04			8	67	9	18	8	6.8	2.0	0.65	0.2	25	22				10
20	6.1	3.4	0.04		0.018						7	54	9	30	11	8.2	2.9	0.45	0.3	15					18
30	7.5	5.5	0.46	0.5	0.214						4	43	10	40	21	14.5	6.9	0.3	0.8	10					6
45	8.0	6.1	0.62	0.7	0.299						7	46	16	31	22	15.5	8.5	0.2	1.2	9					18
A161																									
10	7.8		0.01		0.002															27					
20	7.1		0.08		0.007																				
30	7.4		0.03		0.005																				
50	7.4		0.05		0.004																				11
A162																									
10	7.6	6.3	0.15		0.055		0.4	0.05	0.022	0.032	3	41	6	52	29	13.8	16.4	0.9	2.8	15	13	30	16	14	
20	8.0	5.7	0.18		0.083						5	40	7	50	30	14.3	15.0	1.05	3.1	21					
30	7.2	6.2	0.66	1.1	0.498						4	38	8	50	28	13.6	14.4	0.7	3.0	18		32	17	15	
60	7.0	6.7	1.16	2.1	0.467						5	38	8	49	28	37	14.8	0.65	3.9	29		32	17	15	
120	7.0	7.9	1.35	3.1	0.480				0.022	0.034	7	35	8	50	27	>46	14.0	0.65	3.7	67					
A163																									
10	7.3	4.4	0.05		0.014		0.7	0.06	0.023	0.039	3	45	10	44	24	12.5	8.0	1.35	1.9	40	35	25	14	11	
20	6.8	5.2	0.31	0.4	0.125						16	32	8	45	25	15.5	8.9	0.6	1.9	20					
30	6.6	5.5	1.04	1.2	0.497						13	34	9	46	23	14.2	9.0	0.5	2.4	14		28	15	13	
60	6.7	6.2	0.78	1.0	0.346						12	33	10	46	26	17.0	9.3	0.8	3.3	13		28	16	12	
120	6.8	5.9	1.06	2.9	0.250				0.014	0.025	16	47	6	33	17	>48	7.4	0.4	3.2	20					
A164																									
10	6.9	6.6	0.66	0.8	0.284		0.5	0.05			3	42	9	47	29	18.0	8.0	0.95	1.9	13					
20	6.7	5.0	0.87	3.1	0.266						8	39	10	41	27	>40	5.8	0.7	2.0						
30	6.4	7.0	0.99	3.9	0.302						11	36	9	43	25	>40	7.3	0.4	3.0						
60	6.5	6.9	0.98	3.3	0.320						11	36	9	43	24	>40	8.0	0.45	4.3						
120	6.3	8.0	1.28	3.3	0.391						11	35	7	46	25	>40	8.4	0.5	4.8						
A165																									
10	8.3	5.7	0.04		0.011		0.7	0.06			4	40	10	49	30	24	6.9	1.8	2.0	35					18
20	8.5	6.5	0.08		0.020	2.1					5	39	7	50	32	28	6.2	0.75	3.7	11					9
30	8.5	6.7	0.23		0.076	2.4					3	37	10	50	34	31	6.8	0.6	4.2	13					
60	7.9	7.0	0.81	1.4	0.235	-					2	35	11	52	33	>40	6.0	0.55	8.0	12					
120	7.8	7.5	1.16	2.8	0.382	2.0					3	33	10	51	34	>50	7.1	0.6	6.1	17					

Dth cm	pH H_2O 1:5	A.D. Moist. %	T.S.S. 1:5	T.S.S. 1:50	Cl	$CaCO_3$	Org. C	Total N	Phosphorus Digest	Phosphorus X-Ray	Particle Size CS	FS	Si	C	Ex. Cap.	Ex. Cations Ca	Mg	K	Na	Avail. P Acid	Bic.	H_2O 1/3 bar.	15 bar.	Av. H_2O	Gravel
					% Air Dry Weight						% Oven Dry Weight				m equiv./100 g					ppm		%			
A166																									
10	8.2	6.1	0.04		0.008		0.4	0.05			1	38	10	51	33	25	8.0	1.3	3.0	10					16
20	7.8	7.0	1.11	1.3	0.470						1	38	12	52	32	25	7.8	0.65	5.7	34					
30	8.0	6.7	0.65	0.7	0.293	1.7					1	39	8	50	32	21	6.5	0.5	5.0	39					
60	7.8	7.2	0.99	1.1	0.470	1.7					2	38	10	51	31	22	7.7	0.8	6.5	21					
120	7.8	8.2	1.13	1.5	0.497	1.6					1	35	13	54	33	29	7.8	0.65	6.0	65					
A167																									
10	8.3	5.5	0.05		0.009	1.9	0.4	0.04	0.027	0.036	9	38	8	44	36	37	2.9	1.4	0.5	81	20	28	13	15	
20	8.8	6.5	0.04		0.007	1.9					9	34	9	48	36	38	2.5	1.05	2.2	63					
30	9.0	7.0	0.06		0.008	2.2					8	35	9	48	36	40	2.4	0.8	3.2	60		32	16	16	
60	9.1	7.1	0.06		0.008	2.2					7	34	9	49	38	39	2.3	0.6	4.2	67		32	17	16	
120	8.0	8.7	0.8	3.3	0.003	2.3			0.041	0.050	9	37	12	40	38	>70	2.5	0.35	6.9	>150					
A168																									
10	7.0	7.3	0.05		0.002		0.5	0.05			3	28	8	62	24	20	2.7	1.4	0.5	17					
20	6.9	7.4	0.26	-	0.003						6	26	7	59	26	53	2.1	0.95	0.8	14					
30	6.9	7.5	0.32	-	0.008						9	25	7	58	25	59	3.1	0.95	1.5	5					
60	6.7	7.5	0.57	1.4	0.080	1.0					7	25	8	57	25	60	6.5	0.9	2.9	9					
120	6.7	8.2	0.89	1.8	0.203						8	24	6	61	24	60	10.8	1.05	5.9	7					
A169																									
10	6.0	1.3	0.08		0.003		0.3	0.03	0.024	0.045	24	55	11	13	3-5	1.4	0.5	0.45	0.2	17	15				
20	7.7	4.8	0.17		0.031			0.03	0.024		16	39	8	37	15	6.9	5.1	0.55	2.9	5					
A170																									
10	6.7		0.01		0.004															20					
20	6.6		0.09		0.034																				
30	6.6		0.40	0.5	0.174																				
60	6.6		0.5	0.5	0.204																				
120	7.3		0.5	0.5	0.134																				
A171																									
10	6.1		0.02		0.005															42					
20	6.4		0.08		0.028																				
30	6.2		0.13		0.045																				
60	6.7		0.29		0.119																				
120	6.6		0.76	1.8	0.180																				
A172																									
10	6.9	4.4	0.24		0.067		0.3	0.02	0.017		1	45	11	42	18	10.7	6.3	0.6	2.7	8	5	NA	10		
20	6.3	5.7	1.54	1.7	0.665						2	37	12	50	20	9.0	8.6	0.35	3.3	10					
30	6.1	6.4	1.28	1.8	0.688						1	36	12	49	20	10.5	10.4	0.35	1.9	13		25	12	13	
60	5.9	6.2	1.35	1.7	0.610						1	38	13	48	20	15.0	10.1	0.3	3.3	19		26	12	14	
120	5.9	4.6	0.92	1.1	0.412				0.019	0.031	1	49	14	38	14	9.5	7.5	0.25	1.3	25					
A174																									
10	5.5	0.3	0.01		<0.002		<0.1	<0.01	0.017	0.020	71	27	1	5	<3	<0.1	<0.1	0.1	<0.1	7	7	2	1	1	
20	5.5	0.3	0.01		<0.002						58	40	<1	4	<3	0.1	0.2	0.15	<0.1	7					
30	5.4	0.3	0.01		<0.002						47	48	1	5	<3	0.2	0.1	0.15	<0.1	8		3	1	2	
60	5.4	0.3	0.01		<0.002						51	47	1	5	<3	0.1	0.1	0.1	<0.1	7		3	1	2	
120	5.6	0.2	0.01		<0.002				0.014	0.018	59	39	<1	4	<3	0.1	0.1	0.1	<0.1	7					
A175																									
10	6.2		0.01		<0.002															11					16
20	6.2		0.01		0.002																				44
30	7.0		0.01		<0.002																				51
60	7.2		0.02		0.003																				
100	7.3		0.05		<0.002																				
A176																									
10	6.0		0.01		<0.002				0.025	0.040										8	10	9	4	5	
20	5.8		0.02		0.004																	12	5	7	
30	6.0		0.01		<0.002				0.023	0.043															33
A177																									
10	6.9	6.6	0.02		0.004		0.3	0.03	0.020	0.026	22	10	13	60	26	15.0	8.7	0.95	1.7	12	8				
20	6.4	7.0	0.18		0.071						20	10	13	59	24	15.0	8.6	0.7	1.8						
30	5.9	7.5	0.81	0.9	0.408						21	10	13	59	27	15.5	10.4	0.6	-			28	16	13	
60	5.9	7.1	0.97	1.1	0.471						21	11	15	58	27	15.2	11.1	0.6				32	16	16	
120	6.0	8.0	0.86	1.2	0.380				0.021	0.029	20	6	11	65	24	24	11.5	0.6							
A179																									
10	5.7	2.3	0.01		<0.002		0.6	0.05	0.018	0.030	23	43	10	28	8	4.0	1.9	0.8	0.1	6	7	13	7	6	
20	5.8	2.7	0.01		<0.002						20	43	12	28	8	4.5	2.1	0.65	<0.1	3					
30	6.0	2.8	0.01		<0.002						18	42	11	31	9	5.3	2.4	0.55	<0.1	4		14	9	5	
60	6.2	4.9	0.01		<0.002						35	37	11	17	13	9.2	5.0	0.55	0.1	13		21	14	7	
120	8.0	8.4	0.03		0.002	2.0			0.011	0.016	16	31	7	46	24	17.6	7.6	0.7	0.2	6					
A180																									
10	5.6		0.02		0.002															20					
20	6.2		0.02		0.002																				
30	6.7		0.04		0.011																				
60	6.4		0.12		0.029																				
120	5.2		0.32	0.4	0.101																				
A183																									
10	6.9		0.85		0.014															13					
20	6.6		0.24		0.082																				
30	6.6		0.44	0.5	0.185																				
60	6.5		0.73	0.8	0.335																				
120	6.2		0.83	1.3	0.287																				

Dth	pH H_2O 1:5	A.D. Moist.	T.S.S. 1:6	T.S.S. 1:50	Cl	$CaCO_3$	Org. C	Total N	Phosphorus Digest	Phosphorus X-Ray	Particle Size CS	FS	Si	C	Ex. Cap.	Ex. Cations Ca	Mg	K	Na	Avail. P Acid	Bic.	H_2O 1/3 bar.	15 bar.	Av. H_2O	Gravel
cm		%	% Air Dry Weight								% Oven Dry Weight				m equiv./100 g					ppm		%			
A184																									
10	6.2		0.06		0.017															14					
20	6.8		0.09		0.024																				
30	7.5		0.24		0.064																				
60	7.1		0.84	1.9	0.143																				
120	6.2		1.02	2.0	0.217																				
A187																									
10	6.9	5.6	0.91	1.0	0.360		0.3	0.03			4	42	6	50	26	18.0	9.2	0.55	4.0	7					
20	7.0	6.0	1.0	1.0	0.393						3	42	7	50	25	18.5	8.9	0.45	1.9	8					
30	6.8	6.0	0.93	0.9	0.363						2	41	7	51	28	18.5	9.0	0.50	2.4	8					
60	6.4	6.4	0.69	0.9	0.239						4	37	7	55	28	24	9.2	0.55	2.8	16					
A188																									
10	6.3		0.62	1.2	0.007															26					
20	6.4		0.66	1.3	0.080																				
30	6.3		1.73	2.1	0.690																				
60	6.2		1.02	1.6	0.355																				
120	5.7		0.91	1.3	0.323																				
A189																									
10	6.6	0.8	0.05		0.019		<0.1	0.01	0.006	0.009	59	34	<1	9	3-5	2.2	1.0	0.25	<0.1	8	7	7	2	4	
20	6.8	0.8	0.02		<0.002						73	20	1	9	<3	1.9	1.1	0.3	0.1	7					
30	6.7	0.9	0.01		<0.002						68	22	1	10	<3	1.8	1.4	0.3	0.1	4		5	2	3	
60	6.8	1.3	0.01		<0.002						58	30	<1	13	5	2.4	2.0	0.35	0.2	3		7	4	3	
120	6.9	1.9	0.02		0.003				0.008	0.010	50	34	1	17	6	2.8	3.0	0.45	0.2	4					
A192																									
10	6.7	4.0	0.02		0.004		0.4	0.03			32	28	3	36	11	5.2	4.8	0.95	<0.1	25					
20	6.8	4.3	0.02		0.003						33	27	3	36	12	5.2	5.3	0.95	<0.1	14					
30	6.8	5.0	0.02		0.003						27	23	4	45	16	6.8	6.8	1.35	0.1	12					
60	6.8	5.0	0.02		0.007						24	23	5	47	18	7.8	7.7	1.45	<0.1	10					
A194																									
10	6.4		0.01		<0.002															7	5				
20	6.4		0.01		0.002																				
30	6.3		0.02		0.003																				
60	6.3		0.01		<0.002																				
120	6.4		0.01		<0.002																				
A195																									
10	7.4	5.1	0.02		0.002		0.4	0.03			17	41	7	36	17	11.6	4.8	1.5	0.9	71					
20	7.6	6.9	0.02		0.002						18	29	6	50	24	15.2	5.9	1.65	1.8	75					
30	7.7	7.0	0.03		0.003						13	26	6	50	22	14.2	5.5	1.55	2.5	75					
60	8.5	7.3	0.05		0.010	1.4					13	28	6	51	23	15.6	4.6	1.40	4.8	150					
120	9.3	8.0	0.20		0.024	2.4					14	21	6	55	27	17.4	3.8	1.50	10.3	>150					
A196																									
10	9.5	3.4	0.11		0.010	-	0.2	0.01			43	27	2	27	15	14.0	2.5	0.9	3.9	90					
20	9.7	6.5	0.25		0.031	2.8					21	27	4	43	23	28	2.9	1.15	15.0	<150					
30	9.7	6.7	0.43		0.082	2.6					21	26	6	43	23	28	2.5	0.9	17.0	150					
60	9.1	6.8	1.50	2.0	0.490	4.2					28	24	3	39	21	26	3.1	0.85	17.0	150					
120	8.9	6.9	1.55	2.2	0.410	4.6					33	22	3	37	18	31	4.1	0.95	15.0	31					
A197																									
10	8.6	0.5	0.09		0.015	0.2	0.2	0.01			73	23	<1	5	<3	1.9	0.3	0.3	0.4	8	4	4	2	2	
20	7.9	0.4	0.03		0.004	0.1					62	35	2	5	<3	1.2	0.3	0.45	0.1	4					
30	8.8	1.0	0.04		0.012	0.2					59	32	<1	10	<3	1.2	0.7	0.35	1.4	4		7	3	3	
60	8.9	1.1	0.06		0.018	0.3					59	33	<1	9	<3	1.1	0.8	0.3	2.0	4		8	4	4	
120	9.0	1.7	0.09		0.028	0.1					64	27	<1	10	3-5	1.0	0.8	0.35	3.6	6					
A198																									
10	7.6	0.4	0.02		0.003		0.1	<0.01			82	15	<1	4	<3	0.9	0.2	0.2	0.2	9	5				
20	6.9	0.3	0.02		0.002						83	16	<1	3	<3	1.1	0.1	0.15	<0.1	10					
30	7.1	0.3	0.01		<0.002						81	17	<1	3	<3	0.9	0.1	0.15	<0.1	9					
60	[illegible].8	0.4	0.01		<0.002						75	22	<1	3	<3	0.9	0.1	0.15	<0.1	8					
120	6.7	0.4	0.01		<0.002						76	21	<1	2	<3	0.6	0.1	0.15	<0.1	3					
A199																									
10	6.6		0.02		0.004															13	13				
20	6.7		0.01		0.002																				
30	6.4		0.01		<0.002																				
60	7.9		0.02		0.006	0.8																			
120	8.6		0.14		0.036	1.5																			
A200																									
10	7.1		0.02		0.003															41					
20	7.0		0.02		0.003																				
30	7.0		0.02		0.003																				
40	6.9		0.02		<0.002																				NA
A201																									
10	7.3	1.3	0.02		0.002		0.5	0.03			5	73	9	17	6	4.2	2.1	0.75	0.3	15					39
20	7.6	5.0	0.02		0.005						5	48	6	43	18	11.4	4.5	0.75	1.4	11					
30	7.4	5.4	0.18		0.056						2	45	7	48	24	17.7	6.2	0.55	2.1	6					
60	7.1	5.5	0.36	0.4	0.132						7	50	9	37	25	18.0	6.5	0.3	2.7	11					
A202																									
10	7.4	4.8	0.05		0.013		0.4	0.04	0.026	0.035	2	27	19	55	24	14.6	6.3	1.35	1.8	44	33	27	15	13	
20	7.5	5.0	0.03		0.007						1	26	17	54	24	14.2	6.0	1.2	2.3	45					
30	7.1	5.2	0.13		0.036						1	27	16	56	24	12.8	6.0	1.05	3.2	48		31	15	15	
60	6.2	7.1	1.50	1.6	0.663						<1	25	18	56	23	12.8	9.3	0.8	3.2	59		29	16	14	
120	6.3	6.3	1.07	1.7	0.400				0.026	0.035	<1	31	17	49	24	28	8.2	0.6	2.4	80					

Dth	pH H_2O 1:5	A.D. Moist.	T.S.S. 1:5	T.S.S. 1:50	Cl	$CaCO_3$	Org. C	Total N	Phosphorus Digest	Phosphorus X-Ray	Particle Size CS	FS	Si	C	Ex. Cap.	Ex. Cations Ca	Mg	K	Na	Avail. P Acid	Bic.	H_2O 1/3 bar.	15 bar.	Av. H_2O vol	Gravel
cm		%	% Air Dry Weight								% Oven Dry Weight				m equiv./100 g					ppm		%			
A203																									
10	6.8	5.6	0.03		0.008		0.3	0.03			2	26	12	65	28	16.7	7.7	1.8	1.4	71					
20	7.0	5.9	0.03		0.007						2	22	12	64	29	16.0	7.6	1.8	1.6	75					
30	7.3	5.8	0.03		0.005						2	21	12	64	28	16.8	7.6	1.7	1.9	76					
60	7.0	6.3	0.56	0.6	0.170						2	21	11	63	28	17.5	7.6	1.4	4.2	82					
120	6.6	7.2	1.31	2.2	0.383						3	19	12	62	28	37	9.8	1.1	4.0	98					
A204																									
10	7.0	4.3	1.16	1.2	0.492		0.3	0.02			4	42	9	49	22	12.0	7.7	1.0	3.0	65					
20	6.7	5.3	2.89	3.2	1.370						2	33	11	49	22	14.0	9.5	0.85	2.9	72					
30	6.5	6.0	2.74	3.1	1.250						2	33	11	51	24	11.5	10.2	0.8	3.4	69					
60	6.4	6.4	2.12	2.3	0.896						2	27	11	56	25	16.0	10.3	1.0	3.4	95					
120	7.0	6.4	1.56	2.3	0.455						2	32	14	49	24	>40.0	10.1	0.8	3.8	150					
A205																									
10	7.1		0.14		0.020															65					
20	7.2		0.10		0.005																				
30	7.0		0.09		0.003																				
60	7.7		0.23		0.007																				
120	8.2		0.43	0.7	0.017																				
A208																									
10	6.9	5.0	0.10		0.006		0.7	0.06			10	34	9	50	25	16.4	6.6	2.1	0.7	73					
20	6.9	6.5	0.06		0.004			0.02			7	34	10	51	26	17.2	6.3	1.25	1.0	57					
30	7.1	5.0	0.05		0.006						7	34	10	48	26	18.0	6.4	1.1	1.4	64					
60	7.6	5.1	0.06		0.007						8	37	10	47	23	16.6	5.6	0.9	2.2	55					
120	8.5	3.7	0.07		0.007						4	55	10	34	19	13.3	3.7	0.8	2.5	74					
A209																									
10	6.9	5.2	0.13		0.011		0.4	0.06	0.036	0.054	4	27	12	58	28	20	7.7	1.9	1.1	113	61	28	16	12	
20	7.1	5.5	0.09		0.003						3	27	11	57	27	22	5.8	1.4	0.8	121					
30	7.4	5.7	0.08		0.005						5	28	12	53	27	22	5.4	1.2	0.8	114		29	16	13	
60	7.7	5.7	0.09		0.006						4	28	11	58	28	22	5.4	1.2	1.4	118		30	16	13	
120	7.6	6.1	0.88	1.3	0.096				0.031	0.045	5	26	12	56	29	33	7.9	1.2	5.7	119					
A210																									
10	7.1		0.10		0.008															63					
20	7.2		0.33		0.109																				
30	6.3		1.28	1.3	0.608																				
60	6.3		1.16	1.1	0.533																				
120	6.3		1.02	1.2	0.389																				
A211																									
10	6.8	0.9	0.11		0.024		0.2	0.02	0.013		61	32	1	8	3-5	2.1	1.0	0.8	0.1	13	7	NA	2		
20	6.9	0.7	0.05		0.004						70	25	1	5	<3	1.7	0.8	0.6	0.2	6					
30	7.2	0.7	0.04		0.002						67	27	3	5	<3	1.7	0.8	0.6	0.1	5		4	2	2	
60	7.8	3.1	0.06		0.004						53	22	2	21	12	7.0	4.4	1.15	1.0	5		16	8	8	
120	8.4	3.2	0.08		0.018				0.012	0.026	46	39	7	9	12	6.0	4.4	0.85	1.9	4					
A212																									
10	7.1		0.05		0.004															19					
20	7.2		0.05		0.004																				
30	7.2		0.05		0.006																				
60	7.2		0.30		0.110																				
120	8.0		0.43		0.107	0.5																			
A213																									
10	7.3		0.08		0.008															17					
20	7.4		0.07		0.007																				
30	6.9		0.16		0.044																				
60	6.4		0.93	1.0	0.443																				
120	6.5		1.02	1.9	0.350																				
A214																									
10	7.0	1.6	0.07		0.008		0.4	0.04	0.021	0.043	13	66	11	13	7	5.2	2.5	1.0	0.3	36	27	12	4	7	59
20	7.2	2.1	0.05		0.004						9	65	9	20	9	5.7	2.3	0.7	1.0	17					58
30	8.0	6.5	0.06		0.006	-					5	31	3	60	23	15.2	6.4	1.05	3.1	11		30	18	12	40
40	8.0	5.3	0.08		0.013	-			0.024	0.040	7	40	7	47	23	14.6	6.1	1.05	2.9	17					71
A215																									
10	6.8		0.08		0.013															27					
20	6.8		0.02		0.005																				
30	6.5		0.02		0.003																				
60	7.3		0.04		0.013																				
120	8.6		0.17		0.055																				
A218																									
10	6.3	0.7	0.02		0.005		0.1	0.01	0.011		66	27	<1	7	<3	1.2	0.6	0.35	0.2	6	<2	NA	2		
20	6.7	0.9	0.02		0.004						61	32	1	7	<3	2.4	1.0	0.6	<0.1	5					
30	6.2	0.9	0.02		0.004						57	35	<1	9	3-5	1.8	0.8	0.7	<0.1	7		4	2	1	
60	5.9	1.1	0.01		0.002						60	31	1	9	<3	1.9	0.9	0.55	0.1	3		4	2	1	
120	7.1	1.9	0.02		0.004				0.010	0.025	50	37	1	14	6	3.2	2.9	0.4	0.3	4					
A219																									
10	7.7	5.8	0.04		0.003	0.5	0.4	0.03			19	26	7	46	22	16.1	5.9	2.5	0.3	93					
20	8.1	7.0	0.03		0.002	-					16	24	8	49	24	19.0	6.6	2.2	0.5	95					
30	8.2	6.6	0.04		0.003	1.5					17	27	6	48	22	18.7	6.4	1.45	0.5	96					
60	8.3	7.7	0.04		0.003	1.7					14	24	6	53	24	19.6	7.6	1.35	0.9	93					
120	8.3	7.8	0.06		0.003	2.6					15	24	5	54	24	20	8.7	1.35	2.3	102					

Dth	pH H_2O 1:5	A.D. Moist.	T.S.S. 1:5	T.S.S. 1:50	Cl	$CaCO_3$	Org. C	Total N	Phosphorus Digest	Phosphorus X-Ray	Particle Size CS	Particle Size FS	Particle Size Si	Particle Size C	Ex. Cap.	Ex. Cations Ca	Ex. Cations Mg	Ex. Cations K	Ex. Cations Na	Avail. P Acid	Avail. P Bic.	H_2O 1/3 bar.	H_2O 15 bar.	Av. H_2O	Gravel
cm		%	% Air Dry Weight								% Oven Dry Weight				m equiv./100 g					ppm		%			
A220																									
10	6.7		0.01		0.002															7					
20	5.6		0.02		0.005																				
30	5.2		0.01		0.002																				
60	5.3		0.01		0.002																				
120	8.6		0.09		0.030	0.8																			
A224																									
10	7.2		0.05		0.005															59					
20	7.0		0.03		0.004																				20
30	7.6		0.06		0.003	1.3																			40
B1																									
10	4.6	2.3	0.02		0.002		0.7	0.06	0.021	0.033	34	20	15	33	10	2.4	1.3	0.5	0.2	8	9	20	8	12	
20	4.9	2.5	0.02		<0.002						35	18	15	35	11	2.4	1.8	0.35	0.5	<5					
30	6.3	4.8	0.12		0.054						25	13	11	57	20	2.4	7.4	0.25	3.0	<5		27	18	10	
60	8.0	5.6	0.27		0.114						22	13	12	57	26	10.0	10.0	0.35	5.0	<5		31	20	12	
120	7.6	7.0	0.58	1.11	0.148				0.010	0.013	17	13	11	59	26	12.0	11.5	0.45	7.0	<5					
B2																									
10	5.1	1.8	0.03		0.003		0.9	0.06	0.024	0.041	51	10	13	29	9	2.4	1.1	0.35	0.3	7	7	17	8	8	
20	4.7	1.7	0.02		0.003						47	11	10	36	9	2.0	1.0	0.40	0.5	<5					
30	4.8	1.9	0.02		0.003						48	13	17	18	7	2.4	1.2	0.35	0.8	<5		16	9	7	
60	6.0	2.2	0.02		0.003						35	11	17	41	11	4.0	3.6	0.35	1.3	<5		18	11	7	
120	8.6	2.7	0.02		<0.002				0.013	0.020	34	13	11	47	13	7.0	4.9	0.45	2.6	<5					

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, and weighed, while samples not containing gravel were ground to less than 2 mm. All determinations were carried out using the $<$ 2 mm soil and the results are uncorrected for gravel percentage. All results are reported on an air dry basis except where indicated.

PARTICLE SIZE DISTRIBUTION

Particle size determinations were conducted using 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.

SOLUBLE SALTS

A 1:5 soil de-ionized water suspension was shaken for one hour and the electrical conductivity (E.C.) was determined at 20° C. This was converted to per cent total soluble salts (T.S.S.) using the factor of Piper (1942).

% T.S.S. = E.C. mmho/cm x 0.375 at 20° C

This factor is an approximation, particularly for arid soils with unusually high concentrations of sulphates, bicarbonates, or calcium salts.

A 1: 50 soil water suspension was also used on soils with high T.S.S. %, particularly if gypsum was suspected as being present.

pH

After determination of electrical conductivity, the same suspension was then used to determine pH using a glass electrode and saturated calomel reference.

Some fluctuations of pH with different stirring rates was experienced for the red earths. This group of soils also showed discrepancies between laboratory pH readings and field pH.

CHLORIDES

Chlorides were determined on the same stirred suspension, after conductivity and pH readings were completed, using a specific ion electrode (Haydon, Williams and Ahern, 1974).

CALCIUM CARBONATE

Calcium carbonate determinations were done on all samples which effervesced in HCl. The acid neutralization method described by the U.S. Salinity Laboratory Staff (1954) was used. Results obtained by this method may be somewhat high, because soil constituents other than lime may react with the acid.

ORGANIC CARBON

The wet combustion 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.

TOTAL NITROGEN

The Kjeldahl method with copper catalyst was used.

"AVAILABLE" PHOSPHORUS

Acid Extractable P was determined by the Kerr and von Stieglitz (1938) method. Readings were carried out using an Auto Analyser technique. Results for soils containing less than 5 ppm P are approximate only.

Bicarbonate extractable P was determined by the Colwell (1963) method.

"TOTAL" PHOSPHORUS

Digestion

A modification of the Beckwith and Little (1963) method was used. 4 g of soil was ashed with magnesium acetate for one hour at 500 – 550° C, then extracted with boiling HCl for 4 hours. Phosphorus was measured colorimetrically by the method of Murphy and Riley, (1962).

X-ray fluorescence

About 3 g of soil sample were very finely ground and pelleted with boric acid. The pellet was then exposed to a beam of X-rays in a Philips 1410 vacuum X-ray spectrograph. Simple linear calibration was used to obtain percentage phosphorus from fluorescent intensities.

EXCHANGEABLE CATIONS

Samples were divided into two categories for analysis. Samples with an electrical conductivity > 0.3 mmho/cm were given a pre-wash treatment with 60% aqueous ethanol to remove soluble cations. (Loveday, Beatty and Norris, 1972).

Five grams of soil was shaken for 1 hour in 100 ml of molar aqueous ammonium chloride (pH 7.0) filtered and leached with a further 100 ml. Cations were determined on the leachate, sodium and potassium by flame photometer, and calcium and magnesium, after suitable dilution with a strontium chloride solution, on an atomic absorption spectrophotometer.

The exchange capacity was found by displacing the ammonium absorbed in the extraction of the exchangeable cations, with sodium sulphate.

For the soils with E.C. < 0.3 mmho/cm exchangeable sodium was corrected for soluble sodium by subtracting an amount equivalent to the chloride determined on the 1:5 extract. This correction is an approximation since chlorides other than sodium may occur in this region.

Exchangeable calcium figures may be inflated on soils containing carbonate and gypsum.

Low exchange capacity figures, particularly on very low clay content soils did not reproduce well, and care must be exercised with their interpretation.

MOISTURE CHARACTERISTICS

Moisture percentage at matric potentials of -1/3 and -15 bar 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 water was calculated as the difference between these two measurements.

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PLANT SPECIES LIST

by D.E. Boyland

Two species lists have been prepared. This first a scientific name - common name list covers all species identified in the area during the study. An assessment of toxicity and palatability together with distribution is also given for each species, where possible. The second lists the common name and equivalent scientific name for selected species.

A. Species, species distribution, toxicity, palatability and common name

The families are arranged alphabetically and the genera are listed alphabetically within the family and the species alphabetically within the genus.

The presence of species in the various land zones are indicated by x.

Land zones are represented by the columns as indicated:-

1 Dunefields	4 Hard Mulga Lands	7 Undulating Downs	9 Channel Alluvia
2 Mulga sandplains	5 Dissected Residuals	8 Alluvial Plains, Woodlands	10 Other Alluvia
3 Soft Mulga Lands	6 Undulating Gidgee Lands	(a) Gidgee Woodlands	
		(b) Eucalypt Woodlands	

Each species has been rated according to its palatability and toxicity. Palatability varies and may be dependent on the stage of growth of the plant, the composition of the pasture, the availability of more palatable species and the type of animal. The following abbreviations are used for the three classes of palatability.

H – high M – medium L – low or unknown * – in the drying off state

Toxicity of the various species to animals are indicated as follows.

T – shown to be toxic by feeding trials.
C – known to contain toxins but has not been implicated in field cases of poisoning.
S – suspected on strong field evidence.
U – the plant is not known to be toxic and has not been suspected on reliable field evidence.
* – toxic when it is the only component of the diet.

NOTE: Plants known to be toxic are not always dangerous and may be useful components of the pasture, refer Poisonous Plants section.

Family/Species	Land Zone 1	2	3	4	5	6	7	8(a)	8(b)	9	10	Palat.	Toxity	Common Name
ACANTHACEAE														
Brunoniella australis			x	x								L	U	
Dipteracanthus primulaceus			x									L	U	
Justicia procumbens								x	x		x	L	S	
Xerothamnella parviflora				x	x							L	U	
AIZOACEAE														
Glinus lotoides	x	x										L	U	
Mollugo cerviana			x	x	x							L	U	
Trianthema galericulata	x					x	x		x	x	x	L	S	Hogweed
Trianthema pilosa	x											L	U	
Trianthema portulacastrum						x	x	x		x	x	L	S/C	Giant pigweed or black pigweed
Trianthema triquetra				x		x	x	x			x	*M	T	Red spinach
ALISMATACEAE														
Damasonium minus	x									x	x	L	U	
AMARANTHACEAE														
Alternanthera denticulata			x					x	x		x	L	S	Lesser joyweed
Alternanthera nodiflora	x		x			x	x	x	x	x	x	L	S	Common joyweed
Alternanthera pungens				x								L	S	Khaki-weed
Amaranthus grandiflorus	x											L	U	
Amaranthus interruptus	x											L	U	Native amaranth
Amaranthus mitchellii							x	x		x		*H	T	Boggabri
Gomphrena brownii	x											L	U	
Gomphrena celosioides	x		x									L	T	Gomphrena weed
Ptilotus exaltatus	x				x	x	x					M	U	Fox brush or Prince-of-Wales feathers
Ptilotus gaudichaudii			x	x	x							L	U	
Ptilotus helipteroides			x	x	x							L	U	
Ptilotus latifolius	x											L	U	
Ptilotus leucocoma		x	x	x	x							L	U	
Ptilotus macrocephalus	x		x	x	x				x		x	L	U	Pussy tails
Ptilotus murrayi										x		L	U	
Ptilotus nobilis			x	x		x						L	U	
Ptilotus obovatus	x		x	x	x	x	x	x	x			M	U	
Ptilotus obovatus var. grandiflorus					x							L	U	
Ptilotus parvifolius				x								L	U	
Ptilotus polystachyus	x	x	x	x	x							M	U	Fox brush or pussy tails
AMARYLLIDACEAE														
Calostemma luteum									x	x	x	M/L	S	Wilcannia lily
Crinum pestilentis									x	x	x	M/L	S	
APOCYNACEAE														
Alstonia constricta	x	x			x				x		x	M	T	Bitter bark
Parsonia eucalyptophylla									x					Woodbine

Family/Species	Land Zone 1	2	3	4	5	6	7	8(a)	8(b)	9	10	Palat.	Toxity	Common Name
ASCLEPIADACEAE														
Pentatropis atropurpurea					x							L	U	
Pentatropis lineare	x											L	U	
Sarcostemma australe					x			x				M	T	Caustic-vine
BIGNONIACEAE														
Pandorea doratoxylon					x							L	U	
BORAGINACEAE														
Cynoglossum australe var. drummondi			x	x								L	U	
Heliotropium curassavicum	x										x	L	U	
Heliotropium strigosum	x	x		x								L	U	
Heliotropium tenuifolium	x	x		x								L	U	
Trichodesma zeylanicum	x		x						x			M	S	Camel bush
BRUNONIACEAE														
Brunonia australis				x	x							L	U	
CAMPANULACEAE														
Isotoma petraea					x							L	S	
Pratia puberula					x							L	U	
Wahlenbergia sp.	x	x	x						x		x	L	U	A native bluebell
CAPPARIDACEAE														
Capparis lasiantha					x							H	U	Nipan or split jack
Capparis loranthifolia	x	x		x								M	U	Narrow-leaf bumble
Capparis mitchellii								x	x			H	U	Bumble
Capparis spinosa var. nummularia											x	H	U	Flinders rose
CARYOPHYLLACEAE														
Polycarpaea breviflora			x									L	U	
Polycarpaea sp.			x									L	U	
CASUARINACEAE														
Casuarina cristata											x	H/M	U	Belah
CHENOPODIACEAE														
Arthrocnemum halocnemoides var. pergranulatum								x	x		x	M/L	U	Samphire
Arthrocnemum leiostachyum						x		x			x	M/L	U	Samphire
Atriplex angulata						x						M	U	A saltbush
Atriplex crassipes										x		M	U	A saltbush
Atriplex elachophylla									x		x	M	U	A saltbush
Atriplex eardleyae						x	x		x		x	M	U	A saltbush
Atriplex fissivalvis	x											L	U	
Atriplex holocarpa	x	x							x		x	M	U	
Atriplex limbata					x					x	x	M	U	A saltbush
Atriplex lindleyi						x	x	x		x	x	L	U	A saltbush
Atriplex muelleri							x	x	x			*H	T	Annual saltbush
Atriplex nummularia										x	x	H	C	Oldman saltbush
Atriplex semibaccata									x		x	M	U	Creeping saltbush
Atriplex spongiosa	x					x	x	x	x	x	x	M	U	Pop saltbush
Atriplex stipitata	x					x						L	U	
Atriplex vesicaria					x	x			x			M	U	Bladder saltbush
Babbagia dipterocarpa	x										x	L	U	
Babbagia scleroptera	x					x			x		x	L	U	
Bassia andersonii						x		x	x	x	x	L	U	
Bassia anisacanthoides	x							x			x	H	C	Yellow burr
Bassia bicornis	x	x	x	x		x	x	x	x	x	x	L	U	Goathead burr
Bassia bicornis var. horrida	x	x										L	U	
Bassia birchii		x	x		x				x		x	L	U	Galvanized burr
Bassia brachyptera											x	M	U	Short winged saltbush
Bassia calcarata						x		x			x	H	C	Red burr
Bassia convexula	x	x			x			x				M	U	
Bassia cornishiana			x	x	x							L	U	Cartwheel burr
Bassia diacantha	x					x		x				L	U	Grey copper burr
Bassia divaricata	x		x	x	x	x	x	x	x	x	x	L	U	Copper burr
Bassia eriacantha				x			x		x			M	U	
Bassia intricata	x			x	x	x		x			x	L	U	
Bassia lanicuspis	x		x	x	x	x	x	x			x	L	U	Woolly spinach burr
Bassia limbata	x											L	U	
Bassia longicuspis						x	x					L	U	
Bassia paradoxa	x					x			x	x	x	M	U	Curious saltbush
Bassia paradoxa var. latifolia	x											L	U	
Bassia parallelicuspis	x			x			x	x				L	U	
Bassia quinquecuspis			x					x	x	x		L	S/U	Prickly or black roly-poly
Bassia stelligera	x							x		x	x	M	U	
Bassia tricuspis				x	x	x			x			L	U	Three-spined roly-poly
Bassia ventricosa	x									x		L	U	
Bassia sp. aff. andersonii								x				L	U	
Chenopodium auricomum	x		x					x	x	x	x	*H	C	Queensland bluebush
Chenopodium carinatum			x									H	T	Keeled goosefoot
Chenopodium cristatum			x						x		x	M	T	Crested goosefoot
Chenopodium desertorum		x	x									M	U	
Chenopodium melanocarpum	x		x		x			x	x			M	T	Black crumbweed
Chenopodium polygonoides								x	x			M	U	
Chenopodium rhadinostachyum		x	x	x	x	x						M	C	Green crumbweed

Family/Species	1	2	3	4	5	6	7	8(a)	8(b)	9	10	Palat.	Toxity	Common Name
	Land Zone													
CHENOPODIACEAE (Cont'd)														
Chenopodium trigonon			x	x					x			M	U	Fish-weed
Enchylaena tomentosa	x		x	x	x	x		x	x		x	M	C	Ruby saltbush
Kochia aphylla								x			x	M	U	Round-leaf toadflax
Kochia brevifolia	x											M	S	
Kochia coronata					x	x	x	x		x	x	M	U	
Kochia dichoptera							x		x		x	M	U	
Kochia georgei				x	x							M	U	
Kochia integra								x	x			M	U	
Kochia microcarpa	x										x	M	U	
Kochia pyramidata											x	L	U	
Kochia spongiocarpa	x											M	U	
Kochia triptera				x		x			x		x	M	U	
Kochia villosa		x		x	x	x		x				L	U	
Kochia sp. aff. K. spongiocarpa	x											L	U	
Malacocera tricornis											x	L	U	Soft-horned saltbush
Pachycornia tenuis	x										x	M/L	U	A samphire
Rhagodia nutans	x					x			x			M	U	Climbing saltbush
Rhagodia parabolica						x						M	U	
Rhagodia spinescens	x				x	x		x	x			M	U	A berry saltbush
Salsola kali	x			x	x	x	x	x	x	x	x	*H/M	T	Soft roly-poly
Threlkeldia proceriflora						x	x	x			x	M	T	Soda-bush
CLEOMACEAE														
Cleome viscosa	x	x	x		x							L	U	Tick-weed
COMMELINACEAE														
Commelina cyanea										x		H	U	
COMPOSITAE														
Brachycome ciliaris var. lanuginosa	x	x		x		x		x	x	x	x	H	U	
Brachycome ciliocarpa	x											H	U	
Brachycome curvicarpa	x											H	U	
Brachycome marginata			x	x								H	U	
Brachycome melanocarpa									x			H	U	
Calocephalus multiflorus	x				x							L	U	
Calotis ancyrocarpa									x			L	U	
Calotis erinacea	x								x			M	U	
Calotis hispidula	x			x					x	x	x	H	U	Bogan-flea
Calotis inermis	x		x	x	x				x		x	H	U	
Calotis latiuscula			x								x	M	U	
Calotis multicaulis	x		x	x			x		x	x	x	M	U	
Calotis porphyroglossa	x											M	U	
Carthamus lanatus											x	L	U	
Centipeda minima			x					x	x			L	U	Spreading sneezeweed
Centipeda thespidioides	x		x			x		x	x	x	x	L	U	Desert sneezeweed
Craspedia chrysantha	x	x							x	x	x	H	S	Golden billy-buttons
Craspedia pleiocephala										x		M	U	Soft billy-buttons
Eclipta alba								x	x			L	U	White eclipta
Epaltes cunninghamii										x		L	U	
Glossogyne tenuifolia			x	x								M	U	Native cobbler's peg
Gnaphalodes uliginosum	x	x	x									M	U	
Gnaphalium involucratum			x									M	U	A cudweed
Gnaphalium sp. aff. G. diamentensis	x											M	U	A cudweed
Gnephosis eriocarpa	x											M	U	
Gnephosis foliata	x	x	x	x					x			M	U	
Helichrysum basedowii		x												
Helichrysum bracteatum		x	x									M	U	Yellow everlasting
Helichrysum semiamplexicaule		x	x	x								M	U	
Helipterum corymbiflorum								x	x	x	x	M	U	Small white paper daisy
Helipterum floribundum	x		x	x			x	x		x	x	M	U	
Helipterum hyalospermum								x	x		x	M	U	
Helipterum microglossum											x	M	U	
Helipterum molle		x	x									M	U	Golden paper daisy
Helipterum moschatum	x	x							x			M	U	Musk sunray
Helipterum pterochaetum		x	x	x								M	U	
Helipterum strictum	x		x				x			x	x	M	U	
Isoetopsis graminifolia			x									H	U	Grass cushions
Ixiolaena brevicompta			x						x		x	H	U	
Ixiolaena leptolepis			x						x		x	H	U	Stalked ixiolaena
Ixiolaena sp. aff. leptolepsis									x		x	H	U	
Millotia greevesii ssp. greevesii var. glandulosa									x		x	M	U	
Minuria denticulata									x			M	U	Woolly minuria
Minuria integerrima			x					x	x	x	x	M	U	Smooth minuria
Minuria leptophylla			x							x	x	M	U	Minnie daisy
Myriocephalus rudallii									x			L	U	
Myriocephalus stuartii	x											L	U	Poached-egg plant
Olearia pimeleoides	x	x									x	L	U	
Olearia subspicata									x			L	U	Turkey bush
Pluchea baccharoidea								x	x			L	U	
Podocoma sp.	x											M	U	

Family/Species	1	2	3	4	5	6	7	8(a)	8(b)	9	10	Palat.	Toxity	Common Name
	Land Zone													
COMPOSITAE (Cont'd)														
Podolepis canescens	x		x	x								M	U	
Podolepis longipedata									x		x	M	U	
Pterigeron adscendens	x							x	x		x	H	U	
Pterocaulon sphacelatum						x			x			L	U	
Rutidosis helichrysioides	x		x									M	U	
Senecio bipinnatisectus											x	M	U	
Senecio glossanthus		x	x	x								M	U	
Senecio gregorii	x											M	U	Annual yellow top
Senecio lautus	x									x		L	U	
Senecio quadridentatus		x							x		x	L	C	Cotton fireweed
Sonchus oleraceus			x									H	U	Common sowthistle
Vittadinia brachycomoides									x		x	M	U	
Vittadinia triloba			x	x					x			M	S	Fuzzweed
Xanthium pungens						x			x		x	L	T	Noogoora burr
Xanthium spinosum									x		x	L	T	Bathurst burr
CONVOLVULACEAE														
Bonamia media	x											M	U	
Convolvulus erubescens	x	x		x					x			H	U	Australian bindweed
Evolvulus alsinoides	x	x	x	x					x		x	H	U	
Ipomoea lonchophylla										x	x	H	C	Cow vine
Ipomoea muelleri										x		H	U	
Ipomoea polymorpha	x											M	U	
Polymeria longifolia							x			x		M	U	
Polymeria margmata							x					L	U	
Porona sericea					x							L	U	
CRUCIFERAE														
Blennodia blennodioides											x	H	U	Hairy cress
Blennodia canescens	x	x										H	U	
Blennodia eremigena	x											H	U	
Blennodia nasturtioides										x	x	H	U	Yellow cress
Blennodia pterosperma	x											H	U	
Blennodia trisecta	x					x						H	U	
Cuphonotus humistratus					x							H	U	
Cuphonotus sp. aff. C. humistratus					x							H	U	
Lepidium oxytrichum	x					x	x	x			x	L	U	A peppercress
Lepidium rotundum	x			x	x	x	x	x			x	H	U	A peppercress
Lepidium strongylophyllum					x							M	U	A peppercress
Sisymbrium irio											x	H	U	London rocket
Stenopetalum nutans			x	x	x	x					x	H	U	
CUCURBITACEAE														
Cucumis myriocarpus	x	x				x						L	T	Prickly paddy melon
Melothria maderaspatana		x										M	U	
CUPRESSACEAE														
Callitris columellaris		x									x	M	U	Cypress pine
CUSCUTACEAE														
Cuscuta australis			x				x	x	x			L	U	Dodder
CYPERACEAE														
Bulbostylis barbata	x		x									L	U	
Cyperus bifax							x	x	x		x	H	U	Downs nut-grass
Cyperus bulbosus		x	x								x	L	U	Nalgoo
Cyperus castaneus			x					x				L	U	
Cyperus dactylotes								x	x			L	U	
Cyperus difformis	x							x	x		x	L	U	
Cyperus exaltatus									x			L	U	
Cyperus fulvus									x			M	U	
Cyperus gilesii						x						L	U	
Cyperus gymnocaulos										x	x	L	U	
Cyperus iria	x		x			x		x	x			L	U	
Cyperus rigidellus							x	x	x			L	U	
Cyperus subrigiatulus								x				L	U	
Cyperus victoriensis									x			H	U	
Eleocharis pallens	x		x		x				x			L	U	Pale spike-rush
Fimbristylis dichotoma	x		x	x	x	x			x	x	x	M	U	
Scirpus dissachanthus											x	L	U	
DICRASTYLIDACEAE														
Newcastlia cephalantha	x											L	U	
Spartothamnella juncea			x	x								H	U	
DYSPHANIACEAE														
Dysphania myriocephala			x	x	x	x		x				M	T	Nettle-leaf goosefoot or red crumbweed
EHRETIACEAE														
Ehretia membranifolia								x				H	C	Peach bush
Ehretia saligna								x				H	C	Coonta
Halgania cyanea	x											L	U	

Family/Species	Land Zone 1	2	3	4	5	6	7	8(a)	8(b)	9	10	Palat.	Toxity	Common Name
EUPHORBIACEAE														
Euphorbia australis							x			x	x	M	U	
Euphorbia boophthona				x	x		x				x	M	T	Gascoyne spurge
Euphorbia coghlanii		x	x									M	S	Sandhill caustic
Euphorbia drummondii	x	x	x	x	x	x	x		x	x	x	M	T	Caustic weed
Euphorbia eremophila	x	x	x				x					M	U	Desert spurge
Euphorbia stevenii		x					x			x	x	M	S	Bottle-tree caustic
Euphorbia wheeleri	x		x					x				M	U	
Euphorbia sp. aff. E. drummondii			x	x								L	U	
Phyllanthus maderaspatensis			x							x		M	U	
Phyllanthus rigens					x							L	U	
Poranthera microphylla		x										M	C	
FLINDERSIACEAE														
Flindersia maculosa				x	x	x		x			x	H	U	Leopardwood
FRANKENIACEAE														
Frankenia hamata											x	L	U	
Frankenia serphyllifolia											x	L	U	
Frankenia uncinata											x	L	U	
GERANIACEAE														
Erodium crinitum	x	x		x								H	U	Blue crowfoot
Erodium cygnorum ssp. glandulosum							x		x			H	U	
GOODENIACEAE														
Goodenia berardiana				x								L	U	
Goodenia calcarata					x							M	U	
Goodenia cycloptera	x											L	U	
Goodenia havilandii				x	x							H	U	
Goodenia lunata			x	x								M	U	
Goodenia subintegra			x	x			x	x				M	U	Silky goodenia
Leschenaultia divaricata	x											L	U	
Scaevola depauperata	x											L	U	
Scaevola ovalifolia	x											L	U	
Scaevola spinescens					x	x						L	U	
Velleia glabrata		x	x	x	x	x			x		x	H	U	Pee-the-bed
GRAMINEAE														
Amphipogon caricinus		x	x									L	U	Grey-beard grass
Aristida anthoxanthoides	x		x			x	x	x	x	x	x	M	U	Yellow threeawn
Aristida biglandulosa									x				U	Two-gland threeawn
Aristida browniana	x	x	x									M	U	Erect kerosene grass
Aristida contorta	x	x	x	x	x			x	x		x	M	U	Kerosene grass
Aristida echinata			x	x	x				x			L	U	Prickly threeawn
Aristida glumaris			x	x								L	U	
Aristida helicophylla	x		x									L	U	
Aristida ingrata	x	x	x	x								M	U	
Aristida jerichoensis		x	x	x	x			x	x			M	U	Jericho threeawn
Aristida latifolia							x					M	U	White spear grass or feathertop wiregrass
Aristida obscura			x	x	x							L	U	Brush threeawn
Astrebla elymoides							x	x		x	x	H	U	Hoop Mitchell grass
Astrebla lappacea							x	x				H	U	Curly Mitchell grass
Astrebla pectinata						x	x	x		x	x	H	U	Barley Mitchell grass
Astrebla squarrosa								x				H	U	Bull Mitchell grass
Austrochloris dichanthioides			x	x				x				M	U	
Bothriochloa ewartiana			x									H	U	Desert blue grass
Brachiaria gilesii			x	x		x						H	U	Hairy-edged armgrass
Brachiaria miliiformis			x						x		x	H	U	Green summer grass or armgrass millet
Brachiaria piligera			x									H	U	Hairy armgrass
Brachiaria praetervisa			x						x			H	U	Large armgrass
Brachiaria windersii vel. aff.							x					H	U	
Brachyachne convergens			x			x	x	x	x		x	H	T	Native couch grass or spider grass
Cenchrus ciliaris	x	x										H	U	Buffel grass
Chloris pectinata		x	x	x		x	x	x	x	x	x	H	U	Comb chloris
Chloris scariosa						x					x	L	U	Large-flower chloris or winged chloris
Chloris virgata							x					L	U	Feathertop Rhodes grass
Chrysopogon fallax	x		x	x					x			H	U	Golden-beard grass
Cymbopon obtectus			x	x					x			M	U	Silky-heads
Cynodon dactylon			x					x	x			H	U	Couch
Dactyloctenium radulans	x	x	x	x		x	x	x	x	x	x	H	T	Button grass
Dichanthium affine			x				x		x			H	U	Dwarf bluegrass
Dichanthium sericeum			x	x				x	x			H	U	Queensland bluegrass
Digitaria ammophila			x	x	x	x					x	H	U	Silky umbrella grass
Digitaria brownii	x	x	x	x	x				x			H	U	Cotton panic grass or silver spike grass
Digitaria coenicola	x								x			H	U	Finger panic grass
Digitaria ctenantha		x	x	x								H	U	Comb fingergrass
Digitaria diminuta			x	x								H	U	
Digitaria divaricatissima		x	x									H	U	
Digitaria hystrichoides		x										M	U	
Digitaria orbata					x							M	U	
Diplachne muelleri			x				x	x	x		x	M	U	Water grass

Family/Species	Land Zone											Palat.	Toxily	Common Name
	1	2	3	4	5	6	7	8(a)	8(b)	9	10			
GRAMINEAE (Cont'd)														
Echinochloa colonum			x			x		x	x		x	H	C	Awnless barnyard grass
Echinochloa turnerana									x	x	x	H	U	Channel millet
Elytrophorus spicatus										x	x	L	U	Spike grass
Enneapogon avenaceus	x	x					x				x	H	U	Ridge grass
Enneapogon nigricans						x		x				M	U	A bottle-washers grass
Enneapogon polyphyllus	x	x	x	x	x	x	x		x		x	M	U	A bottle-washers grass
Enteropogon acicularis	x	x	x		x	x	x					H	U	Curly windmill grass
Eragrostis australasica									x	x	x	M	U	Swamp cane grass
Eragrostis basedowii	x								x			M	U	
Eragrostis cilianensis			x			x			x			M	U	Stink grass
Eragrostis confertiflora								x				M	U	Spike love grass
Eragrostis cumingii vel aff.	x											M	U	
Eragrostis dielsii	x		x	x		x		x	x	x	x	H	U	
Eragrostis elongata			x						x			M	U	Clustered lovegrass
Eragrostis eriopoda	x	x	x	x	x							M	U	Woollybutt grass
Eragrostis kennedyae	x		x	x								M	U	Small-flowered lovegrass
Eragrostis lacunaria				x								M	U	Purple lovegrass
Eragrostis laniflora	x											M	U	Hairy-flowered woollybutt grass
Eragrostis leptocarpa			x		x			x	x	x	x	M	U	Drooping lovegrass
Eragrostis microcarpa			x									M	U	
Eragrostis parviflora			x	x			x	x	x			M	U	Weeping lovegrass
Eragrostis pergracilis			x		x	x						M	U	
Eragrostis setifolia	x		x					x	x	x	x	M	U	Neverfail grass
Eragrostis sororia			x						x			M	U	
Eragrostis tenellula	x		x	x		x	x		x	x		M	U	Delicate lovegrass
Eragrostis xerophila							x	x				H	U	Knotty-butt neverfail grass
Eriachne aristidea	x											M	U	Threeawned Wanderrie
Eriachne basedowii	x	x										M	U	
Eriachne helmsii	x	x		x								L	U	Woollybutt Wanderrie
Eriachne mucronata	x	x	x	x	x							M/H	U	Rock grass
Eriachne pulchella				x	x							L	U	Pretty Wanderrie
Eriochloa pseudoacrotricha			x					x	x		x	H	U	Early spring grass
Eulalia fulva			x					x	x		x	H	U	Silky browntop
Iseilema macratherum			x									H	U	Bull Flinders grass
Iseilema membranaceum	x		x	x		x	x	x	x	x	x	H	U	Small Flinders grass
Iseilema vaginiflorum							x			x	x	H	U	Red Flinders grass
Leptochloa digitata								x	x			M	U	Umbrella cane grass
Leptochloa sp.									x			M	U	
Monachather paradoxa	x	x	x	x	x				x			H	U	Mulga oats or bandicoot grass
Neurachne munroi		x	x	x		x						M	U	Dwarf mulga grass
Panicum australiense	x											L	U	Bunch panic
Panicum buncei									x			H	U	
Panicum decompositum	x	x	x	x		x	x			x	x	M	S	Native or wild millet
Panicum effusum		x	x									H	T	Hairy panic
Panicum paludosum									x			M	U	Swamp panic
Panicum whitei	x					x	x	x	x	x	x	M	U	Pepper grass
Paractaenum novae-hollandiae	x											L	U	Reflexed panic
Paraneurachne muelleri	x				x							H	U	
Paspalidium clementii			x		x							M	U	
Paspalidium jubiflorum								x	x		x	H	U	Warrego summer grass
Paspalidium rarum			x	x		x						H	U	
Perotis rara	x	x	x									L	U	Comet grass
Plagiosetum refractum	x											H	U	Bristle-brush grass
Pseudoraphis spinescens									x			M	U	Mud grass
Sporobolus actinocladus				x		x	x	x		x	x	H	U	Katoora
Sporobolus australasicus					x					x	x	H	U	
Sporobolus caroli			x			x	x				x	H	U	Fairy grass
Sporobolus elongatus						x						L	U	Slender rats-tail grass
Sporobolus mitchellii								x	x	x	x	L	U	Rats-tail couch
Sporobolus scabridus						x						H	U	
Themeda australis		x	x						x			H	U	Kangaroo grass
Themeda avenacea			x									H	U	Native oat grass
Thyridolepis mitchelliana		x		x	x							H	U	Mulga mitchell
Thyridolepis xerophila			x									H	U	Mulga mitchell
Tragus australianus	x	x	x	x		x	x	x	x		x	M	U	Small burr grass
Triodia basedowii	x											L	U	Spinifex
Triodia longiceps					x									Soft spinifex
Triodia mitchellii					x									Soft spinifex
Tripogon loliiformis		x	x	x	x	x	x	x	x		x	H	U	Five-minute grass
Triraphis mollis	x											H	T	Purple plume grass
Uranthothecium truncatum										x	x	M	U	
Xerochloa laniflora											x	M	U	
Zygochloa paradoxa	x											M	U	Sand-hill cane grass
GYROSTEMONACEAE														
Codonocarpus cotinifolius	x	x										L	S	Desert poplar
Gyrostemon ramulosus	x											L	U	
HALORAGIDACEAE														
Haloragis heterophylla			x	x								L	U	Raspweed
Haloragis glauca										x	x	L	U	Grey raspweed
Haloragis gossei	x											L	U	
Haloragis odontocarpa			x									H	U	Mulga nettle

Family/Species	1	2	3	4	5	6	7	8(a)	8(b)	9	10	Palat.	Toxity	Common Name
JUNCACEAE														
Juncus sp.									x			L	U	A reed
LABIATAE														
Prostanthera megacalyx					x							L	U	
Prostanthera suborbicularis					x							L	U	Mint bush
Teucrium racemosum	x		x				x		x	x	x	L	S	Grey germander
Westringia rigida					x							L	U	
LEGUMINOSAE														
Acacia ammophila	x	x										L	U	
Acacia aneura	x	x	x	x	x	x			x			H	U	Mulga
Acacia brachystachya					x							M	U	Turpentine mulga
Acacia calcicola	x											L	U	
Acacia cambagei						x		x	x		x	L	U	Gidgee
Acacia cana						x						H	U	Boree
Acacia catenulata					x							M	U	Bendee
Acacia clivicola				x	x							L	U	Bastard mulga
Acacia cyperophylla											x	M	U	Mineritchie
Acacia dictyophleba	x											L	U	
Acacia ensifolia					x							L	U	
Acacia excelsa	x	x		x	x							M	U	Ironwood
Acacia farnesiana							x		x	x	x	H	U	Mimosa bush
Acacia harpophylla						x		x				L	C	Brigalow
Acacia ligulata	x											L	U	
Acacia microsperma					x				x			M	U	Bowyakka
Acacia murrayana	x	x									x	L	U	Colony wattle
Acacia omalophylla									x		x	M	U	Yarran
Acacia oswaldii		x				x			x			M	C	Nelia
Acacia petraea					x							L	C	Lancewood
Acacia ramulosa	x											M	U	Horse mulga
Acacia salicina									x		x	M	U	Doolan
Acacia stenophylla	x	x	x					x	x	x	x	M	U	Belalie
Acacia tetragonophylla	x		x	x	x						x	H	U	Dead-finish
Acacia victoriae		x	x						x	x	x	H	U	Gunda-bluey
Aeschynomene indica									x	x	x	L/M	S	Budda pea
Bauhinia carronii									x		x	H	U	Bauhinia
Cassia artemisioides	x	x	x	x	x	x			x			L	U	Silver cassia
Cassia circinnata		x										L	U	
Cassia desolata	x		x	x		x		x				L	U	
Cassia helmsii			x	x	x						x	L	U	
Cassia nemophila var. coriacea					x							L	U	
Cassia nemophila var. nemophila	x	x	x	x	x	x		x	x		x	L	U	Desert cassia
Cassia nemophila var. zygophylla	x								x			L	U	
Cassia oligophylla	x		x	x	x	x						L	U	
Cassia phyllodinea			x	x		x	x		x		x	M	U	
Cassia pleurocarpa	x											L	U	
Cassia pruinosa					x							L	U	
Cassia sturtii		x	x									M	U	
Crotalaria cunninghamii	x											L	C	Parrot-pea
Crotalaria dissitiflora											x	M	S	Grey rattlepod
Crotalaria eremaea	x											H	T	Bluebush pea
Desmodium campylocaulon							x					H	U	
Desmodium muelleri			x									H	U	
Erythrina vespertilio											x	M	S	Bat-wing coral tree
Indigofera brevidens									x			L	U	
Indigofera colutea	x											L	U	Sticky indigo
Indigofera dominii	x	x	x						x			H	T	Birdsville indigo
Indigofera linifolia			x						x			M	S	
Indigofera parviflora							x					M	U	Small-flower indigo
Indigofera pratensis									x			M	U	
Indigofera sp. aff. I. brevidens					x							L	U	
Isotropis wheeleri	x	x										L	S	
Kennedia prorepens	x											M	U	
Lotus cruentus	x							x	x			H	U	Red-flower lotus
Neptunia dimorphantha			x	x			x			x	x	M	U	
Petalostylis labichoides		x	x	x	x							M/L	U	Butterfly bush
Psoralea cinerea				x			x		x	x	x	M/L	U	Annual verbine
Psoralea eriantha									x			M/L	U	Bullamon lucerne
Psoralea patens									x			M/L	U	
Psoralea sp. aff. P. eriantha	x											M/L	U	
Ptychosema trifoliatum			x									M	U	
Rhynchosia minima							x					M	U	
Sesbania cannabina									x			L/M	U	Sesbania pea
Swainsona campylantha	x		x									M	S	
Swainsona microphylla ssp. affinis	x	x										M	S	
Swainsona microphylla ssp. tomentosa	x											M	S	
Swainsona oligophylla	x		x									M	S	
Swainsona oroboides	x											M	S	Kneed swainsona
Tephrosia rosea var. angustifolia	x											L	S	
Tephrosia supina	x											L	S	

Family/Species	Land Zone 1	2	3	4	5	6	7	8(a)	8(b)	9	10	Palat.	Toxity	Common Name
LEGUMINOSAE (Cont'd)														
Trigonella suavissima									x	x		H	U	Cooper clover
Vigna lanceolata var. latifolia										x		H		
LILIACEAE														
Bulbine sp.							x		x		x	M	S	A native leek
Dianella sp. aff. D. laevis			x								x	L	S	
LINACEAE														
Linum marginale			x									L	C	Wild flax
LORANTHACEAE														
Amyema maidenii			x	x				x				H	U	A mistletoe
Amyema quandong			x	x				x				H	U	A mistletoe
Lysiana lineariifolia			x									H	U	A mistletoe
MALVACEAE														
Abutilon fraseri				x	x							L	U	A flannel-weed
Abutilon leucopetalum			x						x			L	U	Lantern bush
Abutilon malvifolium			x					x				M	U	
Abutilon otocarpum	x		x	x	x	x		x	x			M	U	Flannel weed or desert Chinese lantern
Abutilon oxycarpum			x		x				x			L	U	
Gossypium australe	x				x							L		
Gossypium sturtianum var. sturtianum	x				x							L	U	Sturt's desert rose
Hibiscus brachysiphonius						x			x			M	U	
Hibiscus krichauffianus	x											M	U	
Hibiscus sturtii				x	x							M	U	
Hibiscus trionum			x				x				x	L	U	Bladder ketmia
Lavatera plebeia									x		x	M	U	Australian hollyhock
Malvastrum spicatum	x		x			x	x		x		x	M	C	Malvastrum
Sida aprica					x							L	U	
Sida corrugata							x					M	U	Corrugated sida
Sida cunninghamii		x	x	x	x							M	U	
Sida fibulifera							x					M	U	Silver sida
Sida filiformis		x	x	x	x	x			x			M	U	
Sida goniocarpa								x				L	U	
Sida macropoda				x	x							L	U	
Sida platycalyx		x	x	x	x							L	U	Lifesaver burr
Sida trichopoda			x				x		x			H	U	High sida
Sida virgata vel aff.							x						U	
Sida sp. 'buttercup'											x	L	U	
Sida sp.	x	x										L	U	
MELIACEAE														
Owenia acidula	x					x			x			H	U	Emu apple
MYOPORACEAE														
Eremophila bignoniiflora								x	x		x	H	S	Gooramurra
Eremophila bowmanii	x	x		x								L	U	Silver turkey bush
Eremophila cordatisepala	x				x							L	U	
Eremophila dalyana						x						L	U	
Eremophila duttonii	x											L	U	
Eremophila freelingii					x							L	T	Limestone fuchsia bush
Eremophila glabra						x						M	U	Black fuchsia
Eremophila gilesii	x	x	x	x		x			x			L	U	Charleville turkey bush
Eremophila goodwinii	x			x								L	U	
Eremophila latrobei					x							M	T	
Eremophila longifolia		x	x	x		x						H	T	Berrigan
Eremophila macgillvrayi					x							L	U	
Eremophila maculata	x		x	x		x		x	x		x	H	T	Fuchsia bush
Eremophila mitchellii		x	x	x	x	x		x	x			L	U	Sandalwood
Eremophila obovata	x											L	U	
Eremophila oppositifolia var. rubra					x							L	U	Mountain sandalwood
Eremophila polyclada								x	x		x	H	U	Lignum fuchsia
Eremophila sturtii	x			x		x		x	x			L	U	Budda bush
Eremophila sp.			x									L	U	
Myoporum acuminatum								x	x		x	H	T	Boobialla or water bush
Myoporum deserti	x					x		x	x			H	T	Ellangowan poison bush
MYRTACEAE														
Calytrix longiflora	x											L	U	
Eucalyptus camaldulensis								x	x		x	L	U	River red gum
Eucalyptus cambageana									x			L	U	Dawson gum or blackbutt
Eucalyptus exserta					x							L	U	Bendo
Eucalyptus largiflorens									x			L	U	
Eucalyptus melanophloia				x								L	U	Silver-leaved ironbark
Eucalyptus microtheca	x		x					x	x	x	x	M	U	Coolibah
Eucalyptus ochrophloia								x	x	x		M	U	Yapunyah
Eucalyptus papuana	x				x							M	U	Desert gum
Eucalyptus pilligaensis									x			L	U	Ribbon box or gum-topped box
Eucalyptus polycarpa			x						x			L	U	Long fruited bloodwood
Eucalyptus populnea		x	x	x					x			L	U	Poplar box
Eucalyptus terminalis	x	x	x	x	x				x			L	U	Western bloodwood

Family/Species	Land Zone 1	2	3	4	5	6	7	8(a)	8(b)	9	10	Palat.	Toxity	Common Name
MYRTACEAE (Cont'd)														
Eucalyptus tessellaris									x			L	U	Moreton Bay ash or carbeen
Eucalyptus thozetiana					x	x			x			L	U	Mountain yapunyah
Eucalyptus largiflorens x E. populnea									x			L	U	
Melaleuca adnata	x										x	L	U	
Melaleuca linariifolia									x			L	U	A paper-bark tea-tree
Melaleuca uncinata	x											L	U	
Thryptomene hexandra					x							L	U	
Thryptomene parviflora		x										L	U	
NYCTAGINACEAE														
Boerhavia diffusa	x	x	x	x	x	x		x	x	x	x	H	S	Tar-vine
OLEACEAE														
Jasminum lineare								x				L	U	
OXALIDACEAE														
Oxalis corniculata			x	x			x			x		M	T	Yellow wood sorrel
PAPAVERACEAE														
Argemone ochroleuca									x			L	T	Mexican poppy
PEDALIACEAE														
Josephinia eugeniae	x											L	U	Josephinia burr
PITTOSPORACEAE														
Pittosporum phillyraeoides	x		x	x		x					x	H/M	U	Meemeei or cattle bush
PLANTAGINACEAE														
Plantago pritzelii	x								x	x	x	H	U	A plantain
POLYGONACEAE														
Muehlenbeckia cunninghamii	x								x	x	x	M	U	Lignum
Polygonum lapathifolium									x		x	L	U	
Rumex crispus									x		x	L	U	A dock
PORTULACACEAE														
Calandrinia balonensis	x	x	x									H	T	Broad-leaf parakeelya
Calandrinia ptychosperma	x	x	x						x			M	C	
Calandrinia volubilis	x	x	x									M	C	
Portulaca filifolia				x		x	x					M	C	
Portulaca sp. aff. P. oleracea	x	x		x	x	x	x	x	x		x	H	T	Munyeroo
POTAMOGETONACEAE														
Potamogeton tricarinatus											x	L	U	Floating pondweed
PROTEACEAE														
Grevillea juncifolia	x											L	U	Honeysuckle oak
Grevillea stenobotrya	x											M	U	
Grevillea striata	x	x	x	x					x			H	U	Beefwood
Grevillea sp.	x											L	U	
Hakea collina					x							L	U	Dwarf needlewood
Hakea divaricata	x				x							L	U	
Hakea ivoryi			x									L	U	
Hakea leucoptera	x											M	U	Needlewood
RANUNCULACEAE														
Ranunculus pentandrus var. platycarpus	x								x			L	S	A buttercup
RHAMNACEAE														
Ventilago viminalis	x		x	x		x			x			H	T*	Vinetree or supplejack
RUBIACEAE														
Canthium oleifolium											x			
Canthium latifolium				x	x							H	U	
RUTACEAE														
Eriostemon difformis					x							L	U	
Geijera parviflora					x			x	x		x	H	U	Wilga
Phebalium glandulosum					x							L	U	
SANTALACEAE														
Exocarpos aphyllus								x	x			H	U	Cherrywood
Santalum lanceolatum	x		x			x			x			H	U	Plumwood
SAPINDACEAE														
Atalaya hemiglauca	x		x	x		x			x			H	T	Whitewood
Dodonaea attenuata	x	x				x						L	U	A hopbush
Dodonaea cuneata					x	x		x				L	U	A hopbush
Dodonaea petiolaris				x	x							L	U	A hopbush
Dodonaea tenuifolia					x	x						L	U	A hopbush
Heterodendrum oleifolium									x			H	T	Boonaree
SCROPHULARIACEAE														
Mimulus prostratus	x								x	x		L	U	
Morgania floribunda	x								x			L	T	
Peplidium maritimum			x						x			L	U	
SOLANACEAE														
Duboisia hopwoodii	x											M	T	
Nicotiana glauca											x	L	T	Tree tobacco
Nicotiana velutina	x											L	T	
Solanum ellipticum		x	x	x	x	x		x	x			L	T	Potato-bush

Family/Species	1	2	3	4	5	6	7	8(a)	8(b)	9	10	Palat.	Toxity	Common Name
	Land Zone													
SOLANACEAE (Cont'd)														
Solanum esuriale	x	x	x	x	x	x			x	x	x	H	S	Quena
Solanum ferocissimum			x						x			L	S	
Solanum nigrum			x						x			M	T	Black-berry nightshade
Solanum quadriloculatum				x	x	x		x				M	S	
Solanum sturtianum			x		x				x			M	T	
STACKHOUSIACEAE														
Macgregoria racemigera	x	x	x									L	U	Carpet-of-snow
STERCULIACEAE														
Kerandrenia collina	x				x							L	U	
Melhania ovata						x						L	U	
TETRAGONIACEAE														
Tetragonia tetragonioides	x					x		x	x	x		*H	T	New Zealand spinach
THYMELAEACEAE														
Pimelea microcephala									x			L	S	
Pimelea trichostachya sens strictu	x								x			L	T	Poverty bush or broom bush
Pimelea trichostachya form B			x	x			x		x			L	T	
Pimelea trichostachya form C			x						x			L	T	
TYPHACEAE														
Typha angustifolia											x	M	U	Bullrush
UMBELLIFERAE														
Daucus glochidiatus	x								x	x		H	U	Australian carrot
Eryngium plantagineum	x									x		H	U	
Eryngium rostratum	x									x		H	U	Blue devil
Trachymene cyanantha		x			x							H/M	T	A native parsnip
Trachymene glaucifolia	x											H/M	T	Blue parsnip
Trachymene ochracea		x	x						x			H/M	T	Wild parsnip
VERBENACEAE														
Clerodendrum floribundum	x				x							M	S	Lollybush
VIOLACEAE														
Hybanthus auranticus			x	x								L	S	
XANTHORRHOEACEAE														
Lomandra longifolia								x	x			M	S	Long-leaved mat rush
ZYGOPHYLLACEAE														
Tribulus hystrix	x											M	U	
Tribulus occidentalis	x											L	U	Perennial caltrop
Tribulus terrestris	x		x	x	x	x		x	x		x	H	T	Caltrop
Tribulus sp. aff. T. terrestris	x											L	U	
Zygophyllum ammophilum						x	x	x	x		x	L	T	Sand twin-leaf
Zygophyllum apiculatum				x	x	x		x	x			L	S	Gall-weed
Zygophyllum howittii	x											L	U	
Zygophyllum iodocarpum					x		x					L	U	
PTERIDOPHYTA (FERNS)														
Azollea pinnata											x	L	U	
Cheilanthes sieberi			x	x	x				x			M/H	T	Mulga or rock fern
Marsilea distans			x		x							M	S	Nardoo
Marsilea drummondii	x		x					x	x	x	x	M	S	Nardoo
Marsilea hirsuta			x					x	x	x	x	M	S	Nardoo

B. Common names – scientific names for the more common species

Common Name	Scientific Name	Common Name	Scientific Name
Annual saltbush	*Atriplex muelleri*	Boggabri	*Amaranthus mitchellii*
Annual verbine	*Psoralea cinerea*	Boobialla or waterbush	*Myoporum acuminatum*
Annual yellowtop	*Senecio gregorii*	Boonaree	*Heterodendrum oleifolium*
Bastard mulga	*Acacia clivicola*	Boree	*Acacia cana*
Bathurst burr	*Xanthium spinosum*	Bottle-tree caustic	*Euphorbia stevenii*
Bauhinia	*Bauhinia carronii*	Bowyakka	*Acacia microsperma*
Beefwood	*Grevillea striata*	Brigalow	*Acacia harpophylla*
Belah	*Casuarina cristata*	Bristle-brush grass	*Plagiosetum refractum*
Belalie	*Acacia stenophylla*	Broad-leaf parakeelya	*Calandrinia balonensis*
Bendee	*Acacia catenulata*	Budda bush	*Eremophila sturtii*
Bendo	*Eucalyptus exserta*	Budda pea	*Aeschynomene indica*
Berrigan	*Eremophila longifolia*	Buffel grass	*Cenchrus ciliaris*
Birdsville indigo	*Indigofera dominii*	Bullamon lucerne	*Psoralea eriantha*
Bitter bark	*Alstonia constricta*	Bumble	*Capparis mitchellii*
Black fuchsia	*Eremophila glabra*	Button grass	*Dactyloctenium radulans*
Bladder ketmia	*Hibiscus trionum*	Caltrop	*Tribulus terrestris*
Bladder saltbush	*Atriplex vesicaria*	Camel bush	*Trichodesma zeylanicum*
Bluebush	*Chenopodium auricomum*	Carpet-of-snow	*Macgregoria racemigera*
Bluebush pea	*Crotalaria eremaea*	Cartwheel burr	*Bassia cornishiana*
Blue parsnip	*Trachymene glaucifolia*	Caustic weed	*Euphorbia drummondii*
Bogan-flea	*Calotis hispidula*	Caustic vine	*Sarcostemma australe*

Common Name	Scientific Name
Channel millet or native sorghum	*Echinochloa turnerana*
Coolibah	*Eucalyptus microtheca*
Cooper clover	*Trigonella suavissima*
Cotton panic grass	*Digitaria brownii*
Curly windmill grass	*Enteropogon acicularis*
Climbing saltbush	*Rhagodia nutans*
Clustered lovegrass	*Eragrostis elongata*
Colony wattle	*Acacia murrayana*
Common joyweed	*Alternanthera denticulata*
Comb chloris	*Chloris pectinata*
Comet grass	*Perotis rara*
Cooper burr	*Bassia divaricata*
Couch	*Cynodon dactylon*
Creeping saltbush	*Atriplex semibaccata*
Crested goosefoot	*Chenopodium cristatum*
Curious saltbush	*Bassia paradoxa*
Cypress pine	*Callitris columellaris*
Dawson gum or blackbutt	*Eucalyptus cambageana*
Dead finish	*Acacia tetragonophylla*
Desert blue grass	*Bothriochloa ewartiana*
Desert cassia	*Cassia nemophila var. nemophila*
Desert gum	*Eucalyptus papuana*
Desert poplar	*Codonocarpus cotinifolius*
Desert spurge	*Euphorbia eremophila*
Doolan or sally wattle	*Acacia salicina*
Downs nut-grass	*Cyperus bifax*
Dwarf needlewood	*Hakea collina*
Early spring grass	*Eriochloa pseudoacrotricha*
Ellangowan poison bush	*Myoperum deserti*
Emu apple	*Owenia acidula*
Fish-weed	*Chenopodium trigonon*
Five minute grass	*Tripogon loliiformis*
Flannel weed or desert Chinese lantern	*Abutilon otocarpum*
Flinders rose	*Capparis spinosa var. nummularia*
Fox bush or	*Ptilotus exaltatus* and
Prince-of-Wales feathers	*Ptilotus polystachyus*
Fuchsia bush	*Eremophila maculata*
Galvanized burr	*Bassia birchii*
Gascoyne spurge	*Euphorbia boophthona*
Giant pigweed or black pigweed	*Trianthema portulacastrum*
Gidgee	*Acacia cambagei*
Goathead burr	*Bassia bicornis*
Golden billy-buttons	*Craspedia chrysantha*
Gooramurra	*Eremophila bignoniiflora*
Green crumbweed	*Chenopodium rhadinostachyum*
Grey-beard grass	*Amphipogon caricinus*
Grey copper burr	*Bassia diacantha*
Golden-beard grass	*Chrysopogon fallax*
Hairy panic	*Panicum effusum*
Honeysuckly oak	*Grevillea juncifolia*
Hopbush	*Dodonaea spp.*
Horse mulga	*Acacia ramulosa*
Ironwood	*Acacia excelsa*
Jericho threeawn	*Aristida jerichoensis*
Kangaroo grass	*Themeda australis*
Katoora	*Sporobolus actinocladus*
Keeled goosefoot	*Chenopodium carinatum*
Kerosene grass	*Aristida contorta*
Kerosene grass, erect	*Aristida browniana*
Lancewood	*Acacia petraea*
Leopardwood	*Flindersia maculosa*
Lesser joyweed	*Alternanthera denticulata*
Lifesaver burr	*Sida platycalyx*
Lignum	*Muehlenbeckia cunninghamii*
Lignum fuchsia	*Eremophila polyclada*
Limestone fuschia bush	*Eremophila freelingii*
London rocket	*Sisymbrium irio*
Long fruited bloodwood	*Eucalyptus polycarpa*
Malvastrum	*Malvastrum spicatum*
Mimosa bush	*Acacia farnesiana*
Mineritchie	*Acacia cyperophylla*
Mintbush	*Prostanthera suborbicularis*
Meemeei or cattle bush	*Pittosporum phillyraeoides*
Mitchell grass, barley	*Astrebla pectinata*
Mitchell grass, bull	*Astrebla squarrosa*
Mitchell grass, curly	*Astrebla lappacea*
Mitchell grass, hoop	*Astrebla elymoides*
Moreton Bay ash or carbeen	*Eucalyptus tessellaris*
Mountain sandalwood	*Eremophila oppositifolia var. rubra*
Mountain yapunyah	*Eucalyptus thozetiana*
Mulga	*Acacia aneura*
Mulga mitchell	*Thyridolepis mitchelliana*
Mulga mitchell	*Thyridolepis xerophila*
Mulga oat grass	*Monachather paradoxa*

Common Name	Scientific Name
Mulga fern or rock fern	*Cheilanthes sieberi*
Munyeroo or pigweed	*Portulaca sp. aff. P. oleracea*
Nardoo	*Marsilea spp.*
Narrow-leaf bumble	*Capparis loranthifolia*
Native couch grass or spider grass	*Brachyachne convergens*
Native oat grass	*Themeda avenacea*
Native or wild millet	*Panicum decompositum*
Neverfail grass	*Eragrostis setifolia*
Needlewood	*Hakea leucoptera*
Nelia	*Acacia oswaldii*
Nettle-leaf goosefoot or red crumbweed	*Dysphania myriocephala*
Neverfail grass	*Eragrostis setifolia*
Nipan or split jack	*Capparis lasiantha*
Noogoora burr	*Xanthium pungens*
Oldman saltbush	*Atriplex nummularia*
Parakeelya	*Calandrinia spp.*
Parrot-pea	*Crotalaria cunninghamii*
Peach bush	*Ehretia membranifolia*
Pee-the-bed	*Velleia glabrata*
Pepper grass	*Panicum whitei*
Perennial caltrop	*Tribulus occidentalis*
Plumwood	*Santalum lanceolatum*
Poached-egg plant	*Myriocephalus stuartii*
Pop saltbush	*Atriplex spongiosa*
Poplar box	*Eucalyptus populnea*
Potato bush	*Solanum ellipticum*
Poverty bush	*Pimelea trichostachya*
Pretty wanderrie	*Eriachne pulchella*
Prickly or black roly-poly	*Bassia quinquecuspis*
Purple plume grass	*Triraphis mollis*
Pussy tails	*Ptilotus macrocephalus*
Queensland bluebush	*Chenopodium auricomum*
Queensland bluegrass	*Dichanthium sericeum*
Quena	*Solanum esuriale*
Rats tail couch	*Sporobolus mitchellii*
Red burr	*Bassia calcarata*
Red Flinders grass	*Iseilema vaginiflorum*
Red spinach	*Trianthema triquetra*
Ridge grass	*Enneapogon avenaceus*
River red gum	*Eucalyptus camaldulensis*
Rock grass	*Eriachne mucronata*
Round-leaf toadflax	*Kochia aphylla*
Ruby saltbush	*Enchylaena tomentosa*
Saltbushes	*Atriplex spp.*
Samphire	*Arthrocnemum spp.*
Sandalwood	*Eremophila mitchellii*
Sand-hill cane grass	*Zygochloa paradoxa*
Sand-hill caustic	*Euphorbia coghlanii*
Sand twin-leaf	*Zygophyllum ammophilum*
Sesbania pea	*Sesbania cannabina*
Silky browntop	*Eulalia fulva*
Silky-heads	*Cymbopogon obtectus*
Silky umbrella grass	*Digitaria ammophila*
Silver cassia	*Cassia artemisioides*
Silver-leaved ironbark	*Eucalyptus melanophloia*
Silver sida	*Sida fibulifera*
Silver turkey bush	*Eremophila bowmanii*
Slender rats-tail grass	*Sporobolus elongatus*
Small burr grass	*Tragus australianus*
Small Flinders grass	*Iseilema membranaceum*
Small-flowered lovegrass	*Eragrostis kennedyae*
Soda bush	*Threlkeldia proceriflora*
Soft billy-buttons	*Craspedia pleiocephala*
Soft roly-poly	*Salsola kali*
Soft spinifex	*Triodia mitchellii*
Spike grass	*Elytrophorus spicatus*
Spinifex	*Triodia basedowii*
Sturt's desert rose	*Gossypium sturtianum var. sturtianum*
Swamp cane grass	*Eragrostis australasica*
Tar-vine	*Boerhavia diffusa*
Three-awned, Wanderrie	*Eriachne aristidea*
Three-spined roly-poly	*Bassia tricuspis*
Turpentine mulga	*Acacia brachystachya*
Vinetree or supplejack	*Ventilago viminalis*
Warrego summer grass	*Paspalidium rarum*
Western bloodwood	*Eucalyptus terminalis*
White spear grass or feathertop wire grass	*Aristida latifolia*
Whitewood	*Atalaya hemiglauca*
Wild flax	*Linum marginale*
Wild parsnip	*Trachymene ochracea*
Wilga	*Geijera parviflora*
Woodbine	*Parsonia eucalyptophylla*
Woollybutt grass	*Eragrostis eriopoda*

Common Name	Scientific Name
Woollybutt grass, hairy flowered	*Eragrostis laniflora*
Woollybutt, Wanderrie	*Eriachne helmsii*
Woolly spinach burr	*Bassia lanicuspis*
Yapunyah	*Eucalyptus ochrophloia*
Yarran	*Acacia omalophylla*
Yellow three-awn	*Aristida anthoxanthoides*

PRELIMINARY FAUNA SURVEY

by D.G. McGreevy* and A.K. Searle*

The following list is of all fauna observed and collected during the fauna survey. All species were abundant throughout the area unless otherwise indicated.

MAMMALS

(a) Native mammals

(1) Red kangaroo (*Megaleia rufa* (Desmarest)). Not observed in far western portion only; possibly a consequence of the good season. Abundant elsewhere.
(2) Grey kangaroo (*Macropus giganteus* Shaw). Abundant eastern portion, particularly the Thargomindah-Eulo-Hungerford-Cunnamulla area.
(3) Swamp wallaby (*Wallabia bicolor* (Desmarest)). Hungerford-Eulo-Thargomindah area only.
(4) Long-haired rat (*Rattus villosissimus* (Waite)). Abundant near Cooper Creek.

(b) Exotic species

(1) Feral horse (*Equus equus* (Linnaeus)). Far west only.
(2) Feral pig (*Sus scrofa* Linnaeus).
(3) Feral goat (*Capra hircus* (Linnaeus)). Near Thargomindah only.
(4) Fox (*Vulpes vulpes* (Linnaeus)). One specimen near Eulo.
(5) Rabbit (*Oryctolagus cuniculus* (Linnaeus)). Southern portion, mainly near rivers.

BIRDS

(a) Terrestrial birds

(1) Emu (*Dromaius novaehollandiae* (Latham)).
(2) Fork-tailed kite (*Milvus migrans* (Boddaert)).
(3) Whistling eagle (*Haliastur sphenurus* (Vieillot)).
(4) Wedge-tailed eagle (*Aquila audax* (Latham)).
(5) Nankeen kestrel (*Falco cenchroides* Vigors and Horsfield).
(6) Crested pigeon (*Ocyphaps lophotes* (Temminck)).
(7) Sulphur-crested cockatoo (*Cacatua galerita* (Latham)).
(8) Major Mitchell (*Cacatua leadbeateri* (Vigors)).
(9) Little corella (*Cacatua sanguinea* (Gould)).
(10) Galah (*Cacatua rosecapilla* Vieillot).
(11) Red-winged parrot (*Aprosmictus erythryopterus* (Gmelin)).
(12) Ring-neck parrot (*Barnardius barnardi* (Vigors and Horsfield)).
(13) Mulga parrot (*Psephotus varius* Clark).
(14) Blue bonnet (*Psephotus haematogaster* (Gould)).
(15) Welcome swallow (*Hirundo tahitica* Gmelin).
(16) Wedgebill (*Sphenostoma cristatum* Gould). One specimen in trap near Dynevor lakes.
(17) Zebra finch (*Poephila guttata* (Vieillot)).
(18) Magpie lark (*Grallina cyanoleuca* (Latham)).
(19) Willie wagtail (*Rhypidura leucophrys* (Latham)).
(20) Wood swallows (*Artamus* species).
(21) Black-backed magpie (*Gymnorhina tibican* (Latham)).
(22) Crows and ravens (*Corvus* species).

(b) Wetland birds

(1) Pelican (*Pelecanus conspicillatus* Temminck).
(2) White-necked heron (*Ardea pacifica* Latham).
(3) White-faced heron (*Ardea novaehollandiae* Latham).
(4) White egret (*Egretta alba* (Linnaeus)).
(5) Nankern night-heron (*Nycticorax caledonicus* (Gmelin)).
(6) White ibis (*Threskiornis molucca* (Cuvier)).
(7) Yellow-billed spoonbill (*Platalea flavipes* Gould).
(8) Black swan (*Cygnus atratus* (Latham)).
(9) Grass whistling duck (*Dendrocygna eytoni* (Eyton)).
(10) Black duck (*Anas superciliosa* Gmelin).
(11) Maned wood duck (*Chenonetta jubata* (Latham)).
(12) Brolga (*Grus rubicundus* (Perry)).
(13) Swamphen (*Porphyrio porphyrio* (Linnaeus)).
(14) Masked plover (*Vanellus miles* (Boddaert)).
(15) White-headed stilt (*Himantopus himantopus* (Linnaeus)).
(16) Silver gull (*Larus novaehollandiae* Stephens).
(17) Marsh tern (*Childonias hybrida* (Pallas)).

* Fauna Conservation Branch, Department of Primary Industries, Warwick.

COMMENTS

Fauna observed included only the most obvious and abundant species known from the area. Many species known to be in the area – for example the budgerygah (*Melopsittacus undulatus* (Shaw)) and the bustard (*Ardeotis australis* (Gray)) were not observed, but were freely mentioned by local inhabitants in conversation. Mammals also mentioned in conversations included the koala (*Phascolarctus cinereus* (Goldfuss)) near Langlo, hopping mice (*Notomys* species) – many locations – and a sugar glider (? *Petaurus breviceps* Waterhouse) near Adavale. Other species which are known from far western areas, and must certainly inhabit the surveyed area include the rabbit bandicoot (*Macrotis lagotis* (Reid)), the crest-tailed marsupial mouse (*Dasycercus cristicauda* (Krefft)) (possibly referred to in a conversation at Noccundra) and the crest-tailed marsupial rat (*Dasyuroides byrnei* Spencer). The yellow-footed rock-wallaby (*Petrogale xanthopus* Gray) may still inhabit areas in the vicinity of the Bulloo River – reports indicated its existence since World War II – but no recent sightings.

The need for a full fauna survey of the area was certainly indicated by this preliminary look, with particular attention to be paid to the Cooper's Creek area including the sand dune country, the Bulloo River near the New South Wales border, and the Dynevor and Currawinya lakes.

RECOMMENDATIONS FOR FAUNA RESERVES

Although the survey was superficial in the extreme, there can be little doubt that the habitat types provided by the surveyed area offer little variety to the resident fauna. For the purposes of a recommendation arising from the study, the area may be divided into five habitat types, as follows:-

(1) Wetlands
(2) Open grassy plains
(3) Forested plains
(4) Stony ridges
(5) Sand-dunes

Types 2, 3 and 4 would almost certainly be complementary in providing habitat for a single range of both bird and mammal fauna, types 1 and 5 would carry their own ranges.

Of the sites examined during this survey, the area in the vicinity, and to the south, of Nappermerrie provided a full range of dryland habitats and would represent an excellent reserve. the lakes of Dynevor and Currawinya would, likewise, provide excellent reserve areas for wetland species.

LAND SYSTEMS

by N.M. Dawson and D.E. Boyland

D1 ARRABURY (2,250 km²)

Land Unit and/or Associated Land System	8	14	8	8	8	14	8	21 53	8
Site and/or special comment		190	191 193	194				199 R 275	
Est. % of Land System		7-10	70	15-20				<5	

LANDFORM: Dunes (5-10 m high) with sloping duneflanks superimposed on flat plains. Dunes are longitudinal with some converging and diverging; mobile crests with steep slopes (15-50%). Slopes of duneflanks and interdune plains range from 0-8%.

GEOLOGY: Quaternary sand, mostly overlying Quaternary clay sheets. Qs.

SOILS: Predominantly red, earthy sands, Uc 5.21 (Titheroo, Booka) to sandy, red earths, Gn 2.12, Gn 1.12 on the duneflanks. Textures become sandier towards the crests. Dunes and mobile crests are mainly red, siliceous sands, Uc 1.23 (Yanko). Small areas of claypans with grey clays, Ug 5.24, and sandy surfaced, texture contrast soils occur.

VEGETATION: Spinifex wooded hummock grassland occurs on duneflanks and interdune plains with sand-hill canegrass open hummock grassland, bluebush pea sparse forbland and bare areas on mobile crests. In places mulga, western bloodwood grassy tall open shrubland occurs on interdune plains.

D2 POONGAMULLA (3,070 km²)

Land Unit and/or Associated Land System	D1 D3	8	14	8	20	L2	8	14
Site and/or special comment	A6	189, 191, 193, 194.	190, R86		197 217	192		
Est. % of Land System	<5	>55	20		5	15		

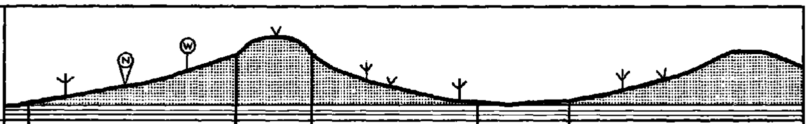
LANDFORM: Dunes (5-12 m high) with steeply sloping (15 to >50%) mobile crests and sloping duneflanks (2-4% W, 2-8% E). Dunes are converging and diverging with flat claypans in the interdune area.

GEOLOGY: Quaternary sand over Quaternary clay sheet. Qs.

SOILS: Predominantly red, earthy sands, Uc 5.21 (Titheroo) to sandy, red earths, Gn 2.12 on duneflanks with red, siliceous sands, Uc 1.23 (Yanko) on mobile crests. Grey clays, Ug 5.2, Ug 5.5 occur on claypans. Cemented, yellow, texture contrast soils frequently occur on edges of claypans at the base of dunes.

VEGETATION: Spinifex wooded hummock grassland on duneflanks and on interdune plains, with sand-hill canegrass open hummock grassland, bluebush pea sparse forbland and bare areas on mobile crests. Sparse herbfields are associated with cemented aprons at the base of dunes. In places mulga grassy tall open shrubland occurs on lower duneflanks. Claypans support bluebush, lignum low open shrubland, occasionally with coolibah low open woodland.

D3 SANTOS (4,420 km²)



Land Unit and/or Associated Land System	D4 R1	8,9	13	8	L2, 19, 21, 53.	8,9
Site and/or special comment	F4 A6		R77 R276			189, 191, 193, 194. R97, R273, R276, R279
Est. % of Land System			5		15	80

LANDFORM: Dunes (4-8 m high) with sporadic, rounded, mobile crests (slopes <25%) and sloping duneflanks (2-8%). Dunes are converging and diverging with claypans in the interdune area.

GEOLOGY: Quaternary sand over Quaternary clay sheets and occasionally dissected Tertiary land surface. Qs.

SOILS: Predominantly red, earthy sands, Uc 5.21 (Titheroo) to sandy, red earths, Gn 2.12, with red, siliceous sands, Uc 1.23 (Yanko) on mobile crest areas. Grey clays, Ug 5.2 and Ug 5.5 and sandy surfaced, texture contrast soils on the interdune claypans.

VEGETATION: Spinifex wooded hummock grassland; spinifex, mulga open hummock grassland and mulga, spinifex tall open shrubland occur on duneflanks and interdune plains. Crests support sparse herbfields with scattered shrubs. Bluebush, lignum low open shrubland and mulga grassy tall open shrubland are associated with the interdune areas.

D4 NARYILCO (9,500 km²)

Land Unit and/or Associated Land System	D3 R1	7,9	21	7	12	7	L2	20	7	A6	7
Site and/or special comment	F4	R97, R273, R276, R279.	220 Runs into A6		198 221		216 219	217	218, 220, 225.		
Est. % of Land System	<5				<5		5–10	<5	70	7	

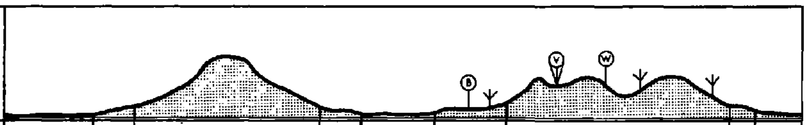
LANDFORM: Dunes (3-5 m high) with rounded crests, which infrequently may be mobile, and sloping duneflanks (1-5%). Dunes are reticulate, approaching longitudinal in places. Vegetated inter-connected interdune areas form drainage lines in places. Claypans which frequently become inundated are common.

GEOLOGY: Quaternary sand overlie Quaternary clay sheets and less commonly the lower sloping parts of the Tertiary land surface. Qs.

SOILS: Predominantly red, earthy sands, siliceous sands and sandy red earths which may become alkaline at depth. Clayey sand cores are common at depth, Uc 5.21, Gn 2.12, Gn 1.12 (Kotri, Booka). On the lower dunes red, texture contrast soils with loose, coarse textured, surfaces and alkaline, sandy-clay-loam subsoil occur. On these soils hardpans are common. On the dunecrests siliceous sands are common. Grey clays and texture contrast soils occur on the interdune claypans with texture contrast soils on the cemented aprons.

VEGETATION: Mulga, whitewood, needlewood forby tall open shrubland with some spinifex mulga open hummock grassland and mulga, spinifex tall open shrubland occurs on duneflanks and interdune plains. Crests support mulga forby tall open shrubland. Sparse herbfields are associated with scald. In places mulga, western bloodwood tall open shrubland occurs on interdune plains. Occasionally coolibah, lignum low woodland and Melaleuca uncinata tall open shrubland are associated.

D5 KYABRA (940 km²)



Land Unit and/or Associated Land System	C Land Zone	20	10	20	A, Land Zone	6	11	20	L2
Site and/or special comment		91 197	206, R278.			174, 176.	174, 185.		
Est. % of Land System		>2½	10			5	75		>5

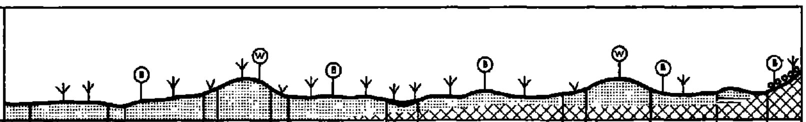
LANDFORM: Dunes (5-10 m high) with mobile crests, slopes (8-50%) often with low sloping flanks (<5%). Central and fringing claypans sometimes occur.

GEOLOGY: Quaternary sand overlying Quaternary alluvia. Qs/Qa.

SOILS: Red and yellow, siliceous sands, Uc 1.23 (Kotri), Uc 1.22 (Chookoo). Soils are loose but may form crusts on the lower slopes. Fringing the dunes loose, sandy surfaced, texture contrast soils (Bygrave) may occur. Cemented aprons may fringe the alluvia and claypans. Grey clays occur on the interdune claypans.

VEGETATION: Wooded forblands with mulga, whitewood and vinetree predominate on dunes and low sloping flanks with occasional forblands devoid of shrubs or trees. Bluebush pea open herbfield is associated. Scalded areas support sparse herbfields.

D6 CLYDE (3,520 km²)



Land Unit and/or Associated Land System	D4	3		3	20	7	20	3	M1	3	20	7	3	S2	H5
Site and/or special comment			220							90	91	93,218 220,225			
Est. % of Land System	5		5			15			5	60	<5				>5

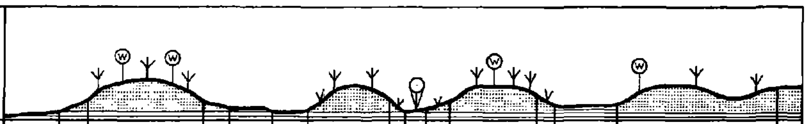
LANDFORM: Flat to gently undulating sandplain with low dunes, frequently with eroded aprons. Poorly defined, well vegetated drainage lines connect the lower parts of the plains.

GEOLOGY: Quaternary sand overlying Quaternary alluvia and the Tertiary land surface. Qs/Tg, Qs/Qc.

SOILS: Moderately deep, red, earthy sands and sandy, red earths generally underlain by a ferruginous hardpan, Uc 5.31, Gn 2.12 (Mirintu, Napoleon). Associated are red, siliceous sands, Uc 5.21 (Yanko) and eroded cemented aprons with red earths and texture contrast soils. Small areas of shallow, stony, red earths, Um 5.51 occur as intrusions.

VEGETATION: Mulga, western bloodwood tall open shrubland occurs on dunes and sandplains. In places tall open shrubland composed mainly of mulga, whitewood and needlewood is associated with upper slopes and crests of dunes. Eroded areas at the base of dunes support sparse herbfields. Mulga tall shrubland to tall open shrubland or mulga, western bloodwood tall shrubland to tall open shrubland occur on run-on areas.

D7 DYNEVOR (870 km^2)



Land Unit and/or Associated Land System	D8, L1	20	7(a)	20	L2	17	7(a)	5	39	5	7(a)	20	L2	7(a)	S2
Site and/or special comment		Eroded 91, 197	103			102			87	32 88 91A					
Est. % of Land System			50		25				5	15					5

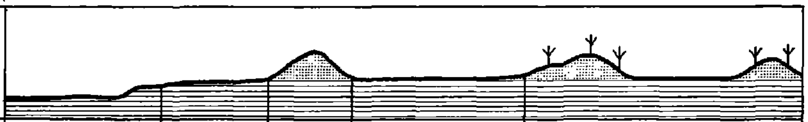
LANDFORM: Flat plains with low rounded dunes (<4 m high) and flat claypans and saltpans. Claypans and saltpans frequently interlink to form drainage lines.

GEOLOGY: Quaternary sand overlying Quaternary alluvium. Qs/Qa.

SOILS: Very deep, alkaline, red, earthy sands on dunes, Uc 5.21 (Booka). Soils are loose, loamy-sands grading into sandy-loams and sandy-clay-loams at depth. On lower slopes of dunes fringing claypans shallow to moderately deep, red, earthy sands and sandy, red earths with a ferruginous hardpan occur. These soils are commonly cemented, Um 5.31, Gn 2.12 (Gooyana). Very deep, alkaline, grey and brown clays occur on saltpans and claypans Ug 5.24, Ug 5.5.

VEGETATION: Mulga, whitewood vinetree tall open shrubland occurs on dunes with lower slopes supporting low shrubland to low open shrubland of budda bush and hopbush. On eroded areas at the base of dunes sparse herbfields occur. Gidgee tall open shrubland is associated with the cracking clays on the drainage lines. Claypans support swamp canegrass low open hummock grassland.

D8 BINDEGOLLY (150 km^2)



Land Unit and/or Associated Land System	L1,L2	30	1	30	D7
Site and/or special comment			104	105	
Est. % of Land System	5		50	30	15

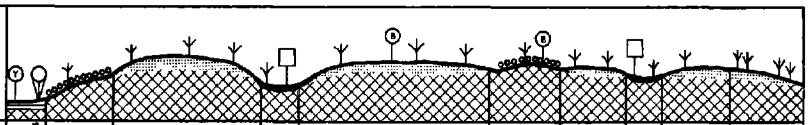
LANDFORM: Crescentic dunes (approximately 4 m high) fringing the major salt lakes.

GEOLOGY: Recent alluvial material on interdune area with recent wind blown material from lake beds forming dunes. Qs/Qa.

SOILS: On dunes, soils are deep, gypseous and calcareous, fine-sands. On flat areas fringing dunes strongly alkaline, poorly drained, grey clays with abundant calcium carbonate and gypsum occur.

VEGETATION: Samphire low shrubland occurs on the flat areas fringing the lakes and between low dunes. Dunes support samphire low open shrubland with forblands of saltbush and bassias. In places closed herbfield of Cyperus gymnocaulis occur.

S1 GREENMULLA (3,740 km²)



Land Unit and/or Associated Land System	Wa. & A	Land Zones	H3,R3,R5	63	M1	54	H3,58	63	45	54	60
Site and/or special comment				5,7,99,101.	31	12,30,106	39,98		6,100		A29,817,820
Est. % of Land System				>40	<2½	40	5		<2½		10

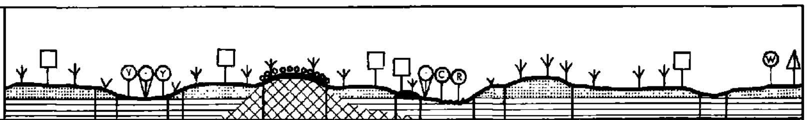
LANDFORM: Flat plains of low relief with gently undulating slopes (<2%) at the edges with few well defined drainage lines. Small local depressions and low stony rises are common.

GEOLOGY: Sandplains formed by the movement of Quaternary aeolian sand over upland surfaces. Qs/Qc or Qs/Tg.

SOILS: Predominantly deep to very deep, acid to neutral, sandy, red earths, Uc 5.21, Gn 2.12, Um 5.52 (Napoleon, Kotri), with shallow to deep, texture contrast soils in local depressions, (Tintinchilla) and shallow to deep, red earths, Gn 2.12 (Tinnenburra), on run-on areas.

VEGETATION: Predominantly mulga, western bloodwood grassy tall open shrubland and woollybutt, mulga, western bloodwood shrubby open tussock grassland. Mulga, poplar box tall shrubland to low open woodland or poplar box low open woodland is associated with local depressions. Groved mulga tall shrubland to tall open shrubland may occur on the gentle slopes at the edge of the plain.

S2 EULO (4,800 km²)



Land Unit and/or Associated Land System	61	5	W3		61	H2	61	M1	W7	5	54	61	L2	48
Site and/or special comment			66,67		72,73	69,70		71		32 88	77			
Est. % of Land System			5		70	<5				5	10		5	<1

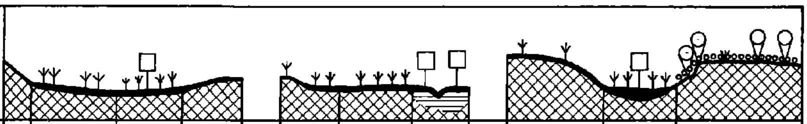
LANDFORM: Flat plains of low relief (slopes <1%) sloping on the edges into clay plains and small claypans. Low stony rises occur infrequently.

GEOLOGY: Sandplains formed by the movement of Quaternary sand mainly over Quaternary clay plains. Qs/Qa.

SOILS: Predominantly shallow to moderately deep, sandy, red earths slightly acid to neutral at the surface and alkaline at depth Gn 2.13, Um 5.31 (Springvale). Hardpans are common. Associated are acid and neutral, sandy, red earths (Napoleon) on low, sandy rises; moderately deep to shallow, cemented, sandy, red earths and earthy sands on the edge of the plain (Gooyana); shallow, loamy, red earths on the stony rises (Coperalla), deep, loamy, red earths on the run-on areas (Tinnenburra) and grey clays on the small areas of claypans and alluvia.

VEGETATION: Predominantly mulga, poplar box shrubby tall open shrubland to low open woodland, rarely poplar box low open woodland and woollybutt, mulga shrubby open tussock grassland. Budda bush, hop bush low shrubland occurs on some low sloping edges of the plain. Mulga, poplar box tall shrubland is found on run-on areas. Low stony rises support mulga sparse tall open shrubland. Yapunyah, gidgee open woodland and coolibah, river red gum, yapunyah gidgee open woodland occur on the fringing alluvia.

M1 BORAN (1,210 km²)



Land Unit and/or Associated Land System		M2	46	H Land Zone		H Land Zone & M2	62	44,47,81, M3,A&W Land Zones		H Land Zone	44,65,66	R Land Zone
Site and/or special comment			41,60 71,179				40,53,82					
Est. % of Land System		15	30				20	15		<10	>10	

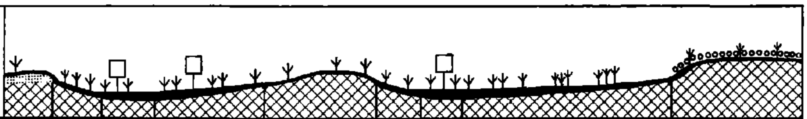
LANDFORM: Flat plains which receive run-on water.

GEOLOGY: Recent deposits derived from erosion of the Tertiary land surface. Qa, Qr.

SOILS: Predominantly moderately deep to deep,acid to neutral, loamy, red earths with ironstone gravel at depth.. Litter accumulates on surface in good seasons. Textures range from sandy-clay-loams to clay-loams at the surface to light and medium clays at depth, Gn 2.12, Uf 6.31 (Tinnenburra). Associated are shallow, red earths, (Nockatunga), alluvial soils, (Tirtywinna) and red and brown, texture contrast soils (Ambathala).

VEGETATION: Predominantly mulga tall shrubland to open scrub; mulga, poplar box tall shrubland to low woodland and poplar box low woodland or poplar box, mulga shrubby low woodland. In more arid areas mulga tall open shrubland and mulga, western bloodwood tall open shrubland are predominant.

M2 BIERBANK (3,900 km²)



Land Unit and/or Associated Land System	S1	60	M1, 46	64	H2	59	M1	64	R&H Land Zones
Site and/or special comment		29 B17 B20		59,179		42			
Est. % of Land System		<2	10	50	10-15	25			

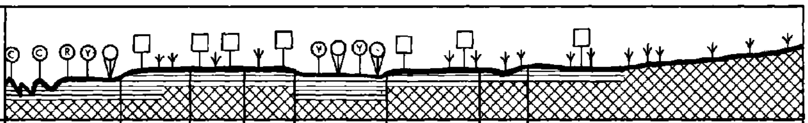
LANDFORM: Flat to gently undulating plains with low slopes ($<1\%$) and few defined drainage lines.

GEOLOGY: Superficial Quaternary deposits derived from erosion of the Tertiary landscape. Qr.

SOILS: Predominantly deep to very deep, acid to neutral, loamy, red earths with ferruginous gravel in the profile. Textures range from sandy-clay-loam to clay-loam at the surface to light and medium clays at depth. Litter may accumulate on the surface at times, Gn 2.11, Gn 2.12 (Tinnenburra). Farther up the slope shallow acid to slightly acid, loamy red earths are common, Gn 2.12 (Coparella). Differences between soils in the grove and intergrove areas are not always obvious but are deeper and lighter textured in some grove areas.

VEGETATION: Predominantly mulga shrubby tall shrubland; mulga, poplar box tall shrubland and diffusely groved mulga shrubby tall shrubland to tall open shrubland. Mulga sparse tall open shrubland is associated.

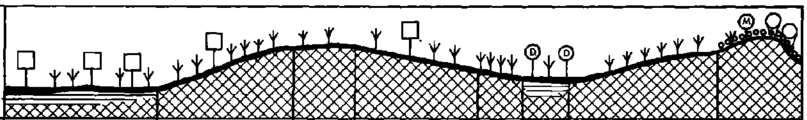
M3 HUMEBURN (1,150 km^2)



Land Unit and/or Associated Land System	W7	81	47	81	W3	81	44 M1	M2 M4
Site and/or special comment		254 256 B1	B2					
Est. % of Land System	5	45	30		5		5	10

LANDFORM: Flat plains grading into alluvial plains on the lower slopes and gently undulating plains on the upper slopes. Slopes are low ($\angle$0.5%).
GEOLOGY: Mixed recent alluvial material and superficial deposits. Qa, Qr.
SOILS: Predominantly deep to very deep, red, texture contrast soils with acid to neutral, earthy, loam to clay-loam surface soil and alkaline, red, clay subsoils, (Ambathala). Associated are loamy, red earths, Gn 2.12 (Tinnenburra) and brown, texture contrast soils.
VEGETATION: Predominantly mulga, poplar box grassy tall shrubland to low woodland; poplar box, mulga shrubby low woodland to low open woodland; poplar box, sandalwood low woodland to low open woodland and poplar box grassy low open woodland. Associated are mulga tall shrubland to tall open shrubland forming groves in places. Yapunyah, gidgee open woodland and coolibah, river red gum, gidgee, yapunyah fringing open woodland.

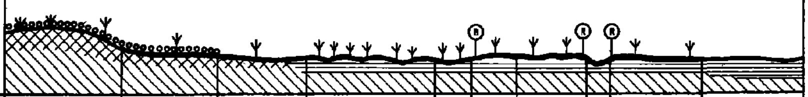
M4 NORAH PARK (2.550 km^2)



Land Unit and/or Associated Land System	M3	49	H2	49	M2	80 M1	49	79, R6
Site and/or special comment		1, R sites				R229 R231		R230
Est. % of Land System	10	>65	10		<5	5		5

LANDFORM: Gently undulating convex plains with slopes (<2%). Small flat areas occur on lower slopes and eroded remnants on upper slopes.
GEOLOGY: Superficial Quaternary deposits derived from erosion of the Tertiary land surface. Qr.
SOILS: Predominantly moderately deep to deep, loamy, red earths with ironshot gravel throughout the profile. Textures grade from clay-loam at the surface to light clay at depth, Gn 2.11, Gn 2.12 (Tilkerie). Associated are red, texture contrast soils on lower slopes and local alluvia with shallow, red earths and lithosols on upper slopes, Gn 2.12, Um 1.43 (Coparella, Grey).
VEGETATION: Predominantly mulga tall shrubland and mulga, poplar box tall shrubland. Associated are limited areas of silver-leaf ironbark, mulga open woodland, Dawson gum, sandalwood open woodland and mulga sparse tall open shrubland.

M5 BERELLA (1,430 km²)



Land Unit and/or Associated Land System	R&H Land Zones	55	H1,68	67	M1 67	68	67	A6	57	A or Other Alluvial Land Systems
Site and/or special comment		142	111, 114, 125	49, 109, 115, 116, 143, 144, 146, 147, 148, 149, 150, 151.	146 147 150 151			138 140	109, 157, 169	
Est. % of Land System		5	20	50	<10			<5	15	

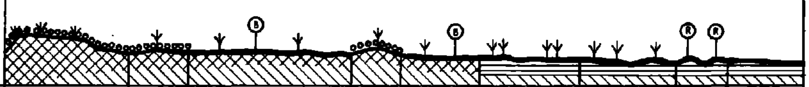
LANDFORM: Flat to very low sloping plains with slopes (<0.5%). Few well defined drainage lines but generally with centrally located run-on areas.

GEOLOGY: Low gradient fans of superficial Quaternary deposits derived from erosion of the Tertiary land surface mainly overlying clay plains. Qr.

SOILS: A complex of deep, red clays, Ug 5.37, Ug 5.38 (Ooliman) and red, texture contrast soils, Dr 2.12, Dr 2.13 (Lymbah, Bullawaria) in the grove with shallow to moderately deep, loamy, red earths (often with ferruginous hardpans) Gn 2.12, Um 5.51 (Mt. Margaret) in the intergrove area. Associated are shallow to moderately deep, texture contrast soils overlying hardpans on lower slopes and very shallow, red earths on upper slopes.

VEGETATION: Predominantly mulga grassy tall shrubland to tall open shrubland forming distinct groves with mulga sparse tall open shrubland and mulga, western bloodwood tall open shrubland in places. Mulga, dead finish tall open shrubland occurs in limited areas. Run-on areas support mulga tall shrubland to tall open shrubland and mulga, western bloodwood tall shrubland to tall open shrubland. Associated is mulga sparse tall open shrubland.

H1 BUNDEENA (2,090 km²)



Land Unit and/or Associated Land System	R Land Zone	55	68	55	68	M5	57	A6	A Land Zone
Site and/or special comment	H3 H4	107,124,142	111, 114, 125	142		143, 144	169		
Est. % of Land System	5		>50	10		15	<10	5	<5

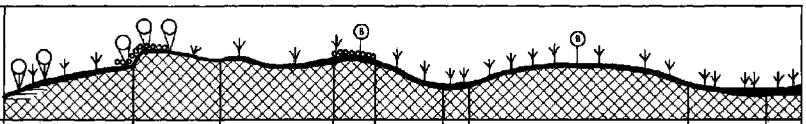
LANDFORM: Flat to very gently undulating plains, slopes of less than 1% except for low rises which may be up to 2%.

GEOLOGY: Low gradient fans and pediments with superficial Quaternary deposits derived from the Tertiary land surfaces overlying deeply weathered Cretaceous sediments. Qr/chemically altered Kw.

SOILS: Predominantly shallow to moderately deep, loamy, red earths with hardpans, Um 5.51, Gn 2.12 (Mt. Margaret). Gravel is common. Textures range from sandy-clay-loam to light clay. pH ranges from acid at the surface to neutral to slightly alkaline in the lower parts of the profile. Associated are shallow, loamy, red earths with silcrete and ferricrete cover, Gn 2.12, Um 5.51, Um 5.31 (Kulki) and shallow to moderately deep, texture contrast soils, often with a ferruginous hardpan Dr 2.13, Dr 2.12 (Bullawaria, Lymbah).

VEGETATION: Predominantly mulga, western bloodwood tall open shrubland with areas of mulga, dead finish tall open shrubland and mulga sparse tall open shrubland on low stony rises. Groved mulga tall open shrubland, rarely tall shrubland occurs in places.

H2 KYEENEE (8,470 km²)



Land Unit and/or Associated Land System	Small areas of G1,G2 and G5 intermixed with H2.	R2,R3,R4,R5	51,52	H3 H4	51,52	M1	51,52	M2	M1
Site and/or special comment							24 43 48 50 61 69 70 79		
Est. % of Land System	<5	<5		10		5	> 70	5	

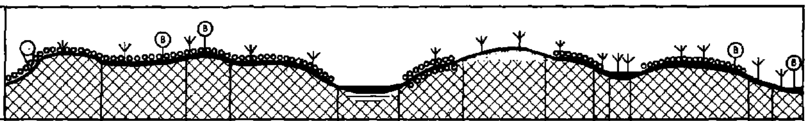
LANDFORM: Gently undulating plains with slopes (<2%) commonly grading into dissected low hills.

GEOLOGY: Superficial Quaternary deposits overlying weathered Cretaceous sandstones which may be occasionally exposed. Chemically altered Kw, with Qr.

SOILS: Predominantly very shallow to moderately deep, acid, loamy, red earths with ironstone gravel throughout the profile. Textures range from sandy-clay-loam at the surface to light clay at depth. Ironshot is common on the surface, Gn 2.11, Gn 2.12, Um 5.51 (Coparella, Tilkerie) Associated are lithosols and stony, red earths (Grey, Corona) on upper slopes and moderately deep to deep, loamy, red earths on lower slopes and run-on areas (Tinnenburra).

VEGETATION: Predominantly mulga tall open shrubland and mulga, western bloodwood tall open shrubland with areas of groved mulga tall open shrubland. Associated are small areas of gidgee, mulga tall open shrubland.

H3 WANKO (5,580 km²)



Land Unit and/or Associated Land System	R3 R5	58	H4	58	A&W Land Zones	58	S1	58	M2	M1	58	H2	66
Site and/or special comment		39		39		89 98			60	97			96 129
Est. % of Land System	<5		10			>65	5		<5			<5	<5

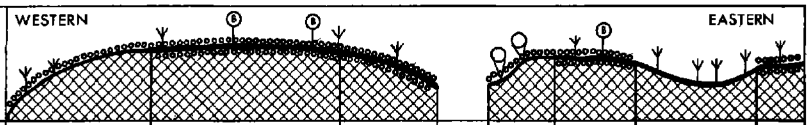
LANDFORM: Gently undulating to undulating convex plains with well defined drainage lines. Commonly dissected on the upper slopes.

GEOLOGY: Remnants of the Tertiary Glendower Formation and intermixed superficial Quaternary deposits. Qc, Tg.

SOILS: Shallow to moderately deep, stony, acid, loamy red earths with silcrete cover, Um 5.51, Gn 2.12 (Corona). Associated are bouldery, lithosols (Grey) on knolls, moderately deep, sandy, red earths on the fringes of the sandplains and alluvial soils on the run-on areas (Nockatunga, Tirtywinna).

VEGETATION: Predominantly mulga tall open shrubland with less extensive areas of mulga, western bloodwood tall open shrubland and mulga sparse tall open shrubland.

H4 BINGARA (2,460 km²)



Land Unit and/or Associated Land System	H5	50	H3		R3 R5	50	H2	50
Site and/or special comment		3,8,25,54,110						
Est. % of Land System	10	70	10		5		5	

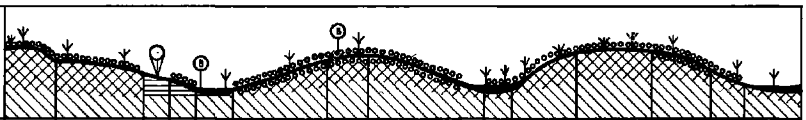
LANDFORM: Gently undulating to flat plains on the upper slopes (<2%) of convex plains and dissected tablelands.

GEOLOGY: Tertiary Glendower Formation and undifferentiated superficial Quaternary deposits. Tg, Qc.

SOILS: Shallow to moderately deep, stony, acid, red earths. Textures range from loams to clay-loams at the surface to light clays on deeper soils, Um 5.51, Gn 2.12 (Corona). Silcrete boulder is intermixed with and overlies the soil mass. Small depressions and stone pattern combine to give this unit a characteristic air photo pattern.

VEGETATION: Predominantly rockgrass, mulga, western bloodwood open tussock grassland. Associated is mulga sparse tall open shrubland and mulga, bastard mulga tall open shrubland.

H5 NOCCUNDRA (6,320 km²)



Land Unit and/or Associated Land System	R3	56	G3	56	66	56	50	58	65	R1	88	56	55	H1
Site and/or special comment					129	108 128	110	89 98	130		131 134 135		107 142	
Est. % of Land System	<5		1		15	35	1	12	3	2	20		5	<3

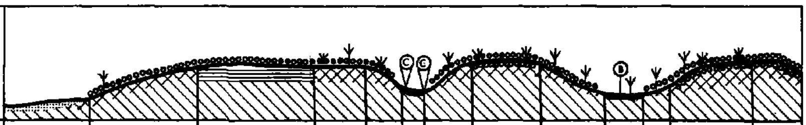
LANDFORM: Gently undulating to undulating plains, with slopes generally less than 2%, dissected in places (slopes <5%).

GEOLOGY: Remnants of the Tertiary Glendower Formation, overlying weathered Winton Formation sediments, covered in places by superficial Quaternary deposits. Tg/Kw, Qc.

SOILS: Predominantly shallow, loamy, red earths with silcrete cover. Soils are neutral to acid and textures range from sandy-loams to clay-loams, Um 5.51, Gn 2.12 (Kulki, Corona). On the hilltops very shallow lithosols, bouldery red earths and exposed rock are common. Stony (Nockatunga) and lighter textured (Tirtywinna) alluvial soils occur in drainage lines.

VEGETATION: Predominantly mulga shrubby tall open shrubland to mulga sparse tall open shrubland with bastard mulga, mulga low open shrubland on the hilltops. In places rockgrass, mulga, western bloodwood open tussock grassland may occur. Drainage lines support mulga tall open shrubland to mulga, western bloodwood grassy tall open shrubland. Small areas of gidgee tall open shrubland are associated.

R1 ORIENTOS (1,480 km²)



Land Unit and/or Associated Land System	Dunefields Land Zone	56	F4	88		65 82		88		66	55		R3 R4
Site and/or special comment		108,128			R272		R272	131,134,135	R272	R272a	107 127 142	R272	
Est. % of Land System		10	15		35	5		20		5	5		5

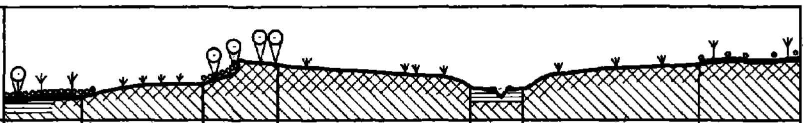
LANDFORM: Dissected undulating plains and low hills with a well defined dendritic drainage pattern. Slopes are low on hilltops being less than 2% but up to 8% on dissected edges.

GEOLOGY: Remnants of the Tertiary Glendower Formation often with exposures of weathered Winton Formation. Tg/chemically altered Kw.

SOILS: Predominantly shallow, stony, acid, red earths with stone cover. Areas of exposed rock are common, Um 5.51, Um 5.31, Um 1.23, Gn 2.12 (Kulki, Grey). Stony (Nockatunga) and lighter textured (Tirtywinna) alluvial soils occur in drainage lines. Desert loams (Chastleton) and red clays (Karmona) commonly occur on upper slopes.

VEGETATION: Predominantly bastard mulga low open shrubland to bastard mulga, mulga tall open shrubland. Mulga tall open shrubland to mulga shrubby tall open shrubland occur on dissected edges. Drainage lines and run-on areas support mulga tall open shrubland to mulga, western bloodwood tall open shrubland and west of Cooper Creek mineritchie tall open shrubland. Associated are herbfields of various composition with a fluctuating climax varying from forblands to Mitchell grass, short grass grasslands.

R2 MAWSON (3,190 km²)



Land Unit and/or Associated Land System	G1	90	R3 R5 R6	90	Alluvial Land Zone	90	H2
Site and/or special comment		47		27 62 181			
Est. % of Land System	10	10	20	40			20

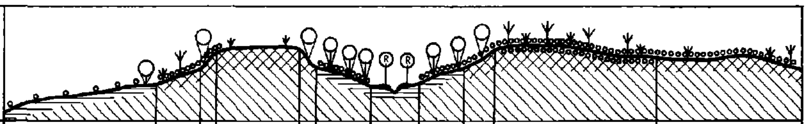
LANDFORM: Eroded remnants of dissected tablelands, which now form dissected low hills and undulating plains. Slopes range from 1-3% but on the more eroded sections may exceed 8%.

GEOLOGY: Hardened, weathered exposures of the Cretaceous Winton Formation sometimes with a thin cover of Cainozoic material. Chemically altered Kw.

SOILS: Very shallow, acid, lithosols with exposed weathered rock covering large proportion of the surface areas. Textures range from gritty-loam to gritty-clay-loams. Ironstone gravel is common on the surface, Um 1.43 (Grey). Associated are shallow, red earths, Um 5.51, Gn 2.12 (Coparella, Corona).

VEGETATION: Predominantly bastard mulga low open shrubland to bastard mulga, mulga low open shrubland, with a complex of bendee, lancewood and mulga forming tall shrubland to low woodland on dissected eroded slopes. Mulga sparse tall open shrubland occurs on the undulating plains.

R3 GREY (4,430 km²)



Land Unit and/or Associated Land System	F2	92	93	88	93	77	A5	G3	93	89	H5 R1
Site and/or special comment		123		121		224			122	119	
Est. % of Land System	5	20		20		<10	<5		10	>20	10

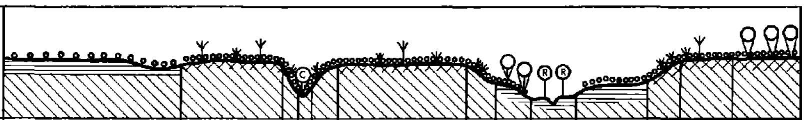
LANDFORM: Cuestas, dissected tablelands, mesas and buttes formed by warping and erosion of the Tertiary land surface. Slopes range from 1 to 5% on the tops and up to 50% on the scarp retreat.

GEOLOGY: Comprises the Tertiary Glendower Formation overlying weathered and fresh Cretaceous Winton Formation sediments, all weathered stages of which may be exposed. Tg/chemically altered Kw.

SOILS: Predominantly very shallow, reddish-brown to red, acid, loamy, lithosols and red earths. Silcrete stone overlies and is intermixed with the soil profile. Boulders are common, Um 1.43, Um 5.51, Um 5.31, Um 1.23 (Grey). Red and brown, stone covered, clays may occur on the lower slopes, Ug 5.37, Ug 5.32 (Ackland).

VEGETATION: Predominantly bastard mulga low open shrubland, bastard mulga, mulga tall open shrubland and turpentine mulga, mulga tall open shrubland with lancewood low open woodland on upper slopes of scarps. Gidgee forby tall open shrubland occurs on the scarp retreat. Associated are herbfields developed on alluvia adjacent to drainage lines with scattered trees of river red gum and coolibah on the creek banks and herbfields of various composition with a fluctuating climax varying from forblands to Mitchell grass, short grass grasslands on adjacent downs.

R4 DURHAM (2,560 km²)



Land Unit and/or Associated Land System	F2, F4	88	89	82	89	88	89	76 77	A6 W5	F2	89	88	R3
Site and/or special comment	201,222	131,134,135		R70	R280			224	200 R71				
Est. % of Land System	10	40		5	25			10	<5	5			<5

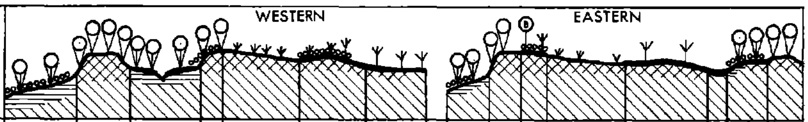
LANDFORM: Scarps and flat to gently undulating tops of dissected tablelands, mesas and buttes. Slopes range from less than 2% on the tops varying to 20% on scarps and 5% to 8% on lower slopes.

GEOLOGY: Thin silcrete cover overlying fresh Cretaceous Winton Formation sediments. Tg/Kw.

SOILS: Very shallow, red, acid, loamy, lithosols and red earths with abundant silcrete stone and boulder intermixed, Um 1.43, Um 5.51, Um 5.31, Um 1.23 (Grey) on scarps and upper slopes, and stony, red and brown cracking clays, Ug 5.37, Ug 5.38, Ug 5.32 (Karmona, Ackland) and desert loams (Chastleton) on flat tops and lower slopes.

VEGETATION: Predominantly bastard mulga low open shrubland and bastard mulga, mulga tall open shrubland with gidgee forby tall open shrubland on some slopes. Herbfields of various composition with a fluctuating climax from forbland to Mitchell grass, short grass grassland occur. Drainage lines and small creeks support mineritchie tall open shrubland. Associated are coolibah, river red gum fringing woodland or mulga, western bloodwood tall shrubland on the major channels.

R5 WILLIES (4,570 km²)



Land Unit and/or Associated Land System	G2,G3,76	93	72,75	91 93	90	89	H1,M5		74,77	91 93	50	90	H2	75	72	91
Site and/or special comment	155	141	141, 159 160, 161	141 182	181	152			80,84	141 182		27,47,62		20 78		21 26
Est. % of Land System	<5		10			15	5		<5	35	<5	20	5	<5		

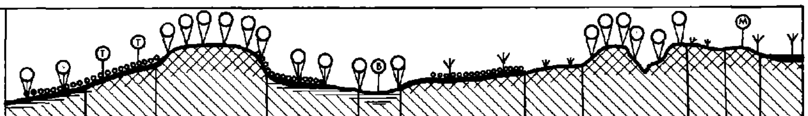
LANDFORM: Scarps and flat to gently undulating tops of dissected tablelands, cuestas, mesas and buttes. Slopes range from less than 5% on the undulating tops to 50% on scarp faces and 8% on detrital slopes.

GEOLOGY: Predominantly deeply weathered Cretaceous <u>Winton Formation</u> sediments sometimes overlain by remnants of the Tertiary <u>Glendower Formation</u> and other superficial Tertiary deposits. Tg/chemically altered Kw.

SOILS: Very shallow, reddish-brown to red, acid, loamy, lithosols, Um 1.43, Um 1.23, Um 5.31 (Grey). Ironstone gravel and ferricrete are common. Small areas of silcrete occur. Weathered base rock is often exposed. On slopes below scarps shallow, lithosols (Woban) and shallow to moderately deep, cracking clays (Ackland) occur with shallow, texture contrast soils. Shallow, red earths (Coparella) occur on backslopes.

VEGETATION: Predominantly a complex of bendee tall shrubland to low woodland; lancewood low woodland to low open woodland with areas of bastard mulga low open shrubland and bastard mulga, mulga tall open shrubland. Limited areas of rock grass, mulga, western bloodwood open tussock grassland occur. On the scarp retreats gidgee forby tall open shrubland is present with boree, gidgee forby low open woodland occurring west of Quilpie. Generally bendee tall shrubland is not well developed in the west and areas of bastard mulga low open shrubland become more extensive and are a larger component than in the eastern sector of the area.

R6 GUMBARDO (3,500 km²)



Land Unit and/or Associated Land System	72	87	91,93	72	69,70	H2	90	91,93	90	79	M4
Site and/or special comment	19, 22,23 44,56,57 64,159,160		4, 21, 26, 45,46, 81, 122, 182				27, 47, 62, 181			R230	
Est. % of Land System	7	7	> 40		<5	10	20			5	5

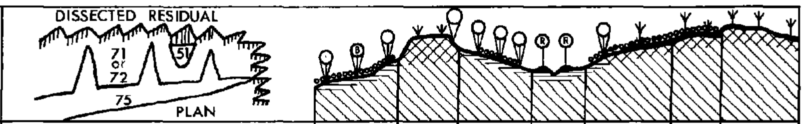
LANDFORM: Scarps, and flat to gently undulating tops of dissected tablelands, cuestas, mesas and buttes. Slopes range from less than 5% on the undulating tops to 50% on scarp faces and less than 8% on detrital slopes.

GEOLOGY: Mainly deeply weathered Cretaceous <u>Winton Formation</u> sediments with a superficial Quaternary covering. Chemically altered Kw.

SOILS: Predominantly shallow, acid, loamy, lithosols, Um 1.43, Um 1.23 (Grey). Ironstone gravel and ferricrete is common and weathered rock is often exposed. On lower slopes small area of lithosols (Woban), grey cracking clays and shallow, red earths (Coparella) may occur. Red earths occur on backslopes of cuestas.

VEGETATION: Predominantly a complex of bendee tall open shrubland to tall shrubland and lancewood low open woodland on scarps with bastard mulga low open shrubland on adjacent flat tops. Mulga sparse tall open shrubland and gidgee forby tall open shrubland occur. Limited areas of gidgee shrubby tall open shrubland and brigalow, gidgee shrubby low open woodland are associated with run-on areas, creeks and drainage lines. Restricted areas of silver-leaf ironbark, mulga low open woodland and mountain yapunyah shrubby low open woodland occur on detrital slopes.

G1 GROTTO (1,090 km²)



Land Unit and/or Associated Land System		G3or G4	Dissected Residual Land Zone	77	75	71,72	51	Dissected Residual Land Zone
Site and/or special comment				80,84	20,78,161	19,22,23,44, 56,57,64,85, 86,141	24,43	
Est. % of Land System		<5	7	20	20	> 40	7	

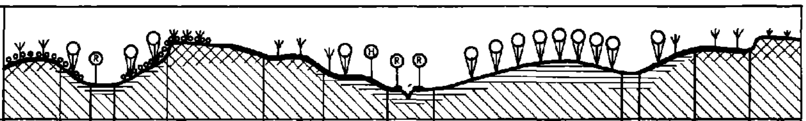
LANDFORM: Scarp retreats and pediment zone of dissected residuals. Slopes range from 2% on lower slopes up to 20% on upper slope. Sloping alluvial fans are a feature.

GEOLOGY: Eroded weathered sediments of the Cretaceous Winton Formation. Both weathered and fresh sediments may be exposed. In places the unit has a superficial cover of Quaternary deposits. Stone cover from the eroded Tertiary land surface is common. Qc/chemically altered Kw.

SOILS: Shallow to very shallow, stony, clay-loams to light clays occasionally with texture contrast profiles, often structured below the surface which is generally hardsetting, Um 1.43, Um 1.21, Dr 1.12 (Woban, Whynot) and shallow, cracking clays, Ug 5.37, Ug 5.32, Ug 5.24 (Ackland). Intermixed are shallow, red earths (Coparella) and moderately deep to deep, alluvial soils (Farnham).

VEGETATION: Predominantly gidgee forby tall open shrubland and gidgee, mulga tall open shrubland on eroded slopes. Areas of herbfield occur on the associated fan alluvia. Drainage lines support scattered trees of river red gum and coolibah. Mulga tall open shrubland and in places mulga, bastard mulga tall open shrubland occur on upper slopes.

G2 TILBOOROO (2,050 km²)



Land Unit and/or Associated Land System	H2	71	W2	77	R5	51	72	W4	76	75	72	51	Dissected Residual Land Zone
Site and/or special comment		85 86		80,84					65	78	19,22,23, 44,56,57, 64		
Est. % of Land System		10		20	5	10		5	>20	<10	20		

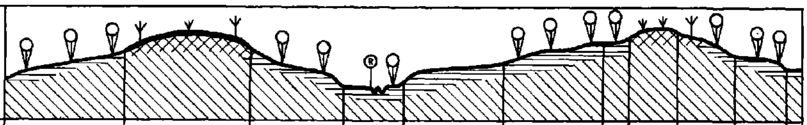
LANDFORM: Gently undulating to undulating plains with scarps on the upper slopes. Slopes are generally less than 5% but with some slopes up to 20% on the upper slopes below the scarps.

GEOLOGY: Weathered and fresh Cretaceous Winton Formation sediment often with a stone mantle derived from erosion of the Tertiary landscape resulting in a superficial cover of Quaternary deposits. Qc/Kw.

SOILS: Predominantly shallow to deep, sometimes strongly gilgaied, stony, red and brown clays, Ug 5.37, Ug 5.32, Ug 5.24, Uf 6.31 (Karmona, Ackland). Associated are red, texture contrast soils, lithosols, shallow, red earths on the rises and alluvial soils in the drainage lines.

VEGETATION: Predominantly gidgee forby tall open shrubland with limited areas of mulga tall open shrubland. Herbfields are developed on the associated alluvia with scattered trees of river red gum and coolibah on drainage lines.

G3 BELLALIE (2,890 km²)



Land Unit and/or Associated Land System	76	H5	76	A5,W4	F2,F4	76	77	R Land Zone	G1,G2,H5	76	75
Site and/or special comment						118,155,165	80 84 153 224				78 161
Est. % of Land System		<5		5	5	>70	<5	5	<5		<5

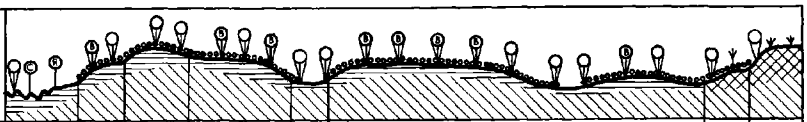
LANDFORM: Gently undulating to undulating plains. Slopes are generally less than 5% but rise to 8-12% near the associated scarps.

GEOLOGY: Mantled pediments formed by erosion of the Tertiary land surfaces exposing fresh Cretaceous Winton Formation sediments. Kw.

SOILS: Soils range from shallow to moderately deep, stony, red and brown cracking clays, Ug 5.31, Ug 5.32 (Ackland) on upper slopes to deep to very deep, very stony, gilgaied, red and brown clays, Ug 5.38, Ug 5.24 (Karmona) on the mid and lower slopes. Associated are alluvial, clay soils and texture contrast soils.

VEGETATION: Predominantly gidgee forby tall open shrubland with limited areas of herbfields. Associated alluvia also supports herbfields and in places coolibah, river red gum fringing open woodland.

G4 BUNGINDERRY (850 km²)



Land Unit and/or Associated Land System	A5,W4	74	G3	74	73	74	G1,G2	R Land Zone
Site and/or special comment					37	36,38,B123		
Est. % of Land System	<10		10		7	65	5	<5

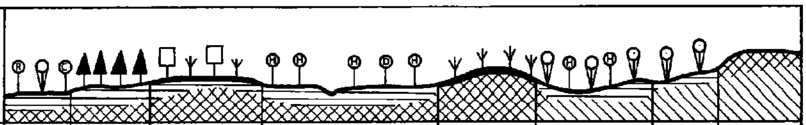
LANDFORM: Gently undulating to undulating plains typically with convex slopes. Slopes range from 0.5 to 3% becoming steeper near the scarps.

GEOLOGY: Derived from fresh sediments of the Cretaceous Winton Formation with silcrete cover derived from erosion products of the Tertiary land surface. Kw.

SOILS: Soils are moderately deep to very deep, self-mulching, stony, red and brown clays overlying fine grained, sandstones and siltstones, Ug 5.32, Ug 5.37, (Karmona, Pinkilla).

VEGETATION: Predominantly boree, gidgee low open woodland, limited areas of boree low open woodland and gidgee, boree tall open shrubland with areas of gidgee forby tall open shrubland. Steeper slopes near scarps support a complex of gidgee and mulga forming tall open shrubland. Associated alluvia supports herbfields and coolibah, river red gum fringing open woodland.

G5 SPRING CREEK (240 km²)



Land Unit and/or Associated Land System	W2,W3 W4,W7	22,70	M3	70	H2,M4	69	76,77	R5,R6
Site and/or special comment		226		R205,R283,R284		R234,R255	65,80	
Est. % of Land System	<5		<5	30	5	40	<15	5

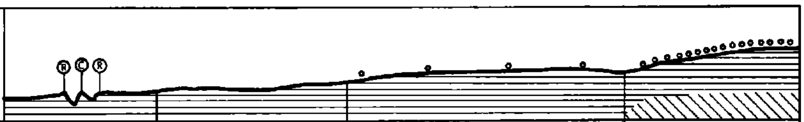
LANDFORM: Gently undulating to flat plains. Slopes less than 2%.

GEOLOGY: Quaternary deposits mostly derived from the Cretaceous Winton Formation. Inclusions of weathered rock occur. Qa/Kw.

SOILS: Soils range from very deep, strongly gilgaied, grey and brown clays to red, texture contrast soils with clay-loam surfaces. Alluvial clay soils occur on drainage lines. Interspersed are loamy, red earths and lithosols on low rises.

VEGETATION: Predominantly gidgee, brigalow shrubby low open woodland to low woodland and brigalow shrubby woodland. Limited areas of belah, gooramurra low open woodland, brigalow, Dawson gum low open woodland and yapunyah low open woodland. Gidgee forby tall open shrubland and mountain yapunyah low open woodland on slopes. Mulga, poplar box tall open shrubland to tall shrubland occurs on interspersed loamy red earths and mulga sparse tall open shrubland to tall open shrubland is associated with lithosols on the low rises.

F1 BRANSBY (690 km²)



Land Unit and/or Associated Land System	A2,A5,24,25	23	84	F2,84,85
Site and/or special comment	212	126	213	
Est. % of Land System	5	5-10	<80	5-10

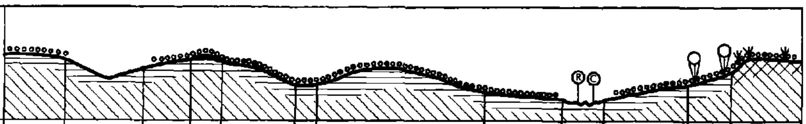
LANDFORM: Flat to gently undulating plains. Slopes less than 1%.

GEOLOGY: Mantled pediments associated with the dissection of the Tertiary land surface resulting in the exposure of fresh Winton Formation sediments from which this system is mainly derived. Silcrete stone cover is a remnant of the Tertiary Glendower Formation. Kw, Qa.

SOILS: Soils are predominantly very deep, weakly gilgaied, stony surfaced, self-mulching, red clays, Ug 5.38 (Karmona). On the lower slopes bordering the alluvia very deep, alkaline, weak to moderately gilgaied, stony, grey and brown clays may occur, Ug 5.24 (Parragona). On local alluvia very deep, red and brown clays with gravel beds may occur, Ug 5.37, Ug 5.38 (Thylungra).

VEGETATION: Seasonally dependent. A fluctuating climax between tussock grasslands including Mitchell grass and short grasses and forblands composed of saltbushes, soda-bush and bassias. Scattered coolibah, gidgee and river red gum occur on drainage lines.

F2 PLEVNA (8,290 km²)



Land Unit and/or Associated Land System	84,85	F3,83	84,85	86	84,85	82	84,85	F1	A2 A5 W4	84,85	G3	R1, R3,R4
Site and/or special comment		167		187 201 214 222		163 200	117,120,133,162, 164,166,188,213				118 165 185	
Est. % of Land System		<2		5		5	>75	5	<3		5	

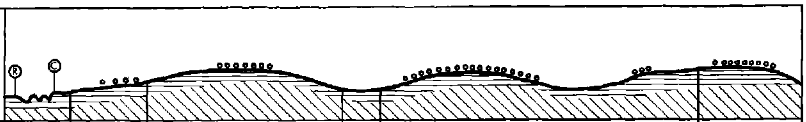
LANDFORM: Gently undulating to undulating rolling plains. Slopes 1 to 5%.

GEOLOGY: Mantled pediments associated with erosion of the Tertiary land surface exposing fresh Cretaceous Winton Formation sediments. Variable silcrete cover is derived from the eroded Tertiary surface. Qc/Kw.

SOILS: Deep to very deep, weakly gilgaied, stony, red and brown clays, Ug 5.38, Ug 5.36 (Karmona). Stone may have a desert varnish or be silcrete coloured. Associated are shallow to moderately deep, desert loams, Dr 1.13, Dr 1.12, Dr 2.13 (Chastleton) and a moderately deep phase of Karmona on crests, with both clay (Pinkilla) and loamy textured (Nockatunga) soils on drainage lines.

VEGETATION: Seasonally dependent. A fluctuating climax between tussock grasslands including Mitchell grass and short grasses and forblands composed of saltbushes, sodabush and bassias. Scattered trees of gidgee, coolibah and river red gum occur on local creeks. Drainage lines and small creeks west of Cooper Creek support mineritchie tall open shrubland. Gidgee tall open shrubland is associated throughout.

F3 MT. HOWITT (700 km²)



Land Unit and/or Associated Land System	A2,A5, 24,25	83	83	82	83	F2
Site and/or special comment		167	B58, B59,B64, B134, B135	B121		
Est. % of Land System	5	20	55	10		10

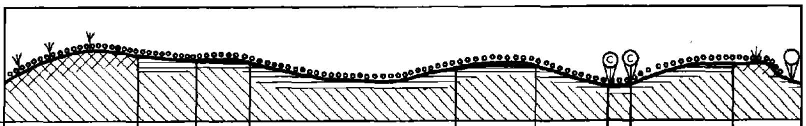
LANDFORM: Gently undulating plain with long slopes ranging from 0.5 to 3% but frequently less than 1%.

GEOLOGY: Fresh, labile sandstones of the Cretaceous Winton Formation with strongly indurated concretions on the surface usually occurring on the highs of anticlines. Kw.

SOILS: Deep to very deep, alkaline, red and brown cracking clays with soft, self-mulching, surface soil, Ug 5.38, Ug 5.22 (Arima). Small outcrops of stony, red clays, (Karmona) occur on upper slopes with moderately deep to very deep, red and brown clays in drainage lines.

VEGETATION: Seasonally dependent. A fluctuating climax between tussock grassland including Mitchell grass and short grasses and forblands composed of saltbushes, sodabush and bassias. Gidgee, coolibah and river red gum occur on local drainage lines.

F4 NAPPAMERRY (3,110 km²)



Land Unit and/or Associated Land System	R1	84,85	86	84,85	86	84,85	82	84,85,86	R4
Site and/or special comment				117,120,133,162,164,166,188,213	187, 201, 214, 222		200		
Est. % of Land System	5			>50	35		<5		5

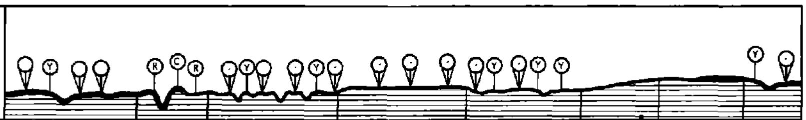
LANDFORM: Undulating to gently undulating plains occasionally slightly dissected. Slopes range from 1 to 5%. Qc/Tg/Kw.

GEOLOGY: Mantled pediments formed by erosion of the Tertiary land surface exposing fresh Cretaceous Winton Formation sediments.

SOILS: A complex of shallow to moderately deep, stony, desert loams often with weak gilgai relief, Dr 1.13, Dr 1.12, Dr 2.13 (Chastleton) and weakly gilgaied, stony, moderately deep to very deep, red clays (Karmona). Associated are stony, red earths and lithosols on some knolls and stony, loamy, alluvial soils on the drainage lines.

VEGETATION: Seasonally dependent. A fluctuating climax between tussock grasslands including Mitchell grass and short grasses and forblands composed of salt bushes, sodabush and bassias. Scattered gidgee tall open shrubland occur on drainage lines. West of Cooper Creek the drainage lines and small creeks support mineritchie tall open shrubland. Associated is bastard mulga low open shrubland and mulga, bastard mulga tall open shrubland.

W1 WINBIN (1,000 km²)



Land Unit and/or Associated Land System	39	42	40	34	40	35	24	39
Site and/or special comment	68, 87, 156	28,55,132, 138,140	10,11,13,75	14,15,127,137,171,184		17,172	33,177	
Est. % of Land System	10	<5	50	20		5–10	5–10	

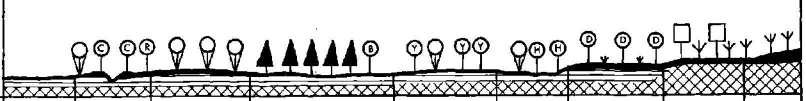
LANDFORM: Alluvial plains with braided channels. Local relief ranges from 0.5 to 3 m. Braided channels are subject to frequent flooding while the low rises are only occasionally flooded.

GEOLOGY: Recent alluvia. Qa.

SOILS: Predominantly very deep, grey clays with thin, surface crusts, Ug 5.24 and Ug 5.25 (Comongin). Associated are gilgaied, grey and brown clays (Cottesmore), brown clays (Thylungra, Kihee), alluvial soils with texture contrast (Okena, Caiwarro, Wanna) and scalded, grey and brown clays (Quilpie).

VEGETATION: Predominantly gidgee, yapunyah tall open shrubland to yapunyah, gidgee open woodland to woodland with areas of gidgee forby tall open shrubland and limited areas of gidgee shrubby tall open shrubland. Various herbfields occur on low rises. Sparse forblands are associated with scalded grey and brown clays. River red gum, coolibah fringing open woodland may be associated with the major channels.

W2 DARTMOUTH (220 km²)



Land Unit and/or Associated Land System	C1, L1	42	39	22	41	69,70	80	M3	M4
Site and/or special comment			68,87	226	66,67,175,51				
Est. % of Land System	<5	<5	30	5	30	10	7	7	<5

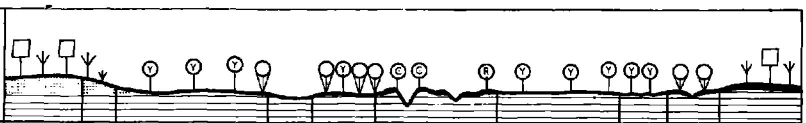
LANDFORM: Flat plains with poorly drained depressions, slight rises and few well defined drainage lines.

GEOLOGY: Recent alluvia. Qa.

SOILS: Predominant soils are very deep, grey and brown clays, Ug 5.25, Ug 5.3, Ug 5.24, (Currawinya, Wittenburra) sometimes with weak to moderate gilgai microrelief, often poorly drained, and texture contrast soils formed from alluvial material, Dr 2.13, Dr 2.12, Dr 1.13, Dr 1.12 (Wanna, Caiwarro). Associated are red, texture contrast soils on low rises, (Ambathala).

VEGETATION: Predominantly yapunyah forby woodland and gidgee shrubby tall open shrubland to low open woodland with areas of gidgee, brigalow shrubby low open woodland to woodland and brigalow low woodland to woodland. Limited areas of Dawson gum, sandalwood shrubby open woodland to woodland and belah, gooramurra low open woodland occur. River red gum, coolibah fringing open woodland to woodland is associated with the major channels. Mulga, poplar box tall shrubland and mulga tall open shrubland may occur on low rises. Associated are restricted areas of "channel country" with bluebush low open shrubland, channel millet forby tussock grassland and swamp canegrass open hummock grassland.

W3 NORLEY (3,080 km²)



Land Unit and/or Associated Land System	S2 or Dunefields Land Zone	5	36,41	L2	40	W7,26	41	28	39	M3
Site and/or special comment		32 88	66,67,175					74	68,87	
Est. % of Land System	5		>40	5	20	15		5	5	<5

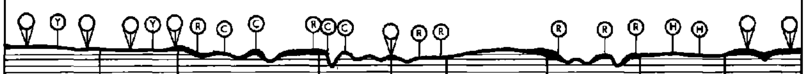
LANDFORM: Flat alluvial plains with low rises (<1 m high) and in places braided channels.

GEOLOGY: Recent alluvia. Qa.

SOILS: Predominantly very deep, alkaline, grey clays Ug 5.24 (Currawinya) with local scalded claypan areas Ug 5.24 (Wittenburra) and weak to moderately gilgaied, grey clays Ug 5.24, Ug 5.25 (Comongin, Cottesmore). Associated are poorly drained, grey clays, Ug 5.24, Ug 5.25, Ug 5.28 (Houdraman), alluvial grey clays near the main channels (Coolah) and red and brown, alluvial, texture contrast soils (Wanna).

VEGETATION: Predominantly yapunyah low open woodland to woodland, gidgee, yapunyah tall shrubland and gidgee tall open shrubland to open woodland with areas of coolibah low open woodland. Limited areas of yapunyah, swamp canegrass, lignum low open woodland to open woodland occur. Budda bush, hopbush low open shrubland and mulga, poplar box tall open shrubland are associated on sandy rises.

W4 BEECHAL (2,560 km²)



Land Unit and/or Associated Land System	W3,W6	35	42	W1,W7	42	A1,A2,A5	42	70	39
Site and/or special comment			28,55,132,138,140 Upper Catchment					In the east only	
Est. % of Land System	10	7	40	10		25		>2	5

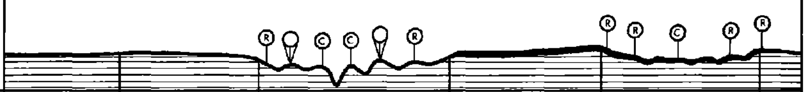
LANDFORM: Alluvial plains with braided channels interspersed with and fringed by flat plains.

GEOLOGY: Recent alluvia. Qa.

SOILS: Predominant soils are alluvial, texture contrast soils, Dr 2.13, Dy 2.12, Dy 2.53, Dr 1.13, Dr 1.12, Db 0.43, Dy 1.42 (Okena, Wanna, Caiwarro and Woorbil) and grey and brown clays, Ug 5.24 and Ug 5.25 (Coolah, Comongin). Associated are brown and red clays (Thylungra, Kihee) and scalded grey and brown clays (Quilpie).

VEGETATION: Predominantly river red gum, coolibah fringing woodland to open woodland and gidgee low woodland to low open woodland on channels with various types of herbfields associated with flat plains between the channels. Limited areas of gidgee tall shrubland occur. Scalded eroded areas support sparse forbland with some areas devoid of vegetation. Patches of brigalow shrubby woodland occur in the eastern sector. Yapunyah, gidgee open woodland to woodland is associated throughout, but becoming less common towards the west.

W5 TICKALARA (700 km²)



Land Unit and/or Associated Land System	35	25	26	24	42	25
Site and/or special comment	172	145, 212	173, 207	33,177	132,138,140	
Est. % of Land System	10	10	30	10	40	

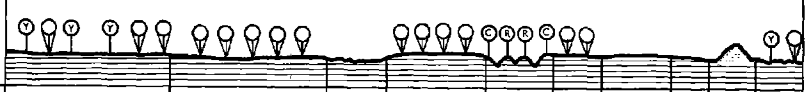
LANDFORM: Alluvial plains with both main and braided channels with occasional deep waterholes. Subject to local seasonal flooding.

GEOLOGY: Recent alluvia. Qa.

SOILS: Predominant soils of the channels and levees are alluvial, grey clays with surface crusts of silt and sand, with sand and silt bands occurring in the profile (Coolah) and alluvial texture contrast soils, Dy 2.12, Dy 2.53, Dr 1.12, Dr 1.13, Dr 2.13 (Okena, Wanna). Associated on the flat inter-channel plains are grey, brown and red clays, Ug 5.24, Ug 5.25, Ug 5.34, Ug 5.37, Ug 5.38 (Thylungra, Kihee) texture contrast soils, (Woorbil) and scalded grey and brown clays and texture contrast soils.

VEGETATION: Predominantly river red gum, coolibah fringing low open woodland to woodland with areas of coolibah fringing low open woodland on major channels and various types of herbfields on adjacent plains. Sparse herbfields are associated with eroded and scalded areas.

W6 COOLOO (3,630 km²)



Land Unit and/or Associated Land System	40	34	37 or 38	34	W7	34	A1 or A2	35	D5	W1 W3 W4
Site and/or special comment	10,11,75	14,15,127,137,171,184	34 168 170		18,35,76			17	Occasional Dune	
Est. % of Land System	25	>50	5		5		10			<5

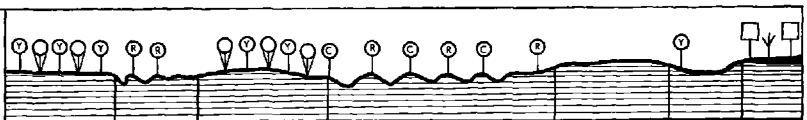
LANDFORM: Flat alluvial plains with small areas of braided channels, "channel country" and isolated sand dunes.

GEOLOGY: Recent alluvia. Qa.

SOILS: Gilgaied, very deep, grey and brown cracking clays. Soils are alkaline to neutral and generally contain large amounts of gypsum in the soil profile, Ug 5.24, Ug 5.25, Ug 5.28, Ug 5.34, Ug 5.38 (Comongin, Cottesmore, Wilson). Associated are grey clays with "channel country" microrelief (Tabbareah), alluvial, clay soils in the major channels (Coolah) and grey, brown and red clays (Kihee, Thylungra). Scalded, grey and brown clays (Quilpie) may occur on the flat treeless areas.

VEGETATION: Predominantly gidgee low open woodland to low woodland or tall open shrubland to shrubland with areas of yapunyah, gidgee open woodland. Swamps support bluebush low open shrubland and bluebush, lignum low open shrubland. Various types of herbfields are associated with the inter-channel flats and alluvia associated with the channels while sparse forblands occur on the scalded areas.

W7 PAROO (1,460 km²)



Land Unit and/or Associated Land System	W1,W3,W6	42	40	26	A1, A2, A3	28	M3, S2
Site and/or special comment	66,67,68	Upper part of catchment 28,55	10,11,75	18,35,76		74	
Est. % of Land System	<10	10	30	40	<10	<2	<2

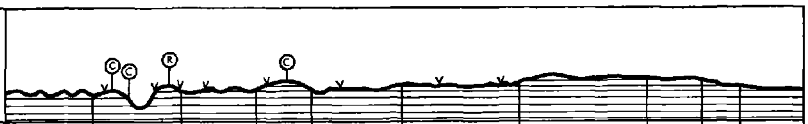
LANDFORM: Predominantly alluvial plains with braided channels (up to 5 m local relief). Associated are poorly drained swamps and flat plains in the inter-channel areas.

GEOLOGY: Recent alluvia. Qa.

SOILS: Predominantly alluvial grey clays with a surface silt and sand crust together with sand bands in the profile (Coolah), and very deep, grey clay, Ug 5.24, Ug 5.25 (Comongin, Cottesmore) subject to scalding. Associated are poorly drained, grey clays (Houdraman) and alluvial, texture contrast soils (Wanna, Woorbil, Okena) subject to scalding.

VEGETATION: Predominantly coolibah fringing open woodland to woodland with gidgee, yapunyah tall shrubland to low woodland; areas of river red gum, coolibah open woodland to woodland and yapunyah, swamp canegrass open woodland. Various types of herbfields occur on some inter-channel flats and adjacent alluvial plains. Associated is mulga, poplar box tall open shrubland.

C1 COOPER (7,230 km²)



Land Unit and/or Associated Land System	A4	26	38	38	38	37	24	35	27 31	17,27,32
Site and/or special comment		Major channels and waterhole		208	168,209 Channelled	94,95,203,170,34 Minor channels	202,210 with Some Dunes(D5)	204		
Est. % of Land System	<5	5		10	35	30	5		<5	10

LANDFORM: Alluvial plains with gradients of less than 1:5,000; with anastomosing channels (0.1 to 1 m relief), main channels (<10 m relief), shallow flood depressions, waterholes, billabongs and swamps, and slightly elevated more stable alluvial islands. Isolated sand dunes.

GEOLOGY: Recent alluvia. Qa.

SOILS: Predominant soils are very deep, alkaline, heavy grey clays which crack widely on drying. Gypsum is common in the lower parts of the profile, Ug 5.28, Ug 5.24 (Tabbareah). Associated are alluvial, grey clays (Coolah) on the main channels, very deep poorly drained, grey clays on the swamps (Tennappera and Houdraman), grey and brown clays (Thylungra and Kihee) and scalded grey and brown clays (Quilpie) on the stable alluvial islands, and alluvial texture contrast soils (Tooratchie).

VEGETATION: Predominantly bluebush low open shrubland; bluebush, lignum low open shrubland and various types of herbfields on flat plains and inter-channel flats. Swamps may support swamp canegrass open tussock grassland. Coolibah fringing open woodland is associated with waterholes and billabongs. Limited areas of old man saltbush low open shrubland to low shrubland occur. Scalded areas support sparse herbfields.

C2 CUNNAWILLA (2,380 km²)

Land Unit and/or Associated Land System	A4	35	24	37	24	38	24	D5	C3
Site and/or special comment		172,204	83,177,183,202	34,94,95, 170,203		208,209			
Est. % of Land System	5	5	60	15		<10		<5	<5

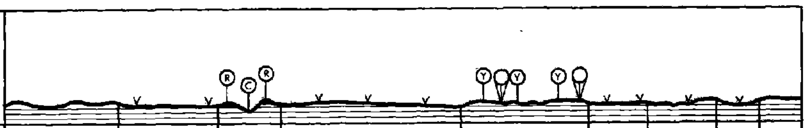
LANDFORM: Flat alluvial plains with the frequently flooding channels dissecting the more stable plains. Isolated sand dunes.

GEOLOGY: Recent alluvia. Qa.

SOILS: Predominant soils are very deep, grey and brown clays. Surface crusts are common. Gypsum commonly occurs in the lower parts of the profile. Ug 5.34, Ug 5.24, and Ug 5.25 (Thylungra, Kihee). Associated are very deep, grey clays (Tabbareah) on the drainage channels, poorly drained, grey clays in the swamps (Tennappera and Houdraman) and scalded, grey and brown clays (Quilpie) on the plains.

VEGETATION: Predominantly various types of herbfields with bluebush, lignum low open shrubland to low shrubland associated with depressions and swamps. Scalded areas support sparse herbfields or otherwise are devoid of vegetation.

C3 WOONABOOTRA (1,490 km²)



Land Unit and/or Associated Land System	A4 and Dunefield Land Zone	17,19	26	17,27	W3,W4	28	C1	32	A1 A2 C2
Site and/or special comment		192,195,219	207	92,93c,102,R sites		74		16	
Est. % of Land System	<5	25	<5	30	<5	5	15	10	<5

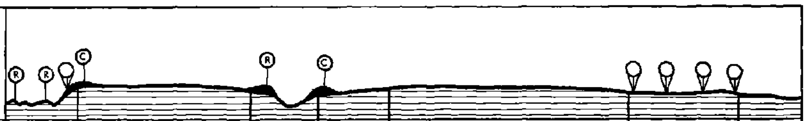
LANDFORM: Poorly drained swamps on alluvial plains sometimes with channels less than 1 m deep.

GEOLOGY: Recent alluvia. Qa.

SOILS: Soils are predominantly very deep, grey clays usually with a thick, surface crust and often with polygonal cracking, Ug 5.5, Ug 5.24, Ug 5.25, Ug 5.28 (Tennappera, Houdraman). Associated are other grey clays (Coolah, Tabbareah) and alluvial soils in drainage lines and associated channels.

VEGETATION: Predominantly bluebush, lignum low open shrubland, swamp canegrass open hummock grassland, with bluebush and lignum forming pure stands in places. Associated with this system are yapunyah, swamp canegrass low open woodland; gidgee, yapunyah low open woodland; coolibah, river red gum fringing woodland and coolibah fringing woodland.

A1 COMONGIN (780 km²)



Land Unit and/or Associated Land System	W4,W7	24	26	35	24	34	32
Site and/or special comment		33,83	18,35	17		14,15	16,34
Est. % of Land System	5	65	<5	5–10		5–10	10

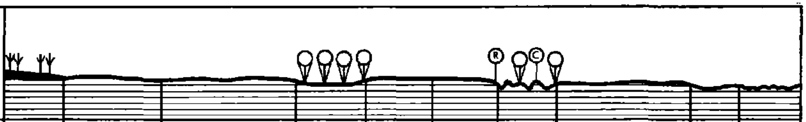
LANDFORM: Flat alluvial plains subject to occasional flooding, with frequently flooded drainage lines and waterholes interspersed, and with poorly drained seasonal back swamps.

GEOLOGY: Recent alluvia. Qa.

SOILS: Predominantly very deep, brown clays, commonly with thin surface crusts, Ug 5.34, Ug 5.24, Ug 5.25 (Thylungra, Kihee) and texture contrast soils with silty-clay-loam to silty-clay surfaces, Db 0.43, Dy 1.43 (Woorbil). Associated are very deep, poorly drained, grey clays Ug 5.25, Ug 5.28 (Houdraman) in swamps, grey and brown clays (Comongin and Cottesmore) in lower areas of the plain and alluvial, clay soils (Coolah) on main channels.

VEGETATION: Predominantly saltbush, bassia grassy herbfield with areas of gidgee forby tall open shrubland. The swamps support bluebush, lignum, low open shrubland with scalded areas characterised by sparse forblands. Coolibah, river red gum fringing forest is associated with the major watercourses.

A2 EROMANGA (5,590 km²)



Land Unit and/or Associated Land System	M5	25	24	W6	24	35	W4	24	32	C1,C2
Site and/or special comment		113,145,212	136,177,183,210	127,137 171,184		172	173	Occasional D5		168,170
Est. % of Land System	<1	25	50	5		5-10	<5		<5	5

LANDFORM: Flat alluvial plains subject to occasional flooding interspersed with frequently flooded braided streams and "channel country".

GEOLOGY: Recent alluvia. Qa.

SOILS: Predominantly very deep, brown and red clays, Ug 5.34, Ug 5.24, Ug 5.25, Ug 5.37, Ug 5.38 (Thylungra, Kihee). Associated are red and brown, silty-clay-loam surfaced, texture contrast soils, Dr 2.13, Db 0.43, Dy 1.43 (Woorbil) and scalded, brown clays (Quilpie) on the flat plains. Grey clays (Tabbareah, Comongin, Houdraman, Cottesmore) occur on the more frequently flooded areas.

VEGETATION: Predominantly saltbush, bassia grassy herbfields with bluebush, lignum low open shrubland on swamps and poorly drained areas. Scalded areas support sparse forblands or are devoid of vegetation. Coolibah, river red gum, yapunyah, gidgee low open woodland and gidgee tall open shrubland to low open woodland are associated.

A3 NOOYEAH (1,780 km²)

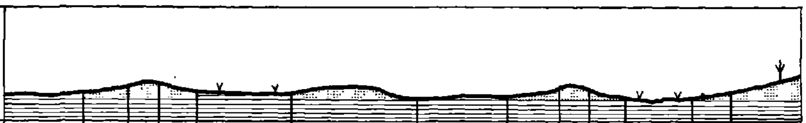
LANDFORM: Flat plains, frequently deflated, and usually with low (20 cm) "blow-up" areas. Frequently associated with the edges of dunefields or alluvia.

GEOLOGY: Recent alluvia. Qa.

SOILS: Predominantly very deep, brown and grey clays and texture contrast soils with scalded surfaces and surface crusts (approximately 1 cm thick) below which the soils are strongly structured. These crusts may be vesicular (honeycombed) or platy. Soil reaction trends are mainly neutral, occasionally becoming alkaline with depth. Mn staining is common, Ug 5.24, Ug 5.25, Ug 5.34 (Quilpie). Associated are areas of Wyara and Woorbil soil mapping units. Degraded forms of Kihee, Thylungra and Comongin soil mapping units occur.
Degrees of scalding occur.

VEGETATION: Predominantly sparse forbland and bare ground. Limited areas of herbfields.
DISTRIBUTION: Land unit 35 - 60%; land unit 36 - 10%; land unit 29 - 5%; land units 24, 25 - 10%; land unit 31 - <5%; land systems C_2, A_1, A_2, A_4 - 10%.

A4 BULLOO (1,760 km²)



Land Unit and/or Associated Land System	31,32	2	2	20	L2,15,17	20	37	2	2	2	27,38,W3	20	D4
Site and/or special comment	202	R269, R270			92, 93c, R247, R196	197, R267A	94,95,203						93A,225, R267
Est. % of Land System	10	40			25	>5	<5				10		5

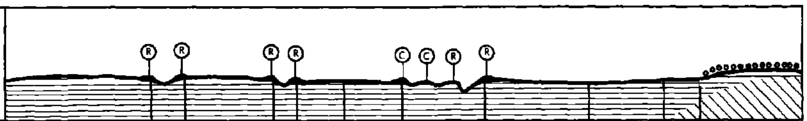
LANDFORM: Flooded alluvial plains commonly with "channel country" microrelief and eroded low dunes less than 1.5 m high.

GEOLOGY: Aeolian sands overlying recent alluvia. Qs/Qa.

SOILS: Predominant soils are shallow to moderately deep, reddish-yellow, earthy sands overlying a clay hardpan, loose on the stable tops of the low dunes and cemented on the aprons (Bygrave) and poorly drained grey clays, alluvial soils and claypans on the alluvia, Ug 5.5, Ug 5.24, Ug 5.25, Ug 5.28 (Tennappera, Wittenburra, Tabbareah, Houdraman, Tooratchie).

VEGETATION: Predominantly herbfields composed of short grasses or forbs with bluebush low open shrubland and bluebush, lignum low open shrubland associated with swamps and poorly drained areas. Old man saltbush low open shrubland occurs. Eroded areas support sparse herbfields or are devoid of vegetation.

A5 DINGERA (1,470 km²)



Land Unit and/or Associated Land System	25	A6	24	A6	24	A3	W5, 26, 42	25	23	82A	F1
Site and/or special comment					210			212	126	163	213
Est. % of Land System		5			>20	5	10	40	<5	5	5–10

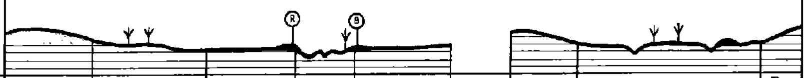
LANDFORM: Flat alluvial plains with well defined, braided, channels. Low outcrops of very gently undulating plain, (<0.5%) occur.

GEOLOGY: Recent alluvia. Qa.

SOILS: Predominantly brown clays with some red and grey clays, Ug 5.32, Ug 5.34, Ug 5.37, Ug 5.38, Ug 5.24, Ug 5.25 (Thylungra, Kihee, Parragona, Pinkilla). Thin surface crusts which break easily are common. Occasionally these soils are underlain by gravel beds. Associated are stony, red clays on the gently sloping low rises, Ug 5.38 (Karmona). Alluvial, clay soils (Coolah) and texture contrast soils (Okena, Wanna) occur on the drainage lines. Scalded brown clays (Quilpie) and texture contrast soils (Woorbil) occur on the flat plains.

VEGETATION: Predominantly various types of herbfields including forbs and grasses with limited areas of river red gum, coolibah fringing open woodland to woodland. Associated is a seasonally dependent fluctuating climax of forbland including saltbushes, soda-bush and bassias and open tussock grassland composed of Mitchell grass and short grasses with some areas devoid of vegetation.

A6 WARRY (2,320 km²)



Land Unit and/or Associated Land System	Dunefields Land Zone	53	A5	26 or 42	A3, L2		Adjoining L.S	57,66,75	Adjoining L.S.
Site and/or special comment								96,109,129,157	
Est. % of Land System		10	10	30	10			40	

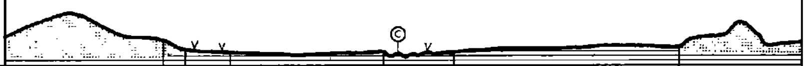
LANDFORM: Alluvial plains with well defined channels, sometimes braided and occasionally with low sandy rises and dunes.

GEOLOGY: Recent alluvia commonly with a cover of aeolian sand. Qa, Qs.

SOILS: Predominantly alluvial soils with texture contrasts, Dr 1.12, Dr 1.13, Dr 2.12, Dr 2.13, Dy 2.12, Dy 2.53 (Okena, Wanna, Tirtywinna) on the channels and fringing plains, and texture contrast soils (Bygrave) and grey and brown cracking clays (Thylungra, Kihee) on the plains. Associated are claypans and scalds.

VEGETATION: Predominantly mulga, western bloodwood tall open shrubland and mulga grassy tall open shrubland. Coolibah, river red gum fringing woodland occurs on the channels with mineritchie tall open shrubland on minor watercourses west of Cooper Creek. Herbfields are associated.

L1 LAKE PURE (1,140 km²)



Land Unit and/or Associated Land System	Dunefields Land Zone	20	L2	17,24,35	C1 or 19	17,24,35	D8
Site and/or special comment					195 Inlet	202,204	104,105
Est. % of Land System	<5	<5			10	80	<5

LANDFORM: Flat lake beds subject to flooding; usually with beach ridges, fringing dunes and lunettes.

GEOLOGY: Recent alluvia. Qa.

SOILS: Predominantly grey clays commonly with a crusting surface, Ug 5.5, Ug 5.24 (Tennappera). Poorly drained clays are associated with channels and swamps, Ug 5.24, Ug 5.25, Ug 5.28 (Tabbareah and Houdraman) and with grey and brown clays (Kihee). Claypans and saltpans with grey clays and texture contrast soils occur on the edges of the lakes Ug 5.2, Dy 2.33, Dy 2.43.

VEGETATION: Commonly sparse. Swamp canegrass open hummock grassland, sparse forbland and saltbush, bassia herbfield may occur on the lake bed. The beach ridges support various types of sparse herbfield. Bluebush, lignum low open shrubland is associated with channels and swamps and coolibah and river red gum may form fringing low open woodlands. Samphire low open shrubland is associated.

L2 EPSILON (1,080 km²)

Land Unit and/or Associated Land System	15,16,18,19	17	15,16,18,19	20	Dunefield Land Zone	20	15,16,18,19	20	Dunefield Land Zone
Site and/or special comment		92,102					192,195,211A,215,216,196	91,197,217	
Est. % of Land System		20					70	5	5

LANDFORM: Flat claypans and seasonal lakes subject to periodic flooding, with low wind-blown rises.

GEOLOGY: Quaternary alluvia often with intermixed dune sand. Qa, Qs.

SOILS: Predominantly massive surfaced, grey clays, Ug 5.5, Ug 5.24 (Tennappera) and structured, grey clays, Ug 5.24, Ug 5.28 (Wittenburra). Associated are texture contrast soils on low, wind-blown rises, Dy 2.33, Dg 2.43. Cemented aprons fringe the claypans. Calcrete may occur on the surface of the claypans.

VEGETATION: Vegetation is usually sparse ranging from sparse forbland to swamp canegrass open hummock grassland. Low wind-blown rises support various forblands. The cemented aprons are almost devoid of vegetation. Bluebush, lignum low open shrubland is associated with swamps, channels and drainage lines.

LAND UNITS

by N.M. Dawson and D.E. Boyland

LAND UNIT 1

LANDFORM: Fringing dunes (lunettes), less than 5 m high fringing playa lakes.

GEOLOGY: Clays, sands, silts and salts, wind transported from the beds of the recent alluvial playa lake to the edge forming a fringing dune. Qs/Qa.

SOILS: Very deep soil composed of predominantly fine grained material such as fine sand, clay, silt and salts on the dune. On the interdune area very deep, alkaline, grey clays occur. Calcium carbonate is common in the surface soil and gypsum occur throughout the profile, increasing with depth.

VEGETATION: Samphire low open shrubland. *Arthrocnemum* spp. (samphire) predominate with other low isolated shrubs emerging. Trees and tall shrubs do not occur. Ground cover is variable composed mainly of forbs but grasses are present. In some situations bands of *Arthrocnemum* spp. low open shrubland alternate with bands of *Atriplex* spp. (saltbushes) open forbland forming a complex. In places near the margins of lakes *Cyperus gymnocaulis* open sedge field is associated with this complex.

STRUCTURAL FORM: Low open shrubland to low shrubland; Ht < 1 m; PFC 6 ± 5%.

LOW SHRUB LAYER: Ht 1 ± 0.5 m, PFC 5 ± 4%.

Predominant spp: *Arthrocnemum halocnemoides* var. *pergranulatum*. Ht < 1 m. PFC 3 ± 2%; *A. leiostachyum*. Ht < 1 m, PFC 3 ± 2%.

Frequent spp: *Pachycornia tenuis*.

Infrequent spp: *Myoporum acuminatum*.

GROUND LAYER: Ht < 0.75 m, PFC 5 ± 4%.

FORBS:

Frequent spp: *Atriplex holocarpa, A. spongiosa, Babbagia dipterocarpa, B. scleroptera, Bassia bicornis, B. biflorus, B. brachyptera, B. divaricata, B. lanicuspis, B. paradoxa, B. ventricosa, Salsola kali, Zyophyllum ammophilum, Z. apiculatum.*

Infrequent spp: *Centipeda thespidioides, Frankenia hamata, Heliotropium curassavicum, Lavatera plebeia, Malacocera tricornis, Plantago pritzelii, Portulaca* sp. aff. *P. oleracea, Senecio bipinnatisectus.*

GRAMINOIDS:

Frequent spp: *Cyperus gymnocaulis* (forms dense bands or zones in some situations); *Dactyloctenium radulans, Eragrostis dielsii, Sporobolus actinocladus, S. caroli.*

Infrequent spp: *Diplachne muelleri, Enneapogon avenaceus, Eragrostis australasica, Triraphis mollis.*

LAND USE: Limited pasture available for grazing as samphire is not eaten. GC < 1 beast/km2; condition static; saline soil, very low fertility; susceptible to wind erosion; dead shrubs < 15%, perennial grasses not abundant: rabbits present; unique area of limited extent.

LAND UNIT 2

LANDFORM: Low due less than 2 m high on flat alluvial plains. Slopes < 2%.

GEOLOGY: Recent aeolian sand overlying Quaternary alluvia. Qs/Qa.

SOILS: Shallow to moderately deep, reddish-yellow, earthy sands overlying a clay hardpan. Cemented (scalded) aprons fringe these low dunes. Degraded *Bygrave*.

VEGETATION: Open herbfield. Forbs and grasses occur forming a sparse to open herbfield with either predominating depending on seasonal conditions. In places scattered shrubs of *Atriplex nummularia* (oldman saltbush) and *Chenopodium auricomum* (bluebush) occur. Isolated trees may occur. *Eucalyptus ochrophloia* (yapunyah) low open woodland and/or *Acacia cambagei* (gidgee) tall open shrubland may be found fringing this association in some situations.

STRUCTURAL FORM: Open herbfield; Ht < 0.5 m, PFC 8 ± 7%.

TREE, TALL SHRUB LAYER: Ht 4 ± 1 m, PFC < 1%.

Infrequent spp: *Atalaya hemiglauca, Eucalyptus ochrophloia.*

LOW SHRUB LAYER: Ht 1.0 ± 0.5 m, PFC 3 ± 3%.

Infrequent spp: *Atriplex nummularia, Chenopodium auricomum.*

GROUND LAYER: Ht < 0.5 m, PFC 8 ± 7%.

FORBS:

Frequent spp: *Atriplex elachophylla, A. spongiosa, Bassia bicornis, Salsola kali.*

Infrequent spp: *Bassia intricata, Kochia brevifolia.*

GRAMINOIDS:

Frequent spp: *Eragrostis dielsii, E. setifolia.*

Infrequent spp: *Tripogon loliiformis.*

LAND USE: Of little grazing value. GC 0.2 beasts/km2, DGC < 0.1 beasts/km2; condition poor, downward trend; low WHC (water holding capacity), very low nutrient levels; susceptible to wind and water erosion; top feed limited, perennial grasses not abundant.

LAND UNIT 3

LANDFORM: Very low sloping flanks of low dunes/sandplain less than 2 m high. Slopes < 0.5%.

GEOLOGY: Aeolian Quaternary sand overlying the Tertiary land surface and in some cases clay plains. Qs/Tg.

SOILS: Moderately deep, slightly acid to neutral, red, earthy sands with a ferruginous hardpan. Surface soil is loose to massive when dry, friable when moist. Textures range from loamy-sand at the surface to sandy-loam at the base of the profile. Uc 5.31, Gn 1.12; *Mirintu.*

VEGETATION: Mulga, western bloodwood forby tall open shrubland. *Acacia aneura* (mulga) predominates usually with *Eucalyptus terminalis* (western bloodwood) conspicuous. Other scattered trees are present. There is no well defined lower shrubby layer but low shrubs may occur. Grasses and forbs may be present. *E. populnea* (poplar box) is found in associated depressions.

STRUCTURAL FORM: Tall open shrubland. Ht 5 ± 1 m, PFC 5 ± 4%.

TREE, TALL SHRUB LAYER: Ht 4.5 ± 1.5 m, PFC 5 ± 4%.

Predominant spp: *Acacia aneura*, Ht 5 ± 1 m, PFC 5 ± 4%, *Eucalyptus terminalis*, Ht 4 ± 1 m, PFC < 1%.

Frequent spp: *Grevillea stricta, Owenia acidula.*

Infrequent spp: *E. populnea.*

LOW SHRUB LAYER: Ht 1.5 ± .5 m, PFC < 1%.

Infrequent spp: *Acacia tetragonophylla.*

GROUND LAYER: Ht < 0.75 m, PFC 10 ± 5%.

FORBS:

Frequent spp: *Bassia paradoxa, Euphorbia drummondii, Heliotropium strigosum, H. tenuifolium, Ptilotus polystachyus, Tribulus terrestris.*

Infrequent spp: *Atriplex holocarpa, A spongiosa, Bassia lanicuspis, Centipeda thespidioides, Josephinia eugeniae, Lepidium rotundum, Portulaca* sp. aff. *P. oleracea; Swainsona microphylla* ssp. *affinis.*

GRAMINOIDS:

Frequent spp: *Aristida contorta, Dactyloctenium radulans, Digitaria brownii, D. coenicola, Fimbristylis dichotoma, Tragus australianus.*

Infrequent spp: *Chrysopogon fallax, Enneapogon avenaceus.*

LAND USE: GC < 2.8 beasts/km^2, DGC 0.6 beasts/km^2; condition stable, trend static; low WHC, very low fertility; susceptible to wind and water erosion causing scalding; top feed not abundant.

LAND UNIT 4

LANDFORM: Flanks of low sand dunes 2-3 m high. Slopes < 1%.

GEOLOGY: Aeolian Quaternary sand over clay plains. Qs.

SOILS: Deep to very deep, texture contrast soil with a red, slightly acid, earthy, loamy-coarse-sand (50 cms) overlying a red, alkaline, sandy-loam to sandy-clay-loam. Surface soil is massive when dry but loose when moist. Dr 1.56; *Bygrave.*

VEGETATION: *Acacia calcicola*, mulga forby tall open shrubland. *Acacia calcicola* and *A. aneura* (mulga) predominate. Scattered low trees or shrubs may be conspicuous in places. A low shrubby layer is not well developed but shrubs are frequently present. Ground cover is variable composed mainly of forbs.

STRUCTURAL FORM: Tall open shrubland rarely tall shrubland; Ht 3 ± 1 m; PFC 7 ± 5%.

TREE, TALL SHRUB LAYER: Ht 3.5 ± 1.5 m, PFC 7 ± 6%.

Predominant spp: *Acacia aneura*, Ht 4 ± 1 m, PFC 2 ± 1%; *A. calcicola*, Ht 3 ± 1 m, PFC 5 ± 4%.

Frequent spp: *Acacia ramulosa, A. tetragonophylla, Santalum lanceolatum.*

Infrequent spp: *A. excelsa.*

LOW SHRUB LAYER: Ht 1 ± 0.5 m, PFC < 1%.

Frequent spp: *Cassia phyllodinea, Enchylaena tomentosa, Eremophila duttonii, Rhagodia spinescens.*

GROUND LAYER: Ht < 0.5 m; PFC 15 ± 5%.

FORBS:

Frequent spp: *Bassia divaricata, B. lanicuspis, B. paradoxa, Kochia spongiocarpa, Ptilotus exaltatus, P. polystachyus, Salsola kali.*

Infrequent spp: *Atriplex stipitata, Boerhavia diffusa, Calocephalus multiflorus, Helipterum floribundum, Ipomoea polymorpha, Lepidium oxytrichum, Portulaca* sp. aff. *P. oleracea, Tetragonia tetragonioides.*

GRAMINOIDS:

Frequent spp: *Enteropogon acicularis, Eragrostis setifolia, Fimbristylis dichotoma, Tragus australianus.*

Infrequent spp: *Dactyloctenium radulans.*

LAND USE: GC 1.6 – 1.7 beasts/km^2, DGC 0.4 – 0.8 beasts/km^2 (0.6); condition static; low WHC, very low fertility; subject to wind and water erosion causing scalding in places; top feed scarce, lightly grazed.

L A N D U N I T 5

LANDFORM: Edges of low dunes and sandplains. Slopes < 1%.

GEOLOGY: Aeolian Quaternary sand. Qs.

SOILS: Shallow to moderately deep, slightly acid to neutral, sandy red earths and earthy sands underlain by a ferruginous hardpan. Surface textures range from loamy-sands to sandy-loam and textures increase to sandy-clay-loam at the base of the profile. Surfaces are either massive or cemented when dry. Gn 2.12, Um 5.21, Um 5.31; *Gooyana, Paroomatoo.* Representative soil analysis: 32, 88.

VEGETATION: Budda bush hopbush shrubby tall shrubland. *Eremophila sturtii* (budda bush) and *Dodonaea attenuata* (a hop bush) predominate with scattered low trees and tall trees emerging. Low shrubs are frequently present. Ground cover is variable composed of forbs and grasses.

STRUCTURAL FORM: Tall shrubland, Ht. 2.5 ± 0.5 m; PFC 20 ± 10%.

TALL SHRUB LAYER: Ht 2.5 ± 0.5 m; PFC 20 ± 10%.

Predominant spp: *Dodonaea attenuata*, Ht 2.5 ± 0.5 m, PFC 15 ± 5%.

Frequent spp: *Hakea leucoptera.*

Infrequent spp: *Acacia stenophylla, Capparis loranthifolia, Santalum lanceolatum.*

LOW SHRUB LAYER: Ht 1.5 ± 0.5 m, PFC 12.5 ± 7.5%.

Predominant spp: *Eremophila sturtii*, Ht 1 ± 0.5 m, PFC 15 ± 5%.

Frequent spp: *Eremophila mitchellii.*

Infrequent spp: *Myoporum deserti, Pachycornia tenuis, Rhagodia spinescens.*

GROUND LAYER: Ht < 0.5 m, PFC 5 ± 4.5%.

FORBS:

Frequent spp: *Bassia anisacanthoides, B. divaricata, B. paradoxa. Boerhavia diffusa, Salsola kali.*

Infrequent spp: *Brachycome ciliaris* var. *lanuginosa, Euphorbia drummondii, Goodenia cycloptera, Heliotropium strigosum, Portulaca* sp. aff. *P. oleracea, Ptychosema trifoliatum.*

GRAMINOIDS:

Frequent spp: *Aristida contorta, Eragrostis laniflora, Eriachne helmsii, E. mucronata.*

Infrequent spp: *Dactyloctenium radulans, Fimbristylis dichotoma, Perotis rara.*

LAND USE: GC < 2.0 beasts/km2, DGC 0.4 beasts/km2; condition unstable, trend downwards; very low WHC, very low fertility; susceptible to wind and water erosion causing scalding; top feed not abundant, woody weeds common.

L A N D U N I T 6

LANDFORM: Low sloping flanks of dunes. Slopes < 2%.

GEOLOGY: Dune sand overlying recent clay alluvia. Qs.

SOILS: Soils are reddish-brown, coarse sands to coarse-sandy-loams overlying sandy-clays which in turn overlie a hardpan. Surface soils are loose. Organic matter build-up occurs under the western bloodwood trees. *Bygrave.*

VEGETATION: Wooded forbland. Scattered trees of *Eucalyptus terminalis* (western bloodwood), *Atalaya hemiglauca* (whitewood) and *Ventilago viminalis* (vine tree) are usually conspicuous. A lower shrubby layer is not well developed but isolated shrubs occur. Ground cover is variable composed mainly of forbs.

STRUCTURAL FORM: Wooded forbland: Ht < 0.5, PFC 10 ± 5%.

TREE, TALL SHRUB LAYER: Ht 4 ± 1 m, PFC < 1% (may be clumped in places).

Frequent spp: *Atalya hemiglauca, Eucalyptus terminalis.*

Infrequent spp: *Acacia aneura, Capparis loranthifolia, Owenia acidula, Ventilago viminalis.* .

LOW SHRUB LAYER: Ht 1.3 ± 0.3 m, PFC < 1%.

Frequent spp: *Dodonaea attenuata.*

GROUND LAYER: Ht < 0.75 m, PFC 10 ± 5%.

Predominant spp: *Bassia bicornis, B. lanicuspis, Salsola kali.*

FORBS:

Frequent spp: *Euphorbia drummondii, E. wheeleri, Hibiscus kirchauffianus, Nicotiana velutina.*

Infrequent spp: *Blennodia canescens, Crotalaria eremaea, Euphorbia eremophila, Portulaca* sp. aff. *P. oleracea.*

GRAMINOIDS:

Frequent spp: *Eragrostis eriopoda.*

Infrequent spp: *Eragrostis basedowii, Tragus australianus, Triraphis mollis.*

LAND USE: GC < 3.2 beasts/km2 (2.2), DGC 0.4 beasts/km2; condition stable, trend static; low WHC, very low fertility; susceptible to wind erosion when bare; top feed scarce.

L A N D U N I T 7

LANDFORM: Convex, low to mid-height, reticulate dunes less than 5 m high. Slopes < 3%.

GEOLOGY: Aeolian Quaternary sand. Qs.

SOILS: Soils are very deep, red, earthy sands to siliceous sands with acid to neutral, red, coarse-sand to loamy-coarse-sand often overlying alkaline, coarse-sandy-clay-loam and coarse-clayey-sand material (60-100 cms). (On a lower dune, the clayey layer occurred at 40 cms.) Ferruginous hardpans may underlie these clayey layers. Surface soil is loose but often has a thin crust. Uc 5.21, Gn 1.12, Uc 1.23, Dr 4.13; *Booka, Yanko.* Representative soil analysis: 198, 211, 218.

VEGETATION: **A** Tall open shrubland. Various tall shrubs or trees predominate depending on local variation in habitat. Scattered low shrubs may be conspicuous and in places these shrubs may form dense stands. Grasses and forbs form a variable ground cover.

STRUCTURAL FORM: Tall open shrubland, Ht 4 ± 1 m, PFC (variable) 3 ± 2%.

TREE, TALL SHRUB LAYER: Ht 4.5 ± 1 m, PFC (variable) 3 ± 2%.

Frequent spp: *Acacia aneura, Atalaya hemiglauca, Hakea leucoptera.*

Infrequent spp: *Grevillea juncifolia, Santalum lanceolatum.*

LOW SHRUB LAYER: Ht 1.5 ± 0.5 m, PFC (variable) < 10%.

Frequent spp: *Acacia tetragonophylla, A. ligulata, Cassia desolata, Dodonaea attenuata.*

Infrequent spp: *Acacia calcicola* (restricted to certain areas, PFC up to 5%); *Cassia nemophila, C. pleurocarpa, Eremophila duttonii, E. sturtii, Enchylaena tomentosa, Rhagodia spinescens.*

GROUND LAYER: Ht < 1 m, PFC (variable) 15 ± 10%.

FORBS:

Frequent spp: *Bassia limbata, B. paradoxa, Crotalaria cunninghamii, C. eremaea, Calandrinia balonensis, Erodium crinatum, Helipterum floribundum, H. moschatum, Lepidium rotundum, L. oxytrichum, Myriocephalus stuartii, Portulaca* sp. aff. *P. oleracea, Ptilotus polystachyus, Sida ammophila, Salsola kali, Senecio gregorii, Trachymene glaucifolia, Tribulus* sp. aff. *T. terrestris.*

Infrequent spp: *Abutilon otocarpum, Blennodia eremigena, Bonamia media, Brachycome ciliaris* var. *lanuginosa, Convolvulus erubescens, Euphorbia drummondii, Gnaphalium* sp. aff. *G. diamentensis, Gnephosis eriocarpa, Ipomoea polymorpha, Lotus cruentus, Newcastlia cephalantha, Nicotiana velutina, Podocoma* sp., *Psoralea* sp. aff. *P. eriantha, Scaevola depauperata, S. ovalifolia, Swainsona campylantha, Teucrium racemosum, Tribulus hystrix, Trichodesma zeylanicum, Trianthema galericulata.*

GRAMINOIDS:

Frequent spp: *Aristida browniana, A. contorta, Dactyloctenium radulans, Enneapogon avenaceus, Eragrostis eriopoda, Eriachne aristidea, Monachather paradoxa, Plagiosetum refractum, Tragus australianus, Tripogon loliiformis.*

Infrequent spp: *Aristida ingrata, Eragrostis basedowii, Paractaenum novae-hollandiae, Triraphis mollis.*

Representative soil analysis for B: 103.

B Tall open shrubland. Usually *Acacia aneura* (mulga) predominates with other scattered trees occurring but in places *Ventilago viminalis* (vine tree), *Atalaya hemiglauca* (whitewood) or *Acacia ammophila* may be co-dominant or even dominant. Frequently, there is no well defined lower shrubby layer but isolated shrubs occur. The ground flora composed of grasses and forbs forms a sparse to mid dense cover.

STRUCTURAL FORM: Tall open shrubland. Ht 5.5 ± 2.5 m, PFC 5 ± 4%.

TREE, TALL SHRUB LAYER:

Predominant spp: *Acacia aneura*, Ht 4.5 ± 1.5 m, PFC 4 ± 3%.

Frequent spp: *Acacia ammophila, Atalaya hemiglauca, Hakea leucoptera, Ventilago viminalis.*

LOW SHRUB LAYER: Ht 1.25 ± 0.75 m, PFC < 1% (better developed up to 5% in places).

Frequent spp: *Enchylaena tomentosa, Eremophila sturtii.*

Infrequent spp: *Dodonaea attenuata, Eremophila mitchellii, Rhagodia spinescens.*

GROUND LAYER: Ht < 1 m; PFC 10 ± 5%.

FORBS:

Frequent spp: *Bassia lanicuspis, B. paradoxa, Ptilotus polystachyus, Salsola kali, Tribulus terrestris.*

Infrequent spp: *Abutilon otocarpum, Bassia biflora, Brachycome curvicarpa, Calotis multicaulis, Chenopodium melanocarpum, Sida ammophila, Trianthema triquetra.*

GRAMINOIDS:

Frequent spp: *Aristida contorta, Eragrostis eriopoda, Eriachne aristidea, Triraphis mollis.*

Infrequent spp: *Eragrostis lanicuspis, Tragus australianus.*

LAND USE: GC 1.5 to 2.8 beasts/km2 (1.6), DGC 0.2 to 0.9 beasts/km2 (0.6); condition stable, trend static; low to moderate WHC but high infiltration, very low fertility; susceptible to wind and water erosion when bare; top feed variable, but not abundant; rabbits a problem in some years.

LAND UNIT 8

LANDFORM: Extended flanks of longitudinal sand dunes. Slopes 1 to 8%. Dunefields superimposed on flat plains.

GEOLOGY: Aeolian Quaternary sand. Qs.

SOILS: Soils are deep to very deep neutral, red earthy sands and occasionally sandy red earths. Some soils increase in texture from loamy coarse sands or coarse sandy loams, to sandy clay loams and sometimes sandy clays at depth. Surface soils are loose commonly with a thin surface crust. Red siliceous sands occur on the upper slopes. The earthy sands are uniform coarse sandy loams and loamy coarse sands. Uc 5.21, Gn 1.12, Uc 1.23. *Titheroo, Yanko.*

VEGETATION: Spinifex wooded hummock grassland. *Triodia basedowii* predominates with scattered low trees and tall shrubs emerging. Usually no well defined low shrubby layer is conspicuous but low shrubs do occur. Ground cover is variable with the areas between the hummocks of *T. basedowii* devoid of vegetation or supporting short grasses and forbs.

STRUCTURAL FORM: Open hummock to hummock grassland. Ht < 1 m, PFC (variable) 20 ± 15%.

TREE, TALL SHRUB LAYER: Ht 2.5 ± 5 m, PFC < 1% (higher in isolated places).

Frequent spp: *Acacia aneura, Eucalyptus terminalis, Grevillea juncifolia, Hakea divaricata, H. leucoptera.*

Infrequent spp: *A. ramulosa, Codonocarpus cotinifolius.*

LOW SHRUB LAYER: Ht 0.5 ± 1.5 m PFC 1% (up to 5% in places).

Frequent spp: *A. ligulata, A. tetragonophylla, Cassia artemisioides, C. desolata, C. nemophila, C. oligophylla, C. pleurocarpa, Dodonaea attenuata, Eremophila duttonii, E. obovata, E. latrobei, Gyrostemon ramulosus.*

GROUND LAYER: Ht 1 m, PFC (variable) 5 ± 35%.

Predominant spp: *Triodia basedowii*, Ht 0.5 ± 1 m, PFC 15 ± 10%.

FORBS:

Frequent spp: *Calocephalus multiflorus, Calotis multicaulis, Crotalaria cunninghamii, E. eremaea, Euphorbia drummondii, E. wheeleri, Helipterum floribundum, H. moschatum, Lepidium rotundum, Macgregoria racemigera, Nicotiana velutina, Ptilotus obovatus, P. polystachyus, Senecio gregorii, Trachymene glaucifolia.*

Infrequent spp: *Bassia ventricosa, Calandrinia balonensis, Calotis hispidula, Centipeda thespidioides, Gossypium sturtianum, Halgania cyanea, Haloragis gossei, Psoralea* sp. aff. *P. eriantha, Pimelea trichostachya, Rhagodia nutans, Salsola kali, Scaevola depauperata, Solanum esuriale, Swainsona microphylla* ssp. affinis, *S. oroboides, Tephrosia rosea* var. *angustifolia, Trichodesma zeylanicum.*

GRAMINOIDS:

Frequent spp: *Aristida browniana, A. contorta, Dactyloctenium radulans, Enneapogon polyphyllus, Eragrostis basedowii, E. cumingii* vel. aff., *E. eriopoda, Eriachne aristidea.*

Infrequent spp: *Aristida anthoxanthiodes, Bulbostylis barbata, Paraneurachne muelleri, Panicum australiense, Triraphis mollis.*

LAND USE: Grazing capacity 1 to 2 beasts/km2; high infiltration rates; low-moderate AWHC (due to depth); susceptible to wind and water erosion if burnt and/or overgrazed; drought feeding, useful after rain; tourism; dead tree 1%; tree per ha (variable) commonly 10 – 40; top feed scarce; perennial grasses abundant; condition static.

LAND UNIT 9

LANDFORM: Extended, convex flanks of reticulate dunes. Slopes mainly 3-5%. Dunefields occur mainly on flat plains extending in some areas on to gently undulating, stony downs.

GEOLOGY: Aeolian Quaternary sand. Qs.

SOILS: Soils are deep to very deep, neutral, red, earthy sands and occasionally sandy red earths. Some soil increase in texture from loamy-coarse-sands or coarse-sandy-loams, to sandy-clay-loams and sometimes sandy-clays at depth. Surface soils are loose often with a thin surface crust. Red, siliceous sands occur on the upper slopes. The earthy sands are uniform, coarse-sandy-loams and loamy-coarse-sands. Gn 1.12, Uc 5.21, Uc 1.23; *Titheroo, Yanko.*

VEGETATION: Spinifex wooded hummock grassland. *Triodia basedowii* (spinifex) predominates usually with scattered low trees and tall shrubs emerging but in places approaches a tall open shrubland with an understorey of *T. basedowii.* Isolated low shrubs occur but in places especially at the base of dunes there is a well developed lower shrubby layer. Ground cover is variable with areas between the hummocks of *T. basedowii* devoid of vegetation or supporting short grasses and forbs.

STRUCTURAL FORM: Hummock grassland Ht < 1 m, PFC 20 ± 15%.

TREE, TALL SHRUB LAYER: Ht 4 ± 1.5 m, PFC variable < 1 to 5% (usually < 1%).

Frequent spp: *Acacia aneura, Eucalyptus terminalis, Grevillea juncifolia, Hakea divaricata, H. leucoptera.*

Infrequent spp: *Acacia ramulosa, Atalaya hemiglauca, Codonocarpus cotinifolius, Grevillea striata, Owenia acidula.*

LOW SHRUB LAYER: Ht 1.25 ± 0.75 m, PFC 3 ± 3% (usually < 1%).

Frequent spp: *Acacia ligulata, A. tetragonophylla, Cassia artemisioides, C. desolata, C. nemophila, C. pleurocarpa, Dodonaea attenuata, Eremophila duttonii, E. obovata.*

Infrequent spp: *Cassia helmsii, Duboisia hopwoodii, Eremophila maculata, E. latrobei, Grevillea stenobotrya, Gryostemon ramulosus.*

GROUND LAYER: Ht < 1 m, PFC (variable) 20 ± 15%.

Predominant spp: *Triodia basedowii*, Ht < 1 m, PFC 15 ± 10%.

FORBS:

Frequent spp: *Calocephalus multiflorus, Calotis erinacea, C. multicaulis, C. porphyroglossa, Crotalaria cunninghamii, C. eremaea, Euphorbia drummondii, E. wheeleri, Helipterum floribundum, H. moschatum, Lepidium rotundum, Macgregoria racemigera, Nicotiana velutina, Ptilotus obovatus, P. polystachyus, Senecio gregorii, Trachymene glaucifolia.*

Infrequent spp: *Bassia bicornis, B. ventricosa, Bonamia media, Calandrinia balonensis, C. ptychosperma, Brachycome ciliocarpa, B. curvicarpa, Centipeda thespidioides, Gossypium sturtianum, Halgania cyanea, Haloragis gossei, Helichrysum semiamplexicaule, Myriocephalus stuartii, Podolepis canescens, Portulaca* sp. aff. *P. oleracea, Pimelea trichostachya, Rutidosis helichrysoides, Rhagodia nutans, Salsola kali, Scaevola depauperata, Solanum esuriale, Swainsona microphylla* spp. *affinis, S. oroboides, Tephrosia rosea* var. *angustifolia, Trichodesma zeylanicum.*

GRAMINOIDS:

Frequent spp: *Aristida browniana, A. contorta, Dactyloctenium radulans, Enneapogon polyphyllus, Eragrostis basedowii, E. cumingii* vel. aff., *E. eriopoda, Eriachne aristidea, E. mucronata.*

Infrequent spp: *Aristida anthoxanthoides, A. ingrata, Bulbostylis barbata, Paraneurachne muelleri, Panicum australiense, Triraphis mollis.*

LAND USE: GC 0.9 to 1.3 beasts/km^2 (0.9), DGC 0.3 to 0.5 beasts/km^2 (0.4); condition stable, trend static; low WHC, but high infiltration rates, very low fertility; susceptible to wind and water erosion if bare and/or burnt; drought feeding; useful after rain; top feed scarce; perennial grasses abundant.

LAND UNIT 10

LANDFORM: Rounded and mobile crests of dunes formed on alluvial plains. Slopes 15 to 25%.

GEOLOGY: Aeolian Quaternary sand. Qs.

SOILS: Very deep, acid to neutral, yellow, siliceous sands. Clay content increases down the slopes. Soils are loose at the crests, with crusts lower down the slope. Uc 1.22; *Chookoo.*

VEGETATION: Soft roly-poly forby open forbland. Vegetation is sparse. Forbs predominate with *Salsola kali* (soft roly-poly) and *Tribulus terrestris* (caltrop) conspicuous on upper slopes of dunes and the former also occurs on lower slopes with *Crotalaria eremaea* (bluebush pea). Grasses are found mainly on lower slopes. Scattered low trees occur on extended flanks and lower slopes.

STRUCTURAL FORM: Open forbland, Ht < 0.5 m, PFC < 2%.

TALL SHRUB LAYER: Ht 3 ± 1 m, PFC < 1%.

Frequent spp: *Hakea leucoptera.*

GROUND LAYER: Ht < 0.5 m, PFC < 2%.

FORBS:

Predominant spp: *Salsola kali,* Ht < 0.5 m, PFC 1%. *Tribulus terrestris,* Ht < 0.1 m, PFC < 1%.

Frequent spp: *Crotalaria eremaea, Ipomoea polymorpha, Tribulus hystrix.*

Infrequent spp: *Bassia bicornis, Helipterum moschatum, Hibiscus kirchauffianus, Kochia brevifolia.*

GRAMINOIDS:

Frequent spp: *Eragrostis basedowii, Triraphis mollis.*

Infrequent spp: *Eragrostis cumingii, E. dielsii, Tragus australianus.*

LAND USE: GC 1.1 to 1.8 beasts/km^2 (1.4), DGC 0.2 to 0.3 beasts/km^2; condition poor, trend downwards, very low WHC, very low fertility; susceptible to wind and water erosion; vegetation is sparse.

LAND UNIT 11

LANDFORM: Rounded mobile crests of dunes formed on alluvial plains. Dunes occur as single dunes or groups forming a reticulate pattern. Slopes 8 to 50%.

GEOLOGY: Quaternary sands overlying recent alluvial plains. Qs.

SOILS: Very deep, neutral to acid, uniform textured, red siliceous sands. Soils are loose. Uc 1.23; *Yanko.* Associated are red, earthy sands, *Kotri, Booka.* Representative soil analyses: 174.

VEGETATION: Bluebush pea, grassy open forbland. Vegetation is sparse with large areas devoid of vegetation. Forbs usually predominate with *Crotalaria eremaea* (bluebush pea) conspicuous. Grasses occur frequently. In places stunted *Atalaya hemiglauca* (whitewood) and *Owenia acidula* (emu apple) may be found.

STRUCTURAL FORM: Open forbland, Ht < 0.6 m, PFC 2.5 ± 2%.

LOW SHRUB LAYER: Ht 1.5 ± 0.5 m, PFC < 1%.

Infrequent spp: *Atalaya hemiglauca, Owenia acidula.*

GROUND LAYER: Ht < 0.6 m, PFC 2.5 ± 2%.

Predominant spp: *Crotalaria eremaea,* Ht < 0.6, PFC 2 ± 2%; *Salsola kali.* Ht < 0.6 m, PFC < 1%.

FORBS:

Frequent spp: *Tribulus terrestris, Euphorbia wheeleri.*

Infrequent spp: *Blennodia pterosperma, Euphorbia eremophila, Glinus lotoides, Nicotiana velutina, Portulaca* sp. aff. *P. oleracea.*

GRAMINOIDS:

Frequent spp: *Eriachne aristidea, Plagiosetum refractum.*

Infrequent spp: *Eragrostis basedowii, E. eriopoda.*

LAND USE: GC 1.8 to 2.4 beasts/km^2 (2.1), DGC 0.2 to 0.6 beasts (0.4); condition stable, trend slightly downwards; low WHC, very low fertility; top feed absent.

LAND UNIT 12

LANDFORM: Rounded crests of reticulate, low dunes, 3 to 5 m high, slopes 1 to 5%.

GEOLOGY: Wind-blown Quaternary sand. Qs.

SOILS: Very deep, neutral, red, siliceous sands. Textures range from coarse-sand to loamy-coarse-sand. Surfaces are loose. Uc 1.23; *Yanko*. Representative soil analysis: 198, 93.

VEGETATION: Mulga forby tall open shrubland, *Acacia aneura* (mulga) and usually *Atalaya hemiglauca* (whitewood) are conspicuous occurring on slopes and on crests in protected situations. Other scattered low trees or midheight shrubs may occur. Usually there is no well defined low shrubby layer but low shrubs are present. Ground cover is variable composed mainly of forbs.

STRUCTURAL FORM: Tall open shrubland. Ht 3.5 ± 0.5 m; PFC < 1 to 5%.

TREE, TALL SHRUB LAYER: Ht 3.5 ± 1.5 m, PFC <1 to 5%.

Predominant spp: *Acacia aneura*, Ht 3.5 ± 0.5 m, PFC 2.5 ± 2%.

Frequent spp: *Acacia tetragonophylla*, *Atalaya hemiglauca*.

Infrequent spp: *Hakea leucoptera*, *Santalum lanceolatum*.

LOW SHRUB LAYER: Ht 1.5 ± 0.5 m, PFC 1 ± 1% (in places up to 5%).

Frequent spp: *Acacia ligulata*, *Cassia desolata*.

Infrequent spp: *Acacia calicola* (restricted distribution in places occurs frequently, PFC < 5%), *Cassia pleurocarpa*, *Dodonaea attenuata*, *Enchylaena tomentosa*, *Eremophila duttonii*, *E. sturtii*.

GROUND LAYER: Ht < 0.6 m, PFC (variable) 10 ± 9%.

FORBS:

Frequent spp: *Bassia bicornis*, *B. paradoxa*, *Crotalaria eremaea*, *Ptilotus polystachyus*, *Salsola kali*, *Senecio gregorii*, *Trachymene glaucifolia*, *Tribulus occidentalis*, *Tribulus* sp. aff. *T. terrestris*.

Infrequent spp: *Abutilon otocarpum*, *Bassia parallelicuspis*, *B. ventricosa*, *Blennodia blennodioides*, *Boerhavia diffusa*, *Brachycome ciliocarpa*, *Calandrinia balonensis*, *C. ptychosperma*, *C. volubilis*, *Calotis inermis*, *Calocephalus multiflorus*, *Crotalaria cunninghamii*, *Cucumis myriocarpus*, *Erodium crinatum*, *Indigofera colutea*, *Lepidium oxytrichum*, *L. rotundum*, *Myriocephalus stuartii*, *Portulaca* sp. aff. *P. oleracea*, *Scaevola ovalifolia*, *Sida ammophila*, *Swainsona campylantha*, *Tephrosia rosea* var. *angustifolia*.

GRAMINOIDS:

Frequent spp: *Aristida browniana*, *A. contorta*, *Dactyloctenium radulans*, *Eragrostis eriopoda*, *Eriachne aristidea*, *E. helmsii*, *Iseilema membranaceum*.

Other spp: *Enneapogon avenaceus*, *Panicum decompositum*, *Tragus australianus*, *Triraphis mollis*.

LAND USE: GC 0.9 to 1.7 beasts/km2 (1.0), DGC 0.1 to 0.4 beasts/km2 (0.3); condition fair, trend slight downwards to stable, low to moderate WHC, very low fertility; susceptible to wind and water erosion when in a bare state; top feed limited; perennial grasses present and regenerating.

LAND UNIT 13

LANDFORM: Mobile rounded crests of reticulate sand dunes (4 to 8 m). Slopes 12 to 25%.

GEOLOGY: Wind-blown Quaternary sand. Qs.

SOILS: Very deep, uniform textured, loose, slightly acid, red, siliceous sands. Texture range from coarse-sand to sand. Uc 1.23; *Yanko*.

VEGETATION: Sparse forbland. Vegetation is sparse. The forbs *Crotalaria cunninghamii* (parrot pea), *Ptilotus* spp. and *Trachymene glaucifolia* (blue parsnip) are conspicuous. Grasses are present. Scattered low shrubs occur very infrequently.

STRUCTURAL FORM: Sparse forbland: Ht < 0.75 m; PFC < 2%.

LOW SHRUB LAYER: Ht 1.5 ± 0.5 m, PFC < 1%.

Frequent spp: *Cassia pleurocarpa*, *Dodonaea attenuata*.

Infrequent spp: *Duboisia hopwoodii*.

GROUND LAYER: Ht < 0.75 m, PFC < 2%.

FORBS:

Predominant spp: *Crotalaria cunninghamii*, Ht < 0.75 m, PFC < 2%, *Ptilotus polystachyus*, Ht < 0.75 m, PFC < 2%.

Frequent spp: *Crotalaria eremaea*, *Ptilotus latifolius*, *Scaevola depauperata*, *Trachymene glaucifolia*.

Infrequent spp: *Blennodia pterosperma*, *Haloragis gossei*, *Salsola kali*, *Trichodesma zeylanicum*.

GRAMINOIDS:

Frequent spp: *Eragrostis eriopoda*, *E. laniflora*, *Plagiosetum refractum*.

LAND USE: GC 0.7 to 0.9 beasts/km2 (0.7), DGC 0.1 beasts/km2; condition fair, trend static: very low WHC, very low fertility; natural erosion; top feed absent.

LAND UNIT 14

LANDFORM: Mobile crest of longitudinal dunes with blow-outs. Slopes 15 to 50%. Crested on western side, rounded on eastern side.

GEOLOGY: Quaternary sand. Qs.

SOILS: Very deep, uniform textured, loose, slightly acid, red, siliceous sands. Textures range from coarse-sand to sand. Uc 1.23; *Yanko.*

VEGETATION: Sandhill cane grass open hummock grassland. The shrub-like grass *Zygochloa paradoxa* (sandhill cane grass) predominates forming scattered clumps with denuded areas between the clumps. *Crotalaria eremaea* is frequently conspicuous. Forbs are usually present. In places stunted *Acacia dictyophleba* occurs on the crest.

STRUCTURAL FORM: Open hummock grassland; Ht < 1.3 m; projective foliage cover < 2%.

LOW SHRUB LAYER: Ht < 1.5 m, PFC < 1%.

Infrequent spp: *Acacia dictyophleba.*

GROUND LAYER: Ht < 1.3 m, PFC < 2%.

Predominant spp: *Crotalaria eremaea,* Ht < 0.75 m, PFC < 2%, *Zygochloa paradoxa,* Ht < 1.3 m, PFC < 1%.

FORBS:

Frequent spp: *Crotalaria cunninghamii, Salsola kali, Tribulus hystrix.*

Other spp: *Blennodia pterosperma, Sida ammophila.*

GRAMINOIDS:

Frequent spp: *Plagiosetum refractum.*

LAND USE: GC 0.4 beasts/km2, DGC 0.1 beasts/km2, condition fair, trend static; very low WHC, very low fertility; natural erosion; top feed absent.

LAND UNIT 15

LANDFORM: Flat claypan with very low rises less than 1 m high.

GEOLOGY: Quaternary alluvium, with wind-blown material from the sand-dunes forming low rises. Qa, Qs.

SOILS: Very deep, strongly alkaline, brown clays with a variable thickness, crust of sandy-clay to clayey-coarse-sand which is vesicular. $CaCO_3$ is present in the profile, particularly below 20 cm. Gypsum may be present in the lower part of the profile. On the sandy rises texture contrast soils occur. Ug 5.2, Dy 2.33; *Wittenburra, Bygrave.* Representative soil analysis: 196.

VEGETATION: Swamp cane grass claypan. Vegetation is sparse. *Eragrostis australasica* (swamp cane grass) predominates. Forbs may occur. Other grasses are rare. Grasses and forbs are frequently found on associated sandy rises.

STRUCTURAL FORM: Nil to scattered vegetation: Ht < 1 m; PFC < 1%.

GROUND LAYER: Ht < 1 m, PFC < 1%.

Predominant spp: *Eragrostis australasica,* Ht < 1 m, PFC < 1%.

FORBS:

Infrequent spp: *Alternanthera nodiflora, Atriplex limbata, A. spongiosa, Bassia bicornis, B. divaricata, B. paradoxa, Centipeda thespidioides, Marsilea drummondii, M. hirsuta, Plantago pritzelii.*

GRAMINOIDS:

Infrequent spp: *Eregrostis dielsii.*

ON THE SANDY RISES:

FORBS:

Infrequent spp: *Atriplex spongiosa, Blennodia eremigena, Daucus glochidiatus, Gnephosis eriocarpa, Helipterum moschatum, Rhagodia nutans.*

GRAMINOIDS:

Infrequent spp: *Diplachne muelleri, Eragrostis leptocarpa.*

LAND USE: GC 0.3 beasts/km2, DGC 0.0; condition poor, trend downwards; poor water penetration; susceptible to wind erosion and scalding; top feed absent.

LAND UNIT 16

LANDFORM: Flat claypans between sand-dunes subject to frequent flooding and inundation.

GEOLOGY: Quaternary alluvia. Qa.

SOILS: Very deep, poorly drained, grey cracking clays. Ug 5.24, Ug 5.28; *Tennappera.*

VEGETATION: Sparse forbland. Vegetation is very sparse. *Atriplex* spp. (saltbush), *Bassia* spp. and other forbs are present. Grasses are rare.

STRUCTURAL FORM: Open forbland; Ht< 0.4 m, projective foliage foliage cover < 1%.

GROUND LAYER: Ht < 0.4 m, PFC < 1%.

FORBS:

Frequent spp: *Atriplex elachophylla, A. eardleyae, A. spongiosa, Bassia divaricata, B. lanicuspis, B. paradoxa.*

Infrequent spp: *Boerhavia diffusa, Salsola kali.*

GRAMINOIDS:

Infrequent spp: *Eragrostis basedowii* (on sandy rises) *E. dielsii.*

LAND USE: GC 0.7 beasts/km2, DGC 0.0; condition poor, trend downward; poor water penetration, subject to scalding; temporary water.

LAND UNIT 17

LANDFORM: Flat, poorly drained, claypan.

GEOLOGY: Recent alluvia. Qa.

SOILS: Very deep, alkaline, grey clays with a surface crust; polygonal cracking surface. Heavy clays throughout. Ug 5.5, Ug 5.24; *Tennappera*. Representative soil analysis: 92.

VEGETATION: **A** Swamp cane grass claypan. Vegetation is sparse. *Eragrostis australasica* (swamp cane grass) predominates. Forbs may occur. Other grasses are rare. Other grasses and forbs are frequently found on associated sandy rises. Scattered low shrubs of *Myoporum deserti* (Ellangowan poison bush) may occur.

STRUCTURAL FORM: Scattered vegetation to sparse open tussock grassland. Ht < 1 m; PFC < 1% – in places up to 10%.

LOW SHRUB LAYER: Ht < 1 m, PFC < 1%.

Infrequent spp: *Myoporum deserti*.

GROUND LAYER: Ht < 1 m; PFC usually < 1% – (in places < 10%).

Predominant spp: *Eragrostis australasica*, Ht < 1 m, PFC variable usually < 1% (up to 10%).

FORBS:

Frequent spp: *Alternanthera nodiflora, Atriplex limbata, A. spongiosa, Bassia bicornis, B. divaricata, B. paradoxa, Centipeda thespidioides, Marsilea drummondii, M. hirsuta, Plantago pritzelii.*

Infrequent spp: *Blennodia eremigena, Daucus glochidiatus, Gnephosis eriocarpa, Helipterum moschatum, Kochia microcarpa, Rhagodia nutans.*

GRAMINOIDS:

Frequent spp: *Eragrostis dielsii.*

Infrequent spp: *Diplachne muelleri, Eragrostis leptocarpa.*

B Swamp cane grass open tussock grassland. *Eragrostis australasica* (swamp cane grass) predominates rarely forming pure stands. Frequently shrubs of *Chenopodium auricomum* (blue bush) and *Muelhenbeckia cunninghamii* (lignum) occur. Grasses, sedges and forbs are present with many of the grasses and forbs occurring on sandy rises.

STRUCTURAL FORM: Open tussock grassland; Ht < 1.5 m, PFC (variable) 10 ± 9%.

LOW SHRUB LAYER: Ht < 1.5 m, PFC < 1%.

Frequent spp: *Chenopodium auricomum, Muelhenbeckia cunninghamii.*

GROUND LAYER: Ht < 1.5 m, PFC (variable) 10 ± 9%.

Predominant spp: *Eragrostis australasica*, Ht < 1.5 m, PFC 8 ± 7%.

FORBS:

Frequent spp: *Aeschynomene indica, Atriplex spongiosa, Malacocera tricornis, Marsilea drummondii, M. hirsuta.*

Infrequent spp: *Atriplex eardleyae, Bassia andersonii, B. quinquecuspis, Minuria denticulata, M. integerrima.*

Frequent spp (on rises): *Bassia bicornis, Portulaca* sp. aff. *P. oleracea, Psoralea eriantha, Salsola kali.*

GRAMINOIDS:

Frequent spp: *Cyperus fulvus, C. rigidellus, Eleocharis pallens, Eragrostis dielsii.*

Infrequent spp: *Diplachne muelleri.*

Frequent spp (on rises): *Dactyloctenium radulans, Eragrostis basedowii, E. setifolia, Iseilema membranaceum, Tragus australianus.*

LAND USE: GC 1.0 to 1.8 beasts/km2 (1.4); DGC –; condition poor, trend stable to slight downwards; poor water penetration; susceptible to wind scalding; topfeed absent; temporary water.

LAND UNIT 18

LANDFORM: Flat claypan fringing the dunefields.

GEOLOGY: Alluvial plain, with stone cover from the Tertiary land surface. Qa.

SOILS: Hardsetting, polygonal cracked, clay with a surface cover of gravel. Surface soil is massive and scalded.

VEGETATION: Claypan. Vegetation is nil. In places scattered plants of *Atriplex* spp., *Bassia* spp., and *Salsola kali* (soft roly-poly) may occur.

LAND USE: GC 0.2 to 0.4 beasts/km2, DGC –; condition poor, trend downward; low infiltration rates; scalded; no top feed; perennial grasses absent.

LAND UNIT 19

LANDFORM: Flat claypans, often linked to local drainage lines, in the dunefields.

GEOLOGY: Quaternary alluvium on which dunefields have been superimposed. Qa.

SOILS: Very deep, poorly drained, grey clays with massive surface soil. Textures are predominantly sandy and silty-clays commonly becoming heavy clays at depth. Soils are often gleyed. Soil reaction range from neutral throughout to neutral over alkaline to alkaline throughout. In the alkaline profiles $CaCO_3$ was present throughout the profile. Low, wind-blown, sandy rises occur in this unit. Ug 5.5, Ug 5.24; *Tennappera*. Representative soil analysis: 192, 195, 219.

VEGETATION: **A** Bluebush, lignum low open shrubland. *Chenopodium auricomum* (bluebush) and usually *Muelhenbeckia cunninghamii* (lignum) predominate. Frequently *Eucalyptus microtheca* (coolibah) occurs and in places predominates. Ground cover is composed mainly of forbs and sedges but grasses do occur. In some situations *E. terminalis* (western bloodwood) may be found fringing the association.

STRUCTURAL FORM: Low open shrubland (in places low open woodland). Ht < 1 m, (4 to 5 m where *E. microtheca* predominates), PFC 5 ± 4.5%.

TREE, TALL SHRUBS LAYER: Ht 4 ± 1 m, PFC 2.5 ± 2.5%.

Infrequent spp: *Eucalyptus microtheca*, Ht 4 to 5 m, PFC (variable) 2.5 ± 2.5%.

LOW SHRUB LAYER: Ht < 1.5 m, PFC 5 ± 4%.

Predominant spp: *Chenopodium auricomum*, Ht < 1 m, PFC (variable) 5 ± 4%, *Muehlenbeckia cunninghamii*, Ht < 1.5 m, PFC 1 ± 0.5%.

GROUND LAYER: Ht < 0.5 m, PFC variable 25 ± 25%.

FORBS:

Frequent spp: *Alternanthera nodiflora, Calotis hispidula, C. multicaulis, Centipeda thespidioides, Damasonium minus, Daucus glochidiatus, Marsilea drummondii, Plantago pritzelii, Ranunculus pentandrus* var. *platycarpus*.

Infrequent spp: *Atriplex fissivalvis, A. spongiosa, Bassia bicornis, Blennodia eremigena, Brachycome curvicarpa, Chenopodium melanocarpum, Eryngium plantagineum, Helipterum strictum, Lotus cruentus, Malvastrum spicatum, Mimulus prostratus, Minuria denticulata, Senecio gregorii, S. lautus, Tetragonia tetragonioides, Trichodesma zeylanicum, Trigonella suavissima, Wahlenbergia* sp.

GRAMINOIDS:

Frequent spp: *Cyperus difformis, C. iria, Eleocharis pallens.*

Infrequent spp: *Dactyloctenium radulans, Elytrophorus spicatus, Eragrostis setifolia, E. tenellula, Panicum whitei.*

B Bluebush, lignum low open shrubland. *Chenopodium auricomum* (bluebush) and/or *Muelhenbeckia cunninghamii* (lignum) predominate. Other forbs and sedges are present. Grasses are abundant.

STRUCTURAL FORM: Low open shrubland. Ht < 0.75 m, PFC 5 ± 4%.

LOW SHRUB LAYER: Ht < 0.75 m, PFC 5 ± 4%.

Predominant spp: *Chenopodium auricomum*, Ht < 0.75 m, PFC 5 ± 4%; *Muelhenbeckia cunninghamii*, Ht < 0.75 m, PFC 5 ± 4%.

GROUND LAYER: Ht < 0.5 m; PFC 5 ± 4%.

FORBS:

Frequent spp: *Alternanthera nodiflora, Centipeda thespidioides, Damasonium minus, Daucus glochidiatus.*

Infrequent spp: *Blennodia eremigena, Mimulus prostratus, Walhenbergia* sp.

GRAMINOIDS:

Frequent spp: *Cyperus iria, Eleocharis pallens, Elytrophorus spicatus.*

Infrequent spp: *Dactyloctenium radulans, Eragrostis setifolia.*

LAND USE: GC 1.7 to 5.5 beasts/km^2 (3.6); DGC 0.1 to 0.3 beasts/km^2; condition poor to fair, trend slight downwards to downwards; low infiltration rates; top feed present; perennial grasses absent; frequently inundated.

LAND UNIT 20

LANDFORM: Cemented aprons on the lower slopes and edges of dunes occurring on flat alluvial plains. Slopes 1 to 4%.

GEOLOGY: Aeolian Quaternary sand overlying Quaternary alluvia. Qs/Qa.

SOILS: A shallow to moderately deep, neutral, red, sandy-loam to sandy-clay-loams usually with a ferruginous hardpan. Surface soil is hard and cemented often with concretionary lime present Um 5.31, Gn 2.12; *Gooyana*. Associated are texture contrast soils. These soils comprise loose, neutral, red, loamy-coarse-sands overlying alkaline, sandy-clay-loams to sandy-clays. Dy 5.53; *Bygrave*. Representative soil analysis: 197.

VEGETATION: **A** *Melaleuca uncinata*, forby fringing tall open shrubland. *Melaleuca uncinata* predominates with *Eucalyptus microtheca* (coolibah) emerging. Scattered low shrubs may occur. Ground cover is composed mainly of forbs but grasses are present.

STRUCTURAL FORM: Tall open shrubland. Ht 3 ± 1 m; PFC 5 ± 4%.

TREE, TALL SHRUB LAYER: Ht 5 ± 3 m, PFC 5 ± 4%.

Predominant spp: *M. uncinata*, Ht 3 ± 1 m, PFC 5 ± 4%.

Frequent spp: *Eucalyptus microtheca.*

LOW SHRUB LAYER: Ht < 1 m, PFC < 1%.

Infrequent spp: *Eremophila maculata.*

GROUND LAYER: Ht < 1 m, PFC variable 15 ± 15%.

FORBS:

Frequent spp: *Salsola kali.*

Other spp: *Alternanthera nodiflora, Centipeda thespidioides, Lepidium rotundum, Mimulus prostratus, Tetragonia tetragonioides.*

LAND UNIT 20 (continued)

VEGETATION: B Herbfield. Grasses or forbs predominate. Scattered shrubs of *Eremophila* spp. and *Acacia* spp. occur. Isolated trees of *Eucalyptus microtheca* (coolibah) emerge.

STRUCTURAL FORM: Herbfield (grasses or forbs predominant). Ht < 0.75 m, PFC 10 ± 10%.

TREE, TALL SHRUB LAYER: Ht 4 ± 1 m, PFC < 1%.

Infrequent spp: *Acacia calcicola, Eucalyptus microtheca.*

LOW SHRUB LAYER: Ht < 1 m, PFC < 1%.

Infrequent spp: *Eremophila duttonii, E. obovata.*

GROUND LAYER: Ht < 0.75 m, PFC 10 ± 10%.

FORBS:

Predominant spp: *Bassia anisacanthoides, B. bicornis* var. *horrida, B. divaricata, B. lanicuspis, B. paradoxa, Ptilotus polystachyus.*

Frequent spp: *Ipomoea polymorpha, Portulaca* sp. aff. *P. oleracea, Sida cunninghamii, S. platycalyx, Salsola kali.*

Infrequent spp: *Abutilon otocarpum, Euphorbia drummondii, Gnephosis eriocarpa, Trianthema triquetra.*

GRAMINOIDS:

Predominant spp: *Aristida browniana, Eragrostis eriopoda.*

Frequent spp: *Aristida contorta, Dactyloctenium radulans, Tragus australianus, Triraphis mollis.*

Infrequent spp: *Digitaria brownii, Enneapogon polyphyllus, Eriachne aristidea, Monachather paradoxa, Sporobolus actinocladus.*

LAND USE: GC 0.2 to 2.0 beasts/km2 (0.8); DGC 0.2 beasts/km2; condition poor, trend downwards; low infiltration, very low fertility; subject to wind and water erosion causing scalding; top feed absent; perennial grasses rare.

LAND UNIT 21

LANDFORM: Flat plains in interdune areas.

GEOLOGY: Quaternary sand over clay plains. Qs/Qa.

SOILS: Deep to very deep, texture contrast soil with acid, red, coarse-sandy-loam surface soil and red, alkaline, sandy-clay subsoil. Surface soil is loose when moist but massive when dry. *Bygrave.*

VEGETATION: Mulga, western bloodwood tall open shrubland. *Acacia aneura* (mulga) predominates with *Eucalyptus terminalis* (western bloodwood) occurring frequently and in places being co-dominant. There is no well defined lower shrubby layer but isolated shrubs occur infrequently. Ground flora is well developed composed of grasses and forbs.

STRUCTURAL FORMATION: Tall open shrubland. Ht 6 ± 2 m, PFC 3 ± 2%.

TREE, TALL SHRUB LAYER: Ht 6 ± 2 m, PFC 3 ± 2%.

Predominant spp: *Acacia aneura* Ht 6 ± 2 m, PFC 3 ± 2% (trees are clumped in places).

Frequent spp: *Eucalyptus terminalis.*

LOW SHRUB LAYER: Ht 1.25 ± 0.75 m, PFC < 1%.

Infrequent spp: *Acacia tetragonophylla, Cassia nemophila* var. *nemophila, C. nemophila* var. *zygophylla.*

GROUND LAYER: Ht < 1 m, PFC 20 ± 15%.

FORBS:

Frequent spp: *Calotis multicaulis, Euphorbia drummondii, Helipterum floribundum, Ptilotus polystachyus.*

Infrequent spp: *Bonamia media, Evolvulus alsinoides, Justicia procumbens, Pimelea trichostachya, Solanum esuriale, Swainsona oroboides, Tephrosea rosea* var. *angustifolia, Trachymene glaucifolia.*

GRAMINOIDS:

Frequent spp: *Enteropogon acicularis, Eriachne aristidea, Tragus australianus.*

Infrequent spp: *Chrysopogon fallax, Eragrostis basedowii, E. eriopoda, E. setifolia.*

LAND USE: GC 2.1 to 3.8 beasts/km2 (2.4); DGC 0.4 to 0.7 beasts/km2 (.5); condition poor to fair, trend slight downwards to downwards; low to moderate WHC; low fertility; susceptible to scalding by wind; top feed not abundant; perennial grasses present.

LAND UNIT 22

LANDFORM: Flat plains with moderate gilgai microrelief (10 to 30 cm).

GEOLOGY: Recent alluvia. Qa.

SOILS: Very deep, poorly drained, grey clay with a silty-clay surface soil which forms a crust. Subject to seasonal inundation. Ug 5.25; *Cottesmore.*

VEGETATION: Belah, gooramurra shrubby low open woodland. *Casuarina cristata* (belah) predominates with scattered trees of *Eucalyptus microtheca* (coolibah) emerging. *Eremophila bignoniiflora* (gooramurra) forms a distinct shrubby layer with scattered *Acacia omalophylla* (yarran). Ground cover is composed mainly of forbs but grasses occur.

STRUCTURAL FORM: Low open woodland; Ht 8 ± 2 m, projective foliage cover 7.5 ± 2.5%.

TREE LAYER: Ht 8 ± 2 m, PFC 7.5 ± 2.5%.

Predominant spp: *Casuarina cristata,* Ht 8 ± 2 m, PFC 5 ± 2%.

Frequent spp: *Eucalyptus microtheca.*

TALL SHRUB LAYER: Ht 3 ± 1 m, PFC 20 ± 10%.

Frequent spp: *Eremophila bignoniiflora.*

Infrequent spp: *Acacia omalophylla.*

LOW SHRUB LAYER: Ht < 2 m, PFC < 1%.

Frequent spp: *Cassia nemophila* var. *nemophila, Muehlenbeckia cunninghamii.*

GROUND LAYER: Ht < 0.75 m, PFC 7.5 ± 2.5%.

FORBS:

Frequent spp: *Bassia stelligera, Centipeda thespidioides, Minuria integerrima.*

Infrequent spp: *Haloragis glabrescens, Teucrium racemosum.*

GRAMINOIDS:

Frequent spp: *Echinochloa colonum, Paspalidium jubiflorum.*

LAND USE: GC 8.5 beasts/km2, DGC 2.7 beasts/km2; condition good, trend stable; moderate to high WHC; top feed present; perennial grasses present; regeneration can be a problem, could be thinned.

LAND UNIT 23

LANDFORM: Flat alluvial fan plains with weak to moderate gilgai micro-relief.

GEOLOGY: Recent alluvial fan plain overlying stone mantled pediments. Qa.

SOILS: Very deep, alkaline, brown and grey clays. Stone predominates on the puff. A hard surface crust, overlies a structured clay. Gypsum is present below 30 cm and may occur on the surface. Boggy when wet. Ug 5.24; *Parragona.*

VEGETATION: Sodabush, bassia grassy herbfield. Forbs or grasses may predominate depending on seasonal conditions. Sedges and *Marsilea* spp. (nardoo) are associated with depressions. Infrequently scattered stunted trees of *Acacia cambagei* are present.

STRUCTURAL FORM: Herbfield to open herbfield. (Grasses or forbs predominant.) Ht < 0.5 m, PFC (variable) 15 ± 10%.

LOW SHRUB LAYER: Ht < 1.5 m, PFC < 1%.

Infrequent spp: *Acacia cambagei.*

GROUND LAYER: Ht < 0.5 m, PFC 15 ± 10%.

FORBS:

Predominant spp: *Atriplex spongiosa, Bassia bicornis, B. divaricata, Threlkeldia proceriflora.*

Frequent spp: *B. lanicuspis, Boerhavia diffusa, Salsola kali.*

Infrequent spp: *Alternanthera nodiflora, Atriplex lindleyi, Helipterum floribundum, Lepidium rotundum, Sida* sp., *Marsilea drummondii, Zygophyllum ammophilum.*

GRAMINOIDS:

Predominant spp: *Iseilema membranaceum.*

Frequent spp: *Dactyloctenium radulans, Eragrostis setifolia.*

Infrequent spp: *Astrebla pectinata, Brachyachne convergens, Cyperus rigidellus, Diplachne muelleri, Eragrostis parviflora, E. tenellula.*

LAND USE: GC 4.0 to 6.4 beasts/km2 (5.0), DGC 0.2 to 0.4 beasts/km2 (0.3); condition fair, trend stable to slight downwards; moderate WHC, infiltration low; perennial grasses present.

LAND UNIT 24

LANDFORM: Flat alluvial plains. Not frequently flooded.

GEOLOGY: Recent clay alluvia. Qa.

SOILS: Very deep, slightly acid to slightly alkaline, brown clays (some grey and red clays occur). Soils are medium to heavy clays commonly becoming lighter in texture with depth. Intermixed are soils with silty-clay-loam to silty-clay surface soil (10 to 20 cm). Thin surface crusts are common. Gypsum commonly occurs in the lower part of the profile < 60 cm. Ug 5.24, Ug 5.25, Ug 5.34, Ug 5.38, Dr 1.43, Db 0.43; *Thytungra, Kihee, Woorbil.* Representative soil analysis: 83, 202, 177, 33.

VEGETATION: Saltbush, bassia grassy herbfield. Forbs or grasses predominate depending on seasonal conditions. Scattered shrubs of *Acacia cambagei* and low shrubs of *Chenopodium auricomum* (bluebush) and *Eremophila polyclada* (lignum fuchsia) occur.

STRUCTURAL FORM: Herbfield (grasses or forbs predominate depending on local variation in the environment), Ht < 0.5 m rarely < 0.75 m, PFC (variable) 20 ± 15%.

TALL SHRUB LAYER: Ht < 2.5 m PFC < 1%.

Infrequent spp: *Acacia cambagei.*

LOW SHRUB LAYER: Ht < 1.5 m, PFC < 1%.

Infrequent spp: *Chenopodium auricomum, Eremophila polyclada.*

GROUND LAYER: Ht < 0.5 m, PFC (variable), 20 ± 15%.

FORBS:

Predominant spp: *Atriplex lindleyi, A. spongiosa, Bassia bicornis, B. divaricata, B. lanicuspis.*

Frequent spp: *Bassia andersonii, Boerhavia diffusa, Lepidium rotundum, Portulaca* sp. aff. *P. oleracea, Salsola kali, Threlkeldia proceriflora, Zygophyllum ammophilum.*

Infrequent spp: *Alternanthera denticulata, Atriplex eardleyae, A. limbata, Bassia anisacanthoides, B. calcarata, B. intricata, B. paradoxa, Bulbine* spp., *Calotis latiuscula, C. multicaulis, Euphorbia australis, E. drummondii, E. stevenii, Frankenia* spp., *Helipterum floribundum, H. microglossum, H. strictum, Kochia coronata, Lepidium oxytrichum, Malacocera tricornis, Marsilea drummondii, M. hirsuta, Minuria integerrima, Neptunia dimorphantha, Plantago pritzelii, Psoralea cinerea, Sida* spp., *Trianthema galericulata, T. portulacastrum, T. triquetra, Velleia glabrata.*

GRAMINOIDS:

Predominant spp: *Brachyachne convergens, Chloris pectinata, Dactyloctenium radulans, Iseilema membranaceum.*

Frequent spp: *Astrebla pectinata, Panicum whitei, Sporobolus actinocladus, Tragus australianus.*

Infrequent spp: *Artistida anthoxanthoides, A. contorta, Cyperus rigidellus, Diplachne muelleri, Eragrostis dielsii, E. leptocarpa, E. setifolia, Enneapogon avenaceus, E. polyphyllus, Tripogon loliiformis, Uranthoecium truncatum.*

LAND USE: GC 4.4 to 10.4 beasts/km2 (5.8) DGC 0.2 to 0.6 beasts/km2 (0.4); condition fair to good, trend stable to slight downwards; high WHC, low to moderate infiltration; subject to scalding if overgrazed; top feed absent; perennial grasses and forbs present.

LAND UNIT 25

LANDFORM: Flat alluvial plains which are only occasionally flooded.

GEOLOGY: Recent clay alluvia. Qa.

SOILS: Very deep, neutral to alkaline, red clays, with a surface crust, generally < 1 cm thick. Gypsum may be present at depth. Beneath this crust the soils are strongly structured. Ug 5.38, Ug 5.37: *Thylungra*. Representative soil analysis: 212.

VEGETATION: Small Flinders grass grassy to forby herbfield. Grasses or forbs may predominate depending on seasonal conditions. Shrubs are rare.

STRUCTURAL FORM: Herbfield (grassland or forbland depending on seasonal influences); Ht < 0.6 m, PFC 30 ± 10%.

LOW SHRUB LAYER: Ht < 0.75 m, PFC < 1%.

Infrequent spp: *Cassia phyllodinea, Enchylaena tomentosa.*

GROUND LAYER: Ht < 0.6 m; PFC (variable): 30 ± 10%.

FORBS:

Frequent spp: *Atriplex spongiosa, Bassia bicornis, B. lanicuspis, Euphorbia boophthona.*

Infrequent spp: *Calotis hispidula, Euphorbia drummondii, Evolvulus alsinoides, Helipterum floribundum, Kochia triptera, Lepidium oxytrichum, Neptunia dimorphantha, Ptilotus macrocephalus, Salsola kali, Stenopetalum nutans, Threlkeldia proceriflora.*

GRAMINOIDS:

Predominant spp: *Aristida contorta, Dactyloctenium radulans, Iseilema membranaceum, Panicum whitei.*

Frequent spp: *Aristida anthoxanthoides, Brachyachne convergens.*

Infrequent spp: *Astrebla pectinata, Chloris pectinata, C. scariosa, Diplachne muelleri, Eragrostis leptocarpa, Fimbristylis dichotoma, Iseilema vaginiflorum, Tragus australianus, Tripogon loliiformis.*

LAND USE: GC 4.4 to 11.5 beasts/km2 (7.6), DGC 0.2 to 0.6 beasts/km2; condition fair to good, trend stable to slight downwards; high WHC, low to moderate infiltration rates; subject to wind and water erosion in places; top feed absent; perennial grasses present.

LAND UNIT 26

LANDFORM: Levees and banks of the major drainage channels on braided alluvial plains.

GEOLOGY: Recent clay alluvia. Qa.

SOILS: Very deep, grey clays. Alluvial soils. Surface silt and sand which forms a surface crust is common. Sand and silt bands are are common in the profile. Small areas of alluvial, texture contrast soils are intermixed. *Coolah.*

VEGETATION: Coolibah, river red gum fringing woodland. *Eucalyptus microtheca* (coolibah) and *E. camaldulensis* (river red gum) predominate. Frequently a tall shrubby layer is well developed. Usually there is no well defined low shrubby layer but scattered shrubs occur in depressions. *Muelhenbeckia cunninghamii* (lignum) may form a well defined layer. Ground cover is variable composed mainly of grasses and sedges but forbs are usually present.

STRUCTURAL FORM: Woodland: Ht 9 ± 3 m, PFC 15 ± 10%.

TREE LAYER: Ht 9 ± 3 m, PFC 15 ± 10%.

Predominant spp: *Eucalyptus camaldulensis*, Ht 9 ± 2 m, PFC 10 ± 5%, *E. microtheca*, Ht 9 ± 3 m, PFC 10 ± 5%.

TALL SHRUB LAYER: Ht 4 ± 1 m, PFC 3 ± 2%.

Frequent spp: *Acacia stenophylla.*

Infrequent spp: *Melaleuca linariifolia* (lining creek banks).

LOW SHRUB LAYER: Ht < 2 m, PFC 5 ± 4%.

Frequent spp: *Chenopodium auricomum, Eremophila bignoniiflora, Muelhenbeckia cunninghamii, Myoporum acuminatum.*

Infrequent spp: *Eremophila sturtii.*

GROUND LAYER: Ht < 1.5 m, PFC 30 ± 10% (in places < 10%).

FORBS:

Frequent spp: *Alternanthera denticulata, A. nodiflora, Atriplex eardleyae, A. muelleri, A. spongiosa, Bassia divaricata, B. quinquecuspis, Bulbine* spp., *Centipeda thespidioides, Marsilea drummondii, M. hirsuta* (depressions), *Plantago pritzelii, Psoralea eriantha, P. patens* (channel country).

Infrequent spp: *Brachycome ciliaris* var. *lanuginosa, Calotis andryocarpa, Helipterum moschatum, Ixiolaena brevicompta, Malvastrum spicatum, Mimulus prostratus, Minuria integerrima, Pimelea trichostachya, Portulaca* sp. aff. *P. oleracea, Psoralea cinerea, Ranunculus pentandrus* var. *platycarpus, Sesbania cannabina, Trigonella suavissima, Xanthium pungens.*

GRAMINOIDS:

Frequent spp: *Cyperus dactylotes, C. difformis, C. exaltatus, C. iria, C. rigidellus, C. victoriensis, Dichanthium sericeum, Eragrostis dielsii, E. leptocarpa, E. parviflora, E. setifolia, E. tenellula, Eulalia fulva, Leptochloa digitata, Lomandra longifolia, Panicum buncei, Paspalidium jubiflorum.*

Infrequent spp: *Bothriochloa ewartiana, Chloris pectinata, Chrysopogon fallax, Dactyloctenium radulans, Eleocharis pallens, Eriochloa pseudoacrotricha, Juncus* sp., *Panicum whitei, Sporobolus actinocladus, S. mitchellii, Tragus australianus.*

LAND USE: GC 4.2 to 10.3 beasts/km2 (7.1), DGC 0.2 to 0.6 beasts/km2 (0.4); condition poor to good, trend slight downwards; high WHC, low to moderate infiltration, fair fertility; bank erosion near the watering points; top feed absent; perennial grasses present.

LAND UNIT 27

LANDFORM: Channels, with 1 to 2 m relief, on alluvial plains.

GEOLOGY: Recent clay alluvia. Qa.

SOILS: Very deep, grey clays. Alluvial soils. Surface silt and sand which forms a surface crust is common. Sand and silt bands are common in the profile. Ug 5; *Coolah.*

VEGETATION: Lignum low open shrubland: *Muehlenbeckia cunninghamii* (lignum) predominates on the upper slopes of channels with scattered low trees and tall shrubs emerging. Isolated low shrubs also occur. Ground flora is sparse composed mainly of forbs.

STRUCTURAL FORMATION: Low open shrubland: Ht 1.5 $\pm$ 0.5 m, PFC 5 $\pm$ 4%.

TREE, TALL SHRUB LAYER: Ht 4 $\pm$ 1 m, PFC < 1%.

Frequent spp: *Acacia victoriae.*

Infrequent spp: *Acacia stenophylla, Atalaya hemiglauca.*

LOW SHRUB LAYER: Ht 1.25 $\pm$ 0.75 m, PFC 5 $\pm$ 4%.

Predominant spp: *Muehlenbeckia cunninghamii,* Ht 2 $\pm$ 0.5 m, PFC 5 $\pm$ 4%.

Frequent spp: *Enchylaena tomentosa.*

GROUND LAYER: Ht < 0.5 m, PFC 5 $\pm$ 4%.

FORBS:

Frequent spp: *Atriplex lindleyi, A. spongiosa, Bassia divaricata, Frankenia hamata.*

Infrequent spp: *Ixiolaena brevicompta, Minuria integerrima.*

GRAMINOIDS:

Frequent spp: *Eragrostis dielsii.*

Infrequent spp: *Uranthothecium truncatum.*

LAND USE: GC 2.2 to 6.4 beasts/km2 (2.9), DGC 0.4 to 1.0 beasts/km2 (0.7); fair to good condition, trend stable; high WHC, low infiltration, fair fertility; limited top feed; subject to surface flooding.

LAND UNIT 28

LANDFORM: Low lying swamp/channel in flat alluvial plains.

GEOLOGY: Recent alluvia. Qa.

SOILS: Soils are very deep, poorly drained, massively cracking, grey clays. Ug 5.24, Ug 5.25, Ug 5.28; *Houdraman.*

VEGETATION: Yapunyah, swamp cane grass complex. *Eucalyptus ochrophloia* (yapunyah) open woodland with *E. microtheca* (coolibah) conspicuous occurs in association with *Eragrostis australasica* (swamp cane grass) open tussock grassland. A tall shrub layer may be well defined in places. Usually there is no well defined low shrub layer but scattered shrubs occur. Ground cover is variable composed of grasses and forbs.

STRUCTURAL FORMATION: Low open woodland, Ht 8 $\pm$ 2 m, PFC 10 $\pm$ 10%; open tussock grassland, Ht 1.3 m, PFC 10 $\pm$ 10%.

TREE LAYER: Ht 8 $\pm$ 2 m, PFC 10 $\pm$ 10%.

Predominant spp: *Eucalyptus ochrophloia,* Ht 8 $\pm$ 2 m, PFC 8 $\pm$ 7%.

Frequent spp: *E. microtheca.*

TALL SHRUB LAYER: Ht 3 $\pm$ 2 m, PFC 2.5 $\pm$ 2.5%.

Infrequent spp: *Acacia stenophylla.*

LOW SHRUB LAYER: Ht < 1.5 m, PFC < 1% (up to 5% in places).

Frequent spp: *Chenopodium auricomum, Muelhenbeckia cunninghamii.*

Infrequent spp: *Eremophila bignoniiflora, Myoporum deserti.*

GROUND LAYER: Ht < 1.5 m, PFC (variable) 10 $\pm$ 10%.

FORBS:

Predominant spp: *Eragrostis australasica,* Ht < 1.3 m, PFC 5 $\pm$ 5%.

Frequent spp: *Aeschynomene indica, Atriplex spongiosa, Marsilea drummondii, M. hirsuta.*

Infrequent spp: *Bassia andersonii, B. quinquecuspis, Minuria denticulata, M. integerrima.*

Infrequent spp (on rises): *Bassia bicornis, Psoralea eriantha* (in the east), *Salsola kali.*

LAND USE: GC 3.2 to 8.0 beasts/km2 (3.7), DGC 0.2 to 0.6 beasts/km2 (0.4); fair condition, trend stable; high WHC, low infiltration rates, fair fertility: top feed absent; seasonal swamp.

LAND UNIT 29

LANDFORM: Flat alluvial plain abutting the lower slopes of gently undulating plains.

GEOLOGY: Recent alluvia. Qa.

SOILS: Very deep, strongly alkaline, grey clays. Gypsum and lime occur throughout the profile and are found at the surface. Surface soil is soft with a thin crust. Ug 5.2; *Wyara*. Representative soil analysis: 63.

VEGETATION: Samphire, Bassia low open shrubland. *Arthrocnemum* spp. (samphire) predominate with forbs usually conspicuous. Grasses may be present usually on the sandy rises. Scattered stunted trees of *Eucalyptus microtheca* (coolibah) and low shrubs occur.

STRUCTURAL FORM: Low open shrubland. Ht < 1 m, PFC 5 ± 4%.

TREE, TALL SHRUB LAYER: Ht 5 ± 1 m, PFC < 1%.

Frequent spp: *Eucalyptus microtheca*.

LOW SHRUB LAYER: Ht 1 ± 0.5 m, PFC 5 ± 4%.

Predominant spp: *Arthocnemum halocnemoides* var. *pergranulatum*, *Ht* < .1 m, PFC 5 ± 4%, *A. leiostachyum*, Ht < .7m, PFC 3 ± 2%.

Frequent spp: *Pachycornia tenuis*.

Infrequent spp: *Malacocera tricornis*, *Myoporum acuminatum*.

GROUND LAYER: Ht < 0.75 m, PFC 5 ± 4%.

FORBS:

Frequent spp: *Atriplex spongiosa*, *Bassia brachyptera*, *B. divaricata*, *B. lanicuspis*, *Babbagia scleroptera*, *Frankenia hamata*.

Infrequent spp: *Babbagia dipterocarpa*, *Portulaca* sp. aff. *P. oleracea*.

GRAMINOIDS:

Frequent spp (on sandy rises): *Dactyloctenium radulans*, *Sporobolus actinocladus*, *S. caroli*.

Infrequent spp: *Eragrostis dielsii*.

LAND USE: GC 0.5 to 1.1 beasts/km2 (0.7), DGC 0.1 to 0.4 beasts/km2 (0.2); poor condition, trend slight downward; saltpan; top feed absent; susceptible to wind and water erosion.

LAND UNIT 30

LANDFORM: Flat plains on edge of playas and adjacent to crecentic dunes.

GEOLOGY: Recent alluvial material. Qa.

SOILS: Very deep, strongly alkaline, grey clays. Surface textures (20 cm) are silty-clays whilst the subsoil is a heavy clay. Sandy layers are common. Lime concretions are common with gypsum prevalent in the subsoil. Representative soil analysis: 105.

VEGETATION: Samphire, saltbush forby low open shrubland. *Arthrocnemum* spp. (samphire) are predominant forming almost pure stands in places. *Atriplex* spp. (saltbushes) and other forbs are usually present. Grasses are not abundant, but *Eragrostis australasica* (swamp cane grass) may occur in depressions. Scattered low shrubs may be present.

STRUCTURAL FORM: Low open shrubland. Ht < 1.5 m, PFC 20 ± 10%.

LOW SHRUB LAYER: Ht < 1.5 m, PFC 20 ± 10%.

Predominant spp: *Arthrocnemum halocnemoides* var. *pergranulatum*, Ht < 0.5 m, PFC 20 ± 10%; *A. leiostachyum*, Ht < 0.5 m, PFC 20 ± 10%.

Frequent spp: *Pachycornia tenuis*.

Infrequent spp: *Myoporum acuminatum*.

GROUND LAYER: Ht < 0.5 m, PFC 10 ± 5%.

FORBS:

Predominant spp: *Atriplex elachophylla*, Ht < 0.5 m, PFC <5%, *A. lindleyi*, Ht < 0.5 m, PFC < 5%, *A. spongiosa*, Ht < 0.3 m, PFC < 5%.

Frequent spp: *Bassia bicornis*, *B. paradoxa*.

Infrequent spp: *Bassia divaricata*, *B. ventricosa*, *Centipeda thespidioides*, *Frankenia hamata*, *Heliotropium curassavicum*, *Lavatera plebeia*, *Mimulus prostratus*, *Plantago pritzelii*, *Senecio bipinnatisectus*.

GRAMINOIDS:

Frequent spp: *Dactyloctenium radulans*, *Eragrostis australasica*.

Infrequent spp: *Diplachne muelleri*, *Eragrostis dielsii*.

LAND USE: GC 0.9 to 2.0 beasts/km2 (1.4), DGC 0.1 to 0.4 beasts/km2 (0.2); fair condition, trend stable; saline soils; plant species not commonly eaten.

LAND UNIT 31

LANDFORM: Flat plains on flooded drainage lines. Mounded due to wind-blown material accumulating on bushes.

GEOLOGY: Wind-blown material overlying recent alluvial clay plain. Qa.

SOILS: A complex of very deep soils. Predominantly texture contrast soils on the mounded areas. Pale-brown, loose, fine-sandy-clay to silty-clay surface soil (30 cm) overlies pale-brown, alkaline, medium clay, subsoil with gypsum common. A surface crust is common. Interspersed are scalded claypans and grey cracking clays. Dy 1.13, Ug 5.25: *Tooratchie*. Representative soil analysis: 205.

VEGETATION: Old man saltbush low open shrubland. *Atriplex nummularia* (old man saltbush) forms a pure stand in places but frequently *Chenopodium auricomum* (bluebush) is present. Infrequently other scattered shrubs emerge. Ground flora is composed of grasses and forbs forming a sparse discontinuous cover.

STRUCTURAL FORM: Low open shrubland; Ht 1.5 ± .5 m; PFC 6 ± 4%.

TALL SHRUB LAYER: Ht 2 ± 1, PFC < 1%.

Infrequent spp: *Acacia farnesiana, A. victoriae.*

LOW SHRUB LAYER: Ht 1.5 ± 0.5 m, PFC 6 ± 4%.

Predominant spp: *Atriplex nummularia*, Ht 1.5 ± 0.5, PFC 1 to 10%.

Frequent spp: *Chenopodium auricomum.*

GROUND LAYER: Ht < 0.75 m; PFC 10 ± 10%.

FORBS:

Frequent spp: *Atriplex holocarpa, A. spongiosa, Boerhavia diffusa.*

Infrequent spp: *Centipeda thespidioides, Helipterum floribundum, H. strictum, Minuria leptophylla, Plantago pritzelii, Psoralea cinerea, Solanum esuriale, Teucrium racemosum.*

GRAMINOIDS:

Frequent spp: *Aristida anthoxanthoides, Sporobolus mitchellii.*

Infrequent spp: *Chloris pectinata, Eragrostis dielsii, E. leptocarpa, E. setifolia, Iseilema vaginiflorum, Panicum decompositum, Sporobolus actinocladus.*

LAND USE: GC 1.7 to 2.6 beasts/km^2 (2.1), DGC 0.8 to 1.1 beasts/km^2 (0.9); condition fair to poor, trend downwards; moderate WHC; susceptible to scalding by wind and water erosion, particularly if old man saltbush is removed; drought fodder supply; regeneration of old man saltbush adequate.

LAND UNIT 32

LANDFORM: Broad depressions (swamps) in flat alluvial plains; weak gilgai microrelief.

GEOLOGY: Recent clay alluvia associated with major drainage lines. Qa.

SOILS: Very deep, poorly drained, acid to neutral, grey clays. Strong, coarse structured, soils with surface crusts. Large cracks. Ug 5.25, Ug 5.28; *Houdraman*. Representative soil analysis: 16, 34.

VEGETATION: Bluebush forby low shrubland. *Chenopodium auricomum* (bluebush) occurs in pure stands. Ground flora is sparse and composed of grasses, sedges and forbs.

STRUCTURAL FORM: Low shrubland to low open shrubland; Ht 1 ± 0.25 m, PFC 10 ± 5%.

LOW SHRUB LAYER: Ht 1.25 m, PFC 10 ± 5%.

Predominant spp: *Chenopodium auricomum*, Ht 1 ± 0.25 m; PFC 10 ± 5%.

GROUND LAYER: Ht < 1 m, PFC 5 ± 5%.

FORBS:

Frequent spp: *Damasonium minus, Marsilea drummondii.*

Infrequent spp: *Aeschynomene indica, Bassia stelligera, Centipeda thespidioides.*

GRAMINOIDS:

Frequent spp: *Cyperus difformis, C. gymnocaulis, Elytrophorus spicatus, Scirpus dissachanthus.*

LAND USE: GC 3.4 to 6.0 beasts/km^2 (5.6); DGC 0.8 to 1.5 beasts/km^2 (1.1); fair to good condition, trend stable; high WHC. fair fertility; poorly drained; valuable standover.

LAND UNIT 33

LANDFORM: Sloping drainage lines in undulating plains. Slopes 0 to 1%.

GEOLOGY: Local alluvia made up of redistributed detritus from the erosion of the weathered Cretaceous *Winton Formation*. Qa/Kw.

SOILS: Soils are stony (and boulders), shallow to deep, clay-loams and sandy-clays. *Nockatunga.*

VEGETATION: Mineritchie fringing tall open shrubland. *Acacia cyperophylla* (mineritchie) predominates forming pure stands in places. *Acacia cambagei* (gidgee) and other scattered trees may be present emerging above the canopy. There is no well defined lower shrubby layer but scattered shrubs may occur. Ground cover is variable composed of forbs and grasses.

STRUCTURAL FORM: Tall open shrubland to tall shrubland: Ht 6 ± 2 m, PFC (variable) 10 ± 9%.

TREE, TALL SHRUB LAYER: Ht 6 ± 2 m, PFC 10 ± 9%.

Predominant spp: *Acacia cyperophylla*, Ht 6 ± 2 m, PFC 10 ± 9%.

Frequent spp: *Acacia cambagei, A. tetragonophylla.*

Infrequent spp: *Acacia victoriae, Atalaya hemiglauca, Bauhinia carronii, Eucalyptus camaldulensis, E. microtheca.*

LOW SHRUB LAYER: Ht < 2 m, PFC < 1%.

Frequent spp: *Cassia helmsii, C. nemophila.*

Infrequent spp: *Cassia oligophylla, Eremophila bignoniiflora, E. duttonii, E. polyclada.*

GROUND LAYER: Ht < .5 m, PFC (variable) 1 to 10%.

FORBS:

Frequent spp: *Atriplex lindleyi, A. spongiosa, Bassia divaricata, B. lanicuspis.*

Infrequent spp: *Boerhavia diffusa, Kochia aphylla.*

GRAMINOIDS:

Frequent spp: *Brachiaria miliiformis, Chloris pectinata, C. scariosa, Dactyloctenium radulans, Enneapogon polyphyllus, Panicum decompositum, P. whitei.*

Infrequent spp: *Astrebla pectinata, Digitaria ammophila, Eragrostis setifolia, Tripogon loliiformis.*

LAND USE: GC 1.6 to 2.1 beasts/km2 (1.6), DGC 0.4 beasts/km3; fair condition, trend stable to slight downwards; low to moderate WHC, low fertility; susceptible to gully erosion; top feed not abundant; provides shade on treeless plains.

LAND UNIT 34

LANDFORM: Flat alluvial plains. Weak to moderate gilgai microrelief up to 30 cm amplitude.

GEOLOGY: Recent clay alluvia. Qa.

SOILS: Very deep, gilgaied, grey and brown cracking clays (some small areas of red clay). Soils are neutral to alkaline and some have large amounts of gypsum in the soil profile. Soils crack widely but have a surface crust which is easily broken. Textures are heavy clays. Ug 5.24, Ug 5.25, Ug 5.28, Ug 5.34, Ug 5.38; *Comongin, Cottesmore, Wilson.* Representative soil analysis: 14, 15, 127.

VEGETATION: Gidgee forby tall open shrubland. *Acacia cambagei* (gidgee) predominates. Scattered emerging trees and very infrequently *A. cana* (boree) may occur. A low shrubby layer is not usually well defined but scattered low shrubs may be present. Ground cover is variable composed mainly of forbs but grasses do occur.

STRUCTURAL FORM: Tall open shrubland to tall shrubland, Ht 6 ± 2 m, PFC 10 ± 5%.

TREE, TALL SHRUB LAYER: Ht 6 ± 2 m, PFC 10 ± 5%.

Predominant spp: *Acacia cambagei*, Ht 6 ± 2 m, PFC 10 ± 5%.

Frequent spp: *Eucalyptus microtheca, E. ochrophloia.*

Infrequent spp: *Acacia cana.*

LOW SHRUB LAYER: Ht 1.5 ± 0.75 m, PFC < 1%.

Frequent spp: *Chenopodium auricomum, Enchylaena tomentosa.*

Infrequent spp: *Cassia desolata, Eremophila bignoniiflora, E. maculata, Rhagodia spinescens.*

GROUND LAYER: Ht < 0.5 m, PFC 15 ± 10%.

FORBS:

Frequent spp: *Atriplex lindleyi, A. muelleri, A. spongiosa, Bassia andersonii, B. anisacanthoides, B. bicornis, B. calcarata, B. divaricata, B. intricata, B. lanicuspis, B. quinquecuspis, Dysphania myriocephala, Portulaca* sp. aff. *P. oleracea, Salsola kali, Threlkeldia proceriflora.*

Infrequent spp: *Abutilon malvifolium, Amaranthus mitchellii, Atriplex elachophylla, Boerhavia diffusa, Chenopodium melanocarpum, Euphorbia wheeleri, Helipterum corymbiflorum, H. floribundum, Kochia aphylla, K. coronata, Lepidium oxytrichum, L. rotundum, Lotus cruentus, Sida goniocarpa, Tetragonia tetragonioides, Trianthema galericulata, T. triquetra, Tribulus terrestris.*

GRAMINOIDS:

Frequent spp: *Dactyloctenium radulans, Eragrostis dielsii, E. leptocarpa, E. parviflora, E. setifolia, Sporobolus actinocladus, S. caroli, Tragus australianus.*

Infrequent spp: *Aristida anthoxanthoides, A. contorta, Astrebla pectinata, Brachyachne convergens, Chloris pectinata, Dichanthium sericeum, Panicum whitei, Tripogon loliiformis.*

LAND USE: GC 3.9 to 10.0 beasts/km2 (5.8), DGC 0.4 beasts/km2; fair to good condition, trend stable to slight downwards; high WHC; low to moderate infiltration rates; susceptible to scalding; top feed absent; frequently flooded.

LAND UNIT 35

LANDFORM: Flat alluvial plains.

GEOLOGY: Recent alluvia subject to deflation. Qa.

SOILS: Soils are very deep, brown clays (small areas of grey clays) with scalded surface. Soils have surface crusts < 1 cm thick, under which the soils are strongly structured. Crusts may be vesicular or platy. Soil reaction trends are mainly neutral with some soils becoming alkaline with depth (gypsum in these soils). Mn staining is common. Ug 5.34, Ug 5.24, Ug 5.25; *Quilpie.* Representative soil analysis: 17, 172, 204.

VEGETATION: Bare to very sparse forbland. *Atriplex* spp. (saltbush), *Bassia* spp., other forbs and scattered grasses form a very sparse forbland with associated areas devoid of vegetation.

STRUCTURAL FORM: Nil vegetation to sparse forbland; Ht < 0.5 m, PFC < 1%.

GROUND LAYER: Ht < 0.5 m, PFC < 1%.

FORBS:

Frequent spp: *Atriplex spongiosa, Bassia lanicuspis, Portulaca* sp. aff. *P. oleracea.*

Infrequent spp: *Atriplex elachophylla, A. lindleyi, Boerhavia diffusa, Tribulus terrestris, Trianthema triquetra, Zygophyllum ammophilum.*

GRAMINOIDS:

Frequent spp: *Dactyloctenium radulans, Tripogon loliiformis.*

Infrequent spp: *Eragrostis dielsii, Panicum whitei, Sporobolus australasicus, Tragus australianus.*

LAND USE: GC 0.4 to 1 beast/km2 (0.7), DGC – ; poor to very poor condition, trend downwards; moderate WHC, infiltration rates extremely low; susceptible to further scalding by wind and water erosion; areas may be reclaimed, at a cost, by ponding water and restricting stocking; extent of areas vary with seasons.

LAND UNIT 36

LANDFORM: Slightly depressed areas in flat alluvial plains.

GEOLOGY: Alluvial plain subject to deflation. Qa.

SOILS: Soils are very deep, grey clays (light-brown in colour) with a hard surface crust (1 cm). They are strongly alkaline with gypsum prevalent in the lower parts of the profile Ug 5.24; *Wittenburra*. Representative soil analysis: 9, 66.

VEGETATION: Bare or very sparse chenopod forbland. Predominantly *Atriplex* spp. (saltbush) and *Bassia* spp. form a very sparse ground cover with grasses rarely present. Extensive areas are devoid of vegetation.

STRUCTURAL FORM: Very sparse forbland.

GROUND LAYER: Ht < 0.4 m, PFC < 1%.

FORBS:

Frequent spp: *Atriplex lindleyi, A. spongiosa, Bassia calcarata, B. lanicuspis.*

Infrequent spp: *Alternanthera nodiflora, Boerhavia diffusa, Centipeda thespidioides, Marsilea* spp., *Portulaca* sp. aff. *P. oleracea, Solanum esuriale, Trianthema galericulata.*

GRAMINOIDS:

Frequent spp: *Eragrostis dielsii.*

Infrequent spp (mainly on sandy rises): *Chloris pectinata, Dactyloctenium radulans, Diplachne muelleri, Iseilema vaginiflorum.*

LAND USE: GC 0.3 to 0.6 beasts/km2 (0.5), DGC – ; poor to very poor condition, trend downwards; moderate WHC, infiltration extremely low; occasionally flooded.

LAND UNIT 37

LANDFORM: Flat alluvial floodplain with shallow channels (< 50 cm deep) spread throughout the "channel country".

GEOLOGY: Recent clay alluvia. Qa.

SOILS: Very deep, alkaline, heavy grey clays. Soils crack widely and are difficult to auger when dry. Lime and gypsum may be present in the profile. Soils have thin surface cursts. Ug 5.24; *Tabbareah*. Representative soil analysis: 94, 95, 203.

VEGETATION: Short grass forby herbfield. Short grasses and forbs predominate. Depending on seasonal conditions *Echinochloa turnerana* (channel millet) may predominate or under other environmental influences *Trigonella suavissima* (Cooper clover) and *Craspedia pleiocephala* (yellowtop) may predominate. Scattered shrubs of *Chenopodium auricomum* (bluebush) and *Acacia stenophylla* (belalie) may be found along the channels.

STRUCTURAL FORM: Herbfield (forbland or grassland depending on seasonal influences): Ht < .75 m; PFC 0 ± 10% on rises, 30 ± 20% in channels.

LOW SHRUB LAYER: Ht 1.5 ± 1 m, PFC < 1%.

Infrequent spp: Scattered: *Acacia stenophylla, Chenopodium auricomum, Muehlenbeckia cunninghamii.*

GROUND LAYER: Ht < 0.5 m, PFC (variable) 30 ± 20%.

FORBS:

Frequent spp (on rises): *Atriplex limbata, A. spongiosa, A. lindleyi, Bassia andersonii, B. divaricata, Boerhavia diffusa, Kochia coronata, Minura integerrima, Neptunia dimorphantha, Psoralea cinerea, Salsola kali, Trianthema galericulata, T. portulacastrum, T. triquetra.*

In channels: *Aeschynomene indica, Alternanthera denticulata, A. nodiflora, Centipeda thespidioides, Euphorbia australis, E. drummondii, Trigonella suavissima.*

Infrequent spp (on rises): *Eryngium rostratum, Amaranthus mitchellii, Atriplex crassipes, Bassia bicornis, B. quinquecuspis, B. stelligera, B. ventricosa, Ptilotus murrayi.*

In channels: *Brachycome ciliaris* var. *lanuginosa, Calostemma luteum, Calotis multicaulis, Crinum pestilentis.*

GRAMINOIDS:

Frequent spp (on rises): *Astrebla pectinata, Dactyloctenium radulans, Eragrostis setifolia, Panicum whitei.*

In channels: *Chloris pectinata, Cyperus iria, Echinochloa turnerana, Iseilema membranaceum, I. vaginiflorum, Uranthothecium truncatum.*

Infrequent spp (on rises): *Astrebla elymoides, A. squarrosa, Diplachne muelleri, Eragrostis dielsii, Fimbristylis dichotoma, Sporobolus actinocladus, Tripogon loliiformis.*

In channels: *Eragrostis tenellula.*

LAND USE: GC 5.1 to 8.1 beasts/km2 (6.3), DGC 0.3 to 0.4 beasts/km2 (0.4); fair to good condition, trend stable; high WHC, infiltration variable; frequently flooded.

L A N D U N I T 3 8

LANDFORM: Flat alluvial flood plain with low rises, swales and channels (< 1 m). Weak gilgai microrelief in places.

GEOLOGY: Recent clay alluvia. Qa.

SOILS: Very deep, widely cracking, light-brownish-grey, heavy clay. Soils are neutral to slightly alkaline in the surface and become alkaline with depth. Gypsum may be present in the lower part of the profile. Ug 5.28, Ug 5.24; *Tabbareah*. Representative soil analysis: 208, 209, 168.

VEGETATION: Bluebush, lignum forby low open shrubland. *Chenopodium auricomum* (bluebush) and *Muehlenbeckia cunninghamii* (lignum) occur the latter associated with the channels. Depending on the incidence and duration of flooding *Trigonella suavissima* (Cooper clover) and *Craspedia pleiocephala* (yellowtop) may predominate the ground layer with *T. suavissima* forms dense stands in the channels and *C. pleiocephala* is conspicuous on the slight rises. Other forbs occur. Grasses are rare after winter flooding but predominate after summer flooding. *Echinochloa turnerana* predominates the ground cover under these conditions. Scattered trees of *Eucalyptus microtheca* (coolibah) are found on the deeper depressions.

STRUCTURAL FORM: Low open shrubland: Ht 1 ± 0.5 m, PFC 3 ± 2%; or forbland (with emerging low shrubs), Ht < 0.5 m, PFC 50 ± 20%.

TREE, TALL SHRUB LAYER: Ht < 4 m, PFC < 1%.

Infrequent spp: *Eucalyptus microtheca*.

LOW SHRUB LAYER: Ht 1 ± 0.5 m, PFC 3 ± 2%.

Predominant spp: *Chenopodium auricomum*, Ht 0.5 ± 0.6 m, PFC 3 ± 2%; *Muehlenbeckia cunninghamii*, Ht < .5 ± 1.5 m, PFC < 1%.

GROUND LAYER: Ht < 0.5 m, PFC (variable) 0 to 70%.

FORBS:

Frequent spp (after autumn-winter floods): *Craspedia pleiocephala, Helipterum corymbiflorum, Senecio lautus, Trigonella suavissima*.

Infrequent spp: *Atriplex spongiosa, Bassia divaricata, Calostemma luteum, Calotis hispidula, Daucus glochidiatus, Eryngium rostratum, Ixiolaena brevicompta, Mimulus prostratus, Psoralea cinera, Tetragonia tetragonioides*.

GRAMINOIDS:

Frequent spp (after summer flooding): *Echinochloa turnerana, Panicum whitei*.

Infrequent spp: *Dactyloctenium radulans, Iseilema membranaceum*.

LAND USE: GC 5.1 to 9.8 beasts/km2 (7.4), DGC 0.4 beasts/km2; good to very good condition, trend stable; high WHC, moderate fertility; frequently flooded; top feed absent.

L A N D U N I T 3 9

LANDFORM: Flat alluvial plains with braided channels (< 0.5 m relief).

GEOLOGY: Recent alluvia. Qa.

SOILS: Deep to very deep, red and brown, texture contrast soils formed from alluvial material. The red and brown texture contrast soils are neutral, clay-loams to silty-clays on the surface and alkaline, medium to heavy clays at depth. They may crack and have surface crusts. Associated are texture contrast soils with neutral, fine-sandy-clay-loams to silty-clay-loams in the surface soil (20 cm) and medium to heavy clays at depth. $CaCO_3$ and gypsum may be present in the subsoil. Dr 1.13, Dr 1.12, Dr 2.13, Dr 2.12; *Caiwarro, Wanna*. Representative soil analysis: 68, 87, 156.

VEGETATION: Gidgee shrubby tall shrubland. *Acacia cambagei* (gidgee) predominates. In places *Eucalyptus ochrophloia* (yapanyah) is conspicuous and other scattered trees may occur. There is a well defined low shrubby layer. Ground cover is variable composed of forbs and grasses.

STRUCTURAL FORM: Tall shrubland to tall open shrubland: Ht 6 ± 1 m, PFC 15 ± 10%.

TREE, TALL SHRUB LAYER: Ht 8 ± 3 m, PFC 15 ± 10%.

Predominant spp: *Acacia cambagei*, Ht 6 ± 1 m, PFC 15 ± 10%.

Frequent spp: *Eucalyptus ochrophloia*.

Infrequent spp: *Eucalyptus camaldulensis*.

LOW SHRUB LAYER: Ht 1.5 ± 0.5 m, PFC 5 ± 4%.

Frequent spp: *Cassia desolata, C. nemophila* var. *nemophila, Eremophila mitchellii, Myoporum deserti*.

Infrequent spp: *Eremophila polyclada, E. sturtii, Exocarpos aphylla* (in places forms dense stands).

GROUND LAYER: Ht < 0.5 m, PFC (variable) 15 ± 10%.

FORBS:

Frequent spp: *Bassia convexula, B. divaricata, B. parallelicuspis, Salsola kali, Solanum ellipticum, S. quadriloculatum*.

Infrequent spp: *Abutilon otocarpum, Kochia villosa, Justicia procumbens, Portulaca* sp. aff. *P. oleracea, Ptilotus nobilis, P. obovatus*.

GRAMINOIDS:

Frequent spp: *Chloris pectinata, Dactyloctenium radulans, Enteropogon acicularis, Eragrostis setifolia, Tragus australianus*.

Infrequent spp: *Sporobolus caroli, Tripogon loliiformis*.

LAND USE: GC 2.3 to 4.7 beasts/km2 (3.8), DGC 0.5 to 1.0 beasts/km2 (0.7); fair condition, trend stable to slightly downwards; moderate WHC, low to moderate infiltration rates; susceptible to sheet and gully erosion; top feed not abundant; woody regrowth; subject to periodic flooding.

LAND UNIT 40

LANDFORM: Alluvial plain, often braided. Gilgai microrelief. Relative relief < 0.5 m.

GEOLOGY: Recent clay alluvia. Qa.

SOILS: Very deep, grey, cracking clays. Common soil reaction is alkaline but acid soil reactions occur at depth. Both lime and gypsum occur in the profile, with gypsum common at depth. Crusting is common. Ug 5.24, Ug 5.25; *Comongin, Cottesmore*. Representative soil analysis: 10, 11, 13.

VEGETATION: Gidgee forby woodland. *Acacia cambagei* (gidgee) predominates. Frequently *Eucalyptus ochrophloia* (yapunyah) occurs and other trees may be present. Scattered mid-height shrubs may occur but usually do not form a well defined layer. A low shrubby layer may well be developed. Ground cover is variable composed of forbs, sedges and grasses.

STRUCTURAL FORM: Woodland: Ht 8 ± 2 m, PFC 17.5 ± 7.5%.

TREE, TALL SHRUB LAYER: Ht 8 ± 2 m, PFC 17.5 ± 7.5%.

Predominant spp: *Acacia cambagei*, Ht 8 ± 2 m, PFC 15 ± 5%.

Frequent spp: *Acacia stenophylla, Eremophila bignoniiflora, Eucalyptus ochrophloia.*

Infrequent spp: *E. camaldulensis, E. microtheca.*

LOW SHRUB LAYER: Ht 1.5 ± 0.75 m, PFC 5 ± 4%.

Frequent spp: *Chenopodium auricomum, Enchylaena tomentosa, Eremophila polyclada, Myoporum deserti.*

Infrequent spp: *Arthrocnemum* spp., *Myoporum acuminatum.*

GROUND LAYER: Ht < 0.75 m, PFC 20 ± 10%.

FORBS:

Frequent spp: *Atriplex lindleyi, A. muelleri, A. spongiosa, Bassia divaricata, B. quinquecuspis, B. stelligera, Portulaca* sp. aff. *P. oleracea, Salsola kali, Trianthema triquetra.*

Infrequent spp: *Brachycome ciliaris* var. *lanuginosa, Goodenia subintegra, Minuria integerrima, Solanum ellipticum, S. quadriloculatum.*

Depressions: *Alternanthera denticulata, A. nodiflora, Bassia divaricata, Centipeda thespidioides, Marsilea drummondii. M. hirsuta.*

GRAMINOIDS:

Frequent spp: *Chloris pectinata, Eragrostis dielsii, E. parviflora, E. leptocarpa, E. setifolia, Eriochloa pseudoacrotricha, Iseilema membranaceum, Sporobolus actinocladus, S. mitchellii, S. caroli.*

Infrequent spp: *Astrebla lappacea, Bothriochloa ewartiana, Brachiaria miliiformis, Dactyloctenium radulans, Echinochloa colonum, Eragrostis confertiflora, Eulalia fulva, Leptochloa digitata, Lomandra longifolia, Paspalidum jubiflorum.*

Depressions: *Cyperus dactylotes, C. difformis, C. iria, C. rigidellus, Diplachne muelleri.*

LAND USE: GC 3.3 to 6.8 beasts/km2 (5.7), DGC 0.5 to 0.9 beasts/km2 (0.7); good to fair condition, trend stable; WHC high, low to moderate infiltration rates; frequently flooded; top feed not abundant; woody weeds may be a problem; tree density affects productivity.

LAND UNIT 41

LANDFORM: Flat plain with deflated, scalded, claypan areas. < 0.5 m relief.

GEOLOGY: Recent alluvia. Qa.

SOILS: Very deep, grey clays with scalded, grey clays intermixed. The grey clays are heavy clays with thin, hard, surface crusts with crack. Soils are neutral to alkaline at the surface and alkaline to strongly alkaline at depth. Scalded claypan areas have a surface crust and are alkaline throughout, with lime in the profile. Ug 5.24; *Currawinya, Wittenburra.* Representative soil analysis: 67, 51.

VEGETATION: Yapunyah forby woodland. *Eucalyptus ochrophloia* (yapunyah) predominates. Other scattered trees may occur and in places *Acacia cambagei* (gidgee) is conspicuous. Usually there is no well defined lower shrubby layer but scattered shrubs may be present. Ground cover is variable composed of forbs and grasses. In places the shrub-like grass *Eragrostis australasica* (swamp cane grass) may be conspicuous.

STRUCTURAL FORM: Woodland, Ht 10 ± 2 m, PFC 15 ± 5%.

TREE, TALL SHRUB LAYER: Ht 10 ± 2 m, PFC 15 ± 5%.

Predominant spp: *Eucalyptus ochrophloia*, Ht 10 ± 2 m, PFC 15 ± 5%.

Frequent spp: *Acacia cambagei.*

Infrequent spp: *Acacia stenophylla, E. populnea, Grevillea striata.*

LOW SHRUB LAYER: Ht 1 ± 0.5 m, PFC 3 ± 2.5%.

Frequent spp: *Chenopodium auricomum, Muehlenbeckia cunninghamii, Myoporum deserti.*

Infrequent spp: *Arthrocnemum* spp., *Eremophila polyclada.*

GROUND LAYER: Ht < .5 m, PFC 30 ± 20%.

FORBS:

Frequent spp: *Alternanthera nodiflora, Bassia bicornis, B. divaricata, B. quinquecuspis, Marsilea drummondii* (depressions), *Solanum ellipticum, Tetragonia tetragonioides.*

Infrequent spp: *Chenopodium melanocarpum, Calotis multicaulis, Evolvulus alsinoides, Helipterum cormybiflorum, Malvastrum spicatum, Portulaca* sp. aff. *P. oleracea, Sarcostemma australe, Teucrium racemosum, Trianthema galericulata, Velleia glabrata.*

GRAMINOIDS:

Frequent spp: *Chloris pectinata, Dactyloctenium radulans, Enteropogon acicularis, Eragrostis dielsii, E. leptocarpa, E. setifolia, E. tenellula, Sporobolus mitchellii, S. caroli.*

Infrequent spp: *Aristida anthoxanthoides, Diplachne muelleri, Eragrostis australasica.*

LAND USE: GC 2.9 to 5.8 beasts/km2 (4.4), DGC 0.3 to 0.6 beasts/km2 (0.4); good to fair condition, trend stable to slight downwards; high WHC, infiltration rates low; frequently flooded; top feed absent; valuable source of honey.

LAND UNIT 42

LANDFORM: Braided alluvial plains usually with one well defined channel. Relief < 3 m.

GEOLOGY: Recent alluvia derived mainly from weathered Cretaceous *Winton Formation* sediments and the weathered Cainozoic mantle. Qa.

SOILS: Soils are predominantly alluvial soils with texture contrast soils intermixed. Some brown and grey clays may also be intermixed but they are of limited area. Soils are deep to very deep with sandy-loam to loam surfaces and red and brown, sandy-clay-loam to sandy-clay subsoils with sand bands intermixed. Dy 2.12, 2.53, Dr 1.13, Dr 1.12, Dr 2.13; *Wanna, Okena*. Representative soil analysis: 55, 132, 138, 140.

VEGETATION: River red gum and/or coolibah and/or gidgee fringing woodland. *Eucalyptus camaldulensis* (river red gum) and or *E. microtheca* (coolibah) and/or *Acacia cambagei* (gidgee) are conspicuous. Other scattered trees may occur. A tall shrubby layer is frequently well developed. Low shrubs may be found but usually do not form a well developed layer. Ground cover is variable composed of forbs and grasses.

STRUCTURAL FORM: Woodland, Ht 9 ± 4 m, PFC (variable) 15 ± 5%.

TREE LAYER: Ht 9 ± 4 m. PFC 15 ± 5%.

Predominant spp: *Acacia cambagei*, Ht 6 ± 1 m. PFC 7.5 ± 7.5%; *Eucalyptus camaldulensis*, Ht 10 ± 3 m. PFC 7.5 ± 7%; *E. microtheca*, Ht 8 ± 3 m, PFC 5 ± 5%.

Infrequent spp: *Atalaya hemiglauca, Eucalyptus populnea, E. terminalis, Grevillea striata, Ventilago viminalis.*

TALL SHRUB LAYER: Ht 4 ± 1 m, PFC < 5%.

Frequent spp: *Acacia stenophylla, A. tetragonophylla, A. victoriae, Eremophila bignoniiflora.*

Infrequent spp: *Acacia aneura, A. oswaldii, Capparis loranthifolia, Owenia acidula, Santalum lanceolatum.*

LOW SHRUB LAYER: Ht 1.5 ± 0.5 m, PFC 3 ± 2.5%.

Frequent spp: *Acacia farnesiana, Cassia phyllodinea, C. nemophila* var. *nemophila, C. nemophila* var. *zygophylla, Eremophila mitchellii, E. sturtii, Myoporum acuminatum, M. deserti.*

Infrequent spp: *Exocarpos aphylla* (in places forms dense stands); *Kochia integra, Rhagodia spinescens.*

GROUND LAYER: Ht < 1 m. PFC (variable) 30 ± 20%.

FORBS:

Frequent spp: *Alternanthera nodiflora, Atriplex muelleri, A. spongiosa, A. vesicaria, Bassia divaricata, Boerhavia diffusa, Calotis hispidula, C. inermis, Centipeda thespidioides, Indigofera dominii, Kochia triptera, Malvastrum spicatum, Minuria integerrima, Portulaca* sp. aff. *P. oleracea, Psoralea eriantha, Ptilotus macrocephalus, Solanum ellipticum, S. esuriale, S. sturtianum, Salsola kali, Tetragonia tetragonioides, Trichodesma zeylanicum.*

Infrequent spp: *Abutilon fraseri, A. leucopetalum, A. otocarpum, Babbagia scleroptera, Bassia eriacantha, Brachycome ciliaris* var. *lanuginosa, Crinum pestilentis, Indigofera brevidens, Lotus cruentus, Marsilea* spp., *Ptilotus nobilis. P. obovatus, P. polystachyus, Pterocaulon sphacelatum, Rhagodia nutans, Sida filiformis, Trachymene ochracea, Vittadinia triloba, Xanthium pungens, Zygophyllum ammophilum, Z. apiculatum.*

GRAMINOIDS:

Frequent spp: *Aristida contorta, A. jerichoensis, Chloris pectinata, Chrysopogon fallax, Cyperus exaltatus, C. victoriensis, Dactyloctenium radulans, Dichanthium affine, D. sericeum, Digitaria brownii, D. coenicola, Eleocharis pallens, Eragrostis cilianensis, E. dielsii, E. elongata, Eriochloa pseudoacrotricha, Eulalia fulva, Leptochloa digitata, Paspalidum jubiflorum, Themeda australis.*

Infrequent spp: *Aristida biglandulosa, Astrebla elymoides, A. pectinata, Brachiaria gilesii, B. miliiformis, B. praetervisa, Echinochloa colonum, Enneapogon polyphyllus, Panicum whitei, Tripogon loliiformis.*

LAND USE: GC 1.2 to 2.5 beasts/km2 (1.9), DGC 0.3 to 0.7 beasts/km2 (0.5); fair to poor condition, trend downwards; low to moderate WHC, low to moderate infiltration rates; susceptible to scalding by wind and water erosion; woody regrowth; sheet flooding.

LAND UNIT 43

LANDFORM: Flat alluvial plains with moderate gilgai microrelief (< 0.5 m). Subject to flooding.

GEOLOGY: Recent alluvia. Qa.

SOILS: Very deep, brown and grey clays neutral at the surface and strongly alkaline at depth. Lime concretions in the subsoil. Surface soil forms a thin hard crust. Representative soil analysis: 52.

VEGETATION: Coolibah low open woodland. *Eucalyptus microtheca* (coolibah) predominates. Usually there is no well defined lower shrubby layer but scattered low shrubs occur. *Muehlenbeckia cunninghamii* (lignum) may be found in depressions. Ground cover is variable composed mainly of forbs but grasses do occur.

STRUCTURAL FORM: Low open woodland; Ht 7 ± 2 m, PFC 7.5 ± 2.5%.

TREE, TALL SHRUB LAYER: Ht 7 ± 2 m, PFC 7.5 ± 2.5%.

Predominant spp: *Eucalyptus microtheca*, Ht 7 ± 2 m, PFC 7.5 ± 2.5%.

LOW SHRUB LAYER: Ht 1.5 ± 0.5 m, PFC < 1%.

Frequent spp: *Chenopodium auricomum, Eremophila maculata.*

Infrequent spp: *Muehlenbeckia cunninghamii* (confined to depressions).

GROUND LAYER: Ht < 0.5 m, PFC 15 ± 10%.

FORBS:

Frequent spp: *Alternanthera nodiflora, Atriplex elachophylla, A. spongiosa, Bassia bicornis, B. quinquecuspis, Centipeda thespidioides, Marsilea drummondii, M. hirsuta* (depressions), *Malvastrum spicatum, Psoralea cinerea, Teucrium racemosum.*

Infrequent spp: *Abutilon oxycarpum, Chenopodium melanocarpum, Convolvulus erubescens, Daucus glochidiatus, Helipterum strictum, Hibiscus brachysiphonus, Indigofera pratensis, Lotus cruentus, Minuria denticulata, M. integerrima, Plantago pritzelii, Portulaca* sp. aff. *P. oleracea, Salsola kali, Sida trichopoda, Solanum esuriale.*

GRAMINOIDS:

Frequent spp: *Cyperus difformis, C. iria, C. rigidellus, Dactyloctenium radulans, Eragrostis dielsii, E. parviflora, E. setifolia.*

Infrequent spp: *Astrebla pectinata, Chloris pectinata, Panicum whitei, Sporobolus caroli.*

LAND USE: GC 3.9 to 10 beasts/km2 (6.0), DGC 0.3 to 0.7 beasts/km2 (0.5); fair to good condition, trend stable; high WHC, low infiltration rates; top feed absent.

LAND UNIT 44

LANDFORM: Flat plain associated with local creek alluvia. Drained by a main channel.

GEOLOGY: Recent alluvia. Qa.

SOILS: Alluvial soil. Texture contrast soil with a red, hardsetting, massive, neutral, clay-loam surface soil (20 cm) overlying alkaline, massive, coarse-sandy-clay subsoil with soft $CaCO_3$ concretions at depth. Bleached A2. Dr 2.83.

VEGETATION: Poplar box grassy open woodland. *Eucalyptus populnea* (poplar box) predominates. There is no well defined lower shrubby layer but scattered shrubs may occur. The ground flora is composed mainly of grasses resulting in a sparse to mid-dense cover. Forbs also may be present.

STRUCTURAL FORM: Open woodland: Ht 10 ± 2 m, PFC 3 ± 2%.

TREE LAYER: Ht 10 ± 2 m, PFC 3 ± 2%.

Predominant spp: *Eucalyptus populnea.*

Infrequent spp: *Grevillea striata.*

TALL SHRUB LAYER: Ht 3 ± 1 m, PFC < 1% (increase up to 5% in places).

Frequent spp: *Eremophila mitchellii.*

LOW SHRUB LAYER: Ht 1.25 ± 0.75 m, PFC < 1%.

Frequent spp: *Acacia tetragonophylla, Eremophila bowmanii.*

Infrequent spp: *Cassia artemisioides.*

GROUND LAYER: Ht 1 ± .5 m, PFC 30 ± 10%.

FORBS:

Frequent spp: *Bassia birchii, B. calcarata, Solanum ferocissimum, S. ellipticum.*

Infrequent spp: *Alternanthera nodiflora, Evolvulus alsinoides.*

GRAMINOIDS:

Frequent spp: *Aristida helicophylla, A. ingrata, Bothriochloa ewartiana, Eragrostis elongata, Themeda australis.*

Infrequent spp: *Chloris pectinata, Enneapogon polyphyllus, Eragrostis kennedyae, Eriachne mucronata.*

LAND USE: GC 2.2 to 4.6 beasts/km2 (3.4), DGC 0.3 to 0.6 beasts/km2 (0.4); fair condition, trend slightly downwards: low to moderate WHC, moderate infiltration rates, low fertility; susceptible to sheet and gully erosion; top feed absent.

LAND UNIT 45

LANDFORM: Drainage depressions in slightly undulating to flat sandplains (run-on areas).

GEOLOGY: Quaternary deposits. Qa/Qs.

SOILS: Shallow to deep, texture contrast soils with massive, earthy, reddish-brown to brown, sandy-loam to sandy-clay-loam surface soil and sandy-clay subsoil. A bleached A2 is well developed. Dy 1.42, Dy 2.43: *Tintinchilla.* Representative soil analysis: 6.

VEGETATION: Mulga, poplar box grassy tall shrubland to woodland. Usually *Acacia aneura* (mulga) and *Eucalyptus populnea* (poplar box) occur with either predominating depending on local variation in habitat. There is no well defined shrubby layer but scattered shrubs may be present. Grasses predominate the ground flora and together with sedges and forbs form a variable ground cover mid-dense to dense in places.

STRUCTURAL FORM: Tall shrubland to woodland (depending on predominant species): Ht 7 ± 1 m, or 10 ± 2 m, PFC 12.5 ± 5%.

TREE, TALL SHRUB LAYER: Ht 7 ± 1 m, PFC 12.5 ± 5%.

Predominant spp: *Acacia aneura,* Ht 7 ± 1 m, PFC 5 ± 5%, *Eucalyptus populnea,* Ht 10 ± 2 m, PFC 7 ± 6%.

LOW SHRUB LAYER: Ht 0.75 ± 0.5 m, PFC < 1%.

Frequent spp: *Cassia artemisioides, Muehlenbeckia cunninghamii* (very rare, confined to depressions).

Infrequent spp: *Eremophila gilesii.*

GROUND LAYER: Ht < 1.0 m, PFC 15 ± 10%.

FORBS:

Frequent spp: *Bassia bicornis, Boerhavia diffusa, Centipeda thespidioides, Marsilea* spp. (in depressions), *Phyllanthus maderaspatensis.*

Infrequent spp: *Alternanthera denticulata, A. nodiflora, Centipeda minima, Cleome viscosa, Evolvulus alsinoides, Helipterum strictum, Malvastrum spicatum, Poranthera microphylla, Solanum ellipticum, S. nigrum, Teucrium racemosum.*

GRAMONOIDS:

Frequent spp: *Chloris pectinata, Cyperus iria, Cynodon dactylon.*

Infrequent spp: *Bothriochloa ewartiana, Diplachne muelleri, Echinochloa colonum, Eleocharis pallens, Eragrostis dielsii, E. kennedyae, E. microcarpa, E. parvifloa, Fimbristylis dichotoma, Perotis rara.*

LAND USE: GC 3.1 to 4.4 beasts/km2 (3.7), DGC 1.3 to 2.5 beasts/km2 (1.9); fair to good condition, stable trend; moderate WHC, run-on area; top feed.

LAND UNIT 46

LANDFORM: Lower slopes of flat plains.

GEOLOGY: Superficial Quaternary deposits. Qr, Qa.

SOILS: Moderately deep to deep, slightly acid to neutral, loamy, red earths with ironstone gravel in the profile. Textures range from sandy-clay-loam to clay-loam at the surface to light to medium clay at depth. Soils are massive throughout with some surface organic matter accumulation in good seasons. Gn 2.12; *Tinnenburra*. Representative soil analysis: 41, 60, 71.

VEGETATION: Mulga, poplar box grassy tall shrubland. *Acacia aneura* (mulga) predominates with *Eucalyptus populnea* (poplar box) usually emerging above the canopy. Other trees may be present. There is no well defined low shrubby layer but scattered low shrubs occur. *E. gilesii* (Charleville turkey bush) may form dense stands in places. Ground cover is variable composed mainly of grasses but numerous forbs are also present.

STRUCTURAL FORM: Tall shrubland to low woodland: Ht 6 $\pm$ 1 m, rarely 10 m, PFC 15 $\pm$ 5%.

TREE, TALL SHRUB LAYER: Ht 8 $\pm$ 2 m, PFC 15 $\pm$ 5%.

Predominant spp: *Acacia aneura*, Ht 6 $\pm$ 1 m, PFC 15 $\pm$ 5%.

Frequent spp: *Eucalyptus populnea.*

Infrequent spp: *Grevillea striata.*

MID-HEIGHT SHRUB LAYER: Ht 3.5 $\pm$ 1.5 m, PFC < 1%.

Infrequent spp: *Eremophila longifolia, E. mitchellii.*

LOW SHRUB LAYER: Ht 0.75 $\pm$ 0.25 m, PFC < 1% (up to 5% in places).

Infrequent spp: *Cassia artemisioides, C. nemophila, Eremophila gilesii* (may form dense stands in places).

GROUND LAYER: Ht < 1.0 m, PFC 25 $\pm$ 15%.

FORBS:

Frequent spp: *Alternanthera nodiflora, Bassia birchii, Boerhavia diffusa, Chenopodium crinatum, Euphorbia drummondii, Malvastrum spicatum, Solanum esuriale, S. ferocissimum.*

Infrequent spp: *Abutilon otocarpum, A. oxycarpum, Centipeda thespidioides, Cheilanthes sieberi, Chenopodium melanocarpum, Convolvulus erubescens, Dianella* sp. aff. *D. laevis, Euphorbia eremophila, Glossogyne tenuifolia, Kochia villosa, Malvastrum spicatum, Pimelea trichostachya, Polycarpaea brevifolia, Portulaca* sp. aff. *P. oleracea, Ptilotus macrocephalus, Sida platyclayx, Sonchus oleraceus, Tribulus terrestris, Velleia glabrata, Vittadinia triloba.*

GRAMINOIDS:

Frequent spp: *Aristida contorta, A. jerichoensis, Chloris pectinata, Dactyloctenium radulans, Dichanthium sericeum, Digitaria brownii, Eriochloa pseudoacrotricha, Tragus australianus.*

Infrequent spp: *Bothriochloa ewartiana, Brachiaria praetervisa, Chrysopogon fallax, Cyperus iria, Digitaria ammophila, Enneapogon polyphyllus, Enteropogon acicularis, Eragrostis eriopoda, E. kennedyae, E. pergracilis, Eulalia fulva, Fimbristylis dichotoma, Panicum decompositum, Themeda australis, Tripogon loliiformis.*

LAND USE: GC 1.9 to 4.6 beasts/km2 (3.4), DGC 1.2 to 2.8 beasts/km2 (2.0); condition fair, trend slight downward; moderate to high infiltration, low fertility; run-on water; abundant top feed, dense stands may be thinned; woody weeds a problem.

LAND UNIT 47

LANDFORM: Flat plain.

GEOLOGY: Mixed Quaternary deposits. Qa.

SOILS: Deep to very deep, texture contrast soil with acid, brown, earthy, fine-sandy-loam to sandy-clay-loam surface soil (30 cm) and yellowish-brown, alkaline at depth, gravelly, light to medium clay. Concretionary lime at depth. Dy 2.13. Representative soil analysis: B2.

VEGETATION: Mulga, poplar box grassy open woodland. *Acacia aneura* (mulga) and *Eucalyptus populnea* (poplar box) are present with *A. aneura* usually predominating. Lower shrubby layers are not usually well defined but scattered shrubs may occur. Ground cover is usually well developed composed of forbs and grasses.

STRUCTURAL FORM: Open woodland, Ht 10 $\pm$ 2 m, PFC 10 $\pm$ 2.5%.

TREE LAYER: Ht 10 $\pm$ 2 m, PFC 10 $\pm$ 2.5%.

Predominant spp: *Acacia aneura*, Ht 10 $\pm$ 2 m, PFC 8 $\pm$ 2%; *Eucalyptus populnea*, Ht 10 $\pm$ 2 m, PFC 3 $\pm$ 2%.

TALL SHRUB LAYER: Ht 3 $\pm$ 1 m, PFC < 1% (up to 5% in places).

Infrequent spp: *Eremophila mitchellii.*

LOW SHRUB LAYER: Ht 0.5 m, PFC < 1% (up to 10% in places).

Infrequent spp: *Eremophila gilesii* (may form well defined layers).

GROUND LAYER: Ht < 0.75 m, PFC 15 $\pm$ 10%.

FORBS:

Frequent spp: *Bassia birchii, Boerhavia diffusa, Cheilanthes sieberi, Chenopodium rhadinostachyum, Malvastrum spicatum, Ptilotus polystachyus.*

Infrequent spp: *Abutilon leucopetalum, A. malvifolium, Dianella* sp. aff. *D. leavis, Evolvulus alsinoides, Ptilotus gaudichaudii.*

GRAMINOIDS:

Frequent spp: *Aristida jerichoensis, Eragrostis dielsii, E. kennedyae, Monachather paradoxa, Neurachne munroi.*

Infrequent spp: *Aristida helicophylla, A. ingrata, Brachiaria gilesii, Digitaria ammophila, D. brownii, D. divaricatissima, Fimbristylis dichotoma, Panicum decompositum, Sporobolus caroli, Tripogon loliiformis.*

LAND USE: GC 2.9 to 4.2 beasts/km2 (3.6), DGC 1.7 to 2.5 beasts/km2 (2.1); fair condition, trend slight downwards to stable; low to moderate WHC, moderate infiltration rates; receives run-on water; abundant top feed; requires thinning in places.

LAND UNIT 48

LANDFORM Slightly undulating to flat sandplain (< 3 m relief) with low dunes and clay drainage lines interspread.

GEOLOGY: Quaternary sands over alluvial clay plains. Qs/Qa.

SOILS: Sandy, red and yellow earths, alkaline at depth.

VEGETATION: Cypress pine low open woodland. *Callitris columellaris* (cypress pine) predominates and places forms pure stands. Frequently, *Acacia excelsa* (ironwood wattle) and other scattered trees are present. Usually there is no well defined tall shrubby layer or low shrubby layer but isolated tall shrubs and low shrubs occur. In some situations *Acacia murrayana* and *Acacia victoriae* may form well defined layers. Ground cover is sparse, composed of forbs and grasses. *Acacia cambagei* and *Eucalyptus populnea* form low open woodlands to tall open shrublands in depressions associated with the sandy rises.

STRUCTURAL FORM: Low open woodland. Ht 8 $\pm$ 2 m, PFC 4 $\pm$ 3%.

TREE, TALL SHRUB LAYER: Ht 7 $\pm$ 3 m, PFC 5 $\pm$ 4%.

Predominant spp: *Callitris columellaris*, Ht 8 $\pm$ 2 m, PFC 4 $\pm$ 3%.

Frequent spp: *Acacia excelsa, A. murrayana, Geijera parviflora.*

Infrequent spp: *Acacia oswaldii, A. salicina, A. victoriae, Alstonia constricta, Atalaya hemiglauca, Canthium latifolium, Capparis loranthifolia, Grevillea striata.*

LOW SHRUB LAYER: Ht 1.25 $\pm$ 0.75 m, PFC 10 $\pm$ 9%.

Frequent spp: *Rhagodia spinescens.*

Infrequent spp: *Cassia nemophila, C. oligophylla, Dodonaea attenuata, Enchylaena tomentosa, Eremophila maculata, Myoporum deserti.*

GROUND LAYER: Ht < 0.75 m, PFC 10 $\pm$ 9%.

FORBS:

Frequent spp: *Bassia bicornis, B. birchii, Salsola kali.*

Infrequent spp: *Brachycome ciliaris* var. *lanuginosa, Helichrysum semiamplexicaule, Millotia greevesii, Portulaca* sp. aff. *P. oleracea, Tetragonia tetragonioides.*

GRAMINOIDS:

Frequent spp: *Aristida browniana, A. ingrata, Dactyloctenium radulans.*

Infrequent spp: *Heteropogon contortus, Tragus australianus.*

LAND USE: GC 2.6 to 3.6 beasts/km2 (3.5), DGC 0.9 to 1.6 beasts/km2 (1.2); condition fair, trend slight downwards; low WHC, high infiltration, low fertility; limited top feed.

LAND UNIT 49

LANDFORM: Slightly to gently undulating convex plains. Slopes 0 to 2%.

GEOLOGY: Superficial Quaternary deposits. Qr.

SOILS: Deep to very deep, loamy, red earths with ironshot gravel throughout the profile. Surface soils are acid, clay-loams whilst at depth the soils are neutral, light clays. Surface soils are massive with thin crusts. Gn 2.12; *Tilkerie.* Representative soil analysis: 1.

VEGETATION: Mulga tall shrubland. *Acacia aneura* (mulga) predominates with scattered *Eucalyptus populnea* (poplar box) emerging in places. A lower shrubby layer of *Eremophila gilesii* is well defined in places. Ground flora is composed of forbs and grasses forming a variable ground cover.

STRUCTURAL FORM: Tall shrubland, Ht 6 $\pm$ 2 m, PFC 15 $\pm$ 5%.

TREE, TALL SHRUB LAYER: Ht 7 $\pm$ 3 m, PFC 15 $\pm$ 5%.

Predominant spp: *Acacia aneura*, Ht 6 $\pm$ 2 m, PFC 15 $\pm$ 5%.

Infrequent spp: *Eucalyptus populnea.*

LOW SHRUB LAYER: Ht 0.75 $\pm$ 0.25 m, PFC 5 $\pm$ 4.5%.

Frequent spp: *Eremophila gilesii.*

Infrequent spp: *Cassia artemisioides.*

GROUND LAYER: Ht < 0.75 m, PFC (variable) 15 $\pm$ 10%.

FORBS:

Frequent spp: *Evolvulus alsinoides, Helichrysum semiamplexicaule, Ixiolaena brevicompta, Ptilotus leucocoma, P. macrocephalus.*

Infrequent spp: *Dianella* sp. aff. *D. laevis, Sida filiformis, S. trichopoda.*

GRAMINOIDS:

Frequent spp: *Digitaria ammophila, D. brownii, Paspalidium rarum, Thryidolepis mitchelliana, T. xerophila.*

Infrequent spp: *Dactyloctenium radulans, Tragus australianus.*

LAND USE: GC 2.8 to 4.0 beasts/km2 (3.1), DGC 2.2 to 2.8 beasts/km2 (2.5); fair condition, trend slight downwards; low to moderate WHC, moderate infiltration, low fertility; top feed abundant; woody weeds a problem; may be necessary to thin to obtain maximum productivity.

L A N D U N I T 5 0

LANDFORM: Gently undulating plains. Slopes 0.5 to 2%. Commonly occurs on the higher parts of the landscape.

GEOLOGY: Tertiary *Glendower Formation* and undifferentiated superficial Quaternary deposits. Tg, Qc, Qr.

SOILS: Very shallow to shallow, acid, stony, red earths. Textures range from loams to clay-loams at the surface to clay-loam and light clay in subsoil. Massive throughout. Stone throughout. Um 5.51, Gn 2.12; *Corona*. Representative soil analysis: 3, 25, 54.

VEGETATION: Rock grass mulga/bloodwood wooded open tussock grassland. *Eriachne mucronata* (rock grass) predominates usually with scattered trees of *Eucalyptus terminalis* (western bloodwood) and shrubs of *Acacia aneura* (mulga) conspicuous. Other isolated shrubs may occur. Ground cover is variable composed mainly of grasses but forbs are present.

STRUCTURAL FORM: Open tussock grassland (rarely tall open shrubland); Ht < 0.5 m, PFC 5 ± 4%.

TREE, TALL SHRUB LAYER: Ht 4 ± 1.5 m, PFC < 1%.

Frequent spp: *Acacia aneura, Eucalyptus terminalis.*

Infrequent spp: *A. tetragonophylla.*

LOW SHRUB LAYER: Ht 0.5 ± 0.25 m, PFC < 1%.

Frequent spp: *Cassia artemisioides.*

Infrequent spp: *C. desolata, C. helmsii, C. nemophila* var. *nemophila, Eremophila gilesii.*

GROUND LAYER: Ht < 0.5 m, PFC 5 ± 4%.

Predominant spp: *Eriachne mucronata*, Ht < 0.5 m, PFC < 5%.

FORBS:

Frequent spp: *Brunonia australis, Euphorbia drummondii, Kochia villosa, Ptilotus macrocephalus, Sida filiformis, Velleia glabrata.*

Infrequent spp: *Bassia cornishiana, B. eriacantha, B. lanicuspis, Calotis hispidula, Chenopodium rhadinostachyum, Cheilanthes sieberi, Evolvulus alsinoides, Glossogyne tenuifolia, Portulaca* sp. aff. *P. oleracea, Psoralea cinerea, Ptilotus leucocoma, Salsola kali, Sida platycalyx, Solanum quadriloculatum, Vittadinia triloba.*

GRAMINOIDS:

Frequent spp: *Amphipogon caricinus, Aristida contorta, A. jerichoensis, Eragrostis eriopoda, E. pulchella, Thridolepis mitchelliana.*

Infrequent spp: *Digitaria ammophila, Eriachne helmsii, Fimbristylis dichotoma, Monachather paradox, Neurachne munroi, Tripogon loliiformis.*

LAND USE: GC 1.7 to 2.4 beasts/km2 (2.0), DGC 0.3 to 0.4 beasts/km2; good condition, trend stable; low WHC, very low fertility; top feed not abundant; rock grass not readily eaten.

L A N D U N I T 5 1

LANDFORM: Gently undulating plains. Slopes < 2%.

GEOLOGY: Superficial Quaternary deposits over weathered Cretaceous sediments. Qr/Kw.

SOILS: Generally shallow, some moderately deep, acid, loamy, red earths with ironstone gravel throughout the profile. Soils are massive throughout. Texture ranges from sandy-clay-loam at the surface to light clay at depth. Gn 2.11, Gn 2.12, Um 5.51; *Coperella, Tilkerie.* Representative soil analysis: 24, 43, 48.

VEGETATION: Mulga tall open shrubland. *Acacia aneura* (mulga) forms almost pure stands with isolated trees of *Eremophila longifolia* (berrigan). Usually there is no well defined shrubby layer but scattered shrubs may occur. In places *Eremophila* spp. forms a well defined low shrubby layer. Ground cover is variable ranging from sparse to mid-dense in places and is composed of grasses and forbs.

STRUCTURAL FORM: Tall open shrubland: Ht 5 ± 2 m, PFC 5 ± 4%.

TREE SHRUB LAYER: Ht 5 ± 2 m, PFC 5 ± 4%.

Predominant spp: *Acacia aneura*, Ht 5 ± 2 m, PFC 5 ± 4%.

Infrequent spp: *Eremophila longifolia.*

LOW SHRUB LAYER: Ht 1.0 ± 0.5 m, PFC usually 1 ± 1% (up to 15% in places).

Frequent spp: Shrubs: *Cassia helmsii, C. nemophila* var. *nemophila, C. oligophylla, Eremophila gilesii* (in places forms a well defined layer).

Infrequent spp: *Eremophila sturtii.*

GROUND LAYER: Ht < 0.75 m, PFC 7.5 ± 7.5%.

FORBS:

Frequent spp: *Chenopodium rhadinostachyum, Kochia villosa, Ptilotus leucocoma, P. macrocephalus, Sida filiformis, Velleia glabrata.*

Infrequent spp: *Bassia divaricata, B. intricata, B. lanicuspis, Boerhavia diffusa, Calotis inermis, Cheilanthes sieberi, Goodenia subintegra, Heliotropium strigosum, Oxalis corniculata, Portulaca* sp. aff. *P. oleracea, Sida cunninghamii, S. platycalyx, Solanum ellipticum, S. quadriloculatum.*

GRAMINOIDS:

Frequent spp: *Eragrostis eriopoda, Fimbristylis dichotoma, Monachather paradoxa.*

Infrequent spp: *Aristida contorta, A. jerichoensis, Dactyloctenium radulans, Digitaria ammophila, D. brownii, Eragrostis kennedyae, Eriachne mucronata, E. pulchella, Paspalum rarum, Thyridolepis mitchelliana, Tripogon loliiformis.*

LAND USE: GC 2.1 to 4.1 beasts/km2 (3.1), DGC 0.9 to 1.7 beasts/km2 (1.3); mediocre to fair condition; trend slight downwards to downwards; low WHC, very low fertility; susceptible to sheet, wind and water erosion particularly if cleared or overgrazed; top feed present.

L A N D U N I T 5 2

LANDFORM: Flat to gently undulating plains. Slopes < 2%.

GEOLOGY: Superficial Quaternary deposits overlying weathered Cretaceous sediments. Qr/Kw.

SOILS: Very shallow to shallow, slightly acid, loamy red earths often gravelly. Textures are usually clay loams but may increase in some cases to light clays. Gn 2.12, Um 5.51; *Coparella*. Representative soil analysis: 79.

VEGETATION: Mulga tall open shrubland. *Acacia aneura* (mulga) predominates usually with other scattered trees present. Usually there is no well defined low shrubby layer but isolated low shrubs occur. Ground cover is variable composed of forbs and grasses.

STRUCTURAL FORM: Tall open shrubland rarely tall shrubland; Ht 5.5 $\pm$ 0.5 m, PFC 8 $\pm$ 7%.

TREE, TALL SHRUB LAYER: Ht 4.5 $\pm$ 1.5 m, PFC 8 $\pm$ 7% (usually < 10%).

Predominant spp: *Acacia aneura*, Ht 5.5 $\pm$ 0.5 m, PFC 7 $\pm$ 6%.

Infrequent spp: *Acacia excelsa, A. tetragonophylla, Capparis loranthifolia, Eremophila longifolia, E. mitchellii, Flindersia maculosa, Ventilago viminalis.*

LOW SHRUB LAYER: Ht 0.6 $\pm$ .2 m, PFC 3 $\pm$ 2%.

Frequent spp: *Cassia artemisioides.*

Infrequent spp: *Cassia nemophila* var. *nemophila, Eremophila gilesii.*

GROUND LAYER: Ht < 0.5 m, PFC (variable) 10 $\pm$ 5%.

FORBS:

Frequent spp: *Euphorbia drummondii, Kochia villosa, Ptilotus macrocephalus.*

Infrequent spp: *Chenopodium rhydinostachyum, Convolvulus erubescens, Evolvulus alsinoides, Heliotropium strigosum, Ptilotus gaudichaudii, Portulaca* sp. aff. *P. oleracea, Sida filiformis, Velleia glabrata.*

GRAMINOIDS:

Frequent spp: *Aristida contorta, Dactyloctenium radulans, Enneapogon polyphyllus.*

Infrequent spp: *Eragrostis dielsii, Eriachne helmsii, E. mucronata, Panicum decompositum, Tragus australianus, Tripogon loliiformis.*

LAND USE: GC 2.0 to 3.4 beasts/km2 (2.7), DGC 1.1 to 2.0 beasts/km2 (1.5); fair to mediocre condition, trend slight downwards to downwards; low WHC, very low fertility; susceptible to sheet, wind and water erosion; top feed present.

L A N D U N I T 5 3

LANDFORM: Flat plains, fringing dune fields, on drainage lines. Slopes < 0.5%.

GEOLOGY: Quaternary sheet sand over Quaternary clay plains. Qs/Qa.

SOILS: Deep to very deep, texture contrast soil with an acid, red, coarse-sandy-loam surface soil (30 cm) and a red, alkaline, sandy-clay subsoil. $CaCO_3$ concretions occur in the lower parts of the B horizon. Surface soil is loose, when disturbed or when moist, but massive when dry. Dr 4.33; *Bygrave*. Representative soil analysis: 199.

VEGETATION: Mulga grassy tall open shrubland. *Acacia aneura* (mulga) predominates usually with scattered trees occurring. There is no well defined lower shrubby layer but isolated low shrubs present. The ground flora is variable consisting of grasses and forbs.

STRUCTURAL FORM: Tall open shrubland, Ht 4 $\pm$ 1 m, PFC 5 $\pm$ 4%.

TALL SHRUB LAYER: Predominant spp: *Acacia aneura*, Ht 4 $\pm$ 1 m, PFC 5 $\pm$ 4%.

Frequent spp: *Eucalyptus terminalis.*

Infrequent spp: *Hakea divaricata.*

LOW SHRUB LAYER: Ht 1.5 $\pm$ 0.75 m, PFC < 1%.

Frequent spp: *Cassia oligophylla, Eremophila gilesii.*

Infrequent spp: Isolated *Acacia tetragonophylla, Kochia spongiocarpa.*

GROUND LAYER: Ht < 0.75 m, PFC 15 $\pm$ 10%.

FORBS:

Frequent spp: *Bassia paradoxa, B. stelligera, B. ventricosa, Calotis multicaulis, Helipterum moschatum, Ptilotus macrocephalus, P. polystachyus, Trachymene glaucifolia.*

Infrequent spp: *Evolvulus alsinoides, Joesphinia eugeniae, Lepidium rotundum, Sida cunninghamii.*

GRAMINOIDS:

Frequent spp: *Aristida anthoxanthoides, A. contorta, Dactyloctenium radulans, Eragrostis eriopoda.*

Infrequent spp: *Enneapogon polyphyllus, Fimbristylis dichotoma, Tragus australianus.*

LAND USE: GC 1.6 to 3.5 beasts/km2 (2.15), DGC 0.6 to 1.2 beasts/km2 (0.9); fair condition, trend slightly downwards; low WHC, low fertility; susceptible to degradation near watering point; top feed present.

LAND UNIT 54

LANDFORM: Gently undulating to flat plains. Slope 0.5 to 2%.

GEOLOGY: Quaternary sheet sand overlying upland land surfaces. Qs.

SOILS: Deep to very deep, acid to neutral, sandy red earths and earthy sands. Textures range from coarse-sandy-loam to sandy-clay-loam. Soils are loose when moist, but slightly hardsetting and massive when dry. Gn 2.12, Uc 5.21, Um 5.52; *Napoleon* small areas of *Kotri*. Representative soil analysis: 12, 30, 77, 106.

VEGETATION: Woollybutt mulga open tussock grassland. Short tussock grasses usually predominate with *Acacia aneura* (mulga) emerging but in places *A. aneura* forms a well defined shrubby layer and is predominant. Frequently other scattered trees are present. A low shrubby layer is not usually well defined but in places dense stands of low shrubs may occur. Ground cover is variable composed mainly of grasses.

STRUCTURAL FORM: Open tussock grassland, Ht < 0.5 m, PFC 15 ± 10% (rarely tall open shrubland); Ht 4 ± 1 m, PFC 2.5 ± 2%.

TREE, TALL SHRUB LAYER: Ht 4 ± 1 m, PFC 2.5 ± 2%.

Predominant spp: *Acacia aneura*, Ht 4 ± 1 m, PFC 2.5 ± 2%.

Frequent spp: *Eucalyptus terminalis, Grevillea striata.*

Infrequent spp: *Codonocarpus cotinifolius, Eremophila longifolia.*

LOW SHRUB LAYER: Ht 1.5 ± 0.75 m, PFC usually 1% (in places up to 20%).

Frequent spp: (At times both species may form dense stands) *Dodonaea attenuata, Eremophila bowmanii.*

Infrequent spp: *Cassia artemisioides, C. nemophila* var. *nemophila, Eremophila duttonii, E. sturtii.*

GROUND LAYER: Ht < 0.5 m, PFC (variable) 15 ± 10%.

FORBS:

Frequent spp: *Evolvulus alsinoides, Kochia villosa, Ptilotus polystachyus, Sida platycalyx.*

Infrequent spp: *Boerhavia diffusa, Brachycome ciliaris* var. *lanuginosa, B. curvicarpa, Chenopodium rhadyinostachyum, Cleome viscosa, Euphorbia coghlanii, E. drummondii, E. eremophila, E. wheeleri, Helichrysum semiamplexicaule, Heliotropium strigosum, Indigofera dominii, Ptilotus leucocoma, Sida ammophila, S. cunninghamii, Trachymene cyanantha, T. ochracea, Velleia glabrata.*

GRAMINOIDS:

Frequent spp: *Aristida contorta, A. jerichoensis, Eragrostis eriopoda, Eriachne helmsii, E. mucronata, Monachather paradoxa, Thyriodolepis mitchelliana.*

Infrequent spp: *Dactyloctenium radulans, Digitaria ammophila, D. divaricatissima, D. brownii, D. hystrichoides, Enneapogon polyphyllus, Panicum decompositum, Perotis rara, Tragus australianus.*

LAND USE: GC 2.2 to 5.6 beasts/km2, DGC 0.2 to 1.0 beasts/km2 (0.6); fair to good condition, trend stable to slight downwards; low WHC, very low fertility; susceptible to wind and water erosion when bare or after firing; top feed present; woody regrowth may be a problem.

LAND UNIT 55

LANDFORM: Gently undulating to undulating plains. Slopes 0.5 to 3%.

GEOLOGY: Undifferentiated superficial Quaternary deposits/weathered Tertiary *Glendower Formation.* Qc, Qr, Tg over chemically altered Kw.

SOILS: Very shallow to shallow, slightly acid to neutral, red earths with ferricrete and silcrete stone cover. Textures range from loams to clay-loams. Rock exposure is common. Gn 2.12, Um 5.51, Um 5.31; *Kulki.*

VEGETATION: Mulga sparse tall open shrubland. *Acacia aneura* (mulga) is conspicuous but is usually very scattered. There is no well defined lower shrubby layer but isolated low shrubs may be present. The ground flora composed of forbs and grasses forms a sparse cover.

STRUCTURAL FORM: Sparse tall open shrubland; Ht 3 ± 1 m, PFC 1 to 1.5%.

TALL SHRUB LAYER: Ht 3 ± 1 m, PFC 1 to 1.5%.

Predominant spp: *Acacia aneura*, Ht 3 ± 1 m, PFC 1 to 1.5%.

Frequent spp: *Acacia tetragonophylla.*

LOW SHRUB LAYER: Ht < 1 m, PFC < 1%.

Infrequent spp: *Acacia clivicola, Cassia phyllodinea.*

GROUND LAYER: Ht < 0.5 m, PFC < 5%.

FORBS:

Frequent spp: *Bassia divaricata, B. lanicuspis, Euphorbia boophthona, Lepidium rotundum, Portulaca* sp. aff. *P. oleracea, Salsola kali, Velleia glabrata.*

Infrequent spp: *Bassia tricuspis, Boerhavia diffusa, Brachycome ciliaris* var. *lanuginosa, Calotis multicaulis, C. inermis, Neptunia dimorphantha, Ptilotus helipteroides, P. macrocephalus, Sida* spp., *Stenopetalum nutans, Trianthema triquetra, Zygophyllum apiculatum.*

GRAMINOIDS:

Frequent spp: *Aristida contorta, Dactyloctenium radulans, Enneapogon polyphyllus, Tragus australianus, Tripogon loliiformis.*

Infrequent spp: *Digitaria brownii, Eragrostis dielsii, E. parviflora, Eriachne pulchella, Iseilema membranaceum.*

LAND USE: GC 1.4 to 3.6 beasts/km2 (1.9), DGC 0.2 to 0.9 beasts/km2 (0.5); fair to mediocre condition, trend slight downwards; very low WHC, very low fertility; sheet, water erosion is common; top feed not abundant.

LAND UNIT 56

LANDFORM: Gently undulating to undulating plains. Slopes 0.5 to 2%.

GEOLOGY: Undifferentiated superficial Quaternary deposits and Tertiary *Glendower Formation*. Qr, Tg.

SOILS: Shallow, loamy, red earths with silcrete stone cover. Soils are massive throughout and are neutral to slightly acid, ranging from sandy-loams to clay-loams. Gn 2.12, Um 5.51; *Kulki*. Representative soil analysis: 128.

VEGETATION: Mulga sparse tall open shrubland, *Acacia aneura* (mulga) predominates with scattered shrubs of *A. tetragonophylla* (dead finish) and less frequently *Eucalyptus terminalis* (western bloodwood) present. There is no well defined lower shrubby layer but scattered shrubs may occur. Ground cover is sparse composed of forbs and grasses.

STRUCTURAL FORM: Sparse tall open shrubland. Ht 4 $\pm$ 1 m, PFC < 1% (rarely up to 2%).

TREE, TALL SHRUB LAYER: Ht 4 $\pm$ 2 m, PFC 1 to 2%.

Predominant spp: *Acacia aneura*, Ht 4 $\pm$ 1 m, PFC 1 to 2%.

Frequent spp: *Acacia tetragonophylla, Eucalyptus terminalis.*

LOW SHRUB LAYER: Ht 0.7 m, PFC < 1%.

Infrequent spp: *Cassia oligophylla, C. phyllodinea, Enchylaena tomentosa; Eremophila bowmanii.*

GROUND LAYER: Ht < 0.7 m, PFC < 5%.

FORBS:

Frequent spp: *Bassia divaricata, B. lanicuspis, Salsola kali, Sarcostemma australe, Sida cunninghamii, S. filiformis.*

Infrequent spp: *Calotis multicaulis, Chenopodium rhadinostachyum, Euphorbia boophthona, Kochia georgei, K. triptera, Portulaca filifolia, P.* sp. aff. *P. oleracea, Ptilotus helipteroides, Velleia glabrata.*

GRAMINOIDS:

Frequent spp: *Dactyloctenium radulans, Enneapogon polyphyllus, Tragus australianus, Tripogon loliiformis.*

Infrequent spp: *Aristida contorta, Eragrostis lacunaria, Eriachne mucronata, E. pulchella.*

LAND USE: GC 1.4 to 3.6 beasts/km2 (2.4), DGC 0.2 to 0.9 beasts/km2 (0.5); fair to mediocre condition, trend downwards; very low WHC, very low fertility; susceptible to sheet erosion; limited top feed.

LAND UNIT 57

LANDFORM: Flat plains.

GEOLOGY: Superficial Quaternary deposits overlying clay sheets. Qr/Qa.

SOILS: Shallow to moderately deep, texture contrast soils overlying a hardpan. Surface soils are slightly acid to neutral, red, earthy, sandy-loams to sandy-clay-loams (10 cm)and subsoils are structured, alkaline, red, light to medium clays with gravel in the profile. Dr 2.13, Dr 2.12; *Bullawaria, Lymbah.* Representative soil analysis: 109, 157, 169.

VEGETATION: Mulga, dead finish tall open shrubland. *Acacia aneura* (mulga) and *A. tetragonophylla* (dead finish) occur usually with *A. aneura* predominating. Scattered low emerging trees may be present. There is no well defined lower shrubby layer but isolated shrubs occur. Grasses, sedges and forbs form a variable ground cover which is usually sparse.

STRUCTURAL FORM: Tall open shrubland: Ht 3.5 $\pm$ 1 m, PFC 5 $\pm$ 4%.

TREE, TALL SHRUB LAYER: Ht 3 $\pm$ 1.5 m, PFC 5 $\pm$ 4%.

Predominant spp: *Acacia aneura*, Ht 3.5 $\pm$ 1 m; PFC 4 $\pm$ 3%; *A. tetragonophylla*, Ht 2.5 $\pm$ 5%, PFC 4 $\pm$ 3%.

Frequent spp: *Eremophila longifolia, Eucalyptus terminalis.*

Infrequent spp: *Atalaya hemiglauca, Canthium latifolium, Flindersia maculosa, Grevillea striata.*

LOW SHRUB LAYER: Ht 0.5 to 1 m, PFC < 1%.

Infrequent spp: *Cassia phyllodinea, Eremophila gilesii, E. maculata.*

GROUND LAYER: Ht < 0.6 m; PFC 6 $\pm$ 4%.

FORBS:

Frequent spp: *Bassia bicornis, B. lanicuspis, Salsola kali.*

Infrequent spp: *Bassia divaricata, B. parallelicuspis, Chenopodium rhadinostachyum, Euphorbia drummondii, Evolvulus alsinoides, Goodenia lunata, G. subintegra, Helipterum floribundum, Heliotropium strigosum, Kochia triptera, Lepidium rotundum, Neptunia dimorphantha, Portulaca* sp. aff. *P. oleracea, Ptilotus macrocephalus, Ptilotus polystachyus, Sida platycalyx, Solanum ellipticum, Velleia glabrata.*

GRAMINOIDS:

Frequent spp: *Aristida contorta, Fimbristylis dichotoma, Tripogon loliiformis.*

Infrequent spp: *Brachiaria gilesii, Chloris pectinata, Dactyloctenium radulans, Dichanthium sericeum, Enneapogon polyphyllus, Eragrostis eriopoda, Eriachne pulchella, Sporobolus actinocladus, Tragus australianus.*

LAND USE: GC 1.6 to 4.9 beasts/km2 (2.5); DGC 0.4 to 1.4 beasts/km2 (0.9); fair condition, trend stable to slight downwards; low to moderate WHC, low fertility; susceptible to sheet and in places gully erosion; top feed present.

LAND UNIT 58

LANDFORM: Gently undulating convex plain. Slopes are < 2%.

GEOLOGY: Remnants of Tertiary *Glendower Formation* and superficial Quaternary deposits. Tg, Qc.

SOILS: Shallow to very shallow, loamy, red earths with silcrete gravel cover. Soils are acid to slightly acid, sandy-loams to sandy-clay-loams. Um 5.51, Gn 2.12; *Corona*. Representative soil analysis: 39, 98.

VEGETATION: Mulga, western bloodwood sparse tall open shrubland. *Acacia aneura* (mulga) and *Eucalyptus terminalis* (western bloodwood) are conspicuous with *A. aneura* predominating. There is no well defined shrubby layer but scattered tall and low shrubs are frequently present. Ground cover is sparse composed mainly of forbs but grasses also occur.

STRUCTURAL FORM: Sparse tall open shrubland, Ht 4 $\pm$ 1 m, PFC<1 to 2% (usually less than 1%).

TALL SHRUB LAYER: Ht 3.5 $\pm$ 1.5 m, PFC < 1%.

Predominant spp: *Acacia aneura*, Ht 4 $\pm$ 1 m, PFC < 1%; *Eucalyptus terminalis*, Ht 4 $\pm$ 1 m, PFC < 1%.

Frequent spp: *Acacia tetragonophylla, Eremophila longifolia.*

LOW SHRUB LAYER: Ht < 0.75 m, PFC < 1%.

Frequent spp: *Cassia desolata, Eremophila bowmanii.*

Infrequent spp: *Cassia artemisioides, C. helmsii, Eremophila gilesii.*

GROUND LAYER: Ht < 0.5 m, PFC (variable) 5 $\pm$ 4%.

FORBS:

Frequent spp: *Bassia cornishiana, B. divaricata, B. eriacantha, Erodium crinatum, Euphorbia drummondii, Kochia villosa, Lepidium rotundum, Portulaca* sp. aff. *P. oleracea, Ptilotus gaudichaudii, P. macrocephalus, Salsola kali, Sida cunninghamii, S. platycalyx, Zygophyllum ammophilum.*

Infrequent spp: *Calotis inermis, C. multicaulis, Convolvulus erubescens, Evolvulus alsinoides, Heliotropium strigosum, Ptilotus helipteroides, Pimelea trichostachya, Portulaca filiformis, Sida filifolia, Stenopetalum nutans, Trianthema triquetra, Velleia glabrata.*

GRAMINOIDS:

Frequent spp: *Aristida contorta, A. jerichoensis, Enneapogon polyphyllus, Eriachne mucronata, E. pulchella, Tripogon loliiformis.*

Infrequent spp: *Digitaria ammophila, D. brownii, Eragrostis eriopoda, E. tenellula, Monachather paradoxa, Thyridolepis mitchelliana.*

LAND USE: GC 1.4 to 3.6 beasts/km2 (2.0), DGC 0.2 to 0.9 beasts/km2 (0.5); fair condition, slight downwards trend; very low WHC, very low fertility; top feed rare.

LAND UNIT 59

LANDFORM: Flat plain with very low slopes < 1%.

GEOLOGY: Superficial Quaternary deposits. Qr.

SOILS: Shallow, acid to slightly acid, loamy, red earths, with ironstone gravel, overlying deeply weathered rock. Surface soils are massive when dry. Gn 2.12; *Coparella*. Representative soil analysis: 42.

VEGETATION: Mulga shrubby tall shrubland. *Acacia aneura* (mulga) predominates with scattered *Eucalyptus populnea* (poplar box) in depressions or associated with drainage lines. Frequently there is a well defined lower shrubby layer with some scattered tall shrubs emerging. Ground flora is variable.

STRUCTURAL FORM: Tall shrubland (frequently this association is very disturbed resulting in a sparse tall open shrubland). Ht 5 $\pm$ 1 m, PFC 15 $\pm$ 5 m (in disturbed areas < 5%).

TALL SHRUB LAYER: Ht 6 $\pm$ 2 m, PFC 15 $\pm$ 5%.

Predominant spp: *Acacia aneura*, Ht 5 $\pm$ 1 m, PFC 15 $\pm$ 5%.

Frequent spp: *Eucalyptus populnea.*

LOW SHRUB LAYER: Ht 1.25 $\pm$ 0.75 m, PFC 5 $\pm$ 4%.

Frequent spp: *Eremophila gilesii.*

Infrequent spp: *Eremophila longifolia.*

GROUND LAYER: Ht < 1 m, PFC (very variable) 20 $\pm$ 15%.

FORBS:

Frequent spp: *Cheilanthes sieberi, Chenopodium rhadinostachyum, Evolvulus alsinoides, Ptilotus macrocephalus, Sida cunninghamii, S. platycalyx.*

Infrequent spp: *Abutilon oxycarpum, Pimelea trichostachya, Phyllanthus maderaspatensis, Solanum ellipticum, Velleia glabrata.*

GRAMINOIDS:

Frequent spp: *Aristida contorta, A. jerichoensis, Digitaria brownii, Eragrostis leptocarpa, Fimbristylis dichotoma.*

Infrequent spp: *Eragrostis dielsii, Panicum effusum, Paspalidium rarum, Tragus australianus, Tripogon loliiformis.*

LAND USE: GC 1.3 to 2.7 beasts/km2 (2.1), DGC 1.3 to 2.6 beasts/km2 (1.9); fair condition, trend slight downwards: very low WHC, very low fertility; receives run-on water; susceptible to erosion if cleared; top feed abundant.

LAND UNIT 60

LANDFORM: Gently undulating edges of flat plains. Slopes 0.5 to 2%.

GEOLOGY: Quaternary sheet sand. Qs.

SOILS: Deep to very deep, acid to slightly acid, sandy, red earths. Textures grade from coarse-sandy-loam to sandy-loam in the surface to sandy-clay-loam and sandy-light clay at depth. Gravel may occur in the lower part of the profile. Surface soil may be hardsetting when dry but loose when moist and when disturbed. Organic matter build up is common. Gn 2.12, Um 5.52; *Napoleon*. Representative soil analysis: 29.

VEGETATION: Mulga shrubby tall shrubland. *Acacia aneura* (mulga) predominates. In places a lower shrubby layer is well defined. Ground cover is variable composed of grasses and forbs.

STRUCTURAL FORM: Tall shrubland Ht 7 $\pm$ 2 m, PFC 15 $\pm$ 5%.

TALL SHRUB LAYER: Ht 7 $\pm$ 2 m, PFC 15 $\pm$ 5%.

Predominant spp: *Acacia aneura*, Ht 7 $\pm$ 2 m, PFC 15 $\pm$ 5%.

LOW SHRUB LAYER: Ht < 0.75 m, PFC 5 $\pm$ 2.5%.

Frequent spp: *Eremophila gilesii*.

Infrequent spp: *Cassia sturtii, E. maculata*.

GROUND LAYER: Ht < 0.75 m, PFC 5 $\pm$ 4%.

FORBS:

Frequent spp: *Euphorbia eremophila, E. wheeleri, Sida cunninghamii, S. filiformis, S. platycalyx, Solanum ellipticum*.

Infrequent spp: *Evolvulus alsinoides, Helipterum pterochaetum, Trachymene cyanantha*.

GRAMINOIDS:

Frequent spp: *Aristida contorta, A. jerichoensis, Digitaria ammophila, Digitaria brownii, Digitaria divaricatissima, Eragrostis eriopoda*.

Infrequent spp: *Monachather paradoxa, Neurachne munroi, Tripogon loliiformis*.

LAND USE: GC 1.6 to 3.2 beasts/km2 (2.4), DGC 1.3 to 2.6 beasts/km2 (1.9); fair condition, trend stable to slight downwards; low WHC, low fertility; top feed present and may be abundant; subject to sheet erosion if bare or cleared.

LAND UNIT 61

LANDFORM: Gently undulating to flat plains.

GEOLOGY: Quaternary sandplains overlying Quaternary clayplains. Qs/Qa.

SOILS: Soils are shallow to moderately deep, sandy red earths, slightly acid to neutral at the surface and generally alkaline at depth. An impermeable hardpan is common. Ironstone gravel is present in the lower parts of the profile. Surface soil is hardsetting when dry but loose when moist. Texture ranges from sandy-loam to sandy-clay-loam at the surface to sandy-clay-loam and sandy-clay at depth. Gn 2.12, Um 5.31; *Springvale*. Representative soil analysis: 72, 73.

VEGETATION: Mulga, poplar box shrubby tall open shrubland. *Acacia aneura* (mulga) and *Eucalyptus populnea* (poplar box) are conspicuous with *A. aneura* usually predominant. Other isolated trees may occur. A low shrubby layer is often well developed. *Eremophila gilesii* (Charleville turkey bush) is prevalent in places. Grasses and forbs form a variable ground cover.

STRUCTURAL FORM: Tall open shrubland to open woodland: Ht 7 $\pm$ 3 m, PFC 6 $\pm$ 3%.

TREE, TALL SHRUB LAYER: Ht 7 $\pm$ 3 m, PFC 6 $\pm$ 3%.

Predominant spp: *Acacia aneura*, Ht 6 $\pm$ 2 m, PFC 4 $\pm$ 3%; *Eucalyptus populnea*, Ht 8 $\pm$ 2 m, PFC 2.5 $\pm$ 2.5%.

Frequent spp: *Grevillea striata*.

Infrequent spp: *Acacia excelsa, Capparis loranthifolia, Hakea leucoptera*.

LOW SHRUB LAYER: Ht < 0.75 m, PFC 10 $\pm$ 10%.

Frequent spp: *Eremophila gilesii*.

Infrequent spp: *Cassia artemisioides, C. nemophila* var. *nemophila*.

GROUND LAYER: Ht < 0.75 m, PFC 7.5 $\pm$ 7.5%.

FORBS:

Frequent spp: *Boerhavia diffusa, Portulaca* sp. aff. *P. oleracea*.

Infrequent spp: *Bassia birchii, B. convexula, Blennodia canescens, Convolvulus erubescens, Erodium crinatum, Euphorbia drummondii, E. stevenii, Heliotropium tenuifolium, Mollugo cerviana, Sida cunninghamii, S. filiformis*.

GRAMINOIDS:

Frequent spp: *Aristida contorta, Eragrostis eriopoda, Eriachne helmsii, Tragus australianus*.

Infrequent spp: *Aristida ingrata, Chloris pectinata, Dactyloctenium radulans, Digitaria brownii, Enneapogon avenaceus, Panicum effusum, Perotis rara, Tripogon loliiformis*.

LAND USE: GC 1.9 to 4.7 beasts/km2 (3.5), DGC 0.7 to 1.7 beasts/km2 (1.2); fair to good condition, trend stable to slight downwards; low to moderate WHC, low fertility; subject to sheet erosion when bare; top feed present and abundant in places; woody weeds may be a problem.

LAND UNIT 62

LANDFORM: Flat plains without defined drainage lines. Run-on area.

GEOLOGY: Superficial Quaternary deposits. Qr.

SOILS: Soils are moderately deep to deep, slightly acid, red earths commonly with ironstone gravel in the lower part of the profile. Textures range from clay-loam or light clay at the surface to light to medium clay at depth. Organic matter build up occurs in the top 3 cm. Gn 2.12, Um 5.52; *Tinnenburra.* Representative soil analysis: 53, 82.

VEGETATION: Mulga open scrub. *Acacia aneura* (mulga) forms pure stands but in places scattered trees of *Hakea ivoryi* occur. There is no well defined shrubby layer. Grasses and forbs form a very variable ground cover.

STRUCTURAL FORM: Open scrub to low open forest: Ht 8 ± 2 m, PFC 30 ± 10%.

TREE, TALL SHRUB LAYER: Ht 8 ± 2 m, PFC 30 ± 10%.

Predominant spp: *Acacia aneura*, Ht 8 ± 2 m; PFC 30 ± 10%.

Infrequent spp: *Hakea ivoryi.*

LOW SHRUB LAYER: Ht < 0.5 m, PFC< 1%.

Infrequent spp: *Eremophila gilesii.*

GROUND LAYER: Ht < 1 m, PFC 15 ± 15%.

FORBS:

Frequent spp: *Cheilanthes sieberi, Phyllanthus maderaspatensis.*

Infrequent spp: *Convolvulus erubescens, Euphorbia drummondii, E. wheeleri, Evolvulus alsinoides, Ptilotus macrocephalus, Sida cunninghamii, Trachymene ochracea, Velleia glabrata, Wahlenbergia* sp.

GRAMINOIDS:

Frequent spp: *Digitaria ammophila, D. brownii, Eragrostis microcarpa, Fimbristylis dichotoma.*

Infrequent spp: *Aristida contorta, A. jerichoensis, Brachiaria miliiformis, Chloris pectinata, Dactyloctenium radulans, Enneapogon polyphyllus, Paspalidium rarum, Perotis rara.*

LAND USE: GC 1.6 to 3.3 beasts/km^2 (2.4), DGC 1.2 to 2.5 beasts/km^2 (1.8); fair to good condition, trend stable; low WHC, low fertility; receives run-on water; top feed abundant; thinning of stands desirable in most cases.

LAND UNIT 63

LANDFORM: Flat and gently undulating plains with slopes < 1%.

GEOLOGY: Quaternary sheet sand overlying the Tertiary land surface. Qs.

SOILS: Deep to very deep, acid to neutral, sandy, red earths. Texture may be uniform or gradational throughout the profile. Surface soil textures range from sandy-loam to sandy-clay-loam. Surface soils are porous and weakly coherent when moist. Gn 2.12, Um 5.21, Um 5.52; *Napoleon.* Representative soil analysis: 5, 7, 99, 101.

VEGETATION: Mulga grassy tall open shrubland. *Acacia aneura* (mulga) predominates usually with scattered trees occurring. A low shrubby layer is not well defined but isolated low shrubs are present. Ground cover is variable, composed mainly of grasses.

STRUCTURAL FORM: Tall open shrubland; Ht 5 ± 1 m, PFC 5 ± 4%.

TREE, TALL SHRUB LAYER: Ht 5 ± 1 m, PFC 5 ± 4%.

Predominant spp: *Acacia aneura*, Ht 5 ± 1 m, PFC 5 ± 4%.

Infrequent spp: *Codonocarpus cotinifolius* (more prevalent in disturbed sites); *Eucalyptus populnea, Grevillea striata.*

LOW SHRUB LAYER: Ht < 0.75 m, PFC 10 ± 10%.

Frequent spp: *Cassia artemisioides, C. sturtii, Eremophila bowmanii* (in places may form a well defined layer).

Infrequent spp: *E. gilesii.*

GROUND LAYER: Ht < 0.75 m, PFC (variable) 15 ± 10%.

FORBS:

Frequent spp: *Euphorbia stevenii, Kochia villosa, Ptilotus leucocoma, P. polystachyus, Sida filiformis, S. platycalyx, Trachymene ochracea.*

Infrequent spp: *Euphorbia drummondii, Evolvulus alsinoides, Heliotropium tenuifolium, Portulaca* sp. aff. *P. oleracea, Sida cunninghamii, Solanum ellipticum, Swainsona microphylla* ssp. *affinis, Trachymene cyanantha.*

GRAMINOIDS:

Frequent spp: *Aristida jerichoensis, Digitaria ammophila, Eragrostis eriopoda, Monachather paradoxa, Thyridolepis mitchelliana.*

Infrequent spp: *Amphipogon caricinus, Aristida contorta, A. ingrata, Enteropogon acicularis, Eriachne helmsii, E. mucronata, Neurachne munroi, Themeda australis.*

LAND USE: GC 2.1 to 5.1 beasts/km^2 (3.6), DGC 0.7 to 2.2 beasts/km^2 (1.4); fair condition, trend slightly downwards; low WHC, very low fertility; susceptible to wind and water erosion when bare or fired; woody weeds a problem in places. top feed present.

LAND UNIT 64

LANDFORM: Flat to gently undulating plains.

GEOLOGY: Superficial Quaternary deposits. Qr.

SOILS: Deep to very deep, acid to neutral, loamy red earths with ironstone gravel in the profile. Texture ranges from sandy-clay-loam to clay-loam at the surface to light to medium clay at depth. Soils are massive and hardsetting when dry with some litter accumulation on the surface. Gn 2.12, Gn 2.11; *Tinnenburra*. Representative soil analysis: 59, 179.

VEGETATION: Mulga tall shrubland. *Acacia aneura* (mulga) predominates frequently with *Eucalyptus* spp. emerging. A shrubby layer is not usually well developed but scattered shrubs may be present. Scattered low shrubs of *E. gilesii* (Charleville turkey bush) occur. The ground flora is very variable composed of forbs and grasses. *Cassia artemisioides* and *C. nemophila* occur sporadically but once the site is disturbed the *Cassia* spp. together with the *Eremophila* spp. form a dense low shrubby layer.

STRUCTURAL FORM: Tall shrubland, Ht 6 ± 2 m, PFC 12.5 ± 2.5%.

TREE, TALL SHRUB LAYER: Ht 6 ± 2 m, PFC 12.5 ± 2.5%.

Predominant spp: *Acacia aneura*, Ht 6 ± 2 m, PFC 12.5 ± 2.5%.

Frequent spp: *Eucalyptus populnea, E. terminalis.*

Infrequent spp: *Cassia artemisioides, C. nemophila* var. *nemophila, Eremophila mitchellii, E. longifolia.*

LOW SHRUB LAYER: Ht < 0.5 m, PFC 5 ± 5%.

Frequent spp: *Eremophila gilesii.*

GROUND LAYER: Ht < 0.75 m, PFC (variable) 10 ± 5%.

FORBS:

Frequent spp: *Alternanthera denticulata, Bassia birchii, Cheilanthes sieberi, Ptilotus gaudichaudii, P. macrocephalus, Pimelea trichostachya, Sida filiformis, Solanum ellipticum, S. esuriale.*

Infrequent spp: *Abutilon oxycarpum, Calandrinia balonensis, Calotis inermis, Euphorbia coghlanii, Oxalis corniculata, Sida* spp., *Wahlenbergia* sp., *Velleia glabrata, Vittadinia triloba.*

GRAMINOIDS:

Frequent spp: *Aristida contorta, A. jerichoensis, Digitaria brownii, Enneapogon polyphyllus, Enteropogon acicularis, Eragrostis eriopoda, Panicum decompositum, Themeda australis.*

Infrequent spp: *Aristida helicophylla, Digitaria ammophila, Eragrostis dielsii, E. microcarpa, E. pergracilis, Fimbristylis dichotoma, Paspalidum clementii.*

LAND USE: GC 2.3 to 3.6 beasts/km2 (3.2), DGC 1.7 to 2.4 beasts/km2 (2.9); fair condition, slightly downwards trend; low to moderate WHC, low fertility; susceptible to sheet and water erosion if overgrazed and cleared; top feed present sometimes abundant; woody weeds may be a problem.

LAND UNIT 65

LANDFORM: Drainage lines associated with undulating plain and dissected lowhills.

GEOLOGY: Quaternary detritus. Qr, Qa.

SOILS: Shallow to moderately deep, red, loams to clay-loams often with stone intermixed. Gn 2.12, Gn 2.11, *Nockatunga*.

VEGETATION: Mulga grassy tall open shrubland. *Acacia aneura* (mulga) predominates with scattered low trees frequently present. There is no well defined shrub layer but isolated shrubs occur. Grasses are the main components of the ground flora and together with forbs form a moderately dense cover.

STRUCTURAL FORM: Tall open shrubland. Ht 6 ± 1 m; PFC 7.5 ± 2.5%.

TREE, TALL SHRUB LAYER: Ht 5 ± 3 m, PFC 7.5 ± 2.5%.

Predominant spp: *Acacia aneura*, Ht 6 ± 1 m, PFC 6 ± 2.5%.

Frequent spp: *Acacia tetragonophylla, Eremophila longifolia, Eucalyptus terminalis.*

Infrequent spp: *Atalaya hemiglauca, Grevillea striata.*

LOW SHRUB LAYER: Ht < 1 m, PFC < 1%.

Frequent spp: *Cassia artemisioides, C. helmsii, Enchylaena tomentosa.*

GROUND LAYER: Ht < 1 m, PFC 25 ± 10%.

FORBS:

Frequent spp: *Malvastrum spicatum, Portulaca* sp. aff. *P. oleracea, Ptilotus macrocephalus.*

Infrequent spp: *Abutilon* sp., *Alternanthera denticulata, Bassia lanicuspis, Calotis inermis, Dysphania myriocephala, Convolvulus erubescens, Euphorbia boophthona, Goodenia subintegra, Hybanthus auranticus, Ptilotus obovatus, Sida cunninghamii, Stenopetalum nutans, Tribulus terrestris, Velleia glabrata.*

GRAMINOIDS:

Frequent spp: *Chloris pectinata, Dactyloctenium radulans, Dichanthium sericeum, Eragrostis parviflora, Themeda australis, Tragus australianus.*

Infrequent spp: *Aristida contorta, Bothriochloa ewartiana, Brachiaria gilesii, Cymbopogon obtectus, Dichanthium affine, Digitaria brownii, Enneapogon polyphyllus, Fimbristylis dichotoma.*

LAND USE: GC 1.4 to 2.3 beasts/km2 (1.7), DGC 0.7 to 1.4 beasts/km2 (1.0); fair to mediocre condition, slightly downwards trend; very low WHC, very low fertility; water erosion; top feed present.

LAND UNIT 66

LANDFORM: Flat alluvial plain with few defined drainage lines.

GEOLOGY: Recent alluvial plains. Qa.

SOILS: Deep to very deep soils with red, sandy-clay-loam surface soil and sandy-clay subsoil. Soils are slightly acid to neutral with earthy fabric. They are massive throughout. *Tirtywinna.* Representative soil analysis: 96, 129.

VEGETATION: Mulga grassy tall shrubland to tall open shrubland. *Acacia aneura* (mulga) predominates but emerging trees including *Eucalyptus populnea* (in the east) and *E. terminalis* (in the west) usually occur. There is no well defined shrubby layer but isolated shrubs are frequently conspicuous. Grasses and forbs form a usually well developed ground cover.

STRUCTURAL FORM: Tall shrubland to tall open shrubland, Ht 7 ± 1 m, PFC 12.5 ± 2.5%.

TREE, TALL SHRUB LAYER: Ht 5 ± 3 m, PFC 12.5 ± 2.5%.

Predominant spp: *Acacia aneura,* Ht 7 ± Q m, PFC 12.5 ± 2.5% (rarely < 10%).

Frequent spp: *Acacia tetragonophylla, Atalaya hemiglauca, Eucalyptus populnea, E. terminalis.*

Infrequent spp: *Acacia stenophylla, A. victoriae, Grevillea striata, Santalum lanceolatum, Ventilago viminalis.*

LOW SHRUB LAYER: Ht < 0.75 m, PFC 2.5 ± 2%.

Frequent spp: *Cassia phyllodinea.*

Infrequent spp: *Cassia nemophila, C. oligophylla, Chenopodium auricomum, Enchylaena tomentosa.*

GROUND LAYER: Ht < 1 m, PFC 20 ± 5%.

FORBS:

Frequent spp: *Alternanthera denticulata, A. nodiflora, Bassia lanicuspis, Malvastrum spicatum, Minuria integerrima, Phyllanthus maderaspatensis.*

Infrequent spp: *Centipeda thespidioides, Indigofera dominii, Pimelea trichostachya, Rutidosis helichrysioides, Solanum ellipticum, Teucrium racemosum, Wahlenbergia* sp.

GRAMINOIDS:

Frequent spp: *Chrysopogon fallax, Dactyloctenium radulans, Cyperus iria, Dichanthium sericeum, Themeda australis.*

Infrequent spp: *Chloris pectinata, Fimbristylis dichotoma.*

LAND USE: GC 1.6 to 4.4 beasts/km2 (2.9), DGC 0.9 to 2.4 beasts/km2 (1.6); fair conditions, stable to downward trend; low to moderate WHC, low fertility, receives run-on water; top feed present; subject to gully erosion when in poor condition.

LAND UNIT 67

LANDFORM: Flat plains with very gentle slopes. < 1%.

GEOLOGY: Superficial Quaternary deposits overlying clay plains. Qr.

SOILS: The unit is a complex of deep, red clays and red, texture contrast soils in the gilgai (slump hole) depressions associated with the grove area, and red, texture contrast soils and red earths in the intergrove area.

A Grove. The red clays are deep and generally have alkaline soil reaction trends. They are cracking but have hard crusts when dry. Ug 5.37, Ug 5.38; *Ooliman.* The texture contrast soils are deep, medium clays with a thin, clay-loam surface. Dr 2.12, 2.13; *Lymbah, Bullawaria.* Representative soil analysis: 144, 149, 116, 143.

B Intergrove. Very shallow to shallow, slightly acid to neutral, loamy, red earth with ferruginous hardpan. Gn 2.12, Um 5.51; *Mt. Margaret.* Representative soil analysis: 115, 148.

VEGETATION: Well defined groved mulga grassy tall to tall open shrubland. *Acacia aneura* (mulga) predominates the grove with grasses, forbs and low shrubs conspicuous in the intergrove areas.

A Grove. Isolated trees, *E. terminalis* (western bloodwood) and *Grevillea striata* (beefwood) may be found. Usually a lower shrub layer is not well developed and only scattered shrubs occur. Ground cover is variable composed of forbs and grasses.

STRUCTURAL FORM: Tall shrubland; Ht 6 ± 2 m; PFC 12.5 ± 7.5%.

TREE, TALL SHRUB LAYER: Ht 5 ± 3 m, PFC 12.5 ± 7.5%.

Predominant spp: *Acacia aneura**; Ht 6 ± 2 m; PFC 12.5 ± 7.5%.

Frequent spp: *E. terminalis.*

Infrequent spp: *Acacia tetragonophylla, A. victoriae, Eremophila longifolia, Eucalyptus populnea, Grevillea striata.*

LOW SHRUB LAYER: Ht < 0.75 m, PFC 3 ± 3%.

Frequent spp: *Cassia artemisioides**, *C. desolata**, *C. oligophylla.*

Infrequent spp: *Eremophila gilesii**.

GROUND LAYER: Ht < 1 m, PFC 10 to 30%.

FORBS:

Frequent spp: *Alternanthera denticulata, A. nodiflora, Bassia cornishiana**, *B. bicornis**, *B. divaricata, Calotis inermis, C. latiuscula**, *C. multicaulis**, *Convolvulus erubescens, Erodium crinatum, Goodenia lunata**, *Neptunia dimorphantha, Phyllanthus maderaspatenus, Ptilotus gaudichaudii, P. heliptepoides, P. macrocephalus, P. polystachyus**, *Salsola kali, Sida platycalyx, Velleia glabrata.*

Infrequent spp: *Abutilon malvifolium, Centipeda thespidioides, Chenopodium rhydinostachyum, Desmodium muelleri, Dianella* sp. aff. *D. laevis, Euphorbia boophthona, E. coghlanii, Helipterum floribundum, H. striatum, Portulaca* sp. aff. *P. oleracea, Pimelea trichostachya, Psoralea cinerea, Rutidosis helichrysioides, Solanum ellipticum, S. sturtianum, S. quadriloculatum, Stenopetalum nutans, Swainsona campylantha, Tribulus terrestris.*

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* Species also occur in intergrove area.

GRAMINOIDS:

Frequent spp: *Aristida contorta**, *Brachiaria miliiformis*, *Chloris pectinata*, *Cyperus iria*, *Dactyloctenium radulans*, *Dichanthium affine*, *D. sericeum*, *Digitaria ammophila**, *D. brownii*, *Enneapogon polyphyllus**, *Eragrostis cilianensis*, *E. leptocarpa*, *E. parviflora*, *E. pergracilis**, *E. setifolia*, *E. tenellula*, *Eriachne pulchella**, *Eriochloa pseudoacrotricha*, *Eulalia fulva*, *Fimbristylis dichotoma*, *Iseilema macratherum*, *I. membranaceum*, *Paspalidum rarum*, *Themeda avenacea*, *T. australis*, *Tragus australianus**, *Tripogon loliiformis*.

Infrequent spp: *Aristida anthoxanthoides*, *A. helicophylla*, *A. jerichoensis**, *Brachyachne convergens*, *Austrochloris dichanthoides*, *Bothriochloa ewartiana*, *Panicum whitei**, *Perotis rara**.

B Intergrove. STRUCTURAL FORM: Herbfield (grasses or forbs predominating depending on seasonal influences), Ht < 0.5 m, PFC (variable) 1 to 25%.

TREE, TALL SHRUB LAYER: Ht 4 ± 2 m, PFC < 1%. Not well defined; scattered.

LOW SHRUB LAYER: Ht < 0.75 m, PFC < 1%. Not well defined; scattered.

GROUND LAYER: Ht < 0.5 m; PFC 15 ± 5%.

LAND USE: GC 2.0 to 5.0 beasts/km2 (2.3), DGC 0.5 to 2.0 beasts/km2 (1.0); moderate WHC, low to moderate fertility; water ponds in the slump holes; top feed abundant; rabbits warrens occur on this unit.

LAND UNIT 68

LANDFORM: Flat plains.

GEOLOGY: Superficial Quaternary deposits. Qr.

SOILS: Shallow to moderately deep, loamy, red earths with hardpans. Gravel is common in the lower part of the profile. Soils are massive throughout, slightly acid to acid, clay-loams at the surface and alkaline to neutral, clay-loams to light clays in the lower parts of the profile. Gn 2.12, Um 5.51; *Mt. Margaret*. Representative soil analysis: 111, 114.

VEGETATION: Mulga, western bloodwood tall open shrubland. *Acacia aneura* (mulga) predominates with *Eucalyptus terminalis* (western bloodwood) occurring frequently. In places *Grevillea striata* (beefwood) may be conspicuous. There is no well defined lower shrubby layer but scattered shrubs may be found. Ground cover is variable composed mainly of grasses but forbs do occur and in places predominate.

STRUCTURAL FORM: Tall open shrubland. Ht 5 ± 1 m; PFC 4 ± 3%.

TREE, TALL SHRUB LAYER: Ht 4 ± 2 m, PFC 4 ± 3%.

Predominant spp: *Acacia aneura*, Ht 5 ± 1 m, PFC 4 ± 3%.

Frequent spp: *Acacia tetragonophylla*, *Eucalyptus terminalis*.

Infrequent spp: *Eremophila longifolia*, *Grevillea striata*.

LOW SHRUB LAYER: Ht < 0.75 m, PFC < 1%.

Frequent spp: *Cassia helmsii*.

Infrequent spp: *Eremophila gilesii*.

GROUND LAYER: Ht < 0.5 m, PFC (variable), 5 ± 4%.

FORBS:

Frequent spp: *Bassia bicornis*, *B. lanicuspis*, *Kochia villosa*, *Ptilotus gaudichaudii*, *P. macrocephalus*, *Salsola kali*, *Velleia glabrata*.

Infrequent spp: *Calotis inermis*, *Convolvulus erubescens*, *Evolvulus alsinoides*, *Goodenia subintegra*, *Heliotropium strigosum*, *H. tenuifolium*, *Minuria leptophylla*, *Portulaca* sp. aff. *P. oleracea*, *Sida platycalyx*, *Stenopetalum nutans*, *Swainsona oroboides*, *Tribulus terrestris*, *Walhenbergia* sp.

GRAMINOIDS:

Frequent spp: *Aristida contorta*, *Enneapogon polyphyllus*, *Eriachne pulchella*, *Fimbristylis dichotoma*, *Tragus australianus*, *Tripogon loliiformis*.

Infrequent spp: *Dactyloctenium radulans*, *Dichanthium affine*, *Eragrostis dielsii*.

LAND USE: GC 1.8 to 3.6 beasts/km2 (2.0), DGC 0.8 to 1.8 beasts/km2 (1.3); fair to mediocre condition, slight downward to downward trend; very low WHC, very low fertility; top feed present; susceptible to sheet, wind and water erosion particularly when bare.

LAND UNIT 69

LANDFORM: Flat to gently undulating plains. Slope < 1%.

GEOLOGY: Quaternary sediments generally derived from the Cretaceous *Winton Formation*. Qa/Kw.

SOILS: Deep to very deep, gilgaied, grey and brown clays, often with surface crust or thin, clay-loam to light clay surface soil.

VEGETATION: Brigalow, gidgee shrubby woodland. This association occurs in situations where it receives more water than surrounding gidgee shrubland. *Acacia harpophylla* (brigalow) predominates. *Acacia cambagei* (gidgee) usually occurs with other scattered trees. A tall shrubby layer is well defined in places composed mainly of *Eremophila mitchellii* (sandalwood) and *Geijera parviflora* (wilga). Low shrubs may be present. Ground cover is sparse. Frequently areas devoid of vegetation occur.

STRUCTURAL FORM: Shrubby woodland; Ht 9 ± 1 m, PFC 20 ± 10%.

TREE LAYER: Ht 8 ± 2 m, PFC 20 ± 10%.

Predominant spp: *Acacia harpophylla*, Ht 9 ± 1 m, PFC 20 ± 10%.

Frequent spp: *A. cambagei*.

Infrequent spp: *Ehretia membranifolia*, *Eucalyptus thozetiana*.

LOW SHRUB LAYER: Ht 1.0 ± 0.5 m, PFC < 1%.

Infrequent spp: *Dodonaea cuneata*, *Myoporum deserti*.

GROUND LAYER: Ht < 1 m, PFC < 1%, frequently devoid of vegetation.

FORBS:

Infrequent spp: *Atriplex spongiosa*, *A. elachophylla*, *A. lindleyi*, *Bassia bicornis*, *B. quinquecuspis*, *Salsola kali*.

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* Species also occur in intergrove area.

LAND UNIT 69 (continued)

GRAMINOIDS:

Infrequent spp: *Dactyloctenium radulans, Enteropogon acicularis, Sporobolus caroli, Tragus australianus.*

LAND USE: GC 6.5 beasts/km2 (9.5), DGC 0.6 beasts/km2; fair condition, slight downward trend; high WHC, infiltration low to moderate, fair fertility; top feed present; woody regrowth a problem; productivity may be improved by thinning.

LAND UNIT 70

LANDFORM: Flat plains commonly with a main gully.

GEOLOGY: Recent alluvial material. Qa.

SOILS: Soils range from very deep, strongly gilgaied, grey clays to alluvial soils with texture contrast. The texture contrast soils are generally hardsetting, clay-loams overlying structured, clays.

VEGETATION: Brigalow shrubby woodland. *Acacia harpophylla* (brigalow) predominates with scattered trees emerging. A lower shrubby layer is conspicuous in places. The ground cover is usually poor composed mainly of forbs.

STRUCTURAL FORM: Woodland to low woodland: Ht 8 ± 2 m; PFC 15 ± 5%.

TREE LAYER: Ht 9 ± 3 m, PFC 15 ± 5%.

Predominant spp: *Acacia harpophylla.* Ht 8 ± 2 m, PFC 15 ± 5%.

Infrequent spp: *Eucalyptus thozetiana.*

TALL SHRUB LAYER: Ht 4 ± 2 m, PFC < 5%.

Infrequent spp: *Eremophila mitchellii, Geijera parviflora, Santalum lanceolatum.*

LOW SHRUB LAYER: Ht 1 ± 0.5 m, PFC < 1%.

Frequent spp: *Myoporum deserti,* Ht 1 ± 0.5 m, PFC < 1%.

Infrequent spp: *Scaevola spinescens.*

GROUND LAYER: Ht < 1 m, PFC (variable) 10 ± 5%.

FORBS:

Frequent spp: *Bassia bicornis, B. calcarata, B. tricuspis.*

Infrequent spp: *Abutilon oxycarpum, Salsola kali.*

GRAMINOIDS:

Infrequent spp: *Chloris pectinata, Dactyloctenium radulans, Enteropogon acicularis, Sporobolus caroli, Tragus australianus.*

LAND USE: GC 5.2 beasts/km2 (6.7), DGC 0.6 beasts/km2; fair to mediocre condition, slight downward trend; high WHC, low to moderate infiltration, low to fair fertility; subject to gully erosion in places; receives run-on water; top feed present.

LAND UNIT 71

LANDFORM: Gently undulating plains. Slopes 1 to 5%.

GEOLOGY: Mixed material formed on mantled pediment slopes, comprising material from the altered Cretaceous *Winton Formation* sediments and eroded Tertiary land surface material.

SOILS: Soils are moderately gilgaied, alkaline, red, silty-clay-loams to silty-light-clays with stone intermixed. Surface crusting is common. Representative soil analysis: 85, 86.

VEGETATION: Gidgee shrubby tall open shrubland. *Acacia cambagei* (gidgee) predominates. A low shrubby layer is not well defined but scattered shrubs occur frequently. Ground flora is variable composed mainly of forbs.

STRUCTURAL FORM: Tall open shrubland. Ht 6 ± 2 m; PFC 5 ± 4%.

TREE, TALL SHRUB LAYER: Ht 6 ± 2 m, PFC 5 ± 4%.

Predominant spp: *Acacia cambagei,* Ht 6 ± 2 m, PFC 5 ± 4%.

LOW SHRUB LAYER: Ht 1.25 ± 0.75 m, PFC < 1%.

Frequent spp: *Enchylaena tomentosa, Rhagodia spinescens.*

Infrequent spp: *Dodonaea attenuata.*

GROUND LAYER: Ht < 0.6 m, PFC 10 ± 5%.

FORBS:

Frequent spp: *Alternanthera nodiflora* (depressions), *Atriplex spongiosa, A. stipitata, Bassia divaricata, B. lanicuspis, Centipeda thespidioides* (depressions), *Dysphania myriocephala, Lepidium rotundum, Zygophyllum ammophilum.*

Infrequent spp: *Bassia tricuspis, Boerhavia diffusa, Tetragonia tetragonioides, Tribulus terrestris, Trianthema galericulata.*

GRAMINOIDS:

Frequent spp: *Chloris pectinata* (depressions), *Cyperus iria* (depressions), *Dactyloctenium radulans, Eragrostis tenellula* (depressions), *Tripogon loliiformis.*

LAND USE: GC 3.4 to 5.6 beasts/km2 (3.5); DGC 0.4 beasts/km2; mediocre to fair condition, trend downwards to slight downwards; moderate WHC, moderate infiltration, low to fair fertility; sheet erosion is common; limited top feed.

LAND UNIT 72

LANDFORM: Lower slopes of dissected low tablelands and scarp retreats. Slopes 2 to 5%.

GEOLOGY: Scarp retreat of the deeply weathered Cretaceous *Winton Formation* with this unit formed on the weathered material, often with significant deposits from the Tertiary profile intermixed. Qr, Kw.

SOILS: Soils are very shallow to shallow, stony, clay-loams to light clays sometimes with texture contrast profiles; usually structured below the surface soil, which is generally hardsetting. Overlying weathered rock. Soils are neutral to alkaline. Um 1.43, Um 1.21, Dy 2.12, Dr 2.12; *Woban, Whynot.* Representative soil analysis: 19, 23, 57, 64, 160.

VEGETATION: Gidgee forby tall open shrubland. *Acacia cambagei* (gidgee) predominates. Scattered shrubs of *A. aneura* (mulga) are frequently present and other isolated trees may occur. There is no well defined low shrubby layer scattered low shrubs may be present. Ground cover is variable composed mainly of forbs but grasses do occur. In depressions and along drainage lines, *Atalaya hemiglauca* (whitewood), *Ventilago viminalis* (vinetree) and *Eremophila mitchellii* (sandalwood) are frequently conspicuous.

STRUCTURAL FORM: Tall open shrubland: Ht 4 ± 1 m; PFC 5 ± 4%.

TREE, TALL SHRUB LAYER: Ht 4 ± 1 m, PFC 5 ± 4%.

Predominant spp: *Acacia cambagei*, Ht 4 ± 1 m, PFC 5 ± 4%.

Frequent spp: *Acacia aneura, Flindersia maculosa.*

Infrequent spp: *Acacia oswaldii, Owenia acidula.*

LOW SHRUB LAYER: Ht < 0.75 m, PFC 2 ± 1.5%.

Frequent spp: *Cassia desolata, C. phyllodinea, Scaevola spinescens.*

Infrequent spp: *Cassia artemisioides, Myoporum deserti, Rhagodia spinescens.*

GROUND LAYER: Ht < 0.5 m, PFC (variable) 5 ± 4%.

FORBS:

Frequent spp: *Bassia calcarata, B. intricata, B. lanicuspis, B. tricuspis, Kochia coronata, K. triptera, K. villosa, Salsola kali.*

Infrequent spp: *Abutilon otocarpum, Atriplex eardleyae, A. vesicaria, Dysphania myriocephala, Euphorbia drummondii, Melhania ovata, Portulaca* sp. aff. *P. oleracea, Sida filiformis, Solanum ellipticum, S. quadriloculatum, Threlkeldia proceriflora, Tribulus terrestris, Velleia glabrata, Zyophyllum ammophilum, Z. apiculatum.*

GRAMINOIDS:

Frequent spp: *Brachiaria gilesii, Chloris pectinata, Dactyloctenium radulans, Enneapogon polyphyllus.*

Infrequent spp: *Eragrostis dielsii, Fimbristylis dichotoma, Neurachne munroi, Paspalidium rarum, Sporobolus actinocladus, S. elongatus, Tragus australianus, Tripogon loliiformis.*

LAND USE: GC 1.4 to 3.7 beasts/km2 (2.5), DGC 0.8 to 2.1 beasts/km2 (1.4); mediocre to poor condition, trend downwards; very low WHC, low to moderate infiltration, low fertility; susceptible to sheet, wind and water erosion; top feed not abundant.

LAND UNIT 73

LANDFORM: Gently sloping alluvia associated with the minor drainage lines of the gently undulating plains. Slopes < 1%.

GEOLOGY: Recent alluvia overlying freshly weathered, Cretaceous *Winton Formation* sediments. Qa, Kw.

SOILS: Moderately deep to deep, red and brown clays overlying fresh, fine grained, sandstones. Soils are medium to heavy clays and are neutral to alkaline. Gravel is often intermixed in the profile. A thin surface crust is common. Ug 5.32, Ug 5.37; *Pinkilla.* Representative soil analysis: 37.

VEGETATION: Gidgee, saltbush forby tall open shrubland. *Acacia cambagei* (gidgee) predominates usually. There is no lower shrubby layer but scattered low shrubs of *Arthrocnemum* (samphire) occur. The ground cover is variable composed mainly of forbs, but grasses are present. *Cyperus gilesii, Echinochloa colonum, Marsilea* spp. and *Xanthium pungens* are associated with the drainage lines.

STRUCTURAL FORM: Tall open shrubland: Ht 5 ± 1 m, PFC 10 ± 5% (PFC up to 20% in clumps developed along drainage lines).

TALL SHRUB LAYER: Ht 5 ± 1 m, PFC 10 ± 5%.

Predominant spp: *Acacia cambagei*, Ht 5 ± 1 m, PFC 10 ± 5%.

LOW SHRUB LAYER: Ht < 0.5 m, PFC < 1%.

Frequent spp: *Arthrocnemum leiostachyum.*

GROUND LAYER: Ht < 0.5 m, PFC 10 ± 5%.

FORBS:

Frequent spp: *Atriplex lindleyi, A. spongiosa, Bassia calcarata, Kochia coronata, Portulaca* sp. aff. *P. oleracea, Salsola kali, Xanthium pungens* (associated with drainage lines).

Infrequent spp: *Cucumis myriocarpus, Euphorbia drummondii, Malvastrum spicatum, Solanum ellipticum, Tribulus terrestris.*

GRAMINOIDS:

Frequent spp: *Chloris pectinata, Cynodon dactylon* (drainage lines), *Cyperus gilesii* (drainage lines), *Dactyloctenium radulans, Eragrostis cilianensis, E. pergracilis.*

Infrequent spp: *Echinochloa colonum* (depressions), *Enneapogon polyphyllus, Tripogon loliiformis.*

LAND USE: GC 2.6 to 5.2 beasts/km2 (2.6), DGC 0.5 beasts/km2; fair to poor condition, trend downwards; high WHC, moderate infiltration, fair fertility; receives run-on water; top feed absent; subject to gully erosion.

LAND UNIT 74

LANDFORM: Gently undulating to undulating plains with convex slopes. Slopes 1 to 3%. Weakly gilgaied.

GEOLOGY: Soil mantle developed from fresh sediments of the Cretaceous *Winton Formation*. Silcrete stone cover is derived from erosion of the Tertiary land surface. Kw.

SOILS: Soils are deep to very deep, self-mulching, stone covered, red and brown clays. Soils are predominantly alkaline throughout, but on those soils where gidgee predominates they may become acid with depth. $CaCO_3$ concretions are found in the surface soil and gypsum is usually present below 45 cm and gradually increases with depth. Thin, easily broken surface crusts may form on this soil. Textures are medium to heavy clays. Ug 5.37, Ug 5.32; *Karmona*. Representative soil analysis: 36, 38.

VEGETATION: Boree, gidgee forby tall open shrubland. *Acacia cana* (boree) predominates and may form pure stands but frequently is associated with *A cambagei* (gidgee). There is no well defined lower shrubby layer but scattered low shrubs may occur. The ground cover is variable depending on the season and is composed of grasses and forbs.

STRUCTURAL FORM: Tall open shrubland to low open woodland: Ht 8 $\pm$ 2 m, PFC 3 $\pm$ 2%.

TREE, TALL SHRUB LAYER: Ht 7 $\pm$ 3 m, PFC 3 $\pm$ 2%.

Predominant spp: *Acacia cana*, Ht 8 $\pm$ 2 m, PFC 3 $\pm$ 2%.

Frequent spp: *Acacia cambagei*.

LOW SHRUB LAYER: Ht 1.5 $\pm$ 0.5%, PFC < 1%.

Infrequent spp: *Eremophila dalyana, E. maculata, Scaevola spinescens*.

GROUND LAYER: Ht < 1 m; PFC 6 $\pm$ 4%.

FORBS:

Frequent spp: *Atriplex lindleyi, A. spongiosa, Bassia calcarata, B. divaricata, B. lanicuspis, B. longicuspis, Lepidium rotundum, Zygophyllum ammophilum, Z. apiculatum*.

Infrequent spp: *Abutilon malvifolium, Sida fibulifera, Solanum esuriale, Threlkeldia proceriflora*.

GRAMINOIDS:

Frequent spp: *Astrebla pectinata*.

Infrequent spp: *Astrebla lappacea, A. elymoides, Dactyloctenium radulans, Sporobolus actinocladus, S. caroli*.

LAND USE: GC 4.2 to 6.9 beasts/km2 (5.2), DGC 0.7 to 1.4 beasts/km2 (1.0); fair to good condition, trend stable; high WHC, moderate infiltration, fair fertility; susceptible to gully erosion, top feed absent.

LAND UNIT 75

LANDFORM: Gently sloping, alluvial fan-plain. Slopes < 0.5%.

GEOLOGY: Alluvial fan emanating from the scarp retreat zone of the deeply weathered Cretaceous *Winton Formation* sediments.

SOILS: Moderately deep to deep, alluvial soils with gravel intermixed. Soils are mainly reddish-brown to yellowish-brown, alkaline, sandy-clays overlain by a surface cover, in some cases, of sandy-clay-loam. In places they may crack, but generally surfaces are hardsetting. *Farnham*. Representative soil analysis: 78.

VEGETATION: Short grass, forby herbfield. Short grasses and forbs predominate. Shrubby layers are not well defined but scattered low shrubs may be found. Low trees are found along or adjacent to drainage lines. Scattered shrubs of *Acacia aneura* (mulga) and *A. cambagei* (gidgee) may occur.

STRUCTURAL FORM: Open herbfield (grassland or forbland depending on seasonal influences): Ht < 0.5 m, PFC 5 $\pm$ 4%.

TREE, TALL SHRUB LAYER: Ht 3.5 $\pm$ 1 m, PFC < 1%.

Frequent spp: *Acacia aneura, A. cambagei, Flindersia maculosa*.

Infrequent spp: *Pittosporum phillyraeoides, Santalum lanceolatum*.

LOW SHRUB LAYER: Ht 1.25 $\pm$ 0.75 m, PFC < 1%.

Frequent spp: *Cassia nemophila* var. *nemophila, C. phyllodinea, Enchylaena tomentosa, Myoporum deserti*.

Infrequent spp: *Dodonaea tenuifolia*.

Sandy rises: *Eremophila glabra, E. mitchellii, E. sturtii*.

GROUND LAYER: Ht < 0.5 m, PFC 5 $\pm$ 4.5%.

FORBS:

Frequent spp: *Bassia andersonii, B. calcarata, B. lanicuspis, B. tricuspis, Portulaca* sp. aff. *P. oleracea, Salsola kali*.

Infrequent spp: *Abutilon otocarpum, Atriplex angulata, Boerhavia diffusa, Brachycome ciliaris* var. *lanuginosa, Chenopodium rhydinostachyum, Goodenia lunata* (sandy rises), *G. subintegra, Hibiscus brachysiphonus, Malvastrum spicatum, Portulaca filifolia, Pterocaulon sphacelatum, Zyophyllum apiculatum*.

GRAMINOIDS:

Frequent spp: *Chloris scariosa, Dactyloctenium radulans, Enteropogon acicularis, Eragrostis dielsii, Sporobolus actinocladus*.

Infrequent spp: *Astrebla pectinata, Fimbristylis dichotoma*.

LAND USE: GC 2.2 to 4.7 beasts/km2 (3.6), DGC 0.4 to 1.3 beasts/km2 (0.8); fair to poor condition, trend downwards; low to moderate, low fertility; receives run-on water; subject to gully and sheet water erosion; top feed not abundant.

LAND UNIT 76

LANDFORM: Gently undulating convex plains. Slopes < 3%. Weak to moderate gilgai development.

GEOLOGY: Derived from fresh sediments of the Cretaceous *Winton Formation*. Stone cover is derived from erosion of the weathered Tertiary land surface, which previously covered this formation. Kw.

SOILS: Deep to very deep, very stony, red and brown clays. Minor occurrence of grey clays. Colours range from yellowish red throughout, which is the common colour, to pale-brown. Soil reaction trend is generally from alkaline, in the top 60 cm of the profile, to acid at depth. Textures range from medium to heavy clays. Soils crack readily but have surface crusts, readily separable from the soil. $CaCO_3$ is common in the upper part of the profile with abundant gypsum occurring at depth. Ug 5.38, Ug 5.24; *Karmona.* Representative soil analysis: 65, 118, 155, 165.

VEGETATION: Gidgee, forby tall open shrubland. *Acacia cambagei* (gidgee) predominates. A low shrubby layer is not well defined but scattered low shrubs occur frequently. Ground cover is variable composed mainly of forbs but grasses may occur.

STRUCTURAL FORM: Tall open shrubland, Ht 6 ± 2 m; PFC 5 ± 4%.

TREE, TALL SHRUB LAYER: Ht 6 ± 2 m, PFC 5 ± 4%.

Predominant spp: *Acacia cambagei*, Ht 6 ± 2 m; PFC 5 ± 4%.

Infrequent spp: *Santalum lanceolatum.*

LOW SHRUB LAYER: Ht < 0.75 m, PFC < 1%.

Frequent spp: *Enchylaena tomentosa, Rhagodia spinescens.*

Infrequent spp: *Cassia oligophylla, Eremophila maculata, Myoporum deserti* (in places may form dense stands).

GROUND LAYER: Ht < 0.6 m, PFC (variable) 5 ± 4%.

FORBS:

Frequent spp: *Atriplex lindleyi, A. spongiosa, A. stipitata, Bassia bicornis, B. divaricata, B. lanicuspis, B. longicuspis, B. paradoxa, B. tricuspis, Salsola kali, Trianthema triquetra, Zyophyllum ammophilum.*

Infrequent spp: *Atriplex vesicaria, Babbagia scleroptera, Boerhavia diffusa, Dysphania myriocephala, Euphorbia stevenii, Kochia triptera, K villosa, Lepidium rotundum, Portulaca* sp. aff. *P. oleracea, Ptilotus exaltatus, Solanum esuriale, Threlkeldia proceriflora, Tribulus terrestris, Trianthema galericulata.*

Spp. associated with depressions: *Alternanthera nodiflora, Centipeda minima, C. thespidioides.*

GRAMINOIDS:

Frequent spp: *Dactyloctenium radulans, Sporobolus actinocladus, S. caroli.*

Infrequent spp: *Astrebla pectinata, Aristida anthoxanthoides, Iseilema membranaceum, Panicum decompositum, P. whitei, Paspalidium rarum, Tragus australianus, Tripogon loliiformis.*

Spp. associated with depressions: *Chloris pectinata, Cyperus iria, Eragrostis tenellula.*

LAND USE: GC 2.4 to 7.1 beasts/km^2 (3.8), DGC 0.4 to 1.0 beasts/km^2 (0.7); fair to good condition, trend stable; high WHC, moderate infiltration, fair fertility; top feed absent; susceptible to gully erosion in places.

LAND UNIT 77

LANDFORM: Upper slopes of gently undulating to undulating plains. Slopes 3 to 20%. Median slope 8%.

GEOLOGY: Derived from fresh sediments of the Cretaceous *Winton Formation*. Stone cover is derived from erosion of the weathered Tertiary land surface. Kw.

SOILS: Shallow to very shallow, stony, red and brown clays. Soil reaction trend ranges from neutral to alkaline. $CaCO_3$ is often present. Textures range from medium to heavy clay. Surface soil tends to crust and seal but is generally cracking. Subsoils are strongly structured. Ug 5.37, Ug 5.32, Ug 5.24; *Ackland.* Representative soil analysis: 80.

VEGETATION: Gidgee, forby tall open shrubland. *Acacia cambagei* (gidgee) predominates. Scattered low trees may be present. A low shrubby layer is not well defined but scattered shrubs occur frequently. Ground cover is variable composed mainly of forbs but grasses do occur.

STRUCTURAL FORM: Tall open shrubland. Ht 6 ± 2 m; PFC 5 ± 2%.

TREE, TALL SHRUB LAYER: Ht 5.5 ± 2.5 m, PFC 5 ± 2%.

Predominant spp: *Acacia cambagei*, Ht 6 ± 2 m, PFC 5 ± 2%.

Infrequent spp: *Atalaya hemiglauca* (very rare), *Eremophila longifolia, Flindersia maculosa.*

LOW SHRUB LAYER: Ht 1.25 ± 0.75 m, PFC < 1%.

Frequent spp: *Cassia oligophylla, Eremophila mitchellii, Myoporum deserti.*

Infrequent spp: *Cassia artemisioides, C. sturtii, Dodonaea tenuifolia, Eremophila gilesii, Rhagodia spinescens.*

GROUND LAYER: Ht < 0.5 m, PFC (variable) 5 ± 4.5%.

FORBS:

Frequent spp: *Atriplex lindleyi, A. spongiosa, Bassia andersonii, B. divaricata, B. lanicuspis, B. tricuspis, Boerhavia diffusa, Salsola kali, Zygophyllum ammophilum, Z. apiculatum.*

Infrequent spp: *Babbagia scleroptera, Ptilotus obovatus, Rhagodia nutans, Stenopetalum nutans, Tetragonia tetragonioides, Threlkeldia proceriflora, Trianthema galericulata.*

GRAMINOIDS:

Frequent spp: *Dactyloctenium radulans, Tragus australianus.*

Infrequent spp: *Brachyachne convergens, Sporobolus caroli, S. scabrides.*

LAND USE: GC 1.7 to 5.2 beasts/km^2 (3.3), DGC 0.4 to 1.4 beasts/km^2 (0.9); fair condition, trend slight downwards; low to moderate WHC, low to fair fertility; top feed absent; susceptible to gully erosion.

LAND UNIT 78

LANDFORM: Low sandy rises on flat plains. Relief < 3 m. Slopes < 1%.

GEOLOGY: Quaternary aeolian sand. Qs.

SOILS: Deep, yellowish-brown, earthy sands and sandy red and yellow earths with loose surfaces.

VEGETATION: Moreton Bay ash, long fruited bloodwood open woodland. *Eucalyptus tessellaris* (Moreton Bay ash) and *E. polycarpa* (long fruited bloodwood) predominate. Scattered trees of *Acacia excelsa* may occur. A lower shrubby layer is often well defined with *Alstonia constricta* occurring. Ground cover is composed of forbs and grasses. *Aristida* spp., *Eragrostis* spp., *Bassia* spp. and *Sida* spp. are usually conspicuous.

STRUCTURAL FORM: Open woodland: Ht 10 ± 2 m; PFC 6 ± 4%.

LAND USE: GC < 3.8 beasts/km2, DGC 0.6 beasts/km2; fair condition, trend stable; low WHC, low fertility, top feed absent.

LAND UNIT 79

LANDFORM: Crests of undulating plains formed by the dissection of the Tertiary land surface. Slopes 1 to 5%.

GEOLOGY: Eroded remnants of the Tertiary land surface comprising chemically altered, Cretaceous sediments.

SOILS: Shallow, loamy, red earths and lithosols. Weathered rock exposure is common. Soils are deeper down the slope. Stone cover is common. Um 1.43, Gn 2.12; *Grey*.

VEGETATION: Silver-leaved ironbark, mulga woodland. *Eucalyptus melanophloia* (silver-leaved ironbark) predominates. Usually a well defined understorey of tall shrubs, predominantly *Acacia aneura*, occurs. A lower shrubby layer is not usually well developed but scattered low shrubs may be found. Ground cover is sparse. *Eucalyptus populnea*, *Acacia aneura* low open woodland is frequently conspicuous further down the slope with *Acacia clivicola* low open shrubland up the slope.

STRUCTURAL FORM: Woodland: Ht 11 ± 2 m; PFC 15 ± 5%.

TREE, TALL SHRUB LAYER: Ht 9 ± 4 m, PFC 15 ± 5%.

Predominant spp: *Acacia aneura*, Ht 8 ± 2 m, PFC 10 ± 9%; *Eucalyptus melanophloia*, Ht 11 ± 2 m, PFC 15 ± 5%.

Infrequent spp: *Eucalyptus populnea*, *E. terminalis*.

LOW SHRUB LAYER: Ht 1 ± 0.5 m, PFC < 1%.

Frequent spp: *Cassia nemophila*.

Infrequent spp: *Cassia artemisioides*.

GROUND LAYER: Ht < 0.6 m, PFC ⊂ 1%.

GRAMINOIDS:

Frequent spp: *Aristida jerichoensis*, *Chrysopogon fallax*.

LAND USE: GC 3.2 beasts/km2, DGC 0.8 beasts/km2; poor to mediocre condition, trend downwards; very low WHC, very low fertility; limited top feed; susceptible to sheet erosion.

LAND UNIT 80

LANDFORM: Flat plains.

GEOLOGY: Mixed Quaternary alluvia. Qa.

SOILS: Soils are red, texture contrast soils with hardsetting, earthy, sandy-loam to clay-loam surface soil and structured clay subsoils.

VEGETATION: Dawson gum, sandalwood open woodland. *Eucalyptus cambageana* (Dawson gum) predominates but other scattered trees may occur. A tall shrub layer is present but frequently not well defined. Isolated low shrubs occur but do not form a well developed layer. In places this association is associated with gidgee shrubland.

STRUCTURAL FORM: Open woodland to open low woodland; Ht 8 ± 3 m; PFC 5 ± 4%.

TREE, TALL SHRUB LAYER: Ht 7 ± 4 m, PFC 7.5 ± 2.5%.

Predominant spp: *Eucalyptus cambageana*, Ht 8 ± 3 m, PFC 7.5 ± 2.5%.

Frequent spp: *Acacia aneura*, *Eremophila mitchellii*.

Infrequent spp: *Acacia excelsa*.

LOW SHRUB LAYER: Ht 0.75 ± 0.25 m, PFC < 1%.

Infrequent spp: *Cassia artemisioides*, *C. nemophila* var. *nemophila*, *Enchylaena tomentosa*.

GROUND LAYER: Ht < 0.5 m, PFC < 1 to 5%.

FORBS:

Frequent spp: *Bassia birchii*, *B. paradoxa*, *Sida* spp., *Salsola kali*.

Infrequent spp: *Malvastrum spicatum*, *Ptilotus nobilis*.

GRAMINOIDS:

Infrequent spp: *Aristida* spp., *Eragrostis* spp.

LAND USE: GC > 3.8 beasts/km2 (5.6), DGC 1.3 beasts/km2; fair condition, trend stable to slightly downwards; moderate WHC, low to moderate infiltration; top feed present; woody weeds are a problem; timber treatment may be practical in some cases.

LAND UNIT 81

LANDFORM: Flat plain.

GEOLOGY: Mixed, recent alluvia material. Qa, Qr.

SOILS: Soils are predominantly red, texture contrast soils with some loamy, red earths intermixed. Soils are acid to neutral, earthy, red, loams to clay-loams (20 cm) overlying alkaline, red, structured, light to medium clays. Lime is commonly present in the B horizon, gypsum being present at depth. Surface soil is hardsetting. A bleach may be conspicuous or absent. Dr 2.43, Dr 2.13; *Ambathala*. Representative soil analysis: B1.

VEGETATION: Poplar box, sandalwood shrubby woodland. *Eucalyptus populnea* (poplar box) predominates. Frequently *Acacia aneura* (mulga) forms a well defined understorey. A tall shrubby layer is usually conspicuous composed mainly of *Eremophila mitchellii* (sandalwood). A low shrubby layer may be well developed in places. Grasses and forbs form a variable ground cover.

STRUCTURAL FORM: Woodland to open woodland: Ht 9 ± 3 m, PFC 10 ± 5%.

TREE, TALL SHRUB LAYER: Ht 9 ± 3 m, PFC 10 ± 15%.

Predominant spp: *Eucalyptus populnea*, Ht 9 ± 3 m, PFC 10 ± 15%.

Frequent spp: *Acacia aneura*.

MID-HEIGHT SHRUB: Ht 3 ± 1 m, PFC 10 ± 5%.

Frequent spp: *Eremophila mitchellii*.

LOW SHRUB LAYER: Ht < 0.5 m, PFC 10 ± 10%.

Frequent spp: *Eremophila gilesii, E. sturtii, Myoporum deserti*.

GROUND LAYER: Ht < 0.7 m, PFC 18 ± 7%.

FORBS:

Frequent spp: *Bassia birchii, B. divaricata, B. quinquecuspis*.

Infrequent spp: *Cheilanthes sieberi, Convolvulus erubescens, Evolvulus alsinoides, Phyllanthus maderaspatensis, Ptilotus macrocephalus, Solanum esuriale, Velleia glabrata, Vittadinia triloba*.

GRAMINOIDS:

Frequent spp: *Aristida contorta, A. jerichoensis, A. helicophylla*.

Infrequent spp: *Brachyachne convergens, Digitaria ammophila, Enteropogon acicularis, Eragrostis kennedyae, E. setifolia, Monachather paradoxa, Panicum decompositum, P. whitei, Tripogon loliiformis*.

LAND USE: GC > 4.7 beasts/km2 (7.4), DGC 0.5 beasts/km2; fair to good condition, trend stable to slight downwards; moderate WHC, moderate infiltration rate, low to fair fertility; susceptible to gully erosion near major drainage lines; woody weeds are a problem; top feed not readily available; receives run-on water.

LAND UNIT 82

LANDFORM: Local alluvial plain in slightly undulating plains. Slopes < 1%.

GEOLOGY: **A** Recent alluvia derived from the fresh Cretaceous *Winton Formation* sediments.

B Recent alluvia derived from mixed fresh and weathered Cretaceous *Winton Formation* material and Tertiary land surface material.

SOILS: **A** Very deep, brown and red clays which are scalded in places. Some mudstone and gravel intermixed. Ug 5.32; *Pinkilla*. Representative soil analysis: 163.

B Shallow to moderately deep, sandy-clay-loam to clay-loams with stone intermixed. Massive throughout. *Nockatunga*.

VEGETATION: **A** Short grass, forby herbfield. Grasses or forbs are predominant. Grasses include *Astrebla pectinata* (barley Mitchell grass), *Dactyloctenium radulans* (button grass), *Eragrostis dielsii, Tragus australianus* and *Uranthothecium truncatum*. Forbs present are *Atriplex spongiosa* (pop saltbush), *Bassia lanicuspis, Boerhavia diffusa* and *Kochia* spp. Trees or shrubs do not occur.

STRUCTURAL FORM: Herbfield to open herbfield (grasses or forbs predominant); Ht < 0.7 m, PFC (variable) 15 ± 10%.

GROUND LAYER: Ht < 0.7 m, PFC 15 ± 10%.

FORBS:

Frequent spp: *Atriplex spongiosa, Bassia lanicuspis, Boerhavia diffusa, Portulaca* sp. aff. *P. oleracea*.

Infrequent spp: *Bassia divaricata, Calotis inermis, C. latiuscula, C. multicaulis, Centipeda thespidioides, Euphorbia drummondii, Frankenia hamata, Minuria integerrima, Salsola kali*.

GRAMINOIDS:

Frequent spp: *Astrebla pectinata, Dactyloctenium radulans, Eragrostis dielsii, Tragus australianus, Uranthothecium truncatum*.

Infrequent spp: *Iseilema membranaceum, Panicum whitei, Sporobolus actinocladus*.

B Mineritchie tall open shrubland. *Acacia cyperophylla* (mineritchie) predominates forming pure stands in places. A low shrubby layer is usually not well defined but scattered shrubs occur. Grasses and forbs form a variable ground cover.

STRUCTURAL FORM: Tall open shrubland. Ht 7 ± 2 m, PFC 1 to 5%.

TREE, TALL SHRUB LAYER: Ht 7 ± 2 m, PFC 1 to 5%.

Predominant spp: *Acacia cyperophylla*, Ht 7 ± 2 m, PFC 1 to 5%.

Infrequent spp: *A. aneura, A. cambagei, Eucalyptus camaldulensis, E. microtheca*.

LOW SHRUB LAYER: Ht < 1.3 m, PFC < 1%.

Infrequent spp: *A. farnesiana, A. tetragonophylla, Cassia helmsii, C. nemophila, C. oligophylla, Capparis lasiantha*.

GROUND LAYER: Ht < 0.75 m, PFC (variable) 10 ± 9%.

FORBS:

Infrequent spp: *Atriplex spongiosa, Bassia divaricata, B. lanicuspis, Kochia coronata, K. villosa*.

GRAMINOIDS:

Infrequent spp: *Astrebla pectinata, Bothriochloa ewartiana, Brachiaria miliiformis, Chloris pectinata, Dactyloctenium radulans, Enneapogon polyphyllus, Eragrostis setifolia, Panicum* spp.

LAND USE: GC 3.3 beasts/km2; DGC 0.4 beasts/km2; fair to poor condition, trend slightly downwards to downwards; **A** has high WHC, **B** has moderate WHC, fertility is low to fair; flash flooding; gully erosion may be a problem; top feed absent.

LAND UNIT 83

LANDFORM: Gently undulating plains with long slopes. Slopes 0 to 3%. Median slope < 1%.

GEOLOGY: Fresh, labile, sandstone of the Cretaceous *Winton Formation* with occasional strongly indurated concretions on the soil surface. Kw.

SOILS: Deep to very deep, red and brown cracking clays with soft, self-mulching surfaces. $CaCO_3$ and gypsum are present in the profile. Textures range from silty-clays to heavy clays and the profile is alkaline to strongly alkaline. Ug 5.38, Ug 5.22; *Arima*. Representative soil analysis: 167. N.B. Pattern of sediments banding.

VEGETATION: Button grass, pop saltbush forby herbfield. *Dactyloctenium radulans* (button grass) and *Atriplex spongiosa* (pop saltbush) predominate. There are no trees or shrubs present.

STRUCTURAL FORMATION: Grassland (or forbland depending on seasonal conditions); Ht < 0.75 m, PFC (variable) 15 ± 10%.

GROUND LAYER: Ht < 0.75 m, PFC 15 ± 10%.

FORBS:

Predominant spp: *Atriplex spongiosa*.

Frequent spp: *Threlkeldia proceriflora*.

Infrequent spp: *Amaranthus mitchellii, Boerhavia diffusa, Euphorbia stevenii, Helipterum floribundum, Lepidium rotundum, Salsola kali, Zygophyllum ammophilum*.

GRAMINOIDS:

Predominant spp: *Dactyloctenium radulans*.

Frequent spp: *Astrebla pectinata, Panicum whitei*.

Infrequent spp: *Astrebla elymoides, A. lappacea, Iseilema* spp., *Tragus australianus*.

LAND USE: GC 3.3 to 8.1 beasts/km2 (4.0); DGC 0.2 to 0.6 beasts/km2; condition fair to good, trend slight downwards to stable; high WHC, fair fertility; top feed absent.

LAND UNIT 84

LANDFORM: Gently undulating to undulating convex plains. Slopes 1 to 5%. Median slope 3%.

GEOLOGY: Mantled pediments and fresh rock associated with the dissection of the Tertiary land surface resulting in the exposure of *Winton Formation* sediments. Silcrete cover is derived from the Tertiary surface. Kw.

SOILS: Deep to very deep, weakly gilgaied, stony surfaced, self-mulching, red clays. Soils are mainly alkaline throughout, with some becoming neutral at depth. $CaCO_3$ and gypsum may occur in the soil profile. Some soils have a thin, surface crust which is easily broken. Ug 5.38; *Karmona*. Representative soil analysis: 117, 166.

VEGETATION: Short grass, forby herbfield. Either short grasses or forbs predominate depending on local variation of the environment. Trees and shrubs do not occur.

STRUCTURAL FORM: Herbfield; Ht < 0.7 m, PFC (variable) 25 ± 15%. In excellent years PFC approaches 80%.

GROUND LAYER: Ht < 0.7 m; PFC (variable) 25 ± 15%.

FORBS:

Predominant spp: *Atriplex spongiosa, Bassia lanicuspis, Salsola kali, Threlkeldia proceriflora*.

Frequent spp: *Boerhavia diffusa, Lepidium rotundum, Portulaca* sp. aff. *P. oleracea*.

Infrequent spp: *Bulbine* sp., *Euphorbia boophthona, E. drummondii, Goodenia subintegra, Indigofera parviflora, Kochia coronata, Lepidium oxytrichum, L. rotundum, Psoralea cinerea, Ptilotus exaltatus, Trianthema portulacastrum, T. triquetra*.

GRAMINOIDS:

Predominant spp: *Astrebla pectinata, Dactyloctenium radulans, Iseilema membranaceum*.

Frequent spp: *Brachyachne convergens, Chloris pectinata*.

Infrequent spp: *Astrebla elymoides, A. lappacea, Enneapogon polyphyllus, Panicum whitei, Sporobolus actinocladus, Tragus australianus*.

LAND USE: GC 3.5 to 8.1 beasts/km2 (4.0), DGC 0.2 to 0.6 beasts/km2 (0.4); condition fair to good, trend stable; high WHC, fair fertility; no top feed; susceptible to gully erosion near drainage lines.

LAND UNIT 85

LANDFORM: Gently undulating to undulating, convex, plains. Slopes 1 to 3%. Median 2 to 3%.

GEOLOGY: Mantled pediments and fresh rock associated with the erosion of the Tertiary land surface exposing the Cretaceous *Winton Formation*. Silcrete cover is derived from the Tertiary surface. Kw.

SOILS: Deep to very deep, weakly gilgaied, stony surfaced, red clays. Surface stone may be desert varnished. Soils are mainly alkaline, medium to heavy clays with both $CaCO_3$ and gypsum present in the profile. Gypsum generally increases with depth. Gilgai microrelief and stone colour give a characteristic air photo pattern to this unit. Ug 5.38, Ug 5.36; *Karmona*. Representative soil analysis: 120, 162, 164.

VEGETATION: Chenopod grassy herbfield. Either grasses or forbs predominate depending on the local variation in the environment. Trees and shrubs are absent.

STRUCTURAL FORM: Herbfield forbland or grassland depending on seasonal influence; Ht < 0.5 m, PFC (variable) 20 ± 10%.

GROUND LAYER: Ht < 0.5 m, PFC (variable) 20 ± 10%.

Predominant spp: *Atriplex lindleyi, A. spongiosa, Bassia lanicuspis, Salsola kali, Threlkeldia proceriflora*.

FORBS:

Frequent spp: *Bassia divaricata, Boerhavia diffusa, Lepidium rotundum*.

Infrequent spp: *Amaranthus mitchellii, Bassia eriacantha, B. parallelicuspis, Euphorbia australis, E. boophthana, Neptunia dimorphantha, Pimelea trichostachya, Portulaca filiformis, Psoralea cinerea, Ptilotus exaltatus, Trianthema portulacastrum, T. triquetra, Velleia glabrata, Zygophyllum ammophilum*.

GRAMINOIDS:

Predominant spp: *Astrebla pectinata, Brachyachne convergens, Dactyloctenium radulans, Sporobolus actinocladus, Tragus australianus*.

Infrequent spp: *Aristida anthoxanthoides, Chloris pectinata, Enneapogon polyphyllus, Iseilema membranaceum, I. vaginiflorum, Panicum decompositum, P. whitei.*

LAND USE: GC 3.2 to 7.4 beasts/km2 (3.6), DGC 0.2 to 0.6 beasts/km2 (0.4); condition fair to good, trend stable to slight downwards; high WHC, fair fertility; top feed absent; gully erosion may be a problem near drainage lines.

LAND UNIT 86

LANDFORM: Upper slopes of gently undulating to undulating, convex plains. Slopes 1 to 8%. Median slope 3%.

GEOLOGY: Fresh, Cretaceous *Winton Formation* sediments, exposed following erosion of the Tertiary cap. Kw.

SOILS: Shallow to moderately deep, weakly gilgaied, desert loams with red clays associated. Soils are red, alkaline, strongly structured, medium to heavy clays with a thin (3 to 15 cm), stone covered, platy, silty-clay-loam to clay-loam surface crust. Dr 1.13, Dr 1.12, Dr 2.13; *Chastleton* and shallow phase of *Karmona*. Representative soil analysis: 187, 201, 214.

VEGETATION: Chenopod grassy herbfield. Either grasses or forbs predominate depending on local variation in the environment. Trees or tall shrubs do not occur but scattered low shrubs of *Cassia phyllodinea* (a silver cassia) may be found.

STRUCTURAL FORM: Herbfield (forbland or grassland depending on seasonal influences): Ht < 0.5 m (0.75 m); PFC (variable) 30 ± 20%.

LOW SHRUB LAYER: Ht < 0.75 m, PFC < 1%.

Frequent spp: *Cassia phyllodinea.*

GROUND LAYER: Ht < 0.5 m (0.75 m); PFC (variable) 30 ± 20%.

FORBS:

Predominant spp: *Atriplex lindleyi, A. spongiosa, Bassia lanicuspis, B. longicuspis, Salsola kali.*

Frequent spp: *Boerhavia diffusa, Bassia divaricata, Lepidium rotundum, Portulaca* sp. aff. *P. oleracea, Ptilotus exaltatus.*

Infrequent spp: *Bassia eriacantha, Calotis multicaulis, Erodium crinatum, E. cygnorum* ssp. *glandulosum, Euphorbia eremophila, E. stevenii, Helipterum strictum, Lepdium oxytrichum, Neptunia dimorphantha, Pimelea trichostachya, Psoralea cinerea, Ptilotus obovatus, Rhynchosia minima, Threlkeldia proceriflora, Trianthema portulacastrum, T. triquetra, Zygophyllum iodocarpum, Z. ammophilum.*

GRAMINOIDS:

Predominant spp: *Astrebla pectinata, Dactyloctenium radulans, Iseilema membranaceum.*

Frequent spp: *Brachyachne convergens, Enneapogon polyphyllus.*

Infrequent spp: *Astrebla lappacea, Iseilema vaginiflorum, Panicum whitei, Sporobolus actinocladus, Tragus australianus, Tripogon loliiformis.*

LAND USE: GC 2.6 to 6.4 beasts/km2 (2.7); DGC 0.2 to 0.6 beasts/km2 (0.4); condition fair to good, trend slightly downwards to stable; high WHC, fair fertility; absence of top feed.

LAND UNIT 87

LANDFORM: Undulating plains and margins of dissected tablelands, mesas and buttes. Slopes 2 to 20%.

GEOLOGY: Eroded remnants of the chemically altered, Cretaceous sediments often with silcrete cover, derived from the Tertiary surface.

SOILS: Shallow, stony, acid, red and reddish-brown, loams with ferricrete and silcrete cover. *Grey.*

VEGETATION: Mountain yapunyah shrubby low open woodland. *Eucalyptus thozetiana* (mountain yapunyah) predominates with scattered *Acacia aneura* (mulga) occurring. In places *Acacia microsperma* (bowyakka) is conspicuous. Other scattered trees may be found. A shrubby layer is not well defined but scattered shrubs may occur. Ground cover is sparse composed of scattered grasses and forbs.

STRUCTURAL FORM: Low open woodland; Ht 8 ± 2 m, PFC 3 ± 2%.

TREE, TALL SHRUB LAYER: Ht 7.5 ± 3 m, PFC 3 ± 2%.

Predominant spp: *Eucalyptus thozetiana*, Ht 8 ± 2 m, PFC 3 ± 2%.

Frequent spp: *Acacia aneura.*

Infrequent spp: *Acacia catenulata, Acacia microsperma, Eucalyptus cambageana, Geijera parviflora.*

LOW SHRUB LAYER: Ht 1.25 ± 1 m, PFC 3 ± 2%.

Frequent spp: *Eremophila mitchellii, E. oppositifolia, Scaevola spinescens.*

Infrequent spp: *Capparis lasiantha.*

GROUND LAYER: Ht < 0.5 m, PFC 3 ± 2%.

FORBS:

Frequent spp: *Bassia divaricata, B. intricata, Solanum quadriloculatum.*

Infrequent spp: *Bassia birchii, Kochia villosa, Salsola kali.*

GRAMINOIDS:

Frequent spp: *Digitaria ammophila, Enteropogon acicularis, Eriachne mucronata.*

Infrequent spp: *Monachather paradoxa.*

LAND USE: GC 0.9 beasts/km2, DGC 0.8 beasts/km2; condition poor, trend stable; very low WHC, very low fertility; excessive slopes; top feed not common.

LAND UNIT 88

LANDFORM: Flat to gently undulating crests of dissected plains. Slopes 1 to 5%.

GEOLOGY: Eroded remnants of the chemically altered, Cretaceous sediménts and the Tertiary *Glendower Formation.*

SOILS: Shallow, stony throughout, acid, red, earthy, loams and clay-loams. Silcrete stones and boulders are spread throughout. Rock exposure is common. *Grey.* Representative soil analysis: 134.

VEGETATION: Bastard mulga, mulga low open shrubland. *Acacia clivicola* (bastard mulga) predominates with scattered low trees of *Eucalyptus terminalis* (western bloodwood) and *Hakea divaricata* (desert oak) and shrubs of *A. aneura* (mulga) occurring. Other low shrubs may be present. Ground cover is sparse composed of forbs and grasses.

STRUCTURAL FORM: Low open shrubland, Ht 1.5 $\pm$ 0.5 m, PFC 2.5 $\pm$ 2%.

TREE, TALL SHRUB LAYER: Ht 4.5 $\pm$ 1.5 m, PFC < 1%.

Frequent spp: *Acacia aneura, Eucalyptus terminalis.*

Infrequent spp: *Hakea divaricata.*

LOW SHRUB LAYER: Ht 1.5 $\pm$ 0.5 m, PFC 2.5 $\pm$ 2%.

Predominant spp: *Acacia clivicola,* Ht 1.5 $\pm$ 0.5 m, PFC 2.5 $\pm$ 2%.

Frequent spp: *Acacia tetragonophylla, Eremophila latrobei, Canthium latifolium,Scaevola spinescens.*

Infrequent spp: *Cassia helmsii, C. pruinosa, Phyllanthus rigens.*

GROUND LAYER: Ht < 0.5 m, PFC < 5%.

FORBS:

Frequent spp: *Brunonia australis, Kochia villosa, Salsola kali, Sida cunninghamii, Velleia glabrata.*

Infrequent spp: *Bassia cornishiana, B. lanicuspis, Boerhavia diffusa, Calotis inermis, Chenopodium melanocarpum, Euphorbia boophthona, E. drummondii, Portulaca* sp. aff. *P. oleracea, Ptilotus exaltatus, P. obovatus, Stenopetalum nutans, Tribulus terrestris.*

GRAMINOIDS:

Frequent spp: *Aristida contorta, Eragrostis eriopoda, Eriachne pulchella, Thyridolepis mitchelliana, Tripogon loliiformis.*

Infrequent spp: *Digitaria brownii, Enneapogon polyphyllus, Eragrostis leptocarpa, Fimbristylis dichotoma.*

LAND USE: GC 1.0 beasts/km2, DGC 0.4 beasts/km2; condition poor, trend slightly downwards; minimal WHC, high runoff, very low fertility; top feed almost absent.

LAND UNIT 89

LANDFORM: Undulating plains and crests of dissected tablelands. Slopes 1 to 12%.

GEOLOGY: Dissected Tertiary land surface made up of the Tertiary *Glendower Formation* overlying chemically altered Cretaceous *Winton Formation* sediments.

SOILS: Very shallow and silcrete covered, earthy, red, loams and clay-loams. Um 1.23, Gn 2.12, Um 1.43; *Grey.*

VEGETATION: Bastard mulga, mulga shrubby low open shrubland. *Acacia clivicola* (bastard mulga) predominates with *A. aneura* (mulga) conspicuous emerging above the shrubby layer. Scattered trees of *Eucalyptus terminalis* (western bloodwood) may occur. Other shrubs may be present. Ground cover is sparse composed of forbs and grasses.

STRUCTURAL FORM: Low open shrubland (in places low shrubland); Ht 1.5 $\pm$ 0.5 m, PFC 8 $\pm$ 7%.

TREE, TALL SHRUB LAYER: Ht 4 $\pm$ 1 m, PFC < 1%.

Frequent spp: *Acacia aneura.*

Infrequent spp: *Canthium latifolium, Eucalyptus terminalis.*

LOW SHRUB LAYER: Ht 1.5 $\pm$ 0.5 m, PFC 8 $\pm$ 7%.

Predominant spp: *Acacia clivicola,* Ht 1.5 $\pm$ 0.5 m, PFC 8 $\pm$ 7%.

Frequent spp: *Dodonaea petiolaris, Eremophila latrobei.*

Infrequent spp: *Enchylaena tomentosa, Phyllanthus rigens, Scaevola spinescens.*

GROUND LAYER: Ht < 0.4 m, PFC variable 5 $\pm$ 5%.

FORBS:

Frequent spp: *Calotis inermis, Cheilanthes sieberi, Salsola kali, Sida filiformis, Velleia glabrata.*

Infrequent spp: *Abutilon otocarpum, Atriplex limbata, A. vesicaria, Boerhavia diffusa, Calocephalus multiflorus, Chenopodium rhydinostachyum, Euphorbia boophthona, Kochia coronata, K. villosa, Lepidium rotundum, Ptilotus exaltatus, P. gaudichaudii, P. macrocephalus, P. nobilis, P. obovatus, Zygophyllum iodocarpum.*

GRAMINOIDS:

Frequent spp: *Aristida contorta, A. jerichoensis, Digitaria brownii, Eriachne mucronata, E. pulchella, Fimbristylis dichotoma.*

Infrequent spp: *Eragrostis pergracilis, Monachather paradoxa, Tripogon loliiformis.*

LAND USE: GC 0.9 to 2.9 beasts/km2 (1.4), DGC 0.2 to 1.2 beasts/km2 (0.7); condition fair to poor, trend downwards; very low WHC, very low fertility; top feed limited.

LAND UNIT 90

LANDFORM: Flat to gently undulating crests and upper slopes of dissected tablelands. Slopes 1 to 3%.

GEOLOGY: Chemically altered Cretaceous *Winton Formation* sometimes with thin superficial Quaternary cover. Kw.

SOILS: Lithosols. Very shallow, acid, loams and clay-loams overlying weathered rock. Exposed weathered rock covers large areas of this unit. Ironstone gravel is often spread on the surface. Um 1.43; *Grey*.

VEGETATION: Bastard mulga low open shrubland. *Acacia clivicola* (bastard mulga) may form pure stands but is frequently associated with *Hakea collina* (dwarf needlewood). In some situations, a shrubby layer with low emerging trees is well developed but usually other shrubs rarely occur. Scattered grasses and forbs are present forming a very sparse ground cover.

STRUCTURAL FORM: Low open shrubland. Ht 1.5 ± 1 m; PFC 5 ± 4%.

TALL SHRUB LAYER: Ht 3 ± 1 m, PFC < 1%.

Infrequent spp: *Eucalyptus exserta, E. papuana, E. terminalis* (rare).

LOW SHRUB LAYER: Ht 1.5 ± 1 m, PFC 5 ± 4%.

Predominant spp: *Acacia clivicola*. Ht 1.5 ± 0.5 m, PFC 5 ± 4%.

Frequent spp: *Hakea collina*.

Infrequent spp: *Acacia brachystachya, Cassia artemisioides, Dodonaea petiolaris, D. tenuifolia, Prostanthera suborbicularis, Sarcostemma australe, Cheilanthes sieberi, Westringia rigida*.

GROUND LAYER: Ht < 0.5 m, PFC < 1%.

FORBS:

Frequent spp: *Bassia convexula, Kochia villosa*.

Infrequent spp: *Chenopodium rhadinostachyum, Ptilotus gaudichaudii, P. macrocephalus, P. polystachyus, Sida* spp.

GRAMINOIDS:

Frequent spp: *Eriachne pulchella*.

Infrequent spp: *Eragrostis eriopoda, Enneapogon polyphyllus, Fimbristylis dichotoma, Tripogon loliiformis*.

LAND USE: GC 0.6 to 1.6 beasts/km2 (1.0), DGC 0.2 to 0.6 beasts/km2 (0.4); condition poor, trend stable to downwards; minimal WHC, very low fertility; top feed absent.

LAND UNIT 91

LANDFORM: Scarp retreats and flat tops of dissected tablelands, mesa and buttes. Slopes 1 to 50%. Median slope 8%.

GEOLOGY: Chemically altered, Cretaceous *Winton Formation* with, in places, Cainozoic cover of the Tertiary *Glendower Formation* or superficial Quaternary cover.

SOILS: Very shallow, yellowish-brown to red, acid, loamy, lithosols with surface stone cover of silcrete and ferricrete. The weathered base rock is often exposed. Um 1.43, Um 1.42; *Grey*. Representative soil analysis: 26.

VEGETATION: Bendee shrubby tall shrubland. *Acacia catenulata* (bendee) predominates with *A. petraea* (lancewood) occurring frequently. Scattered other trees may be present. A lower shrubby layer is usually well defined. Ground cover is sparse composed of grasses and forbs.

STRUCTURAL FORM: Tall shrubland to tall open shrubland, Ht 7 ± 3 m, PFC 15 ± 10%.

TREE, TALL SHRUB LAYER: Ht 7 ± 3 m, PFC 15 ± 10%.

Predominant spp: *Acacia catenulata*. Ht 5 ± 1 m, PFC 15 ± 10%.

Frequent spp: *Acacia petraea*.

Infrequent spp: *A. aneura, A. excelsa, Eucalyptus exserta, E. papuana, E. thozetiana, E. terminalis*.

LOW SHRUB LAYER: Frequent spp: *Canthium latifolium, Dodonaea petiolaris, D. tenuifolia, Eremophila latrobei*.

Infrequent spp: *Acacia clivicola, Capparis lasiantha, Cassia artemisioides, C. nemophila, Eremophila mitchellii, Kerandrenia collina, Scaevola spinescens, Thryptomene hexandra, Westringia rigida*.

GROUND LAYER: Ht < 0.5 m, PFC < 5%.

FORBS:

Frequent spp: *Bassia birchii, B. convexula, B. tricuspis, Chenopodium rhydinostachyum, Cheilanthes sieberi, Dysphania myriocephala, Kochia villosa, Salsola kali, Solanum ellipticum*.

Infrequent spp: *Abutilon oxycarpum, Portulaca* sp. aff. *P. oleracea, Ptilotus leucocoma, Sida filiformis, S. platycalyx, Trachymene cyanantha*.

GRAMINOIDS:

Frequent spp: *Digitaria ammophila, D. orbata, Eriachne mucronata, E. pulchella, Fimbristylis dichotoma, Tripogon loliiformis*.

Infrequent spp: *Enneapogon polyphyllus, Sporobolus australasicus, Thyridolepis mitchelliana*.

LAND USE: GC 2.0 beasts/km2, DGC 0.6 beasts/km2; condition poor to fair, trend stable to downwards; very low WHC, low fertility; top feed not abundant.

LAND UNIT 92

LANDFORM: Gently undulating plains and lower slopes of scarp retreats associated with dissected tablelands. Slopes 1 to 30%. Median slope 3%.

GEOLOGY: Mixed material derived from chemically altered, Cretaceous sediments.

SOILS: Shallow to very shallow, red, loams to clay-loams with much silcrete stone and boulder interbedded. Um 5.51.

VEGETATION: Turpentine mulga, mulga low open shrubland. *Acacia brachystachya* (turpentine mulga) and *A. aneura* (mulga) predominate with *Eucalyptus papuana* (desert gum) and *Canthium latifolium* occurring. Other shrubs may be present. Ground cover is usually sparse composed of mainly forbs.

STRUCTURAL FORM: Low open shrubland; Ht 1.5 ± 0.5 m, with *Acacia aneura* emerging; PFC 3 ± 2.5%.

LOW TREE SHRUB LAYER: Ht 3 ± 0.5 m, PFC 1 ± 1%.

Frequent spp: *Acacia aneura.*

Infrequent spp: *Eucalyptus papuana.*

LOW SHRUB LAYER: Ht 1.25 ± 0.75 m, PFC 5 ± 2.5%.

Predominant spp: *Acacia brachystachya*, Ht 2.0 ± 0.5 m, PFC < 5%.

Frequent spp: *Canthium latifolium, Dodonaea petiolaris, Eremophila latrobei.*

Infrequent spp: *A. clivicola, Cassia oligophylla, C. sturtii, Indigofera* sp. aff. *I. leucotricha.*

GROUND LAYER: Ht < 0.5 m, PFC 2.5 ± 2%.

FORBS:

Frequent spp: *Kochia georgei, Ptilotus leucocoma, P. nobilis, P. obovatus, Salsola kali.*

Infrequent spp: *Calotis inermis, Velleia glabrata.*

GRAMINOIDS:

Frequent spp: *Eragrostis eriopoda, Eriachne pulchella.*

Infrequent spp: *Aristida contorta, Monachather paradoxa, Tripogon loliiformis.*

LAND USE: GC 2.0 to 3.6 beasts/km2 (2.3), DGC 0.3 to 0.9 beasts/km2 (0.6); condition fair, trend slightly downwards; low WHC, low fertility; limited top feed.

LAND UNIT 93

LANDFORM: Scarp retreats and flat tops of dissected tablelands. Slope 0 to 50%. Median slope 10%.

GEOLOGY: Chemically altered, Cretaceous *Winton Formation* with cover of the Tertiary *Glendower Formation* and/or superficial Quaternary cover.

SOILS: Very shallow, reddish-brown to red, acid, loamy, lithosols. Surface stone cover of silcrete and ferricrete. The weathered base rock is often exposed. Um 1.43, Um 1.23, Um 5.31; *Grey.*

VEGETATION: Lancewood shrubby low woodland. *Acacia petraea* (lancewood) predominates. In places *A. aneura* (mulga) and less frequently *A. ensifolia* may be present. Usually there is a well defined shrubby layer. Ground cover is sparse composed of forbs and grasses.

STRUCTURAL FORM: Low woodland to low open woodland (Ht ranges 6 ± but *A. petraea* always tree form): Ht 6 ± 3 m, PFC 15 ± 10%.

TREE, TALL SHRUB LAYER: Ht 6.5 ± 2.5 m, PFC 15 ± 10%.

Predominant spp: *Acacia petraea*, Ht 6 ± 3 m, PFC 15 ± 10%.

Frequent spp: *Acacia aneura.*

Infrequent spp: *A. catenulata, A. ensifolia, Eucalyptus papuana, E. thozetiana.*

LOW SHRUB LAYER: Ht 1.5 ± 0.5 m, PFC 2.5 ± 2%.

Frequent spp: *Canthium latifolium, Dodonaea petiolaris, D. tenuifolia, Eremophila latrobei, E. macgillvrayi, E. oppositifolia.*

Infrequent spp: *Capparis lasiantha, Cassia nemophila* var. *nemophila, Cassia oligophylla, Dodonaea cuneata, Eremophila longifolia, Kerandrenia collina, Rhagodia spinescens, Scaevola spinescens.*

GROUND LAYER: Ht < 0.5 m, PFC < 5%.

FORBS:

Frequent spp: *Kochia georgei, K. villosa, Ptilotus gaudichaudii, P. helipteroides, P. leucocoma, P. macrocephalus, P. obovatus, Salsola kali, Sida aprica, S. cunninghamii, S. filiformis.*

Infrequent spp: *Cheilanthes sieberi, Chenopodium rhydinostachyum, Cleome viscosa, Goodenia calcarata, Indigofera* sp. aff. *I. leucotricha, Solanum esuriale, S. sturtianum, Zygophyllum apiculatum.*

GRAMINOIDS:

Frequent spp: *Aristida contorta, A. jerichoensis, Eriachne mucronata, E. pulchella, Fimbristylis dichotoma, Tripogon loliiformis.*

Infrequent spp: *Digitaria brownii, Enneapogon polyphyllus, Paspalidium clementii.*

LAND USE: GC 0.7 beasts/km2; DGC 0.4 beasts/km2; condition fair, trend stable to downwards; very low WHC, very low fertility; top feed not abundant.

EFFECTS OF LAND TYPES ON GRAZING PERFORMANCE

by J.A. Firth* and J. Morris*

INTRODUCTION

The current economic investigation of the sheep and beef cattle industries of arid south-west Queensland presented here is part of the continuing research programme on arid zone pasture management in Australia. This Bureau, together with State and other Commonwealth bodies, have been involved in a study of south-west Queensland for a number of years. The Bureau of Agricultural Economics conducted an economic survey of graziers over the period 1962-63 to 1967-68 while the Department of Primary Industries, Queensland have been involved in a comprehensive land use study of the area.

This study utilises data from both the Bureau of Agricultural Economics survey and the Department of Primary Industries land use study in an exploratory investigation of land type effects on pastoral production in an attempt to establish relationships which might prove useful for further analysis.

Arid south-west Queensland, defined in this study as that area of Queensland receiving, on average, less than 15 inches of rainfall per annum, is a region of approximately 175,000 square miles in which environmental conditions have so far restricted land use to the grazing of native vegetation by sheep and cattle. Incorporated in this area is the Channel Country comprising the flood plains of the Mulligan, Georgina, Diamantina and Bulloo Rivers and Cooper Creek and supporting a wide variety of pastures. Landholders in arid south-west Queensland have virtually only two production possibilities, sheep and beef cattle. Many areas are restricted to only one of these enterprises. Any form of crop or improved pasture production which depends on natural rainfall is precluded because of arid conditions. Prospects of increasing production per acre, through technological innovation, are limited and management decision-making is largely influenced by climatic uncertainty.

Beef cattle are spread throughout the area but are concentrated mainly in the Channel Country, whilst the sheep grazing is confined primarily to the east of the region, within the bounds of the dingo barrier fence. Over the ten year period ended 1969, arid south-west Queensland, supported, on average, 8% of the State's beef cattle and 19% of the sheep. In a survey of south-west Queensland by the BAE covering 1962-63 to 1967-68 the extreme variability of income to which pastoral zone properties are prone was evident. Because of the severe drought in 1965-66 in the study area, average returns over the six year period showed no surplus over costs on many properties. In the range of property sizes investigated, notwithstanding the general unfavourable seasons experienced, there was evidence of economies of scale with lower unit costs of production on larger properties.

OBJECTIVES

The hypothesis is that land types have an effect on the profitability of sheep and cattle production bearing in mind the strong influence of the seasonal variability.

Broadly, the aims of this study are to assess the effect of the land types on the grazing or economic performance over a six year period where good, bad, and normal seasons were experienced.

Drought is not easily defined, normally it is considered as it affects pastures and through them grazing animals. A drought in this study is defined as a marked departure from a notional norm. The dependent variables selected for the regression analysis were total gross margins, gross margins per unit of production (acre and stock units), net farm income, total revenue and livestock numbers. The independent variables included total land acreage, capital, labour, six land type classifications, livestock numbers, rainfall and flooding indices and dummy variables to take account of the variation in the management and the different six year periods. The results on sheep properties were in the main better than on beef cattle properties, but this finding was influenced by the generally slightly more favourable location of specialist sheep properties on the eastern margin of the study area. The beef cattle properties are situated in an area of lower rainfall expectancy which, in favourable years, depends in substantial measure on beneficial flooding from run-on water from outside the Channel Country.

PROBLEMS ENCOUNTERED IN THE STUDY

(1) The pastoral scene raises particular problems as to the use of animals, which unlike cash cropping, introduces a further management factor of an unmeasured type.

(2) Rainfall and flooding were believed to interact with land types in determining pasture production and a further complicating factor is the variation of both run-on and run-off within a property. There is an interdependence between these two types which could possibly cause problems between the pooling of data over time and in aggregation of types of property.

(3) Climate and stock availability are so variable and distances from markets so large that productivity optimisation from particular land types are not management's short term goal but rather an attempt to maintain a viable enterprise over time.

(4) The extreme variability of income to which pastoral zone properties are prone was evident in the results of the survey. (Haug and Hoy 1970.) Because of severe drought in 1965 and 1966 in the study area, average returns over the six year period 1962-63 to 1967-68 showed no surplus over costs on many properties.

(5) Substantial negative net farm incomes occurred on survey properties in drought years. These arose partly as a result of reduced productivity and partly because of a fall in value of livestock inventories, mainly due to deaths of beef cattle and sheep. These adverse effects could be improved by hedging against seasons and by effective de-stocking policies which would minimise drought death losses.

Unfortunately, drought strategies adopted by different property owners were not measured quantitatively, however, de-stocking amongst the sheep properties was most widely practised, followed by allowing the sheep to die. Very little supplementary feeding took place during periods of drought. The most important objective of management during drought is to have the largest possible flock when good conditions return.

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DATA

The data used were the BAE survey of south-west Queensland and comprised 36 properties; 18 of which were mainly concentrated on beef production and 18 mainly engaged in sheep production. The two groups of properties were analysed separately and were classified according to their broad land types based on the survey by the Queensland Department of Primary Industries.

The major vegetation communities which have important effects in land utilisation in arid south-west Queensland include Mitchell grass, mulga and gidgee associations, the "channel country", spinifex country and sandhill communities. The land classifications used in the analysis for sheep and beef properties differed slightly. For the beef properties, the land was classified into:-

(1) flooded country (2) mulga-hard and soft (3) Mitchell grass
(4) sandy country (5) hilly country (6) plains

For the sheep properties, the land was classified into:-

(1) flooded country (2) Mitchell grass (3) sandy country
(4) hard mulga (5) soft mulga (6) hilly country
(7) plains

PRODUCTIVITY INDICATORS

The measures of productivity used in the analysis were total gross margin (T.G.M.), total returns and stock numbers. Total gross margin was defined as total revenue less the variable costs of labour, materials and services. As economies of scale, especially for labour, were believed to influence net farm income, total returns were used instead. This variable was defined as including the value of wool and skins produced, stock trading and operating gain and other cash returns (which are minimal for the region). The land classification does not, per se, take the climatic differences into account. The land and its vegetation are of course influenced by the climate, but a hardy perennial vegetation such as mulga, once established, demonstrates capacity to survive periods of unfavourable weather conditions. From the grouping of land types adopted, it is probable that rainfall differences have tended to be lost. Consequently, the six year period was generalised into broad seasons, as follows:-

Year 1 (1962/63)	Good rains and flooding.
Year 2 (1963/64)	Good rains and flooding.
Year 3 (1964/65)	Very poor rainfall, no flooding.
Year 4 (1965/66)	Very poor rainfall, no flooding.
Year 5 (1966/67)	Good rainfall, and floods.
Year 6 (1967/68)	Normal rainfall, average flooding.

ANALYSIS

The linear relationship adopted was of the form:-

$$Y_i = a + b_1x_{1i} + b_2x_{2i} + \dots\dots \; b_6x_{6i} + e_i$$

where e_i is a random error term which is assumed to be normally distributed with a mean of zero and variance σ^2. The errors are also assumed to be independent. The variables x_{1i} to x_{6i} are the six different land types on the i^{th} farm, given in acres. Whilst y_i is one of the measures of productivity (either T.G.M., total revenue or stock numbers).

Capital and labour variables were included in the regressions involving total revenue.

REGRESSION RESULTS FOR SHEEP PROPERTIES

Total gross margins were regressed against the six land types. During good years the land type variables afforded reasonable explanation of the variation in total gross margins. For example in 1963-64:-

$$\text{T.G.M.} = 7821 + \underset{(0.389)}{0.802L_1} + \underset{(0.134)}{0.287L_2} + \underset{(0.412)}{1.198L_5}$$

$$R^2 = 0.79$$

where L_1 = flooded country; L_2 = Mitchell grass; L_5 = soft mulga

However, in the drought years, land types were not nearly so useful in explaining variation in total gross margins.

When the regression co-efficients are ordered (see Table IX-1) soft mulga is the highest in every year except 1965-66 which is the second year of a drought.

Table IX-1. Ranking of land types by type of year. y = TGM = f (land types).

Land Type	Type of Year					
	62/63 Good	63/64 Good	64/65 Drought	65/66 Drought	66/67 Good	67/68 Good
Flooded	2	2	5	5	6	4
Mitchell	3	3	3	2	3	3
Sandy	5	5	2	1	4	5
Hard mulga	4	4	4	3	2	2
Soft mulga	1	1	1	4	1	1
Hilly	6	6	6	6	5	6

For each year the hilly country regression co-efficient is smallest except in 1966-67 which was the first good year after two years of severe drought. Soft mulga had the highest regression co-efficient in every year except 1965-66 which was the second year of the severe drought already mentioned. Sandy country, surprisingly had the second ranked regression co-efficient until the drought years when it improved to second and the first place in 1964-65 and 1965-66 respectively. Hard mulga improved its rank during the drought from 4th to 2nd moving up past flooded country and Mitchell grass. Flooded country regression co-efficients ranked poorly during and since the drought with slow improvement back to a rank of 4 in 1967-68.

Regressions of total returns and sheep numbers on land types, capital and labour were derived and rankings appear in Tables IX-2 and IX-3.

Table IX-2. Ranking of land types by type of year. y = TR = f (land types).

Land Type	Type of Year 62/63 Good	 63/64 Good	 64/65 Drought	 65/66 Drought	 66/67 Good	 67/68 Good
Flooded	3	2	4	5	6	4
Mitchell	2	3	3	3	3	2
Sandy	5	5	2	1	4	5
Hard mulga	4	4	5	2	2	3
Soft mulga	1	1	1	4	1	1
Hilly	6	6	6	6	5	6

The rankings of land type regression co-efficients for total gross margins are seen to be very similar to those for total returns, also, although many regression co-efficients are not significantly different from zero, the level of explanation is high (the lowest R^2 is 0.72).

Table IX-3. Ranking of land types by type of year. y = sheep numbers = f (land types, labour, capital).

Land Type	Type of Year 62/63 Good	 63/64 Good	 64/65 Drought	 65/66 Drought	 66/67 Good	 67/68 Good
Flooded	2	1	1	3	6	5
Mitchell	3	3	3	2	4	2
Sandy	5	6	4	3	1	4
Hard mulga	1	2	4	1	2	2
Soft mulga	4	4	2	3	3	1
Hilly	6	5	6	6	5	6

For the model, sheep numbers = f (land types, capital, labour), high rankings of flooded country co-efficients (in Table IX - 3) occur later than for total gross margins (in Table IX-1). Similarly the first ranking regression co-efficient for sandy country (1966-67 in Table IX-3 as compared with 1965-66 in Table IX-1) occurs later for sheep numbers than for total gross margins.

INFERENCES FROM THE RANKING OF LAND TYPE REGRESSION CO-EFFICIENTS

The lower ranking of flooded country during and since the drought is believed to be the result of decreased fodder production on this land type.

In fact the regression co-efficient for flooded country is lower for the years in which it ranks poorly than for the years in which it ranks well. It is inferred that flooded country is one of the more productive land types but that it is badly affected by drought and is slow to recover.

Mitchell grass has regression co-efficient of approximately 0.2 except in 1962-63 when it was -0.044 and 1964-65 when it was 0.488. 1964-66 being a drought year it appears that Mitchell grass is a hardy drought reserve especially as it improved its rank in the second drought year.

Although relatively insignificant, sandy country appears, from its improvement in rank during the drought from 5 to 1, to be capable of contributing markedly to total gross margins during and immediately after severe conditions. The rationale behind this observation is particularly hard to follow.

Post drought, hard mulga has an improved rank and increased regression co-efficient. It is inferred that this land type is relatively more important for sheep during and after drought.

Soft mulga is believed to be the most productive land type for sheep except during sustained drought. Hilly country is believed to have little productive value.

The regressions run using total returns as the dependent variable and including total capital and labour tell the same story as those for total gross margins. However, the lag noticed for flooded country and sandy country with sheep number as compared with total gross margins regression co-efficients in reaching high ranks (compare Tables IX-1 and IX-3) requires additional interpretation. The hard mulga regression co-efficient ranks highest at the end of the drought for the sheep numbers equation. This is assumed to be due to the use of hard mulga for tiding sheep through the drought so that the land type carries more sheep but does not contribute immediately to total gross margins in the short term.

REGRESSION RESULTS FOR BEEF PROPERTIES

The rankings of regression co-efficients for beef properties is shown in Table IX-4. The R^2 statistics are very low and no conclusions have been reached.

Table IX-4. Ranking of land types by type of year. Beef properties. y = TGM = f (land types).

Land Type	Type of Year 62/63 Good	63/64 Good	64/65 Drought	65/66 Drought	66/67 Good	67/68 Good
Flooded	3	3	4	6	3	6
Mulga	6	1	3	1	6	5
Mitchell	4	6	6	2	4	1
Sandy	2	5	5	3	1	3
Hilly	1	4	2	5	5	2
Plains	5	2	1	4	2	4

CONCLUSION

The regression analyses in this Appendix point to the way in which land and vegetation types interact with the seasons in determining productivity of sheep enterprises.

The conclusions about the land types under sheep grazing are that flooded country is badly affected by drought and is slow to recover. Sandy country and hard mulga are relatively better during drought. There is some evidence that severe drought affected soft mulga's productivity while hilly country remained unproductive in all years.

The analysis was inconclusive for beef properties and further work is planned to refine the land type variables using geographical information on fencing and watering points to see if the explanatory power of the equations can be improved. This refinement is seen as especially necessary for cattle as they are more dependent than sheep on watering points.

REFERENCES

Haug, N.F. and Hoy, R.J. (1970) — The economic and financial position of graziers in arid south-west Queensland 1962-63 to 1967-68. *Q. Rev. agric. Econ.*, XXIII: 222-243.

POISONOUS PLANTS

by R. Anson*

In south-west Queensland the following plants are known to be responsible for deaths in sheep.

Common Name	Botanical Name
Native fuschia	** *Eremophila maculata*
Caustic weed	*Euphorbia drummondii*
Gascoyne spurge	*Euphorbia boophthona*
Ellangowan bush	** *Myoporum deserti*
Soda bush	** *Threlkeldia proceriflora*
Inland pigweed or Munyeroo	** *Portulaca* sp. aff. *P. oleracea*
Pencil caustic or caustic vine	*Sarcostemma australe*
Nightshade	** *Solanum sturtianum*
Purple plume grass	** *Triraphis mollis*
Tree tobacco	*Nicotiana glauca*
Boonaree	*Heterodendrum oleifolium*
Bluebush pea	** *Crotolaria eremaea*
Wild parsnip	** *Trachymene ochracea*
Golden Billy buttons	*Craspedia chrysantha*
Mulga fern	*Cheilanthes sieberi*
Soft roly poly	*Salsola kali*

** Most poisonous.

Minor sheep losses have been attributed to the following plants. These are eaten only when other feed is scarce. Usually these plants are found in the 380 mm and under rainfall zone.

Common Name	Botanical Name
Sand spurge	*Phyllanthus fuernrohrii*
Spurge	*Phyllanthus gasstroemii*
Desert spurge	*Euphorbia eremophila*
Erect caustic	*Euphorbia australe*
Bottle tree caustic	*Euphorbia stevenii*
Sandhill caustic	*Euphorbia coghlanii*
Spiked rice	*Pimela trichostachya*
Woolly rattlepod	*Crotalaria dissitiflora*
Nardoo	*Marsilea drummondii*

The following plants are suspected of being toxic to sheep.

Common Name	Botanical Name
Quena	*Solanum esuriale*
Wild mulberry	*Malvastrum spicatum*
Button grass	*Dactyloctenium radulans*

POISONING OF SHEEP BY *SOLANUM* SPP.

Four species of *Solanum* are found in the region. They are Quena *(S. esuriale)*, Nightshade *(S. sturtianum)*, Potato bush *(S. ellipticum)* and Devil's needles *(S. ferocissimum)*. Three of these are suspected of poisoning sheep.

"Quena" – a greyish sub-shrub mostly 254 mm in height commonly found in the Tambo-Warrego districts on the Mitchell grass downs and in the mulga country west of the Paroo. Prickles are few or none, and the leaves are up to 50 mm long and 12 mm wide. The flowers are purple, and the fruit round and yellow when mature. There are a number of recorded cases of poisoning in sheep. The symptoms are staggering gait and loss of power in the hindquarters with a pronounced humpy-backed appearance.

Observations in the Quilpie-Thargomindah, Windorah-Jundah, and Cheepie-Adavale districts in April 1968 showed that 15% of 110,000 wethers on 10 properties were affected by humpy-back when being mustered for shearing. Ewes appeared to have been the least susceptible. The plant is suspected of being poisonous when the fruits are at a certain stage, possibly when green.

"Nightshade" – a shrub growing to about 0.9 metres in height found growing on the red stony plateau and hills of the Quilpie and Bulloo shires. The leaves are about 76 mm long, usually a greyish-green colour, and the flowers are pale purple. The fruit is green to yellow when immature, but when ripe it is black, with dark seeds which are typically wrinkled at the edge. Principles are not known, but symptoms are depression, frothing at the mouth, diarrhoea and collapse.

"Potato bush" – this plant is a low, very prickly shrub, with hairy elliptical leaves, very broad at the centre and up to 127 mm long. The flowers are blue-purple, and the fruit is round and greenish and up to 20 mm in diameter. The plant is fairly common on the lateritic soils of the mulga country. The toxic principle is an alkaloid and the species is a known toxic plant. It has caused death in sheep.

POISONING OF SHEEP BY *TRACHYMENE* SPP.

Three species of wild parsnip grow in the region. The better known species *T. ochracea* (white petals), and *T. cyanantha* (blue petals), have been suspected of being toxic to sheep. A much larger plant *T. glaucifolia* has not been suspected possibly because it grows mainly in areas of cattle country.

T. ochracea is most plentiful in late winter and spring months, but odd plants are found at other times. It occurs on the red-brown loams and low sand-ridges of much of the south-west mulga country, usually after good autumn and winter rain.

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* Sheep and Wool Branch. Qd Dep. Prim. Indus.

The most prolific stands are found in the Boatman-Nebine-Wyandra district the lakes country at Thargomindah and the Gumbardo-Adavale region. It is not confined to these areas as it is particularly abundant in the mulga country of the Paroo, Quilpie and Murweh Shires. It has been found to a lesser extent in the south-east sector of the Barcoo Shire.

T. cyanantha is an annual sometimes bi-ennial herb. The petals vary from very pale to deep blue. This plant is particularly abundant in the sandy red loams and mulga gravels west of the Paroo River and the Beechal Creek. It has been seen along much of the eastern fall of the Grey Range from Adavale to Tobermory and as far west as Eromanga and Windorah.

T. glaucifolia appears to behave as an annual. This plant has been observed to grow on the sandy soils associated with the sand-dunes in the far south-western country of the Bulloo shire. Its most eastern limit is the sandy country around the lakes east of Thargomindah.

T. ochracea collected from the areas described above was toxic when fed to sheep at the Animal Research Institute, Yeerongpilly (L. Laws personal communication).

In the field, the plant is the cause of staggers and inco-ordination of gait, loss of muscular control and even death. Where ewes or their lambs are run-on country growing *T. ochracea* the lambs frequently show a condition in which the long leg bones are bent producing malformation of the limbs giving a bandy appearance.

Other symptoms are collapse, difficult breathing, convulsions, anaemia of the skin and mucous membranes, and often a profuse scouring. Sheep die suddenly or they may linger for up to five minutes. Deaths usually occur from August to September.

BANDY LEGS IN LAMBS

This complaint is prevalent when wild parsnip *(Trachymene ochracea)* and *(Trachymene cyanantha)* grow abundantly throughout the mulga country. Such years were 1936, 1938-39, 1941-42, 1947-49, 1950, 1956, 1958-59, 1963 and 1967.

During 1963 observations were carried out on two properties in the Cooladdi-Cheepie districts. These were "Monamby" and "Plaingrove".

Studies were made on the incidence of bandy lambs. It was found that slightly affected young animals growing to adulthood changed greatly and their original form of bandiness was not recognisable by anything but a detailed examination. The extremely deformed young sheep remained as "bandy" sheep throughout life.

At "Monamby" 5,000 ewes were joined on the 5th November, 1962. On the 29th March, 1963 (144 days) the first lambs were born. The lambs were marked in June, of the 56.8% marked, 25% were affected by a mild to severe form of bent leg.

Studies were carried out on the 26th November and 12% of lambs were still affected. At twelve months of age, 8% were still abnormal.

The studies at "Plaingrove" showed that 8,489 ewes were joined on the 1st February, 1963. On the 1st July (150 days) the first lambs were born, the lambs were marked in October, and of the 73% marked, 15.8% were allocated as being slightly deformed, and 15.3% grossly deformed. A further observation in December showed that 12.0% were still deformed and 10.0% were still classified as bandy lambs at twelve months of age.

These studies were carried out visually. It was felt that future studies should be by the selection of affected young animals, individually identified, and subjected to periodic photographic examination from a standard angle from time to time during life. This would give a more positive figure on the extent of damage incurred by them.

Wild parsnip started to grow in March on both properties and growth was well established by April. It remained lush and green throughout the winter and spring months, before drying off in December. Rainfall is shown in Table X-1.

Table X-1. Rainfall.

Month	"Monamby" Rain in mm	"Monamby" No. of Falls	"Plaingrove" Rain in mm	"Plaingrove" No. of Falls
January	69.85	4	57.0	5
February	19.05	4	13.4	2
March	216.7	9	254.0	16
April	11.1	3	4.7	3
May	25.2	2	5.5	2
June	18.26	1	9.52	1
August	–	–	8.7	3
September	4.76	3	13.4	2
October	8.73	2	14.2	2

SUSPECTED POISONING IN SHEEP BY *CRASPEDIA CHRYSANTHA*

The plant *Craspedia chrysantha* commonly known as "Golden Billy Button" has been suspected for a long time as the cause of death in sheep within the Paroo and Bulloo shires.

Observations have shown that sheep grazing this plant, may die following exertion such as movement from one paddock to another. Symptoms are those of staggering or stiffness of the legs, dopiness, rapid respiration, diuresis, diarrhoea, and sometimes tetanic fits.

Sheep may lie down, and exhibit heavy panting and tongueing. Respiration may be as rapid as 300 per minute, but after rest the rate drops to 200.

Post mortem examination in the Cunnamulla district show mild gastro-enteritis irritation. Nothing of significance has been found by a post mortem examination, but usually craspedia is found in the ruminal contents, deaths range from 4% to 30%. Good winter rainfall in the area usually results in abundant growth of the plant, particularly on the grey self-mulching clay soils of the Cidgeegoara, Warrego and Muttaburra flood plains, although large stands do occur on the red earths and siliceous sands away from the rivers and creeks.

Observations in the field show that the plant gives most trouble when drying off, as mortalities occur from November to December.

PHOTOSENSITIZATION OF SHEEP CAUSED BY "CALTROP" *(TRIBULUS TERRESTRIS)*

T. terrestris grows widely throughout the region, it is known as "bullhead" by pastoralists and stockmen, although "Caltrop" is the appropriate name.

The plant is a prostrate, annual with opposite leaves consisting of four to eight pairs of leaflets each of which is less than 13 mm long. The flowers are yellow, and are followed by the hairy burr which is the fruit, and this is 7 mm long.

The plant is a common cause of the photosensitivity disease in sheep known as yellow bighead. Conditions favouring the development of the disease are abundance of lush green caltrop, shortage of dry feed, and bright sunny days. Greatest loss occurs in hungry sheep and travelling sheep. The disease is seen in sheep after good summer rains (80 to 127 mm).

Outbreaks occur during January and February. The plant grows rapidly after rainfall and once sheep start to eat the plant they soon exhibit swelling of the head and jaundice. Most affected sheep are in the region of Tambo, Augathella, Wyandra, and Cunnamulla.

The disease is characterised by a severe jaundice, sensitivity to sunlight, and kidney damage. The sensitivity to sunlight is seen first as a severe swelling of the exposed or hairless areas of the sking, e.g. the lips, nostrils, eyelids and ears. As the condition progresses the skin dries out and large pieces may slough away leaving open wounds. A severe ophthalmia results and eyeballs may rupture.

"NATIVE FUSCHIA" *(EREMOPHILA MACULATA)*

In the Quilpie shire this plant is grazed by well fed paddock sheep, but it is poisonous to travelling or hungry sheep.

Symptoms of poisoning appear three to five minutes after hungry sheep graze the plant. The plant is dangerous after rain as then young leaves are available for browse. Affected sheep show deep breathing, rapid pulse, trembling and twitching of the muscles, and sheep that consume large amounts of the plant usually fall down with death occurring soon after. If a lesser amount is eaten sheep develop a trembling of limbs but they may recover if left alone.

"CAUSTIC WEED" *(EUPHORBIA DRUMMONDII)*

This is a common weed of the south-west mulga region being most abundant after summer rains. It dominates heavily grazed areas and responds rapidly to small falls of rain. Hungry sheep are likely to consume large quantities of the plant. Symptoms in sheep are typical of those described by Everist 1947, that is affected sheep swell around the head and neck.

"GASCOYNE SPURGE" *(EUPHORBIA BOOPHTHONA)*

This plant is fairly common on the mulga sand plain between the Beechal and Winbin Creeks. Symptoms in sheep are difficult breathing, frothing at the mouth, acute gastritis and swelling of the head and neck.

"ELLANGOWAN POISON BUSH" *(MYOPORUM DESERTI)*

This shrub is common on the alluvial plains of the south-west mulga region associated with that of gidgee and yapunyah. The plant is not eaten to any extent by paddock sheep owing to the bitter tasting leaves. It is mainly consumed by travelling sheep or hungry sheep. The plant has a delayed action and symptoms are not noticed, until 24 to 48 hours after the plant has been eaten.

Symptoms are quite marked. Breathing is deep and the sheep become drowsy. They lower the head and arch their backs, on collapsing they lay on the brisket and are unable to rise. Spasmodic muscular spasms are evident. The Cheepie-Beechal -Winbin districts are troublesome areas.

"PIGWEED" *(PORTULACA* SP. AFF. *P. OLERACEA)*

This is a common succulent herb which grows well on the alluvial plains and undulating gidgee lands west of the Paroo. It is widely regarded as a good fodder and probably harmless mixed with other feed, but dangerous when gorged by hungry sheep. Spectacular losses occur in some districts (Toompine-Eromanga). Symptoms are those of unsteady gait, hypersensitivity, cyanosis of the visible mucous membrane, paralysis of the hindquarters and bloat.

"SODA BUSH" *(THRELKELDIA PROCERIFLORA)*

Heavy stands of this weed occur on overgrazed areas of the alluvial plains of the gidgee-boree association west of Quilpie. The plant grows well after good summer rains and lasts well into winter. Symptoms are well described by Everist in "Plants Poisonous to Sheep" Q.A.J. January-March 1947. The most noticeable feature is that sheep usually develop a rolling gait, their body and face muscles twitch, and they froth at the mouth. Animals usually go down and rest on their briskets with the head turned over the shoulder.

"BLUEBUSH PEA" *(CROTOLARIA EREMAEA)*

Large stands of this plant grow on the dunefields along the Kyabra Creek country in the Quilpie shire. Losses of some proportion have occurred when sheep graze this plant as they move to the dunefields away from the floodwaters.

"SOFT ROLY POLY" *(SALSOLA KALI)*

This annual herb is abundant on the undulating plains of the boree, gidgee open shrublands west of the Bulloo River. In the immature stage the plant is heavily grazed, and is the cause of acute oxalate poisoning in hungrey sheep. Symptoms are very similar to those produced by consumption of pig weed.

THE CAUSTIC PLANTS

This group includes: "bottle tree caustic" (*Euphorbia stevenii*), "sandhill caustic" (*E. coghlanii*), "desert spurge" (*E. eremophila*), "pencil caustic" (*Sarcostemma australe*).

These plants are widely distributed throughout the mulga sandplains, soft mulga lands, and undulating downs of the Quilpie, Bulloo, and lower Barcoo shires. The *Euphorbia* spp. are suspected and very likely are the cause of death in hungry sheep. Symptoms are laboured breathing, frothing at mouth, diarrhoea, and lying on the side with turning of the head towards the flank.

"PENCIL CAUSTIC" *(SARCOSTEMMA AUSTRALE)*

This is found on the hard mulga lands and dissected tablelands, mesas and buttes of the region. In good seasons the plant is not eaten, but during dry times it is consumed by sheep. Animals are then usually found dead. Signs near dead animals show that they struggle or make running movements when laying on the side. Other symptoms as described by Everist Q.A.J. January-March 1947 are, staggers, rapid breathing, marked champing of the jaws, grinding of teeth and a free flow of saliva.

"SAND SPURGE" *(PHYLLANTHUS FUERNROHRII)* **"SPURGE"** *(PHYLLANTHUS GASSTROEMII)*

These plants are abundant in the soft mulga shrubland, the open shrubland and mulga sandplain west of the Paroo, both plants are suspected to cause loss of sheep. Symptoms are deep breathing, trembling, staggering, and enteritis. The plants are unpalatable and only eaten during periods of extreme pasture shortage.

"MULGA FERN" *(CHEILANTHES SIEBERI)*

This is a most common fern in the mulga region. The plant is believed poisonous to sheep and most dangerous when it is mature? Affected animals exhibit a staggering gait, loss of muscular control, difficult breathing, anaemia of the skin and mucous membranes and often diarrhoea is present. In the field the symptoms may be confused with those exhibited by sheep known to have consumed wild parsnip *Trachymene ochracea.*

"BUTTON GRASS" *(DACTYLOCTENIUM RADULANS)*

This species is regarded as a good fodder, however it is cyanogenetic and is suspected of causing death to sheep on the alluvial plains, undulating plains and downs of the Quilpie shire. Sheep are most prone to the toxic principle when they are hungry.

"COMET GRASS" *(PEROTIS RARA)*

When young this grass is regarded as good fodder, but after seeding the recurved awns can cause much mechanical trouble to sheep as they lodge in the lips, and jaws, and form sleeves on the legs seriously hindering the walking ability of the animal. The plant is common in good seasons on the mulga sand plains, soft mulga shrublands and open shrublands west of the Paroo.