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An inventory and condition survey of the lower Murchison River area, Western Australia

P Hennig

GOVERNMENT OF WESTERN AUSTRALIA
Department of Agriculture and Food

Technical Bulletin

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No. 96

Peter Hennig

Front cover: The Murchison River about 90 km inland from the west coast of Western Australia. The trees in the background are river red gums (*Eucalyptus camaldulensis*), a species commonly associated with river courses of arid or semi-arid areas in Western Australia.

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- Members of the pastoral industry, for taking the time to show interest in the survey program. One trusts the information provided within this document will assist in maintaining or improving sustainable land uses.
- Mr David Blood, now with the Department of Environment and Conservation (Geraldton District), thanks for instigating this survey—regretfully you could not participate in the whole survey. Special thanks are extended to Mr Ken Leighton (Manager—Landgate), for guidance, support, encouragement and supervision of map production, and to Mr PJ Waddell for advice, guidance and patience. To Pam Booker, Department of Agriculture and Food Document Support Centre, for her patient and thorough typing and reworking of manuscript drafts. Finally, many thanks to Ms Sharon Zappelli and Mr Stuart Dijkmans for mapping and database support.

Definition

The lower Murchison River area, as used in this report, occurs on the Ajana 1:250 000 map sheet and part of the Yaringa 1:250 000 map sheet, Western Australia.

National Library of Australia Cataloguing-in-Publication entry

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Summary

1. The area defined as the lower Murchison in this report is bounded by the Indian Ocean to the west, freehold farming land to the south and pastoral grazing land or ‘vacant’ land to the east and north. The area is located on part of the Ajana and Yaringa (1:250 000 scale) map sheets. The survey covers 1 303 933 hectares and fieldwork was conducted in late spring 2002 and autumn 2003. Other than the township of Kalbarri, the area is sparsely populated. The Murchison River is a dominant physical feature with the river flow in an east-west direction and an extensive catchment (outside the survey area) further inland.

2. In the late 1840s mineral deposits were found just south of the survey area, leading not only to mineral extraction, but also the establishment of farming enterprises. Pastoral leases were excised in the lower Murchison survey area from the late 1850s onwards. The town of Kalbarri was officially gazetted in 1951, and the Kalbarri National Park, created in 1968, is now a major drawcard for many visitors.

   The climate comprises mild wet winters and warm to hot dry summers. Rainfall is relatively consistent (on an annual basis) and decreases from about 350 mm on the coast to about 275 mm at the eastern margin of the survey area. The geology is principally extensive sheets of sandplain with minor areas of sandstone, calcrete, limestone and granite.

   Outside the township of Kalbarri, land uses include conservation reserves (about half of the total survey area), Unallocated Crown Land (less than one-quarter of the survey area), pastoral grazing enterprises (greater than one-quarter of the survey area), and small areas of freehold land. Resources of the township of Kalbarri and the freehold cropping areas were not described. Minor areas contain feral animals (goats and to a far lesser extent, pigs) and some areas of land (devoid of native vegetation) may support introduced weeds.

3. This report provides a regional inventory and descriptive reference of land resources, accompanied by a 1:250 000 scale land system map. Included are brief reviews of background information, e.g. history, climate, geology, etc., and more detailed information on the soils, vegetation, land systems and resource condition (in terms of pastoral impact). Individual station reports and plant species lists are supplied as appendices.

4. Lands within the area have been described and mapped into 23 land systems comprising 13 broad land types. The broad land type ‘Sandplains supporting acacia, mallee and heath’ comprises over 70 per cent of the survey area.

5. The survey identified 25 soil types. By far the most dominant are the red and yellow sandplain soils. These soils range from shallow near the coast to deep further inland. The soils associated with the Murchison River range from deep loams to shallow loams and sands.

6. Twenty-seven vegetation types were identified. These were further summarised into 11 broad vegetation groups. The most common vegetation is acacia and eucalypt shrubland/woodland and heath communities on sandplain.

7. The primary parameters recorded during traverse of the survey area were vegetation condition and accelerated soil erosion. With about 30 per cent of the survey area under pastoral lease, and the remaining 70 per cent of the area being ‘vacant’ or conservation reserve, it is appropriate to describe the condition of the resource in three formats: all land surveyed; non-pastoral land surveyed; and pastoral lease land surveyed. Most of the pastoral lease land consists of densely vegetated sandplain—land with a low or very low pastoral potential.

   Of the pastoral lease lands, about 82 per cent was in very good, good or fair resource condition. Of the non-pastoral land, all was in very good, good or fair resource condition.

8. Of the 23 land systems, two (Pillawarra and Yandi) were identified as having significant areas of poor or very poor vegetation condition. Poor or very poor vegetation condition was only recorded on land under pastoral lease. Conservation lands or ‘vacant’ land were in good to very good vegetation condition, with only a minority in fair condition.

9. Soil erosion was recorded on 6 per cent of traverse assessments over the whole survey area and all erosion was recorded on pastoral lease land. On pastoral lease lands 5.3 per cent of traverse records indicated minor erosion, 1.5 per cent of records indicated moderate erosion and 1.5 per cent of records indicated severe erosion.

10. Mapped areas of severely degraded and eroded land equated to 0.07 per cent of the total survey area. Measuring 912 ha, this land is present on two land systems (Pillawarra and Zuytdorp), under pastoral lease. The Pillawarra land system (with high pastoral potential) contains many large erosion gullies.

11. Areas identified as severely degraded and eroded, or in very poor resource condition, should be removed from grazing, i.e. destocked of all domestic and feral animals, until at least partial recovery has been demonstrated. Future management options on these areas may be best considered within a formal long-term, binding, management plan between lessees and government.

12. Land systems identified as being susceptible to overgrazing (generally systems with very high or high pastoral potential) should be used in a sustainable way with appropriate ecological monitoring.

Introduction

This report presents findings from a survey of about 13 000 sq km of rangeland country around the lower reaches of the Murchison River (and surrounds) and has been designated the 'lower Murchison River area'. Rangelands are defined as areas of land considered to receive insufficient rainfall to support the economic production of broadacre cereal crops on an annual basis. Rangelands in Western Australia are mainly used for grazing livestock, mining, nature conservation, tourism and townships. The western boundary of this rangeland survey coincides with the rugged, almost continuous, Zuytdorp Cliffs at the Indian Ocean at approximately 114.15 degrees east. The eastern boundary fronts onto the lower part of the Murchison River rangeland survey, at about 115.30 degrees east. The northern boundary equates at approximately 27.00 degrees south and adjoins the southern extremities of the Carnarvon Basin rangeland survey, while the southern boundary links to agricultural cropping and grazing land at about 28.00 degrees south.

This report is part of an ongoing commitment to describe and map the natural resources of pastoral leasehold land within Western Australia. The survey was undertaken by a joint team from the Department of Land Information and the Department of Agriculture with fieldwork conducted during November 2002 and March/April 2003.

The survey methodology and format closely follow other surveys in the rangelands of WA as reported in Van Vreeswyk et al. (2004) and Payne et al. (1998). This report presents information on land classification, mapping and natural resource evaluation.

The surveyed area comprises leased pastoral land, Unallocated Crown Land and conservation reserves.

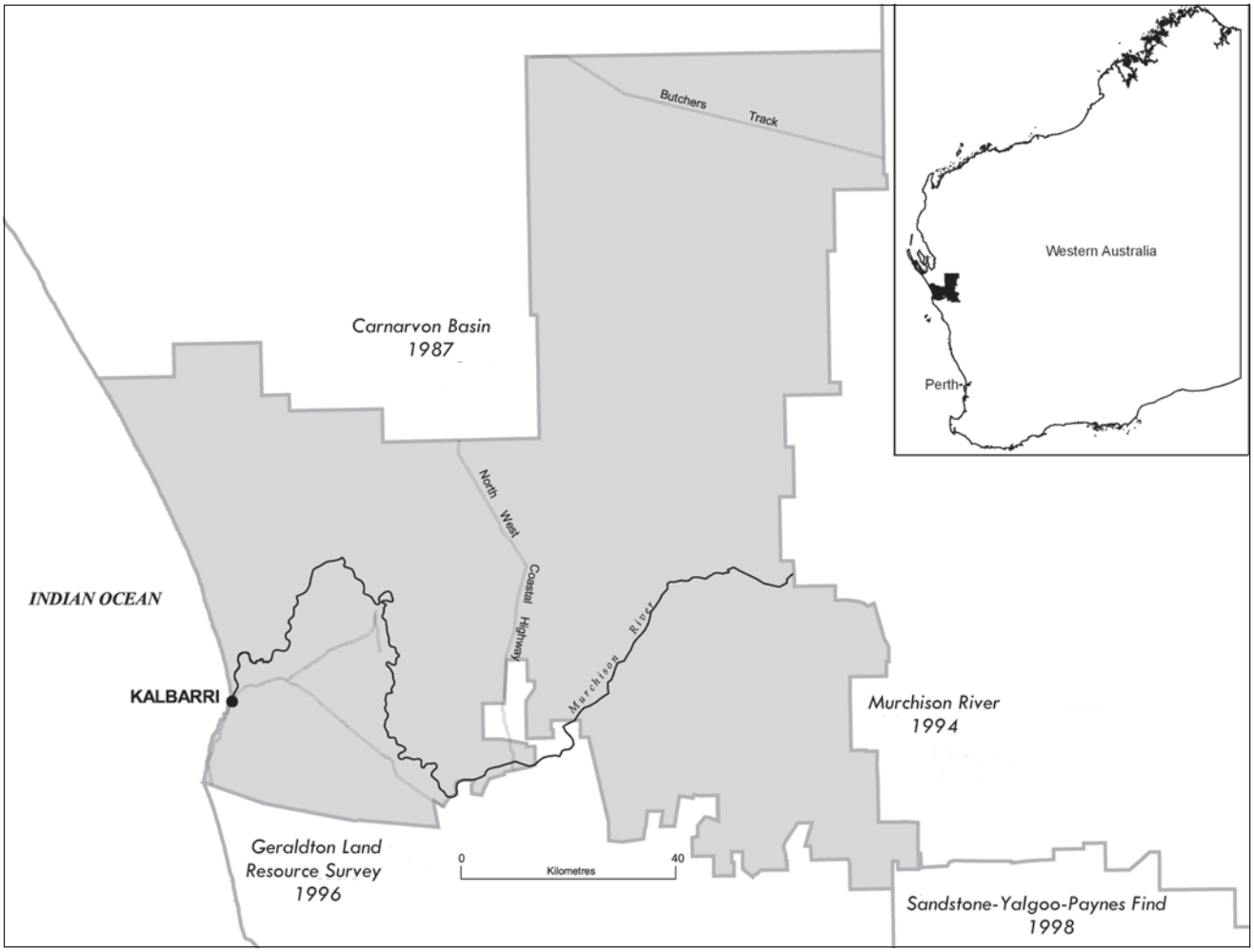

Figure 1 Location map of the lower Murchison survey area and neighbouring survey areas

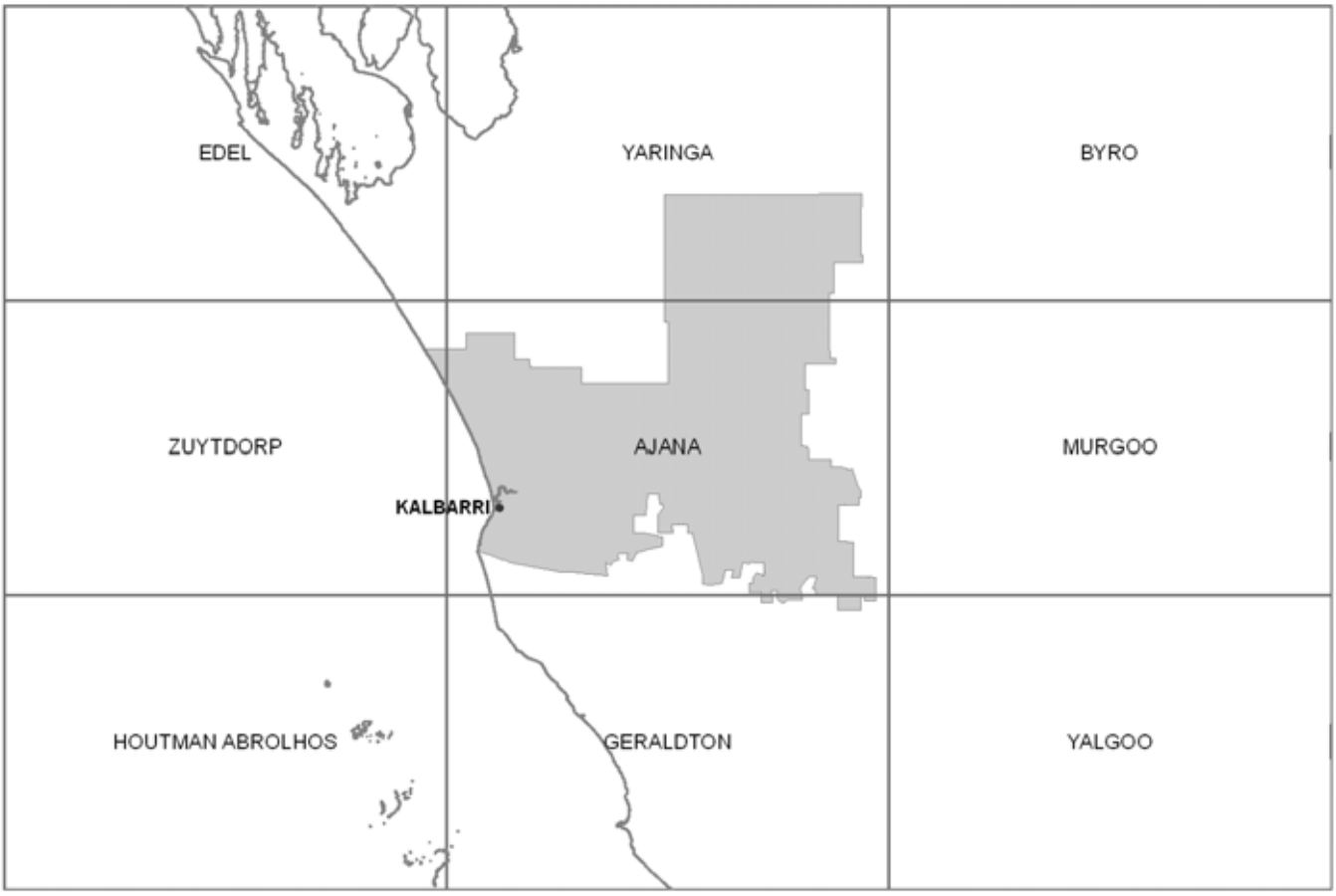

Figure 2 The 1:250 000 map sheets covering the survey area

Purpose of the survey

The purpose of the survey is to provide descriptions and maps of the biophysical resources of the area, together with an assessment of the condition of vegetation and soils. The report and the accompanying map (at 1:250 000 scale) are intended as a reference for land managers, land management advisers and land administrators involved with planning and implementing land management practices. The survey report and map provide a reference on landscape resources, including base vegetation descriptions necessary for the strategic location of monitoring sites and information for the assessment of resource condition.

Contents of the report

Part of this report provides a brief overview of particular aspects of land use and biophysical features of the survey area. The brief history, climate, geology and main declared plants/ animals chapters serve as an introduction to the later more detailed chapters. The methodology chapter explains the survey procedure. Three major chapters present information on land systems, soils and vegetation. These chapters provide information at the land unit level, and when used in conjunction with the accompanying map, provide an inventory of biophysical resources.

The resource condition chapter provides a detailed assessment of land use impacts on the vegetation and soil of the survey area.

Individual station reports, plant species lists and the land system map comprise the appendices. Plant identification was difficult during the fieldwork as it was conducted in summer when very few plants were flowering.

Previous surveys

The areas of pastoral land to the north and east of the lower Murchison area were previously described in Payne et al. (1987, 1998) and Curry et al. (1994). To the south of the survey area freehold farming land was the subject of a report by Rogers (1996). Rogers also described parts of the 129 sq km of freehold land held within some pastoral leases of the lower Murchison survey area.

The only previous pastoral mapping of the lower Murchison area was a pastoral classification plan at a scale of 1:250 000, supervised by Harrington (1967), derived from uncontrolled aerial photo mosaics (dated April 1953). Many pastoral classification plans of this era were produced by experienced pastoral inspectors providing some basic information on the value of grazing lands in terms of broad land types, generalised vegetation and estimated stock carrying capacity. The plans also included station infrastructure and lease boundaries. Pastoral classification plans were not updated after original publication and no reports on the methodology or findings were published.

Formal regional surveys undertaken by scientists were instigated by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in the 1940s within the Northern Territory. The original methodology of these early surveys formed the basis of future surveys. Of the 19 surveys in Western Australia in the last 46 years, four were conducted by CSIRO (Figure 3).

Pastoral lease plans at a scale of 1:100 000 showing resource, topographical and cultural information are provided only to pastoral lessees. General public wishing to access a pastoral lease plan require the written permission of the station lessee or property manager. 'Permission to release' forms are available through the Department of Agriculture and Food and attract a fee.

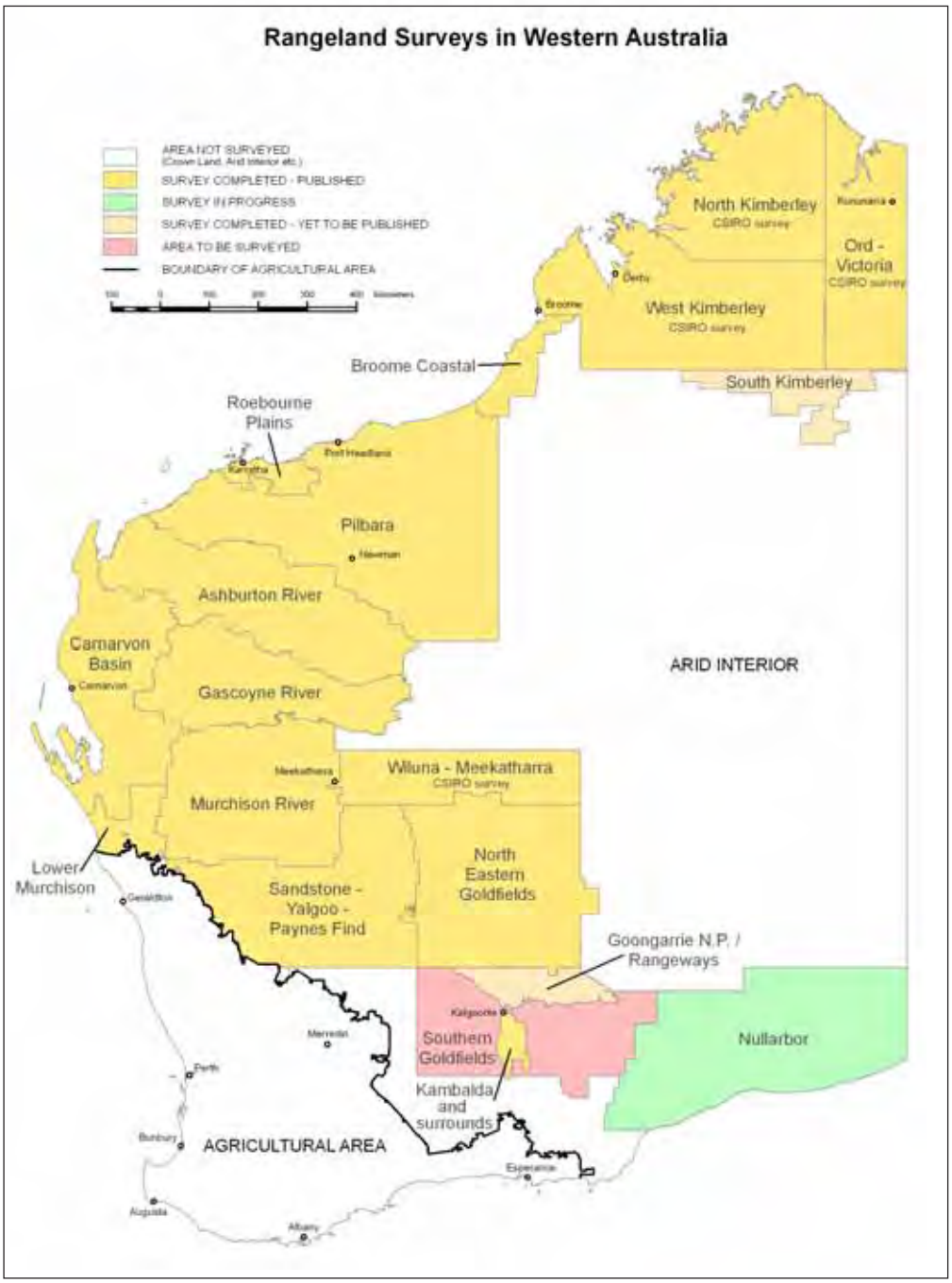

Figure 3 Index to rangeland surveys in Western Australia

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A brief European land use history

In July 1619 a fleet of European vessels under the command of Frederik de Houtman discovered reef and rocky islets off the mid-west coast of Western Australia. The area was named Houtman Abrolhos.

The term ‘abrolhos’, a contraction of several Portuguese words, was used to indicate outlying coastal dangers and the translation to English is ‘open your eyes’ (Hocking et al. 1982). This prophetic term was notable, as the next recorded European encounter in this area was the shipwreck of the *Batavia* in 1629 at the Abrolhos Islands. The tragedy of the shipwreck paled to insignificance compared to the bloody mutiny that followed on the isolated islands. While many mutineers were later executed, two of the *Batavia* crew were put on the mainland (as punishment for mutiny) to fend for themselves in a hostile and yet uncharted land near the mouth of the Murchison River (Fraser 1906).

Over the next 70 years there were several European maritime voyages along the west coast. Many were merchant vessels blown off course en route to Java (Indonesia), some of which never made the destination. Other voyages were to look for missing ships. Exploratory missions from mainly Dutch mariners often described the coastal lands as unfavourable. Reports to Europe did not encourage further exploration until interest was ignited by findings on the east coast of Australia another 70 years on.

The Dutch vessel *Zuiddorp* (pronounced zweedt-dorp) was wrecked about 60 km north of the mouth of the Murchison River in 1711 on cliffs that now bear the name of the vessel. Zuytdorp is probably a phonetic English spelling of the Dutch word (meaning the South Village). Another Dutch vessel the *Zeewijk*, was wrecked on the Abrolhos Islands in 1727 (VOC website). Several major maritime expeditions occurred in the early 1800s including the naming of Gantheaume Bay at the mouth of the Murchison River, by French expedition leader Captain Baudin.

In 1829 the Swan River Settlement was established by the British. In 1839, Captain George Grey and crew attempted the first detailed coastal exploration from Fremantle to Shark Bay, only to have their boats destroyed at the entrance to the Murchison River, necessitating a 500 km overland return journey on foot. Grey’s favourable descriptions of parcels of land created interest in the colony. However with shipping the main mode of transport at this time, the uninviting and dangerous coastline discouraged settlement. From 1846 to 1848 the Gregory brothers led inland expeditions north of Geraldton to find an area rich in mineral ore.

The rugged and inhospitable ‘shipwreck’ coast of the Zuytdorp Cliffs and the Abrolhos Islands discouraged initial settlement.

In 1849 a mining company was formed and purchased 640 acres (about 260 hectares) of land at £1 (about $2) per acre. The mine was named Geraldine and other mines such as Galena and Mary Springs soon followed. This area became the first proclaimed mineral field in Western Australia. Although historical records are incomplete, it is estimated these mines produced about 40 000 tonnes of galena (lead) ore concentrate and several hundred tonnes of copper ore (Hocking et al. 1982). Ore was transported to the nearest port of Pakington (gazetted in 1853 and now known as Port Gregory).

Nearby Lynton Station was established at this time to serve as a hiring station where 'ticket of leave' holders from the convict labour system could work for the mines and farmers in the area. The hiring function of Lynton ceased in 1856 and the property became a livestock grazing enterprise of 48 000 acres (about 19 400 ha) (Henville 1968). The first lots in the town of Geraldton (formerly called Champion Bay) became available in 1850 and Northampton was gazetted as a town in 1864 (Landgate 2007). A railway line was constructed between Geraldton and Northampton in 1879 and was extended to the Ajana area in 1913. The railway brought about the expansion of agriculture, cereal crops and the sheep industry. The Ajana townsite was gazetted in 1915.

Murchison House Station was established in 1858 by Charles (Carl) Von Bibra on the banks of, and near the mouth of the Murchison River. Von Bibra was the Postmaster at the Lynton hiring station in 1856. The original function of Murchison House was to breed Arab stallions for the British Army in India (a main export from the colony at the time). During the 1860s many small pastoral leases were selected, but by the 1870s many of the leases were consolidated into Murchison House Station. By 1876, Von Bibra had moved north to the Shark Bay and Gascoyne areas and his original lease was taken over by AJ Ogilvie.

The properties of Yandi, Mt View and Coolcalalaya stations were established after Murchison House while Eurardy and Nerren Nerren further north, excised suitable grazing blocks within densely vegetated sandplain country. Mr ET Hooley drove livestock from Greenough through the area en route to establish a pastoral property in the Pilbara in 1866. Also around this time pastoral blocks were being established further upstream on the upper Murchison River including the New Forrest area in the late 1870s and the Yallalong lease on the fringing river plains in the early 1880s (Nixon and Lefroy undated).

The Northampton Historical Society's faithful restoration of the original 'convict hiring depot' at Lynton. The station provided labour for the emerging farming and mining sectors from 1853 to 1856.

In 1894 a telegraph line was constructed between Geraldton and Hamelin Pool (Shark Bay). At the time this line provided one of the very few tracks to access land further north, however most of the land was unsuitable for any form of agriculture. Evidence of the old telegraph line is still visible in parts and the telegraph station at Hamelin Pool is now a museum. Between 1904 and 1907 a vermin proof fence was erected from Bluff Point (the most south-western part of the Kalbarri National Park) east toward Yalgoo. This fence is currently not fully maintained as another barrier fence across the north of Murchison House Station serves the purpose of deterring migratory animals attempting to cross to the south-west farming areas.

A small community of fishermen and their families started to occupy an area at the mouth of the Murchison River around the 1940s. This village was gazetted as the town of Kalbarri in 1951. At the time the town was very small but with improved services, especially good roads, it became a major support for the fishing industry, and later a major tourist attraction boosted by the establishment of the Kalbarri National Park in 1968.

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The original cottage of Charles Von Bibra on Murchison House Station (established in 1858). The original function of the station was to breed horses to sell to the British Army.

Climate

The climate was classified as Dry Warm Mediterranean by Beard (1976) following the methods of Bagnouls and Gaussen (1957), and characterised by mild wet winters and warm to hot dry summers.

Most rainfall occurs from May to August, and may extend one month either side in some years. The principal source of the rain is from cold fronts from the Indian Ocean passing over the area from the south-west, commonly from April to November. Rainfall is highest in the south-west of the area and lowest in the north-east. Mean rainfall recorded on the coast at Kalbarri is about 370 mm while the rainfall 50 km inland at Ajana is about 340 mm (Bureau of Meteorology). Further inland, data from 16 recent years from Coolcalalaya (about 90 km east of Kalbarri) show an average rainfall of about 310 mm. The mean annual rainfall for Eurardy is about 350 mm. Toward Mallee (about 120 km east of the coast) the annual rainfall is about 275 mm.

Rogers (1996) notes the growing season for cereal crops in the adjacent farming areas near the coast is four to five months long, but inland the growing season is more commonly three months. Rainfall records from Kalbarri show winter rain between May and August supplies about 75 per cent of the annual total with only 10 per cent occurring between January and April as summer rainfall. Inland at Coolcalalaya Station, about 50 per cent of the total average rainfall is recorded from May to August and about 35 per cent is received between January and April. Heavy rainfall events in the upper catchment of the Murchison River result in river flows about once or twice per year. These river flows are mostly fast and voluminous for several days, and then slowly retreat to minor flows over the following weeks. The river often ceases to flow after about one month with most of the riverbed becoming dry except for some permanent and semi-permanent pools. Once every four or five years the catchment receives increased rainfall resulting in a river flood. These floods tend to inundate the surrounding flat plains of the river and surface water may exist for up to two weeks after flooding.

Rainfall produced from the interaction of atmospheric pressure troughs and moist air from north-west cloud bands results in infrequent rain during the summer months. Occasional tropical cyclones formed in the north-west of Western Australia deteriorate to rain-bearing depressions as they travel southwards and may also bring rainfall during summer. Summer cyclonic activity is varied and is not a regular occurrence. Thunderstorms during the summer months deliver patchy rainfall and are more common inland than on the coast, as reflected in the summer rainfall figures.

In the winter months (May to October) mean daily maximum temperatures are lowest during July with the mean monthly averages around 21 °C on the coast and about 18–19 °C inland. The monthly average minima range from about 10 °C near the coast to about 6 °C inland. The hottest month in Kalbarri is February with a mean monthly maximum temperature of about 34 °C and a minimum of around 19–20 °C. Inland, the hottest month is January with maximum temperatures of 37–38 °C and minima of about 21–22 °C.

Mean monthly wind speeds for Kalbarri during June and July are about 11–13 km/h reaching 17–25 km/h during high summer (January to February). Inland, the wind speeds average around 11–16 km/h in winter and about 16–17 km/h in summer. The difference in the summer wind speeds between the coast and inland is attributed to the sea breeze created by heat convection on the coast.

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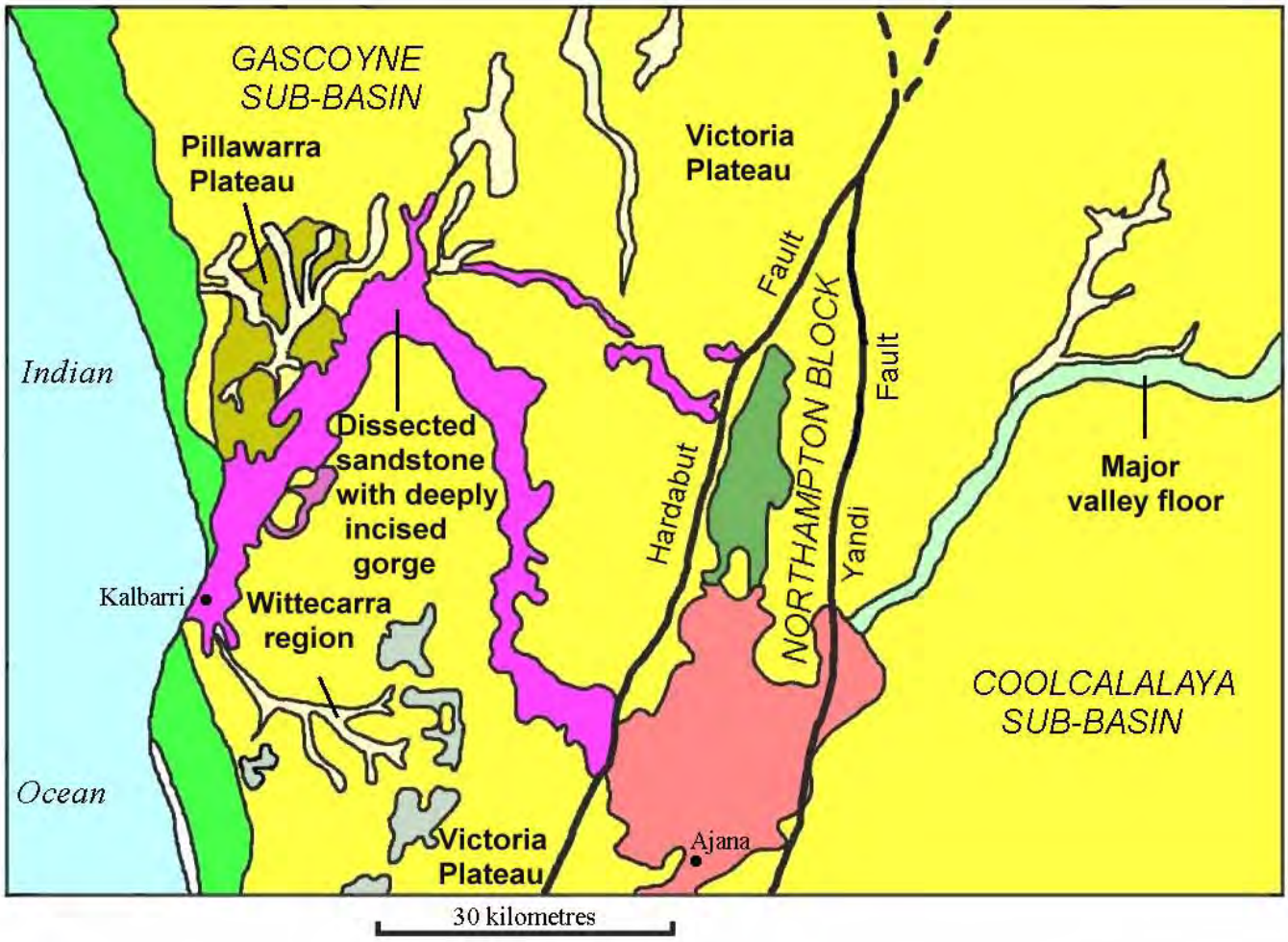
Geology

The broad geology of the survey area is divided into three main zones divided by fault lines (Hocking et al. 1982), the most prominent being the Hardabut and Yandi faults (see Figure 4). Between these two fault lines are the Proterozoic granulites, granites and gneiss of the Northampton Block. The area to the west of the faults is the Gascoyne Sub-basin based mostly on Upper Cretaceous and Lower Cretaceous geology. To the east of the Northampton Block is the Coolcalalaya Sub-basin primarily of Permian geology.

The northern and north-central part of the survey area is dominated by the Victoria Plateau. Toward the south, this plateau is disrupted by other geological features including the Murchison River which traverses the area from east to west. The Northampton Block extends southwards and is met by the southern continuation of the Victoria Plateau to its west. Land associated with the major part of the lower Murchison River is dominated by Tumblagooda Sandstone and Toolonga Calcilutite of the Pillawarra Plateau.



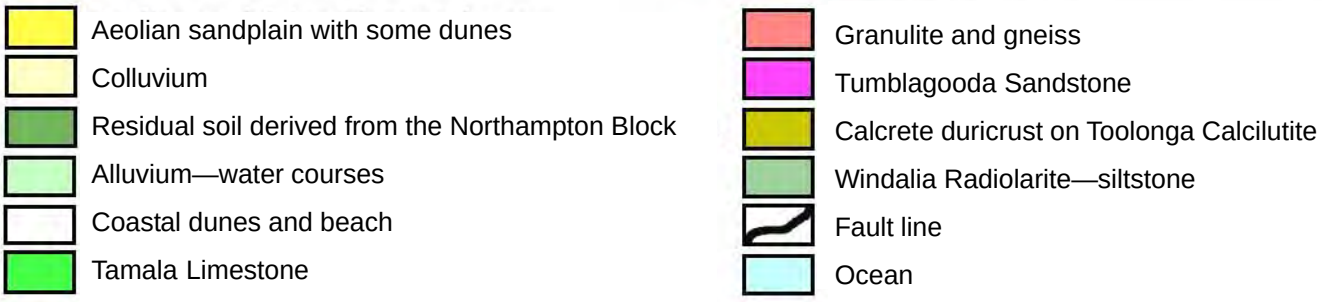


Figure 4 Main physiography and geology regions of the Ajana 1:250 000 map sheet derived from Hocking et al. (1982)

The Victoria Plateau has deep, gently undulating, aeolian sandplain with some residual soil and colluvial deposits, deeply underlain by lateritic duricrust. The plateau is interrupted in the central north by valley floors of the Bungabandi Creek underlain by sandstone. Sandplains of variable depth (from shallow to deep) are associated with the sandstone.

In the southern central area the dominant geology is the Northampton Block, consisting of Proterozoic granite and granulite erosional surfaces. This area (Ajana–Galena) was mined for lead in the early years of European settlement.

To the east of the Ajana–Galena area the valley floors of the Murchison River consist of Quaternary alluvium and exposures of red-brown hardpan or weathered granite substrates. To the west of the Ajana–Galena area, as it approaches the Indian Ocean, the Murchison River cuts a meandering course through deep gorges in the Silurian Tumblagooda Sandstone from which it emerges after about 40 km, into a wide river valley. The gorge and valley are flanked by sandplain plateaux. Ancient deep weathering of the sandstone is evidenced by extensive sandplains with major incision by the Murchison River. The river flows intermittently, once or twice a year. Adjacent to the river system, in the central west is the duricrusted, erosional calcreted remnants of the Pillawarra Plateau on Toolonga Calcilutite.

The Victoria Plateau sandplain occurs again in the southern part of the area adjacent to the sandstone formations in the south-west. It is interrupted in part by valley floors on weathered sandstone in the Wittecarra area. Windalia Radiolarite is found (but is not extensive) in several areas of the south-west and the central north-east.

Tamala Limestone forms the coastal and near-coastal formations. Near the town of Kalbarri and further north the limestone areas rise to over 200 m above sea level and are present as very steeply sloped cliffs.

Reference

Hocking RM, Van De Graaff WJE, Blockley JG, Butcher PB (1982) Ajana, WA: Geological Survey of Western Australia, 1:250,000 Geological Survey – Explanatory Notes SG/50–13.

Land use

Within the survey area, about half of the land is Unallocated Crown Land (UCL). No viable supplies of minerals have been found in the unallocated land to date, and nearly all the area is considered unsuitable for arable farming. Although some of the land within this survey area is suitable for livestock grazing, the UCL is considered unsuitable with much of the vegetation being impenetrable dense scrub and mostly unpalatable for traditional livestock. Aquifers are generally few and cannot produce suitable quality water or guarantee reliable supply.

Pastoral stations occupy just over one-quarter of the area. In most instances the stations cannot use all of the land within their leases due to water supply difficulties or vegetation unsuited to livestock. Generally areas adjacent to major rivers or creeks have been used for animal (wool and meat) production. The development of other grazing areas within leases has depended on wells, bores or dams. Some areas have natural springs, however these water sources are mostly seasonal.

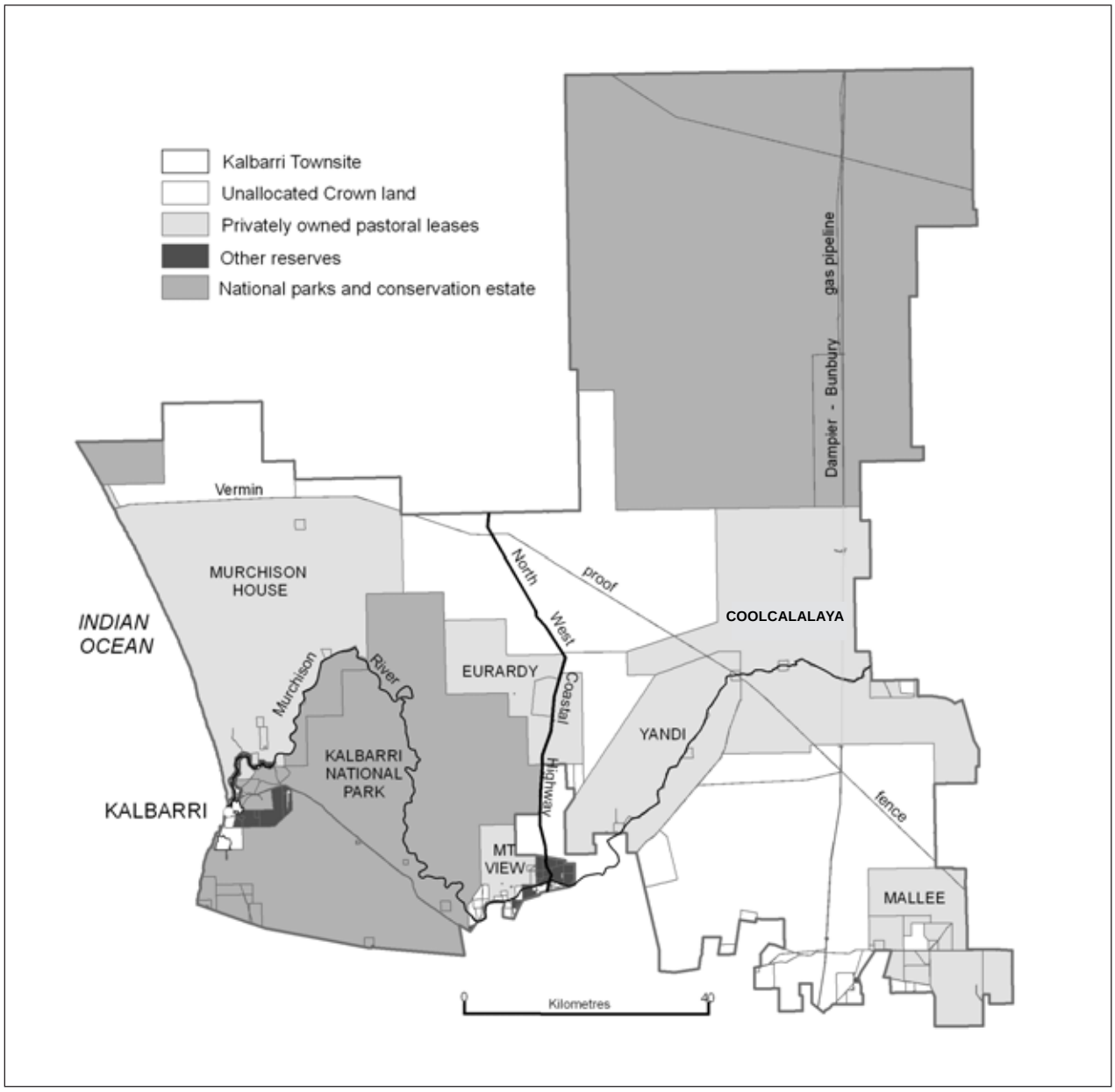


Figure 5 Land use map showing pastoral stations, conservation reserves and Unallocated Crown Land within the survey area

Conservation reserves occupy about half the survey area. The largest reserve is the Kalbarri National Park occupying about 192 000 ha. This park was created in 1968 seeking to preserve the unique and botanically rich heath-sandplains. It also has spectacular landforms where the Murchison River has cut through sandstone. The Toolonga Nature Reserve in the north-east of the survey area consists primarily of acacia sandplain vegetation. Eurardy Station in the centre of the study area was recently purchased for nature conservation. In general, conservation reserves are sought throughout the state to preserve different landscapes. There is currently no indication of any other proposed nature/ conservation reserves for this area. In the centre and the south-east of the survey area are two tracts of Unallocated Crown Land comprising mostly acacia sandplain vegetation.

There are some very small areas of special pastoral lease land where permission has been granted to grow commercial cereal crops. These areas are mostly restricted to some deep yellow sandplains or red loamy earth plains. This land was cleared of native vegetation and now supports an annual cropping regime, in line with freehold farming areas to the south. Due to these tracts of land being in marginal rainfall zones, production is not guaranteed every year. The freehold farming areas were not surveyed.

The only town within this survey area is Kalbarri, with a population of about 2000 permanent residents. The town services the fishing industry and is a popular tourist destination with about 200 000 people visiting each year. No land within the town boundaries was surveyed during the course of this survey.

Declared plants and animals

Weeds

Many of the weeds within the survey area tend to grow in areas associated with land cleared for broadacre farming or road formations. The most common weeds are *Avena barbata* (bearded oat), *A. fatua* (wild oat) and *Poa* sp. *Medicago polymorpha* (burr medic) is also present. These plants, while not declared, may invade areas of native vegetation.

In general, weeds will tend to take root in bare or cleared land provided there is sufficient moisture. Weeds tend to grow faster than native species and areas of bushland can become infested. Beard (1991) noted areas of bushland adjacent to farming areas lost annual wildflowers at the expense of weeds. Roadside verges tend to collect run-off from solid road surfaces providing ideal moisture regimes for some weeds. Annual spraying of herbicides or mechanical slashing of these areas does not appear to diminish seed production sufficiently for total eradication. Dry annual weeds also tend to put areas at increased risk of fires instigated through natural lightning strike during summer thunderstorms or by human carelessness.

Although many annual weeds may provide nutrition to grazing animals during winter months, the plants afford little nutrition during dry times. The annuals rarely afford protection from soil erosion. Some weeds tend to dominate roadside verges, but rarely dominate the heartlands of dense native vegetation.

Saffron thistle (*Carthamus lanatus*)

Saffron thistle was widely found on land cleared for crop production. Areas adjacent to cropping land with depleted native vegetation were also found to be infested. This plant tends to grow only on deep soils with good moisture retention and no plants were observed growing in shallow soils. Saffron thistle seeds may be viable for up to eight years and will only grow during good seasons (DAFWA). Intervention during flowering is recommended to minimise or stop seed set. This process should be repeated during good seasons with many treatments being necessary for control and even more treatments for eradication.

Mexican poppy (*Argemone ochroleuca* subsp. *ochroleuca*)

Mexican poppy was found on the lower plains of the Pillawarra land system. Elsewhere it may occur along the floodplains of river systems. This species originates from Central America and may grow to 1 metre high (DAFWA). Mexican poppy is known to be poisonous to livestock, but is rarely grazed. The foliage is bluish-green and it has large, pale yellow flowers and hollow stems. Prior to flowering (often October to November or dependent on the level of soil moisture) it resembles a thistle because of its toothed and prickly leaf margins. It reproduces only from seed and the seed can stay dormant for many years, making control difficult.

Introduced annual weeds such as Avena barbata *(bearded oat) occur on areas cleared for cereal cropping or on areas subjected to historic overgrazing. While bearded oat is not 'declared', it does out-compete native herbs and shrubs.*

*Saffron thistle (*Carthamus lanatus*) grows in land cleared for crop production or other land devoid of native vegetation. It survives well in deep soils, but usually only germinates during good seasons.*

Double gee (*Emex australis*)

Double gee is an annual, mostly prostrate herb, producing triple-spined seed casings that cause harm to livestock and people. Double gee originates from South Africa and has become a well established noxious weed through the wheatbelt and some pastoral areas. The plant prefers disturbed soil and is ideally suited to growing in a broadacre cropping environment. Leaves contain oxalate levels sufficient to poison sheep, however grazing by livestock is infrequent.

Paterson's curse (*Echium plantagineum*)

Paterson's curse is a declared (noxious) weed originating from the Mediterranean region and was introduced into Australia in the mid to late 1800s. Paterson's curse usually germinates in early autumn, may grow to 1 m high competing with cereal crops and farming pastures without contributing to forage value. It is easily recognised during spring with bright purple flowers. Paterson's curse contains alkaloids toxic to livestock, particularly horses. Sheep may graze this plant in small quantities with little harm, but large quantities or continued grazing may cause liver damage.

Paterson's curse occurs in broadacre farming areas within the Northampton Shire. Otherwise it occurs along roadside verges or regularly disturbed soil. It is not considered a threat to most areas of dense native vegetation.

*Double gee (*Emex australis*) originates from South Africa and is believed to have originally been imported as a form of spinach for human consumption. While the plant contains oxalate levels toxic to sheep, the hard dry seed casing appears to cause the most harm.*

Animals

Goats (*Capra hircus*)

Goats are the most common feral animal in the survey area. Most likely originating from the early colonial years as domestic imports, goats supplied milk, meat and mohair. By 1870 about 50 goats had been taken to the Shark Bay area, and by 1894 there were about 4500 in WA. By 1905 goats were kept in all regions of the state, but with the collapse of the potentially rich mohair industry many goats escaped to survive on natural vegetation.

The feral goat has the ability to survive harsher conditions than traditional livestock. In general, goats can tolerate poorer quality water, eat a broader suite of vegetation types and are able to travel greater distances than Merino sheep. Feral goats tend to have a total disregard for infrastructure maintained to control traditional livestock (especially fences and watering points). Periodic spelling or resting land from the influence of livestock (to encourage an increase in plant numbers and herbage biomass) is often hampered by feral goats. Goats are considered very difficult to muster, tending to separate in many mobs and also seeking protection among very dense vegetation. Goat trap yards (around artificial watering points) are humane and cost effective, yet such control measures are ineffective if not at a regional scale.

Following the reclassification of feral goats to 'authorised stock' under the *Land Administration Act 1997* (LAA), Best Management Practice Guidelines for goats in the rangelands of Western Australia were approved by the Pastoral Lands Board in December 2003. Within the guidelines, goats are defined as 'managed' and 'unmanaged'. Unmanaged or feral goat populations remain an issue in some parts of the survey area. More information on the managed grazing of goats in the pastoral areas is available from the Pastoral Lands Board.

Pigs (*Sus scrofa*)

Domesticated pigs were introduced to Australia during the infancy of the colony. Feral pigs are direct descendents of the domestic variety. They appear to be relatively low in number through the survey area but evidence of wild pig activity was noted on one pastoral lease and one nature reserve. Pigs tend to require regular access to water especially during summer months, accounting for the relatively restricted populations in the survey area. Feral pigs are omnivores but rely on plants for the bulk of their diet. They tend to prefer dense vegetation and disturb certain types of soil while digging for specific plant roots. Feral pigs are classified as vermin as they may harbour pathogens like tuberculosis and brucellosis as well as some parasites.

Evidence of 'rooting' (digging for fleshy plant roots) by feral pigs. Feral pig populations are often regulated by the availability of permanent water supplies.

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Methodology

This report and map detail a survey of natural resources of about 13 000 sq km of rangelands in the lower reaches of the Murchison River, Western Australia. This survey used the land system approach (Christian and Stewart 1953) to describe and evaluate the resource, as used by rangeland resource surveys previously conducted by the Department of Agriculture (e.g. Van Vreeswyk et al. 2004 and Payne et al. 1998).

Land systems are defined as areas or groups of areas throughout which there are recurring patterns of topography, soil and vegetation. Each system has characteristic patterns, visible on aerial photographs, and all systems consist of smaller units or elements, each with a distinctive photo pattern. The relative proportion and arrangements of the component units, defines the signature of the land system.

Fieldwork was undertaken by a team of four officers from the Department of Agriculture and the Department of Land Information (now known as Landgate), with some assistance from officers from the Department of Conservation and Land Management (now called the Department of Environment and Conservation), during November 2002 and March/April 2003.

Black and white aerial photographs of the survey area (scale 1:50 000) were highlighted with topographic features and infrastructure (roads, fences, watering points, etc.). Provisional land system boundaries were marked onto the aerial photos. Information on biophysical resources of the survey area (Beard 1976, Hocking et al. 1982, Rogers 1996) was reviewed to assist provisional land system mapping and provide information on the general area. Background information was sourced from unpublished data held by the Western Australian Departments of Land Information, Planning and Infrastructure, Agriculture, and Conservation and Land Management.

The area was traversed on a station-by-station basis and included Unallocated Crown Land and conservation reserves. Traverse routes were predetermined and marked on the aerial photos and tentative land system boundaries on the photos were verified while traversing in the field. Land system, land unit and vegetation types were recorded at kilometre intervals along the traverses, and included range condition assessments together with assessments of other factors, such as evidence of fire, levels of modification, abundance of exotic species or increaser and decreaser species.

Table 1 **Criteria for assessment of vegetation condition (for traverse points and inventory sites)**

Rating	Condition indicators
1	Excellent or very good For the land unit vegetation type, cover and composition of shrubs, perennial herbs and grasses are near optimal, free of obvious reductions in palatable species or increases in unpalatable species, or the vegetation type supports plants predominantly unattractive to herbivores and is largely unaltered by grazing.
2	Good Perennials present include all or most of the palatable species expected; some less palatable or unpalatable species may have increased, but total perennial cover is not very different from the optimal.
3	Fair Moderate losses of palatable perennials and/or increases in unpalatable shrubs or grasses, but most palatable species and stability desirables still present; foliar cover is less than on comparable sites rated 1 or 2 unless unpalatable species have increased.
4	Poor Conspicuous losses of palatable perennials; foliar cover is either decreased through a general loss of perennials or is increased by invasion of unpalatable species.
5	Very poor Few palatable perennials remain; cover is either greatly reduced, with much bare ground arising from loss of stability desirables, or has become dominated by a proliferation of unpalatable species.

The range condition information was recorded as point data, being a rating of the vegetation condition (see Table 1) and the extent and type of accelerated erosion (see Table 2). The criteria for assessment of accelerated erosion are provided in Table 3. Geographical information was recorded using a Global Positioning System (GPS) navigation unit and a laptop computer with Oziexplorer® (real time mapping) software.

Vegetation condition and soil erosion ratings to assess range condition were recorded on pastoral leases and Unallocated Crown land. Areas not subjected to rating were some conservation lands and areas close to major roads and pastoral infrastructure such as major buildings or man-made stock watering points.

Table 2 **Criteria for assessment of accelerated erosion (for traverse points)**

Quantitative measure of area affected by erosion	
Rating	Severity
0	No accelerated erosion present
1	Slight erosion (<10% of site affected)
2	Minor erosion (10–25% of site affected)
3	Moderate erosion (25–50% of site affected)
4	Severe erosion (50–75% of site affected)
5	Extreme erosion (75–100% of site affected)

Type of erosion present (dominant type recorded)	
Rating	Erosion characteristics present
0	No erosion
A	Microterracing/sheeting
B	Scalding/capping
C	Pedestalling
D	Rilling/guttering
E	Guttering/gullying
F	Accelerated accretion of soil material

Table 3 **Criteria for assessment of accelerated erosion (for inventory sites)**

Type – intensity combination	Rating
No accelerated erosion present	00
Slight erosion (<10% of site affected)	
Slight accumulation of wind-blown soil around plant bases and other obstacles and/or	11
Removal of finer soil particles evident but soil crust is largely intact and/or	12
Occasional rills (<300 mm deep evident) and/or	13
A few scalds present, usually <2 m in diameter	14
Minor erosion (10–25% of site affected)	
Accumulation of soil around plant bases with plant mounds noticeably enlarged and/or	21
Evidence of pedestalling but soil loss minor and plant bases not greatly elevated and/or	22
Breaking of surface crust with small erosion faces and some redistribution of soil and/or	23
Rilling evident but no gully development and/or	24
Scalding evident but scalds relatively small and discontinuous	25
Moderate erosion (25–50% of site affected)	
Wind piling around plant bases and other obstacles is common but no plants completely covered and/or	31
Pedestalling apparent with plant bases distinctly raised and with obvious soil loss and/or	32
Rilling common or gullying present on parts of site and/or	33
Surface sheeting with erosion faces (and/or microterracing) and active redistribution of soil and/or	34
Wind scalds common	35
Severe erosion (50–75% of site affected)	
Extreme hummocking around plants and other obstacles; some plants completely covered and/or	41
Severe pedestalling with plant bases greatly elevated and major soil loss and/or	42
Widespread rilling or major gullying and/or	43
Scalding extensive, smaller scalds have coalesced to form large, more or less continuous scalded areas and/or	44
Surface sheeting with extensive exposure of subsoil or parent material; erosion faces (and/or microterracing) and active redistribution of soil and/or	45
Much of surface generally unstable with ripple mark formation	46
Extreme erosion (75–100% of site affected)	
General surface movement, total surface area bare with formation of shifting dunes and/or	51
Surface sheeting and/or scalding complete with exposure of subsoil or parent material and/or	52
Extensive gullying	53

Vegetation condition and soil erosion ratings are subjective visual assessments based on assessor familiarity with vegetation types supported by landform/soil associations. Experienced assessment requires an understanding of the 'natural' range of attributes such as species composition, density and cover, and likely changes in these attributes occurring as a result of disturbance. An area judged to be in the 'natural' range is rated as being in very good condition. Induced changes in the 'natural' range are rated as good, fair, poor or very poor, depending on the extent of the change. Eight other parameters were evaluated as point data to provide extra information.

Table 4 **Other traverse assessment parameters recorded**

Substantially modified traverse points
Disturbance factor—evidence of fire
Disturbance factor—grazing
Disturbance factor—road effect (water diversion)
Exotic plant species (weeds/introduced) common
Perennial vegetative cover greatly reduced
Increase in undesirable species
Perennial vegetation structure significantly altered

Two areas interpreted as severely degraded and eroded on the aerial photographs, were verified by ground inspection and mapped. Areas less than 40 ha were not mapped due to scale limitations.

Twenty-eight traverse routes, averaging about 40 km long, were conducted throughout the survey area and are shown in Figure 6. Some 1219 traverse points were recorded in the survey area; 825 of these have a range condition assessment.

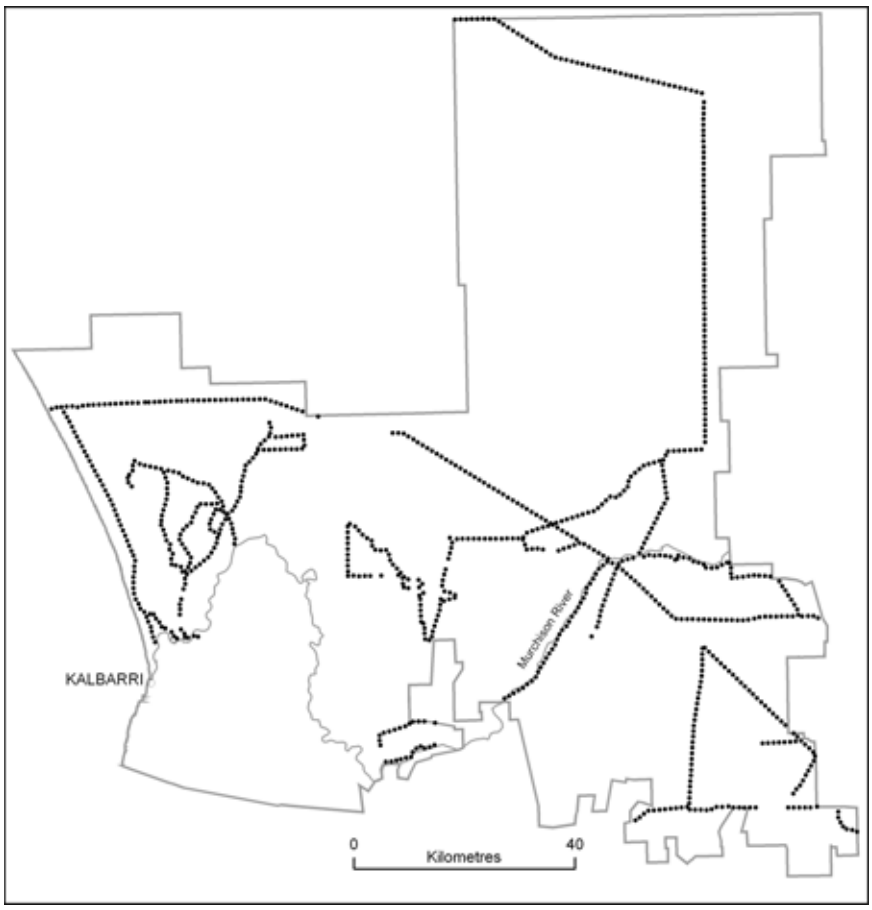


Figure 6 Traverse routes in the survey area

Inventory sites were pre-selected during traverse planning. To assist with interpreting the aerial photo patterns, sites were selected to sample every major land unit within each land system. Additional sites were sampled where different land unit/vegetation/soil associations were encountered en route. Inventory sites provide information at a land unit scale. The site sample area was an approximate 50 m radius from one particular point and detailed information on landform, vegetation and soil was recorded. The attributes were recorded on a standard coded record form based on those used by Van Vreeswyk et al. (2004). The geographical location of sites was captured via GPS. During the fieldwork 112 inventory sites were sampled; their locations are shown in Figure 7. The inventory sites were photographed to show the general vegetation and features of the site. Some site photos are included in this report.

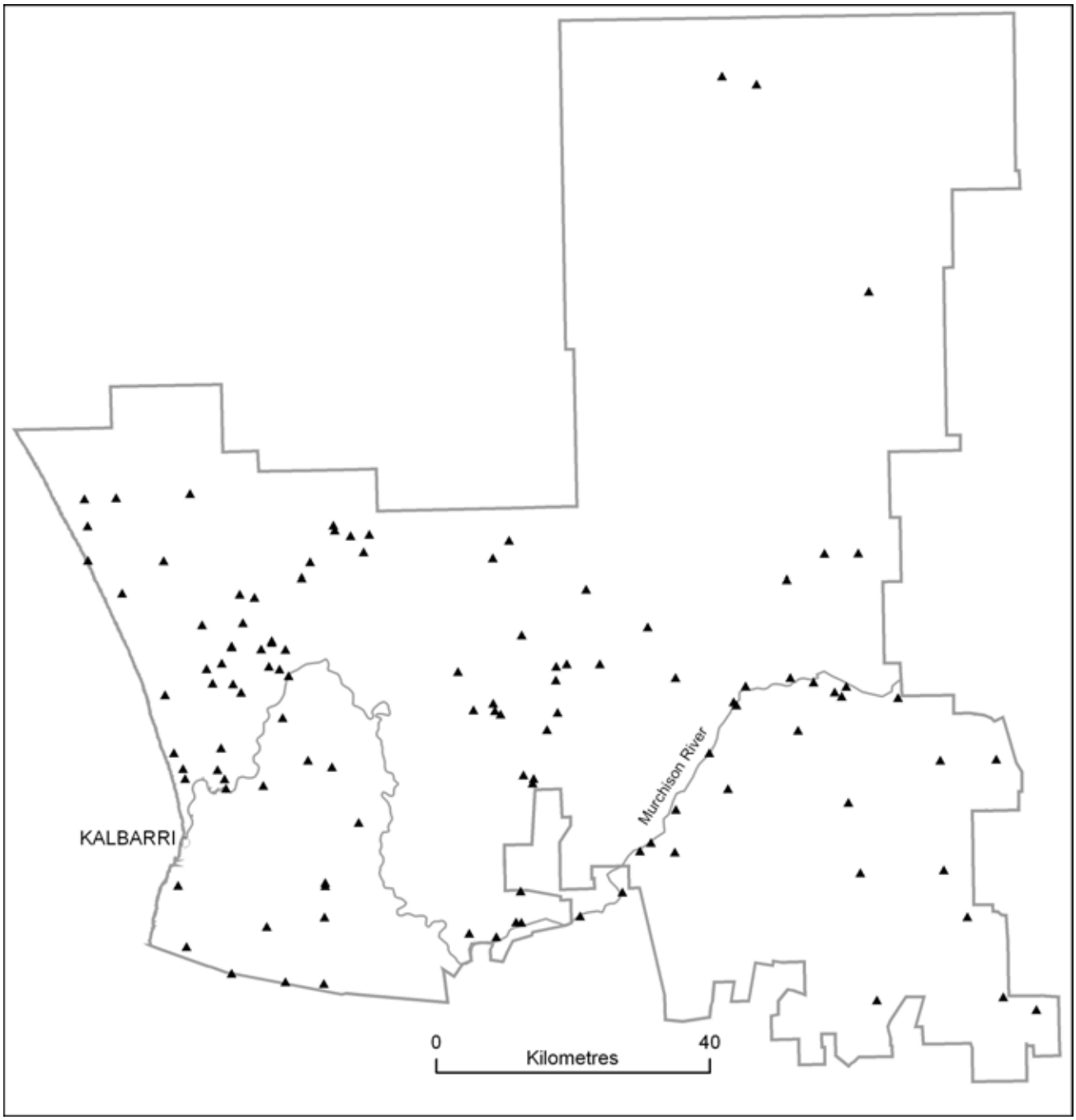


Figure 7 The distribution of inventory sites in the survey area

Projected foliar cover (PFC) is mentioned frequently in the vegetation chapter. PFC is the proportion of the ground surface covered (or shadowed) by living plants (expressed as a percentage). PFC information was collated during previous rangeland surveys and research to develop a set of photo guides to enable rapid PFC assessment in the field. An example of the guides is shown in Figure 8. Isolated PFC is less than 2.5 per cent; very scattered is 2.5–10 per cent; scattered is 10–20 per cent; moderately close is 20–30 per cent; close is 30–50 per cent and closed is greater than 50 per cent.

The types of data collected during this survey (see Table 5) were almost identical to the types collected in two previous surveys (Payne et al. 1998, Van Vreeswyk et al. 2004).

Traverse assessment summaries were derived from database attribute sorts. Land system areas and condition statements for individual pastoral leases in the survey are published in the appendices (Appendix 1).

Inventory site data provided information to derive detailed descriptions of land systems, land units, soil and vegetation. These descriptions are presented in the main chapters of this report.

The land system boundaries were reinterpreted on the original aerial photographs with expertise gained during fieldwork. The aerial photos were scanned and the land system boundaries digitised. Verification plots of the digitised boundaries were produced at 1:50 000 scale for checking against the original land system boundaries on the aerial photos. Topographical and cultural features were updated and land system boundaries were overlain on this background.

Mapped resource information is presented as a 1:250 000 scale land system map accompanying this report. Not all of the data collected during the fieldwork of this survey is presented in this report or on the accompanying map. More detailed information is available on request from the Department of Agriculture and Food.

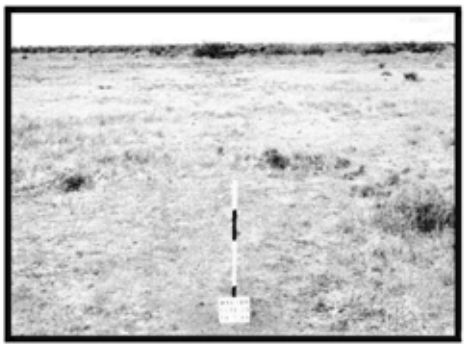
In addition to the 1:250 000 map, Landgate has produced station plans at a scale of 1:100 000 for each of the pastoral leases within the survey area. These are available to leaseholders as full colour maps.

Reports will be made available at low or high resolution digital format on the Department of Agriculture and Food, WA website. Hard copy prints will be available on request.

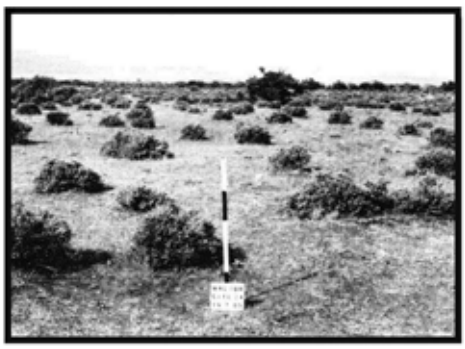
Table 5 **Attributes recorded at inventory sites**

General	**Physical environment**
Site number	Slope (percentage)
Land system	Land unit relief
Land unit	Geology (from Geological Series map)
1:250 000 map sheet name	Site geology (if different to mapped geology)
Land use—pastoral/conservation/unallocated land	Surface mantle abundance, shape, size and type
Aerial photograph year, run and number	Outcrop abundance and type
Date of sampling	Vegetation condition rating (Table 1)
Compass bearing of site photograph	Accelerated erosion type/intensity (Table 3)
	Surface crusting type and extent
Vegetation	**Soil**
Vegetation type	Total soil depth
Dominant species in each stratum	Substrate
Relative dominance in each stratum	Soil surface condition
Basal cover class for perennial grasses	Soil reaction trend (pH)
Height class of tree and tall shrub stratum	Horizon depth, texture and colour (Munsell 1954)
List of perennial plant species	Horizon fabric, structure and ped shape
List of annual plant species (where applicable)	Coarse fragment abundance, size and shape
Projected foliar cover (PFC) class of perennial plant strata (for examples see Figure 8)	Australian Soil Classification class (Isbell 1996)

Projected foliar cover for low shrublands



Projected foliar cover of about 1%

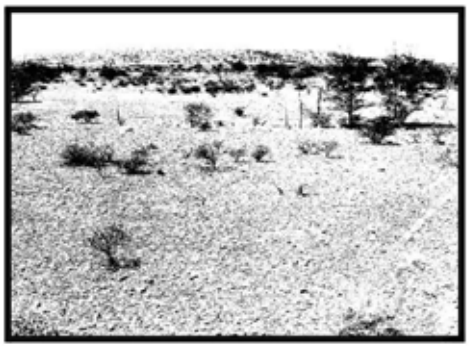


Projected foliar cover of about 6%

Projected foliar cover of about 13%

Projected foliar cover of about 21%

Projected foliar cover for mid and tall shrublands



Projected foliar cover of about 3%

Projected foliar cover of about 9%

Projected foliar cover of about 14%

Projected foliar cover of about 20%

Figure 8 Examples of different projected foliar cover (PFC) assessment for low shrublands and mid/tall shrublands

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Soils

The soils of this area were broadly described and mapped at a scale of 1:2 000 000 by Northcote et al. (1967) as part of *The Atlas of Australian Soils*, providing a general overview of soil distribution. Curry et al. (1994) and Payne et al. (1987, 1998) conducted intensive regional resource inventories of landforms, soils and vegetation to the areas north and east of the lower Murchison River. The area to the south was described by Rogers (1996), primarily mapping soil-landscapes of freehold farming areas. This section reports on the main soil types found within the land systems of the lower Murchison area.

Soil distribution

The general distribution of the main soil types of the survey area is shown in Figure 9.

The westernmost part of the survey area commences at the edge of the land mass where it meets the Indian Ocean. From there the survey extends eastwards for about 140 km (in parts). In moving from west to east the major soil types occur (in general) as north-west to south-east bands, running roughly parallel to the coastline. The Murchison River, in the south of the survey area, runs from east to west, influencing the distribution of some other major soil types.

Approximately three-quarters of the total area surveyed consists of sandy surfaced soils in the form of sandy plains. The remainder, mostly associated with the Murchison River, or to the south-east of the survey area, has varied soil types.

The coastal sands south of the Murchison River mouth are mostly deep grey to white calcareous sands grading to mixed yellow to brown sands inland from the coast. The Zuytdorp Cliffs dominate the coast north of the river and the soils are mostly shallow grey to white coastal calcareous sands. Away from the coast these sands grade into yellow/brown sands overlying limestone at variable depths. Further inland are deep yellow sands. The general area to the north of Murchison River has deep yellow sands, while the south-western area adjoining the farming zones is a mixture of variable depth yellow, brown and white sands. The white sands often overlie ferruginous gravel.

In the central and south-central part of the survey area, minor red deep sands mingle with yellow deep sands, with more red sands in the far east and north.

The upper reaches of the Murchison River have deep red duplex and clayey soils as part of extensive floodplains. As the river progresses westward the river floodplains become more restricted to red loams of variable depth, mostly overlying red-brown hardpan. Passing through the Ajana area (dominated by Proterozoic granulite and gneiss) the river traverses stony soils, red shallow sands and some red loams, while further toward the coast, the Kalbarri gorges consist of stony soils, with red shallow sands and shallow loams based on sandstone. The Murchison River mouth has deep loam alluvial soils on the small lower depositional floodplains.

Adjoining the Kalbarri gorge system in the north-west are plateaux, mesas and hills of red shallow loams with brown loamy earths in the lower margins of the landscape. Small drainage systems either side of the Murchison River support brown shallow loams over sandstone with yellow/brown sand outer margins.

A small area of red sandy earths and red loamy earths occurs in the centre (with sporadic occurrences to the south-east) of the survey area. The remainder of the south-east supports mixed sands and loams of variable depths, before grading to deep red sands further east.

Field sampling methods

Soil profiles were described at 112 representative positions in the landscape. The soils were described using the criteria of the *Australian Soil and Land Survey Field Handbook* (McDonald et al. 1990). Soil profile description involved exposure of the uppermost soil layers to the main subsoil layers where possible. Deeper sampling was conducted using a hand operated soil auger to a depth of 1 metre or to the impermeable layer of underlying rock or hardpan. Soil surface crusting as described by Tongway (1994) was assessed at each sampling site. Soil colour was determined using Munsell Colour charts (Munsell 1954) and soil reaction through the soil paste/colourmetric system of Raupach and Tucker (1959). The electrical conductivity (EC) of soil horizons was determined in the field using a portable EC meter and a one part soil to five parts water suspension.

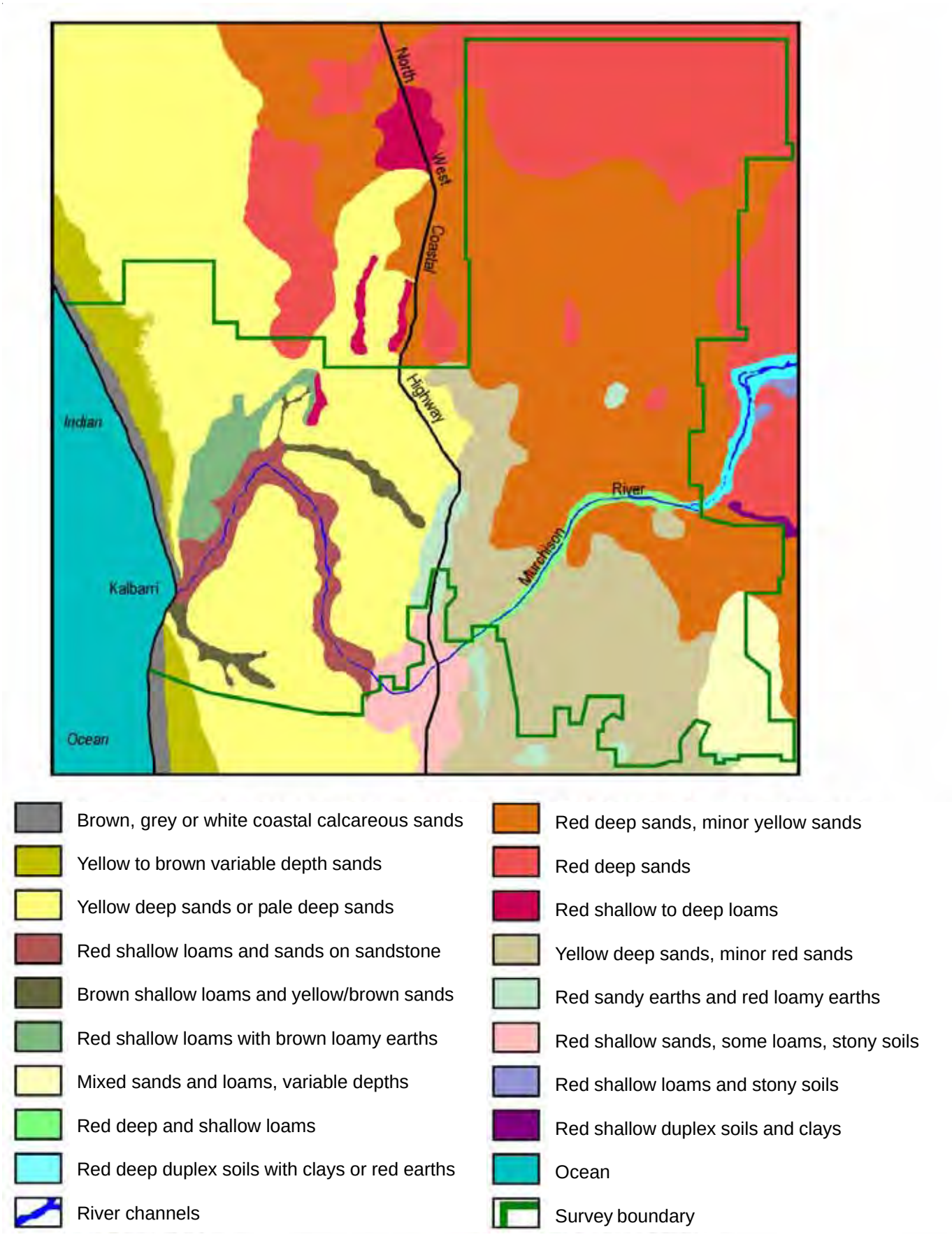


Figure 9 The distribution of the main soil types in the lower Murchison area and surrounds

The following guides were used to describe soil salinity:

- non-saline soils with a topsoil EC of <40 mS/m and a subsoil EC <120 mS/m
- moderately saline soils with a topsoil EC of 40–80 mS/m and a subsoil EC >120 mS/m
- saline soils with a topsoil EC of >80 mS/m and a subsoil EC of >120 mS/m
- where mS/m equals milliSiemens per metre (1 mS/m equates to approximately 5.5 parts per million).

The soils were classified using the Australian Soil Classification (Isbell 1996).

Soil descriptions are presented for 25 soil groups. The soil group names are derived from the terminology of Schoknecht (2002). The soil group concept seeks to summarise and standardise the naming of soils across Western Australia. The soil group names with parentheses indicate local soil variants. Not every soil type described in this report was sampled during field validation. Some descriptions are derived from neighbouring rangeland inventory survey reports and the author's experience.

Soil group 203—Stony soil

Stony soils occur on hill crests, slopes, stony plains and areas of outcropping rock. These soils are mostly shallow (less than 50 cm) or very shallow (less than 25 cm) and contain abundant (more than 50 per cent) coarse fragments of parent material. Soil textures are mostly sandy or loamy and the physical and chemical attributes of the soil are dependent on the parent rock. Stony soils are generally non-calcareous and occur within areas dominated by granite, sandstone, laterite and, less commonly, radiolarite. Stony soils are prominent within the Boulder, Ajana and Tumblagooda land systems and a minor component of the Mongolia land system. Generally stony soils are red to dark red in colour (2.5YR 3/6, 2.5YR 4/6) and have an acidic to neutral (pH 6.0 to 7.5) soil reaction trend. Soil crusting is not common as most of the soil surface has outcropping rock or a dense stony mantle. These soils are not prone to any erosion risk and may support a variety of vegetation types within the Acacia stony shrubland vegetation group.

Stony soils are classified as Petroferric, Lithic or Paralithic Leptic Rudosols within the Australian Soil Classification.

Soil group 304—Shallow gravel (Shallow gravelly yellow sand)

Shallow gravelly yellow sands have textures of fine to medium sand or loamy sand overlying ironstone gravels at a depth of about 50 cm. The medium size (2 to 6 mm) ironstone gravels are few (2 to 10 per cent) in the topsoil and increase in quantity with depth to become abundant (more than 50 per cent) in the subsoil. Gravel size increases to coarse (6 to 20 mm) in the lower soil profile. Below the subsoil gravel concentrations form a dense layer and most likely overlie ferruginous, cemented ironstone duricrust. The soil surfaces have infrequent to common (10 to 50 per cent) cryptogam crusts or infrequent (2 to 10 per cent) surface gravel. Soil colours are dark brown (7.5YR 4/4) to strong brown (7.5YR 4/6) or yellowish red (5YR 5/6, 5YR 5/8). Soil reaction is acidic (pH 5.5 to 6.0) and the soils are non-saline. This soil type occurs on the lateritic plain land unit of the Eurardy land system and the gravelly sand sheet unit of the Highway and Joseph land systems.

These soils mainly support *Acacia sandplain shrubland/woodland* vegetation type (ASSW). Within the Joseph land system the vegetation may be closer to the *Sandplain close mixed shrubland* (SCMS) described in Payne et al. (1998). These soils are generally not prone to erosion.

Shallow gravelly (yellow) sands are classified as Petroferric Leptic Rudosols within the Australian Soil Classification.

Soil group 404—Grey shallow sandy duplex

Grey shallow sandy duplex soils have a thin (5 cm) layer of coarse loamy sand overlying a thin to medium (5 to 20 cm) layer of lighter coloured coarse loamy sand, underlain by a thin to medium layer of light clay. The soil has a radiolarian siltstone substrate. The two uppermost layers of the topsoil are coloured greyish brown (10YR 5/2) and very dark greyish brown (10YR 4/2) and the subsoil is coloured brown or dark brown (10YR 4/3). There are few (2 to 10 per cent) medium to coarse (2 to 20 mm) ironstone gravels in the

profile. The soil surface is mostly hardsetting with abundant (more than 50 per cent) cryptogam crusting but parts of the surface have loose white coarse sand. This soil type is not common and occurs infrequently on the gravelly sandplain land unit of the Kalbarri land system supporting heath vegetation. These soils are non-saline and prone to wind erosion after major vegetation depletion or after fire. Pale (grey) shallow sands (soil group 422) occur in conjunction with grey shallow sandy duplex soils.

Grey shallow sandy duplex soils are classified as Brown Chromosols within the Australian Soil Classification.

Soil group 405—Red deep sandy duplex

Red deep sandy duplex soils mostly have thin (10 to 20 cm) topsoils of loamy sand to sandy loam and overlie deep subsoils of light clay. Subsoil textures may vary from sandy clay loam to medium clay and generally show increases of clay content with depth. The soils are mostly more than 1 m deep with moderately deep soils (50 to 80 cm) often overlying red-brown hardpan. Soil colour is dark reddish brown to dark red (2.5YR 3/4, 2.5YR 3/6) in the topsoil and dark red to red (2.5YR 5/6) in the lower subsoil. Soil reaction is dependent on the location of the soil within the landscape. Soils occurring on some saline alluvial plains and some alluvial plains or floodplains have alkaline soil reaction (pH 7.5 to 9.0) and other soils on alluvial plains have neutral soil reaction (pH 6.5 to 7.5). Red deep sandy duplex soils have very few (less than 2 per cent) medium (2 to 6 mm) coarse fragments of quartz in the topsoil and may have frequent calcareous segregations in the lowest subsoil. Saline alluvial plains and some parts of floodplains and alluvial plains have deep saline subsoils. Soil surfaces are hard-setting and have common cryptogam crusts. These occur on the alluvial plains of the Bayou and Roderick land systems and on the flood-plains and saline alluvial plains of the Bayou land system.

Red deep sandy duplex soils are classified as Red Chromosols, Red Sodosols and Red Dermosols within the Australian Soil Classification system.

Soil group 406—Red shallow sandy duplex

Red shallow sandy duplex soils have thin (less than 10 cm) topsoil textures of sandy loam overlying subsoils of light clay. The soils are underlain by sandstone or red-brown hardpan at about 50 cm. Soil colour is dark reddish brown to dark red (2.5YR 3/4, 2.5YR 3/6) and the soils are partially saline or saline through-out. Soil reaction is neutral (pH 6.5 to 7.5) and the soil profile contains very few to few (less than 10 per cent) coarse fragments. Surface mantles of sandstone or quartz are common on gently sloping plains. These soils occur on saline plains of the Boulder, Holmwood and Mongolia land systems and support *Frankenia shrublands* (FRAN) or *Mixed chenopod shrublands* (MXCS). These soils also occur on shallow alluvial plains underlain by red-brown hardpan in the Bayou and Roderick land systems. The red shallow sandy duplex soils are classified as Red Chromosols and Red Sodosols within the Australian Soil Classification.

Red shallow sandy duplex soils overlying sandstone occur within the narrow drainage floors of the most northern occurrence of the Bungabandi land system. The shallow to medium (20 to 50 cm) soil profile consists of loamy sand. The consistence of the topsoil is weak while the consistence of the subsoil is very firm to strong. Soil colour is dark yellowish brown to dark brown (10YR 4/4, 10YR 3/4) and soil reaction is neutral (pH 6.5 to 7.0). Although the subsoil texture is loamy sand, it is compact with a very firm consistence. Such traits commonly occur in clay subsoils and as such, this soil is grouped within the red shallow sandy duplex soil group.

This soil supports *Frankenia shrubland* (FRAN) vegetation and is classified as a Red Kandosol within the Australian Soil Classification.

Soil group 421—Calcareous shallow sand

Calcareous shallow sands are a minor component, mainly occurring on the narrow coastal margin in the north-west of the survey area. These soils are generally very shallow (less than 25 cm) or shallow (25 to 50 cm) and occur as thin layers of wind deposited sand derived from coastal limestone. Soil textures of fine to medium sand contain no clay element.

The soil surfaces are mostly soft and have a high wind erosion risk. Soil colour is light grey (10YR 7/1) to white (10YR 8/1) and soil reaction is alkaline (pH 9.0). The soils are non-saline and occur on seaward slopes and cliffs within the Zuytdorp land system. On adjacent inland units these soils grade to calcareous deep sands (soil group 442).

Calcareous shallow sands are classified as Leptic Lithic Rudosols within the Australian Soil Classification.

Soil group 422—Pale shallow sand

Pale shallow sands include white, grey or pale yellow colours. Pale (grey) shallow sands have textures of sand overlying radiolarian sandstone or gravel. Soil colour in the topsoil is greyish brown (10YR 5/2) to dark yellowish brown (10YR 4/3) in the lower profile. Soil reaction is acidic (pH 6.0) and the soils are not saline. The soil profile contains few (2 to 10 per cent) medium to coarse (2 to 20 mm) fragments of ironstone gravels or radiolarian sandstone. Soil depth may occasionally be moderately deep (50 to 70 cm) with some gravel on the surface or throughout the profile. Soil surfaces are soft with infrequent cryptogam crusting. These soils are found on the gravelly plains unit of the Kalbarri land system. Pale grey shallow sands support heath associations and grade into deeper pale deep sands (soil group 444) or gravelly pale deep sands (soil group 443) within the adjoining fringing sandplain units and to a lesser extent occur adjacent to minor grey/brown shallow sandy duplex soils (soil group 400).

Pale (grey) shallow sands are classified as Petroferric or Paralithic Leptic Rudosols within the Australian Soil Classification.

Pale (white) shallow sands also occur as a minor component within the Kalbarri land system as sand sheets overlying gravel. Soil textures are sand throughout, soil reaction is acidic (pH 6.0) and non-saline. Soil colour ranges from light brownish grey (10YR 6/2) to brown (10YR 5/3). The soil surfaces are soft with infrequent cryptogam crusting. These soils contain ironstone gravels below the surface layer. The gravels increase in size and abundance to the point of almost pure gravel within 50 cm of the surface. Soil depth is variable but mostly shallow (less than 50 cm).

Pale (white) shallow sands support *Tree heath* (TRHE) vegetation and are classified as Petroferric Leptic Rudosols within the Australian Soil Classification.

Soil group 423—Red shallow sand

Red shallow sands have topsoil textures of coarse clayey to loamy sand or may grade to textures of coarse sandy loam. Soil depth is variable from isolated pockets of soil amongst rock outcrop to about 40 cm deep underlain by gneiss or granite. The soils contain common to many (10 to 50 per cent), medium to large (2 to 60 mm) coarse fragments based on parent material, and soil surfaces tend to have infrequent to abundant (10 to more than 50 per cent) surface crusting. In very shallow situations the soil surfaces may be soft. Soil reaction is weakly acidic to neutral (pH 6.0 to 6.5) and soil colour is dark reddish brown to dark red (2.5YR 3/4, 2.5YR 3/6). Red shallow sands are non-saline and occur within the stony plains, low rises and some narrow drainage tracts of the Ajana land system, supporting *Stony acacia shrublands* (STAS). These soils are not prone to erosion.

Within the plateaux and hillslope land units of the Tumblagooda land system the red sands are very shallow to shallow (less than 30 cm). These soils are underlain by sandstone and often exist as shallow pockets. The sandstone mantle is infrequent to common (10 to 25 per cent), rock outcrop is abundant (50 to 90 per cent) and cryptogam crusting is infrequent (10 per cent). The soils are coarse loamy sands to fine loamy sands and coloured dark brown or dark reddish brown (7.5YR 3/4, 2.5YR 3/4). Soil reaction is weakly acidic (pH 6.0) and the soils are non-saline. Common (10 to 20 per cent), medium to extra large (2 to more than 60 mm) angular, coarse fragments of sandstone occur throughout the soil. These land units are not prone to erosion and support *Scrub heath* (SCHE) or *Acacia hill shrublands* (ACHS).

Red shallow sands are classified as Paralithic Leptic Rudosols within the Australian Soil Classification.

Soil group 424—Yellow/brown shallow sand

Yellow/brown shallow sands over limestone are shallow (less than 50 cm) with loose surfaces and textures of fine sand throughout the profile. Soil colours range from brown (10YR 5/3) within the topsoil, to dark yellowish brown (10YR 4/6) in the subsoil. Soil depth is variable (30 to 50 cm) and dependent on the depth of the undulating limestone substrate. The limestone is sub-rounded and infrequently (10 per cent) outcropping. Soil reaction is weakly acidic to neutral (pH 6.0 to 7.0). These soils are non-saline and support heath vegetation. The wind erosion risk is low except after fire when the risk may be moderate or high. Yellow/brown shallow sands occur adjacent to the coast on infrequent low rises within the Zuytdorp land system. Soils with similar properties were described by Rogers (1996) as Teakle-1, a shallow variant of the Teakle soil series.

Yellow/brown shallow sands are classified as Lithic Leptic Rudosols or Arenic Orthic Rudosols within the Australian Soil Classification.

Yellow/brown shallow sands overlying sandstone have thin (less than 5 cm) topsoils of loamy sand overlying shallow (25 cm) subsoils of loamy sand. Soil depth may vary from 20 to 50 cm. Topsoil colour ranges from strong brown (7.5YR 5/6) to dark brown (10YR 4/3) and subsoils are strong brown (7.5YR 4/6). Soil reaction is weakly acidic (pH 6.0) and the soils are non-saline. The soil contains abundant (more than 50 per cent), coarse to large (6 to 60 mm) fragments of sandstone in the subsoil. Soil surfaces are either soft or loose, with or without infrequent (2 to 10 per cent) mantles of ironstone gravel. These soils may have a moderate to high wind erosion risk immediately after fire, but are otherwise stable. This soil type occurs on the shallow sandplains of the Bungabandi land system and supports heath vegetation. These shallow sands grade to yellow deep sands (soil group 446) on the adjoining Nanga land system and gravelly pale deep sands (443) or pale deep sands (444) where it meets the Kalbarri land system.

Yellow/brown shallow sands are classified as Paralithic Leptic Rudosols within the Australian Soil Classification.

Soil group 441—Brown deep sand

Brown deep sands occur as a minor component of the sand sheet land unit of the Tumblagooda land system. They have thin (5 cm) topsoils with textures of medium grained sand overlying thick subsoils of medium grained loamy sand. Total soil depth is more than 1 m and the soil colours range from dark brown (7.5YR 4/3) to strong brown (7.5YR 5/6). The profile contains few (less than 10 per cent), sub-angular, medium (2 to 6 mm) coarse fragments of quartz and soil reaction is weakly acidic (pH 6.0). These soils are non-saline and support *Acacia sandplain shrubland/woodlands* (ASSW) and some heath vegetation. These brown deep sands share some properties of

Yellow/brown shallow soils with heath vegetation of the Zuytdorp land system grade into yellow deep sands further inland from the coast.

the Indarra soil series identified by Rogers (1996) and share an association with yellow deep sands (soil group 446). Wind erosion risk is moderate to high immediately after fire, but otherwise low.

Brown deep sands are classified as either Arenic Rudosols or Arenic Brown-Orthic Tenosols within the Australian Soil Classification.

Soil group 442—Calcareous (brown) deep sand

Calcareous brown deep sands have thin (5 to 10 cm) topsoils of fine to medium sand or loamy sand overlying thick (more than 30 cm) subsoils of fine or loamy sand. Soil colour is brown to dark brown (7.5YR 4/3, 7.5YR 3/4), often grading to grey or white. Limestone substrates are often below 1 m, but soil depth can be variable. Soil reaction is alkaline (pH 9.5) and the soil profile contains very few (less than 2 per cent), medium (2 to 6 mm) coarse fragments of limestone or occasionally shell. Soil surfaces are loose or soft with infrequent (less than 10 per cent) cryptogam cover and the soils are non-saline. These soils occur within sand sheets adjacent to the coast, infrequent limestone plains and seaward slopes of the Zuytdorp land system and support heath or melaleuca woodland associations. The wind erosion risk for these soils is moderate to high after vegetation depletion or immediately after fire, but otherwise the risk is low. Further inland from the coast these soils grade into brown deep sands (soil group 441). Calcareous brown deep sands share some properties of the Quindalup soil series described by Rogers (1996). At the coast, the Quindalup sands are light grey (10YR 7/1) to white (10YR 8/1), and intergrade with calcareous shallow sands (soil group 421).

Calcareous deep sands and calcareous brown deep sands are classified as Shelly or Arenic Rudosols within the Australian Soil Classification.

Soil group 443—Gravelly pale deep sand

Gravelly pale deep sands have thin (10 cm) topsoils of very coarse sand overlying subsoils of coarse sand. Few (2 to 10 per cent), medium to coarse (2 to 20 mm) sub-rounded ironstone gravels occur in the upper subsoil, increasing in abundance (10 to 50 per cent) and size (6 to 20 mm) in the lower topsoil. Within the subsoils, ironstone gravels are abundant and occupy up to 70 per cent of the soil mass. Soil surfaces of loose coarse sand co-exist with firm surfaces supporting infrequent to common (10 to 50 per cent) cryptogam crusts. Soil colour ranges from light grey (10YR 7/1) at the surface to yellowish brown (10YR 5/4) in the subsoil. Soil reaction is weakly acidic (pH 6.0 to 6.5) and the soils are non-saline. These soils occur within the gravelly plains land unit of the Kalbarri land system and may grade into pale shallow sands (soil group 422) or pale deep sands (soil group 444). The main vegetation association is *Tree heath* and *Scrub heath* (TRHE, SCHE). Low rises of the Kalbarri land system may also support gravelly pale deep sands. The topsoils of this soil group may be prone to wind erosion after fire.

Gravelly pale deep sands are classified as Ferric Clastic Rudosols or Sesqui-Nodular or Ferric Grey-Orthic Tenosols within the Australian Soil Classification.

Soil group 444—Pale deep sand

Pale deep sands have thin (5 to 10 cm) topsoils of medium to coarse sand overlying thick (more than 30 cm) subsoils of medium to coarse sand. Soil colour ranges from light brownish grey (10YR 6/2) at the surface to very pale brown (10YR 7/4) in the subsoil. Deep subsoils may grade to white. Moderate depth grey sands are included within this group. Soil reaction is weakly acidic (pH 6.0), soil surfaces are loose to soft with infrequent (less than 10 per cent) soil crusting, and the profiles contain no coarse fragments. These soils occur primarily within the sand sheet land unit of the Kalbarri land system and support heath vegetation with occasional tall shrubs. This soil was identified by Rogers (1996) as the Balline soil series.

Some sand sheets within the Kalbarri land system contain pale deep sands primarily, with brown to yellow hues; others have white surfaces. These soils have thick (30 cm) topsoils of sand and are yellowish brown to brown or dark brown (10YR 5/4, 10YR 5/3, 7.5YR 4/2). Deep, loamy sand subsoils are yellowish brown (10YR 5/8) or range to pinkish grey (7.5YR 7/2). Soil reaction is weakly acidic to neutral (pH 6.0 to 7.0), the surface is loose to firm with infrequent (10 per cent) cryptogam

crusting and only the topsoil contains few (less than 10 per cent) coarse fragments of quartz. These soils are non-saline, support *Scrub heath* (SCHE) vegetation and have a moderate to high wind erosion risk after fire.

Pale deep sands also occur as a minor component of the sandplain land unit of the Zuytdorp land system supporting *Scrub heath* vegetation and as a minor sandplain component of the Nanga land system supporting *Scrub heath* (SCHE) and *Tree heath* (TRHE). Colours are yellowish brown (10YR 5/4 to 5/6).

Intergrades of pale shallow sands (soil group 422), gravelly pale deep sands (443) and yellow deep sands (446) occur with the pale deep sands mainly in the southern parts of the Kalbarri National Park or further south.

Pale deep sands are classified as Arenic Rudosols or Grey-Orthic Tenosols within the Australian Soil Classification.

Soil group 445—Red deep sand

Red deep sands have thin to medium (10 to 30 cm) topsoils with textures of clayey to loamy sand graduating to thick (more than 30 cm) subsoils with textures of loamy sand to sandy loam. These soils are acidic (pH 5.5 to 6.5) and colour is dark reddish brown to red (2.5YR 3/4, 2.5YR 3/6 to 2.5YR 4/8). The profiles are mostly free of coarse fragments and have soft to firm surfaces supporting infrequent (less than 10 per cent) if any, surface crusting. Red deep sands occur as flat to gently undulating sandplains, are non-saline and are major components of the Cooloomia, Eurardy, Joseph, Kalli, Nanga, Nerren and Sandplain land systems. These soils support heath, *Mallee acacia sandplain* (MASA), *Acacia sandplain shrublands/woodlands* (ASSW) and *Sandplain wanderrie grassy shrubland* (SWGS) vegetation types. They may be prone to wind erosion after fire, but are otherwise stable. Within some areas of red sandplain these soils may intergrade with some red sandy earths (soil group 463). Both soil groups often share similar topsoils, yet the red sandy earths become significantly more clayey with depth. Within the Nanga and Eurardy land systems, red deep sand intergrades with yellow deep sand (soil group 446) and is yellowish red, with most other soil properties remaining very similar.

Red deep sands making up sand dunes within the Nanga land system have slightly lighter textures than the sandplain equivalents. Soil textures of the topsoil are mostly medium to fine sand overlying subsoils of clayey sand. Soil colour remains dark reddish brown to red (2.5YR 3/4 to 2.5YR 3/6) and the soil reaction is marginally more acidic (pH 5.5 to 6.0) than the accompanying sandplain soils. These soils have soft surfaces, are free of coarse fragments and are non-saline. Red deep sands occurring as sand dunes have a high wind erosion risk immediately after fire, otherwise the risk is low to moderate.

Red deep sands occurring on both the sandplains and dunes are classified as Arenic Rudosols or Arenic Red-Orthic Tenosols within the Australian Soil Classification.

Soil group 446—Yellow deep sand

Yellow deep sands mostly have very thin (less than 5 cm) loose to firm surface layers of fine to coarse sand. Below the surface horizons are thin to medium (5 to 15 cm) layers of fine sand to loamy sand overlying subsoils of clayey to loamy sand. Soil colours are most commonly dark yellowish brown (10YR 4/6) to brownish yellow (10YR 6/6) or yellowish brown (10YR 5/6). These soils are acidic (pH 5.5 to 6.5), non-saline and free of coarse fragments. Some sands are moderately deep (less than 80 cm) and overlie limestone. Yellow deep sands are common to the sandplain land units of the Eurardy, Nanga, Kalbarri and Zuytdorp land systems. These soils are less common on the Nerren land system and occur on fringing sand sheet units of the Highway land system. Yellow deep sands share properties of the Teakle soil series described by Rogers (1996).

Dunes of yellow deep sand occur within the Nanga land system. The dunes have fine sand overlying fine loamy sands. Soil surfaces are loose and soil reaction is weakly acidic (pH 6.0). Soil colour is mostly brownish yellow (10YR 6/6). Within the Eurardy, Nanga and Nerren land systems the sandplains supporting yellow deep sands intergrade with yellowish red deep sands. Other soil properties of the yellowish red deep sands are very similar to the yellow deep sands except the colours tend to be of lower hue (strong brown rather than brownish yellow).

The Kalbarri land system occupies a large portion of the south-western zone of the lower Murchison survey. This land system is dominated by yellow deep sand, but white, brown or grey sands are found in the extreme south.

Yellow deep sands are classified as Arenic Rudosols or Arenic Yellow-Orthic Tenosols within the Australian Soil Classification.

Soil group 463—Red sandy earth

Red sandy earths have thin to medium depth (less than 10 to 30 cm) topsoils of loamy sand to sandy loam. Some soils have a thin (less than 5 cm) layer of sand or coarse sand overlying the main topsoil horizon. Sub-surface soil horizons display an increase in clay content with depth. The subsoil textures range from heavy sandy loams to sandy clay loams or sometimes clay loams. Soil colour is principally dark reddish brown or dark red (2.5YR 3/4, 2.5YR 4/4, 2.5YR 3/6). Soil reaction is varied. Where the vegetation has dominant York gums (*Eucalyptus loxophleba*) the acidic to neutral (pH 5.5 to 6.5) topsoils overlie neutral to alkaline (pH 7.0 to 9.0) subsoils suggesting deep calcrete substrates. On areas supporting acacia shrublands, soil reaction is mostly acidic to neutral (pH 5.5 to 7.0). Soil surfaces vary from soft to firm with firm versions supporting infrequent to common (10 to 50 per cent) cryptogam crusting.

Yellow deep sands occupy much of the central survey area.

Red sandy earths occur within the loamy plains of the Highway, Ajana, Sandplain and York land systems. Red sandy earths are non-saline, usually well vegetated and have a low erosion risk, except perhaps immediately after fire.

These soils are classified as Red Kandosols within the Australian Soil Classification.

Soil group 520—Shallow (brown) loam

Shallow brown loams are very shallow to shallow (less than 30 cm) and have soil textures of sandy loam overlying sandstone. The acidic (pH 5.5) non-saline soil contains many to abundant (20 to more than 50 per cent) sub-rounded, coarse to large (6 to 60 mm) coarse fragments of sandstone. Soil colour is dark brown (7.5YR 4/4) and cryptogam crusting is infrequent (less than 10 per cent). This soil supports *Scrub heath* (SCHE) and occurs on the stony plains of the Bungabandi land system. It may also occur with yellow/brown shallow sands (soil group 424). With a common (10 to 20 per cent) mantle of sandstone, this soil type has a low wind erosion risk.

Brown shallow loams are classified as Lithic Leptic Rudosols or Arenic Orthic Rudosols within the Australian Soil Classification.

Soil group 522—Red shallow loam

Red shallow loams exist as three distinct forms: single layered loams, stony red shallow loams and rocky shallow loams with abundant calcrete mantles.

Single layered red shallow loams

Single layered red shallow loams have textures of sandy loam and are very shallow to shallow (less than 10 to 40 cm). Within the lower footslope unit of the Pillawarra land system the soil texture of light loam is underlain by calcrete. These lower footslopes have an infrequent to common (10 to 50 per cent) mantle of calcrete with infrequent (less than 10 per cent) calcrete rock outcrop. Soil surfaces are firm with infrequent (less than 10 per cent) cryptogam crusting. Soil reaction is alkaline (pH 8.5) and soil colour is dark brown (7.5YR 3/2). These soils support *Mixed chenopod shrublands* (MXCS) and have a moderate to high water erosion risk following perennial vegetation loss.

Soils of the stony plains of the Stork land system have textures of loam overlying siltstone at variable but mostly shallow depth (10 to 35 cm). The soil surfaces are hardsetting with infrequent to common (10 to 50 per cent) cryptogam crusting. These stony plains have an infrequent to common (10 to 50 per cent) mantle of angular siltstone or radiolarite and infrequent (less than 10 per cent) rock outcrop. Soil reaction is weakly acidic (pH 6.0) and soil colour is dark brown (7.5YR 3/3). These soils support *Eucalypt saltbush open woodland* (ESOW) and have a low erosion risk due to the stone mantles.

Some stony plains of the Yandi land system also have variable but mostly shallow (5 to 30 cm) loam soils. These soils are underlain by deeply weathered gneiss and have an abundant (more than 50 per cent) stony mantle. Soil surfaces are firm with infrequent (less than 10 per cent) cryptogam crusting. Soil reaction is neutral (pH 7.5) and colour is dark reddish brown (2.5YR 3/4). The soil profile contains many (20 to 50 per cent) coarse to large (6 to 60 mm) fragments of sandstone or silcrete. These soils are non-saline and support the Acacia stony shrubland group.

Single layered red shallow loams are classified as Leptic Lithic Rudosols, Leptic Paralithic Rudosols or Red Kandosols within the Australian Soil Classification.

Stony red shallow loams

Stony red shallow loams have thin (less than 10 cm) topsoils with textures of sandy loam to loam and overlie subsoils of sandy clay loam to clay loam. Soil depth varies from 30 to 60 cm and the subsoils overlie weathered or ferruginous sandstone with infrequent (less than 10 per cent) rock outcrop. Soil reaction is weakly acidic to neutral (pH 6.0 to 7.5) and the soils are non-saline. Colours range from reddish brown (5YR 4/4) to red (2.5YR 4/6) in the topsoil to dark reddish brown (2.5YR 3/6) or dark yellowish brown (10YR 4/4) in the subsoil. These soils contain variable (2 to more than 50 per cent) amounts of sub-angular sandstone coarse fragments. Soil surfaces are firm to hardsetting with infrequent to common (less than 10 to 50 per cent) cryptogam crusting and common (25 to 50 per cent) stony mantles of sandstone. These soils occur within the stony plains of the Yandi land system and support *Ironstone acacia shrublands* (ISAS). They are mostly protected from erosion by a stony mantle and have a low water erosion risk.

Stony red shallow loams are classified as Red Kandosols within the Australian Soil Classification.

Rocky red shallow loams with abundant calcrete mantles

These soils are characterised by boulders of calcrete with minor rock outcrop and mostly have thin to medium (10 to 20 cm) horizons of loam. Some pockets of soil may be up to 50 cm deep. The soil surface mostly has a common to abundant (20 to 90 per cent) surface mantle and infrequent (less than 10 per cent) outcropping. The mantle of extra large boulders and rocks (60 to 200 mm) may cover up to 70 per cent of the land unit surface. Soil reaction is alkaline (pH 7.5 to 8.0) and soil surfaces are firm with infrequent to common (10 to 50 per cent) cryptogam crusting. Soil colour is dark reddish brown (2.5YR 3/4, 5YR 3/4). On the hillcrests, plateaux and stony plains of the Pillawarra system soil colour is often a mixture of dark reddish brown and very dark brown (10YR 2/2) and the soils support *Acacia calcrete stony shrubland* (ACSS).

Rocky red shallow loams also occur within the low rise and stony plain land units of the Bibra land system and support *Calcrete melaleuca acacia shrubland* (CMAS) and *Closed melaleuca shrubland* (CMES).

Rocky red shallow loams with abundant mantles are non-saline, not prone to erosion and are classified as Leptic Lithic Rudosols or Red Kandosols within the Australian Soil Classification.

Soil group 523—Red-brown hardpan shallow loam

Red-brown hardpan shallow loams have medium depth (15 to 25 cm) topsoils with textures of loam to light sandy clay loam overlying subsoils of sandy clay loam or less commonly clay loam. The soil is underlain by red-brown hardpan, an impenetrable layer of silicified colluvium and is commonly up to several metres thick. Soil surfaces are hard-setting with abundant (more than 50 per cent) cryptogam crusts and soil reaction is neutral (6.5 to 7.5). Soil colour is dark reddish brown (2.5YR 3/4) to dark red (2.5YR 3/6).

These soils are non-saline and occur within the hardpan plain or alluvial plain land unit of the Yandi land system and support *Hardpan acacia shrubland* (HPAS) or *Riverine shrubland* (RIVS). Both Teakle (1936) and Bettenay et al. (1974) have described the red-brown hardpan found in much of the Wiluna/Murchison area. The lower Murchison is its most western extent. Rogers (1996) described this soil type and named it the Mindage soil series.

Red-brown hardpan shallow loams are subject to sheet erosion and have a moderate to high erosion risk after major depletion of perennial plants. Within some small areas of the alluvial plain unit of the Yandi land system, the absence of some lighter textured topsoil suggests prior (historic) sheet erosion. This is supported in part by the current lack of species diversity and density. It is likely some of these soils may have been red sandy shallow duplex

Rocky red shallow loams with abundant calcrete occur within the Pillawarra and Bibra land systems.

A hardpan plain with red-brown hardpan shallow loam soils in poor condition. This site has been subject to sheet erosion from overland water flow, resulting in active soil redistribution. This landscape would benefit from livestock/vermin exclusion to encourage regeneration of perennial plants.

types (soil group 406) supporting some saltbush/bluebush prior to European settlement, but with successional topsoil redistribution, are now identified as red-brown hardpan shallow loams.

All red-brown hardpan shallow loams are classified as Duric Red Kandosols within the Australian Soil Classification.

Soil group 541—Brown loamy earth

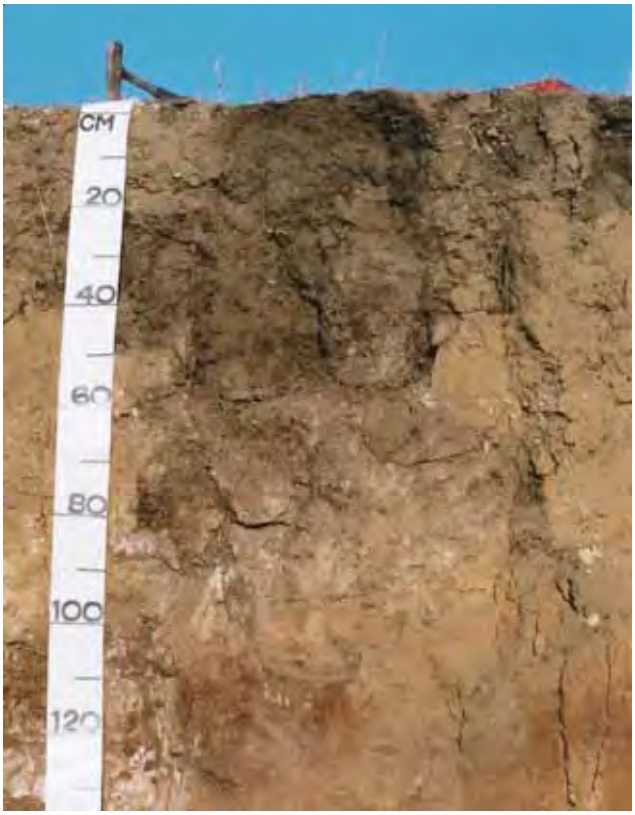
Brown loamy earths are deep soils with thin (5 cm) topsoils of loam overlying thick subsoils of light clay. The topsoil horizon is soft, partially non-wetting and coloured black to dark brown (7.5YR 2/0 to 7.5YR 3/2). The uppermost subsoil is moderately structured and the whole subsoil is dark brown (7.5YR 3/3). The upper topsoil may contain much organic matter as highly incorporated amounts of decomposing vegetation. Soil reaction is weakly acidic to neutral (pH 6.0 to 7.5) and these soils are non-saline. They are found on the narrow floodplains adjacent to the lower main channels of the Murchison River within the Tumblagooda land system. Some soils have been cleared for cropping and have a high water and wind erosion risk after topsoil disturbance. Where the perennial vegetation cover is high the erosion risk is low to moderate. Inundation and flood risk are high.

These soils are classified as Brown Kandosols within the Australian Soil Classification.

Soil group 542—Calcareous (brown) loamy earth

Calcareous brown loamy earths are deep soils with thin to medium (5 to 15 cm) topsoils of clay loam or silty clay loam overlying subsoils of light clay or silty light clay. Few to common (2 to 20 per cent) calcareous soft segregations occur in the lower subsoil and topsoils may contain very few (less than 2 per cent) sub-rounded calcareous coarse fragments. Topsoil colour is black to very dark grey or dark brown (10YR 2/1, 10YR 3/1, 7.5YR 3/2) with subsoils coloured black to yellowish brown or dark brown (10YR 2/1, 10YR 5/4, 7.5YR 3/2). Soil reaction is alkaline (pH 9.0). The soil profiles are mostly non-saline.

Calcareous brown loamy earths occur on the alluvial plains, drainage tracts and lower footslopes of the Pillawarra land system. Within these land units the soil surface is partially self-mulching and partially hardsetting. Where the surface is hardsetting, cryptogam crusting is common (10 to 50 per cent). Partial self-mulching surfaces, some soil scalding, infrequent but large gullies and the absence of some lighter textured topsoil indicate prior (historic) sheet erosion and is supported in part by the current poor diversity of the *Mixed chenopod shrublands* (MXCS). Due to the lack of perennial vegetative cover these areas are highly susceptible to water erosion and without the re-establishment of perennial native vegetation, soil erosion will continue.



Calcareous brown loamy earths are rare in the southern rangelands of Western Australia. These soils have good moisture-holding capacity and offer a sound base for regeneration in conjunction with total grazing control.

Calcareous brown loamy earths are classified as Brown or Red Kandosols or Calcic Calcarosols within the Australian Soil Classification.

Soil group 544—Red loamy earth

This group has four distinctive soil types. They are: red loamy earths on granite, red loamy earths, alluvial red loamy earths and red loamy earths with calcareous subsoils.

Red loamy earths on granite

Red loamy earths on granite are moderate (50 to 80 cm) depth soils with thin to medium (10 to 15 cm) surface layers of coarse sandy loam overlying coarse sandy clay loams and decomposing granite or gneiss. Soil colour is dark reddish brown to dark red (2.5YR 3/4, 2.5YR 3/6). Soil reaction is weakly acidic or neutral (pH 6.0 to 7.5) and the soil profile contains few to common (2 to 10 per cent) medium (2 to 6 mm), sub-angular fragments of granite or gneiss. Soil surfaces are hardsetting with common (10 to 50 per cent) cryptogam crusts and soil profiles are non-saline. These soils occur within the loamy (or occasional alluvial) plains of the Ajana land system and support *Eucalypt acacia woodlands* (EUAW) or occasional *Riverine shrublands* (RIVS). The erosion risk is low to moderate providing optimal vegetative cover is maintained. Significant depletion of perennial vegetation implies a moderate to high erosion risk.

These soils are classified as Red Kandosols within the Australian Soil Classification.

Red loamy earths

Red loamy earths are deep soils with thin (less than 10 cm) or thick (more than 30 cm) topsoils of loam overlying subsoils of slightly heavier textured loam. Soil colour is dark reddish brown (2.5YR 3/4) to dark red (2.5YR 3/6). Soil reaction is acidic to neutral (pH 5.5 to 6.5) and the soil profile contains very few (if any) coarse fragments. Soil surfaces are partially hard-setting with common (25 to 50 per cent) cryptogam crusting but may also have patches of thin (less than 2 cm) sand cover. These soils occur within the loamy plains and drainage zones of the Bibra land system and support the Melaleuca shrubland group. Within the York land system, red loamy earths occur on loamy plains and support the Eucalypt acacia woodland group. The red loamy earths are non-saline and have a low erosion risk.

Red loamy earths are classified as Red Kandosols within the Australian Soil Classification.

Alluvial red loamy earths

Alluvial red loamy earths are deep soils with mostly thin (less than 15 cm) topsoils of sandy loam to loam overlying subsoils of loam to sandy clay loam. Some of these soils may overlie red-brown hardpan. Soil surfaces are firm to hardsetting with common (10 to 50 per cent) cryptogam crusts. Soil colour is dark reddish brown (2.5YR 3/4, 5YR 3/4) to dark red (2.5YR 3/6). These soils occur on alluvial plains of the Yandi land system. Some soils close to the Murchison River have a very thin cover of loose sand, a result of irregular flood deposition. Soil reaction is mostly weakly acidic to neutral (pH 6.0 to 7.5) and there are very few to few (less than 10 per cent), if any, coarse fragments throughout the profile. These soils are non-saline and support *Riverine shrubland* (RIVS) vegetation.

Alluvial red loamy earths are classified as Red Kandosols within the Australian Soil Classification.

Red loamy earths with calcareous subsoils

Red loamy earths with calcareous subsoils are deep soils with thin (less than 10 cm) surface textures of sandy or loam overlying subsoils of clay loam to light clay. Soil colour ranges from dark red and dark reddish brown or reddish brown topsoils (2.5YR 3/6, 2.5YR 3/3, 5YR 3/4) to dark red and yellowish red or dark brown subsoils (2.5YR 3/6, 5YR 5/8, 7.5YR 4/4). Soil reaction is weakly acidic (pH 6.0) at the surface to alkaline in the subsoil (pH 9.0). The subsoils have common to abundant (10 to more than 50 per cent) calcareous soft segregations increasing in size and abundance with depth. The topsoils are non-saline and the subsoils are mostly saline in the lowest depths. Soil surfaces may vary from soft to hardsetting with common (30 per cent) cryptogam crusts.

These soils occur within the alluvial plains of the Bibra land system supporting *Eucalypt acacia woodlands* (EUAW) and the loamy or alluvial plains of the York land system with *Eucalypt saltbush open woodlands* (ESOW).

Red loamy earths with calcareous subsoils are stable, have a low erosion risk and are classified as Red Kandosols within the Australian Soil Classification.

Soil group 601—Hard cracking clay

Hard grey cracking clays are deep soils with surface textures of light or light–medium clay overlying subsoils of medium–heavy clay. Up to half of the soil surface exhibits large cracks several centimetres wide and up to 40 cm deep. The long cracks (up to 4 m in length) are irregularly dispersed with mounded gilgaied surfaces. Soil colour is dark greyish brown to brown or dark brown (10YR 5/2, 10YR 4/3), soil reaction is alkaline (pH 8.0 to 9.0) and the soil is non-saline. This soil type occurs on the drainage focus or swamp land unit within the Yandi land system and supports *Drainage melaleuca shrubland* (DRMS) vegetation. Although these areas are often preferred by grazing animals, the erosion risk is low. Inundation and flood risk are high. Within the drainage foci, hard cracking clays occur alongside grey non-cracking clays. The grey non-cracking clays have a slightly higher micro-relief and do not exhibit seasonal surface cracks, but share similar properties to the hard cracking clays below the topsoil.

Hard cracking clays are classified as Epipedal Grey Vertosols within the Australian Soil Classification. The grey non-cracking clays are classified as Grey Dermosols.

Soil group 622—Red/brown non-cracking clay

Red/brown non-cracking clays are infrequent in the survey area. They are mostly associated with the floodplain, alluvial plain, drainage focus and swamp land units of the Bayou, Roderick or Yandi land systems. These soils are deep (over 1 m) with clay loam topsoils overlying light to medium clay subsoils. Soil reaction is alkaline (pH 7 to 9), and the subsoils may be saline. Soil colour is mostly red or dark red (2.5YR 3/4, 2.5YR 3/6, 2.5YR 4/8). These soils are prone to water erosion after perennial plant loss, but are otherwise stable. They are at high risk of flooding and inundation.

Within a stony plain land unit of the Kalbarri land system is one area of clay most likely derived *in situ* from decomposing Windalia Radiolarite. This soil is brown or dark brown to dark yellowish brown (10YR 4/3 to 10YR 4/6). Soil reaction is acidic to neutral (pH 6.5 to 7.5) and the lower subsoil is saline. The well structured lower soil horizon of light–medium clay is overlain by a very thin (1 to 2 cm) layer

of loam. This soil displayed a minor amount of weak surface cracking with a common (10 to 20 per cent) mantle of ferruginised sandstone and radiolarite. This soil is not prone to erosion and supports an unusual mix of tall shrubs (mallee, tamma, myrtle and wattle) fitting unconformably to the outer limits of the neighbouring *Scrub heath* (SCHE) vegetation.

The red/brown non-cracking soils are classified as Red or Brown Dermosols within the Australian Soil Classification system.

Soil group 700—Miscellaneous soils

Dry riverbed soils are loose sands within the channels, and on levee banks of major rivers or creek tributaries. The sands comprise juvenile materials washed and worn through regular but infrequent river flows. Sand, stones and cobbles make up most of the soil components. Thin layers of silt may be deposited on levee banks. Soil reaction is mostly acidic to neutral (pH 6.5 to 7.5) and the soils are non-saline. Soil colour may vary from pinkish grey to pale brown (7.5YR 6/2, 10YR 6/3) in the river channels to red (2.5YR 3/6) on the levee banks. The riverbeds and some banks often display exposed red-brown hardpan, sandstone or granite. These soils occur within the major channels of the Tumblagooda and Yandi land systems and have a high water erosion, flooding and inundation risk. Dry riverbed soils support *Drainage channel woodlands* (DRCW) and marginal *Riverine shrublands* (RIVS).

These soils and are classified as Stratic Rudosols within the Australian Soil Classification.

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Vegetation

Vegetation overview

The west of this survey area is bordered by the Indian Ocean. Along almost the entire length of the coast are limestone cliffs up to about 200 m high. The vegetation on the seaward face of the cliffs comprises stunted plants able to withstand strong salt-laden sea breezes. North of the Murchison River, on the tops of the cliffs and retreating inland, the thin grey sandy soils support low heath and scrub heath dominated by mimosaceous (*Acacia* spp.) shrubs. Further inland the soils become deeper, are coloured yellow, and trend to red in the east. The yellow soils support myrtaceous scrub heath (*Calothamnus*, *Baeckea*, *Scholtzia*, *Melaleuca* spp.) with mimosaceous shrubs and proteaceous (e.g. *Banksia* sp.) mid shrubs. The red sands tend to support taller mimosaceous shrubs. Toward the Murchison River *Acacia* thickets become dominant and overlie red sands and loams over limestone. South of the Murchison River the coastal vegetation is low heath grading to scrub heath with mainly deep white sands. These sands become less frequent further inland and are replaced by deep yellow sands supporting scrub heath of various species from the Myrtaceae and Mimosaceae families with some proteaceous tree heath including *Banksia*, *Grevillea* and *Xylomelum* spp.

East of the southern sandplains the hilly Ajana area has shallow soils overlying rock. The dominant tall shrubs or small trees are *Acacia acuminata* (jam) with some *Grevillea* species and *Allocasuarina huegeliana* (rock sheoak) on the rocky hillslopes. Further east the landscape changes to sandplain or loamy plains and the vegetation is scrub heath or tree heath with *Actinostrobus arenarius* (sandplain cypress), *Xylomelum angustifolium* (sandplain woody pear), *Allocasuarina* spp. (tamma or black tamma) and various myrtaceous shrubs. There are patches of *Acacia* tall shrublands and mallees.

Near the Murchison River, the gorge systems are dominated by *Acacia* tall shrubs with *Jacksonia* sp. (rattlepod), *Allocasuarina* spp. and some eucalypts. The main river channel is lined with scattered *Eucalyptus camaldulensis* (red river gum), *Casuarina obesa* (sheoak), *Callistemon phoeniceus* (river bottlebrush) and some *Acacia* tall shrubs or small trees. The upper reaches of the Murchison River support *Acacia* scrub and are flanked on both sides by gently sloping sandplain supporting patchy *Acacia* scrub or heath, *Acacia* tall shrublands with patchy eucalypt woodlands and areas with *Callitris columellaris* (inland pine).

In the central north-east the almost flat plains are dominated by eucalypt woodlands with *Atriplex* spp. (saltbush) understoreys. The most north-eastern plains are dominated by *Acacia ramulosa* (wanyu) tall shrublands.

Vegetation types

Through the analysis of 825 traverse assessments and 112 inventory sites, the lower Murchison survey area is classified into 27 vegetation types which are further summarised into 11 broad vegetation groups. The vegetation types are characterised and described in terms of combinations of landforms, soils and plant communities. These features are prominent in summarising the groups into broader vegetation groups (see Table 6).

A vegetation type is defined as being ‘major’ within a land system if it occurs on 30 per cent or more of the system, as ‘common’ where it occurs on 20 to 29 per cent of the system, and as ‘minor’ where it occurs on less than 20 per cent of the system. In previous rangeland surveys these vegetation types have been called pasture groups, pasture types, vegetation types, habitat types and site types. The term vegetation type is considered the most appropriate in this instance. The 11 vegetation groups are broader groupings to aggregate ecologically similar vegetation types. Beard (1976) initially classified the vegetation of this area into eight broad vegetation zones.

Terminology used to describe vegetation structure

The following definitions have been used to describe vegetation structure:

Tree—a plant over 2 m high with a single trunk to at least 1.3 m, including single trunk eucalypts

Mallee—a multi-stemmed eucalypt

Tall shrub—a plant over 2 m tall with more than one main branch below 1.3 m

Mid shrub—a shrub between 1 and 2 m in height

Low shrub—a shrub lower than 1 m in height

Perennial grass—a grass species usually persisting for at least two years

Annual—a short-lived plant usually persisting for less than two years, but more commonly one year.

Terminology used to describe Priority plant species

Priority or Declared Rare species are species of flora or fauna either occurring as restricted geographic populations or populations under threat. Populations under threat of extinction are protected through regulation and management by the Department of Environment and Conservation. Priority levels are a rating of the conservation status of the species. The rating system is summarised as:

Declared Rare Flora (DRF)—rare plant species or genera in danger of extinction or in need of special protection. While some DRF plant species are found in the survey area, none were recorded during this survey.

Priority One (P1)—little known plant species or genera with one or a few known populations under possible threat. One P1 plant species was identified during this survey.

Priority Two (P2)—little known plant species or genera with one or a few known populations, some of which are not under threat. One P2 plant species was identified during this survey.

Priority Three (P3)—known plant species populations or genera with several known populations, some of which are not under threat. Two P3 plant species were identified during this survey.

Priority Four (P4)—known plant species populations or genera, while still rare, are not currently threatened. No P4 plant species were identified during this survey.

Chamelaucium oenanthum*. This Priority 1 plant is endemic to certain parts of the botanically rich sandplains within the survey area. It is related to the Geraldton wax.*

Land use impacts

The primary impacts on the vegetation and lands of this area are from grazing animals, fire and human infrastructure.

Grazing impacts from livestock, feral and/or native herbivores are considered in recognition of their past and present influence on native plants. The present condition of some vegetation in the survey area strongly suggests grazing levels have been too high some time in the past. Of the land use impacts affecting the vegetation, grazing by animals has been the most influential in creating vegetation change or succession.

While fire also impacts on vegetation, its effects are somewhat short-lived as many of the native plants have adapted to survive or regenerate after fire (an adaptation of many Australian plants).

The third land use impact is from man-made infrastructure such as roads, fences and underground pipelines. In general, these impacts are not highly significant in causing long-term change over large areas, however localised effects may occur.

In determining vegetation change through livestock grazing the following terms describe plant species indicators:

Decreasers—plant species whose abundance decreases in response to increasing grazing pressure (species preferentially grazed by herbivores).

Increasers—plant species whose abundance increases in response to increasing grazing pressure (species not preferentially grazed by herbivores and also referred to as ‘undesirable’ or ‘woody weeds’).

Intermediates—plant species whose abundance may fluctuate to a certain level due to grazing pressure (these may be palatable and may eventually decline with increased grazing pressure). These species often recruit in niches vacated by decreasers.

No indicator value—plant species deemed ‘not primarily related to grazing history’ (these species are generally not very palatable and may also be termed ‘stability desirables’ in recognition of their role in maintaining soil stability and ecosystem function).

Differentiation between disturbances caused by grazing and ecological variation is based on the experience of the survey team members and their ability to recognise, interpret and explain signs of impact.

Vegetation groups and types

Table 6 **Vegetation groups and their component vegetation types**

(A)	**ACACIA STONY SHRUBLAND VEGETATION GROUP**	
1.	ISAS	Ironstone acacia shrubland (**page no. 49)**
2.	STAS	Stony acacia shrubland (**page no. 50)**
3.	ACHS	Acacia hill shrubland (**page no. 52)**
4.	ACSS	Acacia calcrete stony shrubland (**page no. 54)**
(B)	**ACACIA SANDPLAIN VEGETATION GROUP**	
5.	ASSW	Acacia (red or yellow) sandplain shrubland/woodland **(page no. 55)**
6.	SWGS	Sandplain wanderrie grassy shrubland **(page no. 59)**
(C)	**CYPRESS SANDPLAIN VEGETATION GROUP**	
7.	CYSS	Cypress sandplain shrubland (**page no. 61)**
(D)	**EUCALYPT/ACACIA SANDPLAIN VEGETATION GROUP**	
8.	MASA	Mallee acacia (red or yellow) sandplain **(page no. 62)**
(E)	**HEATH VEGETATION GROUP**	
9.	HEAT	Low heath **(page no. 65)**
10.	SCHE	Scrub heath **(page no. 67)**
11.	TRHE	Tree heath **(page no. 70)**
12.	COHE	Coastal heath **(page no. 72)**
(F)	**MELALEUCA WOODLAND/SHRUBLAND VEGETATION GROUP**	
13.	CMAS	Calcrete melaleuca acacia shrubland **(page no. 74)**
14.	CMES	Closed melaleuca shrubland **(page no. 75)**
15.	MELS	Melaleuca shrubland **(page no. 76)**
16.	MELW	Melaleuca woodland **(page no. 77)**
17.	MESS	Melaleuca swamp shrubland **(page no. 78)**
(G)	**EUCALYPT/ACACIA WOODLAND VEGETATION GROUP**	
18.	ESOW	Eucalypt saltbush open woodland **(page no. 79)**
19.	EUAW	Eucalypt acacia woodland **(page no. 80)**
(H)	**DRAINAGE WOODLAND/SHRUBLAND VEGETATION GROUP**	
20.	DRCW	Drainage channel woodland **(page no. 82)**
21.	DEOW	Drainage eucalypt open woodland **(page no. 84)**
22.	DRMS	Drainage melaleuca shrubland **(page no. 85)**
(I)	**HARDPAN SHRUBLAND VEGETATION GROUP**	
23.	HPAS	Hardpan acacia shrubland **(page no. 86)**
(J)	**RIVERINE MIXED SHRUBLAND VEGETATION GROUP**	
24.	PLAS	Alluvial plain shrubland **(page no. 88)**
25.	RIVS	Riverine shrubland **(page no. 88)**
26.	FRAN	Frankenia shrubland **(page no. 90)**
(K)	**MIXED CHENOPOD SHRUBLAND VEGETATION GROUP**	
27.	MXCS	Mixed chenopod shrubland **(page no. 92)**

A. ACACIA STONY SHRUBLAND VEGETATION GROUP

Acacia stony shrublands occur on plateaux, hills, low rises and stony plains with shallow sands or loams overlying weathered (often outcropping) rock. The main vegetation strata are tall shrublands with lesser mid shrubs or trees, and generally sparse understoreys of low shrubs with graminoids. (Graminoids appear grass-like but are not true grasses.) The dominant species are from the *Acacia*, *Allocasuarina* and *Hakea* genera.

This group has four vegetation types: *Ironstone acacia shrubland* (ISAS), *Stony acacia shrubland* (STAS), *Acacia hill shrubland* (ACHS) and *Acacia calcrete stony shrubland* (ACSS).

1. Ironstone acacia shrubland (ISAS)

General information

The *Ironstone acacia shrubland* vegetation type is described for the first time and occurs within the stony plains and occasionally on the alluvial plain land unit of the Yandi land system in the central south-east of the survey area.

The vegetation is dominantly mimosaceous tall to mid shrubs with some proteaceous species and some low shrubs.

The soils of the stony plains of the Yandi land system are shallow red loams (soil group 522) overlying ferruginised sandstone or granite and the soil surfaces carry moderate (25 to 30 per cent), mixed size (4 to 30 cm) stony mantles of ferruginised sandstone and some water-worn quartz pebbles. This vegetation is associated with the *Hardpan acacia shrubland (HPAS)* occurring within the Yandi land system and the *Stony acacia shrubland (STAS)* of the stony plains within the Ajana land system.

Structure and composition

The most dominant vegetation stratum is the scattered tall shrub layer with a projected foliar cover of 10 to 15 per cent. Mid shrubs and low shrubs are isolated to very scattered (projected foliar cover (PFC) of less than 2.5 to 10 per cent). There is no tree or perennial grass stratum. The tall and mid shrub layers are dominated by jam (*Acacia acuminata*) and wanyu (*Acacia ramulosa*) with some curara (*Acacia tetragonophylla*). The low shrub layer supports *Mirbelia* sp., warty leaf fuchsia (*Eremophila latrobei*), Wilcox bush (*Eremophila forrestii*) and some *Grevillea* species. Other common species include flannel bush (*Solanum lasiophyllum*) and cotton bush (*Ptilotus obovatus*). No annual plant species were recorded at the time of sampling.

The following species listed by stratum are dominant or common. Dominance is indicated by numbers ([1, 2, 3, 4] or [5]) with the lowest number being most prevalent. Shared numbers indicate co-dominance. Other species are listed in order of dominance:

Tall shrubs:	*Acacia acuminata* (jam)[1], *A. ramulosa* (wanyu)[1], *A. tetragonophylla* (curara), *Grevillea* sp., *Hakea preissii* (needle bush), *H. recurva* (djarnokmurd).
Mid shrubs:	*Acacia acuminata*[2], *A. tetragonophylla*, *Senna artemisioides* subsp. *artemisioides* (banana leaf).
Low shrubs:	*Mirbelia* sp., *Eremophila latrobei* (warty leaf fuchsia), *E. forrestii* (Wilcox bush), *Grevillea* sp., *G. deflexa* (red grevillea), *Solanum lasiophyllum* (flannel bush), *S. nummularium* (wild tomato), *Ptilotus obovatus* (cotton bush).

Condition summary and land management

Sampling: 2 inventory sites and 3 traverse assessments

There were insufficient traverse assessments to derive valid vegetation condition and soil erosion summaries. This vegetation type occurs on a land system with an apparent long livestock grazing history as attested by the generally poor vegetation condition. The number of species considered useful as feed for livestock was low and heavy grazing of these species was noted. In good condition this vegetation type should support plants such as tall saltbush (*Rhagodia eremaea*), ruby saltbush (*Enchylaena tomentosa*), small bluebushes (*Maireana* spp.) and greater numbers of cotton bush (*Ptilotus obovatus*). During winter seasons of adequate rainfall this vegetation type would provide an array of annual plant species. Evidence of unmanaged goats was noted.

Areas in poor to very poor condition should be excluded from grazing until such time as

Left: *The Ironstone acacia shrubland vegetation type—tall shrublands of curara (*Acacia tetragonophylla*) on the right, jam (*Acacia acuminata*) on the left and some cotton bush (*Ptilotus obovatus*) low shrubs in the left foreground. Spelling this vegetation group from grazing will greatly increase plant numbers and diversity.*
Right: *The stony nature of the soil surface assists reducing soil erosion. The stones not only provide surface mulch but also trap leaf litter, creating suitable plant germination niches.*

species diversity and plant numbers increase significantly. Slight (less than 10 per cent) sheet erosion was recorded on the alluvial plain land unit on one occasion. While one record is not statistically valid, it demonstrates the alluvial plains are at slight risk of erosion after significant vegetation depletion due to a lack of moderate stony mantles. The stony plains are far more resistant to erosion due to stony mantles.

ISAS was recorded on pastoral lease land and is not represented within any conservation reserves. No Priority plants were found in it.

2. Stony acacia shrubland (STAS)

General information

The *Stony acacia shrubland* vegetation type is described for the first time and occurs on stony plains and low rises (a major part) of the Ajana land system in the central south of the survey area. The vegetation is dominantly mimosaceous tall shrubs with other variable strata. The soils are red shallow sands (soil group 423) and stony soils (soil group 203). Soil surfaces have common to abundant (20 to 60 per cent) cryptogam crusting, few to common (2 to 20 per cent) stony mantles of quartz, granulite and gneiss with few (less than 10 per cent) granulite/gneiss outcrops. This vegetation is associated with the *Ironstone acacia shrubland* (ISAS) occurring within the Yandi land system.

Structure and composition

The most dominant vegetation stratum is the scattered to moderately close tall shrub layer (PFC 10 to 25 per cent). Mid shrubs make up about a quarter of the vegetative cover and low shrubs, trees and perennial grasses constitute the other strata. The tall and medium shrub strata are dominated by curara (*Acacia tetragonophylla*), jam (*A. acuminata*) and to a lesser extent tamma (*Allocasuarina campestris*). The low shrub stratum may have mixed dominants of cotton bush (*Ptilotus obovatus*), *Jacksonia* sp., or plants from the Myrtaceae botanical family (unidentified). The perennial grass layer is patchy and mostly dominated by pincushions (*Borya* sp.), a low graminoid (grass-like) plant. The isolated tree layer is mostly rock sheoak (*Allocasuarina huegeliana*). Other common species include hopbush (*Dodonaea inaequifolia*), horse mulla mulla (*Ptilotus schwartzii*) and djarnokmurd (*Hakea recurva*).

The following species listed by stratum are dominant or common. Dominance is indicated by numbers ([1, 2, 3, 4] or [5]) with the lowest number being most prevalent. Shared numbers indicate co-dominance. Other species are listed in order of dominance:

Trees:	*Allocasuarina huegeliana* (rock sheoak)[4].
Tall shrubs:	*Acacia tetragonophylla* (curara)[1], *A. acuminata* (jam)[1], *Hakea recurva* (djarnokmurd),

	H. orthorrhyncha (bird hakea), *Dodonaea inaequifolia* (hopbush), *Acacia ramulosa* (wanyu), *A. chartacea*, *A. rhodophloia*, *A.* sp., *Brachychiton* sp., *Grevillea costata* (P3).
Mid shrubs:	*Allocasuarina campestris* (tamma)[2], *Acacia tetragonophylla*, *Melaleuca fulgens* (scarlet honeymyrtle), *Dodonaea inaequifolia*, *Acacia chartacea*.
Low shrubs:	*Ptilotus obovatus* (cotton bush)[3], Myrtaceae family (unidentified)[3], *Jacksonia* sp.[3], *Dianella revoluta* (flax lily), *Acacia andrewsii* (prickly wattle), *Ptilotus schwartzii* (horse mulla mulla), *Daviesia* sp., *Solanum lasiophyllum* (flannel bush).
Perennial grasses:	*Borya* sp. (pincushions—graminoid)[5], *Ecdeiocolea monostachya* (wire stem grass—graminoid).

Condition summary and land management

Sampling: 3 inventory sites

Traverse condition summary (14 traverse assessments):

Vegetation—7% very good; 43% good; 36% fair; 14% poor

Soil erosion—nil

The *Stony acacia shrubland* vegetation type is not suited to continuous livestock grazing as plant species desirable to livestock are few and the biomass of these plants is insufficient for year-round livestock maintenance, growth and wellbeing. Of the 22 species recorded, only three or four have value as fodder for livestock. While this vegetation type was assessed as being in good or fair condition, some of the expected plant species attractive to livestock such as ruby saltbush (*Enchylaena tomentosa*), tall saltbush (*Rhagodia eremaea*) and small bluebush (*Maireana* spp.) were not recorded. Most of this vegetation has been grazed in the past but stock would rely on annual grasses and herbs after wet winter/spring seasons rather than shrubs. Drought reserves over long hot summers are absent.

Permanent or semi-permanent natural waters adjacent to this vegetation type may encourage populations of unmanaged goats during years of abundant water. Evidence of unmanaged feral goats was noted at one inventory site.

Due to the stony protective mantle, this vegetation type is not prone to any significant erosion risk.

This vegetation type is currently not represented in any conservation reserves and is located on Unallocated Crown Land. One Priority 3 plant species (*Grevillea costata*) was recorded.

*A fairly open tall and mid shrubland with scattered rock sheoak (*Allocasuarina huegeliana*) on a gently rounded stony slope in the Ajana land system. Rock sheoak has been identified as highly valued specialty timber for cabinet and furniture production and is suitable for commercial revegetation on non-saline farming lands (Agriculture Western Australia 2000).*

*The Stony acacia shrubland vegetation type has a dominant layer of mid shubs to 2 metres high consisting of curara (*Acacia tetragonophylla*) and jam (*Acacia acuminata*) with a prominent low shrub layer of cotton bush (*Ptilotus obovatus*). This ground layer commonly includes pincushions (*Borya *sp.) a small, prickly, low, grass-like plant often found growing on very shallow sand overlying granite.*

3. Acacia hill shrubland (ACHS)

General information

The *Acacia hill shrubland* vegetation type is described for the first time and occurs on upper hillslopes, rocky benched slopes and plateaux of the Tumblagooda land system in the central south to the central west of the survey area. Based on sandstone, the soils on the plateaux are red shallow sands (soil group 423) and stony soils (soil group 203) while the lower footslopes have occasional pockets of red shallow loams (soil group 522) amongst red shallow sands. Abundant rock outcrop and a common stony mantle contribute to about 70 to 80 per cent of the soil surface. The plateaux end in cliffs or precipices leading toward rocky lower footslopes and rocky benched hillslopes below. The hillslopes have abundant (50 to 90 per cent) surface mantles of stone and common (10 to 50 per cent) rock outcrop. In general, the main plants in ACHS are from the Mimosaceae, Myrtaceae and Proteaceae families. The dominance of these families varies depending on the land unit.

Structure and composition

The plateaux of the Tumblagooda system are 35 to 50 m high and support slightly different vegetation to the hillslopes. The plateaux are dominated by tall shrubs of jam (*Acacia acuminata*) with mid shrubs of various honeymyrtles (*Melaleuca* spp.) and low shrubs of starflower (*Calytrix* spp.). Eucalypt trees are infrequent. The vegetative cover is scattered (15 to 20 per cent PFC). The rocky benched slopes and lower footslopes below the plateaux have a greater dominance of low shrubs, principally starflower, with mid shrubs of curara (*Acacia tetragonophylla*) and no tall shrub or tree strata. Only two species of annuals occurred on the lower footslopes, an unidentified grass (*Poa* sp.) and mulla mulla (*Ptilotus* sp.).

The following species listed by stratum are dominant or common on the **plateaux** of the Tumblagooda land system supporting the *Acacia hill shrubland* vegetation. Dominance is indicated by numbers ([1, 2, 3, 4] or [5]) with the lowest number being most prevalent. Shared numbers indicate co-dominance. Other species are listed in order of dominance:

Trees:	Infrequent *Eucalyptus* sp.
Tall shrubs:	*Acacia acuminata* (jam)[1], *Grevillea* sp., occasional *Eucalyptus* sp.
Mid shrubs:	*Melaleuca oldfieldii*[2] (purple honeymyrtle P2), *M. cardiophylla* (teatree), *M. uncinata* (broom honeymyrtle), *Pileanthus* sp., *Grevillea* aff. *dielsiana*, *G.* sp., *Jacksonia cupulifera* (rattlepod), *Scholtzia umbellifera*.
Low shrubs:	*Calytrix* sp. (starflower)[3], *Acanthocarpus preissii*, *Mesomelaena* sp. (sandplain sedge), *Olearia* sp., *Conostylis prolifera* (graminoid).
Perennial grasses:	*Borya* sp. (pincushions—graminoid).

*The plateaux of the Tumblagooda land system support Acacia hill shrubland vegetation. The dominant tall shrubs are jam (*Acacia acuminata*) with mid shrubs of various honeymyrtles (*Melaleuca *spp.).*

The following species listed by stratum are dominant or common on the **hillslopes and rocky benched slopes** of the Tumblagooda land system supporting *Acacia hill shrubland* vegetation type. Dominance is indicated by numbers ([1, 2, 3, 4] or [5]) with the lowest number being most prevalent. Shared numbers indicate co-dominance. Other species are listed in order of dominance:

Mid shrubs: *Acacia tetragonophylla* (curara)[2], *Olearia* sp., *Grevillea* sp., *Hakea lissocarpha* (honey bush), Myrtaceae genus (unidentified), *Acacia acuminata* (jam).

Low shrubs: *Calytrix* sp. (starflower)[1], *Hibbertia* sp., *Mesomelaena* sp. (sedge), *Desmocladus flexuosus* (wire sedge).

Perennial grasses: *Ecdeiocolea monostachya* (wire stem grass—graminoid).

Annuals: *Ptilotus* sp. (mulla mulla), *Poa* sp.

*The hillslopes and rocky benched slopes below the plateaux of the Tumblagooda land system support Acacia hill shrublands. The low shrubs of starflower (*Calytrix *sp.) and mid shrubs of curara (*Acacia tetragonophylla*) are dominant with some wire stem grass (*Ecdeiocolea monostachya*) in patches. This site was noted for the heavy grazing by feral goats (note the stock pad going up the hillslope in the centre of the image).*

Condition summary and land management

Sampling: 2 inventory sites and 1 traverse assessment

There were insufficient traverse assessments to derive valid vegetation condition and soil erosion summaries, however the two inventory sites were in fair condition. This vegetation type does not support sufficient palatable plants for livestock grazing. There are a few plant species attractive to grazing animals, however these do not occur in sufficient numbers to sustain even moderate numbers of livestock. These species have been heavily grazed by feral goats. Stone outcrop and abundant stony mantles protect the soil from erosion.

As this vegetation type is unsuitable for livestock grazing, management should aim at total exclusion of livestock and feral animals through fencing and/or water denial.

This vegetation type is present on one pastoral lease and the Kalbarri National Park. One Priority 2 plant species (*Melaleuca oldfieldii*) was found.

4. Acacia calcrete stony shrubland (ACSS)

General information

The *Acacia calcrete stony shrubland* vegetation type occurs on the plateaux, mesas and stony plains of the Pillawarra land system in the central west of the survey area. These landforms are very rocky with large calcrete surface boulders and rocks. The soils are shallow red loams (soil group 522) overlying calcrete at variable (10 to 30 cm) depths. Included in this soil group some red/brown loams occur as infrequent small pockets of soil amongst the more red varieties. The sparse vegetation is mainly composed of *Acacia* and *Eremophila* spp. tall shrubs and plant diversity and frequency are low. This vegetation type grades into *Mixed chenopod shrubland* (MXCS) occurring on the upper and lower footslopes of the Pillawarra land system.

Structure and composition

Acacia calcrete stony shrublands are somewhat variable depending on location. Toward the precipice margins of the stony plateaux, the vegetation is mainly very scattered (2.5 to 5 per cent PFC) tall shrubs of curara (*Acacia tetragonophylla*) and berrigan (*Eremophila longifolia*) with some leather leaf wattle (*Acacia galeata*) to 6 m in height. Mid shrubs are few and low shrubs are virtually absent. Away from the margins of the plateaux, low and mid shrubs of shrubby riceflower (*Pimelea microcephala*) take prominence, with occasional berrigan trees, yet ground cover still remains very scattered. Tall shrubs tend to be absent. The stony plains associated with the plateaux support scattered (10 to 15 per cent PFC) tall, mid and low shrubs of curara and prickly wattle (*Acacia andrewsii*). Introduced annual grasses are common. *Acacia calcrete stony shrublands* appear to have been modified in plant species diversity by fire and herbivore grazing.

The following species listed by stratum are dominant or common on the Pillawarra plateaux and stony plain land units supporting *Acacia calcrete stony shrubland* vegetation. Dominance is indicated by numbers ([1, 2, 3, 4] or [5]) with the lowest number being most prevalent. Shared numbers indicate co-dominance. Other species are listed in order of dominance:

Trees:	Occasional *Acacia galeata* (leather leaf wattle), *Eremophila longifolia* (berrigan)[3], rare *Eucalyptus loxophleba*—mallee form (York gum).
Tall shrubs:	*Acacia tetragonophylla* (curara)[1], *Eremophila longifolia*[1], *Grevillea olivacea* (olive grevillea), *Alectryon oleifolius* (mingah bush).
Mid shrubs:	*Pimelea microcephala* (shrubby riceflower)[2], *Acacia andrewsii* (prickly wattle)[3], *Eremophila* aff. *oldfieldii* (pixie bush), *Exocarpos aphyllus* (naked lady), *Melaleuca cardiophylla* (teatree), *Dodonaea inaequifolia* (hopbush), *Capparis* sp., *Solanum nummularium* (wild tomato).
Low shrubs:	*Pimelea microcephala*[2], *Solanum nummularium*.
Perennial grasses:	*Austrostipa* sp. (speargrass).
Annuals:	*Avena barbata* (bearded oat)*, *Austrostipa* sp. (annual speargrass), *Carthamus lanatus* (saffron thistle)*, *Avena fatua* (wild oat)*, *Poa* sp. (annual grass).

* Introduced plant or weed.

The plateaux and associated stony plains of the Pillawarra land system are mostly covered by large calcrete boulders. Historic over-grazing by domestic and feral herbivores is indicated by dead timber, a lack of many shrubs and a browse line on the existing trees. In some areas, fire may also have affected plant species composition. Loss of vegetative cover and soil disturbance have encouraged weed establishment. These areas would benefit from no herbivore grazing pressure to assist in re-establishing native vegetation populations.

Condition summary and land management

Sampling: 3 inventory sites and 1 traverse assessment

ACSS was described from three inventory sites, where one site was in fair condition and two sites were in poor condition. Traverse assessments were insufficient to derive valid vegetation condition or soil erosion summaries, however evidence of past heavy grazing and fire suggests this vegetation type requires spelling from grazing. A general lack of native plants has most likely encouraged the establishment of weed species. Typically this vegetation should support an array of many different shrub species such as tall saltbush (*Rhagodia eremaea*), cotton bush (*Ptilotus obovatus*), ruby saltbush (*Enchylaena tomentosa*), limestone wattle (*Acacia sclerosperma*), warty leaf fuchsia (*Eremophila latrobei*), cottony saltbush (*Chenopodium gaudichaudianum*) with occasional small leaf bluebush (*Maireana brevifolia*) or tall sida (*Sida calyxhymenia*).

Fire, as evidenced by burnt tree stumps on the plateaux, may partially explain the vegetation decline. Continuous grazing of ACSS is not recommended until a significant increase in plant numbers and species diversity is achieved. At the time of survey, feral goats constituted the bulk of the grazing animals in this area. Following significant improvement in range condition, minimal rotational grazing may be a land management option. This vegetation type was recorded on pastoral lease land and is not represented in any conservation reserves. No Priority plants were found within the *Acacia calcrete stony shrublands*.

B. ACACIA SANDPLAIN VEGETATION GROUP

The Acacia sandplain vegetation group consists of two vegetation types. The *Acacia sandplain shrubland/woodland* (ASSW) type primarily dominates the eastern and central northern areas of the survey area. The *Sandplain wanderrie grassy shrubland* (SWGS) occurs mostly to the north and north-east and is an extension of the sandplains described in adjoining rangeland surveys.

5. Acacia sandplain shrubland/ woodland (ASSW)

General information

The *Acacia sandplain shrubland/woodland* has some similarities, but also significant differences, to the *Acacia sandplain* vegetation described in Payne et al. (1987) and the *Sandplain acacia shrubland* described in Curry et al. (1994) and Payne et al. (1998) in adjoining survey areas. As the lower Murchison area represents a transition from the Eremaean Botanical Province to the South-West Botanical Province (Beard 1976), there are significant differences in plant species compared to adjoining surveys. 'Eremaean' vegetation is essentially mimosaceous and dominated by mulga (*Acacia aneura*) or wanyu (*A. ramulosa*), while 'South-western' vegetation contains many myrtaceous shrubs (such as *Scholtzia*, *Baeckea*, *Callistemon*, *Calothamnus* spp.), black tamma (*Allocasuarina acutivalvis*) and southern wattle species like summer-scented wattle (*Acacia rostellifera*). The *Acacia sandplain shrubland/woodland* contains

transitional vegetation, mostly as tall shrublands and a tree layer that may vary from sub-dominance to almost absence. Soils are either red or yellow deep sands (soil groups 445 and 446) or red sandy earths (soil group 463) with different soils supporting different suites of vegetation while still sharing some species.

Structure and composition of the 'red soil' Acacia sandplain shrubland/woodland

The 'red soil' *Acacia sandplain shrubland/woodland* is mostly a moderately close to close tall shrubland with a PFC of 20 to 50 per cent. In the west on sandplains of the Nanga (and to a lesser extent Pillawarra) land systems the dominant tall shrub is summer-scented wattle (*Acacia rostellifera*) with some malallie (*Eucalyptus eudesmioides*) and relatively sparse lower shrubs. The lower strata consist of shrubby riceflower (*Pimelea microcephala*), inland daisy (*Olearia dampieri* subsp. *eremicola*), pebble bush (*Stylobasium spathulatum*), low saltbush (*Rhagodia drummondii*), tall saltbush (*Rhagodia eremaea*), climbing mulla mulla (*Ptilotus divaricatus*), and some feather speargrass (*Austrostipa elegantissima*). The soils are red deep sands (soil group 445).

In the lower central part of the survey area, the 'red soil' *Acacia sandplain shrubland/woodlands* are mainly tall shrublands of black tamma (*Allocasuarina acutivalvis*) with various wattles (*Acacia* spp.). These communities are quite dense (PFC of 30 to 50 per cent) and occur on sand sheets within the southern part of the Highway land system. The dense overstoreys preclude many lower shrubs with desert cassia (*Senna artemisioides* subsp. *coriacea*), Australian boxthorn (*Bursaria occidentalis*), grass leaf hakea (*Hakea multilineata*), flax lily (*Dianella revoluta*), low saltbush (*Rhagodia drummondii*) and very occasional wire stem grass (*Ecdeiocolea monostachya*) being the only understorey plants.

On parts of the upper loamy plains within the Ajana land system, the dominant tall shrub is jam (*Acacia acuminata*) with a mixed understorey of curara (*A. tetragonophylla*), firebush (*Keraudrenia* sp.), horse mulla mulla (*Ptilotus schwartzii*), low saltbush (*Rhagodia drummondii*), false paperbark (*Lamarchea hakeifolia*) and minor feather speargrass. Trees of malallie (*Eucalyptus eudesmioides*) and tall shrubs of desert kurrajong (*Brachychiton gregorii*), Australian boxthorn and inland pine (*Callitris columellaris*) occur sporadically. The soils are red sandy earths (soil group 463).

In the east and north of the survey area, the tall shrublands grade toward Eremaean vegetation. Here the sandplains and dunes of the Sandplain land system support wanyu (*Acacia ramulosa*) tall shrubs with sub-dominant understoreys of poverty bush (*Eremophila* sp.) and minor broad-leaf wanderrie grass (*Monachather paradoxus*). Other plants include *Hakea*, *Grevillea* and *Thryptomene* spp. with needle myall (*Acacia roycei*), horse mulla mulla

*'Red' Acacia sandplain shrubland/woodlands with mostly wanyu (*Acacia ramulosa*) tall shrublands and some inland pine (*Callitris columellaris*) trees in the background. The Australian boxthorn (*Bursaria occidentalis*) occupies the right foreground. This vegetation type is common on the Nerren land system.*

(*Ptilotus schwartzii*), tall saltbush (*Rhagodia eremaea*), wild tomato (*Solanum nummularium*), flax lily (*Dianella revoluta*), Australian boxthorn (*Bursaria occidentalis*) and green cassia (*Senna glutinosa* subsp. *chatelainiana*). The soils are red deep sands (soil group 445).

In the east of the survey the loamy plains of the Nerren land system support somewhat different tall shrublands still dominated by wanyu. Here, inland pine (*Callitris columellaris*) may share dominance in the tree stratum with eucalypts, with the lower stratum supporting typical Eremaean species such as curara (*Acacia tetragonophylla*), cotton bush (*Ptilotus obovatus*), wild tomato (*Solanum nummularium*), bitter quandong (*Santalum lanceolatum*), low saltbush (*Rhagodia drummondii*) and occasional flat leaf bluebush (*Maireana planifolia*). The soils are red sandy earths (soil group 463).

The following species listed by stratum are dominant or common within the 'red soil' *Acacia sandplain shrubland/woodland* vegetation type. Dominance is indicated by numbers ([1, 2, 3, 4] or [5]) with the lowest number being most prevalent. Shared numbers indicate co-dominance. Other species are listed in order of dominance:

Trees: *Eucalyptus eudesmioides* (malallie)[2], *Callitris columellaris* (inland pine)[3], *Bursaria occidentalis* (Australian boxthorn), *Santalum lanceolatum* (bitter quandong), *Brachychiton gregorii* (desert kurrajong).

Tall shrubs: *Acacia acuminata* (jam)[1], *A. rostellifera* (summer-scented wattle)[1], *A. ramulosa* (wanyu)[1], *A.* spp.[1], *Allocasuarina acutivalvis* (black tamma)[1], *Hakea multilineata* (grass leaf hakea), *Hakea* sp., *Acacia roycei* (needle myall), *Lamarchea hakeifolia* (false paperbark), *Acacia rhodophloia*.

Mid shrubs: *Acacia tetragonophylla* (curara)[2], *Pimelea microcephala* (shrubby riceflower)[2], *Eremophila* sp. (poverty bush)[2], *Senna artemisioides* subsp. *coriacea* (desert cassia), *Rhagodia drummondii* (low saltbush), *R. eremaea* (tall saltbush), *R. preissii*, *Stylobasium spathulatum* (pebble bush), *Jacksonia* sp., *Eremaea* sp., *Dodonaea inaequifolia* (hopbush), *Alyxia buxifolia* (dysentery bush), *Lamarchea hakeifolia* (false paperbark), *Thryptomene* sp., *Hakea recurva* (djarnokmurd), *Senna glutinosa* subsp. *chatelainiana* (green cassia).

Low shrubs: *Olearia dampieri* subsp. *eremicola* (inland daisy)[3], *Keraudrenia* sp. (firebush)[3], *Eremophila* sp.[3], *Ptilotus obovatus* (cotton bush)[4], *Solanum nummularium* (wild tomato)[4], *Dianella revoluta* (flax lily), *Mirbelia* sp., *Ptilotus divaricatus* (climbing mulla mulla), *P. schwartzii*

*'Red' Acacia sandplain shrubland/ woodlands in the west of the survey area with moderately open mature stands of summer-scented wattle (*Acacia rostellifera*) and numerous mid and low shrubs. This site has not been burnt or grazed. The bare areas will support many annual species after good winter rains.*

(horse mulla mulla), *Senna artemisioides* subsp. *coriacea*, *Eremophila latrobei* (warty leaf fuchsia), *Maireana planifolia* (flat leaf bluebush).

Perennial grasses: *Monachather paradoxus* (broad-leaf wanderrie)[4], *Ecdeiocolea monostachya* (wire stem grass—graminoid), *Austrostipa elegantissima* (feather speargrass).

Annuals: Infrequently *Ptilotus* sp. (annual mulla mulla), *Aristida contorta* (windgrass).

Others: Infrequently *Amyema preissii* (wireleaf mistletoe).

Structure and composition of the 'yellow soil' Acacia sandplain shrubland/ woodland

Within the *Acacia sandplain shrubland/ woodland* vegetation growing on deep yellow sands, the dominant tall shrub strata consists of black tamma (*Allocasuarina acutivalvis*), wodjil (*Acacia neurophylla*) or white plume grevillea (*Grevillea leucopteris*). The density of the vegetation on the yellow soils tends to be greater (close to closed with a PFC of 30 to over 50 per cent) than the vegetation of the red soils. The lower stratum trend toward genera of the South-West Botanical Province, being myrtaceous plants such as *Calothamnus*, *Chamelaucium*, *Thryptomene*, *Baeckea* and *Scholtzia* spp. The yellow soil ASSW also tends to support more trees than the red soil ASSW. Although sparse, tree species include Oldfield's mallee (*Eucalyptus oldfieldii*), Yuna mallee (*Eucalyptus jucunda*), Mann Range mallee (*Eucalyptus mannensis*) or sandplain cypress (*Actinostrobus arenarius*). The soils are yellow deep sands (soil group 446) and only exhibit surface crusting in open areas where the vegetation is patchy. This vegetation mainly occurs on sand sheets of the Eurardy and, to a lesser extent, the Nanga land systems.

The Highway land system has some small areas of shallow gravelly yellow sand (soil group 304). Within this land unit plant structure, composition and density remain similar to that of the other *Acacia sandplain shrubland/ woodlands* except the tree layer is absent.

In the very east of the survey area small areas of the Eurardy land system support yellow deep sands with ironstone gravels in the substrate. Here, the vegetation is scattered with a PFC of 10 to 15 per cent. The dominant stratum is the myrtaceous low shrub layer with prominent wire stem grass (*Ecdeiocolea monostachya*). The mid and tall shrub layers take less prominence.

On the sand dunes of the Eurardy land system PFC is over 50 per cent. Mid and low shrub strata share dominance and support many equally dominant *Acacia* and myrtaceous plants and proteaceous plants such as *Hakea*, *Grevillea* and *Petrophile* spp.

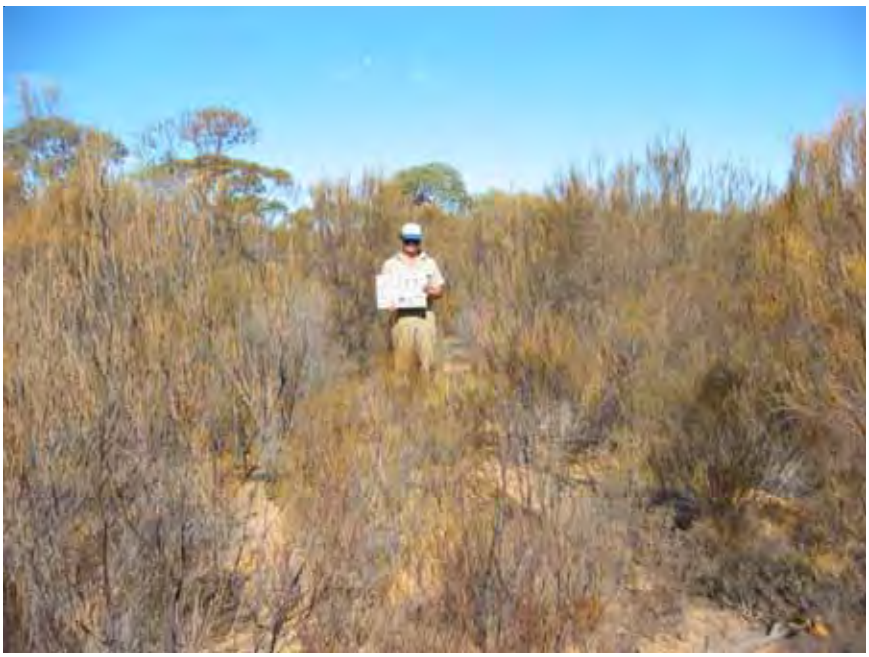
The following species listed by stratum are dominant or common within the 'yellow soil' *Acacia sandplain shrubland/woodland*. Dominance is indicated by numbers ([1, 2, 3, 4] or [5]) with the lowest number being most prevalent. Shared numbers indicate co-dominance. Other species are listed in order of dominance:

Trees: *Actinostrobus arenarius* (sandplain cypress)[4], *Eucalyptus jucunda* (Yuna mallee)[4], *Eucalyptus mannensis* (Mann Range mallee)[4], *Eucalyptus oldfieldii* (Oldfield's mallee)[4], *Acacia rhodophloia*.

Tall shrubs: *Allocasuarina acutivalvis* (black tamma)[1 or 2], *Acacia neurophylla* (wodjil)[1], *Acacia ramulosa* (wanyu)[1], *A.* sp.[1], *Grevillea leucopteris* (white plume grevillea)[3], *Melaleuca* sp., *Hakea multilineata* (grass leaf hakea), *Lamarchea hakeifolia* (false paperbark), *Hakea* sp., *Banksia prionotes* (acorn banksia), *Grevillea annulifera* (prickly plume grevillea—P3), *Grevillea* sp., *Melaleuca megacephala*, *Jacksonia* sp., *Allocasuarina campestris* (tamma).

Mid shrubs: *Allocasuarina acutivalvis*[1], *Calothamnus longissimus*, *C. blepharospermus*, *C.* sp., *Melaleuca cordata*, *M. megacephala*, *Anthotroche* sp., *Acacia chartacea*.

Low shrubs: Myrtaceae family (unidentified)[2 & 3], *Dianella revoluta* (flax lily), *Solanum lasiophyllum* (flannel bush), *Ptilotus schwartzii* (horse mulla mulla), *Petrophile semifurcata*, *Beaufortia squarrosa* (sand bottlebrush).



*'Yellow' Acacia sandplain shrubland/ woodlands with tall shrubs of tamma (*Allocasuarina acutivalvis*), wodjil (*Acacia neurophylla*) and some mallees (*Eucalyptus oldfieldii *or* E. jucunda*). Perennial grasses suitable for livestock grazing are uncommon within the yellow sandplains.*

Perennial grasses: *Ecdeiocolea monostachya* (wire stem grass—graminoid)[2], *Monachather paradoxus* (broad-leaf wanderrie)[5].

Condition summary and land management

Sampling: 18 inventory sites

Traverse condition summary (153 traverse assessments):

Vegetation—57% very good; 31% good; 11% fair; 1% poor

Soil erosion—nil

Acacia sandplain shrubland/woodland vegetation does not support a sufficient density or quantity of palatable plants to warrant year-round stocking. It may produce sufficient feed for short-term grazing during above normal winter seasons, but has no summer reserve for livestock. After wildfire it may provide useful ground feed in the form of young perennial plants for several years, but over time will revert to its original dense state. These sandplains often have little available water to support livestock.

ASSW is very stable and is not subject to any erosion hazards or major long-term species composition changes. Feral goats may frequent this vegetation during winter months or where there may be surface water (such as artificial water points for livestock), but they rarely remain in this vegetation for extended periods.

This vegetation type occurs on pastoral lease lands and is represented in conservation reserves. One Priority 3 species (*Grevillea annulifera*) was recorded.

6. Sandplain wanderrie grassy shrubland (SWGS)

General information

The *Sandplain wanderrie grassy shrubland* vegetation type was first described by Curry et al. (1994) in the Murchison River catchment. It occurs in the northern and north-eastern margins of the lower Murchison survey area. Plants are largely those of the Eremaean and South-West Botanical Provinces as described by Beard (1976). The soils are red deep sands (soil group 445). This vegetation occurs on the Sandplain land system and has similarities to the *Acacia sandplain shrubland/woodland (ASSW)* and *Mallee acacia sandplain (MASA)* vegetation types.

Structure and composition

This vegetation type consists of very scattered (PFC of 5 to 10 per cent) mid to tall shrubs with a prominent perennial grass stratum. The most dominant stratum is the mid shrub layer featuring Wilcox bush (*Eremophila forrestii*) and wild tomato (*Solanum nummularium*) with fire wattle (*Acacia murrayana*) and wanyu (*A. ramulosa*) representing the next most dominant (tall shrub) stratum. At the time of sampling, one site had been subjected to fire

some seven years prior. Throughout the mid and low shrub strata there were many co-dominant species, a function of fire. The perennial grass cover (0.5 to 1.0 per cent basal cover) of broad-leaf wanderrie (*Monachather paradoxus*) was less than that described by Curry et al. (1994), probably related to different rainfall regimes or fire and grazing histories.

Occasionally this vegetation is subject to fire when the medium and tall shrub strata are mature and dense. Post-fire this vegetation is open and supports perennial grasses and low to mid shrubs, with the mid and tall shrub strata assuming dominance over many years. Wind grass (*Aristida contorta*) was the only annual species recorded, however many annual herbs and forbs are known to occur during good winter seasons.

The following species listed by stratum are dominant or common. Dominance is indicated by numbers ([1, 2, 3, 4] or [5]) with the lowest number being most prevalent. Shared numbers indicate co-dominance. Other species are listed in order of dominance:

Trees: *Bursaria occidentalis* (Australian boxthorn), *Eucalyptus mannensis* (Mann Range mallee).

Tall shrubs: *Acacia ramulosa* (wanyu)[2], *A. murrayana* (fire wattle)[2], *Gyrostemon racemiger* (fire tree), *Acacia roycei* (needle myall).

Mid shrubs: *Eremophila forrestii* (Wilcox bush)[1], *Solanum nummularium* (wild tomato)[1], *Rhagodia eremaea* (tall saltbush), *Eremophila latrobei* (warty leaf fuchsia), *Grevillea* sp., *Eremophila* sp. (poverty bush), *Senna glutinosa* subsp. *chatelainiana* (green cassia), *Thryptomene* sp., *Eremophila maitlandii* (sandplain poverty bush).

Low shrubs: *Acacia murrayana* (fire wattle)[4], *Ptilotus obovatus* (cotton bush), *Spartothamnella* sp.

Perennial grasses: *Monachather paradoxus* (broad-leaf wanderrie)[3].

Annuals: *Aristida contorta* (wind grass).

Condition summary and land management

Sampling: 1 inventory site

Traverse assessment summary (13 traverse assessments):

Vegetation—46% very good; 46% good; 8% fair

Soil erosion—nil

SWGS was described from one inventory site, 13 traverse assessments and information from adjoining survey areas. It supports some plants that are attractive to livestock. Three-quarters of the traverse records indicated the presence of wanderrie grass (*Monachather paradoxus*) a palatable livestock feed while green.

*An open Sandplain wanderrie grassy shrubland with senescent broad-leaf wanderrie grass (*Monachather paradoxus*) and occasional tall shrubs of Australian boxthorn (*Bursaria occidentalis*), wanyu (*Acacia ramulosa*) and Wilcox bush (*Eremophila forrestii*). The bare ground is often covered in annual herbage for several months after good winter rains.*

SWGS may vary considerably in plant density depending on fire history. Immediately after fire this community is open, encouraging perennial grasses and low shrubs to become established. Several years after fire, the tall shrub species may start to dominate, restricting some low shrub growth. Mature stands of dense wattles tend to restrict growth of other mid shrubs. Early years after fire support the most attractive vegetation for livestock grazing. The poor availability and quality of water for livestock may also restrict development.

Grazing management is reliant on monitoring the key indicator species. The key desirable indicator species are broad-leaf wanderrie grass (*Monachather paradoxus*), green cassia (*Senna glutinosa* subsp. *chatelainiana*), tall saltbush (*Rhagodia eremaea*) and warty leaf fuchsia (*Eremophila latrobei*), while one key undesirable indicator species is wild tomato (*Solanum nummularium*). Grazing is most suited from autumn to spring. Vegetation degradation and soil erosion are uncommon.

This vegetation type is present on pastoral leases and conservation reserves. No Priority plants were found.

C. CYPRESS SANDPLAIN VEGETATION GROUP

This group consists of a single vegetation type—*Cypress sandplain shrubland* (CYSS).

7. Cypress sandplain shrubland (CYSS)

General information

This vegetation group occurs in the central and central west of the survey area on gently undulating yellow sandplains or sand dunes of the Nanga land system. Plants are commonly those of the South-West Botanical Province (Beard 1976). It is associated with and grades into *Acacia sandplain shrubland/woodland (ASSW)*, *Mallee acacia sandplain (MASA)* and some *Scrub heath (SCHE)* vegetation types.

Structure and composition

The dominant vegetation stratum within *Cypress sandplain shrubland* is the tall shrub layer consisting of about half the total scattered to close (15 to 50 per cent PFC) vegetation. The dominant tall shrub is sandplain cypress (*Actinostrobus arenarius*), with slightly less dominant trees of sandplain woody pear (*Xylomelum angustifolium*) or sceptre banksia (*Banksia sceptrum*). The mid and low shrub layers are very scattered (PFC 2.5 to 10 per cent), and consist mainly of myrtaceous shrubs such as *Calothamnus*, *Scholtzia*, *Melaleuca* and *Eremaea* spp.

CYSS tends to occur on specific landforms. On the higher margins of gently undulating sandplains, sandplain cypress occurs as an almost mono-specific tall shrubland in dense stands, while within the lower margins it tends to merge with *Acacia sandplain shrubland/ woodlands (ASSW)*. On sand dunes within undulating sandplains, sandplain woody pear and sandplain cypress are confined to the dune slopes and do not occur in the lower swales.

The following species listed by stratum are dominant or common. Dominance is indicated by numbers ([1, 2, 3, 4] or [5]) with the lowest number being most prevalent. Shared numbers indicate co-dominance. Other species are listed in order of dominance:

Trees:	*Xylomelum angustifolium* (sandplain woody pear)[2 or 4], *Banksia sceptrum* (sceptre banksia)[2].
Tall shrubs:	*Actinostrobus arenarius* (sandplain cypress)[1], *Banksia attenuata* (slender banksia).
Mid shrubs:	Myrtaceae family (unidentified)[4], rarely *Chamelaucium oenanthum* (purple wax P1)[2], *Calothamnus longissimus*, *C. blepharospermus*, *C.* sp., *Melaleuca ryeae*, *M.* sp., *Eremaea* sp., *Jacksonia rigida*, *Scholtzia* sp., *Petrophile macrostachya*, *P. semifurcata*.
Low shrubs:	Myrtaceae (unidentified)[3], *Melaleuca* sp.[3], *Beaufortia squarrosa* (sand bottlebrush), *Hibbertia* sp., *Mesomelaena* sp. (sedge), *Acanthocarpus preissii*.
Perennial grasses:	Occasionally *Triodia danthonioides* (spinifex).

Condition summary and land management

Sampling: 2 inventory sites

Traverse condition summary (12 traverse assessments):

Vegetation—9% very good; 33% good; 58% fair

Two forms of the Cypress sandplain shrublands. ***Left:*** *Gently undulating sandplain with sandplain cypress (*Actinostrobus arenarius*), sandplain woody pear (*Xylomemum angustifolium*) and some myrtaceous shrubs.* ***Right:*** *The higher margins of the gently undulating sandplains where sandplain cypress occurs in dense stands with few if any, other tall shrubs.*

Soil erosion—nil

The *Cypress sandplain shrubland* vegetation type is unsuitable for grazing livestock as it supports very few palatable plants. Feral goats may graze this vegetation during cool winter months but will not remain in the area without access to water.

CYSS was recorded on pastoral lease land, Unallocated Crown Land and within the Kalbarri National Park. One Priority 1 plant (*Chamelaucium oenanthum*) was found.

D. EUCALYPT/ACACIA SANDPLAIN VEGETATION GROUP

This group consists of a single vegetation type—*Mallee acacia sandplain* (MASA).

8. Mallee acacia sandplain (MASA)

General information

The *Mallee acacia sandplain* vegetation type was previously described in Payne et al. (1998) as 'sandplain with mallees and acacias' within the Eremaean Botanical Province (Beard 1976). MASA of the lower Murchison survey area is mostly within Beard's South-West Botanical Province, being botanically more diverse than the Eremaean. Two variants of sandplain are represented in MASA: red sandplains and yellow sandplains.

The sandplains of the Eurardy and Nerren land systems and the sand sheet land units of the Highway and Sandplain land systems are mostly located in the central and eastern areas of the survey area. Here the soils are predominantly red deep sands (soil group 445) with some sands trending toward more yellow colours. Toward the north and east the vegetation trends toward 'Eremaean' sandplain with some 'South-western' plant species.

Eremaean vegetation is dominated by mimosaceous species (acacias) with mallee eucalypts, while South-western vegetation is dominated more by proteaceous and myrtaceous species.

In the central-east and south-east, the vegetation is dominantly 'South-western Province', with less 'Eremaean type' species. Soils are yellow deep sands (soil group 446) on sandplains of the Eurardy, Nanga and Nerren land systems. The MASA vegetation variants described below are linked to the Acacia sandplain vegetation group and, with the loss of eucalypts, also grade toward the Heath vegetation group.

Structure and composition of the 'red soil' Mallee acacia sandplain

Mallee acacia 'red' sandplains support moderately close to close (20 to 50 per cent PFC) tall shrubs with prominent mallees, few low shrubs and some perennial grasses. The dominant tall shrub stratum contributes up to half the total foliar cover and consists mainly of wanyu (*Acacia ramulosa*) and an unidentified acacia. The mid shrub layer provides up to a quarter of the total foliar cover with the same

acacias plus needle myall (*A. roycei*) and poverty bush (*Eremophila* sp.). The tree layer consists of malallie (*Eucalyptus eudesmioides*), Oldfield's mallee (*E. oldfieldii*), York gum (*E. loxophleba*) and some inland pine (*Callitris columellaris*). Other occasional plants include species from the Myrtaceae family, *Grevillea* sp., cotton bush (*Ptilotus obovatus*) and broad-leaf wanderrie grass (*Monachather paradoxus*).

The following species listed by stratum are dominant or common. Dominance is indicated by numbers ([1, 2, 3, 4] or [5]) with the lowest number being most prevalent. Shared numbers indicate co-dominance. Other species are listed in order of dominance:

Trees: *Eucalyptus eudesmioides* (malallie)[3], *E. mannensis* (Mann Range mallee), *E. oldfieldii* (Oldfield's mallee), *E. loxophleba* (York gum), *Callitris columellaris* (inland pine), *Brachychiton gregorii* (desert kurrajong).

Tall shrubs: *Acacia ramulosa* (wanyu)[1], *Acacia* sp.[1], *A. ligulata* (umbrella wattle), *Lamarchea hakeifolia* (false paperbark), *Acacia tetragonophylla* (curara), *Santalum* sp., *Acacia roycei* (needle myall), *Grevillea* sp., *Bursaria occidentalis* (Australian boxthorn), *Eremaea* sp., *Callitris* sp., *Duboisia hopwoodii* (pituri), *Actinostrobus arenarius* (sandplain cypress).

Mid shrubs: *Acacia ramulosa*[1], *A. roycei*[2], *A.* sp.[2], *Eremophila* sp. (poverty bush)[2], *Allocasuarina acutivalvis* (black tamma), *Grevillea* sp., *Eremophila forrestii* (Wilcox bush), Myrtaceae (unidentified), *Stylobasium spathulatum* (pebble bush), *Olearia dampieri* subsp*. eremicola* (inland daisy), *Rhagodia drummondii* (low saltbush), *Melaleuca* sp., *Hakea* sp., *Alyxia buxifolia* (dysentery bush), *Acacia colletioides* (wait-a-while).

Low shrubs: *Eremophila* sp.[4], Myrtaceae (unidentified)[4], *Grevillea* sp., *Rhagodia eremaea* (tall saltbush), *Dianella revoluta* (flax lily), *Senna artemisioides* subsp. *coriacea* (desert cassia), *Ptilotus obovatus* (cotton bush), *P. schwartzii* (horse mulla mulla), *Solanum nummularium* (wild tomato), *Sida* sp., *Acanthocarpus preissii*, *Pimelea microcephala* (shrubby riceflower).

Perennial grasses: *Monachather paradoxus* (broad-leaf wanderrie)[5], *Ecdeiocolea monostachya* (wire stem grass—graminoid), *Austrostipa elegantissima* (feather speargrass).

*Mallee acacia 'red' sandplain on a sand sheet within the Nerren land system, showing the dominant tall shrub layer of wanyu (*Acacia ramulosa*) with a tree layer of Oldfield's mallee (*Eucalyptus oldfieldii*). Following good winter rains colourful displays of many annuals including the pink everlasting (*Schoenia cassiniana*) grow among the leaf litter of the wanyu. 'Wanyu beans', seed pods produced after good winter rains are a highly nutritious component of the sheep diet.*

Structure and composition of the 'yellow soil' Mallee acacia sandplain

Generally *Mallee acacia 'yellow' sandplains* support patchy areas of mallee and the acacia species are varied. The mallees grow in distinctive groups 6–10 m tall and often support dense vegetation under and adjacent to their canopies. The areas under the mallees are termed 'eucospheres'. Adjacent to these eucospheres the vegetation is more open with low shrubs and graminoids (grass-like or reed-like plants) of wire stem grass (*Ecdeiocolea monostachya*).

The tall shrub layer of mainly wattles (*Acacia* spp.), or mid shrub layer of wattles and white plume grevillea (*Grevillea leucopteris*) and black tamma (*Allocasuarina acutivalvis*) often share dominance. The graminoid layer represents the next most dominant stratum, with a basal cover of 0.5 to 1 per cent. The low shrub layer is less dominant but displays (along with the mid shrub stratum) the most diversity.

The following species listed by stratum are dominant or common. Dominance is indicated by numbers ([1, 2, 3, 4] or [5]) with the lowest number being most prevalent. Shared numbers indicate co-dominance. Other species are listed in order of dominance:

Trees:	*Eucalyptus oldfieldii* (Oldfield's mallee)[4], *E. mannensis* (Mann Range mallee), *E. eudesmioides* (malallie), *E. jucunda* (Yuna mallee), *Callitris columellaris* (inland pine).
Tall shrubs:	*Acacia* sp.[1], or *Acacia ramulosa* (wanyu)[1], *Lamarchea hakeifolia* (false paperbark), *Santalum* sp., *Acacia roycei* (needle myall), *Grevillea* sp., *Bursaria occidentalis* (Australian boxthorn), *Eremaea* sp., *Exocarpos aphyllus* (naked lady).
Mid shrubs:	*Grevillea leucopteris* (white plume grevillea)[2], *Acacia* aff. *colletioides*[2] or *Allocasuarina acutivalvis* (black tamma)[2], Myrtaceae (unidentified), *Olearia dampieri* subsp. *eremicola* (inland daisy), *Rhagodia drummondii* (low saltbush), *Melaleuca* sp., *Eremophila* sp. (poverty bush), *Petrophile* spp., *Alyxia buxifolia* (dysentery bush).
Low shrubs:	Myrtaceae family (unidentified)[3] and *Jacksonia* sp.[3], *Conostylis* sp. (graminoid), *Petrophile* sp., *Rhagodia eremaea* (tall saltbush), *Desmocladus* sp., *Dianella revoluta* (flax lily), *Senna artemisioides* subsp. *coriacea* (desert cassia),

Two examples of mallee acacia 'yellow' sandplain. ***Left:*** *The sandplain consists of mid shrubs dominated by black tamma (*Allocasuarina acutivalvis*), myrtaceous plants (such as* Baeckea *sp. and* Scholtzia *sp.), and stunted Oldfield's mallee (*Eucalyptus oldfieldii*). Wodjil (*Acacia neurophylla*) occupies the foreground. PFC is close to 50 per cent. Evidence of six months without rainfall is shown by the 'yellowing' of many shrubs.* ***Right:*** *The yellow sandplain consists of open areas supporting shrubs of* Petrophile *species and the wire stem grass (*Ecdeiocolea monostachya*). Clumps of Yuna mallee (*Eucalyptus jucunda*) occur in the background. Mallees clumped together support dense vegetation under their canopies in areas termed 'eucospheres'. Many plant species growing within 'eucospheres' have fleshy berries or fruits and are distributed by birds. The PFC over the combined open and closed areas is about 15 per cent.*

Ptilotus obovatus (cotton bush), *P. schwartzii* (horse mulla mulla), *Acanthocarpus preissii*.

Perennial grasses: *Ecdeiocolea monostachya* (wire stem grass—graminoid)[2], *Triodia* sp. (spinifex), infrequent *Monachather paradoxus* (broad-leaf wanderrie).

Condition summary and land management

Sampling: 10 inventory sites

Traverse condition summary (239 traverse assessments):

Vegetation—62% very good; 26% good; 11% fair; 1% poor

Soil erosion—nil

The *Mallee acacia sandplain* vegetation type does not support sufficient quantities of palatable plants to warrant more than moderate livestock numbers during or immediately after good rainfall seasons.

Dense tall shrublands of wanyu 'open up' after fire allowing low shrubs and perennial grasses to dominate for several years. During this time the density of the low shrubs increases, providing more accessible feed for grazing animals. Excessive grazing may decrease species diversity in the short term, however the tall shrub stratum will regain dominance over time. Perennial grasses are generally sparse, and even after fire, the grass density will only increase marginally amongst the low shrubs.

Difficulty in providing adequate water points for livestock may restrict pastoral use and the high density of vegetation may also inhibit full utilisation. During years of good rainfall and longer than average winter growing seasons, the wanyu plant produces seed pods (beans) which are regularly eaten by sheep after annual herbs have dried off. The often thick build-up of leaf litter below wanyu shrubs also serves to encourage annual herbs and forbs during good winter seasons.

Species diversity on yellow sandplain is similar to the red sandplain, but generally the number and density of plant species suited to livestock tends to be lower, and therefore the yellow soil variant of this vegetation type has less pastoral potential. During good seasons most MASA produces valuable amounts of annual herbage for livestock, but lacks sufficient reserves for long dry spells and should be managed accordingly.

This vegetation is not prone to any erosion risk.

MASA occurs on pastoral lease land, Unallocated Crown Land and on conservation reserves. No Priority plants were recorded within this vegetation.

E. HEATH VEGETATION GROUP

This group is the second largest in the survey area. It consists of four separate vegetation types: *Low heath* (HEAT), *Scrub heath* (SCHE), *Tree heath* (TRHE) and *Coastal heath* (COHE). This vegetation group was first described in Payne et al. (1987) who noted 'complex plant assemblages that are generally unsuited to pastoral development and production'.

Low heath communities tend to occur in areas of deep white/grey and yellow sands, near the coast. *Scrub heath* also has mostly deep sands but mostly occurs in the centre of the survey area. *Tree heath* communities are often interspersed throughout the *Shrub heaths* or as fringing units on adjoining sandplains. *Coastal heath* occurs on and around the seaward cliffs.

9. Low heath (HEAT)

General information

The *Low heath* vegetation type occurs within very gently undulating to undulating sandplain or sand sheet units of the Kalbarri, Zuytdorp and Nanga land systems, and as a minor type within the shallow sandplains of the Bungabandi land system. It also occurs as a minor component of gravelly sandplains within the Kalbarri land system.

This vegetation is closely associated with the other heath types and also grades into *Acacia sandplain shrubland/woodland (ASSW)* or *Mallee acacia sandplain (MASA)*.

Soils in the southern sandplains are mostly moderately deep to deep with some gravel inclusions in shallower soils. Calcareous brown deep sands (soil group 442) adjacent to the coastal margin give way to yellow deep sands (soil group 446) or pale deep sands (soil group 444) further inland within the Zuytdorp land system. The soils grade further to red deep sands (445) in the Nanga land system. In the south the soils tend to be calcareous deep sands (soil group 442), more calcareous near the coast and more acidic inland.

Structure and composition

Low heath is dominated by a moderately close to closed low shrub layer (PFC 25 to over 50 per cent). Some very scattered (PFC 2.5 to 10 per cent) mid shrubs or isolated tall shrubs may occur but are never dominant.

The dominant low shrubs on the brown or yellow sandplains of the Zuytdorp land system are a mixture of genera such as *Calothamnus*, *Acacia*, *Melaleuca* and *Petrophile*. Areas dominated by low shrubs tend to support the graminoid wire stem grass (*Ecdeiocolea monostachya*) as the second most dominant stratum. In areas supporting some low and less commonly mid shrubs, the graminoids are infrequently dominated by *Grevillea* and *Acacia* species.

Within the Nanga land system, HEAT has isolated to very scattered (less than 2.5 to 5 per cent PFC) mid and tall shrubs of *Acacia, Melaleuca*, *Verticordia* and sandplain cypress (*Actinostrobus arenarius*) above the much denser and highly diverse low shrubs. In the Kalbarri land system, HEAT occupies sand-plains with mixed dominant myrtaceous and proteaceous genera, including *Baeckea*, *Hakea*, *Petrophile*, *Banksia* and *Scholtzia* species.

The following species listed by stratum are dominant or common. Dominance is indicated by numbers ([1, 2, 3, 4] or [5]) with the lowest number being most prevalent. Shared numbers indicate co-dominance. Other species are listed in order of dominance:

Tall shrubs: Infrequent *Actinostrobus arenarius* (sandplain cypress)[3], *Grevillea candelabroides* (candle grevillea), *G. leucopteris* (white plume grevillea), *Jacksonia cupulifera* (rattlepod), *Banksia prionotes* (acorn banksia), *B. sceptrum* (sceptre banksia), *B. ashbyi* (Ashby's banksia), *Allocasuarina campestris* (tamma), *Eucalyptus foecunda* (narrow-leaved red mallee).

Mid shrubs: *Acacia spathulifolia* (spoon leaf wattle)[1], *Melaleuca* sp.[2], *Allocasuarina* sp., *Acacia ligulata* (umbrella wattle), *Alyxia buxifolia* (dysentery bush), *Exocarpos aphyllus* (naked lady), *Eucalyptus* sp., *Grevillea stenomera* (lace net grevillea), *G. dielsiana* (Diels grevillea), *Pityrodia oldfieldii* (Oldfield's foxglove), *Stylobasium spathulatum* (pebble bush), *Diplolaena grandiflora* (wild rose), *Hakea stenophylla* (golf ball hakea), *Hakea* sp., *Cassytha* sp. (dodder laurel), *Jacksonia* sp., *Dryandra fraseri* subsp. *ashbyi*, *Xylomelum angustifolium* (sandplain woody pear), *Nuytsia floribunda* (Christmas tree).

Low shrubs: Mostly a mixture of *Melaleuca* sp.[1], *Acacia* sp.[1], *A. spathulifolia*[1], Myrtaceae family (unidentified)[1], *Hakea pycnoneura*[1], *Baeckea* sp.[1], *Conospermum* sp.[1], *Scholtzia umbellifera*[1], *Eremaea* sp.[1],

*Two examples of low heath vegetation: one **(right)** showing the effect of a fire 2–3 years ago. Immediately after fire and good rains, many short-lived perennial plants germinate to occupy the open niches left by the original perennials.*

Banksia attenuata (slender banksia)[1], *Petrophile megalostegia*, *P. macrostachya*, *P.* sp., *Melaleuca oldfieldii* (purple honeymyrtle P2), *Persoonia acicularis*, *Hibbertia* sp., *Patersonia occidentalis* (blue flag), *Olearia dampieri* subsp. *eremicola* (inland daisy), *Pimelea leucantha* (big riceflower), *Lepidium* sp., *Acacia andrewsii* (prickly wattle).

Perennial grasses: *Ecdeiocolea monostachya* (wire stem grass—graminoid)[2] where only low shrubs prevail, otherwise, occasional *Mesomelaena preissii* (sandplain sedge), *Triodia danthonioides* (spinifex) or *Borya* sp. (pincushions—graminoid).

Condition summary and land management

Sampling: 10 inventory sites

Traverse condition summary (50 traverse assessments):

Vegetation—88% very good; 12% good

Soil erosion—nil

This vegetation type was described from inventory sites and traverse assessments, plus information provided in Payne et al. (1987). HEAT does not support sufficient desirable plants for livestock and is basically unsuitable for pastoralism. A historic pastoral classification plan (Harrington 1967), shows a few artificial livestock watering points but very few (if any) of these waters are currently in operation. Low numbers of grazing animals may be supported on HEAT during cool winter months with ample rainfall but the vegetation holds no reserves over summer or in dry years. HEAT may support some feral goats obtaining water from springs or soaks during wet cool months but these animals will dissipate during dry times.

This vegetation type is of great interest and significance to the botanical community as it supports a vast diverse array of different and unique plant species, one of the reasons for the creation of the Kalbarri National Park and the Zuytdorp Nature Reserve. One Priority 2 plant (*Melaleuca oldfieldii*) was found.

10. Scrub heath (SCHE)

General information

The *Scrub heath* vegetation type mostly occurs within the sandplains of the Bungabandi, Eurardy, Kalbarri, Nanga and Tumblagooda land systems and on the sand sheets of the Zuytdorp system and to a lesser extent the Ajana and Bibra land systems. It also occurs on the stony plain land unit of the Bungabandi land system, loamy plains of the Bibra system, limestone plains of the Zuytdorp system and gravelly plains of the Highway system. Soils are mostly yellow deep sands (soil group 446), pale deep sands (soil group 444), with minor brown deep sand (soil group 441) or calcareous deep sands (soil group 442). This vegetation type was previously described in Payne et al. (1987) where it similarly occurred amongst other forms of heath vegetation.

This survey identified differences in SCHE in the north-west and the south-west of the area. The southern variant is dominated more by proteaceous and myrtaceous plants whereas the northern variant has greater numbers of mimosaceous species (acacias).

SCHE is associated with the other heath types and may grade into some sandplain vegetation types such as *Acacia sandplain shrubland/ woodland* (ASSW), *Cypress sandplain shrubland* (CYSS) and *Mallee acacia sandplain* (MASA).

Structure and composition of the southern scrub heath

The ‘southern’ *Scrub heath* areas (mainly within the Kalbarri National Park) support close to closed (30 to more than 50 per cent PFC) mid and low shrublands with patches of taller shrubs. Common taller species are acorn banksia (*Banksia prionotes*), sandplain woody pear (*Xylomelum angustifolium*), tamma (*Allocasuarina campestris)* and many species of *Grevillea* and *Hakea*. SCHE supports a vast array of plant species through each of the vegetation strata. The most common tree is inland pine (*Callitris columellaris*) with understoreys of spoon leaf wattle (*Acacia spathulifolia*), various honeymyrtles (*Melaleuca* spp.) and other myrtaceous shrubs such as *Baeckea*, *Scholtzia*, and *Calothamnus* species. Proteaceous shrubs are also common and include *Banksia*, *Hakea*, *Grevillea* and *Petrophile* spp.

Most of the southern *Scrub heath* occurs in the Kalbarri National Park, and as such was not formally assessed in terms of resource condition, but as an inventory of plant species and soil types. The sandplains of the Kalbarri land system were largely in pristine condition and unaffected by soil erosion.

The following species listed by stratum are dominant or common within the southern variant of *Scrub heath*. Dominance is indicated by numbers ([1, 2, 3, 4] or [5]) with the lowest number being most prevalent. Shared numbers indicate co-dominance. Other species are listed in order of dominance:

Trees: *Callitris columellaris* (inland pine)[2], or *Eucalyptus eudesmioides* (malallie)[3], or *Actinostrobus arenarius* (sandplain cypress)[3], *Eucalyptus foecunda* (narrow-leaved red mallee), very occasional *Banksia menziesii* (firewood banksia).

Tall shrubs: *Banksia prionotes* (acorn banksia)[3] and/or *Grevillea leucopteris* (white plume grevillea)[3], or *Xylomelum angustifolium* (sandplain woody pear)[3], *Grevillea* sp.[3], *Acacia ligulata* (umbrella wattle)[3], *A. rostellifera* (summer-scented wattle)[3], *Actinostrobus arenarius*[3], *Banksia sceptrum* (sceptre banksia)[4], *B. attenuata* (slender banksia), *Allocasuarina campestris* (tamma)[4], *Gyrostemon racemiger* (fire tree), *Hakea orthorrhyncha* (bird beak hakea), *Xanthorrhoea preissii* (grass tree).

Mid shrubs: *Acacia spathulifolia* (spoon leaf wattle)[1], *A.* sp.[1], Myrtaceae family (unidentified)[1], *Scholtzia umbellifera*[1], *Olearia dampieri* subsp. *eremicola* (inland daisy)[2], *Actinostrobus arenarius*[2], *Allocasuarina* sp.[2], *Grevillea* sp.[2], *Acacia rostellifera*[2], *Calothamnus oldfieldii*[2], *Melaleuca radula* (graceful honeymyrtle)[2], *M.* sp.[4], *M. scabra* (rough honeymyrtle), *Calothamnus longissimus*, *C.* sp., *Scholtzia* sp., *Allocasuarina campestris*, *Petrophile* sp., *Acacia neurophylla* (wodjil), *Eremaea* sp., *Petrophile conifera* (pine cone petrophile), *P. macrostachya* (long-eared petrophile), *Jacksonia* sp., *Acacia saligna* (golden wreath wattle), *Hakea* sp., *Melaleuca cardiophylla* (teatree), *M. urceolaris*.

Low shrubs: *Acacia spathulifolia*[1], *A.* sp.[1], Myrtaceae (unidentified)[1], *Baeckea* sp.[1], *Melaleuca* sp.[1], *Hakea circumalata*[1], *Calothamnus blepharospermus*[1],

*The white sandplains of the southern part of the Kalbarri National Park support scrub heath with different plant species to those of the northern scrub heath. Here the dominant plant species are slender banksia (*Banksia attenuata*),* Scholtzia umbellifera*,* Dicrastylis *sp. and prickly rattlepod (*Jacksonia *sp.). Small trees such as firewood banksia (*Banksia menziesii*) in the background are mostly uncommon. The openness of this particular site is evidence of a fire several years ago.*

C. oldfieldii[1], *Petrophile conifera*[1], *P. semifurcata*, *P.* sp., *Mesomelaena preissii* (sandplain sedge), *Calytrix* sp., *Leucopogon* sp., *Conospermum* sp., *Conostylis* sp. (sedge), *Dicrastylis* sp., *Leptosema aphyllum* (flat leaf cockies tongues), *Verticordia densiflora* (feather flower).

Perennial grasses: *Ecdeiocolea monostachya* (wire stem grass—graminoid)[3 or 4], *Triodia danthonioides* (spinifex).

Structure and composition of the northern scrub heath

The 'northern' *Scrub heath* vegetation is dominated by the mid and low shrub strata with occasional tall shrubs (*Acacia* spp.). The mid and low shrub layers are often dominated by spoon leaf wattle (*A. spathulifolia*) and summer-scented wattle (*A. rostellifera*). The vegetation is moderately close to close (PFC 20 to 50 per cent).

SCHE shares similarities to the *Heath* vegetation described in Payne et al. (1987) and occurs mainly in the north-west and central parts of this survey area, on sandplains of the Nanga and Zuytdorp land systems. The northern and central areas of sandplain within the Nanga land system are dominated by tall shrubs of *Acacia rostellifera*, fire tree (*Gyrostemon racemiger*), *Grevillea* and *Melaleuca* species with graminoids either present or absent. There are also areas of inland pine (*Callitris columellaris*) scrub heath within the Tumblagooda and central Nanga systems. Adjacent to the coast SCHE supports a different suite of species, including umbrella wattle (*Acacia ligulata*), inland daisy (*Olearia dampieri* subsp*. eremicola*) and *Acanthocarpus preissii*.

The following species listed by stratum are dominant or common. Dominance is indicated by numbers ([1, 2, 3, 4] or [5]) with the lowest number being most prevalent. Shared numbers indicate co-dominance. Other species are listed in order of dominance:

Trees: Rare *Eucalyptus eudesmioides* (malallie), *E.* sp.

Tall shrubs: *Acacia neurophylla* (wodjil)[2], *A. rostellifera* (summer-scented wattle)[3], *Grevillea leucopteris* (white plume grevillea)[3], *A.* sp.[3], *Actinostrobus arenarius* (sandplain cypress)[3], *Gyrostemon racemiger* (fire tree), *Hakea orthorrhyncha* (bird beak hakea).

Mid shrubs: *Baeckea* sp.[1], *Acacia rostellifera*[1], *Grevillea* sp.[2], *A. spathulifolia*[2] (spoon leaf wattle), *Banksia sceptrum* (sceptre banksia), *Melaleuca scabra* (rough honeymyrtle), *Petrophile semifurcata*, *Grevillea annulifera* (prickly plume grevillea P3), *Allocasuarina acutivalvis* (black tamma), *Calothamnus* sp., *Melaleuca* sp., *Scholtzia* sp.,

*The yellow sandplains in the central north of the survey area support mid and low shrubs of wattle (*Acacia *species) and many myrtaceous genera such as* Baeckea *and* Scholtzia*. Tall shrubs of sandplain cypress (*Actinostrobus arenarius*) or stunted malallie (*Eucalyptus eudesmioides*) may be common but rarely dominate. The yellow colour of the vegetation is due to moisture stress. During hot seasons, many of the plants 'shut down' to conserve moisture but response to rainfall is rapid.*

	Allocasuarina sp., *Melaleuca cordata*.
Low shrubs:	*Acacia spathulifolia*[1], *A.* sp.[1], Myrtaceae (unidentified)[1], *Baeckea* sp.[3], *Conospermum* sp. (smokebush), *Petrophile* sp., *Mesomelaena preissii* (sandplain sedge), *Calytrix* sp., *Leptosema aphyllum* (flat leaf cockies tongues), *Mirbelia* sp., *Dicrastylis fulva*, *Dianella revoluta* (flax lily).
Perennial grasses:	*Ecdeiocolea monostachya* (wire stem grass—graminoid)[2 or 3], *Triodia danthonioides* (spinifex).

Condition summary and land management

Sampling: 18 inventory sites

Traverse condition summary (139 traverse assessments):

Vegetation—91% very good; 8% good; 0% fair; 1% poor

Soil erosion—nil

SCHE has limited value for grazing livestock as many of the plant species are not palatable. While there may be some value in annual herbage during the winter and spring it does not provide for livestock grazing over summer. The highly diverse vegetation is more suited to conservation and botanical studies rather than livestock grazing.

SCHE is prone to fire, resulting in temporarily changed structures. Many of the plants are adapted to, and rely on, fire as part of the natural regeneration regime. The sandy soils are prone to wind erosion when the surface is bare, but regeneration is relatively quick post-fire provided there is suitable rainfall. Erosion events are uncommon.

This vegetation type is well represented within conservation reserves. One Priority 3 plant (*Grevillea annulifera*) was found.

11. Tree heath (TRHE)

General information

The *Tree heath* vegetation type mainly occurs on the sand sheet land unit of the Highway land system and sandplains of the Eurardy, Kalbarri and Nanga land systems. Occasional TRHE also occurs on loamy plains of the Bibra land system where it fronts adjoining sand sheet or sandplain units of other systems. The soils of the sand sheets/sandplains are mostly yellow deep sands (soil group 446) or pale deep sands (soil group 444). The gravelly plains of the Kalbarri system have white shallow sands (soil group 422).

This vegetation type was previously described in Payne et al. (1987) in the survey area further north on the Nanga land system where 'eucalypts (mallee form) and other trees occur in isolated clumps or form bands along sandy rises and dune crests above closed lower layers'. In this survey similar 'clumping and banding' of stunted trees within sandplain systems was noted. Within the Kalbarri land system, vegetation is somewhat more dominated by wattles and paperbark/honeymyrtle species.

The *Tree heath* vegetation type is associated with other heath types and may grade into other types within the Acacia sandplain and Eucalypt acacia sandplain vegetation groups.

Structure and composition

Tree heath is similar to *Scrub heath* but with a more dominant tree stratum of eucalypts or, less commonly, wattles. TRHE is common on the Eurardy and Kalbarri land systems. The Eurardy system supports relatively low numbers of malallie (*Eucalyptus eudesmioides*) or Oldfield's mallee (*E. oldfieldii*) with dominant low to mid myrtaceous shrubs, on deep yellow sands. PFC is moderately close to close (25 to 50 per cent). Within the Kalbarri land system, gravelly plains support prominent malallie with a low shrub layer co-dominated by honeymyrtle (*Melaleuca* sp.), *Petrophile* species and various myrtaceous species. Parts of the sandplains within the Nanga land system toward the north-east of the survey area have restricted patches of TRHE dominated by summer-scented wattle (*Acacia rostellifera*) trees and mid shrubs of inland daisy (*Olearia dampieri* subsp. *eremicola*). Cover is moderately close (PFC 25 to 30 per cent). In comparison to TRHE with eucalypts, the species diversity of the wattle TRHE is low.

The following species listed by stratum are dominant or common within the 'eucalypt' *Tree heath* vegetation. Dominance is indicated by numbers ([1, 2, 3, 4] or [5]) with the lowest number being most prevalent. Shared numbers indicate co-dominance. Other species are listed in order of dominance:

Trees: *Eucalyptus eudesmioides* (malallie)[2, 4 or 5], *E. obtusiflora* (Dongara mallee)[3], or *E. oldfieldii* (Oldfield's mallee)[4], *E. jucunda* (Yuna mallee).

Tall shrubs: *Acacia neurophylla* (wodjil)[3], *Lamarchea hakeifolia* (false paperbark)[3], *Acacia* sp.[3], *Hakea pycnoneura*, *Calothamnus blepharospermus* (bottlebrush), *C.* aff. *homalophyllus*, *Allocasuarina acutivalvis* (black tamma), *Xylomelum angustifolium* (sandplain woody pear), *Melaleuca* sp., *Grevillea annulifera* (prickly plume grevillea P3), *Acacia* sp., *Grevillea leucopteris* (white plume grevillea), *Actinostrobus arenarius* (sandplain cypress), *Acacia* aff*. ligulata*, *A. rostellifera* (summer-scented wattle).

Mid shrubs: Myrtaceae family (*Scholtzia, Baeckea, Thryptomene,* etc.)[1], *Calothamnus blepharospermus*[2], *Acacia* sp.[2], *Hakea trifurcata* (twin leaf hakea)[2], *Allocasuarina* sp., *Melaleuca radula* (graceful honeymyrtle), *Calothamnus sanguineus* (silky leaf blood flower), *Melaleuca* sp., *Acacia* aff. *colletioides*, *Calothamnus* sp., *Stylobasium spathulatum* (pebble bush), *Exocarpos* sp., *Olearia dampieri* subsp. *eremicola* (inland daisy).

Low shrubs: Myrtaceae family (*Scholtzia, Baeckea, Thryptomene*, etc.)[1], *Melaleuca* sp.[1], *Petrophile conifera*[1], *Baeckea* sp.[2], *Conospermum* sp., *Anthotroche* sp., *Acacia* aff. *colletioides*, *Mirbelia* sp., *Acanthocarpus preissii*, *Calothamnus blepharospermus*, *Acacia* sp., *Isopogon* sp., *Gastrolobium oxylobioides* (Champion Bay poison).

Perennial grasses: Occasionally *Ecdeiocolea monostachya* (wire stem grass—graminoid)[4], *Austrostipa elegantissima* (feather speargrass), *Borya* sp. (graminoid).

The following species listed by stratum are dominant or common within the 'acacia' *Tree heath* vegetation. Dominance is indicated by numbers ([1, 2, 3, 4] or [5]) with the lowest number being most prevalent. Shared numbers indicate co-dominance. Other species are listed in order of dominance:

*Multi-layered Tree heath vegetation with numerous co-dominants including myrtaceous genera (*Scholtzia*,* Baeckea*,* Thryptomene*, etc.) with eucalypt tree layers of Oldfield's mallee (*Eucalyptus oldfieldii*) and malallie (*E. eudesmioides*). This moderately close to close vegetation occurs on deep, pale or yellow gently undulating sandplains.*

Trees:	*Acacia rostellifera* (summer-scented wattle)[1].
Tall shrubs:	*Olearia dampieri* subsp. *eremicola* (inland daisy)[3], *Acacia rostellifera, Hakea orthorrhyncha* (bird beak hakea).
Mid shrubs:	*Olearia dampieri* subsp. *eremicola*[2], *Acacia rostellifera, Hakea orthorrhyncha*, *Pimelea microcephala* (shrubby riceflower).
Low shrubs:	*Olearia dampieri* subsp. *eremicola*[4], *Baeckea* sp., *Acanthocarpus preissii*.
Perennial grasses:	*Austrostipa elegantissima* (feather speargrass), *Triodia danthonioides* (spinifex).

Condition summary and land management

Sampling: 4 inventory sites

Traverse condition summary (42 traverse assessments):

Vegetation—88% very good; 12% good

Soil erosion—nil

Most TRHE with eucalypts support densely clustered mid and tall shrubs. These strata tend to restrict the lower shrub and perennial grass strata resulting in few plant species being available for livestock grazing. TRHE is prone to regular but infrequent fire and, after such events supports a myriad of regenerating shrubs with annual herbs and forbs as well as coppicing eucalypts. In the months following fire, regeneration may support some livestock, but the support is short-lived as unpalatable shrubs regenerate rapidly.

Acacia *Tree heath* is somewhat more open than eucalypt *Tree heath* allowing grazing, however few perennial plants are palatable to livestock. It is slightly less prone to fire and may not regenerate as quickly as the eucalypt *Tree heath*. Grazing may be possible after good seasons or following regeneration post-fire, however, it does not support sufficient desirable plants for continuous usage by livestock. The soils are not prone to erosion except immediately after wildfire.

TRHE is well represented within conservation reserves. One Priority 3 plant (*Grevillea annulifera*) was found.

12. Coastal heath (COHE)

General information

Coastal heath occurs as a very narrow margin along the coastal fringes of the Zuytdorp land system. These fringes include steep rugged cliffs with minor pockets of skeletal sand supporting little or no vegetation. In a few areas the cliffs give way to sloped or bench-like platforms varying considerably in slope. These slopes may support small sand dunes or sand sheets, being shallow at the ocean edge and the top of the scarp but with mostly calcareous deep sands (soil group 442) mid-slope. The limestone cliffs support very shallow skeletal sand or wind-blown pockets of calcareous

*Less common than the 'eucalypt' tree heath, the 'acacia' tree heath is dominated by summer-scented wattle (*Acacia rostellifera*) with lower shrub layers of inland daisy (*Olearia dampieri *subsp*. eremicola*). This vegetation type occurs as isolated clumps or bands within the Nanga land system in the north-west of the survey area.*

shallow sand (soil group 421). *Coastal heath* merges into *Low heath* (HEAT) and occasionally *Scrub heath* (SCHE) a few hundred metres inland from the cliffs.

Structure and composition

On cliffs with exposed limestone, the vegetation is scattered (PFC 10 to 20 per cent) and is mainly stunted sea heath (*Frankenia* sp.), thick leaf fan flower (*Scaevola crassifolia*), grey saltbush (*Atriplex cinerea*) and coastal daisy bush (*Olearia axillaris*). The mid-slopes of the seaward dunes are dominated by the close (30 to 50 per cent PFC) mid shrub layer. Some very scattered (2.5 to 10 per cent PFC) low shrubs or isolated tall shrubs occur, but are rarely dominant. The dominant low shrub is coastal daisy bush and *Acanthocarpus preissii* and sea heath are common. Common mid shrubs include wild rose (*Diplolaena grandiflora*), sea saltbush (*Rhagodia preissii* subsp. *obovata*) and thick leaf fan flower (*Scaevola crassifolia*). All of these plants are able to withstand high winds and salt-laden sea spray from the Indian Ocean.

The following species listed by stratum are dominant or common. Dominance is indicated by numbers ([1, 2, 3, 4] or [5]) with the lowest number being most prevalent. Shared numbers indicate co-dominance. Other species are listed in order of dominance:

Tall shrubs: Infrequent *Acacia ligulata* (umbrella wattle).

Mid shrubs: *Olearia axillaris* (coastal daisy bush)[1], *Rhagodia preissii* subsp. *obovata* (sea saltbush), *Scaevola crassifolia* (thick leaf fan flower), *Acacia ligulata*, *Pimelea leucantha* (big riceflower), *Atriplex isatidea* (coast saltbush), *A. cinerea* (grey saltbush), *Threlkeldia diffusa* (coast bonefruit).

Low shrubs: *Olearia axillaris*[1], *Diplolaena grandiflora* (wild rose)[1], *Frankenia* sp. (sea heath), *Ptilotus* sp. (mulla mulla), *Maireana* sp. (bluebush), *Acanthocarpus preissii*.

Condition summary and land management

Sampling: 1 inventory site

This vegetation group was insufficiently sampled to derive vegetation condition and soil erosion summaries. The site pictured below was in good condition with no erosion. COHE supports very few palatable plants and is not recommended for livestock grazing. It may support some feral goats obtaining water from springs or soaks during wet cool months but these animals dissipate during dry times.

*One of the few places on the coast not dominated by rugged cliffs, this seaward facing dune within the Zuytdorp land system supports plants able to withstand strong, salt-laden, coastal winds. The dominant shrubs are coastal daisy bush (*Olearia axillaris*), sea saltbush (*Rhagodia preissii *subsp.* obovata*), thick leaf fan flower (*Scaevola crassifolia*), and umbrella wattle (*Acacia ligulata*). The cliff faces with shallow pockets of sand support stunted sea heath (*Frankenia *sp.), thick leaf fan flower, grey saltbush (*Atriplex cinerea*) and coastal daisy bush among exposed limestone rock.*

F. MELALEUCA WOODLAND/ SHRUBLAND VEGETATION GROUP

This vegetation group mainly occurs in the western part of the survey area on the Bibra and Zuytdorp land systems. Much of the Bibra system is low rises and stony plains with abundant calcrete stony mantles and some calcrete outcrop. These units support *Calcrete melaleuca acacia shrublands* (CMAS) or *Closed melaleuca shrublands* (CMES). Unchannelled drainage zones with deep loamy soils support *Melaleuca shrubland* (MELS) vegetation. Within the Zuytdorp land system a very small part of the sand sheet land unit supports dense stands of *Melaleuca woodland* (MELW) with no understoreys. Within drainage zones of the Murchison River, *Melaleuca swamp shrublands* (MESS) occur as very isolated drainage or sink zones.

13. Calcrete melaleuca acacia shrubland (CMAS)

General information

The *Calcrete melaleuca acacia shrubland* vegetation type occurs on low calcrete rises of the Bibra land system. These rises are characterised by many to abundant cobbles and stones amongst common calcrete outcrop with rocky red shallow loams (soil group 522). The vegetation is dominantly myrtaceous tall and mid shrubs of *Melaleuca* with some mimosaceous shrubs and trees. CMAS grades into *Closed melaleuca shrubland (CMES)* of the stony plains in the Bibra land system.

Structure and composition

Calcrete melaleuca acacia shrubland is characterised by close (30 to 50 per cent PFC) tall shrublands or woodlands of teatree (*Melaleuca cardiophylla*) and jam (*Acacia acuminata*). Perennial plant species diversity is generally low with only a few mid and low shrubs such as *A. andrewsii*.

The following species listed by stratum are dominant or common. Dominance is indicated by numbers ([1, 2, 3, 4] or [5]) with the lowest number being most prevalent. Shared numbers indicate co-dominance. Other species are listed in order of dominance:

Trees:	*Acacia acuminata* (jam)[1].
Tall shrubs:	*Melaleuca cardiophylla* (teatree)[1], *Eucalyptus* sp., *Acacia tetragonophylla* (curara).
Mid shrubs:	*Melaleuca cardiophylla*[1], *Acacia andrewsii* (prickly wattle)[2], *Melaleuca oldfieldii* (purple honeymyrtle P2), *M.* sp., *Senna glutinosa* subsp. *chatelainiana* (green cassia).
Low shrubs:	*Acacia andrewsii*[3], *Diplolaena grandiflora* (wild rose), *Ptilotus obovatus* (cotton bush), *Acanthocarpus preissii*.
Annuals:	*Avena* sp. (wild oat)*.

*Introduced plant or weed.

*The Calcrete melaleuca acacia shrubland is characterised by an abundant mantle of calcrete stones and boulders with a closed tall shrubland of teatree (*Melaleuca cardiophylla*) and some jam (*Acacia acuminata*). The less dominant mid shrub layer is mostly young teatree and there is virtually no low shrub stratum. The soils are very shallow red loams overlying calcrete.*

Condition summary and land management

Sampling: 3 inventory sites

CMAS was insufficiently sampled to derive valid vegetation and soil erosion summaries. It does not support sufficient palatable plants for livestock production and the dense vegetation and rough stony mantle restrict access. The few species palatable to livestock are: curara (*Acacia tetragonophylla*), green cassia (*Senna glutinosa* subsp. *chatelainiana*), cotton bush (*Ptilotus obovatus*), and the introduced grass, wild oat (*Avena* sp.). Diggings from feral pigs were evident on low rises of the Bibra land system, and feral goats graze this vegetation type opportunistically.

The stony calcrete mantle offers protection from erosion to the red shallow bouldery loam soils.

Purple honeymyrtle (*Melaleuca oldfieldii*), a Priority 2 species, was found within this vegetation type.

CMAS occurs on pastoral lease land and is not represented in any conservation reserves.

14. Closed melaleuca shrubland (CMES)

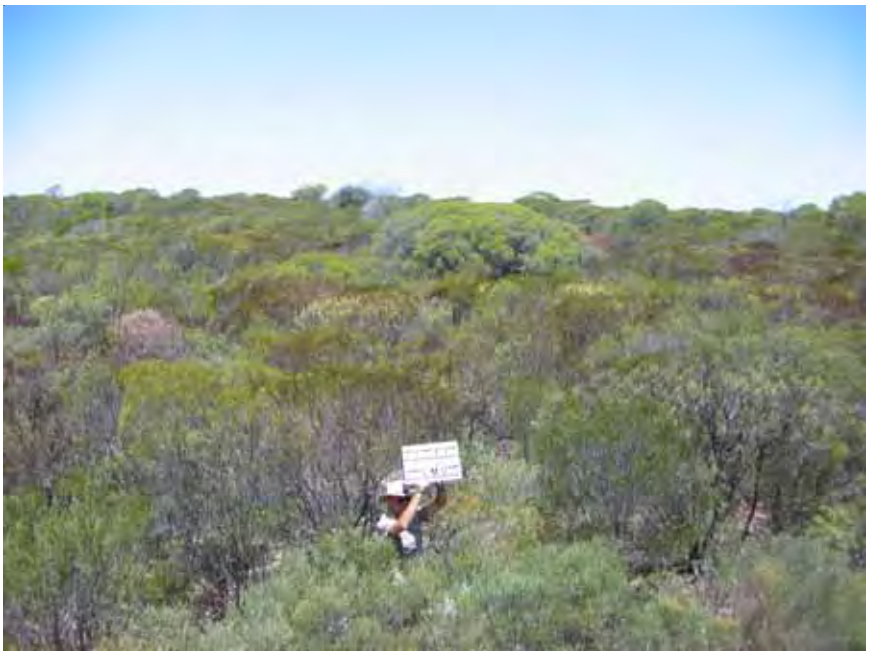
General information

Closed melaleuca shrubland vegetation type occurs on stony plains, some low calcrete rises and loamy plains of the Bibra land system in the west of the survey area. It was also recorded on calcrete rises of the Cooloomia land system. The stony plains are characterised by many to abundant (50 to 90 per cent) cobbles and stones among infrequent calcrete outcrop with stony red shallow loams (soil group 522). The vegetation is dominantly myrtaceous tall and mid shrubs of *Melaleuca* with infrequent trees. CMES grades into *Calcrete melaleuca acacia shrubland (CMAS)* of the low calcrete rises of the Bibra land system.

Structure and composition

CMES is a closed tall shrubland with a PFC of 50 to 90 per cent. Honeymyrtles (*Melaleuca* spp.) and tamma (*Allocasuarina campestris*) are the dominant tall shrubs with very few teatrees (*Melaleuca cardiophylla*) or jam (*Acacia acuminata*) in the uppermost stratum. Low shrubs are virtually absent. The canopies of the tall shrubs restrict development of the lower stratum. Traverse records indicate some mallees occur amongst the honeymyrtles. These are mostly malallie (*Eucalyptus eudesmioides*).

The following species listed by stratum are dominant or common. Dominance is indicated by numbers ([1, 2, 3, 4] or [5]) with the lowest number being most prevalent. Shared numbers indicate co-dominance. Other species are listed in order of dominance:



*The very dense tall shrub canopy of honeymyrtles (*Melaleuca *spp.) and tamma (*Allocasuarina campestris*) defines the Closed melaleuca shrubland vegetation (CMES) type. The dense shrub canopy accounts for the lack of a low shrub stratum. The soil surface is almost totally covered (to 90 per cent) in subrounded calcrete boulders.*

Trees:	Infrequent *Melaleuca cardiophylla* (teatree), *Acacia acuminata* (jam), *Eucalyptus eudesmioides* (malallie).
Tall shrubs:	*Allocasuarina campestris* (tamma)[1], *Melaleuca* aff. *depressa*[1], *M. sp.* (honeymyrtle)[1], *M. cardiophylla*, *Cassytha* sp. (dodder laurel), *Pimelea microcephala* (shrubby riceflower).
Mid shrubs:	*Melaleuca* sp.[2], *M.* aff. *depressa*.
Low shrubs:	*Dianella revoluta* (flax lily).

Condition summary and land management

Sampling: 1 inventory site

Traverse condition summary (6 traverse assessments):

Vegetation—83% very good; 0% good; 17% fair

Soil erosion—nil

CMES is not suitable for livestock grazing. The only plant identified as being palatable to livestock was the infrequent shrubby riceflower (*Pimelea microcephala*).

With a dense stony mantle, infrequent calcrete outcrop and near-level terrain, the risk of soil erosion is negligible. This vegetation would be influenced by infrequent fires.

Closed melaleuca shrubland is not represented within any conservation reserves and no Priority plants were found.

15. Melaleuca shrubland (MELS)

General information

The *Melaleuca shrubland* vegetation type occurs within almost level unchannelled drainage corridor floors between large low rises in the Bibra land system in the west of the survey area. It was also recorded as a minor component on the stony plains of the Bungabandi land system. It comprises mostly myrtaceous co-dominant tall and mid shrubs with infrequent trees. The deep red loamy earths (soil group 544) have no stone mantle or rock outcrop and common surface crusts. MELS grades with *Calcrete melaleuca acacia shrubland (CMAS)* and *Closed melaleuca shrubland (CMES)* as soils become shallower and stonier on calcrete rises and stony plains of the Bibra land system.

Structure and composition

MELS vegetation type consists of close (PFC 30 to 50 per cent) tall and mid shrubs of various species of honeymyrtle (*Melaleuca* spp.), false paperbark (*Lamarchea hakeifolia*) and tamma (*Allocasuarina campestris*) with occasional malallie (*Eucalyptus eudesmioides*). The tall shrubs and low malallie gums can occur in patches with slightly more open areas between supporting wire stem grass

*A weakly distinctive drainage floor between large low rises in the Bibra land system. The close shrubland supports dominant mid and tall shrubs of dense broom honeymyrtle (*Melaleuca uncinata*) with occasional malallie mallee (*Eucalyptus eudesmioides*). The soils are red deep sandy earths and free of boulders and stones, unlike the land units further upslope. The slightly open areas support the graminoid wire stem grass (*Ecdeiocolea monostachya*).*

(*Ecdeiocolea monostachya*) and firebush (*Keraudrina integrifolia*). Some open areas support spinifex (*Triodia danthonioides*).

The following species listed by stratum are dominant or common. Dominance is indicated by numbers ([1, 2, 3, 4] or [5]) with the lowest number being most prevalent. Shared numbers indicate co-dominance. Other species are listed in order of dominance:

Trees:	*Eucalyptus eudesmioides* (malallie)[3 or 4].
Tall shrubs:	*Allocasuarina campestris* (tamma)[1], *Melaleuca* aff. *depressa*[1], *M.* sp. (honeymyrtle)[1], *M. cardiophylla* (teatree), *Cassytha* sp. (dodder laurel), *Pimelea microcephala* (shrubby riceflower).
Mid shrubs:	*Melaleuca uncinata* (broom honeymyrtle)[1] or *Lamarchea hakeifolia* (false paperbark)[1], *Olearia* sp., Malvaceae (unidentified).
Low shrubs:	*Keraudrina integrifolia* (firebush)[3], *Lamarchea hakeifolia*[3], *Mirbelia* sp., *Hemigenia* sp., *Acanthocarpus preissii*, *Thryptomene strongylophylla*, *Acacia idiomorpha*.
Perennial grasses:	*Ecdeiocolea monostachya* (wire stem grass—graminoid)[4], *Triodia danthonioides* (spinifex).

Condition summary and land management

Sampling: 2 inventory sites and 4 traverse assessments

There were insufficient traverse assessments to compile valid vegetation or soil erosion summaries. The dense vegetation and lack of palatable plants means MELS is unsuited to livestock grazing. It may occasionally support feral goats or pigs during cooler months provided water is available. MELS is susceptible to fire and the vegetation strata will temporarily alter in the first few years after fire. Water erosion and wind erosion are considered negligible.

MELS is found on pastoral lease land, but not represented within any conservation reserves. No Priority plants were found.

16. Melaleuca woodland (MELW)

General information

The *Melaleuca woodland* type is uncommon and found sporadically in the southern parts of the Zuytdorp land system. It occurs as occasional pockets surrounded by *Low heath* sandplain within several kilometres of the coast. The soils are calcareous (brown) deep sands (soil group 442).

Structure and composition

MELW is characterised by dense stands of mature teatrees (*Melaleuca cardiophylla*) up to 6 m high and with PFC 30 to 50 per cent. The teatrees tend to form groves with few if any understorey low shrubs. Other areas are only weakly groved and support slightly more low shrubs. Within the groves are occasional patches of mallee (*Eucalyptus* sp.) with abundant leaf litter and no low shrub understoreys.

The following species listed by stratum are dominant or common. Dominance is indicated by numbers ([1, 2, 3, 4] or [5]) with the lowest number being most prevalent. Other species are listed in order of dominance:

Trees:	*Melaleuca cardiophylla* (teatree)[1], *Eucalyptus* sp.
Tall shrubs:	*Pimelea microcephala* (shrubby riceflower).
Mid shrubs:	*Olearia axillaris* (coastal daisy bush), *Pimelea microcephala, Solanum nummularium* (wild tomato), *Sida* sp., *Rhagodia drummondii* (low saltbush).
Low shrubs:	*Pimelea leucantha* (big riceflower)[2], *Acanthocarpus preissii*, *Ptilotus obovatus* (cotton bush).
Perennial grasses:	*Austrostipa elegantissima* (feather speargrass).
Annuals:	*Austrostipa* sp. (annual speargrass), *Avena barbata* (bearded oat)*.

*Introduced weed.

*Dense stands of mature teatree (*Melaleuca cardiophylla*) with occasional patches of mallee (*Eucalyptus *sp.) characterise the Melaleuca woodland vegetation type. The low shrub component of this vegetation is more frequently found around the perimeter of the grove rather than under the tree layer. This vegetation type occurs as infrequent small patches within the southern heath sandplains of the Zuytdorp land system.*

Condition summary and land management

Sampling: 1 inventory site and 1 traverse assessment

There were insufficient traverse assessments to compile valid vegetation or soil erosion summaries but, where sampled, MELW was in good condition without soil erosion.

MELW is at very best, only suited to grazing livestock for very short, controlled times during favourable seasons, and then with minimal stock numbers. Palatable plants include shrubby riceflower (*Pimelea microcephala*), *Sida* sp., low saltbush (*Rhagodia drummondii*), cotton bush (*Ptilotus obovatus*), feather speargrass (*Austrostipa elegantissima*), annual speargrass (*Austrostipa* sp.) and the introduced grass, bearded oat (*Avena barbata*). During favourable winter and spring seasons the flush of annual herbs and grasses will complement the palatable perennials, however grazing levels must be guided by sustainable landscape principles. The heath sandplains surrounding MELW contain very few palatable plants and no shelter areas. As such, the melaleuca groves may be utilised as preferred grazing and camp areas and may be susceptible to overuse.

This vegetation occurs on pastoral lease land and is not represented in any conservation reserves. No Priority plant species were found.

17. Melaleuca swamp shrubland (MESS)

General information

Melaleuca swamp shrubland was first described in Payne et al. (1998) occurring in land systems with significant drainage features. Within this survey MESS was not sampled and was found only infrequently during traverse, suggesting it is uncommon.

Structure and composition

MESS may occur as very small discrete units within the vicinity of water courses and riverine plains associated with the Murchison River. A variant of this vegetation type was recorded as very minor, weakly defined and localised small internal drainage zones within sandplains on the Nanga land system. Scattered tall and mid shrublands of broom honeymyrtle (*Melaleuca uncinata*) dominate over the sparse low shrub stratum. The deep red sandy earth soils (soil group 463) are mostly non-saline, and when weakly saline may support frankenia (*Frankenia* sp.). Non-saline swamps or the margins of partially saline swamps may support currant bush (*Scaevola spinescens*) and feather speargrass (*Austrostipa elegantissima*).

The following species listed by stratum are dominant or common. Dominance is indicated by numbers ($^{1, 2, 3, 4}$ or ^{5}) with the lowest number being most prevalent. Shared numbers indicate co-dominance. Other species are listed in order of dominance:

Trees: Infrequent *Eucalyptus* sp.

Tall shrubs: *Melaleuca uncinata* (broom honeymyrtle)[1].

Mid shrubs: *Melaleuca uncinata*[1], *Scaevola spinescens* (currant bush).

Low shrubs: *Frankenia* sp. (frankenia)[2].

Perennial grasses: *Austrostipa elegantissima* (feather speargrass).

Condition summary and land management

Sampling: 3 traverse assessments

There were insufficient observations to derive valid vegetation condition or soil erosion summaries but MESS is expected to have low vulnerability to erosion.

Information provided from the neighbouring Murchison survey (Payne et al. 1998), suggests MESS in river areas may contain mid or low shrubs such as ruby saltbush (*Enchylaena tomentosa*), occasional saltbushes (*Atriplex* spp.) and perhaps some bluebush species (*Maireana* spp.). Swamp areas are often refuges for animals (native, feral and livestock). As such, some swamps become animal camps and may well be grazed beyond capacity. Where melaleuca swamps are found in riverine systems, (as small isolated pockets), the vegetation should be managed as part of the whole riverine system.

G. EUCALYPT/ACACIA WOODLAND VEGETATION GROUP

Eucalypt acacia woodlands occur in central west and central parts of the survey on nearly flat loamy plains of the Bibra, York, Stork and, to a lesser extent, Ajana land systems. It is characterised by large eucalypt trees, mainly, but not exclusively, York gum. The other dominant strata may vary from open low shrubs (such as saltbush or cotton bush) to closed mid and tall shrubs dominated by wattle species.

This vegetation group consists of two vegetation types: *Eucalypt saltbush open woodland* (ESOW) and *Eucalypt acacia woodland* (EUAW).

18. Eucalypt saltbush open woodland (ESOW)

General information

The *Eucalypt saltbush open woodland* is described for the first time. It is very similar to the *Plain York gum chenopod woodland* (PYCW) vegetation type described in Payne et al. (1998), but contains more plant species from the South-western Botanical Province.

ESOW occurs on alluvial plains and clay plains with deep red loamy earths (soil group 544) or red/brown non-cracking clays (soil group 622) of the York land system. It also occurs on rounded and gently sloping stony plains of the Stork land system with red shallow loams (soil group 522) overlying siltstone and radiolarite.

Structure and composition

Eucalypt saltbush open woodland is scattered to moderately close with a PFC of 15 to 30 per cent. Although described as woodland, the prominent York gum (*Eucalyptus loxophleba*) tree stratum is usually less dominant than the low shrub layer. The main low shrubs are bladder saltbush (*Atriplex vesicaria*) or silver saltbush (*A. bunburyana*). The mid and tall shrub strata occur in patches and may be common or absent. Where common, the dominant shrubs are wattles (*Acacia* sp.) including curara (*A. tetragonophylla*); where absent, the tree layer assumes prominence.

The following species listed by stratum are dominant or common. Dominance is indicated by numbers ([1, 2, 3, 4] or [5]) with the lowest number being most prevalent. Shared numbers indicate co-dominance. Other species are listed in order of dominance:

Trees: *Eucalyptus loxophleba* (York gum)[2 or 4], infrequent *E. horistes*.

Tall shrubs: *Acacia tetragonophylla* (curara)[3], *Scaevola spinescens* (currant bush), *Acacia acuminata* (jam), *A. sclerosperma* (limestone wattle), *A. anthochaera*, *Hakea preissii* (needle bush).

Mid shrubs: *Acacia* sp.[2], *Rhagodia drummondii* (low saltbush), *Dodonaea inaequifolia* (hopbush), *Exocarpos aphyllus* (naked lady), *Pimelea microcephala* (shrubby

	riceflower), *Senna artemisioides* subsp. *coriacea* (desert cassia), *S. artemisioides* subsp. *artemisioides* (banana leaf), *Hakea* sp., *Scaevola spinescens*.
Low shrubs:	*Atriplex bunburyana* (silver saltbush)[1] or *A. vesicaria* (bladder saltbush)[1], *Ptilotus obovatus* (cotton bush), *Enchylaena tomentosa* (ruby saltbush), *Maireana tomentosa* (felty bluebush), *Olearia* sp., *Ptilotus divaricatus* (climbing mulla mulla).
Perennial grasses:	Infrequent *Austrostipa elegantissima* (feather speargrass).
***Annuals*:**	*Sclerolaena uniflora* (two spine bindii), *Ptilotus axillaris* (mat mulla mulla).

Condition summary and land management

Sampling: 2 inventory sites and 1 traverse assessment

ESOW was insufficiently sampled to derive valid vegetation condition statements. It has a relatively high pastoral value with silver saltbush (*Atriplex bunburyana*) and bladder saltbush (*A. vesicaria*) providing the bulk of fodder for livestock. The salt content in the leaves of saltbush is generally high, but other non-saline plants such as curara (*Acacia tetragonophylla*), currant bush (*Scaevola spinescens*), low saltbush (*Rhagodia drummondii*), cotton bush (*Ptilotus obovatus*), ruby saltbush (*Enchylaena tomentosa*) and felty bluebush (*Maireana tomentosa*) assist to counteract this salinity for herbivores. Under conservative stocking the soils are generally not prone to erosion.

Most of this vegetation occurs on pastoral lease land, with only a very small portion of the York land system occurring within the Kalbarri National Park. No Priority plant species were found.

19. Eucalypt acacia woodland (EUAW)

General information

Eucalypt acacia woodland is described for the first time and is very similar to the *Plain York gum acacia woodland* first described by Payne et al. (1998) in the Yalgoo region. The vegetation is mainly Eremaean, but also includes plants common to the South-western Botanical Province.

It occurs on loamy plains of the Ajana, Highway and York land systems, and to a lesser extent, alluvial plains of the Bibra system and loamy plains of the Nerren system. The soils are mostly red loamy earths (soil group 544) with some red sandy earths (soil group 463).

This vegetation type grades into the *Eucalypt saltbush open woodland (ESOW)* as soils become more clayey and the *Calcrete melaleuca acacia shrubland (CMAS)* in the Bibra system.

*This eucalypt saltbush open woodland is in very good condition. An optimum low shrub cover of bladder saltbush (*Atriplex vesicaria*) is complemented by a stable soil surface with moderate crust cover (dark patches in foreground). During above-average winter seasons the soil surfaces between the saltbush support many annual herbs and wildflowers. The large trees are York gum (*Eucalyptus loxophleba*).*

Structure and composition

Eucalypt acacia woodland occurs as either open woodland with prominent low shrubs, or a more closed woodland (or shrubland) with dense mid shrubs. Although differing in vegetation strata dominance (see photos below), the subsets are composed of similar plant species. In the open woodland format the tree strata of York gum (*Eucalyptus loxophleba*) has slight dominance over the prominent low shrub stratum of cotton bush (*Ptilotus obovatus*). Tall shrubs of curara (*Acacia tetragonophylla*) and mid shrubs of wait-a-while (*A. colletioides*) constitute lesser stratum. Total PFC is scattered to moderately close (15 to 25 per cent).

Within the more closed communities tall shrublands dominate with curara (*Acacia tetragonophylla*), jam (*A. acuminata*) or wanyu (*A. ramulosa*) the most common shrubs. Other tall shrubs are broom honeymyrtle (*Melaleuca uncinata*) or honeymyrtle (*M. eleuterostachya*). Total PFC is moderately close to close (25 to 50 per cent). The tree stratum of York gum is mostly isolated to very scattered and may occur as isolated dense groves.

The following species listed by stratum are dominant or common. Dominance is indicated by numbers ([1, 2, 3, 4] or [5]) with the lowest number being most prevalent. Shared numbers indicate co-dominance. Other species are listed in order of dominance:

Trees:	*Eucalyptus loxophleba* (York gum)[1, 2, 3 or 5].
Tall shrubs:	*Acacia ramulosa* (wanyu)[1] or *A. tetragonophylla* (curara)[1] or *A. acuminata* (jam)[1] or *Melaleuca uncinata* (broom honeymyrtle)[1] or *M. eleuterostachya* (honeymyrtle)[1] or *A. sclerosperma* (limestone wattle)[1], *Grevillea* sp., *Santalum spicatum* (sandalwood), *S. acuminatum* (quandong), *Allocasuarina* sp., *Hakea recurva* (djarnokmurd), *Eremophila* aff. *oldfieldii* (pixie bush), *Duperreya sericea* (creeper).
Mid shrubs:	*Acacia ramulosa*[3], *Rhagodia drummondii* (low saltbush)[3], *Pimelea* sp.[3], *A. andrewsii* (prickly wattle)[3], *Hakea preissii* (needle bush)[3], *A. tetragonophylla*[4], *Exocarpos aphyllus* (naked lady), *Senna artemisioides* subsp. *artemisioides* (banana leaf), *Scaevola spinescens* (currant bush), *S. tomentosa* (ragged leaf fanflower), *Dodonaea inaequifolia* (hopbush), *Senna artemisioides* subsp. *coriacea* (desert cassia), *Pimelea microcephala* (shrubby riceflower).

Two formats of the eucalypt acacia woodland: ***(left)*** *open woodland with large York gum (*Eucalyptus loxophleba*) trees (8 to 10 m) with open low shrub understoreys of cotton bush (*Ptilotus obovatus*); and* ***(right)*** *closed tall shrublands with patchy tall shrubs of wanyu (*Acacia ramulosa*) and emergent eucalypts. Both formats support similar plant species, but these species vary in dominance. Soils are mostly red loamy earths, but where the soils become more sandy, species diversity decreases and York gums become less common.*

Low shrubs: *Ptilotus obovatus* (cotton bush)[2, 3 or 4], *Acacia colletioides* (wait-a-while)[4], Myrtaceae (unidentified)[4], *Solanum nummularium* (wild tomato)[4], *Enchylaena tomentosa* (ruby saltbush), *Maireana tomentosa* (felty bluebush), *Atriplex bunburyana* (silver saltbush), *Ptilotus divaricatus* (climbing mulla mulla), *P. schwartzii* (horse mulla mulla), *Dianella revoluta* (flax lily).

Perennial grasses: *Eriachne* sp. (buck wanderrie)[5], occasional *Austrostipa elegantissima* (feather speargrass), *Amphipogon* sp. (grey beard grass).

Annuals: *Sclerolaena* sp. (bindii), *Calandrinia* sp. (parakeelya), *Ptilotus exaltatus* (tall mulla mulla), *Zygophyllum* sp. (twin leaf).

Condition summary and land management

Sampling: 7 inventory sites

Traverse condition summary (31 traverse assessments):

Vegetation—36% very good; 45% good; 10% fair; 6% poor; 3% very poor

Soil erosion—nil

EUAW supports many plant species suited to grazing livestock, including shrubby riceflower (*Pimelea microcephala*), currant bush (*Scaevola spinescens*), cotton bush (*Ptilotus obovatus*), climbing mulla mulla (*P. divaricatus*), ruby saltbush (*Enchylaena tomentosa*), felty bluebush (*Maireana tomentosa*), occasional silver saltbush (*Atriplex bunburyana*), feather speargrass (*Austrostipa elegantissima*), bindii (*Sclerolaena* sp.) and tall mulla mulla (*P. exaltatus*). The patchiness of the vegetation would encourage good flushes of annual herbs, forbs and wildflowers following substantive winter seasons. This vegetation type is not widespread, and one historical pastoral classification plan (Harrington 1967) suggests artificial water supplies for livestock may be difficult to obtain. EUAW is mostly not susceptible to soil erosion.

This vegetation occurs on pastoral lease land and is not represented on conservation reserves. No Priority plants were found.

H. DRAINAGE WOODLAND/ SHRUBLAND VEGETATION GROUP

The drainage woodland/shrubland vegetation group occurs principally along the channels and associated alluvial plains of the Murchison River. In the upper Murchison area described by Curry et al. (1994), the channels of the Murchison River are flanked by broad open flood plains or alluvial plains up to 10 km wide. Decadal scale large river flows result in these plains being inundated for several weeks and water flow across the plains is sluggish. Toward the eastern end of the lower Murchison area, the broad plains give way to more restricted alluvial plains a few kilometres wide alongside the river channels. The meander channels are further restricted in the adjoining Ajana system. These restricted channels then cut into sandstone to form the Kalbarri gorges before opening out onto floodout zones near the river mouth.

The drainage woodland/shrubland association comprises three vegetation types: *Drainage channel woodland* (DRCW) in the centre and east, *Drainage eucalypt open woodland* (DEOW) in the west of the survey area and the very minor *Drainage melaleuca shrubland* (DRMS).

20. Drainage channel woodland (DRCW)

General information

Drainage channel woodlands occur along the major drainage channels of the Murchison River. In the east of the survey area, the Murchison River is mostly mapped within the Yandi land system.

In central survey area the Murchison River falls within the Ajana land system, and joins the Tumblagooda land system in the west. Within these systems, the channels are restricted to a narrow drainage zone. The incised drainage within the Tumblagooda land system is mostly 100 to 200 m wide. Some slightly wider drainages support small floodout zones (to 350 m wide).

The soils are poorly sorted deposits of sand, silt and river-worn pebbles with occasional sand banks to 2 m high. Away from major channels DRCW grades into *Riverine shrubland* (RIVS) and *Hardpan acacia shrubland* (HPAS).

Structure and composition

The main banks of the river channel, with some silt deposits and some areas of exposed hardpan, are lined with 8 to 10 m tall trees of river red gum (*Eucalyptus camaldulensis*) and swamp sheoak (*Casuarina obesa*). The major channel may be incised to a depth of 1 m to about 8 m below truncated levees. Sandy deposits adjacent to the river also support scattered river red gum. There were no low shrubs or reeds normally associated with river channels. Away from the channels are occasional tall shrubs or small trees of coolibah (*E. victrix*).

Within the western narrow drainage zone floodout areas are river red gum and swamp sheoak trees (to 8 m) and honeymyrtle (*Melaleuca eleuterostachya*) tall shrubs. The soil surfaces support common crusts with some sparse herbs and grasses. Perennial plant species diversity, as in the eastern riverine channels, is very low. PFC within DRCW is very scattered to scattered (5 to 15 per cent).

The following species listed by stratum are dominant or common. Dominance is indicated by numbers ([1, 2, 3, 4] or [5]) with the lowest number being most prevalent. Shared numbers indicate co-dominance. Other species are listed in order of dominance:

Trees:	*Casuarina obesa* (swamp sheoak)[1], *Eucalyptus camaldulensis* (river red gum)[1].
Tall shrubs:	*Melaleuca eleuterostachya* (tall honeymyrtle)[2], *Callistemon phoeniceus* (river bottlebrush), *Acacia sclerosperma* (limestone wattle).
Low shrubs:	*Templetonia* sp., *Leptosema aphyllum* (flat leaf cockies tongues).
Annuals:	Unidentified herbs and grasses.

Condition summary and land management

Sampling: 2 inventory sites

Traverse condition summary (6 traverse assessments):

Vegetation—0% very good; 17% good; 17% fair; 33% poor; 33% very poor

Soil erosion—83% nil; 17% minor

The floodout margins and channels of the Murchison River have sand redistribution and exposures of sandstone with flood deposits, quite typical of areas subjected to regular (but infrequent) flooding. The scattered PFC may be indicative of areas subject to regular flooding, but is more likely to suggest historic overgrazing by livestock and/or feral animals as semi-permanent water supplies are afforded by the main river channels. While the river may not provide suitable water all year round it may encourage grazing animals to stay in the area. The lack of species diversity and the low plant numbers (and subsequently ground cover), has resulted in some minor erosion. This erosion

*Drainage channel woodlands. The main tree-lined channel of the Murchison River in the Yandi land system **(left)**, some 100 kilometres upstream from the river mouth and a small floodout narrow drainage zone **(right)** of the Tumblagooda land system (about 30 km upstream from the river mouth). Both areas lack mid and low shrub stratum. While minor erosion was noted, parts of this narrow drainage line are covered by dry, unidentified annual herbs and grasses. This part of the landscape would benefit from destocking and feral animal control.*

was evidenced as accumulation of soil around plant bases with plant mounds noticeably enlarged.

A protected remnant bush area on the banks of the Murchison River adjacent to farming land (about 12 km east of the Galena Bridge), indicates the benefits of excluding grazing animals. This remnant area supports a suite of plants, where all vegetation strata are well represented. Key indicator plants (suggesting improved land condition) such as felty bluebush (*Maireana tomentosa*), flat leaf bluebush (*M. planifolia*) and grey copperburr (*Sclerolaena diacantha*) were found only in the remnant bush area.

21. Drainage eucalypt open woodland (DEOW)

General information

Drainage eucalypt open woodland vegetation type occurs on the river mouth floodplains of the Murchison River within the Tumblagooda land system. The floodplains occur up to 10 km upstream from the river mouth, and are regularly (but infrequently) inundated during large river flows. The plains may be up to a kilometre wide near the river mouth, and narrow further upstream. Most of the floodplains consist of poorly sorted river sand deposited through major river flows, with the outer margins of the plains having silty, stone-free, brown loamy earths (soil group 541).

Structure and composition

Drainage eucalypt open woodlands support large river red gums (*Eucalyptus camaldulensis*) to 10 m high. All of the river red gums are mature with very few young trees. PFC is 20 to 25 per cent. Where the river mouth floodplains have been used for livestock grazing, there are few other perennial shrubs. Some of these plains have been substantially modified, either by land clearing or by grazing, but remain relatively stable in respect to water erosion. Annual grasses dominate, including introduced weed species.

The following species listed by stratum are dominant or common. Dominance is indicated by numbers ([1, 2, 3, 4] or [5]) with the lowest number being most prevalent. Other species are listed in order of dominance:

Trees:	*Eucalyptus camaldulensis* (river red gum)[1].
Tall shrubs:	*Acacia tetragonophylla* (curara), *A. sclerosperma* (limestone wattle).
Low shrubs:	*Pimelea microcephala* (shrubby riceflower), *Solanum nummularium* (wild tomato).
Annuals:	*Eriachne* sp. (annual wanderrie), *Raphanus* sp. (wild radish)*, *Avena barbata* (bearded oat)*, *Medicago polymorpha* (burr medic)*, *Solanum nigrum* (black berry nightshade)*, *Hordeum leporinum* (barley grass)*.

*Introduced plant or weed.

*The outer floodplains toward the mouth of the Murchison River occur near the active river channels and support deep silty soils. The vegetation on this part of the floodplain has been modified to a herbfield of annual native grasses and introduced weeds or medics with an overstorey of large river red gums (*Eucalyptus camaldulensis*). In an ungrazed state, tall shrubs of curara (*Acacia tetragonophylla*) and limestone wattle (*A. sclerosperma*), would complement mixed mid or low shrubs and some perennial grasses.*

Condition summary and land management

Sampling: 1 inventory site and 1 traverse assessment.

Insufficient information was obtained to derive valid vegetation condition or soil erosion assessments for this vegetation type. Where sampled, the vegetation stratum below the trees was devoid of perennial plant species, suggesting long-term overgrazing. Where affected, grazing animals should be excluded to encourage the regeneration of native plants with increased plant diversity and numbers being the primary goal. The deep silty soils (with good soil water storage potential) would assist perennial plant regeneration. During flood episodes overland water movement across the outer floodplains is not rapid, and there was no evidence of significant soil loss.

DEOW occurs on pastoral lease land and is not represented in conservation reserves. No Priority plants were found.

22. Drainage melaleuca shrubland (DRMS)

General information

This vegetation represents only a small part of the Yandi land system as small drainage foci, swamps and claypans. The drainage foci represent the lowest part of the local landscape and are up to 80 metres in diameter. The soils may be grey hard cracking clays (soil group 601) or a mixture of non-cracking clay types (soil group 622).

This vegetation type is associated with *Riverine shrubland* (RIVS).

Structure and composition

Drainage melaleuca shrubland is characterised by very scattered (2.5 to 5 per cent PFC) tall shrublands on deep clay soils. In an ungrazed situation, drainage foci and swamps support tall shrublands, principally broom honeymyrtle (*Melaleuca uncinata*) with some curara (*Acacia tetragonophylla*) and jam (*A. acuminata*). Other strata may contain coolibah (*Eucalyptus victrix*) trees, or shrubs like currant bush (*Scaevola spinescens*), tall saltbush (*Rhagodia eremaea*) and some perennial grasses such as claypan grass (*Eriachne flaccida*) or feather speargrass (*Austrostipa elegantissima*). Some drainage foci may be locally saline where frankenia (*Frankenia* sp.) low shrubs occur in place of the perennial grass stratum.

The following species listed by stratum are dominant or common. Dominance is indicated by numbers ([1, 2, 3, 4] or [5]) with the lowest number being most prevalent. Other species are listed in order of dominance:

Trees:	*Eucalyptus victrix* (coolibah)[2].
Tall shrubs:	*Melaleuca uncinata* (broom honeymyrtle)[1], *Acacia tetragonophylla* (curara).
Mid shrubs:	*Scaevola spinescens* (currant bush), *Melaleuca uncinata*, *Senna glutinosa* subsp. *chatelainiana* (green cassia), *Rhagodia eremaea* (tall saltbush).

*This drainage focus in the Yandi land system would support mid shrubs of currant bush (*Scaevola spinescens*) and tall saltbush (*Rhagodia eremaea*), low shrubs of ruby saltbush (*Enchylaena tomentosa*) and some perennial grasses like claypan grass (*Eriachne flaccida*) when in good condition. Drainage foci are often preferred grazing and camping areas for animals, and as such may be difficult to manage on an individual basis as management requires a 'whole of land system' approach.*

Low shrubs: *Enchylaena tomentosa* (ruby saltbush).

Perennial grasses: *Eriachne flaccida* (claypan grass), *Austrostipa elegantissima* (feather speargrass).

Condition summary and land management

Sampling: 1 inventory site

Where sampled, this vegetation was in poor condition, attributed to excess grazing. Species diversity was low. Damage to tall shrubs from goats suggested uncontrolled grazing. Management of drainage foci and swamps is often difficult as the land units are too small to be treated individually. The condition of these units is often reflected in the adjoining land units (in this case, the alluvial plains), so management should be directed towards adjoining land units or the land system as a whole. There were insufficient traverse assessments to compile valid vegetation or soil erosion summaries.

I. HARDPAN SHRUBLAND VEGETATION GROUP

This group consists of one vegetation type—*Hardpan acacia shrubland* (HPAS).

23. Hardpan acacia shrubland (HPAS)

General information

Hardpan acacia shrubland vegetation is restricted to the Yandi land system in the east of the area where it occurs on hardpan plains, stony hardpan plains and alluvial plains. HPAS is similar to the vegetation habitat described in Payne et al. (1998) as *Hardpan plain acacia shrubland* (HCAS) but differences are noted.

Soils are shallow to moderately deep, sandy loams to loams, overlying red-brown hardpan shallow loam (soil group 523). Red-brown hardpan, described by Teakle (1936) and Bettenay et al. (1974), is a dominant soil feature in the Murchison River catchment to the east of this survey area. On stony plains the soils tend to be shallow and on adjoining alluvial plains the soils trend towards red shallow sandy duplex types. Soil surfaces are mostly hardsetting and the surface cryptogam crusts are usually well established and common. The hardpan plains receive overland water sheet flow from slightly higher units in the landscape, and this flow drains to the main river channels.

HPAS is associated with *Ironstone acacia shrubland* (ISAS) and *Riverine shrublands* (RIVS).

Structure and composition

This vegetation differs from that described by Payne et al. (1998) through the dominance of the tall shrubs like jam (*Acacia acuminata*) and curara (*A. tetragonophylla*), rather than wanyu (*A. ramulosa*). The overall current species diversity also appears to be less than that described toward the Yalgoo area. The tall shrub layer is the most dominant with over two-thirds of the total PFC (15 to 20 per cent). The mid shrub layer and the low shrubs follow in dominance order. There is no tree stratum and minor occurrences of small patches of perennial grass could be expected in an optimal state. The dominant mid and low shrubs are banana leaf (*Senna artemisioides* subsp. *artemisioides*).

The following species listed by stratum are dominant or common. Dominance is indicated by numbers ([1, 2, 3, 4] or [5]) with the lowest number being most prevalent. Shared numbers indicate co-dominance. Other species are listed in order of dominance:

Tall shrubs: *Acacia acuminata* (jam)[1], *A. tetragonophylla* (curara)[1], *A. ramulosa* (wanyu), *A. sclerosperma* (limestone wattle), *Hakea recurva* (djarnokmurd), *H. preissii* (needle bush), *Eremophila longifolia* (berrigan), *Santalum spicatum* (sandalwood), *Duperreya sericea* (creeper).

Mid shrubs: *Senna artemisioides* subsp. *artemisioides* (banana leaf)[2], *Rhagodia eremaea* (tall saltbush), *Eremophila forrestii* (Wilcox bush).

Low shrubs: *Senna artemisioides* subsp. *artemisioides*[3], *Mirbelia* sp.[3], *Solanum nummularium* (wild tomato), *Ptilotus obovatus* (cotton bush), *Sida calyxhymenia* (tall sida).

*The hardpan plains of the Yandi land system have co-dominant tall shrubs of curara (*Acacia tetragonophylla*) and jam (*A. acuminata*). Historical or long-term grazing has reduced the productivity of this landscape. In fair or good condition, Hardpan acacia shrubland should support species such as currant bush (*Scaevola spinescens*), tall saltbush (*Rhagodia eremaea*), flat leaf bluebush (*Maireana planifolia*) and ruby saltbush (*Enchylaena tomentosa*). The decline in plant species diversity and plant density over time has resulted in soil erosion.*

Condition summary and land management

Sampling: 2 inventory sites

Traverse condition summary (17 traverse assessments):

Vegetation—0% very good; 12% good; 23% fair; 18% poor; 47% very poor

Soil erosion—76% nil; 12% slight; 12% minor

HPAS was described from two inventory sites, 17 traverse assessments and information provided in Payne et al. (1998). It generally had small populations of desirable plants. Desirable plants such as cotton bush (*Ptilotus obovatus*), were only recorded on 18 per cent of the traverse point data, with tall saltbush (*Rhagodia eremaea*) and Wilcox bush (*Eremophila forrestii*) only recorded on 12 per cent of the points. In good condition, this vegetation type would support these plants at much higher frequency and frequently include other palatable plants such as currant bush (*Scaevola spinescens)*, flat leaf bluebush (*Maireana planifolia*) and tall sida (*Sida calyxhymenia*).

This vegetation/soil association is currently relatively stable but more erosion may lead to further species decline unless some conservation practices are employed.

HPAS does not appear to support any threatened plant species, but conservation practices or minimal stocking will result in much improved rangeland health and biodiversity.

This vegetation occurs on pastoral lease land and is not represented in conservation reserves. No Priority plants were found.

J. RIVERINE MIXED SHRUBLAND VEGETATION GROUP

Riverine shrublands occur on alluvial plains alongside the main channels of the Murchison River and the Bungabandi Creek. In the east, the Murchison River runs through the Roderick and Bayou land systems which support riverine vegetation. Here the river banks and levees join broad floodplains and alluvial plains up to several kilometres wide. During cyclical flood events these outer plains are inundated for up to several weeks and overland water flow on the outer margins is sluggish. Vegetation is principally a bluebush/saltbush-dominated low shrubland.

Further downstream, in the Yandi and Ajana land systems, the river valley and floodout areas become more restricted and overland water flow across the more restricted plains is less sluggish. With altered water regimes the vegetation also changes from an open low/mid shrubland to a tall shrubland of riverine shrubs similar to that described in Curry et al. (1994). Upon entering the Tumblagooda land system further downstream, the river constricts yet again to be a comparatively narrow drainage floor for most of its remaining length. The Bungabandi Creek (and to a lesser extent, the

Wittecarra Creek) are small drainage lines with some saline areas. Similarly some land systems in the far east of the survey area (for example the Boulder system) may be locally saline and support riverine halophytic shrub communities.

The Riverine mixed shrubland group consists of three vegetation types: *Alluvial plain shrubland* (PLAS), *Riverine shrubland* (RIVS) and *Frankenia shrubland* (FRAN).

24. Alluvial plain shrubland (PLAS)

General information

This vegetation type was originally described by Curry et al. (1994) as part of the *Bluebush shrubland* vegetation type, and by Payne et al. (1998), as the *Plain sago bush shrubland*. In this survey PLAS only occupies a very small percentage of the total area. It occurs on alluvial plains and floodplains of the Bayou and Roderick land systems alongside active channels of the Murchison River. Soils are mostly deep red sandy duplex types or shallow red sandy duplexes overlying red-brown hardpan.

Structure and composition

PLAS was not sampled and descriptions are derived from Curry et al. (1994), Payne et al. (1998) and the author's own experience. PLAS is a low shrubland dominated by sago bush (*Maireana pyramidata*). In good condition it supports other low shrubs including desirable chenopod species of various bluebushes (*Maireana* spp.), saltbushes (*Atriplex* spp.) and some samphire (*Halosarcia* spp.). Other non-chenopod species are common but rarely dominate and include tall shrubs of curara (*Acacia tetragonophylla*), wait-a-while (*A. victoriae*) and needle bush (*Hakea preissii*), with mid shrubs of banana leaf (*Senna artemisioides* subsp. *artemisioides*) and low shrubs of flannel bush (*Solanum lasiophyllum*) and cotton bush (*Ptilotus obovatus*).

The following species listed by stratum are dominant or common. Dominance is indicated by numbers ([1, 2, 3, 4] or [5]) with the lowest number being most prevalent. Other species are listed in order of dominance:

Tall shrubs:	*Acacia tetragonophylla* (curara)[3], *Hakea preissii* (needle bush)[5], *A. victoriae* (wait-a-while).
Mid shrubs:	*Senna artemisioides* subsp. *artemisioides* (banana leaf)[2], *Acacia tetragonophylla, Hakea preissii*, *Rhagodia eremaea* (tall saltbush).
Low shrubs:	*Maireana pyramidata* (sago bush)[1], *Senna artemisioides* subsp. *artemisioides*[4], *Atriplex bunburyana* (silver saltbush), *Frankenia* sp. (frankenia), *Halosarcia* sp. (samphire), *Ptilotus obovatus* (cotton bush), *Solanum lasiophyllum* (flannel bush).
Annuals:	*Sclerolaena* sp. (bindii).

Condition summary and land management

Sampling: 2 traverse assessments

PLAS was insufficiently sampled to derive valid vegetation condition and soil erosion summaries. One traverse point was assessed as in fair vegetation condition and the other as poor.

Alluvial plain shrublands are preferred by livestock and, as a result of long-term grazing, now have altered population densities and structures; however most original species are still present (though not in optimum numbers). The once dominant sago bush has been replaced in parts by undesirable or intermediate species such as needle bush, banana leaf and curara. In the Murchison survey (Curry et al. 1994), about 60 per cent of the bluebush shrubland sites (similar to PLAS) showed incidences of accelerated soil erosion. However, no erosion was noted in this survey.

PLAS only exists in the far east of the survey area and may provide, with appropriate management, a sago bush seed source for areas further downstream.

PLAS occurs on pastoral lease land and is not represented on conservation reserves. No Priority plant species were found.

25. Riverine shrubland (RIVS)

General information

Riverine shrublands flank major drainage lines or water courses of the Murchison River and occur widely on the alluvial plains of the Yandi land system and as minor components of the Roderick, Ajana and Tumblagooda systems. A similar vegetation group was described by Curry et al. (1994) and applied to land systems

further inland where trees are more dominant with varied shrub layers supporting many different plant species. In the lower Murchison survey area, the major drainage tracts tend to be more restricted and as such, overland water flow tends to disperse more rapidly resulting in mostly non-saline soils. The soils are deep red loamy earths mostly overlying red-brown hardpan, with some more shallow loams close to drainage channels. RIVS grades into *Hardpan acacia shrubland (HPAS)* and *Alluvial plain shrubland (PLAS)*.

Structure and composition

Riverine shrubland vegetation is a tall shrubland. The tall shrub layer, consisting of about half to three-quarters of the total PFC of 10 to 25 per cent, is dominant. Jam (*Acacia acuminata*) is the most common species with less common wait-a-while (*A. victoriae*), needle bush (*Hakea preissii*) and banana leaf (*Senna artemisioides* subsp. *artemisioides*). The very scattered mid shrub layer is mostly banana leaf with some curara (*A. tetragonophylla*) and wanyu (*A. ramulosa*). The low shrub layer is isolated (less than 2.5 per cent PFC) and is also dominated by banana leaf with minor occurrences of red grevillea (*Grevillea deflexa*). Perennial grasses and annuals are infrequent.

The following species listed for the alluvial plains by stratum are dominant or common within the Riverine shrubland vegetation. Dominance is indicated by numbers ([1, 2, 3, 4] or [5]) with the lowest number being most prevalent. Shared numbers indicate co-dominance. Other species are listed in order of dominance:

Trees: *Eucalyptus victrix* (coolibah), *E. camaldulensis* (red river gum), *Hakea suberea* (corkwood).

Tall shrubs: *Acacia acuminata* (jam)[1], *A. tetragonophylla* (curara), *Senna artemisioides* subsp. *artemisioides* (banana leaf), *A. victoriae* (wait-a-while), *Hakea preissii* (needle bush), *A. sclerosperma* (limestone wattle), *A. ramulosa* (wanyu), *Santalum acuminatum* (quandong).

Mid shrubs: *Senna artemisioides* subsp. *artemisioides*[2], *Acacia tetragonophylla*[2], *Hakea recurva* (djarnokmurd), *Scaevola spinescens* (currant bush), *Rhagodia eremaea* (tall saltbush), *R. drummondii* (low saltbush), *Eremophila* sp. (poverty bush), *Chenopodium gaudichaudianum* (cottony saltbush), *Grevillea* sp., *Duperreya sericea* (creeper).

Low shrubs: *Senna artemisioides* subsp. *artemisioides*[3], *Grevillea deflexa* (red grevillea), *Solanum lasiophyllum* (flannel bush), *S. nummularium* (wild tomato), *Ptilotus obovatus* (cotton bush), *Enchylaena tomentosa* (ruby saltbush),

The riverine shrublands on alluvial plains flank the Murchison River. This site is only about 200 m from the main channel of the river. During decadal flood events, areas such as these are inundated to a depth of over 1 m. Bare soil surfaces are at risk from erosion. Destocking and feral animal control are needed to encourage plant recovery and minimise the threat of erosion.

	Senna artemisioides subsp. *coriacea* (desert cassia), *Eremophila latrobei* (warty leaf fuchsia), *E.* sp., *Maireana thesioides* (lax bluebush), *M.* sp., *M. planifolia* (flat leaf bluebush).
Perennial grasses:	*Austrostipa elegantissima* (feather speargrass).
Annuals:	*Sclerolaena* sp. (bindii), *Salsola tragus* (roly poly), *Avena barbata* (bearded oat)*.

*Introduced plant or weed.

Condition summary and land management

Sampling: 9 inventory sites

Traverse condition summary (40 traverse assessments):

Vegetation—0% very good; 0% good; 3% fair; 17% poor; 80% very poor

Soil erosion—43% nil; 15% slight; 22% minor; 10% moderate; 10% severe

The *Riverine shrubland* vegetation description is derived from inventory sites, traverse assessments and information provided in Curry et al. (1994). The number of plant species found within this survey area compares favourably with those found in the upper Murchison. However, low numbers of palatable species and high numbers of unpalatable species suggest historic overuse or insufficient animal control. From a total of seven sites within the alluvial plain land unit, six were used for livestock grazing and one site was from a freehold reserve. The group of six sites averaged 10 different perennial species per site with an average of four species palatable to livestock. The freehold reserve site had 18 species of which seven were palatable to livestock. Four of the six sites also showed some form of soil erosion ranging from slight sheeting, to moderate rilling or pedestalling. Ten per cent of traverse records indicated severe erosion.

The *Riverine mixed shrubland* as assessed by Curry et al. (1994) further upstream has high pastoral value. RIVS as described here is very similar and, although not quite as diverse as the upper Murchison, still has high long-term potential with correct management. In its present condition, it requires spelling from grazing to encourage recovery.

RIVS is currently preserved on a small area of freehold land adjacent to the Murchison River. It is likely to have high conservation value as it is restricted to the Murchison River. No Priority plant species were recorded.

26. Frankenia shrubland (FRAN)

General information

Frankenia shrubland occurs as a low shrubland on narrow drainage tracts of the Bungabandi land system, saline plains of the Boulder system and on floodplains of the Bayou and Roderick systems. On floodplains it often occurs as isolated, relatively small depressions mostly surrounded by alluvial plains. Within the Bungabandi land system the soils are red shallow sandy duplex types (soil group 406).

FRAN is relatively infrequent in this survey area. In other surveys, it is described as part of *Mixed halophyte shrublands* (Curry et al. 1994) or as a minor habitat with chenopods (Payne et al. 1998).

Structure and composition

FRAN is almost always a low shrubland with a total PFC of 10 to 15 per cent. On most areas the mid and tall shrub layers are either absent or poorly defined. The dominant low shrub is frankenia (*Frankenia* sp.) or it may share co-dominance with samphire (*Halosarcia* spp.). Scattered mid or tall shrubs are mostly needle bush (*Hakea preissii*) with some curara (*Acacia tetragonophylla*). In areas where frankenia and samphire are co-dominant, low shrubs may include felty bluebush (*Maireana tomentosa*), silver saltbush (*Atriplex bunburyana*) and sweet samphire (*Gunniopsis quadrifida*). Mid or tall shrubs are generally absent when the area is in good condition. This vegetation group does not support perennial grasses. The most abundant annual plants are commonly bindiis (*Sclerolaena* spp.).

The following species listed by stratum are dominant or common. Dominance is indicated by numbers ([1, 2, 3, 4] or [5]) with the lowest number being most prevalent. Other species are listed in order of dominance:

Tall shrubs:	*Hakea preissii* (needle bush)[3], *Acacia saligna* (golden wreath wattle), *A. tetragonophylla* (curara).
Mid shrubs:	*Hakea preissii*[2], *Acacia tetragonophylla*.

*Frankenias are adapted to saline areas such as this narrow drainage zone of the Bungabandi land system (they also grow on the seaward faces of the Zuytdorp Cliffs where strong, salt-laden winds are common). Although salt crystals are often visible on the leaves, the plants are readily grazed by sheep provided non-saline stock water is available. The occasional tall and low shrubs are needle bush (*Hakea preissii*), a plant not grazed by livestock. The presence of the palatable decreaser tie bluebush (*Didymanthus roei*), a small, weakly-branched low shrub to 30 cm, suggests that grazing pressure has not been excessive.*

Low shrubs: *Frankenia* sp. (frankenia)[1], or co-dominant *Frankenia* sp.[1] and *Halosarcia* spp. (samphire)[1], *Atriplex bunburyana* (silver saltbush), *Gunniopsis quadrifida* (sweet samphire), *Lawrencia squamata* (grey fan leaf), *Hakea preissii, Senna artemisioides* subsp. *artemisioides* (banana leaf), *Maireana tomentosa* (felty bluebush), *Didymanthus roei* (tie bluebush).

Condition summary and land management

Sampling: 2 inventory sites

Traverse condition summary (5 traverse assessments):

Vegetation—20% very good; 40% good; 20% fair; 20% poor; 0% very poor

Soil erosion—80% nil; 20% minor

The *Frankenia shrubland* vegetation was described from two inventory sites, two traverse assessments and information in Curry et al. (1994) and Payne et al. (1998). Within the two sites sampled, one was dominated by frankenia (*Frankenia* sp.), the other showed co-dominance with samphire (*Halosarcia* spp.). Tall and mid shrubs of needle bush (*Hakea preissii*), and curara (*Acacia tetragonophylla*) were present as isolated plants. Frankenia plants were represented in numerous age classes (young to mature plants), but there was little species diversity. Where frankenia and samphire were co-dominant, species diversity was greater. One plant species uncommon in the rangelands, tie bluebush (*Didymanthus roei*), was found in FRAN on the Bungabandi land system. Tie bluebush generally grows in the inland northern wheatbelt with sporadic occurrences to Shark Bay. Around the freehold farming area of Mary Springs, tie bluebush is common within roadside reserves but uncommon on pastured farming land, indicating the species is preferred by livestock.

FRAN shrublands occur commonly as small areas in the adjacent Murchison and Yalgoo rangelands. There are currently no plans to reserve it within the lower Murchison survey area.

K. MIXED CHENOPOD SHRUBLAND VEGETATION GROUP

Bluebush, saltbush, samphire and bindii plants are collectively known as chenopods and most are palatable to livestock. In this survey the mixtures of certain chenopods constitute a unique vegetation group significantly different to others in the surrounding rangelands. The group comprises one relatively uncommon vegetation type occurring on undulating plains with (mostly) brown loamy earths.

27. Mixed chenopod shrubland (MXCS)

General information

Mixed chenopod shrublands occur on footslopes and lower plains of the Pillawarra land system. This system is unique with soils of brown loamy earths (soil group 541). They have little or no stony mantle and appear to be more fertile than most southern rangeland soils. In good condition they support highly productive chenopod vegetation.

Many *Mixed chenopod shrublands* have been profoundly degraded by historic overgrazing and fire. On deep soils, relatively distant from water points, it exists as sparse degraded stands of small leaf bluebush (*Maireana brevifolia*), silver saltbush (*Atriplex bunburyana*) and frankenia (*Frankenia* sp.). Close to permanent water points (natural or man-made) the vegetation has been completely altered. The perennial low shrublands have undergone successional change to annual grasslands and herbfields of mostly exotic plants. These grasslands and herbfields are grazed by livestock and feral goats during winter and spring, but provide no benefit to grazing animals during other seasons.

Frequent very large active gullies are common on parts of the Pillawarra land system that support MXCS.

Structure and composition

When in good condition MXCS is dominantly a low shrubland. In areas away from permanent livestock watering points, PFC is about 5 to 10 per cent and consists of a mixture of perennial chenopods, mostly small leaf bluebush (*Maireana brevifolia*) and some silver saltbush (*Atriplex bunburyana*). Some areas closer to permanent stock watering points have undergone grazing induced successional change with cotton bush (*Ptilotus obovatus*) replacing small leaf bluebush. Mid shrubs are isolated and tall shrubs or trees are virtually non-existent. In areas subject to heavy grazing, perennial vegetation is isolated (PFC less than 2.5 per cent) and often less than 1 per cent. Here there are few if any low shrubs, and annual introduced grasses and annual or biennial bindiis have replaced perennial chenopods.

The following species listed by stratum are dominant or common. Dominance is indicated by numbers ([1, 2, 3, 4] or [5]) with the lowest number being most prevalent. Other species are listed in order of dominance:

Tall shrubs:	Very infrequent *Acacia tetragonophylla* (curara).
Mid shrubs:	*Rhagodia eremaea* (tall saltbush)[2], *Hakea preissii* (needle bush), *Acacia tetragonophylla*, *A. sclerosperma* (limestone wattle). In degraded communities the mid shrubs are: *A. tetragonophylla*[3] and *A. galeata* (leather leaf wattle).
Low shrubs:	*Maireana brevifolia* (small leaf bluebush)[1], or *Ptilotus obovatus* (cotton bush)[1], *Atriplex bunburyana* (silver saltbush), *Frankenia* sp. (frankenia), *Maireana tomentosa* (felty bluebush), *Chenopodium gaudichaudianum* (cottony saltbush), *Sclerolaena uniflora* (two spine bindii), *Enchylaena tomentosa* (ruby saltbush). In degraded communities the low shrubs are: *Solanum nummularium* (wild tomato)[2] and/or *Pimelea leucantha* (big riceflower)[2] with a very occasional myrtaceous (unidentified) species.
Annuals:	*Sclerolaena* sp. (bindii), *Atriplex semilunaris* (annual saltbush), *Austrostipa* sp. (annual speargrass). In degraded communities *Avena barbata* (bearded oat)*[1], *Carthamus lanatus* (saffron thistle)*, *Medicago polymorpha* (medic)*, *Mesembryanthemum nodiflorum* (ice plant)*, *Argemone ochroleuca* subsp. *ochroleuca* (Mexican poppy)*.

*Introduced plant or weed.

Condition summary and land management

Sampling: 5 inventory sites

Traverse condition summary (42 traverse assessments):

Vegetation—0% very good; 0% good; 7% fair; 26% poor; 67% very poor

*A Mixed chenopod shrubland in good condition **(left)** and very poor condition **(right)**: the very poor condition site is close to permanent livestock water and has lost valuable perennial species, resulting in visual, botanical and grazing detriment of the landscape. The Mixed chenopod shrublands on the Pillawarra land system are unique in the Western Australian rangelands.*

Soil erosion—nil 52%; slight 12%; minor 12%; moderate 12%; severe 12%

In areas of low or undulating plains associated with permanent stock watering points this vegetation type has undergone severe change. In the most affected areas, no original perennial species remain and have been replaced mostly by annual introduced weeds.

On the plateaux above the undulating plains, burnt tree stumps indicate past fires. Lower plains with abundant annual grasses are susceptible to fire, and fire inhibits the regeneration of chenopods and some other native plant species. Combined with herbivore grazing, fire has assisted successional vegetation change. Away from permanent livestock watering points, areas with perennial chenopods do not have annual introduced grasses to encourage fire.

Over 40 per cent of the traverse records indicated some form of erosion. Half indicated moderate (20 to 50 per cent of the area affected) or severe (50 to 75 per cent of the area affected) erosion in the forms of sheeting and gullying. In areas lacking perennial species, some soils displayed properties in the topsoils, normally associated with subsoil layers. Subsoil layers often display dispersion and slaking properties while intact topsoils are generally non-dispersive and non-slaking. Some degraded sites within this vegetation had unstable soil surfaces suggesting prior topsoil erosion. Sheet erosion was confirmed through the presence of large erosion gullies further downslope.

In areas away from permanent watering points the projected foliar cover for MXCS was very scattered (PFC 5 to 10 per cent). Species diversity was relatively high and did not appear to be affected by grazing, but the number of desirable plants was lower than normally expected. On the hilltops and plateaux, species diversity and the density of desirable perennial plants were also reduced. In general, areas seriously affected by grazing require total grazing exclusion of livestock, feral and native animals.

The Pillawarra land system is unique in Western Australian rangelands and parts of it, and the uncommon MXCS that it supports, should be preserved through excluding livestock and feral animals.

CROPPED LANDS

The southern boundary of the lower Murchison survey area joins freehold farming land of the northernmost extremity of the wheatbelt. The wheatbelt reliably grows annual cereal crops via regular rainfall. During average or above-average winter rainfall seasons, some land in the lower Murchison is capable of producing cereal. However, below-average or late winter rainfall seasons do not provide suitable conditions for cereal crops and on average, production may only be successful in every five to seven years out of ten.

Almost 13 000 hectares of land within the lower Murchison is cleared for cereal production. Land clearing is mostly discouraged on pastoral leases, however, these areas come via

special conditions or special freehold granted by the Pastoral Lands Board. Most of the land cleared for cropping has either deep yellow sands or red sandy earths. Rogers (1996) investigated the cropped areas as part of a separate project.

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Land systems

Twenty-three land systems have been identified within the lower Murchison survey area. Eight land systems are described for the first time and the other 15 have been described previously in adjacent rangeland inventory surveys (Payne et al. 1987, Curry et al. 1994, Payne et al. 1998). The land systems are mapped from aerial photography and satellite images and described from field data.

Land systems are described in alphabetical order in this chapter. A summary description of each system's major features is followed by more detailed accounts of the units that comprise each system. Table 7 summarises the features described for each land system.

Land systems with similar combinations of landforms, vegetation, soils and drainage patterns are grouped into broad land types. Table 8 shows a subset of broadly classified land types across the Western Australian rangelands applicable to this survey. The amalgamation of the 23 lower Murchison land systems into 13 land types provides information and mapping at a scale appropriate in a regional or larger context.

Two land systems had mappable areas of severely degraded and eroded land. Severely degraded and eroded is defined as land where vegetation has been grossly depleted resulting in soil erosion and/or the increase of undesirable plant species.

Table 7 **Land system description features**

Land system name, area and percentage of the survey area
Reference to any previous description
Brief descriptive statement of dominant landform(s) and vegetation
Land type (refer to table 2)
Major geological formation or land surface types
Geomorphology overview
Brief description of land management considerations such as susceptibility to soil erosion
Traverse condition summary
The extent of area mapped as severely degraded and eroded (sde)
A locality map showing the distribution of the land system
A plan or block diagram showing the physical features of the system, and with each land unit identified
A list of land units, normally in order of highest to lowest position in the landscape, with the number of sampling points
Land unit area, estimated from aerial photograph interpretation and field observation, is presented as a percentage of the total land system area
Landform—lists each land unit with a description of the landform
Soils—generalised description with reference to the appropriate soil groupings (refer to the soils chapter)
Vegetation—the vegetation is described in four parts: cover density (% projected foliar cover—PFC); dominant species; height class and formation (e.g. shrubland, grassland, etc.). Four letter codes for the vegetation types (refer to the vegetation chapter) are listed

Table 8 **Land systems of the survey classified into land types**

Land type	Description and land systems
1	**Hills and ranges with acacia shrublands** Land system—Tumblagooda
2	**Low hills with eucalypt or acacia woodlands and halophytic shrubs** Land system—Pillawarra
3	**Low hills and stony plains with acacia shrublands** Land system—Ajana
4	**Stony plains with acacia shrublands** Land system—Boulder
5	**Stony plains with acacia shrublands and halophytic shrublands** Land system—Mongolia
6	**Sandplains and occasional dunes with grassy acacia shrublands** Land system—Kalli, Sandplain
7	**Sandplains with acacia, mallees and heath** Land system—Bungabandi, Cooloomia, Eurardy, Joseph, Kalbarri, Nanga, Nerren
8	**Plains with eucalypt woodlands and non-halophytic shrubs** Land system—Highway
9	**Alluvial plains with acacia shrublands** Land system—Holmwood, Yandi
10	**Alluvial plains with eucalypt woodlands and halophytic shrubs** Land system—Stork
11	**Alluvial plains with halophytic shrublands** Land system—Bayou, Roderick, York
12	**Calcrete plains with acacia shrublands** Land system—Bibra
13	**Coastal plains, cliffs, dunes and beaches** Land system—Zuytdorp

Sampling intensity

Table 9 indicates the area and intensity of sampling on each land system in the survey area. A summary of the condition of each land system is presented in the Resource condition chapter.

Table 9 **Land system areas and sampling intensity**

Land system	Area (ha)	Per cent of total area	No. of inventory sites	No. of traverse assessments	Ha per rating
Ajana	9 017	0.69	5	15	601
Bayou	620	0.05	-	1	620
Bibra	15 561	1.19	7	31	502
Boulder	1 308	0.10	1	3	436
Bungabandi	12 184	0.93	5	20	609
Cooloomia	2 655	0.20	-	4	664
Eurardy	221 378	16.98	12	113	1 959
Highway	16 093	1.23	6	26	619
Holmwood	1 409	0.11	-	-	-
Joseph	1 483	0.11	-	1	-
Kalbarri	98 701	7.75	11	-	-
Kalli	373	0.03	-	-	-
Mongolia	152	0.01	-	-	-
Nanga	215 530	16.53	12	126	1 711
Nerren	394 493	30.25	6	216	1 826
Pillawarra	10 397	0.80	9	44	236
Roderick	252	0.02	-	3	84
Sandplain	188 455	14.45	3	70	2 692
Stork	1 029	0.08	1	4	257
Tumblagooda	41 746	3.20	8	32	1 305
Yandi	11 618	0.89	14	52	223
York	3 124	0.24	3	8	390
Zuytdorp	42 257	3.24	9	56	755
Total	1 289 835				1 563
Other—crop	12 927	0.99	-	-	
riverbed	332	0.03	-	-	
townsite	839	0.06	-	-	
Total survey area (ha)	1 303 933		112	825	

AJANA LAND SYSTEM (9018 ha, 0.7% of the survey area)

Low hills and stony plains supporting acacia-casuarina shrublands.

Land type: 3—Low hills and stony plains with acacia shrublands.

Geology: Proterozoic granulite and gneiss with Quaternary alluvium and colluvium.

Geomorphology: Mostly erosional surfaces; rounded hills and low rises with ridges, and gneissic/granitic mantles; low stony plains with narrow drainage lines; low loamy plains subject to occasional sluggish sheet flow. Overall relief up to 70 m.

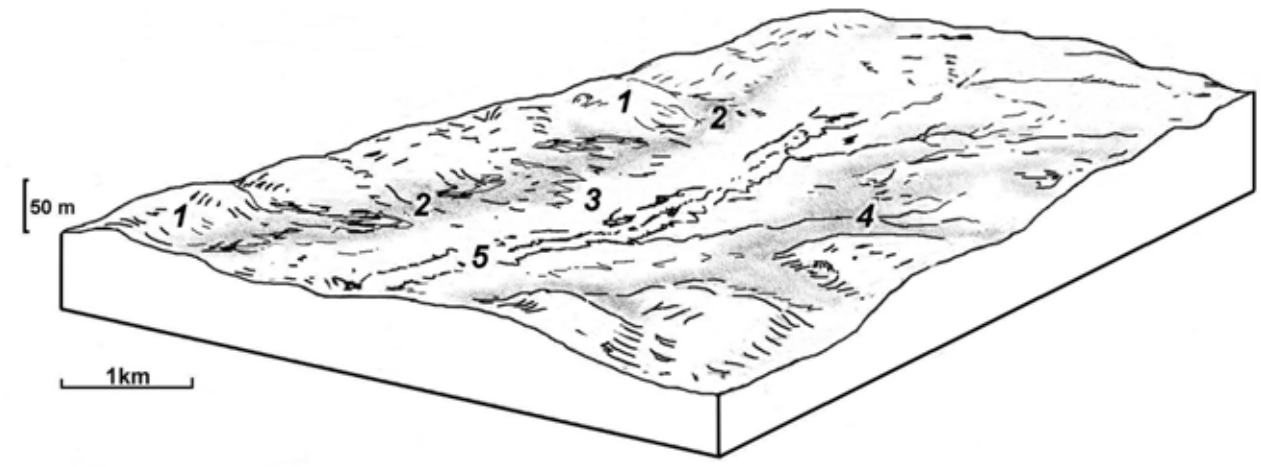
Land management: Much of this system is rugged low hills supporting scattered acacia tall shrublands with understoreys unsuited to livestock grazing. Lower loamy plains support dense tall shrublands or thickets of melaleuca and acacia species with very few low shrubs of negligible use for pastoralism.

Traverse condition summary: (derived from 15 traverse assessments and 5 inventory sites)

Vegetation—very good 13%; good 40%; fair 33%; poor 7%; very poor 7%.
Soil erosion—nil.

Area mapped as sde: Nil.

No.	Unit name	Traverse recordings	Inventory sites
1.	Low rise	1	1
2.	Stony plain	8	2
3.	Loamy plain	3	2
4.	Narrow drainage tract	2	-
5.	Major river channel	1	-
	Total	15	5



Ajana land system

Unit	area (%)	Landform	Soil	Vegetation
1.	40%	**Low rises**—rounded rises with outcropping ridges and heavily mantled upper slopes, relief to 50 m.	Stony soils (203) and red shallow sands (423) overlying granite.	Scattered tall shrublands dominated by *Acacia tetragonophylla* (curara) with mid shrubs of *Allocasuarina campestris* (tamma) and low myrtaceous shrubs (STAS).
2.	30%	**Stony plains**—gently to moderately sloping plains below unit 1 with common to abundant granite/gneiss mantles.	Red shallow sands (423) overlying granite.	Scattered to moderately close tall shrublands of *Acacia acuminata* (jam), *A. tetragonophylla*, *Allocasuarina campestris* and some *A. huegeliana* (rock sheoak) trees. Low shrubs of *Ptilotus obovatus* (cotton bush) and *Jacksonia* spp., with graminoids of *Borya* sp. (pincushions) (STAS).
3.	20%	**Loamy plains**—gently sloping to almost flat plains, below unit 2.	Red loamy earths (544) and red sandy earths (463) overlying granite/gneiss.	Close tall shrublands of *Melaleuca uncinata* (broom honeymyrtle), *M. eleuterostachya* (tall honeymyrtle) and *Acacia acuminata* with some *Eucalyptus eudesmioides* (malallie) or *E. loxophleba* (York gum) trees. Mid shrubs of *Acacia tetragonophylla*, *Melaleuca uncinata* and myrtaceous species, with some *Austrostipa elegantissima* (feather speargrass) (EUAW and ASSW).
4.	5%	**Narrow drainage tracts**—narrow (less than 20 m wide), deep, dendritic, weakly incised channels overlying granite/gneiss carrying through drainage and run-off (from units 1 and 2) towards major tributaries.	Red shallow sand (423) overlying granite/gneiss.	Moderately close to close woodlands of *Eucalyptus loxophleba* with sparse low shrubs including *Acacia andrewsii* (prickly wattle), *Pimelea* sp. (riceflower) and *Ptilotus obovatus* (cotton bush) (EUAW).
5.	5%	**Major river channels—**river channels up to 50 m wide running through the centre of the land system, with occasional semi-permanent pools. Bedloads of boulders, cobbles and stones and coarse sand.	Dry riverbed soils (700).	Moderately close, narrow woodlands of *Eucalyptus camaldulensis* (river red gum) with rushes and sedges. *Casuarina obesa* (swamp sheoak) along levee banks (DRCW), with very scattered mid shrubs of *Acacia sclerosperma* (limestone wattle) beyond levees (RIVS).

BAYOU LAND SYSTEM (620 ha, 0.05% of the survey area)

(modified from Curry et al. 1994)

Saline alluvial meander plains and river flood plains supporting halophytic shrublands with overstorey shrubs and eucalypts.

Land type: 11—Alluvial plains with halophytic shrublands.

Geology: Quaternary alluvium with areas of recent deposition and minor aeolian sand.

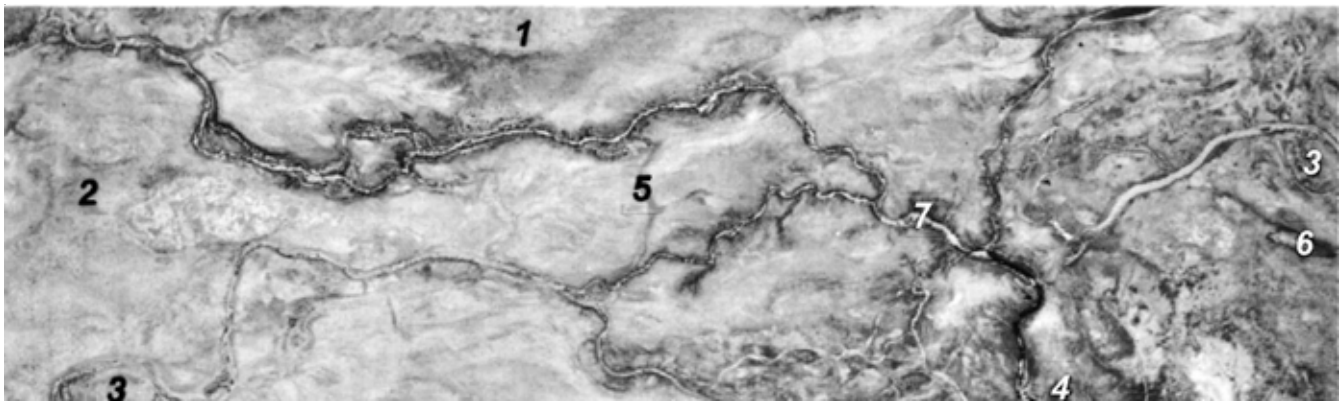
Geomorphology: Depositional surfaces; flat riverine alluvial plains with low sandy banks over minor hardpan tracts on system margins; strongly saline plains 2 to 5 km wide flanking undulating 'bayou' deposits on channel margins; some alluvial surfaces with hummocky redistributed juvenile soils; large meandering channels with sandy bedloads. Relief <3 m.

Land management: Chenopod shrublands succeeded (in parts) by increasing wattle and poverty bush; saline shrublands highly productive in areas with access to fresh water; alluvial plains (unit 2) highly susceptible to water erosion following depletion of halophytic perennials.

Traverse condition summary: This land system was insufficiently sampled (1 traverse assessment) to derive valid vegetation condition or soil erosion summaries.

Area mapped as sde: Nil.

No.	Unit name	Traverse recordings	Inventory sites
1.	Sandy bank	-	-
2.	Alluvial plain	1	-
3.	Alluvial meander plain	-	-
4.	Floodplain	-	-
5.	Saline alluvial plain	-	-
6.	Ephemeral swamp	-	-
7.	Major river channel	-	-
	Total	1	0



Bayou land system

Unit	area (%)	Landform	Soil	Vegetation
1.	5%	**Sandy banks**—sand banks and low dunes to 80 m wide, up to 2 m above adjacent alluvial plains (unit 2).	Red deep sands (445) with minor red deep sandy duplex soils (405).	Scattered saltbush and sand dune shrublands of *Hakea preissii* (needle bush) with *Acacia sclerosperma* (limestone wattle). Mid or low shrubs of *Atriplex amnicola* (swamp saltbush), *Scaevola spinescens* (currant bush), *Senna* spp. (cassia) and *Enchylaena tomentosa* (ruby saltbush) (SDUS—see Curry et al. 1994).
2.	50%	**Alluvial plains**—near-level plains subject to periodic flooding from adjacent major river channels (unit 7).	Red deep sandy duplex soils (405) with some red shallow sandy duplex soils (406) overlying red-brown hardpan.	Scattered to moderately close saltbush/bluebush shrublands of *Atriplex vesicaria* (bladder saltbush), *Cratystylis subspinescens* (sage) and *Maireana pyramidata* (sago bush); some *Hakea preissii* (PLAS).
3.	10%	**Alluvial meander plains**—alluvial deposits in ox-bow or bayou formations receiving regular channel overflow, little or no slope, sandy hummocks 1 to 2 m above surrounding plain.	Red loamy earths (544) and red deep sand (445).	Moderately close saltbush shrublands of *Atriplex amnicola* and *Rhagodia eremaea* (tall saltbush) with some *Eucalyptus victrix* (coolibah) trees and tall shrubs of *Acacia sclerosperma* or *Hakea preissii* (PLAS, RIVS).
4.	20%	**Floodplains**—plains marginally lower than units 2 and 3, subject to fairly regular flooding from major river channels (unit 7).	Deep red/brown non-cracking clays (622) with some red loamy earths (544) and red deep sandy duplex soils (405).	Scattered shrublands (occasionally closed) of riverine mixed shrublands with *Atriplex amnicola*, *Scaevola spinescens*, *Eucalyptus victrix* trees and tall shrubs of *Acacia acuminata* (jam) (RIVS).
5.	10%	**Saline alluvial plains**—flat, highly saline plains marginally lower than adjacent plains (units 2, 3 and 4).	Red deep sands (445) with minor red deep sandy duplex soils (405).	Scattered low mixed shrublands of *Halosarcia* (samphire*) and Frankenia* (frankenia) spp., *Cratystylis subspinescens* or *Atriplex amnicola*. Some tall shrubs of *Acacia victoriae* (wait-a-while) (FRAN).
6.	1%	**Ephemeral swamps**—rounded drainage foci within units 4 and 5.	Red/brown non-cracking clays (622).	Close or closed shrublands with tall shrubs of *Melaleuca uncinata* (broom honeymyrtle) and low shrubs of *Atriplex amnicola* (MESS).
7.	4%	**Major river channels**—major riverbeds and secondary channels to 5 m deep and more than 50 m wide.	Dry riverbed soils (700).	Mostly non-vegetated riverbeds. Levee banks with *Eucalyptus camaldulensis* (river red gum) trees, some *Melaleuca* spp. and *Acacia sclerosperma* mid shrubs (DRCW).

BIBRA LAND SYSTEM (15 561 ha, 1.2% of the survey area)

Calcrete plains and low rises supporting dense melaleuca and acacia shrublands.

Land type: 12—Calcrete plains with acacia shrublands.

Geology: Cainozoic calcrete and Quaternary colluvium.

Geomorphology: Mostly erosional surfaces; calcrete duricrust remnants as rounded rises (up to 20 m relief), and very gentle to gently inclined side slopes, near-level stony plains; narrow unchannelled drainage corridors between rises occasionally becoming broader alluvial tracts subject to sheet flow. Overall relief up to 30 m.

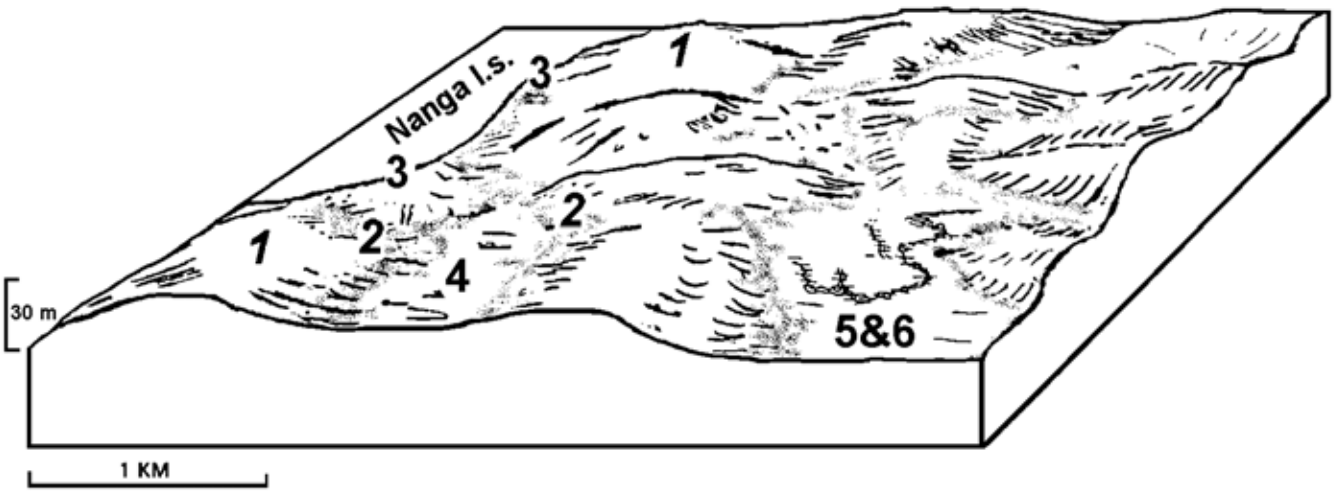
Land management: Mostly very dense tall shrublands or thickets of melaleuca and acacia species with very few low shrubs and of negligible use for pastoralism. Minor alluvial tracts (unit 4) support a few palatable shrubs. The system is not prone to degradation but is subject to infrequent fires resulting in temporarily altered vegetation structures and composition.

Traverse condition summary: (derived from 31 traverse assessments and 7 inventory sites)

Vegetation—very good 84%; good 7%; fair 3%; poor 3%; very poor 3%.
Soil erosion—nil.

Area mapped as sde: Nil.

No.	Unit name	Traverse recordings	Inventory sites
1.	Low calcrete rise	1	3
2.	Stony plain	1	1
3.	Sand sheet	16	-
4.	Loamy plain	8	1
5.	Alluvial plain	2	1
6.	Drainage zone	3	1
	Total	31	7



Bibra land system

Unit	area (%)	Landform	Soil	Vegetation
1.	59%	**Low calcrete rises**—gently rounded rises with level crests and very gently to gently inclined side slopes or calcrete plains, surface mantles of many to abundant cobbles and stones of calcrete, relief to 20 m.	Rocky red shallow loams with abundant calcrete mantles (522).	Mostly close tall shrublands dominated by *Melaleuca cardiophylla* (teatree). Less frequently, *Acacia acuminata* (jam) tall shrublands or patchy mid-height shrublands of *A. andrewsii* (prickly wattle) or *Melaleuca cardiophylla* with minor low shrubs such as *Ptilotus obovatus* (cotton bush) (CMAS, CMES).
2.	10%	**Stony plains**—level plains up to 1 km wide, occasionally adjacent to low rises (unit 1) with abundant mantles of pebbles, cobbles and stones of calcrete.	Rocky red shallow loams with abundant calcrete mantles (522).	Closed tall shrublands of *Allocasuarina campestris* (tamma), *Melaleuca* aff. *depressa* (spoon leaf honeymyrtle) and *Melaleuca* spp. (honeymyrtles) (CMES).
3.	5%	**Sand sheets**—Occasional flat or gently sloping sand sheets often merging with, but not exclusive to, merging sandplain systems (e.g. Nanga).	Red deep sands (445).	Closed tall shrublands of acacia and/or melaleuca often with myrtaceous shrubs or graminoids of *Ecdeiocolea monostachya* (wire stem grass) (ASSW, TRHE, SCHE).
4.	10%	**Loamy plains**—near-level plains as ill-defined sluggish transfer zones on the margins of unit 4.	Red loamy earths (544).	Closed tall shrublands with *Lamarchea hakeifolia* (false paperbark), *Acacia acuminata* and mallee form *Eucalyptus eudesmioides* (malallie). Low shrubs of *Olearia* spp., various myrtaceous shrubs, *Ecdeiocolea monostachya* graminoids and grasses of *Triodia danthonioides* (spinifex) (SCHE, TRHE).
5.	1%	**Alluvial plains**—unchannelled level plains occasionally associated with drainage zones (unit 3), subject to occasional sheet flow.	Red loamy earths (544).	Moderately close to close woodlands of *Eucalyptus loxophleba* (York gum) with sparse low shrubs including *Acacia andrewsii*, *Pimelea* spp. (riceflower) and *Ptilotus obovatus* (EUAW).
6.	15%	**Drainage zones**—narrow (less than 300 m wide), level unchannelled drainage corridors often extending for several kilometres between low rises (unit 1).	Red loamy earths (544).	Close to closed mid-height or tall shrublands of *Melaleuca uncinata* (broom honeymyrtle), with occasional low mallees such as *Eucalyptus eudesmioides*; some *Keraudrenia integrifolia* (firebush) and *Ecdeiocolea monostachya* graminoids (MELS).

BOULDER LAND SYSTEM (1308 ha, 0.1% of the survey area)

(modified from Curry et al. 1994)

Stony plains and low rises supporting patchy acacia mixed shrublands.

Land type: 4—Stony plains with acacia shrublands.

Geology: Tertiary silcrete and colluvium overlying Permian sedimentary rocks: sandstone, siltstone or shale.

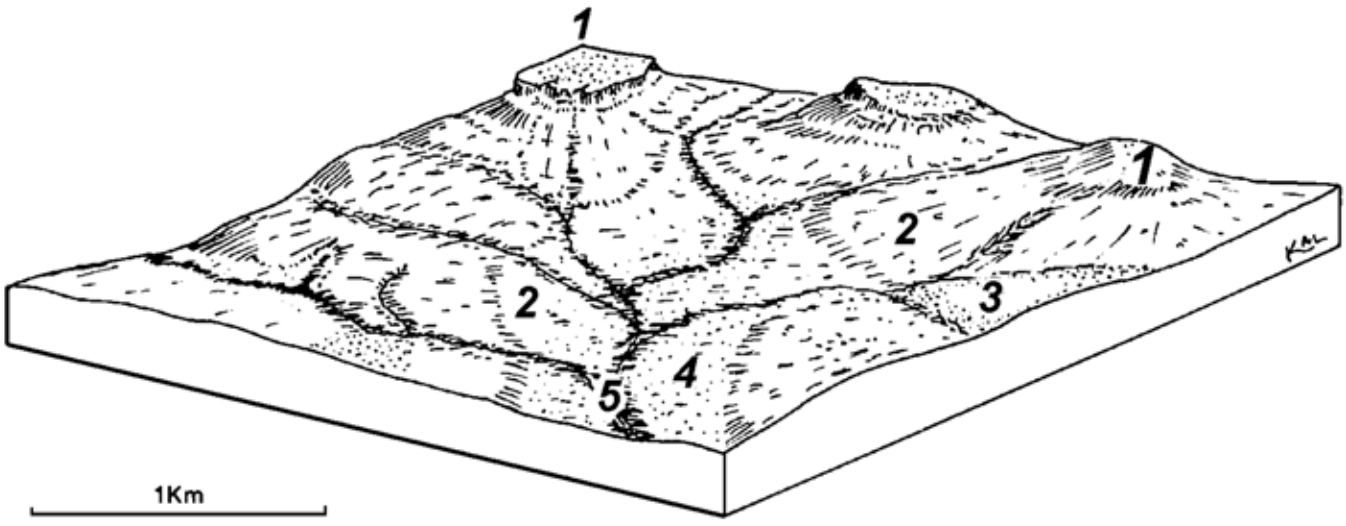
Geomorphology: Erosional surfaces; minor low breakaways with short slopes above gently undulating stony plains, saline plains with occasional sandy banks and restricted drainage floors. Overall relief less than 20 m. Not all land units of this system were recorded within this survey and are best expressed in the adjacent rangelands (Murchison survey).

Land management: Mostly acacia tall shrublands on stony plains with lower saline plains supporting mixed halophyte shrublands of moderately high pastoral potential. The lower saline plains and drainage floors are susceptible to water erosion and invasion by undesirable plant species.

Traverse condition summary: This land system was insufficiently sampled (3 traverse assessments and 1 inventory site) to derive valid vegetation or soil erosion summaries.

Area mapped as sde: Nil.

No.	Unit name	Traverse recordings	Inventory sites
1.	Low hill or breakaway	-	-
2.	Stony plain	1	-
3.	Sand sheet	-	-
4.	Saline lower plain	2	1
5.	Drainage floor	-	-
	Total	3	1



Boulder land system

Unit	area (%)	Landform	Soil	Vegetation
1.	10%	**Low hills or breakaways**—boulder-strewn low hills or less commonly dissected breakaways to 15 m.	Stony soils (203) or red shallow loams with boulders (522).	Mostly scattered mixed tall shrublands with *Acacia acuminata* (jam) and *A. tetragonophylla* (curara) with mid shrubs of *Eremophila* spp. (poverty bush) and *Ptilotus obovatus* (cotton bush) (ACHS).
2.	60%	**Stony plains**—extensive undulating and gently sloping plains with dense stony mantles.	Red shallow loams with boulders (522), stony soils (203) or red-brown hardpan shallow loam (523).	Scattered shrublands of *Acacia acuminata*, *Eremophila* spp., *Senna* spp. (cassia), and various small bluebushes (*Maireana triptera*, *M. georgei*). Some *Ptilotus obovatus*, *P. schwartzii* (horse mulla mulla) and *Rhagodia eremaea* (tall saltbush) (SMMS—see Curry et al. 1994).
3.	5%	**Sand sheets**—occasional flat or gently sloping tracts of sandplain.	Red deep sands (445).	Moderately dense mixed shrublands of *Acacia ramulosa* (wanyu), with *Eremophila* spp., myrtaceous mid shrubs and variable densities of perennial grass *Monachather paradoxus* (broad-leaf wanderrie) (SWGS).
4.	20%	**Saline lower plains**—very gently sloping plains with minor stony mantles.	Red shallow sandy duplex (406) overlying sandstone.	Scattered low shrublands of *Frankenia* spp. (frankenia) with some *Halosarcia* spp. (samphire), *Atriplex bunburyana* (silver saltbush) and *Gunniopsis quadrifida* (sweet samphire) (FRAN).
5.	5%	**Drainage floors**—narrow drainage tracts up to 500 m wide.	Red deep sandy duplex soils (405) or red/brown non-cracking clays (622).	Moderately close to close tall shrublands with *Acacia tetragonophylla*, *A. acuminata* and low shrubs of *Maireana triptera*, *M. pyramidata* (sago bush) and *Rhagodia eremaea* (PLAS).

BUNGABANDI LAND SYSTEM (12 184 ha, 0.9% of the survey area)

Plains with thin sand cover and drainage tracts supporting scrub heath.

Land type: 7—Sandplains with acacia, mallees and heath.

Geology: Silurian sandstone, Quaternary colluvium and residual sand.

Geomorphology: Erosional surfaces; level to gently undulating stony plains, rises and slopes, with residual sandplain patches and central through-going drainage tracts, with channels and shallow incision into sandstone parent material. Relief up to 25 m.

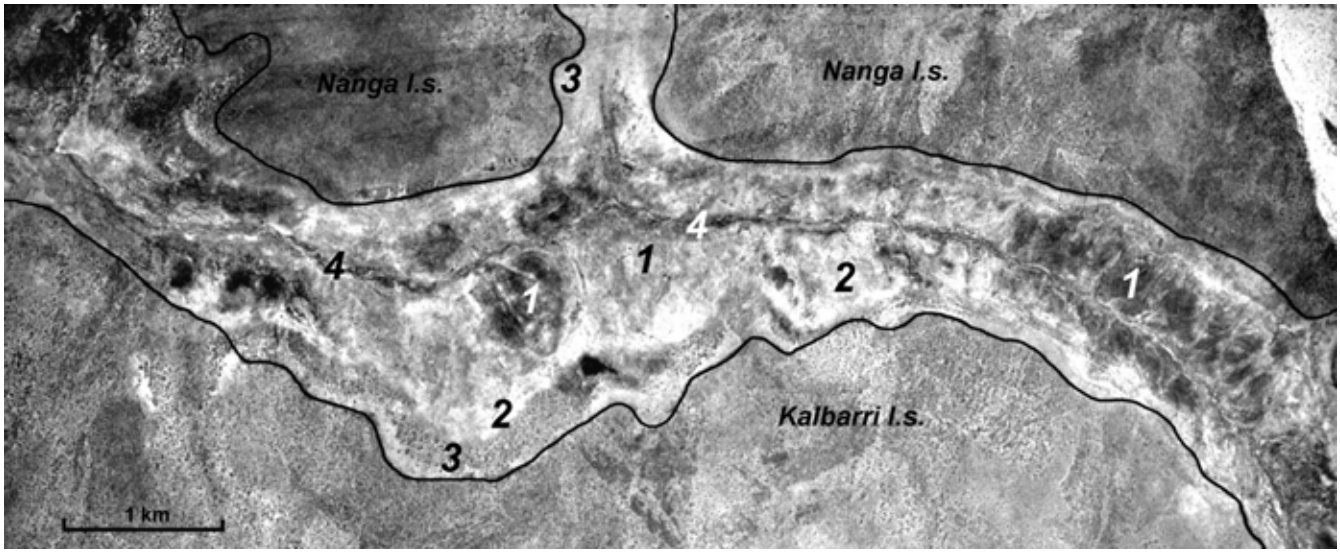
Land management: Most of the vegetation within this system is not preferred by grazing animals and grazing-induced changes are unlikely. Temporary changes in plant composition and biomass due to fires may be regular but infrequent. The narrow drainage tracts support vegetation preferentially grazed by livestock. Narrow drainage tracts are moderately susceptible to water erosion.

Traverse condition summary: (derived from 20 traverse assessments and 5 inventory sites)

Vegetation—very good 35%; good 35%; fair 15%; poor 15%; very poor 0%.
Soil erosion—nil 95%; minor 5%.

Area mapped as sde: Nil.

No.	Unit name	Traverse recordings	Inventory sites
1.	Stony plain	5	1
2.	Plain with thin sand cover	-	-
3.	Sandplain	6	2
4.	Narrow drainage tract	9	2
	Total	20	5



Bungabandi land system

Unit	area (%)	Landform	Soil	Vegetation
1.	50%	**Stony plains**—level to gently inclined plains, rises and slopes adjacent to drainage tracts (unit 4); variably abundant surface mantles of sandstone pebbles and cobbles and rock outcrop.	Shallow (brown) loam (520) and yellow/brown shallow sands (424).	Mostly close to closed low or mid-height shrublands or scrub heath with *Acacia*, *Grevillea*, *Melaleuca* species and numerous myrtaceous shrubs (SCHE).
2.	15%	**Plains with thin sand cover**—level to gently undulating sandplains with thin sand cover over sandstone substrates, with occasional mantles and low outcropping ferruginised sandstone.	Yellow/brown shallow sands (424) overlying sandstone.	Moderately close to closed tall and mid-height shrublands of *Acacia neurophylla* (wodjil) and *Jacksonia cupulifera* (rattlepod), low shrubs of *Melaleuca* and *Baeckea* species, and graminoids of *Ecdeiocolea monostachya* (wire stem grass). Occasional small trees or mallees of *Eucalyptus eudesmioides* (malallie) (HEAT, SCHE).
3.	20%	**Sandplains**—level to gently undulating sandplains up to several hundred metres in extent; no surface mantles.	Yellow/brown shallow sands (424).	Close to closed scrub heath or tree heath with *Acacia*, *Melaleuca* and *Baeckea* species with *Lamarchea hakeifolia* (false paperbark), *Acacia* spp. (wattle), graminoids of *Ecdeiocolea monostachya* with occasional low mallees such as *Eucalyptus eudesmioides* (SCHE, TRHE).
4.	15%	**Narrow drainage tracts**—tracts up to 300 m wide receiving sheet flow with central weakly incised channels, smaller tributary channels and minor fringing sandplains; mantles of sandstone may be present or absent.	Red shallow sandy duplex soils (406) or pale deep (grey) sands (444) overlying sandstone.	Red shallow sandy duplex soils support scattered halophytic low shrublands of *Frankenia* spp. (frankenia), with isolated to very scattered tall and mid shrubs of *Acacia saligna* (golden wreath wattle) and *Hakea preissii* (needle bush) (FRAN, very occasional DRCW). Grey sands support close tall shrublands of *Acacia* spp., *Melaleuca uncinata* (broom honeymyrtle) and various myrtaceous low shrubs (MASA).

COOLOOMIA LAND SYSTEM (2655 ha, 0.2% of the survey area)

(modified from Payne et al. 1987)

Undulating sandplains, minor stony plains or calcrete rises supporting patchy mallee, scrub heath and grassy shrublands.

Land type: 7—Sandplains with acacia, mallees and heath.

Geology: Quaternary aeolian sand and minor Tertiary calcrete.

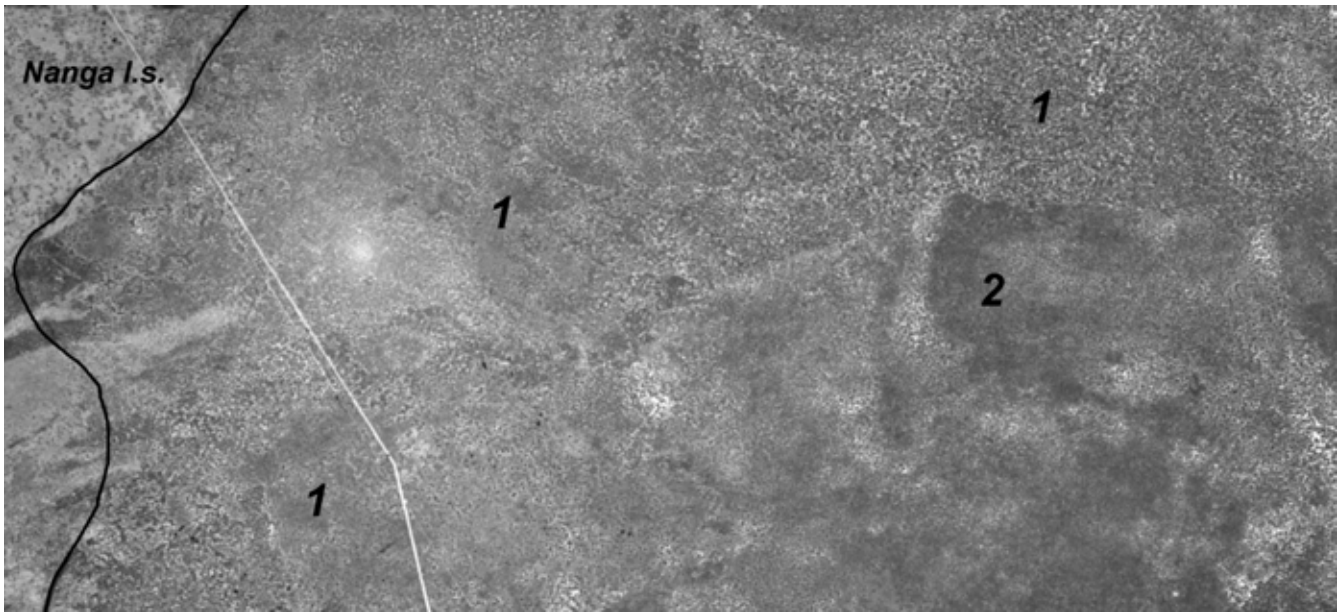
Geomorphology: Depositional surfaces; plains, rounded rises and concave swales with isolated stony slopes and calcrete outcrops; no drainage development. Overall relief up to 15 m.

Land management: A mosaic of mallee clumps, myrtaceous thickets and open slopes with scattered low shrubs, seasonally suited to livestock grazing. There is a minor susceptibility to slight wind erosion immediately after wildfire, but is otherwise stable.

Traverse condition summary: This land system was insufficiently sampled (4 traverse assessments) to derive valid vegetation or soil erosion summaries.

Area mapped as sde: Nil.

No.	Unit name	Traverse recordings	Inventory sites
1.	Undulating sandy plain	3	-
2.	Calcrete rise/stony plain	1	-
	Total	4	0



Cooloomia land system

Unit	area (%)	Landform	Soil	Vegetation
1.	90%	**Undulating sandy plains**—undulating plains with slopes up to 10% and moderate relief up to 20 m.	Red deep sands (445).	Clumped mallees of *Eucalyptus eudesmioides* (malallie) with myrtaceous shrubs. Tall shrub thickets of *Melaleuca cardiophylla* (teatree), *Acacia tetragonophylla* (curara) and *A. sclerosperma* (limestone wattle). Open slopes with very scattered low shrubs of *Ptilotus obovatus* (cotton bush) and *Solanum nummularium* (wild tomato). Heath patches with mixed myrtaceous shrubs with *Keraudrenia* sp. (firebush) and *Acanthocarpus preissii* (MASA, ASSW).
2.	10%	**Calcrete rises/stony plains**—low calcrete rises and restricted stony plains with light limestone mantles. Relief to 5 m.	Red shallow sands (423) to red deep sands (445).	Very scattered to close tall and low shrublands with *Acacia rostellifera* (summer-scented wattle), *A. tetragonophylla*, *Lamarchea hakeifolia* (false paperbark), *Melaleuca* spp. (honeymyrtle), *Rhagodia* spp., *Thryptomene* spp. and *Ptilotus obovatus* (MASA).

EURARDY LAND SYSTEM (221 378 ha, 17% of the survey area)

(modified from Curry et al. 1994)

Gently undulating red and yellow sandplains supporting acacia-mallee shrublands and heath.

Land type: 7—Sandplains with acacia, mallees and heath.

Geology: Quaternary aeolian sand.

Geomorphology: Depositional surfaces; extensive undulating sandplain with occasional sand dunes to 5 m; no drainage features other than scattered or infrequent drainage foci.

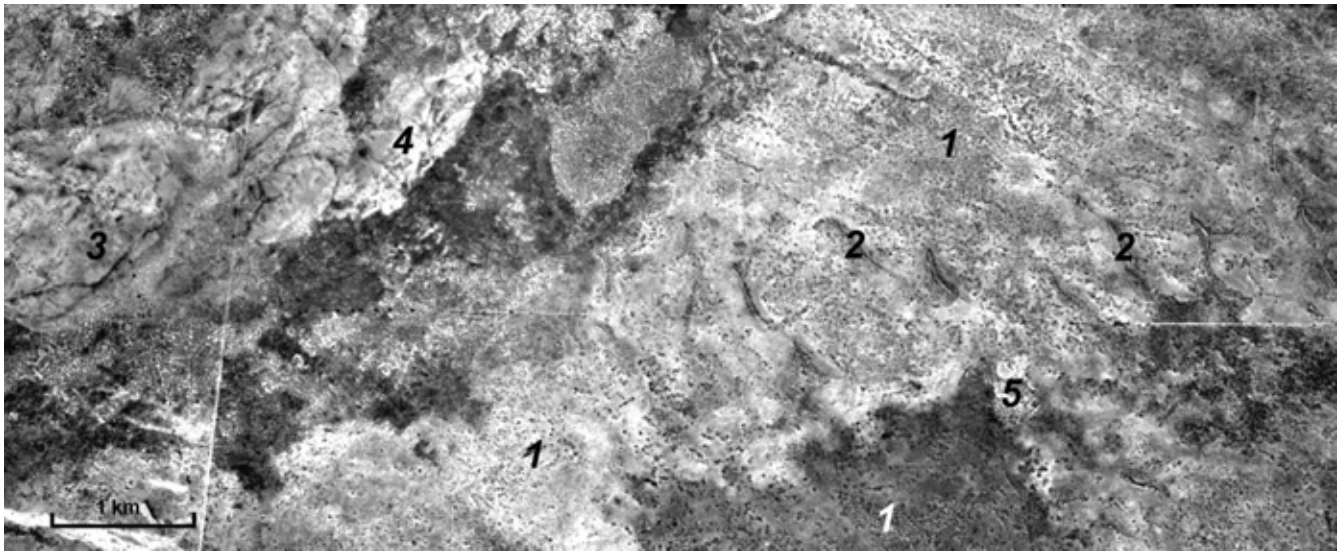
Land management: Very dense tall and mid-height shrublands of acacia species with scattered mallee eucalypts, also heath communities with dense mid and low shrubs; negligible use for pastoralism. Minor areas may support few shrubs palatable to livestock. The system is subject to infrequent fires resulting in temporarily altered vegetation structure and composition.

Traverse condition summary: (derived from 113 traverse assessments and 12 inventory sites)

Vegetation—very good 82%; good 16%; fair 2%; poor 0%; very poor 0%.
Soil erosion—nil.

Area mapped as sde: Nil.

No.	Unit name	Traverse recordings	Inventory sites
1.	Sandplain	96	10
2.	Sand dune	9	1
3.	Gravelly plain	-	1
4.	Lower plain	8	-
5.	Drainage foci and claypan	-	-
	Total	113	12



Eurardy land system

Unit	area (%)	Landform	Soil	Vegetation
1.	78%	**Sandplains—**extensive gently undulating sandplains with little relief.	Yellow deep sands (446) and minor red deep sands (445) including reddish-yellow deep sands.	Mostly close tall shrublands with *Eucalyptus loxophleba* (York gum) and *E. foecunda* (narrow-leaved red mallee) and *Acacia* spp. (wattle) tall shrubs. Mid shrubs of *Acacia* spp., low shrubs of *Ptilotus obovatus* (cotton bush) and perennial grasses of *Monachather paradoxus* (broad-leaf wanderrie) and *Thyridolepis multiculmis* (soft wanderrie) (MASA, ASSW, SCHE, TRHE).
2.	5%	**Sand dunes**—occasional aeolian sand dunes to 5 m occurring within unit 1.	Yellow deep sands (446) and minor red deep sands (445).	Close mid-height shrublands of *Acacia neurophylla* (wodjil), various *Grevillea*, *Hakea*, *Calothamnus* spp. and many myrtaceous low shrubs (ASSW).
3.	5%	**Gravelly plains**—almost flat plains with fine surface gravel mantles occurring mainly in the south-east of the area.	Shallow gravelly yellow sands (304).	Scattered mid shrublands of *Acacia* spp. with isolated tall shrubs of *Acacia ramulosa* (wanyu), *A. tetragonophylla* (curara), with isolated trees of *Melaleuca* spp. (honeymyrtle) (ASSW).
4.	10%	**Lower plains**—flat plains receiving some run-on.	Yellow deep sands (446) and minor red deep sands (445).	Similar to unit 1.
5.	2%	**Drainage foci and claypans**—isolated drainage foci and claypans.	Red loamy earths (544) within drainage foci and red loamy earths (544) or red/brown non-cracking clays (622) in claypans	Drainage foci and claypans mostly fringed with tall shrubs of *Melaleuca* spp. or *A. tetragonophylla* (DRMS, MESS). Claypans are mostly bare of perennial vegetation.

HIGHWAY LAND SYSTEM (16 093 ha, 1.2% of the survey area)

Plains supporting York gum woodlands, acacia shrublands and mixed low shrubs.

Land type: 8—Plains with eucalypt woodlands and non-halophytic shrubs.

Geology: Quaternary colluvium or alluvium with minor aeolian sand.

Geomorphology: Mostly depositional surfaces; near-level loamy plains (some with thin sand cover) and sand sheets or gravelly plains on system margins. Overall relief up to 10 m.

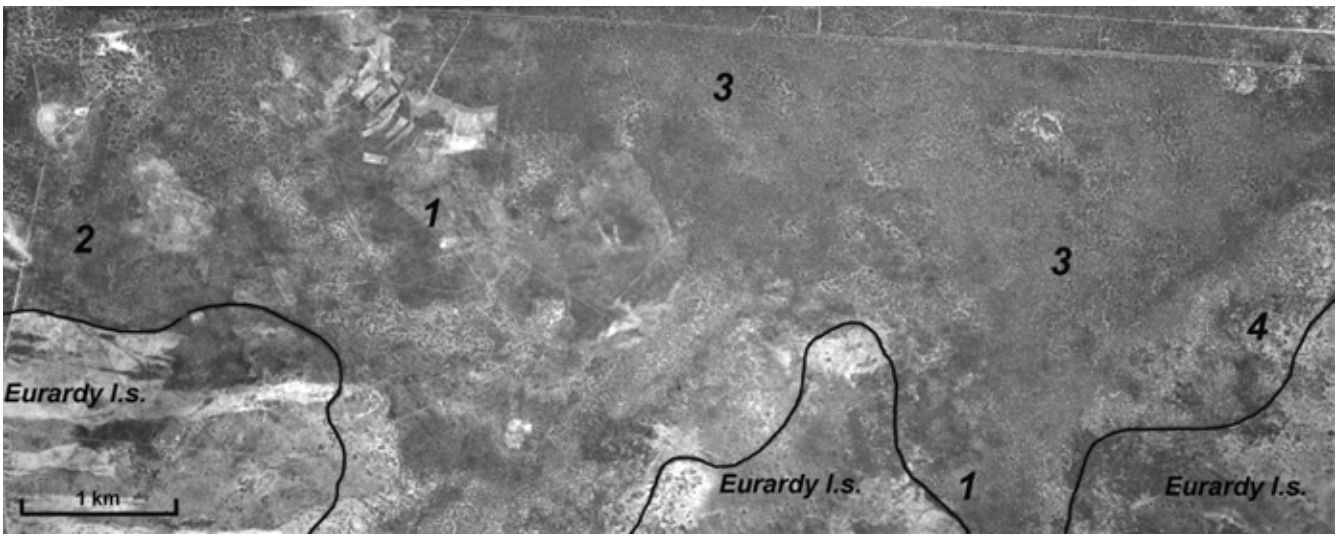
Land management: Mostly open York gum woodlands with variable mid and low shrubs moderately suited for livestock grazing. Dense wattle shrublands with minor sand sheets and gravelly plains do not support many plants suited to livestock. The erosion risk for the whole system is low.

Traverse condition summary: (derived from 26 traverse assessments and 6 inventory sites)

Vegetation—very good 27%; good 61%; fair 8%; poor 4%; very poor 0%.
Soil erosion—nil.

Area mapped as sde: Nil.

No.	Unit name	Traverse recordings	Inventory sites
1.	Gravelly sandplain	2	1
2.	Sand sheet	11	2
3.	Loamy plain	13	3
4.	Alluvial plain	-	-
	Total	26	6



Highway land system

Unit	area (%)	Landform	Soil	Vegetation
1.	10%	**Gravelly sandplains**—near-level plains with infrequent surface gravels on the outer margins of the system.	Shallow gravelly yellow sand (304) overlying dense ironstone gravel.	Close tall shrublands with *Acacia acuminata* (jam) and *A. neurophylla* (wodjil), with low and mid myrtaceous shrubs such as *Baeckea* sp. (ASSW).
2.	20%	**Sand sheets**—near-level sandplains occurring in conjunction with unit 1 and adjacent to other sandplain systems.	Light-textured red sandy earths (463) and yellow deep sands (446).	Woodlands and tall shrublands of *Eucalyptus eudesmioides* (malallie), *Allocasuarina acutivalvis* (black tamma) and *Acacia* spp. (wattle), with very few low shrubs (ASSW). Deep yellow sands with moderately close woodlands and tall shrublands of *Eucalyptus oldfieldii* (Oldfield's mallee), *E. eudesmioides*, *Acacia neurophylla* and *Lamarchea hakeifolia* (false paperbark) with myrtaceous low and mid shrubs (TRHE, MASA).
3.	60%	**Loamy plains**—near-level plains with faint sluggish drainage features.	Moderate textured red sandy earths (463) with some red loamy earths (544).	Moderately close to close patchy woodlands featuring *Eucalyptus loxophleba* (York gum) with tall shrubs of *Acacia ramulosa* (wanyu) and *A. tetragonophylla* (curara). Mid and low shrubs of *Acacia colletioides* (wait-a-while), *Rhagodia drummondii* (low saltbush) and *Ptilotus obovatus* (cotton bush) with minor perennial grasses of *Eriachne* spp. (EUAW).
4.	10%	**Alluvial plains**—open level plains receiving occasional overland water flow from unit 3.	Red loamy earths (544).	Scattered patchy woodlands of *Eucalyptus loxophleba* with understoreys of *Ptilotus obovatus*, *Rhagodia* spp., *Senna artemisioides* subsp. *artemisioides* (banana leaf), *Scaevola spinescens* (currant bush) and *Sclerolaena* sp. (bindii) (EUAW).

HOLMWOOD LAND SYSTEM (1409 ha, 0.1% of the survey area)

(Modified from Curry et al. 1994)

Gently undulating saline stony and alluvial plains below low breakaways supporting snakewood and halophytic shrublands.

Land type: 9—Alluvial plains with acacia shrublands.

Geology: Permian sandstone and siltstone with shale deposits with Quaternary alluvial and colluvial lower slopes and plains.

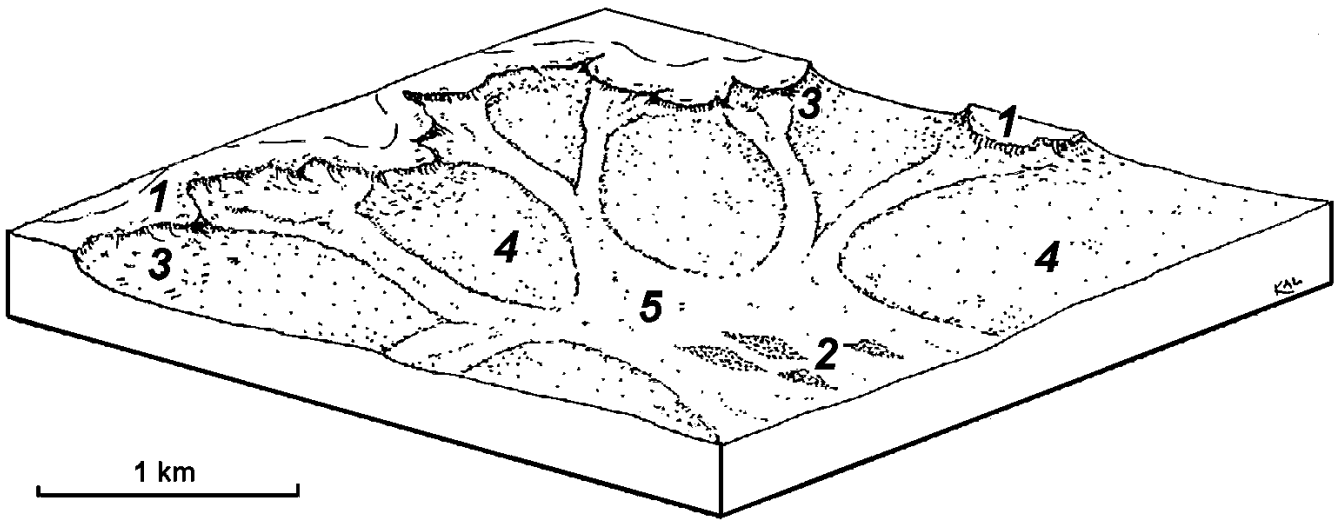
Geomorphology: Erosional surfaces; plateaux with breakaways and footslopes; depositional undulating or near-level plains; isolated sandplain residuals and strongly saline lower alluvial plains with ill-defined drainage patterns. Overall relief mostly <10 m.

Land management: Breakaway footslopes (unit 1) are susceptible to erosion if disturbed. Alluvial plains (unit 4) and lower saline plains (unit 5) often support highly salt tolerant vegetation and are susceptible to erosion after major disturbance or overgrazing.

Traverse condition summary: This land system was not sampled.

Area mapped as sde: Nil.

No.	Unit name	Traverse recordings	Inventory sites
1.	Low breakaway/footslope	-	-
2.	Sandy bank	-	-
3.	Saline stony plain	-	-
4.	Alluvial plain	-	-
5.	Lower saline plain	-	-
	Total	0	0



Holmwood land system

Unit	area (%)	Landform	Soil	Vegetation
1.	10%	**Low breakaways/footslopes**—low breakaways to 10 m high with sloping upper footslopes grading to undulating gentle sloping footslopes with a stony mantle.	Red shallow sandy duplex (406) and red/brown non-cracking clays (622).	Mixed tall and mid shrublands often with few low shrubs dominated by *Acacia ramulosa* (wanyu), and *A. sclerosperma* (limestone wattle) on breakaway plateaux (ACHS). Footslopes of scattered or very scattered low shrublands of *Atriplex vesicaria* (bladder saltbush), various *Maireana* species (bluebush) with *Ptilotus beardii* (low mulla mulla) and *Frankenia* spp. (frankenia) (FRAN, PLAS).
2.	5%	**Sandy banks**—sand banks up to 500 m long and 200 wide with sand sheets adjacent to other sandplain systems.	Red deep sands (445).	Scattered to moderately close mixed grassy shrublands with tall shrubs of *Acacia ramulosa*, mid shrubs of *Eremophila forrestii* (Wilcox bush) and *Senna* sp. (cassia). Grasses of *Monachather paradoxus* (broad-leaf wanderrie) and *Thyridolepis multiculmis* (soft wanderrie) (SWGS).
3.	10%	**Saline stony plains**—gently sloping saline plains with a stony mantle below unit 1.	Red loamy earths (544).	Scattered or very scattered low shrublands of *Atriplex vesicaria* (bladder saltbush) or *Atriplex* spp., with *Maireana* spp. (bluebush), *Frankenia* spp. (frankenia), *Ptilotus beardii* and *Scaevola spinescens* (currant bush) (PLAS).
4.	35%	**Alluvial plains**—flat, weakly saline plains with sluggish unchannelled drainage zones.	Red shallow sandy duplex (406) and shallow red/brown non-cracking clays (622).	Moderately close low mixed chenopod shrublands dominated by *Atriplex bunburyana* (silver saltbush) and *Maireana pyramidata* (sago bush) with some tall shrubs of *Acacia xiphophylla* (snakewood) (PLAS).
5.	40%	**Lower saline plains**—extensive flat saline plains (slightly lower than unit 4) with sluggish drainage and intermittent low sandy banks.	Red shallow sandy duplex (406) and shallow red/brown non-cracking clays (622).	Moderately close low zonated halophytic shrublands of *Maireana atkinsiana* (bronze bluebush), *M. platycarpa* (shy bluebush), *M. pyramidata*, *Atriplex vesicaria*, *Frankenia* spp. and *Gunniopsis quadrifida* (sweet samphire). Some tall shrubs of *Eremophila pterocarpa* (silver poverty bush), *Acacia sclerosperma* (limestone wattle) and *A. tetragonophylla* (curara) (PLAS, FRAN).

JOSEPH LAND SYSTEM (1483 ha, 0.1% of the survey area)

(Modified from Payne et al. 1998)

Undulating yellow sandplains supporting dense mixed shrublands and patchy mallee.

Land type: 7—Sandplains with acacia, mallees and heath.

Geology: Cainozoic alluvial and colluvial sand deposits and minor Archaean granite.

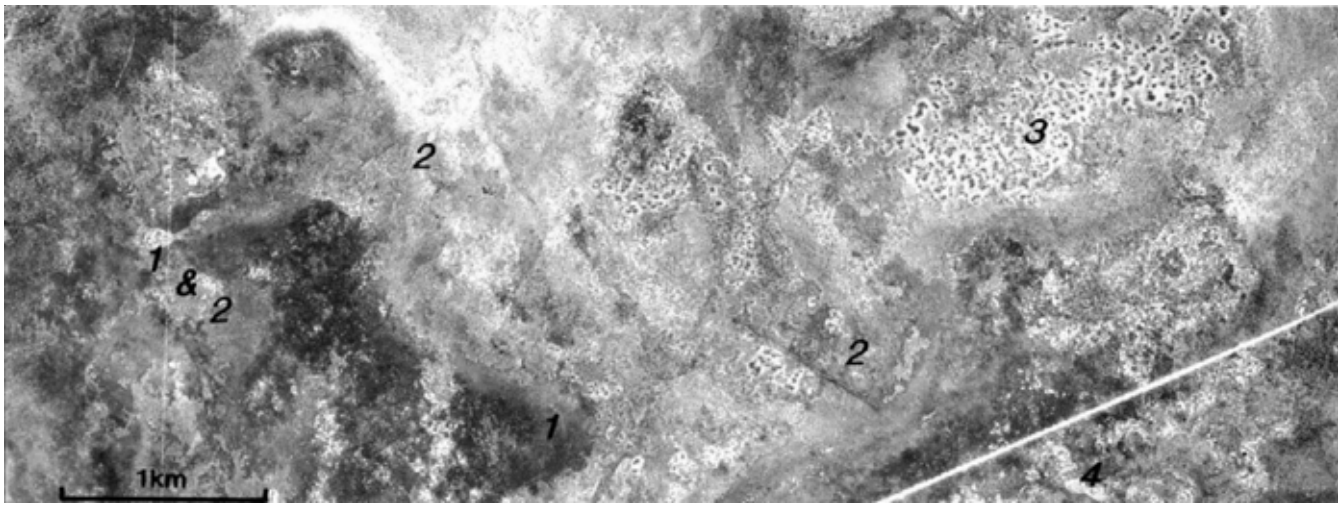
Geomorphology: Depositional surfaces; level to undulating sand sheets, lower areas have ironstone gravel mantles and plains receiving run-on. Minor areas of granite outcrop.

Land management: The lack of desirable fodder plants and very dense vegetation inhibits livestock grazing. Wildfires could temporarily leave the sandy soils subject to wind erosion.

Traverse condition summary: This land system was insufficiently sampled (1 traverse assessment) to derive valid vegetation or soil erosion summaries.

Area mapped as sde: Nil.

No.	Unit name	Traverse recordings	Inventory sites
1.	Gravelly sand sheet	-	-
2.	Sand sheet	1	-
3.	Loamy plain	-	-
4.	Gritty-surfaced plain	-	-
	Total	1	0



Joseph land system

Unit	area (%)	Landform	Soil	Vegetation
1.	20%	**Gravelly sand sheets**—level to gently undulating sand sheet with ironstone gravel/pebble mantles.	Yellow deep sands (446) and shallow gravelly yellow variably deep sands (304) with ironstone gravel substrates.	Close mixed tall shrublands with *Acacia*, *Melaleuca* and *Allocasuarina* species with low heath shrubs and grasses such as *Amphipogon caricinus* (grey beard grass) (ASSW).
2.	60%	**Sand sheets**—level to undulating sand sheet higher than unit 1.	Yellow deep sands (446) and red deep sands (445).	Close to closed mixed shrublands of tall *Acacia* and *Melaleuca* sp. with low heath shrubs of *Eriostemon* and *Thryptomene* sp. (ASSW).
3.	15%	**Loamy plains**—level plains receiving diffuse overland run-on.	Variable red shallow sands (423), red sandy earths (463) and occasional deep red/brown non-cracking clays (622).	Scattered eucalypt woodlands with tall *Acacia ramulosa* (wanyu) shrublands and mixed low shrubs (EUAW).
4.	5%	**Gritty-surfaced plains**—plains with common granite outcrop with stony, gritty and occasionally gravelly stripped surfaces commonly occurring as small areas within sand sheets (units 1 and 2).	Red shallow sand (423) overlying granite.	Scattered tall shrublands of *Acacia* spp., with myrtaceous low shrubs and graminoids of *Borya* spp. (pincushion) (STAS).

KALBARRI LAND SYSTEM (98 701 ha, 7.6% of the survey area)

Gently undulating yellow and grey sandplains supporting tree heath, scrub heath and low heath.

Land type: 7—Sandplains with acacia, mallees and heath.

Geology: Quaternary aeolian and residual sand, minor colluvium.

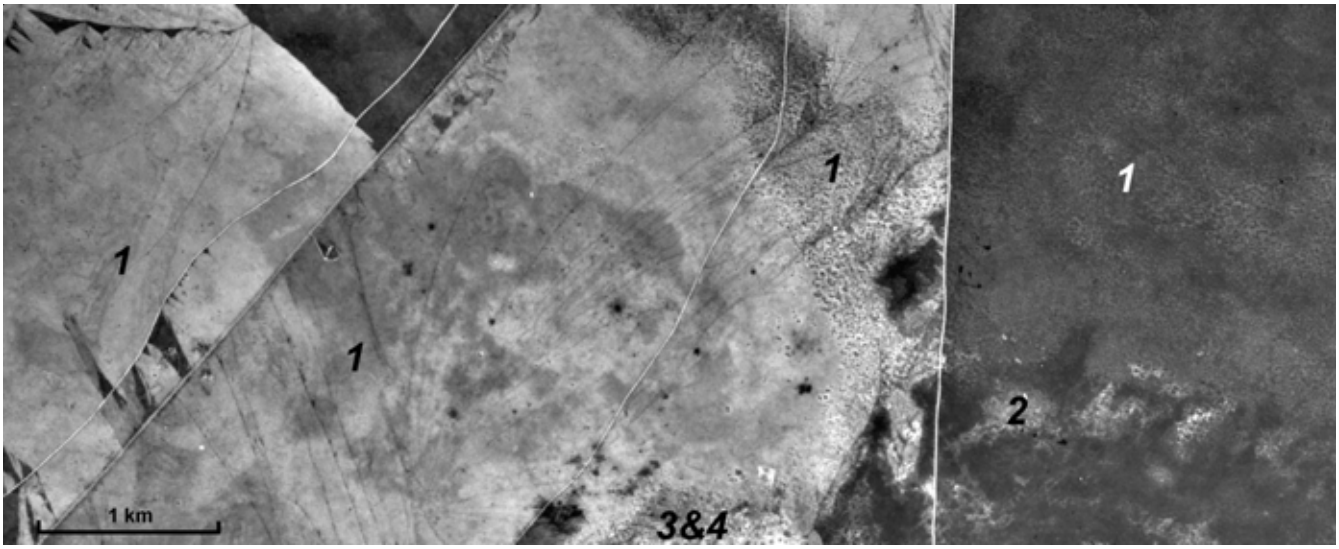
Geomorphology: Depositional surfaces; level to gently undulating plains and rises with deep yellow or grey sand soils, minor colluvial plains with more shallow soils, no defined drainage features. Overall relief up to 20 m.

Land management: Most of this system falls within the Kalbarri National Park. It is unsuitable for grazing domestic livestock, but is subject to some grazing by feral goats and native animals. It is prone to fire and the structure and composition of the vegetation can vary considerably depending on the time elapsed since the last burn.

Traverse condition summary: Lands within the Kalbarri National Park were traversed but not assessed for vegetation condition. Where rated outside the park, vegetation condition was very good or good, and no soil erosion was recorded.

Area mapped as sde: Nil.

No.	Unit name	Traverse recordings	Inventory sites
1.	Sandplain	-	7
2.	Gravelly plain	-	3
3.	Low rise	-	-
4.	Stony plain	-	1
	Total	0	11



Kalbarri land system

Unit	area (%)	Landform	Soil	Vegetation
1.	85%	**Sandplains**—gently undulating sandplain extending for many kilometres.	Yellow deep sands (446) and pale deep sands (444).	Moderately close to closed scrub heath with mixed *Acacia*, *Banksia*, *Grevillea* spp. and *Xylomelum angustifolium* (sandplain woody pear). Numerous myrtaceous genera (*Scholtzia*, *Calothamnus*, *Baeckea*, *Thryptomene*, etc.) low and mid-height shrubs (HEAT, SCHE, TRHE).
2.	8%	**Gravelly plains (with thin soil cover)**—level to gently undulating plains occurring as minor inclusions (up to 500 m in extent) within unit 1.	Yellow/brown shallow sands (424), pale (white/grey) shallow sands (422) and gravelly pale deep sand overlying gravel and duricrust. Grey shallow sandy duplex (404).	Close to closed scrub heath with *Acacia*, and *Melaleuca* spp., numerous myrtaceous low and mid-height shrubs (SCHE). Moderately close heath with numerous myrtaceous genera (*Eremaea*, *Beaufortia*, *Verticordia*, etc.) lower shrubs and occasional trees or tall shrubs of *Banksia menziesii* (firewood banksia) (TRHE, HEAT).
3.	5%	**Low rises (with some outcropping rock)**—gently raised low rises (to 10 m) of sandstone or radiolarite with ferruginised ironstone gravel.	Red shallow sands (423), pale (white/grey) shallow sands (422) and loams (522) with outcropping sandstone or Windalia radiolarite.	Close to closed scrub heath with *Acacia*, and *Melaleuca* spp., numerous low and mid-height myrtaceous shrubs (*Calytrix*, *Baeckea*, *Scholtzia*, etc.) (SCHE).
4.	2%	**Stony plains (associated with low rises)**—small variable surfaced stony plains (up to 200 m in extent) below low rises.	Local weakly cracking and non-cracking red/brown clays (622).	Closed scrub heath with *Acacia*, *Melaleuca* and *Allocasuarina* spp., with *Eucalyptus obtusiflora* (Dongara mallee). Numerous myrtaceous (*Calytrix*, *Baeckea*, *Scholtzia*, etc.) mid shrubs and very few low shrubs (SCHE).

KALLI LAND SYSTEM (373 ha, 0.03% of the survey area)

(modified from Curry et al. 1994)

Gently undulating sandplains edged by stripped surfaces on laterite and granite supporting tall acacia shrublands and wanderrie grass.

Land type: 6—Sandplains and occasional dunes with grassy acacia shrublands.

Geology: Quaternary aeolian sand derived from Archaean gneiss and granite, overlying Tertiary laterite.

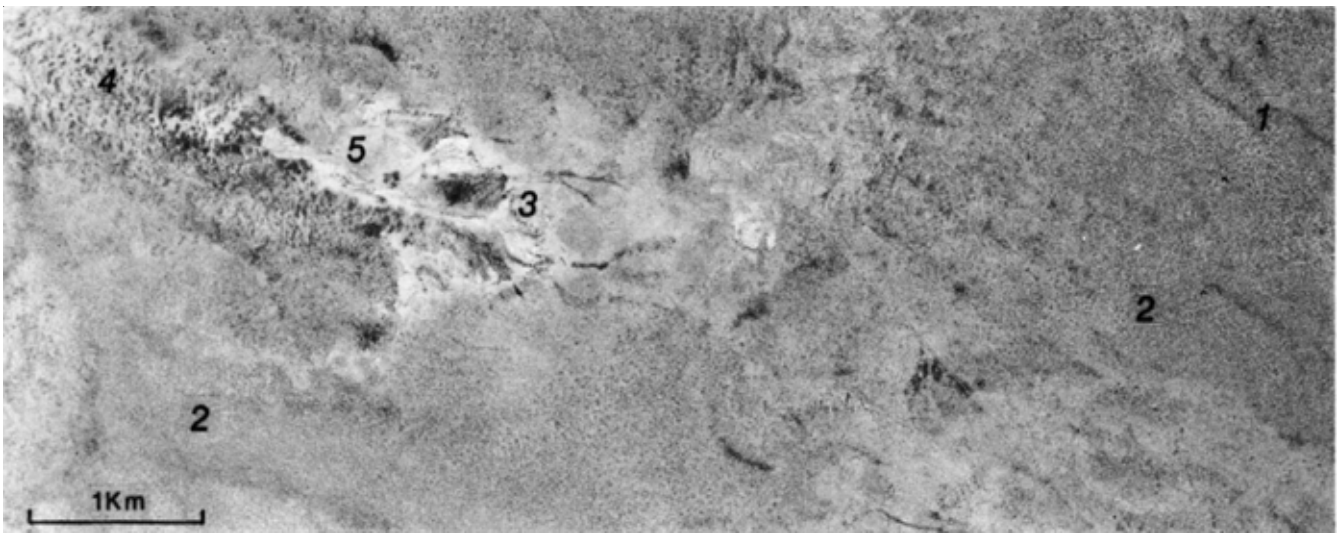
Geomorphology: Broad undulating sandplains with occasional sand dunes, edged by exposed laterite or granite; mostly infrequent diffuse internal drainage. Overall relief up to 10 m.

Land management: Mostly dense wanyu tall shrublands with few mid and low shrubs, supporting stands of wanderrie grass at variable densities. The system generally has low pastoral value, except in growing seasons after fire when grass densities may increase at the expense of tall shrubs in the short term. Thereafter the system reverts to a dense tall shrubland. The system is not prone to degradation or erosion.

Traverse condition summary: This land system was not sampled.

Area mapped as sde: Nil.

No.	Unit name	Traverse recordings	Inventory sites
1.	Sand dune	-	-
2.	Sandy plain	-	-
3.	Lateritic plain	-	-
4.	Drainage tract	-	-
5.	Stripped stony surface	-	-
	Total	0	0



Kalli land system

Unit	area (%)	Landform	Soil	Vegetation
1.	5%	**Sand dunes**—dunes to 200 m wide and up to 2 km in length, relief up to 6 m.	Red deep sands (445).	Scattered to moderately close tall shrublands dominated by *Acacia ramulosa* (wanyu) with some understorey mid shrubs of *Eremophila forrestii* (Wilcox bush) and perennial grasses of *Monachather paradoxus* (broad-leaf wanderrie) and *Austrostipa elegantissima* (feather speargrass) (SWGS).
2.	75%	**Sandy plains**—gently sloping or gently undulating sandy plains with relief to 5 m.	Red deep sands (445).	Moderately close to close tall shrublands of *Acacia ramulosa* and *A. acuminata* (jam) with some eucalypt trees and *Callitris columellaris* (inland pine). Low shrubs of *Eremophila forrestii*, *Thryptomene* spp.; some myrtaceous shrubs and perennial grasses of *Monachather paradoxus*, *Thyridolepis multiculmis* (soft wanderrie), *Eriachne helmsii* (buck wanderrie) and *Eragrostis eriopoda* (woolly butt) (SWGS).
3.	10%	**Lateritic plains**—gently sloping plains with moderately dense mantles of ironstone and lateritic gravels.	Red shallow sands (423) to moderately deep red sandy earths (463) with gravel substrates.	Scattered to moderately close tall shrublands with *Acacia ramulosa* and mid shrubs such as *Eremophila forrestii*, perennial grasses of *Monachather paradoxus* and *Thyridolepis multiculmis* (SWGS). On very shallow sands over laterite, tall shrubs of *Acacia grasbyi* (miniritchie) or *A. acuminata* with mid shrubs of *Thryptomene* spp. (GMUS—see Curry et al. 1994).
4.	5%	**Drainage tracts**—gently sloping broad fans and unchannelled drainage tracts with small areas of (internal) sheet flow.	Red sandy earths (463) and red loamy earths (544).	Closed groves of *Acacia ramulosa*, or *A. acuminata*. Scattered intergroves of *Acacia acuminata* and *A. ramulosa* and mid or low shrubs of *Rhagodia eremaea* (tall saltbush), *Solanum lasiophyllum* (flannel bush) and *Ptilotus obovatus* (cotton bush) (SWGS).
5.	5%	**Stripped stony surfaces**—gently sloping stony plains with outcrops of ferricrete, silcrete or weathered granite with stony mantles of ironstone or laterite gravels.	Red shallow loams (522) and red shallow sands (423).	Very scattered low or mid shrublands with *Acacia grasbyi*, *Eremophila latrobei* (warty leaf fuchsia), *Ptilotus obovatus*, *Senna* spp., *Thryptomene* spp. and graminoids of *Borya* spp. (pincushion) (STAS).

MONGOLIA LAND SYSTEM (152 ha, 0.01% of the survey area)

(modified from Curry et al. 1994)

Level sandy surfaced and gravelly plains supporting acacia shrublands and minor halophytic low shrublands.

Land type: 5—Stony plains with acacia shrublands and halophytic shrublands.

Geology: Quaternary alluvium associated with late Proterozoic siltstone and sandstone; also Tertiary laterite.

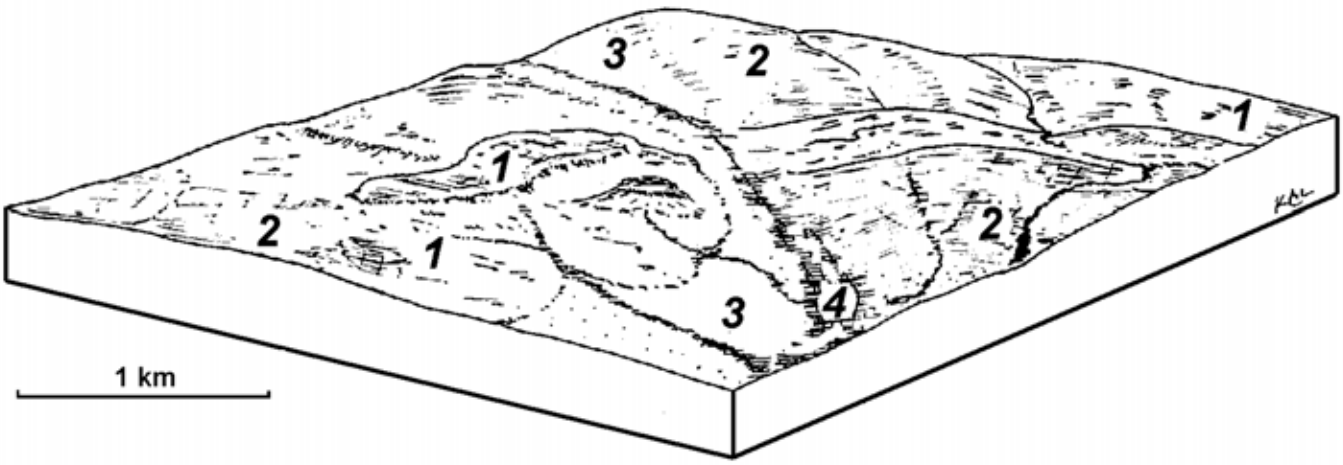
Geomorphology: Erosional surfaces; mostly pediment plains; low rounded rises and interfluves above broad stony plains; lower alluvial plains flanking saline drainage floors; occasional sandplain remnants. Overall relief up to 10 m.

Land management: Much of the system has low to moderate pastoral potential; the lower plains have high potential with controlled low stocking rates. The lower plains may be susceptible to accelerated erosion.

Traverse condition summary: This land system was not sampled.

Area mapped as sde: Nil.

No.	Unit name	Traverse recordings	Inventory sites
1.	Stony plain	-	-
2.	Gravelly plain	-	-
3.	Saline stony plain	-	-
4.	Drainage tract	-	-
	Total	0	0



Mongolia land system

Unit	area (%)	Landform	Soil	Vegetation
1.	40%	**Stony plains**—very gently undulating plains with low stony rises and occasional breakaways; moderately dense stony mantles of sandstone fragments, relief to 10 m.	Stony soils (203) over sandstone or red-brown hardpan shallow loam (523).	Scattered tall shrublands commonly with *Acacia acuminata* (jam) or *A. tetragonophylla* (curara). Mid shrubs of *Senna* spp. (desert cassia and banana leaf), and *Eremophila* spp. (poverty bush) with low shrubs of *Ptilotus obovatus* (cotton bush), *P. schwartzii* (horse mulla mulla), *Rhagodia eremaea* (tall saltbush), and occasional small bluebush (*Maireana* spp.) (SMMS—see Curry et al. 1994).
2.	30%	**Gravelly plains**—almost flat plains on sandstone, siltstone or laterite with dense stony mantles.	Red shallow loams with gravel inclusions (522).	Scattered to moderately close tall shrublands with *Acacia tetragonophylla*, *A. ramulosa*, *Hakea* spp., mid shrubs of *Senna* and *Eremophila* spp., and low shrubs of *Ptilotus obovatus*, *Sida calyxhymenia* (tall sida) and several species of bluebush (*Maireana* spp.) (SMMS—see Curry et al. 1994).
3.	20%	**Saline stony plains**—almost flat plains with small saline depressions and mantled with sandstone, siltstone and quartz often located on the margins of the system.	Red shallow sandy duplex (406).	Moderately close tall shrublands dominated by *Acacia xiphophylla* (snakewood) and *A. tetragonophylla* with understoreys of *Maireana pyramidata* (sago bush), *M. platycarpa* (shy bluebush), *M. georgei* (golden bluebush), *Atriplex bunburyana* (silver saltbush) and other halophytic species like *Frankenia* spp. (frankenia) (SSWS—see Curry et al. 1994).
4.	10%	**Drainage tracts**—flat drainage tracts to 300 m wide based on red-brown hardpan.	Red shallow sandy duplex (406) and red-brown hardpan shallow loams (523).	Scattered to very scattered low or mixed shrublands with *Eremophila pterocarpa* (silver poverty bush) or *Maireana pyramidata* with tall shrubs of *Hakea preissii* (needle bush), *Acacia tetragonophylla*, *Atriplex bunburyana* (silver saltbush), *Scaevola spinescens* (currant bush) and *Ptilotus obovatus* (BLUS—see Curry et al. 1994).

NANGA LAND SYSTEM (215 530 ha, 16.5% of the survey area)

(modified from Payne et al. 1987)

Undulating sandplains and low dunes supporting low heath, scrub heath and tree heath.

Land type: 7—Sandplains with acacia, mallees and heath.

Geology: Quaternary aeolian sand.

Geomorphology: Depositional surfaces; undulating sandplains with reticulate sand ridges or longitudinal dunes; no drainage features. Overall relief up to 30 m.

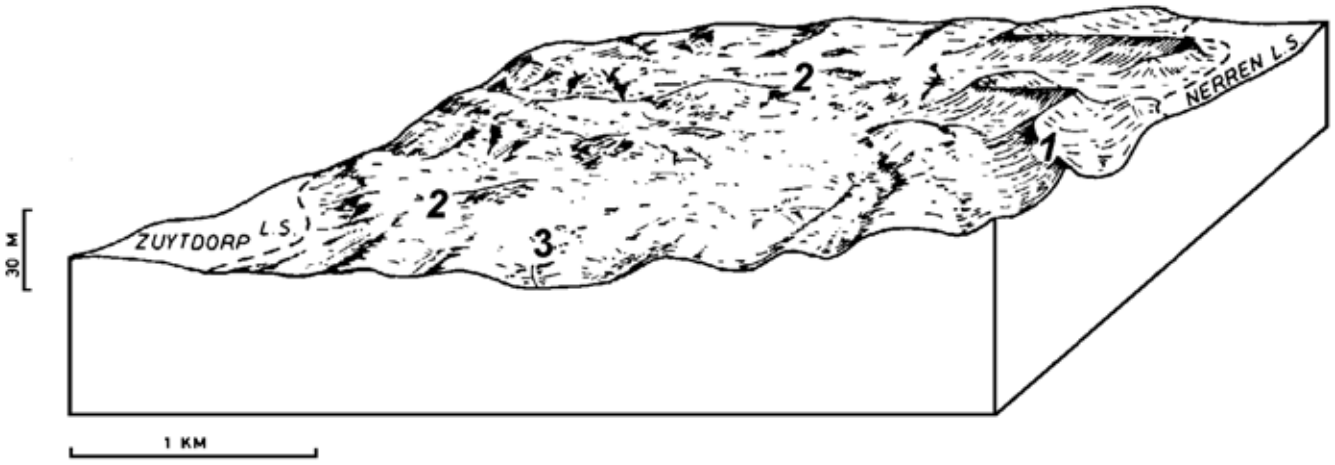
Land management: Heath vegetation is generally deficient in palatable perennial species for livestock and has very low pastoral value. This system generally has very few permanent stock watering points. Susceptibility to erosion is very low except immediately after fire when the wind erosion hazard is high.

Traverse condition summary: (derived from 126 traverse assessments and 12 inventory sites)

Vegetation—very good 90%; good 10%; fair 0%; poor 0%; very poor 0%.
Soil erosion—nil.

Area mapped as sde: Nil.

No.	Unit name	Traverse recordings	Inventory sites
1.	Undulating sandplain	115	10
2.	Sand ridge	11	2
3.	Drainage floor	-	-
	Total	126	12



Nanga land system

Unit	area (%)	Landform	Soil	Vegetation
1.	94%	**Undulating sandplains**—gently to strongly undulating sandplains up to 50 m in relief.	Mostly yellow deep sands (446) with some red deep sands (445) including yellowish red deep sands.	Close tree heath and tall shrublands with *Eucalyptus foecunda* (narrow-leaved red mallee), *E. eudesmioides* (malallie), *Callitris columellaris* (inland pine) and *Lamarchea hakeifolia* (false paperbark). Close mid and low shrubs of *Melaleuca*, *Eremaea*, *Thryptomene* and *Calothamnus* species with hummocking graminoids of *Ecdeiocolea monostachya* (wire stem grass) (HEAT, SCHE, TRHE, MASA, ASSW, CYSS).
2.	5%	**Reticulate sand ridges**—sand ridges and sand dunes, relief to 20 m.	Yellow deep sands (446).	Close tree heath and tall shrublands of *Banksia sceptrum* (sceptre banksia) and *Actinostrobus arenarius* (sandplain cypress) with myrtaceous low shrubs and occasional *Ecdeiocolea monostachya* graminoids (TRHE, SCHE, CYSS).
3.	1%	**Drainage floors**—small unchannelled narrow internal drainage tracts remotely scattered in unit 1.	Red sandy earths (463).	Scattered tall shrublands of *Melaleuca uncinata* (broom honeymyrtle) with very few low shrubs (MESS).

NERREN LAND SYSTEM (394 493 ha, 30.3% of the survey area)

(modified from Curry et al. 1994)

Red sandplains supporting acacia-mallee shrublands/woodlands.

Land type: 7—Sandplains with acacia, mallees and heath.

Geology: Quaternary aeolian sand.

Geomorphology: Depositional surfaces; very gently undulating sandplains with no surface drainage development. Overall relief up to 20 m.

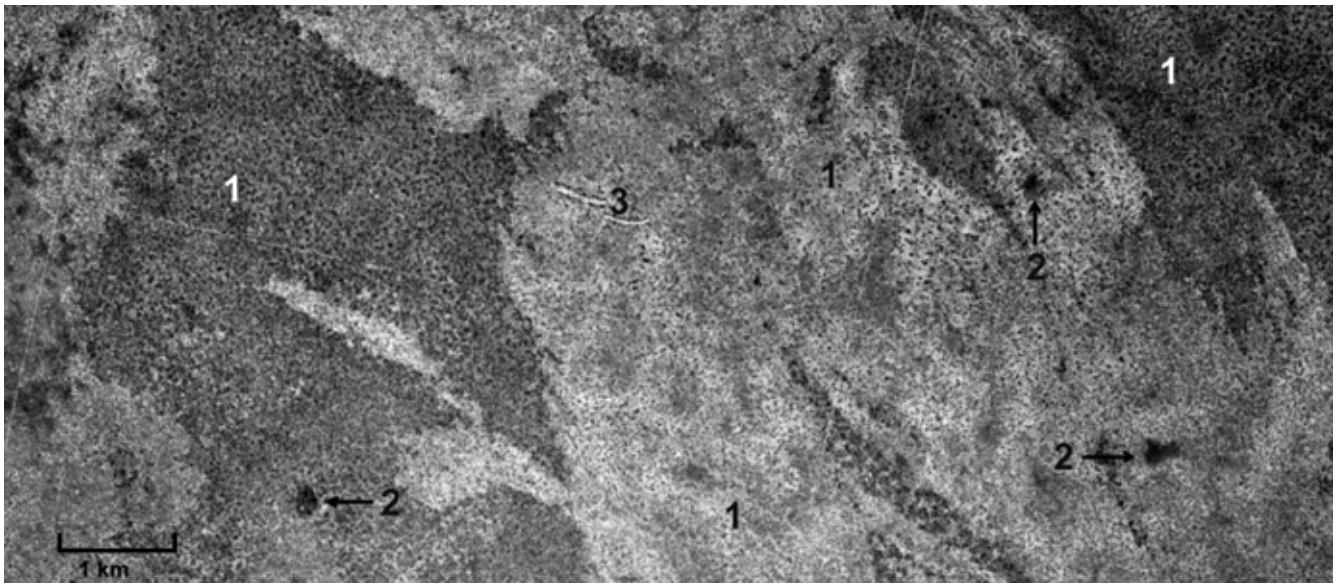
Land management: Eucalypt/acacia shrublands with few palatable perennial species suited for livestock. Herbs and annual species available during good seasons, but no durability during dry seasons; low erosion risk except after fire when the wind erosion risk may be low to moderate.

Traverse condition summary: (derived from 216 traverse assessments and 6 inventory sites)

Vegetation—very good 49%; good 29%; fair 20%; poor 2%; very poor 0%.
Soil erosion—nil.

Area mapped as sde: Nil.

No.	Unit name	Traverse recordings	Inventory sites
1.	Sandplain	204	6
2.	Loamy plain	10	-
3.	Sand dune	2	-
	Total	216	6



Nerren land system

Unit	area (%)	Landform	Soil	Vegetation
1.	94%	**Sandplains**—extensive level to gently undulating sandy plains, relief to 20 m.	Red deep sands (445) including some yellowish-red sands with minor yellow deep sands (446) adjacent to the Nanga land system.	Moderately close to close tall shrublands with trees/mallees including *Eucalyptus eudesmioides* (malallie), *E. foecunda*, *Callitris columellaris* (inland pine) and *Acacia ramulosa* (wanyu). Mid to low shrubs of *Lamarchea hakeifolia* (false paperbark), *Ptilotus obovatus* (cotton bush) and infrequent perennial grasses of *Monachather paradoxus* (broad-leaf wanderrie) grass (ASSW, occasional EUAW).
2.	5%	**Loamy plains**—small near-level to gently undulating sandy surfaced plains within sandplains (unit 1).	Red sandy earths (463).	Close tall shrublands with *Callitris columellaris* trees and tall shrubs of *Acacia tetragonophylla* (curara), *A. ramulosa*, *Hakea* spp., *Bursaria spinosa* (Australian boxthorn) and some *Acacia* spp. (wattle). Low shrubs of *Solanum nummularium* (wild tomato), *Rhagodia eremaea* (tall saltbush) and *Ptilotus obovatus* (cotton bush) (ASSW, MASA).
3.	1%	**Sand dunes**—sand dunes to 5 m high.	Red deep sands (445).	Moderately close tall shrublands with *Acacia* spp. including *A. ramulosa*. In the south-east, myrtaceous shrubs with some hummock grasses of *Triodia danthonioides* (spinifex).

PILLAWARRA LAND SYSTEM (10 397 ha, 0.8% of the survey area)

Plateaux, mesas, hills and footslopes supporting exotic annual grasslands, herbfields and halophytic shrublands.

Land type: 2—Low hills with eucalypt or acacia woodlands and halophytic shrubs.

Geology: Cainozoic calcrete and Cretaceous calcilutite, radiolarite and sandstone.

Geomorphology: Erosional surfaces; gently undulating duricrust plateaux tops, mesas and hills with steep rocky upper slopes and more gently inclined lower slopes; narrow drainage tracts with some deeply incised gullies. Overall relief up to 100 m.

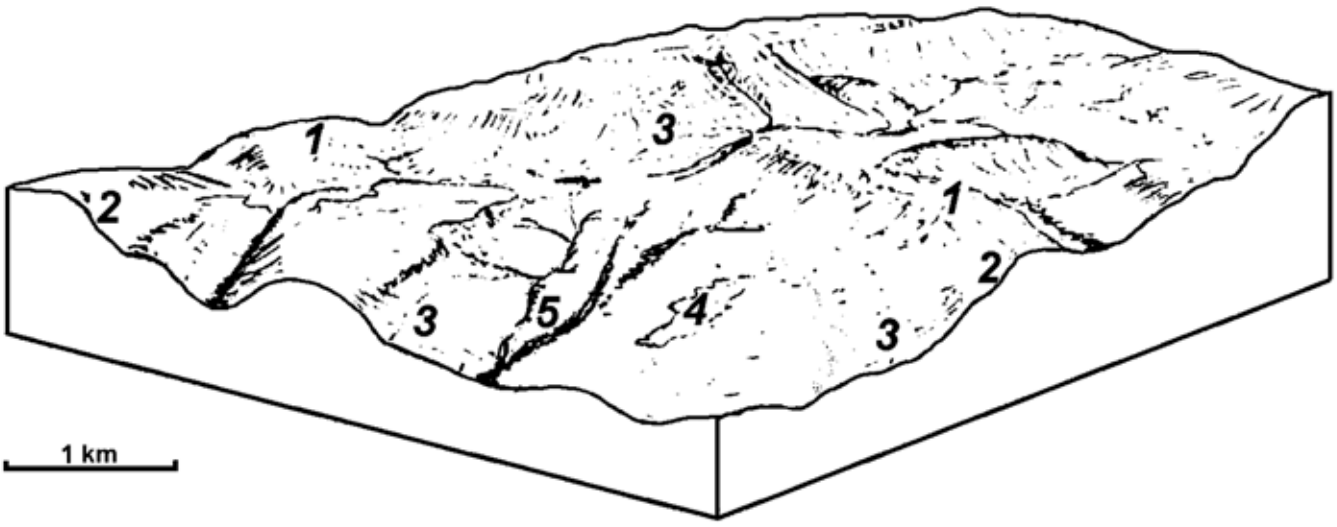
Land management: Vegetation on parts of the system is profoundly altered by grazing; former shrublands on lower slopes are degraded to annual grasslands or herblands of exotic species; parts of the upper and lower slopes and drainage tracts are severely gully eroded; other units are protected from erosion by rocky surface mantles, but still display reduced perennial species diversity.

Traverse condition summary: (derived from 44 traverse assessments and 9 inventory sites)

Vegetation—very good 7%; good 2%; fair 7%; poor 27%; very poor 57%.
Soil erosion—nil 56%; slight 11%; minor 11%; moderate 11%; severe 11%.

Area mapped as sde: 548 ha.

No.	Unit name	Traverse recordings	Inventory sites
1.	Plateau/mesa/hill	1	3
2.	Upper footslope	2	-
3.	Lower footslope	26	4
4.	Sandy plain	4	1
5.	Drainage tract	11	1



Pillawarra land system

Unit	area (%)	Landform	Soil	Vegetation
1.	55%	**Plateaux, mesas and hills**—very gentle to gently inclined plateau, mesa, hilltop surfaces and stony upper plains with abundant surface mantles of calcrete cobbles and stones.	Red shallow loams with abundant calcrete boulders (522).	Very scattered to scattered shrublands of *Acacia tetragonophylla* (curara), *A. galeata* (leather leaf wattle), *A. andrewsii* (prickly wattle), and *Pimelea microcephala* (shrubby riceflower) (ACSS).
2.	10%	**Upper footslopes**—short, moderately inclined to steep upper slopes at plateaux edges with common to abundant surface mantles of calcrete pebbles cobbles and stones.	Red shallow loams with abundant calcrete mantles (522).	As for unit 1. A few patches of low trees of *Acacia galeata* and *Alectryon oleifolius* (mingah bush) (ACSS, MXCS).
3.	30%	**Lower footslopes**—very gently to moderately inclined slopes and lower plains extending for up to 1 km, surface mantles absent or few calcrete pebbles and cobbles.	Calcareous (brown) loamy earths (542).	Predominantly exotic annual grasslands or herbfields. Occasional very scattered low shrublands of *Atriplex bunburyana* (silver saltbush), *Maireana brevifolia* (short leaf bluebush) and *Ptilotus obovatus* (cotton bush) (MXCS).
4.	1%	**Sandy plains**—small (up to 500 m), gently inclined, patches of sandy plains or sand sheet occasionally associated with units 3 and 5.	Red deep sands (445).	Tall shrublands of *Acacia rostellifera* (summer-scented wattle) (ASSW).
5.	4%	**Drainage tracts**—level to gently sloping drainage tracts and alluvial plains up to 500 m wide (but commonly much less in upper parts), deep gullies, channels and creeklines.	Calcareous (brown) loamy earths (542).	Annual grasslands or herbfields with a few isolated shrubs of *Acacia tetragonophylla* (MXCS). Larger creeklines support a few more shrubs and trees of *A. rostellifera*.

RODERICK LAND SYSTEM (252 ha, 0.02% of the survey area)

(modified from Curry et al. 1994)

Saline riverine plains supporting halophytic shrublands, grassy drainage foci, claypans and non-saline marginal hardpan plains with acacia shrublands.

Land type: 11—Alluvial plains with halophytic shrublands.

Geology: Quaternary alluvium with minor aeolian deposits.

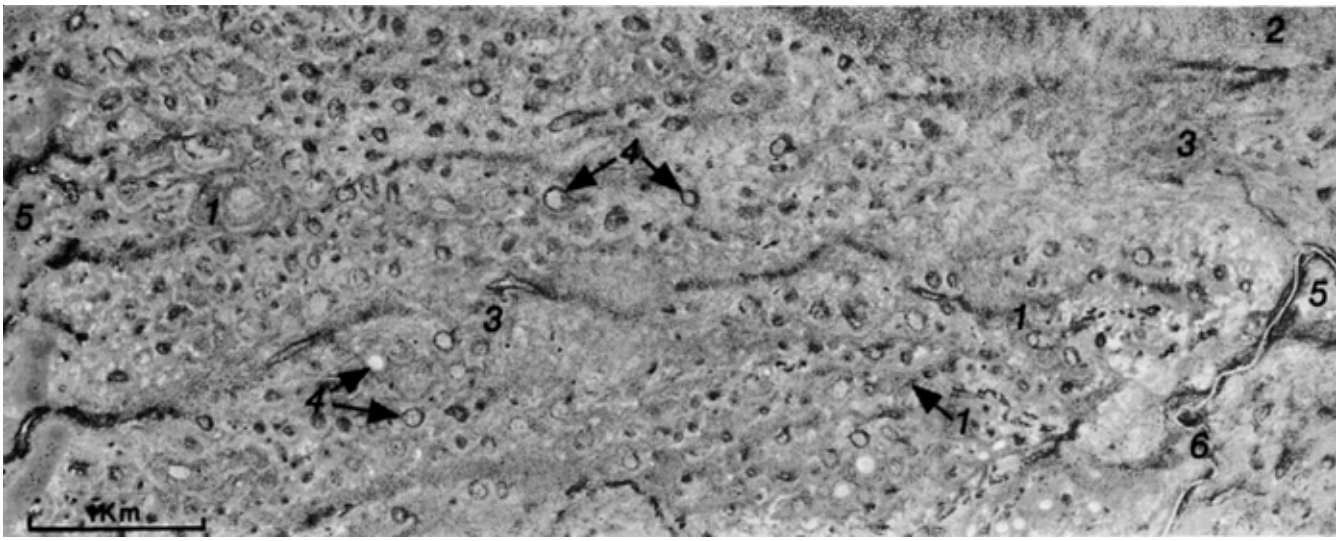
Geomorphology: Depositional surfaces: flat saline alluvial plains, floodplains and numerous claypans and drainage foci; minor sandy banks, incised river channels and partially saline peripheral hardpan plains. Overall relief mostly <5 m.

Land management: Highly productive halophyte vegetation suited to grazing livestock, however much of the system (unit 3) has significant areas of degradation through preferential grazing in the upper Murchison River area. Units 4 and 5 also support palatable vegetation and are sensitive to excess livestock levels. Units 3, 4 and 5 have a moderate to high erosion risk after perennial vegetation loss.

Traverse condition summary: This land system was insufficiently sampled (3 traverse assessments and no inventory sites) to derive valid vegetation or soil erosion summaries.

Area mapped as sde: Nil.

No.	Unit name	Traverse recordings	Inventory sites
1.	Sandy bank	-	-
2.	Hardpan plain	-	-
3.	Alluvial plain	3	-
4.	Claypan and drainage focus	-	-
5.	Saline plain	-	-
6.	Major channel/drainage line	-	-
	Total	3	0



Roderick land system

Unit	area (%)	Landform	Soil	Vegetation
1.	5%	**Sandy banks**—isolated sand banks on units 2 and 3 up to 2 m above surrounding plains.	Red deep sands (445).	Scattered tall shrublands often dominated by *Hakea preissii* (needle bush) or *Senna* spp. (cassia) when in poor condition. Other shrubs include *Acacia tetragonophylla* (curara), *Stylobasium spathulatum* (pebble bush) and *Enchylaena tomentosa* (ruby saltbush) (SDUS—see Curry et al. 1994).
2.	5%	**Hardpan plains**—loamy plains underlain by red-brown hardpan, mostly occurring on the outer margin of the system.	Red-brown hardpan shallow loams (523) or moderately deep red loamy earths (544).	Scattered to moderately close mixed shrublands of *Acacia tetragonophylla*, *A. victoriae* (wait-a-while), *Ptilotus obovatus* (cotton bush) and *Senna* spp. (HPAS).
3.	60%	**Alluvial plains**—extensive near-level plains adjacent to major river channels and drainage tracts (unit 6), partially saline with some areas of soil scalding or soil surface soil redistribution.	Red deep and shallow sandy duplex (405, 406) soils with minor red loamy earths (544) or red/brown non-cracking clays (622).	Very scattered to scattered low or mid-height shrublands dominated by *Maireana* spp. (bluebush) and *Atriplex* spp. (saltbush) when in good condition. Poor condition areas mostly support *Acacia victoriae*, *Senna* spp., *Hakea preissii*, and *Eremophila* spp. (poverty bush) in place of bluebush and saltbush (PLAS).
4.	15%	**Claypans and drainage foci**—claypans to 100 m in diameter and larger irregular ephemeral swamps.	Red/brown non-cracking clays (622) with some hard cracking clays (601) in swamps.	Swamps with some tussock grasses of *Eriachne flaccida* (claypan grass). *Eucalyptus victrix* (coolibah) trees or tall/mid-height shrubs of *Acacia tetragonophylla* on outer margins (ATUG—see Curry et al. 1994). Claypans often weakly vegetated or support only annuals in season.
5.	10%	**Saline plains**—low lying flat plains, mainly adjacent to unit 6 overlying red-brown hardpan or calcrete.	Red/brown non-cracking clays (622) sometimes saline.	Very scattered to scattered low shrublands of *Halosarcia* spp. (samphire) with *Frankenia* spp. (frankenia), *Cratystylis subspinescens* (sage) and some *Atriplex amnicola* (swamp saltbush) (MXHS—see Curry et al. 1994).
6.	5%	**Major channels and drainage lines**—meandering channels and partially saline riverbeds to 50 m wide and 5 m deep, flanked by minor sluggish drainage tracts.	Dry riverbed soils (700) with some juvenile sands on river levees.	Scattered trees of *Eucalyptus camaldulensis* (river red gum), *Casuarina obesa* (swamp sheoak) on channel banks with variable shrub layers including *Atriplex amnicola* with *Melaleuca*, *Acacia* and *Frankenia* spp. (RIVS).

SANDPLAIN LAND SYSTEM (188 455 ha, 14.5% of the survey area)

(modified from Curry et al. 1994)

Red and yellow sandplains with occasional dunes supporting acacia shrublands with mainly shrub (but locally grassy) understoreys.

Land type: 6—Sandplains with occasional dunes supporting grassy acacia shrublands.

Geology: Quaternary sand, partly aeolian.

Geomorphology: Depositional surfaces; flat to gently undulating, extensive sand sheets with infrequent minor dunes; minor weak drainage development and diffuse drainage foci. Overall relief up to 20 m.

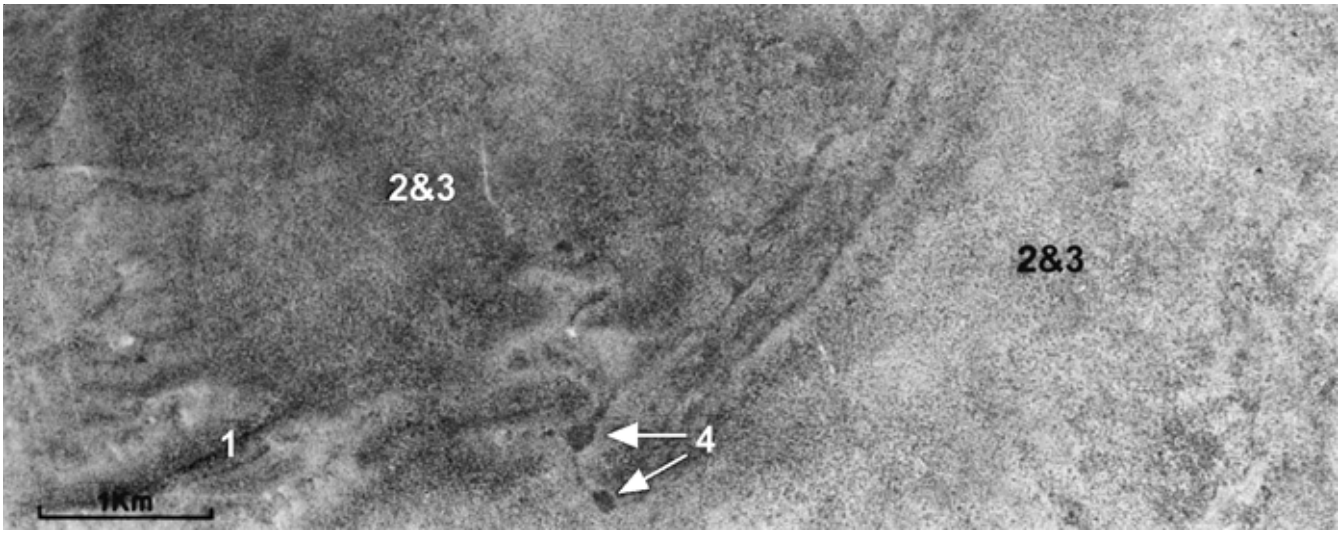
Land management: The vegetation is poorly to moderately productive for livestock dependent on perennial grass densities. Prone to fire following good seasons. Wind erosion risk may be moderate immediately after fire, otherwise the erosion risk is low.

Traverse condition summary: (derived from 70 traverse assessments and 3 inventory sites)

Vegetation - very good 49%; good 40%; fair 11%; poor 0%; very poor 0%
Soil erosion - nil

Area mapped as sde: Nil.

No.	Unit name	Traverse recordings	Inventory sites
1.	Sand dune	-	-
2.	Sand sheet	68	2
3.	Loamy plain	2	1
4.	Drainage foci	-	-
	Total	70	3



Sandplain land system

Unit	area (%)	Landform	Soil	Vegetation
1.	2%	**Sand dunes**—linear dunes up to 2 km long, relief up to 12 m.	Red deep sands (445).	Scattered tall shrublands including *Acacia ramulosa* (wanyu), *A. murrayana* (fire wattle) with mid shrubs of *Thryptomene* and *Eremophila* spp. with infrequent perennial grasses of *Monachather paradoxus* (broad-leaf wanderrie) (ASSW).
2.	92%	**Sand sheets**—extensive very gently to gently undulating broad plains, relief up to 20 m.	Red deep sands (445).	Scattered to moderately close tall shrublands dominated by *Acacia ramulosa* and *A. murrayana* with low shrubs of *Eremophila* and *Thryptomene* spp., and *Monachather paradoxus* grass (SWGS, MASA, ASSW).
3.	5%	**Loamy plains**—infrequent small plains on outer margins of sand sheets (unit 2).	Red sandy earths (463).	Tall shrublands of *Acacia ramulosa*, with some *Eucalyptus* sp. (mallee), *Acacia tetragonophylla* (curara) or *Callitris columellaris* (inland pine). Mid shrubs of *Eremophila forrestii* (Wilcox bush) and *Rhagodia* spp. (ASSW, MASA).
4.	1%	**Drainage foci**—isolated drainage foci and small swamps within either unit 3 or 4.	Red loamy earths (544) and red/brown non-cracking clays (622).	Very scattered mixed shrublands with some small trees of *Eucalyptus victrix* (coolibah), tall shrubs of *Melaleuca uncinata* (broom honeymyrtle). Low shrubs may include *Chenopodium* sp. (swamp bluebush) and *Muehlenbeckia florulenta* (lignum). Grasses are mostly absent (RIMS—see Curry et al. 1994).

STORK LAND SYSTEM (1029 ha, 0.08% of the survey area)

Gently undulating stony plains supporting York gum woodlands and acacia shrublands with saltbush and cotton bush low shrubs.

Land type: 10—Alluvial plains with eucalypt woodlands and halophytic shrubs.

Geology: Cretaceous radiolarite, Cainozoic calcrete and Quaternary colluvium.

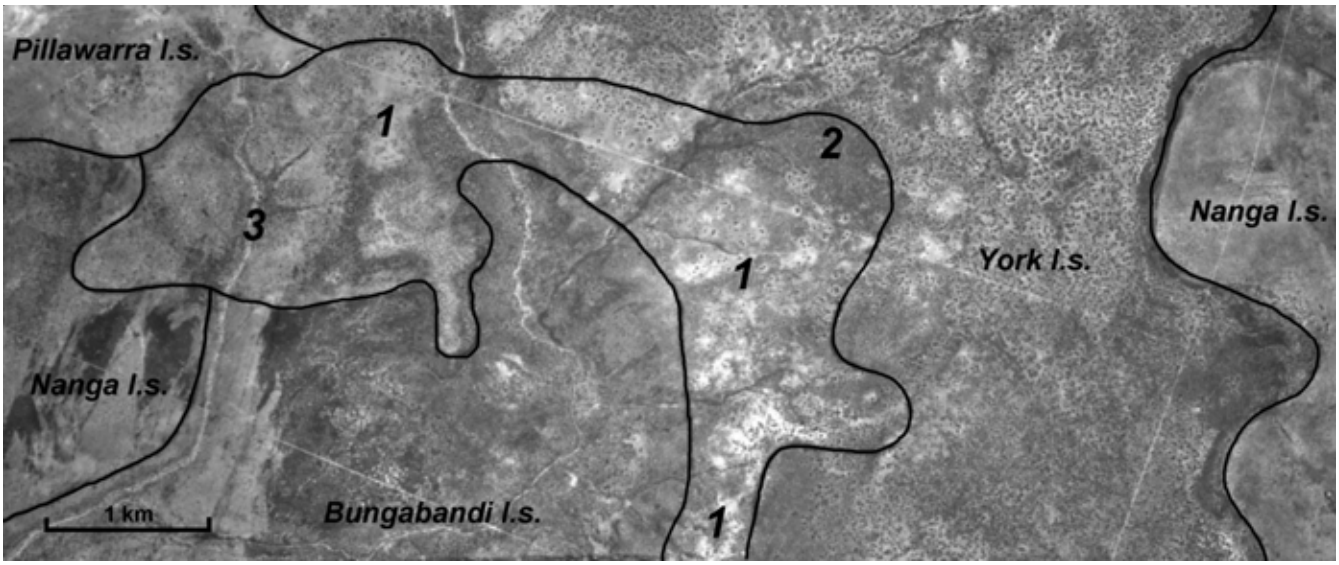
Geomorphology: Mainly erosional surfaces; gently undulating stony plains and low rises, minor sandy plains and narrow drainage zones. Relief up to 10 m.

Land management: This system supports low shrubs and ephemerals in season that are grazed by livestock but vegetation can be degraded by preferential overuse. It is generally not susceptible to erosion due to protection afforded by stony surface mantles.

Traverse condition summary: This land system was insufficiently sampled (4 traverse assessments, 1 site inventory site) to derive valid vegetation or soil erosion summaries.

Area mapped as sde: Nil.

No.	Unit name	Traverse recordings	Inventory sites
1.	Stony plain and low rise	4	1
2.	Sandy plain	-	-
3.	Narrow drainage zone	-	-
	Total	4	1



Stork land system

Unit	area (%)	Landform	Soil	Vegetation
1.	80%	**Stony plains and low rises**—gently undulating plains with common to abundant surface mantles of angular pebbles of radiolarite or calcrete.	Red shallow loams (522) overlying radiolarite or gravel.	Scattered low or mid-height shrublands of *Atriplex bunburyana* (silver saltbush), *Ptilotus obovatus* (cotton bush), *Acacia* spp. (wattles), *A. tetragonophylla* (curara) and patches of *Eucalyptus loxophleba* (York gum) trees (ESOW, EUAW, some STAS on low rises).
2.	5%	**Sandy plains**—level plains up to 400 m in extent as inclusions within stony plains (unit 1), generally without stony mantles.	Red deep sands (445).	Scattered tall shrublands of *Acacia acuminata* (jam), *A. ramulosa* (wanyu) with sparse mid or low shrubs of *Enchylaena tomentosa* (ruby saltbush), *Senna* spp. (cassias) and *Eremophila* spp. (poverty bushes) (ASSW).
3.	15%	**Narrow drainage zones**—narrow (up to 100 m wide) drainage floors with small channels incised up to 5 m.	Deep or moderately deep red loamy earths (544).	Scattered tall shrublands of *Acacia tetragonophylla* or *A. ramulosa* with mid or low shrubs of *Rhagodia* spp., *Ptilotus obovatus*, and *Eremophila* spp. (ACMS—see Payne et al. 1987).

TUMBLAGOODA LAND SYSTEM (41 742 ha, 3.2% of the survey area)

Rugged plateaux, valleys, gorges and slopes supporting acacia and melaleuca shrublands and scrub heath.

Land type: 1—Hills and ranges with acacia shrublands.

Geology: Silurian sandstone, minor Quaternary alluvium, colluvium, aeolian and residual sand.

Geomorphology: Erosional surfaces; stripped plateaux surfaces, deep valleys and gorges with precipitous cliffs, gently inclined to very steep, often benched slopes, minor gently inclined sandplains; tributary drainage tracts with major through-going trunk channels. Relief up to 140 m.

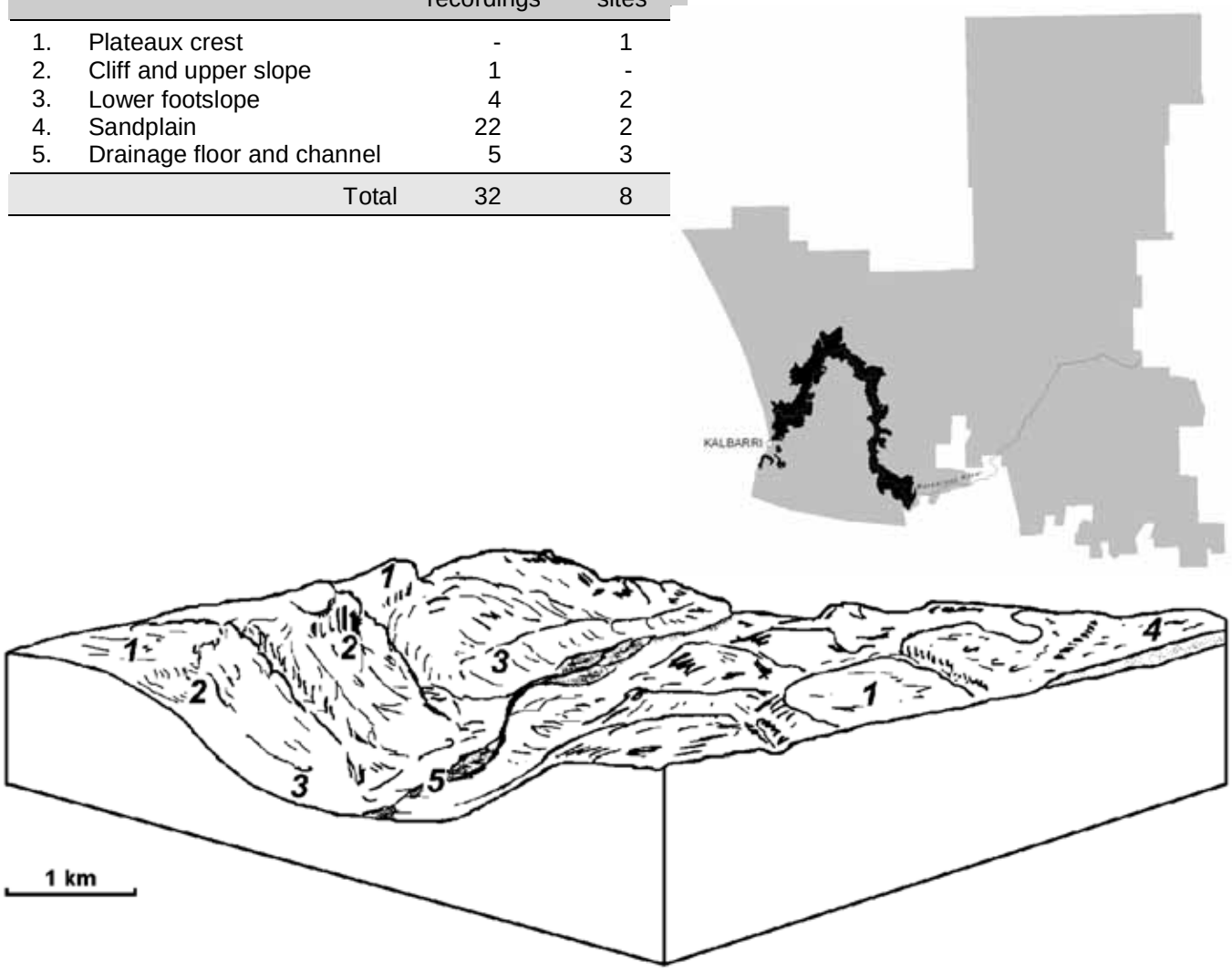
Land management: Much of the system falls within the Kalbarri National Park. Elsewhere it is used for pastoralism but is largely unsuitable for livestock due to the unattractive nature of the vegetation and poor accessibility. The system is a refuge for and is grazed by feral goats. The intermittent Murchison River within the system contains many permanent pools providing water for feral and native animals. Vegetation on drainage floors and along major channels is frequently degraded by overgrazing.

Traverse condition summary: (derived from 32 traverse assessments and 8 inventory sites)

Vegetation—very good 50%; good 28%; fair 3%; poor 6%; very poor 13%.
Soil erosion—nil 97%; minor 3%.

Area mapped as sde: Nil.

No.	Unit name	Traverse recordings	Inventory sites
1.	Plateaux crest	-	1
2.	Cliff and upper slope	1	-
3.	Lower footslope	4	2
4.	Sandplain	22	2
5.	Drainage floor and channel	5	3
	Total	32	8



Tumblagooda land system

Unit	area (%)	Landform	Soil	Vegetation
1.	10%	**Plateaux crests**—rough crests with truncated surfaces and abundant outcrop of sandstone; variable density mantles of sandstone cobbles and stones.	Pockets of red shallow sands (423) and stony soils (203) among outcropping sandstone.	Patches of tall shrublands with *Acacia acuminata* (jam) and *Jacksonia cupulifera* (rattlepod) with dominant mid shrubs of *Melaleuca oldfieldii* (purple honeymyrtle) and low shrubs of *Calytrix* sp. (starflower) (ACHS).
2.	39%	**Cliffs and upper slopes**—precipitous cliffs and gorge faces of sandstone, moderately inclined to very steep slopes with abundant outcrop and mantles of sandstone cobbles and stones.	Occasional pockets of red shallow sands (423) among outcrop and stony soils (203).	Cliffs and gorge faces with little or no vegetation, elsewhere patches of mid-height shrublands similar to unit 1 (ACHS).
3.	38%	**Lower footslopes**—gently to moderately inclined footslopes (sometimes benched), some rock outcrop and variable density mantles of sandstone pebbles and cobbles.	Red shallow loams (522) with sandstone outcrop and some red shallow sands (423).	Scattered to closed shrublands with *Acacia tetragonophylla* (curara) and *A. acuminata*, or scrub heath and low shrubs of *Melaleuca*, *Baeckea* and *Calytrix* spp. (ACHS, some SCHE).
4.	5%	**Sandplains**—level to gently inclined plains or benches as inclusions (up to 1 km in extent) associated with units 1 and 3.	Red deep sands (445) and brown deep sands (441).	Close or closed tall shrublands with *Acacia acuminata*, *Banksia* spp., *Grevillea candelabroides* (candle grevillea), *Callitris columellaris* (inland pine) or scrub heath with *Scholtzia* spp. and other myrtaceous shrubs (SCHE, ASSW).
5.	8%	**Drainage floors and channels**—level drainage floors and minor alluvial plains (up to 600 m wide in lower parts of the Murchison River, but usually much less) flanking channels and subject to flooding; channels up to 100 m wide with banks to 5 m.	Brown loamy earths (541) on minor alluvial plains and dry riverbed soils (700) in river channels.	Scattered or patchy woodlands with *Eucalyptus camaldulensis* (river red gum), *Casuarina obesa* (swamp sheoak) and *Melaleuca* spp. (honeymyrtle), (particularly flanking channels) with understorey annual grasses, herbs and few shrubs (DRCW).

YANDI LAND SYSTEM (11 618 ha, 0.9% of the survey area)

Alluvial plains supporting acacia shrublands and predominantly non-halophytic mid and low shrubs.

Land type: 9—Alluvial plains with acacia shrublands.

Geology: Quaternary alluvium overlying red-brown silicified hardpan.

Geomorphology: Depositional surfaces; almost level alluvial plains and floodplains surrounding seasonally active river channels with sandy bedloads, outer loamy plains subject to sheet flow. Overall relief up to <5 m.

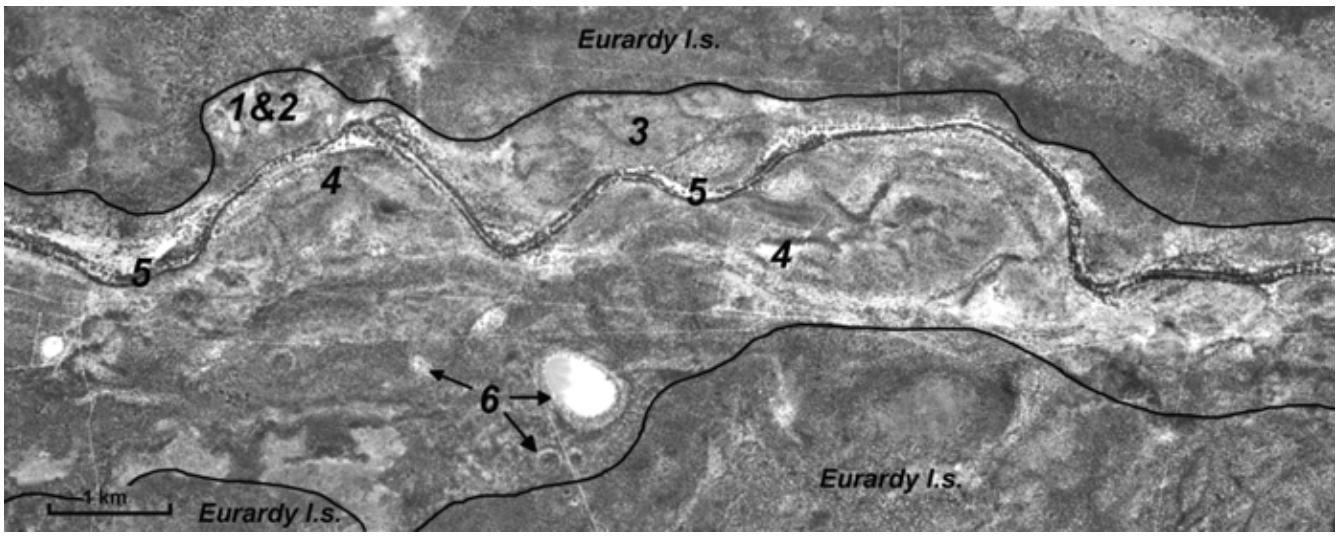
Land management: Mostly tall acacia shrublands with understoreys of low shrubs suited to livestock grazing. Current lack of species diversity indicates prior overgrazing. The system is highly prone to sheet erosion after excessive low shrub loss.

Traverse condition summary: (derived from 52 traverse assessments and 14 inventory sites)

Vegetation—very good 0%; good 0%; fair 2%; poor 19%; very poor 79%.
Soil erosion—nil 48%; slight 15%; minor 21%; moderate 8%; severe 8%.

Area mapped as sde: Nil.

No.	Unit name	Traverse recordings	Inventory sites
1.	Stony plain	4	4
2.	Stony hardpan plain	1	-
3.	Hardpan plain	7	1
4.	Alluvial plain	36	7
5.	Drainage channel	2	1
6.	Drainage focus	2	1
	Total	52	14



Yandi land system

Unit	area (%)	Landform	Soil	Vegetation
1.	10%	**Stony plains**—near-level, but slightly elevated plains (adjacent to units 2 and 3) with common to abundant stone cover.	Red shallow loams (522) mostly overlying sandstone or granite.	Scattered tall and mid shrublands of *Acacia acuminata* (jam) and *A. tetragonophylla* (curara) or *A. ramulosa* (wanyu) with sparse low shrub of *Eremophila forrestii* (Wilcox bush), *Grevillea deflexa* (red grevillea), *Senna artemisioides* subsp*. artemisioides* (banana leaf), *Ptilotus obovatus* (cotton bush) and *Solanum nummularium* (wild tomato) (ISAS, RIVS).
2.	5%	**Stony hardpan plains**—near-level plains with stone mantles flanked by units 1 and 3 and underlain by red-brown hardpan.	Red-brown hardpan shallow loams (523) or moderate depth red loamy earths (544).	As for unit 1 or 3.
3.	15%	**Hardpan plains**—near-level plains flanking unit 4 overlying red-brown hardpan.	Red-brown hardpan shallow loams (523).	Scattered tall and mid-height shrublands dominated by *Acacia acuminata* and *A. tetragonophylla* with low shrubs of *Senna artemisioides* subsp. *artemisioides*, *Hakea recurva* (djarnokmurd), *H. preissii* (needle bush) and *Ptilotus obovatus* (HPAS).
4.	60%	**Alluvial plains**—very gentle sloping plains receiving run-on from unit 2 and seasonal flooding from unit 5.	Red loamy earths (544) with minor red-brown hardpan shallow loams (523) and red deep sand (445).	Scattered tall shrublands of *A. acuminata* and *A. tetragonophylla* with sparse low shrubs of *Senna artemisioides* subsp*. artemisioides*, *Grevillea deflexa* and *Ptilotus obovatus* (HPAS, RIVS and occasional ISAS).
5.	7%	**Drainage channels**—seasonally active major (to 100 m wide) and minor river channels (to 20 m wide) and riverbeds with exposed red-brown hardpan margins or sandy levee banks.	Channels and some levees with riverbed soils (700) and some levees with red-brown hardpan exposure.	Moderately close, narrow woodlands of *Eucalyptus camaldulensis* (river red gum) and *Casuarina obesa* (swamp sheoak) along levee banks with very scattered mid shrubs of *Acacia sclerosperma* (limestone wattle) beyond levees (DRCW, RIVS).
6.	3%	**Drainage foci**—rounded depressions, including occasional swamps and claypans (up to 500 m wide) slightly lower than the surrounding alluvial plains (unit 4).	Clay soils with hard (grey) cracking clays (601) and grey non-cracking clays (621).	Very scattered trees of *Eucalyptus victrix* (coolibah) and tall shrublands of *Melaleuca uncinata* (broom honeymyrtle) with very few low shrubs and some perennial grasses following good seasons (DRMS).

YORK LAND SYSTEM (3.124 ha, 0.2% of the survey area)

(modified from Payne et al. 1987)

Level plains supporting York gum woodlands with saltbush and cotton bush low shrubs.

Land type: 11—Alluvial plains with halophytic shrublands.

Geology: Quaternary colluvium.

Geomorphology: Depositional surfaces; loam and sand covered plains and minor clay plains within former sluggish drainage tracts. Overall relief up to 3 m.

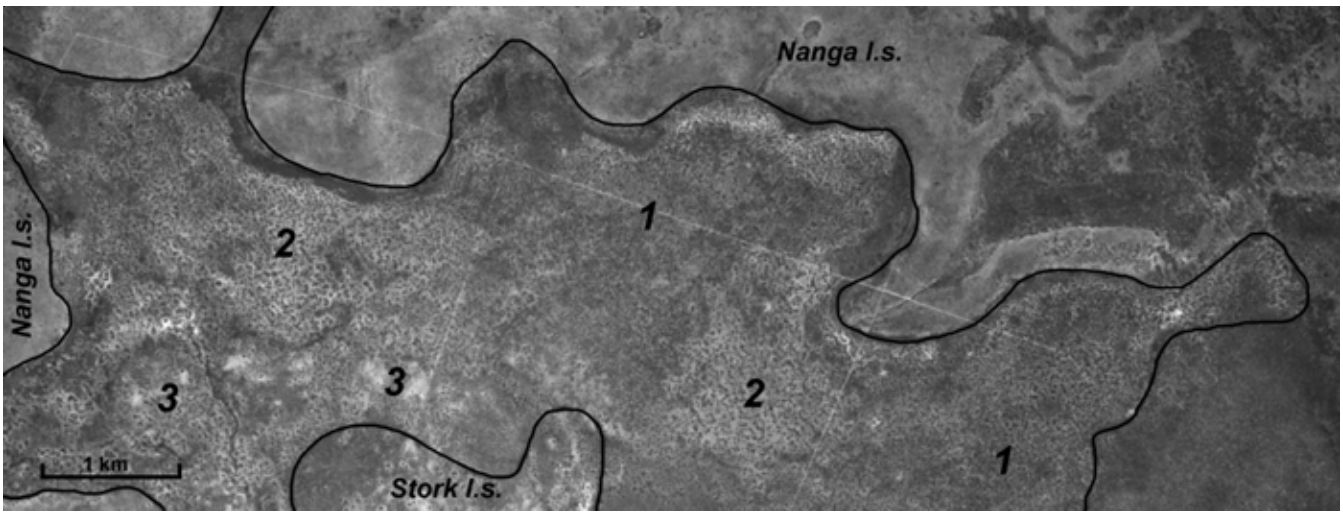
Land management: Mostly open York gum woodlands with numerous low shrubs suitable for grazing livestock. The system is not prone to erosion.

Traverse condition summary: (derived from 8 traverse assessments and 3 inventory sites)

Vegetation—very good 63%; good 25%; fair 0%; poor 12%; very poor 0%.
Soil erosion—nil.

Area mapped as sde: Nil.

No.	Unit name	Traverse recordings	Inventory sites
1.	Loamy plain	3	2
2.	Clay plain	-	-
3.	Alluvial plain	5	1
	Total	8	3



York land system

Unit	area (%)	Landform	Soil	Vegetation
1.	50%	**Loamy plains**—near-level plains slightly higher (<1 m) than unit 2 and 3.	Red loamy earths (544) with some red sandy earths (463) adjacent to sandplain systems.	Red loamy earths support scattered woodlands of *Eucalyptus loxophleba* (York gum) and *Acacia ramulosa* (wanyu) tall shrublands with low shrubs of *Ptilotus obovatus* (cotton bush), *Solanum nummularia* (wild tomato), *Rhagodia drummondii* (low saltbush) and some perennial grass, *Austrostipa elegantissima* (feather speargrass) (EUAW). Red sandy earths have tall shrublands of *Acacia tetragonophylla* (curara) and *A. sclerosperma* (limestone wattle) with low shrubs of *Ptilotus obovatus*, *Scaevola spinescens* (currant bush), occasional *Hakea preissii* (needle bush) and *Atriplex bunburyana* (silver saltbush) (ESOW, EAUW).
2.	30%	**Clay plains**—near-level plains with shallow depressions in sluggish drainage tracts.	Red loamy earths (544) with calcareous subsoils and red/brown non-cracking clays (622).	Scattered to moderately close woodlands of *Eucalyptus loxophleba* with tall shrubs of *Acacia tetragonophylla*. Low shrubs of *Atriplex bunburyana*, *Ptilotus obovatus*, *Scaevola spinescens* and *Maireana tomentosa* (felty bluebush) (ESOW).
3.	20%	**Alluvial plains**—minor, restricted near-level plains adjacent to unit 2.	Red loamy earths (544) with calcareous subsoils.	Moderately close low shrublands of *Atriplex bunburyana*, *Scaevola spinescens*, *Ptilotus obovatus* and short-lived woody herbs of *Sclerolaena uniflora* (two spine bindii), with a very scattered overstorey of *Eucalyptus loxophleba* trees (ESOW).

ZUYTDORP LAND SYSTEM (42 257 ha, 3.2% of the survey area)

(modified from Payne et al. 1987)

Limestone plains with thin sand cover, sandy coastal slopes and cliffs supporting heath.

Land type: 13—Coastal plains, cliffs, dunes and beaches.

Geology: Quaternary Tamala limestone with aeolian sand.

Geomorphology: Very steep stony slopes and cliffs rising from sea level to an elevated plateau; limestone plains and undulating sand sheets inland from coast with no defined drainage features. Relief at coast to 200 m. Relief of undulating sandplains and low hills up to 20 m.

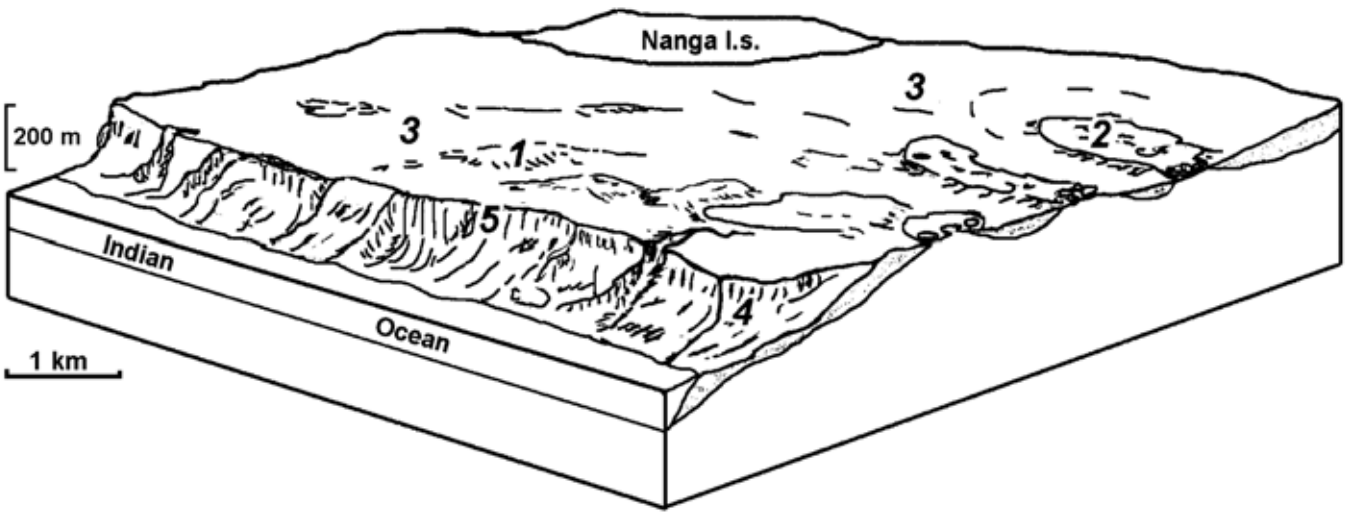
Land management: Heath vegetation is generally not suitable for grazing livestock. The system is not prone to degradation, except on the coast where wind erosion is likely after wildfire or other disturbances that remove much ground cover.

Traverse condition summary: (derived from 56 traverse assessments and 9 inventory sites)

Vegetation—very good 91%; good 8%; fair 1%; poor 0%; very poor 0%.
Soil erosion—nil.

Area mapped as sde: 364 ha.

No.	Unit name	Traverse recordings	Inventory sites
1.	Low rise	-	1
2.	Limestone plain	6	1
3.	Sand sheet	50	6
4.	Seaward slope	-	1
5.	Cliff	-	-
	Total	56	9



Zuytdorp land system

Unit	area (%)	Landform	Soil	Vegetation
1.	10%	**Low rises**—undulations and low hills of coastal limestone with thin sand cover.	Stony yellow/brown shallow sands (424) overlying coastal limestone.	Close mid-height shrublands with *Hakea* spp., *Grevillea stenomera* (lace net grevillea), *Alyxia buxifolia* (dysentery bush) and *Acacia ligulata* (umbrella wattle). Low shrubs of *Melaleuca* spp. (honeymyrtle) and *Olearia axillaris* (coastal daisy) (HEAT, SCHE).
2.	10%	**Limestone plains**—elevated and undulating stony plains with shallow soils and limestone outcrops.	Calcareous (brown) deep sands (442) with limestone fragments.	Close tall and mid shrublands of *Acacia ligulata*, with low shrubs of *Melaleuca cardiophylla* (teatree), *Olearia axillaris*, *Pimelea leucantha* (big riceflower) and *Acanthocarpus preissii* (SCHE).
3.	70%	**Sand sheets**—elevated undulating sandy plains, relief up to 20 m.	Calcareous (brown) deep sands (442) including white and grey coastal deep sands.	Scattered to close tall shrublands of *Acacia ligulata*, with mid shrubs of *Grevillea* spp. and *Olearia axillaris*. Low shrubs of *Melaleuca*, *Calothamnus* and *Petrophile* spp. with occasional tall shrubs of *Banksia* spp. and graminoids of *Ecdeiocolea monostachya* (wire stem grass) (HEAT, SCHE). Some close woodlands of *Melaleuca cardiophylla* (MELW).
4.	5%	**Seaward slopes**—moderately inclined slopes with deep sands (dunes). Steeper slopes with sand cover or very steep slopes with limestone outcrop or thin sand cover.	Variable depth calcareous deep sands (442) and calcareous shallow sands (421).	Close mid-height shrublands with *Olearia axillaris*, *Diplolaena dampieri* (wild rose), *Rhagodia preissii* subsp. *obovata* (sea saltbush), *Scaevola crassifolia* (thick leaf fan flower), *Acacia ligulata* and *Frankenia* spp. (frankenia) on deeper soils (HEAT, COHE). Low shrubs of *Frankenia* sp. (sea heath), *Olearia axillaris* and *Atriplex* spp. (saltbush) on shallow soils facing the ocean (COHE).
5.	5%	**Cliffs**—very steep, rugged, inaccessible sea cliffs with almost vertical faces.	Pockets of calcareous shallow sands (421) or exposed weathered limestone.	Scattered to moderately scattered low shrubs of *Frankenia* sp., *Scaevola crassifolia*, *Olearia axillaris* and *Atriplex* spp. (COHE).

Other mapped areas

The outer boundary of two areas of the Kalbarri townsite were mapped, but not investigated in more detail. The area mapped as the townsite was 839 ha and represents less than 0.1 per cent of the survey area.

The lower floodplains of the Murchison River consist of tidal zones. The area does not support vegetation suitable for livestock grazing and is not included in a pastoral lease. This area (332 ha or 0.03 per cent of the survey area) was mapped but not investigated as part of this survey.

Within some pastoral leases toward the south-western agricultural area, some land has been cleared for broadacre cereal cropping. These areas were cleared with approval from the Pastoral Lands Board. They produce successful cereal crops during years of adequate rainfall. In some years they are not cropped, but used primarily for occasional livestock grazing. These freehold areas, which cover about 12 927 ha (or about 1 per cent of the survey area), were investigated by Rogers (1996).

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Condition of the natural resource

In much of the lower Murchison survey area, the main land uses are tourism, conservation, livestock grazing, farming and urban development (Kalbarri townsite). Unallocated Crown Land is largely unused.

The Kalbarri National Park, Toolonga Nature Reserve and part of the Cooloomia Nature Reserve represent conservation areas. The Kalbarri National Park and Kalbarri townsite are the primary tourist destinations. About 30 per cent of the survey area is leased from the Crown for the purpose of pastoralism. In this instance 'pastoralism' is defined as 'a land use practice whereby livestock graze on native vegetation in rangelands areas, for the purpose of meat or fibre production'.

The areas allocated to farming are special lease areas or freehold title where, in most cases, approval was granted to clear native vegetation for the commercial production of broadacre cereal crops. These farming areas and the area of the Kalbarri townsite were not investigated as part of this survey. Unallocated Crown Land is not used for any commercial production.

Resource condition is defined as 'the current condition of the rangeland in relation to the potential capacity, for the attainment of a particular land use'. In discussing the condition of the soil and vegetation resources of the lower Murchison, distinctions are made between pastoral and non-pastoral lands. Statements or information relating to pastoral lands do not necessarily directly correlate or equally translate to non-pastoral lands, and vice-versa.

A total of 1239 point data observations were recorded in the process of traverse assessment within the survey area. Of these, 414 observations recorded land system changes along traverse routes, infrastructure (such as artificial water points for livestock) or were within the Kalbarri National Park where no condition status is presented, leaving 825 observations assessing condition. Observation points on special lease land used for cereal crop production, points very close to station infrastructure such as homesteads, yards, etc., or points on land unduly influenced by roads, firebreaks or other infrastructure were not assessed for condition.

Vegetation condition

The condition statements for the vegetation are derived from the summary of the traverse assessments. Vegetation condition was assessed in the field as five condition classes, namely: very good; good; fair; poor; or very poor. These condition classes were further summarised into three classes (good, fair and poor) for simplicity. Table 10 shows the impact of pastoralism in terms of vegetation condition.

Table 10 **Vegetation condition summarised into three condition classes**

Condition status	All land	Non-pastoral land	Pastoral land
	% of traverse assessments	% of traverse assessments	% of traverse assessments
Good (very good or good)	77.5	99.0	69.9
Fair	9.0	1.0	11.8
Poor (poor or very poor)	13.5	0.0	18.3

Table 11 summarises those land systems with poor or very poor vegetation condition ratings on pastoral lease land. Of the pastoral lease land assessments, about 18 per cent indicated poor or very poor vegetation condition.

Table 11 shows the Yandi and Pillawarra land systems were significantly poorer in vegetation condition than the other systems. Note: where the 'Total assessments per land system on pastoral land' (column 3) number less than 20, the 'percentage poor condition of land system' figures (column 4) should be disregarded, as the figures are not statistically valid. However, in the case of the insufficiently sampled Roderick system, Curry et al. (1994) noted this was highly susceptible to degradation. This land system is potentially an important seed source for alluvial and flood plains further downstream, and as such should only be grazed sparingly by livestock. Land systems with more than a minor percentage of poor condition require strict livestock management regimes. The two most affected systems require destocking of vulnerable land units. Vermin control is paramount.

Table 11 **Summary of land systems on pastoral land showing poor or very poor vegetation condition (derived from traverse assessments)**

Land system	Number of poor or very poor vegetation condition assessments	Total number of assessments per land system	Percentage poor or very poor vegetation condition
Ajana	2	15	13.3
Bibra	2	31	6.5
Bungabandi	3	20	15.0
Highway	1	26	3.8
Nerren	4	152	2.6
Pillawarra	37	44	84.1
Roderick	2	3	66.7
Stork	2	4	50.0
Tumblagooda	6	32	18.8
York	1	8	12.5
Yandi	51	52	98.1
Zuytdorp	1	56	1.8
Total	112	443	

Soil health

Soil erosion scores were also summarised from traverse assessments. Six scores (nil, slight, minor, moderate, severe and extreme) were further summarised into four classes for simplicity (see Table 12).

Accelerated soil erosion was recorded on 50 traverse assessment points: 28 per cent showing minor erosion, 36 per cent with moderate erosion and 36 per cent with severe erosion. All of the 50 points were in poor to very poor vegetation condition. All but 4 per cent of the erosion recorded occurred in the land systems of high pastoral potential, namely the Roderick, Yandi and Pillawarra systems.

Soil erosion was recorded on only six of the 23 land systems in the survey area (see Table 13).

Table 12 **Soil erosion summarised into four classes**

Erosion class	All land	Non-pastoral land	Pastoral land
	% of traverse assessments	% of traverse assessments	% of traverse assessments
Nil	94.0	100	91.7
Minor (slight or minor)	3.8	0	5.3
Moderate	1.1	0	1.5
Severe (severe or extreme)	1.1	0	1.5

Table 13 **Soil erosion on land systems on pastoral lands (derived from traverse assessments)**

Land system	Total number of traverse assessments	Traverse assessments with erosion	Extent of soil erosion %			
			Nil	Minor	Moderate	Severe
Bungabandi	20	1	95	5	0	0
Pillawarra	44	20	55	23	11	11
Roderick	3	1	67	33	0	0
Tumblagooda	32	1	97	3	0	0
Yandi	52	27	53	33	8	8
Zuytdorp	No erosion recorded while traversing but about 364 ha of coastal dune blowouts are known on pastoral land.					

Severely degraded and eroded areas (sde)

'Severely degraded and eroded' is defined as 'drastically altered areas of land where few, if any, perennial plant species remain, and the area has much bare ground with major soil redistribution or soil deflation'. Areas deemed severely degraded and eroded (sde) were mapped at a scale of 1:250 000. The minimum area of sde for this mapping scale was 40 ha, but this does not necessarily imply there are no areas of severely degraded and eroded land less than 40 ha.

Seven severely degraded and eroded areas totalling 912 ha (9.12 km² or 0.07 per cent of the survey area) were mapped, one on the Pillawarra land system and six within the Zuytdorp land system. All severely degraded and eroded areas within the Zuytdorp system occur on the coast. Two zones of coastal erosion are about 12 km north of Kalbarri.

A pastoral classification plan (Johnson 1967) identified this area as simply 'sand', suggesting it may have been unstable for at least 40 years. Within the vicinity of this 'sand' area is a natural spring. Natural springs occur infrequently on the coast but are rarely permanent supplies of significant amounts of water during the whole year. However, hearsay evidence suggests pastoral pioneers often used these waters for livestock. Similarly the remaining four areas identified as severely degraded and eroded along the northern coast may have developed as a result of livestock watering points.

The Zuytdorp coast is renowned for strong sea winds, especially during summer, meaning unvegetated areas are extremely prone to erosion and very difficult to stabilise. Of the six areas identified (from aerial photographs) as severely degraded and eroded along the coast, only one was inspected by the survey team.

The other area of mapped severely degraded and eroded land occurs within the Pillawarra land system. The Pillawarra land system is unique, unlike any other land system seen in the southern rangelands by the author. The high rocky plateaux dominate lower footslopes and minor drainage tracts with deep calcareous brown loamy earths. These soils are uncommon in the southern rangelands and support cotton bush (*Ptilotus obovatus*) and significant stands of small leaf bluebush (*Maireana brevifolia*), also relatively uncommon in the southern rangelands. Regrettably, this land system also shows some undesirable (grazing-induced) traits such as a lack of perennial plant species, erosion and weed infestation. Uncontrolled historic grazing has effectively removed perennial plants from some lower footslopes. The soil textures tend to suggest the topsoil has been removed, although the amount of soil loss cannot be determined. The system, where severely degraded and eroded, has many very deep erosion gullies. Away from permanent livestock watering points this system was not severely degraded and eroded.

The mid-west and central coast of WA is renowned for strong winds during the summer making regeneration of coastal sand dunes difficult. Six areas along the coast totalling about 364 ha were identified as being 'blowout' sand dune areas.

Erosion gullies caused by historical overgrazing within the Pillawarra land system. Parts of this system should be protected from all grazing animals to encourage re-establishment of perennial native vegetation.

Faced with the legacy of historical over-stocking, there is little or no benefit (in a sustainable future sense) to continue to allow animals to graze some parts of the Pillawarra and Zuytdorp systems. Where pastoral lands are in poor or very poor vegetation condition, continued grazing is not recommended. The affected areas should be denied to all grazing animals and be allowed to recover in terms of native plant numbers and diversity. Mechanical regeneration (for example, deep ripping of the soil to encourage plant establishment) is not recommended in areas with steep gradients, fast overland water flow or strong winds. Instead, treatments such as fencing and shifting stock watering points via piping (leading away from the degraded lands) are more beneficial. Monitoring the recovery of the degraded land should be part of a long-term management plan to restore the area.

The alluvial plains of the Yandi land system in good and poor condition. Diverse species of low shrubs, tall shrubs without 'grazing browse lines' and healthy, intact soil surfaces contrast strongly with the poor condition land. Poor condition lands will remain degraded unless afforded adequate rest and protection from all grazing animals.

Summary of traverse assessments

A total of 825 traverse points were assessed for vegetation condition and soil disturbance. Both pastoral lease land and non-pastoral land were assessed. Unallocated Crown Land was assessed and mapped to 'fill in' the resource gaps left by surrounding rangeland surveys.

Traverse summaries are presented in terms of vegetation condition and soil erosion for each land system for the whole survey area, for non-pastoral lands and pastoral lands (see Tables 14, 15 and 16).

Table 14 **Condition summary of land systems for the whole survey area (derived from traverse assessments)**

Land system	No. of assessments	Condition of perennial vegetation (%)			Extent of soil erosion (%)			
		Good or very good	Fair	Poor or very poor	Nil	Slight or minor	Moderate	Severe or extreme
Ajana	15	53	33	14	100	0	0	0
Bayou	1	100	0	0	100	0	0	0
Bibra	31	90	3	7	100	0	0	0
Boulder	3	67	33	0	100	0	0	0
Bungabandi	20	80	10	10	97	3	0	0
Cooloomia	4	75	25	0	100	0	0	0
Eurardy	113	98	2	0	100	0	0	0
Highway	26	86	9	5	100	0	0	0
Holmwood	-	-	-	-	-	-	-	-
Joseph	1	100	0	0	100	0	0	0
Kalbarri	-	-	-	-	-	-	-	-
Kalli	-	-	-	-	-	-	-	-
Mongolia	-	-	-	-	-	-	-	-
Nanga	126	98	0	2	100	0	0	0
Nerren	216	79	19	2	100	0	0	0
Pillawarra	44	12	7	81	60	21	7	12
Roderick	3	0	33	67	67	33	0	0
Sandplain	70	88	12	0	100	0	0	0
Stork	4	25	25	50	100	0	0	0
Tumblagooda	32	79	3	18	97	3	0	0
Yandi	52	2	2	96	49	36	8	8
York	8	88	0	12	100	0	0	0
Zuytdorp	56	98	0	2	100	0	0	0
Total	825							

Table 15 **Condition summary of land systems on non-pastoral lands (derived from traverse assessments)**

Land system	No. of assessments	Condition of perennial vegetation (%)			Extent of soil erosion (%)			
		Good or very good	Fair	Poor or very poor	Nil	Slight or minor	Moderate	Severe or extreme
Eurardy	76	100	0	0	100	0	0	0
Nanga	17	100	0	0	100	0	0	0
Nerren	64	100	0	0	100	0	0	0
Sandplain	60	97	2	0	100	0	0	0
Total	217							

Table 16 **Condition summary of land systems on pastoral lands (derived from traverse assessments)**

Land system	No. of assessments	Condition of perennial vegetation (%)			Extent of soil erosion (%)			
		Good or very good	Fair	Poor or very poor	Nil	Slight or minor	Moderate	Severe or extreme
Ajana	15	100	0	0	100	0	0	0
Bayou	1	100	0	0	100	0	0	0
Bibra	31	90	3	7	100	0	0	0
Boulder	3	80	20	0	100	0	0	0
Bungabandi	20	80	10	10	97	3	0	0
Cooloomia	4	75	25	0	100	0	0	0
Eurardy	37	96	4	0	100	0	0	0
Highway	26	86	9	5	100	0	0	0
Holmwood	-	-	-	-	-	-	-	-
Joseph	1	100	0	0	100	0	0	0
Kalbarri	-	-	-	-	-	-	-	-
Kalli	-	-	-	-	-	-	-	-
Mongolia	-	-	-	-	-	-	-	-
Nanga	109	100	0	0	100	0	0	0
Nerren	152	100	0	0	100	0	0	0
Pillawarra	44	12	7	81	60	21	7	12
Roderick	3	0	33	67	67	33	0	0
Sandplain	10	97	3	0	100	0	0	0
Stork	4	25	25	50	100	0	0	0
Tumblagooda	32	79	3	18	97	3	0	0
Yandi	52	2	2	96	49	36	8	8
York	8	88	0	12	100	0	0	0
Zuytdorp	56	98	0	2	100	0	0	0
	Total 608							

Resource condition

Resource condition is described by combining the condition of vegetation with the extent of soil erosion. Tables 14, 15 and 16 summarised via a matrix (Table 17) derive three levels (good, fair, poor) of resource condition for the survey area (Table 18).

About 87 per cent of the vegetation and soil resources of the lower Murchison were assessed as being in fair or good condition with about 13 per cent being assessed in poor resource condition. Almost all (about 98 per cent) of non-pastoral land was assessed as being in good resource condition. About 82 per cent of pastoral land was assessed as being in good or fair condition with about 18 per cent being poor. All poor condition assessments occurred on pastoral land.

About 90 per cent of the survey area consists of sandplains. When pioneer pastoralists took up leases in the late 1800s, they generally sought the best land with moderate to high pastoral potential. As parcels of favourable lands (such as along river courses) became less available, blocks of land were excised from land of moderate potential. Sandplain country was (and still is) deemed as being of low or very low potential for pastoralism meaning much of it remains vacant or, if falling within pastoral lease boundaries, is not developed.

In the early years of pastoralism there was no information on the effects of long-term continuous grazing on native vegetation and the soils and some lands were grazed at unsustainable levels. Although historic stock number records are unavailable for the lower Murchison area, it is likely livestock populations followed similar trends as in neighbouring pastoral areas. Information provided by Payne et al. (1987, 1998) and Curry et al. (1994) for the Carnarvon, Yalgoo and upper Murchison show high stock numbers peaking around 1910, 1920, 1930 and 1970. Perhaps the most crucial times (in regard to unsustainable grazing) occurred during the first three or four decades of the twentieth century.

Table 17 **Derivation of three levels of resource condition from vegetation condition and soil erosion ratings**

		Vegetation condition		
		Very good or Good	Fair	Poor or Very poor
Extent of soil erosion	Nil	Good (1)	Fair (2)	Poor (3)
	Slight or Minor	Good (1)	Fair (2)	Poor (3)
	Moderate	Fair (2)	Poor (3)	Poor (3)
	Severe or Extreme	Poor (3)	Poor (3)	Poor (3)

Table 18 **Resource condition of the survey area**

Resource condition status	All land	Non-pastoral land	Pastoral land
Summary of combined vegetation and soil assessments	% of traverse assessments	% of traverse assessments	% of traverse assessments
Good	77.6	97.8	70.0
Fair	9.0	2.2	11.6
Poor	13.4	0.0	18.4

Comparison with other regional surveys

Table 19 summarises the resource condition of the lower Murchison and previous rangeland surveys. There is no valid statistical basis to make direct comparisons between surveys. For example, the Gascoyne area consists of mainly pastoral leasehold land, while the Pilbara and the lower Murchison contain large tracts of Unallocated Crown Land and conservation reserves.

The summary for the lower Murchison survey is presented in two formats, since most of the area surveyed (72 per cent) is non-pastoral land. Of the land within pastoral leases (3685 km²), 87 per cent (or 3202 km²) has low or very low pastoral potential, and in many instances is not fully utilised.

Note: Information presented in the table below should not be used as an indication of the present day resource condition of the pastoral lands in WA. The condition of resources in previous surveys may have altered.

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Table 19 **Resource condition summaries and mapped severely degraded and eroded areas (sde) for regional rangeland surveys**

Region surveyed (and year commenced)	Total area (km²)	No. of traverse assessments	Sde area (as mapped)		Resource condition (% of traverse assessments)		
			km²	%	Good	Fair	Poor
Gascoyne (1969)	63 400	2 426	1205*	1.9*	32	53	15
West Kimberley (1972)	89 600	4 532	2000*	2.2*	20	50	30
Eastern Nullarbor (1974)	47 400	1 273	0	0	50	10	40
Ashburton (1976)	93 600	8 608	534	0.6	50	34	16
Carnarvon Basin (1980)	74 500	10 952	647	0.9	45	32	23
Murchison (1985)	88 360	13 441	1560	1.8	21	37	42
Roebourne Plains (1987)	10 216	1 172	233	2.3	51	27	22
North-eastern Goldfields (1988)	100 570	10 470	452	0.4	39	32	29
Sandstone-Yalgoo-Paynes Find (1992)	94 710	9 435	145	0.2	45	32	23
Pilbara (1995)	181 723	12 518	310	0.2	77	11	12
Lower Murchison (2002) (all areas) ^	**13 039**	**836**	**9**	**0.07**	**78**	**9**	**13**
Lower Murchison (2002) (pastoral leases only)	**3 685**	**607**	**9**	**0.07**	**70**	**12**	**18**
Total areas surveyed	857 118^	75 593					

* Not mapped, estimate only.
^ All areas of lower Murchison included in totals.

Appendix 1—Individual station reports

Pastoral potential and carry capacity

The determination of how many livestock should graze the rangelands of Western Australia has often been a matter of conjecture. Initial reports from explorers in the 1850s for example described grass 'two to three feet high' in parts of the upper Murchison River catchment. They continued to describe 'a fine sward of grass' below the gums on the river. Such encouraging reports from early explorers may not have been so favourable had they conducted expeditions during a 'dry' year.

However, early land managers were able to recognise the vastly variable seasons from year to year. Some pastoralists were managers for absentee landholders whose expectations of high financial returns from the land during good seasons and bad proved detrimental to some landscapes in the long term. The history of the pastoral industry showcases many examples of high expectations. Records suggest (in the southern rangelands) a major dry spell roughly every 40 years. Major dry times are often referred to as drought however the term drought is a self-imposed term referring to water shortages as determined through man-made enterprises. In most instances natural landscapes are adapted to, and survive, dry times.

With varying interpretations on the ability of a landscape to support livestock in a sustainable manner, so too are there varying interpretations of the productivity of the land. Pastoral productivity is a term with a loose interpretation, as is the term drought. Its meaning may vary between individuals. Pastoral potential and its implied meaning (in relation to livestock numbers within a parcel of land), is often used in a production, regulatory, administrative and fiscal related sense.

Pastoral potential is defined as the ability of an area to support a given number of livestock in the long term without causing the loss of desirable perennial species of shrubs and grasses or degradation of soils.

Pastoral potential is influenced by the inherent characteristics of the perennial vegetation (palatable or unpalatable to livestock), and the condition status of the vegetation.

Curry et al. (1994), Pringle (1994), Van Vreeswyk et al. (1998, 2004) and Cotching (2005), provide comment on pastoral productivity. The authors suggest pastoral potential estimates are not to be used for commercial or regulatory purposes. To provide a certain carrying capacity per vegetation group (or land system) implies a certain confidence. Every climatic season is different, and every season provides different amounts of vegetative biomass. Scientific studies on livestock grazing provide information on particular vegetation types, but correlations cannot always be inferred for other types. Pastoral potential is often based on unrealistic principles, for example assuming the vegetation type or land system is in pristine (unaltered) condition and all of the vegetation or land system is available for livestock grazing. In reality, this is very rarely the case.

Rangeland survey reports are required to provide estimates of stocking rates for pastoral properties to be used in regulation. Survey reports often quote two stocking rate figures: 'suggested carrying capacity' and 'potential carrying capacity'. As mentioned above, potential carrying capacity is in reality not a 100 per cent achievable goal in most instances. Suggested carrying capacity is a more realistic baseline figure, dependent on seasonal conditions and present condition of the vegetation. In most cases the 'suggested carrying capacity' is less than 'potential carrying capacity', and the difference between the two 'capacities' can vary in the lower Murchison by 1 to 16 per cent for different leases. In other rangeland areas differences of 30 per cent or greater have been recorded.

Suggested carrying capacity is a guide for numbers of livestock and feral grazers over a dry summer following a significant growth period during the preceding winter. It implies, following a failed winter, livestock numbers would be reduced to minimise the chance of land degradation, and to maximise the health and well-being of the remaining livestock breeding nucleus. It also implies feral animals would be removed from the land.

In the past, financiers or property markets have used potential carrying capacity figures for business planning or property sales. In this sense, the pastoral carrying capacity figures

could lead to unrealistic expectations should the differences between ‘suggested’ and ‘potential’ be great.

Potential carrying capacity is required for broad-scale pastoral lease rental formulae and setting total livestock limits. Suggested carrying capacity is intended for land managers, financiers, property consultants, researchers and others.

More importantly, discussion should revolve less around livestock ‘numbers’ and more around the health of pastoral landscapes. Cotching (2005) suggests: ‘The actual grazing value and appropriate stocking of a particular pasture at any time varies enormously with seasonal conditions, perennial pasture and the degree of recent use. An inflexible adherence to suggested stocking rates is not to be recommended but the aim is rather to match stocking with the variations in pasture condition as closely as possible’.

Variable stocking rates, applied each year to account for seasonal variation in palatable biomass, are crucial. An essential additional aim of manipulating stock numbers is to ensure desirable plants are maintained and soil surfaces are not degraded in the long term. Monitoring systems should be mandatory.

Any discussion of managing stocking rates must include an estimation of feral animals and native grazers such as kangaroos.

Carrying capacity estimates are presented in Tables 21 and 22. They are derived from empirical data on vegetation and animal trials (Holm 1994, Fletcher 1995, Yan et al. 1996), pastoralist experience, pastoral stocking rate workshops and leases achieving perceived long-term resource conservation via monitoring and animal production data (Morrissey and O’Connor 1988). These estimates are for the lower Murchison survey area, and may differ from other pastoral areas in WA.

The carrying capacities presented in the station reports are summarised in sheep units (su). Table 20 provides conversion rates to other grazing animals.

Carrying capacity estimates for land systems in various condition are based on the following condition classes:

Good condition: optimal cover and composition of perennial and annual plant species, many of which are palatable. Unpalatable species occur but do not dominate.

Fair condition: moderate cover and composition of perennial and annual plant species, some of which are palatable. Unpalatable species in increased numbers but do not dominate.

Poor condition: low cover and composition of perennial and annual plant species, few of which are palatable. Unpalatable species dominate.

Carrying capacity changes between good, fair and poor condition vary considerably between pastoral potential categories (see Table 22).

Table 20 **Relative feed requirements for grazing animals based on sheep units**

Sheep
One wether (about 45 kg) = 1 sheep unit
One ewe producing a lamb = 1.3 sheep units
One weaner (up to 1 year) = 0.7 sheep units
One ram = 1.5 sheep units
One steer (about 270 kg) = 7.0 sheep units
Cattle
One cow producing a calf = 9.8 sheep units
One heifer or steer (up to 1 year) = 5.6 sheep units
One bull = 10.5 sheep units
Goats
One mature goat = 1 sheep unit
One (nanny) goat producing a kid = 1.3 sheep units
One (billy) goat = 1.5 sheep units
Kangaroos
One adult kangaroo = 0.6 sheep units

Table 21 **Carrying capacity estimates for land systems in good condition and with different pastoral potentials**

Pastoral potential	Estimated carrying capacity (ha/sheep unit)	Estimated carrying capacity (ha/cattle unit)
Very high	5–14 ha/su	35–98 ha/cu
High	7–16 ha/su	49–112 ha/cu
Moderately high	12–18 ha/su	84–126 ha/cu
Moderate	16–20 ha/su	112–140 ha/cu
Low	20–25 ha/su	140–175 ha/cu
Very low	30–40 ha/su	210–280 ha/cu

Table 22 **Carrying capacity estimates for land systems in three condition classes and with different pastoral potentials**

Pastoral potential	Good condition (ha/sheep unit)	Fair condition (ha/sheep unit)	Poor condition (ha/sheep unit)	Good condition (ha/cattle unit)	Fair condition (ha/cattle unit)	Poor condition (ha/cattle unit)
Very high	5	8	14	35	56	98
High	7	10	16	49	70	112
Moderately high	12	14	18	84	98	126
Moderate	16	18	20	112	126	140
Low	20	25	25	140	175	175
Very low	30	35	35	210	245	245

Changes are greatest for high potential systems. For example, a high pastoral potential system in good condition may have 1200 kg of feed available per hectare but only 500 kg when in poor condition. Thus the reduction in carrying capacity between good and poor condition is fairly substantial. A system with very low potential may have 250 kg and 150 kg of feed available per hectare for good and poor condition respectively. Thus the reduction in carrying capacity between good and poor condition is relatively small.

Table 23 summaries the pastoral potentials of the land systems and vegetation types within the survey area.

Table 24 provides a summary of the pastoral potential of all lands within the survey area. It highlights the generally low productivity of pastoral leases in that 32 per cent of the land allocated to pastoralism is of low pastoral potential and about 55 per cent is of very low pastoral potential.

Table 23 **Summary of pastoral potentials of land systems and vegetation types**

Land system (area in hectares)	Pastoral potential of land system	Dominant vegetation type (% of land system)	Pastoral potential of vegetation type
York (3124 ha)	Very high	Eucalypt saltbush open woodland (ESOW) 75%	Very high
Pillawarra (10 397 ha)	High	Mixed chenopod shrubland (MXCS) 40%	Very high
		Acacia calcrete stony shrubland (ACSS) 55%	Moderate
Holmwood (1409 ha)	High	Alluvial plain shrubland (PLAS) 55%	High
Yandi (11 618 ha)	High	Riverine shrubland (RIVS) 45%	High
		Hardpan acacia shrubland (HPAS) 45%	Moderate
Stork (1029 ha)	High	Eucalypt saltbush open woodland (ESOW) 40%	Very high
		Eucalypt acacia woodland (EUAW) 40%	Moderate
Bayou (620 ha)	High	Alluvial plain shrubland (PLAS) 55%	Very high
		Riverine shrubland (RIVS) 25%	High
Roderick (252 ha)	High	Alluvial plain shrubland (PLAS) 60%	Very high
Boulder (1308 ha)	Moderately high	Stony mulga mixed shrubland (see Curry et al. 1994) 60%	High
Mongolia (152 ha)	Moderately high	Stony mulga mixed shrubland (see Curry et al. 1994) 70%	High
Highway (16 093 ha)	Moderately high	Eucalypt acacia woodland (EUAW) 60%	High
Cooloomia (2655 ha)	Moderate	Mallee acacia sandplain (MASA) 95%	Moderate*
Ajana (9017 ha)	Low	Stony acacia shrubland (STAS) 70%	Low
Kalli (373 ha)	Low	Sandplain wanderrie grassy shrubland (SWGS) 70%	Low^
Sandplain (188 455 ha)	Low	Acacia sandplain shrubland/woodland (ASSW) 95%	Low
Nerren (394 493 ha)	Low	Acacia sandplain shrubland/woodland (ASSW) 90%	Low
Tumblagooda (41 742 ha)	Very low	Acacia hill shrubland (ACHS) 85%	Very low
Bungabandi (12 184 ha)	Very low	Scrub heath (SCHE) 65%	Low
Eurardy (221 378 ha)	Very low	Mallee acacia sandplain (MASA) 40%	Low
		Acacia sandplain shrubland/woodland (ASSW) 40%	Low
Joseph (1483 ha)	Very low	Acacia sandplain shrubland/woodland (ASSW) 80%	Low
Kalbarri (98 705 ha)	Very low	Low heath (HEAT) 45%	Very low
		Scrub heath (SCHE) 45%	Very low
Nanga (215 530 ha)	Very low	Heath vegetation (HEAT, SCHE, TRHE) 90%	Very low
Bibra (15 561 ha)	Very low	Calcrete melaleuca acacia shrubland (CMAS) 65%	Very low
Zuytdorp (42 257 ha)	Very low	Heath vegetation (HEAT, SCHE, TRHE) 90%	Very low

* Mallee-acacia sandplain vegetation has higher pastoral potential in the northern parts of this survey, than the south.
^ Sandplain wanderrie grassy shrubland vegetation has lower pastoral potential than in the neighbouring survey of the upper Murchison due to fewer palatable species.

Table 24 **A summary of pastoral potential in the survey area**

Pastoral potential	Percentage of pastoral land	Percentage of all land
Very high	0.8	0.2
High	6.2	2.0
Moderately high	3.1	1.3
Moderate	0.2	0.2
Low	32.0	45.4
Very low	54.9	49.8
Nil (unvegetated riverbed, town, cropped land)	2.9	1.1
Total land	100.0	100.0

Station reports

Station reports for the six pastoral lease properties within the survey area are presented alphabetically. Each report is a two-page summary derived from traverse records and provides information about the type and condition of the vegetation and soils based on land systems. The reports list the land systems occurring on each station, the pastoral potential of those systems and a summary of soil health. While suggested carrying capacities for small stock units are listed, it must be emphasised these figures must not be used solely as a financial, consultancy, research or managerial guide.

COOLCALALAYA

Pastoral lease: 3114/1211

Area: About 115 592 ha (legal); 115 362 ha (computed)

Area surveyed: 118 272 ha (whole lease plus Reserve)

Summary of land types

No.	Land type	No. of land systems	Area (ha)	% of station
5	Stony plains with acacia shrublands and halophytic shrublands	1	152	0.1
6	Sandplains and occasional dunes with grassy acacia shrublands	1	6 359	5.5
7	Sandplains with acacia, mallee and heath	2	100 880	87.5
8	Plains with eucalypt woodlands and non-halophytic shrubs	1	2 007	1.7
9	Alluvial plains with acacia shrublands	2	5 093	4.4
11	Alluvial plains with halophytic shrublands	2	871	0.8

Rangeland inventory and condition summary

Pastoral potential	Land type	Land system	Area			Traverse assessment and resource condition								
			Total		Sde~	No. of traverse points*	Soil erosion (%)				Perennial vegetation (%)			Scc* (su)	Pcc** (su)
			ha	%	ha		Nil	Minor	Mod.	Severe	Good	Fair	Poor		
High	11	Bayou	620	0.54	0	1	100	0	0	0	0	100	0	56	89
High	9	Holmwood	17	0.01	0	0	0	0	0	0	0	0	0	0	2
High	11	Roderick	251	0.22	0	2	50	50	0	0	0	50	50	19	36
High	9	Yandi	5 076	4.40	0	17	35	47	12	6	0	0	100	231	564
Mod. high	8	Highway	2 007	1.74	0	0	0	0	0	0	0	0	0	0	167
Mod. high	5	Mongolia	152	0.13	0	0	0	0	0	0	0	0	0	0	13
Low	7	Nerren	85 936	74.49	0	121	100	0	0	0	65	32	3	3 996	4 297
Low	6	Sandplain	6 352	5.51	0	10	100	0	0	0	40	60	0	279	318
Very low	7	Eurardy	14 951	12.96	0	11	100	0	0	0	91	9	0	494	498

Pastoral resource summary

Pastoral potential	Area			Traverse assessment and resource condition							Scc* (su)	Pcc** (su)
	Total		Sde~	No. of traverse points	Soil erosion (%)				Perennial vegetation (%)			(from table above)	
	ha	%	ha		Nil	Minor	Mod.	Severe	Good	Fair	Poor		
High	5 965	5.2	0	20	40	45	10	5	0	10	90	306	691
Moderately high	2 159	1.9	0	0	0	0	0	0	0	0	0	0	180
Low	92 287	80.0	0	131	100	0	0	0	63	34	3	4 276	4 614
Very low	14 951	13.0	0	11	100	0	0	0	91	9	0	494	498
Total	115 362	100.0	0	162	80	15	3	2	51	18	31	5 076	5 984
Survey average for land systems traversed on Coolcalalaya Station					86	12	1	1	51	24	25		

^ Indicates minor value not reported in tables.

~ Area mapped as being severely degraded and eroded (sde).

Where there are inadequate observations for a land system the carrying capacity calculations are based on averages for the system over the whole survey area.

* Suggested carrying capacity (sheep units) over the dry season, following an effective winter season.

** Potential carrying capacity (sheep units) over the dry season, assuming all land systems are in good condition.

Station summary

Severely degraded and eroded (ha)	0
Number of traverse assessment points	162
Pastoral resource condition:	
Soil erosion	
% nil	80
% minor	15
% moderate	3
% severe	2
Perennial vegetation	
% good	51
% fair	18
% poor	31

Suggested carrying capacity (su—sheep units) for present condition over the dry season, following an effective winter season and assuming the lease is fully developed for grazing	5076
Potential carrying capacity (su—sheep units) over the dry season, assuming all land systems are in good condition and the lease is fully developed for grazing	5984

It is inappropriate for these carrying capacity estimates to be used alone for commercial or regulatory purposes.

EURARDY

Pastoral lease: 3114/906

Area: About 27 856 ha (legal); 30 057 ha (computed)

Area surveyed: 30 057 ha (whole lease)

Summary of land types

No.	Land type	No. of land systems	Area (ha)	% of station
7	Sandplains with acacia, mallee and heath	3	20 766	69.1
8	Plains with eucalypt woodlands and non-halophytic shrubs	1	6 196	20.6
	Freehold cereal cropping land		3 095	10.3

Rangeland inventory and condition summary

Pastoral potential	Land type	Land system	Area			Traverse assessment and resource condition									Scc* (su)	Pcc** (su)
			Total		Sde~	No. of traverse points*	Soil erosion (%)				Perennial vegetation (%)					
			ha	%	ha		Nil	Minor	Mod.	Severe	Good	Fair	Poor			
Mod. high	8	Highway	6 196	20.6	0	24	100	0	0	0	85	10	5		489	516
Very low	7	Bungabandi	2 923	9.7	0	19	95	5	0	0	68	16	16		95	97
Very low	7	Eurardy	3 236	10.8	0	2	100	0	0	0	100	0	0		108	108
Very low	7	Nanga	14 607	48.6	0	29	100	0	0	0	100	0	0		487	487
Nil		Freehold	3 095		0	0	100	0	0	0	0	0	0		0	0

Pastoral resource summary

Pastoral potential	Area			Traverse assessment and resource condition								Scc* (su) (from table above)	Pcc** (su) (from table above)
	Total		Sde~	No. of traverse points	Soil erosion (%)				Perennial vegetation (%)				
	ha	%	ha		Nil	Minor	Mod.	Severe	Good	Fair	Poor		
Moderately high	6 196	20.6	0	24	100	0	0	0	85	10	5	489	516
Very low	20 766	69.1	0	50	98	2	0	0	88	6	6	690	692
Nil	3 095	10.3	0		100	0	0	0	0	0	0	0	0
Total	30 057	100.0	0	74	99	1	0	0	87	8	5	1 179	1 208
Survey average for land systems traversed on Eurardy Station					99	1	0	0	90	6	4		

^ Indicates minor value not reported in tables.

~ Area mapped as being severely degraded and eroded.

Where there are inadequate observations for a land system the carrying capacity calculations are based on averages for the system over the whole survey area.

* Suggested carrying capacity (sheep units) over the dry season, following an effective winter season.

** Potential carrying capacity (sheep units) over the dry season, assuming all land systems are in good condition.

Station summary

Severely degraded and eroded (ha)	0
Number of traverse assessment points	74
Pastoral resource condition:	
Soil erosion	
% nil	99
% minor	1
% moderate	0
% severe	0
Perennial vegetation	
% good	87
% fair	8
% poor	5

Suggested carrying capacity (su—sheep units) for present condition over the dry season, following an effective winter season and assuming the lease is fully developed for grazing 1179

Potential carrying capacity (su—sheep units) over the dry season, assuming all land systems are in good condition and the lease is fully developed for grazing 1208

It is inappropriate for these carrying capacity estimates to be used alone for commercial or regulatory purposes.

MALLEE

Pastoral lease: 3114/938

Area: About 18 118 ha (legal); 37 006 (computed)

Area surveyed: 37 006 ha (whole lease plus Reserve and freehold)

Summary of land types

No.	Land type	No. of land systems	Area (ha)	% of station
4	Stony plains with acacia shrublands	1	1 008	3
6	Sandplains and occasional dunes with grassy acacia shrublands	1	359	1
6	Sandplains with acacia, mallee and heath	3	26 620	72
8	Plains with eucalypt woodlands and non-halophytic shrubs	1	1 628	4
	Freehold cereal cropping land		7 391	20

Rangeland inventory and condition summary

Pastoral potential	Land type	Land system	Area			Traverse assessment and resource condition								
			Total		Sde~	No. of traverse points*	Soil erosion (%)				Perennial vegetation (%)			Scc* (su)	Pcc** (su)
			ha	%	ha		Nil	Minor	Mod.	Severe	Good	Fair	Poor		
Mod. high	4	Boulder	1 008	2.7	0	3	100	0	0	0	67	33	0	76	84
Mod. high	8	Highway	1 628	4.4	0	2	0	0	0	0	100	0	0	136	136
Low	6	Kalli	359	1.0	0	0	0	0	0	0	100	0	0	18	18
Low	7	Nerren	4 832	13.1	0	13	100	0	0	0	85	15	0	234	242
Very low	7	Eurardy	20 303	54.8	0	22	100	0	0	0	95	5	0	674	677
Very low	7	Joseph	1 485	4.0	0	1	100	0	0	0	100	0	0	30	30
Nil		Freehold	7 391	20.0	0	0	100	0	0	0	0	0	0	0	0

Pastoral resource summary

Pastoral potential	Area			Traverse assessment and resource condition							Scc* (su)	Pcc** (su)
	Total		Sde~	No. of traverse points	Soil erosion (%)				Perennial vegetation (%)			(from table above)	
	ha	%	ha		Nil	Minor	Mod.	Severe	Good	Fair	Poor		
Moderately high	2 636	7.1	0	5	100	0	0	0	67	33	0	212	220
Low	5 191	14.1	0	13	100	0	0	0	85	15	0	252	260
Very low	21 788	58.8	0	23	100	0	0	0	96	5	0	703	706
Nil	7 391	20.0	0	0	0	0	0	0	0	0	0	0	0
Total	37 006	100.0	0	41	100	0	0	0	83	17	0	1 167	1 186
Survey average for land systems traversed on Mallee Station					100	0	0	0	88	11	1		

^ Indicates minor value not reported in tables.

~ Area mapped as being severely degraded and eroded.

Where there are inadequate observations for a land system the carrying capacity calculations are based on averages for the system over the whole survey area.

* Suggested carrying capacity (sheep units) over the dry season, following an effective winter season.

** Potential carrying capacity (sheep units) over the dry season, assuming all land systems are in good condition.

Station summary

Severely degraded and eroded (ha)	0
Number of traverse assessment points	41
Pastoral resource condition:	
Soil erosion	
% nil	100
% minor	0
% moderate	0
% severe	0
Perennial vegetation	
% good	83
% fair	17
% poor	0

Suggested carrying capacity (su—sheep units) for present condition over the dry season, following an effective winter season and assuming the lease is fully developed for grazing 1167

Potential carrying capacity (su—sheep units) over the dry season, assuming all land systems are in good condition and the lease is fully developed for grazing 1186

It is inappropriate for these carrying capacity estimates to be used alone for commercial or regulatory purposes.

MOUNT VIEW

Pastoral lease: 3114/852

Area: About 8041 ha (legal); 8110 (computed)

Area surveyed: 8110 ha (whole lease)

Summary of land types

No.	Land type	No. of land systems	Area (ha)	% of station
3	Low hills and stony plains with acacia shrublands	1	3110	38
7	Sandplains with acacia, mallee and heath	1	5000	62

Rangeland inventory and condition summary

Pastoral potential	Land type	Land system	Area			Traverse assessment and resource condition									
			Total		Sde~	No. of traverse points*	Soil erosion (%)				Perennial vegetation (%)			Scc* (su)	Pcc** (su)
			ha	%	ha		Nil	Minor	Mod.	Severe	Good	Fair	Poor		
Low	3	Ajana	3110	38	0	15	100	0	0	0	62	23	15	144	156
Very low	7	Nanga	5000	62	0	10	100	0	0	0	100	0	0	167	167

Pastoral resource summary

Pastoral potential	Area			Traverse assessment and resource condition								Scc* (su) (from table above)	Pcc** (su) (from table above)
	Total		Sde~	No. of traverse points	Soil erosion (%)				Perennial vegetation (%)				
	ha	%	ha		Nil	Minor	Mod.	Severe	Good	Fair	Poor		
Low	3110	38	0	15	100	0	0	0	62	23	15	144	156
Very low	5000	62	0	10	100	0	0	0	100	0	0	167	167
Total	8110	100	0	25	100	0	0	0	81	12	7	311	322
Survey average for land systems traversed on Mount View Station					100	0	0	0	76	16	8		

^ Indicates minor value not reported in tables.

~ Area mapped as being severely degraded and eroded.

Where there are inadequate observations for a land system the carrying capacity calculations are based on averages for the system over the whole survey area.

* Suggested carrying capacity (sheep units) over the dry season, following an effective winter season.

** Potential carrying capacity (sheep units) over the dry season, assuming all land systems are in good condition.

Station summary

Severely degraded and eroded (ha)	0
Number of traverse assessment points	25
Pastoral resource condition:	
Soil erosion	
% nil	100
% minor	0
% moderate	0
% severe	0
Perennial vegetation	
% good	81
% fair	11
% poor	7

Suggested carrying capacity (su—sheep units) for present condition over the dry season, following an effective winter season and assuming the lease is fully developed for grazing 311

Potential carrying capacity (su—sheep units) over the dry season, assuming all land systems are in good condition and the lease is fully developed for grazing 322

It is inappropriate for these carrying capacity estimates to be used alone for commercial or regulatory purposes.

MURCHISON HOUSE

Pastoral lease: 3114/969

Area: About 126 516 ha (legal); 127 193 (computed)

Area surveyed: 127 193 ha (whole lease plus Reserves)

Summary of land types

No.	Land type	No. of land systems	Area (ha)	% of station
1	Hills and ranges with acacia shrublands	1	13 921	11.0
2	Low hills with eucalypt or acacia woodlands and halophytic shrubs	1	10 280	8.1
7	Sandplains with acacia, mallees and heath	4	58 188	45.8
10	Alluvial plains with eucalypt woodlands and halophytic shrubs	1	1 029	0.8
11	Alluvial plains with halophytic shrublands	1	2 838	2.2
12	Calcrete plains with acacia shrublands	1	15 561	12.2
13	Coastal plains, cliffs, dunes, mudflats or beaches	1	25 174	19.7

Rangeland inventory and condition summary

Pastoral potential	Land type	Land system	Area			Traverse assessment and resource condition								Scc* (su)	Pcc** (su)
			Total		Sde~	No. of traverse points*	Soil erosion (%)				Perennial vegetation (%)				
			ha	%	ha		Nil	Minor	Mod.	Severe	Good	Fair	Poor		
Very high	11	York	2 838	2.2	0	8	100	0	0	0	87	0	13	432	473
High	2	Pillawarra	10 280	8.1	548	44	61	22	7	10	10	7	83	611	1 285
High	10	Stork	1 029	0.8	0	4	100	0	0	0	25	25	50	90	147
Moderate	7	Cooloomia	554	0.4	0	4	100	0	0	0	75	25	0	35	37
Very low	12	Bibra	15 561	12.3	0	31	100	0	0	0	90	3	7	514	549
Very low	7	Bungabandi	1 537	1.2	0	1	100	0	0	0	100	0	0	51	51
Very low	7	Kalbarri	2	0	0	0	100	0	0	0	-	-	-	0	0
Very low	7	Nanga	56 096	44.1	0	70	96	1	3	0	96	0	4	1 863	1 870
Very low	1	Tumblagooda	13 921	10.9	0	32	97	3	0	0	83	3	14	457	464
Very low	13	Zuytdorp	25 173	19.9	364	56	100	0	0	0	98	2	0	838	827
Nil		Freehold	202			0	-	-	-	-	-	-	-	-	-

Pastoral resource summary

Pastoral potential	Area			Traverse assessment and resource condition								Scc* (su)	Pcc** (su)
	Total		Sde~	No. of traverse points	table				Perennial vegetation (%)			(from table above)	
	ha	%	ha		Nil	Minor	Mod.	Severe	Good	Fair	Poor		
Very high	2 838	2.2	0	8	100	0	0	0	87	0	13	432	473
High	11 309	9.0	548	48	64	20	7	9	11	9	80	701	1432
Moderate	554	0.4	0	4	100	0	0	0	75	25	0	35	37
Very low	112 290	88.3	364	190	98	1	1	0	94	1	5	3 723	3 743
Nil	202			0									
Total	127 193	100.0	912	250	91	5	2	2	67	9	24	4 891	5 685
Survey average for land systems traversed on Murchison Station					95	3	1	1	75	7	18		

^ Indicates minor value not reported in tables.

~ Area mapped as being severely degraded and eroded.

Where there are inadequate observations for a land system the carrying capacity calculations are based on averages for the system over the whole survey area.

* Suggested carrying capacity (cattle units) over the dry season, following an effective summer season.

** Potential carrying capacity (cattle units) over the dry season, assuming all land systems are in good condition.

Station summary

Severely degraded and eroded (ha)	912 (0.7% of station)
Number of traverse assessment points	250
Pastoral resource condition:	
Soil erosion	
% nil	91
% minor	5
% moderate	2
% severe	2
Perennial vegetation	
% good	67
% fair	9
% poor	24

Suggested carrying capacity (su—sheep units) for present condition over the dry season, following an effective winter season and assuming the lease is fully developed for grazing	4890
Potential carrying capacity (su—sheep units) over the dry season, assuming all land systems are in good condition and the lease is fully developed for grazing	5685

It is inappropriate for these carrying capacity estimates to be used alone for commercial or regulatory purposes.

YANDI

Pastoral lease: 3114/890

Area: About 49 706 ha (legal); 50 813 (computed)

Area surveyed: 49 706 ha (whole lease)

Summary of land types

No.	Land type	No. of land systems	Area (ha)	% of station
4	Stony plains with acacia shrublands	1	244	0.5
7	Sandplains with acacia, mallees and heath	2	44 826	88.2
8	Plains with eucalypt woodlands and non-halophytic shrubs	1	122	0.2
9	Alluvial plains with acacia shrublands	1	5 621	11.1

Rangeland inventory and condition summary

Pastoral potential	Land type	Land system	Area			Traverse assessment and resource condition								Scc* (su)	Pcc** (su)
			Total		Sde~	No. of traverse points*	Soil erosion (%)				Perennial vegetation (%)				
			ha	%	ha		Nil	Minor	Mod.	Severe	Good	Fair	Poor		
High	9	Yandi	5 621	11.1	0	32	53	33	6	8	0	3	97	260	625
Mod. high	4	Boulder	1 244	0.5	0	0	100	0	0	0	100	0	0	20	20
Mod. high	8	Highway	122	0.2	0	0	100	0	0	0	100	0	0	10	10
Low	7	Nerren	17 313	34.1	0	18	100	0	0	0	82	18	0	834	866
Very low	7	Eurardy	25 513	54.1	0	2	100	0	0	0	100	0	0	917	917

Pastoral resource summary

Pastoral potential	Area			Traverse assessment and resource condition								Scc* (su) (from table above)	Pcc** (su) (from table above)
	Total		Sde~	No. of traverse points	Soil erosion (%)				Perennial vegetation (%)				
	ha	%	ha		Nil	Minor	Mod.	Severe	Good	Fair	Poor		
High	5 621	11.1	0	32	53	33	6	8	0	3	97	260	625
Moderately high	366	0.7	0	0	100	0	0	0	100	0	0	30	30
Low	17 313	34.1	0	18	100	0	0	0	82	18	0	834	866
Very low	27 513	54.1	0	2	100	0	0	0	100	0	0	917	917
Total	50 813	100.0	0	56	88	8	2	2	71	5	24	2 041	2 438
Survey average for land systems traversed on Yandi Station					90	7	2	1	66	13	21		

^ Indicates minor value not reported in tables.

~ Area mapped as being severely degraded and eroded.

Where there are inadequate observations for a land system the carrying capacity calculations are based on averages for the system over the whole survey area.

* Suggested carrying capacity (sheep units) over the dry season, following an effective winter season.

** Potential carrying capacity (sheep units) over the dry season, assuming all land systems are in good condition.

Station summary

Severely degraded and eroded (ha)	0
Number of traverse assessment points	56
Pastoral resource condition:	
Soil erosion	
% nil	88
% minor	8
% moderate	2
% severe	2
Perennial vegetation	
% good	71
% fair	5
% poor	24

Suggested carrying capacity (su—sheep units) for present condition over the dry season, following an effective winter season and assuming the lease is fully developed for grazing	2041
Potential carrying capacity (su—sheep units) over the dry season, assuming all land systems are in good condition and the lease is fully developed for grazing	2438

It is inappropriate for these carrying capacity estimates to be used alone for commercial or regulatory purposes.

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Appendix 2A—Plant species recorded at inventory sites (*introduced species)

Annuals

Argemone ochroleuca subsp. *ochroleuca* (Mexican poppy)*
Aristida contorta (windgrass)
Atriplex semilunaris (annual saltbush)
Austrostipa sp. (annual spear grass)
Avena barbata (bearded oat)*
Avena fatua (wild oat)*
Avena sp. (wild oat)*
Calandrinia sp. (parakeelya)
Carthamus lanatus (saffron thistle)*
Eriachne sp. (annual wanderrie)
Hordeum leporinum (barley grass)*
Medicago polymorpha (burr medic)*
Mesembryanthemum nodiflorum (ice plant)*
Poa sp. (unidentified grass)
Poa sp. (unidentified grass)*
Ptilotus axillaris (mat mulla mulla)
Ptilotus exaltatus (tall mulla mulla)
Ptilotus sp. (annual mulla mulla)
Raphanus sp. (wild radish)*
Salsola tragus (roly poly)
Schoenia cassiniana (pink everlasting)
Sclerolaena sp. (bindii)
Sclerolaena uniflora (two spine bindii),
Solanum nigrum (black berry nightshade)*
Zygophyllum sp. (twin leaf)

Perennial grasses (includes sedges and graminoids)

Amphipogon caricinus (grey beard grass)
Amphipogon sp. (beard grass)
Austrostipa elegantissima (feather speargrass)
Austrostipa sp. (spear grass)
Borya sp. (pincushions—graminoid)
Ecdeiocolea monostachya (wire stem grass—graminoid)
Eragrostis eriopoda (woolly butt)
Eriachne flaccida (claypan grass)
Eriachne helmsii (buck wanderrie)
Mesomelaena preissii (sandplain sedge)
Monachather paradoxus (broad-leaf wanderrie)
Thyridolepis multiculmis (soft wanderrie)
Triodia danthonioides (spinifex)
Triodia sp. (spinifex)

Low shrubs

Acacia aff. *colletioides*
Acacia andrewsii (prickly wattle)
Acacia colletioides (wait-a-while)
Acacia idiomorpha
Acacia murrayana (fire wattle)
Acacia sp.
Acacia spathulifolia (spoon leaf wattle)
Acanthocarpus preissii
Anthotroche sp.
Atriplex amnicola (swamp saltbush)
Atriplex bunburyana (silver saltbush)
Atriplex vesicaria (bladder saltbush)
Baeckea sp.
Banksia attenuata (slender banksia)
Beaufortia squarrosa (sand bottlebrush)
Calothamnus blepharospermus
Calothamnus oldfieldii
Calytrix sp. (starflower)
Chenopodium auricomum (swamp bluebush)
Chenopodium gaudichaudianum (cottony saltbush)
Conospermum sp. (smokebush)
Conostylis prolifera (sedge)
Conostylis sp. (sedge)
Daviesia sp.
Desmocladus sp.
Dianella revoluta (flax lily)
Dicrastylis fulva
Dicrastylis sp.
Didymanthus roei (tie bluebush)
Diplolaena grandiflora (wild rose)
Enchylaena tomentosa (ruby saltbush)
Eremaea sp.
Eremophila forrestii (Wilcox bush)
Eremophila latrobei (warty leaf fuchsia)
Eremophila sp. (poverty bush)
Frankenia sp. (frankenia)
Frankenia sp. (sea heath)
Gastrolobium oxylobioides (Champion Bay poison)
Grevillea deflexa (red grevillea)
Grevillea sp.
Gunniopsis quadrifida (sweet samphire)
Hakea circumalata
Hakea preissii (needle bush)
Hakea pycnoneura
Halosarcia sp. (samphire)
Hemigenia sp.
Hibbertia sp.
Isopogon sp.
Jacksonia sp.
Keraudrenia sp. (firebush)
Keraudrenia integrifolia (firebush)
Lamarchea hakeifolia (false paperbark)
Lawrencia squamata (grey fan leaf)
Lepidium sp.
Leptosema aphyllum (flat leaf cockies tongues)
Leucopogon sp.
Maireana brevifolia (small leaf bluebush)
Maireana georgei (golden bluebush)
Maireana planifolia (flat leaf bluebush)
Maireana platycarpa (shy bluebush)
Maireana pyramidata (sago bush)
Maireana sp. (bluebush)
Maireana thesioides (lax bluebush)
Maireana tomentosa (felty bluebush)
Melaleuca oldfieldii (purple honeymyrtle Priority 2 species)
Melaleuca aff. *depressa*
Melaleuca sp.

Mesomelaena preissii (sandplain sedge)
Mesomelaena sp. (sedge)
Mirbelia sp.
Olearia axillaris (coastal daisy)
Olearia dampieri subsp. *eremicola* (inland daisy)
Olearia sp.
Patersonia occidentalis (blue flag)
Persoonia acicularis
Petrophile conifera
Petrophile macrostachya
Petrophile megalostegia
Petrophile semifurcata
Petrophile sp.
Pimelea leucantha (big riceflower)
Pimelea microcephala (shrubby riceflower)
Pimelea sp. (riceflower)
Ptilotus beardii (low mulla mulla)
Ptilotus divaricatus (climbing mulla mulla)
Ptilotus obovatus (cotton bush)
Ptilotus schwartzii (horse mulla mulla)
Ptilotus sp. (mulla mulla)
Rhagodia eremaea (tall saltbush)
Scholtzia umbellifera
Sclerolaena diacantha (grey copperburr)
Sclerolaena uniflora (two-spined bindii)
Senna artemisioides subsp. *artemisioides* (banana leaf)
Senna artemisioides subsp. x *coriacea* (desert cassia)
Sida calyxhymenia (tall sida)
Solanum lasiophyllum (flannel bush)
Solanum nummularium (wild tomato)
Spartothamnella sp.
Templetonia sp.
Threlkeldia diffusa (coast bonefruit)
Thryptomene strongylophylla
Verticordia densiflora (feather flower)

Mid shrubs

Acacia acuminata (jam)
Acacia aff. *colletioides*
Acacia andrewsii (prickly wattle)
Acacia chartacea
Atriplex cinerea (grey saltbush)
Acacia colletioides (wait-a-while)
Acacia ligulata (umbrella wattle)
Acacia neurophylla (wodjil)
Acacia ramulosa (wanyu)
Acacia rostellifera (summer-scented wattle)
Acacia saligna (golden wreath wattle)
Acacia sclerosperma (limestone wattle)
Acacia sp. (wattle)
Acacia spathulifolia (spoon leaf wattle)
Acacia tetragonophylla (curara)
Actinostrobus arenarius (sandplain cypress)
Allocasuarina acutivalvis (black tamma)
Allocasuarina campestris (tamma)
Allocasuarina sp.
Alyxia buxifolia (dysentery bush)
Anthrotroche sp.
Baeckea sp.
Banksia sceptrum (sceptre banksia)
Callistemon phoeniceus (river bottlebrush)
Calothamnus blepharospermus
Calothamnus longissimus
Calothamnus oldfieldii
Calothamnus sanguineus (silky leaf blood flower),
Calothamnus sp.
Capparis sp.
Cassytha sp.
Chamelaucium oenanthum (purple wax Priority 1 species)
Chenopodium gaudichaudianum (cottony saltbush)
Chenopodium sp. (swamp bluebush)
Cratystylis subspinescens (sage)
Diplolaena grandiflora (wild rose)
Dodonaea inaequifolia (hopbush)
Dryandra fraseri subsp. *ashbyi*
Duperreya sericea (creeper)
Eremaea sp.
Eremophila forrestii (Wilcox bush)
Eremophila latrobei (warty leaf fuchsia)
Eremophila maitlandii (sandplain poverty bush)
Eremophila sp. (poverty bush)
Exocarpos aphyllus (naked lady)
Exocarpos sp.
Grevillea aff.
Grevillea annulifera (prickly plume grevillea—Priority 3 species)
Grevillea deflexa (red grevillea)
Grevillea dielsiana (Diels grevillea)
Grevillea leucopteris (white plume grevillea)
Grevillea stenomera (lace net grevillea)
Grevillea sp.
Hakea lissocarpha (honey bush)
Hakea orthorrhyncha (bird beak hakea)
Hakea preissii (needle bush)
Hakea recurva (djarnokmurd)
Hakea sp.
Hakea stenophylla (golf ball hakea)
Hakea trifurcata (twin leaf hakea)
Jacksonia cupulifera (rattlepod)
Jacksonia rigida
Jacksonia sp.
Lamarchea hakeifolia (false paperbark)
Melaleuca aff. *depressa*
Melaleuca cardiophylla (teatree)
Melaleuca cordata
Melaleuca eleuterostachya (tall honeymyrtle)
Melaleuca fulgens (scarlet honeymyrtle)
Melaleuca megacephala
Melaleuca oldfieldii (purple honeymyrtle Priority 2 species)
Melaleuca radula (graceful honeymyrtle)
Melaleuca ryeae
Melaleuca scabra (rough honeymyrtle)
Melaleuca sp.
Melaleuca urceolaris
Melaleuca uncinata (broom honeymyrtle)
Mirbelia sp.
Muehlenbeckia florulenta (lignum)
Nuytsia floribunda (Christmas tree)
Olearia dampieri subsp. *eremicola* (inland daisy)
Olearia sp.
Petrophile conifera (pine cone petrophile)

Petrophile macrostachya (long-eared petrophile)
Petrophile semifurcata
Petrophile sp.
Pileanthus sp.
Pimelea leucantha (big riceflower)
Pimelea microcephala (shrubby riceflower)
Pimelea sp.
Pityrodia oldfieldii (Oldfield's foxglove)
Rhagodia drummondii (low saltbush)
Rhagodia eremaea (tall saltbush)
Rhagodia preissii subsp. *obovata* (sea saltbush)
Scaevola crassifolia (thick leaf fanflower)
Scaevola spinescens (currant bush)
Scaevola tomentosa (ragged leaf fanflower)
Scholtzia sp.
Scholtzia umbellifera
Senna artemisioides subsp. x *coriacea* (desert cassia)
Senna artemisioides subsp. *artemisioides* (banana leaf)
Senna glutinosa subsp. *chatelainiana* (green cassia)
Solanum lasiophyllum (flannel bush)
Solanum nummularium (wild tomato)
Stylobasium spathulatum (pebble bush)
Thryptomene sp.
Xylomelum angustifolium (sandplain woody pear)

Tall shrubs

Acacia aff. *ligulata*
Acacia acuminata (jam)
Acacia anthochaera
Acacia chartacea
Acacia grasbyi (miniritchie)
Acacia ligulata (umbrella wattle)
Acacia murrayana (fire wattle)
Acacia neurophylla (wodjil)
Acacia ramulosa (wanyu)
Acacia rhodophloia
Acacia roycei (needle myall)
Acacia saligna (golden wreath wattle)
Acacia sclerosperma (limestone wattle)
Acacia sp.
Acacia spathulifolia (spoon leaf wattle)
Acacia tetragonophylla (curara)
Acacia victoriae (wait-a-while)
Acacia xiphophylla (snakewood)
Actinostrobus arenarius (sandplain cypress)
Alectryon oleifolius (mingah bush)
Allocasuarina acutivalvis (black tamma)
Allocasuarina campestris (tamma)
Allocasuarina sp.
Alyxia buxifolia (dysentery bush)
Banksia ashbyi (Ashby's banksia)
Banksia attenuata (slender banksia)
Banksia prionotes (acorn banksia)
Brachychiton sp.
Bursaria occidentalis (Australian boxthorn)
Callistemon phoeniceus (river bottlebrush)
Callitris sp.
Calothamnus aff. *homalophyllus*
Calothamnus blepharospermus (bottlebrush)
Cassytha sp. (dodder laurel)
Diplolaena grandiflora (wild rose)
Dodonaea inaequifolia (hop bush)
Dryandra fraseri subsp. *ashbyi*
Duboisia hopwoodii (pituri)
Duperreya sericea (creeper)
Eremaea sp.
Eremophila aff. *oldfieldii* (pixie bush)
Eremophila longifolia (berrigan)
Eremophila pterocarpa (silver poverty bush)
Eucalyptus sp.
Exocarpos aphyllus (naked lady)
Grevillea annulifera (prickly plume grevillea Priority 3)
Grevillea candelabroides (candle grevillea)
Grevillea costata (Priority 3 species)
Grevillea dielsiana (Diels grevillea)
Grevillea leucoptera (white plume grevillea)
Grevillea olivacea (olive grevillea)
Grevillea sp.
Grevillea stenomera (lace net grevillea)
Gyrostemon racemiger (fire tree)
Hakea multilineata (grass leaf hakea)
Hakea orthorrhyncha (bird beak hakea)
Hakea preissii (needle bush)
Hakea pycnoneura
Hakea recurva (djarnokmurd)
Hakea sp.
Hakea stenophylla (golf ball hakea)
Jacksonia sp.
Lamarchea hakeifolia (false paperbark)
Melaleuca aff. *depressa* (spoon leaf honeymyrtle)
Melaleuca cardiophylla (teatree)
Melaleuca eleuterostachya (tall honeymyrtle)
Melaleuca megacephala
Melaleuca sp.
Melaleuca uncinata (broom honeymyrtle)
Nuytsia floribunda (Christmas tree)
Pimelea microcephala (shrubby riceflower)
Pityrodia oldfieldii (Oldfield's foxglove)
Santalum acuminatum (quandong)
Santalum lanceolatum (bitter quandong)
Santalum spicatum (sandalwood)
Scaevola spinescens (currant bush)
Stylobasium spathulatum (pebble bush)
Xanthorrhoea preissii (grass tree)
Xylomelum angustifolium (sandplain woody pear)

Trees

Acacia acuminata (jam)
Acacia aneura (mulga)
Acacia galeata (leather leaf wattle)
Acacia ligulata (umbrella wattle)
Acacia rhodophloia
Acacia rostellifera (summer-scented wattle)
Actinostrobus arenarius (sandplain cypress)
Allocasuarina huegeliana (rock sheoak)
Banksia menziesii (firewood banksia)
Banksia sceptrum (sceptre banksia)
Brachychiton gregorii (desert kurrajong)
Bursaria occidentalis (Australian boxthorn)
Callitris columellaris (inland pine)
Casuarina obesa (swamp sheoak)
Eremophila aff. *longifolia* (berrigan)

Eucalyptus camaldulensis (river red gum)
Eucalyptus eudesmioides (malallie)
Eucalyptus foecunda (narrow-leaved red mallee)
Eucalyptus horistes
Eucalyptus jucunda (Yuna mallee)
Eucalyptus loxophleba—mallee form (York gum)
Eucalyptus loxophleba (York gum)
Eucalyptus mannensis (Mann Range mallee)
Eucalyptus obtusiflora (Dongara mallee)
Eucalyptus oldfieldii (Oldfield's mallee)
Eucalyptus sp.
Eucalyptus victrix (coolibah)
Hakea suberea (corkwood)
Melaleuca cardiophylla (teatree)
Xylomelum angustifolium (sandplain woody pear)

Other

Amyema preissii (wireleaf mistletoe)

Appendix 2B—Plant species recorded at inventory sites sorted by botanical family (*introduced species)

Aizoaceae

Gunniopsis quadrifida (sweet samphire)
Mesembryanthemum nodiflorum (ice plant)*

Amaranthaceae

Ptilotus axillaris (mat mulla mulla)
Ptilotus beardii (low mulla mulla)
Ptilotus divaricatus (climbing mulla mulla)
Ptilotus exaltatus (tall mulla mulla)
Ptilotus obovatus (cotton bush)
Ptilotus schwartzii (horse mulla mulla)
Ptilotus sp. (annual mulla mulla)
Ptilotus sp. (mulla mulla)

Apocynaceae

Alyxia buxifolia (dysentery bush)

Asteraceae

Carthamus lanatus (saffron thistle)*
Cratystylis subspinescens (sage)
Olearia axillaris (coastal daisy)
Olearia dampieri subsp. *eremicola* (inland daisy)
Olearia sp.
Schoenia cassiniana (pink everlasting)

Boryaceae

Borya sp. (pincushions)

Brassicaceae

Lepidium sp.
Raphanus sp. (wild radish)*

Caesalpiniaceae

Senna artemisioides subsp. *artemisioides* (banana leaf)
Senna artemisioides subsp. *coriacea* (desert cassia)
Senna glutinosa subsp. *chatelainiana* (green cassia)

Capparaceae

Capparis sp.

Casuarinaceae

Allocasuarina acutivalvis (black tamma)
Allocasuarina campestris (tamma)
Allocasuarina huegeliana (rock sheoak)
Allocasuarina sp.
Casuarina obesa (swamp sheoak)

Chenopodiaceae

Atriplex amnicola (swamp saltbush)
Atriplex bunburyana (silver saltbush)
Atriplex cinerea (grey saltbush)
Atriplex semilunaris (annual saltbush)
Atriplex vesicaria (bladder saltbush)
Chenopodium gaudichaudianum (cottony saltbush)
Chenopodium sp. (swamp bluebush)
Didymanthus roei (tie bluebush)
Enchylaena tomentosa (ruby saltbush)
Halosarcia sp. (samphire)
Maireana brevifolia (small leaf bluebush)
Maireana georgei (golden bluebush)
Maireana planifolia (flat leaf bluebush)
Maireana platycarpa (shy bluebush)
Maireana pyramidata (sago bush)
Maireana sp. (bluebush)
Maireana thesioides (lax bluebush)
Maireana tomentosa (felty bluebush)
Rhagodia drummondii (low saltbush)
Rhagodia eremaea (tall saltbush)
Rhagodia preissii subsp. *obovata* (sea saltbush)
Salsola tragus (roly poly)
Sclerolaena diacantha (grey copperburr)
Sclerolaena sp. (bindii)
Sclerolaena uniflora (two spine bindii)
Threlkeldia diffusa (coast bonefruit)

Convolvulaceae

Duperreya sericea (creeper)

Cupressaceae

Actinostrobus arenarius (sandplain cypress)
Callitris columellaris (inland pine)
Callitris sp.

Cyperaceae

Mesomelaena preissii (sandplain sedge)
Mesomelaena sp. (sedge)

Dasypogonaceae

Acanthocarpus preissii

Dilleniaceae

Hibbertia sp.

Ecdeiocoleaceae

Ecdeiocolea monostachya (wire stem grass)

Epacridaceae

Leucopogon sp.

Frankeniaceae

Frankenia sp. (frankenia)
Frankenia sp. (sea heath)

Goodeniaceae

Scaevola crassifolia (thick leaf fanflower)
Scaevola spinescens (currant bush)
Scaevola tomentosa (ragged leaf fanflower)

Gyrostemonaceae

Gyrostemon racemiger (fire tree)

Haemodoraceae

Conostylis prolifera (sedge)
Conostylis sp. (sedge)

Iridaceae

Patersonia occidentalis (blue flag)

Lamiaceae

Dicrastylis fulva
Dicrastylis sp.
Hemigenia sp.
Pityrodia oldfieldii (Oldfield's foxglove)
Spartothamnella sp.

Lauraceae

Cassytha sp. (dodder laurel)

Loranthaceae

Amyema preissii (wireleaf mistletoe)
Nuytsia floribunda (Christmas tree)

Malvaceae

Lawrencia squamata (grey fan leaf)
Sida calyxhymenia (tall sida)

Mimosaceae

Acacia acuminata (jam)
Acacia aff. *colletioides*
Acacia andrewsii (prickly wattle)
Acacia aneura (mulga)
Acacia anthochaera
Acacia colletioides (wait-a-while)
Acacia chartacea
Acacia galeata (leather leaf wattle)
Acacia grasbyi (miniritchie)
Acacia idiomorpha
Acacia ligulata (umbrella wattle)
Acacia murrayana (fire wattle)
Acacia neurophylla (wodjil)
Acacia ramulosa (wanyu)
Acacia rhodophloia
Acacia roycei (needle myall)
Acacia saligna (golden wreath wattle)
Acacia rostellifera (summer scented wattle)
Acacia saligna (golden wreath wattle)
Acacia sclerosperma (limestone wattle)
Acacia sp.
Acacia spathulifolia (spoon leaf wattle)
Acacia tetragonophylla (curara)
Acacia victoriae (wait-a-while)
Acacia xiphophylla (snakewood)

Myoporaceae

Eremophila aff. *longifolia* (berrigan)
Eremophila aff. oldfieldii (pixie bush)
Eremophila forrestii (Wilcox bush)
Eremophila latrobei (warty leaf fuchsia)
Eremophila longifolia (berrigan)
Eremophila maitlandii (sandplain poverty bush)
Eremophila pterocarpa (silver poverty bush)
Eremophila sp. (poverty bush)

Myrtaceae

Baeckea sp.
Beaufortia squarrosa (sand bottlebrush)
Callistemon phoeniceus (river bottlebrush)
Calothamnus aff. *homalophyllus*
Calothamnus blepharospermus (bottlebrush)
Calothamnus longissimus
Calothamnus oldfieldii
Calothamnus sanguineus (silky leaf blood flower)
Calothamnus sp.
Calytrix sp. (starflower)
Chamelaucium oenanthum (purple wax Priority 1)
Eremaea sp.
Eucalyptus camaldulensis (river red gum)
Eucalyptus eudesmioides (malallie)
Eucalyptus foecunda (narrow-leaved red mallee)
Eucalyptus horistes
Eucalyptus jucunda (Yuna mallee)
Eucalyptus loxophleba (York gum)
Eucalyptus mannensis (Mann Range mallee)
Eucalyptus obtusiflora (Dongara mallee)
Eucalyptus oldfieldii (Oldfield's mallee)
Eucalyptus sp.
Eucalyptus victrix (coolibah)
Lamarchea hakeifolia (false paperbark)
Melaleuca aff. *depressa* (spoonleaf honeymyrtle)
Melaleuca cardiophylla (teatree)
Melaleuca cordata
Melaleuca eleuterostachya (tall honeymyrtle)
Melaleuca fulgens (scarlet honeymyrtle)
Melaleuca megacephala
Melaleuca oldfieldii (purple honeymyrtle Priority 2)
Melaleuca radula (graceful honeymyrtle)
Melaleuca ryeae
Melaleuca scabra (rough honeymyrtle)
Melaleuca sp.
Melaleuca uncinata (broom honeymyrtle)
Melaleuca urceolaris
Pileanthus sp.
Scholtzia sp.
Scholtzia umbellifera
Thryptomene sp.
Thryptomene strongylophylla
Verticordia densiflora (feather flower)

Papaveraceae

Argemone ochroleuca subsp. *ochroleuca* (Mexican poppy)*

Papilionaceae

Daviesia sp.
Gastrolobium oxylobioides (Champion Bay poison)
Jacksonia cupulifera (rattlepod)
Jacksonia rigida
Jacksonia sp.
Leptosema aphyllum (flat leaf cockies tongues)
Medicago polymorpha (burr medic)*
Mirbelia sp.
Templetonia sp.

Phormiaceae

Dianella revoluta (flax lily)

Pittosporaceae

Bursaria occidentalis (Australian boxthorn)

Poaceae

Amphipogon caricinus (grey beard grass)
Amphipogon sp. (beard grass)
Aristida contorta (windgrass)
Austrostipa elegantissima (feather speargrass)
Austrostipa sp. (annual spear grass)
Austrostipa sp. (spear grass)
Avena barbata (bearded oat)*
Avena fatua (wild oat)*
Avena sp. (wild oat)*
Eragrostis eriopoda (woolly butt)
Eriachne flaccida (claypan grass)
Eriachne helmsii (buck wanderrie)
Eriachne sp. (annual wanderrie)
Hordeum leporinum (barley grass)*
Monachather paradoxus (broad-leaf wanderrie)
Poa sp. (unidentified grass)
Poa sp. (unidentified grass)*
Thyridolepis multiculmis (soft wanderrie)
Triodia danthonioides (spinifex)
Triodia sp. (spinifex)

Polygonaceae

Muehlenbeckia florulenta (lignum)

Portulacaceae

Calandrinia sp. (parakeelya)

Proteaceae

Banksia ashbyi (Ashby's banksia)
Banksia attenuata (slender banksia)
Banksia menziesii (firewood banksia)
Banksia prionotes (acorn banksia)
Banksia sceptrum (sceptre banksia)
Conospermum sp. (smokebush)
Dryandra fraseri subsp. *ashbyi*
Grevillea aff. *dielsiana*
Grevillea annulifera (prickly plume grevillea P3)
Grevillea candelabroides (candle grevillea)
Grevillea costata (P3)
Grevillea deflexa (red grevillea)
Grevillea dielsiana (Diels grevillea)
Grevillea leucopteris (white plume grevillea)
Grevillea olivacea (olive grevillea)
Grevillea sp.
Grevillea stenomera (lace net grevillea)
Hakea circumalata
Hakea lissocarpha (honey bush)
Hakea multilineata (grass leaf hakea)
Hakea orthorrhyncha (bird beak hakea)
Hakea preissii (needle bush)
Hakea pycnoneura
Hakea recurva (djarnokmurd)
Hakea sp.
Hakea stenophylla (golf ball hakea)
Hakea suberea (corkwood)
Hakea trifurcata (twin leaf hakea)
Isopogon sp.
Persoonia acicularis
Petrophile conifera (pine cone petrophile)
Petrophile macrostachya (long-eared petrophile)
Petrophile megalostegia
Petrophile semifurcata
Petrophile sp.
Xylomelum angustifolium (sandplain woody pear)

Restionaceae

Desmocladus sp.

Rutaceae

Diplolaena grandiflora (wild rose)

Santalaceae

Alectryon oleifolius (mingah bush)
Dodonaea inaequifolia (hop bush)
Exocarpos aphyllus (naked lady)
Exocarpos sp.
Santalum acuminatum (quandong)
Santalum lanceolatum (bitter quandong)
Santalum spicatum (sandalwood)

Solanaceae

Anthotroche sp.
Duboisia hopwoodii (pituri)
Solanum lasiophyllum (flannel bush)
Solanum nigrum (black berry nightshade)*
Solanum nummularium (wild tomato)

Sterculiaceae

Brachychiton gregorii (desert kurrajong)
Brachychiton sp.
Keraudrenia integrifolia (firebush)
Keraudrenia sp. (firebush)

Surianaceae

Stylobasium spathulatum (pebble bush)

Thymelaeaceae

Pimelea leucantha (big riceflower)
Pimelea microcephala (shrubby riceflower)
Pimelea sp.

Xanthorrhoeaceae

Xanthorrhoea preissii (grass tree)

Zygophyllaceae

Zygophyllum sp. (twin leaf)

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